

Georgia
Milestones
Assessment System



Assessment Guide
Biology



Assessment Guide



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THE GEORGIA MILESTONES ASSESSMENT SYSTEM

The purpose of the Georgia Student Assessment Program is to measure student achievement of the state-adopted content standards and inform efforts to improve teaching and learning. Results of the assessment program are utilized to identify students failing to achieve mastery of content, to provide educators with feedback about instructional practice, and to assist school districts in identifying strengths and weaknesses in order to establish priorities in planning educational programs.

The State Board of Education is required by Georgia law (O.C.G.A. §20-2-281) to adopt assessments designed to measure student achievement relative to the knowledge and skills set forth in the state-adopted content standards. The Georgia Milestones Assessment System (Georgia Milestones) fulfills this requirement and, as a key component of Georgia's Student Assessment Program, is a comprehensive summative assessment program spanning Grade 3 through high school. Georgia Milestones measures how well students have learned the knowledge and skills outlined in the state-adopted content standards in English Language Arts, Mathematics, Science, and Social Studies. Students in grades 3 through 8 take an end-of-grade assessment in English Language Arts and Mathematics; additionally, students in grades 5 and 8 are assessed in Science; and students in grade 8 are assessed in Social Studies. High school students take an end-of-course assessment for each of the five courses designated by the State Board of Education. In accordance with State Board Rule, Georgia Milestones end-of-course measures serve as the final exams for the specified high school courses.

The main purpose of Georgia Milestones is to inform efforts to improve student achievement by assessing student performance on the standards specific to each course or subject/grade tested. Specifically, Georgia Milestones is designed to provide students and their parents with critical information about the students' achievement and, importantly, their preparedness for the next educational level. The assessment system is a critical informant of the state's accountability measure, the College and Career Ready Performance Index (CCRPI), providing an important gauge about the quality of the educational services and opportunities provided throughout the state.

The ultimate goal of Georgia's assessment and accountability system is to ensure that all students are provided the opportunity to engage with high-quality content standards, receive high-quality instruction predicated upon those standards, and are positioned to meet high academic expectations.

Features of the Georgia Milestones Assessment System include:

- technology-enhanced items in all grades and courses;
- open-ended (constructed-response) items in English Language Arts (all grades and courses);
- a writing component (in response to passages read by students) at every grade level and course within the English Language Arts assessment; and
- online administration as the primary mode of administration.

The mode of administration for the Georgia Milestones program is online. Paper/pencil test materials, such as Braille forms, will be available for the small number of students who cannot interact with the computer due to their disability as documented in an IEP, IAP/504, or EL-TPC Plan.

Georgia Milestones follows guiding principles to help ensure that the assessment system:

- is sufficiently challenging to ensure Georgia students are well positioned to compete with other students across the United States and internationally;
- is intentionally designed across grade levels to send a clear signal of student academic progress and preparedness for the next level, whether it is the next grade level, course, or college or career;
- is accessible to all students, including those with disabilities or limited English proficiency, at all achievement levels;
- supports and informs the state’s educator-effectiveness initiatives, ensuring items and forms are appropriately sensitive to quality instructional practices; and
- includes innovative technology-enhanced items.

GEORGIA MILESTONES END-OF-COURSE (EOC) ASSESSMENTS

As previously mentioned, Georgia law (§20-2-281) mandates that the State Board of Education adopt EOC assessments for core courses to be determined by the Board. An EOC assessment serves as a student’s final exam in the associated course. With educator input and State Board approval, the Georgia Milestones EOC assessments measure student achievement in the following courses: American Literature and Composition, Algebra I, Coordinate Algebra, Biology, and United States History.

Any student enrolled in and/or receiving credit for one of the above-mentioned courses, regardless of grade level, is required to take the Georgia Milestones EOC assessment upon completion of that course. This includes middle school students completing a course associated with a Georgia Milestones EOC assessment, regardless of whether they are receiving high school credit. Students enrolling from non-accredited programs are required to take and pass the Georgia Milestones EOC assessment prior to receiving credit for the course.

A student’s final grade in the course will be calculated using the Georgia Milestones EOC assessment as follows (State Board Rule 160-4-2-.13):

- For students enrolled in Grade 9 for the first time before July 1, 2011, the EOC assessment counts as 15% of the final grade.
- For students enrolled in Grade 9 for the first time on or after July 1, 2011, the EOC assessment counts as 20% of the final grade.

Results of the EOC assessments, according to the legislated and identified purposes, must:

- provide a valid measure of student achievement of the state content standards across the full achievement continuum;
- serve as the final exam for each course, contributing 15% or 20% to the student’s final course grade;
- provide a clear signal of each student’s preparedness for the next course and ultimately post-secondary endeavors (college and career);
- allow for the detection of the academic progress made by each student from one assessed course to the next;
- support and inform educator-effectiveness measures; and
- inform state and federal accountability measures at the school, district, and state levels.

Additional uses of the EOC assessments include: (1) certifying student proficiency prior to the awarding of credit for students enrolling from non-accredited private schools, home study programs, or other non-traditional educational centers and (2) allowing eligible students to demonstrate competency without taking the course and earn course credit (e.g., “test out”). In both cases, students are allotted *one* administration.

ASSESSMENT GUIDE

The Georgia Milestones Biology EOC Assessment Guide is provided to acquaint Georgia educators and other stakeholders with the structure of and content assessed by the test. Importantly, this guide is not intended to inform instructional planning. It is essential to note that there are a small number of content standards that are better suited for classroom or individual assessment than for large-scale summative assessment. While those standards are not included in the tests and therefore are not included in this Assessment Guide, the knowledge, concepts, and skills inherent in those standards are often required for the mastery of the standards that are assessed. Failure to attend to all content standards within a course can limit a student’s opportunity to learn and show what he or she knows and can do on the assessment.

The Georgia Milestones Biology EOC Assessment Guide is in *no way* intended to substitute for the state-mandated content standards; it is provided to help educators better understand the structure and content of the assessment, *but it is not all-encompassing of the knowledge, concepts, and skills covered in the course or assessed on the test*. The state-adopted content standards and associated standards-based instructional resources, such as the Content Frameworks, should be used to plan instruction. This Assessment Guide can serve as a *supplement* to those resources, in addition to any locally developed resources, **but should not be used in isolation**. In principle, the Assessment Guide is intended to be descriptive of the assessment program and should not be considered all-inclusive. The state-adopted content standards are located at www.georgiastandards.org.

TESTING SCHEDULE

The Georgia Milestones Biology EOC assessment is offered during three Main Administrations. Main Administrations are primarily intended to provide an opportunity to assess student achievement at the completion of a course and to serve as the final exam for the associated course as required by State Board Rule. As a result, the EOC assessment should occur as close to the conclusion of the course as possible. Main Administrations can also be utilized to verify credit from a non-accredited school or home schooling. In addition to the Main Administrations, Mid-Month Administrations are provided in order to allow students additional testing opportunities for the various reasons noted below.

Purpose for EOC Assessment	Winter & Spring Main Administrations	Mid-Month Administrations	Summer Main Administration
Completion of Course	Yes	Yes	Yes
Makeup from Previous Administration	Yes	Yes	Yes
Retest	No*	Yes	Yes
Test Out	No	Yes**	Yes
Validation of Credit	Yes	Yes	Yes

*Winter and Spring Main Administrations cannot be used for the purpose of a retest.

**August, September, and March Mid-Month Administrations as well as the Summer Main Administration can be used for the purpose of a test out.

Note: Each district determines a local testing window within the state-designated testing window.

TEST STRUCTURE

DESCRIPTION OF TEST FORMAT AND ORGANIZATION

The Georgia Milestones Biology EOC assessment is a criterion-referenced test designed to provide information about how well a student has mastered the state-adopted content standards within the course. The assessment consists of both operational items and field test items (newly written items that are being tried out and do not contribute to the student's score). Each student will receive one of four Achievement Level designations, depending on how well the student has mastered the course content standards. The four Achievement Level designations are Beginning Learner, Developing Learner, Proficient Learner, and Distinguished Learner. In addition to criterion-referenced information, the Georgia Milestones measures will also produce an estimate of how Georgia students are achieving relative to their peers nationally. The norm-referenced information provided is supplementary to the criterion-referenced Achievement Level designation and will not be utilized in any manner other than to serve as a barometer of national comparison. Only the criterion-referenced scores and Achievement Level designations will be utilized in the accountability metrics associated with the assessment program (such as student growth measures, educator-effectiveness measures, or the CCRPI).

The table on the following page outlines the number and types of items included on the Biology EOC assessment.

Biology EOC Assessment Design

Description	Number of Items	Number of Points
1-point Selected-Response and Technology-Enhanced Items ^{1, 2}	30	30
2-point Technology-Enhanced Items ¹	8	16
Field Test Items ³	4	0
Total⁴	42	46

¹**Technology-Enhanced:** Possible variants of the technology-enhanced item types used for Biology include multiple-part selected-response, multiple-select, drag-and-drop, and drop-down.

²**1-point Selected-Response and Technology-Enhanced Items:** The ratio of selected-response to technology-enhanced items may vary. The target range of 1-point technology-enhanced items is 0 to 5.

³**Field Test Items:** Field test items may include 1-point selected-response, 1-point technology-enhanced, and 2-point technology-enhanced items.

⁴**Total:** Of the total 42 items, 38 contribute to the student's Biology score.

The test will be given in two sections. Students may have up to 40 minutes per section to complete Sections 1 and 2. The total estimated testing time for the Biology EOC assessment ranges from approximately 40 to 80 minutes. Total testing time describes the amount of time students have to complete the assessment. It does not take into account the time required for the test examiner to complete pre-administration and post-administration activities (such as reading the standardized directions to students). Sections 1 and 2 may be administered on the same day or across two consecutive days based on the district's testing protocols for the EOC measures (in keeping with state guidance).

CONTENT MEASURED

The Biology EOC assessment will measure the Biology standards that are described at www.georgiastandards.org.

The content of the assessment is organized into five groupings, or domains, of standards for the purposes of providing feedback on student performance. A content domain is a reporting category that *broadly* describes and defines the content of the course, as measured by the EOC assessment. The standards for Biology are grouped into five domains: Cells, Cellular Genetics and Heredity, Classification and Phylogeny, Ecology, and Theory of Evolution. Each domain was created by organizing standards that share similar content characteristics. The content standards describe the level of expertise that Biology educators should strive to develop in their students. Educators should refer to the content standards for a full understanding of the knowledge, concepts, and skills subject to be assessed on the EOC assessment.

The approximate proportional number of points associated with each domain is shown in the following table. A range of cognitive levels will be represented on the Biology EOC assessment. Educators should always use the content standards when planning instruction.

Biology: Domain Structures and Content Weights
Reporting Categories and Content Standards

Reporting Category/Domain	Content Standards Assessed	Approximate # of Points	Approximate % of Test
Cells	SB1 (a, b, c, d, e)	9	20%
Cellular Genetics & Heredity	SB2 (a, b, c)	11	23%
	SB3 (a, b, c)		
Classification & Phylogeny	SB4 (a, b, c)	6	13%
Ecology	SB5 (a, b, c, d, e)	12	27%
Theory of Evolution	SB6 (a, b, c, d, e)	8	17%
Total		46	100%

ITEM TYPES

Operational items in the Biology EOC assessment consist of selected-response and technology-enhanced items.

A selected-response item, sometimes called a multiple-choice item, is defined as a question, problem, or statement that is followed by several answer choices, sometimes called options or response choices. The incorrect choices, called distractors, usually reflect common errors. The student's task is to choose, from the choices provided, the best answer to the question (the stem). The Biology selected-response items will have four answer choices.

A technology-enhanced item is an innovative way to measure student skills and knowledge by using scaffolding within a multi-step process. Technology-enhanced items are worth one or two points. If the item is worth two points, partial credit is awarded for special combinations of responses that do not include all the correct answers. For Biology, there are a number of specific technology-enhanced item types being used:

- In multi-select items, the student is asked to pick two correct responses from six answer options.
- In multi-part items, the student responds to a two-part item that combines multiple-choice questions. For these item types, the student selects the responses from the choices provided.
- In drag-and-drop items, the student uses a mouse, touchpad, or touchscreen to move responses to designated areas on the screen.
- In drop-down menu items, the student uses a mouse, touchpad, or touchscreen to open a drop-down menu and select an option from the menu. A drop-down menu item may have multiple drop-down menus.
- Since some technology-enhanced items in this guide were designed to be used in an online, interactive-delivery format, some of the item-level directions will not appear to be applicable when working within the format presented in this document (for example, "Move the characteristics into the boxes" or "Click To Respond").
- This icon  identifies special directions that will help the student answer technology-enhanced items as shown in the format presented within this guide. These directions do not appear in the online version of the test but explain information about how the item works that would be easily identifiable if the student were completing the item in an online environment.

To give students practice using technology-enhanced items in an online environment very similar to how they will appear on the online test, visit "Experience Online Testing Georgia."

1. Go to the website "Welcome to Experience Online Testing Georgia" (<http://gaexperienceonline.com/>).
2. Select "Test Practice."
3. Under "End-of-Course (EOC) All Assessments," select "Online Tools Training."
4. Select "EOC Test Practice."
5. Select "Technology Enhanced Items."
6. You will be taken to a login screen. Use the username and password provided on the screen to log in and practice navigating technology-enhanced items online.

Please note that Google Chrome is the only supported browser for this public version of the online testing environment.

DEPTH OF KNOWLEDGE DESCRIPTORS

Items found on the Georgia Milestones assessments, including the Biology EOC assessment, are developed with a particular emphasis on cognitive complexity or Depth of Knowledge (DOK). DOK is measured on a scale of 1 to 4 and refers to the level of cognitive demand required to complete a task (or in this case, an assessment item). The higher the level, the *more complex* the item; however, higher levels do not necessarily mean *more difficult* items. For instance, a question can have a low DOK but a medium or even high difficulty level. Conversely, a DOK 4 question may have a low difficulty level but still require a great deal of cognitive thinking (e.g., analyzing and synthesizing information instead of just recalling it). The following descriptions and table show the expectations of the four DOK levels in greater detail.

Level 1 (Recall of Information) generally requires students to identify, list, or define, often asking them to recall who, what, when, and where. Consequently, this level usually asks students to recall facts, terms, concepts, and trends and may ask them to identify specific information contained in documents, excerpts, quotations, maps, charts, tables, graphs, or illustrations. Items that require students to “describe” and/or “explain” could be classified at Level 1 or Level 2, depending on what is to be described and/or explained. A Level 1 “describe” and/or “explain” would require students to recall, recite, or reproduce information.

Level 2 (Basic Reasoning) includes the engagement of some mental processing beyond recalling or reproducing a response. A Level 2 “describe” and/or “explain” would require students to go beyond a description or explanation of recalled information to describe and/or explain a result or “how” or “why.”

Level 3 (Complex Reasoning) requires reasoning, using evidence, and thinking on a higher and more abstract level than Level 1 and Level 2. Students will go beyond explaining or describing “how and why” to justifying the “how and why” through application and evidence. Level 3 questions often involve making connections across time and place to explain a concept or “big idea.”

Level 4 (Extended Reasoning) requires the complex reasoning of Level 3 with the addition of planning, investigating, applying significant conceptual understanding, and/or developing that will most likely require an extended period of time. Students should be required to connect and relate ideas and concepts *within* the content area or *among* content areas in order to be at this highest level. The distinguishing factor for Level 4 would be a show of evidence (through a task, a product, or an extended response) that the cognitive demands have been met.

The following table identifies skills that students will need to demonstrate at each DOK level, along with question cues appropriate for each level.

Level	Skills Demonstrated	Question Cues
<p>Level 1 Recall of Information</p>	<ul style="list-style-type: none"> • Make observations • Recall information • Recognize properties, patterns, processes • Know vocabulary, definitions • Know basic concepts • Perform one-step processes • Translate from one representation to another • Identify relationships 	<ul style="list-style-type: none"> • Tell what, when, or where • Find • List • Define • Identify; label; name • Choose; select • Compute; estimate • Express • Read from data displays • Order
<p>Level 2 Basic Reasoning</p>	<ul style="list-style-type: none"> • Apply learned information to abstract and real-life situations • Use methods, concepts, theories in abstract and real-life situations • Perform multi-step processes • Solve problems using required skills or knowledge (requires more than habitual response) • Make a decision about how to proceed • Identify and organize components of a whole • Extend patterns • Identify/describe cause and effect • Recognize unstated assumptions, make inferences • Interpret facts • Compare or contrast simple concepts/ideas 	<ul style="list-style-type: none"> • Apply • Complete • Describe • Explain how; demonstrate • Construct data displays • Construct; draw • Analyze • Extend • Connect • Classify • Arrange • Compare; contrast

Level	Skills Demonstrated	Question Cues
<p style="text-align: center;">Level 3 Complex Reasoning</p>	<ul style="list-style-type: none"> • Solve an open-ended problem with more than one correct answer • Create a pattern • Generalize from given facts • Relate knowledge from several sources • Draw conclusions • Make predictions • Translate knowledge into new contexts • Compare and discriminate between ideas • Assess value of methods, concepts, theories, processes, formulas • Make choices based on a reasoned argument • Verify the value of evidence, information, numbers, data 	<ul style="list-style-type: none"> • Plan; prepare • Predict • Create; design • Ask “what if?” questions • Generalize • Justify; explain why; support; convince • Assess • Rank; grade • Test; judge • Recommend • Select • Conclude
<p style="text-align: center;">Level 4 Extended Reasoning</p>	<ul style="list-style-type: none"> • Analyze and synthesize information from multiple sources • Examine and explain alternative perspectives across a variety of sources • Combine and synthesize ideas into new concepts 	<ul style="list-style-type: none"> • Design • Connect • Synthesize • Apply concepts • Critique • Analyze • Create • Prove

SCORES

Selected-response and technology-enhanced items are machine scored. The operational items in the Biology EOC assessment consist of selected-response and technology-enhanced items.

Students will receive a scale score and an Achievement Level designation based on total test performance. In addition, students will receive information on how well they performed at the domain level. For more information on scoring, please see the *Georgia Milestones End-of-Course (EOC) Interpretive Guide for Score Reports*.

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EXAMPLE ITEMS

Example items, which are representative of the applicable DOK levels across various Biology content domains, are provided.

All example and sample items contained in this guide are the property of the Georgia Department of Education.

Example Item 1

Selected-Response: 1 point

DOK Level: 1

Biology Domain: Cells

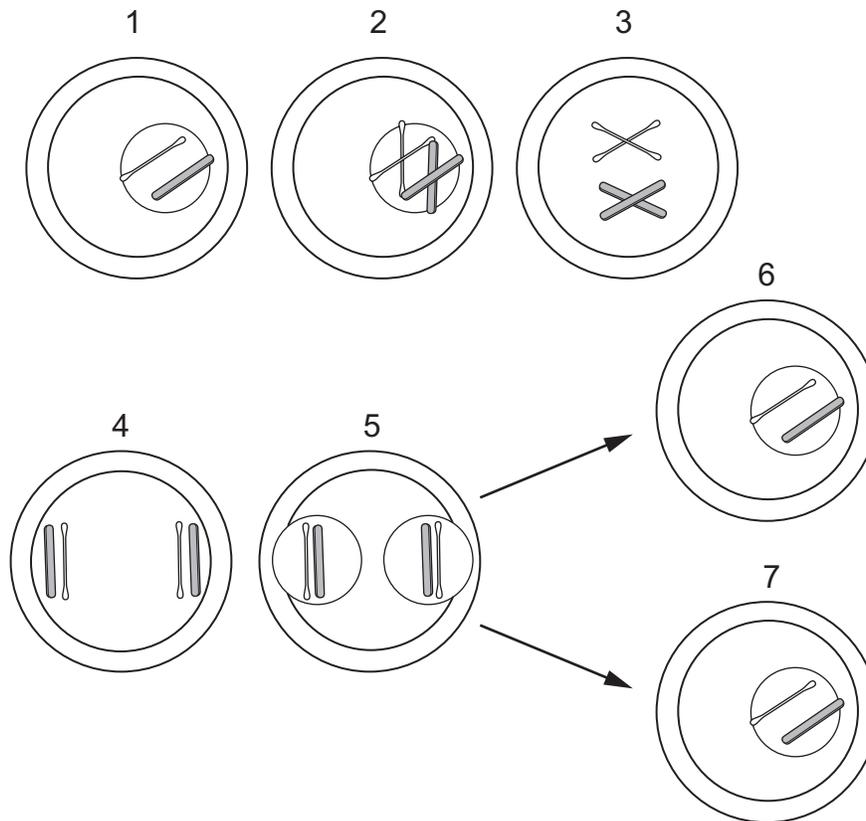
Standard: SB1. Obtain, evaluate, and communicate information to analyze the nature of the relationships between structures and functions in living cells.

- b. Develop and use models to explain the role of cellular reproduction (including binary fission, mitosis, and meiosis) in maintaining genetic continuity.

Go on to the next page to finish example item 1.

Example Item 1. Continued.

Students modeled the changes in cells during mitosis, using paper plates, flat wooden sticks, cotton swabs, and construction paper.



Which statement correctly uses the model to explain how mitosis maintains genetic continuity?

- A. The chromosomes in cell 1 are the same as in cells 6 and 7.
- B. Crossing-over occurs in cell 4, which increases the genetic diversity in cells 6 and 7.
- C. When the nuclear membrane reforms in cell 5, each nucleus becomes diploid in number.
- D. The independent assortment that is represented in cell 2 ensures that cell 3 has the correct number of chromosomes.

Correct Answer: A

Explanation of Correct Answer: The correct answer is choice (A) The chromosomes in cell 1 are the same as in cells 6 and 7. Choice (B) is incorrect because crossing-over does not occur in mitosis. Choice (C) is incorrect because the chromosomes in step 5 are haploid, not diploid as shown in the picture. Choice (D) is incorrect because it is not an independent assortment.

Example Item 2

Drop-Down Technology-Enhanced: 1 point

DOK Level: 2

Biology Domain: Genetics

Standard: SB2. Obtain, evaluate, and communicate information to analyze how genetic information is expressed in cells.

- c. Ask questions to gather and communicate information about the use and ethical considerations of biotechnology in forensics, medicine, and agriculture.

Scientists recently developed a technique for synthesizing proteins outside of cells. These cell-free systems are used to produce pure proteins that can be used in many ways. One use is in the manufacturing of medicine.

Use the drop-down menus to construct an ethical question that should be considered before using cell-free systems to manufacture medicine.

Do cell-free systems the cost of producing some medicines so that more the medicine?

- ➡ Use a mouse, touchpad, or touchscreen to click the arrow beside each of the two blank boxes. When you click the arrow, a drop-down menu will appear, showing you all the possible options for that blank. Each drop-down menu with its options is shown below.

Do cell-free systems the cost of producing some medicines so that more the medicine?

increase
decrease

people can afford to buy
companies can profit from

Example Item 2. Continued.**Scoring Rubric**

Points	Description
1	The student correctly selects both drop-down menu options.
0	The student correctly selects one or no drop-down menu options.

Exemplar Response

The correct response is shown below.

Do cell-free systems the cost of producing some medicines so that more the medicine?

“Decrease” is the correct response for the first drop-down menu and “people can afford to buy” is the correct response for the second drop-down menu because the potential to decrease the cost of medicine and make it accessible to more people is an ethical consideration that should be taken into account when developing new methods to manufacture medicine. Increasing the cost of production decreases the likelihood that a new method will be utilized by companies that manufacture medicine, and increasing profits is not an ethical consideration that should drive efforts to develop new methods of manufacturing medicine.

Example Item 3

Selected-Response: 1 point

DOK Level: 2

Biology Domain: Evolution

Standard: SB6. Obtain, evaluate, and communicate information to assess the theory of evolution.
b. Analyze and interpret data to explain patterns in biodiversity that result from speciation.

Geographic isolation caused the separation of rainforest frog populations into a population in the north and a population in the south. The separated populations later reconnected because the climate became wetter and warmer, causing the rainforest to expand. When males from the north mated with females from the south, the offspring failed to develop past the tadpole stage. When males from the south mated with females from the north, the offspring developed more slowly than the offspring of pairs of northern frogs. Based on these data, which event occurred while the two populations of frogs were separated?

- A. The two populations developed into new species.
- B. The two populations mated with other species of frogs.
- C. The two populations began a new method of reproduction.
- D. The two populations had fewer offspring than before the separation.

Correct Answer: A

Explanation of Correct Answer: The correct answer is choice (A) The two populations developed into new species. Choice (B) is incorrect because hybridization would not have resulted in new species. Choice (C) is incorrect because the frogs reproduced as they always had. Choice (D) is incorrect because there is no indication that population sizes were reduced.

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Example Item 4

Multi-Select Technology-Enhanced: 2 points

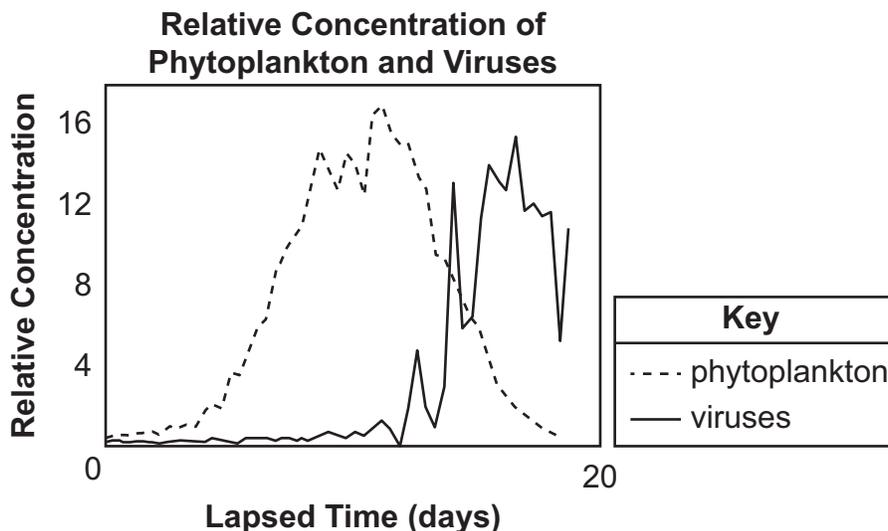
DOK Level: 3

Biology Domain: Classification & Phylogeny

Standard: SB4. Obtain, evaluate, and communicate information to illustrate the organization of interacting systems within single-celled and multi-celled organisms.

- c. Construct an argument supported by empirical evidence to compare and contrast the characteristics of viruses and organisms.

Scientists studied a species of phytoplankton. These phytoplankton are an important part of marine food webs and are major primary producers. As all organisms are regulated by their environment, so are the phytoplankton. The scientists looked at the relationship between the populations of the phytoplankton and viruses found in the same environment. They created three environments in a laboratory setting to collect data on the numbers of phytoplankton and viruses over a period of time and graphed the results once they were averaged, as shown below.



Go on to the next page to finish example item 4.

Example Item 4. Continued.

The scientists claimed that the growth and stability of the phytoplankton populations were affected by the viruses. Using the information given, which TWO arguments support this claim?

- A. The phytoplankton population was unable to absorb the light necessary for growth because the viruses covered the surface of the water.
- B. The phytoplankton population was affected by the viruses because the viruses were competitors for the food sources in the environment.
- C. As the phytoplankton population increased, the number of viruses began to increase because the phytoplankton were consumed by the viruses.
- D. As the phytoplankton population reached capacity, the number of viruses began to increase because the phytoplankton were the hosts to the viruses and replicated the viruses' genome.
- E. The phytoplankton population was affected by the increase in the number of viruses in the environment because the viruses used most of the carbon found in the environment.
- F. The phytoplankton population decreased as the number of viruses increased because the cells of the phytoplankton were destroyed as the viruses used them to increase the number of viruses in the environment.

Correct Answers: D, F

Explanation of Correct Answers: The correct answers are choice (D) As the phytoplankton population reached capacity, the number of viruses began to increase because the phytoplankton were the hosts to the viruses and replicated the viruses' genome.

and choice (F) The phytoplankton population decreased as the number of viruses increased because the cells of the phytoplankton were destroyed as the viruses used them to increase the number of viruses in the environment.

Choice (A) is incorrect because nothing in the graph indicates that the viruses are able to block sunlight. Choice (B) is incorrect because viruses do not require a food source. Choice (C) is incorrect because the viruses do not eat phytoplankton. Choice (E) is incorrect because viruses do not use carbon like living things do.

Example Item 5

Multi-Part Technology-Enhanced: 2 points

DOK Level: 3

Biology Domain: Genetics

Standard: SB3. Obtain, evaluate, and communicate information to analyze how biological traits are passed on to successive generations.

- c. Construct an argument to support a claim about the relative advantages and disadvantages of sexual and asexual reproduction.

Today, the common type of banana we buy and eat is a Cavendish banana. They arose from chance mutants that were produced sexually from wild banana plants. The Cavendish banana is infertile and can only be produced by cloning from root shoots. Large commercial growers worldwide now plant only the mutant type. Some information about both types of banana is recorded in the table.

Wild Banana Plants	Mutant Cavendish Banana Plants
Sexual and asexual reproduction occurs to produce new plants.	Only asexual reproduction is used to produce new plants.
New gene combinations and clones are possible.	Only clones are produced.
Cells are diploid with two sets of homologous chromosomes.	Cells are triploid with three sets of homologous chromosomes.
Bananas contain large, hard seeds.	Bananas are seedless.
Very little edible flesh is found around the seeds.	Large amount of sweet, edible flesh is produced.

Part A

Why are scientists warning that exclusively growing this mutant type by asexual reproduction presents a serious disadvantage?

- A. The loss of an adequate Cavendish banana seed supply could result in extinction of this variety.
- B. The changes in characteristics from a parent plant to a clone will produce inconsistent plants that are less healthy.
- C. The lack of genetic variability among clones puts the whole species at increased risk of extinction through a catastrophic disease or pest.
- D. The increasing number of homologous sets of chromosomes with each successive generation of clones will eventually result in widespread death of banana plants.

Go on to the next page to finish example item 5.

Example Item 5. *Continued.***Part B**

Growers on large banana farms that supply food commercially have chosen to limit their plantings exclusively to Cavendish banana plants. What advantage is likely cited by the growers for continued planting of these asexually produced crops year after year?

- A. Seedless cloned plants are not damaged by disease and pest organisms.
- B. Successive generations of clones produce larger bananas and healthier plants.
- C. The cloned banana plants rapidly adapt to extreme environmental changes due to their limited genetic variation.
- D. The bananas produced maintain consistent characteristics in quality, taste, and appearance from one crop of clones to the next.

Correct Answers: C, D

Explanation of Correct Answers: The correct answer for Part A is choice (C) The lack of genetic variability among clones puts the whole species at increased risk of extinction through a catastrophic disease or pest. Choice (A) is incorrect because Cavendish bananas do not produce seeds. Choice (B) is incorrect because cloned plants are very consistent. Choice (D) is incorrect because cloned organisms do not increase homologous chromosomes.

The correct answer for Part B is choice (D) The bananas produced maintain consistent characteristics in quality, taste, and appearance from one crop of clones to the next. Choice (A) is incorrect because cloned plants can be damaged by disease and pests. Choice (B) is incorrect because cloned organisms are identical to parents. Choice (C) is incorrect because limited genetic variety does not encourage adaptation.

ADDITIONAL SAMPLE ITEMS

This section has two parts. The first part is a set of 17 sample items for Biology. The second part contains a table that shows for each item the standard assessed, the DOK level, the correct answer (key), and a rationale/explanation about the key and distractors. The sample items can be utilized as a mini-test to familiarize students with the item formats found on the assessment.

All example and sample items contained in this guide are the property of the Georgia Department of Education.

Item 1**Multi-Select Technology-Enhanced:** 2 points

Bromothymol blue (BTB) is a pH indicator that is also used to detect carbon dioxide (CO₂). BTB is blue when pH is basic and CO₂ is low. BTB is yellow when pH is acidic and CO₂ is high. BTB is green when pH is neutral. A group of students are planning to perform an investigation in which they will place either a stalk of the aquatic plant elodea or a snail in a test tube that contains water with a neutral pH of 7 and BTB. The students will also include a test tube that contains elodea and a snail. Observing color change once the tubes have been placed under a growth light for several hours will allow the students to answer which TWO of the following questions?

- A. Do both elodea and snails require oxygen to survive?
- B. Does elodea produce oxygen during photosynthesis?
- C. Do snails respire faster when placed in a tube with elodea?
- D. Do snails use the CO₂ produced by elodea to produce oxygen?
- E. Does photosynthesis performed by elodea remove CO₂ from the water?
- F. Does cellular respiration occur at a higher rate than photosynthesis in the tube with only elodea?

Item 2**Selected-Response:** 1 point

The ribosome of the bacterium *E. coli* includes the ribosomal protein L4 (rpl4). The rpl4 gene carries the instructions for making rpl4 protein. Which of the following arguments provides support for the claim that *E. coli* has a common ancestor with all other organisms?

- A. Every organism depends on proteins to carry out essential cellular processes. Ribosomes are needed by all organisms to synthesize proteins such as rpl4.
- B. Every organism possesses in its ribosome a protein that is similar to rpl4. This protein has an amino acid sequence that is similar to the sequence of *E. coli*'s rpl4.
- C. Every organism contains a structure that is similar to a ribosome. This structure helps convert the instructions from the rpl4 gene into amino acids.
- D. Every organism has proteins made of amino acids. The code for amino acids is the same in *E. coli* because the instructions for amino acids come from the DNA. DNA contains the same components in all organisms.

Item 3

Drop-Down Technology-Enhanced: 1 point

This Punnet square shows the inheritance of flower color in snapdragon flowers.

		Snapdragon Punnett Square		
		R	R	
r	Rr	Rr		Key RR = red flowers rr = white flowers Rr = pink flowers
r	Rr	Rr		

Use the drop-down menus to explain the inheritance of flower color in snapdragons.

The alleles for flower color show because both alleles are in individuals.

➡ Use a mouse, touchpad, or touchscreen to click the arrow beside each of the three blank boxes. When you click the arrow, a drop-down menu will appear, showing you all the possible options for that blank. Each drop-down menu with its options is shown below.

The alleles for flower color show because both alleles are in individuals.

- homozygous
- heterozygous

- codominance
- incomplete dominance

- partly expressed
- completely expressed

Item 4**Selected-Response:** 1 point

A male and female have a child that has three copies of chromosome 18. Although both parents are unaffected, their doctor claims that the disorder associated with having an extra chromosome 18 is the result of a chromosomal mutation in cells that carry inherited material. Which argument supports this claim?

- A.** A mutation occurred when crossing over caused chromosome 18 to be replicated twice during meiosis, allowing one parent to donate two copies of chromosome 18 to the child.
- B.** A nondisjunction mutation was caused by the improper separation of the genetic material during meiosis, allowing the gamete of one parent to donate two copies of chromosome 18 to the child.
- C.** A substitution mutation during replication allowed the genetic material of chromosome 18 to replace the genetic material of a nearby chromosome, causing the child to have three copies of chromosome 18.
- D.** An insertion mutation during replication allowed the genetic material of chromosome 18 to be inserted into the genetic material of another chromosome, causing three copies of chromosome 18 to be made.

Item 5

Drop-Down Technology-Enhanced: 2 points

The common cuckoo is a parasitic bird that lays its eggs in the nests of host birds. The cuckoo's ability to copy the marking patterns on host birds' eggs has evolved over time. However, the egg patterns of host bird species have also evolved, making them harder to copy and easier for parents to recognize. When host birds do not recognize an egg in their nest, they push it out of the nest. When host birds fail to reject a cuckoo egg, they care for the extra egg, and when it hatches, the baby cuckoo pushes the host bird's eggs out of the nest. The table shows the rate at which three host species recognize their own eggs and the rate at which it rejects cuckoo eggs.

Host Egg Recognition and Rejection of Cuckoo Eggs

Host Species	Host Egg Recognition Rate (%)	Cuckoo Rejection Rate (%)
brambling	52	90
red-backed shrike	48	99
reed warbler	33	39

First, use the drop-down menus to explain the data.

Based on the data, the has coevolved with cuckoos over the longest period of time. This is because it has a developed ability to produce recognizable eggs and the rejection rate of cuckoo eggs.

Next, use the drop-down menus to support an explanation about genetic change in cuckoo and host populations.

The coevolution of genetic traits that allow cuckoos to copy host eggs and their hosts to produce recognizable eggs is a result of because the genes of successful birds are passed to offspring, the frequency of the genes that cause those beneficial traits in these populations.

- ➡ Use a mouse, touchpad, or touchscreen to click the arrow beside each of the five blank boxes. When you click the arrow, a drop-down menu will appear, showing you all the possible options for that blank. Each drop-down menu with its options is shown on the next page.

Go on to the next page to finish item 5.

Item 5. *Continued.*

Based on the data, the has
 coevolved with cuckoos of time. This
 is because it has a to produce
 recognizable eggs and rate of
 cuckoo eggs.

- brambling
- red-backed shrike
- reed warbler

Based on the data, the has
 coevolved with cuckoos over the longest period of time. This
 is because it has a developed ability to produce
 recognizable eggs and the rejection rate of
 cuckoo eggs.

- highly
- poorly

Next, use the drop-down menus to support an explanation

Based on the data, the has
 coevolved with cuckoos over the longest period of time. This
 is because it has a developed ability to produce
 recognizable eggs and the rejection rate of
 cuckoo eggs.

- lowest
- highest

Next, use the drop-down menus to support an explanation

The coevolution of genetic traits that allow cuckoos to copy
 host eggs and their hosts to produce recognizable eggs is a
 result of because the genes of
 successful offspring, the
 frequency of those these pop-

- genetic drift
- natural selection

- increasing
- decreasing

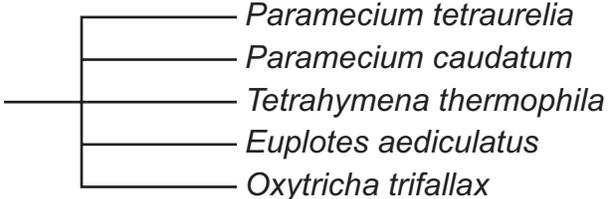
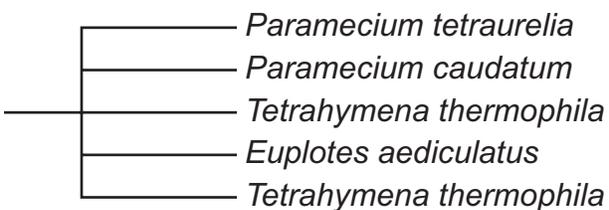
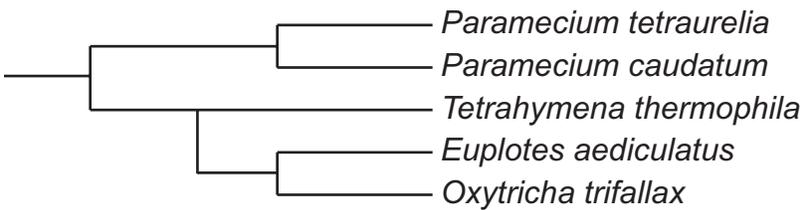
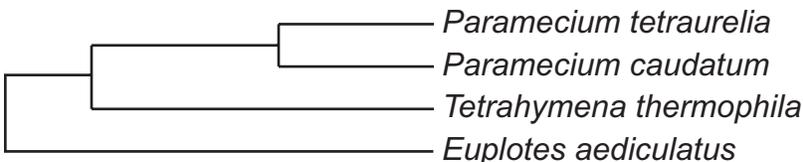
Item 6

Selected-Response: 1 point

Portions of the protein sequence alignments for a group of ciliates are shown.

Ciliate	Protein Sequence Alignment
<i>Tetrahymena thermophila</i>	NOYTYPEIORSOIFYCNH
<i>Paramecium tetraurelia</i>	KSNNOEKICROOILYCNH
<i>Paramecium caudatum</i>	KOOIAEKIOROOILYCNK
<i>Euplotes aediculatus</i>	NINVPNWNMKSRTTRIFYCH
<i>Oxytricha trifallax</i>	NINKGFWDDOIKRNRLFYCAH

Which of the following cladograms BEST represents these data?

- A. 
- B. 
- C. 
- D. 

Item 7

Drop-Down Technology-Enhanced: 2 points

A genome is the complete set of genetic material present in a species. Genome analysis usually includes the study of both the structure and the function of genes. Analysis of the structure involves determining the sequence of all genes in the chromosomes of individuals, and analysis of the function involves determining how the genes are expressed in an individual.

Part A

Use the drop-down menus to explain how the two areas of genome analysis help researchers determine the sequence and patterns of expression of the genes in a species' genome.

Analysis of genome structure and function helps researchers understand how the products of genes, , interact during the of individuals of the species.

Part B

Use the drop-down menu to explain how information about the genomes of different species could influence our understanding of genetics.

Understanding the structure and function of the genomes of species helps researchers determine .



Use a mouse, touchpad, or touchscreen to click the arrow beside each of the three blank boxes. When you click the arrow, a drop-down menu will appear, showing you all the possible options for that blank. Each drop-down menu with its options is shown below.

Part A

Analysis of genome structure and function helps researchers understand how the products of genes, , interact during the of individuals of the species.

mutation
evolution
development

proteins
amino acids
nucleic acids

Part B

Use the drop-down menu to explain how information about the genomes of different species could influence our understanding of genetics.

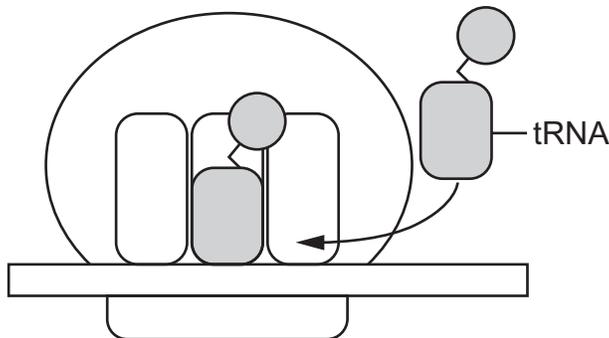
Understanding the structure and function of the genomes of species helps researchers determine .

how to prevent genetic mutations
how species are related to each other
why some species' traits don't change over time
why some genes are passed on and others are not

Item 8

Selected-Response: 1 point

The model shows part of a process that uses tRNA.



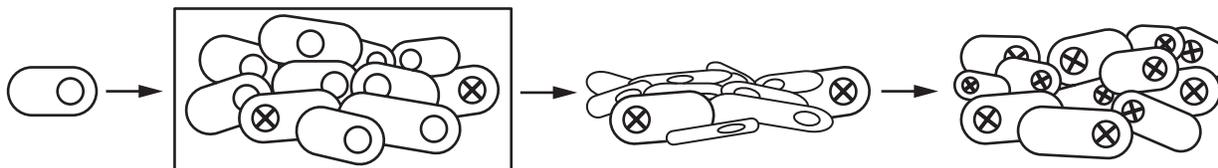
Which description explains the role of the tRNA in the process shown in this model?

- A. The tRNA delivers amino acids to the ribosome so that they can be added to the developing peptide.
- B. The tRNA recognizes the stop codon of a developing peptide so that no new amino acids are added.
- C. The tRNA signals the release of the peptide from the ribosome once all of the amino acids have been added.
- D. The tRNA scans the developing peptide to make sure that the sequence of the amino acids matches the mRNA.

Item 9

Selected-Response: 1 point

The diagram represents a model of how bacteria become resistant to an antibiotic, allowing bacteria to survive treatment.



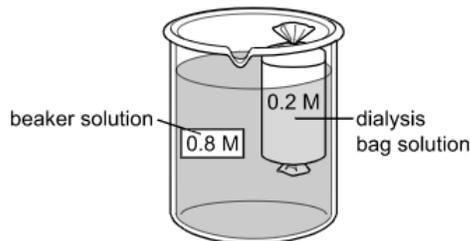
Which BEST explains how the indicated step in the model allows bacteria to develop resistance?

- A. Genetic mutations that promote resistance occur.
- B. The bacteria are infected by viruses that confer resistance.
- C. Alleles for antibiotic resistance become dominant over recessive alleles.
- D. A portion of the genetic material is re-replicated, allowing for resistance.

Item 10

Drag-and-Drop Technology-Enhanced: 1 point

A student is performing an investigation using two solutions. The solution in the dialysis bag has a lower solute concentration in moles per liter (M) than the solution in the beaker.



Move a description into the boxes under the dialysis bag and the beaker to describe each solution. Not all options will be used.

Then, move an arrow into the direction box to identify which direction the water will move based on the concentrations of the solutes. Not all options will be used.

dialysis bag	direction	beaker
<input type="text"/>	<input type="text"/>	<input type="text"/>
<u>Solutions</u>		<u>Direction</u>
<input type="button" value="hypotonic"/>		<input type="text" value="→"/>
<input type="button" value="hypertonic"/>		<input type="text" value="←"/>
<input type="button" value="isotonic"/>		



Use a mouse, touchpad, or touchscreen to move a description into the box under “dialysis bag” and to move a description into the box under “beaker.” Then, move an arrow into the box under “direction.” Each option can be used once. Some options will not be needed.

Item 11

Selected-Response: 1 point

Hemoglobin is a protein found in the red blood cells of vertebrates and in the plasma of many invertebrates. The function of this protein is to transport oxygen throughout the body and to bring carbon dioxide back to be expelled from the organism. If the amino acid sequence of the protein is altered, the mutated protein is not as efficient at carrying oxygen as is the normal hemoglobin. Which argument is supported by this information?

- The mutated hemoglobin protein can still carry carbon dioxide to be expelled from the organism.
- Hemoglobin must be a simple molecule because it is found in both vertebrates and invertebrates.
- Structural changes of hemoglobin affect its ability to carry oxygen, indicating that the shape of a protein is important to its function.
- Normal hemoglobin must be a larger molecule than the mutated hemoglobin since it has sufficient space to attach to and carry both oxygen molecules and carbon dioxide molecules.

Item 12

Drag-and-Drop Multi-Part Technology-Enhanced: 2 points

Part A

A long-term study off the coast of Japan found that sea urchin populations are affected by harmful algal blooms known as red tides. Sea urchins are shallow-water herbivores that play an important role in the structure of coastal marine communities. Red tides discolor the water, deplete oxygen levels in the water, and release harmful toxins into the water and air. Four main components are necessary for an algal population to bloom:

1. The presence of certain algae species
2. A major nutrient source
3. Wind and water currents that move the algae close together
4. Increasing water temperatures

Part A

Some human activities can have a direct effect on the four components that increase the number of algal blooms. Other human activities can have an indirect effect that can be observed only over long periods of time. Move the components into the boxes to show which are directly affected by human activities. Not all components will be used.

The screenshot shows a digital interface for a drag-and-drop activity. At the top, there is a header bar with a pencil icon on the left and a question mark on the right. Below the header, there is a box titled "Directly Affected by Human Activities" with two empty rectangular slots for dropping items. Underneath this box is a section titled "Components" with a list of four items: "Presence of the algae", "Nutrient sources", "Wind and water currents", and "Water temperatures". At the bottom of the interface, there is a blue button labeled "Click To Respond".

- ➡ Due to the size of the response area, this item has a “Click To Respond” button on the screen. Clicking this button will bring up the response area at full size.

This is a full-size screenshot of the assessment interface. It features a header bar with a pencil icon and a question mark. The main area contains a box titled "Directly Affected by Human Activities" with two empty slots. Below this is a section titled "Components" with a list of four items: "Presence of the algae", "Nutrient sources", "Wind and water currents", and "Water temperatures".

- ➡ Use a mouse, touchpad, or touchscreen to move the components below the chart into the boxes. Each component can be used once.

Go on to the next page to finish item 12.

Item 12. *Continued.*

Part B

A long-term study off the coast of Japan found that sea urchin populations are affected by harmful algal blooms known as red tides. Sea urchins are shallow-water herbivores that play an important role in the structure of coastal marine communities. Red tides discolor the water, deplete oxygen levels in the water, and release harmful toxins into the water and air. Four main components are necessary for an algal population to bloom:

1. The presence of certain algae species
2. A major nutrient source
3. Wind and water currents that move the algae close together
4. Increasing water temperatures

Part B

Move the TWO solutions into the boxes that would directly reduce the impact of human activities on the components that cause algal blooms.

Solutions That Directly Reduce the Impact of Human Activities on Algal Bloom Components

Solutions

- Reduce overfishing in rivers and oceans.
- Reduce fertilizer runoff into rivers and oceans.
- Reduce the use of nonrenewable energy sources.
- Reduce the temperature of wastewater released into rivers and oceans.

Click To Respond

- ➡ Due to the size of the response area, this item has a “Click To Respond” button on the screen. Clicking this button will bring up the response area at full size.

Solutions That Directly Reduce the Impact of Human Activities on Algal Bloom Components

Solutions

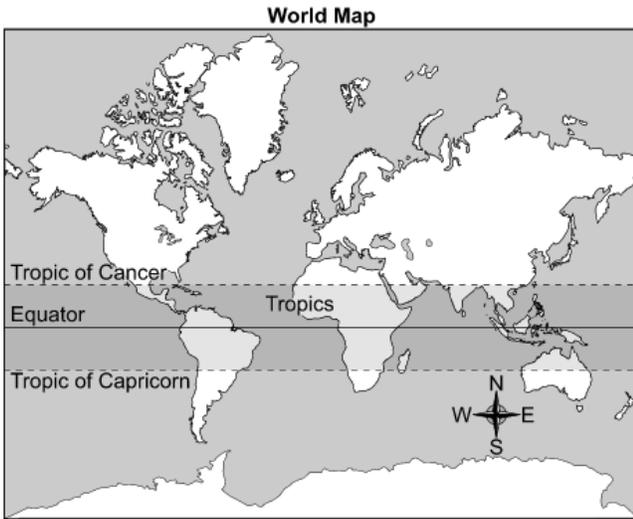
- Reduce overfishing in rivers and oceans.
- Reduce fertilizer runoff into rivers and oceans.
- Reduce the use of nonrenewable energy sources.
- Reduce the temperature of wastewater released into rivers and oceans.

- ➡ Use a mouse, touchpad, or touchscreen to move the solutions below the chart into the boxes. Each solution can be used once. Some solutions will not be needed.

Item 13

Drag-and-Drop Technology-Enhanced: 2 points

Researchers recently compiled data about 2,300 mammal species and 6,700 bird species and determined that the number of species found at tropic latitudes is greater than the numbers found at temperate and polar latitudes.



Move the statements that BEST explain why biodiversity is greatest in the tropics into the chart. Not all statements will be used.

?

Explanation of Greatest Biodiversity in the Tropics

-
-
-

There is less land in temperate and polar latitudes.

Tropic latitudes experience less seasonal changes in climate.

There is a large amount of annual precipitation in tropic latitudes.

Regions near the equator have a longer growing season for plants.

Temperate and polar latitudes have a large amount of water from snowmelt.

Species in temperate and polar latitudes are better adapted to extreme weather.

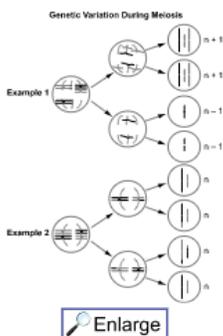
➡ Use a mouse, touchpad, or touchscreen to move the statements below the chart into the boxes. Each statement can be used once. Some statements will not be needed.

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Item 14

Drag-and-Drop Technology-Enhanced: 2 points

A student is investigating genetic variation in chromosomes. The diagram shows two ways that meiosis can result in genetic variation.



The student makes two claims.

Claim 1: Genetic variation in example 1 is a result of nondisjunction.

Claim 2: Genetic variation in example 2 is a result of crossing over.

Move evidence into each box to construct arguments to support each claim. Not all evidence will be used.

?
Supporting Evidence for Claim 1
Supporting Evidence for Claim 2

Deletions during replication are passed to daughter cells.

Daughter cells have too much or too little genetic material.

Daughter cells are all haploid but are not genetically identical.

Homologous chromosomes exchange genetic material during meiosis.

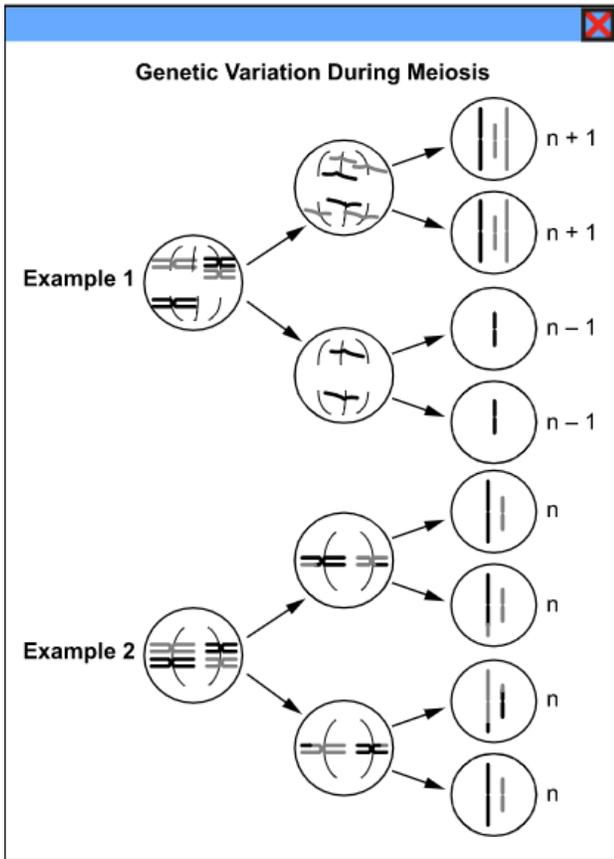
Heritable mutations caused by environmental factors result in the loss of entire chromosomes.

Homologous chromosomes separate incorrectly, producing daughter cells with unequal amounts of genetic material.

➡ Due to the size of the graphic on the left side of the screen, the graphic has an “Enlarge” button. Clicking this button will bring up the graphic at full size. (See below). After you have studied the graphic, use a mouse, touchpad, or touchscreen to move the statements below the table into each box. Each statement can be used once. Some statements will not be needed.

Go on to the next page to finish item 14.

Item 14. *Continued.*



➡ Click on the red X at the top right to reduce the graphic again.

Item 15

Drag-and-Drop Technology-Enhanced: 2 points

A group of researchers gathered data from 40 forest sites and determined that forests with many different species of trees are less affected by drought (long periods of dry conditions) than forests with few or only one tree species. Since different species of trees have traits that cause them to use and move water in different ways, they are not equally impacted by dry conditions.

Move the traits into the chart to indicate which would MOST LIKELY increase the ability of a tree species to survive during a drought.

Increase Drought Survival

has thick bark
has deep roots
has large leaves
produces fleshy fruit
sheds and grows new leaves annually
has needles instead of large, flat leaves

➡ Use a mouse, touchpad, or touchscreen to move the phrases below the chart into the boxes. Each phrase can be used once. Some phrases will not be needed.

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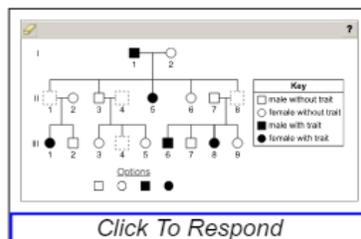
Item 16

Drag-and-Drop Multi-Part Technology-Enhanced: 2 points

The diagram shows an incomplete pedigree for the inheritance of an autosomal dominant trait (G). With autosomal dominant traits, only one copy of the gene is needed for the trait to be inherited and expressed by offspring.

Part A

Move the shapes to complete the pedigree based on the inheritance patterns for an autosomal dominant trait. Each option may be used only once.



Part B

Move one option to show what percent chance each offspring has of inheriting the trait when only one parent passes on the gene. Next, move one option to show the genotype of individuals represented in the pedigree who do NOT inherit the trait. Not all options will be used.

25%	GG
50%	Gg
100%	gg

➡ Due to the size of the response area, this item has a “Click To Respond” button on the screen. Clicking this button will bring up the response area at full size.

Go on to the next page to finish item 16.

Item 16. *Continued.*

Part A

Use a mouse, touchpad, or touchscreen to move the shapes below the pedigree into the boxes. Each shape can be used once.

Part B

Chance of inheriting the trait:	
Genotype of unaffected offspring:	

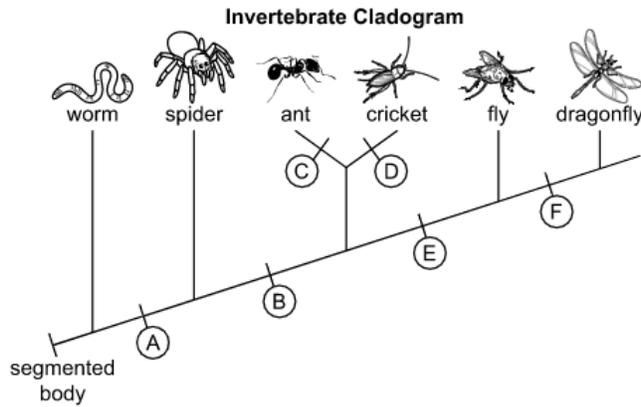
25% GG
 50% Gg
 100% gg

Use a mouse, touchpad, or touchscreen to move the options below the chart into the boxes. Each option can be used once. Some options will not be needed.

Item 17

Drop-Down Technology-Enhanced: 1 point

Organisms can be organized by their similarities and differences. The incomplete cladogram shows the relationship between some invertebrates based on their body structures.



Use the drop-down menus to construct an argument about the development of six legs in invertebrates, based on the body structures shown.

The development of six legs should be placed at letter on the cladogram because the body structure is present only in organisms that point on the cladogram.

➡ Use a mouse, touchpad, or touchscreen to click the arrow beside each of the two blank boxes. When you click the arrow, a drop-down menu will appear, showing you all the possible options for that blank. Each drop-down menu with its options is shown below.

The development of six legs should be placed at letter on the cladogram because the body structure is present only in organisms that point on the cladogram.

- A
- B
- C
- D
- E
- F

- at
- after
- before

ADDITIONAL SAMPLE ITEM KEYS

Item	Standard/ Element	DOK Level	Correct Answer	Explanation
1	SB1e	3	E, F	<p>The correct answer choices are choice (E) Does photosynthesis performed by elodea remove CO₂ from the water?</p> <p>and choice (F) Does cellular respiration occur at a higher rate than photosynthesis in the tube with only elodea?</p> <p>Choice (A) is incorrect because the amount of oxygen present or missing from the test tubes cannot be measured with this setup. Choice (B) is incorrect because there is no way to measure oxygen with this setup. Choice (C) is incorrect because there is no way to measure this and because the rate of respiration should not vary. Choice (D) is incorrect because this question cannot be answered using this investigation.</p>
2	SB6c	2	B	<p>The correct answer is choice (B) Every organism possesses in its ribosome a protein that is similar to rpl4. This protein has an amino acid sequence that is similar to the sequence of <i>E. coli's</i> rpl4. Choice (A) is incorrect because just the fact that all organisms make proteins does not support a common ancestor. Choice (C) is incorrect because sharing ribosomes does not indicate a common ancestor. Choice (D) is incorrect because having common amino acids is not support for a common ancestor.</p>
3	SB3b	2	N/A	See scoring rubric and exemplar response on page 49.
4	SB2b	2	B	<p>The correct answer is choice (B) A nondisjunction mutation was caused by the improper separation of the genetic material during meiosis, allowing the gamete of one parent to donate two copies of chromosome 18 to the child. Choice (A) is incorrect because crossing over does not cause a chromosome to replicate. Choice (C) is incorrect because an extra chromosome is not the result of a substitution mutation. Choice (D) is incorrect because an insertion mutation does not result in extra chromosomes.</p>
5	SB6d	3	N/A	See scoring rubric and exemplar response on page 50.
6	SB4b	1	C	<p>The correct answer is choice (C). Choice (A) is incorrect because the organisms are not equally related. Choice (B) is incorrect because one ciliate is duplicated in the cladogram. Choice (D) is incorrect because one ciliate is omitted.</p>
7	SB6a	2	N/A	See scoring rubric and exemplar response on page 51.

Item	Standard/ Element	DOK Level	Correct Answer	Explanation
8	SB2a	1	A	The correct answer is choice (A) The tRNA delivers amino acids to the ribosome so that they can be added to the developing peptide. Choice (B) is incorrect because the tRNA does not recognize the stop codon. Choice (C) is incorrect because tRNA is not responsible for releasing the polypeptide. Choice (D) is incorrect because quality control is not a function of tRNA.
9	SB6e	2	A	The correct answer is choice (A) Genetic mutations that promote resistance occur. Choice (B) is incorrect because no viruses are present. Choice (C) is incorrect because survival and reproduction of the mutated bacteria is responsible for resistance in a population, not the dominance of the alleles. Choice (D) is incorrect because replication of genetic material on its own is not enough to confer resistance.
10	SB1d	2	N/A	See scoring rubric and exemplar response on page 52.
11	SB1c	2	C	The correct answer is choice (C) Structural changes of hemoglobin affect its ability to carry oxygen, indicating that the shape of a protein is important to its function. Choice (A) is incorrect because nothing in the information indicates the ability or inability of the altered hemoglobin to carry carbon dioxide. Choice (B) is incorrect because nothing in the information indicates whether the molecule is simple or complex. Choice (D) is incorrect because hemoglobin changes shape not size.
12	SB5d	3	N/A	See scoring rubric and exemplar response beginning on page 54.
13	SB6b	2	N/A	See scoring rubric and exemplar response on page 56.
14	SB2b	3	N/A	See scoring rubric and exemplar response on page 57.
15	SB5e	2	N/A	See scoring rubric and exemplar response on page 58.
16	SB3b	3	N/A	See scoring rubric and exemplar response beginning on page 60.
17	SB4a	2	N/A	See scoring rubric and exemplar response on page 62.

EXAMPLE SCORING RUBRICS AND EXEMPLAR RESPONSES

Item 3

Scoring Rubric

Points	Description
1	The student correctly selects all three drop-down menu options.
0	The student does not correctly select all three drop-down menu options.

Exemplar Response

The correct response is shown below.

The alleles for flower color show because both alleles are in individuals.

“Incomplete dominance” is the correct response for the first drop-down menu and “partly expressed” is the correct response for the second drop-down menu because when different alleles for the flower-color gene are only partially expressed, they result in a blended flower color, which is pink in this case. If the alleles demonstrated complete dominance, both colors would be completely expressed in the same flower, resulting in a pattern of red and white. “Heterozygous” is the correct response for the third drop-down menu because two different alleles must be present to result in conflicting instructions for the expression of the genetic trait. When an offspring inherits two of the same alleles, there is no conflict in instructions, and therefore, the trait is fully expressed.

Item 5

Scoring Rubric

Points	Description
2	The student correctly selects the drop-down menu options for both paragraphs.
1	The student correctly selects the drop-down menu options for one paragraph.
0	The student does not correctly select the drop-down menu options for either paragraph.

Exemplar Response

The correct response is shown below.

Based on the data, the has coevolved with cuckoos over the longest period of time. This is because it has a developed ability to produce recognizable eggs and the rejection rate of cuckoo eggs.

“Red-backed shrike” is the correct response for the first drop-down menu, “highly” is the correct response for the second drop-down menu, and “highest” is the correct response for the third drop-down menu because red-backed shrikes have a high egg recognition rate and the highest cuckoo rejection rate when compared to other species in the table. The evolution of highly recognizable egg patterns and a high success rate of rejecting the eggs of nest parasites indicates that red-backed shrikes have experienced these selective pressures over a longer period than other species with less recognizable eggs and lower rates of nest parasite rejection.

The coevolution of genetic traits that allow cuckoos to copy host eggs and their hosts to produce recognizable eggs is a result of because the genes of successful birds are passed to offspring, the frequency of the genes that cause those beneficial traits in these populations.

“Natural selection” is the correct response for the fourth drop-down menu and “increasing” is the correct response for the fifth drop-down menu because individuals of a host species that are more successful at distinguishing between their own eggs and those of nest parasites are more likely to pass their genetic traits to offspring, ultimately increasing the frequency of that beneficial trait in the population over time. As the complexity of host species’ egg patterns increases in response to selective pressures from nest parasites, in turn, the selective pressure on nest parasites to mimic those complex egg patterns also increases, resulting in coevolution.

Item 7

Scoring Rubric

Points	Description
2	The student correctly selects the drop-down menu options for both Part A and Part B.
1	The student correctly selects the drop-down menu options for either Part A or Part B.
0	The student does not correctly select the drop-down menu options for either part.

Exemplar Response

Part A

The correct response is shown below.

Analysis of genome structure and function helps researchers understand how the products of genes, , interact during the of individuals of the species.

“Proteins” is the correct response for the first drop-down menu because most genes contain the coded information needed to make functional molecules called proteins. “Development” is the correct response for the second drop-down menu because offspring receive genetic material from each parent during sexual reproduction, and the unique combination of genes inherited by each offspring directs the development of that individual’s physical traits.

Part B

Understanding the structure and function of the genomes of species helps researchers determine .

“How species are related to each other” is the correct response for the third drop-down menu because comparing the complete genome (set of genes) for an individual or a species allows scientists to better understand how individuals or species are related to each other.

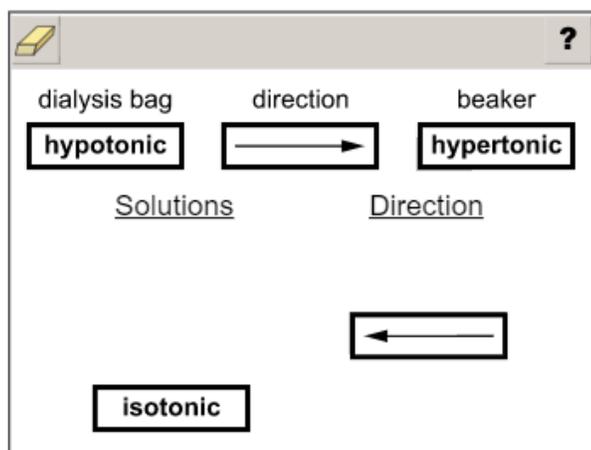
Item 10

Scoring Rubric

Points	Description
1	The student correctly fills in all boxes.
0	The student does not correctly fill in all boxes.

Exemplar Response

The correct response is shown below.



This is the correct response because during osmosis, water moves from an area of lower solute concentration to an area of higher solute concentration. The membrane of the dialysis bag is semipermeable, allowing water to pass through without allowing solute to pass through. Since the solution in the dialysis bag has a lower concentration of solute than the solution in the beaker, the solution in the dialysis bag is “hypotonic” compared to the “hypertonic” solution in the beaker. As a result, water will move out of the dialysis bag into the beaker.

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Item 12

Scoring Rubric

Points	Description
2	The student correctly answers both Part A and Part B.
1	The student correctly answers either Part A OR Part B.
0	The student does not correctly answer either part.

Exemplar Response

Part A

The correct response is shown below.

The screenshot shows a digital assessment interface. At the top left is a yellow eraser icon, and at the top right is a question mark icon. Below these is a table with three rows:

Directly Affected by Human Activities
Nutrient sources
Water temperatures

Below the table is a section titled Components with two rows:

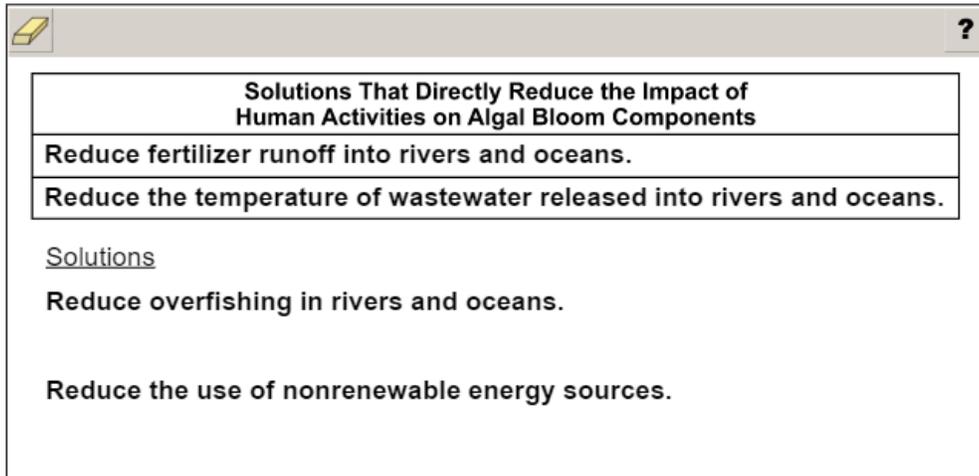
Presence of the algae
Wind and water currents

Humans can have an effect on water bodies by adding excess nutrients. They can also increase the temperature of water bodies by adding warm wastewater. Humans are unlikely to have an effect on the presence of algae or have a direct impact on wind or water currents. The order within each column does not matter.

Go on to the next page to finish item 12.

Item 12**Part B**

The correct response is shown below.



The screenshot shows a digital assessment window with a yellow pencil icon in the top left and a question mark icon in the top right. The main content area contains the following text:

Solutions That Directly Reduce the Impact of Human Activities on Algal Bloom Components

Reduce fertilizer runoff into rivers and oceans.
Reduce the temperature of wastewater released into rivers and oceans.

Solutions

Reduce overfishing in rivers and oceans.

Reduce the use of nonrenewable energy sources.

Reducing fertilizer runoff and reducing the temperature of wastewater are the only two solutions that directly relate to the four main components necessary for an algae bloom and can be directly impacted by human activities. The order of the responses does not matter.

Item 13

Scoring Rubric

Points	Description
2	The student places all three correct statements in the box in any order.
1	The student places two correct statements in the box in any order.
0	The student does not place at least two correct statements in the box.

Exemplar Response

The correct response is shown below.

Explanation of Greatest Biodiversity in the Tropics

- **Tropic latitudes experience less seasonal changes in climate.**
- **There is a large amount of annual precipitation in tropic latitudes.**
- **Regions near the equator have a longer growing season for plants.**

There is less land in temperate and polar latitudes.

Temperate and polar latitudes have a large amount of water from snowmelt.

Species in temperate and polar latitudes are better adapted to extreme weather.

The correct statements shown are best because they support the idea that tropical regions have consistent climate patterns between seasons. This means that these regions will have more consistent temperatures and more rainfall throughout the entire year. These factors allow plants to grow better all year long in the tropics, which leads to biodiversity.

Although temperate regions do have more water from snowmelt and species that are better adapted to extreme weather, these factors do not support the finding that greater biodiversity can be found in the tropics. The statement about less land in temperate and polar regions is inaccurate.

Item 14

Scoring Rubric

Points	Description
2	The student places both statements in the correct table for each claim. Statement order within each table does not matter.
1	The student places both correct statements in Claim 1, OR places both correct statements in Claim 2. Statement order within each table does not matter.
0	The student gives a response that does not meet the criteria to receive 1 or 2 points.

Exemplar Response

The correct response is shown below.

Supporting Evidence for Claim 1	
Homologous chromosomes separate incorrectly, producing daughter cells with unequal amounts of genetic material.	
Daughter cells have too much or too little genetic material.	
Supporting Evidence for Claim 2	
Daughter cells are all haploid but are not genetically identical.	
Homologous chromosomes exchange genetic material during meiosis.	
Deletions during replication are passed to daughter cells.	
Heritable mutations caused by environmental factors result in the loss of entire chromosomes.	

Nondisjunction is an error resulting from genetic material unevenly or incorrectly separating during meiosis. Claim 1 is supported by the observations that the daughter cells shown in example 1 have unequal amounts of genetic material in their cells, as well as having more ($n + 1$) or less ($n - 1$) than half of the original amount ($2n$).

Crossing over results when genetic material recombines to make new arrangements in the chromosomes. Claim 2 is supported by the observation that the daughter cells resulting from example 2 all have the same amount of genetic material in their cells, which is half (n) of the original amount ($2n$). The chromosome patterns in the genetic material are different across the daughter cells, which is evidence of an exchange of material during meiosis.

Item 15

Scoring Rubric

Points	Description
2	The student fills in all three correct descriptions in any order.
1	The student fills in two of the three correct descriptions in any order.
0	The student does not fill in at least two correct descriptions in the box.

Exemplar Response

The correct response is shown below.


?

Increase Drought Survival
has thick bark
has deep roots
has needles instead of large, flat leaves

has large leaves

produces fleshy fruit

sheds and grows new leaves annually

Drought survival is increased in tree species that have thick bark, deep roots, and leaves reduced to needles. These features would help the plant reduce water loss, find water below ground, and efficiently photosynthesize without losing much water.

Drought survival is decreased in tree species that have large leaves, produce fleshy fruits, and lose and grow leaves each year. These features cause water loss and require a lot of water to produce the physical structures. These would be harmful during a dry period.

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Item 16

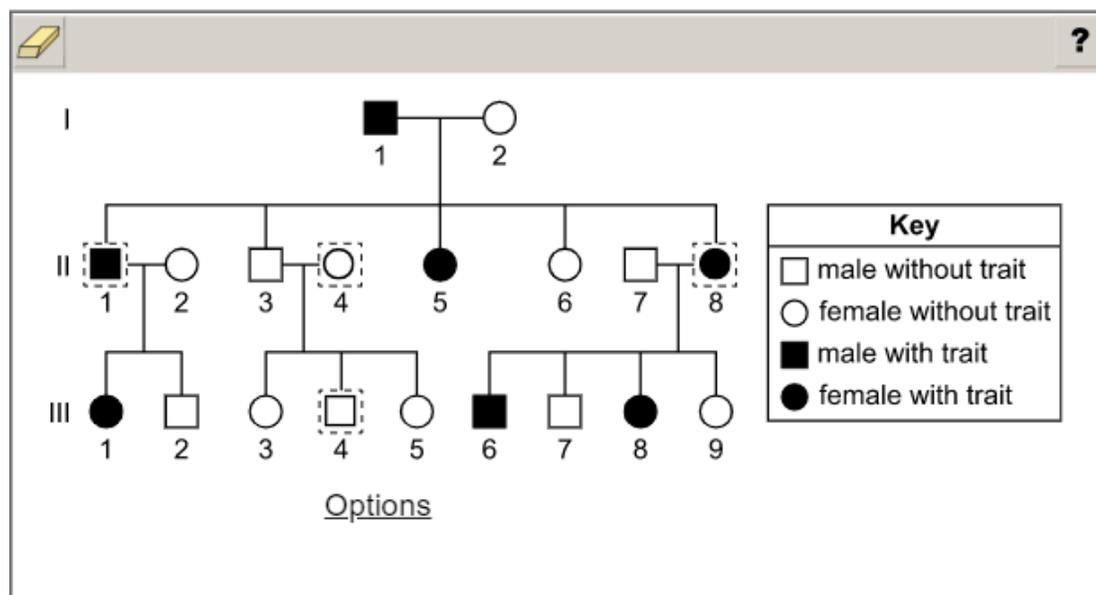
Scoring Rubric

Points	Description
2	The student correctly answers both Part A and Part B.
1	The student correctly answers either Part A OR Part B.
0	The student does not correctly answer either part.

Exemplar Response

Part A

The correct response is shown below.



Individual II1 must be a male and must have the trait (shaded) since he has offspring with the trait and the female II2 does not have the trait.

Individual II8 must be a female and must have the trait (shaded) since she has offspring with the trait and the male II7 does not have the trait.

Individual II4 must be a female without the trait because the offspring do not have the trait.

Individual III4 must be the remaining male without the trait. This is confirmed since neither of his parents have the trait.

A correct arrangement of the symbols would result in 1 point. Since this item is scored 1 point for Part A and 1 point for Part B, any other arrangement in Part A will receive 0 points.

Go on to the next page to finish item 16.

Item 16

Part B

The correct response is shown below.

Chance of inheriting the trait:		50%
Genotype of unaffected offspring:		gg
25%	GG	
	Gg	
100%		

Each parent has two copies of each gene, but only one copy is passed on to the offspring. Because the other parent also has two copies and passes only one copy, there are four arrangements possible for each offspring. The dominant trait will show up in two of the four arrangements, which is 50 percent.

The genotype of an individual is the specific set of traits inherited, known as alleles, and is shown with either uppercase or lowercase letters or both. The only way to be unaffected in this scenario is to not have an uppercase G, which removes options “GG” and “Gg.” Only individuals with “gg” alleles would be unaffected by the trait. Since this item is scored 1 point for Part A and 1 point for Part B, any other arrangement in Part B will receive 0 points.

Item 17**Scoring Rubric**

Points	Description
1	The student correctly selects both drop-down menu options.
0	The student does not correctly select both drop-down menu options.

Exemplar Response

The correct response is shown below.

The development of six legs should be placed at letter on the cladogram because the body structure is present only in organisms that point on the cladogram.

“B” is the correct response for the first drop-down menu and “after” is the correct response for the second drop-down menu because the worm does not have legs, the spider has eight legs, and all the organisms on the cladogram after B have six legs, a key trait distinguishing between arachnids and insects. In this cladogram, all the organisms are related because they all possess a segmented body. They must be further distinguished from each other by other distinctive traits. The development of the trait for six legs occurred after the evolution of spiders and before the evolution of ants.

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