Despite decades of science education reform, numerous legal decisions declaring the teaching of creationism in public-school science classes to be unconstitutional, overwhelming evidence supporting evolution, and the many denunciations of creationism as nonscientific by professional scientific societies, creationism remains popular throughout the United States (e.g., Moore 2008). Creationism also remains surprisingly popular among biology teachers. Indeed, numerous studies conducted throughout the United States for several decades have shown that 20 to 35 percent of high-school biology teachers include creationism in their courses (Moore 2008). Some states even encourage teachers to promote creationism. For example, although it would probably not withstand scrutiny in a court of law, section 158.177 of the Kentucky Revised Statutes (www.lrc.ky.gov/KRS/158-00/177.pdf) allows teachers to teach “the theory of creation as presented in the Bible” and to reward students on exams for answers based on biblical creationism (Moore and Decker 2008). Although the inclusion of creationism in high-school biology courses is surprisingly common (Moore 2008), the impact of such instruction remains largely unknown.

In this study, we have—for the first time—empirically determined how the treatment of evolution and creationism in high-school biology courses is associated with (a) whether students major in biology or other disciplines, and (b) students’ ideas about evolution and creationism when they enter college. We wanted to answer several questions: Are incoming biology majors more or less likely to accept evolution or creationism than are nonmajors? Are incoming biology majors more likely to have been taught evolution or creationism in their high school biology courses than were nonmajors? How are biology majors’ and nonmajors’ views of evolution and creationism associated, if at all, with the treatment of these topics in their high school biology courses?

What we measured
Below we briefly describe how we conducted our survey.

Study population. During 2007 and 2008, we surveyed 1008 students enrolled in introductory biology courses for majors and nonmajors at the Twin Cities campus of the University of Minnesota. The surveys were conducted during or before...
the first day of classes. Most of the students in this study attended high school in the upper Midwest, and all of the students in this study had taken a biology course in a public high school. The two groups of students in the study included biology majors and nonmajors; students indicated whether they had declared biology to be their major. Biology majors (N = 290) had an average high-school graduation percentile of 93.8 percent (± 5.2 percent) and an average ACT composite score of 27.0 (± 3.1). Nonmajors (N = 718) had an average high-school graduation percentile of 84.8 percent (± 12.5 percent) and an average ACT composite score of 25.9 (± 4.0).

**The survey instrument.** Our survey began with a question asking students to tell us whether their high-school biology course included (a) evolution but not creationism, (b) creationism but not evolution, (c) both evolution and creationism, or (d) neither evolution nor creationism (table 1). We then asked students to respond to the 20 statements in the Measure of Acceptance of the Theory of Evolution (MATE) instrument developed and validated by Rutledge and Sadler (2007). Students could answer “strongly agree,” “agree,” “unsure,” “disagree,” or “strongly disagree,” or decline to answer at all. Our survey concluded with an optional opportunity for students to comment about the survey. The study was voluntary, anonymous, and approved by the university’s institutional review board. Students’ responses were tabulated electronically and had no effect on students’ grades.

For our statistical analysis, students’ numerical responses to the MATE items were assigned the following values: strongly agree = 5, agree = 4, unsure = 3, disagree = 2, and strongly disagree = 1. Means were tested for significant differences through a one-way analysis of variance, and differences were considered significant at \( p < 0.05 \).

**Students’ evaluations of their high-school biology courses.** Students’ descriptions of their high-school biology courses are shown in table 1. Regardless of their majors, approximately two-thirds (i.e., 64 percent) of the students in this study had taken high-school biology courses that included evolution and not creationism. Although only 1 to 2 percent of students reported having been taught only creationism, biology majors were more likely than nonmajors to have had biology courses in high school that included both evolution and creationism (but not evolution only), and less likely to have had biology courses in high school that included neither evolution nor creationism (table 1). Ninety-three percent of biology majors took high-school biology courses that included evolution (with or without creationism); 85 percent of nonmajors took such courses.

The mean responses of biology majors and nonmajors to eight statements from the MATE instrument are shown in table 2, as are how students’ responses vary according to whether their high-school biology classes included only evolution, only creationism, or neither evolution nor creationism. Majors’ and nonmajors’ responses to these questions were not significantly different. The mean responses of biology majors were significantly different from those of nonmajors to only 3 of the 20 questions on the MATE instrument:

- Nonmajors were approximately two times more likely than biology majors (i.e., 26.5 percent versus 13.5 percent, respectively) to accept the claim that the theory of evolution is speculative and not scientific (\( p < 0.0001 \)).

- Biology majors were approximately 12 percent more likely than nonmajors (74.2 percent versus 66.5 percent, respectively) to accept the claim that the theory of evolution unifies biology (\( p < 0.01 \)).

- Biology majors were approximately 50 percent more likely than nonmajors (i.e., 22.0 percent versus 14.8 percent, respectively) to accept the claim that the data are unclear as to whether evolution actually occurs (\( p < 0.01 \)).

Regardless of the MATE statement, and regardless of a student’s major, students whose high-school biology class included creationism (with or without evolution) were more likely to accept creationism-based responses than were students whose high-school biology class included only evolution. Similarly, students whose high-school biology course included evolution (and not creationism) were more likely to accept evolution-based statements than were students whose high-school biology course did not include evolution. The entire analysis of the MATE instrument is available from the authors.

Approximately 24 percent (i.e., 69 of 290) of the biology majors submitted comments in response to the survey. Of these responses, 20.8 percent advocated evolution only (e.g., “evolution rules,” “evolution is really the only thing that makes sense”), 45.3 percent advocated creationism (e.g., “I believe in creationism and intelligent design,” “I do not believe [evolution] happened”), and 34 percent expressed uncertainty (“I am a little confused about it,” “I really don’t

**Table 1. Students’ descriptions of their high-school biology classes.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage of students agreeing with the description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Biology majors</td>
</tr>
<tr>
<td>My high-school biology class included evolution but not creationism.</td>
<td>64</td>
</tr>
<tr>
<td>My high-school biology class included creationism but not evolution.</td>
<td>1.4</td>
</tr>
<tr>
<td>My high-school biology class included both evolution and creationism.</td>
<td>29</td>
</tr>
<tr>
<td>My high-school biology class included neither evolution nor creationism.</td>
<td>6</td>
</tr>
</tbody>
</table>

*Note: For biology majors, the sample size was 290 students; for non–biology majors, the sample size was 718 students.*
know what to think,” “I don’t know enough on the issue to have much [of] an opinion”).

**Limitations of the study**

This study had several possible limitations. For example, all of the students in this study attended the same university, and therefore are probably not a truly random sampling of all incoming college students. Similarly, students’ recollections of their high-school biology courses may have been imperfect or colored by their personal views of evolution and creationism. Some students may have been exposed to evolution or creationism in nonbiology courses (e.g., students’ views of evolution and creationism may have also been influenced by their local communities). In light of these limitations, we do not assign a completely causative link between students’ high-school biology experiences and students’ subsequent acceptance of evolutionary theory. Nevertheless, much evidence suggests that the data reported here are reliable and representative. Our sample was large and diverse, the trends are clear, and students’ responses about the prevalence of evolution and creationism in their high-school biology courses are consistent with those reported by biology teachers (Kraemer 1995, Moore 2004a, 2008, Moore and Kraemer 2005) and other researchers (Tatina 1989, Aguillard 1999, Weld and McNew 1999, Randak 2001, Rutledge and Mitchell 2002, Trani 2004).

**The prevalence of evolution and creationism in high-school biology classrooms**

As reported by recent matriculates, almost two-thirds (i.e., 64 percent) of high-school biology teachers include evolution and not creationism in their biology courses (table 1). That is, these teachers comply with the state educational guidelines and recommendations from professional organizations of science teachers (e.g., NAS 1999). These results are consistent with the report that most biology teachers accept evolutionary theory (Moore and Kraemer 2005).

Although only 1 to 2 percent of biology teachers teach creationism and not evolution, 21 to 29 percent of biology teachers teach both evolution and creationism (table 1). Sim-

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**Table 2. Relation of the responses of biology majors and nonmajors to the MATE instrument to whether their high-school biology courses included creationism (with or without evolution), evolution only, or neither evolution nor creationism.**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Percentage of students agreeing with the statement</th>
<th>Biology majors</th>
<th>Non–biology majors</th>
</tr>
</thead>
<tbody>
<tr>
<td>The theory of evolution cannot be correct since it disagrees with the biblical account of creation.</td>
<td>Overall 14.2 Creationism 14.9 Evolution only 8.7 Neither evolution nor creationism 11.8</td>
<td>14.2 10.8</td>
<td>20.2 11.7</td>
</tr>
<tr>
<td>With few exceptions, organisms on earth came into existence at about the same time.</td>
<td>Overall 16.7 Creationism 21.6 Evolution only 14.2 Neither evolution nor creationism 17.7</td>
<td>20.7 25.5</td>
<td>25.5 25.5</td>
</tr>
<tr>
<td>The age of the earth is at least four billion years.</td>
<td>Overall 59.2 Creationism 61.8 Evolution only 69.0 Neither evolution nor creationism 35.3</td>
<td>64.8 46.9</td>
<td>63.5 60.4</td>
</tr>
<tr>
<td>Evolution is a scientifically valid idea.</td>
<td>Overall 67.7 Creationism 57.3 Evolution only 78.0 Neither evolution nor creationism 56.3</td>
<td>70.4 59.2</td>
<td>71.6 64.2</td>
</tr>
<tr>
<td>Evolution is not a scientifically valid theory.</td>
<td>Overall 10.4 Creationism 18.4 Evolution only 7.07 Neither evolution nor creationism 5.88</td>
<td>11.0 12.3</td>
<td>9.66 14.6</td>
</tr>
<tr>
<td>Current evolutionary theory is the result of sound scientific research and methodology.</td>
<td>Overall 59.9 Creationism 46.6 Evolution only 68.5 Neither evolution nor creationism 35.3</td>
<td>61.7 52.8</td>
<td>66.1 56.3</td>
</tr>
<tr>
<td>Humans exist today in essentially the same form in which they always have.</td>
<td>Overall 17.7 Creationism 25.3 Evolution only 14.7 Neither evolution nor creationism 11.8</td>
<td>19.4 28.7</td>
<td>15.7 21.1</td>
</tr>
<tr>
<td>Modern humans are the product of evolutionary processes that have occurred over millions of years.</td>
<td>Overall 64.0 Creationism 54.8 Evolution only 69.0 Neither evolution nor creationism 58.8</td>
<td>65.9 55.8</td>
<td>70.8 60.6</td>
</tr>
</tbody>
</table>
ilar percentages have been reported in numerous other stud-
ies (Tatina 1989, Aguillard 1999, Weld and McNew 1999,
Randak 2001, Rutledge and Mitchell 2002, Trani 2004, Bow-
man 2008, Moore 2008), including those involving surveys of
teachers (Moore and Kraemer 2005, Bandoli 2008). Students’
claims that approximately 25 percent of biology courses in-
clude creationism are also consistent with reports that almost
one-fourth of biology teachers believe that creationism has
a valid scientific foundation (Moore and Kraemer 2005). Taken
together, these results indicate that creationism con-
tinues to be part of approximately one-fourth of high-school
biology classes. The inclusion of creationism in high-school
biology classes occurs even though this violates the re-
commendations of numerous professional scientific organi-
sations and state science-education guidelines, and is
unconstitutional. As Don Aguillard, the nominal plaintiff in
Edwards v. Aguillard (482 US 578 [1987]) noted, “Creation-
ism is alive and well among biology teachers” (Moore 1999).
Berkman and colleagues (2008) claimed that the prevalence
of creationism in science classrooms has been overstated be-
cause some teachers’ inclusion of creationism in their courses
is actually a critique of creationism. This assertion is proba-
tively true to some extent, but the same can be said for the re-
ported prevalence of evolution—that is, the teaching of
evolution might be overstated because some teachers’ inclu-
sion of evolution in their courses is actually a critique of
evolution. This conclusion is consistent with reports that
only 67 to 77 percent of the teachers who teach evolution are
instructing that evolution is a credible scientific theory (e.g.,
Bandoli 2008). Many students’ comments in our study also sup-
port this conclusion, as responses indicated that the coverage
of evolution in high-school biology courses is often trivial or,
in fact, an attack on evolution or an endorsement of cre-
ationism. Some of our respondents noted, “Evolution was only
briefly discussed in my high-school [advanced placement]
biology course; it was also challenged by the teacher,” “Evolu-
tion was barely covered,” “I didn’t have the chance to learn
much about the theory in high school,” “We merely touched
on it,” and “In high school, my science teacher briefly touched
on evolution and said it wasn’t true.”

Comparing the responses of biology majors
and nonmajors
Varying majorities of biology majors and non–biology
majors accepted all of the evolution-based statements and re-
jected all of the creationism-based statements on the MATE
instrument (table 2). For example, most students surveyed
accepted that modern organisms are the result of evolution
occurring over millions of years, that the theory of evolution
can be tested scientifically, that most scientists accept evolution,
and that evolution is a scientifically valid theory that is sup-
ported by much scientific evidence. Similarly, only 16 to 21
percent of students accepted the claim that the theory of
evolution cannot be tested scientifically; only 10 to 11 percent
believed that evolution cannot be correct because it disagrees
with the biblical account of creationism; and only 8 to 23
percent thought that organisms came into existence at the
same time, that the available data are unclear about the
occurrence of evolution, and that much of the scientific
community questions evolution (table 2). Although this
acceptance of evolution and rejection of creationism is
encouraging, large percentages of students nevertheless reject
several teneits of science; for example, 35 to 41 percent of
students believe that Earth is young, and 27 to 40 percent
reject that evolution is a scientifically valid theory and that
humans and other organisms are the products of evolution
occurring over millions of years.

Biology majors’ acceptance of creationism is supported
by their voluntary comments, in which the percentage of com-
ments endorsing creationism (45.3) was more than twice
that of those endorsing evolution (20.8). These comments were
often an explicit rejection of evolution or were in support of
creationism; for example: “I do not believe in the theory of
evolution,” “I do not believe [evolution] is proven,” “I do believe in creationism,” “I strongly disagree with things
such as...that we evolved from primates... I am very strong in
my beliefs and will not change them,” “[Evolution] is in-
correct,” “Evolution is far from proven,” “Evolution cannot
be tested or observed, it is not scientifically valid,” “The Bible
has a correct explanation of the origins of life in a literal six-
day creation and that the Fossil Record and Geological Record
is [sic] in agreement with a worldwide flood,” “I disagree
with our having evolved from primates,” and “Intelligent
design is a very sensible idea.” Taken together, these results
both indicate that large percentages of biology majors accept
creationism and support the claim by Rutledge and Mitchell
(2002) that “instruction in evolutionary biology at the
high school level has been absent, cursory or fraught with
misinformation.”

The fact that the responses of biology majors and non-
majors were statistically indistinguishable on 17 of the 20 items
on the MATE instrument indicates that students’ decisions to
major in biology are not associated with different degrees of
exposure to evolution in their high-school biology courses (see
above), nor are they associated with dramatic differences in
students’ exposure to evolution or creationism in their high-
school biology classes.

High-school biology background and student responses
If students’ exposure to evolution or creationism in their
high-school biology courses had had no impact on students’
views of these topics when they entered college, then we
would have expected similar responses by different subsets of
students (e.g., those students whose high-school biology
courses included evolution, as compared with those whose
courses included creationism) to items on the MATE in-
strument. We did not observe this on any of the 20 items on
the survey. On the contrary, on every one of the MATE items,
students whose high-school biology class included creation-
isim were more likely to accept creationism-based claims and
reject evolution-based claims than were students whose high-
school biology courses included evolution only (table 2).
Similarly, students whose high-school biology courses included evolution were more likely to accept evolution-based claims and reject creationism-based claims than were students whose high-school biology courses included creationism. Although the extent of the differences between these two groups varied, in several instances the difference was dramatic, and it was true for nonmajors as well as biology majors on every item on the MATE instrument. For example, nonmajors whose biology classes included creationism were 73 percent (i.e., 20.2 percent versus 11.7 percent) more likely to reject evolution because it disagrees with the Bible than were nonmajors whose high-school biology class included evolution. Biology majors whose high-school biology course included creationism were 71 percent (i.e., 14.9 percent versus 8.7 percent) more likely to reject evolution for the same reason than were biology majors whose high-school biology courses included evolution but not creationism. These results indicate that regardless of whether a student is a biology major or nonmajor, the acceptance of evolution and creationism when he or she enters college is strongly associated with the inclusion of evolution or creationism in the high-school biology course.

Why do so many biology teachers endorse creationism? It matters when biology teachers teach students about evolution, because students who are taught evolution in high school are more likely to accept evolution when they enter college than are students who are taught creationism. However, it also matters when biology teachers include creationism in their courses, for doing so is associated with students’ greater acceptance of creationism and rejection of evolution when they enter college. In light of the overwhelming evidence supporting evolution, as well as the arbitrary and nonscientific claims of creationism, why do so many biology teachers endorse creationism in their courses? We suggest the following reasons.

Teachers’ poor understanding of evolution. Many biology teachers claim that they are unprepared to teach evolution (Zimmerman 1987, Tatina 1989, Kraemer 1995, Moore and Kraemer 2005), possibly because they did not take courses in college that emphasized evolution (Rutledge and Warden 2000, Rutledge and Mitchell 2002). Indeed, in a recent study by Eileen Gregory, 54 college biology teachers were asked to identify, from a list of 39 biological subjects, the 28 subjects that are most important for inclusion in an introductory biology course. More than one-fifth of the teachers did not include evolution as one of the top 28 subjects (Eileen Gregory, Rollins College, Winter Park, Florida, personal communication, November 2008). This may help account for the fact that many biology teachers do not even recall hearing the word “evolution” in their college biology courses (Moore 1999, 2002). Moreover, teachers who best understand evolution allocate more time to evolution and do a better job of teaching it (Rutledge and Mitchell 2002). Compounding the problem is the fact that more than one-third of biology teachers were not biology majors (NCES 2003).

Almost one-fourth of biology teachers believe that creationism has a valid scientific foundation (Kraemer 1995), one-sixth of biology teachers are young-Earth creationists (Bandoli 2008), and 15 percent of biology teachers believe that evolution is not a scientifically valid idea (Moore and Kraemer 2005). These factors may help explain why most high-school biology teachers either ignore evolution or teach evolution for less than one week per year (Bandoli 2008). The situation may worsen, as less than half of preservice elementary teachers accept Darwin’s theory of evolution, and almost 90 percent of students preparing to teach science in elementary school and 63 percent 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; see also Troost 1979).

Teachers’ religious beliefs. Teachers’ personal views of a subject influence their teaching of the subject (Carlesen 1991), and individuals having the strongest religious beliefs are the most likely to reject evolution (Lawson and Worsnop 1992). Since relatively large percentages of high-school biology teachers are creationists—many of whom reject evolution while claiming that creationism is scientifically valid (see Kraemer 1995, Moore and Kraemer 2005, Moore 2008)—it is not surprising that many biology teachers who include creationism in their courses do so because of their religious beliefs (Trani 2004).

External pressure. Large percentages of high-school biology teachers are pressured—by parents, colleagues, administrators, and others—to minimize or omit evolution and enhance their teaching of creationism (Moore and Kraemer 2005, NSTA 2005).

Lack of consequences. Since little attention is paid to the details of what goes on in most classrooms, there are usually no consequences for teachers who do not teach evolution or who promote creationism in their biology courses. For example, for more than a decade, Ohio middle-school science teacher John Freshwater allegedly prayed in class, led “healing sessions,” taught creationism in his biology classes, and used an electrical device to brand crosses into students’ arms (Demartini 2008). Only when a lawsuit was filed against Freshwater and the school district did the district investigate and begin proceedings to fire him. Similarly, Larry Booher taught creationism to his biology students in Bristol, Virginia, for 15 years without complaint (Associated Press 2005). Although many biology teachers include creationism in their courses, few are stopped from doing so.

Ignorance of the law. Although most biology teachers know that they are not required to give equal time to creationism, more than 25 percent of teachers believe that they can give equal time to creationism (Moore 2004b). Many teachers do not know that courts have ruled that it is unconstitutional to teach creationism and that creation science has no scientific merit or educational value as science because it is not science (McLean
Success of the Discovery Institute’s “wedge” strategy. In keeping with the Discovery Institute’s governing goals—specifically, the concerted replacement of materialism with theism—the “wedge” document cites the five-year goal of seeing “intelligent design theory as an accepted alternative in the sciences” (see the discussion in Pennock 2003). Although intelligent design (ID) has contributed nothing to scientific knowledge, its publicity campaign has succeeded on various fronts, from the incorporation of wedge catchphrases (specifically, “teach the controversy” and “irreducible complexity”) in the public dialogue (Pennock 2003, Forrest and Gross 2007, Chinsamy and Plagányi 2008) to the growing perception among nonscientists that ID is a legitimate alternative to evolutionary explanations (Warnick and Fooce 2007, Cavanagh 2008). The appeal of ID is presumably that it mitigates some of evolution’s perceived threats to morality, society, and religion (Brem et al. 2003). The influence of the ID movement may be behind that student comments as: “I believe in creationism and intelligent design is a very sensible idea. I believe in evolution within species to adapt to climates and situations, but the ape to man theory is, for lack of better word, bogus to me”; “I was taught creationism, and...evolution.... I do not believe that [evolution] happened without the design of an intelligent being”; “While I think creationism is nonsense, I do consider intelligent design as a viable means of religiously explaining the nature of the universe that aptly meshes with scientific data.” Clearly, students’ comments differ about whether ID is creationism, which reflects a mixed message to students out of an understanding of one of history’s greatest ideas.

What shapes college students’ views on evolution? We do not mean to imply that a student’s exposure to evolution or creationism in high school is the sole determinant of their subsequent views of these subjects in college. The quality of that instruction is also important, as may be the influence of students’ local communities. We also do not discount the pervasive and long-standing influence of religious beliefs; as Lawson and Worsnop (1992) noted, “Highly religious students are more likely to express a belief in special creation and are less likely to give it up during instruction.” However, data presented here suggest that students’ high-school biology courses have a lasting impact on students’ ideas regarding evolution and creationism. Moreover, students’ misconceptions often remain “well ingrained even after a thorough coverage of the evidences supporting evolution” in college (Johnson and Peebles 1987).

In 1991, Eve and Harrold (1991) concluded that “over a quarter—and perhaps as many as half—of the nation’s high-school students get educations shaped by creation influence.” Little has changed; creationism remains popular among high-school biology teachers. The educational malpractice of teaching of creationism affects students’ attitudes about evolution and creationism when they enter college, and cheats students out of an understanding of one of history’s greatest ideas.

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Randy Moore (e-mail: rmoore@umn.edu) and Sehoya Cotner (e-mail: harri054@umn.edu) are with the biology program at the University of Minnesota in Minneapolis.