

## SCIENCE EDUCATION

# Defeating Creationism in the Courtroom, But Not in the Classroom

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Just over 5 years ago, the scientific community turned its attention to a courtroom in Harrisburg, Pennsylvania. Eleven parents sued their Dover, Pennsylvania, school board to overturn a policy explicitly legitimizing intelligent design creationism. The case, *Kitzmiller v. Dover*, followed a familiar script: Local citizens wanted their religious values validated by the science curriculum; prominent academics testified to the scientific consensus on evolution; and creationists lost decisively. Intelligent design was not science, held the court, but rather an effort to advance a religious view via public schools, a violation of the U.S. Constitution's Establishment Clause (1). Many scientists cheered the decision, agreeing with the court that the school board displayed "breathtaking inanity" [p. 765 (1)]. We suggest that the cheering was premature and the victory incomplete.

## Systematic Undermining of Science

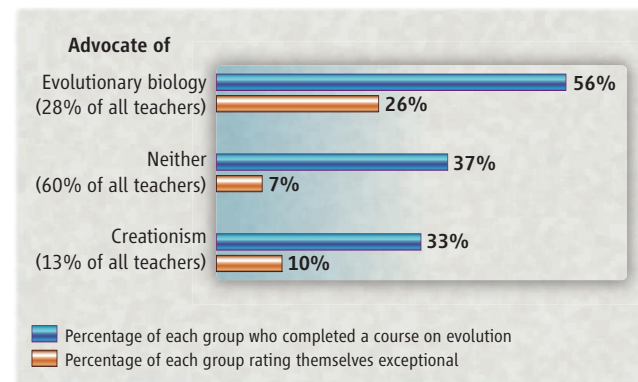
Creationism has lost every major U.S. federal court case for the past 40 years, and state curricular standards have improved (2). But considerable research suggests that supporters of evolution, scientific methods, and reason itself are losing battles in America's classrooms, where instruction in evolutionary biology "has been absent, cursory, or fraught with misinformation" [p. 21 (3), and (4)]. Extending this research, we have been investigating the evolution-creationism battle in state governments (5) and the nation's classrooms (2, 6). Central to this research is the National Survey of High School Biology teachers, based on a nationally representative probability sample of 926 public high school biology instructors (2, 6) (see the figure). [See supporting online material (SOM) for details.] The data reveal a pervasive reluctance of teachers to forthrightly explain evolutionary biology.

The data further expose a cycle of ignorance in which community antievolution attitudes are perpetuated by teaching that reinforces local community sentiment. For example, we ranked school districts from

least to most socially conservative, and in the 15% most socially conservative school districts, nearly 4 in 10 teachers personally do not accept human evolution (compared with 11% in the least conservative districts) and, consequently, devote only minimal time to evolutionary biology in their classes [table A8.2 in (2)]. The next generation of adults is thus predisposed to share the antievolution views of their parents.

More promising data suggest that America's high schools contain thousands of outstanding, effective educators of evolutionary biology. We estimate that 28% of all biology teachers consistently implement the major recommendations and conclusions of the National Research Council (7): They unabashedly introduce evidence that evolution has occurred and craft lesson plans so that evolution is a theme that unifies disparate topics in biology (2).

At the opposite extreme are 13% of the teachers surveyed who explicitly advocate creationism or intelligent design by spending at least 1 hour of class time presenting it in a positive light (an additional 5% of teachers report that they endorse creationism in passing or when answering student questions). The boldness and confidence of this minority should not be underestimated. Although 29% percent of all other teachers report having been "nervous at an open house event or meeting with parents," only 19% of advocates of creationism report this ( $\chi^2 = 5.1$ ,  $P = 0.024$ ).



**Self-reports of qualifications of teachers, classified by approach to teaching evolution.** Based on responses from 926 U.S. public high school biology teachers. See SOM for survey details.

Sixty percent of U.S. high school biology teachers are not advocates for either evolutionary biology or nonscientific alternatives.

Some advocates of creationism insisted that they—not bench scientists—are the ones practicing proper science: A Minnesota teacher commented, "I don't teach the theory of evolution in my life science classes, nor do I teach the Big Bang Theory in my [E]arth [S]cience classes.... We do not have time to do something that is at best poor science." Others rejected the possibility that scientific methods can shed light on the origin of species. An Illinois teacher responded, "I am always amazed at how evolution and creationism are treated as if they are right or wrong. They are both belief systems that can never be truly or fully proved or discredited."

## The Cautious 60%

But if mainstream science and the modern creationist movement each have their classroom allies, they still account for only about 40% of all high school biology teachers. What of the majority of teachers, the "cautious 60%," who are neither strong advocates for evolutionary biology nor explicit endorsers of nonscientific alternatives?

Our data show that these teachers understandably want to avoid controversy. Often they have not taken a course in evolution and they lack confidence in their ability to defend it (see the figure, see SOM for details). Their strategies for avoiding controversy are varied, but three were especially common and each has the effect of undermining science (8). Some teach evolutionary biology as though it only applies to molecular biology—com-

pletely ignoring macroevolution of species. At best, this approach sacrifices a rich understanding of the diversity of species. At worst it lends credence to the creationist claim that there is no evidence for one species giving rise to others.

Others defend the teaching of evolution as a necessary evil, using state examination requirements as a convenient means to disassociate themselves from

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the very material they are expected to teach. These examinations have only been recently introduced in most states. Yet, many teachers told us that they tell students that it does not matter if they really “believe” in evolution, so long as they know it for the test. One Michigan teacher tells students that they need to understand evolution because the biology curriculum “is organized *as if* evolution is true” [emphasis added].

Finally, a sizable number of teachers expose their students to all positions—scientific or not. Students should make up their own minds, explained a Pennsylvania teacher, “based on their own beliefs and research. Not on what a textbook or on what a teacher says.” Many of these teachers might have great confidence in their students’ ability to learn by exploration. But does a 15-year-old student really have enough information to reject thousands of peer-reviewed scientific papers? This approach tells students that well-established concepts like common ancestry can be debated in the same way we debate personal opinions.

The cautious 60% may play a far more important role in hindering scientific literacy in the United States than the smaller number of explicit creationists. The strategies of emphasizing microevolution, justifying the curriculum on the basis of state-wide tests, or “teaching the controversy” all undermine the legitimacy of findings that are well established by the combination of peer review and replication. These teachers fail to explain the nature of scientific inquiry, undermine the authority of established experts, and legitimize creationist arguments, even if unintentionally.

### Courts, Standards, Preservice Teachers

Biology will be the only high school science class for 21 to 25% of U.S. high school graduates, and more high school students take general biology than any other science course (9). But many are not afforded a sound science education, which is problematic in a democracy dependent on meaningful citizen input on highly technical, but consequential, public policies. Research suggests several ways that scientists and scientific organizations can address this situation.

First, continued participation in federal law suits is essential, as federal courts have been shown to limit effectively the ability of state and local governments to endorse non-scientific alternatives to evolution (5). Likewise, the active role of scientists and scientific organizations has improved curricular standards in many states, and such reform has the potential to be especially effective in states having high-stakes science tests

(2). But change due to improved standards is likely to be slow, because standards have the greatest impact on the newest teachers—those who were socialized in an era of standards-based education and who take standards and testing for granted (2). In addition, further improvements in state standards may be difficult because public opinion has been remarkably immune to outreach and public science efforts over the past three decades (10).

We suggest that increased focus be placed on preservice teachers (i.e., those preparing to be, but not yet, teachers). Teachers who are advocates for evolutionary biology are more likely to have completed a course in evolution than teachers who are ambivalent about evolution or who teach creationism (see the figure). Indeed, completing an evolution course is a powerful predictor of the classroom time devoted to evolution (6, 11) and the likelihood that teachers will integrate evolution into their class as a unifying theme (2). Many nonresearch institutions lack the resources to offer a stand-alone evolution course regularly, however, and such institutions educate many high school science teachers. Requiring an evolution course for all preservice biology teachers, as well as provision of resources to provide such a course, would likely lead to meaningful improvement in secondary school science instruction.

In addition to their relative lack of evolution coursework, teachers in the ambivalent middle 60% also resemble those who endorse creationism in that few believe that they have an exceptional understanding of evolutionary biology (see the figure). Yet, unlike creationists, few of these ambivalent teachers hold a young-Earth belief system (e.g., that the universe is only about 10,000 years old) that would prevent them from becoming strong advocates for evolutionary biology. Therefore, improving the instruction they receive in evolution as undergraduates is essential. Outreach efforts such as webinars, guest speakers, and refresher courses—the types of efforts currently aimed at secondary school teachers—could be tailored and targeted for both preservice teachers and for biology and science education professors at teaching-oriented colleges. This two-pronged effort may help increase the percentage of new teachers who accept and embrace the findings of evolutionary biology. Better understanding of the field should provide them with more confidence to teach evolution forthrightly, even in communities where public opinion is sympathetic to creationism.

More effectively integrating evolution into the education of preservice biology teachers

may also have the indirect effect of encouraging students who cannot accept evolution as a matter of faith to pursue other careers. Effective programs directed at preservice teachers can therefore both reduce the number of evolution deniers in the nation’s classrooms, increase the number who would gladly accept help in teaching evolution, and increase the number of cautious teachers who are nevertheless willing to embrace rigorous standards. This would reduce the supply of teachers who are especially attractive to the most conservative school districts, weakening the cycle of ignorance.

Outreach efforts primarily benefit teachers who want to be helped, so expanding the corps of science teachers who want to be helped is critical. Thus, focusing on the preservice stage may be “the most effective way for scientists to help to improve the understanding of evolution” [p. 332 (12)]. Better-trained teachers will be able to more effectively take advantage of details in their textbooks and supplementary material published by the National Academy of Sciences and to put aside fear of reactions and pressures from members of their communities. It would also make them more critical advocates for high-quality standards and textbooks. Combined with continued successes in courtrooms and the halls of state government, this approach offers our best chance of increasing the science literacy of future generations.

### References and Notes

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### Supporting Online Material

[www.sciencemag.org/cgi/content/full/331/6016/404/DC1](http://www.sciencemag.org/cgi/content/full/331/6016/404/DC1)

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