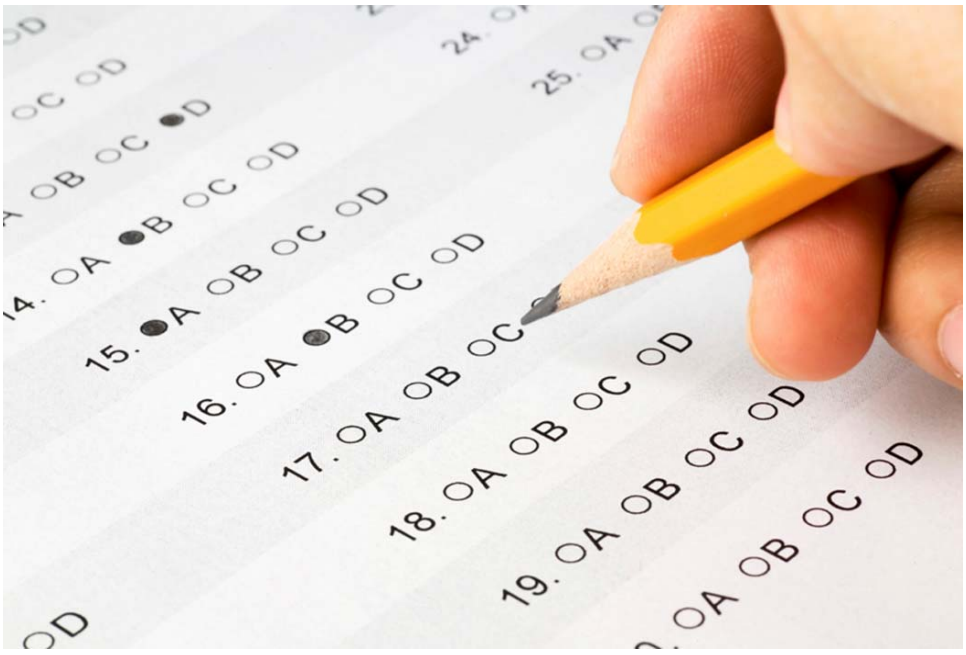
Biology
High School
Assessment

Review



Dear Parent and/or Student,

All students beginning high school after 2004 are required to take and pass the state-mandated Biology High School Assessment in order to graduate. During the test, students are asked to demonstrate their ability to use the skills and processes of science and apply the concepts of biology. To be considered proficient, students must receive a score of 396 or higher. The test is approximately three hours long, with approximately 70 items: several Brief Constructed Responses (4 points total each), and the remainder being Selected Response items (1 point each). Beginning with the May 2009 administration, Brief Constructed Response items will be discontinued.

To help review and prepare for the Biology HSA, parents and students should review the information on the next several pages. This packet includes the following information to help students prepare for the HSA:

- Brief review of Science Skills and Processes
- Brief review of the Concepts of Biology
- "Websites" – links to helpful sites, including
    - *MSDE* High school Assessment Program including practice tests for each section
    - *The HSA Biology Online course, 2008-2009* for more in-depth review

Good luck with this important endeavor!

Biology High School Assessment Review

PART 1: SCIENCE AS INQUIRY

Science is a search for evidence in order to answer questions or ***problems***. Since solutions to problems can have more than one answer, we make ***observations***, collect data, and ask questions so we can ***investigate*** answers or possible solutions.

In order to choose one solution over another:

- Research information from many sources
- Eliminate research that uses data that cannot be verified or supported by evidence.
- Be able to recognize if data is ***biased***. Eliminate data that has a set idea of the outcome of before it is tested

  - Example: before testing the effect of plant growth hormones on pea plant seedlings, your teacher tells you that she has used this particular hormone on her plants last year and the results were great. Her comment may lead you to expect better results from the test plants getting the hormones and that may affect the accuracy of your measurements.

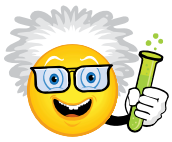
PART 2: EXPERIMENTAL DESIGN / THE SCIENTIFIC METHOD

The steps in logically solving problems are often called the ***scientific method*** and may begin by clearly stating the problem you are trying to solve.

Example: Will pea plants seedlings grow taller if a growth hormone is added to their water?

Once you establish your question, you can make an "educated prediction" based on your prior knowledge and the research you have completed. This "educated prediction" is called the ***hypothesis***. No hypothesis can be proven correct without being tested. The process of testing is your ***experimental design*** and means setting up an experiment according to the procedure below:

Steps of the Scientific Method:



- ***Problem –*** identify the problem or ask a question.
  What is it that you need to find out?

- ***Research*** the problem – check books, scientific papers, and other sources for information for what is already known.

- Form a ***hypothesis*** – state how the independent variable will affect the dependent variable

  - ***Dependent variable***: the variable that is measured in the experiment (the height of the pea plants)
  - ***Independent variable***: the factor that is changed in an experiment (growth hormone)
  - ***Example***: Pea plants will grow taller (*dependent variable)* if a growth hormone (independent variable) is added to their water.

- Create an ***experimental design*** to test your hypothesis.
  - List the ***procedure*** and ***materials***
  - Identify experimental ***controls*** – unchanging factors

- ***Data*** - ***Observe*** and ***record*** results with ***charts, lists, graphs***, etc.
  - *Make a chart* to record your data.

  - Graph you data – graph your data after collecting it to give a visual comparison between the independent and dependent variables. Graph the control data with one line and the ***average of the height of the test group*** **plants on another line.** Be sure to include a legend explaining which line on the graph represents the control and which represents the test group (for example, a dash line for one and solid for the other). Remember that the independent variable data is on the X-Axis and the dependent is on the Y-Axis.

- ***Analyze to predict*** trends and examine data to see if data supports the hypothesis

- Draw a ***conclusion*** based on the results of your data.

    - Use data to describe how the independent variable affected the dependent variable

- Do the results support the hypothesis?
  - Use data to describe whether the results support or do not support the hypothesis
  - ***Extension –*** Report results and offer uses for this information.

Web Resource: Scientific Method
http://library.thinkquest.org/J001402F/

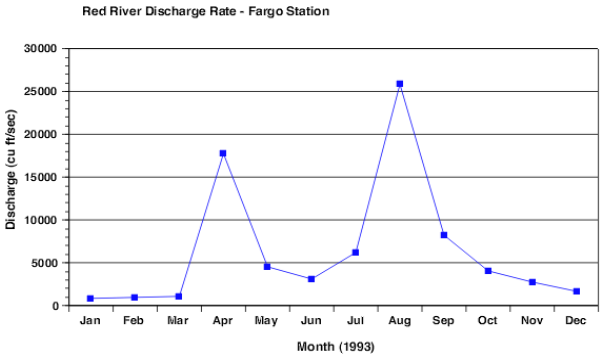
Important Notes About Designing an Experiment:

- To have valid results, use multiple subjects and ***test trials***
- Practice safety procedures
- The ***list of materials*** must include everything you need to complete the experiment
- The ***procedure*** must include every step in your experiment completed in a logical step-by-step process in order to eliminate bias about the outcome of the experiment.
- Make a ***chart or table*** to organize and record the data you collect.
- Use mathematics to interpret your data and ***graph*** the results of both sets of data for a comparison.

Graphing:

A ***graph*** is a visual comparison of quantitative data that you have recorded. It is standard procedure that the ***independent variable*** goes on the ***X-Axis*** and the ***dependent variable*** goes on the ***Y-Axis***.

Below is a sample ***line graph*** showing the discharge from a river measured by a monitoring station for one year. The months are the ***independent variable*** and are listed on the ***X axis***. The amount of discharge is the ***dependent variable*** and is written on the ***Y axis.***



Practice making graphs at the following web resource on graphing:
Web Resource: Graphing
http://nces.ed.gov/nceskids/createAgraph/default.aspx

Conclusion and Extension: Use your data to evaluate your hypothesis. If your data supports your hypothesis, write your ***conclusion*** to analyze and show that result. If your data does not support your hypothesis or if you had to make changes or adjustments in your experimental design, you may have to revise your experimental design and redo your experiment. You may also have to do more trials to support outcomes that you are not 100% sure of. ***Extend*** the **information by reporting the results and letting others know how the information might be used.**

PART 3: USING MATHEMATICS IN SCIENCE

You may plot the data you gather from any experimental design with a ***graphing calculator*** or ***computer graphing programs***. You may also use ***computer simulations*** to help to understand how to interpret the results of your data.

Ratio and proportion are used in science to predict genetic outcomes like cross-pollinating certain plant types to produce stronger, tastier, or larger plants or ones with particular colors of flowers. The knowledge of ratio predicts possible effects of passing defective genes from parent to offspring in Punnett squares.

Web Resource: Practice Taking the HSA - Biology
Skills and Processes (2008, 2007, 2006, 2005, 2004)
http://www.mdk12.org/assessments/high_school/index_d.html

Online HSA Course, User Name: "biology" / Password: "student" Click on "Online HSA Biology," then on "content" in the top gold menu bar: Module II, Sections A through L: *Nature of Science.*
http://msde.mdk12online.org

PART 1: WATER, CHEMICAL COMPOUNDS AND MACROMOLECULES

All organisms are made from ***chemical compounds*** and also use chemical compounds to maintain life processes. Growth and survival of organisms depends on the physical environment as well as the living environment. The part of the environment that is physical is referred to as ***abiotic*** substances. Living factors that influence other living organisms are the ***biotic*** factors.

Water: There is more water on Earth than any other substance. A water molecule has two atoms of hydrogen and one atom of oxygen bonded together which makes the water molecule slightly positive on the hydrogen side and slightly negative on the oxygen side. This is a picture of a water molecule showing the positive and negative sides.

This is why water is called a ***polar*** molecule. Water's ***polarity*** allows it to pull many other molecules apart and therefore it is known as the ***universal solvent*** – it dissolves many substances like Koolaid, lemonade, salt, etc, plus dissolving and transporting oxygen, nutrients, and wastes in the bodies of organisms. Water cannot dissolve non-polar substances. Oil is a nonpolar substance (no charge) which is why water and oil will not mix. Water is also unique because it gets ***denser*** as it cools. ***Density*** is the term used to describe the amount (molecules) of a substance in a specific volume. Water is densest at 4 °C. This means that its molecules are packed the closest together at that point. However, once the temperature goes below 4 °C to 0 degrees, the molecules form a circular shape and water becomes lighter (**less dense)** as it forms ice. This is why ice floats and helps living organisms survive under ice during colder months because it insulates.

Macromolecules: Large chemical compounds are called ***macromolecules.*** Macromolecules are ***organic*** compounds and contain ***carbon. Organic macromolecules*** are found in all living things. The classes of macromolecules used by living things are ***carbohydrates, lipids, proteins, and nucleic acids.***

- ***Carbohydrates*** are made from building blocks of sugar. Carbohydrates include carbon, hydrogen, and oxygen. Carbohydrates include all sugars and starches (polysaccharides) such as potatoes and flour. Carbohydrates provide ***quick energy*** for living things. A type of carbohydrate found in the cell wall of plants is the polysaccharide, ***cellulose.*** Cellulose cannot be used by animal cells but is very important in providing ***fiber*** for our ***diets.***
- ***Lipids*** also contain carbon, hydrogen, and oxygen. Lipids contain all fats, oils, waxes, etc. Lipids are part of the cell membrane and also store high energy.

- ***Proteins*** contain carbon, hydrogen, oxygen, and ***nitrogen*** and are made of the building block, ***amino acid.*** Proteins make up most body structures. They also make up the body chemicals called ***hormones*** that regulate body functions and ***enzymes*** that work on specific areas called ***substrates*** to speed up chemical reactions. ***Enzymes*** have a specific pH and temperature range where they work best (optimum conditions) and if those conditions change, the enzyme no longer works correctly.
- ***Nucleic Acids*** are macromolecules that contain carbon, hydrogen, oxygen, nitrogen, and ***phosphate.*** Nucleic Acids include DNA and RNA. DNA contains the organism's genetic information for making proteins. DNA is able to copy itself ***(replicate)*** to make whole new cells. RNA is able to ***transcribe*** (copy) portions of DNA to make proteins (***protein synthesis).*** Both DNA and RNA are made from nucleotides. A ***nucleotide*** is a three-part unit made of a ***phosphate***, a ***sugar***, and a ***nitrogen base***.
- ***Minerals*** are ***inorganic*** molecules (do not contain carbon) and are used in cellular processes.
- ***Vitamins*** are ***organic*** compounds used in the body:
  Vitamin C is used in wound healing; ***Vitamin K*** is used in blood clotting;
  Vitamin D is used for bone growth (calcium absorption).

PART 2: HOMEOSTASIS, OSMOSIS, DIFFUSION AND pH

All the chemicals of life (water, macromolecules, enzymes, hormones and others) must be kept in balance and in the range of temperature and pH where organisms can survive. This balance is called ***homeostasis*** and depends on the ability of the organism to communicate with itself (***feedback mechanisms)*** so it can adjust processes as necessary - move substances and to speed up or slow down as needed (***metabolic rate)***.

- ***Diffusion*** is the movement of molecules from where they have the most number (***high concentration)*** to where there are less of them (***low concentration)*** so they can spread out and take up all the space that is available and have an equal distance between each molecule (think of air freshener being sprayed in a room – it smells strongest in the area where it is first sprayed and then seems to "disappear"). This is called ***equilibrium.*** Like with all chemical reactions, temperature affects the rate of diffusion – cold slows down diffusion and heat speeds up diffusion.

- ***Osmosis*** is the diffusion of water. Water will always move from an area of high concentration to an area of low concentration through a ***selectively permeable membrane*** (cell membrane). This means that if the environment the cell is in has a higher concentration of water than inside the cell, water will move ***into the cell*** and the cell will swell. If the concentration of water in the cell is higher than in its outside environment, water will move ***out of the cell*** and the cell will shrink. Anything dissolved in water has a less concentration of water than freshwater.

  Examples: *If a fresh water organism like a paramecium is placed in a salt water solution, the concentration of water on the inside of the cell would be greater than its surrounding environment and water would move out of the cell causing the paramecium to shrink. If a human blood cell was placed in a drop of water, the concentration of water on the inside of the cell would be less than its surroundings and water would move into the cell, causing it to*

swell and finally burst. Like all substances, water will continue to move from where it is most concentrated to where it is least concentrated until it reaches ***equilibrium.***

- ***pH*** : When substances dissolve in water, some bonds of the hydrogen and oxygen atoms are broken. The ***pH scale*** is measured from 0 to 14. Any substance with a pH of 0 to 7 is an ***acid*** and any substance with a pH of 7 to 14 is a ***base.*** A pH of 7 is ***neutral.*** Most living things survive best in a neutral environment. pH is important in the regulation of enzyme activity and a pH (like temperature) that is too high or too low can affect how the enzyme works (functions).

Web Resource: Practice Taking the HSA
Biology
Biological Molecules (2008, 2007, 2006, 2005, 2004)
http://www.mdk12.org/assessments/high_school/index_d.html

Online HSA Course, User Name: "biology" / Password: "student"
Click on "Online HSA Biology" then on "content" in the top gold menu bar and go to the following lessons:
Module V, Sections A through E: *Biological Molecules*, all lessons
http://msde.mdk12online.org

PART 3: CELLS AND LIFE PROCESSES

All living things are made of cells, the basic unit of life. A single cell can carry out all the processes necessary to keep an organism alive. The difference in how organisms function is determined by the type and number of cells they have. A single celled organism (***unicellular)*** is a functioning ***system*** and ***multicellular organisms*** are ***organized systems of cells.*** Whether the organism is unicellular or multicellular, the cells that make them up can only live in a ***narrow range of environment***. This includes ***pH***, a specific ***temperature range***, ***light***, ***water, oxygen, carbon dioxide, radiation*** (cancer or mutations***),*** and ***toxic substances.*** Any natural or manmade changes to this environment can affect how the cell functions and therefore, determines if the organism lives or dies.

- ***Cells are*** either ***prokaryotic*** or ***eukaryotic. Prokaryotic*** cells are very primitive with no nucleus or organelles and are found in ***bacteria. Eukaryotic*** cells have a membrane bound nucleus and organelles and are found in plants, animals, protists, and funguses.
- ***Cell organelles*** are the working parts of the cell and can carry out all life processes in ***eukaryotic cells***. Important cell organelles are listed below:
  1. **Cell membrane:** decides what enters and leaves the cell.
  2. **Cell Wall:** found only in **plants** and gives plant cells their shape. It is made of ***cellulose***, a complex carbohydrate that cannot be digested by humans, but provides ***fiber*** in our diets.
  3. **Nucleus:** the control center of the cell that regulates cell activities and contains the genetic code on ***DNA.***
  4. **Mitochondria:** the ***power house*** of the cell that burns food to release the stored heat energy (***cellular respiration***) which produces ***ATP, the cell's energy molecule.***
  5. **Chloroplasts:** the energy molecule in the ***plant and some other organisms*** the traps the sun's energy and uses it to produce ***ATP*** for the process of ***photosynthesis.***

6. **Ribosomes:** are located in the cytoplasm and are where ***protein synthesis*** takes place. They assemble ***amino acids*** to make proteins.
7. **Vacuoles:** bubble-like spaces in the cell. The ***central water vacuole*** in plants stores water. ***Contractile vacuoles*** in single celled organisms collect extra water and take it to the surface of the cell membrane – controls ***osmosis*** and maintains ***homeostasis*** (balance).

- ***Life Processes*** are all of the processes carried out by a single cell or by multicellular organisms so they can stay alive. Some key life processes are listed below:
  1. **Excretion – The Excretory System:** getting rid of wastes that result from the cell's normal ***metabolic*** processes like burning food to release heat energy. Excretion in all organisms begins with the cell membrane; other specialized ***excretory*** structures found in organisms are ***vacuoles*** in single celled organisms and ***kidneys, lungs, and skin*** that get rid of carbon dioxide and urine in humans and other mammals.
  2. **Movement – The Skeletal/Muscular Systems**: the ability of organisms to change position. Special structures or processes that allow a single cell or an organism to move are listed below.
     Flagella are long protein fibers that whip back and forth to help single celled organisms like the Euglena move. ***Flagella*** are also found on individual cells in multicellular organisms like human sperm.
     Cilia are hair-like fibers that wave back and forth and allow movement in organisms like the paramecium. Cilia are also found in the human respiratory
     Pseudopods systems are extensions of protoplasm found in the amoeba and create ***amoeboid movement.***
     Bones make up the ***Skeletal System*** and ***muscles*** make up the ***Muscular System.*** These systems work together in humans and other animals to provide movement, support, and protection.
  3. **Transport - The Circulatory System**: the movement of food and wastes through a cell or through the whole organism. Transport and transport systems are also called ***circulatory*** systems in animals and ***vascular tissue in plants.*** All transport systems are designed to maintain ***homeostasis.*** Some specialized cell and organism transport structures are listed below.
     Cytoplasmic streaming is the movement of the cytoplasm inside of the cell which helps transport food and wastes.
     Vacuoles – "bubbles" in single-celled organisms that carry wastes, food, and extra water.
     Vascular Tissue is found in the roots, stems, and leaves of plants and carries water and minerals up from the soil through the plant to the leaves and carries food made in ***photosynthesis*** to the rest of the plant.
     Heart, arteries, veins, and capillaries carry blood with nutrients, oxygen, and wastes through the bodies of animals (humans).

  4. **Response/Sensitivity – The Nervous System:** is how an organism ***reacts*** or ***responds*** to its environment. This is how an organism is able to protect itself, how it gets materials for energy, and how it is able to reproduce and carry out other life processes so it can maintain ***homeostasis.*** In humans, the structures that carry out this process are known as the ***nervous system*** and include the ***brain, spinal cord, nerves, and the special senses of smell, taste, hearing, sight, and touch.***

5. **Secretion – The Endocrine System:** special organs that make body chemicals that go directly into an organ or the blood stream instead of through a "tube" are called ***glands.*** The body chemicals made by the endocrine glands are called ***hormones*****.** Hormones regulate body activities. An example of an endocrine gland is the ***pancreas*** which makes ***insulin*** to help cells absorb sugar.
6. **Feedback – Feedback Loops:** the body's ability to communicate with itself to maintain homeostasis – speeds up or slows down processes.

PART 4: ENERGY TRANSFER

All living things must have energy to carry out life processes and reproduce the species. ***Energy Transfer*** refers to how cells/organisms get and use energy. All energy for living things on Earth comes from the sun. Only ***green plants*** can trap the sun's energy on ***chlorophyll***, a special energy molecule located in the ***chloroplast*** of the plant. The plant uses this energy from the sun to make ***glucose,*** which is ***chemical energy,*** through the process of ***PHOTOSYNTHESIS.*** All other living things must get this chemical energy and release it in the form of heat to use to carry out life processes. This is called ***CELLULAR RESPIRATION.***

PHOTOSYNTHESIS: ***Chlorophyll*** is the pigment found in the ***chloroplasts*** of green plants that reflects green light and absorbs red and blue light. The plant uses the energy from this light to combine carbon dioxide and water to produce glucose and give off oxygen as a waste.
The word equation for photosynthesis is:

carbon dioxide + water → glucose (sugar) and oxygen

The balanced chemical equation for photosynthesis is:

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

The ***reactants*** or ***raw materials*** are ***carbon dioxide*** and ***water***.
The ***products*** are **glucose** and ***oxygen.***

Energy is stored in a chemical form in the glucose molecule. The rate of photosynthesis is affected by the color and intensity of the light and by the temperature. You can measure the rate of photosynthesis in a lab setting by measuring the amount of oxygen bubbles given off by a sprig of elodea in a test tube under light.

Chemosynthesis: Some forms of bacteria are still able to make ***ATP energy*** from inorganic chemicals in their environment. This process is called ***chemosynthesis (chemo- chemical / synthesis – to make).***

CELLULAR RESPIRATION: All eukaryotic cells have ***mitochondria*** that store the energy carrier molecule, ***ATP***. The energy for ATP is formed when the cell burns food and releases the heat energy that is stored on ATP. This energy is used for all cell processes.
The ***reactants*** are glucose (food) and oxygen and the ***products*** are carbon dioxide and water.

Cellular respiration is the opposite reaction of photosynthesis.

- The word equation for cellular respiration is:

  glucose (sugar) + oxygen → carbon dioxide and water

- The balanced chemical equation for cellular respiration is:

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

  There are two forms of cellular respiration, ***aerobic*** and ***anaerobic***. In ***aerobic respiration***, the cell uses more oxygen and makes more ATP. In ***anaerobic respiration***, the cell does not have as much oxygen and it makes less ATP.

  When ***anaerobic respiration*** happens in human muscle cells, it makes a waste product called ***lactic acid*** which causes muscle cramping.
  When ***anaerobic respiration*** *happens* in plants, it produces ***alcohol.***

Web Resource: Practice Taking the HSA
Biology
Cells and Organisms (2008, 2007, 2006, 2005, 2004)
http://www.mdk12.org/assessments/high_school/index_d.html

Online HSA Course, User Name: "biology" / Password: "student"
Click on "Online HSA Biology" and then on "content" in the top gold menu bar and go to the following lessons:
Module IV, Sections A through C: *Structure and Function of Cells and Organisms*, all lessons. Module V, Sections F and G: *Transfer of Energy*
http://msde.mdk12online.org

PART 5: ASEXUAL AND SEXUAL REPRODUCTION

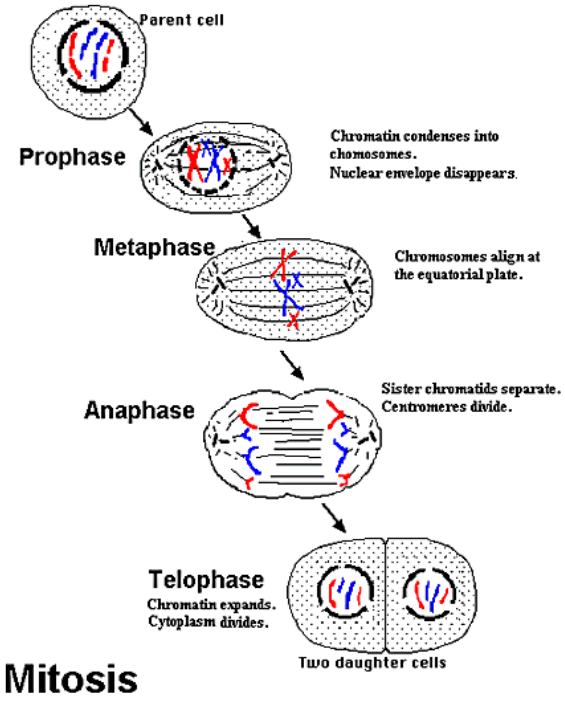
When cells and organisms reproduce using only the genetic information from one parent, it is ***asexual*** reproduction and the new cell or organism receives an exact copy of the genetic information contained the parent's cell. When half of the genetic information from each parent is joined during reproduction, it is two-parent or ***sexual*** reproduction.

- ***Asexual Reproduction:*** produces large numbers of offspring with the exact genetic information as the parent, but has ***little genetic variation***.

  MITOSIS is a four-step process that forms new cells identical to the parent cell.
  - In the first phase of mitosis the DNA (chromosomes) ***replicates*** (copies itself). The cell now has an exact copy of all of its genetic information held on its chromosomes.
  - The chromosomes and their new copies line up in the center of the cell.
  - The chromosome pairs separate, with half of the chromosomes moving to each opposite end of the cell.

- The cytoplasm then divides in half, a new nuclear membrane and cell membrane form. The original cell is now two new cells that are exactly like the original.

The number of chromosomes in the nucleus of any cell is referred to as ***2n***, with the ***n*** representing the chromosomes. The original cell is called the ***parent cell*** and each new cell is called a ***daughter cell.*** Since the new cells are exact copies, there is little ***genetic variation.***

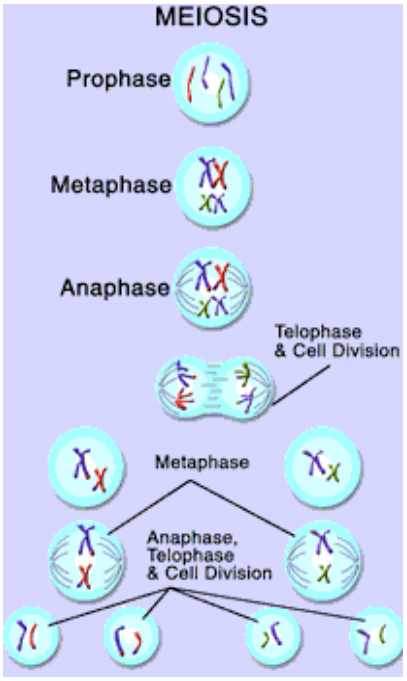


Examples of asexual reproduction that produces whole new organisms from one parent are:

1. **Binary fission:** in single celled organisms, the cell just divides in half after making a copy of its genetic information ***(mitosis)***. Example: bacteria, amoeba.
2. **Budding:** a new organism forms off the side of the adult from mitosis and falls off when it reaches maturity. Example: hydra
3. **Vegetative Propagation:** plants only and occurs when cuttings are taken and planted to grow new plants. The new plant grows through mitosis.

- ***Sexual Reproduction:*** sex cells, ***sperm and eggs,*** are called ***gametes.*** The gametes from each parent contain half the genetic information for the species and are formed by a special process of cell division called ***meiosis.*** During meiosis, the chromosome number of the cell is divided in half and new cells are formed, each with half the number of chromosomes from the parent cell. When these cells join during reproduction, the new organism gets genetic information from both parents. Sexual reproduction provides ***genetic variation*** because segments of chromosomes sometimes switch places during meiosis (***crossing over – which makes new gene combinations)*** and also because the new organism has chromosome combinations from two parents.

MEIOSIS is made of two cell divisions. Mitosis occurs first, making two new cells identical to the parent cell. Then each of the new cells divide again, forming four new daughter cells, each with half the number of chromosomes of the parent cell.
These new cells are sex cells called ***gametes.***



1. **Gametes:** the specialized cells with half the genetic information from the parent that is formed during ***meiosis*** are called ***sperm*** in males and ***eggs*** in females. During sexual reproduction, the ***sperm fertilizes*** the ***egg.*** The half-number of chromosomes in each gamete join together in pairs to form a ***full set*** of chromosomes. A new individual is formed. The fertilized cell is called a ***zygote*** and continues to grow through regular cell division, ***mitosis.***
2. **Flowering Plants:** reproduce sexually and are the male and female reproductive organs of the plant containing both sperm (***pollen)*** and eggs. The sperm in the pollen grain can fertilize the eggs in the same flower (***self-pollination)*** or be carried to another flower and ***pollinate*** (fertilize) the eggs of that flower ***(cross-pollination).***

Online HSA Course, User Name: "biology"/ Password: "student" Click on "Online HSA Biology" and then on "content" in the top gold menu bar and go to the following lessons:
Module IV, Sections C, #8, Section D, all Lessons: *Structure and Function of Cells and Organisms.* Module VI, Section F: *Genetics and Traits*
http://msde.mdk12online.org

PART 6: GENETICS

The characteristics that make any organism who or what it is come from that organism's parents. ***Genes*** are segments of the DNA in the chromosome. The passing of traits from parents to offspring (children) is called ***heredity.***

- ***Genes***: sections of DNA in the chromosome that carry the information for the traits of an organism such as hair color, eye color, height, etc. Genes, like the chromosomes they make up, are in pairs. One half of the pair comes from one parent and one half from the other parent and are joined into pairs when the sperm fertilizes the egg during reproduction. Each member of a pair of genes is called an ***allele.***
- ***Dominant and Recessive Genes:*** occur because the new pair of ***alleles*** may carry two versions of the same trait (like one for brown eyes and one for blue eyes). The traits usually do not blend together, but the one that is stronger, or ***dominant,*** will show up in the organism and the weaker, or ***recessive*** allele, will just continue to be carried on the gene without showing up in the organism's physical characteristics. This means that the gene is still in the organism and could be passed on to its offspring when sperm or eggs are formed.
- ***Genotype:*** the term used to describe the actual gene alleles that an organism carries on its chromosomes. The genotype of an organism can be written out by using the upper and lower case versions of the letter that symbolizes the dominant and recessive alleles. Alleles that are the same (either both dominant or both recessive) are called ***homozygous (same) alleles*** and are represented by two upper case letters for dominant or two lower case letters for recessive***.*** Gene pairs that contain one of each type of gene from the parents are called ***heterozygous*** (different) ***alleles*** and are represented by one upper case and one lower case letter.
  1. **Homozygous dominant –** means if the alleles from both parents are the dominant form of the trait, they are represented by the two upper case letters such as BB, TT, or PP. This is called ***homozygous dominant.***
  2. **Homozygous recessive –** means if the alleles from both parents are the recessive form of the trait, they are represented by the two lower case letters such as bb, tt, or pp. This is called ***homozygous recessive.***
  3. **Heterozygous –** means if the alleles from both parents have one dominant and one recessive version of the trait, they are represented by one upper case letter and one lower case letter such as Bb, Tt, or Pp and are called ***heterozygous.***
- ***Phenotype:*** the physical trait that you see when you look at an organism such as brown hair, tallness, pink flowers.

- ***Punnett Squares:*** are mathematical charts used to predict or interpret the results of genetic crosses. Using Punnett Squares show the possible combinations of alleles an offspring will receive from its parents.

Punnett Square for one parent with brown eyes and one parent with blue eyes:

B = dominant allele for brown eye color

b = recessive allele for blue eye color

POSSIBLE SPERM THAT COULD FERTILIZE ONE OF THE EGGS ON THE SIDE

(POSSIBLE EGG THAT COULD FERTILIZED BY THE SPERM ON THE TOP OF THE CHART)

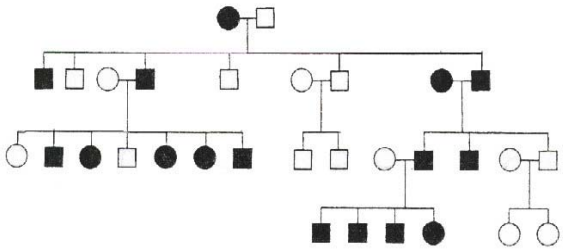
	B	**b**
b	**Bb**	**bb**
b	**Bb**	**bb**

- By moving the letters down and across the chart, you can see which predicted gene combinations might occur out of every four offspring
- Because two of the squares have one dominant and one recessive allele, the dominant would show up in the phenotype and you could expect to have two brown-eyed offspring for every four that are born
- Because two of the four blocks have a bb, or recessive combination, there is no dominant gene to overpower it so the recessive gene for blue eyes can express itself (show up) in the offspring.
- Mathematically the ratio can be expressed as 2:2, dominant to recessive.

- ***Sex-linked Traits:*** The pair of chromosomes that determines the sex of the organism are the X and Y chromosomes. The combination of alleles XX produces a female and the combination of XY forms a male. Some defective traits found in humans are carried on the X chromosome and are passed from mother to son. This means that any defective gene carried by the mother's X chromosome will be passed onto the son such as colorblindness and hemophilia. Example for colorblindness: X^cY. Most defective genes are recessive and therefore have a "good" gene on the other X chromosome in females to dominant over it.

  Example: $\mathbf{X^CX^c}$ and no colorblindness would occur in the girls.

- ***Pedigree charts:*** are used to interpret patterns of inheritance within a family. They are another way to show how traits are passed from parents to offspring. Pedigree charts show females as a circle and the males as a square. If a parent carries the trait that is being tracked from generation to generation, the circle or square is shaded in to indicate that the parent is carrying that gene. Each generation is joined by a horizontal line and the vertical lines leading down from the horizontal line indicate the number of children from that set of parents. A ***pedigree chart*** is shown below.



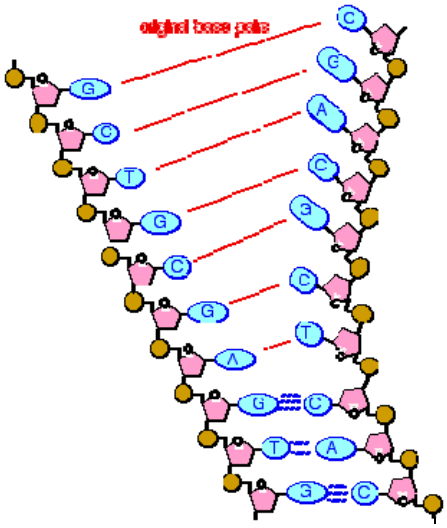
- ***Mutations:*** changes that occur in a gene or chromosome. Mutations can occur for a variety of reasons. For example, when chromosomes (genes) separate and reform during meiosis a segment of one gene will sometimes switch places with a segment on the other DNA strand. This is called ***crossing over*** and helps provide genetic variation in the species. When these mutations are passed

to the offspring, the offspring may have a different ***phenotype*** from what would be expected. ***Mutations*** can have a negative affect on the organism or no effect at all. Mutations can also be caused by environmental factors such as UV light, X-rays, drugs, or alcohol. Some mutations can cause cancer.

PART 7: MAKING PROTEINS – *PROTEIN SYNTHESIS*

All genetic information for all organisms is contained in its chromosomes which are made of ***DNA***, ***deoxyribonucleic acid.*** Segments of bases of DNA are called ***genes*** and code for specific proteins. DNA is located in the nucleus of the cell. Cell parts are made on the ribosomes in the cytoplasm of the cell. Since the DNA molecule is too large to leave the nucleus with the "recipe" to make the organism's proteins, it makes a special molecule called ***RNA, ribonucleic acid,*** that copies the section of the DNA molecule needed to make the proteins. ***RNA*** is able to take the needed information from the DNA back to the ribosomes to be used as a ***template*** (pattern or "recipe") to make (***synthesize*****)** proteins.

DNA and ***RNA*** are both macromolecules called ***nucleic acids. DNA*** is a ***double helix*** that looks like a spiral staircase. The sides are made from alternating units of phosphate and ***deoxyribose sugar***. Attached to the sugar molecule are ***nitrogen bases***. There are four nitrogen bases in DNA: ***adenine*** and ***thymine*** pair together (A-T) and ***guanine*** and ***cytosine*** pair together (G-C) like steps on a ladder. ***RNA*** is a ***single helix*** (spiral) that also has alternating sides of a sugar called ***ribose*** and phosphate. Sticking out from the sugar molecule are nitrogen bases just like those in DNA with one change – every place there is a ***thymine*** base in DNA, it is replaced with a base called ***uracil*** in RNA***.*** The DNA code is used to make the three forms of RNA, named for the task they perform: ***mRNA, tRNA, and rRNA.***



- ***Replication:*** When cells reproduce, all of the genetic information contained in the cell's chromosomes (DNA) has to be copied for each new cell. This process is called ***replication*** and only involves ***DNA***.

- ***Protein Synthesis:*** When protein synthesis takes place, the RNA is used to copy parts of the DNA molecule in the nucleus and take it to the ribosome in the cytoplasm so proteins can be synthesized. There are three forms of RNA and each has a special job to do so protein synthesis can take place.
  1. ***Transcription – mRNA***: in this process RNA copies the DNA in the nucleus in sets of three bases in a row, called ***codons,*** and carries it to the ribosome in the cytoplasm. ***Codons*** are the "codes" or "recipes" for a specific amino acid. This form of RNA is called ***messenger RNA (mRNA)*** and the process of making a copy of a section of DNA is called ***transcription. rRNA (ribosomal RNA)*** makes ribosomes where the mRNA attaches.

  2. ***Translation – tRNA: Transfer RNA (tRNA)*** is another form of RNA that floats around the cytoplasm carrying a complimentary end to the tRNA (meaning opposite bases) called an ***anti-codon.*** On the opposite end of the ***tRNA*** are amino acids that code for specific proteins and they are lined up on the ribosome and a new protein is made according to the original information on the DNA in the nucleus. Proteins (amino acids) always start with the codon AUG, and also have a specific stop codon.

     EXAMPLE: DNA Code: T-A-C-C-C-C-G-T-A-T-C-G-G-G-T

(In groups of three) ***codons***:	TAC	CCC	GTA	TCG	GGT
mRNA Codons:	AUG	GGG	CAU	AGC	CCA
tRNA Anti-Codons:	UAC	CCC	GUA	UCG	GGU

PART 8: BIOTECHNOLOGY/ ALTERATION OF DNA

Biotechnology is the term used to describe a field of science that specializes in changing the base sequences on DNA to change or improve traits in an organism. There are many positive effects of biotechnology including producing disease resistant crops and finding new medications. There are also possible negative side effects in that a changed characteristic of an organism could upset the balance in its ecosystem. Forms of ***biotechnology*** are listed below.

- ***Genetic engineering:*** changes the gene to produce better results (crops, etc.)
- ***Recombinant DNA:*** "recombines" DNA from two or more organisms to improve its characteristics.
- ***Gene Splicing:*** uses enzymes to remove a gene from the section of DNA in one organism and place it in another organism for beneficial reasons like the use of a bacterium to produce human insulin.
- ***Cloning:*** making an exact copy of an organism

Web Resource: Practice Taking the HSA
Biology
Inheritance of Traits (2008, 2007, 2006, 2005, 2004)
http://www.mdk12.org/assessments/high_school/index_d.html
Online HSA Course, User Name: "biology" / Password: "student"
Click on "Online HSA Biology" and then on "content" in the top gold menu bar and go to the following lessons:
Module IV, Section C, #7: *Structure and Function of Cells and Organisms* and Module VI, Section A – E and G: *Genetics and Traits*
http://msde.mdk12online.org

PART 9: NATURAL SELECTION AND CLASSIFICATION

Natural selection is the term used to describe changes in populations of organisms over a long period of time. Over time, organisms that have traits that allow them to survive ***environmental pressures*** such as disease, predators, natural disasters, etc. pass those traits on to their offspring, making a stronger version of the species. This also creates ***genetic variation*** among members of the same species. Organisms with the traits best suited to their particular environment would be the ones to survive and reproduce. This is sometimes referred to as "***survival of the fittest."*** Positive traits would be passed on to their offspring. This increases the number of genes for successful traits in any species.

- ***Adaptation:*** is the term used to describe these genetic ***variations*** (traits) that an organism inherits that allow survival in its particular environment.
- ***Variation:*** different versions of the same trait found in any species such as hair color, eye color, height, etc.
- ***Fossils:*** are preserved remains of ancient members of a species or of extinct organisms that give clues about the organisms of the past.
- ***Homologous Structures:*** are ***anatomical similarities*** (body structures) in different species that suggest that they may have developed from a common ancestor.

- ***Embryonic Development:*** is the study of the stages of development in an organism that may show relationships or links to other organisms. In humans, traits found in each stage of early embryo development resemble other members of the animal kingdom (like gill slits and tails). These features disappear before birth so the organism at birth carries the features of its species.
- ***DNA and Amino Acids:*** a process called ***gel electrophoresis*** allows biochemists to study the sequence of amino acids for protein synthesis in organisms. This allows scientists to study the similarities and differences between species as a way of looking for genetic relationships.

Classification**:** all of the information above is used to help scientists classify living things into groups based on similarities. Being able to place an organism in a kingdom, phylum, etc. helps us to understand the organism and its relationship to other organisms and to the environment.

Web Resource: Practice Taking the HAS - Biology
Evolutionary Change (2008, 2007, 2006, 2005, 2004)
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Module VII, Sections A through F: Evolution and Natural Selection
http://msde.mdk12online.org

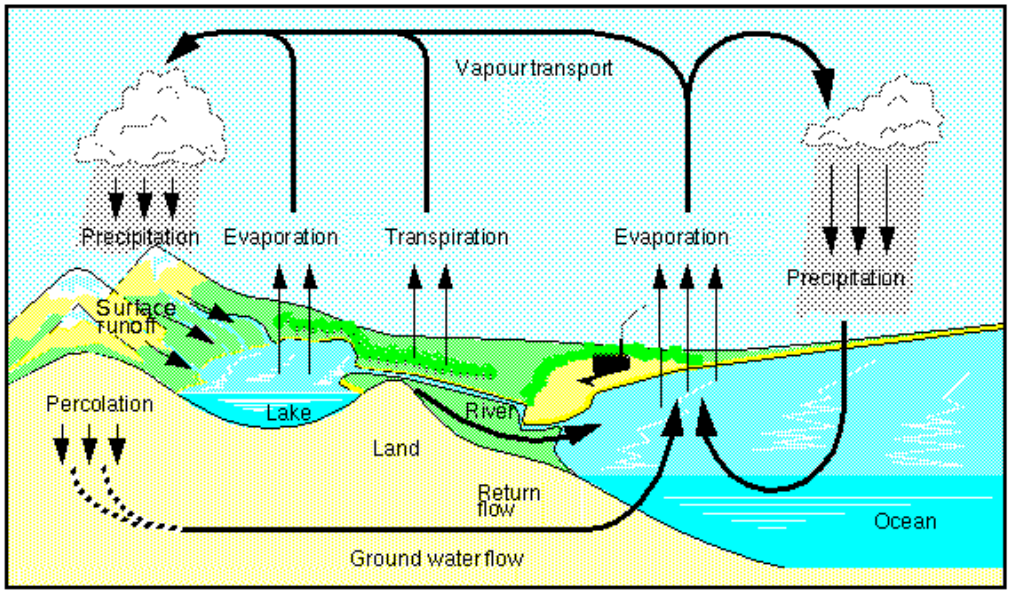
PART 10: ECOLOGY

Ecology is the study of the interactions between living things and their ***environment***. ***Environment*** is all of the organism's surroundings in which it has to survive, including both the ***abiotic*** (non-living) and ***biotic*** (living) factors. **The sun provides the energy for life on Earth**. This energy can only be trapped by green plants in the process of ***photosynthesis*** and converted to ***chemical energy*** (food), which holds stored energy for ***life processes*** and the ***macromolecules*** needed to repair, replace (maintain),

and reproduce cells and cell parts. Other organisms get this chemical energy from the green plant through the process of ***cellular respiration***. Where an organism lives is called its ***habitat*** and is important in determining how that organism gets food and shelter. All the organisms living in an area and their interactions with the biotic and abiotic environments are called an ***ecosystem.***

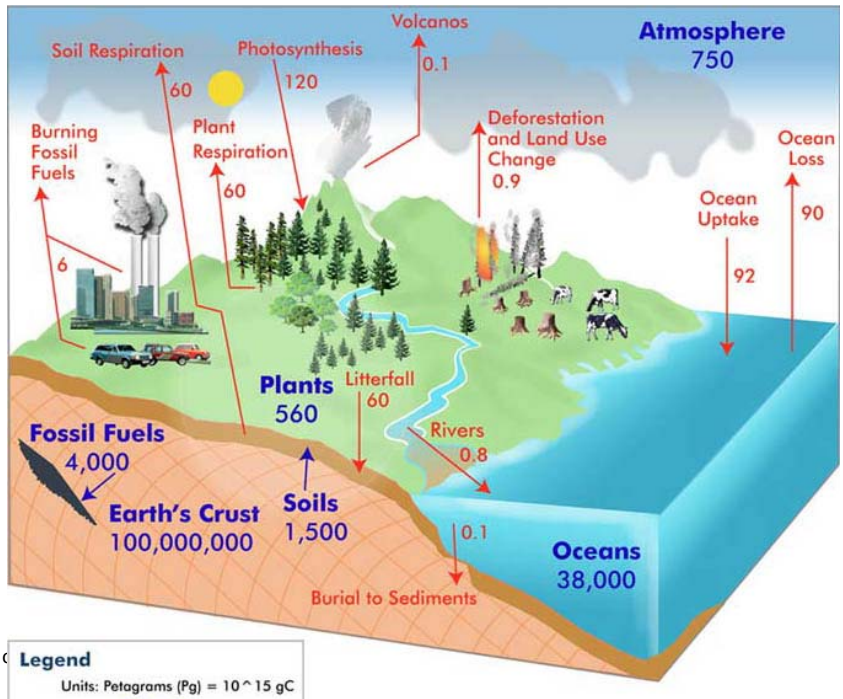
- ***Abiotic factors:*** are the non-living parts of the environment that are used as raw materials in photosynthesis and respiration. These raw materials are ***recycled*** in the following major cycles:

1. **Water Cycle:**

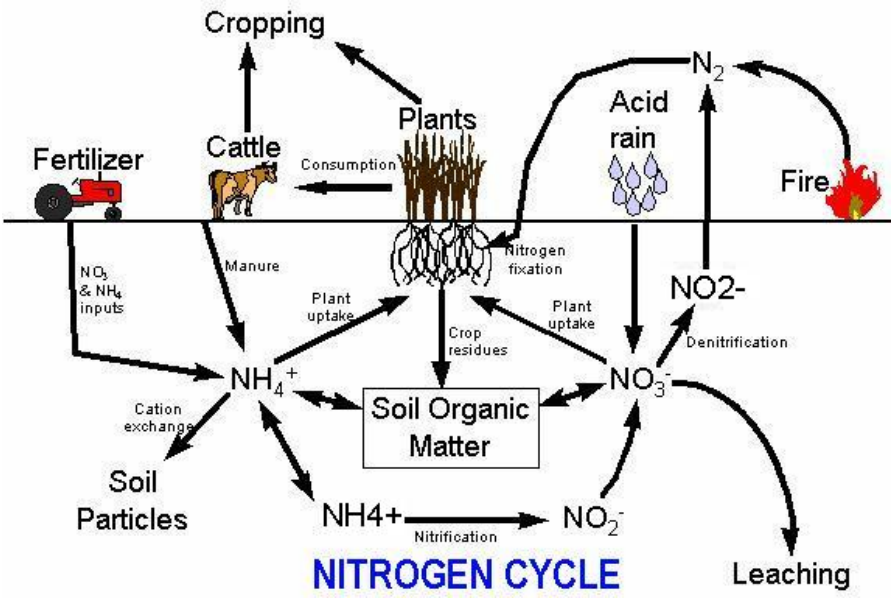


Courtesy Erich Roeckner, Max Planck Institute for Meteorology

2. **Carbon Cycle:**



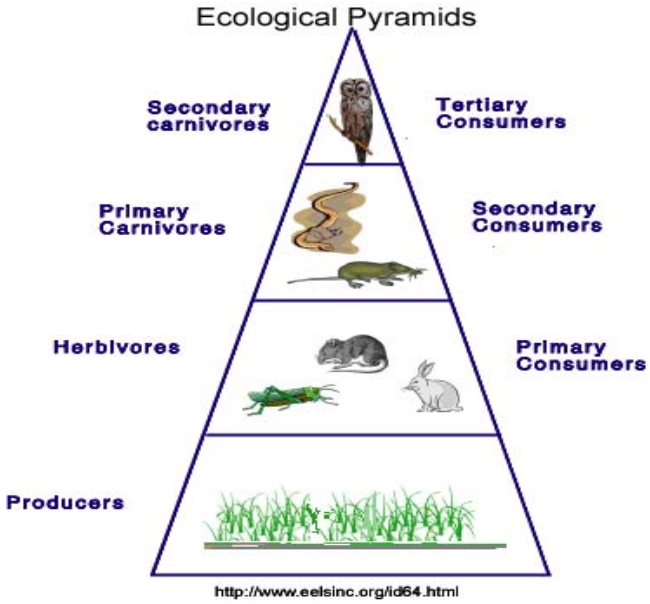
3. **Nitrogen Cycle:**



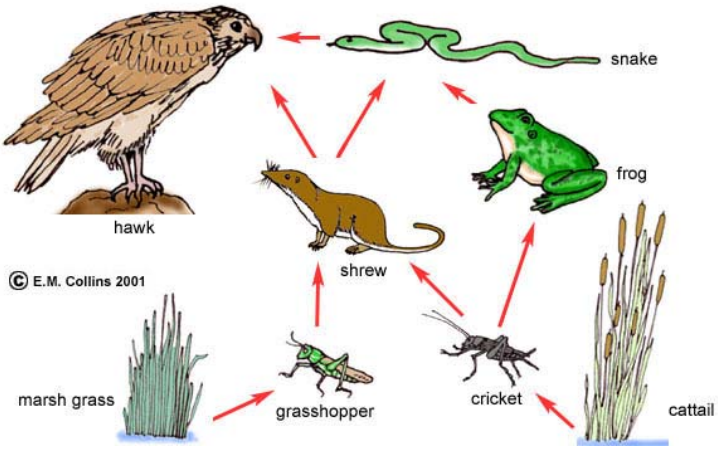
- ***Energy Pyramids:*** show how energy is passed through the environment. All energy transfer from the sun begins when the green plant traps that energy through photosynthesis. From that point, all other organisms must tap into that energy in order to survive.
  An energy level is called a ***trophic level*** and is illustrated by an ***energy pyramid.*** The total number of organisms in an energy pyramid is called the ***biomass.***
  1. **Producers / Autotrophs (self-energizing) –** plants are getting energy directly from the sun which they use to ***produce*** glucose and therefore these ***producers*** have the most energy. Producers make up the base of the ***energy pyramid***.
  2. **Consumers / Heterotrophs (other energizing) –** "use" food as opposed to making food and are grouped by where they are on the pyramid (who eats what):
     - ***Primary consumers*** are on the second level and eat plants and therefore are called ***herbivores.***
     - ***Secondary consumers*** are the next level above primary consumers (meaning that they eat the primary consumer and can be either ***carnivores*** (meat eaters) or ***omnivores*** (eat both plants and animals).
     - ***Tertiary consumers*** are the third level of consumers and the fourth total level on the pyramid. They may be either carnivores or omnivores. Energy levels can continue if more organisms above this level eat the organism on this level and so on. Example: You eat a shark steak for dinner. The shark had eaten a large fish. The large fish had eaten a medium sized

fish which had eaten a small fish which fed on plankton. This energy pyramid would have six levels.

3. ***Decomposers*** are bacteria and funguses that can't make food or eat food so they have to live off dead organisms to get energy. This benefits the environment because it makes dead things "rot" and puts nitrogen and other minerals back into the soil.
4. ***Scavengers*** feed off dead organism and therefore help to break down and recycle both organic and inorganic materials.
5. ***Energy –*** The further along the pyramid you go, the less food (and hence energy) remains available. As a rule, only 10% of the energy is passed from each level to the next because the other 90% is used by the organism for life processes.



- ***<u>Food Chains and Food Webs:</u>*** are other ways of diagramming the energy pyramid by showing "who eats whom." It shows the path of energy from organism to organism. Food webs can exist on land ***(terrestrial)*** or in the ocean ***(marine)*** as long as there are producers to begin the energy flow.



- ***Oceanic and Terrestrial Food Webs:*** are the two major global food webs that provide energy for all living things, including humans. As with all food webs, the base of the web is a green plant. The other organisms are at each level of the energy pyramid.
  1. **Oceanic food web –** a food web based on marine organisms. As with all food webs, marine plants, including phytoplankton, trap the sun's energy through photosynthesis. The other organisms in the ocean form the rest of the food web as they eat.
  2. **Terrestrial food web –** a food web based on land instead of the ocean water.
- ***Relationships among Organisms:*** are the ways organisms relate or interact with each other in getting food and in survival in general. ***Competition*** among organisms for food and shelter lead to a number of relationships.
  1. **Predator/Prey –** one organism hunts and eats another organism.
  2. **Scavengers –** organisms that feed off dead organisms.
  3. **Symbiosis –** a relationship among organisms that must exist in order for one or both of them to exist. The forms of ***symbiosis*** are listed below:
     - **Mutualism –** both organisms benefit from the relationship
     - **Commensalism** – one organism benefits but does *not* harm the other one.
     - **Parasitism –** one organism benefits and the other is harmed.
  4. **Niche –** is the role or "job" of the organism in its environment – what it has to do to stay alive.
  5. **Competition –** the "fight" between organisms in an ecosystem for food and shelter.

- ***Ecosystem:*** is a large area where organisms live and is characterized by both its physical (abiotic) and living (biotic) factors. Within the ***ecosystem*** the numbers of organisms of the same species are called a ***population.*** The numbers of different populations that live together in this area are called a ***community.*** The specific place in the ecosystem where an organism lives is its ***habitat.*** The varieties (different kinds) of organisms in the ecosystem are referred to as its ***biodiversity.***
  The more biodiversity an ecosystem has the more food sources it has and therefore is more likely to be a successful ecosystem.
  1. ***Natural Influences on Ecosystems*** – can determine how long an ecosystem lasts and therefore how long the organisms living there can survive. **Highly successful ecosystems overpopulate which reduces the food supply. Habitats can also be destroyed by disease and natural disasters.**
  2. ***Man-made Influences on Ecosystems*** – can also destroy ecosystems by pollution and urbanization (destroying an ecosystem to build homes and businesses).
  3. ***Succession –*** A cycle of changes in an ecosystem over time from an area where life cannot exist (was never there or was destroyed for some reason) to an area that can support life. ***Succession*** begins with soil formation and then the appearance of grass and small plants. Once the plant is present and photosynthesis can take place, the area can support other small organisms. Then small trees and scrubs appear followed by larger animals. Once the area progresses to large trees, it is an established ecosystem.

Web Resource: Practice Taking the HSA
Biology
Interdependence of Organisms (2008, 2007, 2006, 2005, 2004)
http://www.mdk12.org/assessments/high_school/index_d.html

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Click on "Online HSA Biology" and then on "content" in the top gold menu bar and go to the following lessons:
Module III, Sections A through I: Ecology http://msde.mdk12online.org