Biology Study Guide

Introduction

This study guide was devised to enable students to review the basic biological concepts that they may need in preparing for the Biology Exit Assessment. It is not intended to be a comprehensive course in biology. The study of biology as in all sciences contains investigations and activities that are integral parts of the courses. As students and teacher use this guide they should be ever mindful of basic scientific principals that require investigation and discovery.

Basic Scientific Principles

Scientific Method

Observe
Define Problem
Formulate **Hypotheses** (Always a statement. Never a question)
Test **Hypothesis** (possible explanation based on research and prior (knowledge)
Collect, Organize, and Analyze **Data** (facts collected during an Investigation. Could be measurements or other observations)
Draw Conclusions
Report Findings

There are variations on this method that all scientists use.

Observations lead to questions. These questions are often how a problem is defined.
Example

Problem: Is growth of spinach plants influenced by light wavelength?
Hypothesis: Spinach growth will be influenced by different wavelengths of light.
Test: Spinach plants will be grown in the following way:

Experimental Group
100 plants grown in red light
100 plants grown in orange light
100 plants grown in yellow light
100 plants grown in green light
100 plants grown in blue
100 plants grown in indigo light
100 plants grown in violet light

Control Group

100 plants grown in white light

The **control group** data is compared to the data of the experimental groups. Without a control group, changes in the experimental group or groups could not be determined.

There are three types of variables In an investigation, **independent**, **dependent** and **controlled**. A variable is anything that can change or be changed. Things such as measurements of length, width, volume, temperature, as well as differences in color, texture, odor, and quantities are just some examples of variables The variable that is changed is called the independent variable. In the investigation described above the independent variable would be the different colors or wavelengths of light. It is the variable that is being tested. The variable that shows the effects of the change would be the dependent variable. In this investigation it would be data collected about the spinach plants. The dependent variables could be measurements such as size, weight, or color of plants. The investigator would determine what dependent variable is to be measured.

The controlled variable would be all the variables that were kept the same (held constant) during the experiment. In the control group all the variables are held constant. In the experimental group one variable is changed. In other words all variables in all groups were controlled except for one, the independent variable (colors of light) in all groups. White light would be the typical light in which spinach would be grown so that is the color of the light in the control group. The type of soil, amount of water given each day, temperature, humidity, length of time exposed to light and any other variables are held constant in all groups. All of the groups are compared separately to the control. The red group is compared to the control and then the orange and then the yellow and so on. Any changes observed between the various groups and the control would therefore have been because of the independent variable which is the various colors of light.

Try This:

Average Height Of Plants in Cm after 30 Days

Color of light	
Red	60 cm
Orange	50 cm
Yellow	40cm
Green	20 cm
Blue	45 cm
Indigo	50 cm
Violet	57 cm
White	58 cm

1. Draw a bar graph to represent the data table.

2. Does the data table support or reject the hypothesis? Explain. Include data to help defend your answer

3. Design an investigation to test the effects of a liquid fertilizer on bean plants.

4. In your experiment identify the following:

Independent variable
Dependent Variable
Controlled variables
Experimental Group or Groups
Control Group

What type of data might you collect as the dependent variable?

Vocabulary List for Introduction

1. Data
2. Hypothesis
3. Variables
4. Controlled Variables
5. Dependent Variables
6. Independent Variables
7. Scientific Methods

1. The Nature of Matter

Matter

All matter in the universe is made up of tiny particles called **atoms**. Atoms themselves are made up of three basic types of subatomic particles.

The three **subatomic particles** are the protons, neutrons, and electrons.

The **protons** have a positive charge and are located in central part of the atom which is called the **nucleus.**

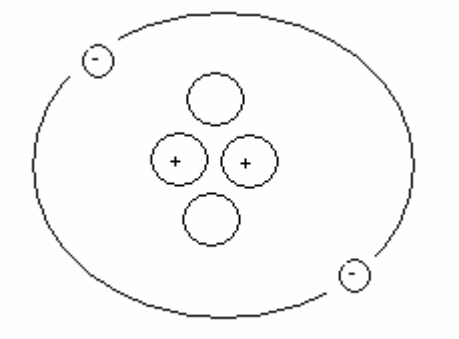
The **neutrons** have no charge and are located in the nucleus along with the protons.

The **electrons** have a negative charge and are located in a region surrounding the nucleus known as the **electron cloud**.

The number and arrangement of the electrons are what gives an atom its **chemical properties** which are the ability to react with other atoms. An example of a chemical property is ability of iron to react with the oxygen in air to form rust.

Try These:

1. *Identify the two main parts on this diagram of an atom and identify the three subatomic particles:*



2. *If an example of a chemical property of iron is its ability to react with oxygen, what is an example of a chemical property of oxygen?*

Elements

The universe is composed of approximately 100 types of atoms. Each type of atom is referred to as an **element**. Carbon (C) and oxygen (O) are examples of elements.

In nature most elements combine with other elements to form **chemical compounds.** Carbon dioxide (CO_2) is an example of a chemical compound.

Try These:

1. *Which of the following is an element and which is a compound?*

a) S b) SO_3 c) $ZnCl_2$ d) Na

2. If the universe is only composed of about 100 types of atoms, explain why there are millions of different chemical substances.

Chemical Bonding

Atoms form compounds through interactions between their electron clouds in a process called **chemical bonding**.

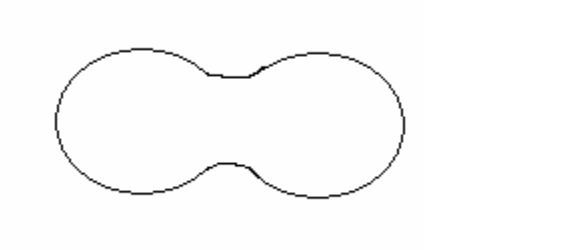
The two main types of chemical bonding are ionic bonding and covalent bonding. In both cases atoms join each other to become new substances, but do so in different ways.

In **ionic bonding** atoms lose or gain electrons to become positively or negatively charged particles called **ions**. These ions then are attracted to each other because of the opposite charges, forming chemical compounds with new properties. Many ionic compounds exist as crystals that can break apart into separate ions when dissolved in water. An example of a common substance formed by ionic bonding is sodium chloride (NaCl).

In **covalent bonding** atoms share electrons between them. In effect their electron clouds become fused together forming a **molecule** with new properties. An example of a covalent molecule is carbon dioxide (CO_2). In some cases atoms of the same types can covalently bond together to form molecules. Oxygen atoms (O) bond to form oxygen molecules (O_2) or ozone molecules (O_3).

Try These:

1. *Compare and contrast an ionic and covalent bond.*
2. *What type of bonding is depicted by this diagram? Explain.*

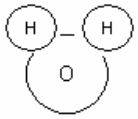


Water

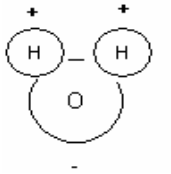
Water is extremely important to life on earth for many reasons. Many different substances can dissolve in it and therefore it is a substance in which the chemical reactions supporting life can occur. It is an excellent absorber of heat energy and allows living cells to remain at stable temperatures despite temperature changes outside the cell. It also moderates the Earth's temperature as large bodies of water absorb or release energy.

Water molecules consist of two hydrogen atoms covalently bonded to an oxygen atom.

Water has the **formula** H_2O and the molecular structure depicted in the diagram at the right.



Water electrons are not shared evenly. This is because oxygen has an extraordinarily large attraction for the shared electron and hydrogen has a fairly weak attraction for the shared electrons. Because of this uneven sharing, the oxygen atom has a partial negative charge and the hydrogen atoms have a partial positive charge giving the water molecule a positive side and a negative



side:

A charged molecule such as water is said to be **polar covalent**. Some molecules, where there is no difference in attraction for electrons, (or one that is very small) have no charge and are said to be **nonpolar covalent**.

Because the positive parts of one water molecule are attracted to the negative parts of other water molecules, weak bonds called **hydrogen bonds** are formed between water molecules.

These hydrogen bonds cause water molecules to be cohesive and stick together. This **cohesive property** of water greatly influences the properties of water. An example of a property of water influenced by hydrogen bonding is boiling point. Based on its size alone, water should boil at a much lower temperature than it does, but because of the cohesion of the water molecules, the amount of energy required to break the hydrogen bonds requires that water be heated to 100^{o}C before boiling will occur.

Try These:

1. *Explain why water is so important to living things.*
2. *Examine the table below. Explain methane's extremely low boiling point compared to that of water:*

Substance	Formula	Molecular Weight (g/mol)	Boiling Point (^{o}C)
Water	H_2O	18	100
Methane	CH_4	16	-161.6

Vocabulary List for 1. The Nature of Matter

1. atom
2. subatomic particle
3. proton
4. neutron
5. electron

6. nucleus
7. electron cloud
8. chemical properties
9. element
10. chemical compound
11. chemical bonding
12. ionic bonding
13. ion
14. covalent bonding
15. molecule
16. water molecules
17. formula
18. polar covalent
19. nonpolar covalent
20. hydrogen bond
21. cohesive property

2. The Chemistry of Life

The Elements of Life

Most living things are composed primarily of only six elements: carbon (C), hydrogen (H), oxygen (O), Nitrogen (N), sulfur (S), and Phosphorus (P).

Of these elements, carbon is important because it can form millions of large, complex molecules essential to life. These large complex molecules are referred to as **macromolecules**.

Organic Compounds in Living Things

Four main groups of **organic** (carbon-based) compounds are carbohydrates, lipids, proteins, and nucleic acids.

Carbohydrates are composed primarily of carbon, hydrogen and oxygen and used primarily by living things as a source of energy and for structure.

The simplest carbohydrates are sugars called **monosaccharides**. An example of a monosaccharide is the sugar glucose $C_6H_{12}O_6$.

Monosaccharides can bond together to form larger carbohydrates called **polysaccharides**. An example of a polysaccharide is starch as is found in potatoes or pasta.

Monosaccharides are used directly by living cells to produce energy. Since they can be broken down into monosaccharides, polysaccharides allow living things to store energy for energy for future use.

Some large polysaccharides can be used by living things for structure. The cellulose making up wood is an example of a structural polysaccharide.

The **lipids** are a class of organic compounds made up of carbon, hydrogen and oxygen and will not dissolve in water. Examples of lipids are fats, waxes, and sterols.

Lipids are used by living things primarily for energy storage since they contain even more energy than the carbohydrates.

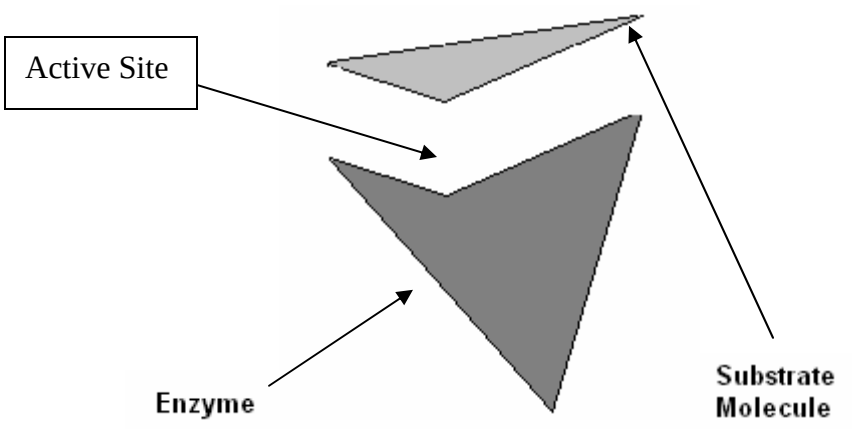
Lipids also form an important part of cellular membranes and are also used by living things when waterproof coatings (such as the waxy coatings on some leaves) are needed.

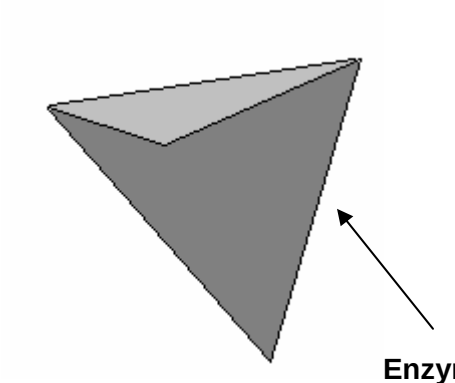
Fats are a type of lipid composed of fatty acid molecules bonded to glycerol molecules and may be **saturated** (such as the solid fats found in beef, butter, and cheese) or **unsaturated** (such as the oils found in olives, nuts, and fish).
Proteins are compounds made of carbon, hydrogen, oxygen and nitrogen and serve as structural and regulatory substances. Proteins are composed of smaller molecular units called **amino acids**.

The collagen that makes up tendons and cartilage is an example of a structural protein.

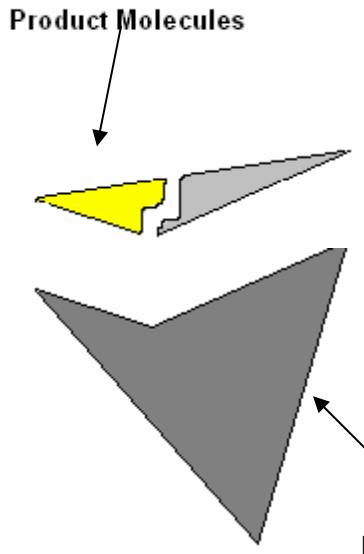
Enzymes are proteins that increase the rate of a chemical reaction. Most of the chemical reactions involved with the metabolism of living things would occur so slowly without enzymes that life would be impossible.

Each enzyme acts on a particular target molecule or **substrate**. The enzyme has a region known as the **active site** that is able to chemically bond with the substrate molecule and allow chemical changes to occur in that substrate much faster than without the enzyme.





Enzyme-Substrate Complex



Enzyme releases products and is once again ready for a new substrate

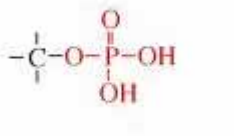
An example of enzyme action would be enzymes in saliva breaking down the starch from bread as it is being chewed, changing the starch into monosaccharides.

Nucleic acids are macromolecules made of carbon, hydrogen, oxygen, nitrogen and phosphorus. They store and transmit hereditary information in living things.

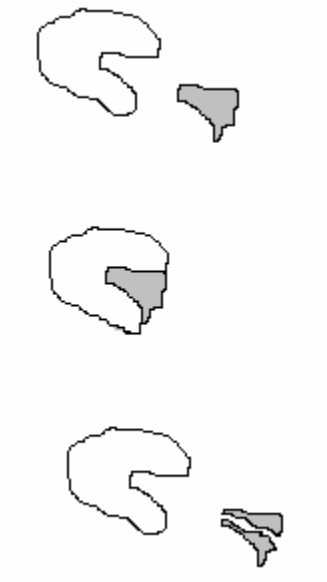
The two types of nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).

Try These:

1. *Give an example of a carbohydrate, a lipid, a protein and a nucleic acid and discuss the function of each.*
2. *Is the chemical structure below a fragment of a protein, nucleic acid, or carbohydrate? How do you know?*



3. *Describe the process by which an enzyme speeds up a chemical reaction.*
4. *Label this diagram of the process in #3 above.*



Vocabulary List for 2. The Chemistry of Life

1. macromolecules
2. C H O N S P
3. organic compound
4. monosaccharide
5. polysaccharide
6. lipid
7. saturated fat
8. unsaturated fat
9. protein
10. amino acid
11. enzyme
12. substrate
13. nucleic acid
14. DNA
15. RNA

The Nature of Matter Web Resources

http://corrosion.ksc.nasa.gov/electrochem_nature.htm

http://www.biology.arizona.edu/biochemistry/tutorials/chemistry/page3.html

http://www.infoplease.com/cig/biology/water.html

3. Cell Biology

The characteristics of life state that an organism must be made of cells, able to reproduce, grow, develop have organization, use energy/ATP, evolve, have heredity, adapt to their environment, and maintain **homeostasis** (stable internal environment).

There are 3 parts to the cell theory: all living things are made of **cells** (smallest units of life), cells are the basic units of structure and function in an **organism** (anything living) and existing cells produce new cells.

An organism is considered to be alive even if it is just made of one cell. This organism would be said to be **unicellular**.

Microscopes

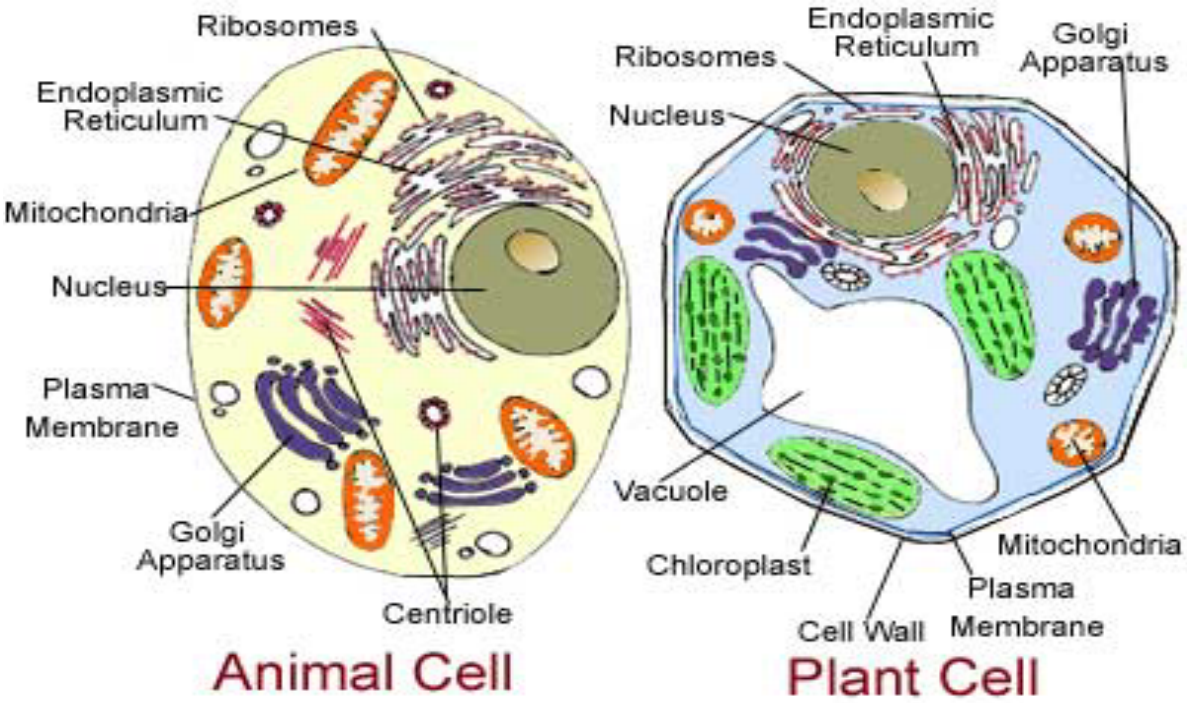
Microscope-is an instrument that is used to produce enlarged images of an object. There are two types of microscopes: the more commonly used compound light microscope which has the ability to **magnify** (increase) an objects size up to 1000 times and the electron microscope which can magnify objects up to 200,000 times. The power of the microscope to show detail more clearly is called **resolution**.

Cells

The two types of cells are: **prokaryotes** which have no nucleus and **eukaryotes** which have a nucleus.

Prokaryotes are comprised of a cell membrane, cytoplasm, ribosomes and genetic material.
Cytoplasm is the material in the cell which takes up space between the the cell membrane and other structures. Prokaryotic organisms are unicellular.

The two main eukaryotic cells are plants and animals. A diagram has been provided



http://www.beyondbooks.com/lif71/images/00046824.jpg

Eukaryotic organisms contain various **organelles** that are specialized compartments that carry out specific functions. Some organelles are: the **nucleus** which directs the major activities of the cell and stores the genetic information, known as DNA, the **mitochondria** which produces energy/ATP, the

ribosomes which make proteins, the **endoplasmic reticulum and golgi apparatus** which direct materials through the cell, the **centrioles** which aid in the process of **mitosis** (cell division), the **vacuoles** which stores water and waste and also takes up about 80% of space in a plant cell, the **chloroplasts** help make energy/ATP in plant cells through the process of **photosynthesis** and contains a green pigment called **chlorophyll** , and a **cell wall** which provides an extra barrier in plant cells.

Try This:

Given data you should be able to determine whether a cell being described is eukaryotic or prokaryotic. Furthermore you should be able to tell whether it is a plant or animal cell.

1. *You are on a class trip at the Liberty Science Center and one of the attractions is viewing cells under the microscope. You look into the microscope and see a cell with a clearly defined nucleus and a large central vacuole. What can you conclude about this cell?*

Vocabulary List for 3. Cell Biology

1. Homeostasis
2. Cells
3. Organism
4. Unicellular
5. Microscope
6. Magnification
7. Resolution
8. Prokaryotes
9. Eukaryotes
10. Cytoplasm
11. Organelles
12. Nucleus
13. Mitochondria
14. Ribosome
15. Endoplasmic Reticulum
16. Golgi Apparatus
17. Centrioles
18. Mitosis
19. Vacuoles
20. Chloroplast
21. Photosynthesis
22. Chlorophyll
23. Cell Wall

Ch. 3 Cell Biology Web Resources

http://images.google.com/imgres?imgurl=http://evolution.berkeley.edu/evosite/lines/images/cells.gif&imgrefurl=http://evolution.berkeley.edu/evosite/lines/IIDmolecular.shtml&h=275&w=511&sz=18&hl=en&start=3&tbnid=IXWsNpEjFuwJjM:&tbnh=70&tbnw=131&prev=/images%3Fq%3Danimal%2Band%2Bplant%2Bcells%26gbv%3D2%26svnum%3D10%26hl%3Den

http://images.google.com/imgres?imgurl=http://www.biologycorner.com/resources/cell.gif&imgrefurl=http://www.biologycorner.com/bio1/cell.html&h=311&w=429&sz=27&hl=en&start=9&tbnid=0yE2Vhz3ielzaM:&tbnh=91&tbnw=126&prev=/images%3Fq%3Danimal%2Band%2Bplant%2Bcells%26gbv%3D2%26svnum%3D10%26hl%3Den

http://images.google.com/imgres?imgurl=http://www.biologycorner.com/resources/MICRO-labeled.gif&imgrefurl=http://sps.k12.ar.us/massengale/parts_of_a_compound_light_micros.htm&h=441&w=472&sz=44&hl=en&start=3&tbnid=IBLNc48P3MC9rM:&tbnh=121&tbnw=129&prev=/images%3Fq%3Dcompound%2Blight%2Bmicroscope%26gbv%3D2%26svnum%3D10%26hl%3Den

4. Cell Boundaries

Cells have a **cell membrane** that regulates what enters and leaves a cell, and also provides protection and support.

The cell membrane is said to be **semi-permeable**-allows some things in and out of the cell.

The cell membrane can also be referred to as a **lipid bilayer** (two distinct layers). Each layer is made of **phospholipids.** Each phospholipid is comprised of a **hydrophilic (**water attracting) head and a **hydrophobic** (water repeling) tail.

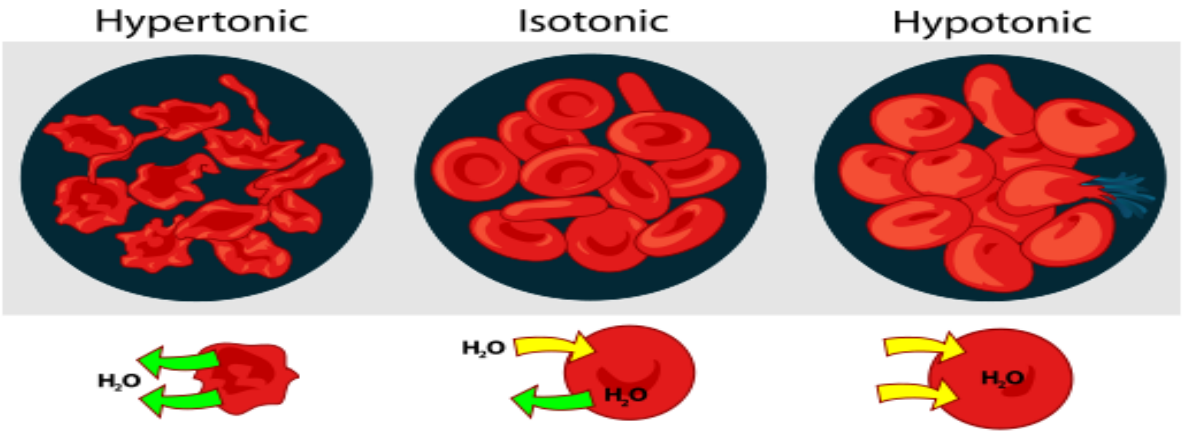
The cell membrane is not a rigid structure, rather it behaves more like a fluid than a solid, that is why it is often referred to as a **fluid mosaic model**.

Types of Movement Across a Membrane

Diffusion is the movement of molecules from high concentration to low concentration and
Osmosis is the diffusion of water molecules from high concentration to low concentration are the two main ways for molecules to cross the cell membrane both of which do not require the use of the cells energy/ATP. Molecules can freely move across the membrane until **equilibrium** is reached. This is when the concentration of substances are the same on both sides of the membrane.

Active transport is the energy requiring process that moves materials across a cell membrane against a **concentration gradient**. This is the difference in concentration of a substance across space. The movement of the molecules is from low concentration to high concentration, opposite of diffusion and osmosis.

There are three types of osmotic solutions a cell could be in: **hypotonic** which is when the concentration of solute molecules is lower on the outside of the cell forcing water into the cell, making it expand/swell, **hypertonic** when the concentration of solute molecules is higher on the outside of the cell forcing water out of the cell, making it shrink/shrivel and **isotonic** when the concentration of solute molecules are the same on the outside and the inside of the cell forcing water in and out of the cell at equal rates.



http://upload.wikimedia.org/wikipedia/commons/7/76/Osmotic_pressure_on_blood_cells_diagram.svg

Try This:

1. *Hypothesize what would happen if a red blood cell were placed in 100% H_2O water (distilled H_2O) and a 10% NaCl solution. Explain how you would test this hypothesis.*

Vocabulary list for 4. Cell Boundaries

1. Cell Membrane
2. Semi-Permeable
3. Lipid Bilayer
4. Phospholipid
5. Hydrophilic

6. Hydrophobic
7. Fluid mosaic model
8. Diffusion
9. Osmosis
10. Equilibrium
11. Active Transport
12. Concentration Gradient
13. Hypotonic
14. Hypertonic
15. Isotonic

Ch.4 Cell boundaries Web Resources

http://images.google.com/imgres?imgurl=http://www.biologycorner.com/resources/cell_membrane.jpg&imgrefurl=http://www.biologycorner.com/bio3/notes-cell_membrane.html&h=294&w=600&sz=24&hl=en&start=37&tbnid=OLP9DbWab7EclM:&tbnh=66&tbnw=135&prev=/images%3Fq%3Dcell%2Bmembrane%26start%3D20%26gbv%3D2%26ndsp%3D20%26svnum%3D10%26hl%3Den%26sa%3DN

5. Cellular Organization

Multicellular organisms have two or more cells. Organisms develop in different ways to perform particular functions within the organism, which is called **differentiation**.

The four levels of organization in multicellular organisms are: cells, **tissues** (groups of similar cells that carry out a common function), **organs** (several types of body tissues that together perform a function) and **organ system** (a group of organs that interact to perform a set of related tasks).

Try This:

1. *Name a cell, tissue, organ and an organ system in the human body.*

Vocabulary List for 5. Cellular Organization

1. Multicellular
2. Differentiation
3. Tissues
4. Organs

5. Organ System

Ch 5. Cellular Organization Web Resources

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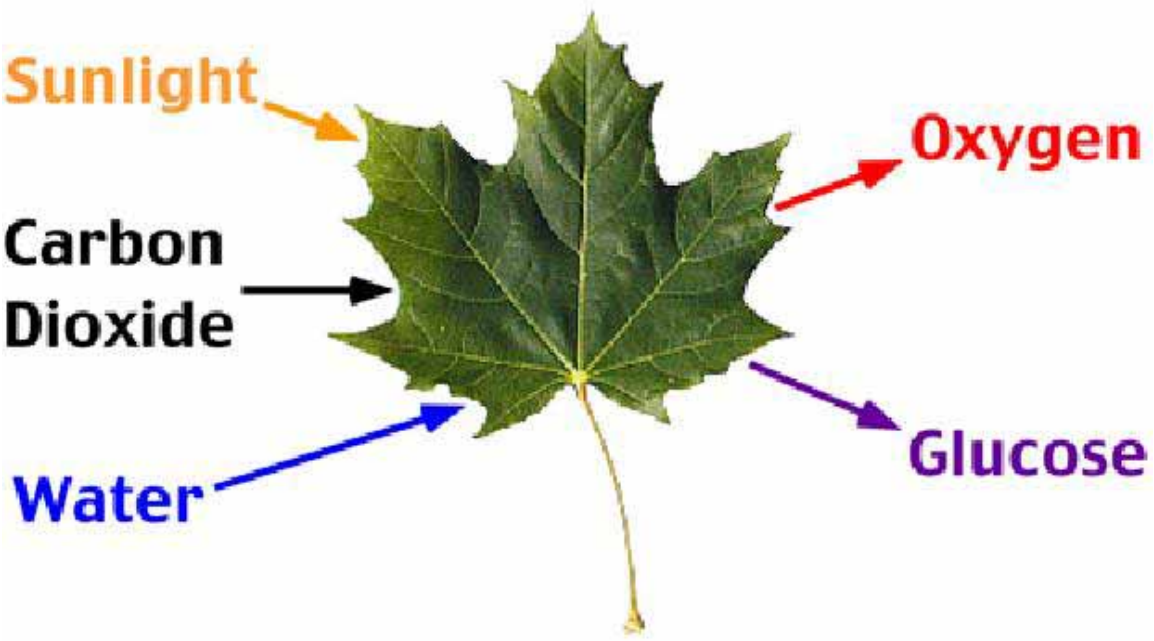
6. Energy and Life

Photosynthesis

All things need energy to live. Energy starts with the sun. Plants use the sun's energy in **photosynthesis** – the process by which plants and some microorganisms use light energy to produce food.



(http://students.salisbury.edu/~ak09850/images/photosynthesisBASIC.jpg)

Chloroplasts are organelles (cell parts) that convert light energy into chemical energy in chemical bonds. **Chlorophyll** is a green pigment in the chloroplast that absorbs the light.

Equation for photosynthesis:

$6CO_2 + 6H_2O$ (+ light energy) → $C_6H_{12}O_6 + 6O_2$

$C_6H_{12}O_6$ is the sugar (glucose). It is a monosaccharide.

Stomata are openings on the bottom surface of leaves where water and oxygen exit and carbon dioxide enters.

Photosynthesis begins by using light energy (light dependent) in which water is split and energy is stored in **ATP** (an energy storing molecule) and NADPH.

Photosynthesis continues in a light independent stage in which molecules like sugar are made from CO_2, H_2O, and from the energy in molecules like ATP.

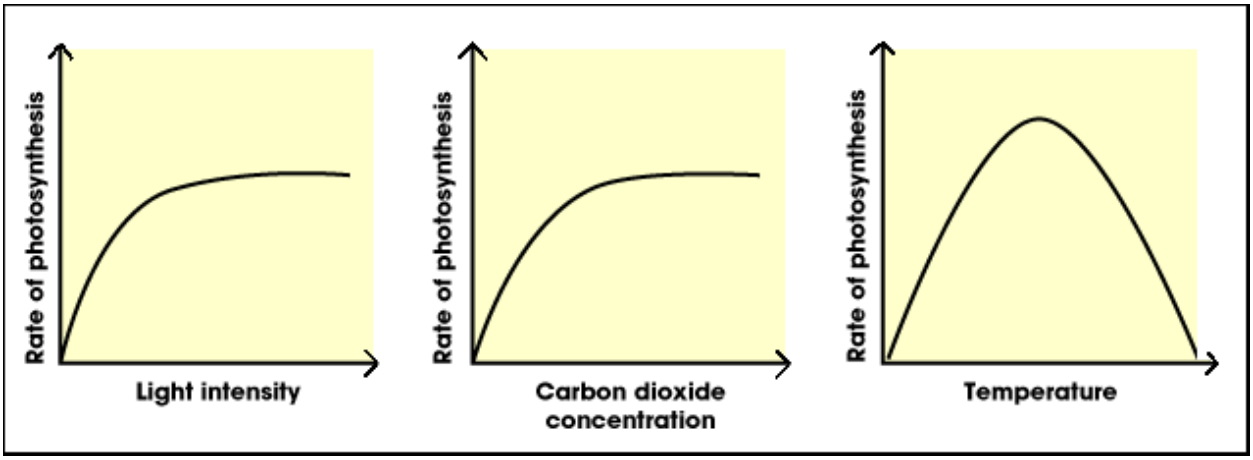
Plants now have "food." This food still has to be broken down by the plant and by the animals that eat plants to get the energy living things need to grow, develop, repair themselves – to live.

Animals are able to use the food produced by plants.

Carbohydrates are organic compounds containing carbon, hydrogen and oxygen – example glucose. How do the plants and animals get energy from chemicals like carbohydrates? They use respiration.

Try These:

1. *Use your knowledge of photosynthesis to explain what is happening in the following graphs.*



(http://www.bbc.co.uk/schools/gcsebitesize/img/biphotorate.gif)

2. *How might blocking the sun's rays by a meteor impacting the earth cause the extinction of dinosaurs (think photosynthesis)?*
3. *White light is made up of these wave lengths of colors red, green, blue, indigo, and violet. Hypothesize how each of these wave lengths might*

effect photosynthesize. Explain how you would test this hypothesis? What would you use as a control?

Cellular Respiration

In **cellular respiration** plants and animals break down molecules (like carbohydrates) to release and store energy.

Different organisms use different methods of respiration. The first step for all organisms is glycolysis. It occurs in the cytoplasm. In **glycolysis** glucose is broken down.

If no oxygen is present the next step is **fermentation** in which pyruvic acid is broken down. Yeast uses fermentation, as do some other organisms, when oxygen is not present. Fermentation is an example of **anaerobic** respiration, meaning no oxygen is present.

When oxygen is present (**aerobic** respiration) much more energy is produced. Oxidative respiration occurs in the mitochondria and more ATP is made.

The equation for respiration is very similar to photosynthesis reversed:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ATP(energy)$$

The end products of photosynthesis are the starting products of respiration.
The end products of respiration are the starting products of photosynthesis.
This is one example of interdependence, living things depending on each other to survive.

During both processes chemicals are being broken down, electrons are being moved, and energy is being used and stored to maintain life.

In addition to energy, chemicals necessary for building, repairing and maintaining living things are being broken down and built up. These chemicals and the energy they contain are cycled from organism to organism in food webs. Plants (photosynthetic organisms) will always be the **producers** of energy because of their ability to convert solar energy to food. **Herbivores** (plant eaters) will be the next level of energy. Consumers such as **carnivores** (meat eaters) and **omnivores** (plant and meat eaters) will follow. Even dead organisms are recycled by **decomposers** (break down wastes).

Try These:

1. *When you exercise you use oxygen very quickly. Sometimes your muscles use oxygen and can not produce energy fast enough for your body. But your muscles still work. How can they still work?*
2. *How could the destruction of the rainforests and ocean pollution (destroying algae) impact human respiratory disorders?*
3. *Hypothesize how providing O_2 to long distance runners might influence their performance. Explain how you could test this hypothesis?*

Vocabulary List for 6. Energy and Life

1. Photosynthesis
2. Chloroplasts
3. Chlorophyll
4. Stomata
5. ATP
6. Carbohydrates
7. Cellular Respiration
8. Glycolysis
9. Fermentation
10. Anaerobic
11. Aerobic
12. Producers
13. Herbivores
14. Carnivores
15. Omnivores
16. Decomposers

Energy and Life Web Resources

http://micro.magnet.fsu.edu/primer/java/photosynthesis/

http://www.homestead-farm.net/KidsLinks/Photosynthesis.html

http://defiant.corban.edu/gtipton/sc-134/inspir-photosynth/index.html

http://staff.jccc.net/pdecell/cellresp/respoverview.html

http://bioweb.cs.earlham.edu/9-12/cellularrespiration/

http://trc.ucdavis.edu/biosci10v/bis10v/week3/06aerobicrespirintro.html

7. Disease

All organisms strive to stay healthy, to maintain a steady state (**homeostasis**). Many things can disrupt normal functioning. What causes diseases?

Bacteria - (simple microscopic organisms with no membrane bound organelles)
Strep throat, tetanus, and tuberculosis are some diseases caused by bacteria.

Viruses - (nonliving particles with a nucleic acid and protein coat)
Colds, chickenpox, flu, rabies, and AIDS are caused by viruses.

Fungus – (microscopic, non-photosynthetic organisms)
Athlete's foot, ringworm, and yeast infections are produced from fungi.

Other Organisms - (living things such as protozoans and other parasites)
Malaria, lyme disease, and heartworm are carried by one living thing to another.

Some infections result from touching the infecting agent (athlete's foot). Others are carried and transmitted in bodily fluids (HIV). Parasites may enter your body in contaminated food (tapeworm) or through the bite of another animal (malaria). Many viruses are spread though the air (flu).

Why do some people "catch" a cold and not others?
Why do some people need a flu shot, but not everyone?

Our bodies have defenses against disease. Our skin, our blood, our genes, our overall health all work together to determine if we will become infected. Some infectious agents like viruses are usually destroyed by our immune system. Most bacteria can be killed using antibiotics.

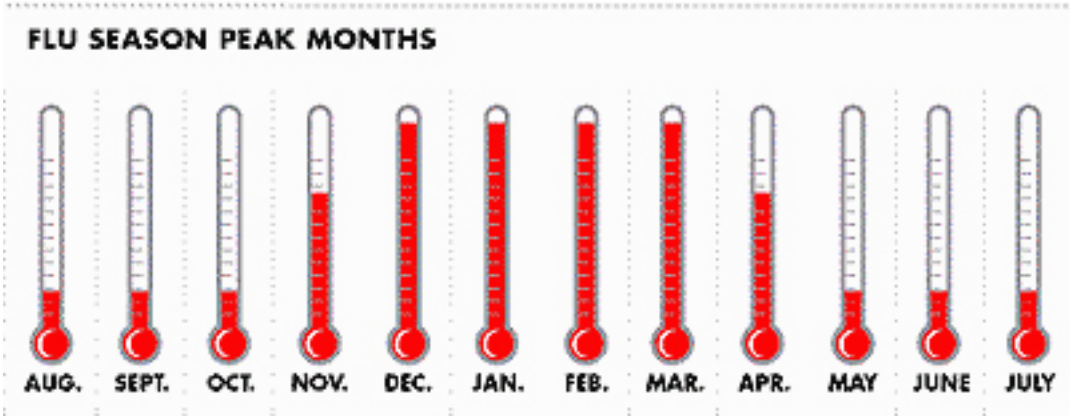
When our systems are compromised – older, younger, already sick, genetically mutated – they are less able to fight off diseases.

Why do some medicines like antibiotics become less effective?
Disease causing agents are evolving, mutating, changing to become immune to the antibiotics.

Medical technology has resulted in new medications, vaccines, tests, and other procedures that have greatly reduced the impact of disease. Some cancers and other diseases are now detected and treated earlier, some are cured, some are kept from becoming infectious. This results in humans being healthier and living longer than their ancestors.

Try These:

1. *HIV is the virus that causes AIDS. Scientists have had some success treating patients with medications for short periods of time. But no long term medication has been successful in destroying the HIV virus. Why do you think the medicines are helpful, but then stop working?*
2. *Based on the way flu is spread, why do you think people are infected according to the statistics below?*



(http://kidshealth.org/teen/infections/common/images_53644/T_flushot.jpg)

Vocabulary List for 7. Disease

1. Homeostasis
2. Bacteria
3. Virus
4. Organisms
5. Fungus

Disease Web Resources

http://www.mcgill.ca/hostres/diseases/

http://www.cnn.com/HEALTH/library/ID/00004.html

http://www.mayoclinic.com/health/vaccines/ID00023

8. Diversity

Classification

Taxonomy is the science of classifying organisms.

Carl Linnaeus used the similarities and differences among organisms to place them into groups. This system includes seven major groups into which each

organism is placed from very general to very specific. Today's classification system has sub groups that Linnaeus did not include.

The groups are:
Kingdom
Phylum (Division in Plants)
Class
Order
Family
Genus
Species

The **scientific name** of an organism is the genus and species name. The scientific name of humans is *Homo sapiens.* The genus is always capitalized and both words and emphasized (written in bold type, underlined, or italicized).

This two word naming is **binomial nomenclature.**

Although not all scientists agree, there are generally 6 kingdoms:
(Prokaryotic organisms have no nuclear membrane and no membrane bound organelles = bacteria. Eukaryotic organisms have those membranes = everything else).

Kingdoms
(With some examples)

ARCHAEBACTERIA – single celled, found in extreme places, prokaryotic - bacteria
EUBACTERIA – more common, round, spiral, rod shaped, prokaryotic - bacteria
FUNGI – cannot make food, they absorb food – mushrooms, mold, yeast
PROTISTA – plant and animal-like organisms – algae, paramecium
PLANTAE – photosynthetic, multicellular organisms with cell walls
ANIMALIA – cannot make food, no cell walls, some simple, some complex, multicellular - vertebrates (fish, dogs) have backbones, invertebrates (snails, insects) do not

Modern classification systems use a number of methods to group organisms**.** These include: **morphology** (form and structure), embryologic development**,** molecular analysis (such as DNA, RNA), and **phylogeny** (evolutionary decent).

Members of a species are very similar in structure. They are naturally able to reproduce, and their offspring are fertile.

The **Domain System** is a more modern system of classification based on molecular structure. In this system there are only three divisions:

ARCHAEBACTERIA (Archea) – oldest, primitive bacteria
EUBACTERIA (Bacteria) – more advanced forms of bacteria
EUKARYA – all organisms with membrane bound organelles (everything but bacteria)

Some Phyla of Animals

1. Porifera – simplest animals: sponges
2. Cnidaria – have stinging cells: jellyfish, sea anemones, corals
3. Platyhelminthes – flatworms: planaria, flukes, tapeworms
4. Nematoda – roundworms: nematodes
5. Mollusca - soft bodies: snails, octopus
6. Annelida - segmented worms: earthworms, leeches
7. Echinodermata – spiny skinned, radially symmetrical: starfish, sea cucumbers, sand dollars
8. Arthropods – exoskeleton: arachnids, crustaceans, centipedes, insects
9. Chordata - have nerve chords: vertebrates like fish, birds, mammals

Try These:

1. *The scientific name for dog is Canis familiaris. The scientific name for wolf is Canis lupus. Which classification groups do dogs and wolves have in common? How can you tell they are similar organisms just by looking at their scientific names?*
2. *Insects are very successful organisms. What adaptations and characteristics of insects contribute to their success and how?*

Vocabulary List for 8. Diversity

1. Taxonomy
2. Scientific Name
3. Binominal Nomenclature
4. Morphology
5. Phylogeny

6. Domain System

Diversity Web Resources

http://www.kidsbiology.com/biology_basics/classification/classification1.php

http://instruct.uwo.ca/biology/284/intro.html

http://virtuallaboratory.net/Biofundamentals/lectureNotes/Topic1-5_Evo.htm

9. Biological Evolution

Early Investigations

Research by geologists in the 19th and 20th century indicated that the earth had changed greatly over time and that the geological processes which had caused these changes in the past were still operating today in a principle known as **uniformitarianism**. Some researchers rejected the idea that uniformitarianism was responsible for the creation of huge mountains, canyons, and other geologic features. It was argued that the small day to day changes in the earth observed today, even if operating in the past, would not be able to produce large-scale changes because the Earth was not old enough for such small changes to accumulate in a significant way.

Evidence from plate tectonics, the decay of radioactive elements, and other methods eventually established the **age of the Earth** at approximately 4 billion years – far greater than the 6 000 to 10 000 years previously hypothesized. This new and longer **geological timetable** provided enough time for the slow changes proposed by uniformitarianism to have produced large-scale changes on the Earth's surface.

By the mid 19th century, evidence that not just the Earth, but living species had changed over time was starting to accumulate. When the fossils of organisms were studied, it became apparent that many of the living things found today closely resemble prehistoric species, only with varying degrees of modification. This **fossil "record"** demonstrates that new species appear and others become extinct, while still others remain largely unchanged over long periods of geologic time.

One theory proposed by **Jean Baptiste de Lamarck** explained the changes in organisms as a result of the **inheritance of acquired characteristics**. In

Lamarck's theory, individual organisms caused changes to body parts while using them to perform specific functions. These acquired characteristics were passed on to offspring and further developed over time with each successive generation. An example of this would be a short-necked giraffe stretching its neck to reach leaves (food source) growing on high branches. Lamarck proposed that the stretching would lengthen the neck slightly and that this acquired length could be passed on to offspring which would continue the process by stretching to reach the leaves on even higher branches. Over time, the long-necked giraffe familiar to us would be the result.

Lamarck's theory was shown to be incorrect for several reasons, but was important in that it attempted to explain the reason for the changes that organisms appeared to develop over time.

Try These:

1. *Identify and discuss the discovery that allowed for the acceptance of uniformitarianism.*
2. *Why was Lamarck's theory of evolution important, even if its mechanism was shown to be incorrect?*

Modern Evolutionary Theory

In 1858 **Charles Darwin** and **Alfred Wallace** presented the basis for modern evolutionary theory. Based on the study of fossils, geologic changes, and most importantly the anatomy and behavior of a great many species, Darwin and Wallace concluded that modern species were descended from earlier, distinct species that had changed over time. They also had developed an explanation as to how these changes could have occurred.

Darwin's book ***On the Origin of Species by Means of Natural Selection***, published in 1859 described the principles and evidence for biological evolution in great detail.

First, Darwin explained that all of the species present today were descended from earlier species that had changed over time. He called this idea **descent with modification**. Next, Darwin proposed the concept of **natural selection** to explain how this modification could occur. Darwin knew that more offspring were produced than could ultimately survive. He also knew that offspring, even in the same litter or family had different physical characteristics. He reasoned that some individuals would possess traits that would give them an advantage in the struggle for survival. Those traits that were advantageous would accumulate in

the population over time. Given enough time, species could change bit by bit, generation after generation and change into new forms. New species are said to have increased **fitness** in the environment which means that they are better able to survive (better **adapted)** to their environment and thus able to produce more offspring.

We now know that the source of the "variation" discussed by Darwin was genetic **mutation** or changes in the DNA resulting in new traits in an organism.

Try These:

1. *Plot the data from the table below on a graph:*

Year	Number of Light Colored Moths Observed	Number of Dark Colored Moths Observed
1	556	64
2	537	112
3	484	198
4	392	210
5	246	281
6	225	357
7	193	412
8	147	503
9	84	594
10	56	638

a) *What trend in the number of light colored moths observed?*
b) *What trend in the number of dark colored moths observed?*
c) *Which statement is correct in relating natural selection to the population trend shown by the data: 1) White moths changed into dark moths in response to a change in the environment. 2) Dark moths increased in population size and white moths decreased in population size as a result of a change in the environment. 3) What environmental factor caused the change?*
d) *Since we can see that originally most moths were light colored, how might the first dark colored moths have appeared?*
e) *Research the term "peppered moth" in your textbook or on the Internet to help you understand the complete process illustrated by this data.*

f) *Hypothesize on how the trends in moth numbers could be reversed. Explain your hypothesis.*
g) *How might you test this hypothesis in a laboratory situation?*

Evidence for Evolution and Natural Selection

The evidence for evolution and natural selection is abundant and encompasses many different areas of biology.

The **fossil record** shows that some organisms have changed over time, some have died out or become **extinct**, and others have not changed a great deal.

The study of **comparative embryology** demonstrates that at early stages of development, distantly-related organisms possess similar structures – evidence of common ancestry. For example, at a very early stage of development, human embryos possess gill slits much like those of a fish.

The study of the anatomy of the adult stages of distantly-related organisms demonstrates common ancestry. Many organisms possess **homologous** structures. These are structures that while they may appear to be different, can actually be seen to have developed from the same original structure. For example, the similar number and placement of arm, wrist, and finger bones in diverse creatures such as humans, dogs, and whales show that they are all descended from a common ancestor. Other organisms possess **vestigial** structures. These structures are the "leftovers" of structures that were useful in ancestors, but serve no purpose today. Some whales and snakes, both lacking hind legs, possess small leg and pelvic bones within their bodies – evidence that their ancestors were legged creatures.

Modern molecular biology has shown that DNA and protein structures possessed by living organisms agree with evolutionary relationships that scientists had already established by the study of fossils, embryology, anatomy and other methods.

The modern classification of living organisms reflects the evolutionary descent (**phylogeny**) of organisms as opposed to just anatomical similarities.

Try These:

1. *If you look at a human skeleton several bones resembling tail vertebrae at the base of the pelvis are visible. What kind of structures do these bones represent and what do they indicate about human ancestry?*
2. *Despite the large differences in the lengths of their necks, both a mouse and a giraffe each have 7 neck vertebrae. What kind of structures are represented by the same numbers of neck vertebrae of such different-sized, but related animals?*

Patterns of Evolution

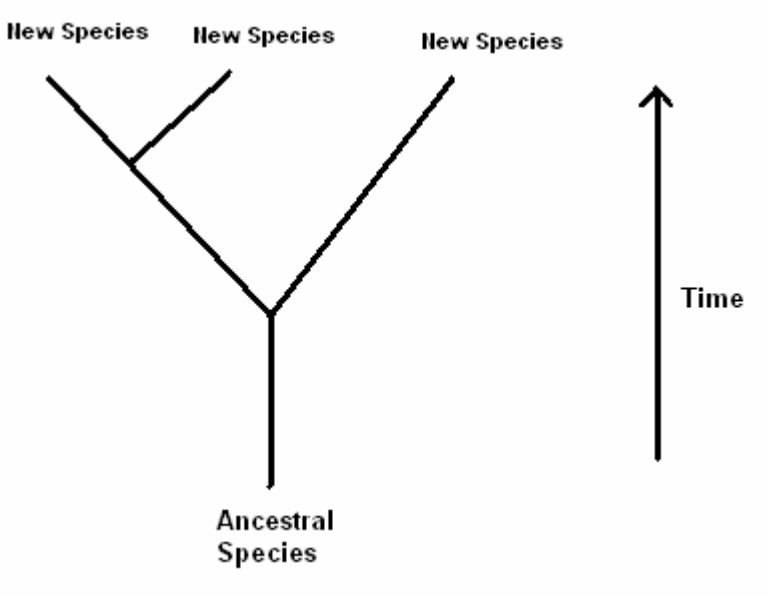
Natural selection, acting in different ways, has resulted in the great variety of species seen on our planet today. The common theme of this speciation is the adaptation of organisms to their particular environment. Those organisms that survive and reproduce are not "better" or stronger, they are simply better *adapted* to that particular environment.

In **coevolution**, two or more species evolve characteristics that result from a close association between those species. The characteristics of flowers and their pollinators or the structures and behaviors of parasites and hosts are examples of co-evolution.
In **convergent evolution**, two or more species that are only distantly related evolve similar behavior and appearance as a result of having to adapt to similar environments. A dolphin and a shark are distantly related with one being an air-breathing mammal and the other being a water-breathing fish, but both are streamlined, finned creatures that possess many similarities.

In **divergent evolution** two or more species that are derived from a common ancestor and closely-related evolve a range of different characteristics and behaviors as a result of adapting to different environments. In **adaptive radiation** (a type of divergent evolution) two or more species can develop from a common ancestor to take advantages of variations of natural resources in a particular habitat. The finches studied by Darwin on the Galapagos Islands are an example of this. Most likely descended from one common ancestor arriving on the islands many thousands of years ago, these finches have evolved into different forms, each specializing on eating a different food source present on the islands.

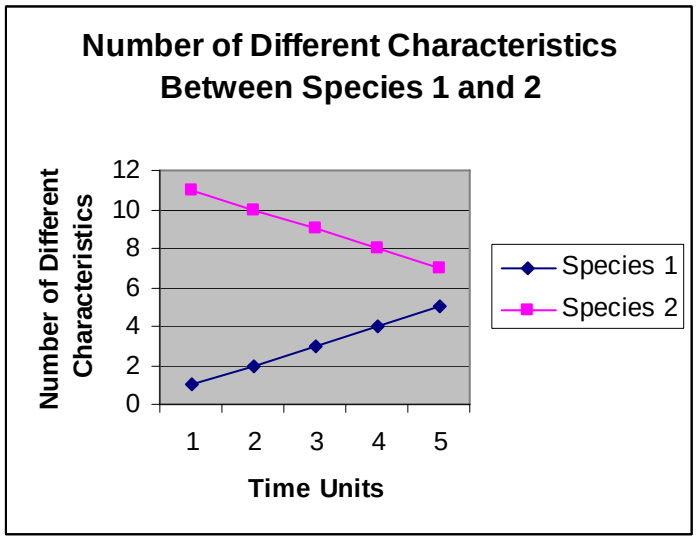
The principle of **punctuated equilibrium** helps explain several aspects of evolution that confused early researchers. Why for example, does the fossil record demonstrate long periods of time where no evolution appeared to occur and why do some present day species show little or no change when compared to ancient varieties? Punctuated equilibrium is the idea that species living in stable environments do not accumulate a large degree of evolutionary changes. If a species moves into a new environment or the existing environment changes, then the species is subject to a new set of selective "pressures" thus stimulating a rapid burst of evolutionary change and speciation.

Evolutionary change is not a ladder of progress with a species gradually moving higher and higher towards "perfection". While evolution is a change in species over time, those changes may accumulate relatively quickly or slowly depending on changes in the environment. Some species become extinct and others survive, but all branch off from common ancestors.



Try These:

1. *Study the graph below:*



Is this an example of convergent evolution or divergent evolution? Explain.

2. *Some critics of evolutionary theory state that evolution doesn't make sense since some organisms have remained relatively stable over time when the fossil record is examined. Explain why this criticism is unfounded based on the principle of punctuated equilibrium.*

3. *A tiger is clearly stronger than a jellyfish yet in some environments, a jellyfish would clearly be more evolutionarily "fit" than a tiger. In what sort of environment would a jellyfish be more fit than a tiger?*
4. *Research using your textbook or the internet to give examples of adaptive radiation besides Darwin's Galapagos finches.*

Vocabulary List for 9. Biological Evolution

1. uniformitarianism
2. age of the Earth
3. geological timetable
4. fossil record
5. Jean Baptiste de Lamarck
6. inheritance of acquired characteristics
7. Charles Darwin
8. Alfred Wallace
9. *On the Origin of Species by Means of Natural Selection*
10. descent with modification
11. natural selection
12. fitness
13. adaptation
14. extinct
15. comparative embryology
16. homologous
17. vestigial
18. phylogeny
19. coevolution
20. convergent evolution
21. divergent evolution
22. adaptive radiation
23. punctuated equilibrium

Biological Evolution Web Resources

http://www.pbs.org/wgbh/evolution/

http://evolution.berkeley.edu/evolibrary/article/0_0_0/history_01

http://evolution.berkeley.edu/evolibrary/article/0_0_0/history_14

http://evolution.berkeley.edu/evolibrary/article/0_0_0/medicine_01

10. DNA: Secret of Life

Deoxyribonucleic Acid often referred to as, DNA, was identified through scientific experimentation to transmit and store genetic information from one generation to another.

The scientists Watson and Crick first discovered DNA and made a model of it in the shape of a **double helix**, which resembles a twin spiral staircase. They were able to use data collected from other scientists to make and support their model of DNA.

DNA Structure

There are three parts to a DNA nucleotide: **deoxyribose** (sugar), a phosphate group and a nitrogenous base.

DNA has four types of bases which can be identified using Chargaff's rule. This rule states **purines** (large bases), equals **pyrimidines** (small bases). The purines are made up of two bases: adenine and guanine. The pyrimidines are also made up of two bases: thymine and cytosine. Chargaff's rule can be stated as adenine equals thymine and guanine equals cytosine or more easily as A=T and G=C, which is known as the **base pairing rule**.

DNA Replication

DNA is made up of two separate strands that are held together by hydrogen bonds. This is important when DNA **replicates** (makes a copy).

During replication the DNA is split by an enzyme (helicase), which breaks the hydrogen bonds. The point of separation is called a **replication fork.** Using the base pairing rules wherever there is an adenine base or an A, the **complimentary** (new strand), will have a thymine or a T. The DNA needs to be bonded back together. This is performed by another enzyme called **DNA polymerase.**

This process occurs for both strands of the DNA making two brand new, but identical, DNA strands.

For example:
Original DNA strand: GGC CAT TGA GCA TCA
Complimentary strand: CCG GTA ACT CGT AGT

Try This:

1. *You should be able to write the complimentary strand of DNA when the original strand is given.*

DNA: *GGC CTA ATT GCG AGC CTA*
Complimentary:

RNA

Ribonucleic Acid or RNA is the carrier of the genetic information from the nucleus out into the cytoplasm.

There are three main types of RNA: **mRNA** (messenger), **rRNA** (ribosomal) and **tRNA** (transfer).

Ribose is the sugar in RNA and there is no Thymine (T). Instead the base that is used is called Uracil (U).

Protein Synthesis

The whole process of converting genetic information from DNA into proteins is called **Gene expression**.

Gene expression can be broken down into two main parts transcription and translation.

Transcription

Transcription is converting the code from DNA into mRNA.

When converting DNA into mRNA we still use the base pairing rules with one exception we do not use the base thymine.

For example:
DNA strand: ACT TAG CTA GCA TCG
mRNA strand: **U**GA A**U**C GA**U** CG**U** AGC

In order to transcribe RNA from DNA another enzyme needs to be present, **RNA polymerase**.

Try This:

1. *You should be able to convert a DNA strand into a new RNA or mRNA strand. They both code the same way.*

DNA : TGC CGA ATA CGA TTG GAT
mRNA:

Translation

Translation is converting the code from RNA into proteins.

When converting mRNA code into proteins a codon is used. A **codon** is a three nucleotide sequence of mRNA (nuceoltide triplet). For example: AUG. These codons are specific in picking up particular amino acids. Scientists use a chart to show which codons represent particular amino acids.

Exons are portions of a gene that gets translated.

Introns are noncoding portions of DNA.

Tranposons are genes in a chromosome that have the ability to move.

A codon chart has been provided.

FIRST LETTER	SECOND LETTER U	SECOND LETTER C	SECOND LETTER A	SECOND LETTER G	THIRD LETTER
U	Phenylalanine	Serine	Tyrosine	Cysteine	U
	Phenylalanine	Serine	Tyrosine	Cysteine	C
	Leucine	Serine	Stop	Stop	A
	Leucine	Serine	Stop	Tryptophan	G
C	Leucine	Proline	Histidine	Arginine	U
	Leucine	Proline	Histidine	Arginine	C
	Leucine	Proline	Glutamine	Arginine	A
	Leucine	Proline	Glutamine	Arginine	G
A	Isoleucine	Threonine	Asparagine	Serine	U
	Isoleucine	Threonine	Asparagine	Serine	C
	Isoleucine	Threonine	Lysine	Arginine	A
	(Start) Methionine	Threonine	Lysine	Arginine	G
G	Valine	Alanine	Aspartate	Glycine	U
	Valine	Alanine	Aspartate	Glycine	C
	Valine	Alanine	Glutamate	Glycine	A
	Valine	Alanine	Glutamate	Glycine	G

http://images.encarta.msn.com/xrefmedia/aencmed/targets/illus/tab/T014282A.gif

Amino acids join together by **peptide bonds** forming proteins.

For example:

mRNA strand:	AUG	AGU	AUC	AAU	UAG
Codons:	Methionine	Serine	Isoleucine	Asparagine	Stop

An **anticodon** is a nucleotide triplet made from the tRNA. Pairing of an anticodon with a codon ensures that the amino acids are added to the growing **polypeptide** chain. This chain of amino acids forms a protein.

For example:
mRNA strand: AUG AGU AUC AAU UAG
tRNA strand: UAC UCA UAG UUA AUC

There are two special codons and they are the stop and start codon. Typically AUG is the start of the protein and UAA,UAG, or UGA will end the protein. This tells the organism where to begin protein production and where to stop protein production.

Try These:

1. *You should be able to convert mRNA into codons and you should be able to make anticodons of tRNA.*

mRNA : AUG CAG UCG GGC AGU CGA UGA
codon :
anticodon:

Mutations

Mutations are changes to the genes or the genetic code. Mutations can occur for any number of reasons such as the inserting or deleting of a base spontaneously. Environmental factors such as UV light or exposure to radiation are called **mutagens** because they cause mutations.

These altered genes can be passed on to every cell that develops from it. This can result in the cell being benefited, harmed or have little effect on the offspring's success in its environment.

In sexually reproducing organisms only mutations in **germ cells** (sperm and egg) can be passed on to an organism's offspring.

Vocabulary list for 10. DNA: Secret of Life

1. Double Helix
2. Deoxyribose
3. Purines
4. Pyrimidines
5. Base Pairing Rule
6. Replication
7. Helicase
8. Replication Fork
9. Complimentary
10. DNA polymerase
11. mRNA
12. rRNA
13. tRNA

14. Gene Expression
15. Transcription
16. Translation
17. RNA Polymerase
18. Exons
19. Introns
20. Tranposons
21. Peptide Bond
22. Anticodon
23. Polypeptide Bond
24. Mutation
25. Mutagen
26. Germ Cells

DNA: Secret of Life Web Resources

http://www.biologycorner.com/bio1/DNA.html

http://www.bio.miami.edu/dana/104/104F02_10.html

http://www.ornl.gov/sci/techresources/Human_Genome/publicat/primer/fig4.html

http://www.biologycorner.com/bio4/notes/gene-expression.php

http://nobelprize.org/educational_games/medicine/dna/b/translation/translation.html

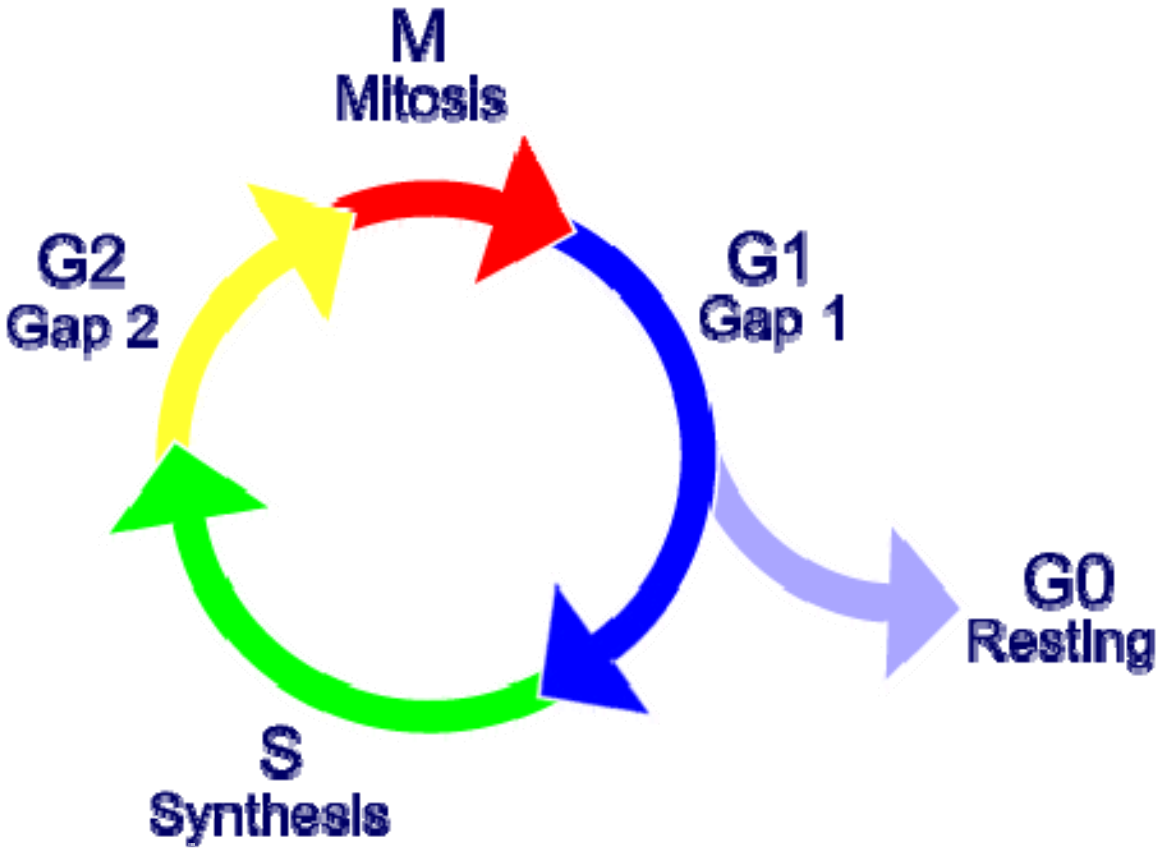
http://uk.encarta.msn.com/media_461541337_761559887_-1_1/Different_Types_of_RNA.html

11. Reproduction

Cellular Reproduction

Why do cells reproduce? The cell membrane (surface area) brings nutrients and other necessary materials into the cell and removes wastes from the cell. The interior of the cell (volume) increases. When the volume gets too demanding, when the inside of the cell needs more things than the surface can provide, the cell must die or reproduce. During it's lifetime a cell goes through a cycle – a series of events. This is the cell cycle.

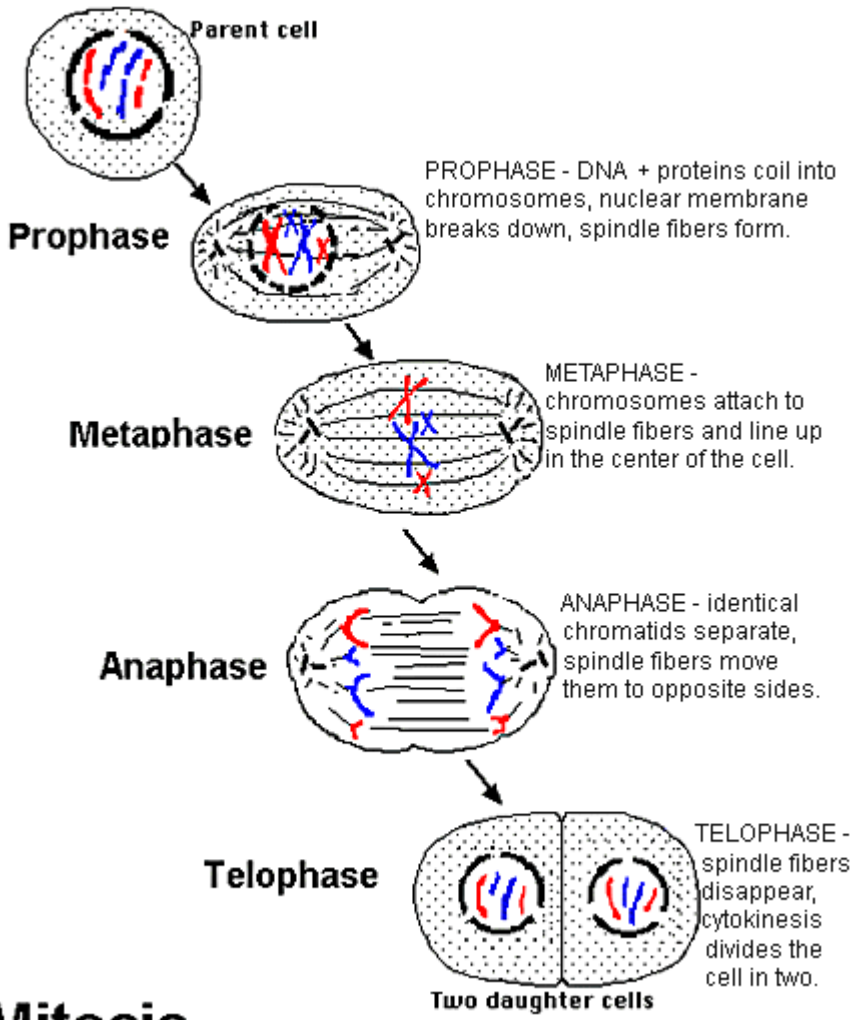
THE CELL CYCLE



(http://www.med.unibs.it/~marchesi/cellcycle.gif)

G1 – growth and chromosomes prepare to replicate
G0 – a resting stage for some cells
S - DNA doubles (interphase occurs during this stage)
G2 – the cell prepares to divide
M - mitosis – the cell divides
Cyclins are proteins that regulate cellular reproduction by switching on different stages.

Interphase is the most active growth phase for the cell and the phase in which DNA replicates. It is also the longest phase. It is not part of mitosis. Mitosis begins after G2.



(**Picture - http://library.thinkquest.org/C0123260/basic%20knowledge/images/basic%20knowledge/cell%20division/mitosis.gif**)

Cytokinesis (division of the cytoplasm) occurs at the end of telophase.

Chromosomes that are similar and carry genes for the same traits are **homologous chromosomes.**

Mitosis produces two cells, identical to the parent cell. The cells are **diploid** (2n).

This means they contain a complete set of chromosomes, all the homologous pairs.

This is how normal cells (body cells, somatic cells) reproduce. Each cell has the same number of chromosomes as the cell it came from. But you do not always want the cells you produce to have the diploid number of chromosomes.

If **gametes** (sex cells) had all the chromosomes**, fertilization** (union of **gametes)** would produce a **zygote** (fertilized egg) with twice the normal number of chromosomes.

Sex cells are produced differently. **Meiosis** is the process of producing gametes and reducing the number of chromosomes in each sex cell in half. But each sex cell must have half of the complete set of genes. Each sex cell must have one of each pair of homologous chromosomes. Gametes have a **haploid** (n) number of chromosomes – half the original number, and one from each pair of homologous chromosomes.

Meiosis

In meiosis, sex cells (gametes) are made. There is another division and the chromosomes line up differently than in mitosis. The result is the formation of four cells from the original one. Each of the new cells has ½ the number of chromosomes. When fertilization occurs, ½ + ½ = the normal number of chromosomes.

In humans:

23 chromosomes + 23 chromosomes = 46 chromosomes.
The chromosome number is back to diploid after fertilization.

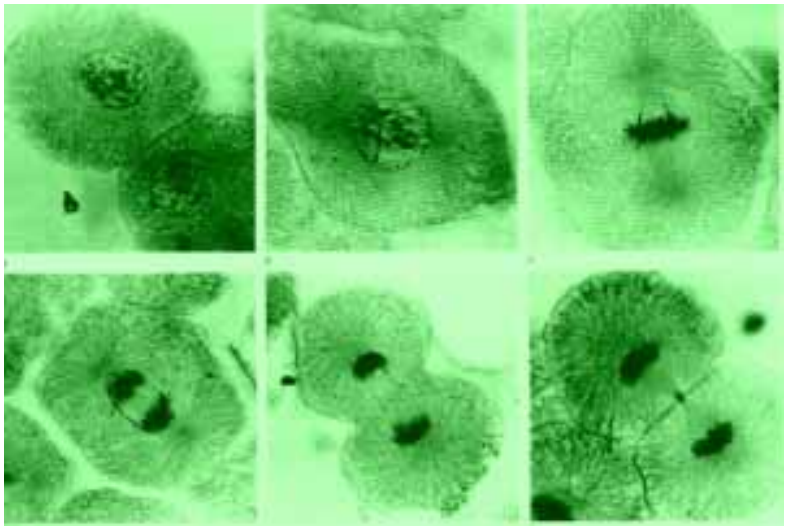
In mitosis the chromosomes line up individually. In meiosis the chromosomes that make homologous pairs line up together. This is to make sure each new gamete has one of the original chromosomes from each homologous pair.

When homologous chromosomes are lined up together, they sometimes overlap. This overlapping allows an exchange of chromosome pieces between the two. This exchange of alternate forms of genes coding for the same characteristic (**alleles**) is called **crossing over**.

Sometimes the homologous chromosomes do not separate correctly. One sperm cell might miss a chromosome because it stayed together and went to the other sperm. This failure of the homologous chromosomes to separate correctly is called **nondisjunction**. The results are gametes with the wrong number of chromosomes and, if fertilization occurs, the results can cause serious mutations in the offspring.

Try These:

1. *Explain how crossing over increases genetic variety in a species.*
2. *See if you can tell which phase of mitosis is represented in each of these real cell pictures:*



(http://www.karlloren.com/biopsy/images/mitosis.jpg)

3. *Nerve cells like those in your spinal cord and brain do not undergo mitosis when they are mature. Cancer cells undergo uncontrolled mitosis. How do these reproductive properties contribute to the medical disorders related to brain and spinal cord injury and to cancer treatment?*

Vocabulary List for 11. Reproduction

1. Cyclins
2. Cytokinesis
3. Homologous chromosomes
4. Diploid
5. Gametes
6. Fertilization
7. Zygote
8. Meiosis
9. Haploid
10. Alleles
11. Crossing over
12. Nondisjunction

Reproduction Web Resources

http://www.pbs.org/wgbh/nova/baby/divi_flash.html

http://www.bishopstopford.com/faculties/science/arthur/mitosis%20drag%20&%20drop.swf

http://highered.mcgraw-hill.com/sites/0072437316/student_view0/chapter11/animations.html#

http://www.wisc-online.com/objects/index_tj.asp?objID=AP13604

http://science.education.nih.gov/supplements/nih1/cancer/activities/activity2_animations.htm

12. Heredity

Heredity is the transmission of characteristics from parents to offspring.

The principle of **probability** is the likelihood that something will occur. This can be used to predict the outcomes of genetic crosses.

This was first discovered by Gregor Mendel's work with garden variety pea plants. His mathematical documentation led future scientists on the road to success in the areas of probability and genetics.

Mendelian chart of pea plants

Trait	Seed Shape	Seed Color	Pod Shape	Plant Height
Parent 1	Round	Yellow	Smooth	Tall
Parent 2	Wrinkled	Green	Constricted	Short

When two parent organisms are crossed together the resulting offspring is known as the **F1 generation.**

Trait	Seed Shape	Seed Color	Pod Shape	Plant Height
F1	Round	Yellow	Smooth	Tall

In Mendel's experiment all the F1 plants showed the characteristics of Parent 1. Most people believed that there would be some sort of blending between the two parents but this was not true in the case of pea plants. When Mendel crossed members of the F1 generation with themselves he got some interesting results.

When two F1 generation organisms are crossed the result would be the **F2 generation.**

Trait	Seed Shape	Results	Seed Color	Results
F2	Round	5,474	Yellow	6,022
	Wrinkled	1,850	Green	2,001

The characteristics that were supposedly lost in the F1 generation (wrinkled plants and green peas) came back in the F2 generation. If we reduce the number of plants (5,474/1,850 or 6,022/2,001) we get an almost perfect 3 to 1 ratio or 3:1. This would prove to be very important in the field of **genetics.** (the study of heredity)

Scientists now have the ability to predict what those F1 and F2 generations will look like and what is their genetic make-up.

When flipping a coin you have a 50% probability to get heads or tails. If you were to flip that coin 100 times you should be able to predict about how many times heads will come up. That actual number may not be exactly the same as the prediction if you were to perform that experiment.

Try These:

1. *If you were to roll a die 102 times how many times would the number four come out using the rules of probability?*
2. *If you picked one card from a standard deck of 52 playing cards, what would be the probability of picking the ace of spades?*

Genetics

The **phenotype** is the physical characteristic of an organism and the **genotype** is the genetic make up of the organism. Both phenotype and genotype can be expressed as a number ratio.

Traits are the characteristics of an organism. For example traits of a pea plant would be seed shape, pod color or plant height. **Alleles** are the different forms of the genes and usually come in pairs. **Genes** are factors located on a chromosome. Using the traits just mentioned the alleles would be round or wrinkled, green or yellow and tall or short, respectively.

Alleles

There are two types of alleles: **dominant** which are more likely to be expressed and **recessive** which are least likely to be expressed.

Scientists usually depict dominant and recessive alleles by using letters. If an allele is dominant we use a capital letter and if an allele is recessive we use a lower case letter. It is important that you use the same letter, such as (A, a)

Since offspring have two parents they inherit one type of allele from each parent resulting in two alleles.

Two dominant alleles, AA, is known as **homozygous dominant.**

Two recessive alleles, aa, is known as **homozygous recessive.**

One dominant allele and one recessive allele, Aa, is known as **heterozygous**.

For example:

Trait = Plant Height

AA= Tall

Aa = Tall – this one is tall because it contains a dominant allele

aa = short

Try These:

You should be able to make up your own traits or alleles with the appropriate letters. (either capital or lower case).

1. *Make up the two corresponding alleles when you are given plant height as the trait.*
2. *Show the letters that could represent smooth pods and constricted pods.*

Monohybrid Cross

When crossing two parents with a single trait and two corresponding alleles it is called a **monohybrid cross.**

Using Mendel's chart you should be able to tell which alleles are dominant and which ones are recessive.

A punnett square is a way to predict the outcome of the offspring from two parents.

Using Mendel's experiment we will now be able to see why the events that took place from the parents, to the F1 generation, and to the F2 generation occurred.

We will be using seed shape as our test subject.
Trait = Seed Shape
Allele 1 = Round (This is dominant so we will use a capital letter) A
Allele 2 = Wrinkled (This is recessive so we will use a lower case letter) a

We will first cross a homozygous round parent #1 (AA) with a homozygous recessive parent #2 (aa).
AA x aa

During gamete formation we know that a parent can only donate one allele each this is known as the **law of segregation**.

Parent#1 can only donate capital A's
Parent #2 can only donate a lower case a's

	a	a
A	Aa	Aa
A	Aa	Aa

All of the F1 generation would be Aa resulting in them all being round. This is the same thing that happened with Mendel's experiment.

When crossing the F1 generation with the F1 generation you should be able to predict the out come.

Cross two heterozygous round plants. Aa x Aa

	A	a
A		
a		

After finishing the next section you should be able to see that this is exactly what happens in Mendel's experiment.

Determining Ratios

We can determine the genotype and the phenotype in a mathematical relationship called a ratio.

The genotype is determined by how many offspring are homozygous dominant followed by heterozygous followed by homozygous recessive.

The phenotype is determined by how many of the offspring have at least one dominant allele and how many have two recessive alleles.
For example:

	a	a
A	Aa	Aa
A	Aa	Aa

Using this cross we can determine the genotype and phenotype of the offspring.

The genotype = 0:4:0
The first number shows how many boxes are homozygous dominant (AA),
The second number shows how many boxes are heterozygous (Aa)
The third number shows how many boxes are homozygous recessive (aa).

The phenotype = 4:0
The first number shows how many boxes have at least one dominant letter (A_).
The underscore just shows that the next letter does not matter. As long as the offspring has one capital letter it will show the dominant trait.
The second number shows how many boxes have two recessive letters (aa).

Try These:

You should be able to make and fill-in monohybrid crosses when information is given. There are six monohybrid crosses which you should be able to complete with genotypes and phenotypes.

1. *AA x AA*
2. *BB x Bb*
3. *DD x dd*
4. *Ee x Ee*
5. *Gg x gg*
6. *rr x rr*

Sometimes word problems may be given.

1. *Cross a heterozygous tall plant with a short one.*
2. *Cross a plant that is homozygous for round seeds and one that is heterozygous for round seeds.*

Dihybrid Cross

A **dihybrid cross** is a cross that involves two traits, such as seed shape and plant height.

Each trait has its own set of alleles and its own set of letters.
For example:

Trait #1 Seed Shape
AA or Aa = Round
aa = wrinkled

Trait #2 Plant Height
BB or Bb = Tall
bb = short

The parents would then look something like this: AaBb x AAbb.
Parent #1 would be Round and Tall while Parent #2 would be Round and short.

We can also use a punnett square to predict outcomes of parents who are being crossed to have F1 generation offspring.

In order to produce gametes in a dihybrid cross we have to use the **law of independent assortment**, which is when two, or more pairs of alleles segregate independently of one another during gamete formation.

The gametes formed by parent #1 would be AB, Ab, aB, and ab.
The gametes formed by parent #2 would be Ab, Ab, Ab, and Ab.

The punnett square would look like this:

	Ab	Ab	Ab	Ab
AB	AABb	AABb	AABb	AABb
Ab	AAbb	AAbb	AAbb	AAbb
aB	AaBb	AaBb	AaBb	AaBb
ab	Aabb	Aabb	Aabb	Aabb

The phenotypes for the offspring would be 50% Round and Tall and 50% Round and short.

Try These:

You should be able to cross the parents and come up the four different gametes for each. You should be able to fill in the punnett square and describe the different phenotypes.

Use seed shape and plant height as your two traits:

1. *AABB x aabb*
2. *AaBb x AaBb*

Incomplete Dominance

Incomplete dominance is a blending or an intermediate form of the traits.

Snapdragons and Japanese four o'clocks are two types of flowering plants that exhibit this behavior.

Trait = Flower color
AA = Red
Aa = Pink
aa = White

In traditional complete dominant crosses the heterozygous (Aa) individual would carry the dominant trait, in this case it blends with the recessive trait, red and white makes pink.

We can also show this in a punnett square:

Cross a pink snapdragon with a white one. Aa x aa

	a	a
A	Aa	Aa
a	aa	aa

50% are Pink and 50% are white.

Try These:

You should be able to recognize what the parents' genotypes would be and state the offsprings' phenotype as a percentage.

1. *Cross a red Japanese four o'clock with a white one.*
2. *Cross a pink snapdragon with a red one.*

Codominance

Codominance is when both genes are equally expressed. This happens in certain cow hair and chicken feathers.
Since there is no recessive allele we use all capital letters.

For example:
Trait: Feather color
BB – Black
BW – Speckled
WW – White

The BW or heterozygous individual is not a blending as in incomplete dominance. They are equally expressed and have an equal number of white and black feathers.

We can also show this in a punnett square:
Cross a speckled chicken and one with white feathers. BW x WW

	W	W
B	BW	BW
W	WW	WW

50% are speckled and 50% are white.

Try These:

You should be able to recognize what the parents' genotypes would be and state the offsprings' phenotype as a percentage.

1. *Cross a black feathered chicken and a white one.*
2. *Cross a speckled chicken and a black one.*

Multiple alleles

Multiple alleles occur when genes that have more than two alleles control the trait. This is the case in human blood types. There are four types of blood, A, B, AB and O.

For example:
Trait: Blood Types
A = $I^A I^A$ or $I^A i$
B = $I^B I^B$ or $I^B i$
AB = $I^A I^B$
O = ii
$I^A i$ and $I^B i$ are heterozygous.

We can also show this in a punnett square:
Cross a homozygous B person with a person who has AB blood. BB x AB

	I^B	I^B
I^A	$I^A I^B$	$I^A I^B$
I^B	$I^B I^B$	$I^B I^B$

50% would have AB blood and 50% would have B blood.

Try These:

You should be able to recognize what the parents' genotypes would be and state the offsprings' phenotype as a percentage.

1. *Cross a person who is heterozygous for A blood and a person who has O blood.*
2. *If a child is born with O type blood and the mom has A type blood and the dad has A blood, is this possible? If so, show your work.*
3. *Cross a person with AB blood and a person with O blood.*

Sex linked inheritance

Sex linked inheritance is when the traits are transmitted on the **sex chromosomes**. In humans this is the 23rd pair. Color blindness and hemophilia are two examples. **Hemophilia** is when a person cannot stop bleeding on their own, they are missing a protein that clots blood.

The 23rd pair for males is XY, for females it is XX. The Y chromosome is not as large as the X and some alleles are missing. This means that for some recessive traits males only have to have one allele to get the trait. Females would have to get two. It is easier for a man to get sex-linked disorders than it is for a woman.

Trait: Hemophilia
Male:
X^H Y = Normal
X^h Y = Has the disorder

Female:
X^H X^H = Normal
X^H X^h = Carrier-has no side effects
X^h X^h = Has the disorder

We can also show this in a punnett square:
Cross a man who is normal with a woman carrier. X^H Y x X^H X^h

	X^H	Y
X^H	$X^H X^H$	X^H Y
X^h	$X^H X^h$	X^h Y

50% of the females are normal and 50% of the females are carriers.
50% of the males are normal and 50% of the males have the disorder.

Try These:

You should be able to recognize what the parents' genotypes would be and state the offsprings' phenotype as a percentage.

1. *Cross a man with hemophilia and a woman who is a carrier.*
2. *Cross a woman who is normal with a man who is normal.*

Genetic Engineering

Genetic engineering is the process of moving genes from one organism to another to improve different varieties of plants, animals and medicines.

Artificial selection is the breeding of organisms by humans for particular traits. This can be seen in domestic animals and in plants. Many different breeds of dogs are interbred to get new breeds that people want, this type of breeding is called designer dogs. For example, a poodle is a great breed of dog for people who are allergic to dog dander, but people like more playful dogs like a golden retriever. Breeding a poodle and a golden retriever gives you the new designer dog, a golden doodle.

This can also be done with plants. Breeding two corn plants that are six feet high and have 15 ears of corn each should give you offspring with the same phenotypic qualities.

Genetic engineering has also given people in the medicine industry a new way to make drugs, such as insulin or kumatin. This is very beneficial for people who have diabetes or high blood pressure.

Vocabulary List for 12. Heredity

1. Heredity
2. Probability
3. F1 generation
4. F2 generation
5. Genetics
6. Phenotype
7. Genotype
8. Traits
9. Alleles
10. Genes
11. Dominance
12. Recessive
13. Homozygous dominant
14. Homozygous recessive
15. Heterozygous

16. Monohybrid Cross
17. Law of segregation
18. Dihybrid Cross
19. Incomplete dominance
20. Codominance
21. Multiple alleles
22. Sex-linked inheritance
23. Sex chromosomes
24. Hemophilia
25. Genetic engineering
26. Artificial selection

Ch. 12 Heredity Web Resources

http://images.google.com/imgres?imgurl=http://academic.kellogg.cc.mi.us/herbrandsonc/bio111/images/13_11.jpg&imgrefurl=http://academic.kellogg.cc.mi.us/herbrandsonc/bio111/genetics.htm&h=505&w=900&sz=153&hl=en&start=1&tbnid=9mu-JA3iswj1pM:&tbnh=82&tbnw=146&prev=/images%3Fq%3Dmonohybrid%2Bcrosses%26gbv%3D2%26svnum%3D10%26hl%3Den

http://images.google.com/imgres?imgurl=http://www.rogers.k12.ar.us/users/ehutches/dihybrid_cross.gif&imgrefurl=http://www.rogers.k12.ar.us/users/ehutches/advgenetics.phtml&h=480&w=385&sz=53&hl=en&start=1&tbnid=AZoFKEh4DOFDKM:&tbnh=129&tbnw=103&prev=/images%3Fq%3Ddihybrid%2Bcrosses%26gbv%3D2%26svnum%3D10%26hl%3Den

13. Environmental Studies

Ecology and the Biosphere

The **environment** is a system of independent components affected by natural phenomena and human activity.

Ecology is the study of how organisms interact with each other and with their environment.

The **biosphere** is a term used to describe the portion of the Earth where living things are found. The Earth's forests, grasslands, deserts, oceans, etc. are all part of the biosphere. Some parts of the biosphere may have more living organisms than others. For example there are many more organisms inhabiting the tropical rainforests than the bottom of the cold, dark ocean trenches, but both still are part of the biosphere because they support life.

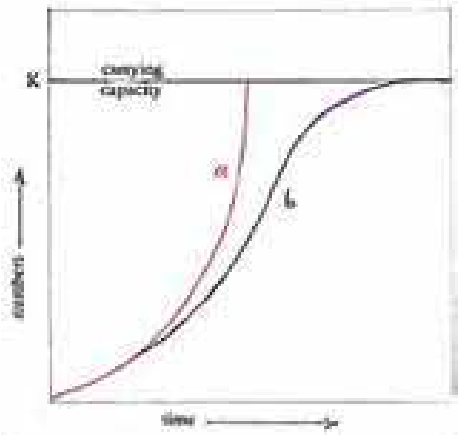
A **biome** is a large region of the Earth's landmass possessing a characteristic climate and organisms. Some of the Earth's major biomes are tropical rain forests, temperate forests, boreal forests, deserts, temperate grasslands, tropical grasslands and tundra

An **ecosystem** describes all of the organisms living in a particular place and their environment. The living component of an ecosystem is called the **biotic** component and the nonliving component is called the **abiotic** component. If you were describing a forest ecosystem, then the trees and animals would be examples of biotic factors and the soil, water, and air would be examples of abiotic factors. Sometimes abiotic factors are non-physical things such as sunlight or temperature.

An ecosystem may contain many different **habitats** or places where organisms live. In a forest ecosystem there is a soil habitat, a forest floor habitat, and other habitats where organisms live.

All of the organisms living in a particular place are known as a **community**. In a forest, the soil community might include fungi, worms, moles and other organisms. The canopy community would include the trees, birds, squirrels and other organisms.

A **population** consists of all of the members of one particular species. For example, all of the squirrels in the forest canopy would make up a population. Populations change over time and are affected by a great many factors. Usually a population will grow rapidly in what is known as **exponential growth**. Eventually **limiting factors** such as decreasing food supply or disease causes the growth to level off in a pattern known as **logistic growth**. When a population levels off in this fashion, it is said that the population has reached the **carrying capacity** of the environment.



Population growth curve where "a" represents exponential growth and "b" represents logistical growth.

Try These:

1. *Place these ecological definitions in order from the largest to smallest in terms of the amount of organisms it contains:*
   ecosystem, community, population, biosphere, biome
2. *In which biome do you currently live?*
3. *All of the chimpanzees in a valley would make up a community, population, or ecosystem?*
4. *What kind of growth curve is shown by the population trend for humans?*

Relationships Between Organisms – Energy Flow

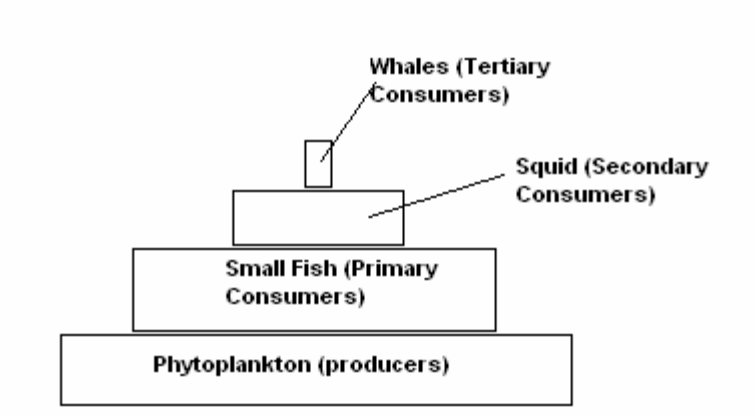
The interaction between living things with each other and their environment is a very complex system involving many components.

Living things that produce their own food through photosynthesis or chemosynthesis are called **producers** or **autotrophs**. Examples of autotrophs are green plants such as the trees in forests and phytoplankton on the ocean's surface or chemosynthetic bacteria found in deep sea volcanic vents. All of these organisms produce their own food from raw materials in their surroundings. Producers are important because they convert the raw energy found in sunlight and chemicals into carbohydrates and other molecules used by consumers.

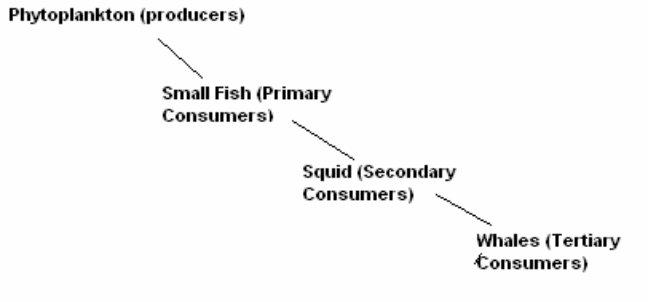
Living things that get their energy by consuming other living things are called **consumers** or **heterotrophs**. Examples of heterotrophs are tigers, cows or mushrooms. Each one consumes a different food source, but none of them produce the food themselves. **Carnivores** such as tigers are consumers that eat meat while **herbivores** such as cows are consumers that eat plants.

Some heterotrophs that specialize in breaking down the remains of dead organisms are called **decomposers** or **saprotrophs**. Mushrooms and bacteria are examples of saprotrophs. They are important in returning valuable nutrients from dead organisms back into the soil, water and atmosphere where they are available for the producers.

An **ecological pyramid** is a way of describing the energy flow in an ecosystem. In such a pyramid, the base is formed by the producers since they contain the most energy. The herbivores form the next smaller upper block of the pyramid and the carnivores form the remaining smaller upper blocks. Less and less energy is available to organisms with each higher step on the pyramid:



The ecological pyramid above could also be described as a food chain. In a **food chain**, the flow of energy is shown with a series of arrows interconnecting the parts of the system:



Relationships Between Organisms – Coevolution

Organisms interact in other ways besides energy flow. Through **coevolution** or evolving together, many organisms have become linked together in a variety of ways. The living organisms in an ecosystem interact with each other and **compete** for resources such as sunlight, food and living space. Each organism in an ecosystem occupies a particular **niche** or "place" in that ecosystem by consuming a particular food source, producing certain substances and physically occupying a particular habitat among other things. This serves to reduce competition between different species though competition between individuals occupying the same niche is always present.

Species have evolved particular interactions through evolution. **Predators** are carnivores that feed on other organisms (their **prey**). As the population of prey organisms changes, the predators change also. For example, prey organisms may evolve the ability to run away from predators faster and the predator organisms may respond in turn by evolving the ability to increase their speed as well.

Other forms of coevolutionary interactions are mutualism, commensalism and parasitism. **Mutualism** describes an interaction between species where both organisms obtain some sort of benefit. For example, there are insects that survive by sucking the sap of plants. In some cases these insects are protected by ants. The ants chase away any would be predators and the sap sucking insects in turn, provide the ants with drops of sugary fluid. **Commensalism** describes an interaction between species where one organism benefits and the other does not. A snake living in the burrow of a tortoise is an example of commensalism. The snake benefits by having the tortoise provide it with a living space. The tortoise is indifferent to the presence of the snake and obtains no benefit from its presence. In **parasitism** one organism benefits and the other is harmed. And example of parasitism is the disease malaria. The malaria parasite is a microbe that lives in and feeds on the blood cells of humans. The parasite benefits by obtaining a living space and food source. The human host of the disease is harmed by its presence.

Try These:

1. *Use these populations: hawks, grass, snakes, and mice to draw an ecological pyramid, labeling each consumer level as well.*
2. *Decide if each example below is an example of mutualism, commensalism, or parasitism and explain why:*

   A rattlesnake feeds on mice.
   A tick sucks the blood of a dog.
   A bird follows a water buffalo and feeds on the insects disturbed by the buffalo's feet.
   Bacteria living in the human digestive system help us digest food.

Nutrient Cycling

Unlike energy which flows in one direction through an ecosystem and is eventually lost as heat, the nutrients in an ecosystem are continually recycled over time. In the **water cycle**, water molecules are evaporated from the surface of the sea and other large bodies of water. This water vapor rises into the atmosphere where it is cooled and condensed into droplets of liquid water in the form of clouds. When the cloud droplets become too large and

heavy to stay aloft, they fall to the earth as rain, snow and other precipitation. This precipitation runs off the land and enters rivers and the groundwater system and eventually makes its way back to the sea where the cycle can continue.

In the **carbon cycle**, carbon dioxide gas in the atmosphere is absorbed by plants during photosynthesis and changed into other forms of carbon-containing molecules such as sugars and cellulose. Organisms that consume these materials release carbon dioxide back into the atmosphere as a by-product of respiration. The carbon-containing materials also may be stored in the earth as fossil fuels such as coal and petroleum

In the **nitrogen cycle** atmospheric nitrogen, which is largely chemically inactive, is converted by bacteria living in the soil and in the roots of certain types of plants into chemical forms that can be utilized by plants. The nitrogen-containing nutrients are utilized by plants and returned to the soil by the death of the plants and animals as well as through waste products produced by the animals. Certain bacteria in the soil also convert some of the nitrogen compounds in the soil back into atmospheric nitrogen.

Try These:

1. *In the carbon cycle, what process absorbs carbon dioxide from the atmosphere?*
2. *If bacteria in the soil and in plant roots convert atmospheric nitrogen into nitrogen compounds used by plants, why doesn't all the nitrogen in the atmosphere eventually get used up?*

Succession

When an area of bare soil is left undisturbed, seeds of various plants will eventually be deposited by wind, birds and from other sources. Over time these seeds will sprout and a community of plants will begin to colonize the landscape. Eventually new types of plants will replace the original ones and over time the area will slowly change from one type of plant community to another. This pattern of change from bare soil to different types of plant communities is called **succession**. Eventually a stable **climax community** (usually a forest community) will result and the ecosystem will remain in equilibrium until it is disturbed. Succession occurs in aquatic ecosystems as well. A nutrient-poor, deep water, lake with low species diversity known as an **oligotrophic** ecosystem will slowly change into a shallow, vegetation and species-rich environment known as a **eutrophic** ecosystem as nutrients collect in a body of water over time.

Try These:

1. *Based on what you know of a eutrophic environment, what do you think is meant by the term "eutrophication"?*
2. *What would happen to your front lawn if no one ever mowed it again?*

Human Effects on the Environment

Human activities greatly affect the environment and it is essential that humans continue to use scientific methods to assess the degree of environmental impact caused by human activity.

Humans have disrupted the carbon cycle by burning fossil fuels for energy, thus releasing large amounts of carbon dioxide back into the atmosphere that would otherwise have remained trapped in the earth. Evidence is accumulating that these recent increases of atmospheric carbon dioxide are leading to a gradual increase in the earth's temperature in a process known as the **greenhouse effect**. Carbon dioxide and other gases act like the glass of a greenhouse, allowing light energy from the sun to reach the surface where it is converted to heat which can then not escape back into the atmosphere. That **global warming** of the Earth's atmosphere has occurred in recent years is fairly certain. The extent to which it is being caused by human disruption of the carbon cycle is still debated in scientific circles, and much of this debate has become a political, rather than scientific discussion.

The water cycle has been disrupted by human activity when pollutants such as gaseous oxides of sulfur and nitrogen have been released into the atmosphere as a by-product of industry. These gases decrease the pH of the rainwater falling to Earth resulting in **acid rain**. Acid rain is responsible for decreased survivability of aquatic fresh water organisms and the decreased availability of nutrients to terrestrial plants.

The earth's atmosphere as been affected by human-caused pollutants in other ways. Chlorofluorocarbons (CFCs) released into the atmosphere have the ability to reduce the formation of ozone in the upper atmosphere. CFC molecules inhibit the formation of ozone and once a CFC molecule has destroyed one ozone molecule it is ready to destroy another in a process that can last for many years before the CFC molecule disintegrates. Destruction of the **ozone layer** in this fashion may result in increased ultraviolet radiation reaching the Earth's surface and produce many damaging effects on organisms exposed to the increasing radiation.

Try These:

1. *Explain how acid rain harms the environment?*
2. *Devise an investigation to test the hypothesis that "acid rain" inhibits the growth of pollen tubes in plants. What would your control be?*

3. *When discussing ozone depletion, students often ask why we can't simply manufacture ozone down here at the Earth's surface and transport it to the upper atmosphere where it is disappearing from the ozone layer. Can you think of a reason why such a plan would not work?*

Vocabulary List for 13. Environmental Studies

1. environment
2. ecology
3. biosphere
4. biome
5. ecosystem
6. biotic
7. abiotic
8. habitat
9. community
10. population
11. exponential growth
12. limiting factors
13. logistic growth
14. carrying capacity
15. producer
16. autotroph
17. consumer
18. heterotroph
19. carnivore
20. herbivore
21. decomposer
22. saprotroph
23. ecological pyramid
24. food chain
25. competition
26. coevolution
27. niche
28. predator
29. prey
30. mutualism
31. commensalism
32. parasitism
33. water cycle
34. carbon cycle
35. nitrogen cycle
36. succession
37. climax community
38. oligotrophic
39. eutrophic

40. greenhouse effect
41. global warming
42. acid rain
43. ozone layer

Environmental Studies Web Resources

http://www.policyalmanac.org/environment/archive/ozone.shtml

http://www.informaction.org/cgi-bin/gPage.pl?menu=menua.txt&main=soilerosion_gen.txt&s=Soil+erosion

http://www.marietta.edu/~biol/102/ecosystem.html#Pyramids5

http://www.marietta.edu/~biol/102/ecosystem.html#BioGeoChemicalCycles8

http://www.physicalgeography.net/fundamentals/4e.html

Relate the structure of molecules to their function in cellular structure and metabolism.

A student designed an experiment to see if plants grow better when watered with a sugar solution. He divided the plants into six groups, measured the initial height of each plant, and calculated the average height for each group. Once a week for two months, he watered the plants in each group using a different sugar solution for each plant group. At the end of two months, he measured the final height of each plant and calculated the average height for each group. The student's data are shown in the table below.

EFFECT OF SUGAR SOLUTION ON THE HEIGHT OF PLANTS

Plant Group	Percent Sugar Solution	Average Initial Height (centimeters)	Average Final Height (centimeters)
A	0	2	30
B	10	2	28
C	20	3	15
D	30	2	10
E	40	3	(died)
F	50	3	(died)

Based on the data, write a response in paragraph form that addresses each of the following:

1. Explain the biological processes responsible for the data obtained for plant groups A through F.
2. Explain why plant group A experienced the largest increase in height.
3. Explain why the plants in Plant Groups E and F died.
4. Write a hypothesis that you might test in a future experiment now that you have these data as prior knowledge.
5. Graph percent sugar solution versus average final height.

(5.5.12 A 2)

Explain how plants convert light energy to chemical energy.

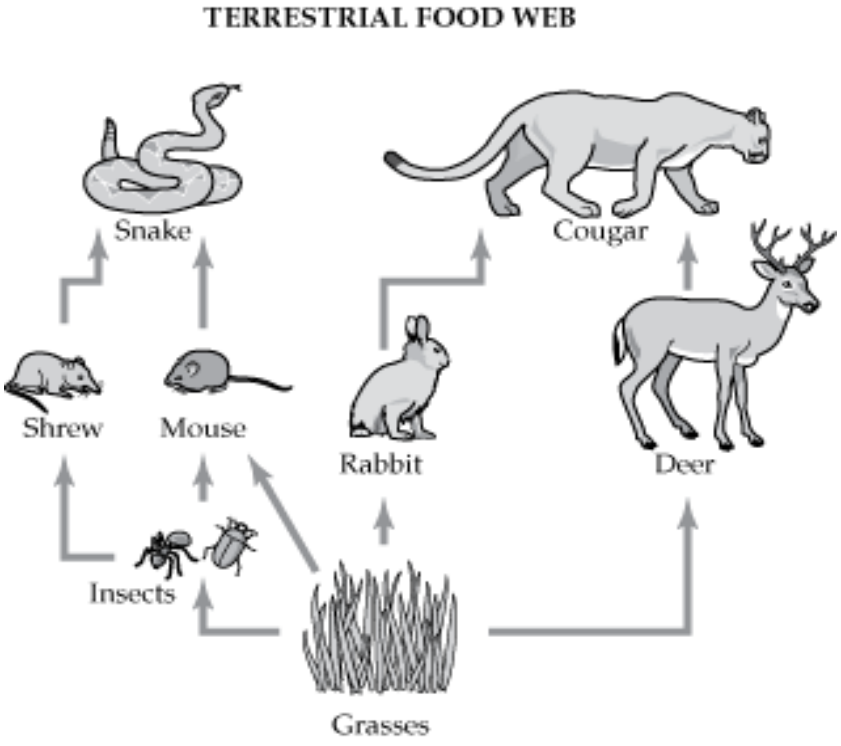
A group of students studied the effect of light intensity on the rate of a cell process in Elodea plants. The students exposed Elodea plants to different light intensities by varying the distance of a light source to a beaker that contained these aquatic plants. A gas was produced by the cell process as evidenced by the formation of bubbles that exited through the leaves and stems of the plants. The amount of this gas produced in a five minute period was measured and recorded in the following data table as number of bubbles produced.

Distance of light source from beaker of Elodea (cm)	Number of gas bubbles produced per 5 minute period
10	100
15	85
20	50
30	45
40	35

1. Explain the biological processes responsible for producing these data.
2. Write a hypothesis to explain the trend in the data.
3. Graph the data presented above.
4. Design an experiment to further test your hypothesis. Be sure to include the following in your experimental design:
    a. Identification of the independent variable, dependent variable, and control group.
    b. Experimental procedures, including method of data collection.
    c. How you plan to report your results and conclusions.

(5.5.12 A 3)

Describe how plants (*and other organisms*) produce substances high in energy content that become the primary source of energy for life.



Carefully examine the food web above, which is representative of organisms found in some New Jersey communities. Address each of the following:

1. Identify all of the producers and consumers included in the food web, and explain some of the changes that would occur in this food web as the months change from July through February.
2. Identify the number of different trophic levels included in the food web, and explain the effects that an increase in the cougar population would have on each different trophic level.
3. Construct a data table and graph to represent the amount of energy included at each of the different trophic levels included in the food web if the total amount of energy

4. available as grasses is 5.5 x 10^8 kcal. Explain any changes that occur at each separate trophic level in the food web.

Relate disease in humans and other organisms to infections or intrinsic failures of system.

Medical researchers are studying a new drug to treat pathogenic bacteria. Eligible patients are asked if they would like to participate in the study. If a patient does participate, there is a 50% chance that the patient will receive the actual antibiotic in development and a 50% chance that the patient will receive a placebo, or sugar pill. The placebo is not meant to have any effect on the pathogenic bacteria. The study is double-blinded, meaning that neither the researchers nor the patients know which kind of pill is being taken—the actual medication or the placebo.

The researchers collected the following data regarding the effect of different antibiotics on these pathogenic bacteria. Sensitivity refers to effectiveness. The higher the sensitivity, the more effective the antibiotic is at killing the bacteria.

Antibiotic	Sensitivity
Ampicillin	3
Bacitracin	0
Cephalosporin	0
Penicillin	0
Rifampin	0
STUDY ANTIBIOTIC	3
Tetracycline	2

1. What can you conclude from these data? Explain which antibiotics you would use to treat a person infected with pathogenic bacteria and why would chose them?
2. Explain why a placebo is being used in the study.
3. Explain why it is important to conduct a double-blinded study.
4. Describe both the possible benefits and risks of drug trials, such as the one in the example, to both the patient and society.

Explain how the theory of natural selection accounts for extinction as well as an increase in the proportion of individuals with advantageous characteristics within a species.

The table below includes data that scientists collected regarding the average beak size of Galapagos Finches over a 10 year period beginning in 1976. The primary source of food for these particular finches is seeds.

Average Beak Sizes in Galapagos Finches

Year	Beak Size (mm)
1976	9.5
1977	9.8
1978	9.7
1979	9.6
1980	9.8
1981	9.6
1982	9.8
1983	9.6
1984	9.4
1985	9.4

In a separate study, scientists concluded that average beak size in these finches is related to the size of the seeds they can eat. The scientists also concluded that fluctuating beak size ensures survival for these finches.

Perform the following tasks to analyze the above data and draw conclusions:

1. Graph the data included in the data table titled: Average Beak Size in Galapagos Finches.
2. Explain why the beak size of finches does not remain constant from one year to the next.
3. Provide possible explanations as to what environmental factors would affect the size of the seeds that the finches fed on.

Distinguish naturally occurring process from those believed to have been modified by human interaction or activity.

• Climate change

• Ozone production

• Erosion and deposition

• Threatened and endangered species

A recent trend in the industrialized world has been to develop alternative fuels, which hopefully will reduce the world's reliance on petroleum based fuels. However, a recent study revealed that ethanol, an alternative fuel produced from plant matter, actually contributes more greenhouse gases to the atmosphere than do petroleum based fuels.

The following table compares the contribution of greenhouse gases into the atmosphere from petroleum based fuels and ethanol based fuels ever a four-year period:

	2004	2005	2006	2007
Ethanol based fuels	344 ppm	350 ppm	356 ppm	361 ppm
Petroleum based fuels	340 ppm	347 ppm	355 ppm	360 ppm

Perform the following tasks to analyze the above data, draw conclusions, and hypothesize future outcomes.

1. Graph the data contained in the table
2. Explain the environmental impact of the increase in greenhouse gases with the continued use of either ethanol based or petroleum based fuels.

3. Together with the data and your explanation, hypothesize the continued use of either of these fuels, and whether other alternative can be researched to reduce the amount of greenhouse gases introduced into the atmosphere.

Use scientific, economic, and other data to assess environmental risks and benefits associated with societal activity.

In a local recycling effort, a student urges her classmates to track the amount of aluminum, glass, and plastic containers they recycle at home by recording data in a table. After three months of data collection, the student compiles the class data, which are represented in the following table:

Average Household Recycling

	Aluminum (kg)	Glass (kg)	Plastic (kg)	Total (kg)
Month 1	8	15	7	30
Month 2	10	21	12	43
Month 3	18	28	15	61

Perform the following task to analyze the above data, draw conclusions, and predict future outcomes.

1. Graph the data contained in the table
2. Explain any trends you observe in the data and provide explanations regarding why you think these trends were observed.
3. Predict what will happen if this student continues to collect data for another six-month period.
4. Hypothesize the impact of this recycling program on total household trash output.

Mystery of the Bloated Clownfish

Your biology classroom has decided to create an aquarium for the purpose of not only maintaining a supply of Elodea but also to house several fish for animal behavior studies later in the course. As a class, you choose to populate the tank with a clownfish among other species. Your teacher sets up the tank and you introduce the fish. However, after several minutes the clownfish begins to look bloated as if it ate something that disagreed with it. You take the mass of the fish once an hour and watch it over the course of a school day to determine if it is just the aquarium glass playing visual tricks on you or if there is something wrong with the fish. You compile the following data:

Time (hours)	Mass of the clownfish (kg)
0	0.8
1	0.85
2	0.90
3	1.1
4	1.2
5	1.3
6	1.3

Your Task:

Hypothesize what is causing the fish to gain mass and offer a reasonable solution to return the fish to its original state. Using the situation presented above and the data gathered:

- Construct a graph to depict the change in mass of the fish over time.
- Based on all of the information available to you:
    - Explain the biological process responsible for the resulting data;
    - Propose a solution to return the fish to its original state (pre-bloat);
    - Predict how this solution would change your graph.

Birds, Seeds and an Island

A species of birds lives on an island. The thickness of the birds' beaks varies within the population. The birds feed mainly on seeds from plants. Birds with thinner beaks can eat only small seeds. Only birds with thicker beaks can crush and eat large seeds.

There are many small seeds during years with more rain. During dry years, there are very few small seeds and many large seeds. The large seeds are harder to crush than small seeds.

Ornithologists studying the area have collected the average beak thickness in the bird population from 2000 to 2007. The following table represents their findings.

Year	Average Beak Thickness (mm)
2000	9.65
2001	9.8
2002	9.65
2003	9.85
2004	9.7
2005	9.45
2006	9.6
2007	9.75

In addition to the beak size data, they noted that 2001, 2003, and 2007 were dry years; 2005 was a wet year; 2000, 2002, 2004 and 2006 received normal rainfall.

Your Task:

Hypothesize why the average beak size fluctuates between the eight years in the study period, and offer a reasonable prediction for beak thickness in the next ten years, if these years are wet years. Using the information above and the data collected:

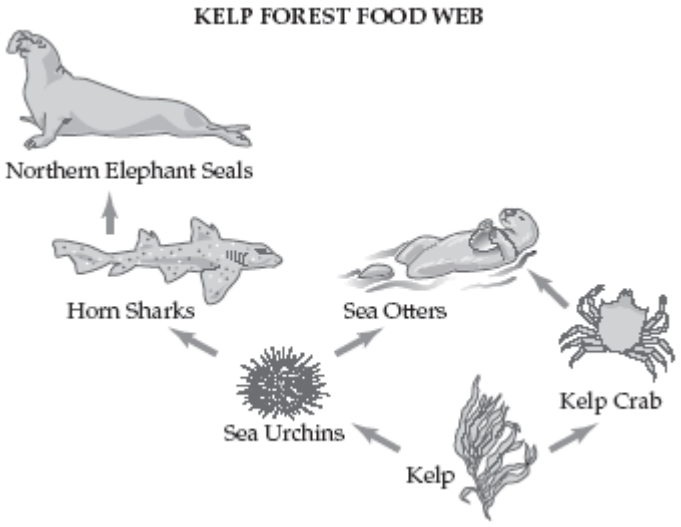
- Construct a graph to show the relationship between average beak thickness over time.
- Based on all of the data:
    - Explain why the average beak thickness changed with the fluctuation in precipitation;
    - Offer a reasonable prediction for beak thickness in the next ten years, if these years are wet years;
    - Name the process that led to this change.

Struggle in the Kelp Forest

A population of sea urchins in a kelp forest ecosystem is being overfished. A team of students believe that a decline in the number of sea urchins will affect the organisms in the kelp forest ecosystem. The following data has been collected for a quadrant of the kelp forest:

Organism	Number Observed
Kelp	150
Kelp crab	80
Sea urchins	40
Sea otters	10
Horn sharks	5
Northern Elephant Seals	2

The kelp forest food web below shows the relationships among the organisms in the kelp forest ecosystem.



The students believe that the kelp crab population will decrease if the sea urchin population decreases.

Your task:

Support or refute the student's conclusion. In your response, be sure to:

- Construct a graph that represents your population data;
- Describe the relationship between the kelp crab, sea otter, and sea urchin;
- Offer an explanation as to how each organism in the food web would be affected by a change in the sea urchin population and what effect a restoration of the sea urchin population may have on the food web.

Breaking Down Breakfast

Two important digestive enzymes are pepsin and trypsin. The tables below provide pH data for these enzymes.

pH	Activity of pepsin (percentage of maximum)
0.9	0
1.5	65
3.0	100
5.0	20
5.1	0

pH	Activity of trypsin (percentage of maximum)
4.0	0
5.0	75
6.5	100
7.5	90
9.0	0

Your Task:

Use your understanding of the structure and function of enzymes to:

- Construct a graph depicting the relationship between enzyme activity and pH for the two enzymes represented.
- Predict how the activity of pepsin will change after it moves from the stomach to the small intestine.
- Explain your prediction using data from the table.
- Describe how changes in pH affect enzyme activity.

Grow Fishy Grow

Students studied a species of fish. They wanted to find out if these fish grow faster in warmer water. The students designed an experiment to determine how different water temperatures affect the growth of the fish.

They placed one fish in a tank at 26°C and another fish in a tank at 22°C. The fish were fed the same amount of food during the experiment. The mass of each fish was recorded over a 10-day period. The data the students collected are shown in the table below.

Mass of fish kept in 26°C tank

Day	Mass (g)
0	3.6
1	4.2
2	4.7
3	5.0
4	5.1
5	5.5
6	5.9
7	6.4
8	6.8
9	7.5
10	7.8

Mass of fish kept in 22°C tank

Day	Mass (g)
0	6.8
1	6.9
2	7.0
3	7.1
4	7.4
5	7.7
6	7.9
7	8.2
8	8.5
9	8.9
10	9.1

Your Task:

Analyze the procedure and data from the experiment. In your response, be sure to

- Construct a graph to depict the change in fish mass over time for both tanks.
- Using all of the information offered above:
    - State the hypothesis that the students were most likely investigating;
    - Explain whether their data supports this hypothesis;
    - Describe how other variables would affect the outcome of the results;
    - Explain how the experiment could be redesigned to gather more reliable data.

Bottom of the Barnegat

There are approximately 14 species of bay grasses in Barnegat Bay. Bay grasses provide a habitat for birds, fish, and shellfish. Most bay grasses grow attached to the bottom substrate in shallow water.

Scientists estimate that the area covered by bay grasses once exceeded 600,000 acres. In 1978, scientists learned that bay grasses only covered 41,000 acres.

Scientists began working to improve environmental conditions in the bay. They replanted bay grasses in some areas. They set a goal of having 110,000 acres of bay grasses by the year 2000. The data collected from yearly surveys of bay grasses is shown in the table below.

Year	Acres of Bay Grass
1984	40000
1985	50000
1986	48000
1987	50000
1988	No data
1989	60000
1990	60000
1991	61000
1992	70000
1993	72000
1994	65000
1995	60000
1996	61000
1997	69000
1998	61000
1999	65000
2000	68000

Your Task:

Evaluate the success of this project. In your response, be sure to

- Construct a graph depicting the acreage of bay grass over time.
- Predict the most likely value for the missing data in 1988; explain your answer.
- Describe the trend in the area covered by bay grasses in Barnegat Bay from 1984 to 2000; use specific information from the graph to support your answer.
- Suggest possible reasons for the changes in the graph between 1993 and 1995.

Every Breath We Take

Billions of years ago, the atmosphere of early Earth lacked oxygen. Today Earth's atmosphere is 21% oxygen. Ice cores obtained from Polar Regions have been analyzed and dated for oxygen content. The data collected is represented below.

Millions of years ago	Percent oxygen
0	20
100	20
200	20
300	20
400	10
500	1.0
600	0.2
700	0.1
800	0.05

Your Task:

- Construct a graph that shows the relationship between percent oxygen and time.
- Using the data above as well as your graph:
    - Identify two time periods where the slope of the graph becomes steeper;
    - Offer an explanation for the increases in oxygen over time.
    - Hypothesize why atmospheric oxygen may decrease over the next century.

Fighting off the Flu

Every school year, many students are plagued with a variety of diseases that cause them to miss class. A group of students in biology class decide to investigate the effect of temperature on disease causing viruses and obtained the following data from the National Institutes of Health.

Temperature (°C)	Number of individuals
36.1	250000
36.4	500000
36.6	1000000
36.9	2000000
37.2	1000000
37.5	500000
37.7	250000
38.3	100000
38.9	50000
39.4	5000

Your Task:

- Construct a graph that represents the relationship between temperature and magnitude of the colony.
- Using your graph and the data above:
    - Discuss the effect of temperature on colony health;
    - The normal body temperature of a human being is 37°C. Explain how a fever helps protect the human body against viral invasion.

Lichens – Better Together or Separate?

An experiment was conducted in which lichen, the lichen's component fungus, and the lichen's component alga were all grown in three different locations. In each location, 10 1-cm diameter disks each of the lichen, the fungus and the alga were set on the ground, watered and allowed to grow for three months. The data in the table below show the average size of the disks of lichen, fungus and alga in each of the three locations after three months.

Average disk diameter (cm)			
Organism	Location 1	Location 2	Location 3
Lichen	4	5	5.5
Fungus alone	1.5	0	5
Alga alone	1	0	4.5

Your Task:

- Construct a graph to show the relationship between growth and location among the three organisms.
- Using the data above and the graph you constructed:
  - Offer a hypothesis for this experiment;
  - Identify the independent and dependent variables;
  - Interpret the results obtained in the experiment;
  - Draw a conclusion about the hypothesis;
  - Explain how lichen might contribute to ecological succession if location 2 is bare rock.

Monkey Tails

In a make believe population of monkeys, there are genes which effects tail size. Tail length is critical to survival in this monkey population. Their tails allow them to grasp onto tree limbs, and also allow them to maintain their balance when swinging and jumping from tree to tree. The length of the monkey tails are a result of multiple alleles. The only disadvantage that long tails have is when monkeys are running along the ground. Long tails allow for predators to more easily capture the fleeing monkeys by grabbing onto their long tails. The monkeys' tails range from a length of 40 cm to the exceptionally long tails of 160 cm in length. Monkeys that had less than 90 cm tails were considered to have short tails.

Scientists studying the monkey's ecosystems collected many types of data for the population of monkeys and also for- the ecosystem in which they lived. During the course of the 20 year study many changes occurred in the ecosystem that included events such as forest fires, droughts, and floods as well a commercial logging.

Yearly Average Length of Monkey Tails In cm 1980-2000

Year	Average Length of Monkey Tail in cm
1980	140
1981	150
1982	145
1983	155
1984	117
1985	114
1986	117
1987	100
1988	95
1989	98
1990	95
1991	93
1992	95
1993	80
1994	75
1995	75
1997	60
1998	60
1999	60
2000	60

Genetically, how can you explain the variation in monkeys' tails?

Formulate a hypothesis to explain the data given in the table.

What do you predict will happen to the gene(s) that are responsible for longer tails in the monkeys if the trends in the data table continue? Explain your prediction .

Relate the structure of molecules to their function in cellular structure and metabolism

1. Explain the biological processes responsible for the data obtained for plant groups A through F.

Your explanation must include a discussion of osmosis and diffusion, as well as a discussion of the importance of water to living things. Explain that the average final height of the plants decreased as the percent sugar solution increased due to the movement of water. The 0 percent sugar solution was hypotonic relative to the plant cells, therefore water moved into the plant cells. As the percentage of sugar increased, less water moved into the plant cells, thereby limiting plant growth. At 40 and 50 percent sugar solution, the sugar solution was hypertonic relative to the plant cells, therefore water moved out of the plant cells. The net loss of water ultimately caused the plants to die.

2. Explain why plant group A experienced the largest increase in height.

Plant group A experienced the largest increase in height because at 0 percent sugar solution, water would move into the plant cells. The plant cells are hypertonic relative the solution, so via osmosis, water would move into the plant cells. An abundance of water would allow the plant to experience the most growth.

3. Explain why the plants in Plant Groups E and F died.

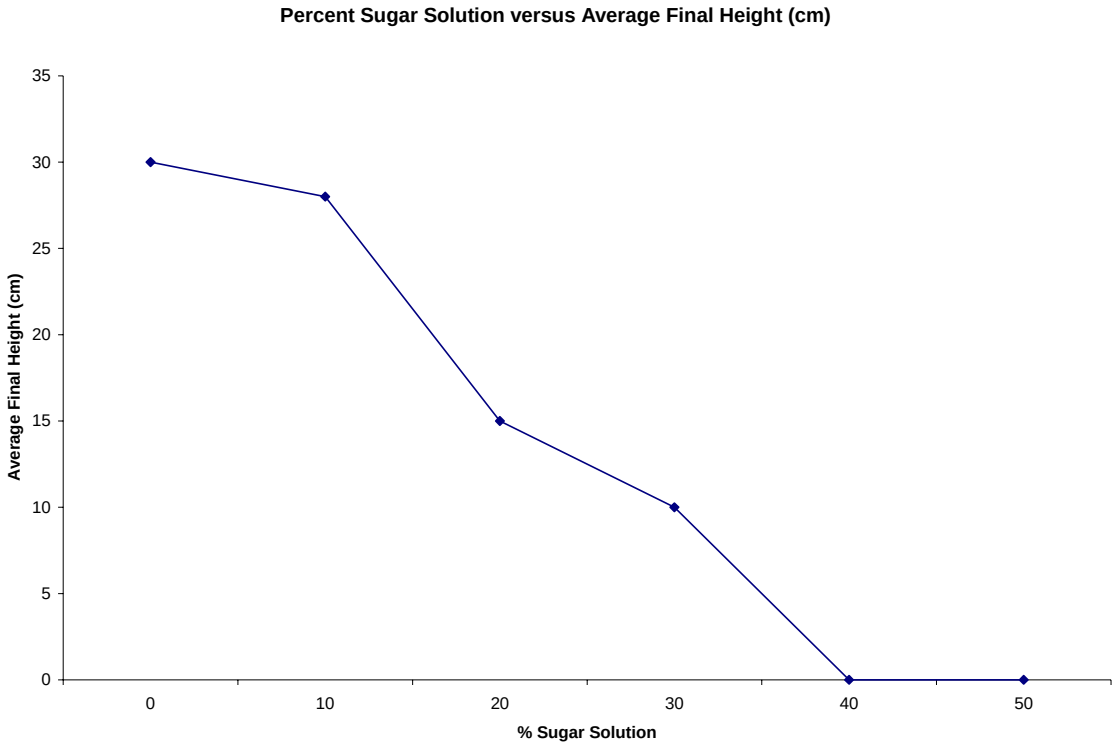
Plant groups E and F died because the plant cells lost water. Plant group E was watered with a 40 percent sugar solution, and plant group F was watered with a 50 percent sugar solution. These concentrations were hypertonic to the plant cells, so water moved out of the cells. As a result, the plants died because they did not have sufficient amounts of water.

4. Write a hypothesis that you might test in a future experiment now that you have these data as prior knowledge.

Answers here will vary, but one example follows:

If three different species of plants are watered with 0, 20, and 40 percent sugar solutions, then the three different species of plants will experience the most growth when watered with a 0 percent sugar solution.

5. Graph percent sugar solution versus average final height.



Explain how plants convert light energy to chemical energy

1. Explain the biological processes responsible for producing these data.

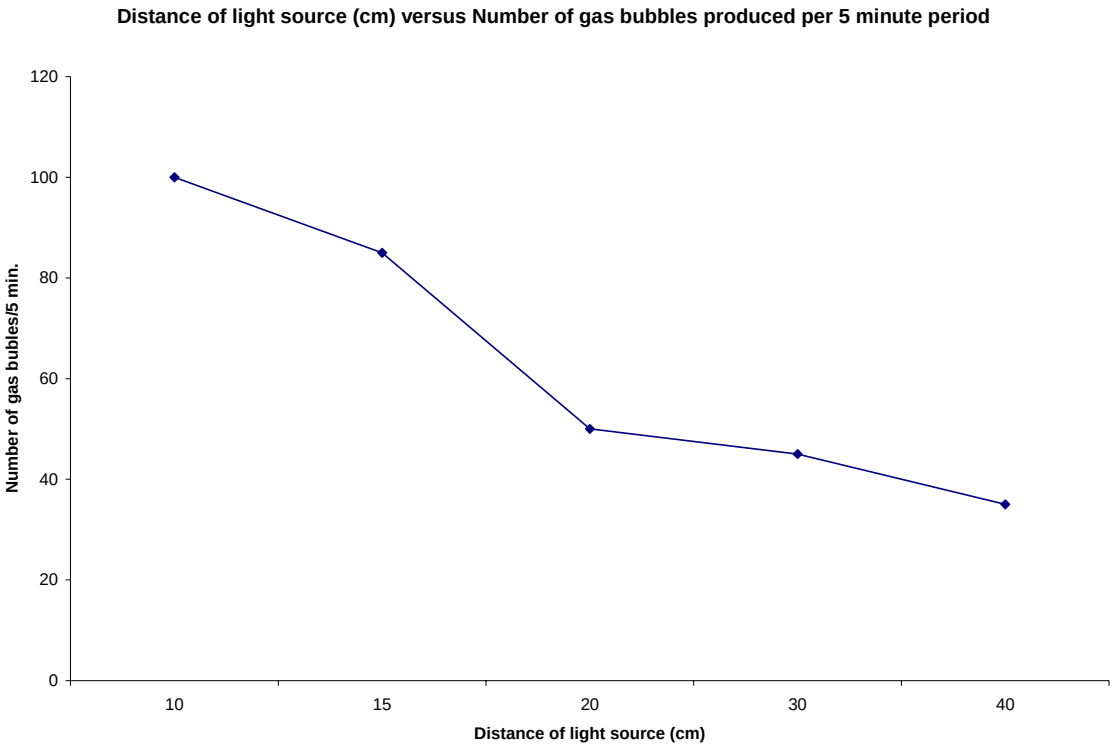
The biological process responsible for producing these data is photosynthesis. Plants use carbon dioxide and water to synthesize glucose and oxygen. Terrestrial plants obtain carbon dioxide from the atmoshpere and water from the soil. Aquatic plants obtain both carbon dioxide and water from their surrounding aquatic environment. As light intensity increases, which the students did by keeping the light source close to the beaker of Elodea, the cellular process of photosynthesis increases. As light intensity decreases, the rate of photosynthesis decreases. The above data support these statements. One hundred gas bubbles were produced when the light source was 10 cm from the beaker of Elodea. The number of gas bubbles continued to decrease as the light was moved a greater distance away from the beaker of Elodea.

2. Write a hypothesis to explain the trend in the data.

Answers here will vary, but one example follows:

If the reactants of the cellular process photosynthesis increase, then the photosynthetic rate and products of the photosynthetic reaction will increase.

3. Graph the data presented above.



4. Design an experiment to further test your hypothesis. Be sure to include the following in your experimental design:

Answers here will vary, but one example follows:

One could design an experiment to test both light intensity and availability of carbon dioxide on photosynthetic rate. In addition to the experiment discussed in this problem, a student could dissolve sodium bicarbonate in the beakers that contain Elodea. The sodium bicarbonate would act as a source of carbon dioxide.

a. Identification of the independent variable, dependent variable, and control group.

Light intensity and carbon dioxide are independent variables, photosynthetic rate measured as number of bubbles produced is the dependent variable, and a beaker of elodea without added sodium bicarbonate would be the control.

b. Experimental procedures, including method of data collection.

Establish several beakers of Elodea. Add a fixed amount of sodium bicarbonate to half of the beakers. Keep the light source the same distance from all beakers. Record the number of bubbles produced per five minute intervals.

c. How you plan to report your results and conclusions.

Results of this experiment could be reported in tables and graphs. Conclusions would be in written form and would discuss the effect of both independent variables on the dependent variables, and whether these results differed from the results obtained for the control group.

Describe how plants (*and other organisms*) produce substances high in energy content that become the primary source of energy for life.

1. Identify all of the producers and consumers included in the food web, and explain some of the changes that would occur in this food web as the months change from July through February.

Producer: Grasses
Consumers: Insects, Shrew, Mouse, Snake, Rabbit, Deer, Cougar

As the seasons change from summer, to autumn, to winter in NJ, the availability of the producer in this food change would decrease. As the amount of available grasses decreases, so too would the herbivores in the food web. The insects, mice, rabbits, and deer would likely decline in population as the seasons progress from summer to winter in NJ. As a result, the carnivores in this food web, represented by snakes and cougars, would observe a decrease in their food source and begin to rely on other sources of food.

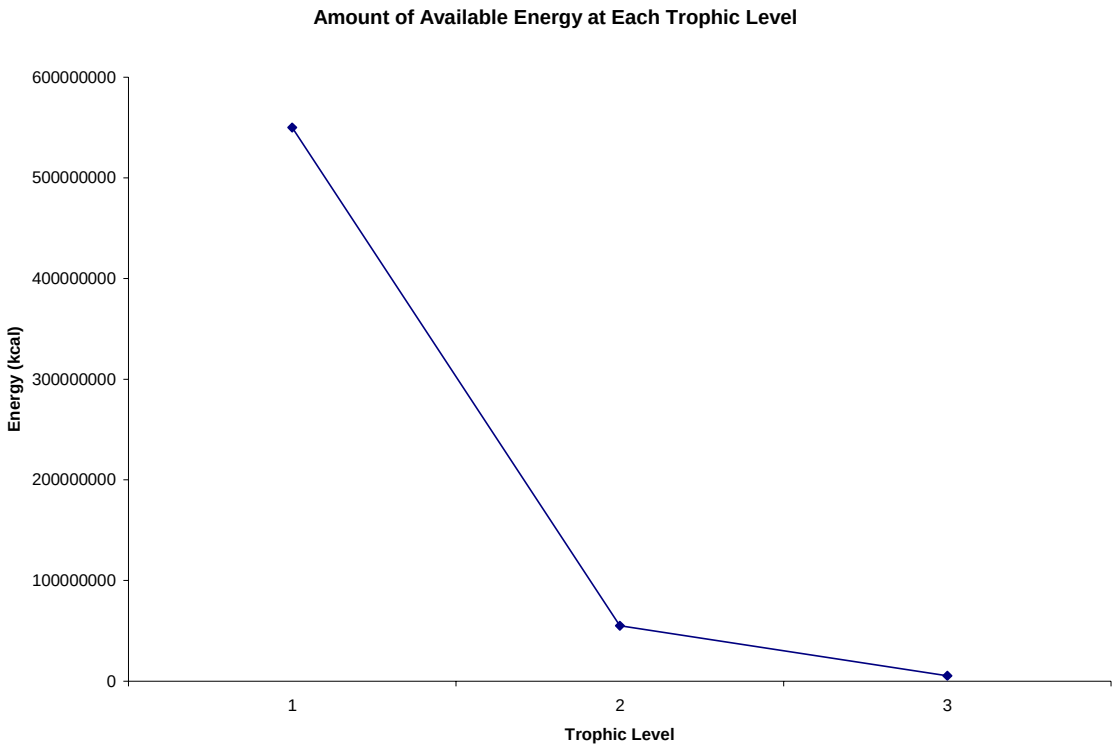
2. Identify the number of different trophic levels included in the food web, and explain the effects that an increase in the cougar population would have on each different trophic level.

Three different trophic levels are represented in this food web. The producer in this food web, grasses, belongs to the first trophic level. The herbivores, represented by insects, mice, rabbits, and deer, belong to the second trophic level. The carnivores, represented by the snake and cougar belong to the third trophic level.

3. Construct a data table and graph to represent the amount of energy included at each of the different trophic levels included in the food web if

the total amount of energy available as grasses is 5.5 x 10^8 kcal. Explain any changes that occur at each separate trophic level in the food web.

Trophic Level	Amount of Available Energy
1	550000000
2	55000000
3	5500000



Relate disease in humans and other organisms to infections or intrinsic failures of system.

1. What can you conclude from these data? Explain which antibiotics you would use to treat a person infected with pathogenic bacteria and why would chose them?

These data suggest that ampicillin, the study antibiotic, and tetracycline are the only antibiotics that were studied that are effective against pathogenic bacteria. These data also suggest that ampicillin and the study antibiotic offer equivalent sensitivity.

2. Explain why a placebo is being used in the study.

A placebo is being used in the study as a control. A placebo looks identical to the other medications, but is usually made of sugar. Rather than give the patients nothing, researchers often use a placebo so patients think they are getting the “real thing.” A placebo group is often used in this type of research to further confirm that any effect is the result of the study medication and not of a patient’s perception.

3. Explain why it is important to conduct a double-blinded study.

Answers here will vary, but one example follows:

A double-blinded study is important to conduct because neither the researchers nor the patients are aware of the specific medication that they are receiving. Both parties are unaware as to administration of study antibiotic, currently available medication, or placebo.

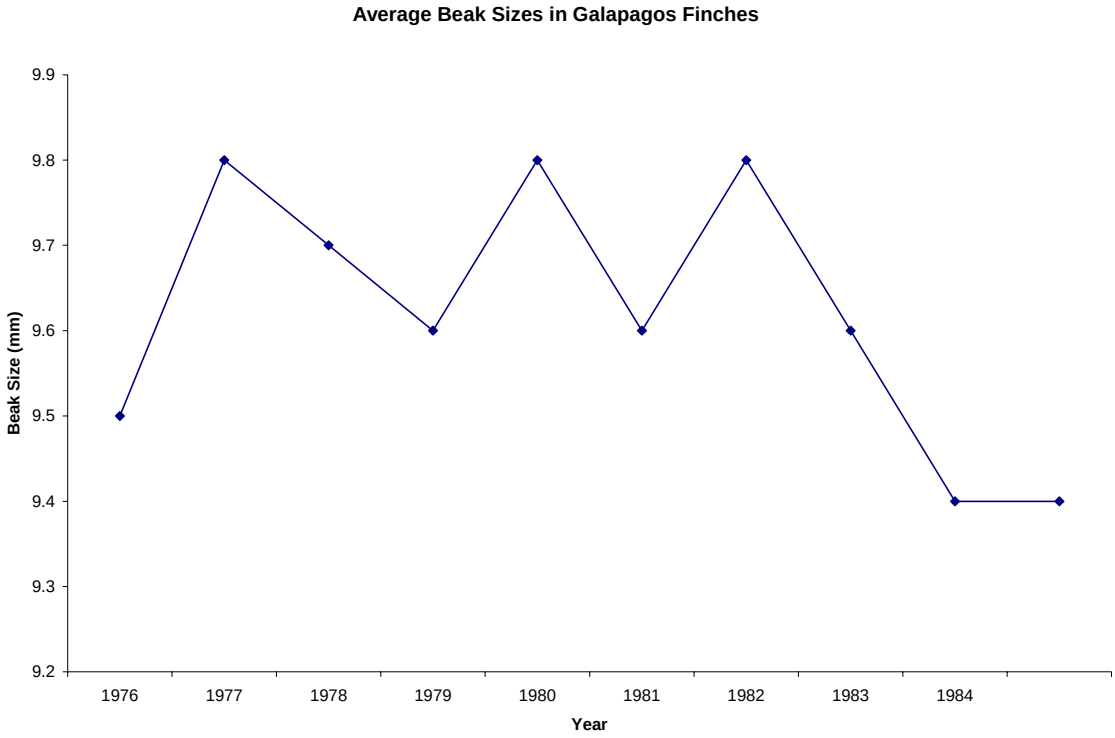
4. Describe both the possible benefits and risks of drug trials, such as the one in the example, to both the patient and society.

Answers here will vary, but one example follows:

These types of trials benefit patients because the researchers might determine that the study medication is more effective than anything that is currently available. As a result, more patients might be cured of serious illnesses or diseases. However, patients also put themselves at risk when participating in these types of research studies because the long-term safety record of the study medication is often unknown. Although the new medication might cure a certain bacterial disease, perhaps it will harm the patient in some other way. Similar risks and benefits are associated with society in general. For example, a benefit to society of a new antibiotic could be a substantial reduction in specific bacterial illnesses or diseases. Over time, all members of society no longer need to be concerned with these specific bacterial infections. However, this research also produces risks in that members of society might begin to change their behaviors in such ways that creates an environment that will allow other pathogenic organisms to thrive. Also, more powerful antibiotics have been associated with increased bacterial resistance to other antibiotics.

Explain how the theory of natural selection accounts for extinction as well as an increase in the proportion of individuals with advantageous characteristics within a species.

1. Graph the data included in the data table titled: Average Beak Size in Galapagos Finches.



2. Explain why the beak size of finches does not remain constant from one year to the next.

Based on the data provided and the conclusions of other scientists, the beak size of finches does not remain constant from one year to the next because the size of the seeds available as food changes. The finches must be able to use their beaks to get the energy contained in the seeds, so they are able to develop beaks that ensure access to this food source.

3. Provide possible explanations as to what environmental factors would affect the size of the seeds that the finches fed on.

Answers here will vary, but one example follows:

One possible explanation regarding an environmental factor that might affect the size of seeds that the finches fed on is rainfall. Increased amounts of rainfall are likely to allow various species of plants to produce larger seeds. As a result, the finches would develop larger beaks in order to be able to eat the seeds.

Distinguish naturally occurring process from those believed to have been modified by human interaction or activity.

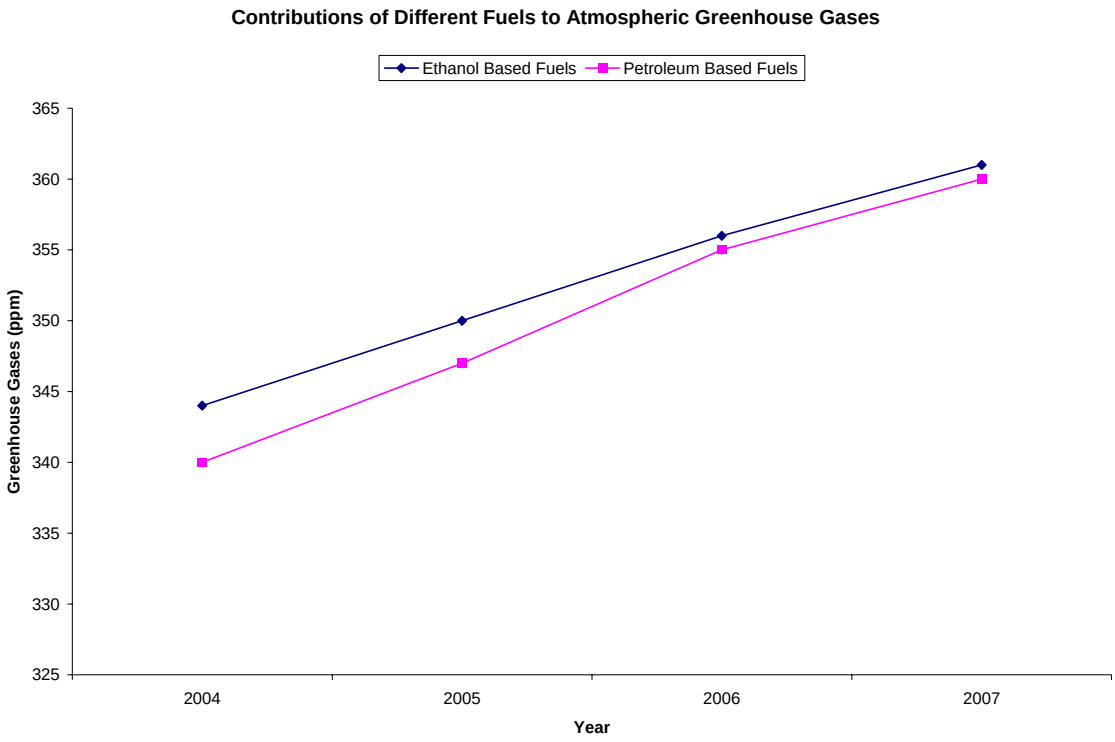
• Climate change

• Ozone production

• Erosion and deposition

• Threatened and endangered species

1. Graph the data contained in the table



2. Explain the environmental impact of the increase in greenhouse gases with the continued use of either ethanol based or petroleum based fuels.

Answers here will vary, but one example follows:

The environmental impact of an increase in greenhouse gases with either ethanol or petroleum based fuels is global warming. Although global warming has become a political issue, the majority of the scientific community is in agreement that the Earth's average temperature over the past century has increased. However, less agreement amongst scientists occurs when various causes of the Earth's warming and cooling cycles are proposed. Nevertheless, the greenhouse gases produced by both petroleum and

ethanol based fuels may contribute to an increase in the Earth's temperature, which can lead to global climate change.

3. Together with the data and your explanation, hypothesize the continued use of either of these fuels, and whether other alternatives can be researched to reduce the amount of greenhouse gases introduced into the atmosphere.

Answers here will vary, but one example follows:

The data presented in this problem can allow one to hypothesize that if petroleum and ethanol based fuels continue to be used at current levels, then the amount of greenhouse gases in Earth's atmosphere will continue to increase. Alternative fuel sources that reduce the amount of greenhouse gases entering the atmosphere should continue to be researched. Some possible alternatives to petroleum and ethanol based fuels include solar, wind, and water to generate electricity. The electricity can than be used in place of these fuels that contribute to greenhouse gases. Additional research should be conducted to examine the impact of these alternative energy sources regarding their contribution of greenhouse gases into Earth's atmosphere.

Assess the impact of human activities on the cycling of matter and the flow of energy through ecosystems.

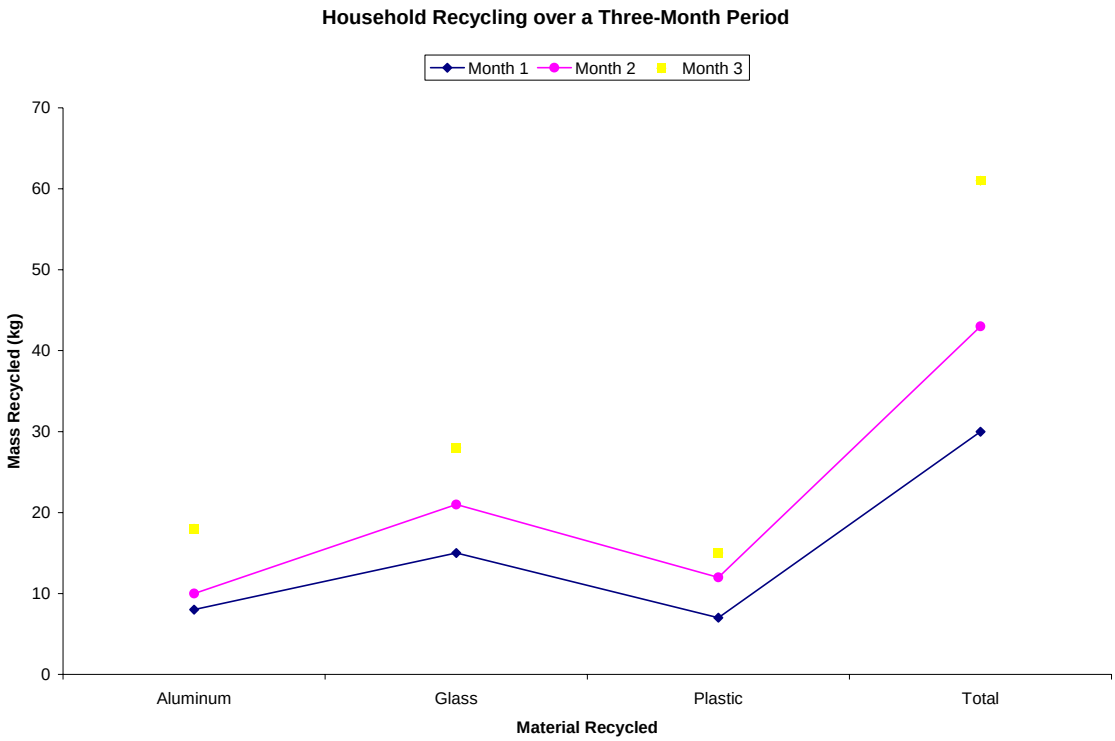
1. Explain the impact that a massive oil spill would have on the carbon cycle. Begin your explanation with the destruction of phytoplankton.

A massive oil spill would kill off a substantial portion of the phytoplankton population. As a result, a decreased amount of oxygen would be produced and entered into Earth's atmosphere, and the amount of carbon dissolved in this aquatic environment would increase as a result of a decline in the phytoplankton population. An increase in aquatic carbon dioxide would occur because the phytoplankton would not be around to take in the carbon dioxide in order to perform photosynthesis. As the aquatic carbon dioxide levels increase, the less carbon dioxide from the atmosphere will be able to dissolve into the water. So, as phytoplankton die off as a result of this oil spill, both aquatic and atmospheric carbon dioxide levels would increase.

2. Design an experiment to test the impact of human activities on the carbon cycle. Be sure to state your hypothesis, list your procedures, and describe how you would analyze data and draw conclusions.
   Answers here will vary.
   What kind of data would you expect to collect?

Use scientific, economic, and other data to assess environmental risks and benefits associated with societal activity.
Acceptable Responses

1. Graph the data contained in the table



2. Explain any trends you observe in the data and provide explanations regarding why you think these trends were observed.

The amount of aluminum, glass, and plastic recycled over the three month period increased, as well as the total amount of recycled material. These trends were probably observed because as the households began and continued the recycling program they changed their behavior. As a result, individuals in the household put a priority on recycling. Another possible explanation is that as the study progressed, the classmates were in competition with each other regarding total amount of material recycled.

3. Predict what will happen if this student continues to collect data for another six-month period.

It is likely that the amount of material recycled will continue to increase, but a plateau should be reached by each household. A plateau is likely because at

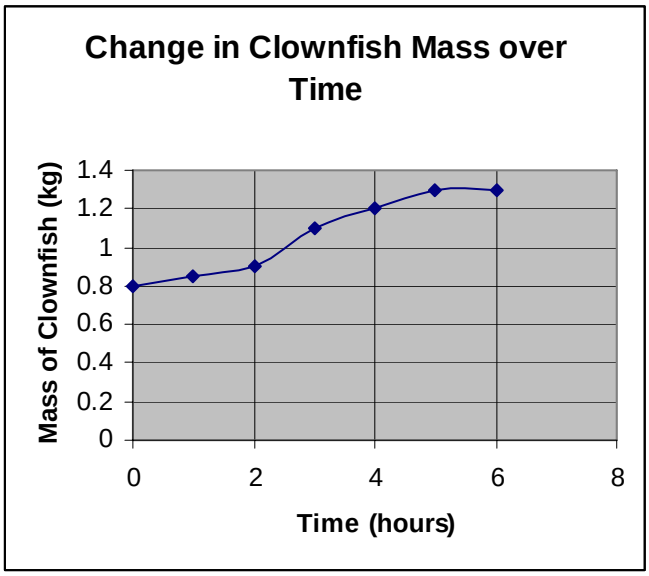
some point over another six-month period, households will reach a recycling threshold. That is, at some point in time over the next six-month period, the amount of material to be recycled will be limited by the use of each material in the various households.

4. Hypothesize the impact of this recycling program on total household trash output.

If households continue to implement this recycling program, then the total household trash output will decrease.

Mystery of the Bloated Clownfish

- Construct a graph to depict the change in mass of the fish over time.



- Based on all of the information available to you:
  - Explain the biological process responsible for the resulting data;

    Osmosis is the biological mechanism that is causing the cells of the clownfish to take in water. The clownfish, a saltwater fish, takes on water as it is placed in a hypotonic environment (freshwater of the tank.) The cells of the clownfish have a higher salt concentration than the freshwater. As a result, water moves into the cells and the fish bloats, gaining mass.

  - Propose a solution to return the fish to its original state (pre-bloat);

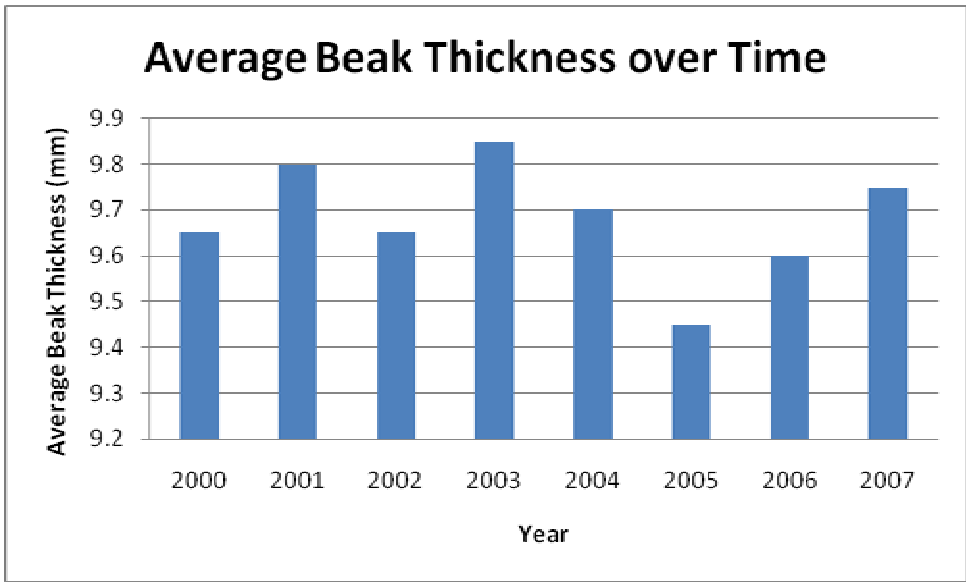
    Place the clownfish in an environment where the water has a higher salt concentration. The clownfish should lose water until it is isotonic to its environment.

  - Predict how this solution would change your graph.

    Over time the line graph should descend until it gets closer to the clownfish's original mass where it should then plateau.

Birds, Seeds and an Island

- Construct a graph to show the relationship between average beak thickness and time.



- Based on all of the data:
  - Explain why the average beak thickness changed with the fluctuation in precipitation;

    In wet years, seed size was smaller. Smaller seeds do not require thicker beaks shown by the graph above. In 2005, a wet year, the average beak size was the smallest one record. In dry years, the seeds grew larger which required thicker beaks. Thicker beaks were found in 2001, 2003, and 2007 which correlated with dry years.

  - Offer a reasonable prediction for beak thickness in the next ten years, if these years are wet years;

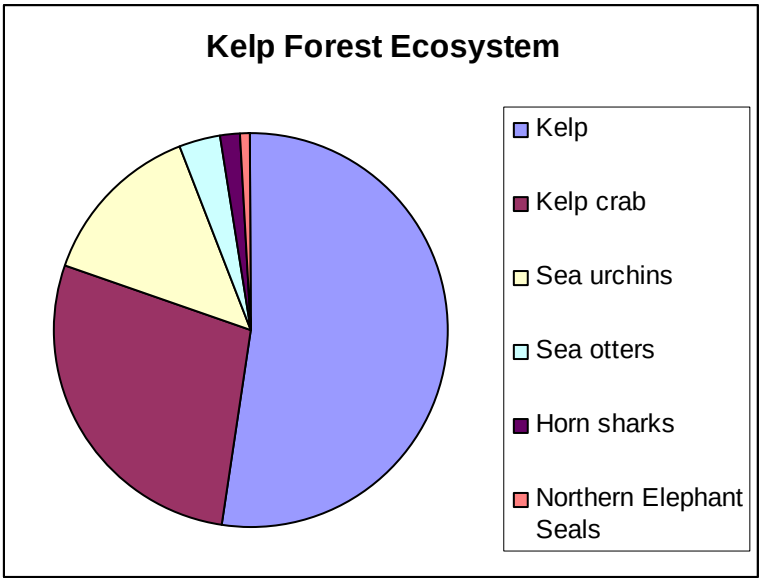
    Beak thickness should decrease if the next ten years are wet years as beak thickness was least in 2005 which was a wet year. In wet years, there is an increase in small seeds that are easier to crush and do not require a thick beak.

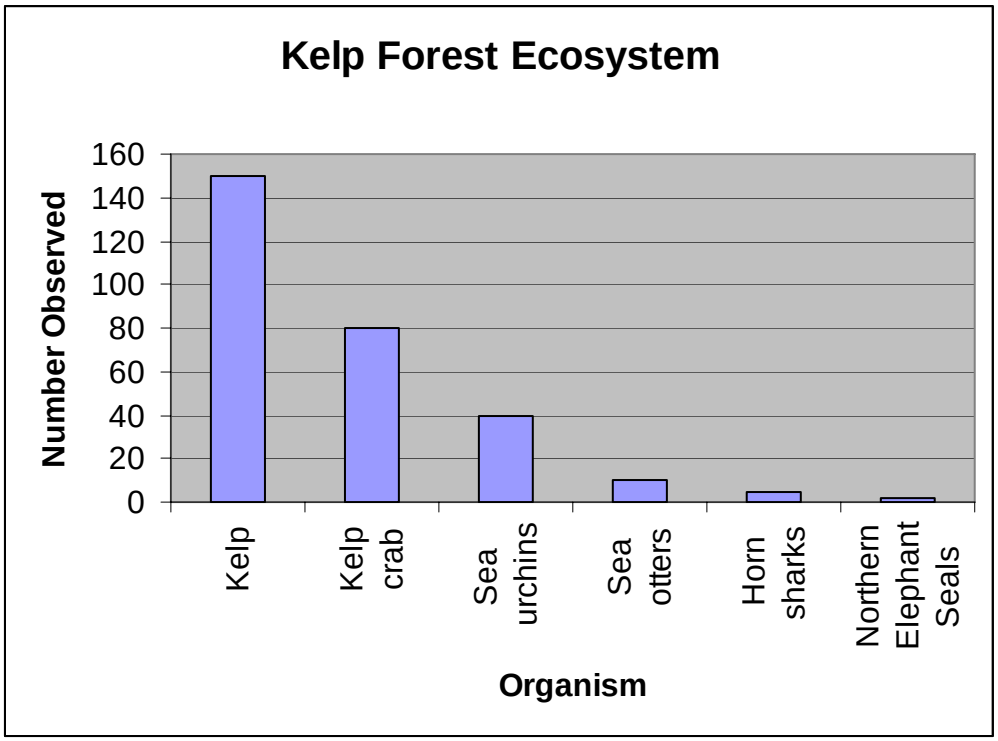
  - Name the process that led to this change.

    Natural selection will lead to this change. For natural selection to occur there must be a favorable trait (thinner beaks) and there must be a population of organisms that has that trait which can reproduce to carry that trait forward.

Struggle in the Kelp Forest
Support or refute the student's conclusion. In your response, be sure to:

- Construct a graph that represents your population data;





- Describe the relationship between the kelp crab, sea otter, and sea urchin;

The kelp crab and sea urchin are primary consumers that feed on the kelp. The kelp crab and sea urchin are in competition for a food source. They both serve as a food source for the sea otter, which is a secondary consumer. Sea urchins also serve as a food source for the horn sharks.

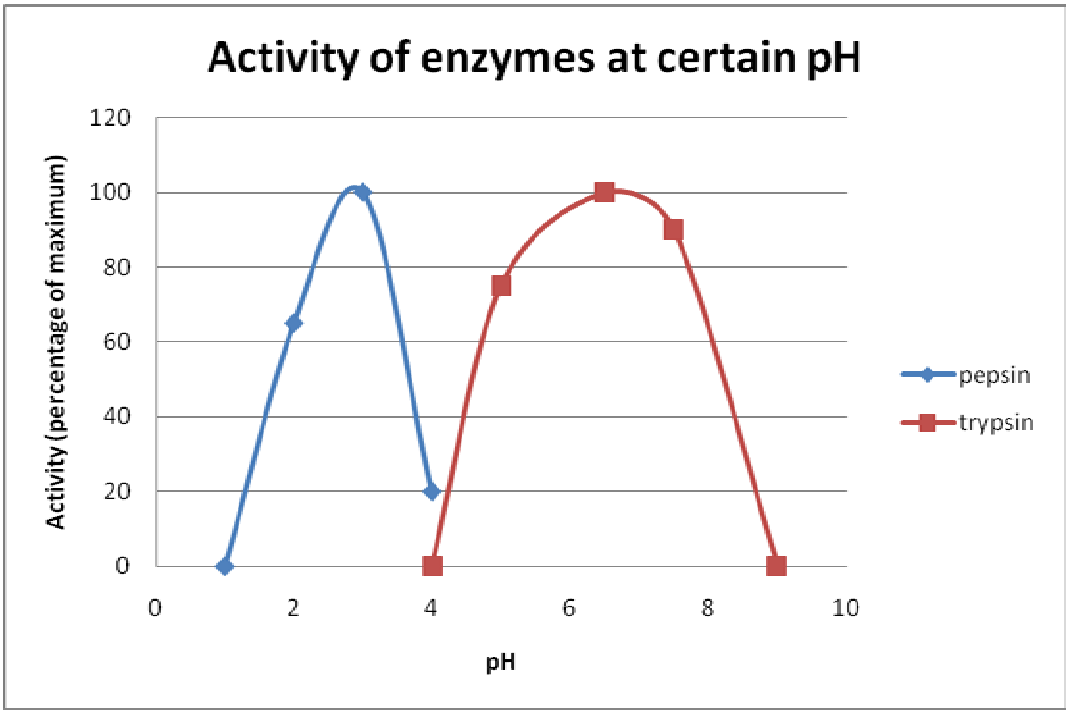
- Offer an explanation as to how each organism in the food web would be affected by a change in the sea urchin population and what effect a restoration of the sea urchin population may have on the food web.

  A decrease in the sea urchin population would affect various levels in the kelp forest ecosystem. Without sea urchins to feed on them, the kelp should flourish until the number of kelp crab increases due to the increase in a food source. The horn sharks may see a decline due to a lack of food source in the sea urchin. As they find alternative food sources, their numbers may level off. If the horn sharks decline that may subsequently cause a decrease in the Northern Elephant Seals.

Breaking Down Breakfast

Use your understanding of the structure and function of enzymes to:

- Construct a graph depicting the relationship between enzyme activity and pH for the two enzymes represented.



- Predict how the activity of pepsin will change after it moves from the stomach to the small intestine.

As shown by the graph, pepsin becomes less active as the pH rises. Pepsin functions most efficiently in an acidic environment of 3.0 or less. As pepsin leaves the stomach and the food that it is acting upon enters the small intestine, the digestive environment becomes more neutral and basic and the pepsin decreases in activity.

- Explain your prediction using data from the table.

  I believe that pepsin will be less active due to the decline shown by the line graph above where the pepsin activity line descends at a pH of 3-4.

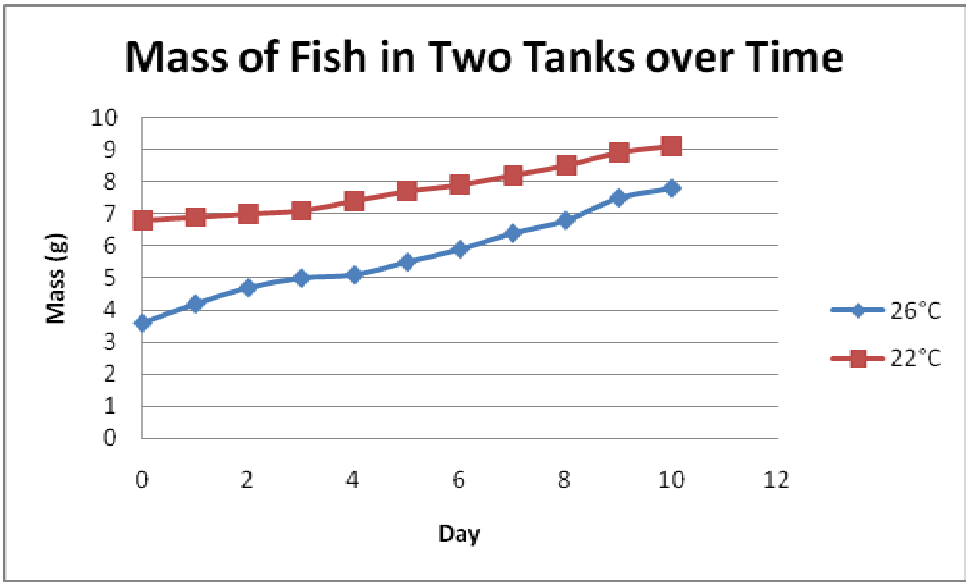
- Describe how changes in pH affect enzyme activity.

  Enzymes work best within certain parameters. One of these parameters is pH. As seen in the graph above, pepsin and trypsin work together within their environments to digest food so that the nutrients can obtained and carried to where it is needed throughout an organism.

Grow Fishy Grow

Analyze the procedure and data from the experiment. In your response, be sure to

- Construct a graph to depict the change in fish mass over time for both tanks.



- Using all of the information offered above:

- State the hypothesis that the students were most likely investigating;

  If the water is warmer, than the fish will grow faster.

- Explain whether their data supports this hypothesis;

  Their data supports their hypothesis. There is a greater increase in mass in the tank that was kept at 26°C than the tank that was kept at 22°C. The slope of the 26°C line is steeper than the 22°C line.

- Describe how other variables would affect the outcome of the results;

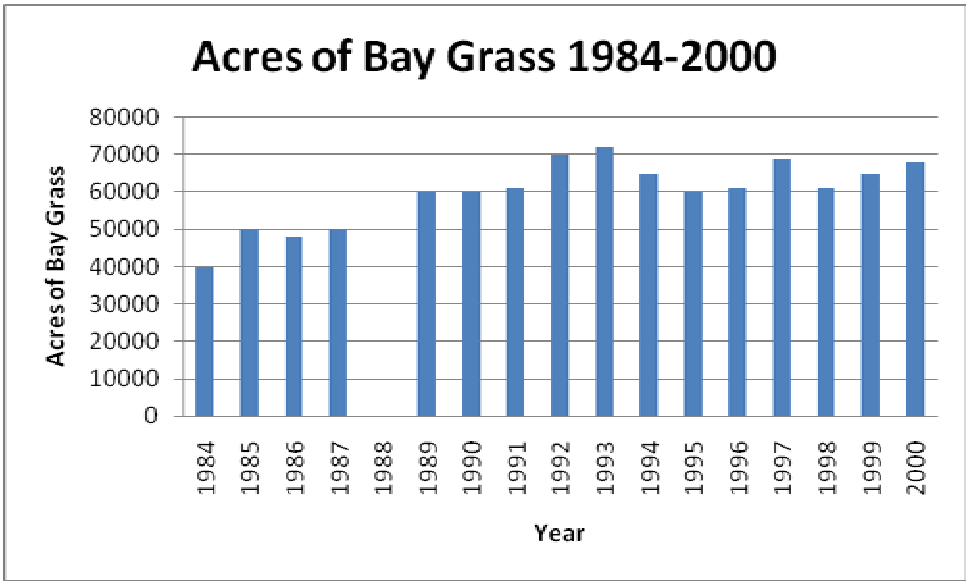
  If the amount of food or the number of organisms in each tank was varied as well as if the water were properly maintained for fresh or saltwater fish would affect the outcome of the results. If more than one variable was tested at a time, you might not be able to determine which one caused any change in mass.

- Explain how the experiment could be redesigned to gather more reliable data.

  You should set up a control and you may want to gather more data for a longer period of time.

Bottom of the Barnegat

- Construct a graph depicting the acreage of bay grass over time.



- Predict the most likely value for the missing data in 1988; explain your answer.

  55000. Bay grasses were on the rise and this number falls between the data that was collected for 1987 and 1989.

- Describe the trend in the area covered by bay grasses in Barnegat Bay from 1984 to 2000; use specific information from the graph to support your answer.

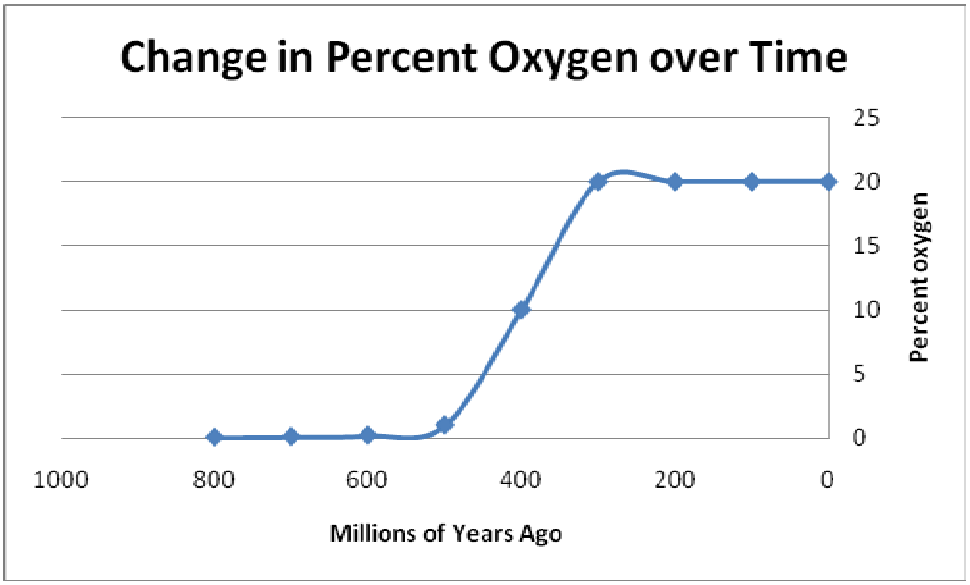
  Initially, bay grasses were recovering and increasing in numbers through the early 1990's. In 1992 and 1993 the grasses recovered to their highest numbers. In the late 1990's, bay grasses were generally found in the 60000-70000 acres.

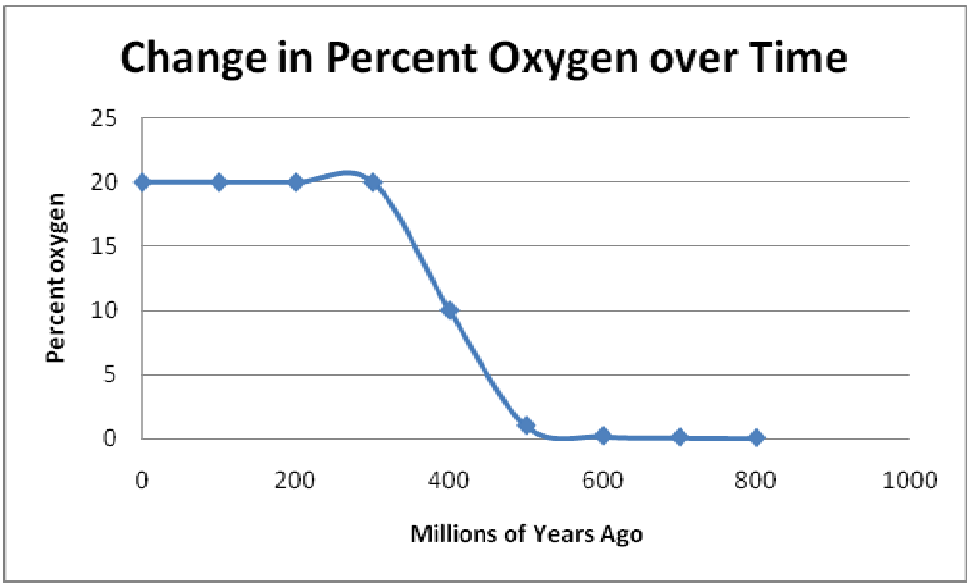
- Suggest possible reasons for the changes in the graph between 1993 and 1995.

  The decrease in bay grasses could be due to the return of primary consumers that use the bay grass as a food source. Another reason for the decrease could be harsh aquatic conditions caused by weather. If there were increased hurricanes or other storms in the area during those years, the bay could have been churning up the bottom of the bay and causing bay grasses to be destroyed.

Every Breath We Take

- Construct a graph that shows the relationship between percent oxygen and time.





- Using the data above as well as your graph:
  - Identify two time periods where the slope of the graph becomes steeper;

    Two time periods where the slope becomes steeper are between 500-350 million years ago and between 300-200 million years ago.

  - Offer an explanation for the increases in oxygen over time.

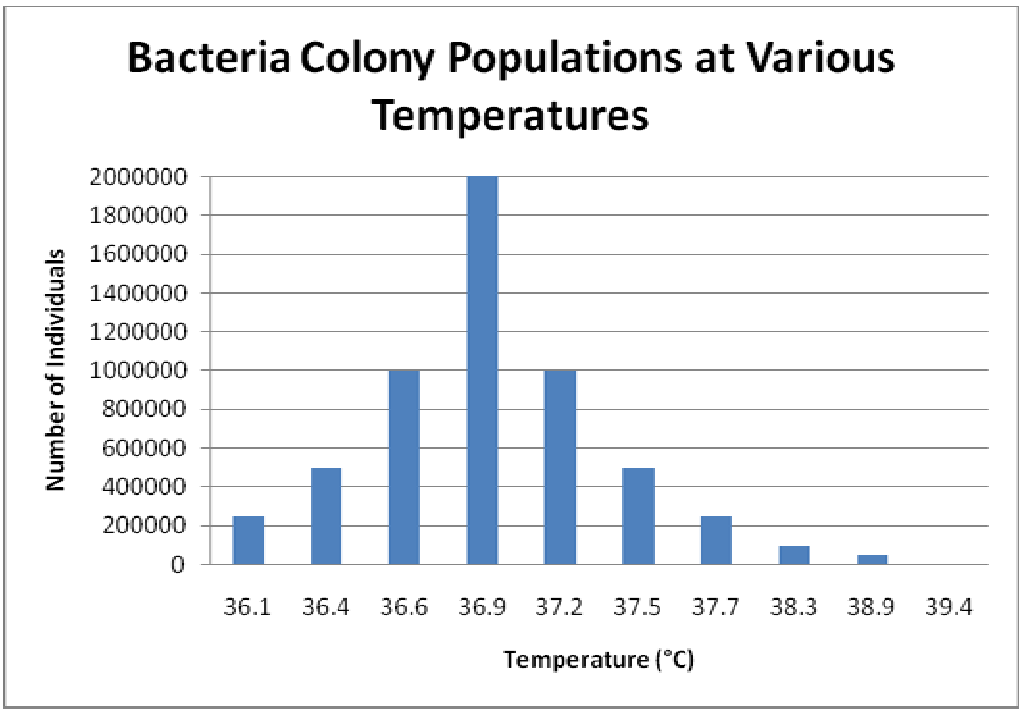
    Oxygen increased over time due to the presence of photosynthetic organisms.

  - Hypothesize why atmospheric oxygen may decrease over the next century.

    If the number of photosynthetic organisms decreases, then the atmospheric oxygen will decrease over the next century.

Fighting off the Flu

- Construct a graph that represents the relationship between temperature and magnitude of the colony.



- Using your graph and the data above:
  - Discuss the effect of temperature on colony health;

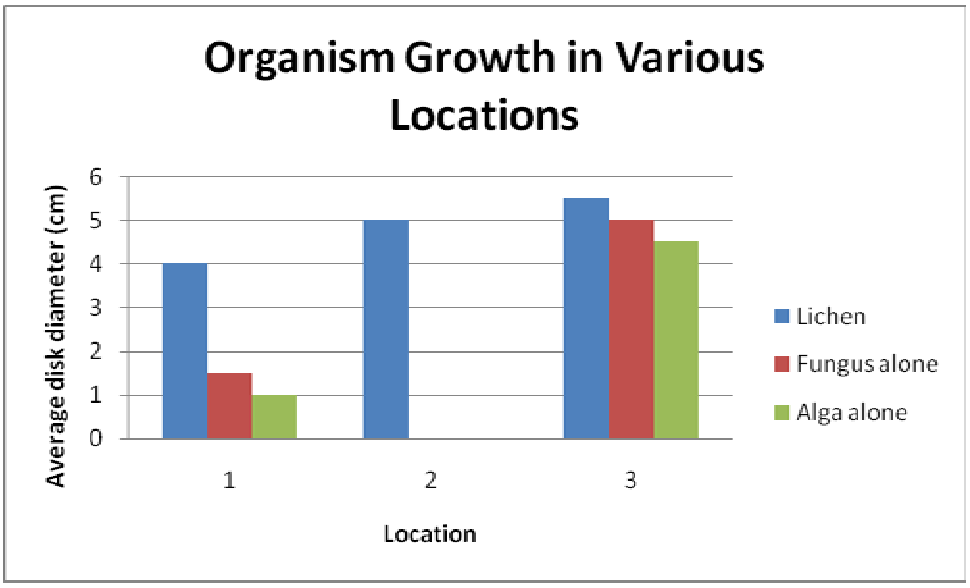
    As the temperature increases, the number of individuals in the colony increases until an optimal temperature of 36.9°C is reached. Temperatures of 37°C or greater cause a decrease in the number of individuals.

  - The normal body temperature of a human being is 37°C. Explain how a fever helps protect the human body against viral invasion.

    A fever raises the body temperature above 37°C. Fever protects the body against viral invasion because it creates an environment that is unfavorable for viruses. The number of individuals would be low and hopefully the body's immune defenses would be able to destroy the smaller number of individuals that try to invade

Lichens – Better Together or Separate?

- Construct a graph to show the relationship between growth and location among the three organisms.



- Using the data above and the graph you constructed:
  - Offer a hypothesis for this experiment;

    If lichen and its component organisms are grown in a specific location under certain conditions, then they will all show increases in growth.

  - Identify the independent and dependent variables;

    Independent variable – location, dependent variable – average disk diameter

  - Interpret the results obtained in the experiment;

    All three organisms showed the most growth in location 3. In locations 1 and 2, the lichen showed the most growth were the components did not.

  - Offer a possible conclusion for the hypothesis;

    The lichen and its component organisms must have had ideal conditions in location 3.

  - Explain how lichen might contribute to ecological succession if location 2 is bare rock.

    Bare rock is an ideal environment for lichen as they root themselves into the rock and exist under conditions that would not be moist enough for the fungus or alga alone. Ecological succession occurs when gradual and sequential regrowth

occur in an area. The lichen taking up on bare rock would be an example of primary succession as it has not previously supported life.

Monkey Tails

Genetically, how can you explain the variation in monkeys' tails?
Multiple alleles can contain combinations all of which are expressing themselves.

The tails would differ in length depending on the combinations of genes that were inherited.

Formulate a hypothesis to explain the data given in the table. Explain how you arrived at this hypothesis.

The decrease in length of monkey tails was caused by predation.
Explanation- Tress may have decreased in the monkeys' habitat because of forest fires, logging, floods and other environmental influences. This would cause the monkeys to spend more time on the ground. Monkeys with longer tails would be at a disadvantage and would be preyed upon more easily than those with longer tails.

What do you predict will happen to the gene(s) that express themselves as longer tails in the monkey population if the trends in the data table continue? Explain reasoning for your prediction.

Because this trait is a result of multiple alleles the genes may be retained in the gene pool but their frequency would decline.

How would you explain an increase in the length of the monkeys' Tails over a period of time?

An increase in the number of tress would allow for the expression of genes responsible that influence longer tails since monkeys with longer tails would have an advantage over those with shorter tails.