

Problem Concepts in Evolution Part I: Purpose and Design

Louise S. Mead · Eugenie C. Scott

Published online: 9 March 2010
© Springer Science+Business Media, LLC 2010

Abstract In 1999, Scott suggested that evolution has existential repercussions for some students because they confuse methodological naturalism with philosophical naturalism: conflating the incapacity of scientific explanations to appeal to the supernatural with the idea that God must not exist. Unfortunately, part of the reason for the confusion involves terms that are used in a technical sense by evolutionary biologists but that also convey existential meanings to the general public. Such terms therefore should be used carefully by teachers, and their scientific meanings distinguished from their common meanings. We revisit these problem concepts, particularly in light of recent papers in cognitive psychology as they relate to understanding evolution, in a two-part series of articles. Here, in part I, we address *design* and *purpose*.

Keywords Purpose · Design · Methodological naturalism · Philosophical naturalism

Introduction: Worldviews and Methodological and Philosophical Naturalism

Students begin a high school or college course in biology with varied worldviews and opinions that can influence their acceptance or rejection of evolution. One study of more than 100,000 first-year college students found that 47% rated themselves either “above average” or in the “top 10% in spirituality” and indicated that 80% believe in God (Higher Education Research Institute 2005). Cotner et al.

(2010) reported that students with more conservative religious views show a greater likelihood of endorsing young-Earth beliefs. Political and cultural differences correlate with student understanding of evolution. The more liberal a student’s political views, the more likely he or she is to acknowledge the great age of the Earth (Cotner et al. 2010).

Numerous polls indicate that the United States is a nation with a high percentage of individuals professing belief in God, compared to other developed nations (see www.beliefnet.org for comparative data). Numerous polls also indicate that acceptance of evolution in the United States is unusually low among developed countries (British Council 2009; Miller et al. 2006). But in terms of general scientific literacy, compared to other developed nations, the U.S. does well on some measures, and less well on others (National Science Board 2008). So science literacy in the U.S. is not strictly a function of religion, although acceptance of evolution is probably strongly conditioned by the particular religious pattern and history of our nation (Scott 2009). To improve the public understanding of science, more attention needs to be paid to instruction in the nature of science itself. Highly relevant to the understanding of evolution is the distinction between methodological and philosophical (or ontological) naturalism (Pennock 1999).

Methodological naturalism is the practice in science of restricting scientific inquiry to natural (or material—matter and energy) causes. For the purposes and readership of this journal, rather than for philosophers of science, we briefly outline the argument for the necessity of methodological naturalism. Philosophers of science discuss these and other issues at length, of course, but teachers rarely need to get into great detail with their students.

The essence of science is testing. To test an explanation requires that variables be held constant: an experimenter

L. S. Mead (✉) · E. C. Scott
National Center for Science Education,
PO Box 9477, Berkeley, CA 94709-0477, USA
e-mail: mead@ncse.com

has to control the amount of water, and cultivation, and sunlight to test whether the fertilizer works on the plants. Only the variables (light, water, weeds) that can be held constant in this manner can be studied scientifically. A variable that cannot be held constant cannot be scientifically tested. Because a supernatural God is unconstrained, scientists leave God out of scientific explanations—whether or not they believe in God. This is because any test using God as a cause has no predictable outcome: any outcome is possible, so nothing can be learned from such a test. If the experimenters wanted to test whether God affected the growth of the plants, how would they ensure that the experimental group was subject to God’s influence and isolate the control group from God’s influence? So scientists are stuck with methodological naturalism, appealing only to natural causes in explaining natural phenomena. It works, so we stick with it.

Methodological naturalism is contrasted with philosophical naturalism, a worldview—not a scientific methodology—that contends that matter and energy are all there is: there is no God, or gods, or supernatural entities of any kind. This is a long-standing philosophical perspective, going back at least as far as the ancient Greeks, but it is logically independent of methodological naturalism or science. True, it is highly likely that all philosophical naturalists are also methodological naturalists, but the converse is neither logically necessary nor empirically true. Many scientists are theists who, like Gregor Mendel, an Augustinian monk, restrict themselves only to natural causes in their scientific work.

This is not a mere digression, but central to the point of this and its companion article. Many students confuse methodological and philosophical naturalism, or infer the latter from the former, reasoning that because it is possible to explain so much of the natural world through natural causes (methodological naturalism), it follows that there are no supernatural entities and (in particular) no God (philosophical naturalism). We believe that this is a misunderstanding of science that erects unnecessary barriers to the acceptance of evolution that teachers should be aware of and which they can mitigate.

Anderson (2006) points out that while biology classrooms in public schools are “a place to teach science and not religion,” ignoring the religious perspectives of students will not facilitate acceptance of evolution, nor will such approaches correct misconceptions rooted in a misunderstanding of the nature of science (Lombrozo et al. 2008). Sinatra et al. (2008) suggest that “helping people to understand evolution is not a matter of adding on to their existing knowledge, but helping them to revise their previous models of the world to create an entirely new way of seeing”, specifically challenging default ways of thinking (Sinatra et al. 2008). Considering these elephants

in the living room, it appears to us that more attention needs to be paid to some underlying ways of thinking that could influence the learning of evolution in negative ways. In this first of a two part series, we start with two concepts: *purpose* and *design*. The follow-up article, to be published in the next issue of *Evolution: Education and Outreach*, will address *cause* and *chance*.

Purpose

Children readily take the position that things are made for a purpose (Keleman 1999), and of course, for many of the phenomena children encounter, this is not irrational. Toddlers and elementary schoolchildren are learning the names of things, and “things” (tools, toys, machines, clothes, furnishings, etc.) do indeed have a purpose. Unfortunately, children often conflate living things with human-made artifacts and classify them in the same way. Such a teleological constraint hampers future understanding and acceptance of evolution (Sinatra et al. 2008). Even Darwin recognized that the tendency for humans to ascribe purpose to living things posed an issue for understanding his theory, addressing the seemingly purposeful nature of structures in his discussion of “Difficulties on Theory” (Darwin 1859). Darwin, however, went on to explain in detail how seemingly “purposeful” structures, such as the placement of pollen and stigmatic surface of flowers for self-fertilization, evolved through the retention of slight heritable variations that promoted survival and reproduction.

Of course, the devil is in the details, and the word “purpose” is slippery in its range of meanings to people. Sometimes it is used as a synonym for function, as Darwin does in the above case, referring to parts of plants. Sometimes, again in the context of evolution, purpose is attributed to an internal or external directional force to evolution. (Sometimes purpose has a more existential meaning, as in “there is a purpose to the universe”, or “my life has meaning”—subjects well outside of what science can comment upon.) The idea of a directional force in evolution although long-rejected by paleontologists and other evolutionary biologists, is still pervasive in the public understanding of evolution. In its crudest form, it can be seen in the idea that all of evolution has led to a pinnacle—*Homo sapiens*! Some of the outmoded iconography of evolution—e.g., the unilineal evolution of horses from four-toed browsers to single-toed grazers—provides cases in point. Such iconography mistakenly assumes an inevitability of evolution resulting in a particular result: for example, an intelligent, tool-using bipedal ape eventually will appear in the primate lineage, or a one-toed grazing equid in the horse lineage. Teachers also may believe that “traits appear

only when they are needed,” a misconception that reflects a sense of purpose or directionality to evolutionary change (Nehm and Schonfeld 2007). This sort of purposefulness of evolution has no basis in science, and is often what scientists mean to deny when they say, informally, that “there is no purpose to evolution.”

But teachers well know that what students hear is more important than what teachers say. To a student, “purpose” is not likely to mean orthogenesis! Purpose is more likely to have the connotation of either of the two other meanings: the everyday, functional meaning (the purpose of my pen or keyboard is to take notes) or the more existential (and extrascientific) definition of meaningfulness of life. So it behooves a scientist to use the term purpose carefully. When members of the nonscientific public hear a sentence such as “man is the result of a purposeless and natural process that did not have him in mind” (Simpson 1967:344) or that “life developed gradually from nonliving matter to its present state of diverse complexity through purposeless natural mechanisms that are known to science” (Johnson 1990:33), they are led toward believing that evolution is not merely non-orthogenetic, but purposeless in a religious or philosophical sense—and therefore inherently antireligious. What they hear is “God had nothing to do with it,” a statement that, given the distinction between methodological and philosophical naturalism, is outside of science.

It might be retorted that cell division, gene fusion, and all other scientific topics are no more or less purposeful in this cosmic sense than evolution. We agree. Yet questions arise about evolution that don’t arise over cell division, so teachers and professors should be alert for miscommunications and avoid even inadvertently reinforcing these barriers to the public’s acceptance of evolution, which often bulwark creationist “alternatives” to evolution.

Design

Design and purpose are related concepts, and have some of the same problems. Both children and adults tend to attribute design and purpose to nature (Sinatra et al. 2008), and children have cognitive biases towards creationist explanations (Evans 2000). Researchers find that people specifically ascribe causation by intentional agents to nature (Sinatra et al. 2008). Design is the way that a purpose or a goal is achieved. Such ideas, while articulated to some extent even by ancient Greek philosophers (Gregory 2009), are most commonly associated with William Paley’s biological version of the Argument from Design. Just as a complex artifact such as a watch is evidence of the existence of a watchmaker, so is the intricacy of the natural world evidence of the existence of a divine designer. The biological version of the Argument

from Design was abandoned after Darwin devised a purely natural explanation—natural selection—for the fit between a structure of an organism and the functions it performs. Yet, despite Darwin (1859) pointing out that reference to “the plan of creation” or “unity of design” revealed our ignorance rather than provided an explanation, a natural, agent-less cause like natural selection is difficult for most Americans to understand.

Because the nonscientific public readily assumes that organisms, their components, and other natural phenomena are not only purposeful, but also are designed and brought about by an intentional agent, statements that “there is no design in nature” are easily interpreted to mean “God had nothing to do with it”, setting up the familiar equation of evolution with atheism. Because so many American students are religious, the intelligent design and other antievolution arguments are automatically appealing.

Scientists, however, use the term *design* differently. Because science depends on methodological naturalism, it does not, and cannot, use the explanation of divine design. Scientists often speak of a structure having a “design” that allows an organism to do something or have something done to it—the shape of an orchid encourages pollination by a particular species of insect. In this descriptive sense, all that is meant by a structure’s having a design is that its parts work together or are put together to get something done. Hence the *purpose* of a structure is what it was good for, whereas the *design* is how it achieves its purpose. If the *purpose* of the vertebrate eye is to allow an organism to visually perceive its environment, the *design* of the eye (lens, ocular muscles, rods, cones, etc.) is how the eye achieves its purpose (Scott 1999). Philosophers of biology can (and do) argue about the details, of course, but this sketch comports well with the bulk of biological practice.

Within evolutionary biology, *design* can also be used to indicate a driving force of evolutionary change—not in response to a designer, or an internal directional force such as orthogenesis, but in response to directional selection, as might be found in signal-receiver systems. For example, Tobias and Seddon (2009) report “signal design” as evidence of convergent evolution in *Hypocnemis* antbirds. Since methodological naturalism does not, and cannot, use the explanation of divine design, we interpret the use of *design* here to refer to natural selection, but—again distinguishing between methodological and philosophical naturalism—the ability to explain through a natural cause such as natural selection is not proof there is no designer. Such “proof” is outside of science.

Instructors should regularly emphasize to students that science is limited to natural explanations; whether there is an ultimate design is beyond scientific test and therefore a matter for individual student decision. This leaves the door open for students to make their own choices. The scientific

community itself is not monolithic regarding religion, of course. Historically, religious scientists of the late nineteenth century managed to view natural selection as a cause of design in living things much as they viewed gravitation as the cause of the planets staying in their orbits (Numbers 1998). Direct supernatural cause gave way to indirect supernatural cause for these religious scientists. God's agency was preserved, while science could proceed in a methodologically naturalistic fashion. Today, in a survey of biologists, physicists, and chemists at elite institutions, 33% reported belief in God or a higher power; the percentage is higher at community colleges (Ecklund and Scheitle 2007). This means that the percentage of scientists who believe in God, although certainly not zero, is likely to be lower than that of the student body. The percentage of teachers who believe in God is similar to that of the general public (see for example Trani 2004).

Conclusion

Some of the problems associated with the understanding of evolution arise from students' perceptions that evolution is inherently irreligious, partly arising from a misunderstanding of the nature of science itself. Professors and teachers should distinguish between methodological and philosophical naturalism to decrease the likelihood of students mistaking the *inability* to use supernatural causes to provide scientific explanations of natural phenomena with the outright *rejection* of the supernatural. In this first of two articles, we propose that professors and teachers separate the scientific usages of *design* and *purpose* from the more existential meanings that these terms evoke in students' minds. They should make clear to students that the nature of science says nothing about ultimate purpose, design, and direction of evolution. Science can tell us that the fossil record and the factors affecting evolution suggest that many contingencies affect the history of lineages through time, and that there is no evidence of orthogenesis. But ultimately, whether there is existential purpose and meaning or direction to the universe is a matter of philosophy, not scientific proof. It is also suggested that as educators we rethink our use of "design"—which implies for many students that there is a plan at work—and use terms such as "structure" and "adaptation" where more appropriate. For example, "How is an aardvark designed to eat ants?" could be replaced by "How is an aardvark adapted to eating ants?" or "What structures and behaviors aid an aardvark in eating ants?" We also suggest, whether teaching adaptation to elementary school students, evolution to high school students, or cell biology to college students, we (scientists

and science educators) clarify the use of *purpose* and *design* to be independent of both theistic and atheistic worldviews.

References

- Anderson RD. Teaching the theory of evolution in social, intellectual, and pedagogical context. *Sci & Educ*. 2006;91:664–77.
- British Council. Darwin survey shows international consensus on acceptance of evolution. London: Great Britain. 2009. Press release: <http://www.britishcouncil.org/new/press-office/press-releases/Darwin-survey-shows-international-consensus-on-acceptance-of-evolution/>.
- Cotner S, Brooks DC, Moore R. Is the age of the Earth one of our "sores troubles"? *Evolution*; accepted article. 2010.
- Darwin C. On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for life. 1st ed. London: John Murray; 1859.
- Ecklund E, Scheitle CP. Religion among academic scientists: distinctions, disciplines, and demographics. *Soc Probl*. 2007;54:289–307.
- Evans EM. The emergence of beliefs about the origins of species in school-age children. *Merrill-Palmer Q*. 2000;46:221–54.
- Gregory TR. The argument from design: a guided tour of William Paley's *Natural Theology* (1802). *Evol Edu Outreach*. 2009;2:602–11.
- Higher Education Research Institute. A national study of college students' search for meaning and purpose. 2005. http://www.spirituality.ucla.edu/spirituality/reports/FINAL_EXEC_SUMMARY.pdf.
- Johnson P. *Evolution as Dogma*. Dallas: Houghton Publishing Co; 1990.
- Keleman D. Why are rocks pointy? Children's preference for teleological explanations of the natural world. *Dev Psychol*. 1999;35:1440–52.
- Lombrozo T, Thanukos A, Weisberg M. The importance of understanding the nature of science for accepting evolution. *Evol Edu Outreach*. 2008;1:290–8.
- Miller JD, Scott EC, Okamoto S. Public acceptance of evolution. *Science*. 2006;2006(313):765–6.
- National Science Board. *Science and engineering indicators 2008*. Arlington: National Science Foundation; 2008.
- Nehm RH, Schonfeld IS. Does increasing biology teacher knowledge of evolution and the nature of science lead to greater preference for the teaching of evolution in schools? *J Sci Teacher Educ*. 2007;18:699–723.
- Numbers RL. *Darwinism comes to America*. Cambridge: Harvard University Press; 1998.
- Pennock RT. *Tower of Babel: the evidence against the new creationism*. Cambridge: Bradford; MIT; 1999.
- Scott EC. Problem concepts in evolution: cause, purpose, design, and chance. *Paleontol Soc Pap*. 1999;5:169–82.
- Scott EC. *Creationism vs evolution: an introduction*. 2nd ed. Westport: Greenwood; 2009.
- Simpson GG. *The meaning of evolution*. New Haven: Yale University Press; 1967.
- Sinatra GM, Brem SK, Evans EM. Changing minds? Implications of conceptual change for teaching and learning about biological evolution. *Evol Edu Outreach*. 2008;1:189–95.
- Tobias JA, Seddon N. Signal design and perception in *Hypocnemis* antbirds: evidence for convergent evolution via social selection. *Evolution*. 2009;63:3168–89.
- Trani RI. Won't teach evolution; It's against my religion. And now for the rest of the story. *Am Biol Teach*. 2004;6:419–27.