ONLINE ARTICLE

How Biology Students in Minnesota View Evolution, the Teaching of Evolution & the Evolution-Creationism Controversy

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Throughout the United States, various individuals and groups have tried to subvert science education by removing evolution from state science education standards or by demanding that non-science topics such as creationism (e.g., "intelligent design") be included in the standards. These individuals and groups have had varying degrees of success, as documented by Lerner's (2000) study which concluded that only 10 states have evolution education standards that are "very good" to "excellent" (i.e., a grade of A), 14 states have standards that are "good" (i.e., a grade of B), seven states have standards that are "satisfactory" (i.e., a grade of C), six states have standards that are "unsatisfactory" (i.e., a grade of D), and 13 states have standards that are "reprehensible," "disgraceful," "an embarrassing display of ignorance," and "useless for purposes of teaching evolution" (i.e., a grade of F or F-). Ten states (e.g., Illinois, Florida) do not include the word *evolution* in their guidelines, and another (i.e., Maine) mentions it only once. Weak standards are not restricted to the Bible Belt; for example, the evolution standards of North Carolina and South Carolina are excellent (i.e., earned a grade of A), whereas those of several northern states (e.g., New Hampshire, Maine) are "useless" (i.e., earned a grade of F). But do these standards matter? And how do these standards relate to students' views of evolution and the teaching of evolution?

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Minnesota provides an interesting and informative case study for investigating students' views of evolution and the roles of state standards in evolution education. The *Minnesota K-12 Framework for Science* (2003), which includes evolution education standards that are "good" (Lerner, 2000), states that "The focus of instruction in life science for all students at the high school level is on developing an understanding of cell structure and function, the relationship of matter and energy in biological systems, heredity, biological evolution, the behavior and interdependence of organisms and apply their understandings in a variety of situations" (p. 3-192). The *Framework* also includes the *National Science Education Standards* (which discuss natural selection, similarities among organisms, common descent, and the 4.6-billion-year age of Earth; National Research Council, 1996) as well as a sample curriculum titled "Life Sciences on Location 9-12" that includes competition and natural selection (p. 3-193). Similarly, Minnesota's "Graduation Standards—High School Level" specify that all high school graduates should "understand biological change over time," including natural selection and biodiversity (p. 3-199). Minnesota's evolution education standards are supported by the Minnesota Science Teachers Association, which supports the teaching of evolution and whose Board of Directors in 2003 endorsed the position statement of the National Association of Biology Teachers (NABT) stating that "teaching biology in an effective and scientifically honest manner requires classroom discussions and laboratory experiences on evolution" (National Association of Biology Teachers, 2002). Clearly, there is strong and consistent support for the teaching of evolution in science classes of Minnesota's public schools. Creationism and intelligent design—both of which are explicitly rejected by the Minnesota Science

Teachers Association and NABT (National Association of Biology Teachers, 2002)—are not included in Minnesota's science education standards.

Contrasting Minnesota's strong support for the teaching of evolution is Minnesota's long history of anti-evolution activity. For example:

- Famed fundamentalist and anti-evolution activist William Bell Riley, who was pastor of the First Baptist Church of Minneapolis for almost 50 years, was the person who convinced fellow fundamentalist William Jennings Bryan to help prosecute John Scopes at Tennessee's famous Scopes Trial in 1925. It was Bryan's entry into the trial—which came at the request of Riley—that transformed the Scopes Trial into a world-class event. The rest, as they say, is history.
- Republicans occupy many of the highest offices in Minnesota, including the governorship. The platform of the Republican Party in Minnesota (and several other states; see Paterson & Rossow, 1999) is decidedly pro-creationism. For example, the Republican Party of Minnesota is dedicated to "protecting educators from disciplinary action for including discussion of creation science, adopting science standards that acknowledge the scientific controversies pertaining to the theory of evolution" (Republican Party of Minnesota 2004 Permanent Platform, 2004).
- The U.S. Supreme Court has ruled that it is unlawful to teach creationism in public schools (*Edwards v. Aguillard,* 1987). Nevertheless, Cheri Yecke, the governor's nominee to be Minnesota's Commissioner of Education, wanted "every local [school] district [to] have the freedom to teach creationism if that is what they choose" (Creationism a topic ..., 2003).
- The Board of Directors of the Minnesota Science Teachers Association—a group that collectively advocates strong science education standards—includes members who promote creationism. These leaders include science teachers who claim that 1) science teachers who teach evolution are "forcing ... atheism on students," 2) the teaching of evolution gives students "only one side of the story," 3) evolution is not the basis for cellular structure or any other aspect of biology, and 4) science teachers who teach evolution are violating the Judeo-Christian foundation on which the Declaration of Independence and Constitution are based. These teachers, like creationists of old, want to encourage their students to explain nature not with rational scientific inquiry, but instead with an appeal to supernaturalism and misrepresentations of science (see discussion in Cracraft, 2004).
- There have been numerous outbursts of anti-evolution activity in Minnesota (Moore, 2002a). For example, Faribault, Minnesota creationist and science teacher Rodney LeVake lost a highly publicized lawsuit (*Rodney LeVake v. Independent School District #656;* Moore, 2002a) demanding the right to teach his own science curriculum that included creationism. LeVake, like many other anti-science activists, believes that evolution is "impossible," is not science, and violates the second law of thermodynamics. In early 2004, numerous anti-evolution activists testified before the Minnesota Senate and House Committees on Education, claiming, among other things, that evolution is "a false and humanistic worldview" that is "pseudoscience," that teachers should teach students about the alleged "controversies" that surround evolution, and that the teaching of evolution has promoted teenagers' suicides, drug use, sexual activity, and lower scores on college entrance exams (Welsh, 2004).

Thus, there has been longstanding support in Minnesota for anti-evolutionism, despite the fact that the state has some of the best (i.e., most scientifically thorough and valid) standards for teaching evolution in the United States. In light of this inconsistency, we wanted to 1) determine if Minnesota's biology teachers do, in fact, emphasize evolution in their biology classes (as mandated by Minnesota's state educational standards), 2) understand how high school students in Minnesota view the evolution-creationism controversy, and 3) compare the views of Minnesota's high school students with those of Minnesota's college students. We believed that this information could help us and other biology teachers teach evolution more effectively, for the most important thing for a teacher to know about his or her students prior to instruction is what they already know about the subject being taught (see discussion in Lawson & Worsnop, 1992).

Methods

The Survey

Survey questions used in this study were patterned after those used in similar studies of students' views of evolution and creationism (e.g., Lawson & Worsnop, 1992) and are shown in Table 1. Students provided their responses on a five-point Likert-type scale. We obtained all required approvals before administering the survey; these approvals included endorsements from the University of Minnesota Institutional Review Board, from administrators at the private high school, from district officials at the public high school, and from parents of the high school students included in this study. For students who were not native speakers of English, the permission letters were provided in the native language of the students' parents.

College Students

We administered a written, anonymous survey to students enrolled in a large, introductory biology course at the Twin Cities campus of the University of Minnesota. To reduce the possibility of students trying to answer questions in ways that we expected, we administered the survey

at the beginning of the first day of class. A total of 884 students were surveyed between fall, 2002 and spring, 2004. Completion of the survey was voluntary and had no impact on students' grades. Approximately 94% of the students in the classes completed the survey.

High School Students

We administered the same survey (Table 1) to 111 students in biology classes at Central High School (a public school in St. Paul, Minnesota) and 135 students in biology classes at Cretin-Derham Hall (a private school affiliated with the Catholic Church in St. Paul, Minnesota). Completion of the survey was voluntary and had no impact on students' grades. Only one parent inquired about the survey, and that parent allowed her daughter to take the survey.

Results

When we began this study, we had hoped to replicate the survey published earlier by Lawson and Worsnop (1992). However, district officials of the St. Paul Public School District would not approve that survey. After several months and numerous changes in the survey, we obtained approval for the questions shown in Table 1. There was no resistance by officials at the University of Minnesota or Cretin-Derham (i.e., the religiously affiliated high school), who approved the survey quickly and without comment.

The responses of students from the private high school (PVT-HS), public high school (PUB-HS), and public university (UNIV) are shown in Table 1. Numbers in the table represent percentages of students who strongly agreed (SA), somewhat agreed (A), were unsure (U), somewhat disagreed (D), and strongly disagreed (SD) with the statements.

Table 1.

How biology students in a private high school (PVT-HS), a public high school (PUB-HS), and a research university (UNIV; The University of Minnesota) in Minnesota view evolution, the teaching of evolution, and the evolution-creationism controversy. Numbers in the table represent percentages of students who strongly agreed (SA), somewhat agreed (A), were unsure (U), somewhat disagreed (D), and strongly disagreed (SD) with the statements.

STATEMENT	SCHOOL	SA	A	U	D	SD
All species were created at about the same time.	PVT-HS	2	3	11	49	35
	PUB-HS	0	0	6	31	63
	UNIV	5	13	36	25	22
People lived when dinosaurs lived.	PVT-HS	4	21	27	33	15
	PUB-HS	0	8	23	25	44
	UNIV	1	12	44	30	14
Certain types of organisms, such as dinosaurs, no longer exist.	PVT-HS	34	34	11	18	3
	PUB-HS	48	26	15	10	1
	UNIV	33	45	11	10	1
Nearly all biologists accept that life evolved during the past 3.5 billion years or so.	PVT-HS	7	47	39	6	1
	PUB-HS	17	16	50	17	0
	UNIV	23	39	11	19	8
We can learn a lot about humans by studying other animals.	PVT-HS	14	47	18	18	3
	PUB-HS	17	61	12	10	0
	UNIV	23	48	15	11	3
Earth is 6,000-10,000 years old.	PVT-HS	4	13	22	20	59
	PUB-HS	2	7	18	25	57
	UNIV	6	21	12	28	33
The universe is billions of years old.	PVT-HS	6	40	32	15	7
	PUB-HS	9	44	40	2	5
	UNIV	19	42	14	16	9
Humans share genes with apes and bacteria.	PVT-HS	5	36	43	14	2
	PUB-HS	13	55	25	8	0
	UNIV	6	33	43	15	3
There are many good scientific theories that explain the diversity of life.	PVT-HS	18	61	16	4	1
	PUB-HS	23	60	12	2	2
	UNIV	31	43	18	6	2
We cannot really know whether evolution occurred because no one was there when it happened.	PVT-HS	7	25	19	36	13
	PUB-HS	10	13	8	56	13
	UNIV	11	20	12	45	12
The fossil record is so full of gaps that one cannot have confidence that evolution occurred.	PVT-HS	4	21	40	31	4
	PUB-HS	2	9	28	58	2
	UNIV	10	32	17	30	11

continued

Table 1. *continuation*

STATEMENT	SCHOOL	SA	A	U	D	SD
The evidence for evolution is full of conflicts and contradictions.	PVT-HS	17	53	22	6	2
	PUB-HS	14	57	20	8	2
	UNIV	3	41	38	15	4
The evidence for evolution is clear and unambiguous.	PVT-HS	3	21	32	35	9
	PUB-HS	2	23	35	35	5
	UNIV	1	33	41	22	4
Analyses of DNA show that humans are closely related to chimpanzees.	PVT-HS	25	53	14	5	3
	PUB-HS	27	45	22	2	4
	UNIV	37	50	9	2	2
A theory in science is a hunch or "educated guess."	PVT-HS	10	44	20	19	8
	PUB-HS	16	26	9	42	7
	UNIV	17	26	8	30	19
Scientists assume that events have natural rather than supernatural causes.	PVT-HS	21	53	18	5	3
	PUB-HS	13	60	21	6	0
	UNIV	24	58	11	5	2
Evolution should be taught in biology classes of public schools.	PVT-HS	29	51	13	5	2
	PUB-HS	57	35	4	2	1
	UNIV	22	49	24	4	1
If evolution is taught in science classes of public schools, then creationism should also be taught in science classes.	PVT-HS	12	30	22	24	12
	PUB-HS	7	33	7	47	6
	UNIV	7	41	20	24	8
Students should not be taught about evolution in school if they or their parents object.	PVT-HS	7	20	11	51	11
	PUB-HS	5	19	19	43	14
	UNIV	9	22	11	46	12

A summary of University of Minnesota students' views of their high school biology classes and the teaching of evolution and creationism is shown in Table 2. Numbers in the table represent percentages of students who strongly agreed (SA), somewhat agreed (A), were unsure (U), somewhat disagreed (D), and strongly disagreed (SD) with the statements. Students' responses each semester were similar. Ninety-eight percent of the students at the University of Minnesota who participated in this survey had taken a biology class in high school.

Discussion

Students' prior declarative knowledge is the most important consideration in determining what students will (or will not) learn, as summarized by David Ausubel's oft-quoted adage: "If I had to reduce all of educational psychology to just one principle, it would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (Ausubel, Novak, & Hanesian, 1978; see discussion in Lawson & Worsnop, 1992). In this study we determined high school and college students' prior declarative knowledge about evolution, the teaching of evolution, and the evolution-creationism controversy so that we could improve our and others' abilities to teach students about evolution and evolution-related topics.

Views of High School Students

Students at Cretin-Derham (a private, religiously-affiliated school) and Central High School (a public school) have similar views of evolution and creationism. For example, most students at both of these schools reject claims that all species were created at the same time, that humans lived with dinosaurs, and that Earth is only a few thousand years old. Similarly, most students accept claims that some species (e.g., dinosaurs) have become extinct, that the universe is billions of years old, that humans are related to other organisms, that we can know the past even though no humans were there to witness it, that scientists assume that events have natural rather than supernatural causes, and that we can learn about ourselves by studying other animals (Table 1). These views are consistent with some of the major tenets of evolution (e.g., competition, extinction, similarities of closely-related species).

However, the high school students in this study also had misconceptions about evolution. For example, most students believe that the evidence for evolution is full of conflicts and contradictions, that there are many good scientific theories to explain the diversity of life, and that a scientific theory is a hunch or educated guess. These misconceptions can easily be countered, for there is overwhelming evidence that supports evolution, and a scientific theory is

Table 2.
How students at the University of Minnesota view their high school biology classes and the teaching of evolution. Numbers in the table represent percentages of students who attended public high schools who strongly agreed (SA), somewhat agreed (A), were unsure (U), somewhat disagreed (D), and strongly disagreed (SD) with the statements.

STATEMENT	SA	A	U	D	SD
My high school biology class emphasized					
evolution.	2	36	27	27	9
creationism.	4	16	33	36	11
evolution and creationism.	1	22	40	29	8
In public schools, biology teachers should teach					
evolution.	10	70	18	1	1
creationism.	5	52	28	14	1
evolution and creationism.	6	56	27	10	1
In public schools, biology teachers should teach only					
evolution.	1	16	42	37	4
creationism.	1	6	40	43	8
In public schools, it is unlawful for a biology teacher to teach					
evolution.	1	3	20	58	18
creationism.	5	14	36	40	5
evolution and creationism.	0	4	46	44	6
In public schools, a biology teacher can be reprimanded for teaching					
evolution.	0	6	36	45	12
creationism.	1	20	42	33	4
evolution and creationism.	0	9	50	36	5

not just an idea or educated guess (as is often assumed in light of the popular use of the word *theory*). Darwin's "theory" is a major construct that is supported by numerous related postulates (e.g., the struggle for existence, fossil record, competition, fitness, natural selection, extinction, variation) that have not been credibly falsified. The power of Darwin's theory to explain and make accurate predications about life is why it is "the most powerful theory within the field of biology" (Rutledge & Warden, 2000) and why the National Academy of Sciences encourages teachers "to use evolution as the organizing theme in teaching biology" (Alles, 2001; National Science Teachers Association, 2004; see discussion in Blackwell, Powell & Dukes, 2003).

Data presented here about the teaching of evolution in Minnesota's high school biology classrooms are similar to those reported elsewhere. For example, students in Wilson's (2001) survey shared many of the understandings (and misunderstandings) held by students in this study (e.g., regarding the age of the Earth, evidence against evolution, and dinosaurs). McKeachie, Lin and Strayer (2002) reported that large percentages of students either reject or are unsure of evolution, and that students who reject evolution are more likely to withdraw from or fail biology courses than are students who accept evolution.

Views of College Students

The evolution-related beliefs of first-year students at the University of Minnesota are similar to those of students who are beginning high-school biology (Table 1). For example, large percentages of first-year college students believe that there are many valid scientific theories for the diversity of life (Table 1). Similar misunderstandings regarding evolution and the nature of science are common (Moore, 2002a, b). The similarities of high school and college students' beliefs about evolution (Table 1) may not be surprising in light of the fact that biology courses have "almost no effect" on many of these beliefs (Lawson & Worsnop, 1992). Students' beliefs are often extremely resistant to change, and teaching students what we want them to know is often ineffective when students already have their own deeply held ideas (e.g., Arnaudin &

Mintzer, 1985; Bishop & Anderson, 1990; Brumby, 1984; Chinn & Brewer, 1993; Short, 1992; Simpson & Marek, 1988; see discussion in Lawson & Worsnop, 1992).

The Teaching of Evolution in Minnesota's Biology Classrooms

Although Minnesota's science-education standards treat evolution effectively and mandate that evolution be a focus of biology classes, only 38% of the university students in this survey claimed that their high school biology course emphasized evolution (Table 2). Similarly, 20% of the students claimed that their high school biology courses emphasized creationism, despite the facts that creationism is not part of the state's educational standards and that the teaching of creationism in science classes of public schools is unlawful (Moore, 2002b). These data are consistent with reports that 1) 40% of biology teachers in Minnesota spend little or no time teaching evolution (Hessler, 2000), 2) approximately 15% of Minnesota's biology teachers include creationism in their classes, 3) 28% of Minnesota's biology teachers believe that creationism has a scientific basis, 4) 20% of Minnesota's biology teachers are pressured not to teach evolution, and 5) only one-third of Minnesota's biology teachers are adequately prepared to teach evolution (Kraemer, 1995).

The disturbing inconsistency noted here between what is mandated by state educational standards and what is actually taught (or not taught) in science classrooms is not unique to Minnesota. For example, Indiana's standards for teaching evolution are "excellent" (i.e., received a grade of "A"; Lerner, 2000) and are among the 10 best in the United States. However, one-third of Indiana's high school biology teachers spend less than three days on evolution, 43% characterize their teaching of evolution as "avoidance" or "briefly mention," and at least 20% reject or are undecided about the scientific validity of evolution (Rutledge & Warden, 2000; Rutledge & Mitchell, 2002). These and similar data from a variety of other states (Moore, 2002b) support the claim that state standards for evolution education are largely irrelevant to the teaching of evolution in biology classrooms of public schools.

Although many of Minnesota's biology teachers avoid or briefly mention evolution (Hessler, 2000), most of Minnesota's high school and college students want to be taught about evolution, even if other students or students' parents object (Table 1). Most students also want their biology classes to include discussions of creationism (Table 2). Similar beliefs have been reported elsewhere (Stephens & Mangels, 2002). For example, surveys of students at The Ohio State University (Fuerst, 1984; Holland, 1985) "showed a surprisingly low level of acceptance for the theory of evolution, and by an 80% to 20% rate favored the concept of equal time for competing theories of origins." At the University of Minnesota, almost two-thirds of first-year students believe that evolution and creationism should be taught in public schools (Table 2; also see discussion in Moore, 2002a). Students, like most members of the general public, do not know that it is unlawful to teach creationism in science classes of public schools, regardless of the local popularity of creationism or the wishes of local citizens (Edwards v. Aguillard, 1987; Moore, 2002a).

Much evidence indicates that what we've described here for evolution education in Minnesota also occurs in many other states. For example:

- Large percentages of biology teachers throughout the country do not emphasize evolution in their classes. Many of these biology teachers do not teach evolution at all (Aguillard, 1999; Bergman, 1999; Johnson, 1986; Trani, 2004; Randak, 2001; Roelfs, 1987; Tatina, 1989; Weld & McNew, 1999; Zimmerman, 1987).
- Approximately 20% of biology teachers throughout the country teach creationism; even larger percentages of biology teachers (some of whom teach evolution reluctantly) endorse creationism and want it to be part of the science curriculum (Aguillard, 1999; Bergman, 1999; Buckner, 1983; Ellis, 1983; Troost, 1979; Nickels & Drummond, 1988; Randak, 2001; Shankar, 1989; Tatina, 1989; Weld & McNew, 1999; Zimmerman, 1987). Similar results have been reported for several decades (e.g., Muller, 1959; Riddle, 1941; see discussion in Moore, 2002a).
- Many biology teachers continue to be pressured to avoid evolution and/or teach creationism (Eglin, 1983; Ellis, 1983; Kraemer, 1995; Kibbler, 2001).
- The public continues to want discussions of creationism to be included in biology classrooms of public schools (Moore, 2002a and references therein). Many endorse William Jennings Bryan's argument that the public's support of creationism is a mandate to include creationism in science classes (Moore, 2002a).
- Substantial percentages of science teachers in professional organizations such as the National Science Teachers Association (NSTA) and NABT are creationists and/or support the teaching of creationism in science classes (Nelkin, 1982; Moore, 2002a, b). For example, there is a "noticeable drop" in NSTA's membership every time the word *evolution* is featured prominently on the cover of one of NSTA's journals (D. Beacom, personal communication, 2004).
- Less than half of pre-service elementary teachers (and less than 80% of pre-service secondary teachers) accept Darwin's theory of evolution. Eighty-eight percent of students preparing to teach science in elementary school (and 63% of students preparing to teach secondary science) want other views, including "the divine origin of life through special creation," to be taught with evolution (Kibbler, 2001; also see Troost, 1979).

These data are troubling, for they document a dramatic failure of science education in the United States. Scientists do not debate whether evolution has occurred;

evidence from biochemistry, geology, anthropology, geochronology, biology, medicine, and other scientific disciplines shows emphatically that it has. This is why publications such as *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993) and other national calls for science education reform (e.g., National Academy of Sciences, 1998; National Research Council, 1996) all name evolution as a unifying concept of science and note that sciences such as geology, biology, and anthropology "cannot be taught with integrity if evolution is not emphasized" (National Science Teachers Association, 2004). Nevertheless, large percentages of biology teachers—that is, *our former students*—continue to avoid or neglect evolution in their classrooms. As Don Aguillard has noted, "creationism is alive and well in biology classrooms" (Moore, 1999).

Conclusions & Recommendations

Despite state educational standards that explicitly require biology teachers to emphasize evolution, most biology teachers in Minnesota's public schools do not emphasize evolution in their courses. A similar disregard for evolution and state educational standards, as well as a comparable frequency of biology courses that emphasize creationism, typifies a variety of other states (Moore, 2002b).

Students in college and high school have similar understandings and misunderstandings about evolution and the teaching of evolution. The evolution-related views of students in religiously-affiliated high schools are not necessarily more scientifically inaccurate than are those of students in public high schools. Evolution is a foundation of modern biology, but many students have nonscientific beliefs about the origin of life's diversity.

Students, like the general public, want biology teachers to include evolution and creationism in their biology classes. Students want to be taught evolution, even if their parents or classmates object.

Colleagues considering the use of surveys to study students' views of evolution and creationism should recognize that they might encounter significant resistance from school officials. In our study, we were surprised that this resistance was triggered by seemingly benign questions that have been included in previously published surveys. When designing a survey-based study of students' understandings of evolution-related topics, include a plan for how you will handle delays that might accompany such resistance.

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