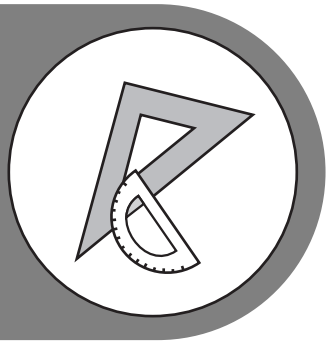
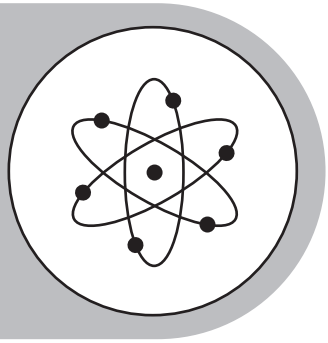
BIOLOGY

Study Guide





Georgia End-Of-Course Tests

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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 nine through twelve for the following core high school subjects:

Mathematics

- Algebra I
- Geometry

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**.

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
- ✓ Highlighter
- ✓ Paper

Resources:
- ✓ Dictionary
- ✓ English 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

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 each domain and the strategies for answering questions that assess the standards in that 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.)

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 will be given three times a year: once in the spring, once in the summer, and once in the winter.

Administration Time:

Each EOCT is comprised of two sections; each section will take 45 to 60 minutes to complete. You will have 100 to 135 minutes to complete each EOCT. You will be given a 5-minute 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 EOCT contains 40 questions; there are a total of 80 questions on the EOCT.

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

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

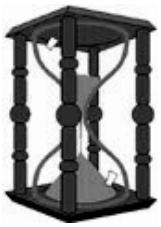
Before you begin preparing for this test, you might want to consider your answers to the following questions. You may write your answers here or on a separate piece of paper.

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: _____

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. (See Appendices A–D for SAMPLE STUDY PLAN SHEETS that you can use to help you create 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).

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 do not contribute to your success.
   Response: _____
5. What would you like to learn about taking tests?
   Response: _____

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: _____

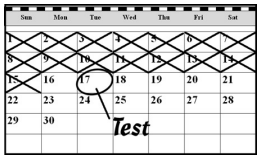
- What changes should you implement to achieve higher scores?

  Response: _____

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

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.



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 8 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.

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 45 to 60 minutes.

4. **Use positive self-talk.** If you find yourself saying negative things to yourself like, "I can't pass this test," it is important to recognize that you are doing this. Stop and think positive thoughts like, "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.

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 a section 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, standards, and elements** 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 elements would be the types of apples: fuji, gala, red delicious, etc.

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 **performance standards**. Each performance standard is broken down into more specific standards called elements. 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

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 is organized by 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.

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. The questions will assess your understanding of and ability to:

- Differentiate between prokaryotic and eukaryotic cells
- Comprehend the importance of homeostasis
- Characteristics of enzymes
- Characteristics of the four major biomolecules

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- and multicellular organisms that have cells containing internal, membrane-bound structures. They have a true nucleus containing the cell's DNA. Examples: Plants Animals Mushrooms Amoebas

Living vs. Nonliving

All living things, or organisms, share certain characteristics such as:

- Require food for energy to carry out life processes
- Use energy to maintain homeostasis
- Respond to stimuli in their environment
- Reproduce similar offspring, passing genetic information to them
- Made of cells

Cells must have boundaries.

Cells have **plasma membranes** that serve as a boundary between the cell and its external environment. The plasma 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 plasma membrane also helps maintain a chemical balance within the cell.

An additional boundary outside of the plasma membrane is the **cell wall**. The cell wall is thicker than the plasma membrane and 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:

1 Unlike prokaryotic cells, eukaryotic cells have the capacity to

A assemble into multicellular 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 **A**. Eukaryotic cells are capable of specialization and forming multicellular organisms. Both prokaryotic and eukaryotic cells are capable of symbiosis, photosynthesis, and storing DNA.

2 Inside eukaryotic cells are membrane-bound structures called

A cell walls
B cilia
C organelles
D cytoplasm

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

Some examples of organelles and their functions:

Nucleus: contains DNA, which controls cellular function
Chloroplasts: capture solar energy for photosynthesis
Golgi bodies: modify, sort, 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 their function. They may also ask you to distinguish between plant and animal cells.

Spotlight on the Standards

★*The Importance of Homeostasis*★

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

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

Plasma Membrane

One function of the plasma membrane is to control what comes into and out of a cell. In this way, the plasma 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 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 plasma membrane without the use of the cell's energy.*

Diffusion: the movement of substances across the plasma 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 lower water concentration.

Facilitated transport: occurs when a carrier molecule embedded in the plasma membrane transports a substance across the membrane by means of diffusion.

Active transport is the movement of materials across cell membranes that requires energy. Active transport is the process by which materials are moved against a concentration gradient, as in the sodium-potassium pump. Also, the movement of large particles into or out of the cell is done by the process of active transport.

Endocytosis: a process in which a cell surrounds and takes in material from its environment.
Exocytosis: a process by which materials leave the cell.

• BOTH REQUIRE ENERGY •

STRATEGY BOX

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

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

An example of 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 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 as a nervous signal is sent to the muscle cells. So, the correct answer is **A**.

Spotlight on the Standards

★*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.

Enzymes have four special features in common:

1. They do not make processes happen 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. The same enzyme works for the forward and reverse directions of a reaction.
4. Each enzyme is highly selective about its substrate.

Substrates are molecules which 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 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.

- **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.

On 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 **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.

Spotlight on the Standards

★ *The Four Major Biomolecules* ★

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.

"Saccharide" means sugar. **"Mono"** means one. Put the two together: one sugar unit. 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, where you may have 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. Cells use lipids for long-term energy storage, insulation and protective coatings. Lipids are the major component of the membranes surrounding all living organisms. *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 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 the membranes that surround cells. Collagen, enzymes, hemoglobin, insulin and antibodies are examples of proteins.

Nucleic Acids:

Nucleic acids are complex macromolecules that store 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. They make up ATP, NAD^+, $NADP^+$, DNA, and RNA.

Sample Questions for Content Domain I: Cells

This section has some sample questions for you to try. After you have answered all of 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 cytoplasm
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 reactions in cells?

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

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 **D** has to be the correct answer. Answers **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.*
   Answers **A**, **C**, and **D** are processes that occur as a result of organisms maintaining homeostasis. **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 **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 so do not provide as much energy.

6. Answer: **A** Standard: SB1.b; *Explain how enzymes function as catalysts.*
   The correct answer is **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.

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. This domain is based on the following standards:

- Energy is needed by all organisms to carry out processes
- Understanding the binomial nomenclature system and its basis

Spotlight on the Standards

★*Energy Is Needed by all Organisms to Carry Out Processes*★

Energy in a Cell

All life on Earth depends on the flow of energy. The number one source of this energy is the Sun. Plants and other photosynthetic organisms are the entry point for this flow of energy. The process of photosynthesis supports almost all life on Earth directly or indirectly. Carbohydrates are a temporary depository of this transferred solar energy, ready to be used by the cells of these photosynthetic organisms or by the cells of organisms, such as animals, fungi, or microbes that consume plant materials. Energy from the sun is stored in nutrient molecules and then released by the metabolism of living cells. In all cells, the processes of life are constantly moving and rearranging atoms, ions, and molecules. All this biological work requires energy.

Understanding ATP

ATP, ***adenosine triphosphate***, is a special molecule that stores and releases the energy in its bonds when the cell needs it. Cells work constantly to maintain a vast supply of this energy storage molecule. The energy stored is released when ATP is split into ADP, ***adenosine diphosphate***, plus an inorganic phosphate. Remember that ATP and ADP are nucleotides, which are the building blocks of nucleic acids. 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 used to power other biological processes. Most of these processes are endergonic biological reactions in cells.

An ***endergonic reaction*** is any chemical reaction in which the products have more total energy and more free energy than did the reactants. Endergonic reactions require the input of energy from another source before they can take place.

Consider the following reaction:

ATP ↔ ADP + P + energy

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. The double arrow indicates that the reaction occurs in both directions.

ATP seems to have become the major energy link between energy-using and energy-releasing reactions. The amount of free energy released when it breaks down is suitable for use in most cellular reactions.

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 many deep-sea organisms produce light from 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.

An example of a question on the ***Biology*** **EOCT** may look like this:

Compared to unicellular organisms, cells of multicellular organisms have

A fewer functions
B thicker membranes
C larger nuclei
D less variation

The correct answer is **A**. Unicellular organisms are self contained. All functions are performed in the one cell. Multicellular organisms have use of specialized and differentiated cells, which perform specific functions. The more complex the organism, the more specialized the cells. Cells of multicellular organisms do not have thicker cell membranes or larger nuclei than unicellular organisms. Multicellular organisms have greater variation between them by nature of their specialization.

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. These organisms must also break down carbohydrates to form ATP. These carbohydrates are usually in the form of simple sugars, mainly glucose.

Autotrophs 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***.

The general equation for photosynthesis is as follows:

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

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 *synthesi*s part of photosynthesis.

The Light Reaction in Summary

Light reactions take place in the chloroplasts. A lipid bilayer membrane surrounds the chloroplast. 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 to each other. It is in the thylakoids that the light reaction takes place. Light hitting chlorophyll causes electrons in the chlorophyll to gain energy and leave the chlorophyll molecule. As these electrons pass down the electron transport chain, they lose energy. This energy is used to make ATP. Water breaks up into hydrogen and oxygen and electrons from water replace the electrons lost by the chlorophyll. Electrons, along with hydrogen ions from water, are added to $NADP^+$ to produce NADPH, which carries the energy to the Calvin cycle.

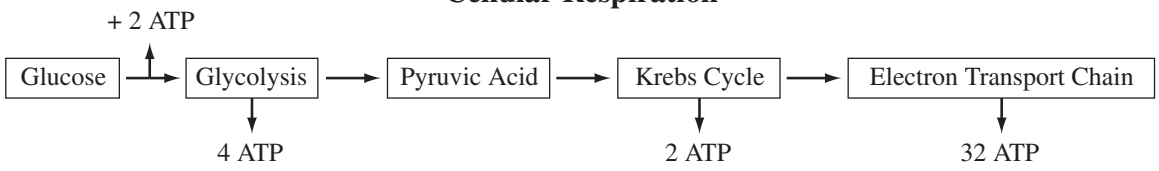
The Calvin Cycle in Summary

The Calvin cycle reaction takes place in the stroma of the chloroplasts. Carbon dioxide combines with hydrogen to form simple sugars that 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, 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.

Cellular Respiration and ATP Cycle

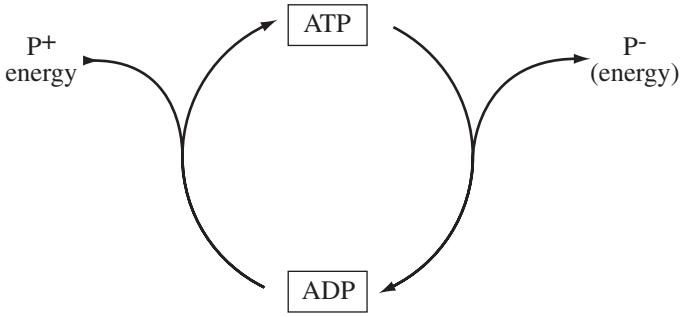
Once plants use light energy to form carbohydrates, other organisms, called consumers, can then use this carbohydrate energy for their own life processes. One way carbohydrate energy is used by organisms is through the process of cellular respiration. This is a multi-step operation. First, glucose is carried to the cell by the bloodstream. In the cytoplasm, the glucose is formed into pyruvic acid by the process of glycolysis. This process uses 2 molecules of ATP, but produces 4 molecules of ATP. The pyruvic acid moves into the mitochondria, where it is broken down into CO and a 2-carbon acetyl group. This acetyl group binds to coenzyme A and then enters the Krebs cycle. In the Krebs cycle, further reactions take place that release CO and high-energy electrons. These electrons are accepted by NAD+ and FAD+, forming NADH and FADH. NADH and FADH then move to the inner membrane of the mitochondrion where they pass through the electron transport chain. Here, electrons are gradually released, producing a total of 32 ATP molecules. The NAD+ and FAD+ then return to the Krebs cycle and repeat the process.

Cellular Respiration



The ATP produced in the process of cellular respiration then provides energy for other cellular processes. To release this energy, ATP loses a phosphate group, becoming ADP. This ADP can then gain a phosphate group during cellular respiration to once again store energy as ATP.

ATP Cycle



The ***Biology*** **EOCT** will assess your knowledge and understanding of the process of photosynthesis, the ATP-ADP cycle, and the importance of energy to all life. A question on the test may look like this:

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

The correct answer is **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 multicellular, but does not have tissues organized into organs.

The Binomial Nomenclature System

Have you ever been to a zoo and been overwhelmed by the number of different species of animals you saw? Or have you taken a walk in a forest and been amazed by the different plants that you see on the forest floor? What you have seen is a small fraction of what is actually inhabiting 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. Aristotle, who lived from 384 to 322 BC, was the first to use the classification system. He classified living things into two categories: plants and animals. Plants were classified as shrubs, herbs, or trees. Animals were classified according to where they lived. It wasn't until the 18th century that Carolus Linnaeus, a Swedish botanist, developed a system that is still used today. Linnaeus based his classification on characteristics of organisms that were similar. Take bats, for example. Even though bats fly, Linnaeus grouped bats with mammals because they share similar characteristics; they have hair and produce milk to feed their young. Linnaeus also developed the two word system used to identify species: ***binomial nomenclature***. The first word identifies the genus and is always capitalized. The second word, species, is a descriptive word of that genus and is never capitalized. An example of this would be the following:

Quercus alba: is the name for the white oak (*alba* is Latin for "white")
Quercus rubra: is the name for the red oak (*rubra* is Latin for "red")

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 organisms. They compare the internal and external structures, analyze the chemical makeup, and compare the evolutionary relationships of species. The taxonomist has a tremendous job. The number 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 "new" species into the right class.

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 **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.

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. Phylogenetic relationships were not a part of classifying organisms. 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. From Aristotle's two divisions, plants and animals, we now have the six kingdom system.

The six kingdoms are comprised of the following:

Eubacteria
Archaebacteria
Protists
Fungi
Plants
Animals

Kingdoms *Eubacteria* (true bacteria) and *Archaebacteria* contain prokaryotes, cells without membrane-bound organelles. Prokaryotes are microscopic, and most are unicellular. The Archaebacteria are mainly found in extreme environments like the deep oceans, hot springs, and swamps. *Protists* are unicellular and multicellular organisms with a variety of characteristics. Protists are eukaryotic organisms that lack complex organ systems and live in moist environments.

Fungi are consumers that stay put. They are unicellular or multicellular heterotrophic eukaryotes that absorb nutrients from dead and decaying matter by decomposing dead organisms and wastes in the environment. *Plants* are multicellular eukaryotes that photosynthesize. Most have cellulose cell walls and tissues that have been organized into organs and organ systems. *Animals* are multicellular consumers. Animal cells do not have cell walls. Their tissues have been organized into complex organ systems; the nervous system, muscle system and digestive system, as well as others. The 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.

Levels of Classification

Kingdom
Phylum
Class
Order
Family
Genus
Species

Below is an example of classification. This is the classification of the largemouth bass, the official state fish of Georgia.

Kingdom *Animalia* (multicellular organisms that eat food)
Phylum *Chordata* (animals with a backbone)
Class *Actinopterygii* (ray-finned fishes)
Order *Perciformes* (perch-like fishes)
Family *Centrarchida* (sunfishes)
Genus *Micropterus* (types of bass)
Species *salmoides* (largemouth bass)

Sample Questions for Content Domain II: Organisms

This section has some sample questions for you to try. After you have answered all of 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 table shows an early method of classifying animals.

Group	Air Dwellers	Water Dwellers	Land Dwellers
Examples	flying insects, birds, bats	fish, whales, sea snakes	reptiles, land mammals

Which of the following best illustrates why the modern Linnaean classification system has replaced the system developed by Aristotle?

A Flying insects fly over both land and water.
B Eating habits of reptiles and some land mammals are different.
C Sea snake bones are similar to those of reptiles that live on land.
D Birds are warm-blooded like mammals.

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

Answers to the Content II Domain Sample Questions

1. Answer: **C** Standard SB3.a; *Relate the complexity and organization of organisms to their ability for obtaining, transforming, transporting , releasing, and eliminating the matter and energy used to sustain the organism.*
Light reactions are the first step in the process of photosynthesis. It is the job of the chlorophyll to trap this light energy. So **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.b; *Examine the evolutionary basis of modern classification systems. (six kingdoms)*
Archaebacteria is the correct answer. 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; *Examine the evolutionary basis of modern classification systems. (six kingdoms)*
The correct answer is **C**. The modern classification systems employ the use of homologous structures to determine evolutionary relationships. Habitat location and eating habits are not accurate indicators of relationships because animals have evolved to be successful in different environments, but may still have common ancestors. Birds are warm-blooded, but are more closely related to reptiles than to mammals.

4. Answer: **A** Standard SB3.b; *Examine the evolutionary basis of modern classification systems. (six kingdoms)*
The correct answer is **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.

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*** ★

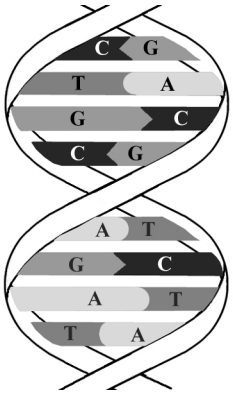
★ ***Explain the role of DNA in storing and transmitting cellular information*** ★

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 are encoded with information that is needed to produce a trait. When an acorn falls from an oak tree, the acorn 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 certain 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**.

DNA

You have learned that DNA is an example of a complex biological polymer called a **nucleic acid**. Remember that 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. These nitrogen bases are in the shape of a ring that contains one or more atoms of nitrogen. In DNA, there are four possible nitrogen bases – adenine (A), guanine (G), cytosine (C), and thymine (T). Let's take a closer look at the structure of DNA.



In DNA, nucleotides combine to form two long chains that intertwine with each other, like a ladder that has twisted into a spiral. Another name for this spiral is the **double helix** (double because there are two strands). The two strands of nucleotides are held together by weak hydrogen bonds between the nitrogen-containing bases. The sides of the ladder consist of phosphate groups alternating with a five-carbon sugar. In DNA, deoxyribose is the 5-carbon sugar. The hydrogen bonding allows for only certain base pairings. In DNA, adenine will bond with thymine, and guanine will bond with cytosine (A-T and G-C).

The sequence of nucleotides forms the unique genetic information of an organism. How can organisms be so different if their genetic material is made of the same molecules? A squirrel is different from a cat that is different from a dog because the order of nucleotides in their DNA are 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 strands together. This enzyme "unzips" the DNA molecule, allowing free nucleotides in the nucleus to bond to the new single strands by base-pairing. This process will continue until the entire molecule has been unzipped and replicated. Each new strand formed is a complement of one of the original, or parent, strands. That means it matches the original strand. When all the DNA in the chromosomes of the cell have been copied by replication, there are now two copies of the genetic information that will be passed on to new cells during mitosis or to new generations through the process of meiosis.

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

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

The correct answer is **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. Genes are located on strands of DNA and contain information for specific traits. Chromosomes are composed of DNA molecules and proteins. Cell respiration is a process by which energy is transformed so it can be used for cell activities. ATP is an energy-storage molecule that is used in some forms of cell respiration. Amino acids are the molecules used to construct proteins.

Remember that DNA is found inside the cell's nucleus, coiled into chromosomes.

RNA

RNA molecules, like DNA, are made of nucleotides. The difference is that in RNA nucleotides, the sugar is **ribose** and the nitrogen-containing base **uracil** replaces thymine. Uracil is paired with adenine. RNA is a single strand of nucleotides. Scientists have discovered that it is the RNA that moves the information from DNA in the nucleus to the ribosomes in the cytoplasm in a process known as **transcription**.

Transcription is similar to the DNA process of replication, but only one strand of nucleotides is formed. It is the job of mRNA (messenger RNA) to carry the message of the genetic code from the DNA in the nucleus to the ribosomes in the cytoplasm, where proteins are synthesized. Some portions of the DNA "code" for the RNA that makes up ribosomes. This type of RNA is called rRNA, (ribosomal RNA). Scientists have recently discovered that it is this rRNA that helps to produce enzymes needed to bond amino acids together during protein synthesis.

Translation is the process of converting the information in a sequence of nitrogen bases in mRNA into a sequence of amino acids that make up proteins. If proteins are to be formed, the amino acids located in the cytoplasm must be brought to the ribosomes. This is accomplished by tRNA (transfer RNA). Transfer RNA brings the amino acids to 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 3 nitrogenous bases on an mRNA molecule that carries the code for a specific amino acid. An anticodon is a set of 3 nitrogenous bases on a tRNA molecule that matches a codon on an mRNA molecule.

Remember to 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.

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.

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

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

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

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

From the Punnett square, you can determine that half of the offspring would be black (Bb) while the other half 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 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.

(Be sure to remember, **gametes** are sex cells.)

Genetic terms

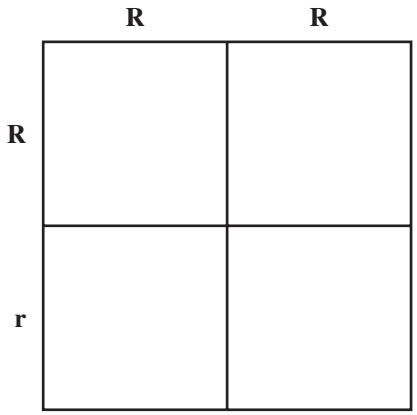
- Allele
- Dihybrid
- Dominant
- Gene
- Genotype
- Heterozygous
- Homozygous
- Monohybrid
- Phenotype
- Recessive
- Trait

Be sure to remember to 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.

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

Pea plants have seeds that are either round or wrinkled. In this cross, what will be the phenotypic ratio of the offspring?

Punnett Square



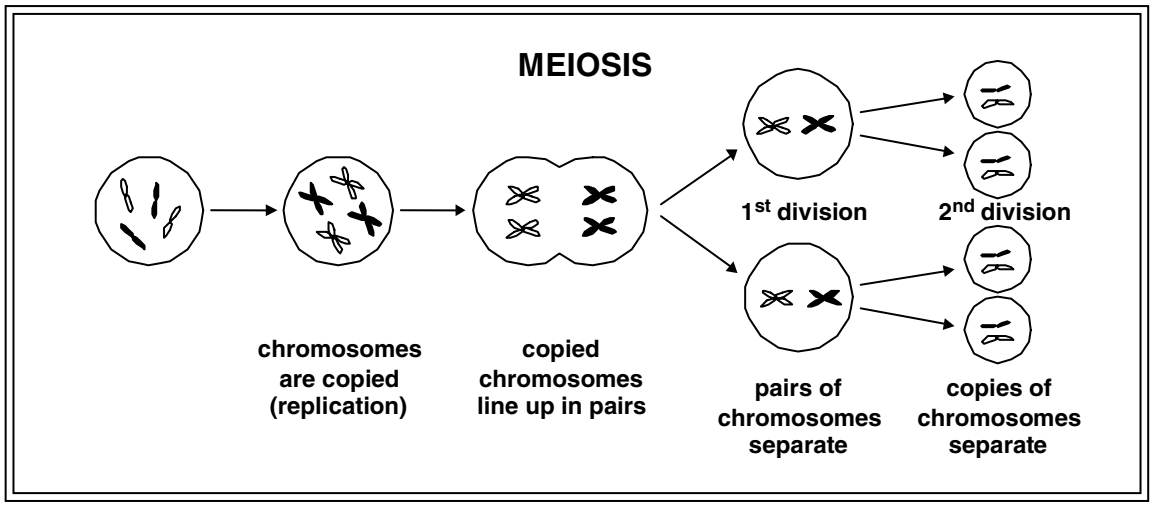
R = Round Seeds
r = Wrinkled Seeds

A 50% RR and 50% Rr
B 25% RR, 50% Rr, and 25% rr
C 50% round seeds and 50% wrinkled seeds
D 100% round seeds

The correct answer is **D**. The genotype of the offspring can be RR, or Rr. Both will result in a round seed, because the phenotype, or outward expression of the genotype, will express the dominant allele. Answers **A** and **B** are incorrect because they are stating genotype, not the phenotype.

Meiosis is the process by which gametes that contain half the number of chromosomes as the parent body cell are produced. Meiosis occurs in two phases, Meiosis I and Meiosis II.

Consider the following chart:



Meiosis occurs only in 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** (2*n*) 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** *(*1*n)* cells.

Remember, male gametes are called **sperm**; female gametes are called **eggs**. When a sperm fertilizes an egg, the resulting cell is called a **zygote**, and the zygote has a diploid number of chromosomes.

The process of meiosis provides the opportunity for the shuffling of chromosomes and the genetic information they contain. If a cell has two pairs of chromosomes, four kinds of gametes are possible. It all depends on how the chromosome pairs line up at the equator during meiosis I. When the zygotes are formed, there are 16 possible combinations that can occur. Let's look at the pea plant again. Mendel studied seven traits of the pea plant that are carried on seven pairs of chromosomes. Each of these seven pairs of chromosomes can line up in two different ways producing 128 different combinations of traits. These numbers will greatly increase as the number of chromosomes increase within a given species. Humans have 23 chromosomes. So the number of different kinds of gametes a person can produce is astounding—more than 8 million! When fertilization occurs, 2^{23} x 2^{23} different zygotes can occur. That is 70 trillion! During meiosis, crossing-over can occur two or three times per chromosome. This results in an endless number of different possible chromosomes. Whether by crossing-over or by independent segregation of homologous chromosomes, the end result

is a reassortment of chromosomes and the genetic information they carry. This is known as **genetic recombination**.

Every so often genes do change. One base may be substituted for another in the DNA sequence. Sometimes an extra base is inserted or even lost. When something changes the code of a gene, the result will be a change in the protein coded for by that gene. Changes in the nucleotide sequence of a DNA molecule are known as **gene mutations**. Some mutations are the result of exposure to mutagens. These are agents such as ultraviolet light, ionizing radiation, free radicals, and substances in tobacco products. Still, mutations can occur in the absence of these mutagens. Spontaneous mutations may occur as a result of replication errors, when adenine wrongly pairs with a cytosine. Also, the enzymes that repair a mistake may "fix" the wrong base.

Base pair substitutions 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 frameshift mutation occurs when one or more base pairs are inserted into a DNA molecule or deleted from it. Remember that polymerases read a nucleotide sequence in blocks of three. 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 mutation
B adaptation
C replication
D transcription

The correct answer is **A** because the two basic sources of genetic variation are mutations and the random assortment of genes that occurs during sexual reproduction. Replication and transcription are both cellular processes.

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 up river to spawn in the place of their birth. The females have turned red, a color that indicates that they will spawn and then die. The trip up river 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 have 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, death, and rebirth. As with any organism, growth as well as reproduction depends on cell division.

When a cell divides, its two daughter cells must receive the required number of DNA molecules. In eukaryotes, DNA is sorted into two nuclei in the process of mitosis. A separate process divides the cytoplasm in two. **Mitosis** is the process in which threadlike nuclear material is divided equally between two daughter cells. Mitosis keeps the number of chromosomes constant from one cell generation to the next. In eukaryotes mitotic cell division is the main process by which growth and tissue repair is accomplished. Mitosis is also the main process by which single-celled and many multi-celled eukaryotes reproduce asexually.

Mitosis

Mitosis can be broken into four phases: prophase, metaphase, anaphase, and telophase. These are briefly described below.

- During **prophase**, the duplicated chromosomes become distinct and spindle fibers radiate across the cell. The nuclear envelope starts to break up.
- During **metaphase**, the duplicated chromosomes line up randomly in the center of the cell between the spindles at the spindle equator.
- During **anaphase**, the duplicated chromosomes are pulled to opposite ends of the cell. Every chromosome that was present in the parent cell is now represented by the daughter chromosome at the poles.
- During **telophase**, a nuclear membrane forms around the chromosomes at each end of the cell. The spindle fibers disappear and the chromosomes disperse and

become less distinct. Each nucleus has the same chromosome number as the parent cell. The process of mitosis is now complete.

Cytokinesis

At the end of telophase, the cytoplasm begins to divide. In animal cells, the plasma membrane forms a groove and "pinches in" at the middle of the cell. This separates the two new nuclei and splits the cell in half. In plant cells, the rigid cell wall prevents a groove from forming. Instead, a cell plate forms along the center of the cell and cuts the cell in half. The cell plate forms new cell walls. Two daughter cells are formed as a result of cytokinesis. They are identical to their parent cell.

Cell division allows unicellular organisms to duplicate themselves in a process called **asexual reproduction**. In multicellular organisms, cell division allows them to grow (i.e., increase the size of the organism), develop from a single cell into a multicellular organism, and make other cells to repair and replace worn out cells.

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

Why is it important for the cells of multicellular 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 **D**. Multicellular 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 germ cells set aside for sexual reproduction.

Advances in DNA technology have resulted in its increased use in medicine, forensics and agriculture. Our body's first defense against injuries and infections is our skin. When a person has third degree burns, bacteria and other harmful organisms can enter the body. Skin grafts from other parts of the body have been used in the past to help the patient recover. Sometimes it is unsuccessful because the cells that produce new skin have been destroyed. Today, burn specialists can develop cloned skin in about 20 days. They remove a postage-sized piece of unburned skin, cut it into tiny pieces, and suspend the pieces in a nutrient-rich solution. By the process of mitosis, the skin cells grow into

colonies. These colonies continue to grow, forming a thin sheet of skin that is used for grafting.

There are many other uses for DNA technology. Police labs use DNA technology to identify people through a process known as DNA fingerprinting. Plant biologists have used DNA technology to produce plants with many desirable traits. These include increased disease resistance, herbicide resistance, and increased nutritional content.

Genetic Engineering

Today, researchers use recombinant DNA technology to analyze genetic changes. They cut, splice together, and insert the modified DNA molecules from different species into bacteria or another type of cell that rapidly replicates and divides. 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 the CFTR 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 modified cotton plant resist these worms, resulting in increased cotton production. These gene insertions are ecologically safer than pesticides. They affect only the targeted pest.

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

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

Sample Questions for Content Domain III

This section has some sample questions for you to try. After you have answered all of 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 mutagenic factor that can alter DNA by the loss of a chromosome segment is known as

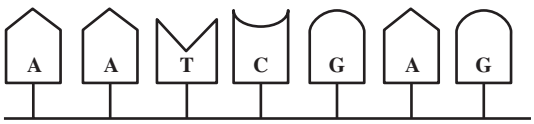
A translocation
B crossing over
C deletion
D nondisjunction

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

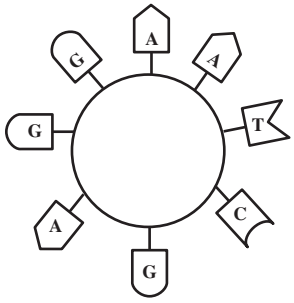
A homozygous trait
B dominant trait
C recessive trait
D heterozygous trait

4 Which of the following correctly shows the shape of a DNA molecule?

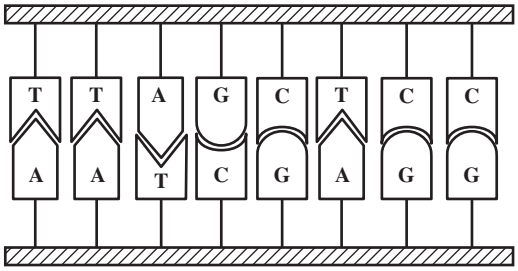
A



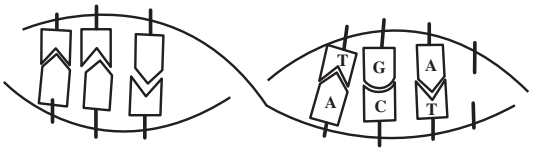
B



C



D



5 Changes to an organism's DNA can cause unexpected traits to be expressed in its offspring. 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

6 Agricultural companies have developed the ability to control the genetic characteristics of their crops. 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

7 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

8 The process of meiosis produces gametes. How does this process increase reproductive variability?

A Different combinations of alleles are produced.
B Each allele from the parent cell forms a separate gamete.
C Each pair of genes undergoes crossing-over with different genes.
D The two genes are passed on to a daughter cell, resulting in new traits.

9 DNA and RNA are nucleic acids. 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

10 ATG is a DNA triplet that codes for an amino acid. Which mRNA codon will pair with the ATG triplet?

A ATG
B GTU
C TAC
D UAC

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 **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 potential appearance of new traits*
The correct answer is **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 **C**, recessive trait. The dominant trait masks or hides the recessive trait. Heterozygous indicates 2 different alleles for a particular trait. Homozygous is having identical alleles for a particular trait.

4. Answer: **D** Standard SB2.d: *Distinguish between DNA and RNA*
The correct answer is **D**. The DNA molecule is best described as a double helix with two strands of nucleotides connected by hydrogen bonds. Option **A** is a single strand. RNA is a single strand, but has uracil in place of thymine. Option **B** shows a ring shape. Option **C** depicts the double strand, but does not show the twisting pattern.

5. Answer: **A** Standard SB2.d; *Explain the relationship between changes in DNA and potential appearance of new traits.*
The correct answer is **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. Loud sounds, magnetic fields, and extreme temperatures may damage the cells themselves but are not known to cause the DNA to mutate.

6. Answer: **D** Standard SB2.d; *Explain the relationship between changes in DNA and potential appearance of new traits.*
The correct answer is **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.

7. Answer: **B** Standard SB2.c; *Using Mendel's laws, explain the role of meiosis in reproductive variability.*
The correct answer is **B**. Using a Punnett square, the cross can be diagrammed. 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.

8. Answer: **A** Standard SB2.c; *Using Mendel's laws, explain the role of meiosis in reproductive variability.*
The correct answer is **A**. When cells undergo meiosis, homologous chromosomes separate and each chromosome from the pair ends up in a different gamete, randomly combined with other chromosomes. This results in many random combinations of chromosomes from the parent cell. Each individual allele does not form a different gamete. Sections of chromosomes usually cross-over with homologous chromosomes, not individual genes. In meiosis, only one pair of homologous chromosomes is passed on to the daughter cell (gamete), not pairs.

9. Answer: **B** Standard SB2.a; *Distinguish between DNA and RNA.*
The correct answer is **B**. RNA functions to transcribe the information on the DNA molecule and carry 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.

10. Answer: **D** Standard SB2.a; *Distinguish between DNA and RNA.*
The correct answer is **D**. The nitrogenous bases in DNA are thymine, guanine, cytosine, and adenine. Thymine (T), pairs with adenine (A) and guanine (G) pairs with cytosine (C) in DNA. The nitrogenous bases in RNA are guanine, uracil, cytosine, and adenine. Uracil (U), pairs with adenine (A) and guanine (G) pairs with cytosine (C) in RNA.