Extending Learning Beyond the Classroom

School is out, but learning continues!

High School: Biology

Clayton County Public Schools

Clayton County Public Schools

Department of Curriculum, Instruction, & Assessment

1058 Fifth Avenue • Jonesboro, Georgia 30236 • (770) 473-2700

DR. MORCEASE J. BEASLEY
Superintendent of Schools

DR. EBONY T. LEE
Director of Curriculum, Instruction, & Assessment

Dear Parents,

We want your child to be well prepared for the demands of the Georgia Milestones Assessment System (GMAS) which measures college and career readiness. The Department of Curriculum, Instruction, and Assessment is *Extending Learning Beyond the Classroom* by providing academic assignments for students to complete to support and reinforce their learning. The assignments focus on standards-based practice that reflects what students are expected to demonstrate on the Georgia Milestones in each core content area.

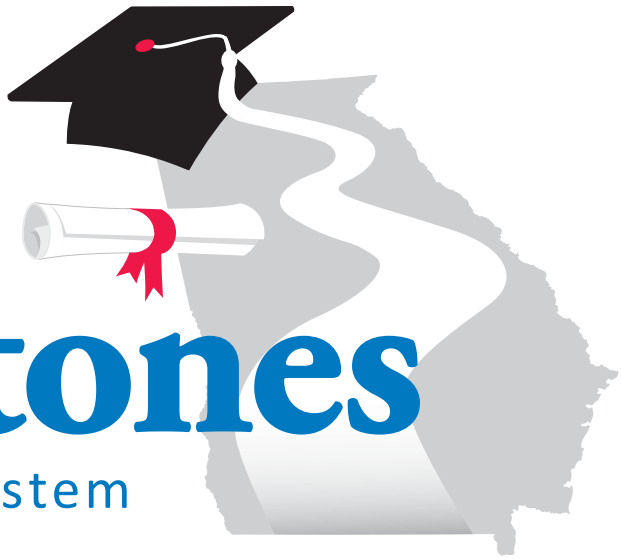
Assignments are provided for students in grades 3-12. Students are encouraged to complete the assignments while away from school. Students can bring their finished work to school for teachers to review and support their areas of need. As always, students are encouraged to read at least 30 minutes every day. Parents are asked to engage students in conversations about what they are reading and learning from the assignments. Parents may consider having a scheduled time for students to complete their work, and they may assist students – as needed - with the completion of assignments. Finally, an electronic version of the assignments and additional online resources can be found on the Clayton County Public Schools website (www.clayton.k12.ga.us).

Thank you for your partnership and your commitment to high performance!

Regards,

Dr. Ebony T. Lee
Director of Curriculum, Instruction, & Assessment

Georgia Milestones Assessment System



Study/Resource Guide for Students and Parents

Biology

Study/Resource Guide

The Study/Resource Guides are intended to serve as a resource for parents and students. They contain practice questions and learning activities for the course. The standards identified in the Study/Resource Guides address a sampling of the state-mandated content standards.

For the purposes of day-to-day classroom instruction, teachers should consult the wide array of resources that can be found at www.georgiastandards.org.

Table of Contents

THE GEORGIA MILESTONES ASSESSMENT SYSTEM

Dear Student,

The **Georgia Milestones Biology EOC Study/Resource Guide for Students and Parents** is intended as a resource for parents and students.

This guide contains information about the core content ideas and skills that are covered in the course. There are practice sample questions for every section. The questions are fully explained and describe why each answer is either correct or incorrect. The explanations also help illustrate how each question connects to the Georgia state standards.

In addition, the guide includes activities that you can try to help you better understand the concepts taught in the course. The standards and additional instructional resources can be found on the Georgia Department of Education website, www.georgiastandards.org.

Get ready—open this guide—and get started!

GEORGIA MILESTONES END-OF-COURSE (EOC) ASSESSMENTS

The EOC assessments serve as the final exam in certain courses. The courses are:

English Language Arts

- Ninth Grade Literature and Composition
- American Literature and Composition

Mathematics

- Algebra I
- Analytic Geometry
- Coordinate Algebra
- Geometry

Science

- Physical Science
- Biology

Social Studies

- United States History
- Economics/Business/Free Enterprise

All End-of-Course assessments accomplish the following:

- Ensure that students are learning
- Count as part of the course grade
- Provide data to teachers, schools, and school districts
- Identify instructional needs and help plan how to meet those needs
- Provide data for use in Georgia's accountability measures and reports

HOW TO USE THIS GUIDE

Let's get started!

First, preview the entire guide. Learn what is discussed and where to find helpful information. Even though the focus of this guide is Biology, you need to keep in mind your overall good reading habits.

- Start reading with a pencil or a highlighter in your hand and sticky notes nearby.
- Mark the important ideas, the things you might want to come back to, or the explanations you have questions about. On that last point, your teacher is your best resource.
- You will find some key ideas and important tips to help you prepare for the test.
- You can learn about the different types of items on the test.
- When you come to the sample items, don't just read them, *do* them. Think about strategies you can use for finding the right answer. Then read the analysis of the item to check your work. The reasoning behind the correct answer is explained for you. It will help you see any faulty reasoning in the ones you may have missed.
- With the Depth of Knowledge (DOK) information, you can gauge just how complex the item is. You will see that some items ask you to recall information and others ask you to infer or go beyond simple recall. The assessment will require all levels of thinking.
- Plan your studying and schedule your time.
- Proper preparation will help you do your best!

OVERVIEW OF THE BIOLOGY EOC ASSESSMENT

ITEM TYPES

The Biology EOC assessment consists of selected-response and technology-enhanced items.

A **selected-response** item, sometimes called a multiple-choice item, is a question, problem, or statement that is followed by four answer choices. These questions are worth one point.

A **technology-enhanced** item has a question, problem, or statement. You may be asked to select more than one right answer. Or, you may be asked to answer the first part of the question. Then, you will answer the second part of the question based on how you answered part one. These questions are worth 2 points. Partial credit may be awarded if you select some but not all of the correct answers or if you get one part of the question correct but not the other.

DEPTH OF KNOWLEDGE DESCRIPTORS

Items found on the Georgia Milestones assessments, including the Biology EOC assessment, are developed with a particular emphasis on the kinds of thinking required to answer questions. In current educational terms, this is referred to as Depth of Knowledge (DOK). DOK is measured on a scale of 1 to 4 and refers to the level of cognitive demand (different kinds of thinking) required to complete a task, or in this case, an assessment item. The following table shows the expectations of the four DOK levels in detail.

The DOK table lists the skills addressed in each level as well as common question cues. These question cues not only demonstrate how well you understand each skill but they relate to the expectations that are part of the Characteristics of Science and Nature of Science standards.

Level 1—Recall of Information

Level 1 generally requires that you identify, list, or define. This level usually asks you to recall facts, terms, concepts, and trends and may ask you to identify specific information contained in documents, maps, charts, tables, graphs, or illustrations. Items that require you to "describe" and/or "explain" could be classified as Level 1 or Level 2. A Level 1 item requires that you just recall, recite, or reproduce information.

Skills Demonstrated	Question Cues
• Make observations • Recall information • Recognize formulas, properties, patterns, processes • Know vocabulary, definitions • Know basic concepts • Perform one-step processes • Translate from one representation to another • Identify relationships	• Tell what, when, or where • Find • List • Define • Identify; label; name • Choose; select • Compute; estimate • Express • Read from data displays • Order

Level 2—Basic Reasoning

Level 2 includes the engagement (use) of some mental processing beyond recalling or reproducing a response. A Level 2 "describe" and/or "explain" item would require that you go beyond a description or explanation of recalled information to describe and/or explain a result or "how" or "why."

Skills Demonstrated	Question Cues
• Apply learned information to abstract and real-life situations • Use methods, concepts, and 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	• Apply • Calculate; solve • Complete • Describe • Explain how; demonstrate • Construct data displays • Construct; draw • Analyze • Extend • Connect • Classify • Arrange • Compare; contrast

Level 3—Complex Reasoning	
Level 3 requires reasoning, using evidence, and thinking on a higher and more abstract level than Level 1 and Level 2. You will go beyond explaining or describing "how and why" to justifying the "how and why" through application and evidence. Level 3 items often involve making connections across time and place to explain a concept or a "big idea."	
Skills Demonstrated	**Question Cues**
• 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, and formulas • Make choices based on a reasoned argument • Verify the value of evidence, information, numbers, and data	• Plan; prepare • Predict • Create; design • Ask "what if?" questions • Generalize • Justify; explain why; support; convince • Assess • Rank; grade • Test; judge • Recommend • Select • Conclude

Level 4—Extended Reasoning	
Level 4 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. You may 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 Level 4 items would be a show of evidence, through a task, a product, or an extended response, that the cognitive demands have been met.	
Skills Demonstrated	**Question Cues**
• Analyze and synthesize information from multiple sources • Examine and explain alternative perspectives across a variety of sources • Apply mathematical models to illuminate a problem or situation • Design a mathematical model to inform and solve a practical or abstract situation • Combine and synthesize ideas into new concepts	• Design • Connect • Synthesize • Apply concepts • Critique • Analyze • Create • Prove

DEPTH OF KNOWLEDGE EXAMPLE ITEMS

Example items that represent the applicable DOK levels across various Biology content domains are provided on the following pages.

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

Example Item 1

Selected-Response

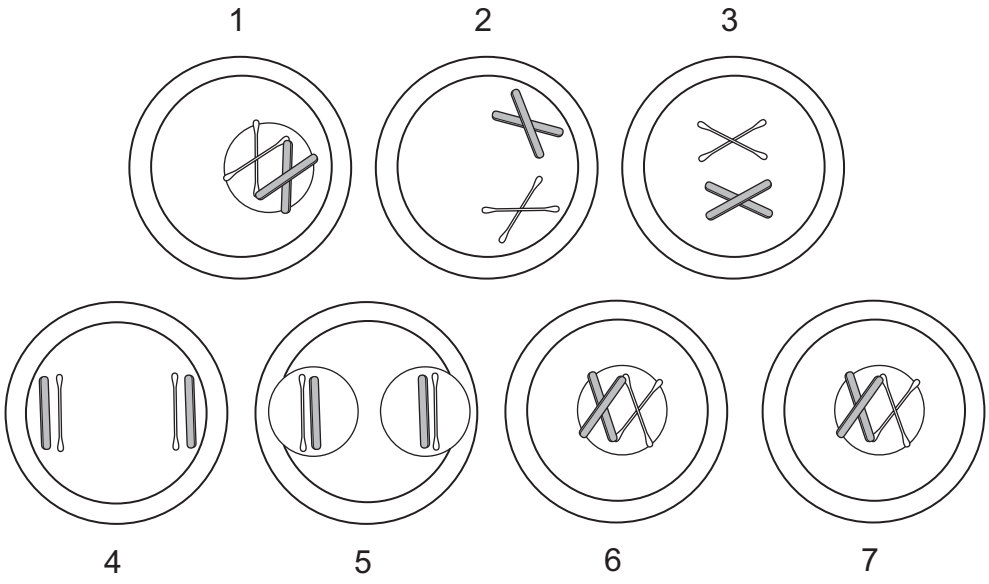
DOK Level 1: This is a DOK level 1 item because it requires the student to recall information about the role of mitosis in maintaining genetic continuity.

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 homeostasis.

Students created the following model 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 diploid, not haploid. Choice (D) is incorrect because it is not an independent assortment.

Example Item 2

Selected-Response

DOK Level 2: This is a DOK level 2 item because it requires the student to apply learned information to abstract and real-life situations.

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.

Agriculture companies produce plants that have genetic modifications that give the plants desired traits, such as resistance to drought or pests. Which question would gather information about an ethical consideration of genetically modified plants?

A. Will these plants cause pollinators to avoid large areas of land?
B. Can the amount of excess food produced by these plants be calculated?
C. Can the genetic modifications of these plants be acquired by noxious plants?
D. Will these plants require more land to grow than an equal amount of non-genetically modified plants require?

Correct Answer: C

Explanation of Correct Answer: The correct answer is choice (C) Can the genetic modification of these plants be acquired by noxious plants? Choice (A) is incorrect because genetically modified plants would still attract pollinators. Choice (B) is incorrect because genetically modified crops and non-genetically modified crops would produce the same amount of food. Choice (D) is incorrect because genetically modified crops and non-genetically modified crops would both require the same amount of land.

Example Item 3

Selected-Response

DOK Level 3: This is a DOK level 3 item because it requires the student to construct arguments supported by evidence, analyze and interpret data, and construct explanations.

Biology Domain: Organisms

Standard: SB5. Obtain, evaluate, and communicate information to assess the interdependence of all organisms on one another and their environment.

a. Plan and carry out investigations and analyze data to support explanations about factors affecting biodiversity and populations in ecosystems. (Clarification statement: Factors include size, carrying capacity, response to limiting factors, and keystone species.)

Students are studying factors that affect population sizes. They plan an investigation to explore the effect of the starting population size on growth rate and on the carrying capacity of the environment. The students select duckweed for the experiment because it has continuous growth. Duckweed is a free-floating aquatic plant that at times clogs waterways. It most commonly reproduces asexually by producing a new leaflike structure that breaks off from the parent plant once the new structure has roots. The students agree on a hypothesis stating that the greater the number of individuals of the starting population, the faster the population will reach carrying capacity. The following procedure is developed by the students.

1. Each lab group will prepare fertilizer according to the manufacturer's instructions.
2. Each lab group will have one petri dish with 50 mL of the fertilizer solution prepared. The solution of each petri dish will be kept constant by refilling.
3. Two lab groups will have the same number of starting populations. The number of starting duckweed populations will be 5, 10, 20, 30, 40, and 50.
4. Each lab group will place the starting population number of plants into each petri dish.
5. Place a petri dish cover on each petri dish.
6. Expose each petri dish to the same amount of light for the same amount of time.
7. Count the numbers of plants each week for eight weeks and record the numbers in the data table.
8. Share the data with all the groups.

(This item continues on the next page.)

Weekly Plant Count by Group

Group	Week								
	0	1	2	3	4	5	6	7	8
1	5	6	9	12	15	15	16	10	10
2	5	6	8	13	13	15	17	35	43
3	10	12	17	27	33	41	45	55	65
4	10	11	24	26	34	42	47	45	67
5	20	21	33	35	39	44	47	49	51
6	20	20	42	37	47	53	55	57	59
7	30	33	38	40	48	53	68	59	50
8	30	37	39	41	40	44	46	47	50
9	40	52	59	81	67	71	80	74	72
10	40	47	76	78	76	77	81	70	68
11	50	64	78	93	115	124	118	118	110
12	50	67	77	91	118	127	124	117	112

Analyze the data from the investigation to identify which statement BEST explains the results.

A. Each population reached the carrying capacity at different weeks.
B. Populations 9 and 10 were unable to reach the carrying capacity before the end of the investigation period.
C. Populations 11 and 12 reached carrying capacity at week 5 because there were fewer plants for the rest of the investigation period.
D. The populations had different starting population numbers that grew at the same rate and reached their carrying capacities at the same time.

Correct Answer: C

Explanation of Correct Answer: The correct answer is choice (C) Populations 11 and 12 reached carrying capacity at week 5 because there were fewer plants for the rest of the investigation period. Choice (A) is incorrect because some groups did not reach the carrying capacity. Choice (B) is incorrect because group 9 reached carrying capacity in week 3 and group 10 reached it in week 6. Choice (D) is incorrect because the populations actually reached their carrying capacities at different times.

DESCRIPTION OF TEST FORMAT AND ORGANIZATION

The Georgia Milestones Biology EOC assessment consists of a total of 76 items. You will be asked to respond to selected-response (multiple-choice) and technology-enhanced items.

The test will be given in two sections.

- You may have up to 70 minutes per section to complete Sections 1 and 2.
- The total estimated testing time for the Biology EOC assessment ranges from approximately 90 to 140 minutes. Total testing time describes the amount of time you 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).

Effect on Course Grade

It is important that you take this course and the EOC assessment very seriously.

- For students in Grade 10 or above beginning with the 2011–2012 school year, the final grade in each course is calculated by weighing the course grade 85% and the EOC score 15%.
- For students in Grade 9 beginning with the 2011–2012 school year, the final grade in each course is calculated by weighing the course grade 80% and the EOC score 20%.
- A student must have a final grade of at least 70% to pass the course and to earn credit toward graduation.

PREPARING FOR THE BIOLOGY EOC ASSESSMENT

STUDY SKILLS

As you prepare for this test, ask yourself the following questions:

- How would you describe yourself as a student?
- What are your study-skills strengths and/or weaknesses?
- How do you typically prepare for a classroom test?
- What study methods do you find particularly helpful?
- What is an ideal study situation or environment for you?
- How would you describe your actual study environment?
- How can you change the way you study to make your study time more productive?

ORGANIZATION—OR TAKING CONTROL OF YOUR WORLD

- Establish a study area that has minimal distractions.
- Gather your materials in advance.
- Develop and implement your study plan.

ACTIVE PARTICIPATION

The most important element in your preparation is *you*. You and your actions are the key ingredient. Your active studying helps you stay alert, interact with the course content, and be more productive. Here's how you do it.

- Carefully read the information and then DO something with it. Mark the important material with a highlighter, circle it with a pen, write notes on it, or summarize the information in your own words.
- Ask questions. As you study, questions often come into your mind. Write them down and actively seek the answers.
- Create sample test questions and answer them.
- Find a friend who is also planning to take the test and quiz each other.

TEST-TAKING STRATEGIES

Part of preparing for a test is having a set of strategies you can draw from. Include these strategies in your plan:

- Read and understand the directions completely. If you do not understand the directions, ask a teacher.
- Read each question and all of the answer choices carefully.
- If you use scratch paper, make sure you copy your work to your test accurately.
- Underline important parts of each task. Make sure that your answer goes on the answer sheet.

- Be aware of time. If a question is taking too much time, come back to it later.
- Answer all questions. Check your answers for accuracy.
- Stay calm and do the best you can.

PREPARING FOR THE BIOLOGY EOC ASSESSMENT

Read this guide to help prepare for the Biology EOC assessment.

The section of the guide titled "Content of the Biology EOC Assessment" provides a snapshot of the Biology course. In addition to reading this guide, do the following to prepare to take the assessment:

- Read your textbooks and other materials.
- Think about what you learned, ask yourself questions, and answer them.
- Read and become familiar with the way questions are asked on the assessment.
- Answer the sample Biology questions.
- There are additional items available online to help you practice your skills. Ask your teacher about online practice sites that are available for your use.

CONTENT OF THE BIOLOGY EOC ASSESSMENT

Up to this point in the guide, you have been learning how to prepare for taking the EOC assessment. Now you will learn about the topics and standards that are assessed in the Biology EOC assessment and will see some sample items.

- The first part of this section focuses on what will be tested. It also includes sample items that will let you apply what you have learned in your classes and from this guide.
- The next part contains a table that shows the standard assessed for each item, the DOK level, the correct answer (key), and a rationale/explanation of the right and wrong answers.
- You can use the sample items to familiarize yourself with the item format found on the assessment.

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

The Biology EOC assessment will assess the Biology standards documented at www.georgiastandards.org. The Georgia Standards of Excellence for Biology embody science as a way of thinking and investigating and include a growing body of knowledge about the natural world. You will need to understand the Georgia Standards of Excellence for Biology.

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.
- On the actual test, the standards for Biology are grouped into five domains: Cells; Cellular Genetics & Heredity; Classification & 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 understanding each student is expected to achieve. The Characteristics of Science and Nature of Science standards describe the practices used by scientists to acquire these understandings. Both sets of standards combined include the knowledge and skills assessed on the EOC assessment, and they are used to plan instruction throughout the course.

SNAPSHOT OF THE COURSE

This section of the study guide is organized into four sections that review the material covered within the five domains of the Biology course. The material is presented by topic rather than by category or standard. In each section you will find sample items similar to what you will see on the EOC assessment. The next section of the guide contains a table that shows, for each item, the standard assessed, the Characteristics of Science alignment, the DOK level, the correct answer (key), and a rationale/explanation about the key and distractors.

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The more you understand about the topics in each section, the greater your chances of getting a good score on the EOC assessment.

As you read through each section, you will find that some material is repeated in two or more texts. The sections are designed to show how the key ideas within the sections apply in many different ways.

ORGANIZATION

Life is organized at all levels from cell to biosphere.

AREAS OF FOCUS

Cells

- Organelles and structures within a cell interact to maintain homeostasis. (SB1a)
- The structures of macromolecules within a cell are related to their interactions in carrying out cellular processes. (SB1c)

Organisms

- Viruses and organisms are different in some ways and similar in others. (SB4c)
- Clades of organisms are constructed to represent patterns of structure and function of the organisms within the three domains of organisms: archaea, bacteria, and eukarya. (SB4a)

Evolution

- Cladograms and phylogenetic trees are models based on patterns of common ancestry and the theory of evolution and they are used to determine relationships among major groups of organisms. (SB4b)
- Our understanding of biology has been influenced by new understandings of the age of Earth, the emergence of new species from preexisting species, and our understanding of genetics. (SB6a)
- Speciation results in patterns of biodiversity. (SB6b)
- Comparative morphology, embryology, biochemistry, and genetics support the theory that all living organisms are related by way of common descent. (SB6c)
- Undirected genetic changes in natural selection and genetic drift have led to changes in populations of organisms. (SB6d)
- Evolution plays a role in causing biological resistance. (SB6e)

KEY IDEAS

Differentiate Between Prokaryotic and Eukaryotic

Biologists once looked for clues to aging and diseases by studying organs, tissues, and cultures of cells. With the development of the microscope, biologists focused their attention upon smaller elements of living things: the organelles within the cells. With advancements in the microscope, biologists discovered two types of cells: prokaryotic and eukaryotic cells.

PROKARYOTES:	**EUKARYOTES:**
Prokaryotes are single-celled organisms that lack internal structures surrounded by membranes. They lack a true nucleus. Examples: Bacteria Archaea	Eukaryotes are single-celled and multi-cellular organisms that have cells containing internal membrane-bound structures. They have a true nucleus containing the cell's DNA. Examples: Plants Animals Mushrooms (fungi) Amoebas (protists)

Cells Must Have Boundaries

Each cell has a cell membrane that serves as a boundary between the cell and its external environment. The cell membrane is flexible and allows the cell to vary its shape if necessary. It controls the movement of materials entering and exiting the cell. The cell membrane also helps maintain a chemical balance within the cell, which is called homeostasis.

An additional boundary outside of the cell membrane is the cell wall. The cell wall is thicker than the cell membrane and is inflexible. It protects the cell and gives the cell its shape. Plants, fungi, most bacteria, and a few protists have cell walls. Animal cells do not have cell walls.

Some examples of organelles and their functions

Nucleus: contains DNA, which controls cellular function

Chloroplasts: capture solar energy for photosynthesis

Golgi bodies: modify, sort, and ship proteins and lipids

Mitochondria: produces ATP

Ribosomes: synthesizes protein chains

It is very important that you refer to your textbook for a complete list of cell organelles and their specific functions.

Compare the Structures and Functions of Organisms of Different Domains

The Three Domains

The number of domains in early classification systems varied greatly. In Aristotle's time, scientists had not yet studied geological time frames. These early classification systems were based on visible structural differences. As scientists discovered evolutionary relationships among species, the classification systems changed or were modified to fit these new discoveries. Comparisons of DNA sequences and similarities in proteins have helped to identify relationships among different organisms. From Aristotle's two divisions, plants and animals, we now have the three-domain system.

The three domains are the following:

Three Domains
Eukarya
Archaea
Bacteria

All prokaryotic organisms are either in the domain Bacteria or the domain Archaea. The domain Bacteria contains all of the bacteria that cause disease as well as the bacteria that are beneficial. The domain Archaea contains bacteria mainly found in extreme environments such as the deep oceans, hot springs, and swamps. All the organisms in the domain Eukarya contain membrane-bound organelles. The organisms formally known as protists are eukaryotic and may be either unicellular or multicellular. Information acquired through genome analysis has resulted in movement of these organisms to different locations within the domain. They lack complex organ systems and live in moist environments. Fungi are consumers that do not move. They are unicellular or multicellular heterotrophic eukaryotes that absorb nutrients from decomposing organisms and wastes in the environment. Plants are photosynthetic multicellular eukaryotes. Most plants have cellulose cell walls and tissues that have been organized into organs and organ systems. Animals are multicellular eukaryotic consumers. Animal cells do not have cell walls. Their tissues have been organized into complex organ systems such as the nervous system, muscular system, and digestive system.

Taxonomy is the branch of biology dealing with the grouping and naming of organisms. A person who studies taxonomy is called a taxonomist. There is a vast array of organisms that we know of, but taxonomists are still identifying newly discovered organisms. They compare the internal and external structures, sequence the genome, compare the amino acid sequence of common proteins, and compare the evolutionary relationships of species. The numbers of species identified by taxonomists are growing at different rates among different groups of organisms. With the advancing technology of the microscope, many more microorganisms have been discovered. Scientists are also exploring tropical forest canopies and deep ocean areas, where they are discovering new species. Knowledge of relationships among species helps the taxonomist identify and group these newly discovered species.

The Modern Classification System

Have you ever been to a zoo and been overwhelmed by the number of different species of animals you saw? Or have you taken a walk in a forest and been amazed by the different plants that you see on the forest floor? What you have seen is a small fraction of what actually inhabits our planet with us. One tool that scientists use in an attempt to make sense of the diversity of life is the classification system.

Classification is the grouping of objects based on similarities. Modern classification uses the following levels to classify organisms:

Levels of Classification
Kingdom
Phylum
Class
Order
Family
Genus
Species

Although the six-kingdom system has been replaced by the three-domain system and many organisms now find themselves on a different limb of the tree of life, this traditional classification system is still useful for identifying organisms. At the phylum level, organisms are subdivided again based on evolutionary traits. Organisms are further divided into different classes based upon shared characteristics. Within each class, organisms are grouped into orders based on a more specific and limited set of characteristics. This subdividing and grouping has seven levels in the modern classification system. The most specific level is species. Members of a species are considered to be the same “kind” of organism and can reproduce with other members of their species to produce viable offspring.

Compare and Contrast Viruses with Living Organisms

Viruses are infectious particles made of a protein shell called a capsid, which contains either DNA or RNA. The genetic material is single-stranded or double-stranded, depending on the kind of virus. Some viruses have an outer membranous envelope that covers the capsid. These viral envelopes, derived from the host cell membrane, may contain both viral and host cell lipids and proteins.

Viruses are not considered living organisms because they are not cells and they cannot reproduce outside of a host cell. Viruses must infect a living cell, a host, in order to reproduce their viral genetic material and make new viral proteins. Like living organisms, viruses contain genetic material (either DNA or RNA), respond to their environment, and evolve. Unlike living organisms, viruses are not cells, do not contain organelles, and are unable to reproduce in the absence of a host cell. Further, viruses are able to form crystals and still be functional. Living cells are not able to survive crystallization.

Explain the History of Life in Terms of Biodiversity, Ancestry, and the Rates of Evolution

Our understanding of biology has been influenced by the age of Earth, the emergence of new species from existing species, and the still growing body of knowledge of genetics. The work of Charles Darwin and Gregor Mendel laid a foundation to explain the large diversity of species found today. Adaptation can occur when a population colonizes a new area. A good example is the large number of finch species that Darwin observed on the different Galápagos Islands. He counted over a dozen different species of finches that he believed evolved from a single founding species.

As molecular biologists developed new techniques for analyzing DNA, new understanding emerged about how different modes of evolution can occur. As more and more data were gathered, evolutionary biologists became intrigued with DNA and the information that it provided about the relationships among organisms. Data collected show that segments of DNA, and even entire sequences of the amino acids in some proteins, seem to be identical in many organisms.

The similarity between the DNA of all living organisms shows that once life began, it diversified by changing the genetic code of organisms. This resulted in the biodiversity of life on Earth today. Biodiversity is the variety of organisms, their genetic information, and the communities in which they live. Scientists use three different terms when talking about biodiversity:

1. Ecosystem diversity includes the variety of habitats, living communities, and ecological processes in the living world.
2. Species diversity includes the vast number of different organisms on Earth.
3. Genetic diversity refers to the sum total of all the different forms of genetic information carried by all living organisms on Earth. It gives rise to inheritable variation, which provides the raw material for evolution.

Speciation is the evolution of a new species that occurs because of changes in gene flow between populations of the ancestral species. Evolution of new species because of geographic isolation occurs when physical barriers separate populations, preventing mating of individuals. Volcanoes, sea-level changes, and earthquakes are a few examples of natural occurrences that divide populations. So over time, each smaller population will adapt to their new environment through the process of natural selection. Eventually, this causes the gene pool of each group to become so different that a new species is formed.

Fossil and Biochemical Evidence Supports the Theory

The fossil record provides biologists with an incomplete picture of the evolution of plants and animals. Most fossils are the remains of the hard parts of an organism. Shells, bones, or the remains of plants with thick cell walls are most likely to leave a fossil. Very few fossils capture the details of skin or internal organs. There are also impressions left behind in sediments along rivers and lakes.

One problem with the fossil record is that there are few remains of any "intermediate" or transitional forms. There are several reasons that few transition species are found. Approximately two-thirds of all the organisms that have ever lived were soft-bodied; these organisms do not usually become fossilized. It also depended on where and how an organism died as to whether its remains could be fossilized. Fossils also could have been destroyed by erosion or pressure from overlying rocks. Exposure to wind, rain, and soil erosion could prevent fossils from forming.

Fossil Age

Biologists use a number of ways to determine the age of fossils. They recognize distinct groups of fossils in specific rock layers. By matching rock layers with fossils, geologists can determine the age of the rocks, while paleontologists can determine the age of the fossils. This is called relative dating.

Biologists use radioisotope dating to determine the relative ages of fossils within a time period. These isotopes act as clocks for measuring time. To use this method, scientists must know the following:

1. The half-life of the isotope being measured
2. How much of the isotope was originally present in the fossil or in the rock containing the fossil
3. How much of the isotope is left

Carbon-14 (C-14) is the primary isotope used in radioisotope dating. When an organism dies, no additional carbon is added to the carbon already in the organism before death. Scientists measure the ratio of carbon-14 to determine how long ago the organism lived. This ratio changes every year because the amount of C-14 decreases over time. The half-life of C-14 is 5,770 years. That means that it takes 5,770 years for half of the C-14 to become N-14, which is stable, while the other half is still radioactive. One problem in this is that the half-life of carbon is relatively short compared to how old Earth really is. So after about 50,000 years, the traceable amounts of carbon in the remains of an organism are gone. Scientists often use other isotopes, such as uranium-235, which decays into the daughter element, lead-207, in approximately 700 million years.

By using the ages of fossils, scientists can determine interrelationships among organisms. Organizing similar fossils by age shows how species change over time. An example of this change is horse evolution. A phylogeny is a description of the lines of descent of plants and animals. A phylogenetic tree shows the interrelationship of several species. Fossil collections are often not complete enough to determine any evolutionary patterns or traits. In many cases, a biologist will infer likely phylogenies by comparing morphological features, DNA sequences, and chromosomal characteristics.

SAMPLE ITEMS

Item 1

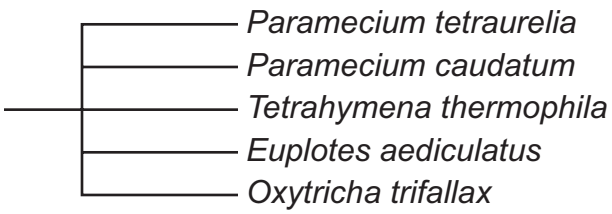
Selected-Response

Portions of the sequence alignments for a specific protein in some ciliates are shown below.

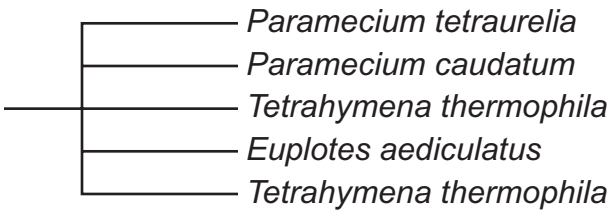
Ciliate	Sequence
Tetrahymena thermophila	NOYTYPEIORSOIFYCNH
Paramecium tetraurelia	KSNNOEKICROOILYCNH
Paramecium caudatum	KOOIAEKIOROOILYCNK
Euplotes aediculatus	NINVPNWNNMKSRTRIFYCH
Oxytricha trifallax	NINKGFWDDOIKRNRLFYCAH

Which of the following cladograms BEST represents these data?

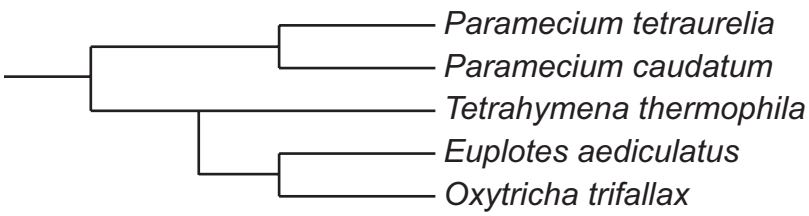
A.



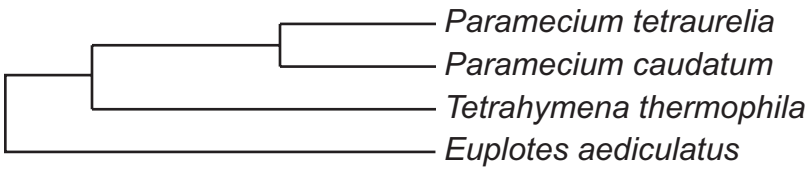
B.



C.



D.



Item 2

Selected-Response

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

Selected-Response

Some information about bacteria and viruses is arranged in this table.

Characteristic	Bacteria	Viruses
size	larger (1000 nm)	smaller (20–400 nm)
benefits	some are beneficial such as decomposers	not beneficial but occasionally useful, as in genetic engineering
enzymes	yes	yes, in some
treatment	antibiotics are used to destroy bacteria; vaccinations are used to prevent their spread	vaccines are used to prevent spread; antiviral medications are used to help slow viral reproduction but cannot stop it completely
reproduction	fission	invades a host cell, uses the host cell to make new viral components, destroys cell when new viruses are released
structure	DNA and RNA float in the cytoplasm; has a cell wall and a cell membrane	DNA or RNA is enclosed in a coat of protein
number of cells	unicellular	no cells
nucleus	no	no
ribosomes	yes	no
cell wall	disaccharides and amino acids	there is no cell wall, but a protein coat is present

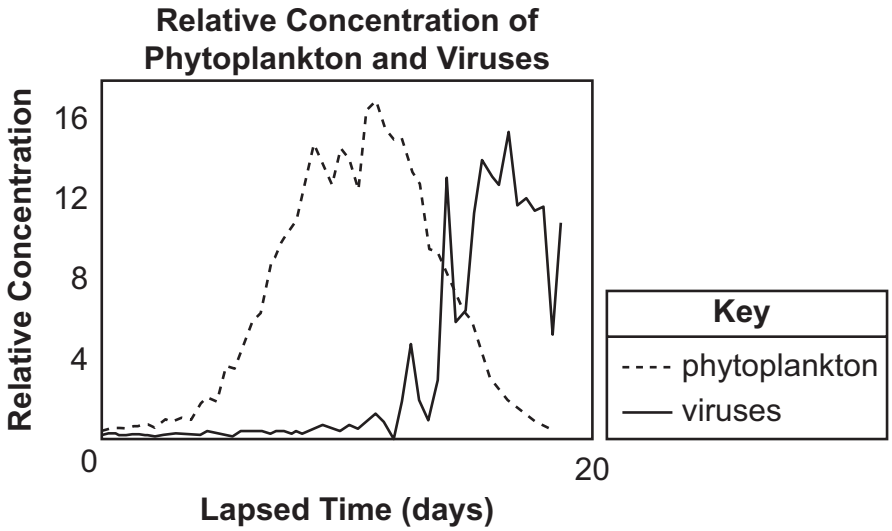
Which argument about bacteria and viruses is supported by this information?

A. Bacteria are larger than viruses but are still small enough to enter cells.
B. Bacterial infections such as diphtheria and tetanus cannot be prevented by vaccines.
C. Only bacteria can acquire new characteristics, which makes them more difficult to treat.
D. Both bacteria and viruses are surrounded by protective coverings, though the composition of each covering may be different.

Item 4

Multi-Select Technology-Enhanced

Scientists have studied a type of phytoplankton species. 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 plankton. 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 growth of the plankton population and the viruses for a period of time and graphed the results once they were averaged, as shown below.



The scientists claim that the growth and stability of the population of plankton 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 increased, the number of viruses increased because the phytoplankton were the hosts to the viruses and replicated the viruses' genome.

E. The phytoplankton population was affected by the increase in number of viruses in the environment because the viruses used most of the carbon found in the environment.

F. The plankton 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.

ENERGY TRANSFORMATIONS

Energy can neither be created nor destroyed, but it can be transformed as it flows through organisms and ecosystems.

AREAS OF FOCUS

Cells

- Photosynthesis and respiration are essential in the cycling of matter and energy within the cell. (SB1e)
- It is important to understand the inputs, outputs, and functions of photosynthesis and respiration. (SB1e)
- The functions of the major subprocesses of photosynthesis and respiration include glycolysis, Krebs cycle, electron transport chain, light reactions, and Calvin cycle. (SB1e)

Organisms

- Energy transformation and the cycling of matter are the reasons organisms within an ecosystem depend on one another. (SB5b)
- Specific factors that affect ecosystems are size, carrying capacity, response to limiting factors, and keystone species. (SB5a)

Ecology

- Food webs are useful models to represent the flow of energy. (SB5b)
- An energy pyramid is a model that can provide information about biomass and energy moving from producer to consumer and on to higher-order consumers. (SB5b)
- The carbon cycle, oxygen cycle, and hydrogen cycle model how these major biochemical elements move through ecosystems. (SB5b)

Understand the Characteristics of the Four Major Macromolecules

Carbohydrates, lipids, proteins, and nucleic acids are the foundations for the structure and function of every living cell in every organism. They are the building materials of the body and the storehouse for energy for every activity. Most of these macromolecules are made up of repeating units called monomers. Monomers are bonded together to make up a polymer.

Carbohydrates

A carbohydrate is a simple sugar or a molecule composed of two or more simple sugars. In general, the ratio of carbon, hydrogen, and oxygen atoms is 1:2:1 in a carbohydrate molecule. There are three classes of carbohydrates: monosaccharides, oligosaccharides, and polysaccharides. Glucose, sucrose, glycogen, and cellulose are examples of carbohydrates. In all living organisms, carbohydrates are broken down to provide usable chemical energy for cells. In plants, the carbohydrate cellulose is used for structural support in making cell walls.

Mono means "one." Saccharide means "sugar." Put the two together and you have one sugar unit. Oligo means "few." An oligosaccharide is a short chain of two or more covalently bonded sugar units. Poly means "many." A polysaccharide is a straight or branched chain of sugar units in which there may be hundreds or thousands of the same kind or different kinds of sugars bonded to one another.

Lipids

Lipids are organic compounds that have more carbon-hydrogen (C-H) bonds and fewer oxygen atoms than carbohydrates. They are extremely important for the proper functioning of organisms. Lipids are commonly called fats and oils. They are insoluble in water because of the nonpolarity of the molecules. Lipids are used by cells for long-term energy storage. Lipids are also a major component of cell membranes. *Waxes* are longchain fatty acids attached to an alcohol. An example is cutin in plants. It helps the plants retain water.

Proteins

Proteins belong to the most diverse group. They are large, complex polymers essential to all life. They are composed of chains of amino acids. These amino acids are made of carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur. Proteins are important in muscle contraction, transporting oxygen in the blood, and the immune system. Proteins, like lipids, are an important component of cell membranes. Collagen, enzymes, hemoglobin, insulin, and antibodies are examples of proteins.

Nucleic Acids

Nucleic acids are complex macromolecules that store and transmit genetic information in cells in the form of a code. To form nucleic acids, four different kinds of nucleotides are strung together. A nucleotide is a small organic compound that consists of a five-carbon sugar, a nitrogen-containing base, and a phosphate group. Nucleotides are the structural units of adenosine phosphates, nucleotide coenzymes, and nucleic acids. Examples of nucleotides include ATP, NAD^+, and $NADP^+$, and examples of nucleic acids include RNA and DNA.

Explain the Flow of Energy Needed by All Organisms to Carry Out Life Processes

Energy in a Cell

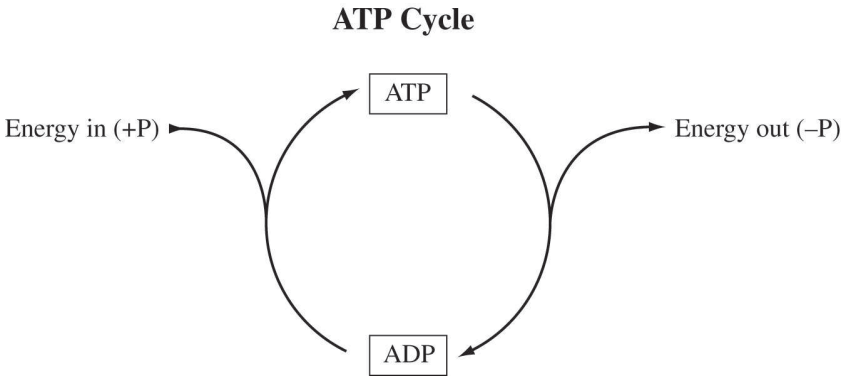
All life on Earth depends on the flow of energy. The primary source of this energy is the Sun. Plants and other photosynthetic organisms (for example, cyanobacteria, or blue-green algae) are the entry point for this flow of energy. The process of photosynthesis supports almost all life on Earth directly or indirectly. Photosynthesis is the process that converts solar energy to chemical energy in the form of carbohydrates. Carbohydrates are then broken down by the metabolism of the cells of these photosynthetic organisms or by the cells of other organisms, such as animals, fungi, or microbes that consume plant materials. In all cells, the processes of life are constantly moving and rearranging atoms, ions, and molecules. All this biological work requires energy.

Understanding ATP

ATP, adenosine triphosphate, is a special molecule that stores and releases the energy in its bonds in response to the energy needs of the cell. Cells work constantly to maintain a vast supply of this energy storage molecule. The stored energy is released when ATP is split into ADP, adenosine diphosphate, and an inorganic phosphate. Remember that ATP and ADP are nucleotides. When the appropriate enzyme is present, the terminal phosphate group of an ATP molecule can be transferred to a variety of other compounds.

The energy released when ATP is split is stored in other energy-intermediate molecules and is used to power other biological processes. Most of these processes are energy-requiring biological reactions in cells.

Consider the following cycle:



This process is known as phosphorylation.

When a phosphate group is removed, energy is released for chemical reactions to occur in the cell, and ATP becomes ADP. When the cell has an excess of energy, the energy is stored in the bond when the phosphate group is added to the ADP.

ATP is the major energy link between energy-using and energy-releasing reactions. The amount of energy released when the phosphate group bond breaks is suitable for use in most cellular reactions.

The Biology EOC assessment will assess your knowledge and understanding of the ATP-ADP cycle and the importance of energy to all life.

Examples of Ways That Cells Use Energy

Cells use energy to make new molecules, including enzymes, and to build cell organelles and membranes. Cells also use energy to maintain homeostasis. Some cells, such as muscle cells, use energy from ATP in order to move. Nerve cells are able to transmit impulses by using ATP to power the active transport of certain ions. Lightning bugs, certain caterpillars, and some deep-sea organisms produce light by a process known as bioluminescence. The light that is produced is a result of a chemical reaction that is powered by the breakdown of ATP.

Many of the carbon atoms and oxygen molecules that you breathe once cycled through the tissues of a plant. Plants, algae, and other photosynthetic organisms are important to the maintenance and balance of life on Earth. They convert solar energy to chemical energy in the form of carbohydrates. Photosynthetic organisms must also break down carbohydrates to form ATP. These carbohydrates are usually in the form of simple sugars, mainly glucose. The process of breaking down carbohydrates for ATP is called cellular respiration.

Trapping Energy—Photosynthesis

Autotrophs are organisms that can manufacture their own energy-providing food molecules. Most autotrophic organisms trap energy from the Sun and use this energy to build carbohydrates in a process known as photosynthesis. This trapped energy is used to convert the inorganic raw materials CO_2 and H_2O to carbohydrates and O_2. The key to this process is the pigment chlorophyll, which is the molecule in the chloroplasts of plants that absorbs energy from sunlight.

The general equation for photosynthesis is as follows:

$$\mathbf{6CO_2 + 6H_2O + \text{energy from sunlight} \rightarrow C_6H_{12}O_6 + 6O_2}$$

Two Main Reactions of Photosynthesis

1. Light reactions: These reactions split water molecules, providing hydrogen and an energy source (ATP and NADPH) for the Calvin cycle. Oxygen is given off.
2. Calvin cycle: This cycle is the series of reactions that form simple sugars using carbon dioxide and hydrogen from water.

The light reaction is the *photo* part of photosynthesis.
The Calvin cycle is the *synthesis* part of photosynthesis.

Using Energy—Cellular Respiration

The general equation for cellular respiration is as follows:

$$\mathbf{C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}}$$

Once light energy is used to make carbohydrates, any organism can then use the carbohydrates for energy for life processes. Organisms get energy from carbohydrates through the process of cellular respiration to make ATP.

Three Main Reactions of Cellular Respiration

1. Glycolysis: The series of reactions takes place in the cell's cytoplasm and is anaerobic (without oxygen). The glucose that entered the cell by active transport is broken down by enzymes into pyruvic acid. Two molecules of ATP are also produced.
2. Krebs cycle: This cycle breaks down the products of glycolysis to produce molecules used in the electron transport chain.
3. Electron transport chain: This chain consists of a series of proteins in the mitochondrial membranes that convert ADP to ATP by transferring electrons.

The Biology EOC assessment will assess your knowledge and understanding of the process of photosynthesis, the ATP-ADP cycle, the process of cellular respiration, and the importance of energy to all life.

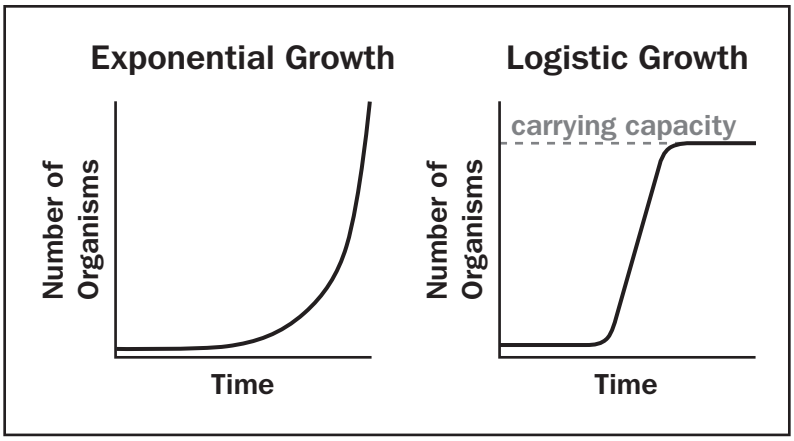
Investigate the Relationships among Organisms, Populations, Communities, Ecosystems, and Biomes

Populations

A group of organisms of one species that lives in the same place at the same time is a population. Organisms in a population compete for food, water, mates, and other resources. The way that organisms in a population share the resources of their environment will determine how far apart the members of the population will live and how large that population will be. Population density is the number of organisms living in a given area. Some organisms, such as tigers, require much space, while others, such as pine trees, can live close together. Keep in mind that some species have adaptations that minimize the competition within a population. An example is the frog. The first stage of a frog's life is a tadpole. Tadpoles are completely different from adult frogs. Their food source is different. They have gills and live in the water. Many insects have juvenile stages at which they require resources very different from those of their adult counterparts. This minimizes competition within a population.

Communities

A population usually does not live independently of other species. Each population is connected. A community is made up of several populations interacting with each other. This is where balance becomes very important. If there is a change in one population, it can dramatically affect the others living within the community. An increase in one population can cause a decrease in another, sometimes with devastating effects. This change in population size is known as growth rate. A growth rate can be positive, negative, or zero. If a population is provided with ideal conditions, it will increase in number. Healthy organisms reproduce at a rate greater than their death rate. As long as these ideal conditions continue, as the population grows larger the rate of growth increases. This growth is called exponential growth. This pattern of exponential growth is in the shape of a J curve. But growth has limits. If deer were allowed to continually reproduce, the planet would be overrun with deer! However, as the population increases, the resources that are available become limited and the growth of the population slows and begins to stabilize. This pattern of logistic growth is an S-shaped curve. The point at which the population becomes stable is known as the carrying capacity. It is the maximum stable population size an environment can support over time. On the Biology EOC assessment, you may be given a chart or graph and may be asked to identify growth rates.



Remember, when working with graphs, carefully read the title and the label on each axis.

When a population reaches its carrying capacity, a number of factors help stabilize it at that size. They are called density-dependent limiting factors.

Density-Dependent Limiting Factors
Competition
Predation
Parasitism
Crowding/Stress

Density-Independent Limiting Factors
Weather
Fires
Droughts/Floods
Human Activities

The Flow of Matter and Energy through Ecosystems

Energy Flow

Energy is constantly flowing through ecosystems. The primary source of this energy is the Sun. Plants, algae, and some bacteria are producers. Producers harness the Sun's energy to make energy-rich molecules that they and all other organisms can use to make living tissues. The process of photosynthesis uses the Sun's energy to convert carbon dioxide and water into glucose and oxygen. Glucose is the molecule that provides all organisms with a source of energy. Producers are also called autotrophs, meaning "self-feeding," because they do not need other organisms to provide them with energy-rich molecules.

Because animals cannot harness energy from the Sun, they need to eat other organisms to obtain energy and matter. Animals are consumers. They are also known as heterotrophs, meaning they need to feed on other organisms. Animals store energy in their bodies in the forms of complex carbohydrates, fats, and proteins. Decomposers are organisms that feed on dead bodies of animals and plants or on their waste products. Organisms are grouped into trophic levels based on their source of energy—organisms with the same energy sources are on the same trophic level.

Consumer	Energy Source	Example
Herbivores	Eat plants	Deer
Carnivores	Eat other animals	Lions
Omnivores	Eat both plants and animals	Raccoons
Decomposers	Break down dead organisms	Bacteria

Because energy cannot be recycled, there must be a way for it to move through an ecosystem. As sunlight hits Earth, the energy flows first to producers, then to consumers, and finally to decomposers. This is called a food chain.

A food chain shows how energy and matter flow through an ecosystem.

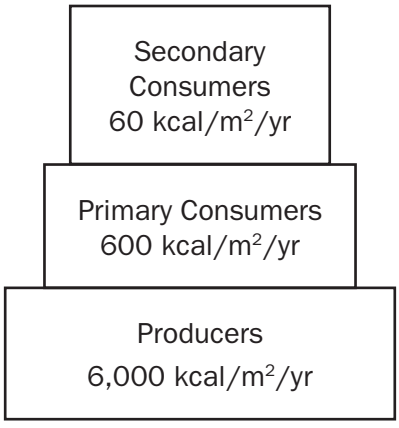
A Food Chain

Sun → grass → mice → hawk

On the Biology EOC assessment, you may be given a diagram of a food chain or web and may be asked to describe the roles of different organisms.

A food chain is a simplified way for ecologists to study how energy and matter flow. But it is not always that simple. Relationships exist between organisms that feed on more than one species. In an actual ecosystem, there are many more plants and animals involved. A more complex interconnected system of food chains is called a food web.

Ecologists use energy pyramids to show how energy decreases at each succeeding trophic level. The total energy transferred from one trophic level to the next is only about 10 percent. Not all the food consumed at each level is actually used for growth. Every time one organism eats another, most of the energy is used for energy by the consuming organism, excreted as waste, or lost as heat rather than being stored as living tissue. Ecologists construct energy pyramids based on the available energy at each trophic level. This explains why population sizes decrease through the trophic levels.



Recycling of Matter

Unlike energy, which flows in one direction through an ecosystem, matter is recycled. Matter (or elements) cycles from one organism to another through food webs. Matter cannot be replenished in an ecosystem, unlike the energy from the Sun. For example, carbon is found in the environment as carbon dioxide (CO_2) gas. From the atmosphere, carbon dioxide is used during photosynthesis to form sugar. Respiration and decay are two ways that carbon returns to the atmosphere as a gas. Carbon also returns to the atmosphere when fossil fuels are burned.

As a second example, nitrogen gas makes up 78% of Earth's atmosphere, but it is in an unusable form. Lightning and some bacteria convert atmospheric nitrogen into usable nitrogen-containing compounds. Plants use these nitrogen compounds to make proteins and nucleic acids. Herbivores eat the plants and convert plant proteins into animal proteins and nucleic acids. Organisms return nitrogen to the atmosphere through decay.

Refer to your textbook for diagrams and additional information about the cycles of the elements carbon, oxygen, hydrogen, and nitrogen. On the Biology EOC assessment, you may be asked to describe the interactions of biotic and abiotic factors in these various cycles.

SAMPLE ITEMS

Item 5

Selected-Response

Hemoglobin is a protein found in 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?

A. The mutated hemoglobin protein can still carry carbon dioxide to be expelled from the organism.
B. Hemoglobin must be a simple molecule because it is found in both vertebrates and invertebrates.
C. Structural changes of hemoglobin affect its ability to carry oxygen indicating that the shape of a protein is important to its function.
D. 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 6

Multi-Select Technology-Enhanced

Bromothymol blue (BTB) is a pH indicator that is also used to detect carbon dioxide (CO_2). BTB is blue when pH is basic and CO_2 is low. BTB is yellow when pH is acidic and CO_2 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 CO_2 produced by elodea to produce oxygen?
E. Does photosynthesis performed by elodea remove CO_2 from the water?
F. Does cellular respiration occur at a higher rate than photosynthesis in the tube with only elodea?

Item 7

Selected-Response

Ruby-throated hummingbirds are found throughout eastern North America. They are omnivores, feeding on nectar, pollen, tree sap, insects, and spiders. They get all the water they need from nectar. Most nests are in forested areas, citrus groves, marshes, and scrubland. The hummingbirds breed in the spring and the summer, and females raise one to three broods per breeding season. Most of the hummingbirds migrate to Mexico or Central America for the winter. Many fly nonstop for 20 hours to cross the Gulf of Mexico. However, increasing numbers of the hummingbirds have begun to winter north of the gulf. Researchers have documented that the hummingbirds' winter range has expanded northward by about 300 km in recent years.

Which explanation BEST predicts the ability of the hummingbirds to survive their first winter in this new environment?

A. Finding suitable nesting materials and sites is the most important task the hummingbirds must accomplish because they must produce offspring.

B. Finding a sufficient supply of flowering plants, flowering trees, and insects is the most important task for the hummingbirds because they need food to survive.

C. Finding bodies of water is the most important task for the hummingbirds because they need to supplement the supply of nectar if it is inadequate to provide all the calories the hummingbirds need to survive.

D. Finding mates to allow the hummingbirds to lay fertile eggs and have two parents to feed the new hatchlings is the most important task for the hummingbirds because they need to ensure there is a new generation of hummingbirds in the region.

GROWTH AND HEREDITY

Organisms must be able to grow and reproduce to ensure species survival.

AREAS OF FOCUS

Cells

- The structures of DNA and RNA lead to the expression of information within the cell. (SB2a)
- The processes of replication, transcription, and translation are the mechanisms by which information in DNA becomes a protein. (SB2a)
- Genetic variation can result from meiosis, mutations to DNA during replication, or mutations to reproductive cells caused by environmental factors. (SB2b)

Genetics

- Mendel's laws increase reproductive variability during meiosis. (SB3a)
- Mathematical models (Punnett squares and probability) can be used to predict and explain patterns of inheritance. (SB3b)
- Inheritance patterns include dominance, codominance, and incomplete dominance. (SB3b)
- Environmental conditions determine the relative advantages and disadvantages of sexual and asexual reproduction for a population. (SB3c)
- Biotechnology in forensics, medicine, and agriculture should be evaluated for its benefits and the ethics of its use. (SB2c)

Evolution

- Genetic variation within a species is one of the foundational themes of natural selection. Genetic variations may result from meiosis, nonlethal errors that occur during DNA replication, or inheritable mutations caused by environmental factors. (SB2b)

Ecology

- Heritable mutations may be caused by environmental factors (radiation, chemicals, and viruses). (SB2b)

KEY IDEAS

Explain the Role of Genetic Information in Storing and Transmitting Cellular Information

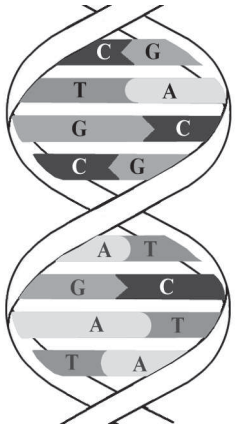
When you visit a library, you will find a host of information readily available to you on many subjects. A library can be considered a storehouse of information. Our bodies contain millions of cells that are considered storehouses as well. Just as each book in a library contains information, cells also contain information that is used to carry out cell functions. An acorn from an oak tree will grow into another oak tree, not into a maple tree or a pine tree. For thousands of years, people have wondered how sons and daughters have characteristics similar to their parents. How does this happen? Where does it all take place? The phrase "like begets like" becomes very clear when we study genetics.

Genetics is the branch of biology that studies heredity, the passing on of characteristics from parents to offspring. These characteristics are called traits.

DNA

DNA forms a complex biological polymer called a nucleic acid that is used for information storage. Nucleic acids are made up of monomers called nucleotides. The components of a DNA nucleotide are deoxyribose, a phosphate group, and a nitrogen base. DNA has four nitrogen bases—adenine (A), guanine (G), cytosine (C), and thymine (T).

In DNA, nucleotides combine to form two long chains similar to a ladder that has twisted into a spiral. This spiral is the double helix, or double-stranded DNA. The two strands of nucleotides are held together by hydrogen bonds between the nitrogen-containing bases. The sides of the ladder consist of phosphate groups alternating with five-carbon sugars. In DNA, deoxyribose is the five-carbon sugar. The hydrogen bonding in DNA allows for only certain base pairings. In DNA, adenine bonds with thymine (A-T) and guanine bonds with cytosine (G-C). DNA carries information in a triplet code; each sequence of three nucleotides either codes for a particular amino acid or indicates the beginning or end of a sequence. The DNA sequences are unique for each organism.



How can organisms be so different if their genetic material is made of the same molecules? A squirrel is different from a tree because the order of nucleotides in their DNA—their genetic code—is different.

DNA has the unique ability to make an exact copy of itself in a process called replication. During DNA replication, an enzyme breaks the hydrogen bonds between nitrogen bases that hold the two DNA strands together. This enzyme "unzips" the two DNA molecules, allowing free nucleotides to bond to the two single strands by base pairing. This process continues until the entire molecule has been replicated. Each new strand formed is a complement of one of the original, or parent, strands. At the end of replication, there are two copies of the genetic information that will be passed on to new cells through mitosis or to new generations through meiosis.

In eukaryotic cells, DNA is found inside the nucleus, coiled into chromosomes. Prokaryotes lack nuclei, and their DNA is either attached to the cell membrane or is free-floating in the cytoplasm. A small amount of DNA is also found in mitochondria, in eukaryotes, and in small circular units calls plasmids in prokaryotes.

RNA

RNA, like DNA, is made of nucleotides. The sugar in RNA is ribose, and the nitrogen-containing base uracil replaces the thymine found in DNA. The uracil in RNA pairs with adenine during complimentary base pairing. RNA is a single strand of nucleotides. In the process of transcription, RNA transfers the genetic information from DNA to the ribosomes in the cytoplasm. At the ribosomes, the process of translation uses the genetic code on the RNA to form proteins from amino acids.

Transcription is similar to the DNA process of replication, but only one strand of nucleotides is formed. DNA is used as a template to make messenger RNA (mRNA). The mRNA carries the genetic information from DNA to ribosomes in the cytoplasm.

Translation is the process of converting the information in the mRNA into a sequence of amino acids that make proteins. Transfer RNA (tRNA) brings the amino acids to the mRNA at the ribosomes so protein synthesis can take place. To have the correct translation of the code, mRNA codons must join with the correct anticodon of the tRNA. A codon is a group of three nitrogenous bases on an mRNA molecule that carries the code for a specific amino acid. An anticodon is a set of three nitrogenous bases on a tRNA molecule that matches a codon on an mRNA molecule.

Review your textbook for additional information and diagrams to help you understand these processes.

In summary, messenger RNA (mRNA) carries the message of the genetic code from the DNA in the nucleus to the ribosomes in the cytoplasm. At the ribosomes, the mRNA sequence is translated into a protein in a process known as translation. Transfer RNA (tRNA) transfers the amino acids in the cytoplasm to the ribosomes. The amino acids are lined up in the coded sequence to form a specific protein.

Using Mendel's Laws, Explain the Role of Meiosis in Reproductive Variability

Gregor Mendel, an Austrian monk, was the first to succeed in predicting how traits are carried from one generation to the next. He used pea plants in his experiments because they reproduce sexually. He was very careful to study one trait at a time to control the variables. He would manipulate flower parts in order to fertilize the female gamete with the male gamete in the desired parent plants. Mendel discovered that when he crossed tall plants with short plants, the first generation of offspring (F_1) were all tall. When he let the F_1 plants self-pollinate, Mendel found that three-fourths of their offspring (F_2) were tall and one-fourth of the F_2 plants were short. The short trait had reappeared in the second generation (F_2). Mendel came to the conclusion that each organism has two factors for each of its traits. Mendel called the trait that appeared in the first generation dominant and the trait that seemed to disappear recessive. Today, scientists call the locations for these factors genes. Genes are located on the chromosomes and can exist in alternative forms called alleles. Alleles are found on different copies of chromosomes, one from the female parent and the other from the male parent. The genotype is a list of the alleles for a particular trait in an organism. The phenotype is the physical appearance of an organism, or how the alleles influence the function of that particular gene in the organism.

If the two alleles in a pair are identical, then the trait is called homozygous. If the two alleles are different, then the trait is called heterozygous. Genetic crosses that involve one trait are called monohybrid crosses, while dihybrid crosses involve two traits. Outcomes of genetic crosses can be predicted by using the laws of probability. Using a Punnett square will give the possible results of genetic crosses.

Consider the following genetic cross and its corresponding Punnett square:

In rabbits, black fur (B) is dominant over brown fur (b). If one parent rabbit is heterozygous (Bb) and the other parent rabbit is homozygous brown (bb), what is the probability of producing an offspring with brown fur? Use the Punnett square to determine your answer.

For this cross, the Punnett square would look like this:

	B	**b**
b	**Bb**	**bb**
b	**Bb**	**bb**

From the Punnett square, you can determine that half (50%) of the offspring would be black (Bb), while the other half (50%) would be brown (bb). Therefore, the probability of producing an offspring with brown fur is 50%, or 2 out of 4.

Mendel's work can be summarized in three laws:

- The Law of Dominance states that the dominant allele will prevent the recessive allele from being expressed. The recessive allele will appear when it is paired with another recessive allele in the offspring.
- The Law of Segregation (separation) states that gene pairs separate when gametes are formed, so each gamete (sex cell) has only one allele of each pair.
- The Law of Independent Assortment states that different pairs of genes separate independently of each other when gametes are formed.

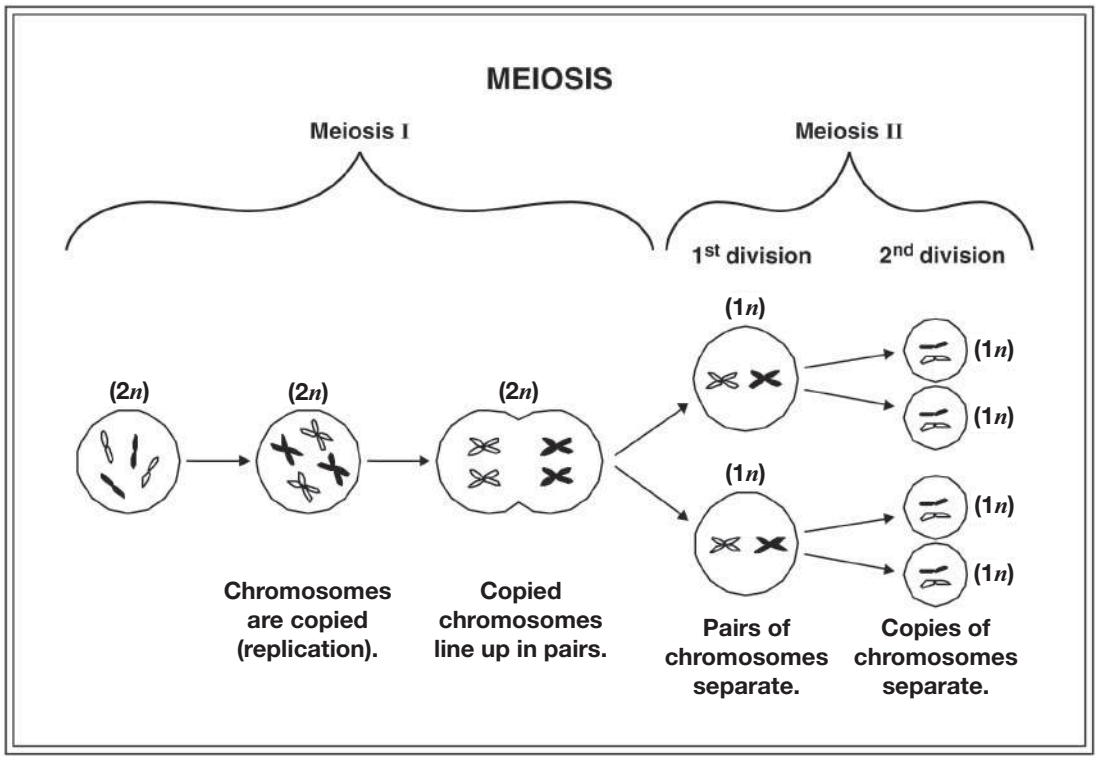
Genetic Terms

- Allele
- Dihybrid
- Dominant
- Gene
- Genotype
- Heterozygous
- Homozygous
- Monohybrid
- Phenotype
- Recessive
- Trait

Review the terms in the box and study their definitions to gain a better understanding of the concept of heredity through Mendel's experiments.

Meiosis, which occurs in two phases, Meiosis I and Meiosis II, is the process by which gametes (sex cells) are produced. In males, gametes are called sperm, and in females, they are called eggs. Meiosis reduces the number of chromosomes in the gamete to one-half the number of chromosomes in the parent's body cells. When fertilization—the union of two gametes—occurs, a zygote is formed. Fertilization restores the original chromosome number in the resulting zygote (new individual).

Consider the following diagram, which illustrates meiosis beginning with two pairs of chromosomes:



Meiosis occurs only in the formation of sex cells. This process consists of two cell divisions but only one chromosome replication.

- The first meiotic division produces two cells containing half the number of double-stranded chromosomes. These are called haploid (1*n*) cells.
- The second meiotic division results in the formation of four cells, each containing half the number of single-stranded chromosomes. These are also called haploid (1*n*) cells.

Sources of Variation during Meiosis

The process of meiosis provides the opportunity for the shuffling of chromosomes and the genetic information they contain. The way that the chromosome pairs line up at the equator during meiosis influences how they are distributed to the gametes. (To help you visualize this process, refer to diagrams in your textbook and class notes.) For example, Mendel studied the pea plant, which has seven pairs of chromosomes. Each of these seven pairs of chromosomes can line up during meiosis in two different ways, producing 128 (2^7) different combinations of traits. The number of possible combinations will greatly increase as the number of chromosomes increases within a given species. Human gametes have 23 chromosomes. So the number of different kinds of genetic combinations a person can produce is astounding—more than 8 million! When fertilization occurs, $2^{23} \times 2^{23}$ different genetic combinations can occur. That is 70 trillion!

Another source of variation during Prophase I of meiosis is crossing over. Crossing over occurs when two chromosomes physically overlap and exchange chromosome material. This process occurs more often on some chromosomes than on other chromosomes and changes the DNA sequence within each chromosome. This results in an endless number of different possible genetic combinations. Whether by crossing over or by independent assortment of homologous chromosomes, the end result is a reassortment of chromosomes and the genetic information they carry.

Refer to your textbook and class notes for illustrations of these processes.

Describe the Relationships between Changes in DNA and the Appearance of New Traits

DNA Mutations

Every so often genes do change. Changes in the nucleotide sequence of a DNA molecule are known as gene mutations. Mutations may cause a change in the protein resulting from the genetic code for that gene. Some mutations are the result of exposure to agents such as ultraviolet light, ionizing radiation, free radicals, and substances in tobacco products and other chemical compounds. These agents that harm DNA are called mutagens. Mutations can also occur in the absence of these mutagens. Spontaneous mutations may occur as a result of replication errors. Also, the enzymes that repair a mistake may "fix" the wrong base.

Regardless of the cause of the mutation, there are several types of changes that may result: base-pair substitution, base insertion, and base deletion. Base-pair substitutions occur when one nucleotide base is replaced by another. This change may lead to the substitution of one amino acid for another during protein synthesis. An example of this is sickle-cell anemia, a genetic disorder that has structural and physiological consequences. A base insertion mutation is an addition of an extra nucleotide base into the DNA sequence. A base deletion mutation is the removal of a nucleotide base from the DNA sequence. In both base insertion mutations and base deletion mutations, a frame shift occurs. Remember that the nucleotide sequence is read as a triplet code. A deletion or an insertion in a gene region will shift this reading frame, causing an abnormal protein to be synthesized.

Whether a gene mutation is harmful, neutral, or beneficial will depend on how the resulting proteins interact with other proteins and with the environment in which they are placed.

Review your textbook for more in-depth information regarding genes and gene mutations and alterations during replication.

Compare the Advantages of Sexual and Asexual Reproduction in Different Situations

At the mouth of the Saco River in Biddeford, Maine, thousands of mature salmon have returned from the open ocean to travel upriver to spawn in the place of their birth. The females have turned red, a color that indicates that they will spawn and then die. The trip upriver will be a tough one for the salmon. As the female salmon releases translucent pink eggs into a shallow nest dug out by her fins in the riverbed, a male salmon comes along and sheds a cloud of sperm that will fertilize the eggs. In about three years the pea-sized eggs will become salmon, made of billions of cells. A portion of these cells will become eggs or sperm. In time, the life cycle of the salmon will begin again: birth, growth, reproduction, and death. As with any organism, growth as well as reproduction depends on cell division.

Advantages of Sexual and Asexual Reproduction

Single-celled and many multicelled organisms reproduce asexually by a process called mitosis, which is simple cell division. In mitosis, DNA is divided equally between two daughter cells. In mitosis in eukaryotes, the DNA is sorted into the two new nuclei formed. A separate process divides the cytoplasm in two. Mitosis keeps the number of chromosomes constant from one cell generation to the next. In multicellular organisms, cell division allows them to grow (i.e., increase the size of the organism), develop from a single cell into a multicellular organism, and make other cells to repair and replace worn-out cells.

Asexual reproduction does not require another partner, and the resulting organism is identical genetically to the parent organism. Organisms that reproduce asexually can produce many identical offspring in a short period of time. Asexual reproduction is an advantage in a stable environment where the parental genotype is well-suited. Many colonizers of new environments reproduce asexually.

Sexual reproduction involves much more time than asexual reproduction. Gametes must be formed through the process of meiosis, and mating must occur between two organisms of different sexes. There is also time involved in the growth and development of the offspring. The benefit of sexual reproduction is the genetic variability that results from the process of meiosis. Genetic recombination allows offspring greater diversity and increases the likelihood that some offspring will have more advantageous traits than the parents. Sexual reproduction is an advantage in a rapidly changing environment because the diversity of the population increases the possibility that some organisms will both survive and reproduce.

Questions on the Biology EOC assessment may ask you to state the significance of cell division for unicellular and multicellular organisms.

Examine the Use of DNA Technology in Forensics, Medicine, and Agriculture

DNA Technology and Genetic Engineering

New DNA technologies have resulted in advances in medicine, forensics, and agriculture. Certain genetic diseases may be cured by reinserting a corrected gene into the patient to replace a damaged gene. Forensic labs use DNA technology to identify people through DNA fingerprinting. Crime scene evidence such as blood or hair samples can be used to connect suspects to the crime by looking for DNA sequence similarities. Plant biologists have used DNA technology to produce plants with many desirable traits. These include increased disease resistance, increased herbicide resistance, and increased nutritional content.

Today, researchers use recombinant DNA technology to analyze genetic changes. They cut, splice together, and insert modified DNA molecules from different species into bacteria or other types of cells that rapidly replicate and divide. The cells copy the foreign DNA right along with their own DNA. An example of this is the gene for human insulin. When the gene is transferred into a bacterium, the bacterium will use the "recombined" genetic code to produce human insulin. This is how human insulin is mass-produced. This insulin has saved the lives of many people with diabetes. Genetic engineering not only has applications in medicine and the environment but also has uses in industry and agriculture. Sheep are used in the production of alpha-1 antitrypsin, which is used in the treatment of emphysema. Goats are also producing a human protein used in the treatment of cystic fibrosis.

In the plant world, the buds of cotton plants are vulnerable to worm attacks. The buds of a genetically modified cotton plant resist these worms, resulting in increased cotton production. These gene insertions are ecologically safer than pesticides because they affect only the targeted pest.

Scientists today have developed genetically altered bacteria to eat up oil spills, manufacture alcohol and other chemicals, and process minerals. There is, however, concern about possible risks as genetically engineered bacteria are introduced into the environment.

It is important to remember that recombinant DNA technology and genetic engineering have a great potential for application in medicine, agriculture, and industry. As with any new technology, the potential risks must be taken into account, including social and environmental risks.

SAMPLE ITEMS

Item 8

Selected-Response

Students studied Mendel's laws of segregation and independent assortment. They created a Punnett square to show a cross between a homozygous furred mouse (FF) and a homozygous furless mouse (ff). The students then created a Punnett square for a cross between two heterozygous F_1 mice.

FF × ff

	F	F
f	Ff	Ff
f	Ff	Ff

F_1 generation

Ff × Ff

	F	f
F	FF	Ff
f	Ff	ff

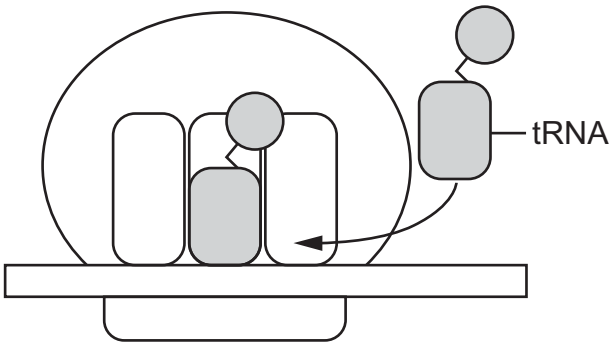
F_2 generation

Which question could be answered using the information from the Punnett squares?

A. Can furred mice produce furless mice?
B. How many mice will be produced in the F_1 generation?
C. Will fewer furless mice survive to adulthood than furred mice?
D. Are furred mice the best organism to use for this investigation?

Item 9

Selected-Response



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

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

Item 10

Selected-Response

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 11

Selected-Response

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

Snapdragon Punnett Square

	R	*R*
r	*Rr*	*Rr*
r	*Rr*	*Rr*

Key
RR = red flowers
rr = white flowers
Rr = pink flowers

Which statement BEST explains the inheritance of flower color in snapdragons?

A. The allele for pink flower color is dominant because heterozygous individuals display this trait.

B. The alleles for white flower and red flower color are dominant because they are expressed in homozygous individuals.

C. The alleles for flower color show incomplete dominance because both alleles are partly expressed in heterozygous individuals.

D. The alleles for flower color show codominance because both alleles are completely expressed in heterozygous individuals.

Item 12

Multi-Part Technology-Enhanced

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.

Part B

Growers on large banana plantations 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.

EQUILIBRIUM

Survival and stability require that living things maintain biological balance at all levels.

AREAS OF FOCUS

Cells

- Cell structures and organelles (including nucleus, cytoplasm, cell membrane, cell wall, chloroplasts, lysosome, Golgi, endoplasmic reticulum, vacuoles, ribosomes, and mitochondria) interact as a system to maintain homeostasis. (SB1a)
- Cellular transport (i.e., active, passive, and osmosis) plays an important role in maintaining homeostasis. (SB1d)

Ecology

- Environmental change impacts the stability of an ecosystem. (SB5c)
- Human activities such as chemical use, consumption of natural resources, introduction of nonnative species, and greenhouse gas production have a negative impact on the environment. (SB5d)
- Organisms are limited in their ability to survive within a changing environment (e.g., temperature, pH, drought, fire). (SB5e)

KEY IDEAS

The Importance of Homeostasis

Organisms maintain their internal equilibrium by responding and adjusting to environmental stressors. For example, aquatic organisms must respond to changes in water temperature, sunlight, chemicals, and other organisms. All organisms must adjust and respond to changes in their environment. Failure to do so may result in death.

Living cells maintain a balance between materials entering and exiting the cell. Their ability to maintain this balance is called homeostasis. It is important for a cell to control internal concentrations of water, glucose, and other nutrients while also eliminating cellular wastes.

Cell Membrane

One function of the cell membrane is to control what comes into and goes out of a cell. In this way, the cell membrane helps maintain the proper concentrations of substances inside the cell.

Selective permeability is the property of the membrane that allows certain materials to pass through the cell while keeping others out. It also allows different cells to perform different activities within the same organism. An example of this is the nerve cell. Nerve cells respond to a certain chemical that is present in the bloodstream. Other cells are exposed to this chemical but are not affected by it.

Passive/Active Transport

There are various mechanisms that transport materials into and out of the cell. Passive transport is the movement of materials across the cell membrane without the use of the cell's energy. Different types of passive transport are shown in the box below.

Diffusion: the movement of substances across the cell membrane from an area of high concentration to an area of lower concentration

Osmosis: the diffusion of water molecules through a selectively permeable membrane from an area of low solute concentration to an area of high solute concentration

Facilitated transport (facilitated diffusion): occurs when a carrier molecule embedded in the cell membrane transports a substance across the membrane by means of diffusion

Active transport, endocytosis, and exocytosis are processes that use energy to transport materials into or out of the cell. Active transport is the process by which materials are transported through the cell membrane against a concentration gradient, as in the sodium-potassium pump. Endocytosis and exocytosis move large particles into or out of the cell as described in the boxes below.

Active transport: a process that drives molecules across the cell membrane from a region of lower concentration to a region of higher concentration

Endocytosis: a process in which a cell surrounds and takes in material from its environment

Exocytosis: a process in which a cell surrounds and removes materials from inside the cell

• ALL REQUIRE ENERGY •

STRATEGY BOX—Word Parts

Studying the following word parts will help you determine the meanings of certain words you will come across on the Biology EOC assessment.

BIO—"life"

ENDO—"inside"

EXO—"outside"

LOGY—"study of"

CYTO—"cell"

OSIS—"process or action"

Relate Plant Adaptations, Including Tropisms, to the Ability to Survive Stressful Environmental Conditions

Even though plants do not have nervous systems, they do possess mechanisms that enable them to respond to their environment. These responses are known as tropisms. It is a Greek word that means "to turn." Plants will shift the positions of their roots, stems, leaves, and flowers in response to environmental conditions such as sunlight, temperature, water, and gravity. There are several types of tropisms. Gravitropism is the response of seedlings to the force of gravity. It is important when seeds are sprouting. Gravitropism causes the roots to grow downward and the stems to grow upward, no matter what the position of the seed when it is planted. Phototropism is the ability of the plant to respond to light. If a plant is placed near a window or another light source, the plant will grow in the direction of the light source. A phototropic response can happen so quickly that even a seedling will respond within a few hours. Thigmotropism is the response of a plant to touch. Climbing plants, ivy, and vines use thigmotropism in order to find their way up or around a solid object for support. It is also used by some plants for protection. Some plants respond to other stimuli from the environment, such as length of night (photoperiodism) and the seasons. Some flowers bloom once a year, while some others, like some cacti, bloom at night.

Examples of Adaptations

Seeds of many plants will go dormant in unfavorable conditions. In a drought period, many will lay dormant until the rains come. Then they will sprout. Roots and stems are modified in many plants into storage organs in order to survive through winter or drought underground. Tulips, daffodils, and crocuses are examples. Many trees drop their leaves and go dormant for the winter. The leaves of conifers have a waxy coating over them to reduce evaporation and to conserve water. The bark on conifers is thick, helping to insulate the tissues from fire. The branches of conifers are flexible, allowing them to bend instead of breaking under the weight of ice and snow. These adaptations help plants survive adverse conditions in their environment.

Plants also have adaptations for reproduction. For example, flowers can be pollinated in many ways, including wind, insects, birds, or other animals. Maple trees produce seeds that are shaped like wings and are carried over long distances by the wind. Some plants produce seeds that have hooks or barbs on them that attach to the fur of passing animals. These have the nickname "hitchhikers." Many flowers are brightly colored and fragrant to draw the attention of insects that aid in pollination. Pollen will rub off on the insect and then will be carried to another flower. The coconuts from palm trees float, which allows seeds to travel from one island to another.

A mechanical defense is incorporated into the physical structure of the organism. Plants have mechanical defenses. Many have thorns, spines, and stiff hair that repel a predator. Some grasses in the African savannas have a thick deposit of silica that wears away the teeth of grazing animals. However, some of these grazing animals have counter-adapted and have developed large, hard molars that resist the abrasive action of the mineral. A chemical defense occurs when a plant produces stinging sensations, paralysis, poisoning, or just a bad taste.

Remember to review your textbook for further study of plant adaptations to environmental conditions. Questions on the Biology EOC assessment may ask you to describe and identify certain characteristics of adaptations that plants have undergone in order to survive.

Relate Animal Adaptations, Including Behaviors, to the Ability to Survive Stressful Environmental Conditions

Inherited Behavior

Inheritance plays an important role in an animal's behavior. An animal's genetic composition determines how it responds to stimuli. An animal's hormonal balance, in combination with its nervous system, affects how sensitive an animal is to stimuli. Inherited behavior of animals is also known as innate behavior. It includes both automatic responses and instinctive behaviors. When people touch hot surfaces, they automatically withdraw their hands from the source of heat. Eyes automatically blink in bright lights. Such reflex behaviors are simple, automatic responses that require no thinking at all.

Instincts are a complex pattern of innate behaviors. Reflexes can happen within a second. Instinctive behaviors may take longer and may be a combination of behaviors. For example, an animal's courtship behavior is instinctive. Animals will recognize certain behaviors exhibited by members of the same species. Each species has its own specific courtship behaviors. The male and female black-headed gull dance in unison side by side and turn their heads away from each other. The female taps the male's bill and he gives her a regurgitated fish. Then the courtship is over and the pair mate. Different species of fireflies flash distinctive patterns of light. The female responds only to the male that exhibits the species-correct flashes.

Migration

Migration is the instinctive seasonal movement of a species. Over half of the birds that nest in the United States fly south for the winter. Many head to South America, where food is more abundant during the winter months. Then they fly north in the spring to breed. Arctic terns migrate between the Arctic Circle and the Antarctic. Animals use various environmental cues to navigate during migration. Scientists believe that some species use geographical clues (orientation) such as mountain ranges. Other species use Earth's magnetic field (navigation).

Scientists have also found that migration is triggered in part by hormones that are produced in response to environmental changes, such as changing day length. Migration also takes place in response to changing environmental conditions, such as overcrowding or reduced food supplies.

Many animals that do not migrate undergo physiological changes that reduce their need for energy. Some animals and birds hibernate during cold winter months. Hibernation is a condition in which the animal's body temperature drops, oxygen consumption decreases, and breathing rates decrease to just a few breaths per minute. Estivation is a condition in which animals reduce the rate of their metabolism due to extreme heat, lack of food, or long periods of drought.

Adaptations for Defense

Most species of animals have adaptations that serve as defenses against a predator. They fall into two categories: mechanical defenses and chemical defenses.

- A mechanical defense is incorporated into the physical structure of the organism.
- A chemical defense occurs when the animal produces stinging sensations, paralysis, poisoning, or just a bad taste.

Mechanical Defenses

Many animal defenses are physical structures such as claws, sharp tusks, stingers, and shells. Octopuses squirt a liquid ink that darkens the water and allows them to escape predators. An animal's size is sometimes enough to deter a predator from attacking.

Another defense is camouflage. It involves colors and patterns that enable the organism to blend into its environment or appear to be something it is not. Cryptic coloration is when an organism has the same color or pattern as its background. Gecko lizards, tree frogs, and leafhoppers are examples. Disruptive coloration is another example in which an organism's silhouette is broken up by color patterns. Countershading is when an organism is two-toned. Light and dark colors reduce visual cues to predators. Many ocean fish are dark on top and light on the bottom. Predators on top can't see the fish against the dark waters below, and predators underneath can't see the fish against the light sky above. Fish and some mammals form large groups (schools and herds) to confuse predators and make choosing one individual more difficult.

Chemical Defenses

Chemical defenses are used in a variety of strategies for deterring predators. Many marine organisms have neurotoxins in their tissues that attack the nervous system of their attackers. Bombardier beetles shoot out a boiling-hot chemical to irritate would-be predators. Other chemical defenses include poisons and venoms, which are used by snakes, toads, and stinging bees and wasps. Some animals take on the chemical defenses of other species. The monarch butterfly is an example. As larvae, monarchs feed on milkweed plants, which contain compounds that are poisonous to vertebrates and many insects. After pupation, the tissues of the adult monarch are saturated with the milkweed's poison. Birds that eat the monarch will vomit violently and learn to avoid the monarch's bright coloration.

Chemical defenses are also used in plants. Some plants contain chemical compounds that taste bad, while others contain sap that is an irritant or poison. Another defense is nutrient exclusion. Some plants aren't worth eating because their tissues are lacking a sufficient amount of nutrients.

We have covered a lot of information on plant and animal adaptations. Remember to review your textbook for further study.

On the Biology EOC assessment, you may be asked to identify and describe certain behaviors or characteristics of plant tropisms, animal behavior, and survival strategies of organisms as they relate to their environment.

Species Evolve over Time by Natural Selection

Charles Darwin

When Charles Darwin set sail in 1831 on the HMS *Beagle*, he carried with him Charles Lyell's *Principles of Geology*, published in 1830. While on the *Beagle*, Darwin read Lyell's proposal that plant and animal species had arisen, had developed variations, and then had become extinct over time. Lyell also believed that Earth's physical landscape had changed over a long period of time. Darwin also read an essay written in 1798 by Thomas Malthus called *An Essay on the Principle of Population.* In his essay, Malthus proposed that populations outgrew their food supplies, causing competition between organisms and a struggle for one species to survive against another. But the most important impact on Darwin was his 40,000-mile trip on the *Beagle*. Darwin found a vast treasure of fossilized bones of extinct sloths and giant armadillos in Patagonia. He saw a variety of plants and animals that were very different due to their geographical location.

In the Galápagos Islands, Darwin found many species specific to the various islands. He saw large iguanas swimming in the ocean and eating seaweed. He also found giant tortoises with carvings on their backs from whalers who had passed through a hundred years before. From all the information gathered by Darwin, two central concepts emerged to form the basis of his theory of evolution.

First, Darwin observed that variations within a species were dependent on the environment. Adaptations are genetically coded traits that occur in organisms and enable them to be more successful in their environment. Darwin reasoned that the purpose of these adaptations is to ensure the survival through reproduction of that species. Successful adaptations help organisms to both survive and reproduce so that these advantageous adaptations are passed on to future generations. Natural selection is a mechanism that explains changes in a population that occur when organisms with favorable variations for that particular environment survive, reproduce, and pass on these variations to the next generation.

Second, the organisms on the Galápagos Islands had become geographically separated from one another. This resulted in reproductive isolation. There is no interbreeding between organisms of the same species that are located on different islands. For example, finches on one island could not cross the ocean to mate with finches of the same species on another island. Darwin theorized that within a population of a species, adaptations would arise due to reproductive isolation. The organisms would develop adaptations to their specific environment over time that would result in significant differences between the same species on different islands.

While Darwin was composing a theory of evolution, another man, Alfred Russel Wallace, was also formulating his own theory of evolution. He studied plants and animals in Brazil and in Southeast Asia. Wallace's emphasis was on the idea of competition for resources as the main force in natural selection. Darwin focused on reproductive success. It was the tremendous amount of data gathered by Darwin that supported his idea, and the comprehensive explanation that he put together became the dominant evolutionary theory.

Darwin knew nothing about genes or principles of heredity. Mendel's work was not published until 1866, and it wasn't appreciated for decades. It wasn't until the rediscovery of Mendel's work that scientists were able to put together the concepts of natural selection with genetics. This opened the door for scientists to account for phenotypic variations in populations. It is where scientists derive the term population genetics. It is an area of biology in which researchers use mathematical descriptions of genetic phenomena to help them trace evolutionary trends within populations.

Explain the History of Life in Terms of Biodiversity, Ancestry, and the Rates of Evolution

In theory, DNA changes should occur at a constant rate. In reality, it is complicated by a number of factors. Different positions in DNA sequences acquire mutations faster than others. Different organisms acquire mutations at different rates. Some genes are under a more intense pressure from natural selection *not* to change. So, in order for researchers to time recent evolutionary events, they must use "time clocks" that tick fairly quickly. But to estimate how long ago there was a shared ancestry, they must use clocks that tick very slowly. Molecular clocks are proteins that have changed very slowly and are shared by many species.

Whether the rate of evolution occurs slowly over long periods of time or rapidly, the debate will continue as new evidence is compiled and alternative theories are brought to light. It is the nature of science to modify theories as new evidence becomes available.

For the Biology EOC assessment, it is important to review your textbook in order for you to understand and explain the history of the evolutionary theory. Also review terms and definitions that will help you in understanding this concept.

You may also be asked to identify and describe historical ideas that led to modern thinking on theories of origin. Remember that scientific theories are subject to change as new information becomes available. Keep in mind that technological advances are taking us places we have not been before. Marine biologists have discovered gigantic tubeworms near the deep-sea vents in the Marianas Trench. Paleontologists are uncovering fossils never seen before in Montana.

Relate Natural Selection to Changes in Organisms

Remember that the key to Darwin's theory of evolution came from the concept that some organisms have an advantage over others. This advantage increases the organism's survival rate and increases the chances that this favorable advantage will be passed on to the next generation. Within each species is a vast array of phenotypic differences. Natural selection acts on an organism's phenotype and indirectly on its genotype. Natural selection results in adaptations that allow populations to survive in their environments.

Fitness

Geneticists define the term fitness as the relative reproductive efficiency of various individuals or genotypes in a population. The fitness of an individual depends on the probability that the individual will both survive and reproduce successfully. It is not necessarily the strongest, biggest, or most aggressive animal that has the highest fitness rating. It is a measure of how well the organism's structure, physiology, biochemistry, and behavior allow the organism to survive and reproduce in its environment. When a population has a variety of phenotypes and biological capabilities, it enables the population to survive under a wide range of environmental factors.

Environment plays an important role in determining which alleles are optimum for a population's survival. Natural selection does not always increase the complexity of an organism's structures or behaviors. Also, natural selection does not produce new genotypes and phenotypes, but it eliminates the less fit, leaving the more fit to reproduce and ensure the species' survival. If environmental conditions change so that a population lacks alleles for survival, the population (and possibly the species) goes extinct.

Relationships among Organisms, Populations, Communities, Ecosystems, and Biomes

When you watch the news or read a newspaper, it seems that not a day goes by without a story on the environment: "El Niño," "American Songbirds Vanish," "Coral Reef Dies in the Virgin Islands." These are just a few of the headlines that you might have seen. The single thread that connects these very different environments is called ecology. Ecology is the scientific study of the interactions between different kinds of living things and their environment. The word *ecology* comes from the Greek word *oikos*, which means "house." Ecology is the study of our house, our planet—Earth. An ecologist is a scientist who studies ecology.

The term biosphere includes all organisms and the environments in which they live (biotic and abiotic factors). Organisms adapt to survive in particular environments. Penguins are adapted to live in cold water, and ostriches are adapted to live on dry savannas. Organisms have adaptations for obtaining food, for protecting themselves, and for reproducing.

Within an ecosystem, two types of environmental factors can be found: biotic factors and abiotic factors. All the living organisms in an ecosystem are known as biotic factors, while the nonliving factors are known as abiotic factors. On the Biology EOC assessment, you may be asked to identify biotic and abiotic factors and describe how they interact within an ecosystem.

Some Examples of Environmental Factors

Biotic	Abiotic
Plants	Climate
Animals	Light
Bacteria	Soil
	Water

Organization of Life

Ecologists study the interactions of organisms at five main levels of organization. Yet all the levels are interdependent. To study only one level would not give the ecologist the whole picture.

Organisms: Ecologists study the daily movements, feeding, and general behavior of individual organisms.

Populations: A population includes all the organisms in the same species in a given area. Ecologists study the relationships between populations and the environment, focusing on population size, density, and rate of growth.

Communities: A community is a collection of populations that interact with each other in a given area. Ecologists study the interactions among the different populations in a community and the impact of additions to or losses of species within communities.

Ecosystems: An ecosystem includes all biotic and abiotic factors in a given area. Ecologists study interactions of the biotic and abiotic factors of an ecosystem with emphasis on factors that may disrupt an ecosystem. Earth supports a diverse range of ecosystems. The type of ecosystem in a particular part of the world largely depends on the climate of that region. Ecosystems are identified by their climax communities. Terrestrial ecosystems are those found on land. Aquatic ecosystems are in either fresh or salt water. Saltwater ecosystems are also called marine ecosystems.

Biomes: A biome is a group of ecosystems in the same region having similar types of vegetation governed by similar climatic conditions. Ecologists study biomes such as tropical rainforests, prairies, and deserts.

Within each community, particular species have particular jobs to help maintain balance. An example would be a forest community. On a forest floor, fungi have the job of breaking down the organic material from a decaying log. Underneath the log are worms, centipedes, and beetles also at work. At first glance, it looks like they are all competing for food. But a closer look reveals that they are feeding on different things, in different ways, and at different times. The role that a species plays in its community is called its niche. A niche includes not only what an organism eats but also where it feeds and how it affects the energy flow in an ecosystem. The place where the organism lives is called its habitat. Even though several species may share a habitat, the food, shelter, and other resources of that habitat can be divided into several niches.

Assess and Explain Human Activities That Influence and Modify the Environment

In today's world, there is high demand for resources. There are natural resources that humans use every day. When we turn on a light to read a book that is made from paper, we are using natural resources. They include soil, plants, water, crops, animals, gas, and oil. A natural resource that is replaced or replenished by natural processes within a human life span is known as a renewable resource.

Nonrenewable resources are those that are available only in limited amounts. Once they are gone, they are gone! Metals such as tin, silver, gold, uranium, and copper are some examples of nonrenewable resources. Minerals, such as phosphorus, are recycled so slowly in the environment that they are considered nonrenewable. Topsoil is also considered a nonrenewable resource because it takes hundreds of years to develop from decomposed plant material. Fossil fuels are always being formed, but they too are considered nonrenewable because they form slowly over long periods of time. Humans use them faster than they are replaced.

One of the major ways humans affect the environment is pollution. Pollution is the contamination of soil, water, or air and is a result of human activity. Although pollution has been around for many years, it has increased worldwide as countries have become more industrialized. Pollution affects living organisms, including humans, as well as the physical environment. Cow and horse manure can be considered a good plant fertilizer. But if too much manure is produced due to overcrowding and the decomposers cannot break the manure down as fast as it is produced, large amounts of nitrogen run off into waterways. This nitrogen will increase the growth rate of algae in water systems, causing a decrease in the amount of oxygen in the water. This can result in the death of the fish, insects, and other animals in the water.

Air pollution is caused primarily by the burning of fossil fuels to produce electricity. However, the burning of fuel for other activities such as driving cars, heating homes, and flying planes has also contributed to air pollution. Examples of air pollutants include dust, smoke, ash, carbon monoxide, and sulfur oxides. Smoke that is released by burning fuels contains gases and particulates. These are solid particles of soot that can harm living organisms now or have an impact later in life. Workers in coal mines can develop black lung disease from breathing in the dust from the coal. A combination of smoke, gases, and fog is called smog. Smog containing sulfur oxides reacts with water vapor in the atmosphere to produce sulfuric acid. This sulfuric acid falls to the ground as acid rain, which damages crops, kills organisms in aquatic ecosystems, and erodes buildings and monuments. Acid precipitation leaches calcium, potassium, and other valuable nutrients from the soil, making the soil less fertile. This causes a decrease in the number of living things that can grow (e.g., plants, trees, ferns). It also has a great effect on lake ecosystems by causing a decrease in the pH level. This excess acidity disrupts the natural balance of the organisms living there.

Another form of air pollution is the increased production of carbon dioxide. When fossil fuels such as oil, coal, and natural gas are burned, carbon dioxide is released into the atmosphere. Excess carbon dioxide in the air can contribute to the greenhouse effect, which is believed to cause global warming. Gases in the atmosphere trap much of the radiant energy from the Sun that reaches the surface of Earth. The surface of Earth heats up and radiates heat back into the atmosphere. The atmosphere prevents much of this heat from escaping. This is known as the greenhouse effect. If this process did not occur, Earth would be too cold for any living thing to survive. All the Sun's energy would be radiated back into space. The ozone layer that surrounds Earth prevents lethal doses of ultraviolet radiation from the Sun from reaching organisms here on Earth. Scientists discovered that the ozone layer is thinning because of the release of CFCs (chlorofluorocarbons) into the atmosphere. CFCs were manufactured for coolants in refrigerators and air conditioners as well as for making disposable foam products.

Water pollution is caused by contaminants from sewers, industries, farms, and homes entering water sources such as lakes, rivers, groundwater, and oceans. Sewage, chemical wastes, fertilizer, and dirty wash water can enter lakes, streams, rivers, and eventually oceans. Pollutants that trickle down through the soil can make their way to the underlying groundwater, which is the source of drinking water for some people.

Humans are, however, becoming more aware of the possible negative effects they have had on the environment and are trying to offset past damage. As a result, greater efforts are being made to conserve energy resources, to protect and conserve material resources, and to control pollution. For example, wildlife conservation efforts protect species from habitat loss, overhunting, and pollution.

People are making an effort to conserve energy by limiting the use of energy resources, such as fossil fuels, through the increased use of public transportation and carpooling. Another way energy resources are being conserved is by reducing energy waste by making homes and buildings more energy efficient. Using alternative forms of energy can also conserve energy resources. For example, solar energy and wind energy provide an unlimited supply of energy with minimal impact on the environment.

You've probably heard of the "three Rs" of conservation: reduce, reuse, and recycle. Reducing, reusing, and recycling resources can decrease the amount of new material taken from Earth. For example, buying products in recyclable packages or products that can be recycled helps conserve material resources. Another way to conserve material resources is to reuse materials instead of throwing them away.

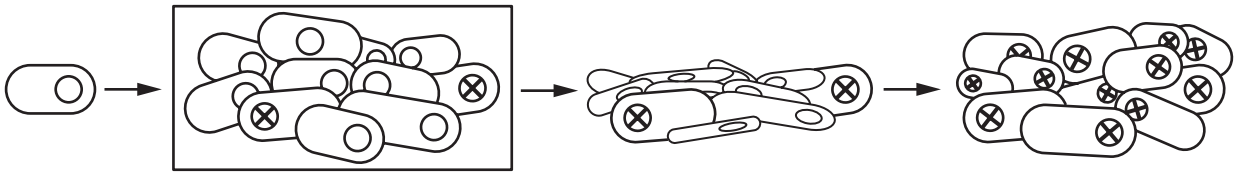
What happens to the materials that are not recycled or cannot be recycled or reused? They probably end up in the garbage, which is hauled to a landfill to be buried underground. In a sanitary landfill, layers of compacted garbage are spread between layers of soil and eventually covered with grass and other plants. New techniques of sanitation and waste disposal are also being developed.

SAMPLE ITEMS

Item 13

Selected-Response

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 14

Selected-Response

Invasive insect species can cause severe damage to native trees and plants. Some insects bore into live trees and then get transported when trees are cut for use in numerous products. Wooden crates used for packing materials may be infested with insects or eggs that are then transported over long distances. What is one safe and practical way that people can act responsibly to prevent spreading potentially harmful and invasive insects?

A. Store unused firewood from one winter until the next winter in a shaded grassy area to starve the insects and stop their propagation.
B. Spray all wooden products with pesticide before bringing them into homes or other buildings to kill the insects before they can enter structures.
C. Chop down trees suspected of being infected and use a wood chipper to make mulch for landscaping to chop up some of the insects before they can infect other trees.
D. Buy local firewood near campsites instead of transporting raw wood from one area to another and then leave any extra for the next camper to prevent transferring the insects in infected wood.

Item 15

Selected-Response

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 got 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. These data support that 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.

ADDITIONAL SAMPLE ITEM KEYS

Item	Standard/ Element	DOK Level	Correct Answer	Explanation
1	SB5a	1	C	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.
2	SB6c	2	B	The correct answer is choice (B) Every organism possesses in their 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. 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.
3	SB4c	3	D	The correct answer is choice (D) Both bacteria and viruses are surrounded by protective coverings, though the composition of each covering may be different. Choice (A) is incorrect because bacteria do not enter cells. Choice (B) is incorrect because many vaccines have been developed against different bacteria. Choice (C) is incorrect because both can acquire new characteristics.
4	SB4c	3	D, F	There are two correct answers: Choice (D) As the phytoplankton population increased, the number of viruses increased 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 phytoplankton population increases before the viruses increase. Choice (B) is incorrect because phytoplankton are not consumers and viruses are not consumers. Choice (C) is incorrect because the viruses do not eat phytoplankton. Choice (E) is incorrect because viruses do not take in carbon like living things do.

Item	Standard/ Element	DOK Level	Correct Answer	Explanation
5	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.
6	SB1e	3	E, F	There are two correct answers: choice (E) Does photosynthesis performed by elodea remove CO_2 from the water? and choice (F) Does cellular respiration occur at a higher rate than photosynthesis in the tube with only elodea? 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.
7	SB5e	3	B	The correct answer is choice (B) Finding a sufficient supply of flowering plants, flowering trees, and insects is the most important task for the hummingbirds because they need food to survive. Choice (A) is incorrect because most of the south will have adequate places and materials for nesting, although there might be some areas with sparse vegetation, the birds would be able to winter in wooded areas, marshes, citrus groves, etc. Choice (C) is incorrect because they do not need to drink water, which contains no calories, since they get the water they need from nectar. Choice (D) is incorrect because finding a mate is not as important as finding food and shelter.
8	SB3a	2	A	The correct answer is choice (A) Can furred mice produce furless mice? Choices (B), (C), and (D) are incorrect because the question cannot be answered using the Punnett square.
9	SB2a	1	A	The correct answer is choice (A) The model delivers amino acids to the ribosome where they are 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.

Item	Standard/ Element	DOK Level	Correct Answer	Explanation
10	SB2b	2	B	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 an extra chromosome.
11	SB3b	2	C	The correct answer is choice (C) The alleles for flower color show incomplete dominance because both alleles are partly expressed in heterozygous individuals. Choice (A) is incorrect because pink flower color is the result of incomplete dominance. Choice (B) is incorrect both heterozygous genotypes can't be dominant. Choice (D) is incorrect because heterozygous individuals exhibit incomplete dominance.
12	SB3c	3	C, D	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.
13	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 genetic variety is necessary not dominant recessive. Choice (D) is incorrect because replication of genetic material on its own is not enough to confer resistance.

Item	Standard/ Element	DOK Level	Correct Answer	Explanation
14	SB5d	3	D	The correct answer is choice (D) Buy local firewood near campsites instead of transporting raw wood from one area to another and then leave any extra for the next camper to prevent transferring the insects in infected wood. Choice (A) is incorrect because storing firewood does not kill the pests. Choice (B) is incorrect because spraying with pesticides causes another set of problems. Choice (C) is incorrect because using infected trees as mulch will only spread the pests.
15	SB6b	2	A	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 reproduce as they always had. Choice (D) is incorrect because there is no indication that population sizes were reduced.

Study/Resource
Guide for Students
and Parents
Biology
End-of-Course