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2018 NSSME+: Status of High School Biology

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Disclaimer

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Additional Information

More details and products from the 2018 NSSME+, as well as previous iterations of the study, can be found at: http://horizon-research.com/NSSME/

TABLE OF CONTENTS

LIST OF TABLES

High School Biology Instruction

Resources Available for High School Biology

Factors Affecting High School Biology Instruction

Introduction

In 2018, the National Science Foundation supported the sixth in a series of surveys through a grant to Horizon Research, Inc. The first survey was conducted in 1977 as part of a major assessment of science and mathematics education and consisted of a comprehensive review of the literature; case studies of 11 districts throughout the United States; and a national survey of teachers, principals, and district and state personnel. A second survey of teachers and principals was conducted in 1985–86 to identify trends since 1977. A third survey was conducted in 1993, a fourth in 2000, and a fifth in 2012. This series of studies has been known as the National Survey of Science and Mathematics Education (NSSME).

The 2018 iteration of the study included an emphasis on computer science, particularly at the high school level, which is increasingly prominent in discussions about K–12 STEM education and college and career readiness. The 2018 NSSME+ (the plus symbol reflecting the additional focus) was designed to provide up-to-date information and to identify trends in the areas of teacher background and experience, curriculum and instruction, and the availability and use of instructional resources. The research questions addressed by the study are:

1. To what extent do computer science, mathematics, and science instruction reflect what is known about effective teaching?
2. What are the characteristics of the computer science/mathematics/science teaching force in terms of race, gender, age, content background, beliefs about teaching and learning, and perceptions of preparedness?
3. What are the most commonly used textbooks/programs, and how are they used?
4. What influences teachers' decisions about content and pedagogy?
5. What formal and informal opportunities do computer science/mathematics/science teachers have for ongoing development of their knowledge and skills?
6. How are resources for computer science/mathematics/science education, including well-prepared teachers and course offerings, distributed among schools in different types of communities and different socioeconomic levels?

The 2018 NSSME+ is based on a national probability sample of schools and computer science, mathematics, and science teachers in grades K–12 in the 50 states and the District of Columbia. The sample was designed to yield national estimates of course offerings and enrollment, teacher background preparation, textbook usage, instructional techniques, and availability and use of facilities and equipment. Every eligible school and teacher in the target population had a known, positive probability of being sampled. A total of 7,600 computer science, mathematics, and science teachers in 1,273 schools across the United States participated in this study, a response rate of 78 percent.

This report describes the status of high school (grades 9–12) biology instruction based on the responses of 726 biology teachers.[1] For comparison purposes, many of the tables include data from all 1,740 respondents who teach high school science, regardless of the subject area, and/or data for chemistry and physics teachers.[2] Each teacher responding to the survey was asked to provide detailed information about a randomly selected class. Science teachers who were assigned to teach both biology and other science classes may have been asked about any of those classes. Accordingly, the number of biology classes included in the analyses reported below (481) is smaller than the number of responding teachers of biology. Generally, the larger standard errors are a reflection of the reduced sample size.

Details on the survey sample design, data collection and analysis procedures, and creation of composite variables[3] are included in the *Report of the 2018 NSSME+*.[4] The standard errors for the estimates presented in this report are included in parentheses in the tables. The narrative sections of the report generally point out only those differences that are substantial as well as statistically significant at the 0.05 level.[5]

This status report of high school biology teaching is organized into major topical areas:

- Characteristics of the biology teaching force;
- Professional development of biology teachers;
- Biology courses offered;
- Biology instruction, in terms of time spent, objectives, and activities;
- Resources available for biology instruction; and
- Factors affecting biology instruction.

High School Biology Teachers' Backgrounds and Beliefs

A well-prepared teaching force is essential for an effective education system. This section provides data about the nation's high school biology teachers, including their demographics, course backgrounds, beliefs about teaching and learning, and perceptions of preparedness.

Teacher Characteristics

Almost two-thirds of biology teachers are female, a higher proportion than high school science teachers in general (see Table 1). Similar to all high school science teachers, however, the

[1] A biology teacher is defined as someone who teaches at least one class of non-college prep, 1st year college prep, or 2nd year advanced biology.

[2] Detailed information for high school chemistry and physics teachers can be found in *2018 NSSME+: Status of High School Chemistry* (Smith, 2019) and *2018 NSSME+: Status of High School Physics* (Banilower, 2019).

[3] Factor analysis was used to create several composite variables related to key constructs measured on the questionnaires. Composite variables, which are more reliable than individual survey items, were computed to have a minimum possible value of 0 and a maximum possible value of 100.

[4] Banilower, E. R., Smith, P. S., Malzahn, K. A., Plumley, C. L., Gordon, E. M., & Hayes, M. L. (2018). *Report of the 2018 NSSME+*. Chapel Hill, NC: Horizon Research, Inc.

[5] The False Discovery Rate was used to control the Type I error rate when comparing multiple groups on the same outcome. Benjamini, Y. and Hochberg, Y. (1995). Controlling the false discovery rate: A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society: Series B, 57*(1), 289–300.

overwhelming majority of biology teachers are white. As with high school science teachers in general, slightly more than half of biology teachers have had 11 or more years of science teaching experience. Also similar to all high school science teachers, over one-third of biology teachers have had prior full-time job experience in a science- or engineering-related field.

Table 1
Characteristics of the High School Science Teaching Force

	PERCENT OF TEACHERS	
	ALL SCIENCES	BIOLOGY
Sex		
Female	57 (1.9)	65 (2.5)
Male	43 (1.9)	35 (2.5)
Other	0 (0.0)	0 ---†
Hispanic or Latino		
Yes	6 (0.8)	7 (1.1)
No	94 (0.8)	93 (1.1)
Race		
White	91 (1.2)	92 (1.4)
Black or African American	5 (0.9)	5 (0.9)
Asian	5 (0.9)	4 (1.4)
American Indian or Alaska Native	2 (0.5)	2 (0.8)
Native Hawaiian or Other Pacific Islander	0 (0.1)	0 (0.1)
Age		
≤ 30	14 (0.9)	14 (1.5)
31–40	31 (1.5)	31 (2.6)
41–50	28 (1.3)	28 (1.9)
51–60	20 (1.1)	19 (1.9)
61+	8 (0.9)	8 (1.2)
Experience Teaching Science at the K-12 Level		
0–2 years	15 (1.1)	15 (1.7)
3–5 years	13 (0.9)	12 (1.5)
6–10 years	17 (1.4)	18 (2.1)
11–20 years	35 (1.9)	35 (2.6)
≥ 21 years	20 (1.2)	20 (1.7)
Full-Time Job in Science Prior to Teaching		
Yes	36 (2.1)	35 (3.4)
No	64 (2.1)	65 (3.4)

† No high school biology teachers in the sample selected this response option. Thus, it is not possible to calculate the standard error of this estimate.

As can be seen in Table 2, nearly 80 percent of high school biology teachers have more than one preparation. Biology teachers, like chemistry and physics teachers, are slightly more likely to have four or more preparations than high school science teachers more broadly.

Table 2
Number of Science Preparations

	PERCENT OF TEACHERS			
	ALL SCIENCES	BIOLOGY	CHEMISTRY	PHYSICS
1	28 (1.6)	21 (2.2)	16 (1.4)	15 (2.5)
2	48 (1.8)	46 (2.6)	46 (2.1)	46 (3.3)
3	17 (1.3)	20 (2.6)	23 (2.0)	26 (2.4)
4 or more	7 (0.9)	12 (1.8)	15 (2.5)	13 (2.8)

Biology teachers are very likely to have had formal preparation for teaching leading to a teaching credential (see Table 3). About 4 in 10 biology teachers received their teaching credential as part of an undergraduate program, 3 in 10 as part of a master's program, and almost a quarter as part of a post-baccalaureate credentialing program. Only 7 percent have not earned a teaching credential.

Table 3
High School Science Teachers' Paths to Certification

	PERCENT OF TEACHERS			
	ALL SCIENCES	BIOLOGY	CHEMISTRY	PHYSICS
An undergraduate program leading to a bachelor's degree and a teaching credential	40 (1.9)	39 (2.9)	40 (2.8)	42 (4.8)
A master's program that also awarded a teaching credential	28 (2.2)	30 (4.3)	26 (2.3)	25 (3.6)
A post-baccalaureate credentialing program (no master's degree awarded)	25 (1.7)	23 (2.7)	24 (2.4)	23 (3.4)
Has not earned a teaching credential	7 (1.0)	7 (1.4)	9 (2.3)	10 (2.3)

The vast majority of biology teachers are certified to teach their subject (see Table 4). They are also more likely than physics, Earth/space science, and ecology/environmental science teachers to be certified in their subject.

Table 4
High School Science Teachers Certified in Subjects They Teach

	PERCENT OF TEACHERS†
Biology	88 (1.9)
Chemistry	85 (2.8)
Physics	75 (4.0)
Earth/Space Science	70 (5.5)
Ecology/Environmental Science	43 (5.9)

† Teachers assigned to teach classes in more than one subject area are included in each subject area.

Content Preparedness

Nine in 10 biology teachers have a college degree in either science/engineering or science education (see Table 5). Of those, 80 percent have a degree in science/engineering.

Table 5
High School Science Teacher Degrees

	PERCENT OF TEACHERS	
	ALL SCIENCES	BIOLOGY
Science/Engineering	79 (1.4)	80 (1.7)
Science Education	57 (2.1)	60 (3.2)
Science/Engineering or Science Education	91 (1.1)	90 (1.7)

In terms of the number of college courses they have taken in their subject, biology teachers tend to be better prepared than other high school science teachers (see Table 6). Almost two-thirds of biology teachers have a degree in their field, compared to only 42 percent of chemistry and 24 percent of physics teachers.

Table 6
High School Science Teachers With Varying Levels of Background in Subject

	PERCENT OF TEACHERS		
	BIOLOGY	CHEMISTRY	PHYSICS
Degree in field	63 (2.5)	42 (2.7)	24 (2.6)
No degree in field, but 3+ courses beyond introductory	25 (2.6)	28 (2.2)	27 (3.1)
No degree in field, but 1–2 courses beyond introductory	6 (1.1)	20 (2.1)	15 (2.6)
No degree in field or courses beyond introductory	5 (1.4)	9 (1.9)	30 (3.7)
No coursework in field	1 (0.5)	1 (0.6)	4 (1.2)

As can be seen in Table 7, nearly all biology teachers have taken an introductory biology/life science course, and 94 percent have taken one or more biology/life science courses beyond the introductory level (e.g., genetics, ecology, anatomy/physiology). About two-thirds have taken a biology/life science teaching methods course.

Table 7
High School Biology Teachers Completing Various Biology College Courses

	PERCENT OF BIOLOGY TEACHERS
Introductory Biology/Life Science	99 (0.5)
One or More Biology/Life Science Courses Beyond the Introductory Level	94 (1.5)
Genetics	71 (2.4)
Ecology	65 (2.4)
Anatomy/Physiology	64 (2.9)
Cell Biology	64 (2.5)
Microbiology	61 (2.6)
Botany	52 (2.8)
Biochemistry	51 (3.0)
Zoology	50 (3.0)
Evolution	43 (2.4)
Other biology/life science beyond the general/introductory level	59 (2.6)
Biology/Life Science Teaching Methods Course	68 (2.7)

The survey also asked biology teachers to rate how well prepared they feel to teach each of a number of fundamental topics in biology. A large majority of biology teachers feel very well prepared to teach each of the topics, especially cell biology, structures and functions of organisms, and genetics (see Table 8). Very few biology teachers do not feel adequately prepared in any of the areas.

Table 8
High School Biology Teachers' Perceptions of Their Preparedness to Teach Each of a Number of Topics

	PERCENT OF BIOLOGY TEACHERS			
	NOT ADEQUATELY PREPARED	SOMEWHAT PREPARED	FAIRLY WELL PREPARED	VERY WELL PREPARED
Cell biology	1 (0.6)	4 (1.3)	21 (2.0)	73 (2.2)
Structures and functions of organisms	1 (0.8)	4 (1.1)	24 (2.6)	71 (2.9)
Genetics	0 (0.1)	6 (1.4)	24 (2.6)	70 (2.9)
Ecology/ecosystems	1 (0.4)	8 (1.3)	27 (2.6)	64 (2.5)
Evolution	1 (0.4)	8 (1.1)	29 (3.1)	62 (2.7)

Data from items asking teachers how well prepared they feel to teach the content of their randomly selected course were combined into a composite variable called Perceptions of Science Content Preparedness. As can be seen in Table 9, biology teachers feel similarly prepared to teach their course content as high school science teachers in general, but they feel slightly less prepared than chemistry teachers.

Table 9
Mean Scores for High School Science Teachers' Perceptions of Content Preparedness Composite†

	MEAN SCORE
All sciences	88 (0.6)
Biology	85 (0.9)
Chemistry	91 (0.9)
Physics	83 (1.3)

† Composite definition is based on the content of each teacher's randomly selected class.

The survey also asked teachers to respond about their preparedness to teach engineering concepts such as developing solutions, defining problems, and optimizing design solutions. Few high school biology teachers feel very well prepared to teach engineering; the large majority feel only somewhat prepared or not adequately prepared to do so (see Table 10).

Table 10
High School Biology Teachers' Perceptions of Their Preparedness to Teach Engineering

	PERCENT OF BIOLOGY TEACHERS			
	NOT ADEQUATELY PREPARED	SOMEWHAT PREPARED	FAIRLY WELL PREPARED	VERY WELL PREPARED
Developing possible solutions	39 (2.6)	38 (2.8)	17 (1.9)	6 (1.5)
Defining engineering problems	43 (2.8)	43 (2.8)	13 (1.7)	4 (1.4)
Optimizing a design solution	48 (2.7)	36 (2.8)	12 (1.5)	4 (1.4)

Data from these items were combined into a composite variable called Perceptions of Preparedness to Teach Engineering. As can be seen in Table 11, biology teachers are less likely to feel prepared to teach engineering than other high school science teachers.

Table 11
Mean Scores for High School Science Teachers' Perceptions of Preparedness to Teach Engineering Composite

	MEAN SCORE
All sciences	33 (1.0)
Biology	28 (1.4)
Chemistry	33 (1.6)
Physics	46 (2.4)

Pedagogical Preparedness

The survey asked teachers a series of items focused on their preparedness for a number of tasks associated with instruction. As with high school science teachers in general, the majority of biology teachers do not feel very well prepared for most of these tasks (see Table 12). About half of biology teachers feel very well prepared to develop students' conceptual understanding and use formative assessment to monitor student understanding. Roughly 40 percent of biology teachers feel very well prepared to develop students' abilities to do science, encourage their interest in science and/or engineering, and encourage participation of all students in science and/or engineering. Biology teachers are least likely to feel very well prepared to provide instruction based on students' ideas, develop students' awareness of STEM careers, and incorporate students' cultural backgrounds into their instruction.

Table 12
High School Science Teachers Considering Themselves Very Well Prepared for Each of a Number of Tasks

	PERCENT OF TEACHERS	
	ALL SCIENCES	BIOLOGY
Develop students' conceptual understanding	58 (1.5)	54 (2.5)
Use formative assessment to monitor student learning	52 (1.6)	48 (2.9)
Develop students' abilities to do science (e.g., develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)	46 (1.6)	44 (2.1)
Encourage students' interest in science and/or engineering	44 (1.6)	42 (2.5)
Encourage participation of all students in science and/or engineering	43 (1.6)	39 (2.6)
Differentiate science instruction to meet the needs of diverse learners	35 (1.5)	33 (2.4)
Provide science instruction that is based on students' ideas	25 (1.4)	21 (2.1)
Develop students' awareness of STEM careers	21 (1.2)	18 (1.7)
Incorporate students' cultural backgrounds into science instruction	18 (1.4)	17 (1.9)

The survey also asked teachers how well prepared they feel to carry out a number of tasks related to teaching in a specific unit, including monitoring and addressing student understanding. As can be seen in Table 13, in a majority of biology classes, like high school science classes more generally, teachers feel very well prepared to: (1) assess student understanding at the conclusion of a unit, (2) implement unit instructional materials, and (3) monitor student understanding during a specific unit.

Table 13
High School Science Classes in Which Teachers Feel Very Well Prepared for Each of a Number of Tasks in the Most Recent Unit in a Designated Class

	PERCENT OF CLASSES	
	ALL SCIENCES	BIOLOGY
Assess student understanding at the conclusion of this unit	59 (1.8)	60 (3.8)
Implement the instructional materials to be used during this unit	53 (1.6)	56 (3.4)
Monitor student understanding during this unit	53 (1.8)	56 (3.6)
Anticipate difficulties that students may have with particular science ideas and procedures in this unit	45 (1.6)	46 (3.3)
Find out what students thought or already knew about the key science ideas	38 (1.6)	41 (2.9)

Data from these two sets of items were combined into two composite variables: Perceptions of Pedagogical Preparedness and Perceptions of Preparedness to Implement Instruction in Particular Unit. As can be seen in Table 14, there is little difference among biology teachers and high school science teachers more broadly on either composite.

Table 14
Mean Scores for High School Science Teachers' Perceptions of General and Unit-Specific Pedagogical Preparedness Composites

	MEAN SCORE	
	PEDAGOGICAL PREPAREDNESS	PREPAREDNESS TO IMPLEMENT INSTRUCTION IN PARTICULAR UNIT
All sciences	71 (0.6)	80 (0.5)
Biology	69 (0.9)	80 (0.8)
Chemistry	71 (1.1)	81 (1.0)
Physics	71 (1.4)	79 (1.6)

Pedagogical Beliefs

Teachers were asked about their beliefs regarding effective teaching and learning in science. As can be seen in Table 15, biology teachers and high school science teachers in general hold a number of views that are in alignment with reform-oriented instruction. For example, at least 90 percent of biology teachers agree that: (1) teachers should ask students to support their conclusions about a science concept with evidence, (2) students learn best when instruction is connected to their everyday lives, (3) students should learn science by doing science, and (4) most class periods should provide opportunities to apply scientific ideas to real-world contexts. In addition, fewer than 4 in 10 biology teachers agree that teachers should explain an idea to students before having them consider evidence that relates to the idea.

However, as with high school science teachers more broadly, many biology teachers also hold traditional views that are inconsistent with effective science instruction. About two-thirds believe that students should be provided with definitions for new vocabulary at the beginning of instruction on a science idea, and about 6 in 10 believe that students learn best in classes with students of similar abilities. In addition, half of biology teachers believe that hands-on/laboratory activities should be used primarily to reinforce a science idea.

Table 15
High School Science Teachers Agreeing† With Various Statements About Teaching and Learning

	PERCENT OF TEACHERS	
	ALL SCIENCES	BIOLOGY
Reform-Oriented Beliefs		
Teachers should ask students to support their conclusions about a science concept with evidence.	99 (0.3)	99 (0.4)
Students learn best when instruction is connected to their everyday lives.	96 (0.7)	97 (1.0)
Students should learn science by doing science (e.g., developing scientific questions; designing and conducting investigations; analyzing data; developing models, explanations, and scientific arguments).	93 (1.2)	92 (2.4)
Most class periods should provide opportunities for students to apply scientific ideas to real-world contexts.	91 (1.4)	91 (2.3)
Most class periods should provide opportunities for students to share their thinking and reasoning.	89 (1.4)	88 (2.4)
It is better for science instruction to focus on ideas in depth, even if that means covering fewer topics.	77 (2.0)	77 (3.0)
Traditional Beliefs		
At the beginning of instruction on a science idea, students should be provided with definitions for new scientific vocabulary that will be used.	66 (2.1)	67 (3.2)
Students learn science best in classes with students of similar abilities.	60 (1.7)	57 (3.0)
Hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned.	52 (2.0)	53 (3.5)
Teachers should explain an idea to students before having them consider evidence that relates to the idea.	37 (2.3)	36 (3.1)

† Includes high school science teachers indicating "strongly agree" or "agree" on a five-point scale ranging from 1 "strongly disagree" to 5 "strongly agree."

Data from items asking teachers about their pedagogical beliefs were combined into two composite variables called Traditional Teaching Beliefs and Reform-Oriented Teaching Beliefs. Beliefs are generally uniform across high school science teachers and reflect a higher alignment with reform-oriented beliefs than with traditional beliefs (see Table 16).

Table 16
Mean Scores for High School Science Teachers' Beliefs About Teaching and Learning Composites

	MEAN SCORE	
	TRADITIONAL BELIEFS	REFORM-ORIENTED BELIEFS
All sciences	59 (0.7)	85 (0.5)
Biology	59 (1.0)	85 (0.8)
Chemistry	58 (1.0)	85 (0.8)
Physics	56 (1.3)	83 (1.2)

Leadership Roles and Responsibilities

Teachers were also asked whether they have served in various leadership roles in the profession in the last three years. As can be seen in Table 17, the percentage of biology teachers serving in the various roles is similar to that of high school science teachers more broadly. About half have observed another teacher's lesson for the purpose of giving feedback and served on a school or district/diocese-wide science committee. Less common leadership roles for biology teachers (reported by about a quarter or fewer) are leading a workshop or professional learning community focused on science teaching, serving as a formal mentor or coach, and supervising a student teacher in their classroom.

Table 17
High School Science Teachers Having Various Leadership Responsibilities Within the Last Three Years

	PERCENT OF TEACHERS	
	ALL SCIENCES	BIOLOGY
Observed another teacher's science lesson for the purpose of giving them feedback	50 (2.3)	49 (3.2)
Served on a school or district/diocese-wide science committee	51 (2.0)	46 (2.8)
Taught a science lesson for other teachers in their school to observe	38 (2.1)	34 (2.7)
Served as a lead teacher or department chair in science	33 (2.0)	33 (3.1)
Led or co-led a workshop or professional learning community for other teachers focused on science or science teaching	28 (1.7)	24 (2.3)
Served as a formal mentor or coach for a science teacher	27 (1.8)	24 (2.2)
Supervised a student teacher in their classroom	22 (2.3)	23 (3.2)

Professional Development of High School Biology Teachers

Biology teachers, like all professionals, need opportunities to keep up with advances in their field, including both disciplinary content and how to help their students learn important science content. The 2018 NSSME+ collected data on teachers' participation in professional development, as well as characteristics of the professional development.

One important measure of teachers' continuing education is how long it has been since they last participated in professional development. The vast majority of biology teachers have participated in science- and/or engineering-focused professional development (i.e., focused on science/engineering content or the teaching of science/engineering) in the last three years (see Table 18).

Table 18
High School Science Teachers' Most Recent Participation in Science-Focused Professional Development

	PERCENT OF TEACHERS	
	ALL SCIENCES	BIOLOGY
In the last 12 months	59 (1.8)	58 (3.0)
1–3 years ago	24 (1.5)	26 (2.8)
4–6 years ago	5 (0.8)	6 (1.4)
7–10 years ago	2 (0.4)	1 (0.4)
More than 10 years ago	2 (0.6)	3 (1.0)
Never	7 (0.9)	6 (0.9)

Although most biology teachers have participated in professional development in the last three years, most have not had extensive amounts. Fewer than a third of high school biology teachers have spent 36 or more hours in science- and/or engineering-related professional development in the last three years (see Table 19).

Table 19
Time Spent by High School Science Teachers on Science-Focused Professional Development in the Last Three Years

	PERCENT OF TEACHERS	
	ALL SCIENCES	BIOLOGY
None	18 (1.3)	16 (2.1)
Less than 6 hours	8 (1.3)	9 (2.0)
6–15 hours	18 (1.6)	22 (3.0)
16–35 hours	22 (1.3)	23 (2.1)
36–80 hours	21 (1.4)	20 (1.7)
More than 80 hours	14 (1.0)	10 (1.2)

As to how this time is spent, a program/workshop is by far the most common form of professional development, with 90 percent of biology teachers attending professional development in the previous three years (see Table 20). Just over half have participated in a professional learning community or other type of teacher study group.

Table 20
High School Science Teachers Participating in Various Science-Focused Professional Development Activities in the Last Three Years

	PERCENT OF TEACHERS†	
	ALL SCIENCES	BIOLOGY
Attended a professional development program/workshop	91 (1.5)	90 (2.3)
Participated in a professional learning community/lesson study/teacher study group	55 (1.7)	53 (3.5)
Attended a national, state, or regional science teacher association meeting	40 (2.0)	39 (3.0)
Received assistance or feedback from a formally designated coach/mentor	35 (2.1)	33 (3.1)
Completed an online course/webinar	34 (2.2)	33 (2.7)
Took a formal course for college credit	16 (1.4)	14 (2.0)

† Only high school science teachers indicating that they participated in science-focused professional development in the last three years are included in these analyses.

It is widely agreed upon that teachers need opportunities to work with colleagues who face similar challenges, including other teachers from their school and those who have similar teaching assignments. Other recommendations include providing opportunities for teachers to engage in investigations, both to learn disciplinary content and to experience inquiry-oriented learning; examine student work and other classroom artifacts for evidence of what students do and do not understand; and apply what they have learned in their classrooms and subsequently discuss how it went.[6] Accordingly, teachers who had participated in professional development in the last three years were asked a series of additional questions about the nature of those experiences.

As can be seen in Table 21, over half of biology teachers participating in professional development in the last three years have had substantial opportunities to work closely with other teachers from their school or with other teachers of the same grade and/or subject. Forty-five percent have had substantial opportunities to engage in science investigations/engineering design challenges and experience lessons as their students would. Only about one-third have had opportunities to rehearse instructional practices during the professional development. The data are similar for high school biology teachers and high school science teachers more generally.

Table 21
High School Science Teachers Whose Professional Development in the Last Three Years Had Each of a Number of Characteristics to a Substantial Extent†

	PERCENT OF TEACHERS‡	
	ALL SCIENCES	BIOLOGY
Worked closely with other teachers from their school	55 (2.3)	54 (3.4)
Worked closely with other teachers who taught the same grade and/or subject whether or not they were from their school	54 (2.1)	54 (3.6)
Had opportunities to engage in science investigations/engineering design challenges	45 (2.4)	45 (3.1)
Had opportunities to experience lessons, as their students would, from the textbook/modules they use in their classroom	45 (2.4)	45 (3.2)
Had opportunities to apply what they learned to their classroom and then come back and talk about it as part of the professional development	43 (2.4)	44 (3.9)
Had opportunities to examine classroom artifacts (e.g., student work samples, videos of classroom instruction)	39 (2.3)	41 (3.6)
Had opportunities to rehearse instructional practices during the professional development (i.e., try out, receive feedback, and reflect on those practices)	35 (2.3)	35 (3.5)

† Includes high school science teachers indicating 4 or 5 on a 5-point scale ranging from 1 "not at all" to 5 "to a great extent."
‡ Only high school science teachers indicating that they participated in science-focused professional development in the last three years are included in these analyses.

[6] Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*(3), 181–199.

Elmore, R. F. (2002). *Bridging the gap between standards and achievement: The imperative for professional development in education.* Washington, DC: Albert Shanker Institute.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915–945.

Another series of items asked about the focus of the professional development opportunities teachers have had in the last three years. About half of high school biology teachers have had professional development with a heavy emphasis on deepening their understanding of how science is done, monitoring student understanding during instruction, deepening their own science content knowledge, and differentiating science instruction to meet the needs of diverse learners (see Table 22). Only about a quarter have had professional development with a heavy emphasis on incorporating students' cultural backgrounds into instruction, which may explain why relatively few reported feeling well prepared to do so.

Table 22
High School Science Teachers Reporting That Their Professional Development in the Last Three Years Gave Heavy Emphasis† to Various Areas

	PERCENT OF TEACHERS‡	
	ALL SCIENCES	BIOLOGY
Deepening your understanding of how science is done	51 (2.4)	50 (3.0)
Monitoring student understanding during science instruction	47 (2.0)	50 (3.7)
Deepening your own science content knowledge	45 (1.9)	47 (3.2)
Differentiating science instruction to meet the needs of diverse learners	46 (2.0)	46 (3.4)
Finding out what students think or already know prior to instruction on a topic	37 (2.0)	40 (3.1)
Learning about difficulties that students may have with particular science ideas	40 (2.0)	39 (3.1)
Learning how to provide science instruction that integrates engineering, mathematics, and/or computer science	34 (2.1)	31 (2.5)
Implementing the science textbook/module to be used in your classroom	29 (1.9)	30 (3.0)
Deepening your understanding of how engineering is done	23 (1.8)	24 (3.0)
Incorporating students' cultural backgrounds into science instruction	23 (2.1)	23 (3.2)

† Includes high school science teachers indicating 4 or 5 on a five-point scale ranging from 1 "not at all" to 5 "to a great extent."
‡ Only high school science teachers indicating that they participated in science-focused professional development in the last three years are included in these analyses.

Data from the items about professional development characteristics and areas of emphasis were combined into two composite variables called Extent Professional Development Aligns with Elements of Effective Professional Development and Extent Professional Development Supports Student-Centered Instruction. As can be seen in Table 23, the data indicate that the alignment of biology teachers' professional development with elements known to be effective is only partial and, in this regard, is similar to the professional development attended by other high school science teachers. In addition, high school science teachers' professional development, regardless of subject taught, has had only a partial emphasis on supporting student-centered instruction.

Table 23
High School Science Teacher Mean Scores for Professional Development Composites

	MEAN SCORE	
	EXTENT PROFESSIONAL DEVELOPMENT ALIGNS WITH ELEMENTS OF EFFECTIVE PROFESSIONAL DEVELOPMENT	EXTENT PROFESSIONAL DEVELOPMENT SUPPORTS STUDENT-CENTERED INSTRUCTION
All sciences	55 (1.1)	52 (0.8)
Biology	55 (1.5)	53 (1.2)
Chemistry	54 (1.7)	53 (1.7)
Physics	52 (2.0)	51 (2.0)

High School Biology Courses Offered

Of the high schools (schools including grades 9, 10, 11, or 12) in the United States, almost all (97 percent) offer at least one biology course (see Table 24). Seventy-three percent of high schools offer a 1st year biology course, and 60 percent offer a 2nd year course. Only about 4 in 10 high schools offer Advanced Placement (AP) Biology. There is a large disparity between the percentage of high schools offering AP Biology and the percentage of high school students with access to the course, most likely due to the fact that large schools are more likely than small ones to offer advanced biology courses, and that small schools outnumber large schools in the United States. Only 3 percent of high schools offer International Baccalaureate (IB) biology.

Table 24
Access to Biology Courses at High Schools, by Schools and Students

	PERCENT OF HIGH SCHOOLS OFFERING	PERCENT OF HIGH SCHOOL STUDENTS WITH ACCESS
Any level	97 (1.7)	99 (0.4)
Non-college prep	70 (3.0)	73 (2.1)
1st year college prep, including honors	73 (3.4)	87 (1.6)
2nd year advanced	60 (3.8)	86 (1.7)
AP Biology	43 (3.1)	73 (2.4)
IB Biology	3 (0.7)	8 (1.6)

In terms of the percentage of high school science classes offered in the nation, 1st year biology is the most common, accounting for almost a quarter of classes (see Table 25). Biology is also the most commonly offered science subject and accounts for 37 percent of all science classes.

Table 25
Most Commonly Offered High School Science Courses

	PERCENT OF CLASSES
Life Science/Biology	
Non-college prep	7 (0.9)
1st year college prep, including honors	22 (1.4)
2nd year advanced	8 (1.3)
Chemistry	
Non-college prep	3 (0.5)
1st year college prep, including honors	16 (1.1)
2nd year advanced	3 (0.5)
Physics	
Non-college prep	2 (0.4)
1st year college prep, including honors	8 (0.8)
2nd year advanced	2 (0.4)
Earth/Space Science	
Non-college prep	3 (0.8)
1st year college prep, including honors	2 (0.5)
2nd year advanced	0 (0.2)
Environmental Science/Ecology	
Non-college prep	3 (0.6)
1st year college prep, including honors	2 (0.6)
2nd year advanced	2 (0.4)
Multi-Discipline Science Courses (e.g., General Science, Integrated Science, Physical Science)	
Non-college prep	8 (0.8)
1st year college prep, including honors	5 (0.8)
2nd year advanced	1 (0.4)

The typical biology class has approximately 22 students; two-thirds of the classes have between 15 and 29 students. Fifty-one percent of 1st year biology students are female, equal to chemistry but significantly more than the 41 percent of students in 1st year physics who are female (see Table 26). Despite the fact that students from race/ethnicity groups historically underrepresented in STEM fields[7] make up about half of the student body, only 35 percent of students who take 1st year biology, similar to the other 1st year college prep science courses, are from these groups.

Table 26
Demographics of Students in 1st Year High School Science Courses

	PERCENT OF STUDENTS	
	FEMALE	HISTORICALLY UNDERREPRESENTED
1st Year Biology	51 (1.5)	35 (3.0)
1st Year Chemistry	51 (1.1)	35 (2.2)
1st Year Physics	41 (1.9)	30 (3.0)

[7] Includes students identified as American Indian or Alaskan Native, Black or African American, Hispanic or Latino, or Native Hawaiian or Other Pacific Islander.

Biology classes are about as likely as chemistry and physics classes to be heterogeneously grouped, with almost a third of classes containing a mixture of prior achievement levels (see Table 27). The majority of classes, however, are composed of mostly average or mostly high prior-achieving students.

Table 27
Prior Achievement Grouping in 1st Year High School Science Courses

	PERCENT OF CLASSES			
	MOSTLY LOW ACHIEVERS	MOSTLY AVERAGE ACHIEVERS	MOSTLY HIGH ACHIEVERS	A MIXTURE OF LEVELS
1st Year Biology	9 (1.8)	32 (4.1)	29 (4.2)	30 (3.5)
1st Year Chemistry	5 (0.9)	32 (2.4)	32 (2.6)	31 (2.7)
1st Year Physics	6 (1.7)	24 (3.2)	42 (5.0)	28 (4.5)

High School Biology Instruction

This section of the report draws on teachers' descriptions of what transpires in biology classrooms, in terms of their autonomy for making decisions regarding the content and pedagogy, instructional objectives, class activities, and homework and assessment practices.

Teachers' Perceptions of Their Decision-Making Autonomy

Teachers were asked the extent to which they had control over a number of curriculum and instruction decisions for their classes. Similar to high school science classes in general, in the majority of biology classes teachers are likely to perceive themselves as having strong control over pedagogical decisions, such as determining the amount of homework to be assigned, selecting teaching techniques, and choosing criteria for grading student performance (see Table 28). In a third or fewer classes, teachers perceive themselves as having strong control over curricular decisions, such as selecting curriculum materials, determining course goals and objectives, and selecting what content, topics, and skills to teach.

Table 28
High School Science Classes in Which Teachers Report Having Strong Control Over Various Curricular and Instructional Decisions

	PERCENT OF CLASSES	
	ALL SCIENCES	BIOLOGY
Determining the amount of homework to be assigned	74 (1.8)	74 (3.0)
Selecting teaching techniques	68 (2.3)	65 (4.3)
Choosing criteria for grading student performance	54 (2.2)	53 (4.0)
Selecting the sequence in which topics are covered	51 (2.1)	49 (3.7)
Determining the amount of instructional time to spend on each topic	48 (2.1)	42 (4.0)
Selecting curriculum materials (e.g., textbooks/modules)	36 (2.0)	33 (3.7)
Determining course goals and objectives	36 (2.5)	32 (4.2)
Selecting content, topics, and skills to be taught	34 (2.2)	30 (3.8)

These items were combined into two composite variables—Curriculum Control and Pedagogy Control. Curriculum Control consists of the following items:

- Determining course goals and objectives;
- Selecting curriculum materials;
- Selecting content, topics, and skills to be taught; and
- Selecting the sequence in which topics are covered.

For Pedagogy Control, the items are:

- Selecting teaching techniques;
- Determining the amount of homework to be assigned; and
- Choosing criteria for grading student performance.

Composite scores confirm this trend, with a much higher mean score for pedagogy control than curriculum control in biology classes. The mean scores for biology, however, are not significantly different from the mean scores for chemistry, physics, and high school science classes in general (see Table 29).

Table 29
High School Science Class Mean Scores for Curriculum Control and Pedagogy Control Composites

	MEAN SCORE	
	CURRICULUM CONTROL	PEDAGOGY CONTROL
All sciences	67 (1.4)	87 (1.0)
Biology	65 (2.4)	86 (2.0)
Chemistry	68 (1.9)	88 (0.9)
Physics	69 (2.7)	89 (1.7)

Instructional Objectives

Teachers were given a list of potential objectives and asked to rate each in terms of the emphasis it receives in the randomly selected class. As can be seen in Table 30, understanding science concepts receives a heavy emphasis in three-quarters of biology classes and high school science classes in general. All other objectives are heavily emphasized in fewer than half of biology classes, including learning how to do science (38 percent of classes), developing student confidence that they can successfully pursue careers in science/engineering (31 percent), and increasing students' interest in science/engineering (28 percent). Biology classes are more likely than high school science classes in general to emphasize learning science vocabulary and/or facts (42 vs. 32 percent).

Table 30
High School Science Classes With Heavy Emphasis on Various Instructional Objectives

	PERCENT OF CLASSES	
	ALL SCIENCES	BIOLOGY
Understanding science concepts	76 (1.8)	74 (3.1)
Learning science vocabulary and/or facts	32 (1.6)	42 (3.1)
Learning how to do science (develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)	41 (1.3)	38 (3.4)
Developing students' confidence that they can successfully pursue careers in science/engineering	35 (1.5)	31 (2.9)
Increasing students' interest in science/engineering	31 (1.5)	28 (2.6)
Learning test-taking skills/strategies	23 (1.4)	28 (2.6)
Learning about real-life applications of science/engineering	29 (1.2)	27 (2.7)
Learning about different fields of science/engineering	7 (0.8)	6 (1.4)
Learning how to do engineering (e.g., identify criteria and constraints, design solutions, optimize solutions)	5 (0.7)	2 (0.6)

The following items were combined into a composite variable called Reform-Oriented Instructional Objectives:

- Understanding science concepts;
- Learning how to do science;
- Learning about different fields of science/engineering;
- Learning how to do engineering;
- Learning about real-life applications of science/engineering;
- Increasing students' interest in science/engineering; and
- Developing students' confidence that they can successfully pursue careers in science/ engineering.

As can be seen in Table 31, biology classes are slightly less likely than high school science classes in general to emphasize reform-oriented objectives. Biology classes are also less likely than chemistry and physics classes to emphasize these objectives.

Table 31
High School Science Class Mean Scores for the Reform-Oriented Instructional Objectives Composite

	MEAN SCORE
All Sciences	65 (0.5)
Biology	63 (1.1)
Chemistry	66 (0.8)
Physics	70 (1.1)

Class Activities

The 2018 National Survey included several items that provide information about how biology is taught at the high school level. One series of items listed various instructional strategies and asked teachers to indicate the frequency with which they used each in a randomly selected class.

As can be seen in Table 32, the vast majority of biology classes include, at least once a week, the teacher explaining ideas to the whole class. A large majority of classes include students working in small groups, whole class discussions, and students doing hands-on/laboratory activities at least once a week. It is somewhat striking that, in contrast to what is known from learning theory about the importance of reflection, only 29 percent of biology classes have students write reflections on what they are learning. Overall, the data for biology classes are similar to those for high school science in general.

Table 32
High School Science Classes in Which Teachers Use Various Activities at Least Once a Week

	PERCENT OF CLASSES	
	ALL SCIENCES	BIOLOGY
Explain science ideas to the whole class	92 (0.9)	94 (1.0)
Have students work in small groups	84 (1.5)	85 (2.4)
Engage the whole class in discussions	78 (1.3)	82 (2.2)
Have students do hands-on/laboratory activities	68 (1.6)	69 (2.9)
Focus on literacy skills (e.g., informational reading or writing strategies)	33 (1.6)	36 (2.9)
Have students write their reflections (e.g., in their journals, on exit tickets) in class or for homework	28 (1.4)	29 (2.9)
Engage the class in project-based learning (PBL) activities	28 (1.7)	27 (3.0)
Have students read from a textbook, module, or other material in class, either aloud or to themselves	26 (1.7)	27 (2.7)
Have students practice for standardized tests	20 (1.5)	26 (3.1)
Use flipped instruction (have students watch lectures/demonstrations outside of class to prepare for in-class activities)	15 (1.3)	16 (2.2)

The survey also asked how often students in science classes are engaged in doing science as described in documents like *A Framework for K–12 Science Education*[8]—i.e., the practices of science such as formulating scientific questions, designing and implementing investigations, developing models and explanations, and engaging in argumentation. As can be seen in Table 33, students in about half of biology classes are asked to organize and represent data and make and support claims with evidence at least once a week. Students tend to not be engaged very often in aspects of science related to evaluating the strengths/limitations of evidence and the practice of argumentation. For example, fewer than a quarter of biology classes have students, at least once a week, evaluate the credibility of scientific information, identify the strengths and limitations of a model or competing scientific explanations, pose questions about scientific arguments, determine what details about an investigation might persuade a targeted audience about a scientific claim, or construct a persuasive case.

Overall, student engagement in these aspects of the practices is similar in biology classes and high school science classes more broadly, with two exceptions. Biology classes are less likely to have students select and use mathematical and/or statistical techniques for data analysis (22 vs.

[8] National Research Council. (2012). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13165.

30 percent) and use mathematical and/or computational models to generate data to support a claim (17 vs. 26 percent).

Table 33
High School Science Classes in Which Teachers Engage Students in Various Aspects of Science Practices at Least Once a Week

	PERCENT OF CLASSES	
	ALL SCIENCES	BIOLOGY
Organize and/or represent data using tables, charts, or graphs in order to facilitate analysis of the data	58 (1.5)	56 (2.8)
Make and support claims with evidence	50 (1.5)	50 (2.8)
Conduct a scientific investigation	50 (1.6)	43 (2.8)
Analyze data using grade-appropriate methods in order to identify patterns, trends, or relationships	47 (1.4)	42 (3.0)
Generate scientific questions	38 (1.8)	38 (3.1)
Determine what data would need to be collected in order to answer a scientific question	39 (1.4)	37 (2.8)
Use multiple sources of evidence to develop an explanation	33 (1.6)	34 (2.5)
Compare data from multiple trials or across student groups for consistency in order to identify potential sources of error or inconsistencies in the data	36 (1.5)	33 (3.0)
Determine whether or not a question is scientific	28 (1.5)	33 (2.9)
Develop scientific models—physical, graphical, or mathematical representations of real-world phenomena	34 (1.5)	31 (2.7)
Use data and reasoning to defend, verbally or in writing, a claim or refute alternative scientific claims	27 (1.7)	29 (3.3)
Develop procedures for a scientific investigation to answer a scientific question	32 (1.4)	27 (2.7)
Summarize patterns, similarities, and differences in scientific information obtained from multiple sources	28 (1.5)	27 (2.8)
Revise their explanations based on additional evidence	28 (1.4)	26 (2.6)
Pose questions that elicit relevant details about the important aspects of a scientific argument	23 (1.6)	24 (2.7)
Select and use grade-appropriate mathematical and/or statistical techniques to analyze data	30 (1.6)	22 (2.7)
Consider how missing data or measurement error can affect the interpretation of data	27 (1.5)	22 (2.4)
Evaluate the credibility of scientific information—e.g., its reliability, validity, consistency, logical coherence, lack of bias, or methodological strengths and weaknesses	20 (1.6)	21 (2.8)
Identify the strengths and limitations of a scientific model—in terms of accuracy, clarity, generalizability, accessibility to others, strength of evidence supporting it	22 (1.1)	19 (2.4)
Evaluate the strengths and weaknesses of competing scientific explanations	23 (1.4)	18 (2.4)
Use mathematical and/or computational models to generate data to support a scientific claim	26 (1.3)	17 (2.3)
Determine what details about an investigation might persuade a targeted audience about a scientific claim	17 (1.3)	17 (2.4)
Construct a persuasive case, verbally or in writing, for the best scientific model or explanation for a real-world phenomenon	15 (1.1)	14 (2.2)

The data from these items were combined into a composite variable called Engaging Students in the Practices of Science. As can be seen in Table 34, mean scores for this composite are roughly equal across biology, chemistry, physics, and high school science classes more broadly.

Table 34
High School Science Class Mean Scores for Engaging Students in the Practices of Science Composite

	MEAN SCORE
All Sciences	50 (0.6)
Biology	49 (1.1)
Chemistry	51 (1.0)
Physics	52 (1.4)

Science teachers were asked about the frequency with which they incorporate engineering and coding into their science instruction in the randomly selected class. As can be seen in Table 35, a large majority of biology classes rarely or never incorporate engineering into science instruction. Coding is even more unlikely to be incorporated into biology instruction, with 95 percent of classes never doing so.

Table 35
High School Science Classes in Which Teachers Report Incorporating Engineering and Coding Into Science Instruction

	PERCENT OF CLASSES	
	ALL SCIENCES	BIOLOGY
Engineering		
Never	20 (1.8)	23 (2.7)
Rarely (e.g., a few times per year)	50 (1.9)	59 (3.6)
Sometimes (e.g., once or twice a month)	24 (1.5)	16 (2.6)
Often (e.g., once or twice a week)	6 (1.1)	3 (1.3)
All or almost all science lessons	1 (0.2)	0 ---†
Coding		
Never	89 (1.2)	95 (1.4)
Rarely (e.g., a few times per year)	6 (0.9)	4 (1.4)
Sometimes (e.g., once or twice a month)	4 (0.8)	1 (0.5)
Often (e.g., once or twice a week)	0 (0.1)	0 (0.2)
All or almost all science lessons	0 (0.0)	0 (0.1)

† No high school biology teachers in the sample selected this response option. Thus, it is not possible to calculate the standard error of this estimate.

In addition to asking about class activities in the course as a whole, the 2018 National Survey asked teachers about activities that took place during their most recent science lesson in the randomly selected class. About 8 in 10 of biology lessons include the teacher explaining a science idea to the whole class and students working in small groups (see Table 36). Whole class discussion and students writing about science occur in 66 and 44 percent of biology lessons, respectively; both of which occur less frequently in high school science classes in general.

Table 36
High School Science Classes Participating in Various Activities in Most Recent Lesson

	PERCENT OF CLASSES	
	ALL SCIENCES	BIOLOGY
Teacher explaining a science idea to the whole class	81 (1.3)	81 (2.4)
Students working in small groups	81 (1.4)	79 (2.5)
Whole class discussion	59 (1.6)	66 (2.8)
Students writing about science	34 (1.8)	44 (3.3)
Students doing hands-on/laboratory activities	40 (1.6)	38 (3.1)
Students completing textbook/worksheet problems	44 (1.6)	37 (2.9)
Students reading about science	29 (1.6)	33 (2.9)
Teacher conducting a demonstration while students watched	31 (1.6)	23 (2.7)
Practicing for standardized tests	8 (0.9)	14 (2.1)
Test or quiz	16 (1.2)	9 (1.5)

The survey also asked teachers to estimate the amount of time spent on each of a number of activities in the most recent science lesson. There is no significant difference between biology and high school science classes more broadly (see Table 37). Forty percent of biology class time is spent on whole class activities, 34 percent on small group work, and 17 percent on students working individually. Non-instructional activities, including attendance taking and interruptions, account for 10 percent of class time.

Table 37
Average Percentage of Time Spent on Different Activities in the Most Recent High School Science Lesson

	AVERAGE PERCENT OF CLASS TIME	
	ALL SCIENCES	BIOLOGY
Whole class activities (e.g., lectures, explanations, discussions)	38 (0.8)	40 (1.6)
Small group work	34 (0.8)	34 (1.9)
Students working individually (e.g., reading textbooks, completing worksheets, taking a test or quiz)	19 (0.8)	17 (1.2)
Non-instructional activities (e.g., attendance taking, interruptions)	10 (0.2)	10 (0.4)

Homework and Assessment Practices

Teachers were asked about the amount of homework assigned per week in the randomly selected class. About 6 in 10 biology classes were assigned between 31 and 90 minutes of homework per week in the class (see Table 38).

Table 38
Amount of Homework Assigned in High School Science Classes Per Week

	PERCENT OF CLASSES	
	ALL SCIENCES	BIOLOGY
None	3 (0.5)	2 (1.0)
1–15 minutes per week	9 (1.3)	10 (2.8)
15–30 minutes per week	19 (1.3)	16 (2.2)
31–60 minutes per week	33 (1.6)	36 (3.3)
61–90 minutes per week	22 (1.9)	23 (3.7)
91–120 minutes per week	7 (0.9)	6 (1.4)
More than 2 hours per week	7 (0.9)	7 (2.1)

The survey also asked how often students in the randomly selected class were required to take assessments the teacher did not choose to administer, such as state assessments or district benchmarks. About three-quarters of biology classes are required to take such an assessment at least once a year compared to about two-thirds of high school science classes overall (see Table 39).

Table 39
Frequency of Required External Testing in High School Science Classes

	PERCENT OF CLASSES	
	ALL SCIENCES	BIOLOGY
Never	31 (2.0)	24 (3.4)
Once a year	33 (2.0)	36 (3.7)
Twice a year	14 (1.7)	14 (3.6)
Three or four times a year	16 (1.5)	18 (2.8)
Five or more times a year	6 (0.9)	8 (1.7)

Resources Available for High School Biology

The quality and availability of instructional resources are major factors affecting science teaching. The 2018 NSSME+ included a series of items on instructional materials—which ones teachers use and how teachers use them. Teachers were also asked about their ability to access resources such as facilities and equipment for their science instruction.

Instructional Materials

The survey collected data on the use of instructional materials in science classes. As can be seen in Table 40, biology classes, as well as high school science classes in general, are likely to have district-designated materials.

Table 40
High School Science Classes for Which the District Designates Instructional Materials to Be Used

	PERCENT OF CLASSES
All Sciences	58 (2.0)
Biology	60 (3.2)

Teachers who responded that their randomly selected class had designated instructional materials were asked which types of materials are designated to be used. Commercially published textbooks are the most commonly designated material type, regardless of the subject of the class (see Table 41). The data also indicate that for many classes, multiple types of materials are being designated.

Table 41
High School Science Classes for Which Various Types of Instructional Resources Are Designated

	PERCENT OF CLASSES†	
	ALL SCIENCES	BIOLOGY
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	95 (0.9)	96 (1.5)
State, county, district, or diocese-developed units or lessons	27 (1.7)	26 (2.3)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)	25 (2.0)	24 (3.1)
Commercially published kits/modules (printed or electronic)	22 (2.0)	19 (2.9)
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)	16 (1.5)	17 (1.5)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)	11 (1.8)	11 (2.2)

† Only high school science classes for which instructional materials are designated by the state, district, or diocese are included in these analyses.

Regardless of whether materials were designated for the class, teachers were asked how instruction is based on various types of materials. The most frequently used type, serving as the basis of instruction at least once a week in 86 percent of high school biology classes, is units or lessons teachers created (see Table 42). Other resources used in about half of biology classes at least once a week are commercially published textbooks and units or lessons collected from other sources such as conferences, journals, or colleagues.

Table 42
High School Science Classes Basing Instruction on Various Instructional Resources at Least Once a Week

	PERCENT OF CLASSES	
	ALL SCIENCES	BIOLOGY
Units or lessons you created (either by yourself or with others)	86 (1.0)	86 (1.9)
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	50 (1.7)	55 (3.4)
Units or lessons you collected from any other source (e.g., conferences, journals, colleagues, university or museum partners)	49 (1.7)	51 (3.0)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)	31 (1.8)	36 (3.4)
Commercially published kits/modules (printed or electronic)	21 (1.5)	25 (3.1)
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)	16 (1.1)	17 (2.0)
State, county, district, or diocese-developed units or lessons	14 (1.2)	15 (1.9)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)	9 (1.0)	10 (1.9)

Teachers who indicated that the randomly selected class used commercially published materials were asked to record the title, author, year, and ISBN of the material used most often in the class. Using this information, the publisher of the material was identified. The most commonly used materials for high school biology are:

- *Biology* (Pearson);
- *Biology* (Houghton Mifflin Harcourt); and
- *Biology* (McGraw-Hill).

Table 43 shows the publication year of commercially published instructional materials used. About 7 in 10 high school biology classes use materials published prior to 2013.

Table 43
Publication Year of Textbooks Used in High School Science Classes

	PERCENT OF CLASSES†	
	ALL SCIENCES	BIOLOGY
2009 or earlier	43 (2.1)	36 (3.6)
2010–12	27 (1.9)	35 (3.8)
2013–15	20 (1.8)	19 (2.7)
2016–18	9 (1.4)	9 (2.5)

† Only high school science classes using commercially published textbooks/modules are included in these analyses.

Teachers were also asked whether the most recent unit in their randomly selected class was based primarily on either a commercially published textbook or materials developed by the state or district. As can be seen in Table 44, slightly more than half of biology and high school science classes in general based their most recent unit on commercially published textbooks or materials developed by the state or district.

Table 44
High School Science Classes in Which the Most Recent Unit Was Based on a Commercially Published Textbook or a Material Developed by the State or District

	PERCENT OF CLASSES†
All Sciences	54 (1.9)
Biology	53 (3.5)

† Only high school science classes using commercially published or state/district-developed materials at least once a month are included in these analyses.

When teachers responded that their most recent unit was based on one of these materials, they were asked how they used the material. As can be seen in Table 45, although high school biology classes are very likely to use these materials to guide the structure and content emphasis of instruction, teachers also deviate from these materials quite often. About three-quarters or more of biology classes incorporate other activities to supplement the materials and modify activities. Further, in about half of biology classes, teachers "pick and choose" lessons from the materials.

Table 45
Ways High School Science Teachers Substantially† Used Their Materials in Most Recent Unit

	PERCENT OF CLASSES‡	
	ALL SCIENCES	BIOLOGY
I incorporated activities (e.g., problems, investigations, readings) from other sources to supplement what these materials were lacking.	78 (2.1)	81 (3.3)
I used these materials to guide the structure and content emphasis of the unit.	76 (2.0)	76 (3.6)
I modified activities from these materials.	71 (2.7)	74 (3.7)
I picked what is important from these materials and skipped the rest.	53 (2.6)	52 (4.6)

† Includes high school science teachers indicating 4 or 5 on a five-point scale ranging from 1 "not at all" to 5 "to a great extent."
‡ Only high school science classes in which the most recent unit was based on commercially published or state/district-developed materials are included in these analyses.

Teachers were asked why they skip parts of their materials. As can be seen in Table 46, teachers of many biology classes, and high school science classes more broadly, have a number of reasons. About three-quarters skip activities due to a lack of instructional time, having other activities that work better, and the ideas not being in teachers' pacing guide/standards.

Table 46
Reasons Why Parts of High School Science Materials Are Skipped

	PERCENT OF CLASSES†	
	ALL SCIENCES	BIOLOGY
I did not have enough instructional time for the activities I skipped.	74 (3.5)	76 (5.9)
I have different activities for those science ideas that work better than the ones I skipped.	77 (4.0)	73 (7.6)
The science ideas addressed in the activities I skipped are not included in my pacing guide/standards.	73 (3.2)	71 (6.0)
The activities I skipped were too difficult for my students.	59 (3.4)	55 (6.7)
My students already knew the science ideas or were able to learn them without the activities I skipped.	52 (3.5)	51 (6.9)
I did not have the materials needed to implement the activities I skipped.	54 (3.7)	50 (6.1)
I did not have the knowledge needed to implement the activities I skipped.	20 (2.6)	18 (4.3)

† Only high school science classes in which (1) the most recent unit was based on commercially published or state/district-developed materials and (2) teachers reported skipping some activities are included in these analyses.

Teachers in more than 8 of 10 biology classes that supplement their materials do so because they have other activities they like, to help students at different levels of achievement learn targeted ideas, or to provide students with additional practice (see Table 47). In around half of biology classes, teachers supplement to prepare students for standardized tests or because their pacing guide indicated that they should.

Table 47
Reasons Why High School Science Materials Are Supplemented

	PERCENT OF CLASSES†	
	ALL SCIENCES	BIOLOGY
I had additional activities that I liked.	88 (2.6)	88 (4.6)
Supplemental activities were needed so students at different levels of achievement could increase their understanding of the ideas targeted in each activity.	86 (3.5)	86 (7.0)
Supplemental activities were needed to provide students with additional practice.	86 (3.7)	81 (7.6)
Supplemental activities were needed to prepare students for standardized tests.	53 (3.6)	55 (7.3)
My pacing guide indicated that I should use supplemental activities.	46 (3.3)	46 (6.5)

† Only high school science classes in which (1) the most recent unit was based on commercially published or state/district-developed materials and (2) teachers reported supplementing some activities are included in these analyses.

In 71 percent of biology classes, teachers modify materials because of a lack of instructional time to implement the activities as designed (see Table 48). In about half of biology classes, teachers modify activities because they are too difficult conceptually for students or lack the necessary materials or supplies.

Table 48
Reasons Why High School Science Materials Are Modified

	PERCENT OF CLASSES†	
	ALL SCIENCES	BIOLOGY
I did not have enough instructional time to implement the activities as designed.	71 (2.8)	71 (5.3)
The original activities were too difficult conceptually for my students.	58 (3.3)	57 (6.5)
I did not have the necessary materials/supplies for the original activities.	53 (3.4)	52 (5.9)
The original activities were too easy conceptually for my students.	44 (3.6)	46 (7.5)
The original activities were too structured for my students.	38 (3.1)	42 (6.5)
The original activities were not structured enough for my students.	40 (3.5)	36 (6.3)

† Only high school science classes in which (1) the most recent unit was based on commercially published or state/district-developed materials and (2) teachers reported modifying some activities are included in these analyses.

Other High School Biology Instructional Resources

Teachers were presented with a list of instructional technologies and asked about their availability, either always in the classroom or upon request, in the randomly selected class. As can be seen in Table 49, nearly all high school biology classes have access to projection devices, balances, and microscopes. Most biology classes also have access to probes for collecting data.

Table 49
Availability† of Instructional Resources in High School Science Classes

	PERCENT OF CLASSES	
	ALL SCIENCES	BIOLOGY
Projection devices (e.g., Smartboard, document camera, LCD projector)	98 (0.8)	99 (0.6)
Balances (e.g., pan, triple beam, digital scale)	97 (0.8)	98 (1.1)
Microscopes	94 (1.0)	98 (1.3)
Probes for collecting data (e.g., motion sensors, temperature probes)	81 (2.3)	77 (4.1)

† Includes high school science teachers indicating the resource is always available in their classroom or available upon request.

Teachers were also presented with a list of laboratory facilities and asked about their availability, either in the classroom or in another room. The vast majority of biology classes have the listed laboratory facilities available to them (see Table 50).

Table 50
Availability† of Laboratory Facilities in High School Science Classes

	PERCENT OF CLASSES	
	ALL SCIENCES	BIOLOGY
Electric outlets	98 (0.6)	99 (0.6)
Faucets and sinks	94 (1.1)	97 (1.2)
Lab tables	95 (0.9)	95 (1.5)
Gas for burners	82 (1.8)	90 (2.0)
Fume hoods	85 (1.7)	84 (2.4)

† Includes high school science teachers indicating the resource is located in the classroom or available in another room.

When asked about the adequacy of resources for instruction, teachers in about three-quarters of high school biology classes consider their access to equipment and facilities adequate (see Table 51). In two-thirds of biology classes, teachers consider their access to instructional technology and consumable supplies adequate.

Table 51
Adequacy† of Resources for High School Science Instruction

	PERCENT OF CLASSES	
	ALL SCIENCES	BIOLOGY
Equipment (e.g., thermometers, magnifying glasses, microscopes, beakers, photogate timers, Bunsen burners)	73 (1.9)	75 (4.0)
Facilities (e.g., lab tables, electric outlets, faucets and sinks)	72 (2.0)	74 (3.6)
Instructional technology (e.g., calculators, computers, probes/sensors)	70 (2.1)	69 (3.8)
Consumable supplies (e.g., chemicals, living organisms, batteries)	67 (2.1)	68 (4.2)

† Includes high school science teachers indicating 4 or 5 on a five-point scale ranging from 1 "not adequate" to 5 "adequate."

Data from these items were combined into a composite variable called Adequacy of Resources for Instruction. As can be seen in Table 52, biology class scores are not significantly different from chemistry, physics, or high school science classes in general.

Table 52
High School Science Class Mean Scores for the Adequacy of Resources for Instruction Composite

	MEAN SCORE
All Sciences	76 (1.1)
Biology	76 (2.0)
Chemistry	81 (1.6)
Physics	78 (2.4)

Factors Affecting High School Biology Instruction

Teachers were asked about factors that affect instruction in their randomly selected class. As can be seen in Table 53, in the majority of biology classes, many factors are seen as promoting effective instruction, including the amount of planning time; principal support; students' motivation, interest and effort in science; students' prior knowledge and skills; and state standards. At the other end of the spectrum, state and district testing and accountability policies are seen as promoting effective instruction in only about a quarter of biology classes.

Table 53
Factors Promoting† Effective Instruction in High School Science Classes

	PERCENT OF CLASSES	
	ALL SCIENCES	BIOLOGY
Amount of time for you to plan, individually and with colleagues	69 (2.2)	72 (3.7)
Principal support	66 (1.9)	66 (3.5)
Students' motivation, interest, and effort in science	60 (1.9)	59 (3.6)
Students' prior knowledge and skills	59 (2.2)	58 (4.1)
Current state standards	55 (2.2)	58 (3.6)
Amount of time available for your professional development	52 (2.2)	53 (3.8)
College entrance requirements	53 (2.1)	51 (3.6)
Pacing guides	48 (2.3)	47 (4.1)
Teacher evaluation policies	42 (2.3)	46 (3.9)
Parent/guardian expectations and involvement	43 (2.6)	43 (4.1)
Textbook/module selection policies	38 (2.5)	38 (3.6)
State/district/diocese testing/accountability policies‡	29 (1.8)	27 (3.1)

† Includes high school science teachers indicating 4 or 5 on a five-point scale ranging from 1 "inhibits effective instruction" to 5 "promotes effective instruction."
‡ This item was presented only to teachers in public and Catholic schools.

Three composites from these questionnaire items were created to summarize the extent to which various factors support effective instruction: (1) Extent to Which School Support Promotes Effective Instruction (i.e., amount of time for professional development, and amount of planning time); (2) Extent to Which the Policy Environment Promotes Effective Instruction (i.e., testing/ accountability, textbook selection, pacing guides, teacher evaluation, and current state standards); and (3) Extent to Which Stakeholders Promote Effective Instruction (i.e., students' motivation and interest, students' prior knowledge, parent/guardian expectations and involvement). The means are shown in Table 54. Overall, these data indicate that the climate is somewhat, but not strongly, supportive for biology instruction in particular as well as high school science more broadly.

Table 54
High School Science Class Mean Scores for Factors Affecting Instruction Composites

	PERCENT OF CLASSES			
	ALL SCIENCES	BIOLOGY	CHEMISTRY	PHYSICS
Extent to Which School Support Promotes Effective Instruction	69 (1.5)	69 (2.7)	68 (1.9)	69 (2.9)
Extent to Which Stakeholders Promote Effective Instruction	64 (1.0)	64 (2.1)	64 (1.6)	69 (2.4)
Extent to Which the Policy Environment Promotes Effective Instruction	61 (0.8)	60 (1.5)	61 (1.4)	62 (2.5)

Summary

Like high school science teachers in general, nearly all high school biology teachers are white; however, biology teachers are more likely to be female than high school science teachers in general. In terms of teaching experience, biology teachers are representative of high school science teachers more broadly, with about a third in their first five years of teaching and a fifth having more than 20 years of experience. Over one-third have had prior full-time job experience in a science- or engineering-related field. The majority of biology teachers have a degree in their field, a significantly higher percentage than for teachers of chemistry or physics. Overall, biology teachers perceive themselves as being well prepared to teach biology. However, few biology teachers feel well prepared to incorporate engineering into their instruction.

In terms of pedagogical preparedness, biology teachers are similar to high school science teachers more broadly. About half of biology teachers feel very well prepared to develop students' conceptual understanding and use formative assessment to monitor student understanding. Fewer than half, however, feel very well prepared to develop students' abilities to do science, encourage student interest, encourage participation of all students, develop students' awareness of STEM careers, or incorporate students' cultural backgrounds into their instruction. Data on biology teachers' beliefs about effective teaching show that they hold a number of beliefs that are in alignment with what is known about effective science instruction (e.g., teachers should ask students to support their conclusions about a science concept with evidence), but they also hold views that are inconsistent with this research. For example, about two-thirds of biology teachers believe that students should be provided with definitions for new vocabulary at the beginning of instruction on an idea.

When asked about their professional development experiences, the vast majority of high school biology teachers have participated in science- and/or engineering-focused professional development in the last three years. However, only 30 percent have had sustained professional development (more than 35 hours) in that time period. In addition, biology teachers' professional development experiences have been only somewhat aligned with best practices. A majority of teachers have had professional development experiences with substantial opportunities to work closely with other teachers, either from their own school or those who also taught biology or their grade level. In contrast, fewer than half have had substantial opportunities to examine classroom artifacts or rehearse what they learned in the professional development.

Data on biology courses indicate that nearly all students in the nation have access to one or more biology courses at their schools. Furthermore, biology is the most commonly offered science subject, accounting for 37 percent of high school science courses. Female students are just as likely as males to take a 1st year biology course; however, despite constituting about half of the student population, students from race/ethnicity groups historically underrepresented in STEM make up only about a third of the enrollment in 1st biology classes.

Data on instruction indicate that biology instruction relies heavily on lecture, discussion, and students working in small groups. The data also indicate that students are engaged in some science practices fairly regularly, such as organizing and representing data to facilitate analysis and making and supporting claims with evidence, although students tend to not be engaged very often in aspects of science related to evaluating the strengths/limitations of evidence and the practice of argumentation. In addition, high school biology classes only rarely incorporate engineering or coding into instruction, if they do so at all.

Teacher-developed lessons and units are by far the most commonly used type of instructional material in high school biology classes, with commercially published textbooks being a distant second. When teachers do use textbooks, they often modify the materials, supplementing and skipping elements for a variety of reasons. In terms of other resources for instruction, the vast majority of biology classes have access to instructional technologies like projection devices, balances, and microscopes, as well as laboratory facilities, and teachers consider their access to equipment, facilities, technology, and consumables adequate.