Keystone Exam Study Guide

INTRODUCTION

This study guide is designed to help students prepare to take the Biology Keystone Exam (BKE). This study guide provides information about the BKE, tips on how to prepare for it, and some suggested strategies students can use to perform their best.

What are the Keystone Exams? The Keystone Exams are end-of-course assessments designed to assess proficiency in various subjects. During the 2012-2013 school year the following Keystone Exams will be available: Algebra I, Literature and Biology. In future years, pending funding, additional Keystone Exams will be administered.

The Keystone Exams are one component of Pennsylvania's proposed system of high school graduation requirements. Keystone Exams will help school districts guide students toward meeting state standards.

Since the introduction of the Keystone Exams, the Pennsylvania Department of Education (PDE) has been working to create a set of tools designed to help educators improve instructional practices and better understand the Keystone Exams. The Assessment Anchors, as defined by the Eligible Content, are one of the many tools the Department believes will better align curriculum, instruction, and assessment practices throughout the Commonwealth. Without this alignment, it will not be possible to significantly improve student achievement across the Commonwealth.

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 BKE, and suggests some steps for preparing for the ***Biology Keystone***.

HOW TO USE THE STUDY GUIDE

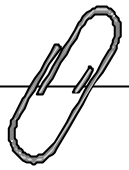
This study guide is designed to help you prepare to take the ***Biology Keystone***. It will give you valuable information about the BKE, explain how to prepare to take the BKE, and provide some opportunities to practice for the BKE. The study guide is organized into three sections. Each section focuses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

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

The **PREPARING FOR THE BKE** 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 Keystone*** measures. When you know the test content and how you will be asked to demonstrate your knowledge, you will be better prepared for the BKE. This section also contains some test-taking strategies for successfully answering questions on the BKE.

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



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

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 BKE.)

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

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

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

OVERVIEW OF THE BKE

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 BKE and how to pace yourself during the test. The box below gives you a snapshot of the ***Biology Keystone***.

THE BKE AT A GLANCE

Administration Dates:

The BKE has three primary annual testing dates: once in the spring, once in the summer, and once in the winter.

Administration Time:

Each BKE is composed of two modules, and students are given as much time as they need for each section. The PA Department of Education states that a typical student should be able to complete the test in 144 minutes. There is also a short stretch break between the two sections of the test.

Question Format:

Each module consists of 24 multiple-choice questions and 3 constructed-response questions. There are two modules to complete.

Impact on Course Grade:

As of right now, there is no impact on a student's final grade. However, all students are required to take the test in order to graduate high school.

If you have additional administrative questions regarding the BKE, please visit the Pennsylvania Department of Education Web site at http://www.pdesas.org/module/assessment/Keystone.aspx

PREPARING FOR THE BKE

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 BKE will take time, effort, and practice.

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

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

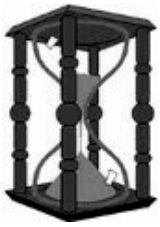
Before you begin preparing for this test, you might want to consider your answers to the following questions. You may write your answers here or on a separate piece of paper.

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 BKE can be divided into three categories.

Time Management
Organization
Active Participation

Time Management



Do you have a plan for preparing for the BKE? 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).

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 BKE, 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: _____

Suggested Strategies to Prepare for the BKE

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?

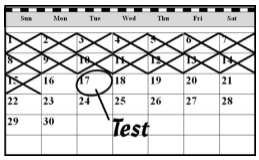
Response: _____

Before taking the BKE, 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 BKE is to be prepared. In order to do this, it is important that you know what standards/skills will be measured on the ***Biology Keystone*** and then practice understanding and using those standards/skills. The OVERVIEW OF THE BKE and TEST CONTENT sections of this study guide are designed to help you understand which specific standards are on the ***Biology Keystone*** 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 BKE.

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 BKE will be administered so you can allocate your time appropriately.

Suggested Strategies the Day before the BKE



- **Review what you learned from this study guide.**
  1. Review the general test-taking strategies discussed in the TOP 10 SUGGESTED STRATEGIES DURING THE BKE on page 10.
  2. Review the content module-specific information discussed in the section TEST CONTENT beginning on page 11.
  3. Focus your attention on the standards 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 BKE

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 BKE.

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 BKE

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

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.

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 module-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

This section of the study guide focuses on what will be tested in the exam. It also includes sections of sample questions that will let you apply what you have learned in your classes and from this study guide.

The Keystone Biology Exam is designed to test major areas of biological knowledge. Each of the two modules consists of broad categories featuring all aspects of biology. Within each module there are standards, which cover specific knowledge within each module.

> One way to think about the module content 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 module content, and all the various items—apples, oranges, bananas— are the standards that fall under that particular module.

Each question on the Keystone measures an individual standard within an assessment anchor.

The chart below lists the two thematic modules for the ***Biology Keystone***.

Module Content
I. Cells and Cell Processes
II. Continuity and Unity of Life

Studying the Content Modules

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

A Look at the Content Modules: a broad overview of what will be assessed.

Spotlight on the Standards: information about the specific standards that will be assessed

Sample Questions: sample questions ***similar*** to those that appear on the BKE

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.

Module 1: Cells

A LOOK AT MODULE 1

Test questions in this area will measure your knowledge of Cells and Cell Processes. Your knowledge will be tested within the following areas:

*Basic Biological Principles
*The Chemical Basis of Life
*Bioenergetics
*Homeostasis and Transport

Spotlight on the Standards

Describe the characteristics of life shared by all prokaryotic and eukaryotic organisms
Compare cellular structures and their functions in 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)

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 Keystone***, 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.

Spotlight on the Standards

*****Describe and interpret relationships between structure and function at various levels of biological organization (i.e. organelles, cells, tissues, organs, organ system and multicellular organisms*****

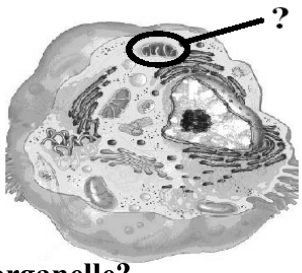
What are life's levels of organization?
Atom—molecule—organelles—cell (smallest unit of life!)—tissue—organ—organ system—organism—population—community—ecosystem—biome—biosphere

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 Keystone*** 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 **B**, mitochondrion.

Alveoli are microscopic air sacs in the lungs of mammals. Which statement best describes how the structure of the alveoli allows the lungs to function properly?
A. They increase the amount of energy transferred from the lungs to the blood.
B. They increase the flexibility of the lungs as they expand during inhalation.
C. They increase the volume of the lungs, allowing more oxygen efficient gas exchange
D. They increase the surface area of the lungs, allowing efficient gas exchange.

Spotlight on the Standards

Describe the unique properties of water and how these properties support life on Earth (e.g. freezing point, high specific heat, cohesion)*

Water is the most abundant compound on Earth's surface, constituting about 70% of the planet's surface. In nature it exists in liquid, solid, and gaseous states.

•**Water** is a polar molecule because the oxygen side is slightly negative and the hydrogen side is slightly positive. The three atoms are constantly at a "tug of war" for their electrons. This polarity helps water to bind to other substances.

Water Property	Definition	Example(s)
Cohesion	Water tends to stick together	Droplets of dew on grass
Surface Tension	The top layer of water is very strong	Insects can walk on water
Adhesion	Water tends to stick to OTHER things	Water sticks to glass after washing
Capillary Action	Movement of water against gravity	Allows water to rise up narrow tubes in plant stems
High Specific Heat	Water is able to resist changes in temperature	Helps organisms retain body heat and resist freezing in cold temps.
Universal Solvent	Water can dissolve many things Solvent – the material that is doing the dissolving Solute – the material that is dissolved Hydrophobic – not mixing with water (water and oil) Hydrophilic – mixing with water	Putting sugar in tea (you don't see the sugar)
Density	The degree of compactness of a substance	Ice is less dense than liquid water

Which statement best describes an effect of the low density frozen water in a lake?

- **A.** When water freezes, it contracts, decreasing the water level in a lake.
- **B.** Water in a lake freezes from the bottom up, killing most aquatic organisms.
- **C.** When water in a lake freezes, it floats, providing insulation for organisms below
- **D.** Water removes thermal energy from the land around a lake, causing the lake to freeze.

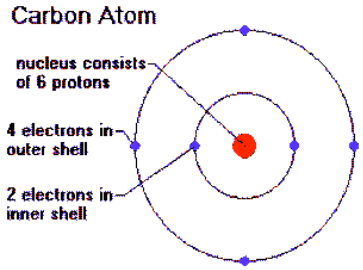
The correct answer is C.

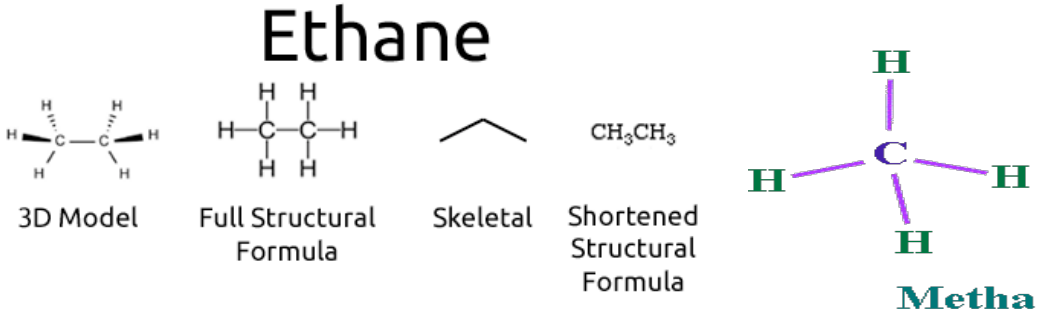
Spotlight on the Standards

Explain how carbon is uniquely suited to form biological macromolecules
Describe how biological macromolecules form from monomers.

Why Carbon?

- Carbon is the second most abundant element in living organisms
- Carbon establishes covalent bonds (stable, high energy bonds)
- Carbon can share four electrons, therefore it can bond to four additional atoms
- Carbon molecules have strength, flexibility and can chemically react to other atoms





Sample Question

Which statement correctly describes how carbon's ability to form bonds makes it uniquely suited to form macromolecules?

A. It forms short, simple carbon chains
B. It forms large, complex. Diverse molecules
C. It forms covalent bonds with other carbon atoms
D. It forms covalent bonds that can exist in a single plane.

The correct answer is C.

Spotlight on the Standards

Explain how organisms maintain homeostasis (e.g., thermoregulation, oxygen regulation).

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.

Spotlight on the Standards

Compare the structure and function of carbohydrates, lipids, proteins, and nucleic acids in organisms

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.

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.

Sample Essay Question

Describe the general composition of a protein molecule.

Describe how the structures of proteins differ from the structures of carbohydrates.

Describe how the functions of proteins differ from the functions of carbohydrates.

Spotlight on the Standards

Describe the role of an enzyme as a catalyst in regulating a specific biochemical reaction*

****Explain how factors such as pH, temperature, and concentration levels can affect enzyme function****

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.

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 Keystone***, 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 Keystone*** 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.

Spotlight on the Standards

Describe the role of ATP in biochemical reactions*

Energy in a Cell

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

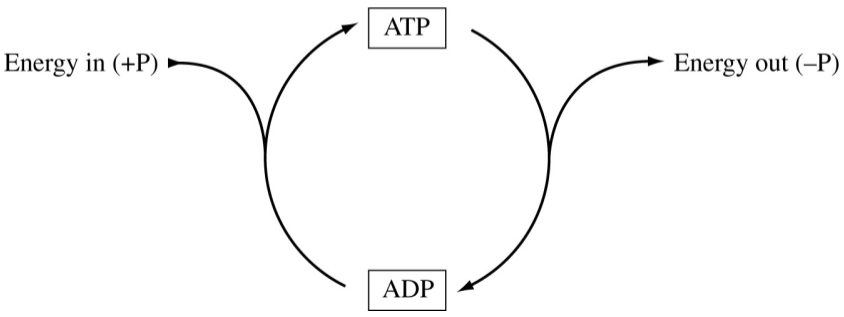
Understanding ATP

ATP, **adenosine triphosphate**, is a special molecule that stores and releases the energy in its bonds in response to the energy 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 Keystone*** will assess your knowledge and understanding of the ATP-ADP cycle and the importance of energy to all life.

Sample Question

A protein in a cell membrane changed its shape to move sodium and potassium ions against their concentration gradients. Which molecule was most likely used by the protein as an energy source?

A. ATP
B. ADP
C. Catalase
D. amylase

The correct answer is A.

Spotlight on the Standards

Describe the fundamental roles of plastids (e.g., chloroplasts) and mitochondria in energy transformations

Compare the basic transformation of energy during photosynthesis and cellular respiration

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. 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.

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:

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

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.

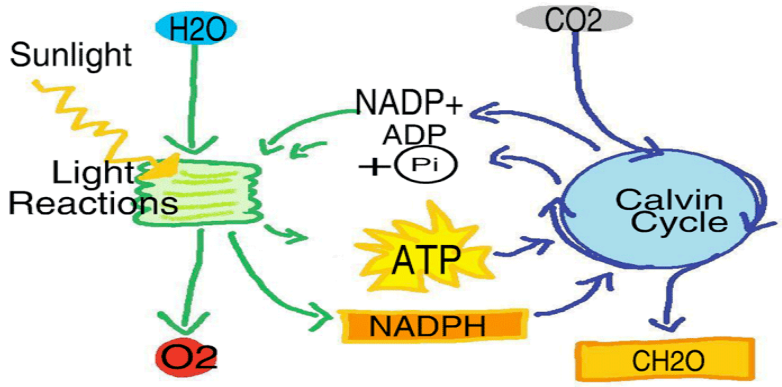
The light reaction is the *photo* part of photosynthesis. The Calvin cycle is the *synthesis* part of photosynthesis.

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 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.



Using Energy—Cellular Respiration

The general equation for cellular respiration is as follows:

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

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

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.

Glycolysis		Krebs Cycle		Electron Transport Chain	
Glucose	➔	Pyruvic Acid	➔	$NADH + FADH_2$	➔	CO_2 and H_2O and 38 ATP

The ***Biology Keystone*** 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.

Spotlight on the Standards

Describe how the structure of the plasma membrane allows it to function as a regulatory structure and/or protective barrier for a cell

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.

Spotlight on the Standards

Compare the mechanisms that transport materials across the plasma membrane

Passive/Active Transport

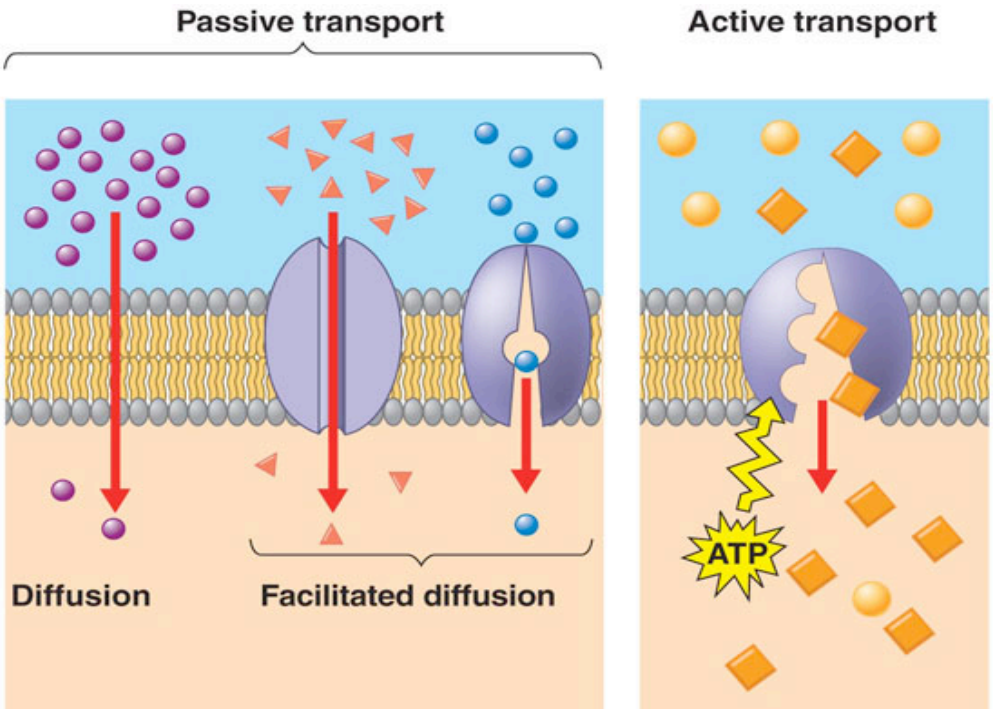
There are various mechanisms that transport materials in and out of the cell. **Passive transport** is the movement of materials across the cell membrane without the use of the cell's energy. Different types of passive transport are shown in the box below.

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.



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 Keystone***.

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

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

Sample Question

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**.

Spotlight on the Standards

Describe how membrane-bound cellular organelles (e.g., endoplasmic reticulum, Golgi apparatus) facilitate the transport of materials within a cell.*

Organelle	Function
Cell Membrane (Plasma membrane)	Boundary between intracellular & extracellular environments. Regulates entry/exit of substances.
Cell wall	Rigid structure providing support for cell.
Cytoplasm	Jelly-like substance filling intracellular space contains dissolved substances.
Cyto-skeleton	Network of fine tubes and threads. Provides internal structural support.
Centrioles	Paired rods, which help organize microtubules during mitosis.
Nucleus	Membrane-bound structure containing cells' genetic information (DNA) and support molecules.
Nucleolus	Small structure within nucleus. Site of production of ribosomal RNA.
Nuclear membrane	Boundary between nucleus and cytoplasm. Regulates passage of materials between the two.
Flagella, pili, cilia	Structures used to enable movement of cells or sometimes to propel substances across outer surface of the cell. Predominantly protein in composition.
Mitochondria	Membrane bound organelles. Folded membranes within contain enzymes for aerobic respiration. (A little DNA in here too.)
Chloroplasts	Membrane bound organelles. Folded membranes within contain chlorophyll and enzymes for photosynthesis. (A little DNA in here too.)
Vacuole	Membrane bound area filled with water and assorted solutes. Role in maintenance of water balance of the cell.
Ribosomes	Small organelles at which protein synthesis occurs. May be free floating or membrane-bound.
Endoplasmic Reticulum (smooth E.R.)	Network of flattened membranes forming tunnels. Enzymes assisting synthesis of some lipids and final processing of proteins found here.
Endoplasmic Reticulum (rough E.R.)	Similar to smooth ER, but with ribosomes embedded in membrane. Proteins to be exported from cell produced here.
Golgi Apparatus (aka Golgi Body)	Stacks of saucer shaped membranes where

	export proteins are modified and stored prior to entering secretory vesicles for exocytosis.
Lysosomes	Membrane bound structure-containing enzymes, which break down toxic or unwanted molecules.
Plastids	Membrane bound structures with varied functions. Leucoplasts - starch storage. Chromoplasts - colored pigments within (eg flower petals).
Vesicles	Packages for storage (eg fat droplets) or temporary transport associated with endocytosis/exocytosis.

Sample Question

The rough endoplasmic reticulum and Golgi apparatus work together in eukaryotic cells. What is one way that the rough endoplasmic reticulum assists the Golgi apparatus?

A. It assembles nucleic acids from monomers.
B. It breaks down old, damaged macromolecules
C. It packages new protein molecules into vesicles
D. It determines which protein molecules to synthesize.

The correct answer is C. The rough E.R. exports proteins produced here.

Sample Questions for Module 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 Module 1 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

Answers to the Module 1 Sample Questions

1. Answer: **C**
   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**
   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**
   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**
   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**
   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**
   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.

Module II: Community and Unity of Life

A LOOK AT MODULE II

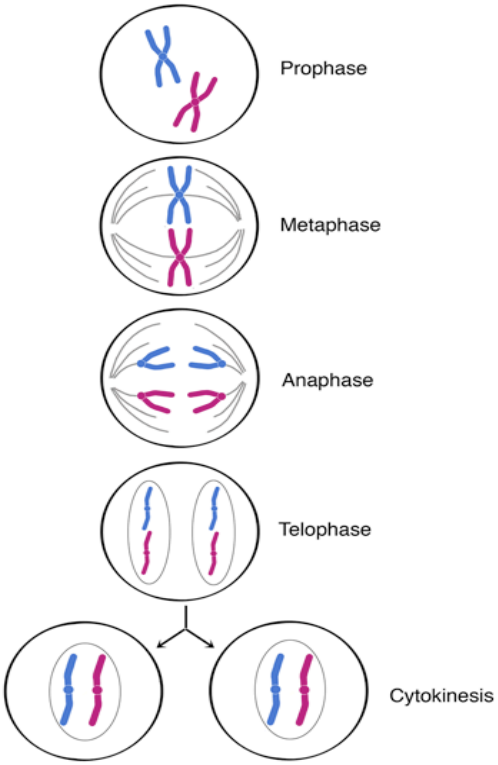
Test questions in this module will measure your understanding of the Continuity and Unity of Life. Your knowledge will be tested according to the following areas:

*Cell Growth and Reproduction
*Genetics
*Theory of Evolution
*Ecology

Spotlight on the Standards

Describe the events that occur during the cell cycle: interphase, nuclear division (i.e., mitosis or meiosis), cytokinesis

Mitosis Overview



Interphase (not shown in diagram)

1. **Cell matures & carries on normal activities**
2. **DNA copied & appears as chromatin**
3. **Nucleolus visible**

Prophase

1. **Chromosomes condense & become visible**
2. **Centrioles separate & spindle starts forming**
3. **Spindle forms with aster at each pole**
4. **Nuclear membrane & nucleolus disintegrate**
5. **Centromere of chromosomes attaches to spindle fibers**

Metaphase

1. **Chromosomes line up at the equator of the cell attached to kinetochore fibers of spindle**

Anapahse

1. **Centromeres split apart**
2. **Homologs move to opposite poles of the cell**

Telophase

1. **Nuclear membrane forms at each end of the cell around the chromosomes**
2. **Nucleolus reform**
3. **Chromosomes become less tightly coiled & appear as chromatin again**
4. **Cytokinesis begins**

Cytokinesis

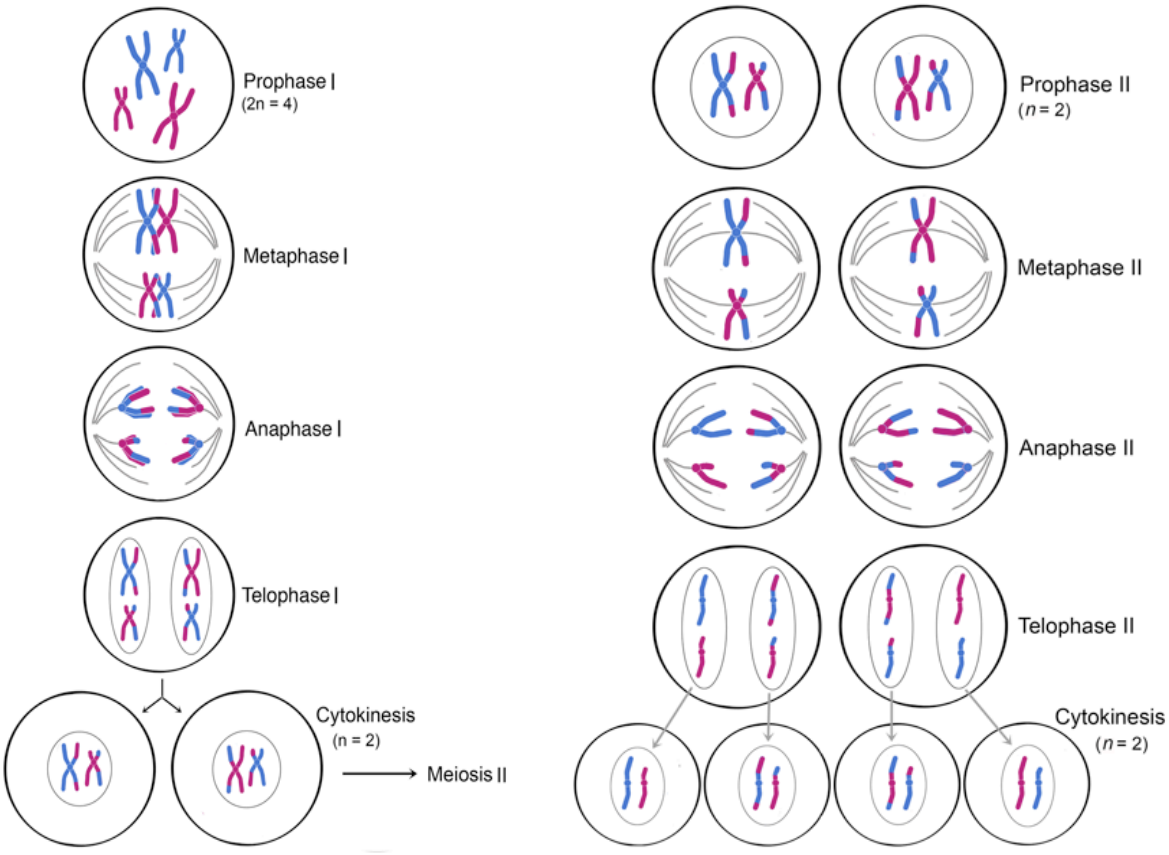
1. **Cytoplasm of the cell and its organelles separate into 2 new daughter cells**

Purpose of Mitosis

Cell Growth

Repair and Replacement of damaged cell parts

Asexual reproduction



The cell that undergoes Meiosis I is a primary spermatocyte or oocyte

Prophase I:

- **Chromosomes coil tightly & are visible**
- **Nuclear membrane & nucleolus disintegrate**
- **Spindle forms**
- **Synapsis (joining) of homologous chromosomes occurs making tetrads**
- **Chromosomes in tetrad exchange fragments by a process called crossing over**

Metaphase I:

- **Tetrads become aligned in the center of the cell attached to spindle fibers**

Anaphase I:

- **Homologous chromosomes separate**

Telophase I:

- **Nuclear membrane forms at each end of the cell around the chromosome**
- **Chromosomes become less tightly coiled & appear as chromatin again**

Cytokinesis:

- **Splits cytoplasm producing producing 2 cells**

Prophase II:

- **DNA is not copied before cell divides**
- **Chromosomes condense and become visible**

Metaphase II:

- **Chromosomes become aligned in the center of the cell attached to spindle fibers**

Anaphase II:

- **Sister chromatids separate randomly**
- **Called independent assortment**

Telophase I:

- **Nuclear membrane forms at each end of the cell around the chromosomes**
- **Nucleolus reform**
- **Chromosomes become less tightly coiled & appear as chromatin again**

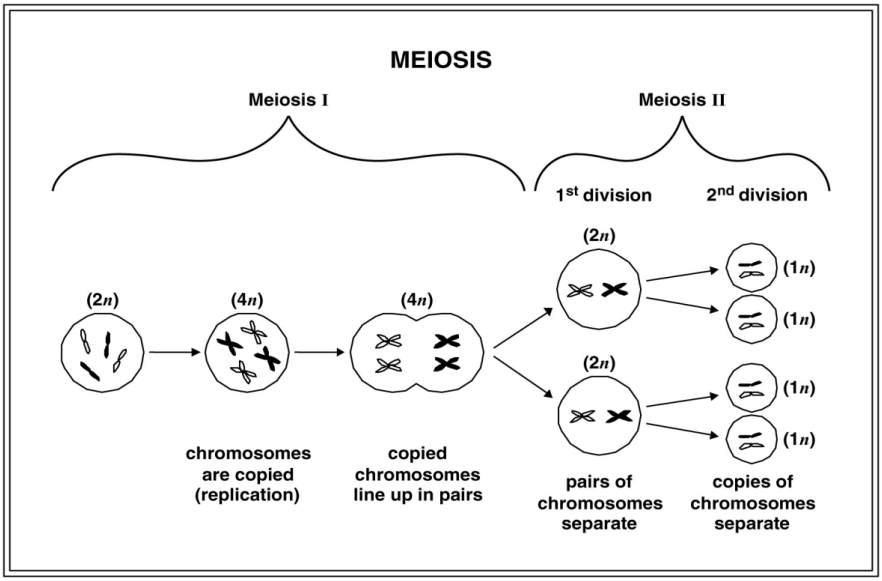
Cytokinesis:

- **Cytoplasm divides producing 4 cells in males called spermatids**
- **Spermatids mature & form flagellum to become sperm**
- **Cytokinesis in females produces an ootid.**
- **Ootids mature to become ovum or egg**

Purpose of Meiosis

To produce gametes

Meiosis is a special version of cell division that occurs only in the testes and ovaries; the organs that produce the sperm and eggs. Why is this different? Normal body cells have a complete set of chromosomes. If normal body cells from mom and dad fused to form a baby, the fertilized egg would have twice as many chromosomes as it should. Meiosis is sometimes called "reduction division" because it reduces the number of chromosomes to half the normal number so that when fusion of sperm and egg occurs, baby will have the correct number. Therefore the purpose of meiosis is to **produce gametes**; the sperm and eggs.



Spotlight on the Standards

Compare the processes and outcomes of mitotic and meiotic divisions.

Comparison chart

	Meiosis	Mitosis
Definition:	A type of cellular reproduction in which the number of chromosomes are reduced by half through the separation of homologous chromosomes in a diploid cell.	A process of asexual reproduction in which the cell divides in two producing a replica, with an equal number of chromosomes in haploid cell
Function:	sexual reproduction	Cellular Reproduction & general growth and repair of the body
Type of Reproduction:	Sexual	Asexual
Occurs in:	Humans, animals, plants, fungi	all organisms
Genetically:	different	identical
Crossing Over:	Yes, mixing of chromosomes can occur.	No, crossing over cannot occur.
Pairing of Homologues:	Yes	No
Number of Divisions:	2	1
Number of Haploid Daughter Cells produced:	4	2
Chromosome Number:	Reduced by half	Remains the same
Steps:	The steps of meiosis are Interphase, Prophase I, Metaphase I, Anaphase I, Telophase I, Prophase II, Metaphase II, Anaphase II and Telophase II.	The steps of mitosis are Interphase, Prophase, Metaphase, Anaphase, Telophase and Cytokinesis
Cytokinesis:	Occurs in Telophase I & Telohpase II	Occurs in Telophase
Creates:	Makes sex cells, eggs and sperm	Makes everything other than sex cells

Sample Essay Question

Patau syndrome can be a lethal genetic disorder in mammals, resulting from chromosomes failing to separate during meiosis.

A. Identify the step during the process of meiosis when chromosomes would most likely fail to separate.

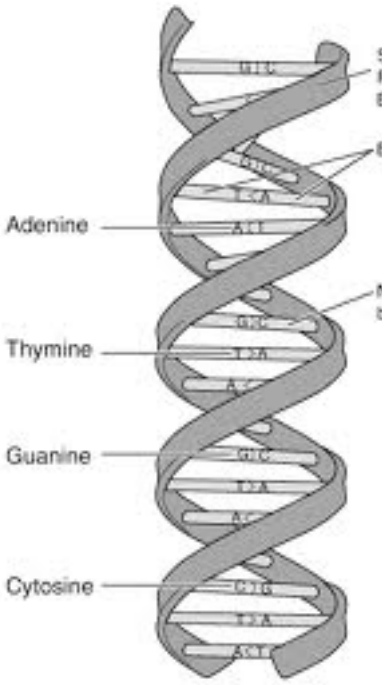
B. Describe how chromosome separation in meiosis is different from chromosome separation in mitosis.

C. Compare the effects of a disorder caused by chromosomes failing to separate during meiosis, to the effects of chromosomes failing to separate during mitosis.

Spotlight on the Standards

****Describe how the process of DNA replication results in the transmission and/or conservation of genetic information.****

What is DNA?



DNA is a polymer, long chain, of nucleotides. These molecules contain the genetic information of the cell. DNA is a nucleic acid.

- *For DNA*, each nucleotide contains three parts
  - **A five-carbon sugar**
    - Deoxyribose in DNA
  - **A nitrogenous base**
    - Purines: 2 rings
      - ***Adenine*** and ***Guanine***
    - Pyrimidines: 1 ring
      - ***Thymine*** and ***Cytosine***
    - *Adenine* pairs with *Thymine*
      - There are held by 2 hydrogen bonds
    - *Guanine* pairs with *Cytosine*
      - They are held by 3 hydrogen bonds
  - **Phosphate group**

Important features of DNA:

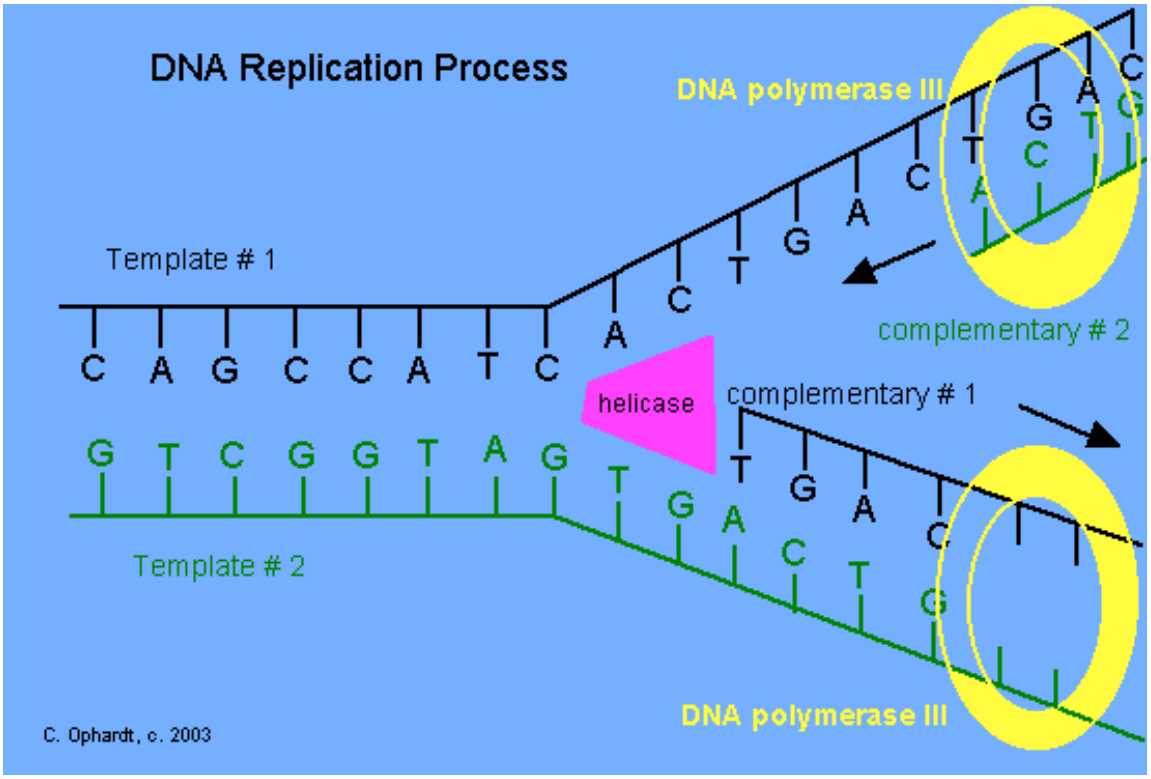
- Typically recognized as a ***double helix*** shape
  - The double helix has a constant diameter
- It is right-handed
- DNA strands are complementary
  - This means that each DNA strand has the information to construct the other strand.
- DNA is anti-parallel
  - One strand runs in the 3' to 5' direction and the other strand runs in the 5' to 3' direction.
- Follows a ***semi-conservative replication*** pattern

How does DNA Replicate?

DNA has the unique ability to make an exact copy of itself in a process called ***replication****. In DNA Replication, the double helix unwinds and separates into two template strands. Then new nucleotides are added to the new strand at the 3' position. This sequence will depend on the complementary base pairing.*

DNA Replication Process

- The process begins at the origin of replication, which is a specific DNA sequence where enzymes can start separating the double helix
- An enzyme called **helicase** *unwinds the DNA double helix* and separates it into two strands.
  - A Y-shaped **replication fork** will form as the double unwinds
  - **Single-stranded DNA binding proteins** help keep the strands separate and *prevent the strands from getting back together*
  - **This process will continue until the entire molecule has been replicated.**



Sample Test Question

Which process helps to preserve the genetic information stored in DNA during DNA replication?

A. the replacement of nitrogen base thymine with uracil
B. enzymes quickly linking nitrogen bases with hydrogen bonds
C. the synthesis of unique sugar and phosphate molecules for each nucleotide
D. nucleotides lining up along template strand according to base pairing rules

The correct answer is D. An enzyme complex called **DNA polymerase** "walks" down the DNA strands and adds new nucleotides to each strand. The nucleotides pair with the complementary nucleotides on the existing stand (A with T, G with C).

Spotlight on the Standards

Explain the functional relationships between DNA, genes, alleles, and chromosomes and their roles in inheritance*

What is Genetics?

Genetics is the scientific study of heredity. Heredity involves the transmission of genetic characteristics from generation to generation.

Definitions

Trait:

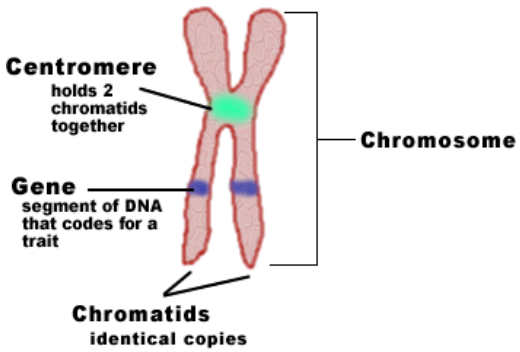
- form of a physical feature

Chromosome:

- A long, stringy aggregate of genes that carries heredity information (DNA) and is formed from condensed chromatin.

Gene:

- genetic material on a chromosome that provides instructions on creating a certain trait
  - **Allele**: different forms of a gene (PP) (pp) (Pp)
    - **Homozygous**:
      - individuals with two copies of the same allele (PP) (pp)
    - **Heterozygous**:
      - individuals with two different alleles (Pp)



Genotype

- the genetic makeup of the organism (Pp)

Phenotype

- the physical appearance of the organism (Purple)

Spotlight on the Standards

Describe and/or predict observed patterns of inheritance (i.e., dominant, recessive, co-dominance, incomplete dominance, sex-linked, polygenic and multiple alleles.*

Make sure you understand how to draw and interpret a Punnett square!

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.

Take a look at some special situations:

Incomplete Dominance- *Traits in which the heterozygote shows a different phenotype from the homozygous dominant phenotype.*

Genotypes
BB=Homozygous Black
BW=Heterozygous
WW=Homozygous White

Resulting Phenotype
BB=Black Fur
BW=Grey Fur
WW=White Fur

Codominant: *Allelles that are fully expressed in the heterozygous condition.*

Genotypes
BB=Homozygous Black
BW=Heterozygous
WW=Homozygous White

Resulting Phenotype
BB=Black Fur
BW=Black and White Fur
WW=White Fur

Polygenic: Traits in which several genes contribute to the overall phenotype.

Example: skin type of humans has four genes involved and that is why there is such a wide variety of human skin types.

Multiple Alleles: traits that are a result of more than 2 types of alleles.

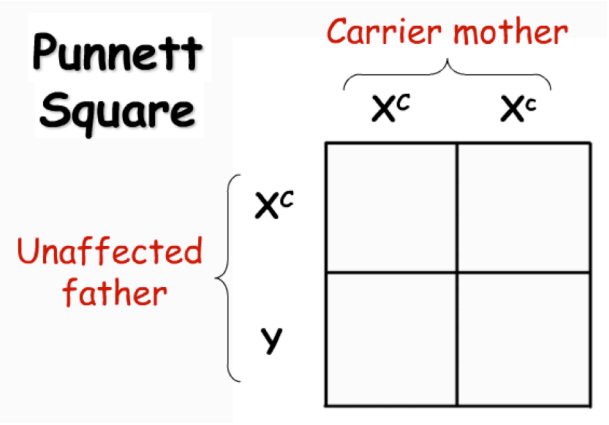
Example: Human blood type

There are 3 different alleles for blood type, (A, B, & O). A is dominant to O. B is also dominant to O. A and B are both codominant.

Phenotype	Posible Genotypes
O	OO
A	AA or AO
B	BB or BO
AB	AB

Sex-linked Traits: Phenotype of an allele located on a sex chromosome.

Example: color blindness (an x-linked recessive trait)



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

Sample Question

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.

Sample Question

Use the table below to answer the question.

Blood Types

Genotype(s)	Phenotype
ii	O
I^AI^A, I^Ai	A
I^BI^B, I^Bi	B
I^AI^B	AB

Blood type is inherited through multiple alleles, including I^A, I^B, and i. A child has type A blood. If the father has type AB blood, what are all the possible phenotypes of the mother?

A. phenotypes O or A
B. phenotypes A or AB
C. phenotypes A, B, AB
D. phenotypes O, A, B, AB

The correct answer is D.

If you construct a Punnett square comparing Type AB with all other blood types you will get at least get one type A blood result for each.

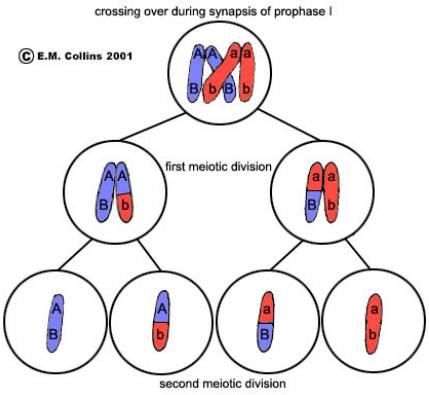
Spotlight on the Standards

***Describe processes that can alter composition or number of chromosomes (i.e., crossing over, nondisjunction, duplication, translocation, deletion, insertion, and inversion**

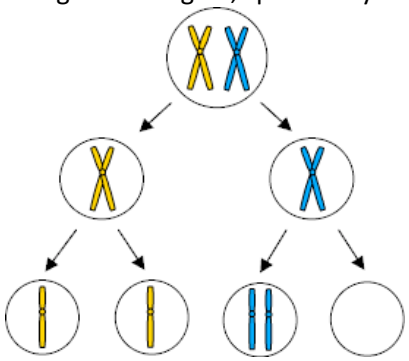
Sources of Variation during Meiosis

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.

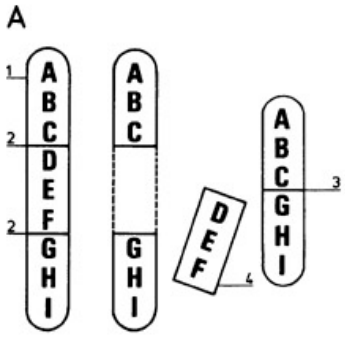
Crossing over: occurs when two chromosomes physically overlap and exchange chromosome material. This process occurs more often on some chromosomes than other chromosomes and changes the DNA sequence within each chromosome. This results in an endless number of different possible genetic combinations



nondisjunction: ("not coming apart") is the failure of chromosome pairs to separate properly during meiosis stage 1 or stage 2, specifically in the anaphase

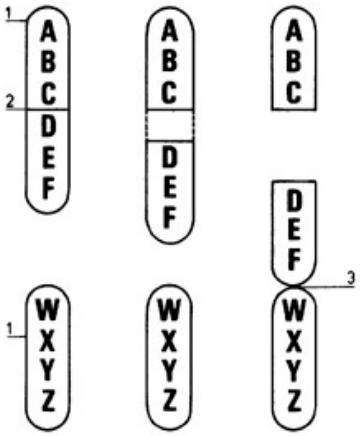


Deletion-In genetics, a deletion is a mutation in which a part of a chromosome or a sequence of DNA is missing.

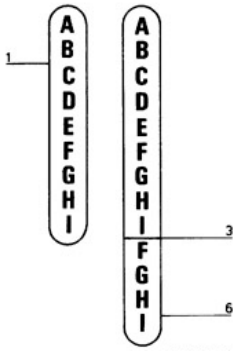


Insertion-In genetics, an insertion is the addition of one or more nucleotide base pairs into a DNA sequence.

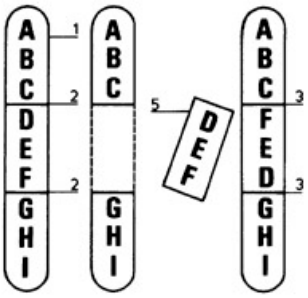
Translocation- transfer of part of a chromosome to a different position especially on a nonhomologous chromosome



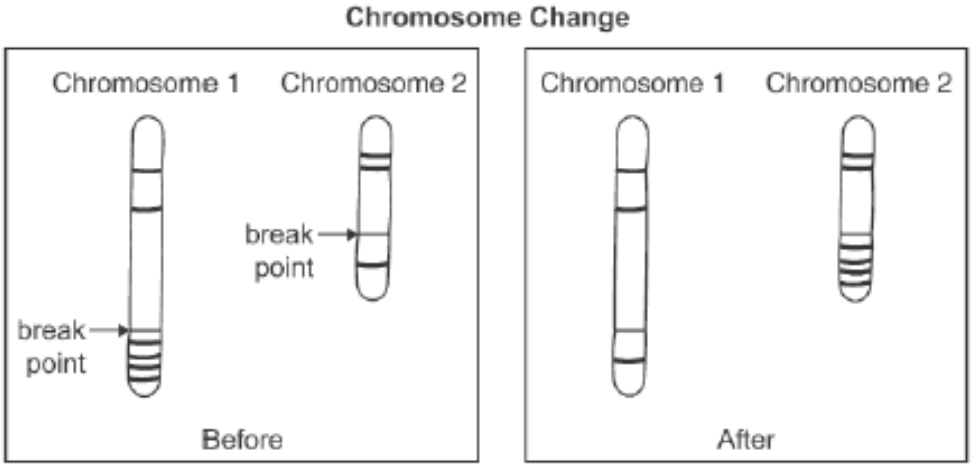
Duplication- a mutation in which there are two or more copies of a gene or of a segment of a chromosome.



Inversion-a mutation that causes a reversal in the order of a segment of a chromosome within the chromosome, or a gene.



Sample Question



Which type of change in chromosome composition is illustrated in the diagram?

A. deletion
B. insertion
C. inversion
D. translocation

The correct answer would be D. As you can see the chromosome broke off and attached to a different, nonhomologous chromosome.

What is a source of genetic variation?

A adaptation
B mutation
C respiration
D transpiration

Sample Question

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

Describe how the processes of transcription and translation are similar in all organisms*

RNA

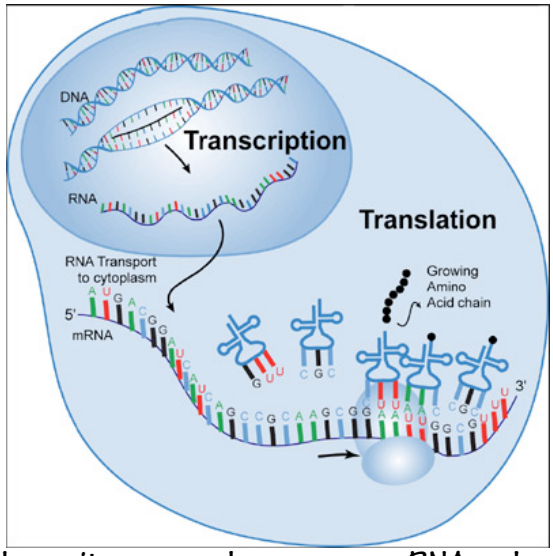
RNA, like DNA, is made of nucleotides. The sugar in RNA is ribose and the nitrogen containing base uracil replaces the thymine found in DNA. The uracil in RNA pairs with adenine during complimentary base pairing. RNA is a single strand of nucleotides. In the process of transcription, RNA transfers the 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.

RNA is Different than DNA

1. RNA is single stranded
2. The sugar is ribose
3. It contains Uracil

Transcription:

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:

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 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.

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

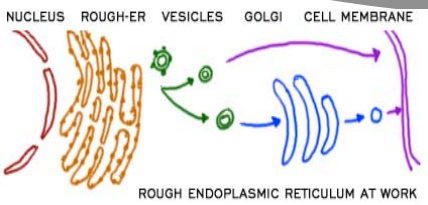
Sample Question

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

Describe the role of ribosomes, endoplasmic reticulum, Golgi apparatus, and the nucleus in the production of specific types of proteins.*



Sample Question

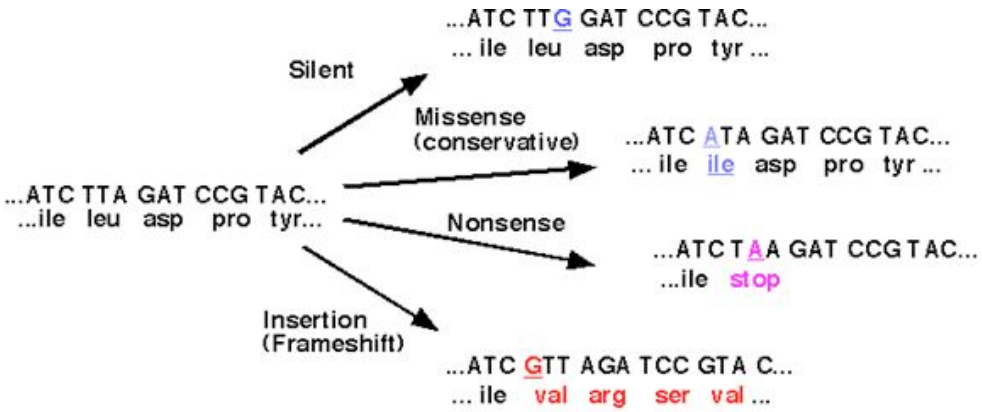
The endoplasmic reticulum is a network of membranes within the cell, and it is often classified as rough or smooth, depending on whether there are ribosomes on its surface. Which statement best describes the role of rough endoplasmic reticulum in the cell?

a. It stores all proteins for later use.
b. It provides an attachment site for larger organelles.
c. It aids in the production of membrane and secretory proteins.
d. It stores amino acids required for the production of all proteins.

The correct answer is C. *Rough E R (RER) is involved in some protein production, protein folding, quality control and dispatch. It is called 'rough' because it is studded with ribosomes.*

Spotlight on the Standards

Describe how genetic mutations alter the DNA sequence and may or may not affect phenotype (e.g., silent, nonsense, frameshift)



Point Mutations: Changes in single DNA nucleotides.

- A **nonsense** mutation results in a STOP codon being inserted someplace before the end of the gene.
- **Silent** mutations are point mutations that do not change the amino acid sequence of the protein. **These are most likely to have no effect**. Redundancy of the Genetic Code reduces the chance that point mutations do not alter the specified amino acids.
- **Frameshift Mutations**: Additions or deletions of one or more nucleotides.
    - May result in "garbage" genes, as the entire amino acid sequence in the code after the change is devastated.
    - Large deletions may remove a single amino acid, or an entire chunk of chromosome. The most common mutation that causes severe cystic fibrosis deletes only a single codon.

A genetic mutation resulted in a change in the sequence of amino acids of a protein, but the function of the protein was not changed. Which statement best describes the genetic mutation?

Sample Question

A. It was a silent mutation that caused a change in the DNA of the organism.
B. It was a silent mutation that caused a change in the phenotype of the organism.
C. It was a nonsense mutation that caused a change in the DNA of the organism.
D. It was a nonsense mutation that caused a change in the phenotype of the organism.

The correct answer is A. Since the function of the protein did not change, the only change that could place is in the DNA. Nonsense mutations would result in changes in proteins.

Spotlight on the Standards

***Explain how genetic engineering has impacted the fields of medicine, forensics, and agriculture (e.g., selective breeding, gene splicing, cloning, genetically modified organisms, gene therapy**

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 production. These gene insertions are ecologically safer than pesticides because they affect only the targeted pest.

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

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

Sample Question

Genetic engineering has led genetically modified plants that resist insect pests and bacterial and fungal infections. Which outcome would most likely be a reason why some scientists recommend caution in planting genetically modified plants?

A. Unplanned ecosystem interactions
B. Reduced pesticide and herbicide use
C. Improved agricultural yield and profit
D. Increased genetic variation and diversity

The correct answer is A.

Sample Questions Before Moving On

This section has some sample questions for you to try. After you have answered all the questions, check your answers in the "Answers to 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

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

Answers to Sample Questions

1. Answer: **C**
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**
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**
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**
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**
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** .
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.

7. Answer: **B**
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**
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.

Spotlight on the Standards

Describe the levels of ecological organization (i.e., organism, population, community, ecosystem, biome, and biosphere*

Describe characteristic biotic and abiotic components of aquatic and terrestrial ecosystems*

The term **biosphere** includes all organisms and the environments in which they live (biotic and abiotic factors). Organisms adapt to survive particular environments. Penguins 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 Keystone***, 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.

Spotlight on the Standards

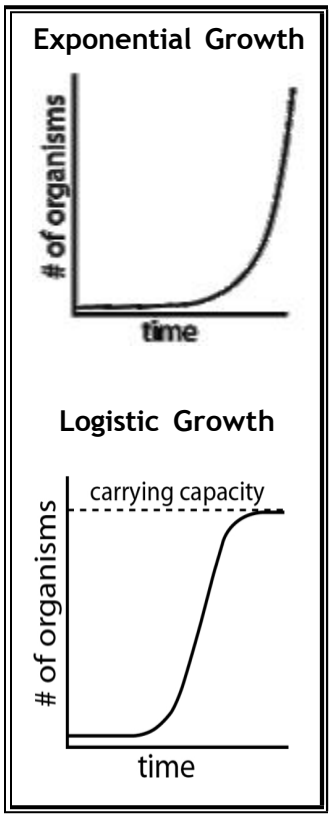
Describe the effects of limiting factors on population dynamics and potential species extinction.*

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 Keystone***, you may be given a chart or graph and may be asked to identify growth rates.



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

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

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

Spotlight on the Standards

Describe how ecosystems change in response to natural and human disturbances (e.g., climate changes, introduction of nonnative species, pollution, fires).*

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.

Spotlight on the Standards

Describe how energy flows through an ecosystem (e.g., food chains, food webs, energy pyramids).

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,** 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 Keystone***, 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:

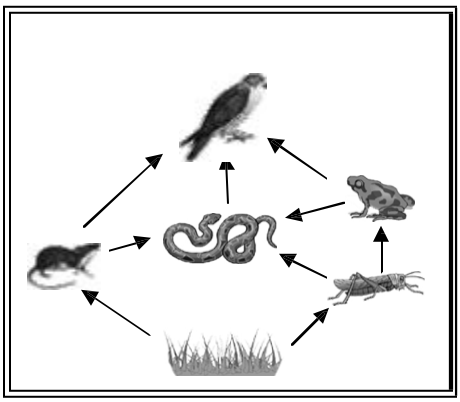
In the food chain below, which population will most likely decrease if snakes are removed from the food chain?

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.

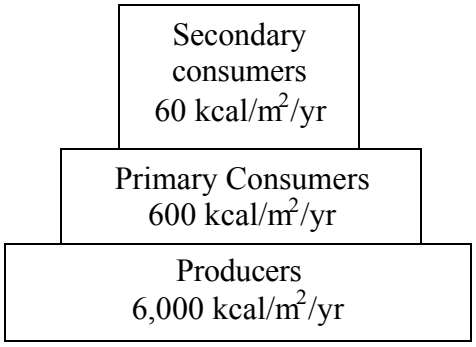
A food chain is a simplified way for ecologists to study how energy and matter flow. But it is not always that simple. Relationships exist between organisms that feed on more than one species. In an actual ecosystem there are many more plants and animals involved. A more complex interconnected system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



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.



Spotlight on the Standards

***** Describe how matter recycles through an ecosystem (i.e., water cycle, carbon cycle, oxygen cycle, and nitrogen cycle)*****

Chemical cycling through the ecosystem and the atmosphere

Water

evaporation from rivers, lakes, streams, ocean leads to condensation into clouds in the atmosphere rainfall sends water back to earth, picked up by plant tissues, enters ecosystem, remaining water enters the watershed
see diagram

Carbon

Terrestrial: carbon dioxide in the atmosphere is picked up by plants during photosynthesis, enters the ecosystem, released back into the atmosphere by respiration, burning, volcanic activity, artificial sources: combustion engines, can become buried when organisms die and are covered by sediments, later recovered in the form of coal, oil or natural gas

Aquatic

carbon dioxide diffuses into the water, picked up by marine algae, enters the ecosystem, carbon dioxide released back into the water through respiration, can diffuse back into the atmosphere, also ends up in sediments due to death of organisms that float to the floor of the ocean

Nitrogen

nitrogen is assimilated into plant tissues from nitrogen in the solid or sometimes from the atmosphere with aid of nitrogen-fixing bacteria, enters the ecosystem, leaves the ecosystem through nitrogenous wastes of organisms or death of organisms, denitrifying bacteria can release nitrogen back into the atmosphere, artificial sources - agriculture

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

A question on the ***Biology Keystone*** 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

*****Describe biotic interactions in an ecosystem (e.g., competition, predation, symbiosis).*****

Interspecific competition occurs when different species of organisms prey on the same essential resource that is in limited supply.

Competition: may be harmful to either one or both ends of an interaction.

Predation: interaction is useful for the predator but mostly fatal to the prey.

Symbiosis: an interaction between two species that keep a close, physical association, there are three types:

- Parasitism: relation is advantageous to one species but harmful to the other.
- Mutualism: relation is advantageous to both interacting individuals.
- Commensalism: relation is advantageous to one end of the interaction while the other end remains unaffected.

A species of snapping turtles has a tongue that resembles a worm. The tongue is used to attract small fish. Which best describes the interaction between the fish and the snapping turtle.

A. predation
B. symbiosis
C. parasitism
D. competition

The correct answer is A

Spotlight on the Standards

Explain how natural section can impact allele frequencies of a population.

What is natural selection?

Natural selection is a mechanism of evolutionary changes that happens when individuals that are better adapted in the challenges of the environment than other individuals produce more offspring.

Natural selection accounts for the differences among individuals in a population in survival and the ability to successfully reproduce. Essentially, some individuals have alleles that produce phenotypes that help these individuals survive in their environment than other individuals. These successfully individuals will then be able to pass these traits to their offspring.

Charles Darwin noted that the slight variations among individuals can affect the chances of *surviving* and *producing offspring*.

Charles Darwin proposed several arguments to support his theory about natural selection:

- Populations tend to produce more offspring than what the environment can support
- Population sizes are stable
- Resources are limited
- Individuals have to compete for survival
- There is variation among the individuals in a given population
- These variations can be inherited by the offspring
- Survival of the fittest
    - The most fit individuals are best adapted to survival
- Over time, evolution can occur due to the advantageous traits accumulating in a population

Individuals do not evolve. However, populations can evolve.

A question for this standard on the ***Biology Keystone*** 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

*****Describe the factors that can contribute to the development of new species (e.g., isolating mechanisms, genetic drift, founder effect, migration*****

Population Genetics

Population genetics is a useful tool for studying evolution and quantifying how evolution operates. It emphasizes counting allele and genotype frequencies to understand how phenotype frequencies in a population change over time.

Models can be built that incorporate the varied effects of selection, genetic drift, migration, etc. For example, with population genetics, you can ask:

How long would it take for a given allele to be fixed given a certain selective force for it?

How strong would migration of the alternative allele into the population have to be to counteract the effects of selection and maintain the alternative allele at the original frequency?

Hardy-Weinberg

The Hardy-Weinberg Theorem states that the allele frequencies of a gene in a population will remain constant, as long as evolutionary forces are not acting. H-W therefore provides a baseline (a null expectation) for a population that is not evolving. For a population to be in H-W equilibrium, the following conditions or assumptions must be met:

1. The population is very large; there is no genetic drift
2. Matings are random
3. There is no mutation
4. There is no migration
5. There is no selection

If one of these conditions is broken, an evolutionary force is acting to change allele frequencies, and the population may not be in H-W equilibrium. Natural populations probably seldom meet all of these conditions; H-W provides a nice model to study evolution via deviations from H-W equilibrium.

Forces of evolution / Violations of H-W assumptions

Genetic drift

Genetic drift = changes in the gene pool of a small population due to chance.

- If a population is small, its existing gene pool may not be accurately represented in the next generation because of sampling error.
- Chance events may cause the frequencies of alleles to drift randomly from generation to generation, since the existing gene pool may not be accurately represented n the next generation.
- For example, assume a theoretical wildflower population contains only 25 plants, and the genotypes for flower color occur in the following numbers: 16 AA, 8 Aa and 1 aa. In this case, a chance event could easily change the frequencies of the two alleles for flower color.

The Bottleneck Effect

- The size of a population may be reduced drastically by such natural disasters as volcanic eruptions, earthquakes, fires, floods, etc. which kill organisms nonselectively.
- The small surviving population is unlikely to represent the genetic makeup of the original population.
- Genetic drift which results from drastic reduction in population size is referred to as the bottleneck effect.
- By chance some individuals survive. In the small remaining population, some alleles may be overrepresented as some underrepresent and some alleles may be totally absent.
- Genetic drift which has occurred may continue to affect the population for many generations, until it is large enough for random drift to be insignificant.

The bottleneck effect reduces overall genetic variability in a population since some alleles may be entirely absent.

The Founder Effect

When a few individuals colonize a new habitat, genetic drift is also likely to occur. Genetic drift in a new colony is called the founder effect.

- The smaller the founding population, the less likely its gene pool will be representative f the original population's genetic makeup.
- The most extreme example would be when a single seed or pregnant female moves into a new habitat.
- If the new colony survives, random drift will continue to affect allele frequencies until the population reaches a large enough size for its influence to be negligible.
- No doubt, the founder effect was instrumental in the evolutionary divergence of the Galapagos finches.

Gene Flow

Gene flow: The migration of fertile individuals, or the transfer of gametes, between populations

- Natural populations may gain or lose alleles by gene flow, since they do not have gene pools which are closed systems required for Hardy-Weinberg equilibrium.
- Gene flow tends to reduce between-population differences, which have accumulated by natural selection or genetic drift.
- An example of gene flow would be if our theoretical wildflower population was to begin receiving wind blown pollen from an all white-flower population in a neighboring field. This new pollen could greatly increase the frequency of the white flower allele, thus also altering the frequency of the red flower allele.
- Extensive gene flow can eventually group neighboring populations into a single population

For the ***Biology Keystone***, 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.

Spotlight on the Standards

Explain how genetic mutations may result in genotypic and phenotypic variations in a population.*

Mutations
A new mutation that is transmitted in gametes immediately changes the gene pool of a population by substituting one allele for another.

In a theoretical wildflower population, if a mutation in a white flowered plant caused a plant to begin producing gametes which carried a red flower allele, the frequency of the white flower allele is reduced and the frequency of the red flower allele is increased.

Mutation itself has little quantitative effect on large populations in a single generation, since mutation at any given locus is very rare.

- Mutation rates of one mutation per 105 to 106 gametes are typical, but vary depending on the species and locus.
- An allele with a 0.50 frequency in the gene pool that mutates to another allele at a rate of 10-' mutations per generation would take 2000 generations to reduce the frequency of the original allele from 0.50 to 0.49.
- The gene pool is effected even less, since most mutations are reversible.
- If a new mutation increases in frequency, it is because individuals carrying this allele are producing a larger percentage of offspring in the population due to genetic drift or natural selection, not because mutation is producing the allele in abundance.

Mutation is important to evolution since it is the original source of genetic variation, which is the raw material for natural selection.

Spotlight on the Standards

Interpret evidence supporting the theory of evolution (i.e., fossil, anatomical, physiological, embryological, biochemical and universal genetic code).

Evidence of Evolution

1. Fossil Evidence

- If today's species came from ancient species, then we should be able to find remains of those species that no longer exist.
- We have tons of fossils of creatures that no longer exist, but bear striking resemblance to creatures that do exist today.
- Carbon dating–gives an age of a sample based on the amount of radioactive carbon is in a sample.
- Fossil Record–creates a geologic time scale.

2. Evidence from Living Organism

- Evidence of Common Ancestry –Hawaiian Honeycreeper
- **Homologous Structures**–structures that are embryologically similar, but have different functions, the wing of a bird and the forearm of a human

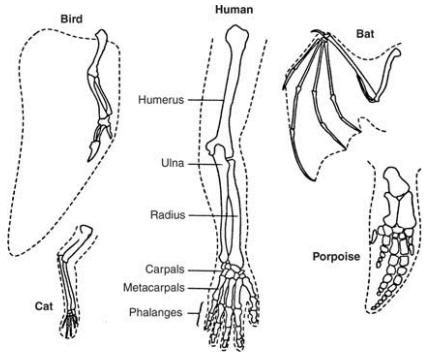


Figure 1 The forelimbs of a human and four animals showing the similarity in construction. This similarity was offered by Darwin as evidence that evolution has occurred.

- **Vestigial Organs**–seemingly functionless parts, snakes have tiny pelvic and limb bones, humans have a tail bone
- Biochemistry and DNA

  Although the biochemistry of organisms was not well known in Darwin's time, modern biochemistry indicates there is a biochemical similarity in all living things. For example, the same mechanisms for trapping and transforming energy and for building proteins from amino acids are nearly identical in almost all living systems. DNA and RNA are the mechanisms for inheritance and gene activity in all living organisms. The structure of the genetic code is almost identical in all living things. This uniformity in biochemical organization underlies the diversity of living things and points to evolutionary relationships.
- Embryological development–Embryos of different species develop almost identically
- Observation of species change (wolves/dogs, peppered moths)

For the ***Biology Keystone***, 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.

Sample Evolution Questions

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 Evolution 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

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

Answers to Evolution Sample Questions

1. Answer: **C**
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**
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**
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**
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**
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

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**
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).

Spotlight on the Standards

Distinguish between the scientific terms: hypothesis, inference, law, theory, principle, fact, and observation*

- ✓ **Theory:** The summary of a hypothesis or group of hypotheses that have been supported by repeated testing.

- ✓ **Hypothesis:** Possible explanation for observations or possible answer to a scientific question; educated guess.

- ✓ **Law:** Generalizes a group of observations for which no exceptions have been found (e.g., law of gravity).

- ✓ Observation- n act or instance of viewing or noting a fact or occurrence for some scientific or other special purpose.

- ✓ Fact- a truth known by actual experience or observation; something known to be true: Scientists gather facts about plant growth.

- ✓ Principle- a fundamental, primary, or general law or truth from which others are derived: example, the principles of modern physics.

- ✓ Inference- arrival of conclusions from given information by any acceptable form of reasoning. Inferences are commonly drawn by deduction, formed by analyzing valid arguments or from accepted premises or by induction, a conclusion based on repeated observation of fact.

Use the table below to answer the question.

Student's Observations of a Pond Ecosystem

Quantitative	Qualitative
37 fish and 3 frogs	Leaves lie on the bottom of the pond.
2 types of aquatic grass	Water insects move along the water's surface.
12 small rocks and 1 medium rock	All 3 frogs are sitting on a pond bank.
sand	

A group of students measured a ten-square-meter section of a pond ecosystem and recorded observations. Which statement is a testable hypothesis?

A. The frogs living in the pond represent a population.

B. Water is an abiotic component in the pond ecosystem.

C. If the fish are given more food, then they will be happier.

D. If the frogs are startled, then they will jump into the water.

The correct answer is D. This is the only statement you can design an experiment to test.