MAAP-EOC Exam
Biology I Student Review Guide

Author:
Kelly D. Berg

2018 Mississippi College- and Career-Readiness Standards for Science

Published by Enrichment Plus, LLC
PO Box 2755
Acworth, GA 30102
Toll Free: 1-800-745-4706 • Fax 678-445-6702
Web site: www.enrichmentplus.com

Table of Contents

Table of Contents

Preface

The ***MAAP-EOC Exam Biology I Student Review Guide*** is written to help students review the skills needed to pass the Biology I end-of-course exam in Mississippi. This comprehensive review book is based on the 2018 Mississippi College- and Career-Readiness Standards (MCCRS) for Science as published by the Mississippi Department of Education.

How To Use This Book

Students:
You are required to pass Biology I in order to graduate, and the MAAP-EOC exam for Biology I factors heavily towards you getting graduation credit for the course. This book covers what you need to know to pass the MAAP-EOC exam in Biology I.

① Read the instructional material in this review book, do the practice exercises, and take the section review tests at the end of each section.

② After reviewing the material, take the pre-test (provided as a separate booklet). The actual MAAP-EOC exam you take will probably be given in a computer format, but these pre-test questions are written to be similar to the types of computer questions you may encounter on the exam.

③ After taking the pre-test, use the pre-test evaluation chart, which is found directly after the test, to identify areas for further review and practice.

Teachers:
This review book is also intended to save you, the teacher, time in the classroom. It can be used for classroom instruction or for individual student review. Since this student book offers review for ALL of the MCCRS for Biology I, you have one consolidated resource of materials to help your students prepare for the end-of-course exam.

① When teaching or tutoring individual students, use the strategy outlined above for students.

② For classroom study, use this book to supplement lesson plans and to give additional review for skills required by the MAAP-EOC for Biology I. Purchase a class set of books for use in the classroom or assign books to students for out-of-classroom work.

③ Assign the pre-test (provided in a separate booklet) as a comprehensive review.

④ Use the pre-test evaluation chart found after the test to identify areas needing further review.

⑤ Please **DO NOT** photocopy materials from this book or the pre-test booklet. These materials are intended to be used as student workbooks, and individual pages should not be duplicated by any means without permission from the copyright holder. To purchase additional or specialized copies of sections in this book, please contact the publisher at 1-800-745-4706.

Biology I
Pre-Test
Overview

Introduction
The pre-test that follows is designed to identify areas where you can improve your skills before taking the MAAP-EOC exam in Biology I. This pre-test has 60 questions in various forms. These questions may be similar to the ones you will see on the actual test.

The MAAP-EOC Exam for Biology I
The actual MAAP-EOC exam may be given online and may have a variety of different test questions. Read each question carefully. Some questions may have multiple correct answers, so consider each of the answer choices when making multiple selections.

Scoring
The following pre-test can be used as practice for the MAAP-EOC exam in Biology I, but it is primarily a diagnostic tool to help you identify which skills you can improve in order to prepare better for the actual exam. Any pre-test question answered incorrectly may identify a skill needing improvement or mastery. Review the corresponding skill(s) indicated in the Pre-Test Evaluation Chart by reading the instructional material on the given pages and completing the practice exercises and reviews. The Pre-Test Evaluation Chart is found on page Pre-32. By reviewing each skill, you will improve mastery of the material to be tested on the MAAP-EOC exam and potentially increase the score you receive on that exam.

On this pre-test, each correct response counts as one point for a total of 68 points. If a question asks for more than one correct response, be sure that you select only the correct number of responses. Erase completely any marks not intended as an answer choice.

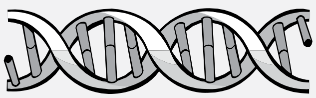
Biology I Pre-Test Question Types

The questions below are examples of the types of question you will see in this pre-test. Be sure you understand how to answer each type.

Most questions will be multiple choice. For multiple choice questions, be sure to select only one answer choice.

EXAMPLE 1
MULTIPLE CHOICE, select <u>one</u> answer choice.

Study the diagram below.



This diagram models which of the following molecules?

Ⓐ RNA
Ⓑ DNA
Ⓒ a protein
Ⓓ a carbohydrate

Some questions will be multiple select with more than one correct answer choice. Read each question carefully and select only the number of answer choices indicated by the question. Marking more than the specified number of correct answers will result in a score of zero for that question. For example, if the question indicates two correct answers but you choose three, you will score a zero on that question. Partial credit may be given, however, for each correct answer choice that you choose. For example, the question indicates two correct answers, and you choose one correct answer choice and one incorrect answer choice. You will be given partial credit for your correct choice.

EXAMPLE 2
MULTIPLE SELECT, select more than one answer choice depending on the specific question.

Which <u>three</u> elements are commonly found in nearly all macromolecules?

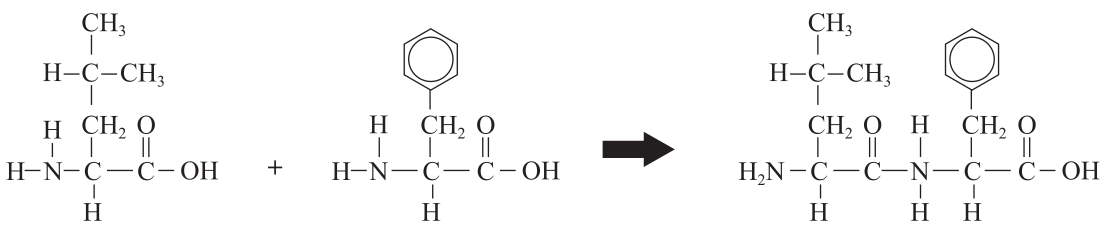
Ⓐ carbon
Ⓑ phosphorus
Ⓒ nitrogen
Ⓓ hydrogen
Ⓔ sulfur
Ⓕ oxygen

4. **Within the scientific community, there has been some ongoing debate as to whether or not viruses represent living organisms. The debate hinges on the definition of life. All of the following describe the characteristics of viruses. Which <u>two</u> characteristics of viruses give the <u>best</u> support that viruses could be classified as living organisms?**

Ⓐ They are surrounded by a protein coat.
Ⓑ They contain genetic information in the form of either DNA or RNA.
Ⓒ They are specific in the type of cell they can infect.
Ⓓ They evolve over time through mutations in their genetic code.
Ⓔ They do not seek food or energy to grow and develop on their own.

---

5. **The following question has two parts. The graphic below models a dehydration synthesis reaction that is occurring in the ribosomes of a cell. Study the reaction carefully. First, answer Part A. Then, answer Part B.**



PART A

Which of the following correctly describes the reactants and product?

Ⓐ Two monosaccharides are being combined to form a disaccharide.
Ⓑ Fatty acids are being combined to form a phospholipid molecule.
Ⓒ Nucleotides are being combined in the process of forming a molecule of RNA.
Ⓓ Amino acids are being combined in the process of forming a protein.

PART B

Which evidence from the model <u>best</u> support your answer?

Ⓐ Amino acids and proteins contain nitrogen.
Ⓑ Fatty acids contain a carboxyl group, –COOH.
Ⓒ Monosaccharides and carbohydrates contain the elements or carbon, hydrogen, and oxygen.
Ⓓ Nucleotides contain a sugar, a phosphate group, and a nitrogen-containing base.

GO ON

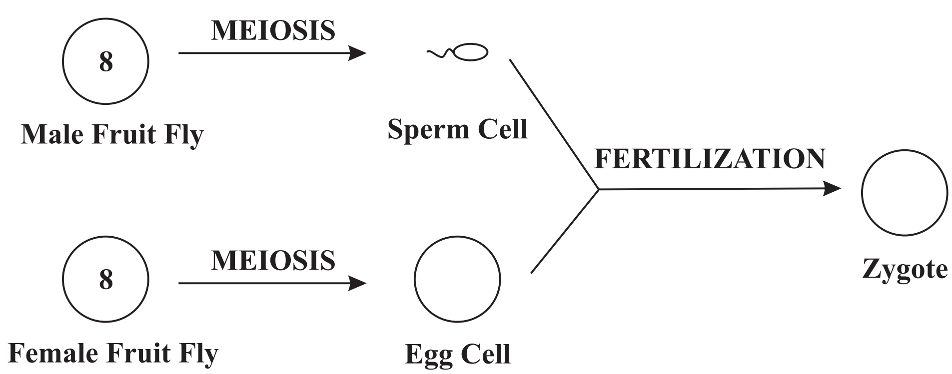
24. **Study the chemical reaction shown below that creates carbon dioxide as a product and releases energy in the form of ATP. X, Y, and Z represent unknown compounds.**

$$X + Y \xrightarrow{\text{enzymes}} CO_2 + Z + ATP$$

Which <u>two</u> compounds could represent X and Y in this reaction?

Ⓐ glucose ($C_6H_{12}O_6$)
Ⓑ oxygen (O_2)
Ⓒ water (H_2O)
Ⓓ phosphate (PO_4^{-3})
Ⓔ hydrogen (H_2)

25. **Fruit flies have 8 chromosomes in their somatic cells. The diagram below shows the results of meiosis and fertilization in fruit flies.**



After meiosis is complete, how many chromosomes will be in the sperm cell?

Ⓐ 2
Ⓑ 4
Ⓒ 8
Ⓓ 16

GO ON

43. A biologist has found what he believes to be a new species of fish. He identifies the following gene sequence in the newly discovered fish and compares it to the gene sequence of four other fish species.

Newly Discovered Species: 5' – CCA AGG CAT GGT CCT GAC TTT ACT – 3'

Species	DNA Base Sequence
1	5' – CAA AGC CTT GGT CCT GAC TTT ACT – 3'
2	5' – CAA AGG CAT GGT CCT GAC TTT ACT – 3'
3	5' – CAA AGG CAT GGT CCC GAC CTT ACT – 3'
4	5' – CCA AGG CTT GGT CTT GAC CTT ACT – 3'

Based on gene sequence homology, which species in the table is <u>most</u> closely related to the newly discovered species?

Ⓐ species 1
Ⓑ species 2
Ⓒ species 3
Ⓓ species 4

44. Female sockeye salmon will lay an average of 3,500 eggs during a spawning season. Only an average of 25% of these eggs will hatch into fry (baby fish), and only two to three of those fry will survive and mature into adult salmon that reproduce in the future. How does the overproduction of salmon eggs allow natural selection to act upon sockeye salmon populations?

Ⓐ Only the fittest fry survive to eventually reproduce.
Ⓑ The female salmon choose only the most aggressive males to fertilize her eggs.
Ⓒ The unhatched eggs become food for other species.
Ⓓ Most of the fry are an integral part of the freshwater food web by supplying nutrients to other predators.

45. Which of the following might be studied as a part of a marine ecosystem but would <u>not</u> be included if studying only a marine community?

Ⓐ the number of different species of fish
Ⓑ water salinity and temperature
Ⓒ the size of a particular population
Ⓓ producers, such as algae and other phytoplankton

GO ON

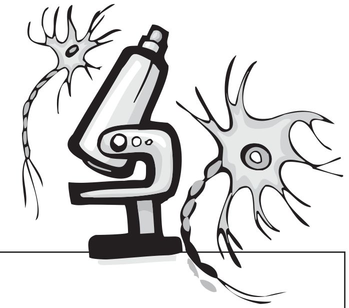
Biology I Pre-Test
Evaluation Chart

Circle the questions you answered incorrectly on the chart below, and review the corresponding sections in the book. Read the instructional material, do the practice exercises, and take the section review tests at the end of each section.

If you missed question #:	Go to section(s):	If you missed question #:	Go to section(s):	If you missed question #:	Go to section(s):
1	1.1, 2.1	21	15.1, 15.2, 15.3	41	6.3
2	2.4	22	4.2, 4.5	42	11.1, 11.3, 11.4, 11.6
3	5.4, 5.5, 5.6	23	8.1, 8.2, 8.4	43	13.3
4	1.1, 2.6	24	4.3	44	11.1
5	1.2, 1.5, 1.8	25	5.4, 5.5	45	14.1
6	1.7, 6.3	26	5.4, 5.5, 5.6	46	12.3
7	1.6	27	7.1	47	14.2
8	2.3, 2.4	28	8.2, 9.1	48	11.6, 11.7
9	2.3	29	15.1, 15.2	49	17.1
10	2.2, 2.4	30	8.2, 9.1	50	16.4
11	3.2	31	8.1, 8.2, 8.5, 9.4	51	14.2
12	2.1	32	8.1, 8.2, 9.3, 9.4	52	16.1
13	2.5	33	6.3, 7.1	53	4.3, 4.4
14	3.4	34	10.3, 10.4	54	17.3
15	4.3	35	6.1, 6.3	55	8.1, 8.2
16	3.3	36	7.2	56	5.1, 5.3
17	5.1	37	13.1	57	14.3, 15.4
18	5.1, 6.1, 6.2	38	6.3	58	2.6
19	5.1, 5.2	39	10.3	59	5.1, 5.3, 5.6
20	4.1	40	11.1, 11.3, 11.4	60	8.1, 8.2, 8.3, 8.4

The Components of Life

Section 1.2
Organic Chemistry



Pre-View 1.2

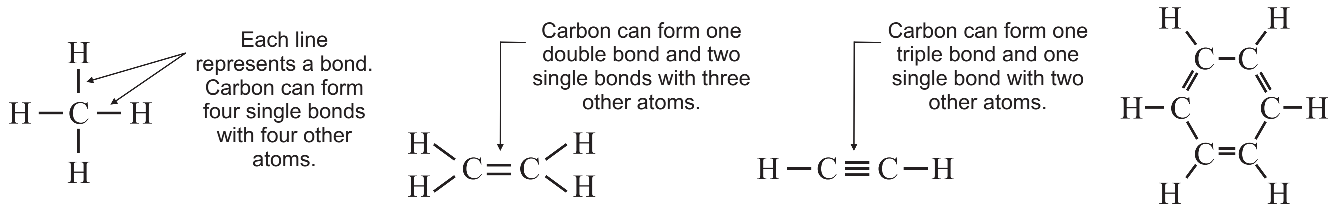
- **Atom** – the smallest portion of an element found in the periodic chart; examples include carbon, oxygen, gold
- **Biomolecule** – an organic molecule produced by a living organism
- **Chemical bond** – a connection made between atoms when electrons are attracted, shared, or transferred
- **Condensation reaction** (or **dehydration synthesis**) – a chemical reaction that combines smaller molecules and forms water as a byproduct; the reaction is often used to form polymers
- **Covalent bond** – a chemical bond formed when elements *share* electrons
- **Hydrolysis reaction** – a chemical reaction between water and another molecule that breaks down the molecule into simpler molecules; the reaction splits a water molecule to break apart a polymer into monomers
- **Inorganic molecule** – a molecule that is not organic; most (but not all) do not include carbon; examples include water (H_2O), ammonia (NH_3), table salt (NaCl), and carbon dioxide (CO_2)
- **Ion** – an electrically charged "atom" that has either gained or lost electrons
- **Ionic bond** – a chemical bond formed when elements *transfer* (donate or accept) electrons
- **Macromolecules** (or **macronutrients**) – the large biomolecules that make up living organisms; include proteins, carbohydrates, lipids, and nucleic acids
- **Molecule** – a chemical combination of two or more atoms that forms a separate substance; for example, one molecule of water (H_2O) is made up of two hydrogen atoms and one oxygen atom
- **Monomer** – a small molecule that may be chemically bonded to other like molecules to form a polymer
- **Organic molecules** – carbon-containing molecules that are generally associated with living organisms
- **Polymer** – a long chain of monomers (small, repeating molecules)
- **Polymerization** – the chemical process of combining monomers to form a polymer; often uses condensation reactions

Chemistry Review

Atoms are the basic building blocks of the universe. An atom is the smallest possible portion of an element found in the periodic chart. You should remember that elements in the periodic chart include carbon, oxygen, nitrogen, aluminum, silver, and gold, to name a few. If you continued to split a sample of gold in half, you would eventually get a piece so small that it could not be separated anymore without losing the properties of gold. That "smallest piece" of the element gold would be one *atom* of gold.

There are only about 118 elements known to man and listed in the periodic chart. Why then do we have the incredible number of substances that exist in our world today? Many of these substances are compounds, or chemical combinations of two or more elements. The smallest unit of a chemical compound can also be called a **molecule**.

Simple Organic Molecules



Methane, CH_4 Ethene, C_2H_4 Ethyne, C_2H_2 Benzene, C_6H_6

Fig. 1-2

As you can see in figure 1-2 above, carbon can form bonds with other carbon atoms. These bonds allow carbon to form straight chains, branched chains, or ring structures. In this way, carbon can form thousands of different structures, including some that are very large and complex.

Biomolecules and Macromolecules

Organic molecules that are specifically produced by living organisms are called **biomolecules**. Biomolecules include vitamins, hormones, and ATP, to name a few. Biomolecules can be simple organic molecules, or they can be long and complex. A special class of biomolecules are long, complex molecules called **macromolecules**. The four main types of macromolecules are carbohydrates, proteins, lipids, and nucleic acids. These macromolecules are sometimes called **macronutrients**. The elements responsible for forming the basis of most biomolecules are carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), and sulfur (S). Remember these as CHONPS (like CHOMPS, but with an N instead of an M).

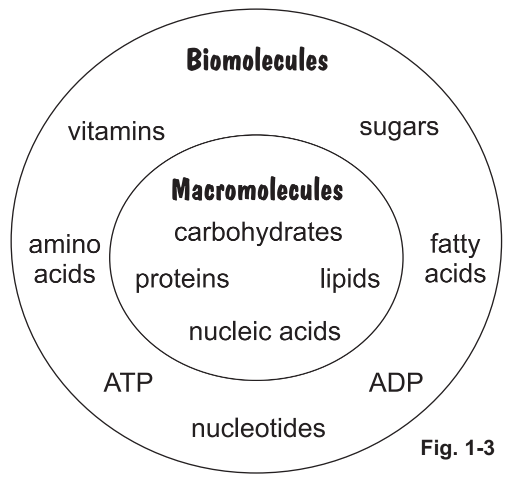
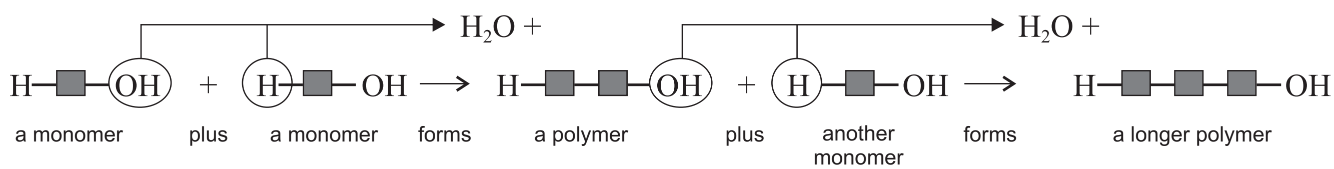


Fig. 1-3

Polymerization

Macromolecules are formed when smaller molecules called **monomers** are joined together in a process known as **polymerization** (figure 1-4). Polymerization forms **polymers**, which may be made from hundreds or thousands of monomers. Monomers combine to form a polymer by using a **condensation reaction** (also called **dehydration synthesis**). This type of reaction forms a molecule of water every time a monomer is added.

Example of Polymerization (Condensation Reaction/Dehydration Synthesis)



Condensation reactions build polymers and form water molecules.

Fig. 1-4

Fatty Acids

Before reviewing the different types of lipids and their chemical structures, let's review fatty acids, which are a component of some lipids. A **fatty acid** is an organic acid that is made up of a long chain of hydrocarbons. At first glance, a fatty acid looks similar to a carbohydrate because it contains a straight chain of carbon atoms bonded to hydrogen atoms along this chain. However, unlike a carbohydrate, a fatty acid typically contains an even number of carbon atoms and contains a carboxyl group at one end of the chain. The carboxyl group has the chemical formula of -COOH, which makes the compound an acid. Look at figure 1-9 and notice the carboxyl group at the left end of each fatty acid chain. Fatty acids make up a part of fats, phospholipids, and waxes.

Examples of Fatty Acids

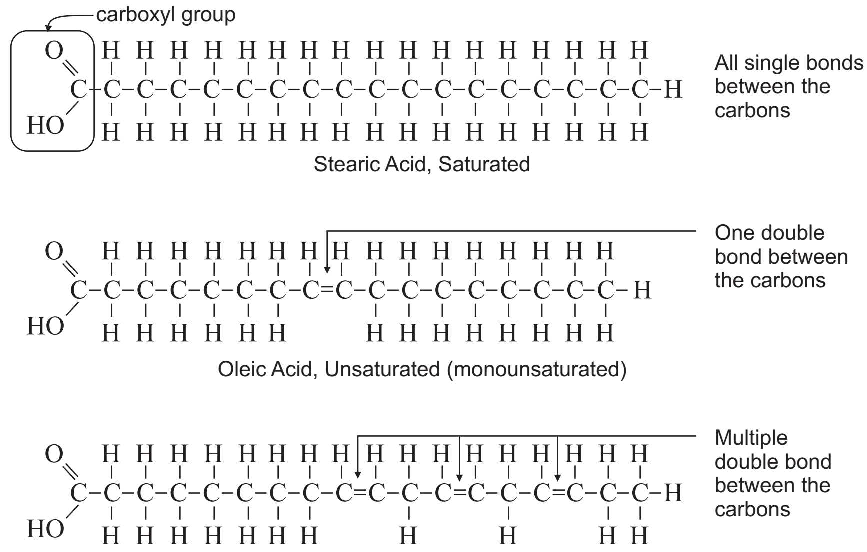


Fig. 1-9

Fatty acids can be saturated or unsaturated. When every carbon atom in the fatty acid chain has a single bond with another carbon atom, the fatty acid is saturated. Being saturated means that it has the maximum number of hydrogen atoms possible. An unsaturated fatty acid has one or more double carbon to carbon bonds.

Fats

Fats, also called *triglycerides*, are made of a glycerol molecule bonded to three fatty acid molecules (figure1-10). Fats can be classified as saturated or unsaturated depending on the types of fatty acids they contains. Refer to figure 1-9 for the types of fatty acids.

Fats that are solid at room temperature, such as butter, shortening, and lard, are usually **saturated fats**; they are made up of saturated fatty acids, which contain only single carbon to carbon bonds.

General Structure of a Fat

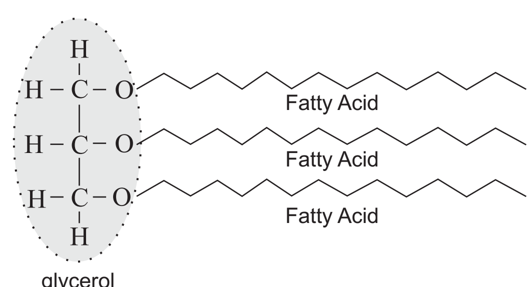
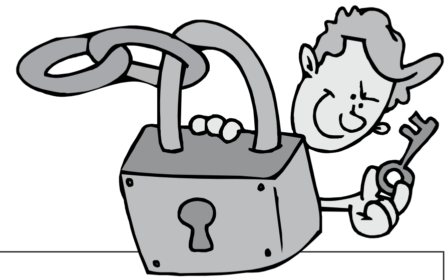


Fig. 1-10

Unsaturated fats have one or more double bonds in their fatty acids and are classified as either monounsaturated or polyunsaturated. Unsaturated fats are usually liquid at room temperature. **Monounsaturated fats** have one double carbon to carbon bond, and **polyunsaturated fats** contain fatty acids with more than one double bond. Nuts, seeds, avocados, olive oil, and peanut oil contain monounsaturated fatty acids. Vegetable oils, nuts, seeds, and cold-water fish contain polyunsaturated fatty acids. You may have seen these terms on food labels.

The Components of Life

Section 1.6
Enzymes



Pre-View 1.6

- **Activation energy** – the energy needed for a chemical reaction to take place
- **Active site** – the part of an enzyme that "attaches to" a substrate
- **Catalyst** – a substance that speeds up a chemical reaction without being consumed in the reaction
- **Denature** – to change the structure of a protein so that it no longer functions in the same way
- **Enzyme** – a biological catalyst that enables chemical reactions to take place in cells
- **Enzyme-substrate complex** – the structure that is formed when a substrate binds to the active site of an enzyme
- **Metabolic pathway** – a series of reactions, one after another, that occurs in a cell
- **pH** – a measure of the acidity or alkalinity of a substance
- **Substrate** – a substance that is changed by an enzyme

Organisms rely on thousands of chemical reactions to occur in cells in order to live. To make these reactions possible, special proteins called **enzymes** are used.

Enzymes and Activation Energy

The energy needed for any chemical reaction to take place is called the **activation energy** (abbreviated E_A). In living cells, most of the required chemical reactions occur too slowly or require too much energy to take place on their own. Enzymes act as catalysts to lower the activation energy. (A **catalyst** is a substance that speeds up a chemical reaction without itself being affected by the reaction.) In other words, enzymes speed up the reactions by lowering the amount of energy needed for the reactions to occur.

In figure 1-15, the two lines represent the same reaction pathway, one catalyzed (with enzymes) and one uncatalyzed (without enzymes). Notice that the catalyzed reaction requires less energy.

Enzymes Lower Activation Energy

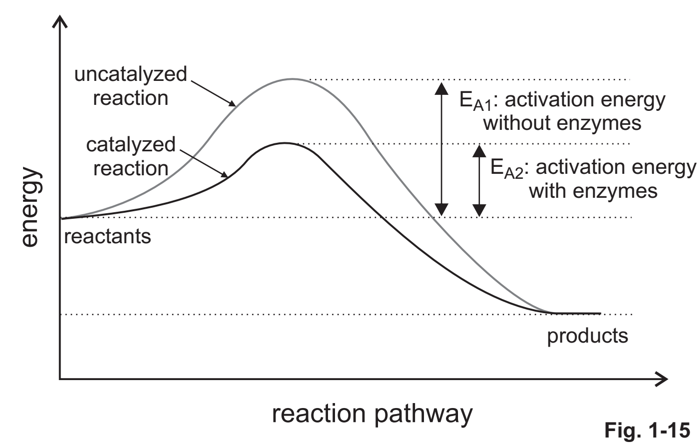


Fig. 1-15

How Enzymes Work

Enzymes are very large molecules that provide a location where the reactants of a reaction can be brought together. These reactants are also called the **substrates**. An enzyme is very specific in that it will only work with specific substrates.

Prokaryotic and Eukaryotic Cells

You'll see more about specific organelles in Section 2.3. For now, review the similarities and differences in these two types of cells in the following chart.

Similarities and Differences in Prokaryotic and Eukaryotic Cells

	PROKARYOTIC CELLS	EUKARYOTIC CELLS
Average Cell Size	1-10μm	10-100μm
Have a Cell Wall?	YES, most do	SOME
Have a Cell Membrane?	YES	YES
Have a Nuclear Membrane/Nucleus?	NO	YES
Have Cytoplasm?	YES	YES
Have DNA?	YES, in cytoplasm	YES, in nucleus
Have Ribosomes?	YES	YES
Have Membrane Enclosed Organelles?	NO	YES
Mode of Locomotion?	May have one or more flagella for locomotion	May have one or two flagella or cilia for locomotion
Found in —	bacteria only	fungi, protists, plants, animals

Both prokaryotic bacteria and single-celled eukaryotic organisms can have one or more **flagella** for locomotion. A flagellum (singular) is a long, hair-like filament that propels a cell forward.

Eukaryotic cells may also have **cilia**, which are shorter hair-like projections used like oars for movement. Multicellular organisms may have ciliated cells to produce movement, not necessarily for the cells themselves, but to produce the movement of debris. For example, cells in your nose are ciliated to move mucus and debris!

When you compare the two diagrams given in figures 2-1 and 2-2 below, you can tell how much more complex eukaryotic cells are than prokaryotic cells. The eukaryotic cell has more organelles. Examples of cell organelles are ribosomes, mitochondria, endoplasmic reticulum, etc.

Prokaryotic Cell

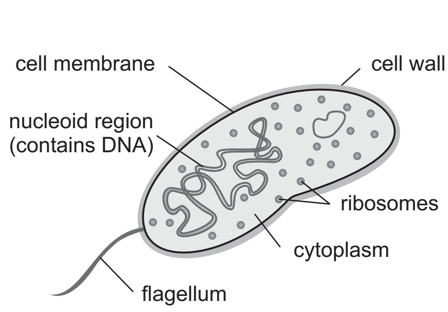


Fig. 2-1

Eukaryotic Cell

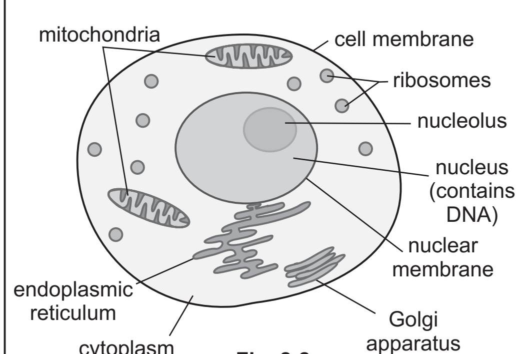


Fig. 2-2

Hint: To help you remember that eukaryotic cells are the cells that make up most organisms, including humans, think about how eukaryote is pronounced. It sounds like "you," and you are human!

Viruses

Figure 2-13 shows a diagram of the lytic cycle and the lysogenic cycle for a *bacteriophage*, a type of virus that infects bacteria.

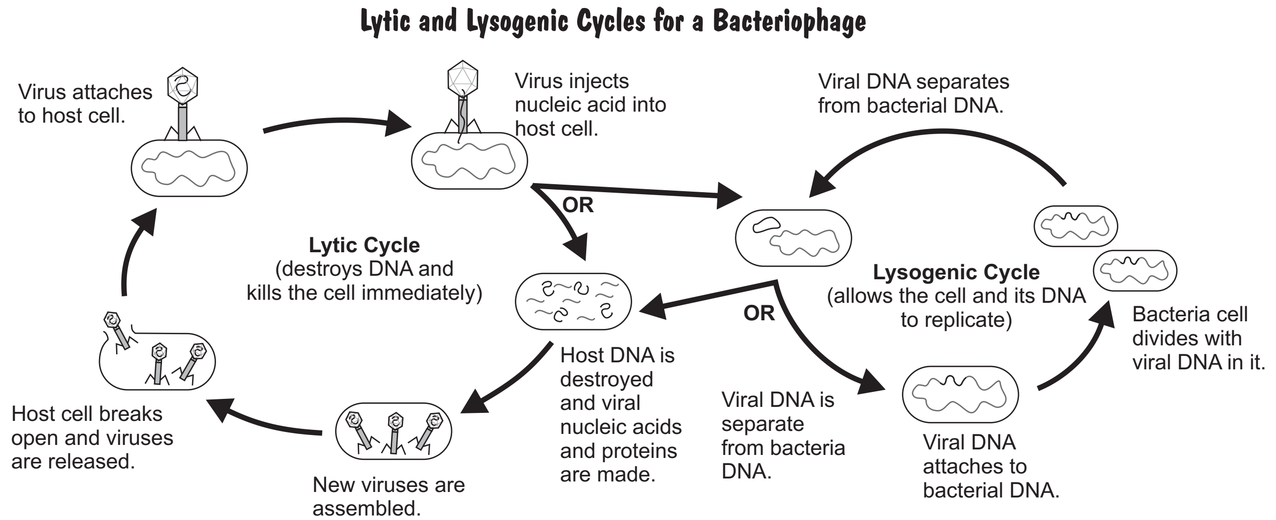


Fig. 2-13

Viruses: Living or Nonliving?

Should viruses be considered living organisms? The idea that viruses are living is sometimes debated because not everyone agrees on the definition of life. The characteristics of viruses can blur the lines between living and nonliving.

In Section 1.1 and again in Section 2.1, you saw eight commonly accepted characteristics of living things. Most scientists classify viruses as nonliving because they do not meet many of the commonly cited characteristics of life. In the following chart, consider how viruses meet or fail to meet each of these common characteristics of living things.

COMMON CHARACTERISTICS OF LIVING THINGS	VIRUS?	EXPLANATION
Made of one or more cells	No	A virus is not a cell, but it contains some of the components of a cell. It contains genetic material and a protein coat, but it does not have a cell membrane or organelles.
Has a way to reproduce	Yes and No	A virus can reproduce BUT only once it is inside a host cell.
Grows and develops	No	A virus does not have stages of development. It does not grow.
Shares a universal genetic code	Yes	A virus does contain genetic information in the form of either DNA or RNA. This genetic information forms genes used to create more virus particles.

continued on the next page

Passive Transport: Osmosis

Hint: Will a cell shrink or swell if placed in a hypotonic solution? It will swell. A simple word association may help you to remember this answer. Associate "hypo" with an "o" with "hippo." Hippos are large animals. Remember that cells in a hypotonic solution will swell up to the size of a hippo.

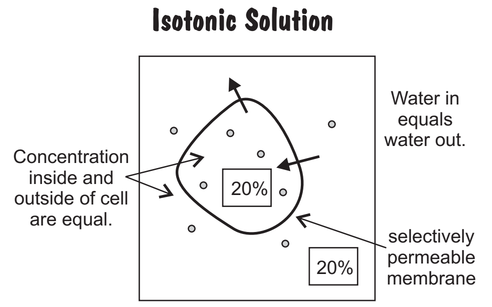


Fig. 3-9

Isotonic Solution

Isotonic (*iso = same*) means that the solution on the outside of the cell membrane has the same solute concentration as the solution on the inside of the membrane, so there is no net movement of water molecules across the membrane.

In figure 3-9, the solute concentration on both sides of the membrane is equal at 20%. Water molecules will pass in through the membrane at the same rate as they will pass out of the membrane. The cell will remain the same size since it is not gaining or losing water.

Quick Review

hypertonic	hyper = more	*more solute* and less water in the outside solution	cell shrinks
hypotonic	hypo = less	*less solute* and more water in the outside solution	cell swells
isotonic	iso = same	solute concentrates inside and outside are equal	no change in size

Effects of Osmosis on Animal Cells

Since an animal cell has only its cell membrane surrounding it, the cell is very vulnerable to the effects of osmosis. The effects of solute concentrations on a red blood cell can be seen in figure 3-10.

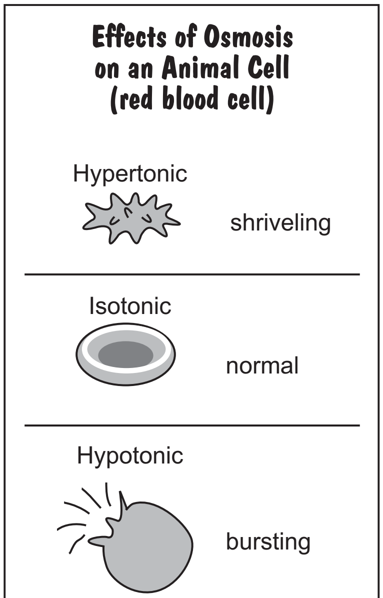


Fig. 3-10

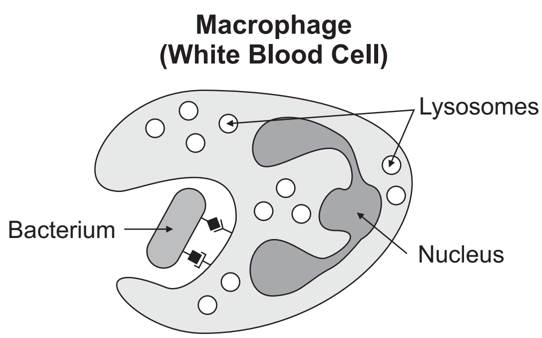
Hypertonic solutions will cause animal cells to shrink, causing a shriveled or "spiked" appearance. If the concentrations are very different inside and outside the cell, an animal cell in a hypertonic solution will shrivel and die. For example, salt water is hypertonic to the cells of most vertebrates that live in the ocean. To avoid dehydration that could be fatal to them, these animals constantly drink sea water and then desalt it by pumping the salt out of their gills using *active transport*. (We'll get to that next.) You may have seen pictures of marine turtles that blow salt out of special glands on their noses for the same reason. If a freshwater animal, however, is put in salt water for an extended period of time, its cells will lose too much water in the hypertonic solution, and the animal will die of dehydration.

In a hypotonic solution, animal cells swell. If the cell membrane is not strong enough, the cells will burst. For example, a red blood cell that contains almost 1% solutes will burst if it is put in pure water (0% solute). A saltwater fish that is put in fresh water will eventually die because its cells will gain too much water.

15. **In plants, root hairs are responsible for both water and mineral uptake. Water is not required for the root hairs to absorb the minerals. Minerals such as potassium (K^+) are absorbed via membrane transport proteins against as much as a ten thousand-fold concentration gradient. This uptake of minerals through plant root hairs is an example of —**

Ⓐ osmosis.
Ⓑ facilitated diffusion.
Ⓒ active transport.
Ⓓ diffusion.

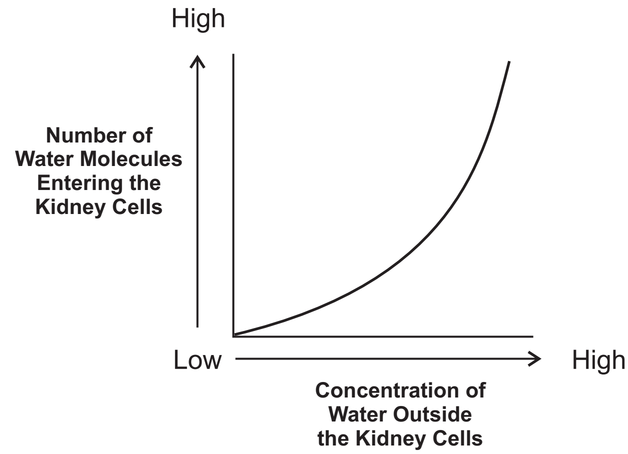
16. **Human macrophages are specialized white blood cells that are able to attack and "swallow" bacteria in order to fight or prevent bacterial infection. Macrophages have many lysosomes that contain enzymes to dissolve the engulfed bacterium cell. See the diagram below.**



What process are these cells specifically designed to carry out?

Ⓐ osmosis
Ⓑ endocytosis
Ⓒ facilitated diffusion
Ⓓ exocytosis

17. **Human kidney cells function to regulate the concentration of water and minerals in the blood. Study the graph below.**



The graph shows that as the concentration of water increases outside the cells, more and more water molecules enter the cells. Which <u>two</u> statements are accurate conclusions that can be drawn from this graph?

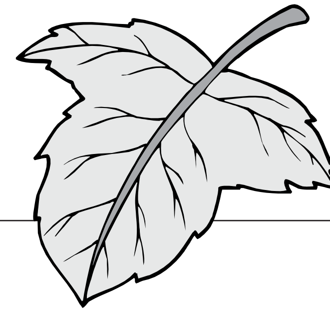
Ⓐ Water is nonpolar.
Ⓑ The lysosomes are regulating the action of the kidney cell membranes.
Ⓒ The kidney cell membranes are selectively permeable to water.
Ⓓ The movement of water across the kidney cell membranes requires energy.
Ⓔ Water enters kidney cells through the process of osmosis.

18. **Which <u>two</u> substance would animal intestinal cells most likely take in via facilitated diffusion?**

Ⓐ glucose
Ⓑ calcium ions
Ⓒ carbon dioxide
Ⓓ oxygen
Ⓔ hormones

Cellular Energy

Section 4.2
Photosynthesis



Pre-View 4.2

- **Autotrophs** (also called ***producers***) – organisms such as plants that usually use energy directly from the sun to produce glucose and other carbohydrates
- **Calvin cycle** – the stage of photosynthesis that does not require light
- **Carbon fixation** – the process of converting the inorganic carbon found in carbon dioxide to organic carbon in glucose
- **Chlorophyll** – the green pigment found in the chloroplasts of plant cells that absorbs energy from the sun and uses that energy in the first stage of photosynthesis
- **Chloroplasts** – organelles found in plant cells (and photosynthetic autotrophs); where photosynthesis takes place
- **Granum** – a stack of thylakoids within a chloroplast (plural: grana)
- **Heterotrophs** (also called ***consumers***) – organisms such as animals that obtain energy by consuming plants and other animals
- **Photosynthesis** – process used by autotrophs that uses the sun's energy to convert water and carbon dioxide to glucose (simple sugar) and oxygen
- **Stroma** – the water-based fluid region outside of the thylakoid membranes where the Calvin cycle takes place
- **Thylakoids** – sac-like membranes found within chloroplasts that contain the photosynthetic pigments

You know that all living organisms need energy, but where does that energy come from? In Section 4.1, you saw how chemical potential energy in glucose (or simple sugar) is converted into chemical energy stored in and released from ATP, but where does the glucose come from? The sun is actually the main source of energy for living organisms although many organisms can't use that energy in its original form. All living organisms live by releasing energy found in chemical compounds such as glucose, but some can also use light energy directly from the sun to make glucose. This light energy from the sun is stored in the chemical bonds between atoms of the glucose molecule. Energy is released from glucose when these bonds are broken.

Living organisms can be divided into two main groups: autotrophs and heterotrophs. **Autotrophs** are organisms such as plants that can directly use the sun's energy to produce energy-containing chemical compounds such as glucose and other carbohydrates. Autotrophs are also called ***producers*** since they can produce their own food. **Heterotrophs** are organisms such as animals that get energy from the sun indirectly by consuming foods that have energy stored in them. Heterotrophs are also called ***consumers*** since they must consume food for energy.

Through the process of **photosynthesis**, most autotrophs use the energy in sunlight (called *solar energy*) to change water and carbon dioxide (CO_2) into glucose and oxygen. The light energy from the sun is converted to chemical energy that is stored in the bonds of the glucose molecules. The net equation for photosynthesis is shown in figure 4-4.

Photosynthesis

$$\underset{\text{carbon dioxide}}{6CO_2} + \underset{\text{water}}{6H_2O} \xrightarrow[\text{enzymes and chlorophyll}]{\text{light energy}} \underset{\text{glucose (simple sugar)}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2}$$

Fig. 4-4

Section 4.3, continued
Aerobic and Anaerobic Cellular Respiration

After glycolysis, there are two possibilities depending on whether or not oxygen is present. One possibility is aerobic respiration, and the other possibility is anaerobic respiration. The pathways for each are summarized below in figure 4-8.

Aerobic versus Anaerobic Respiration Pathways

Is oxygen present?

YES	NO
AEROBIC RESPIRATION	**ANAEROBIC RESPIRATION**
• must have oxygen to occur • takes place in mitochondria • produces a net of approximately 34 ATP molecules from one glucose molecule (not considering glycolysis)	• no oxygen needed • takes place in cytoplasm • produces 2 ATP molecules from one glucose molecule

Fig. 4-8

Aerobic Respiration

Aerobic respiration occurs only when oxygen is present. In order for aerobic respiration to proceed from the cytoplasm into the mitochondria, the pyruvate molecules formed from glycolysis must be further modified. The pyruvate reacts to form carbon dioxide and a molecule called acetyl CoA. The acetyl CoA molecule enters the mitochondrion and is used to begin another step to produce ATP called the **Krebs cycle**. The Krebs cycle takes place in a part of the mitochondrion called the mitochondrial matrix, and this process releases more carbon dioxide and produces a net gain of two more ATP. The Krebs cycle is sometimes called the citric acid cycle because citric acid is formed from the acetyl CoA at the beginning of the cycle.

Glycolysis and the Krebs cycle produce electrons that are carried by energy carrying molecules (NADH and $FADH_2$). These electrons are used in a third step of ATP production called the **electron transport chain** (**ETC**). The electron transport chain takes place across the inner mitochondrial membrane, and this step is by far the most efficient at producing ATP. The electron transport chain produces a net gain of between 32 and 34 ATP molecules. Mitochondrial membrane enzymes, hydrogen ions (H^+), and oxygen are used in this process. In addition to the ATP, water is also produced.

The Three Steps of ATP Production in Aerobic Respiration

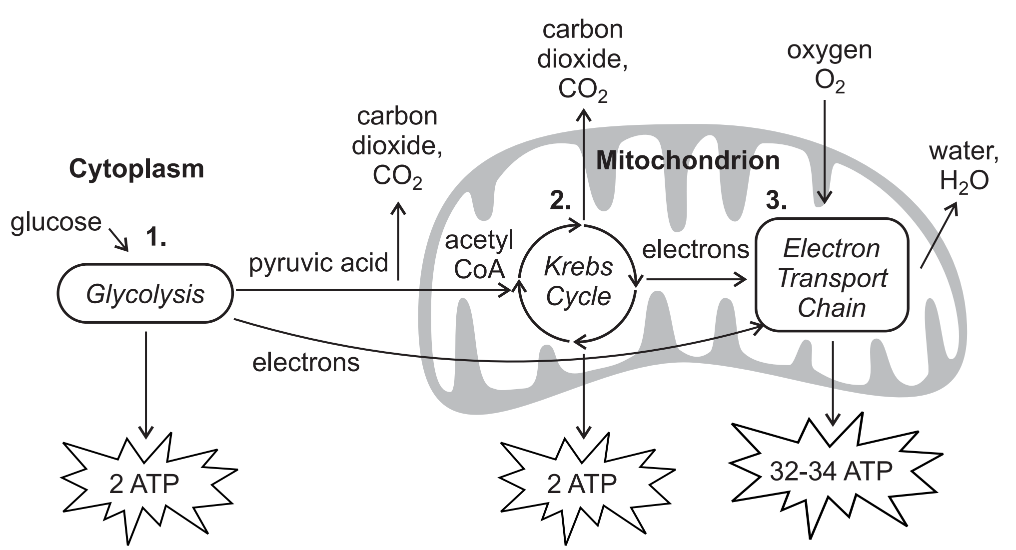


Fig. 4-9

Section 5.2, continued
Cell Cycle Regulation and Cancer

Programmed cell death, or **apoptosis**, occurs when cells become damaged or worn. For example, if a cell encounters a problem at an internal checkpoint, proteins may signal for apoptosis. Apoptosis can occur when factors either outside or inside the cell signal for genes to produce self-destructive enzymes. The enzymes break the cell into parts without damaging surrounding cells. Apoptosis also plays a key role in the development of tissues and organs. For instance, a developing human embryo has webbed fingers and toes. Apoptosis is responsible for the disintegration of the webbing and the development of well-defined individual fingers and toes.

The Cell Cycle Checkpoints

Now consider the three specific internal cell cycle checkpoints a little more closely.

The ***G_1 checkpoint*** determines if the cell has reached an appropriate size and has adequate energy reserves and nutrients to proceed through the cell cycle. Additionally, the cell checks for any damage to the DNA and ensures that the cell is receiving signals from growth factors to indicate the cell should divide. If either is found insufficient, the cell will not progress to the S phase. If all requirements are met, the cyclins and cyclin-dependent kinases will signal for the cell to proceed.

The ***G_2 checkpoint*** is a second gatekeeper that can prevent a cell's entry into mitosis if certain conditions are not met. The cell's appropriate size is evaluated again at this checkpoint. But more importantly, this checkpoint is in place to ensure that all of the chromosomes were duplicated correctly. Any DNA mutations or DNA damage will halt the cell cycle in an attempt to repair the mutated or damaged DNA. If the DNA is found to be correctly duplicated, the cyclin-dependent kinases initiate the beginning of mitosis.

The ***M checkpoint*** is the last cell cycle checkpoint, and it takes place near the end of metaphase. This checkpoint ensures that all of the sister chromatids are adequately attached to the spindle microtubules, so it is also known as the spindle assembly checkpoint or simply the spindle checkpoint. Once again, if mistakes are found, such as the sister chromatids are not firmly attached to the spindle fibers, the cell cycle will be halted.

Figure 5-7 shows each of these cell cycle checkpoints.

Checkpoints Within the Cell Cycle

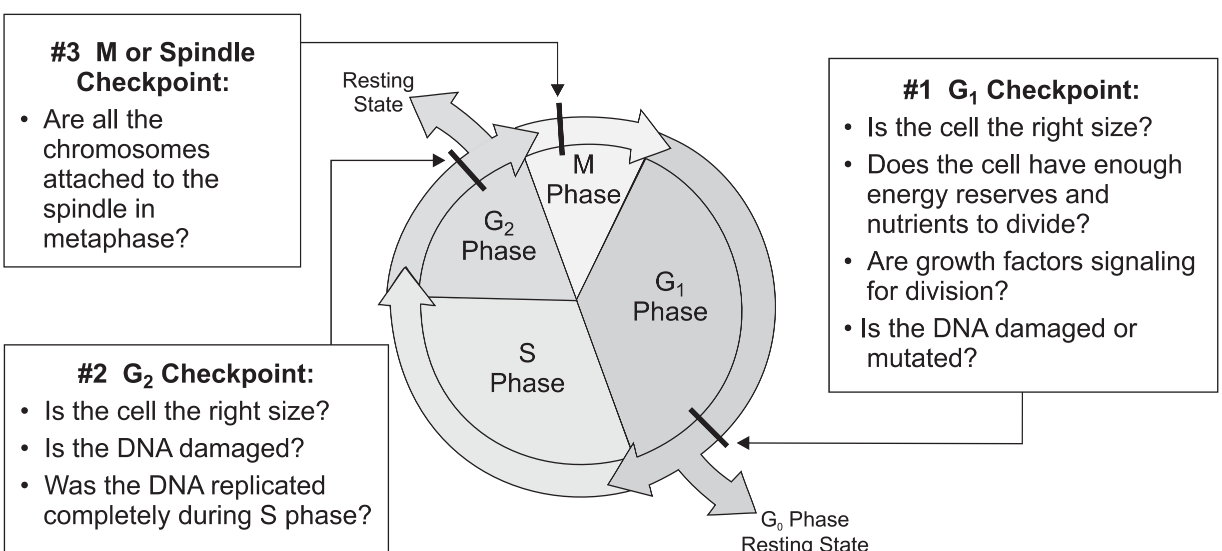


Fig. 5-7

Section 5.2, continued
Cell Cycle Regulation and Cancer

Example 1: Red blood cells carry oxygen to other cells in the body. When oxygen levels in the body become low, specialized cells in the kidneys release a protein called *erythropoietin*, or *EPO*. EPO signals bone marrow cells to create more red blood cells. In what way does EPO signal bone marrow cells to create red blood cells?

EPO acts as an external growth factor. It binds to receptor sites on the surface of bone marrow cells to signal those cells to produce more red blood cells. It acts as a “go” signal for the cell cycle to begin.

Disruption of the Cell Cycle

What happens if an abnormal cell or a cell with DNA mutations gets past one of the checkpoints as the cell proceeds through the cell cycle? If an abnormal cell is not destroyed at the checkpoints, internal growth factors may not be suppressed, and the cell cycle may continue and result in uncontrolled cell growth and division. This situation is considered a disruption of the normal cell cycle. Cells may grow and divide uncontrollably. A mass of cells that is growing out of control is called a **tumor**. Some tumors are benign (noncancerous). Benign tumors form a mass, but they do not invade and destroy healthy tissues. These tumors may be called cysts. Malignant (cancerous) tumors, however, do invade and destroy healthy tissues.

Cancer results from cells growing and dividing abnormally and then invading healthy tissues. Cancer can be caused by environmental exposure to substances called **carcinogens** that damage the DNA in cells and transform the cells into cancer cells. Common examples of carcinogens are asbestos, UV radiation, x-rays, some viruses, and cigarette smoke.

Carcinogens can cause a **mutation** in a gene, which is a permeant change in its DNA sequence. If a gene that controls the cell cycle becomes mutated, it can become an **oncogene**, a gene that has the potential to cause cancer. For example, a gene may contain the code to create a protein that causes cells to grow and divide. If a mutation occurs in that gene that changes its instructions, the mutated gene may produce too much of the protein and cause cells to divide too quickly. Cancer may then result from uncontrolled cell division.

Metastasis is the spread of cancer to other areas in the body and occurs when cancer cells grow aggressively, break off from their home tissues, and travel through either the blood or the lymph vessels as seen in figure 5-8. These portable cancer cells are soon able to form new tumors in new locations. One way of treating cancer is by using chemotherapy drugs. These drugs work by disrupting the cell cycle in cancer cells, but they can often disrupt the cell cycle in normal cells as well.

Metastasis

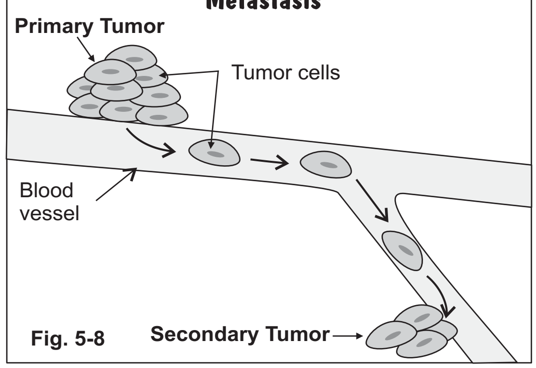


Fig. 5-8

Example 2: A chemotherapy drug named Pacitaxel prevents microtubules from forming the mitotic spindles necessary for cell division. A common side effect of Pacitaxel is low immunity due to neutropenia, which is a decrease in the number of white blood cells. Why does Pacitaxel have this side effect?

Most chemotherapy drugs disrupt the cell cycle in all rapidly dividing cells whether the cells are cancerous or not. Pacitaxel, as well as many other chemotherapy drugs, negatively affects bone marrow cells. Since bone marrow creates white blood cells, chemotherapy drugs also decrease the number of white blood cells found in the blood. Low white blood cell counts decrease immunity and increase the chances for infection.

Molecular Genetics

Section 6.3
Transcription and Translation

Pre-View 6.3

- **Anticodon** – the sequence of three nucleotides on transfer RNA that pairs with the codons of messenger RNA
- **Codon** – a sequence of three nucleotide bases that represents the code for one amino acid
- **Messenger RNA (mRNA)** – a type of RNA that transfers the code from DNA in the nucleus to the cytoplasm
- **Peptide bond** – the bond between each amino acid in a protein
- **Ribosomal RNA (rRNA)** – a type of RNA that "reads" the codons from messenger RNA
- **Ribonucleic acid (RNA)** – a single strand of nucleotides; different types are used to translate instructions from DNA into making proteins
- **RNA polymerase** – the enzyme responsible for creating RNA from a DNA template
- **Stop codon** – a sequence of three nucleotide bases that indicates the end of protein synthesis
- **Transcription** – the process occurring in the nucleus of a cell that copies the instructions from a part of DNA onto a strand of messenger RNA
- **Transfer RNA (tRNA)** – a type of RNA that carries an amino acid and transfers it to the protein chain being assembled in the ribosome
- **Translation** – the process occurring in the cytoplasm of a cell that builds proteins

How do the genes on a chromosome determine how proteins are made? The sequence of nucleotide bases on a strand of DNA is like a language. The only letters in the language are A, T, C, and G, which stand for the four nucleotide bases. Words in this language are made up of three letters. There are 64 possible "words" that can be made from the four letters. Genes are like sentences made up of these three letter words. Each three letter word in the DNA is re-written (or is *transcribed*) into messenger RNA and represents (or is *translated* into) an amino acid. There are 20 amino acids. Some of the 64 "words" represent the same amino acid, and other "words" are like a period at the end of the sentence and indicate a "stop." Amino acids bond together to form polypeptides, and polypeptides bond together to form proteins. Each "word" represents an amino acid, and the sequence of amino acids in the "sentence" determines the type of protein that is made. To help you visualize this relationship, study figure 6-7.

The DNA Sequence of a Gene is the "Code" for a Protein

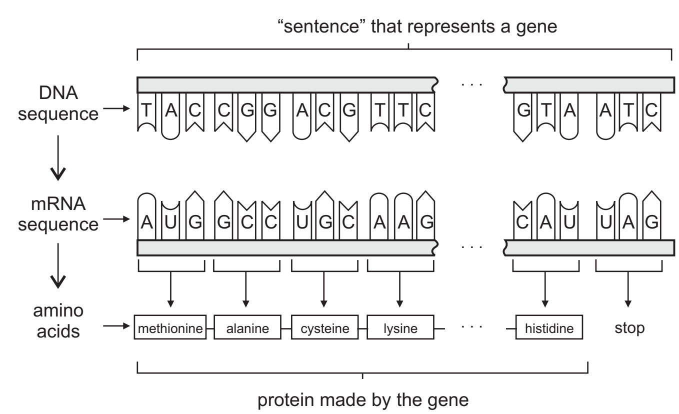


Fig. 6-7

Genetic Disorders Caused by Chromosome Mutations

Most chromosomal mutations are fatal. Some of the exceptions are nondisjuction errors in chromosome 21 and in the sex chromosomes. These types of chromosomal disorders are called trisomy disorders because there are three copies of one particular chromosome present in cells instead of the normal pair of two.

One of the most common examples of a chromosomal mutation is **Down syndrome**. The most common type of Down syndrome is trisomy 21, which means that the person affected has three copies of chromosome 21 instead of just two. Most of the time, Down syndrome can be traced to the mother where it is most often caused when homologous chromosomes fail to separate during meiosis I. Regardless of cause, the affected person has 47 chromosomes in each body cell instead of 46. A person with Down syndrome usually has mild to severe mental retardation and is more likely to have heart problems and other health issues.

Figure 7-5 shows an example of a karyotype of a female with Down syndrome.

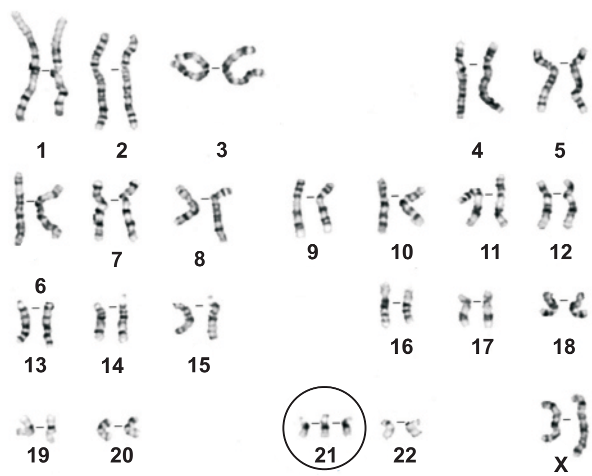
Example 3: How can you tell from this karyotype that it is from a female and not a male?

Females have two X chromosomes as shown on the karyotype. Notice that the karyotype shown in figure 7-4 has one X and one Y chromosome. Do you see the difference?

Example 4: How does this karyotype indicate Down syndrome?

In a normal karyotype, a person has two of each chromosome. In this karyotype, the person has three copies of chromosome 21. A person with three copies of chromosome 21 has the type of Down syndrome called trisomy 21.

Karyotype of Female with Down Syndrome



Used with permission: "GENETIC COUNSELING AIDS"
Fourth Edition, Copyright 2002 by the Greenwood Genetic Center

Fig. 7-5

Turner syndrome is a chromosomal mutation resulting from nondisjunction during either meiosis I or meiosis II in forming either sperm or egg cells. This syndrome affects the sex chromosomes (also known as the 23rd pair). In the case of Turner syndrome, there is a missing or incomplete X chromosome, so instead of having two X chromosomes, the female has only one (XO). Turner syndrome is also known as Monosomy X. The female possesses only 45 chromosomes. Turner syndrome affects the genes involved in growth and sexual development. Turner syndrome females have abnormal sexual characteristics that include infertility. They also typically have a short, stocky build. These females may also have heart and kidney defects, high blood pressure, and problems with swelling of the hands and feet.

Klinefelter syndrome is also a nondisjunction chromosomal mutation that occurs during either meiosis I or meiosis II in forming either sperm or egg cells. It affects the sex chromosomes and results in males that possess an additional X chromosome (XXY). Males with Klinefelter syndrome have a total of 47 chromosomes instead of the normal 46 chromosomes. Klinefelter syndrome affects the genes involved in testes development and the production of testosterone hormone. These males are usually tall and often lack typical secondary sex characteristics. Coincidentally, this disorder is usually not identified until puberty. The onset of puberty in Klinefelter males may include the development of breast tissue, very little facial or body hair, and diminished muscle definition. These males may also be infertile due to their inability to produce sperm.

Section 7.2, continued
DNA Technology

Results of the Human Genome Project
The Human Genome Project revolutionized biotechnology innovations around the world, and the project was able to surpass its original goals. According to the National Institutes of Health, the Human Genome Project had the following notable accomplishments:

Notable Accomplishments of the Human Genome Project

- It sequenced 99% of the gene-containing regions of human DNA with a 99.99% accuracy.
- It mapped 3.7 million variations in the human DNA sequence that may account for difference in inherited traits or that may indicate genetic disorders.
- It enabled the discovery of over 1,800 disease genes.
- It enabled the development of over 2,000 genetic tests for human genetic conditions, which give patients the ability to know disease risks and allow healthcare professions to better diagnose diseases.
- In addition to sequencing human DNA, it also sequenced the DNA of animals important in research. These include the genomes of the mouse and rat, as well as several others.

Ethical Concerns of the Human Genome Project
The knowledge and discoveries sought by the Human Genome Project raised significant concerns from its beginning, so part of the project also funded the Ethical, Legal, and Social Implications (ELSI) program to anticipate and address these concerns. Many of these concerns centered around an individual's right to privacy and the risk of discrimination. Think about some of the questions that arose. How should genetic information of an individual be kept private? Could genetic information from an individual be obtained without consent? Could genetic information indicating a disease risk be used to deny employment or to deny health insurance coverage? What are the implications for family planning? Could knowing a fetus's genetic profile lead to an increase in the abortion rate? These are only a few of the questions raised by increasing knowledge of the human genome.

Practice 1

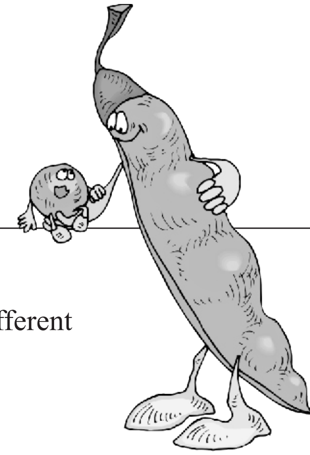
Match each vocabulary word with its definition. Write the letter that corresponds to the correct definition in each blank.

______ 1. gel electrophoresis
______ 2. genome
______ 3. stem cells
______ 4. transgenic organism
______ 5. DNA fingerprint
______ 6. plasmid
______ 7. recombinant DNA
______ 8. Human Genome Project
______ 9. cloning

A. a unique pattern created from DNA segments that can be used to identify an individual or to identify family relationships
B. a laboratory technique that runs electrical current through a gel to separate DNA fragments by their size
C. all of an organism's hereditary information
D. DNA that is formed by joining a short piece of DNA from one organism to the DNA of another organism
E. a process of producing genetically identical copies of genes, tissues, or an entire organism
F. an international effort that successfully sequenced human DNA
G. a circular piece of DNA found in bacterial cells
H. undifferentiated cells that have the ability to become different types of specialized cells
I. an organism that contains genes from a different species

Mendelian Genetics and Inheritance

Section 8.1
Introduction to Mendelian Genetics



Pre-View 8.1

- **Alleles** – different variations of the same gene; for example, blue and brown are different alleles for eye color
- **Dominant** – a trait that is expressed over another trait
- **Gene** – a section of DNA that determines a specific trait, such as eye color
- **Genetics** – the study of heredity
- **Genotype** – the combination of alleles for a particular trait (homozygous or heterozygous)
- **Heredity** – the passing of traits from one generation to the next
- **Heterozygous** (or **hybrid)** – having two different alleles for a trait
- **Homozygous** (or **pure)** – having two of the same alleles for a trait
- **Homozygous dominant** – having two dominant alleles for a trait
- **Homozygous recessive** – having two recessive alleles for a trait
- **Law of dominance** – a natural law stating that a dominant allele will always mask a recessive allele
- **Mendel**, **Gregor** – an Austrian monk whose study of garden peas earned him the title Father of Genetics
- **Phenotype** – the physical characteristics of an organism that show how genes are expressed
- **Recessive** – a trait that can be hidden by another trait
- **Traits** – characteristics; often physical qualities such as color, height, etc.
- **True-breeding** – homozygous organism that always produces offspring with identical traits

In the 1800s, an Austrian monk named **Gregor Mendel** studied garden peas. He studied a LOT of garden peas — thousands of them. (Just think about it. He was living in a monastery with no TV, no radio, no telephone, no computer, no internet, and no video games, so garden peas were pretty interesting!) He started writing his observations, and he noticed that, over time, certain patterns appeared in the plants. For many of the plants' characteristics, or **traits**, the peas would have two contrasting forms. Flowers would be purple or white, plant height would be tall or short, the seeds would be wrinkled or smooth, etc. He also noticed that some of the plants were **true-breeding** for certain traits — that is, they always produced offspring that had traits identical to the parent plants. Then he began experimenting with the plants. Through his experiments, he was able to discover some of the basic concepts of genetics and heredity. Because of his work, Mendel is known as the Father of Genetics.

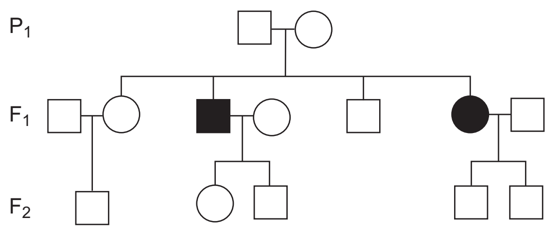
Genetics is the study of heredity, and **heredity** is the passing on of traits from one generation to the next. To study genetics, Mendel started with true-breeding parent plants. We'll label them *P* for parental. The parental plants had contrasting forms of a trait. For example, one parental plant would have white flowers, and the other parental plant would have purple flowers. When he crossed these plants, the offspring (we'll call them F1 for *first filial*) were identical to each other and to one of the parent plants. In the case of one parent having white flowers and the other parent having purple flowers, the offspring all had purple flowers. From this, Mendel reached several conclusions, and these conclusions later became known as Mendel's Laws. It's pretty amazing that Mendel was able to come up with these laws a long time before people knew anything about DNA, genes, and chromosomes!

Section 9.4, continued
Pedigrees

Pedigrees can be used to show different modes of inheritance: autosomal recessive, autosomal dominant, sex-linked recessive (X-linked), and sex-linked (Y-linked). Y-linked disorders are few and rare, so you will not commonly see a pedigree for a sex-linked trait that is carried on the Y chromosome.

As you may have noticed, sometimes pedigrees show carriers and sometimes they do not. When carriers are not identified, it can be a little more difficult to determine what kind of trait is being traced. To identify the type of inheritance pattern shown in a pedigree, consider the following tips and trends.

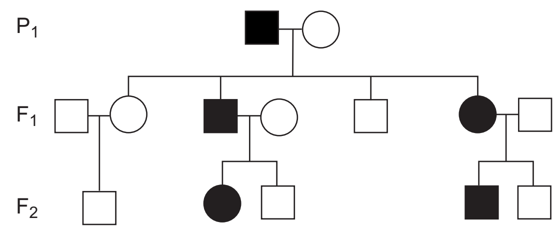
Autosomal Recessive



Autosomal recessive traits and disorders show up in either male or female offspring of unaffected parents. Although not indicated, both P_1 parents must be carriers.

The F_2 generation will often be carriers of the trait but not express it. Notice the skip of generations having the trait.

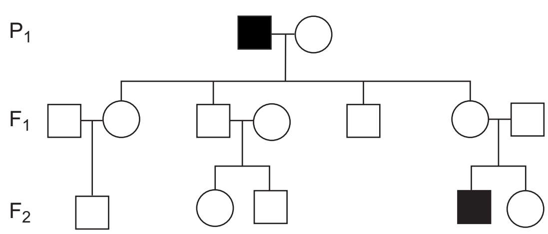
Autosomal Dominant



Autosomal dominant traits will often show up in every generation instead of skipping generations. Both male and female offspring are equally affected.

If one parent has the trait but is heterozygous for the trait, about half the offspring will have the trait. The P_1 male above is heterozygous. If one parent has the trait and is homozygous, every offspring will also have the trait (not shown).

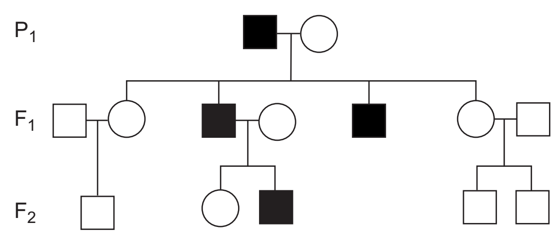
Sex-Linked Recessive (X-Linked)



Sex-linked traits carried on the X chromosome are similar to autosomal recessive traits, except they show up most often in male offspring.

Remember, females carry these traits that are passed on to their male children. These pedigrees will follow a pattern of female carriers having affected male offspring. ALL daughters of an affected male parent will be carriers.

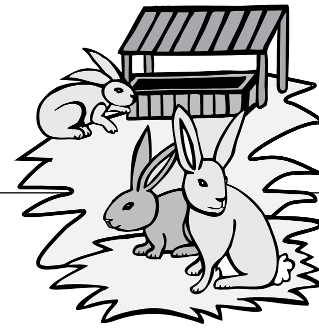
Sex-Linked (Y-Linked)



Sex-linked traits carried on the Y-chromosome are rare but easy to see on a pedigree. Every male offspring of an affected male will have the trait in every generation. Females are unaffected because they never carry a Y chromosome.

Note: If a pedigree *does* indicate carriers, the trait MUST be either autosomal recessive or sex-linked recessive.

Evolution of Populations
Section 11.1
Review of Natural Selection



Pre-View 11.1

- **Adaptation** – any physical characteristic or behavior that helps an organism to better survive
- **Competition** – the interaction among organisms to better obtain resources or mating opportunities over others in order to survive
- **Decent with modification** – another term for evolution; the idea that all organisms share a common ancestor but that species change over time due to the natural selection of favorable adaptations
- **Evolution** – the gradual change of living organisms over time
- **Habitat** – the place where an organism lives
- **Natural selection** – a process of nature that favors organisms that are best adapted to their environment
- **Overproduction** – creating more offspring than can be supported by the environment
- **Population** – organisms of the same species that live in the same place at the same time and compete for resources such as food and water
- **Reproductive success** – the passing on of genes to the next generation
- **Species** – a group of similar organisms that can interbreed and produce fertile offspring
- **Struggle for existence** – the idea that organisms must compete with one another and that only the most fit will survive
- **Variation** (or **genetic variation**) – differences in a specific trait found within a population

Introduction to Natural Selection

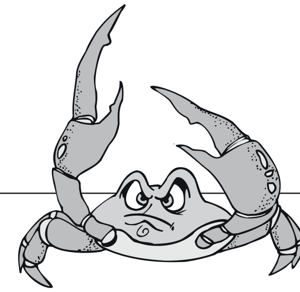
The process of **natural selection** describes how organisms that are best adapted to their environment survive and reproduce. When talking about natural selection, we often use the terms *species* and *population*. Be sure you understand what these terms mean.

A **species** is a group of very similar organisms that can interbreed and produce fertile offspring. Although horses, donkeys, and zebras appear to be very similar, they are not the same species. A female horse and a male donkey can interbreed and produce offspring called mules, but since most mules are infertile, they are not considered the same species. On the other hand, an American Thoroughbred and an American Quarter Horse will produce fertile offspring; these two types of horses are considered the same species.

A **population** is made of organisms of the same species that live in the same place at the same time. They may compete with each other for food, shelter, water, and other resources.

As previously mentioned in Section 10.2, Charles Darwin is the scientist credited with coining the term *natural selection*. Darwin traveled the world and collected and studied a great variety of species to help him draw conclusions about natural selection. Darwin's ideas on natural selection are summarized in the following chart.

Evolution of Populations
Section 11.6
Introduction to Speciation



Pre-View 11.6

- **Common ancestor** – the “parent” species from which two or more separate species evolved
- **Divergent evolution** – the accumulation of differences that results in the formation of different species from a common ancestor
- **Speciation** – the formation of a new species through the process of divergent evolution

Thus far, our study of evolution has revealed how natural selection, genetic drift, selective breeding, and mutations can change the gene pool of a population over time. As the gene pool continues to change, new species can be formed. **Divergent evolution** occurs when a population of a certain species accumulates differences over time. The differences eventually become so great that they can no longer interbreed with other populations of their original species. **Speciation** is the formation of new species through this process of divergent evolution. The original species before the accumulated changes is the **common ancestor** for species that are created through divergent evolution. A simple diagram of divergent evolution that leads to speciation is seen in figure 11-6.

Divergent Evolution/Speciation

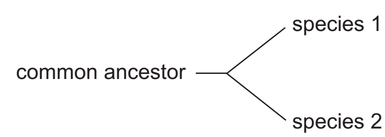


Fig. 11-6

The Effect of Natural Selection on Speciation

As you have already seen, natural selection favors specific traits or adaptations that allow organisms to better survive in their environment. An organism with a trait or adaptation that gives it a competitive advantage in obtaining needed resources (food, shelter, mating sites, etc.) will often thrive and reproduce. The advantageous trait is then passed to offspring. As a population continues to adapt to specific environmental changes via natural selection, a new species can emerge. Consider the following example.

Example 1: Through ballast water released from international trading ships, a species of crab from Asia is introduced to the Atlantic shore of North America. To survive, the crab species must adapt by eating a different species of clams found in the Atlantic. The available clams in the Atlantic have harder shells, so only the crabs with the largest, strongest claws thrive. Over time, all of this crab species living in its new Atlantic home have larger, stronger claws than the average crab population in Asia. When crabs from the Atlantic population are reintroduced to their original Asian population, they will no longer interbreed. How did natural selection lead to speciation in this example?

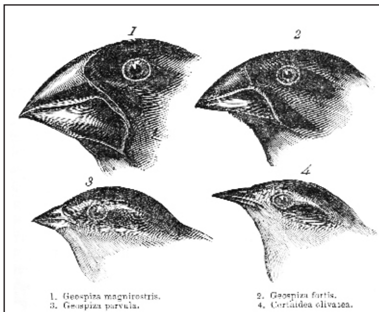
Moving from Asia to North America represents an environmental change for the crab species. Some of the crabs had a trait for larger, stronger claws that allowed them to better survive in their new environment by giving them a competitive advantage over crabs with smaller, weaker claws. Through the process of natural selection, this trait for larger, stronger claws became more frequent in their gene pool. This example shows speciation because the original crab population can no longer interbreed with the new Atlantic crab population.

Section 11.7, continued
Geographic Isolation and Adaptive Radiation

Adaptive Radiation

Adaptive radiation occurs when a single species diverges rapidly into several distinct species. Evidence of adaptive radiation is often seen when a population of a species becomes isolated on islands. An island or a group of islands often contain many **habitats** (or *niches*), which are different areas where plants and animals can live, each having different environmental conditions and types of available food. An island, for example, may have the following habitats just to name a few: along the beach, along a tree line, on the ground of a forest, in the trees of a forest, in different trees or bushes, or along a river. When a population of a certain species is introduced to an island, it may have enough genetic variation (a large enough gene pool) that it can separate and adapt to these different habitats. Over time, the different populations in the different habitats may become so different from one another that they no longer interbreed and therefore become new species.

Example 4: A common example given for adaptive radiation is the speciation seen in the Galapagos finches. Remember, the finches on the Galapagos Islands were different from finches found on the mainland. Darwin and others believe that finches from the mainland may have originally populated the islands, but over time, these finches were geographically isolated from the finches on the mainland. As these finches adapted to new habitats on the island, they diverged into several new species. John Gould's drawings on the right show four of the different Galapagos finches, but there are many others as well. Notice the differences in beak shapes. These differences were likely a result of the finches adapting to the different types of available food in their various habitats. As with any type of speciation, adaptive radiation is an example of divergent evolution.



By John Gould (14.Sep.1804 - 3.Feb.1881) [Public domain], via Wikimedia Commons

Practice

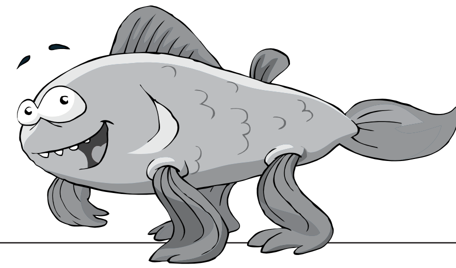
Answer the following questions on geographic isolation and adaptive radiation. Darken the circle that corresponds to your answer choice.

1. Eleven different species of tortoises are found on the Galapagos Islands, and all are different from any species on other continents. Scientists believe that the tortoises on the islands share a common ancestor with mainland tortoises, so at some point, a mainland tortoise population must have become isolated on the islands. Which of the following **best** explains how the island tortoises became different from the mainland tortoise species?
   - Ⓐ Only the island tortoises adapted to their environment and survived.
   - Ⓑ A mutation prevented some of the tortoises from breeding.
   - Ⓒ Physical separation prevented gene flow and was followed by genetic change.
   - Ⓓ The island tortoises interbred with another island tortoise species to form a hybrid species.

2. An earthquake separated a piece of land from the mainland to form a new island. As a result, a population of lizards was isolated from other members of its species on the mainland. Which of the following is **most** likely to happen to the isolated population of lizards?
   - Ⓐ The population may grow exponentially since they no longer have competition.
   - Ⓑ Natural selection may cause them to look different as they adapt to a new environment.
   - Ⓒ Without the ability to breed with the mainland lizards, they will become extinct.
   - Ⓓ They will begin to breed with a different species of lizards.

Classification of Organisms

Section 12.3
Phylogenetic Trees



Pre-View 12.3

- **Common ancestor** – the "parent" species from which two or more separate species evolved
- **Phylogenetic tree** – diagram that shows possible evolutionary relationships sometimes in proportion to evolutionary time
- **Speciation** – the formation of a new species through the process of evolution

Think about a biological family. Brother and sister share the same parents, so their parents are their closest common ancestors. Further up the family tree, they also share grandparents and great grandparents. How about cousins? Cousins do not share the same parents, but they do share the same grandparents. The grandparents, then, are the closest common ancestors for cousins.

Similar to a human family tree, a **common ancestor** in evolution is a species from which two or more separate species evolved. For example, many biologists believe all types of cats, from lions and tigers to wildcats and domestic cats, share a common cat-like ancestor that lived over ten million years ago.

Going back to Darwin's original theory of evolution, scientists attempt to trace all living organisms back in time to a single-celled ancestor that evolved over time, branched into separate species, and formed all of the past and present diverse forms of life. As you saw in Section 11.6, the formation of each new species is called **speciation**. Every time speciation occurs, the new species share a common ancestor.

Biologists often represent evolutionary relationships by using a diagram called a **phylogenetic tree**, which is similar in many ways to a family tree. Instead of looking at parent organisms, phylogenetic trees look at relationships among taxa.

In Section 12.2, you reviewed the six different kingdoms. Figure 12-1 shows a very simple phylogenetic tree of how biologists believe these kingdoms (Eubacteria, Archaebacteria, Protista, Fungi, Plantae, and Animalia) are related. This phylogenetic tree represents how a single cell may have evolved into the six kingdoms.

Phylogenetic "Tree of Life"

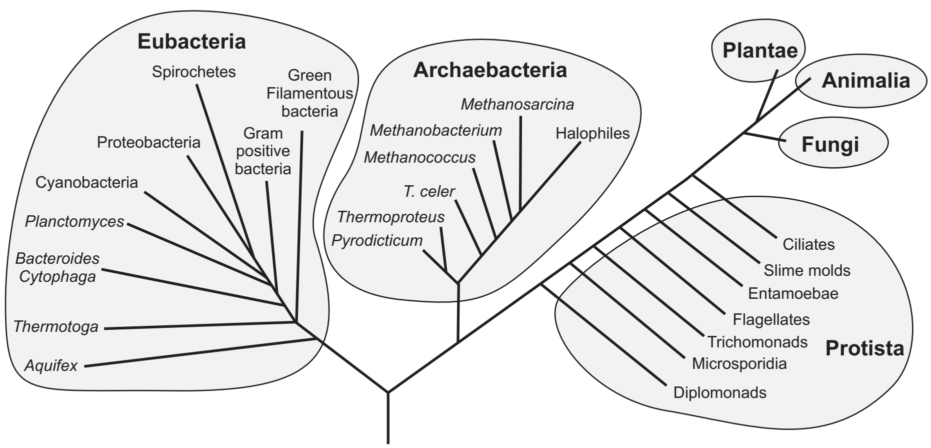


Fig. 12-1

As was introduced in Section 11.6, divergent evolution is the formation of new species by speciation. Phylogenetic trees trace divergent evolution, the times in history when speciation is believed to occur.

Section 13.3, continued
Sequence Homology

Example 1: Compare the homologous DNA sequences below from two different related species. How many differences are found between the two species in these sections of DNA?

same

Species A: 5’ – A G A T G C A A C T A G T T G – 3’

Species B: 5’ – A G A G G C A G C T G G T T G – 3’

different

> **Note:** The 5’ and 3’ on the ends of a DNA sequence indicate the orientation of the strand. 5’ indicates the phosphate group (PO_4) is on the end, and 3’ indicates the hydroxide group (OH) is on the end.

Notice that many of the bases in the sequences are the same, but a few are different. Differences are shown in the rectangles. There are 3 differences in the sequences between the two species.

Example 2: The chart below compares the nitrogenous base sequences for a section of DNA in five different species. Which two species are likely the most closely related? Which are likely the most distantly related?

Species	DNA Sequence														
A	A	C	A	G	A	C	A	G	A	C	C	A	T	A	G
B	A	C	A	T	A	C	A	G	A	C	C	A	G	A	G
C	T	C	A	G	T	A	A	G	A	C	C	A	T	A	G
D	T	C	A	G	T	A	A	G	C	C	C	A	T	A	G
E	T	C	G	G	T	T	A	G	C	C	C	A	T	A	G
		*					*	*		*	*	*		*	*

An asterisk * indicates that all the letters in the column match.

The two species that are likely the most related will have the fewest differences in their DNA sequences, and the two species that are likely the most distantly related (least related) will have the most differences. The only way to determine relatedness is by comparing each species against the others. To help make the comparison, you can make a list or table that records the differences between each species.

Since species C and species D have only one difference, they are likely the most closely related. Species B and E have 7 differences, so they are likely the most distantly related.

Number of Differences:
A vs. **B** = 2
A vs. **C** = 3
A vs. **D** = 4
A vs. **E** = 5
B vs. **C** = 5
B vs. **D** = 6
B vs. **E** = 7 ←
C vs. **D** = 1 ←
C vs. **E** = 3
D vs. **E** = 2

As scientists sequence all the genes in different species, they can compare different species according to the similarities in their entire genetic code. Different species that have a higher percentage of similar DNA sequences (or similar genes) are considered more closely related. Comparisons are often made to the human genome. Scientists have been able to determine the DNA sequences of the species in the table shown in figure 13-4. The table gives commonly calculated percentages that compare the genes of each to human genes.

Introduction to Ecology
Section 14.1
Ecological Organization

Pre-View 14.1

- **Abiotic factors** – nonliving parts of an ecosystem; examples: soil, rocks, water, pH, salinity, temperature
- **Biodiversity** – the variety of plants, animals, etc. in a given area
- **Biome** – a large geographic area with a similar climate that consists of many ecosystems
- **Biosphere** – all the combined biomes on Earth where organisms can survive
- **Biotic factors** – the living organisms in an ecosystem
- **Community** – all the different populations of different species living in the same place at the same time
- **Ecologist** – a scientist who studies the relationships between living organisms and their environment
- **Ecology** – the study of the relationships between living organisms and their environment
- **Ecosystem** – a community of living organisms plus their nonliving environment
- **Habitat** – the place where an organism lives
- **Niche** – an organism's role in its ecosystem
- **Organism** – an individual living thing; examples: a mouse, an ant, a mountain lion
- **Population** – a group of organisms of the same species that live in the same place at the same time
- **Species** – a group of similar organisms that can interbreed and produce fertile offspring

What is Ecology?

Ecology is the study of the relationships between living organisms and their environment. **Ecologists** are the scientists who study these relationships. Their work can include the study of an individual organism, a population, a community, an ecosystem, a biome, and/or the entire biosphere. These are considered the ecological levels of organization. Review each of these terms related to the study of ecology and their relationship with one another.

Levels of Ecological Organization

Ecologists study the various levels of ecological organization mentioned above. The lowest level of organization studied in ecology is an **organism**, or an individual living thing such as a field mouse. A **species** is defined as a group of very similar organisms that can interbreed and produce fertile offspring. A group of organisms of the same species living in the same place at the same time make up a **population**. All of the different populations of different species living in the same place at the same time make up a **community**. Most communities consist of a variety of species coexisting and interacting with one another. For example, a field of grass, field mice, earthworms, insects, lizards, birds, and buffalo might make up a grass prairie community. A community includes only the living things, or **biotic factors**, found in a particular location. A community of living organisms *and* the nonliving surroundings, including soil, rocks, and bodies of water make up an **ecosystem**. The nonliving parts of the ecosystem, such as the soil, rocks, water, pH, salinity, temperature, atmospheric gases, pollution, etc., are called **abiotic factors**. Even larger than an ecosystem, a **biome** consists of many ecosystems covering a large geographic area with a similar climate. Examples of biomes include deserts, deciduous forests, tropical rainforests, arctic tundra, etc. In figure 14-1, the shaded area within the United States represents a grassland biome. All of the biomes on Earth make up the **biosphere**, the part of Earth where living organisms can survive.

Ecosystem Interdependence

Section 15.3
Ecological Pyramids

Pre-View 15.3

- **Biomass** – the mass of dry organic material in an organism
- **Biomass pyramid** – an ecological pyramid that shows the amount of biomass in each trophic level; biomass generally decreases as trophic levels increase
- **Energy pyramid** – an ecological pyramid that shows how energy is passed from one trophic level to the next
- **Pyramid of numbers** – an ecological pyramid that shows the number of organisms in each trophic level; the number of organisms generally decreases as trophic levels increase

Food chains and food webs indicate a transfer of both energy and nutrients from one organism to another. Ecological pyramids show similar information. Consider three types of ecological pyramids.

Energy Pyramid

An **energy pyramid**, also called a *food pyramid*, shows how energy is transferred to each trophic level in an ecosystem. The transfer of energy is fairly inefficient. As a general rule of thumb, only about 10% of the energy at each level is transferred to the next higher level. As a result, less energy enters the higher trophic levels. Most of the energy captured from feeding is used by the organism itself for respiration, metabolism, movement, etc. A small remaining portion of energy is lost to the environment as heat.

Example of an Energy Pyramid

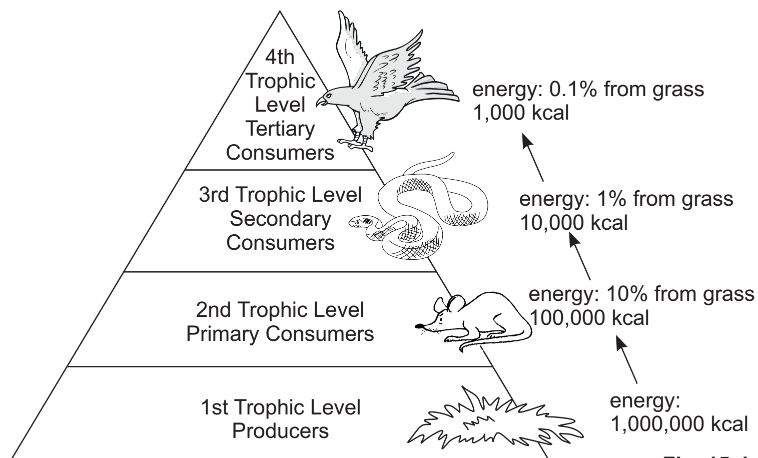


Fig. 15-4

An example of an energy pyramid illustrating the 10% rule is given in figure 15-4 where energy is expressed as kilocalories (kcal). Notice that the grass shown as the producer has the most energy, 1,000,000 kilocalories. When the primary consumer, the mouse, eats the grass, only 10% of the energy captured by the grass ends up in the tissues of the mouse. Then, only 10% of that energy, or 1% of the original amount from the grass, goes to the snake that eats the mouse. Even less energy is then available to the hawk that eats the snake. The higher up an organism is on the energy pyramid, the less energy is available for that organism. A tertiary consumer has less energy available to it than a secondary consumer.

Example 1: For the energy pyramid given in figure 15-4, which organism receives the <u>least</u> energy from producers?

Energy decreases as trophic levels increase. The apex predator in a food chain or energy pyramid receives the least energy. Hopefully you identified the hawk at the top of the energy pyramid as receiving the least energy from the grass shown in trophic level one.

Section 16.1, continued
The Water Cycle

Some of the precipitation is taken in and used by plants and animals. Plants also give off water through a process called **transpiration**, which puts water back into the atmosphere. Some of the precipitation sinks into the ground and becomes groundwater beneath the earth's surface. Eventually, it may flow into lakes and oceans where some is evaporated into the atmosphere.

When conditions are right, the water vapor in the atmosphere cools and condenses to form clouds and water droplets. These water droplets accumulate and eventually fall back down to the earth as precipitation for organisms to use in a natural cycle.

Importance and Effects on Ecosystems

Water is arguably the most important chemical compound found in ecosystems, so how it cycles between biotic and abiotic factors is equally important. An **ecosystem** is made up of all the living organisms in an area plus the nonliving parts of the environment. The amount of water an ecosystem receives determines the plants and animals that can live in the area. As you saw in Section 14.1, deserts that receive little precipitation have few plants and animals, but tropical rainforests that receive a lot of precipitation have many plants and animals. In general, the more precipitation in an ecosystem, the greater the biodiversity.

Human activities impact the water cycle. Consider how the following human actions may affect the water cycle and have negative consequences on ecosystems.

Acid Precipitation

The human practice of burning fossil fuels causes sulfur dioxide gas and nitrogen oxide gas to be released into the atmosphere. These gases react with water in the atmosphere to form sulfuric acid and nitric acid. The water that precipitates from the air in the form of rain, snow, fog, etc., is now acidic. Acid rain can leach minerals from the soil that are important for plant growth. Acid rain can also lower the pH of lakes and result in the death of aquatic animals.

Global warming

The burning of fossil fuels is believed to be contributing to **global warming**, the trend of increasing average temperatures on land and in the oceans world-wide due to an increase in atmospheric greenhouse gases. Warmer temperatures may affect the water cycle and impact ecosystems in several ways:

Higher atmospheric temperatures increase the rate of evaporation, and warm air can hold more water vapor. Since water vapor is a greenhouse gas, the increased evaporation may cause global temperatures to rise further.

About 97% of all the water on the earth is found in the ocean. The remaining 3% of the earth's water is freshwater, but most of that freshwater, almost 70% of it, is frozen in glaciers or icecaps. Higher atmospheric temperatures due to global warming will cause more ice to melt from glaciers and icecaps. As this ice melts, ocean levels are predicted to rise. Melting ice can negatively affect the tundra biome and arctic ecosystems since many animals rely on ice coverage as a part of their survival. Rising ocean levels and higher ocean temperatures can negatively affect coral reef ecosystems by killing the coral.

Global warming may also speed up the water cycle. As more water evaporates, more water also falls as precipitation. Many scientists believe that this change in the water cycle may result in more severe weather events, such as violent storms. They also believe the precipitation will not be evenly distributed. Because the cycling of water between evaporation and precipitation is accelerated, wet ecosystems may get more precipitation, but dry ecosystems may get less. Droughts in already-dry ecosystems can lead to a decrease in ecosystem biodiversity. The more intense rainfall may increase freshwater runoff, which increases soil erosion, but it may also decrease the amount of available groundwater.

Section 17.1, continued
Ecological Succession

As a community undergoes primary succession, a pond may form. Ponds are never climax communities. The states of pond succession can be seen in figure 17-2. In a pond ecosystem, blue-green bacteria and algae may be the primary producers. These producers support zooplankton, small fish, amphibians, and a variety of invertebrates. Aquatic plants begin to grow in the layer of mud under the water's surface. On the shore of the pond, grasses and other aquatic plants may begin to grow. Sediment continuously falls to the bottom of the pond, and the pond becomes more and more shallow. Eventually, the pond will be filled completely with sediments. Grasses yield to trees, and the climax community becomes a forest.

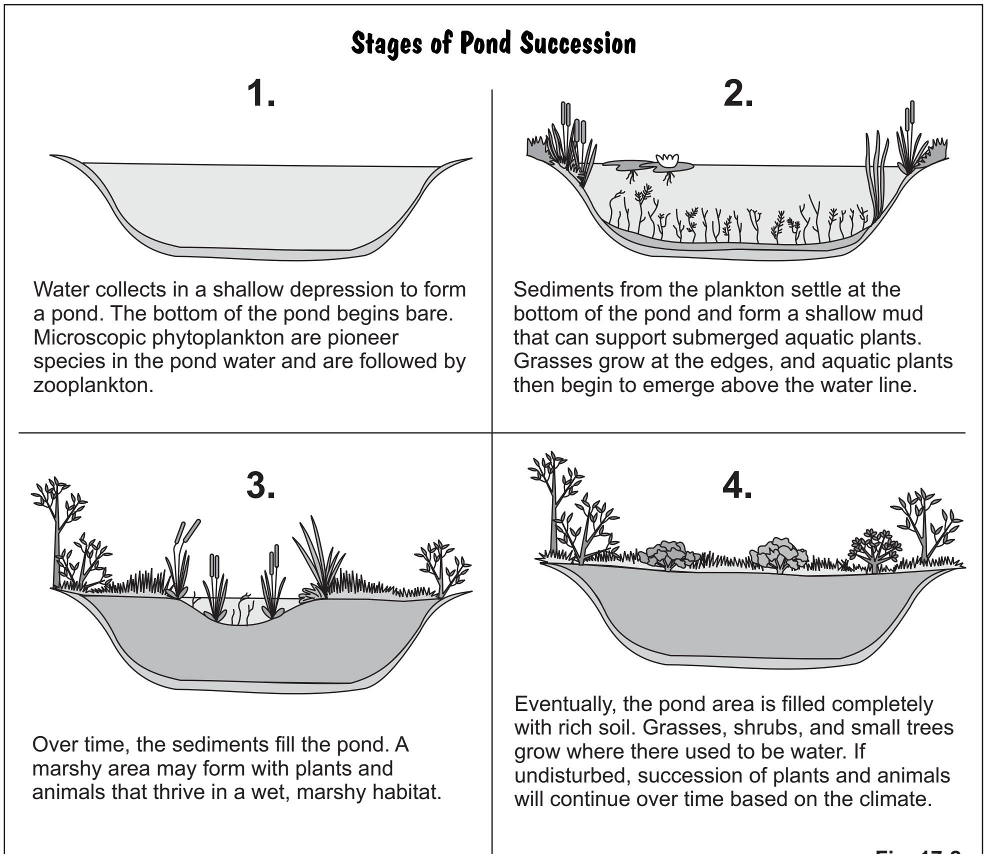


Fig. 17-2

Secondary Succession

Secondary succession occurs when something changes an existing community but does so without removing the soil. A large wildfire or clearing and plowing could cause secondary succession. Secondary succession occurs more quickly than primary succession because the ecosystem isn't starting from scratch. Seeds and organisms that survive underground may already by present. The stages of secondary succession are usually about the same as with primary succession but without the stage of forming soil. The end result is still a climax community.

Examples and Factors of Secondary Succession

Longleaf Pine Forests

Many ecosystems and communities are in a constant cycle of secondary succession because of either natural disasters or human disturbances. Consider the longleaf pine ecosystem that dominated many areas of the southeastern United States before European colonization. Longleaf pine communities were once prevalent in the southern half of Mississippi. Ecologists have named these communities "fire-climax communities" because they depend on the regular disturbance of wildfires to thrive. These communities are characterized by longleaf pine trees, which prefer full sun and plenty of space to grow, and a wiregrass understory (An *understory* is the underlying plants that form under tree canopies). Wiregrass is susceptible to wildfires, and as a result, these longleaf pine communities are frequently burned by fires that are started either by thunderstorms or by humans. Longleaf pine trees are resistant to these fires, and the trees' dominance in an area depends on them.

Ecological Dynamics
Section 17.3
Global Warming

Pre-View 17.3

- **Albedo** – the fraction of solar radiation (energy) reflected from the earth back into outer space
- **Anthropogenic global warming** (or **AGW**) – an increase in global temperatures caused specifically by human activities
- **Climate** – average weather over a period of time
- **Climate sensitivity** – the change in temperature caused by radiative forcing
- **Global warming** – the trend of increasing average atmospheric and ocean temperatures around the world
- **Radiative forcing** – the change in the earth's energy balance (energy coming in vs. energy going out) caused by a given variable, such as a change in greenhouse gas concentration
- **Solar irradiance** – the rate of energy received from the sun

Global warming is simply defined as an increase in average atmospheric and ocean temperatures over time, regardless of cause. You may have heard a lot about global warming in the news or from social media sources. The global warming you hear so much about is **anthropogenic global warming** (or **AGW**), global warming caused specifically by human activities. Let's look at several aspects of global warming and the data associated with it.

Factors that Influence Global Temperature

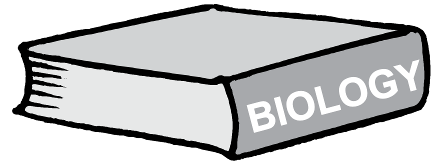
Both global warming and global cooling have occurred throughout Earth's history, and scientists have tried to determine the factors that drive global temperatures. To better understand global warming, it may be helpful to understand the factors that determine climate. **Climate** may be defined as the average weather in a location over a period of several years or decades. Weather conditions that determine climate would include factors such as temperature, humidity, and rainfall. Geography (location) is a major factor in *local* climates. Locations closer to the equator are warmer than those nearer the north or south poles. Lower altitudes, those nearer sea level, are generally warmer than higher altitudes, such as those high in the mountains.

What factors determine changes in *global* climate and specifically, average global temperature? Several factors help to determine the earth's global temperature, some long-term and others short-term. Long-term influences include variations in Earth's orbit around the sun and plate tectonic dynamics. Shorter term influences are energy from the sun, reflectivity of solar radiation, ocean and atmospheric interactions, and greenhouse gas concentrations. Consider each of these more closely.

Earth's Orbit

The earth's orbit around the sun does not remain constant but undergoes several cycles of changes. The shape of the earth's orbit changes from more elliptical to less elliptical every 100,000 years. The angle of the earth's tilt varies in a cycle over 41,000 years. And finally, the earth wobbles on its axis in a cyclical pattern lasting 21,000 years. All of these factors concerning the earth's orbit affect climate, and they correlate with past glacial formations. However, these climate factors affect slow changes over thousands of years. They are not a likely cause for short-term global warming.

Science Basics
Appendix 1.1
Common Biology Root Words and Affixes



From your English classes, you probably remember root words and affixes. The main part of any word is called a *root word*. An *affix* is a part of a word that is added either to the beginning of a root word or to its end. A *prefix* is an affix added to the beginning of a word and a *suffix* is an affix added to the end of a word. The root word and the affix(es) make up a complete word.

The vocabulary words of biology often contain specific roots, prefixes, and suffixes. Knowing what these roots and affixes mean ahead of time can help you to remember and retain the meaning of important biology terms. The word *biology* itself is made up of a common root word and suffix. *Bio-* can be a root word or a prefix that means *life*, and *-logy* is a suffix that means *the study of*, so *biology* means *the study of life*.

Review common biology root words and affixes. Memorize the ones you don't already know.

Common Biology Root Words and Affixes

root or affix	meaning	example	root or affix	meaning	example
a-	not, without	abiotic	hydra-/hydro-	water	hydrolysis
aero-	air	aerobic	hyper-	over, excessive	hypertonic
anti-	against	antibiotic	hypo-	under, below	hypotonic
auto-	self	autotroph	iso-	same	isotonic
bi-	two	binomial	-lysis	split	glycolysis
bio-/biot-	life	biology, biotic	macro-	large	macromolecule
-bios	life, living	symbiosis	meio-	less	meiosis
chloro-	green	chlorophyll	micro-	small	microscope
co-/com-/con-	together, with	codominance	mono-	one	monomer
cyto-	cell	cytoplasm	muta-	change	mutation
di-/diplo-	two	dihybrid	-ology	the study of	geology
endo-	within, inner	endocytosis	-phil	loving	hydrophilic
ex-/exo-	out, outside	exoskeleton	-phob	fearing	hydrophobic
geo-	the earth	geology	photo-	light	photosynthesis
gluco-/glyco-	sweet, sugar	glucose	-phyll	leaf	chlorophyll
-graphy	the science of	geography	poly	many	polypeptide
haplo-	single	haploid	sym-	with, together	symbiosis
hetero-	other, different	heterotroph	-troph	food, nourishment	autotroph
homeo-/homo-	same, alike	homologues	uni-	one	unicellular

Practice

Using the chart above, make an educated guess at the meaning of the following biology terms.

______________________ 1. chlorophyll

______________________ 2. hydrophilic

______________________ 3. hydrophobic

______________________ 4. symbiotic

______________________ 5. abiotic

______________________ 6. geology

______________________ 7. hydrolysis

______________________ 8. glycolysis

Scientific Investigations

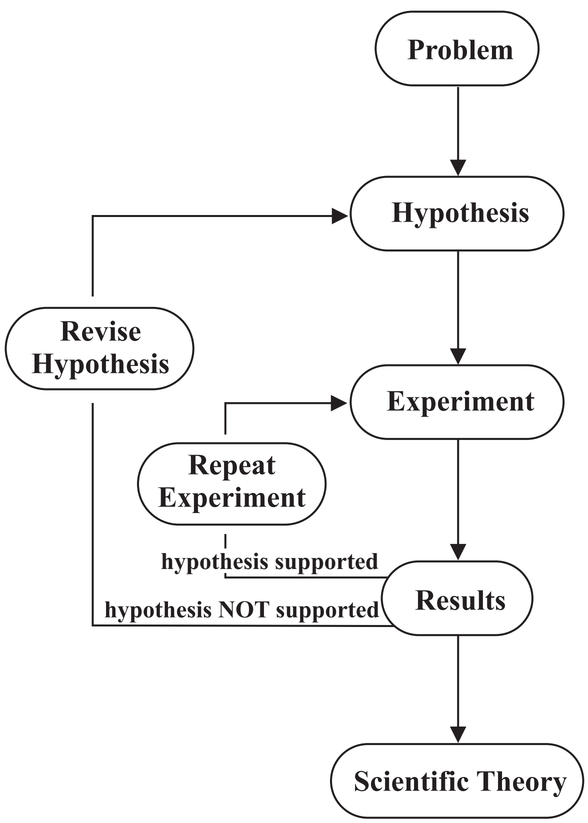
Appendix 2.1
The Scientific Method

Appendix 2.1 Important Terms

- **Experiment** – a step-by-step procedure used to test a hypothesis
- **Hypothesis** – a possible explanation or answer to a scientific problem that can be tested
- **Scientific method** – a logical set of steps used by scientists to solve a problem or to answer a scientific question
- **Theory** – an idea that is accepted as true because it is supported by repeated evidence and unifies a broad range of subjects

The **scientific method** is a series of steps in logical order that scientists use to help them solve a problem or to answer a scientific question. The general steps of the scientific process are shown below.

Steps of the Scientific Method



Start with an observation or a question.
State the problem. What do you need to find out?
Research the problem. What is already known about it?

Develop a testable statement that describes what you think will happen. This testable statement is called a **hypothesis**.

Develop a plan, called an **experiment**, to test the hypothesis:
- Determine dependent, independent, and control variables.
- Determine a control group and experimental groups.

Perform the experiment. Record and organize data.

Analyze the data. Does the data support the hypothesis?
- If so, repeat the experiment to verify the results.
- If not, revise the hypothesis and do a new experiment.

Verified results can then be reported or published.

An experiment repeated and verified many times may lead to a **theory**, an idea that is accepted as true because much evidence supports it.

Study these steps and the explanations. As you can see, each general step can be broken down into smaller steps.

Scientific Evaluation and Engineering

Appendix 3.3
The Engineering Design Process

Appendix 3.3 Important Terms

- **Engineer** – a person who designs or builds new processes, structures, machines, etc.
- **Engineering design process** – the steps, similar to the scientific method, used in designing and implementing a new technology

As you have seen, scientists use a series of steps called the scientific method to ask questions, develop a hypothesis, design and perform an experiment, and analyze the resulting data. Similar to scientists, **engineers** are people who design new or better ways of doing things, build structures, or create new machines. Engineers also use a series of steps called the **engineering design process** when designing and implementing a new technology, whether it is a process, a structure, or some other invention. The general steps to this process are shown below.

Steps of the Engineering Design Process

Identify the Problem	Engineers start with a problem. Who needs what, and why do they need it?
Research the Problem	Research existing solutions and technologies. What improvements are needed? What technologies already exist that may be applied to this problem?
Specify Requirements	Based on the problem, what are key requirements for a new process or product? What features must be included?
Brainstorm	Generate new ideas. Discuss and consider many different possible solutions, designs, or approaches.
Select the Best Solution	Which solutions, designs, or approaches are the most promising? What are the pros and cons of each promising idea? After carefully analyzing each idea, which is the best? Choose the most promising solution, design, or approach.
Build a Model or Prototype	Build an operating version of the solution in order to test it. The model or prototype answers the question, “Will it really work?”
Test, Refine, Redesign	Use the model or prototype to test the solution. What changes need to be made? Refine or redesign based on the testing.

Performance Objective Correlation Chart (Teacher's Edition)

The chart below correlates each performance objective for the Biology I course as given in the 2018 Mississippi College- and Career-readiness Standards for Science. The Text Section column gives the section numbers in the text where each performance objective is reviewed. The Pre-Test column gives the question number(s) in the pre-test that correlates to each performance objective. (Enrichment Performance Objectives, marked with an asterisk*****, are addressed in the text as noted, but they have no corresponding pre-test questions since they are not tested on the MAAP-EOC exam.

MS CCRS Biology Disciplinary Core Idea, Standard, and Performance Objective	Text Section(s)	Pre-Test
BIO.1 Cells as a System **BIO.1A Students will demonstrate an understanding of the characteristics of life and biological organization.**		
BIO.1A.1 Develop criteria to differentiate between living and non-living things.	Subsections 1.1, 2.1, 2.6	1
BIO.1A.2 Describe the tenets of cell theory and the contributions of Schwann, Hooke, Schleiden, and Virchow.	Subsection 2.1	12
BIO.1A.3 Using specific examples, explain how cells can be organized into complex tissues, organs, and organ systems in multicellular organisms.	Subsection 2.5	13
BIO.1A.4 Use evidence from current scientific literature to support whether a virus is living or non-living.	Subsection 2.6	4
BIO.1B Students will analyze the structure and function of the macromolecules that make up cells.		
BIO.1B.1 Develop and use models to compare and contrast the structure and function of carbohydrates, lipids, proteins, and nucleic acids (DNA and RNA) in organisms.	Subsections 1.2, 1.3, 1.4, 1.5, 1.7, 1.8, 6.2, 6.3	5, 6
BIO.1B.2 Design and conduct an experiment to determine how enzymes react given various environmental conditions (i.e., pH, temperature, and concentration). Analyze, interpret, graph, and present data to explain how those changing conditions affect the enzyme activity and the rate of the reactions that take place in biological organisms.	Subsection 1.6	7
BIO.1C Students will relate the diversity of organelles to a variety of specialized cellular functions.		
BIO.1C.1 Develop and use models to explore how specialized structures within cells (e.g., nucleus, cytoskeleton, endoplasmic reticulum, ribosomes, Golgi apparatus, lysosomes, mitochondria, chloroplast, centrosomes, and vacuoles) interact to carry out the functions necessary for organism survival.	Subsections 2.3, 2.4	8, 9
BIO.1C.2 Investigate to compare and contrast prokaryotic cells and eukaryotic cells, and plant, animal, and fungal cells.	Subsections 2.2, 2.4, 12.2	2, 10
BIO.1C.3 Contrast the structure of viruses with that of cells, and explain why viruses must use living cells to reproduce.	Subsection 2.6	58
BIO.1D Students will describe the structure of the cell membrane and analyze how the structure is related to its primary function of regulating transport in and out of cells to maintain homeostasis.		
BIO.1D.1 Plan and conduct investigations to prove that the cell membrane is a semi-permeable, allowing it to maintain homeostasis with its environment through active and passive transport processes.	Subsection 2.3, Section 3	11
BIO.1D.2 Develop and use models to explain how the cell deals with imbalances of solute concentration across the cell membrane (i.e., hypertonic, hypotonic, and isotonic conditions, sodium/potassium pump).	Subsections 3.3, 3.4	14, 16

Performance Objective Correlation Chart, continued

MS CCRS Biology Disciplinary Core Idea, Standard, and Performance Objective	Text Section(s)	Pre-Test
BIO.1E Students will develop and use models to explain the role of the cell cycle during growth, development, and maintenance in multicellular organisms.		
BIO.1E.1 Construct models to explain how the processes of cell division and cell differentiation produce and maintain complex multicellular organisms.	Subsections 2.5, 5.1, 5.5, 7.2	17
BIO.1E.2 Identify and describe the changes that occur in a cell during replication. Explore problems that might occur if the cell does not progress through the cycle correctly (cancer).	Subsections 5.1, 5.2, 6.2	18, 19
BIO.1E.3 Relate the processes of cellular reproduction to asexual reproduction in simple organisms (i.e., budding, vegetative propagation, regeneration, binary fission). Explain why the DNA of the daughter cells is the same as the parent cell.	Subsections 5.3, 5.6	56, 59
BIO.1E.4 *Enrichment: Use an engineering design process to investigate the role of stem cells in regeneration and asexual reproduction, then develop applications of stem cell research to solve human medical conditions.	Subsection 7.2	
BIO.2 Energy Transfer **BIO.2 Students will explain that cells transform energy through the processes of photosynthesis and cellular respiration to drive cellular functions.**		
BIO.2.1 Use models to demonstrate that ATP and ADP are cycled within a cell as a means to transfer energy.	Subsection 4.1	20
BIO.2.2 Develop models of the major reactants and products of photosynthesis to demonstrate the transformation of light energy into stored chemical energy in cells. Emphasize the chemical processes in which bonds are broken and energy is released, and new bonds are formed and energy is stored.	Subsections 4.2, 4.5, 16.3	22
BIO.2.3 Develop models of the major reactants and products of cellular respiration (aerobic and anaerobic) to demonstrate the transformation of the chemical energy stored in food to the available energy of ATP. Emphasize the chemical processes in which bonds are broken and energy is released, and new bonds are formed and energy is stored.	Subsections 4.3, 4.5, 16.3	24, 53
BIO.2.4 Conduct scientific investigations or computer simulations to compare aerobic and anaerobic cellular respiration in plants and animals, using real world examples.	Subsection 4.3	15
BIO.2.5 *Enrichment: Investigate variables (e.g., nutrient availability, temperature) that affect anaerobic respiration and current real-world applications of fermentation.	Subsections 4.3, 4.4	
BIO.2.6 *Enrichment: Use an engineering design process to manipulate factors involved in fermentation to optimize energy production.	Subsections 4.3, 4.4	
BIO.3 Reproduction and Heredity **BIO.3A Students will develop and use models to explain the role of meiosis in the production of haploid gametes required for sexual reproduction.**		
BIO.3A.1 Model sex cell formation (meiosis) and combination (fertilization) to demonstrate the maintenance of chromosome number through each generation in sexually reproducing populations. Explain why the DNA of the daughter cells is different from the DNA of the parent cell.	Subsections 5.4, 5.5, 5.6, 8.1	3, 25
BIO.3A.2 Compare and contrast mitosis and meiosis in terms of reproduction.	Subsections 5.3, 5.4, 5.6	26
BIO.3A.3 Investigate chromosomal abnormalities (e.g., Down syndrome, Turner's syndrome, and Klinefelter syndrome) that might arise from errors in meiosis (nondisjunction) and how these abnormalities are identified (karyotypes).	Subsection 7.1	27

MS CCRS Biology Disciplinary Core Idea, Standard, and Performance Objective	Text Section(s)	Pre-Test
BIO.3B Students will analyze and interpret data collected from probability calculations to explain the variation of expressed traits within a population. **BIO.3B.1** Demonstrate Mendel's law of dominance and segregation using mathematics to predict phenotypic and genotypic ratios by constructing Punnett squares with both homozygous and heterozygous allele pairs.	Subsections 8.1, 8.2, 8.3, 8.5	23, 55
BIO.3B.2 Illustrate Mendel's law of independent assortment using Punnett squares and/or the product rule of probability to analyze monohybrid crosses.	Subsections 8.2, 8.3, 8.4, 8.5	60
BIO.3B.3 Investigate traits that follow non-Mendelian inheritance patterns (e.g., incomplete dominance, codominance, multiple alleles in human blood types, and sex-linkage).	Subsections 9.1, 9.2, 9.3	28, 30
BIO.3B.4 Analyze and interpret data (e.g., pedigrees, family, and population studies) regarding Mendelian and complex genetic traits (e.g., sickle-cell anemia, cystic fibrosis, muscular dystrophy, color-blindness, and hemophilia) to determine patterns of inheritance and disease risk.	Subsection 8.5, Section 9	31, 32
BIO.3C Students will construct an explanation based on evidence to describe how the structure and nucleotide base sequence of DNA determines the structure of proteins or RNA that carry out essential functions of life. **BIO.3C.1** Develop and use models to explain the relationship between DNA, genes, and chromosomes in coding the instructions for the traits transferred from parent to offspring.	Subsection 6.1	35
BIO.3C.2 Evaluate the mechanisms of transcription and translation in protein synthesis.	Subsection 6.3	38, 41
BIO.3C.3 Use models to predict how various changes in the nucleotide sequence (e.g., point mutations, deletions, and additions) will affect the resulting protein product and the subsequent inherited trait.	Subsection 7.1	33
BIO.3C.4 Research and identify how DNA technology benefits society. Engage in scientific argument from evidence over the ethical issues surrounding the use of DNA technology (e.g., cloning, transgenic organisms, stem cell research, and the Human Genome Project, gel electrophoresis).	Subsection 7.2	36
BIO.3C.5 *Enrichment: Investigate current biotechnological applications in the study of the genome (e.g., transcriptome, proteome, individualized sequencing, and individualized gene therapy).	Subsection 7.3	
BIO.4 Adaptations and Evolution **BIO.4 Students will analyze and interpret evidence to explain the unity and diversity of life.** **BIO.4.1** Use models to differentiate between organic and chemical evolution, illustrating the steps leading to aerobic heterotrophs and photosynthetic autotrophs.	Subsections 10.1, 10.3, 10.4	34, 39
BIO.4.2 Evaluate empirical evidence of common ancestry and biological evolution, including comparative anatomy (e.g., homologous structures and embryological similarities), fossil record, molecular/biochemical similarities (e.g., gene and protein homology), and biogeographic distribution.	Subsection 12.1, Section 13	37, 43
BIO.4.3 Construct cladograms/phylogenetic trees to illustrate relatedness between species.	Subsections 12.1, 12.2,12.3, 12.4	46
BIO.4.4 Design models and use simulations to investigate the interaction between changing environments and genetic variation in natural selection leading to adaptations in populations and differential success of populations.	Subsection 5.6, Section 11	40, 42

Performance Objective Correlation Chart, continued

MS CCRS Biology Disciplinary Core Idea, Standard, and Performance Objective	Text Section(s)	Pre-Test
BIO.4.5 Use Darwin's Theory to explain how genetic variation, competition, overproduction, and unequal reproductive success acts as driving forces of natural selection and evolution.	Subsection 10.2, Section 11	44
BIO.4.6 Construct explanations for the mechanisms of speciation (e.g., geographic and reproductive isolation).	Subsections 11.6, 11.7, 11.8	48
BIO.4.7 *Enrichment: Construct explanations for how various disease agents (bacteria, viruses, chemicals) can influence natural selection.	Subsections 11.3,11.4, 11.5	
BIO.5 Interdependence of Organisms and Their Environments **BIO.5 Students will Investigate and evaluate the interdependence of living organisms and their environment.**		
BIO.5.1 Illustrate levels of ecological hierarchy, including organism, population, community, ecosystem, biome, and biosphere.	Subsection 14.1	45
BIO.5.2 Analyze models of the cycling of matter (e.g., carbon, nitrogen, phosphorus, and water) between abiotic and biotic factors in an ecosystem and evaluate the ability of these cycles to maintain the health and sustainability of the ecosystem.	Section 16	50, 52
BIO.5.3 Analyze and interpret quantitative data to construct an explanation for the effects of greenhouse gases on the carbon dioxide cycle and global climate.	Subsections 16.1, 16.2, 17.3	54
BIO.5.4 Develop and use models to describe the flow of energy and amount of biomass through food chains, food webs, and food pyramids.	Section 15	21, 29
BIO.5.5 Evaluate symbiotic relationships (e.g., mutualism, parasitism, and commensalism) and other co-evolutionary (e.g., predator-prey, cooperation, competition, and mimicry) relationships within specific environments.	Subsection 14.2	47, 51
BIO.5.6 Analyze and interpret population data, both density-dependent and density-independent, to define limiting factors. Use graphical representations (growth curves) to illustrate the carrying capacity within ecosystems.	Subsections 14.3, 15.4	57
BIO.5.7 Investigate and evaluate factors involved in primary and secondary ecological succession using local, real world examples.	Subsection 17.1	49
BIO.5.8 *Enrichment: Use an engineering design process to create a solution that addresses changing ecological conditions (e.g., climate change, invasive species, loss of biodiversity, human population growth, habitat destruction, biomagnification, or natural phenomena).	Subsections 17.2, 17.3, 17.4	
BIO.5.9 *Enrichment: Use an engineering design process to investigate and model current technological uses of biomimicry to address solutions to real-world problems.	Subsection 17.5	