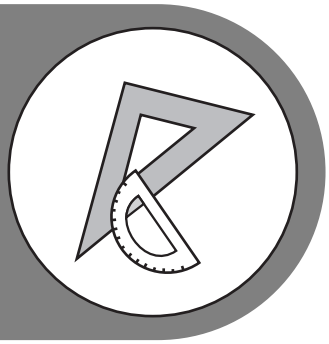
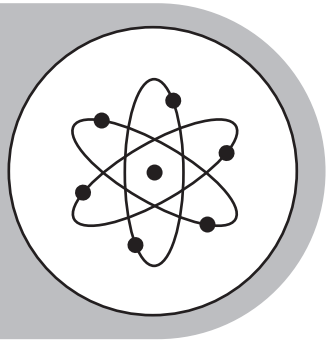
BIOLOGY

Study Guide





Georgia End-Of-Course Tests

TABLE OF CONTENTS

Georgia Department of Education
Kathy Cox, State Superintendent of Schools
August 2008
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INTRODUCTION

This study guide is designed to help students prepare to take the Georgia End-of-Course Test (EOCT) for ***Biology***. This study guide provides information about the EOCT, tips on how to prepare for it, and some suggested strategies students can use to perform their best.

What is the EOCT? The EOCT program was created to improve student achievement through effective instruction and assessment of the standards in the Georgia Performance Standards specific to the eight EOCT core high school courses. The EOCT program also helps to ensure that all Georgia students have access to a rigorous curriculum that meets high performance standards. The purpose of the EOCT is to provide diagnostic data that can be used to enhance the effectiveness of the instructional programs of schools.

The Georgia End-of-Course Testing program is a result of the A+ Educational Reform Act of 2000, O.C.G.A. §20-2-281. This act requires that the Georgia Department of Education create end-of-course assessments for students in grades 9 through 12 for the following core high school subjects:

Mathematics

- Mathematics I: Algebra/Geometry/Statistics
- Mathematics II: Geometry/Algebra II/Statistics

Social Studies

- United States History
- Economics/Business/Free Enterprise

Science

- Biology
- Physical Science

English Language Arts

- Ninth Grade Literature and Composition
- American Literature and Composition

Getting started: The HOW TO USE THE STUDY GUIDE section on page 2 outlines the contents in each section, lists the materials you should have available as you study for the EOCT, and suggests some steps for preparing for the ***Biology*** **EOCT**.

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HOW TO USE THE STUDY GUIDE

This study guide is designed to help you prepare to take the ***Biology*** **EOCT**. It will give you valuable information about the EOCT, explain how to prepare to take the EOCT, and provide some opportunities to practice for the EOCT. The study guide is organized into three sections. Each section focuses on a different aspect of the EOCT.

The **OVERVIEW OF THE EOCT** section on page 4 gives information about the test: dates, time, question format, and number of questions that will be on the ***Biology*** **EOCT.** This information can help you better understand the testing situation and what you will be asked to do.

The **PREPARING FOR THE EOCT** section that begins on page 5 provides helpful information on study skills and general test-taking skills and strategies. It explains how to prepare before taking the test and what to do during the test to ensure the best test-taking situation possible.

The **TEST CONTENT** section that begins on page 11 explains more specifically what the ***Biology*** **EOCT** measures. When you know the test content and how you will be asked to demonstrate your knowledge, you will be better prepared for the EOCT. This section also contains some test-taking strategies for successfully answering questions on the EOCT.

With some time, determination, and guided preparation, you will be better prepared to take the ***Biology*** **EOCT**.

GET IT TOGETHER

In order to make the most of this study guide, you should have the following:

Materials:

* This study guide
* Pen or pencil
* Paper
* Highlighter

Resources:

* Dictionary
* Biology textbook
* A teacher or other adult

Study Space:

* Comfortable (but not too comfortable)
* Good lighting
* Minimal distractions
* Enough work space

Time Commitment:

* When are you going to study?
* How long are you going to study?

Determination:

* Willingness to improve
* Plan for meeting goals

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SUGGESTED STEPS FOR USING THIS STUDY GUIDE

1 Familiarize yourself with the structure and purpose of the study guide. (You should have already read the INTRODUCTION and HOW TO USE THE STUDY GUIDE. Take a few minutes to look through the rest of the study guide to become familiar with how it is arranged.)

2 Learn about the test and the expectations for performance. (Read OVERVIEW OF THE EOCT.)

3 Improve your study skills and test-taking strategies. (Read PREPARING FOR THE EOCT.)

4 Learn what the test will assess by studying the standards in each domain. Also, study the strategies for answering questions that assess the standards in the domain. (Read TEST CONTENT.)

5 Answer the sample questions at the end of each domain section. Check your answers against the annotated answers to see how well you did. (See TEST CONTENT.)

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OVERVIEW OF THE EOCT

Good test takers understand the importance of knowing as much about a test as possible. This information can help you determine how to study and prepare for the EOCT and how to pace yourself during the test. The box below gives you a snapshot of the ***Biology*** **EOCT**.

THE EOCT AT A GLANCE

Administration Dates:

The EOCT has three primary annual testing dates: once in the spring, once in the summer, and once in the winter. There are also mid-month, online tests given in August, September, October, November, February, and March.

Administration Time:

Each EOCT is composed of two sections, and students are given 60 minutes to complete each section. There is also a short stretch break between the two sections of the test.

Question Format:

All the questions on the EOCT are multiple choice.

Number of Questions:

Each section of the ***Biology*** **EOCT** contains 40 questions; there are a total of 80 questions on the ***Biology*** **EOCT**.

Impact on Course Grade:

A student's EOCT score is averaged in as 15% of his/her final course grade.

If you have additional administrative questions regarding the EOCT, please visit the Georgia Department of Education Web site at www.doe.k12.ga.us, see your teacher, or see your school test coordinator.

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PREPARING FOR THE EOCT

WARNING!
You cannot prepare for this kind of test in one night. Questions will ask you to apply your knowledge, not list specific facts. Preparing for the EOCT will take time, effort, and practice.

In order to do your best on the ***Biology*** **EOCT**, it is important that you take the time necessary to prepare for this test and develop those skills that will help you take the EOCT.

First, you need to make the most of your classroom experiences and test preparation time by using good **study skills**. Second, it is helpful to know general **test-taking strategies** to ensure that you will achieve your best score.

Study Skills

A LOOK AT YOUR STUDY SKILLS

Before you begin preparing for this test, you might want to consider your answers to the following questions. You may write your answers here or on a separate piece of paper.

1. How would you describe yourself as a student?
   Response: _____
2. What are your study skills strengths and/or weaknesses as a student?
   Response: _____
3. How do you typically prepare for a biology test?
   Response: _____
4. Are there study methods you find particularly helpful? If so, what are they?
   Response: _____
5. Describe an ideal study situation (environment).
   Response: _____
6. Describe your actual study environment.
   Response: _____
7. What can you change about the way you study to make your study time more productive?
   Response: _____

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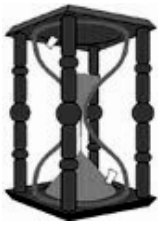
Effective study skills for preparing for the EOCT can be divided into three categories.

- **Time Management**
- **Organization**
- **Active Participation**

Time Management



Do you have a plan for preparing for the EOCT? Often students have good intentions for studying and preparing for a test, but without a plan, many students fall short of their goals. Here are some strategies to consider when developing your study plan:

- Set realistic goals for what you want to accomplish during each study session and chart your progress.
- Study during your most productive time of the day.
- Study for reasonable amounts of time. Marathon studying is not productive.
- Take frequent breaks. Breaks can help you stay focused. Doing some quick exercises (e.g., sit-ups or jumping jacks) can help you stay alert.
- Be consistent. Establish your routine and stick to it.
- Study the most challenging test content first.
- For each study session, build in time to review what you learned in your last study session.
- Evaluate your accomplishments at the end of each study session.
- Reward yourself for a job well done.

Organization

You don't want to waste your study time. Searching for materials, trying to find a place to study, and debating what and how to study can all keep you from having a productive study session. Get organized and be prepared. Here are a few organizational strategies to consider.

- Establish a study area that has minimal distractions.
- Gather your materials in advance.
- Develop and implement your study plan (see Appendices A–D for sample study plan sheets).

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Active Participation

Students who actively study will learn and retain information longer. Active studying also helps you stay more alert and be more productive while learning new information. What is active studying? It can be anything that gets you to interact with the material you are studying. Here are a few suggestions.

- Carefully read the information and then DO something with it. Mark the important points with a highlighter, circle them with a pen, write notes on them, 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

There are many test-taking strategies that you can use before and during a test to help you have the most successful testing situation possible. Below are a few questions to help you take a look at your test-taking skills.

A LOOK AT YOUR TEST-TAKING SKILLS

As you prepare to take the EOCT, you might want to consider your answers to the following questions. You may write your answers here or on your own paper.

1. How would you describe your test-taking skills?
   Response: _____
2. How do you feel when you are taking a test?
   Response: _____
3. List the strategies that you already know and use when you are taking a test.
   Response: _____
4. List test-taking behaviors you use when preparing for and taking a test that contribute to your success.
   Response: _____
5. What would you like to learn about taking tests?
   Response: _____

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Suggested Strategies to Prepare for the EOCT

Learn from the past. Think about your daily/weekly grades in your science classes (past and present) to answer the following questions.

- In which specific areas of science were you or are you successful?

  Response: _____

- Is there anything that has kept you from achieving higher scores?

  Response: _____

- What changes should you implement to achieve higher scores?

  Response: _____

Before taking the EOCT, work toward removing or minimizing any obstacles that might stand in the way of performing at your best. The test preparation ideas and test-taking strategies in this section are designed to help guide you to accomplish this.

Be prepared. The best way to perform well on the EOCT is to be prepared. In order to do this, it is important that you know what standards/skills will be measured on the ***Biology*** **EOCT** and then practice understanding and using those standards/skills. The standards that will be measured in this EOCT are located in the **Biology Georgia Performance Standards** (GPS). The OVERVIEW OF THE EOCT and TEST CONTENT sections of this study guide are designed to help you understand which specific standards are on the ***Biology*** **EOCT** and give you suggestions for how to study the standards that will be assessed. Take the time to read through this material and follow the study suggestions. You can also ask your science teacher for any suggestions he or she might offer on preparing for the EOCT.

Start now. Don't wait until the last minute to start preparing. Begin early and pace yourself. By preparing a little bit each day, you will retain the information longer and increase your confidence level. Find out when the EOCT will be administered so you can allocate your time appropriately.

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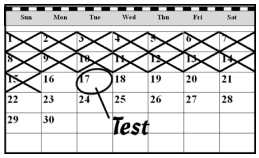
Suggested Strategies the Day before the EOCT



✓ **Review what you learned from this study guide.**

1. Review the general test-taking strategies discussed in the TOP 10 SUGGESTED STRATEGIES DURING THE EOCT on page 10.
2. Review the content domain-specific information discussed in the section TEST CONTENT beginning on page 11.
3. Focus your attention on the domain or domains that you are most in need of improving.

✓ **Take care of yourself.**

1. Try to get a good night's sleep. Most people need an average of eight hours, but everyone's sleep needs are different.
2. Don't drastically alter your routine. If you go to bed too early, you might lie in bed thinking about the test. You want to get enough sleep so you can do your best.

Suggested Strategies the Morning of the EOCT

Eat a good breakfast. Eat some food that has protein in it for breakfast (and for lunch if the test is given in the afternoon). Some examples of foods high in protein are peanut butter, meat, and eggs. Protein gives you long-lasting, consistent energy that will stay with you through the test to help you concentrate better. Also, don't eat too much. A heavy meal can make you feel tired. So think about what you eat before the test.

Dress appropriately. If you are too hot or too cold during the test, it can affect your performance. It is a good idea to dress in layers so you can stay comfortable, regardless of the room temperature, and keep your mind on the EOCT.

Arrive for the test on time. Racing late into the testing room can cause you to start the test feeling anxious. You want to be on time and prepared.

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TOP 10
Suggested Strategies during the EOCT

These general test-taking strategies can help you do your best during the EOCT.

1. **Focus on the test.**  Try to block out whatever is going on around you. Take your time and think about what you are asked to do. Listen carefully to all the directions.

2. **Budget your time.**  Be sure that you allocate an appropriate amount of time to work on each question on the test.

3. **Take a quick break if you begin to feel tired.** To do this, put your pencil down, relax in your chair, and take a few deep breaths. Then, sit up straight, pick up your pencil, and begin to concentrate on the test again. Remember that each test section is only 60 minutes.

4. **Use positive self-talk.** If you find yourself saying negative things to yourself such as "I can't pass this test," it is important to recognize that you are doing this. Stop and think positive thoughts such as "I prepared for this test, and I am going to do my best." Letting the negative thoughts take over can affect how you take the test and your test score.

5. **Mark in your test booklet.**  Mark key ideas or things you want to come back to in your test booklet. Remember that only the answers marked on your answer sheet will be scored.

6. **Read the entire question and the possible answer choices.** It is important to read the entire question so you know what it is asking. Read each possible answer choice. Do not mark the first one that "looks good."

7. **Use what you know.**  Draw on what you have learned in class, from this study guide, and during your study sessions to help you answer the questions.

8. **Use content domain-specific strategies to answer the questions.** In the TEST CONTENT section, there are a number of specific strategies that you can use to help improve your test performance. Spend time learning these helpful strategies so you can use them while taking the test.

9. **Think logically.** If you have tried your best to answer a question but you just aren't sure, use the process of elimination. Look at each possible answer choice. If it doesn't seem like a logical response, eliminate it. Do this until you've narrowed down your choices. If this doesn't work, take your best educated guess. It is better to mark something down than to leave it blank.

10. **Check your answers.** ☑ When you have finished the test, go back and check your work.

A WORD ON TEST ANXIETY

It is normal to have some stress when preparing for and taking a test. It is what helps motivate us to study and try our best. Some students, however, experience anxiety that goes beyond normal test "jitters." If you feel you are suffering from test anxiety that is keeping you from performing at your best, please speak to your school counselor, who can direct you to resources to help you address this problem.

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TEST CONTENT

Up to this point in this study guide, you have been learning various strategies for how to prepare for and take the EOCT. This section focuses on what will be tested. It also includes sections of sample questions that will let you apply what you have learned in your classes and from this study guide.

UNDERSTANDING THE STANDARDS

One way to think about **content domains** and **standards** is to think about a supermarket. Supermarkets often group similar foods in the same aisles or areas of the store. For example, the section of the store marked "Fresh Fruits" will be a section filled with apples, oranges, and bananas, to name just a few. So the part of the store called "Fresh Fruits" is like the domain name, and all the various items—apples, oranges, bananas—are the standards that fall under that domain.

The Georgia End-of-Course Test (EOCT) for ***Biology*** is designed to test five major areas of knowledge, called **content domains**. The content domains are broad categories. Each of the content domains is broken down into smaller ideas. These smaller ideas are called **standards**. Each content domain contains standards that cover different ideas related to its content domain. Each question on the EOCT measures an individual standard within a content domain.

The five content domains for the ***Biology*** **EOCT** are important for several reasons. Together they represent the ability to understand and communicate biological concepts. Another more immediate reason that the content domains are important has to do with test preparation. The best way to prepare for any test is to study and know the material measured on the test. Since the ***Biology*** **EOCT** covers the five content domains and nothing else, isn't it a good idea to learn as much about these domains as you can? The more you understand about these domains, the greater your opportunity to be successful on the EOCT.

The chart below lists the five content domains for the ***Biology*** **EOCT**.

CONTENT DOMAINS

I. Cells
II. Organisms
III. Genetics
IV. Ecology
V. Evolution

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Studying the Content Domains

You should plan to study and review the standards for ALL the content domains. To learn what the EOCT will cover, work through this TEST CONTENT section. It organizes the content domains into the following areas:

- **A Look at the Content Domain:** an overview of what will be assessed in the content domain
- **Spotlight on the Standards:** information about the specific standards that will be assessed (Note: The names of the standards may not be the exact names used by the Georgia Department of Education. Some of the names in this study guide may have been modified to reflect the fact that this book is designed for students and not for professional educators.)
- **Sample Questions:** sample questions *similar* to those that appear on the EOCT
- **Answers to the Sample Questions:** in-depth explanations of the answers to the sample questions

Read All About It

Biology is a very broad subject. To provide you with most of the information related to biology would take hundreds of pages. Instead, this guide will help to direct your study efforts. Your biology textbook will be your best source of additional information.

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Content Domain I: Cells

A LOOK AT CONTENT DOMAIN I

Test questions in this content domain will measure your knowledge of cell structure and organization within the cell. Your knowledge will be tested according to the following standards:

- Differentiate between prokaryotic and eukaryotic cells
- Comprehend the importance of homeostasis
- Understand the characteristics of enzymes
- Understand the characteristics of the four major macromolecules
- Comprehend the importance of osmosis and diffusion on life processes

Spotlight on the Standards

★Differentiate between prokaryotic and eukaryotic cells★

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 cell. With advancements in the microscope, biologists discovered two types of cells: **prokaryotic** and **eukaryotic cells.**

PROKARYOTES:	**EUKARYOTES:**
Single-celled organisms that lack internal structures surrounded by membranes. They lack a true nucleus. Examples: Bacteria Archaea	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)

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Cells must have boundaries.

Cells have **cell membranes** that serve 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.

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.

For the ***Biology*** **EOCT**, it is important that you understand the differences between prokaryotic and eukaryotic cells, as well as living and nonliving organisms. Questions for this standard might look like this:

Unlike prokaryotic cells, eukaryotic cells have the capacity to

A assemble into multi-cellular organisms
B establish symbiotic relationships with other organisms
C obtain energy from the Sun
D store genetic information in the form of DNA

The correct answer is choice **A**. Eukaryotic cells are capable of specialization and forming multi-cellular organisms. Both prokaryotic and eukaryotic cells are capable of symbiosis, photosynthesis, and storing DNA.

Inside eukaryotic cells are membrane-bound structures called

A cell walls
B cilia
C organelles
D cytoplasm

Choice **C** is the correct answer because the question is asking about membrane-bound structures. Choices **A**, **B**, and **D** are not membrane-bound structures found inside the cell.

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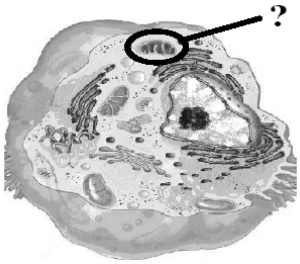
Some examples of organelles and their functions:

Nucleus: contains DNA, which controls cellular function
Chloroplasts: capture solar energy for photosynthesis
Golgi bodies: modify, sort, and ship proteins and lipids
Mitochondria: ATP formation
Ribosomes: synthesis of polypeptide chains

It is very important that you refer to your textbook for a complete list of cell organelles and their specific functions. Questions relating to this standard may ask you to describe an organelle's function. They may also ask you to distinguish between plant and animal cells. A question on the ***Biology*** **EOCT** may look like this:

The function of the cell organelle circled below is to produce energy.



What is the name of this organelle?

A Gogli apparatus
B mitochondrion
C nucleus
D ribosome

The correct answer is choice **B**, mitochondrion.

Spotlight on the Standards

★ Comprehend 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.

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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 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 to 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 in 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 high concentration to an area of lower water 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 box on the next page.

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Active transport: a process that drives large 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 by 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*** **EOCT**.

BIO-"life"
ENDO-"inside"
EXO-"outside"
LOGY-"study of"
CYTO-"cell"
OSIS-"process or action"

A question on the ***Biology*** **EOCT** may look like this:

Which of the following examples illustrates osmosis?

A Water leaves the tubules of the kidney in response to the hypertonic fluid surrounding the tubules.
B Digestive enzymes are excreted into the small intestine.
C White blood cells consume pathogens and cell debris at the site of an infection.
D Calcium is pumped inside a muscle cell after the muscle completes its contraction.

Osmosis is the movement of **water** across a membrane due to differential solute concentrations. Excretion of digestive enzymes is triggered by chemical changes in the stomach. White blood cells are released in response to the presence of a pathogen. Calcium is released when a nervous signal is sent to the muscle cells. Therefore, the correct answer is choice **A**.

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Spotlight on the Standards

★Understand the characteristics of enzymes★

All cells maintain, increase, and decrease the concentration of substances by developing metabolic pathways. A metabolic pathway is an orderly sequence of reactions with specific **enzymes** that act at each step along the way.

Enzymes are catalytic molecules. That is, they speed up specific reactions without being used up in the reaction. Enzymes are proteins.

All enzymes have three special features in common:

1. Enzymes do not create processes that would not take place on their own. They just make the processes take place faster!
2. Enzymes are not permanently altered or used up in reactions.
3. Each enzyme catalyzes only one specific type of reaction, but can catalyze many of this particular reaction one after another.

Substrates are molecules that a specific enzyme can chemically recognize and to which it can bind. Substrates undergo chemical changes to form new substances called **products**.

Each substrate fits into an area of the enzyme called the *active site*. It is like a **lock-and-key mechanism**. Once the enzyme-substrate complex is together, the enzyme holds the substrate in a position where the reaction can occur. Once the reaction is complete, the enzyme *unlocks* the product and the enzyme is free to facilitate another reaction.

CRITICAL THINKING

The rate of a reaction depends in part on the concentration of the enzyme. If the enzyme is diluted, its concentration is lowered, which slows the reaction rate.

Once substrates have reached the transition state, they react spontaneously. Substrate molecules must collide with a minimum amount of energy to reach the transition state. This amount of energy is called the **activation energy**. It is like traveling over a hill. The lower the hill, the less energy it takes to get to the top, and the faster you can go over it. The higher the hill, the more energy it takes to get to the top and the longer it will take you to go over it.

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It takes less energy to boost reactants to the transition state of a lower energy hill. The reaction will proceed more rapidly.

Enzymes are critical to life processes. Carbonic anhydrase is an enzyme that speeds up the process by which carbon dioxide leaves cells and enters the bloodstream so it can be removed from the body. The enzyme lipase is produced by the pancreas and functions in the digestion of lipids. RNA polymerase is an enzyme that facilitates the process of transcription. Some diseases, such as Tay-Sachs and phenylketonuria, occur when the body fails to make a critical enzyme. The human genetic disease Tay-Sachs can cause seizures, blindness, and eventual death because a critical enzyme that breaks down lipids in brain cells does not function properly. In another human genetic disease, PKU (or phenylketonuria), an enzyme is either lacking or totally deficient that is needed to break down one amino acid (phenylalanine) to form a second essential amino acid (tyrosine). Without this enzyme, phenylalanine and other chemicals accumulate in the blood and body tissues and cause eventual death.

For the ***Biology*** **EOCT**, it is important to understand how enzymes work and the pathways that they follow. Refer to your textbook and study the different biological pathways that enzymes follow. Study the activation sites, activation energies, and the effects of temperature and pH on enzyme activity. A question on the ***Biology*** **EOCT** may look like this:

Food is commonly refrigerated at temperatures 2° C to 7° C to slow the rate of spoilage by bacteria. Which of the following best explains why refrigeration at these temperatures slows the spoilage of food?

A Bacteria that cause food spoilage are killed by these low temperatures.
B Bacteria that cause food spoilage multiply rapidly at these temperatures.
C The enzymes in bacteria that cause food spoilage are not active at these temperatures.
D The enzymes in bacteria that cause food spoilage are denatured at these temperatures.

The correct answer is choice **C**. The enzyme activity of food spoilage bacteria is greatly reduced at typical food refrigeration temperatures. The rate of reproduction of food spoilage bacteria is decreased, not increased, at low temperatures. Typical refrigeration temperatures are not low enough to kill bacteria. Enzymes, which are proteins, are denatured by high, not low temperatures.

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Spotlight on the Standards

★ 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.

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, starch, and cellulose are examples of carbohydrates. In all living organisms, carbohydrates, such as glucose, are broken down to provide usable chemical energy for cells. In plants, the carbohydrate cellulose is used for structural support in making cell walls.

"Saccharide" means sugar. **"Mono"** means one. Put the two together: 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 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 due to 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 long-chain 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 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.

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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 nucleic acids include ATP, NAD^+, $NADP^+$, DNA, and RNA.

Spotlight on the Standards

★ Comprehend the importance of osmosis and diffusion on life processes★

Water is essential for life on Earth. All living cells contain mostly water. The transport of important materials for life's processes depends on the properties of diffusion and osmosis. It is important for students to know the definitions of diffusion and osmosis (see information below).

Diffusion: The movement of dissolved molecules in a fluid or gas from a region of high concentration to a region of low concentration.

Osmosis: The diffusion of water molecules across a semipermeable membrane from a region of higher water concentration (or low solute concentration) to an area of lower water concentration (or higher solute concentration).

Please note: Further information on this topic may also be found on page 16 of this study guide in the discussion of passive/active transport.

Diffusion and osmosis are important in the transport of materials across cell membranes. Passive transport allows these two processes to take place without the cell using any energy. Carbon dioxide, oxygen and small lipids diffuse easily across the cell membrane. Osmosis through cell membranes happens in two ways—water diffuses directly through the cell membrane and through water channels in the cell membrane called aquaporins.

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

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Sample Questions for Content Domain I

This section has some sample questions for you to try. After you have answered all the questions, check your answers in the "Answers to the Content Domain I Sample Questions" section that follows. This section will give you the correct answer to each question, and it will explain why the other answer choices are incorrect.

1 The assembly of proteins in a cell takes place in the

A nucleus
B vacuoles
C ribosomes
D mitochondria

2 Which of the following is an organism whose cell(s) lack(s) membrane-bound organelles?

A nucleolus
B chromatin
C eukaryote
D prokaryote

3 In all reptiles, birds, and mammals, the processes of excretion, water and salt balance, and the regulation of pH in body fluids are controlled by the kidneys. This is an example of the organism maintaining

A reabsorption
B homeostasis
C insulation
D hibernation

4 Proteins are long chains or polymers made up of

A nucleotides
B carbohydrates
C amino acids
D lipids

5 Which of the following molecules provides the greatest amount of energy per gram of mass when metabolized?

A carbohydrate
B nucleic acid
C protein
D lipid

6 Which of the following environmental changes can cause an increase in the rates of chemical reactions in cells?

A increased temperature
B decreased enzyme concentrations
C increased activation energy requirement
D decreased diffusion rates

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Answers to the Content Domain I Sample Questions

1. Answer: **C** Standard: SB1.a; *Explain the role of cell organelles for both prokaryotic and eukaryotic cells, including the cell membrane, in maintaining homeostasis and cell reproduction.*
   The nucleus is the location of the cell's DNA, which contains the code for producing proteins. Vacuoles store various substances in the cell. Mitochondria are organelles that convert energy to forms useful to the cell. The synthesis of proteins takes place on ribosomes, which are located in the cytoplasm of the cell.

2. Answer: **D** Standard: SB1.a; *Explain the role of cell organelles for both prokaryotic and eukaryotic cells, including the cell membrane, in maintaining homeostasis and cell reproduction.*
   A prokaryotic cell is the one that lacks membrane-bound organelles. Therefore, choice **D** has to be the correct answer. Choices **A** and **B** are both found within eukaryotic cells.

3. Answer: **B** Standard: SB1.a; *Explain the role of cell organelles for both prokaryotic and eukaryotic cells, including the cell membrane, in maintaining homeostasis and cell reproduction.*
   Choices **A**, **C**, and **D** are processes that occur as a result of organisms maintaining homeostasis. Choice **B** is the correct answer because that is the main process by which the others can occur.

4. Answer: **C** Standard: SB1.c; *Identify the function of the four major macromolecules (i.e., carbohydrates, proteins, lipids, nucleic acids).*
   Nucleotides are molecules made of phosphate groups, sugar, and a nitrogenous base. Carbohydrate molecules are composed of carbon, hydrogen, and oxygen. Lipids are composed of carbon, hydrogen, and oxygen and contain fewer oxygen atoms than carbohydrates. Amino acids are the building blocks of proteins.

5. Answer: **D** Standard: SB1.c; *Identify the function of the four major macromolecules (i.e., carbohydrates, proteins, lipids, nucleic acids).*
   The correct answer is choice **D**. Lipid molecules store about 9 kilocalories of energy per gram because of the number of double bonds between the carbon and oxygen atoms. The other macromolecules do not contain as many high-energy bonds per gram and, therefore, do not provide as much energy.

6. Answer: **A** Standard: SB1.b; *Explain how enzymes function as catalysts.*
   The correct answer is choice **A**. The enzymes in organisms must be at the appropriate temperature to function. Enzymes will work more rapidly as temperatures increase, until they reach temperatures at which they become denatured. If enzyme concentrations are decreased, there are fewer available enzyme molecules to combine with substrate molecules, and the rate of reaction will decrease. Each substrate molecule will have to wait for an enzyme molecule to be freed up after catalyzing a reaction. Increasing the activation energy will slow the reaction because more energy will be required for the reaction to take place. Decreasing the rate of diffusion of water into and out of the cell would have little effect on the rate of reaction catalyzed by enzymes.

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Content Domain II: Organisms

A LOOK AT CONTENT DOMAIN II

Test questions in this content domain will measure your understanding of the relationship between single-cell and multi-cellular organisms and the increasing complexity of systems. The questions will also measure your ability to trace the development of the classification of organisms according to the six kingdom model. Your knowledge will be tested according to the following standards:

- Explain the flow of energy needed by all organisms to carry out life processes
- Compare the structures and functions in organisms of different kingdoms
- Understand the evolutionary basis of modern classification systems
- Compare and contrast viruses with living organisms

Spotlight on the Standards

★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.

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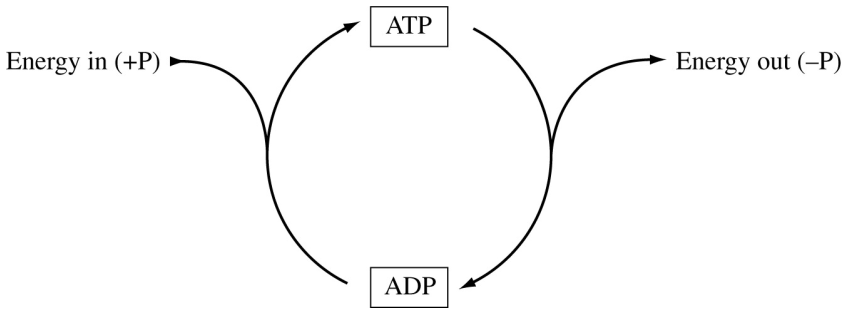
Understanding ATP

ATP, **adenosine triphosphate**, is a special molecule that stores and releases the energy in its bonds in response to the energy need 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. This process is known as **phosphorylation**.

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:

ATP Cycle



By removing a phosphate group, 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*** **EOCT** 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.

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Trapping Energy—Photosynthesis

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**.

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 for the Calvin cycle. Oxygen is given off.
2. Calvin cycle – 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.

The Light Reaction in Summary

Light reactions take place in chloroplasts. Chloroplasts contain chlorophyll and other light-absorbing molecules which absorb energy from sunlight. Inside the chloroplast is a gel-like matrix called the stroma, which contains the ribosomes, DNA, and material for carbohydrate synthesis. The most prominent structures in the chloroplasts are stacks of flattened sacs called grana. Each of these grana contains **thylakoids**, which are interconnected. It is in the thylakoids that the light reaction of photosynthesis takes place. The energy from sunlight causes electrons in chlorophyll to gain energy and pass the energy to other molecules which are used to make ATP. Electrons, along with hydrogen ions from water, are added to $NADP^+$ to produce NADPH. $NADP^+$ is the oxidized form (the form that lacks electrons) of nicotinamide adenine dinucleotide phosphate. NADPH is the reduced form (the form that has electrons) of the same molecule. NADPH carries the energy to the Calvin cycle.

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The Calvin Cycle in Summary

The Calvin cycle reaction takes place in the stroma of the chloroplasts. Carbon dioxide from the air combines with hydrogen from the light reaction to form simple sugars. These sugars are used to make other carbohydrates such as complex sugars, starches, and cellulose. An enzyme adds the carbon atom of carbon dioxide to a 5-carbon molecule. The carbon is now fixed in place in an organic molecule. This process is known as **carbon fixation**. When the carbon combines with the 5-carbon molecule, a 6-carbon molecule forms and immediately splits into two 3-carbon molecules. The two 3-carbon molecules formed are called PGA molecules (phosphoglyceric acid). These molecules are converted into two 3-carbon sugars, PGAL (phosphoglyceraldehyde), using the hydrogens of NADPH + H^+ and energy from ATP. Some of these sugars leave the cycle and are used to form other complex carbohydrates.

Using Energy—Cellular Respiration

The general equation for cellular respiration is as follows:

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

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. However, the carbohydrates must first be broken down by the process of glycolysis. Glycolysis takes place in the cell's cytoplasm and is an anaerobic (without oxygen) process. First, glucose enters a cell by active transport. The glucose is broken down by enzymes into pyruvic acid. Glycolysis produces 2 molecules of ATP.

Two Main Reactions of Cellular Respiration:

1. Krebs Cycle – Breaks down the products of Glycolysis to produce molecules used in the electron transport chain.
2. Electron Transport Chain – Consists of a series of proteins in the mitochondrial membranes that convert ADP to ATP by transferring electrons.

The Krebs Cycle in Summary

The first main part of cellular respiration is the Krebs cycle. The Krebs cycle takes place in the mitochondria and breaks down the products of glycolysis, releasing CO_2 and 2 ATP. The main function of the Krebs cycle is to move high energy electrons to molecules for the electron transport chain, the second main part of cellular respiration.

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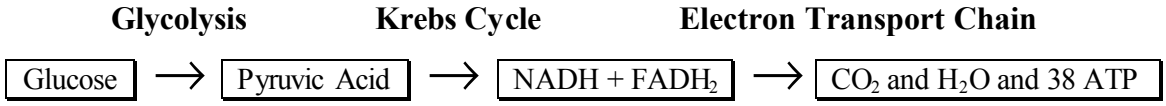
The Electron Transport Chain in Summary

The electron transport chain takes place in and across the inner membrane of the mitochondrion. High energy electrons travel through the proteins and makes 34 ATP. The process of cellular respiration releases carbon dioxide and water.



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

A question on the test may look like this:

In glycolysis, the first stage of cellular respiration, ATP molecules are produced. What is the net gain of ATP molecules (per molecule of glucose) from glycolysis?

A 1
B 2
C 4
D 36

The correct answer is choice **B**. Glycolysis splits glucose into two three-carbon molecules and makes two molecules of ATP. Glycolysis takes place in the cell's cytoplasm, does not need oxygen to take place, and is necessary for cellular respiration. The products of glycolysis are broken down in the mitochondria to make many more ATP. The other numeric options are incorrect.

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Spotlight on the Standards

★ ***Compare the structures and functions in organisms of different kingdoms*** ★

★ ***Understand the evolutionary basis of modern classification systems*** ★

The Six Kingdoms

The number of kingdoms 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 structural differences that were seen. As scientists discovered evolutionary relationships among species, the classification system changed or was modified to fit these new discoveries. Comparisons of DNA sequences and similarities in proteins have helped to identify relationships between different organisms. From Aristotle's two divisions, plants and animals, we now have the six kingdom system.

The six kingdoms are composed of the following:

Six Kingdoms

Eubacteria
Archaebacteria
Protists
Fungi
Plants
Animals

All prokaryotic organisms are either in the kingdom **Archaebacteria** or the kingdom **Eubacteria** (true bacteria). The Eubacteria contain all of the bacteria that cause disease as well as the bacteria that are beneficial. The Archaebacteria are mainly found in extreme environments such as the deep oceans, hot springs, and swamps. The **Protists** kingdom contains eukaryotic organisms that are either unicellular or multi-cellular. They lack complex organ systems and live in moist environments. **Fungi** are consumers that do not move. They are unicellular or multi-cellular heterotrophic eukaryotes that absorb nutrients from decomposing dead organisms and wastes in the environment. **Plants** are photosynthetic multi-cellular eukaryotes. Most plants have cellulose cell walls and tissues that have been organized into organs and organ systems. **Animals** are multi-cellular eukaryotic consumers. Animal cells do not have cell walls. Their tissues have been organized into complex organ systems such as the nervous system, muscle system and digestive system.

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Taxonomy is the branch of biology dealing with the grouping and naming of organisms. The 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, analyze the chemical makeup, and compare the evolutionary relationships of species. The numbers of species identified by taxonomists is 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 was 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. In an attempt to make sense of the diversity of life, one tool that scientists use 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

All organisms are grouped into kingdoms based on genetic and anatomic similarities. At the phylum level, organisms are subdivided again based on evolutionary traits. Organisms are further divided into different classes based upon shared physical characteristics. Within each class, organisms are grouped into orders based on a more specific and limited set of characteristics. This subdividing and grouping has 7 levels in the modern classification system. The most specific level is Species. Members of a species are considered to be the same "kind" of animal and can reproduce with other members of the same species.

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A question on the ***Biology*** **EOCT** may look like this:

One main difference between members of the Kingdoms Plantae and Animalia is the ability to

A obtain energy
B reproduce
C move
D exchange gases

The correct answer is choice **C**. Members of the Kingdom Plantae can grow and bend toward light, but they cannot move their structural parts. Both plants and animals obtain energy and reproduce to maintain life, and both exchange gases in the process of respiration. Plants also take in carbon dioxide in the process of photosynthesis.

Spotlight on the Standards

★ 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 which 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 to make new viral proteins. Like living organisms, viruses contain genetic material (either DNA or RNA), can reproduce, 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 viable. Living cells are not able to survive crystallization.

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Sample Questions for Content Domain II

This section has some sample questions for you to try. After you have answered all the questions, check your answers in the "Answers to the Content Domain II Sample Questions" section that follows. This section will give you the correct answer to each question, and it will explain why the other answer choices are incorrect.

1 The function of chlorophyll in a light reaction is to

A bind CO_2 to H_2O
B split to produce O_2
C trap light energy
D act as a source of CO_2

2 A group of prokaryotes that live in extreme environments are the

A viruses
B protists
C eubacteria
D archaebacteria

3 The complexity of body systems differs greatly among organisms. Which of the following organisms has developed organ systems for obtaining and utilizing energy?

A bacterium
B mushroom
C mouse
D virus

4 Scientists have discovered a new species of animal. Which would provide the best basis for classifying this new species?

A DNA comparison
B diet of animal
C habitat of animal
D appearance of animal

5 Which statement is true about viruses?

A They can reproduce.
B They are autotrophs.
C They contain organelles.
D They are living organisms.

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Answers to the Content II Domain Sample Questions

1. Answer: **C** Standard: SB3.a; *Explain the cycling of energy through the processes of photosynthesis and respiration.*
Light reactions are the first step in the process of photosynthesis. It is the job of the chlorophyll to trap this light energy. So choice **C** is the correct answer. Remember, light reactions do not involve CO_2 and no sugars are produced, making the other answers incorrect.

2. Answer: **D** Standard: SB3.c; *Examine the evolutionary basis of modern classification systems.*
The correct answer is choice **D**. Eubacteria are considered the true bacteria, such as streptococcus and cyanobacteria. Protists are eukaryotes and live in moist environments. Viruses are genetic entities that can reproduce only in living cells.

3. Answer: **C** Standard: SB3.b; *Compare how structures and function vary between the six kingdoms (archaebacteria, eubacteria, protists, fungi, plants, and animals).*
The correct answer is choice **C**. The mouse has complex body systems formed from specialized cells that form tissues that are organized into organs, such as the stomach, pancreas, small intestine, and liver. These organs work together in organ systems to perform specific roles that support life. Bacteria are single-cell organisms that do not have tissues or organ systems. Viruses do not exist as cells. The mushroom is multi-cellular, but does not have tissues organized into organs.

4. Answer: **A** Standard SB3.c *Examine the evolutionary basis of modern classification systems.*
The correct answer is choice **A**. DNA contains the genetic information that results in organisms having specific proteins that are arranged to form cells and body systems. Organisms with similar DNA have a common ancestor. Diet and appearance are more a result of adaptations to habitat.

5. Answer: **A** Standard SB3.d *Compare and contrast viruses with living organisms.*
The correct answer is choice **A**. Viruses can reproduce by using a host cell's DNA and metabolic processes to make new viruses. A virus is not an autotroph as it cannot synthesize energy-rich compounds. A virus does not contain any organelles. A virus is not considered a living organism because it cannot reproduce on its own.

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Content Domain III: Genetics

A LOOK AT CONTENT DOMAIN III

Test questions in this content domain will measure your ability to understand how biological traits are passed on to successive generations. Your knowledge will be tested according to the following standards:

- Distinguish between DNA and RNA
- Explain the role of DNA in storing and transmitting cellular information
- Using Mendel's laws, explain the role of meiosis in reproductive variability
- Describe the relationships between changes in DNA and appearance of new traits
- Compare advantages of sexual and asexual reproduction in different situations
- Examine the use of DNA technology in forensics, medicine, and agriculture

Spotlight on the Standards

★ ***Distinguish between DNA and RNA*** ★

★ ***Explain the role of DNA 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 a maple tree or pine tree. For thousands of years, people have wondered how sons and daughters have characteristics like 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**.

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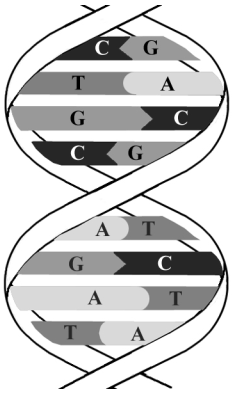
DNA

DNA forms a complex biological polymer called a **nucleic acid** used for information storage. Nucleic acids are made up of smaller subunits 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. Another name for 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 codes either for a particular amino acid, or indicates the beginning or end of a sequence. The genetic code is 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 will continue 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 and chloroplasts.

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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.

A question on the ***Biology*** **EOCT** may look like this:

Information on mRNA is used to make a sequence of amino acids into a protein by which of the following processes?

A replication
B translation
C transcription
D transference

The correct answer is **B**, translation. Remember, replication takes place in DNA. Transcription is a process in which enzymes make an RNA copy of a DNA strand. Transference is when tRNA brings amino acids to the ribosomes, so they can be assembled into proteins.

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.

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Spotlight on the Standards

★ Using Mendel's laws, explain the role of meiosis in reproductive variability★

★ Describe the relationships between changes in DNA and appearance of new traits★

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 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 and the other from the male. 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.

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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:

- **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.
- **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.
- **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 above and study their definitions to gain a better understanding of the concept of heredity through Mendel's experiments.

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A question on the ***Biology*** **EOCT** may look like this:

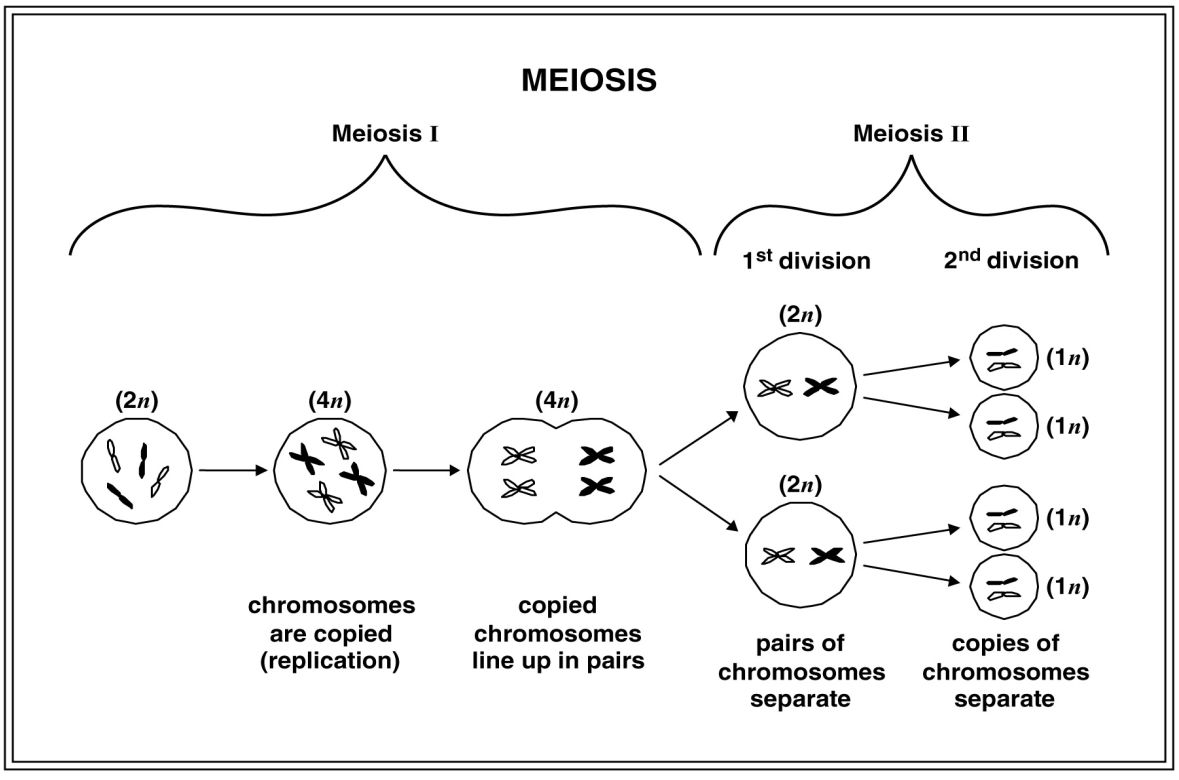
When an organism has two different alleles for a trait, it is said to be

A recessive
B dominant
C homozygous
D heterozygous

The correct answer is choice **D**, heterozygous. A recessive trait is hidden by a dominant trait. A dominant trait is observed and masks a recessive form of the trait. Homozygous refers to a pair of identical alleles for a certain trait.

Meiosis 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 occurs, the union of two gametes, a zygote is formed. Fertilization restores the original chromosome number in the resulting zygote (new individual). Meiosis occurs in two phases, meiosis I and meiosis II.

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



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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 **diploid** ($2n$) cells.
- The second meiotic division results in the formation of four cells, each containing half the number of single-stranded chromosomes. These are called **haploid** ($1n$) 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 that has seven pairs of chromosomes. Each of these seven pairs of chromosomes lines 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 increase 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} x 2^{23} different genetic combinations can occur. That is 70 trillion!

Another source of variation during 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 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 re-assortment of chromosomes and the genetic information they carry. This is known as **genetic recombination**.

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

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. For example, adenine may incorrectly pair with cytosine. 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**

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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 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.

A question on the ***Biology*** **EOCT** may look like this:

What is a source of genetic variation?

A adaptation
B mutation
C respiration
D transpiration

The correct answer is choice **B** because the two basic sources of genetic variation are mutations and the random assortment of genes that occurs during sexual reproduction. Adaptation, respiration and transpiration are not process that change the nucleotide sequences of DNA.

Spotlight on the Standards

★Compare the advantages of sexual and asexual reproduction in different situations★

★Examine the use of DNA technology in forensics, medicine, and agriculture★

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

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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 multi-celled 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 multi-cellular organisms, cell division allows them to grow (i.e., increase the size of the organism), develop from a single cell into a multi-cellular organism, and make other cells to repair and replace worn-out cells.

Asexual reproduction does not require another partner, is quicker than sexual reproduction, 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.

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Questions on the ***Biology*** **EOCT** may ask you to state the significance of cell division for unicellular and multi-cellular organisms. A question for this standard might look like this:

Why is it important for the cells of multi-cellular organisms to undergo mitosis?

A Mitosis allows for reproduction with male and female gametes.
B Mitosis increases variation within an organism.
C Mitosis produces cells that are different from the original dividing cell.
D Mitosis produces identical cells to the original dividing cell.

The correct answer is choice **D**. Multi-cellular organisms grow in size and replace worn-out cells by the process of mitosis. Meiosis is the process that results in gametes, which are reproductive cells. Mitosis does not usually contribute to variation within an individual because mitosis normally results in identical daughter cells.

Remember that meiosis is another form of nuclear division but occurs only in the formation of gametes in sexually-reproducing organisms.

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 back 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, 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. Not only does genetic engineering have applications in medicine and the environment, it 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

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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.

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Sample Questions for Content Domain III

This section has some sample questions for you to try. After you have answered all the questions, check your answers in the "Answers to the Content Domain III Sample Questions" section that follows. This section will give you the correct answer to each question, and it will explain why the other answer choices are incorrect.

1 Which of the following is the correct base-pairing rule for DNA?

A A-U; C-G
B A-G; T-C
C A-T; G-C
D A-C; T-G

2 A type of mutation that can alter DNA by the loss of a nucleotide base is known as

A substitution
B crossing over
C deletion
D insertion

3 In Mendel's experiments with a single trait, the trait that disappeared in the first generation and reappeared in the next generation is called the

A homozygous trait
B dominant trait
C recessive trait
D heterozygous trait

4 DNA in an individual's gametes will most likely be altered before being passed to offspring if exposed to

A x-rays
B loud sounds
C magnetic fields
D extreme temperatures

5 Genetic engineering techniques have been used to produce all of the following effects except

A grow salt-tolerant crop plants
B decrease harvesting time
C make crop plants resistant to disease
D decrease soil nitrogen levels

6 In fruit flies, the gray body color (G) is dominant to the ebony body color (g). What is the genotypic ratio of the offspring of a heterozygous gray female and an ebony male?

A 25% Gg, 75% gg
B 50% Gg, 50% gg
C 75% gray, 25% ebony
D 100% gray

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7 A characteristic of RNA is that it

A remains in the chromosomes in the nucleus
B is involved in translating information in DNA into proteins
C undergoes crossing-over during meiosis
D is replicated during the process of mitosis

8 Which of the following shows how information is transformed to make a protein?

A DNA ? RNA ? protein
B gene ? chromosome ? protein
C cell respiration ? ATP ? protein
D ATP ? amino acid ? protein

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Answers to the Content Domain III Sample Questions

1. Answer: **C** Standard SB2.a: *Distinguish between DNA and RNA.*
According to the base-pairing rules, adenine pairs with thymine and cytosine pairs with guanine; therefore choices **A**, **B**, and **D** are incorrect. "U" represents uracil, a base found in RNA but not in DNA.

2. Answer: **C** Standard SB2.d: *Explain the relationship between changes in DNA and alterations during replication.*
The correct answer is choice **C**, deletion. Crossing over is the exchange of genetic material by non-sister chromatids, resulting in new combinations of alleles. Nondisjunction is the failure of homologous chromosomes to separate during meiosis. Translocation is the process by which part of one chromosome has exchanged places with the corresponding part of another.

3. Answer: **C** Standard SB2.c: *Using Mendel's laws, explain the role of meiosis in reproductive variability.*
The correct answer is choice **C**, recessive trait. The dominant trait masks or hides the recessive trait. Heterozygous indicates two different alleles for a particular trait. Homozygous refers to having identical alleles for a particular trait.

4. Answer: **A** Standard SB2.d: *Explain the relationship between changes in DNA and alterations during replication.*
The correct answer is choice **A**. X-rays can cause mutations to the DNA in cells. If these cells undergo meiosis to form gametes, the mutated DNA will be passed on to the gametes, deletion.

5. Answer: **D** Standard SB2.d; *Explain the relationship between changes in DNA and potential appearance of new traits.*
The correct answer is choice **D**. Genetic engineering has allowed farmers to develop crops that are less likely to be infected with disease, such as fungal infection. Genes from salt-tolerant marsh plants have been inserted into crop plants to make plants that are salt-tolerant. Tomatoes have been genetically modified to make them easier to harvest. Plants have not been modified to decrease soil nitrogen content because high nitrogen content is desirable.

6. Answer: **B** Standard SB2.c; *Using Mendel's laws, explain the role of meiosis in reproductive variability.*
The correct answer is choice **B**. The cross can be diagrammed using a Punnett square. The female fly is Gg and the male fly is gg. The genotype of the offspring will be 50% Gg and 50% gg. Gray and ebony describe the phenotype, or appearance, of the flies, not the genotype, and the percentages are also incorrect for the phenotypes given of the offspring.

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7. Answer: **B** Standard SB2.a: *Distinguish between DNA and RNA.*
The correct answer is choice **B**. RNA transcribes the information on the DNA molecule and carries it into the cytoplasm, where it also functions to retrieve the needed amino acids to form proteins. Therefore, RNA does not remain in the chromosomes in the nucleus. Crossing-over is a process of homologous chromosomes in DNA. DNA is replicated during mitosis.

8. Answer: **A** Standard SB2.a: *Distinguish between DNA and RNA.*
The correct answer is choice **A**. DNA contains the genetic information for producing proteins. RNA copies this information, collects the needed amino acids and carries them to the ribosomes, where they are assembled into proteins. Choice **B** is incorrect. Genes are located on strands of DNA and contain information for specific traits. Chromosomes are composed of DNA molecules and proteins. Choice **C** is incorrect. Cellular respiration is a process by which energy is transformed so it can be used for cell activities. Choice **D** is incorrect. ATP is an energy-storage molecule that is used in some forms of cell respiration. Amino acids are the molecules used to construct proteins.

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Content Domain IV: Ecology

A LOOK AT CONTENT DOMAIN IV

Test questions in this content domain will measure your ability to explain the interrelationships between organisms and their environments. Your knowledge will be tested according to the following standards:

- Investigate the relationships among organisms, populations, communities, ecosystems, and biomes
- Explain the flow of matter and energy through ecosystems
- Relate environmental conditions to successional changes in ecosystems
- Assess and explain human activities that influence and modify the environment: global warming, population growth, pesticide use, water and power consumption
- Relate plant adaptations, including tropisms, to the ability to survive stressful environmental conditions
- Relate animal adaptations, including behaviors, to the ability to survive stressful environmental conditions

Spotlight on the Standards

★Investigate the 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 Nino," "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 particular environments. Penguins

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are adapted to live in cold water and ostriches are adapted to live on dry savannas. They have adaptations for obtaining food, for protection, 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* EOCT**, 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 between 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.

Biomes — A group of ecosystems in the same region having similar types of vegetation governed by similar climatic conditions. Ecologists study biomes such as tropical rain forests, prairies, and deserts.

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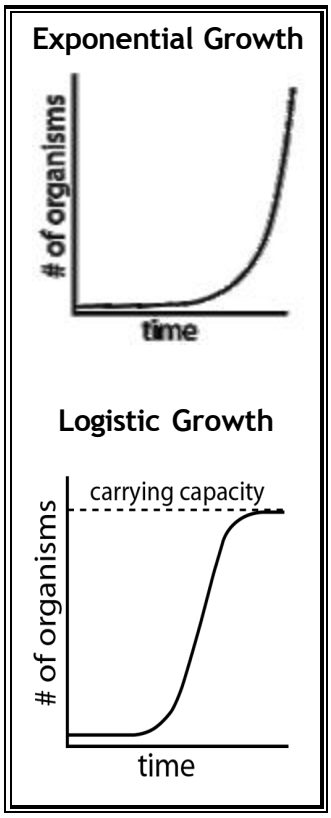
Populations

A **population** is a group of organisms of one species that lives in the same place at the same time. 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 that require very different resources from 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 bacteria were allowed to continually reproduce, the planet would be overrun with bacteria! 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*** **EOCT**, 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.

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

Density-Dependent Limiting Factors	**Density-Independent Limiting Factors**
Competition	Weather
Predation	Fires
Parasitism	Droughts/Floods
Crowding/Stress	Human Activities

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.

Ecosystems

Ecologists also study the interactions between populations (biotic factors) and their physical surroundings (abiotic factors). An **ecosystem** is the interactions among the populations in a community and the physical surroundings of the community. **Terrestrial ecosystems** are those found on land. **Aquatic ecosystems** are in either fresh or salt water. **Salt water ecosystems** are also called **marine** ecosystems.

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.

Biomes

Biomes are a group of ecosystems in the same region having similar types of vegetation governed by similar climatic conditions. The six terrestrial biomes are:

1. tundra
2. taiga
3. tropical rain forest
4. temperate deciduous forest
5. desert
6. grassland

Refer to your textbook and class notes for the locations of these biomes.

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Terrestrial Biomes

Tundra

Abiotic Factors: −40°C to 10°C, annual precipitation is less than 25 cm, windy, permafrost

Biotic Factors: vegetation—nearly treeless, mainly grasses, sedges, and lichens
animals—arctic hare, lemming, arctic fox, snowy owl

Tropical Rain Forest

Abiotic Factors: 20°C to 30°C, annual precipitation is greater than 200 cm

Biotic Factors: vegetation—broad-leafed evergreen trees, ferns, orchids
animals—monkey, tapir, flying squirrel, birds/parrots, jaguar

Desert

Abiotic Factors: from −30°C to 38°C in cool deserts to 20°C up to 49°C in hot deserts; annual precipitation less than 25 cm

Biotic Factors: vegetation—brush, cacti, small plants
animals—camels, antelope, rabbits, many reptiles, arachnids

Grassland

Abiotic Factors: −10°C to 25°C, annual precipitation 25 to 75 cm

Biotic Factors: vegetation—grasses, small plants, mosses, lichens
animals—grazing herbivores: bison, antelope, zebra, elephant, wildebeest
predators—wolves, lions, leopards

Taiga

Abiotic Factors: −30°C to 20°C, annual precipitation 30 to 50 cm, soil thaws completely in summer

Biotic Factors: vegetation—coniferous trees, ferns, mosses, mushrooms
animals—snowshoe hare, timber wolf, weasel, black bear, woodpecker

Temperate Deciduous Forest

Abiotic Factors: −10°C to 25°C, annual precipitation 75 to 125 cm

Biotic Factors: vegetation—sugar maple, birch, pine, oak, flowering plants, moss
animals—white-tailed deer, cottontail rabbit, squirrel, raccoon

There are also aquatic biomes, divided into fresh water and marine ecosystems. Fresh water ecosystems are the lakes, rivers, streams and ponds. Marine ecosystems include the open ocean, the rocky intertidal zones, and the estuaries.

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Aquatic Ecosystems

Open Ocean

Abiotic Factors: temperature range varies with latitude and water depth, sunlight decreases with water depth, water density changes with temperature and salt content, etc.
Biotic Factors: phytoplankton, fish, dolphins, whales, seals, sea birds, etc.

Rocky Intertidal

Abiotic Factors: alternating exposure to direct sunlight and submergence, salinity changes, rocky substrate, etc.
Biotic Factors: algae, sea urchins, clams, mussels, starfish, etc.

Estuaries

Abiotic Factors: large fluctuations in salinity, extreme temperature changes, etc.
Biotic Factors: algae, mosses, aquatic plants, insects, shrimp, crabs, amphibians, birds, etc.

Freshwater

Abiotic Factors: seasonal fluctuations of depth and temperature
Biotic Factors: freshwater plants, algae, insects, fish, wading birds, phytoplankton, zooplankton

Spotlight on the Standards

★ ***Explain 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 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**,

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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	raccoon
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 the Earth, the energy flows first to primary 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*** **EOCT**, you may be given a diagram of a food chain or web and may be asked to describe the role of different organisms. A question for this standard might look like this:

In the food chain below, which population will most likely decrease if snakes are removed from the food chain?

grass → grasshopper → frog → snake → hawk

A grass
B grasshopper
C frog
D hawk

The correct answer is choice **D**. The food chain indicates that hawks feed on snakes. If snakes are removed from the food chain, hawks would be negatively affected because they would have to depend more on other food sources. Frogs would most likely increase in number for a short time in response to not being eaten by snakes.

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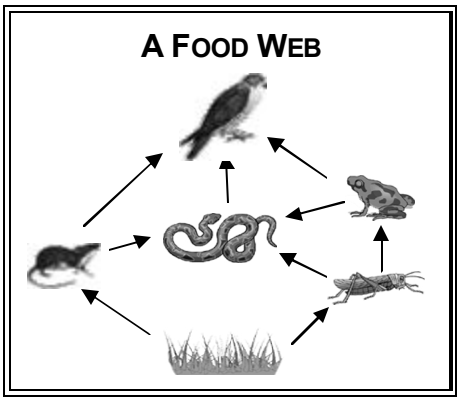
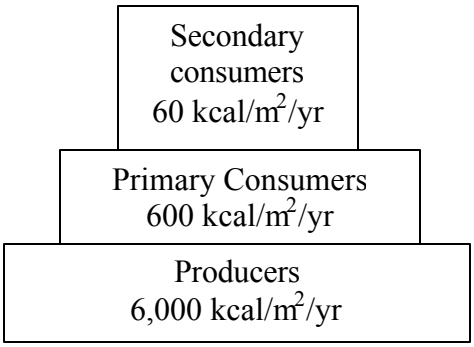


A food chain is a simplified way for ecologists to study how energy and matter flow. But it is not always that simple. Relationships exist between organisms that feed on more than one species. In an actual ecosystem there are many more plants and animals involved. A more complex interconnected system 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 transfer from one trophic level to the next is only about 10%. 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 organism 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 in 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.

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

A question on the ***Biology* EOCT** may look like this:

Which element's cycle depends on certain kinds of bacteria to keep the element available to other organisms?

A carbon
B hydrogen
C nitrogen
D phosphorus

The correct answer is choice **C**, nitrogen. Although bacteria are part of the cycles of all the elements listed, only nitrogen requires the use of nitrogen-fixing bacteria to keep the cycle going.

Spotlight on the Standards

★Relate environmental conditions to successional changes in ecosystems ★

Succession

Ecosystems are constantly changing. Some changes happen quickly, such as a forest fire, flood, or volcanic eruption. Some changes happen slowly over a period of time, such as new saplings growing into tall, mature trees. When an ecosystem changes, the organisms in that ecosystem may need to change to survive. Succession is the natural change that takes place within a community of an ecosystem. There are two types of succession that ecologists study.

Primary succession is the gradual development of a new community where no organisms have lived before. An example is the changes that take place after a volcanic eruption and the lava flow cools, hardens, and weathers. In 1963, scientists were able to observe the birth of a new volcanic island, named Surtsey. The island measured 1 square mile. Seabirds were the first to arrive. Seeds, whether airborne or "hitchhikers" on the feathers of the birds, then reached the island. The first plant, a sea rocket, bloomed in 1965. Spiders were visible, and lichens and mosses soon grew. As these pioneer organisms died, their remains formed soil. Seals used Surtsey's beaches to have their young. However, over time, Surtsey has lost about one-fourth of its mass due to erosion.

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Eventually, primary succession slows down and the community becomes stable. This community is known as a **climax community**.

Secondary succession occurs when a natural disaster or human activity partially destroys a community. Like primary succession, the community of organisms inhabiting an area changes over time. However, when secondary succession takes place, soil is already present. In secondary succession, the species replacing the pioneer species are often different. It also takes less time to become a climax community.

In Yellowstone National Park, thousands of acres burned as a result of a lightning strike. After the fire, wildflowers grew first. Wildflowers do not usually grow in forest shade. Within three years, flowers, grasses, ferns, and saplings began to take hold and grow. Once the saplings began to grow, they shaded the forest floor and a mature forest began to develop.

Spotlight on the Standards

★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 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

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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 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 (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 the Earth. The surface of the Earth heats up and radiates 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, the Earth would be too cold for any living things to survive. All the Sun's energy would be radiated back into space. The **ozone layer** that surrounds the Earth prevents lethal doses of ultraviolet radiation from the Sun from reaching organisms here on the Earth. Scientists have discovered that the ozone layer is thinning because of the release of CFCs (chlorofluorocarbons) into the atmosphere. CFCs are manufactured for coolants in refrigerators and air conditioners as well as for making Styrofoam.

Water pollution is caused by contaminants from sewers, industries, farms, and homes, which enter 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.

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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 to reduce 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 the 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.

Learning about the possible causes and solutions to certain ecological problems will help you answer a question like the following:

The theory of global warming suggests that a trend toward warmer temperatures on Earth will cause glaciers to lose mass. Which result is a major consequence of glacial melting?

A flooding coastal regions
B destruction of fossil records
C increased saltiness of the oceans
D an increase in atmospheric carbon dioxide

The correct answer is choice **A**. Glaciers contain more fresh water (2.15%) than any other fresh water source on Earth. If glaciers and other bodies of fresh water ice melted, low coastal regions would be flooded by the rising ocean water. Some fossil records might be destroyed, but this would not be a major consequence. The ocean would become less salty, not more salty, as it is diluted with fresh water. The melting of glaciers would not cause an increase in atmospheric carbon dioxide, but increasing atmospheric carbon dioxide could contribute to further warming.

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Spotlight on the Standards

★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. **Geotropism** is the response of seedlings to the force of gravity. It is important when seeds are sprouting. Geotropism 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 day and the seasons. Some flowers bloom once a year, while some others, like some cacti, bloom at night.

Tropism—a plant's response to its environment
Geotropism—a plant's response to gravity
Phototropism—a plant's response to light
Thigmotropism—a plant's response to touch

Most plants control their growth in response to environmental stimuli by using chemical messengers known as **hormones**. A hormone is a chemical that is produced in one part of an organism and transferred to another part to affect the activities of that part of the plant. One type of hormone is called **auxin**. Auxins are responsible for regulating phototropism in a plant by stimulating the elongation of cells. The cells on the auxin-rich shaded side of a stem will grow longer than the cells on the other side, causing the stem to bend toward the light. High concentrations of auxin help promote the growth of fruit and minimize the falling off of fruit from the plant. When auxin concentrations decrease in the autumn, the ripened fruit will fall. The plants will begin to lose their leaves. **Gibberellins** are growth hormones that cause plants to grow taller. They also increase the rate of seed germination and bud development. There are certain tissues in the seeds that release large amounts of gibberellins to signal that it is time to sprout.

There are also hormones that do the opposite: they inhibit plant growth and cell division. **Abscisic acid** is one of these. It inhibits plant growth during times of stress, such as cold

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temperatures or drought. In studying these hormones, scientists have found that it is the balance of different hormones that determines the plant growth, rather than one hormone by itself.

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 the conifers are flexible, allowing for them to bend instead of break 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 attention of insects that aid in pollination. Pollen will rub off on the insect and then is carried to another flower. The coconuts from palm trees float which allows seeds to travel from one island to another.

A question for this standard may look like this:

What characteristics of some pine trees allow the species to survive a sudden environmental change?

A modified leaves from needle bundles
B seeds that germinate after fires
C pollen that is easily carried by wind
D bark that is lightly colored

The correct answer is choice **B**. Several species of pine have seeds that are resistant to fire. They are in cones that must be exposed to fire to open and release the seeds. The modified leaves conserve moisture. The pollen blows easily; therefore, insect and bird activity isn't necessary to spread the pollen from tree to tree. The color of the bark does not make the tree resistant to disaster. Bark thickness is a more important characteristic.

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

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Spotlight on the Standards

★Relate animal adaptations, including behaviors, to the ability to survive stressful environmental conditions★

Behavior

Behavior is defined as anything an animal does in response to stimuli in its environment. A squirrel gathering nuts and acorns in the autumn is a behavior that is stimulated by shorter days and colder weather. Gathering food for themselves and their young, caring for their young, avoiding predators, seeking shelter, and finding a mate are important behaviors to the survival of many animals. Many animals have learned and inherited behaviors.

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 a person touches a hot surface, they automatically withdraw their hand from the source of heat. Bright lights make eyes automatically blink. 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 will mate. Different species of fireflies flash distinctive patterns of light. The female will respond only to the male that exhibits the species-correct flashes.

Territorial Behavior

A **territory** is a physical space that contains the breeding grounds, feeding area, shelter, or potential mates of an animal. Animals that have territories use different behaviors to defend their space against an animal of the same or different species. Setting up territories is a way to reduce conflict, control populations, and decrease competition. It also is a problem solver in that it helps provide for efficient use of environmental

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resources by spacing animals out over an area. There is a greater chance for survival of young, increasing the survival rate of the species.

Aggression is another behavior exhibited by animals to fend off predators and competitors. It is a way to protect young and to protect food sources. Animals of the same species will not usually fight to the death. Usually it will be the stronger animal that will stop the fighting when the weaker animal shows signs of submission.

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 Antarctic. Animals use various environmental cues to navigate during migration. Scientists believe that some species use geographical clues such as mountain ranges. Other species use the Earth's magnetic field.

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.

Learned Behavior

Learned behavior is a result of previous experiences of an animal that modifies their current behavior. Learned behavior has survival value because it allows animals to change their behavior in a changing environment. It allows animals to increase the chance for survival. Feral horses learn to allow people to ride them. Deer have learned to come into yards to feed with no fear of people or barking dogs. This type of learned behavior is called **habituation**. It occurs when an animal is repeatedly given a stimulus that is not harmful and does not have a negative impact on the animal. **Imprinting** is another form of a learned behavior. An example is when an animal returns to the place of its birth to lay its eggs, or when an animal imprints on its mother or other organism in its environment. Kemp's Ridley sea turtles will return to the beach where they were hatched to lay their eggs. It is not yet known exactly what the turtles imprint on, whether it is the sand or in the water. Salmon also return to the same river to spawn.

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Adaptations for Defense

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

- **Mechanical defense** is incorporated into the physical structure of the organism.
- **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 ivory 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. Plants also have mechanical defenses. Many have thorns, spines, and stiff hairs 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.

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. 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 larva, monarchs feed on milkweed plants, which contain compounds which 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.

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

On the ***Biology*** **EOCT**, 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.

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Sample Questions for Content Domain IV

This section has some sample questions for you to try. After you have answered all the questions, check your answers in the "Answers to the Content Domain IV Sample Questions" section that follows. This section will give you the correct answer to each question, and it will explain why the other answer choices are incorrect.

1 A group of organisms of a certain species that is in one area at a given time is known as

A an ecosystem
B a community
C a population
D a trophic level

2 As energy flows through an ecosystem, at each trophic level it

A increases
B decreases
C fluctuates
D remains the same

3 Predators often feed on weak or sick animals in an ecosystem. The role of the predator is described as its

A community
B habitat
C niche
D population

4 Lightning causes a fire that destroys all the plants in a forest community. Which of the following will MOST likely be the first to occupy the burned area?

A oak seedlings
B pine trees
C grasses and annual plants
D woody shrubs

5 The state of California has several large cities and very productive croplands that divert and use large amounts of water from rivers. What is one damaging effect of this use of the rivers' water?

A increased amounts of solid waste pollution in oceans
B decreased amounts of fresh water in marshes and estuaries
C changes in local rainfall amounts
D changes in upstream water tables

6 Plants that live in the rain forest have many adaptations to their environment. Some plants, such as vines, have adaptations that allow them to attach themselves to the trunks of trees. These adaptations allow vines to successfully compete for which of the following limited resources in the rain forest?

A sunlight
B water
C carbon dioxide
D oxygen

7 Birds have been observed puffing up their feathers under certain conditions. By trapping air between feathers, this behavior helps the bird

A hide from enemies
B expend less energy during flight
C shelter offspring
D trap body heat

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Answers to the Content Domain IV Sample Questions

1. Answer: **C** Standard SB4.a: *Investigate the relationships among organisms, populations, communities, ecosystems, and biomes*
The correct answer is choice **C**, population. An ecosystem consists of all biotic and abiotic factors. A community consists of several populations living in an area. Trophic levels have to do with energy pyramids. One trophic level can include many species.

2. Answer: **B** Standard SB4.b: *Explain the flow of matter and energy through ecosystems by*
- *Arranging components of a food chain according to energy flow*
- *Comparing the quantity of energy in the steps of energy pyramids*
- *Explaining the need for cycling of major nutrients*

The correct answer is choice **B**. As energy is transferred up the energy pyramid, remember that only about 10% of the energy moves to each successive level. The rest of the energy is used by the organisms themselves or is given off as heat.

3. Answer: **C** Standard SB4.a: *Investigate the relationships among organisms, populations, communities, ecosystems, and biomes*
The correct answer is choice **C**. The community describes the different populations in an ecosystem, while population describes all individuals of the same species. The niche of any organism is the functional role within the ecosystem. A habitat is the physical environment of an organism.

4. Answer: **C** Standard SB4.c: *Relate environmental conditions to successional changes in ecosystems*
The correct answer is choice **C**. In most ecosystems, secondary succession begins with grasses and annual plants, whose seeds either are fire-resistant or are carried easily on the wind or by animals. These plants are then followed by shrubs and perennial plants, then by trees.

5. Answer: **B** Standard SB4.d: *Assess and explain human activities that influence and modify the environment such as global warming, population growth, pesticide use, water and power consumption*
The correct answer is choice **B**. The rivers flow into marshes and estuaries, and excessive water use results in decreased amounts of fresh water and increased salinity in the marshes and estuaries. The primary cause of solid waste pollution in oceans is the dumping of garbage. The use of water from rivers has not been found to significantly affect local climate conditions. The underground water tables in upstream watersheds are not affected by downstream water use.

6. Answer: **A** Standard SB4.e*: Relate plant adaptations, including tropisms, to the ability to survive stressful environmental conditions*
The correct answer is choice **A**. The tree canopies in rain forests block most light from reaching the ground. The vines have adapted in ways that make it possible for them to live in a part of the rain forest that has more available light.

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7. Answer: **D** Standard SB4.f: *Relate animal adaptations, including behaviors, to the ability to survive stressful environmental conditions*
The correct answer is choice **D**. Air trapped between feathers acts as an insulator. Puffing up will not help the bird become less visible, fly faster, or act more protectively.

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Content Domain V: Evolution

A LOOK AT CONTENT DOMAIN V

Test questions in this content domain will measure your knowledge and understanding of the role of natural selection in the development of the theory of evolution. The questions will assess your ability to:

- Trace the history of the theory
- Explain the history of life in terms of biodiversity, ancestry, and the rates of evolution
- Explain how fossil and biochemical evidence support the theory
- Relate natural selection to changes in organisms
- Recognize the role of evolution to biological resistance

Spotlight on the Standards

★Trace the history of the theory★

The Origins of the Theory

Evolution is most often connected to the name of Charles Darwin. But the concept of evolution began much earlier than Darwin. In fact, in 1809, the year that Darwin was born, a French zoologist named Jean Baptiste de Lamarck presented a new evolutionary theory. Lamarck believed that all life forms evolved and that the driving force of evolution was the inheritance of acquired characteristics. He believed that organisms changed due to the demands of their environment. This "passing on of acquired characteristics" helped lower life forms climb the ladder of life to become more complex organisms. The example that he used in explaining his theory is that of a giraffe's neck. He believed that in order for the giraffe to reach its food, it had to stretch its neck. So, over many generations, an elongated neck became part of the giraffe's body. He also believed that if a body part of an organism wasn't used, that body part would be lost. Lamarck's work has an important relationship to Darwin's theory that evolution of living things proceeds according to natural laws.

Geologists were also discovering ancient bones, shells, and fossilized plants in England in the late 1800s. They were finding these remains on hillsides and in riverbeds. These findings caused people to look for an explanation for the existence of the fossils. This

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new revolutionary concept of evolution would soon become a fundamental theory, explaining the diversity of organisms.

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, developed variations, and then became extinct over time. Lyell also believed that the Earth's physical landscape 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 Galapagos 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 that 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 importance 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 these variations on to the next generation.

Secondly, the organisms on the Galapagos 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. He 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 based 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

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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.

A question for this standard on the ***Biology*** **EOCT** may look like this:

Ancestors of the koala lived on the ground, but modern koalas live in trees and eat eucalyptus leaves, which are poisonous to most other animals. The difference between the ancestor and modern koalas was caused by

A the presence of homologous structures
B the presence of vestigial organs
C selective breeding
D natural selection

The correct answer is choice **D**. Koalas changed gradually over time through the process of natural selection to fit a niche in which there was little competition for food or habitat. Homologous structures and vestigial organs are a result of evolution, not a cause. Koalas were not selectively bred by humans to have the traits they have today.

Spotlight on the Standards

★Explain the history of life in terms of biodiversity, ancestry, and the rates of evolution★

The work of Charles Darwin and Gregor Mendel laid a foundation to explain the large diversity of species found today. **Adaptive radiation** is when species diversity occurs in a relatively short time. It occurs when a population colonizes a new area. A good example is the large number of finch species that Darwin observed on the different Galapagos Islands. He counted over a dozen different species of finches that he believed evolved from a single founding species.

Another mode of evolution is **convergent evolution**. This is where unrelated species may independently evolve superficial similarities because of their adaptations to similar environments. When molecular biologists developed new techniques for analyzing DNA

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new understanding developed about how these 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 between 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.

One structure of great interest is the ribosome. Molecular biologists have found that the DNA sequences that build bacterial ribosomes are similar to the genes that make human ribosomes. Another example is myosin. **Myosin** is a protein found in muscle cells of humans and other multi-cellular organisms. Myosin reacts with other proteins to cause muscles to contract, causing movement. Myosin is also found in yeast cells. Yeast have organelles that require movement. This is accomplished when the myosin interacts with other proteins to make the organelles move within cells. The similarity between 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. Researchers 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 scientists believe provides the raw material for 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.

Speciation is the evolution of a new species that occurs due to changes in gene flow in populations of the ancestral species. Evolution of new species due to **geographic isolation** occurs when physical barriers cause populations to divide and prevent 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 different so that a new species is formed.

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Gradualism is evolution that occurs over a long period of time when adaptive changes accumulate slowly and steadily over time in a population. Darwin believed in gradualism.

Punctuated equilibrium states that speciation occurs quickly in rapid bursts, with long periods of stability.

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*** **EOCT**, 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. A question may look like this:

Horses and tapirs have a common ancestor, but they now look very different from one another. Horses are now grassland animals adapted for grazing on grass and shrubs. Tapirs are jungle animals that live in dense forests and eat fruit, leaves, and aquatic vegetation. Which of the following led to the development of such differences in the two species?

A selective breeding
B convergent evolution
C DNA hybridization
D natural selection

The correct answer is **D**. The animals with traits that contributed to success in a particular environment reproduced and passed on those traits. Horses and tapirs were not developed by selective breeding. DNA hybridization is a laboratory technique used to evaluate DNA similarities and differences. Convergent evolution is a process by which unrelated organisms develop similar attributes due to living in similar environments.

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.

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Spotlight on the Standards

★Explain how fossil and biochemical evidence support 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 transition forms. There are several reasons that few transition species are found. Approximately two-thirds of all the organisms that ever lived were soft-bodied. It also depended on where and how an organism died as to whether their remains could be fossilized. Fossils also could have been destroyed by erosion or pressure from overlaying rocks. Exposure to wind, rain, and soil erosion could prevent fossils from forming.

Fossil Age

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:

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 (^{14}C) is the primary isotope used in radioisotope dating. When an organism dies there is no additional carbon that is added to it. Scientists measure this carbon 14 to carbon 12, which is in living matter (that is, the ratio of ^{14}C to ^{12}C). This ratio will change every year as the half-life of ^{14}C decreases over time. The half-life of ^{14}C is 5,770 years. That means that it takes 5,770 years for half of the carbon to become 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 some scientists believe the Earth really is. So after about 50,000 years, the traceable amounts of carbon are gone. Scientists often use other isotopes such as uranium 235, which will decay into the daughter element, lead 207, in approximately 713 million years.

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**.
By using the ages of fossils, interrelationships between organisms can be determined. Organizing similar fossils by age show how species become more complex over time. An

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example of advancing complexity 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.

For the ***Biology*** **EOCT**, it is important that you are able to explain the concepts of how the fossil record and biochemical evidence support the theory of evolution. A question on the test may look like this:

Fossils of Archaeopteryx show that this animal had feathers, like a bird. It also had a bony tail, teeth, and claws on its wings, like a reptile. These fossils are evidence that support the idea that

A birds and reptiles have a common ancestor
B birds have changed very little over millions of years
C reptile species are more advanced than bird species
D reptiles are warm-blooded like birds

The correct answer is choice **A**. These fossils are transition fossils, showing the gradual loss of some unnecessary physical structures and the gradual development of those characteristics that were beneficial to survival. Most birds are very different from the Archaeopteryx fossils and have changed a great deal over millions of years. There is no evidence in these fossils to show that reptiles are more advanced than birds. Reptiles are not warm-blooded like birds.

Extinction

Extinction is the permanent loss of a species. Extinctions have occurred over time. Paleontologists have come to the conclusion that there have been five mass extinctions, resulting in a great number of species being completely wiped out. They believe one of these mass extinctions occurred at the end of the Permian period, when 96% of marine invertebrates became extinct. The other extinction occurred at the end of the Cretaceous period, when they believe 60–75% of marine species died.

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Spotlight on the Standards

★*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 one 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 their 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.

Stabilizing Selection

Stabilizing selection, also called normalizing selection, is responsible for maintaining the status quo for an organism's genetic makeup in an environment. It is common in environments that have remained stable over long periods of time. Possibly, the phenotype has not changed much because it has become very well adapted to its environment, such as the open sea or the high-pressured regions of the sea floor.

Directional Selection

Directional selection involves changes from one phenotypic property to a new one. When environmental conditions favor the survival of individuals carrying a genetic variant, the outcome is an increase in the frequency of that variant in the population. Many insects have become resistant to pesticides. Those with the ability to survive the insecticides sprayed on them reproduce, passing on the genes for this survival ability.

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Disruptive Selection

Disruptive selection results in the disappearance of forms that are considered intermediate between several extreme variants. Disruptive selection will split a species into two or more groups by strongly selecting against the intermediate or average phenotypes.

Natural selection can take on many forms and produce diverse effects on populations. In summary, natural selection may maintain the status quo for a population in its genotype or in its phenotype. Trends may occur in different directions; decreasing a species or increasing a species. Increasing the diversity in genotype and phenotype may result in a new species.

It is important for you to review your textbook. On the ***Biology*** **EOCT**, you may be asked to identify and describe the different variations of natural selection and their impact on a species. A question may look like this:

Although the arctic fox and the kit fox are closely related, they look very different because the individuals

A acquired traits during their lifetimes that contributed to survival
B with traits most suited to their environment reproduced most successfully
C migrated long distances to environments that most suited their traits
D passed on to their offspring acquired behaviors that were helpful

The correct answer is choice **B**. The animals gradually evolved to have very different traits that helped them succeed in very different environments. Traits and behaviors acquired by an animal during its lifetime are **not** passed on to the next generation. The animals also would not have moved to a dramatically different region to try to fit their traits to their environment.

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Spotlight on the Standards

★Recognize the role of evolution to biological resistance★

New techniques in molecular biology have given researchers new insight into genetic mechanisms that may be involved in some types of directional selection. Directional selection involves change from one phenotypic property to a new one. For example, when a bed of oysters in Malpeque Bay was infected with a lethal pathogen in 1915, it almost wiped out the oyster industry. But 10 years later, the oysters were making a comeback. By 1940, the Malpeque Bay was producing more oysters than it ever had. They began to repopulate other areas that had been wiped out. What brought about this drastic change for the oyster? Directional selection. Out of the 50 million or so offspring that were produced each year by the oysters, a fraction of those offspring carried an allele that was resistant to this pathogen. So when the environmental conditions were favorable for the offspring that carried this allele, the outcome was an increase in that variant in the population. This resulted in an increase in healthy oysters.

Many insects have developed resistance to insecticides. Mutations can modify a protein so the insect is no longer susceptible to an insecticide. In a swamp treated with an insecticide, surviving mosquitoes had a gene that produced a protein making these mosquitoes resistant to the insecticide. Successive generations of mosquitoes in this swamp had greater resistance to the insecticide.

Viruses are another organism that are constantly evolving in response to changes in their environment. Some don't change quickly, like smallpox or measles. This gave biologists time to create a vaccine against them. Others change very quickly, such as the flu. The flu virus mutates rapidly, constantly changing its genotype and phenotype, so the flu virus changes year to year. The human body does not recognize the new virus as anything harmful, so it doesn't send out anything to attack it. Another adaptation of viruses is that certain viruses can live in two or more different hosts. One virus may originally live in pigs and geese and then move on to live in humans and ducks. Viruses carry their genetic information on eight pieces of DNA. So if two strains of the virus infect the same cell, some of those genes will get mixed up, resulting in a new strain of the virus. This can cause major problems for the host.

It is very important to review your textbook and study these concepts. On the ***Biology* EOCT** you may be asked to explain the importance of evolutionary changes on organisms that are affected by biological resistance and how these changes come about.

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A sample ***Biology*** **EOCT** question may look like this:

Some viral diseases require only one vaccination, which lasts for years. For other diseases such as the flu, vaccinations last only one season. The flu vaccine lasts such a short time because the flu virus

A is more easily transmitted than other viruses
B mutates much more rapidly than other viruses
C is less dangerous than other viruses
D is much smaller than other viruses

The correct answer is **B**. The flu virus mutates much more rapidly than other viruses.

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Sample Questions for Content Domain V

This section has some sample questions for you to try. After you have answered all the questions, check your answers in the "Answers to the Content Domain V Sample Questions" section that follows. This section will give you the correct answer to each question, and it will explain why the other answer choices are incorrect.

1 Which of the following is considered by most biologists to be the most accurate in supporting the theory of evolution?

A fossils
B embryology
C DNA sequencing
D genetic equilibrium

2 The development of radiocarbon dating allows scientists to see how many times carbon atoms have been through half-lives. Since scientists know the length of a C-14 half-life, they can gain knowledge about fossils using the C-14 dating technique. When radiocarbon dating was introduced, it changed the way people thought about how organisms evolved because the technique showed

A how long ago some organisms were alive
B that eating habits have changed in some animals
C how different the chemical composition was long ago
D that most plants were gymnosperms

3 There are currently millions of species of organisms and new species are still being discovered. Based on Darwin's theory of evolution, which of the following best describes how millions of species have developed?

A Organisms passed on acquired characteristics to evolve from lower life forms to higher life forms.
B Organisms were selectively bred to create different species.
C Completely different species crossed with one another to form the many different organisms.
D Different genetic variations in organisms were selected in different environments.

4 Which of the following best supports the idea that organisms and environments have changed over time?

A the discovery of fossilized fern plants in Antarctica
B the production of sterile hybrid animals such as the mule
C the many different species of plants in tropical areas
D the ability of many animals to learn new behaviors

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5 **The cotton whitefly has become a key pest for farmers, damaging many kinds of crops. The cotton whitefly has developed resistance to a variety of pesticides. Pesticide resistance would most likely develop in insects that**

A reproduce rapidly
B feed on few types of plants
C undergo complete metamorphosis
D live in very limited regions

6 **The DNA of an organism contains information that is used to sequence amino acids to form specific proteins. The existence of different organisms with very similar amino acid sequences is evidence of**

A a common ancestor
B common adaptive behaviors
C a similar diet
D a similar environment

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Answers to the Content Domain V Sample Questions

1. Answer: **C** Standard: SB5.c: *Explain how fossil and biochemical evidence support the theory*
The correct answer is choice **C**. DNA is the most accurate tool for determining relatedness among individuals. Remember that when Darwin developed his theory of natural selection, he did so without the benefit of the knowledge of genes. We have learned that adaptations of species are determined by the genes encoded in the DNA. Fossils are a way to determine the evolutionary process, but they are not the best way. There are a lot of missing puzzle pieces that are not accounted for. Genetic equilibrium is when there is no change in the frequency of alleles within a population. It is believed that when a population is in genetic equilibrium, it is not evolving.

2. Answer: **A** Standard: SB5.c: *Explain how fossil and biochemical evidence support the theory*
The correct answer is choice **A**. Using the half-life value of carbon and knowing how many half-lives the carbon had experienced allows scientists to calculate estimates of how long organisms were alive. In many cases the time frame was much larger than originally thought. Radiocarbon dating offers no information about eating habits or chemical composition (other than carbon). C-14 dating does not provide information about the reproductive strategies of organisms.

3. Answer: **D** Standard SB5.d: *Relate natural selection to changes in organisms*
The correct answer is choice **D**. As organisms reproduced, different combinations of traits and genetic mutations produced organisms with different characteristics. Organisms with different traits were successful in different environments. Many species evolved to fit the many different niches in the different environments. Characteristics acquired during an organism's life are not passed on to future generations. Selective breeding by humans did not take place until long after millions of different species already existed. Organisms of completely different species rarely cross successfully because of incompatibility of their DNA.

4. Answer: **A** Standard SB5.a: *Trace the history of the theory*
The correct answer is choice **A**. The existence of fossilized ferns in Antarctica is evidence that the environment of Antarctica has changed greatly. The organisms that live in Antarctica now are adapted for a very different climate from the fossilized ferns that once lived there. The breeding of sterile hybrid animals such as the mule would not contribute to the change of organisms over time because the hybrids would not be able to reproduce to pass on their unique combination of traits. The existence of many species of tropical plants does not show that the plants have changed over time. Learned behaviors are not passed on to future generations.

5. Answer: **A** Standard SB5.e: *Recognize the role of evolution to biological resistance*
The correct answer is choice **A**. Organisms that reproduce rapidly can fix new traits quickly because there are many generations in a short time period, and mutations that

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help the organism survive are passed on to many more organisms in a short time. Usually, living in a limited region or eating only a few types of plant does not help organisms develop resistance because if there are significant environmental changes, these organisms are more likely to be reduced in numbers because they are not very adaptable. The process of metamorphosis does not help organisms develop pesticide resistance.

6. Answer: **A** Standard: SB5.c: *Explain how fossil and biochemical evidence support the theory*

The correct answer is choice **A**. Organisms with similar amino acid sequences are related to a common ancestor and will have similarities in their DNA. Many organisms have a similar body structure due to their environment or diet but are not related (seals and penguins).

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Co-requisite Domain: Characteristics (and Nature) of Science

A LOOK AT THE CO-REQUISITE DOMAIN

Test questions in this content domain will be integrated within the five biological science domains. These questions will measure content as well as your ability to use scientific processes and solve problems. Along with your knowledge of the five domains of biological science, your answers to the questions will help show how well you:

- Identify tools, terms, and processes used in scientific inquiry, including laboratory safety and scientific research.
- Comprehend how scientific knowledge is developed.
- Recognize how scientific information is properly verified and communicated.

This part of the domain will test how well you understand the importance of ethics in science. Scientists should be curious, honest, open, and skeptical in the pursuit of knowledge. You should develop these traits during your own activities in the lab and classroom. In the lab, you might have noticed that different explanations can often be given for the same evidence. The four qualities just mentioned should lead you and others to find the most accurate explanation for the evidence. This requires further understanding of the scientific problem. It will require you to design and perform new experiments. These experiments will either support or weaken the opposing explanations.

Before starting the experiments, you and your classmates should use standard safety practices. These should be carefully followed in the classroom, in the laboratory, and in the field. These practices include the following:

- Always use correct procedures when working with scientific apparatus.
- Always use proper techniques in the laboratory.
- Immediately identify and report safety problems and violations.

Laboratory Safety

- Conduct and Preparation in the Laboratory
- Eye Safety
- Safety Equipment
- Dress Code and Neatness
- Working with Sharp Instruments
- Working with Chemicals
- Working with Glassware
- First Aid and Handling Emergencies
- Waste Disposal and Cleanup

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After you have addressed all safety issues, you are ready to identify and investigate a scientific problem. First, reasonable hypotheses should be suggested for an identified problem. Then procedures should be developed to solve the problem. These procedures, when carried out, will require you and your lab groups to gather, organize, and record data. At the end of the experiment, the data points should be graphed so you can compare and analyze your results. Statistics should be summarized as well. Based on this work, you should develop reasonable conclusions based on the data. You will evaluate whether your conclusions are reasonable by reviewing the process and checking your data against all other available information.

You will find that good data collection and organization are vital for success. As a result, you should learn to use tools and instruments for observing and measuring data. As part of this process, you should do the following:

- Develop and use orderly procedures for recording and organizing information.
- Use technology to produce tables and graphs.
- Use technology to develop, test, and revise your experimental or mathematical models.

STRATEGY BOX—Graphs

When working with graphs, carefully read the title and the label on each axis. Check for any other information that might be included in the graph. When you think you have the answer, double check the information given in the graph.

On the test, you will need computation and estimation skills to analyze data and create scientific explanations. Sometimes you will notice large differences between your estimates and your calculated answers. Measurement errors may have a noticeable effect on calculations. Good computation and estimation skills are needed to produce reliable results. You should know that **accuracy** indicates how close your measurements approach the accepted value. **Precision** is the agreement between two or more measurements. You should be able to express the correct number of **significant figures** in your calculations. **Scientific notation** should be used to report very large or very small values. Finally, you should be able to solve problems by substituting values into simple algebraic formulas. You might also use dimensional analysis.

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Below is an example of a question that assesses your computational skills in a lab activity.

In a field investigation, students predicted the population density of birch trees in a temperate forest. Three groups of students gathered data by counting the number of birch trees in a 1- m^2 area. They recorded their data in the table below.

Group	1	2	3
Number of Trees	11	3	7
Average diameter of trunk (cm)	5	14	8

Based on the data above, what is the average number of trees that live in a 400 m^2 section of the temperate forest, and what is the average diameter of the trunk of each tree?

A 2800 trees with an average trunk diameter of 9 cm
B 21 trees with an average trunk diameter of 9 cm
C 21 trees with an average trunk diameter of 27 cm
D 280 trees with an average trunk diameter of 27 cm

The correct answer is choice **A**. The average number of trees per square meter was multiplied by 400. The average of the measurements for trunk diameter is correctly determined. Choices **B** and **C** are wrong because the trees for the three plots were added. Choice **C** is wrong also because the trunk size was not averaged. Choice **D** is wrong because the trunk diameter was not averaged.

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One of the goals of scientists is to communicate scientific investigations and information clearly. With this in mind, you should be able to write clear, logical laboratory reports. You should also be able to write clear, understandable critiques of current scientific issues, including possible alternative interpretations of scientific data. When presenting data, you should use it to support scientific arguments and claims during a group discussion.

Investigating Like a Scientist

- State the Problem: Ask a question.
- Do Background Research: Gather information.
- Form a hypothesis: Suggest an answer.
- Design an Investigation: Perform an experiment to test the answer.
- Collect Data: Record the Results of the experiment; make a data table if necessary.
- Analyze Data: Interpret the results of the experiment.
- Draw Conclusions: Explain your results.
- Ask questions: Identify new questions raised by the Conclusions for further investigation.
- Communicate Results: Share your results.

To understand how science leads to new discoveries, you should be able to analyze how scientific knowledge is developed. In order for science to grow and develop, certain assumptions are required. First, scientists assume that the universe is a vast single system in which basic principles are the same everywhere.

These universal principles are accepted through observation and experimental confirmation. Science is not exact or perfect. From time to time, scientific explanations may change as new data result in changes in the scientific view of how the world works. Most of the time, small changes to previous models lead to shifts in scientific knowledge. Major changes in scientific views typically occur when a new phenomenon is observed. These changes also occur when an individual or research group gives an insightful interpretation of existing data. Hypotheses often cause scientists to develop new experiments. These experiments produce additional data. The results of these experiments are tested and revised. New and old theories may occasionally be rejected. The process of testing and fine-tuning theories never ends as scientists try to gain new insights into old problems.

Finally, you should understand the important characteristics of the process of scientific inquiry. These characteristics include the following:

- The conditions of the experiment should be controlled to obtain valuable data.
- The quality of data, including possible sources of bias in hypotheses, observations, data analyses, and interpretations, should be critically examined and tested.

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- Peer review and publication should be employed to increase the reliability of scientific activity and reporting.
- It should be remembered that the merit of a new theory is judged by how well scientific data are explained by the new theory.
- The ultimate goal of science should be to develop an understanding of the natural universe that is free of human bias.
- It should be remembered that scientific disciplines and traditions differ from one another. These differences include what is being studied, the techniques used, and the outcomes being sought.

A question that addresses scientific process might look something like this:

The development of a useable theory may be hindered by errors and mistaken beliefs. The process followed by the scientist, however, should eventually lead to more accurate theories because

A contemporary scientists appreciate the scientific method more than ever
B new computer technology immediately detects the scientists' errors
C more complex scientific models lower the probability of inaccurate results
D additional scientific research either confirms or replaces flawed results

The correct answer is choice **D**. Continuing research leads to better explanations of phenomena. This leads to the revision or rejection of present-day theories. Choice **A** is incorrect because it is not correct to assume that scientists today appreciate the scientific method more than previous scientists. Computers do not eliminate human error, so choice **B** is incorrect. Just because a model is more complex, it does not lessen the likelihood of inaccurate results; it could make inaccurate results more likely. Therefore, choice **C** is incorrect.

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Appendix A
EOCT Sample Overall Study Plan Sheet

Here is a sample of what an OVERALL study plan might look like. You can use the Blank Overall Study Plan Sheet in Appendix B or create your own.

Materials/Resources I May Need When I Study:
(You can look back at page 2 for ideas.)

1. *This study guide*
2. *Pens*
3. *Highlighter*
4. *Notebook*
5. *Dictionary*

Possible Study Locations:

- First Choice: *The library*
- Second Choice: *My room*
- Third Choice: *My mom's office*

Overall Study Goals:

1. *Read and work through the entire study guide*
2. *Answer the sample questions and study the answers*
3. *Practice reading and answering the general questions*

Number of Weeks I Will Study: *6 weeks*

Number of Days a Week I Will Study: *5 days a week*

Best Study Times for Me:

- Weekdays: *7:00 p.m. – 9:00 p.m.*
- Saturday: *9:00 a.m. – 11:00 a.m.*
- Sunday: *2:00 p.m. – 4:00 p.m.*

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Appendix B
Blank Overall Study Plan Sheet

Materials/Resources I May Need When I Study:
(You can look back at page 2 for ideas.)

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____

Possible Study Locations:

- First Choice: _____
- Second Choice: _____
- Third Choice: _____

Overall Study Goals:

1. _____
2. _____
3. _____
4. _____
5. _____

Number of Weeks I Will Study: _____

Number of Days a Week I Will Study: _____

Best Study Times for Me:

- Weekdays: _____
- Saturday: _____
- Sunday: _____

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Appendix C
EOCT Sample Daily Study Plan Sheet

Here is a sample of what a DAILY study plan might look like. You can use the Blank Daily Study Plan Sheet in Appendix D or create your own.

Materials I May Need Today:

1. *Study Guide*
2. *Pen*
3. *Notebook*

Today's Study Location: *The desk in my room*

Study Time Today: *From 7:00 p.m. to 8:00 p.m. with a short break at 7:30 p.m.*
(Be sure to consider how long you can actively study in one sitting. Can you sit for 20 minutes? 30 minutes? An hour? If you say you will study for three hours, but get restless after 40 minutes, anything beyond 40 minutes may not be productive—you will most likely fidget and daydream your time away. "Doing time" at your desk doesn't count for real studying.)

If I start to get tired or lose focus today, I will: *do some sit-ups.*

Today's Study Goals and Accomplishments: (Be specific. Include things such as the number of pages, sections, or standards. The more specific you are, the better able you will be to tell if you reached your goals. Keep it REALISTIC. You will retain more if you study small "chunks" or blocks of material at a time.)

Study Task	*Completed*	*Needs more work*	*Needs more information*
1. Review what I learned last time	X		
2. Study the first standard in Content Domain I	X		
3. Study the second standard in Content Domain I		X	

What I learned today:

1. *The difference between ATP and ADP*
2. *What the questions about organisms and genetics might look like*
3. *How to tell the difference between the Calvin cycle and Krebs cycle*

Today's reward for meeting my study goals: *Eating some popcorn*

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Appendix D
Blank Daily Study Plan Sheet

Materials I May Need Today:

1. _____
2. _____
3. _____
4. _____
5. _____

Today's Study Location: _____

Study Time Today: _____
(Be sure to consider how long you can actively study in one sitting. Can you sit for 20 minutes? 30 minutes? An hour? If you say you will study for three hours, but get restless after 40 minutes, anything beyond 40 minutes may not be productive—you will most likely fidget and daydream your time away. "Doing time" at your desk doesn't count for real studying.)

If I start to get tired or lose focus today, I will: _____

Today's Study Goals and Accomplishments: (Be specific. Include things like number of pages, sections, or standards. The more specific you are, the better able you will be to tell if you reached your goals. Keep it REALISTIC. You will retain more if you study small "chunks" or blocks of material at a time.)

Study Task	*Completed*	*Needs more work*	*Needs more information*

What I learned today:

1. _____
2. _____
3. _____

Today's reward for meeting my study goals: _____

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