The famous geneticist and co-founder of the modern theory of evolution, Theodosius Dobzhansky, published an article in this journal in 1973 with the title “Nothing in Biology Makes Sense Except in the Light of Evolution” (Dobzhansky, 1973). In that article he responded to religious attacks on the theory and defended its importance by noting how evolution explains the enormous diversity of life, its unity, and the myriad empirical facts of biology.

What does Dobzhansky’s dictum mean today? Most biologists would say that Dobzhansky had it correct: The theory of evolution is the central organizing theory of the life sciences. The theory explains the facts of biology, i.e., the theory tells us why the living world appears as it does. It gives us the answer to a number of interesting questions: Why do we observe so much diversity of life (750,000 named insects, 170,000 dicots, 12,000 nematodes, and 18,000 bony fish, for example)?

Given the vast amount of biodiversity, why are so many chemical pathways (e.g., the Krebs Cycle) the same in otherwise greatly different organisms? Why is DNA found so widely as the genetic material? Evolution provides for us an understanding. It also addresses questions like, Why do organisms have highly specialized functions that permit them to live in hostile environments (hot springs), or in extraordinarily limited environments (like the nematode Panagrellus redivivus which lives in German beer coasters)? Biology is a truly amazing subject, and evolution helps explain why.

The theory of evolution similarly explains biological relationships. Why do we observe complex patterns of distribution among plants and animals? Why do some birds have limited ranges while others are cosmopolitan? The theory also relates bodies of scientific information. Subjects of study that utilize different methods, focus on different orders of magnitude, conceive of nature in different time frames, or in different spatial categories are unified by the theory of evolution. Paleontology, biogeography, physiology, ecology, systematics, embryology, genetics, and cytology are vastly different disciplines. Unlike the physical sciences, which are still searching for a plausible unifying theory, the life sciences have a single unifying theory that synthesizes...
them all and brings them into relationship with one another. Finally, the theory of evolution provides a powerful guide to research. The questions raised by the theory have been extraordinarily productive in the past 140 years. Much of 20th century genetics grew out of scientists’ attempts to reconcile Darwin’s theory with the ideas on inheritance in his day. At present the theory of evolution provides direction in bringing knowledge in ecology to illuminating problems in paleontology; or knowledge in genetics to shedding light on issues in embryology, and suggesting new paths of investigation.

The Teaching of Evolution in the United States

The theory of evolution, then, is impressive, productive, and important. To become a serious biologist, one needs to have a grasp of what evolution means, and to be an informed citizen, one should have a general understanding of what the theory claims. People in most of the modern, industrialized world take that for granted. It is terribly ironic, however, that the United States, where so much of the contemporary theory of evolution developed, has such an unsatisfactory record of teaching it, both in K-12 and in post-secondary education.

Consider the situation in K-12. The Thomas B. Fordham Foundation published in January, 2000, Good Science, Bad Science: Teaching Evolution in the States (Lerner, 2000). The report is unsettling. It reviews and evaluates the treatment of evolution by looking at state science standards state by state. State standards do not tell the full story, but by looking at them we can get a reasonably broad stroke picture of the situation. The good news in the report is that 31 of the states do an adequate to excellent job; the bad news is that 19 states do a “weak to reprehensible job,” 12 omit the word “evolution,” and four omit teaching biological evolution altogether. Since the report was issued there have been some changes, most notably, the Kansas Board of Education has reversed its scandalous deletion of all references to biological evolution in its standards. But the story is far from over, and the opposition to teaching evolution in the public schools continues to be a well-financed and powerful force.

The author of the report, Professor Lawrence Lerner, explains that the opposition to the teaching of evolution does not come from reservations in the scientific community about whether or not evolution occurs. Yet, a significant number of Americans believe that both Creation and evolution should be taught in the public schools, and the general public is less than convinced in the validity of evolution. Some people worry about the moral effects of teaching biological evolution; and there is a diverse coalition of young Earthers, Biblical literalists, intelligent design proponents, new age spiritualists, and others, who add up to a potent force that can influence state boards of education, and, just as important, local school boards.

What emerges from the Fordham report is a picture of a country that differs radically in its teaching of evolution from others in the modern industrialized world. There is less of a commitment for instruction on evolution, and if Dobzhansky is correct, many of the K-12 students in the United States are not receiving an adequate preparation for understanding the life sciences.

What about post-secondary education? The problems differ from K-12 but carry implications for them. Colleges and universities, for the most part, teach evolution in biology courses. How they do it is another issue. I find two main problems (which also are reflected in most major and non-major biology textbooks) with the approach generally used.

The first problem with what I shall call the “standard treatment of evolution” is that it is taught as one unit among a number of others. In a typical course we are likely to find a sequence something like this: the cell, genetics, evolution, animal/plant form and function, and ecology. A few programs use evolution as an organizing principle. For the most part, however, evolution is just another topic. Students have to master the Hardy-Weinberg formula and memorize different forms of isolating mechanisms; then they move on to another seemingly unrelated set of hurdles, like the nitrogen cycle and the characteristics of the biomes. Evolution, which synthesizes the disparate disciplines of the life sciences, rarely emerges in biology courses or texts as the unifying thread that makes sense of all the material.

The second problem that concerns me with most college teaching of evolution has to do with the organization and presentation of the subject matter. Many programs and texts present evolution in the following manner. The unit starts with some Pre-Darwinian ideas including: a brief look at some early naturalists who discussed change in time, such as the famous naturalists Georges-Louis Leclerc, Comte de Buffon, and Jean-Baptiste de Lamarck, followed by some great figures of the past who, although they did not accept change in time, nonetheless contributed to the accumulation of knowledge that made the “discovery” of evolution possible. Carl Linnaeus makes a cameo appearance here, as well as Georges Cuvier, the great comparative anatomist and paleontologist.

Next a short biographical sketch of Charles Darwin, sometimes pointing out that he was not a particularly promising university student (perhaps to suggest that students should not give up hope of becoming a useful citizen someday, even if they get a “C” in the course), and then, from Darwin’s youth to his voyage on the H.M.S. Beagle, focusing on the Galapagos Islands with
their famous iguanas, tortoises, and finches. This is followed by a description of natural selection, the main force of evolutionary change according to Darwin, and then an extensive treatment of the "evidence for evolution:” fossils, diversity, distribution, comparative anatomy (adult and embryo), and finally, a case study in speciation–favorite examples include the Galapagos finches, the Hawaiian Drosophila, or the cichlids of Lake Victoria. The evidence for evolution is intended to provide a compelling argument for accepting evolution, i.e., there is so much evidence for the theory it must be correct, and, by implication, only an obscurantist or religious fanatic would go against all that evidence.

After establishing the validity of evolution, programs elucidate evolutionary mechanisms: chiefly focusing on population genetics (explaining the implications of the Hardy-Weinberg formula) and reproductive barriers. Finally, students are given a concluding wiz through the record of 700 million years of life on Earth, with lots of interesting photos and even more Latin names.

What is wrong with this approach? There are two major problems that concern me: the impression it conveys and the opportunities it misses. Going from Darwin, to a sketch of his central idea of natural selection, to a long list of evidence gives students the impression of a fortress mentality: Stake out a claim, build an intellectual fortress of evidence to defend against all on-comers, and pour boiling oil over the ramparts on the barbarians who attack. As such, it can easily appear not only dauntingly dogmatic, but also static. And, if combined with a couple of throw-away lines on religion, the approach can come off as threatening to students’ deeply held values, even if they do not subscribe to any fundamentalist position. More important, the typical method of presenting evolution misses a great opportunity to discuss the nature of science.

A caveat about the nature of science is in order here. Like many others, I think it is important that those learning about evolution be given a broader sense of the subject. Likewise, it is necessary that those teaching evolution (or any science) have an adequate conception of the nature of science if they expect to teach their students effectively. It is pretty much a common sense notion—you should know the general nature of what you teach (Abd-El-Khalick, Bell, & Lederman, 1998; American Association for the Advancement of Science, 1990, 1993; National Academy of Sciences, 1998). Students and those preparing to be teachers, therefore, should be taught about the nature of science. The problem, of course, is that scholars have been grappling with the subject since the early part of the 20th century without achieving any consensus. It may not be necessary to achieve total consensus on the matter, but many feel that the current lack of agreement undercuts attempts to teach the subject.

Part of what makes uncovering and explaining the nature of science difficult lies in the diversity of the scientific enterprise itself. Consider the list in Table 1 of the sections of the American Association for the Advancement of Science which includes physics, chemistry, geology, geography, engineering, biology, statistics, psychology, political science, and linguistics. What is it that holds together statistics, the historical development of the surface of Earth, classification of plants, and experimentation on the behavior of rats? Even the individual sciences (take biology, for instance), encompass a vast array of disciplines—as exemplified by the 78 member societies (and organizations) of the American Institute of Biological Sciences which include people who work at a range of activities: constructing computer models, giving names to previously unknown lichens of the rain forest, testing the physiological consequences of alterations in diet, and elucidating the life cycle of liver flukes in Africa.

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<td>Sections of the American Association for the Advancement of Science</td>
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<td>4. Geosciences and Hydrospheric Sciences</td>
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A Case Study Approach

In spite of the perils of attempting to construct a model that captures the nature of science, we can, nonetheless, make a number of useful observations about the contemporary nature of science and about scientific inquiry. Teaching the theory of evolution is an invitation to do so. An effective way to do so is by using a historical case study approach, one that focuses on scientific problems. Instructors present biology as a case of questions that biologists are investigating, on how those questions came into existence, and what are currently proposed answers. This perspective stresses the lineages of questions that guide scientific research.

Evolution as a case study illustrates this well. In such a treatment, one can start with Charles Darwin as a young man and survey what constituted the world of the life sciences in his day. Students learn that “biology” was not a term widely used, and that what lay at the heart of understanding the living world was “natural history.” Natural history’s goals were to describe and classify the products of nature and to uncover the underlying order in nature (Farber, 2000). The tradition in which Darwin worked had been established in the century before by Carl Linnaeus, who popularized and pioneered a system of classifying and naming, and Georges-Louis Leclerc, Comte de Buffon, who stressed the importance of extensive observation and argued for a complete survey of the living world (by which he meant external and internal characteristics, life stages, geographical distribution, geographical variation, and behavior). Naturalists believed that with sufficient empirical observations they could someday penetrate the veils of mystery that shrouded the living world, and discern the order in nature.

Between the founders of modern natural history and the generation of naturalists to which Darwin belonged, stood a major revision of the naturalist tradition: the emergence of comparative anatomy as a serious science. Combining the careful anatomical research tradition on the human body with extensive new studies on animals, a set of researchers hoped to find the key to understanding the order in nature by examining structure. The most well-known proponent of this new discipline was Georges Cuvier of the Paris Museum of Natural History. He claimed that his exhaustive dissections revealed a set of fundamental body plans. These basic plans could be further subdivided into subgroups by using examination of the structure of various organ systems. What was important about the new comparative anatomy was Cuvier’s claim that each species could be rigorously defined, and was morphologically stable. They could not change because the individual units were so complex that any change would destroy their functional integrity.

When Darwin was a young man, comparative anatomy was the queen of the life sciences. Comparative anatomists were uncovering the underlying structures of animal form, and they regarded these underlying structures as the foundation for classification. Systems of classification, it was hoped, would mirror the order in nature. Enriching that picture was the study of embryology. Of equal importance was the study of fossils which revealed that the structures of extinct animals followed the same general patterns as living ones. That is, the picture that Cuvier constructed applied to living as well as to extinct forms.

Darwin also lived at a time when the Industrial Revolution in Europe was leading Europeans to actively colonize the globe. Nations sought new markets and new raw materials, and in the exploration and exploitation of the world, Europeans uncovered thousands of new plants and animals. The material coming back to the museums and collections in Europe revealed interesting geographical patterns. Large areas of the globe seemed to have plants and animals that possessed family resemblances. Darwin’s generation, therefore, was heir to the largest collections ever assembled. His colleagues differed qualitatively from earlier naturalists because of the consequences of the Industrial Revolution. Increased leisure time, lower cost of printing, innovations in the reproduction of illustrations, and development of popular education had made it possible for more people to work on natural history than ever before. This new, more professional, generation held high standards, and they were in communication with one another through such new genres as the monograph and scientific article (Farber, 1997).

Darwin’s contemporaries puzzled over a number of problems concerning their data. For one, naturalists were amazed by the diversity that existed. Beetles! Why should God have created so many beetles? You could find a thousand different species just in the area where Darwin received his university education. Does God have an inordinate fondness for beetles (as a later biologist would quip?). Given that there were so many different species on the planet, naturalists asked where they all had come from. One could imagine a Garden of Eden with a few hundred species; or Noah’s ark with several thousand kinds, but naturalists were uncovering a staggering number of life forms. Paleontologists compounded the problem by showing that there were thousands, perhaps millions, of extinct forms that formerly inhabited Earth. Where had all the new species come from? Why did all the old ones die off? What accounted for the similarities we notice among different species, among genera, etc.? On a practical level, what criteria should we use in classifying them?

In addition to diversity and its origin (and the related issue of classification), the patterns of distribution
called out for some explanation. Why should Australian animals today resemble Australian animals of the past, rather than the animals of other continents? Why should plants on islands in the ocean resemble those of the closest continent? Why should plants at high altitudes resemble plants living at great distances away, but at the same altitude?

When Darwin began his momentous voyage on the H.M.S. Beagle, his contemporaries were asking the above questions, and it is hardly surprising that he found himself asking the same ones on his journey. He discovered interesting fossils (e.g., armadillos) in South America that resembled animals still living in the region, and noted that similar animals and plants inhabited adjacent territories. He noticed that the life on the Galapagos resembled South American forms, but were separate species.

After Darwin returned to England he spent a number of years compiling his data and farming it out to experts for them to describe and to name. One of his collaborators informed him that his collection of finches from the Galapagos consisted of almost a dozen different species. Another verified that the fossil llama he found in South America represented a different species than the ones found alive there today. These novel findings reenforced his puzzlement over the leading questions in natural history. At some fairly early point in these years after his return, Darwin realized that if species changed, if one species could give rise to another, then many of the central problems that he and other naturalists confronted could be answered. But, how could a species change? The comparative anatomy of his day suggested it could not happen. So he spent years reading. He found earlier attempts to establish change in nature unconvincing. Buffon and Lamarck were too speculative. Darwin felt that to be convincing he had to discover the mechanism responsible for the change of species. Why a mechanism? We do not know for sure, but it certainly seems that he had absorbed the scientific ethos of the generation of naturalists to which he belonged. They wanted the study of living organisms to be a science like the study of chemistry or physics. Since the days of Newton, the physical sciences had pursued a vision of nature as a vast, complex machine. During the 18th and 19th centuries the picture of nature became more and more that of machine, like the machines driving the Industrial Revolution throughout Western Europe. While Darwin was working on his explanation of the origin of species, those studying physiology were discovering the workings of the animal and plant body—a series of physical and chemical mechanisms that explained nutrition, respiration, and other biological functions. So, looking for a mechanism to explain evolution was in keeping with the most advanced science of his day, and is a tradition that still characterizes a lot of what we do in the life sciences.

Finally, as we know from Darwin’s diary and notebooks, on September 28, 1838 he read a work by the Rev. Thomas Malthus on the consequences of overpopulation. In a flash he made a leap from the pressure that resulted from overpopulation to the notion that in nature, since there was so much destruction of life and so much variation, there must be a natural selection operating that in time could modify the descendants of a population (Browne, 1995, Mayr, 1972, Ruse, 1979).

It was a huge leap. He went from thinking of a species as a blueprint—a unit rigorously defined by comparative anatomy—to a population of individuals. He realized that individuals with variations that gave them an adaptive advantage were more likely to survive and reproduce, and that in time the process would give rise to new species. Fossil forms resembled living forms because they were directly or indirectly related. Distribution patterns were the traces of ancient movement of plants and animals. The resemblances noted in classification were not the result of an abstract plan, but the faint outlines of common descent.

Notice what is happening here pedagogically. Those categories that we usually present as “evidence for evolution” are presented as the problems that Darwin solved (fossils, diversity, distribution, comparative anatomy). These problems gave rise to the theory; rather than being the bricks and mortar of a fortress constructed after the theory was conceived. By reorganizing the materials that are generally used we can convey knowledge of the theory in a manner that avoids the static “fortress mentality” and better illustrates the nature of science.

Darwin’s euphoria of discovery did not last long, for he realized that there were many problems with his new theory. So much so that he doubted if he could ever convince anyone of it. This is not fortress science; just the opposite (more like ecosystem development, if we need a different metaphor). Darwin worked for over 20 years before publishing his theory, for he knew that it would be controversial and he knew that he had not solved many of the problems that the theory faced. In this regard, Darwin was like other proponents of new, revolutionary theories.

What were some of the major scientific problems? First off, of course, was the issue raised by comparative anatomy—that species were so complex it was difficult to fathom how they could change. Next, if the species inhabiting Earth were the descendants of previous species, then there would have to have been a vast amount of variation in those earlier populations to permit natural selection to create new forms. Was there? Where did it come from? Were there forces operating on the production of new variations? Closely related to the issue of variation was the concern about whether new
variation could be inherited. The study of inheritance in Darwin's day also posed the challenging observation that characteristics seemed to blend when they were inherited—a red flowering plant crossed with a white flowering plant often gave rise to a pink flowering plant. Or, if the characteristics did not blend, then they seemed to mix—the children in a family typically seemed to have features resembling the father, some the mother. Blending inheritance suggested that advantageous variation, so important for Darwin, might get swamped in successive generations and therefore not be acted upon by natural selection.

The problems that Darwin faced were real and serious. Not surprisingly, therefore, many scientists had serious reservations about his theory when he published it in 1859, and a lively debate ensued. The debate, however, stimulated a vast amount of significant research. The research done on heredity, for example, turned out to be of critical importance in biology, for it led ultimately to the rediscovery of "Mendel's Laws" (which had been completely ignored in Mendel's day) and to the development of modern genetics.

So, one set of problems, the ones Darwin grappled with, led to a solution, Darwin's theory of evolution based on natural selection, which led to another set of problems. The work on those problems led to new solutions in genetics, and other subjects, and eventually to a new theory of evolution (the Modern Synthesis that was formulated by Theodosius Dobzhansky, Ernst Mayr, George Gaylord Simpson, Julian Huxley, Ledyard Stebbins, and others beginning in the late 1930s). And, of course, the new theory raised a host of new and exciting issues and questions. The lineage of problems continues, and when we teach this way students see how fundamental questions are to science.

Religion

What about religion? Religion resides under the surface in any discussion of evolution. Here, again, I think an historical approach helps greatly. In Darwin's day many scientists and most educated people in the English-speaking world had grown up with the view that the wonders of nature served as testimony to the wisdom and power of God, the Creator. Darwin, however, had come to the view that natural history would be more productive if it severed its explicit ties with religion. That is, if scientific explanation did not include any reference to the supernatural about which we have no way of resolving disputes. Such was the case in physics, chemistry, and recently, in Darwin's day, geology. Not everyone agreed with that position.

We most often, however, read caricatures of the story: for example, accounts of the famous Huxley-Wilberforce debate at the 1860 British Association for the Advancement of Science meeting where Darwin's bulldog allegedly defeated and put down "Soapy Sam," the Bishop of Oxford. What is left out of this rendition is the very serious consideration given to Darwin's ideas by the religious minded (cf. Livingstone, 1987, Moore, 1979). There were a number of theologians who considered Darwin's theory a threat to received opinion. Charles Hodge, for example, argued that by stressing a deterministic universe, Darwin was slipping into atheism. But other theologians argued that Darwin's theory opened the path for a renewed Christianity. John Fiske, a leading popularizer of evolution in America, made that a central argument in his writings. Similarly, Asa Gray, Darwin's chief scientific supporter in the United States, wrote a set of articles showing how Darwin could be reconciled with traditional Christian beliefs (Gray, 1963). To Gray, Darwin had shown how the Creator operated. Instead of what Gray took to be the commonly held naive and crude belief that God had created every new species individually (think of all those beetles!), Darwin's Origin of Species gave a dynamic dimension to Creation and removed the awkwardness the fossil and geological record posed to men of faith. Fiske and Gray were not alone. Benjamin Warfield, foremost defender of the theologically conservative doctrine of the inerrancy of the Bible was an evolutionist. One enthusiastic American writer even produced a book titled, The Gospel According to Darwin that claimed the Origin was the fifth Gospel. It is not an overstatement to say that the majority of the American biologists who accepted evolution in the late 19th century did not believe it posed any threat to religion, but, quite the contrary, felt their religious beliefs were strengthened by it.

Now, the point is not to teach the history of religion in biology classes, but rather to briefly convey that there are many ways to interpret Darwin, and there are many ways to reconcile evolution with religion. My experience has been that once students see that, they realize that evolution is not the flame-breathing dragon of atheism, but a theory that explains biological phenomena, that relates bodies of information, and that guides research, and like other aspects of science, is open to many philosophical and religious interpretations. They have to work out for themselves how they want to view it. But it is not an either/or situation: science or religion. There are a number of models of negotiated relationships (cf. Miller, 1999).

Nature of Science

So given this case-study approach to the theory of evolution, which presents science as a lineage of questions, which sees Darwin's theory as a response to a set of problems in his day, and which sees Darwin's solution as one that raised new questions which ultimately resulted in a new theory, how can we use it to exemplify
aspects of the nature of science? What generalizations about the nature of science might we be able to draw out of our story?

One obvious generalization is the dynamic nature of science. Science changes through time. In Darwin's case we see the basic concepts of biology redefined (species, distribution, etc.) We also see a new interpretation of how to explain the facts of biology come into being. The changing dimension of science needs to be conveyed to students who too often are given a simplistic view that science consists of the "Truth" about nature. This is not to say that we need get entangled in a post-modern free-for-all, but merely to make the point that in science new questions emerge, new interpretations come into being, opinions, often long held, can be revised.

Another important dimension to understanding science is its levels of generality. Although we discuss facts, hypotheses, laws, and theories, we often neglect to point out in our science teaching at what level the material under consideration falls, and the result can generate a lot of confusion. How, after all, can we evaluate a scientific claim if we do not know the intended level of generalization? Is the claim a fact (a well-confirmed observation or empirical statement), a hypothesis (a calculated guess open to investigation), a law (a well-confirmed regularity, or, a definition usually of a relationship thought to be invariable and universal), or a theory (a complex explanation, based on assumptions and definitions, that relates observations and bodies of knowledge and guides research)? All have different appropriate strategies for evaluation. One uses observation for most facts and experiments for most hypotheses. Theories are evaluated on how well they explain and relate, and therefore are not "proved" or "disproved." They are inherently open-ended and always have "problems" to be solved, which is a strength, not a weakness.

The theory of evolution has to be presented as a theory, and this is an invitation to discuss the levels of generality in science. It also permits us to circumvent pseudo-arguments, like the alleged "scientific problems" of the theory which turn out to be areas of research. The theory of evolution has problems. Yes; they make the theory more interesting! Looking at levels of generality gives students a more sophisticated framework with which to judge claims, and permits them to see how a theory like evolution can be considered "powerful" while being "unproved" and raising serious questions.

Related to the issue of the level of generality is the level of certainty in science. Science makes some statements about the world that have a high degree of certainty, but science is not a monolithic enterprise. Some of the claims in science we hold with a great deal of certainty: Mendel's laws, the gas laws, for example. They are highly confirmed, and some of us would literally bet our lives on them. Other claims in science are less confidently held. The Big Bang theory explains a lot, but one could imagine another theory replacing it given new observations or new discoveries in physics. What about evolution? That life has changed on Earth is well established and one could say with great confidence that evolution has occurred. Some of the broader claims of the theory, however, are held with less confidence, and other parts, for example, the evolutionary history of individual groups, such as Homo sapiens, rest on slight evidence and are constantly being rethought in light of new discoveries.

Scientific method? There is not, of course, a single scientific method. Scientists use a number of methods depending upon what questions or problems they are tackling. In the case of evolution, biologists use different methods to examine different issues. Some of the work is experimental, as in the investigation of the peppered moths in Britain; some of the work is observational or comparative, as in paleontology, that continually broadens our understanding of past flora and fauna; and finally, some of it consists of creative intellectual constructions, like Darwin making an analogy to human population growth to formulate the concept of natural selection. By paying attention to the methods scientists employ, we obtain a sense of the wide range of issues that they can tackle.

Finally, science is always done in a specific cultural context. Darwin's work took place in industrial England. The vast amount of material pouring into European museums raised specific scientific problems. Competition was a fact of life, and the metaphors Darwin employed fit his day. Had he lived at a different place or period he may well have framed his ideas differently.

Dobzhansky passionately believed that the process of evolution was fundamental to an understanding of biology. Today, his contention is as valid as it was when he made it more than a quarter of a century ago. Moreover, the theory of evolution can serve as an exemplar of how scientists examine the natural world. Biology is not a body of facts to memorize but a quest towards understanding, one that is ever changing and one that has roots not only in the phenomena that we observe, but in the human world that shapes our concerns and questions. If we can move the study of biology toward what excites biologists and away from what makes students' eyes glaze over, we shall have accomplished an important and valuable task.
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References


