Unit 1: Introduction to Biological science

After completing Unit 1, students should understand…

1. The presence of six characteristics that are present in all living things indicates that all life on Earth has evolved from a common ancestor that lived over 3.5 billion years ago.
    a. Six characteristics present in all living things on Earth represents a Unity of Life: Cellular organization, Metabolism, Homeostasis, Growth and Development, Heredity, Response to Stimuli
    b. The exposure of life on Earth to constantly changing environmental stimuli has caused the natural selection of extreme diversity of life.

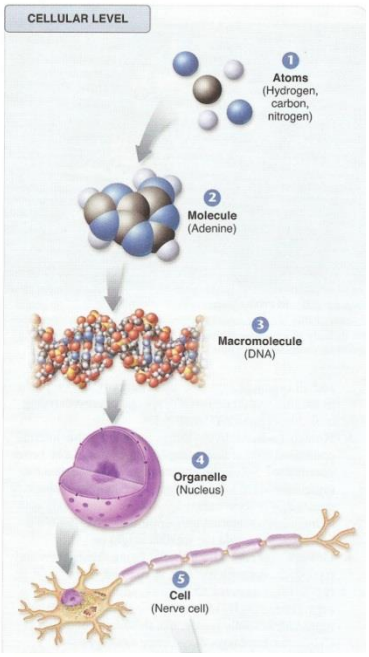
2. Today's highly varied forms of life demonstrate how natural selection can change a population over very long periods of time.
    a. Since the era when our common ancestor lived, mutations have resulted in variation among individuals in a population.
    b. When competition exists, individuals with favorable variations survive to reproduce, while those disadvantaged individuals perish and take their ineffective genes with them.

3. The scientific method is a systematic approach to problem solving that increases the speed at which discoveries are made AND allows scientists to have confidence in the theories that are generated.
    a. A hypothesis is an educated guess, while a conclusion is based upon data that is collected in an experiment.
    b. Experiments are *controlled* when they have no more than one manipulated variable; this variable is evaluated by making observations on a responding variable. For instance, if a scientist wants to evaluate the effect of exercise on the body, she might collect data related to the participants' heart rate.
    c. A scientific theory is accepted based upon data collected from many investigations; while it is possible that a theory might be revised if new and unexpected data is collected, theories are not something one may choose to believe or not believe – they are simply accepted based upon the best available evidence.

After completing Unit 1, students should be able to…

1. Determine whether or not a specimen is alive based upon the characteristics it possesses.
2. Write a hypothesis (and predictions) based upon a manipulated and responding variable.
3. Carry out a controlled experiment and record objective data.
4. Make a conclusion based upon data in written or graphical form.
5. Explain why a scientific theory is widely accepted and what it would take to revise it.

After completing Unit 1, students should be able to interpret and explain the following diagrams:

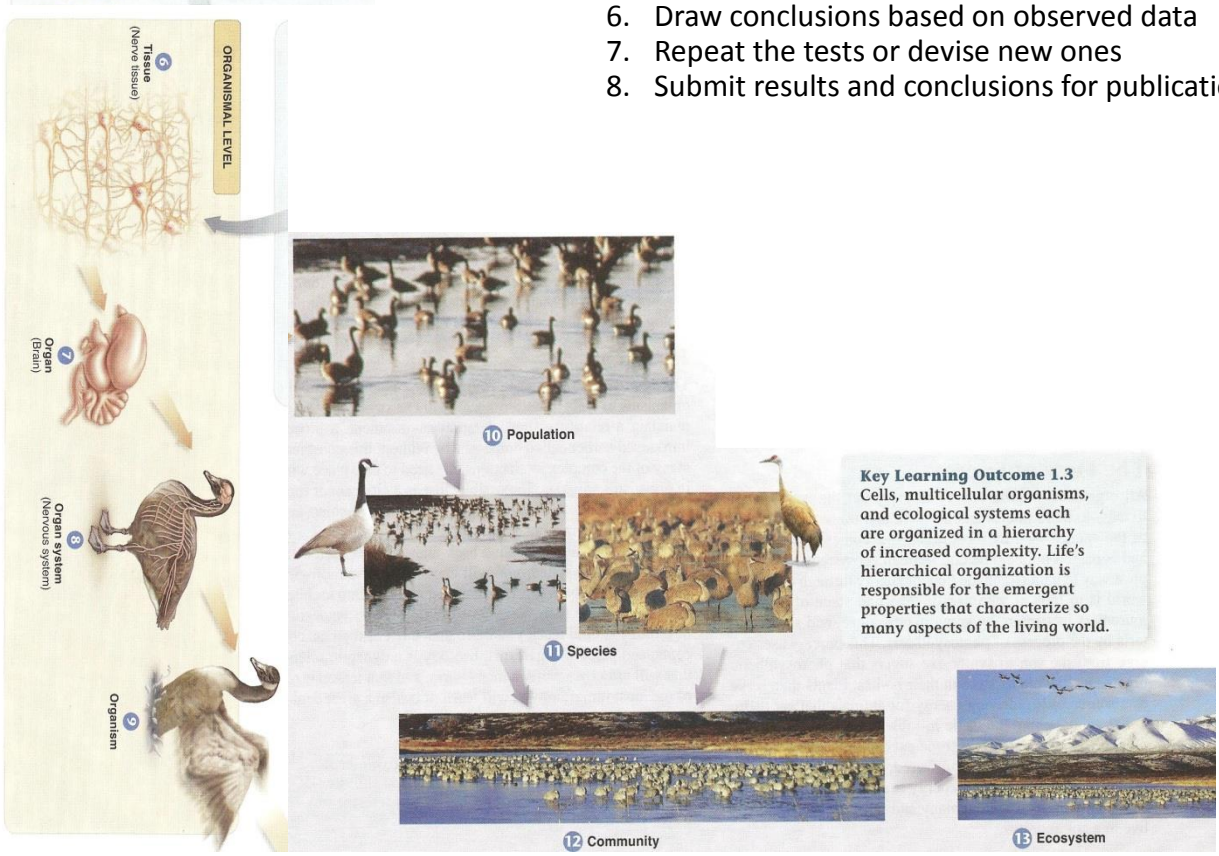


Characteristics of life

1. Cellular organization
2. Metabolism
3. Homeostasis
4. Growth and development
5. Heredity
6. Response to stimuli

Steps in the Scientific Method

1. Generate questions
2. Conduct background research
3. Develop a hypothesis and make predictions
4. Devise an experiment to test the prediction
5. Conduct the experiment and analyze data
6. Draw conclusions based on observed data
7. Repeat the tests or devise new ones
8. Submit results and conclusions for publication



Unit 2: The Chemistry of Life

After completing Unit 2, students should understand…

1. Atoms bond with one another in order to fill their outer (valence) shell.
    a. Ionic bonds occur when electrons are transferred from atom to atom in order to produce full outer shells; this produces positively and negatively charged ions which stick together.
    b. Covalent bonds occur when electrons are shared between multiple atoms in order to produce full outer shells.
    c. When the electrons of covalent bonds are not shared equally between atoms, a polar molecule is produced; this molecule is neutral overall, but maintains partial positive charges on one end and partial negative charges on the other.
    d. Since water is a polar molecule, it tends to stick to itself through hydrogen bonds that occur between the positively charged hydrogen atoms and the negatively charged oxygen atoms.

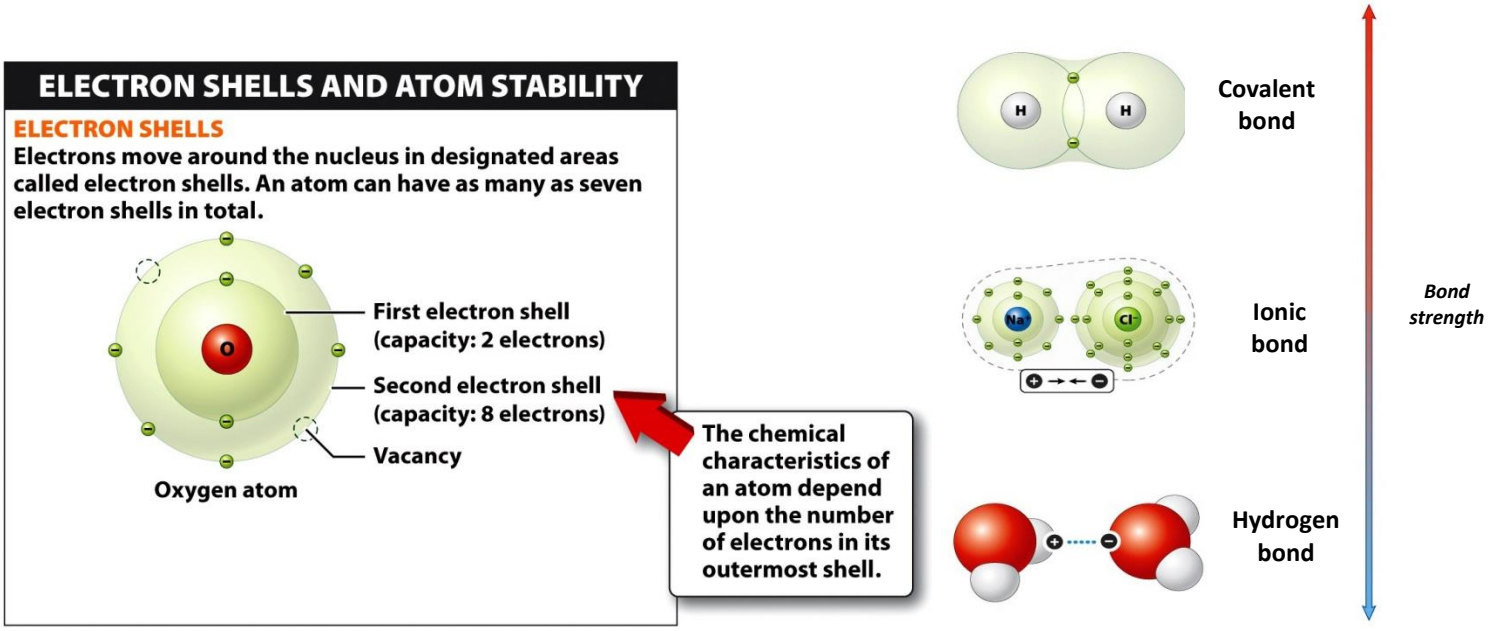
2. The fact that water is a polar molecule allows it to have many special properties that are vital to the survival of life on Earth.
    a. Cohesion (water sticks to water) and adhesion (water sticks to other polar molecules) allow plants to take in water through their roots.
    b. Since water demonstrates cohesion, it has a high specific heat capacity, which allows it to resist temperature change; this allows organisms to maintain homeostasis more easily.
    c. Water is an effective solvent, since its partial positive (on the hydrogen atoms) and negative charges (on the oxygen atom) will pull apart ionically bonded solutes.
    d. Since the cohesion of water causes it to form a crystal structure when it freezes, the density of ice is lower than that of liquid water; this allows it to it float on the surface and help maintain liquid conditions in ponds, lakes and other bodies of water.

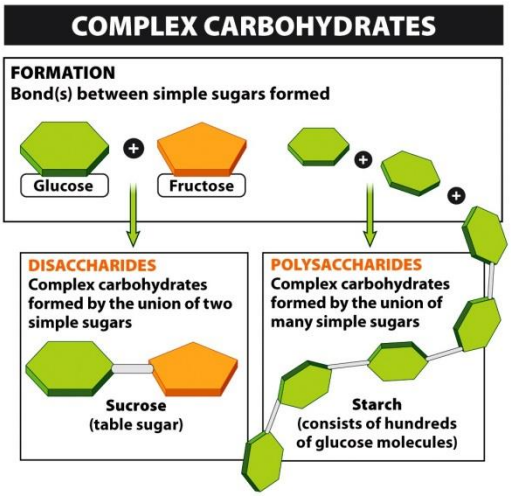
3. Each of the four biological important macromolecules have a form that allows it to complete its specific function within a living organism:
    a. Carbohydrates hold energy that can easily be converted into ATP; this conversion occurs during a process called cellular respiration.
    b. Lipids are non-polar molecules that hold energy for long term storage (fast deposits) and help to build structures like the phospholipid bilayer of the cell membrane.
    c. Nucleic acids (DNA and RNA) store the genetic information needed to make proteins.
    d. Proteins work together with other proteins, such as enzymes, to control the activities of a cell.

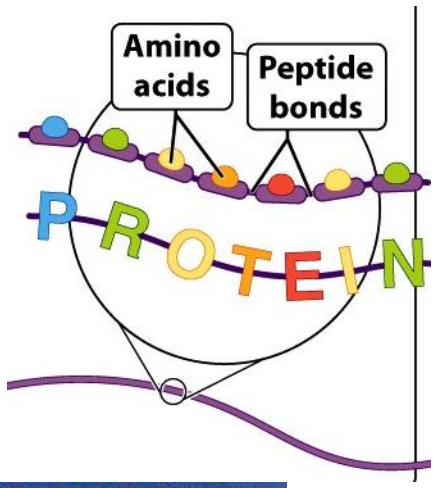
After completing Unit 2, students should be able to…

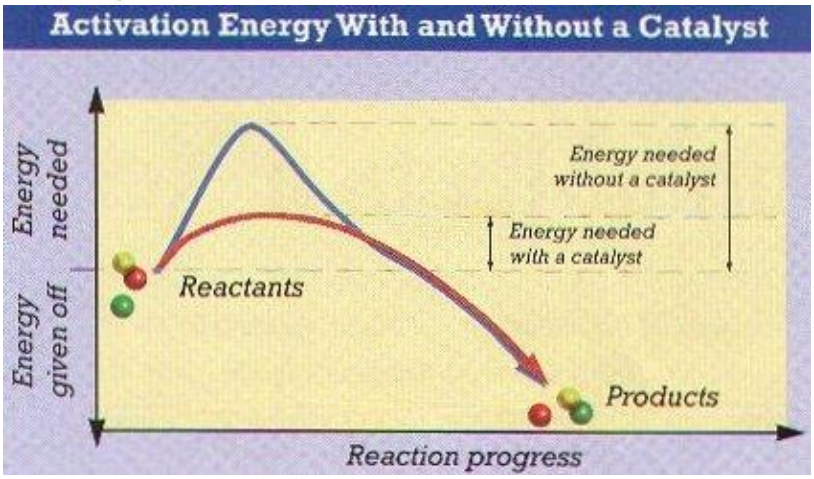
1. Use a periodic table to identify the number or subatomic particles (protons, neutrons and electrons) present in a given atom and construct a Bohr model that shows their placement.
2. Illustrate an enzymatic reaction that demonstrates how the shape of an enzyme is linked to its function.

After completing Unit 2, students should be able to interpret and explain the following diagrams:









Unit 3: Cellular structure

After completing Unit 3, students should understand…

1. Eukaryotic cells differ from Prokaryotic cells due to the presence of highly specialized organelles that carry out advanced functions.
    a. In general terms, Prokaryotes (such as bacteria) are simple cells with only the five essential cell parts: plasma membrane, cytoplasm, cytoskeleton, nucleic acids, ribosomes.
    b. In general terms, Eukaryotes (such as Protists, Fungi, Plants and Animals) are more complex, and often demonstrate the coordinated behavior necessary to form a true multicellular organism.

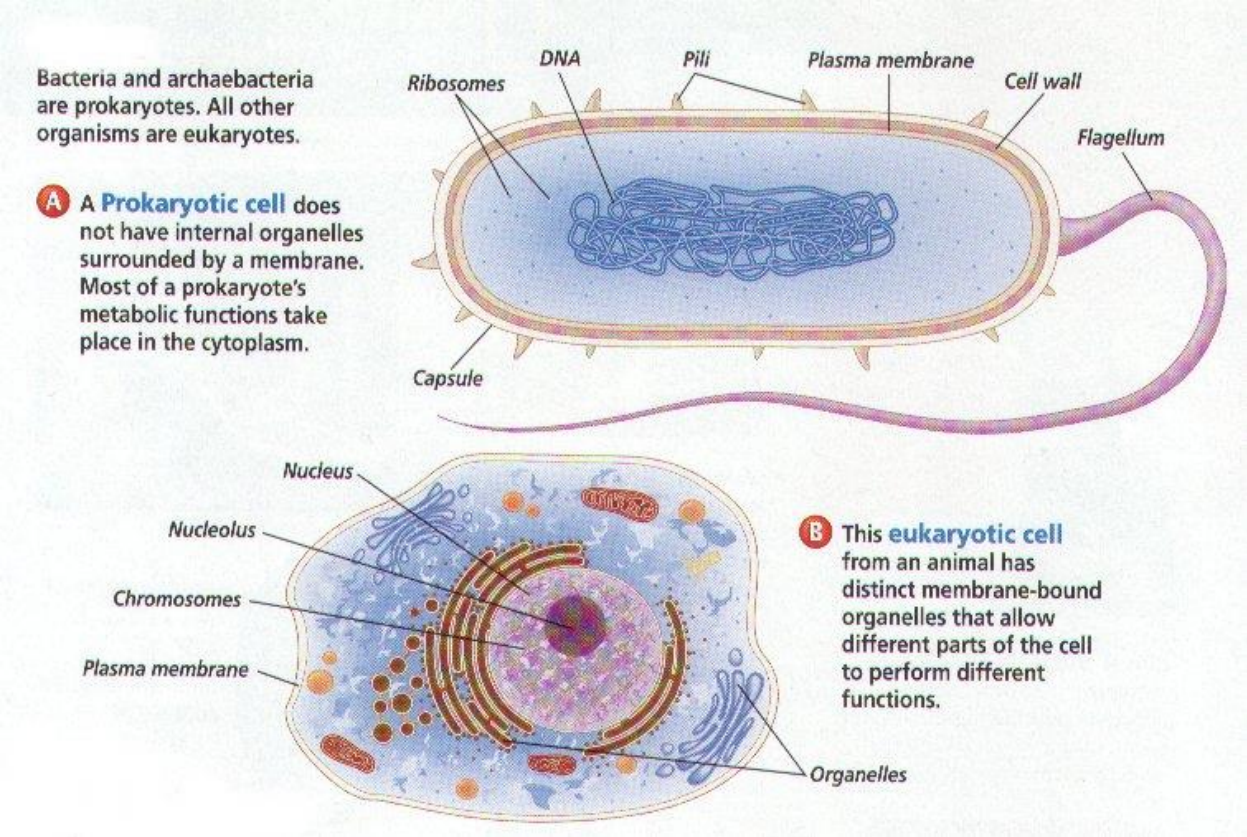
2. A cell functions like a city with many parts working together; for instance, an endomembrane system of endoplasmic reticulum (ER), Golgi bodies, and vesicles provides the cell with an efficient system for moving proteins around during their production process.

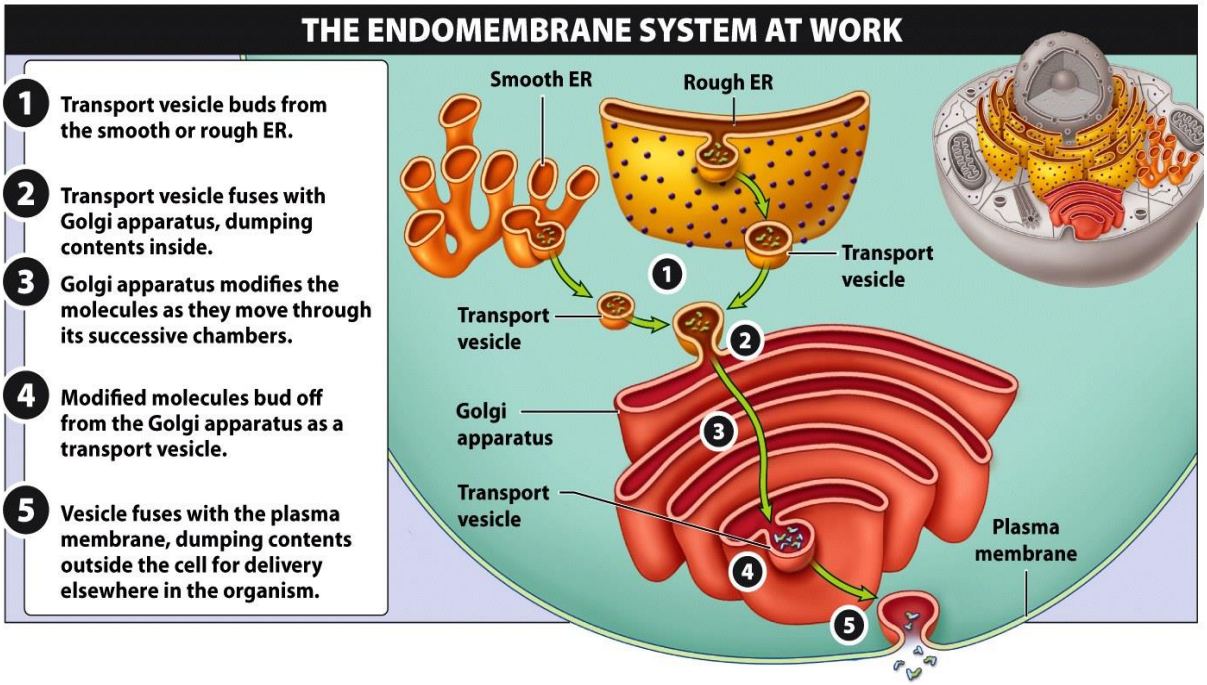
3. A light microscope is focused by beginning with the low power objective lens and shifting to increasingly more powerful lenses.
    a. The total magnification of a compound scope is calculated by multiplying the power of the ocular lens ("eyepiece", which is usually 10x) by the power of the objective lens (generally 4x, 10x, 40x, and 100x)
    b. Resolving power is the ability to a microscope to focus a clear and sharp image; this decreases as magnification increases such that most light microscopes are incapable of producing a clear image above 1000x magnification.
    c. Electron microscopes can produce extremely clear images of the surface (scanning electron microscope – SEM) or internal structures of an object (transmission electron microscope – TEM)

After completing Unit 3, students should be able to…

1. Compare and contrast prokaryotes and eukaryotes.
2. Use an analogy to explain how the parts of a cell work in unison.
3. Explain how the endomembrane system facilitates the production of proteins.
4. Use a microscope to examine microscopic structures.

After completing Unit 3, students should be able to interpret and explain the following diagrams:





Unit 4: The Functional cell membrane

After completing Unit 4, students should understand…

1. The plasma membrane of a cell is a *fluid mosaic* bilayer of phospholipids and membrane proteins.
    a. The fluidity of the membrane exists because the phospholipids are held together only by the attraction of the polar phosphate ends (hydrophilic) to polar water molecules and a repulsion of the non-polar lipid ends (hydrophobic) to water.
    b. The mosaic of the membrane exists because proteins are embedded within the phospholipid bilayer in order to carry out functions such as:
        - Transporting charged atoms (ions) or polar molecules that cannot pass through the non-polar interior of the bilayer (e.g. ion channels, carrier proteins)
        - Communicating with other cells (receptor proteins)
        - Identifying the cell (marker proteins)

2. Diffusion is the net movement of material from an area of high concentration to an area of low concentration; this movement is described as moving *down the concentration gradient*.
    a. The diffusion of water (osmosis) is determined by the difference in dissolved particle concentrations on one side of the cell membrane versus the other.
    b. The difference in concentrations is described by the words hypertonic (more dissolved particles outside the cell), isotonic (an equal number of dissolved particles outside the cell), hypotonic (less dissolved particles outside the cell).
    c. Water will move from an area of high concentration to an area of low concentration; these concentrations will be the opposite of the concentrations of dissolved particles.

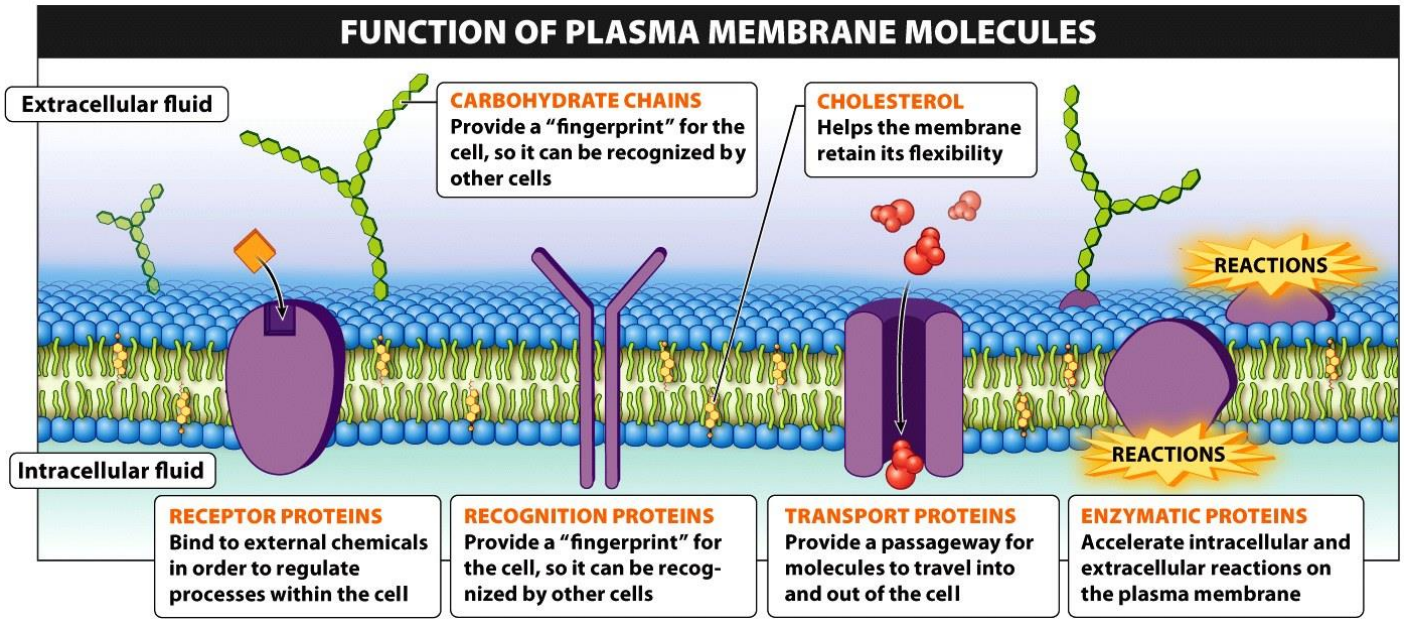
3. When substances must be moved from an area of low concentration to an area of high concentration, active transport must occur; this transport requires the use of energy, and is described as moving *up the gradient*.
    a. The sodium-potassium pump is used to establish the concentration gradient required for the transmission of nerve impulses.
    b. Cells can conduct the transport of large amounts of something in bulk through the use of vesicle transport; this can bring in substances as in the consumption of food by a single celled creature (endocytosis), or release substances such as wastes (exocytosis).

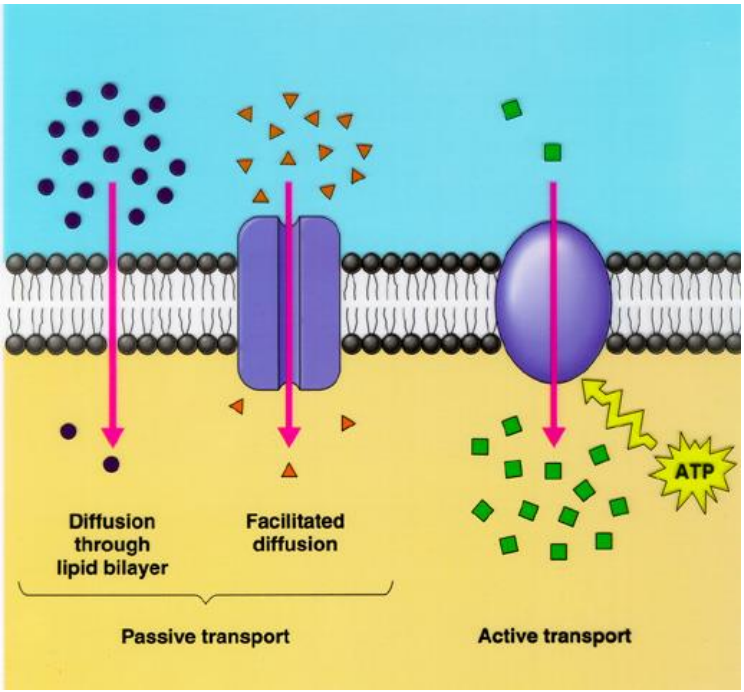
4. Wastes and raw materials can be exchanged by a small cell more efficiently than by a large one.
    a. As a cell grows in size, its volume (this can be thought of as its needs) grows faster than its surface area (this can be thought of as its ability to address those needs, as in the absorption of nutrients or the release of wastes).
    b. Because of this, cells are generally small, or at least very thin.

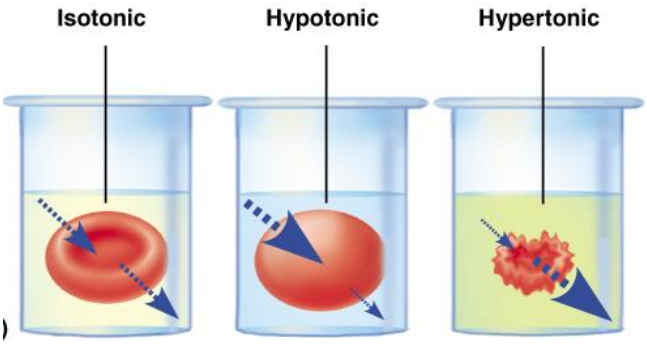
After completing Unit 4, students should be able to…

1. Create a visual depiction diffusion, osmosis, facilitated diffusion and active transport.
2. Predict the direction of osmosis in a model system.
3. Explain several reasons why a cell must remain small.

After completing Unit 4, students should be able to interpret and explain the following diagrams:







Unit 5: Cellular Energetics

After completing Unit 5, students should understand…

1. Autotrophs "produce" the energy that they use, while heterotrophs must "consume" their energy sources.
    a. Autotrophs use photosynthesis to capture light energy and store it in the form of sugars (chemical energy).
    b. Both Autotrophs and Heterotrophs use the process of cellular respiration to release the energy in sugars and store it in the form of ATP, which is a common energy carrier within many cellular systems.

2. The processes of photosynthesis and cellular respiration are complementary in that the products of one become the reactants of the other.
    a. Oxygen (O_2) is generated as a waste product of photosynthesis, but is essential for a complete release of energy during cellular respiration.
    b. The breakdown of sugars releases carbon dioxide (CO_2), which is the source of carbon for sugar production during photosynthesis.

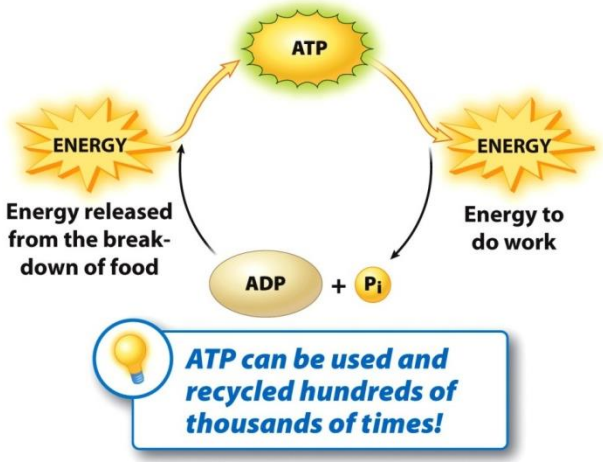
3. When molecules are synthesized, energy is stored in the form of new bonds; when molecules are decomposed, the bonds that are broken release energy can be used to build new bonds, or for processes such as active transport.
    a. ATP is an important energy carrying molecule in cells; ATP (adenosine triphosphate) is formed when available energy is used to attach a third phosphate group to ADP (adenosine diphosphate).
    b. NADPH, NADH, $FADH_2$ play the same role as ATP and are important energy carriers through the processes of photosynthesis and cellular respiration.

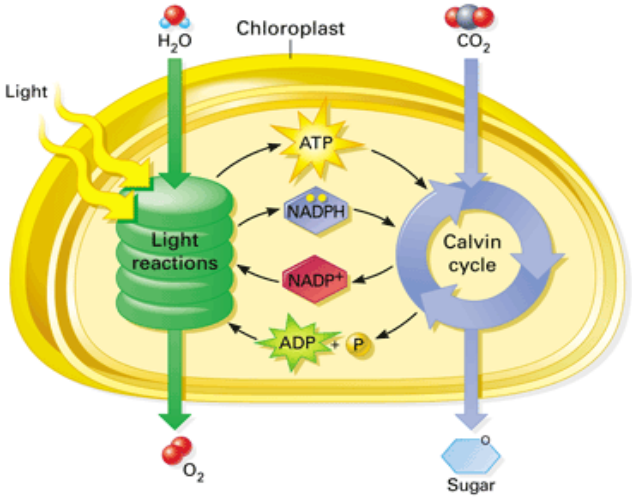
4. Chloroplasts and mitochondria play key roles in cellular energetics; both organelles contain internal membranes that provide the “sac-within-a-sac” necessary to establish the concentration gradients that drive ATP production.
    a. In photosynthesis, a gradient of hydrogen ions (H^+) is created within the thylakoid space such that the ions can flow back out through ATP synthase channels and harness the energy of the concentration gradient to form ATP.
    b. In cellular respiration, a gradient is produced in the space between the mitochondrial membranes, which allows the ions to flow into the inner mitochondrial space and produce ATP.

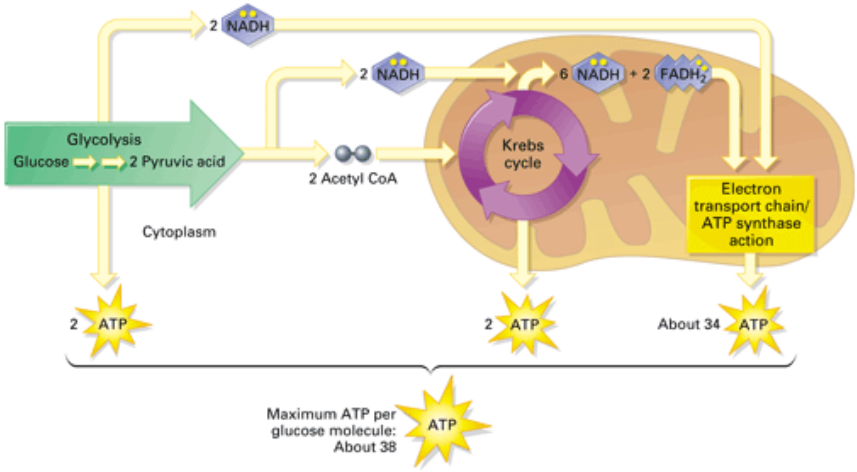
After completing Unit 5, students should be able to…

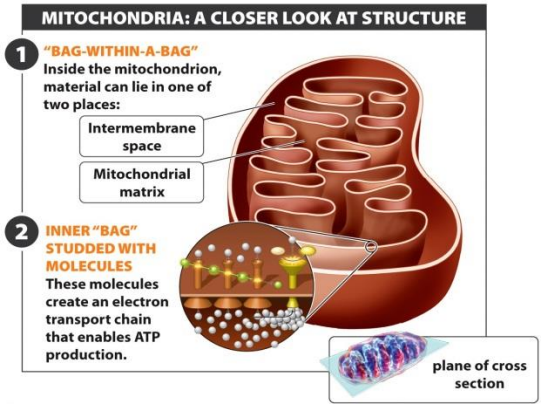
1. Identify reactants, products, waste products and energy carriers within the processes of photosynthesis and cellular respiration.
2. Explain how energy is involved in synthesis and decomposition reactions.
3. Explain how the structure of chloroplasts and mitochondria facilitate the production of ATP.

After completing Unit 6, students should be able to interpret and explain the following diagrams:









Unit 6: Replication and Expression of DNA

After completing Unit 6, students should understand…

1. DNA (Deoxyribonucleic acid) is the primary information storage molecule for life on Earth.
    a. The monomer of DNA is a nucleotide formed from a sugar (deoxyribose), a phosphate and a nitrogen base; the nitrogen bases present in DNA nucleotides are adenine, thymine, guanine and cytosine.
    b. Nucleotides are connected by strong covalent bonds between the sugars and phosphates (sugar-phosphate backbone), and then by weaker hydrogen bonds that connect the bases such that two spiraled strands form a double helix; adenine always pairs with thymine and cytosine always pairs with guanine.
    c. The nucleotides of each strand face in opposite directions like two lanes of opposing traffic.
    d. Genetic information is stored as a specific sequence of nitrogen bases found in the nucleotides.

2. Prior to cell division, DNA molecules are unwound and copied in order to produce an identical copy of every gene on every chromosome; this process is called replication.
    a. Replication occurs in the nucleus of Eukaryotic cells.
    b. The enzyme DNA helicase unwinds the molecule and breaks the hydrogen bonds which separate a section of the double helix into two separate strands.
    c. DNA polymerase enzymes work in opposite directions on each strand to connect new nucleotides to each strand according the base pairing rules (A-T, G-C).
    d. Each of the new chromosomes contains one strand from the original DNA molecule and one new complementary strand that formed through replication.

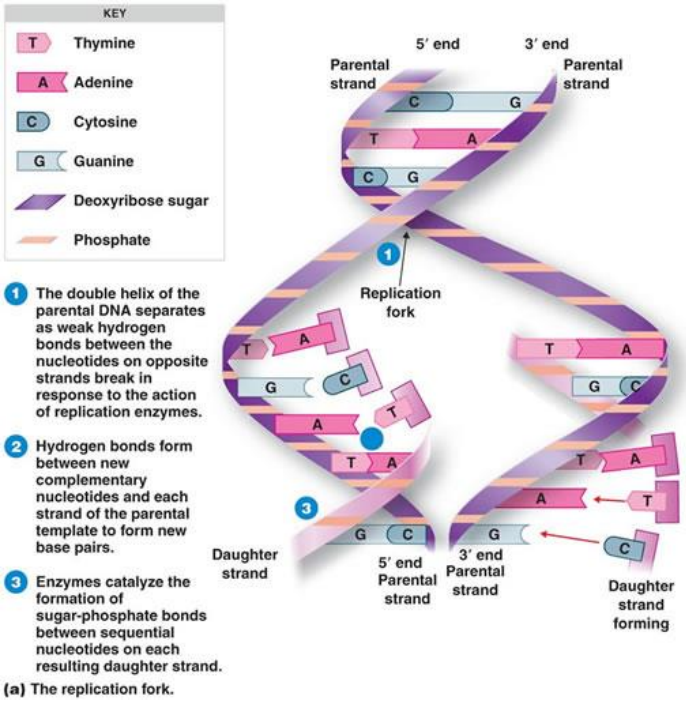
3. The information in a gene is used to produce a protein through a process called gene expression, which takes place in two stages: transcription (in the nucleus) and translation (in the cytoplasm, at a ribosome)
    a. During transcription, an RNA polymerase enzyme opens up the double helix of DNA at the start of a gene and pairs complementary RNA nucleotides until the whole gene is copied.
        - RNA nucleotides are similar to DNA nucleotides, except that they contain the sugar Ribose and replace thymine with a nitrogen base called uracil.
        - Once the DNA code is transcribed, the single strand of mRNA (messenger RNA) leaves the nucleus and travels into the cytoplasm.
    b. During translation, a ribosome captures a piece of mRNA and uses tRNA (transfer RNA) molecules to interpret the code and select the proper amino acids to form a polypeptide chain (otherwise known as a protein).
        - mRNA code is read in three-letter segments called codons by complementary three-letter segments called anti-codons which are present on tRNA molecules.

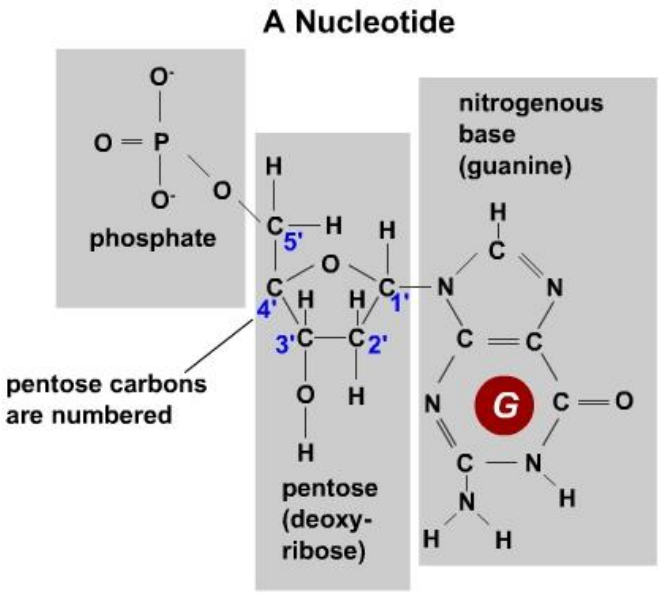
4. Copying errors may occur during the replication of DNA; these mutations may disrupt the coded message, resulting in new sequence of amino acids when the protein is produced.
    a. Substitution mutations occur when a nucleotide is improperly matched during replication; this usually affects a small number of amino acids and is called a point mutation.
    b. Mutagens (e.g. high energy light, chemicals, viruses) cause mutations and can often be prevented with healthy lifestyle choices
    c. Deletions or insertions of nucleotides into DNA code results in a shifting of nucleotides between codons and often affects all of the amino acids after the point of mutation (frame-shift mutation).
    d. DNA polymerase often catches mutations that occur during replication and fixes the errors.

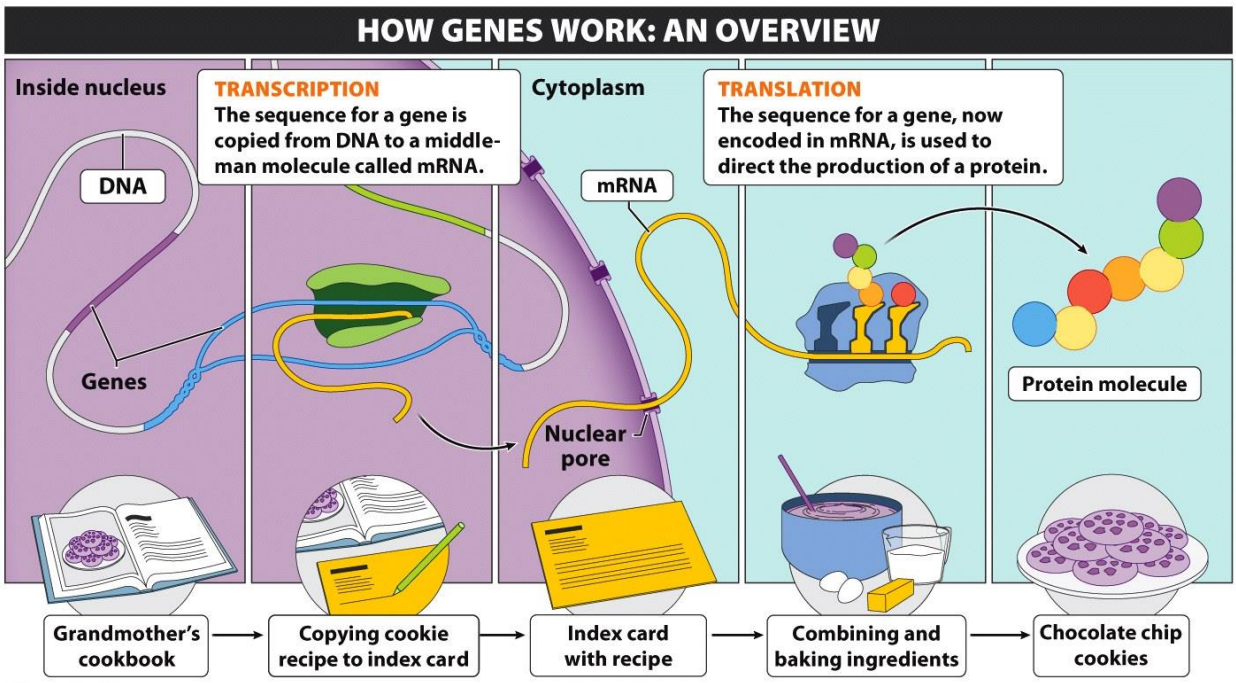
After completing Unit 6, students should be able to…

1. Compare and contrast the structures of DNA and RNA.
2. Use DNA base pairing rules to create a complementary strand of DNA nucleotides.
3. Transcribe and translate a sequence of DNA code into a sequence of amino acids.
4. Use a model to depict the process of gene expression.
5. Explain how genetic information is stored in nucleic acids and how various mutations might alter the outcome of gene expression.

After completing Unit 6, students should be able to interpret and explain the following diagrams:







Unit 7: Cellular and organismal reproduction

After completing Unit 7, students should understand…

1. Prokaryotic cells reproduce through a simple asexual cell division process called binary fission; Eukaryotic cells use the process of Mitosis to prepare for cell division during growth and Meiosis to produce sperm and eggs for sexual reproduction.

2. The fertilization process in sexually reproducing organisms increases the genetic variation of a species by bringing together a copy of each chromosome from each parent to produce homologous pairs of chromosomes; this means that these organisms will have two copies of each gene, but not necessarily two of the same version of that gene (e.g. blue eyes versus brown eyes).
    a. The variable "n" is used to describe the total number of chromosomes in a species; cells with homologous chromosome pairs are referred to as "2n".
    b. Sex cells called gametes (sperm or egg) unite during fertilization; these cells have only one copy of each chromosome and are described as being haploid or simply "n" (one of each of the chromosome types for the species.
    c. Body cells called somatic cells (anything but sperm or eggs) have two copies of each chromosome and are described as being diploid, or simply "2n" (2x the number of chromosome types for the species).
    d. Humans have 46 chromosomes in somatic cells (2n) and 23 chromosomes in gametes (n). 22 pairs of chromosomes are referred to as autosomes and have nothing to do with the gender of the individual; one pair, referred to as the sex chromosomes, determine the gender of the individual (XX = female, XY = male).

3. The cell cycle describes the life span of a cell and is broken into 5 phases: G_1, S, G_2, M, Cytokinesis.
    a. G_1, S, G_2 are known collectively as Interphase, and occupy about 90% of a cell's lifespan (24 hours on average).
    b. Cells in nervous system tissue will not proceed past G_1 since they no longer divide; cells in tissues like skin that are constantly dividing will replicate their chromosomes in S phase, make preparations for division in G_2 and then divide their nuclei during M phase, and their cytoplasm during Cytokinesis.
    c. During S phase, replication is used to produce duplicate copies of every chromosome; these duplicate copies are attached together and referred to as sister chromatids.

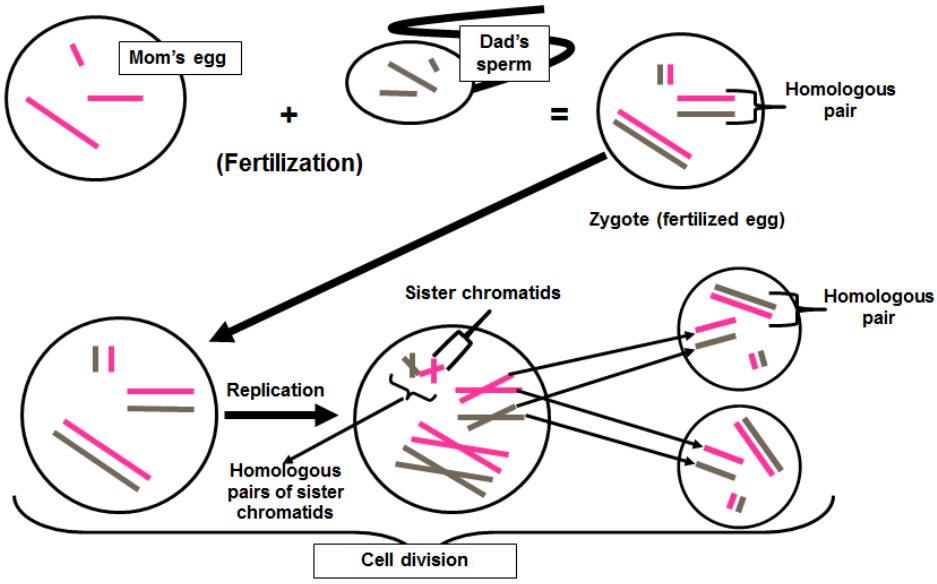
4. Prior to Eukaryotic cell division, Mitosis (M phase of the cell cycle) is used to divide a cell's nucleus into two nuclei.
    a. Mitosis is composed of 4 stages:
        - Prophase: the nucleus breaks down, chromatids become visible and the spindle apparatus is constructed.
        - Metaphase: chromatids line up in single file on equator of the cell.
        - Anaphase: The spindle apparatus is used to separate sister chromatids and pull them to opposite poles of the cell.
        - Telophase: New nuclei reform around each cluster of recently separated chromosomes.
    b. During Cytokinesis, the cell's cytoskeleton draws the equator together, producing a cleavage furrow that eventually divides the cell into two daughter cells.

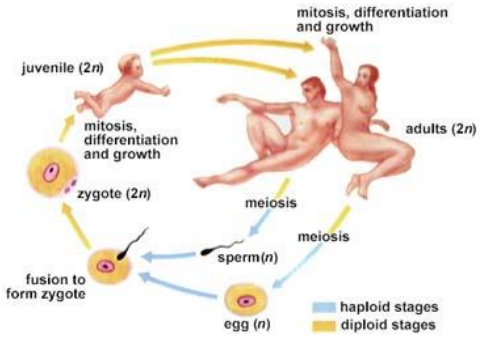
5. Sexually reproducing organisms use the reduction division process called Meiosis in order to produce haploid sex cells (i.e. sperm, egg).
    a. Meiosis occurs stages similar to Mitosis, but the process is repeated a second time to produce four daughter cells.
    b. During Meiosis I, a reduction division that separates homologous chromosomes rather than sister chromatids produces two haploid cells.
    c. Following Meiosis I, Meiosis II occurs in an identical manner to Mitosis, but with half the normal number of chromosomes to produce a total of four daughter cells.

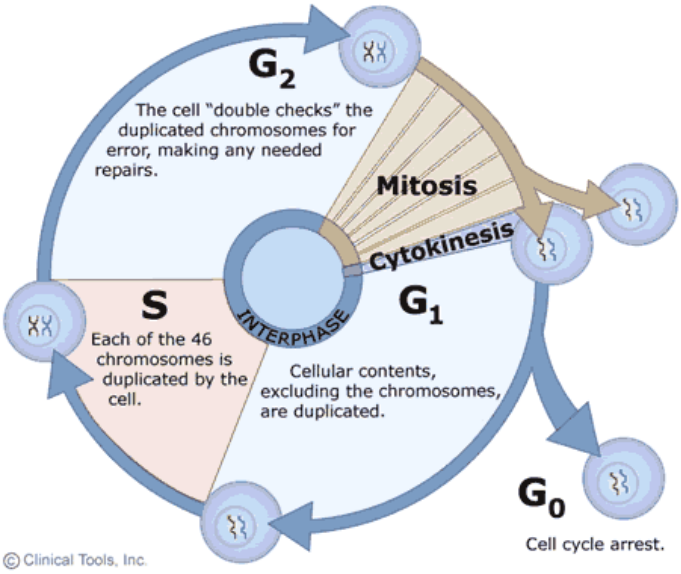
After completing Unit 7, students should be able to…

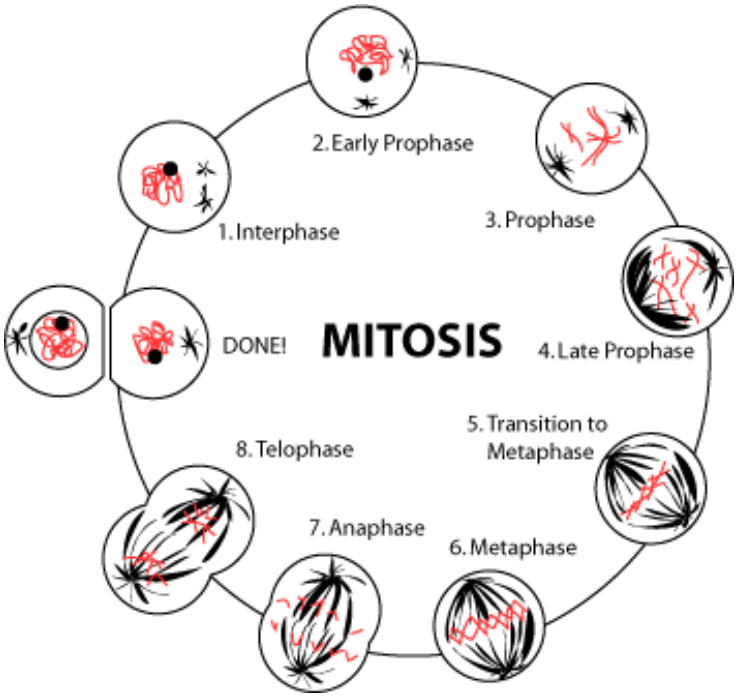
1. Explain how the processes of replication and fertilization maintain the chromosome number of a species.
2. Compare and contrast the processes of Mitosis and Meiosis.
3. Identify or describe a cell in a given stage of division (e.g. Prophase, Anaphase I, Telophase II).

After completing Unit 7, students should be able to interpret and explain the following diagrams:









Unit 8: Heredity and Genetic Analysis

After completing Unit 8, students should understand…

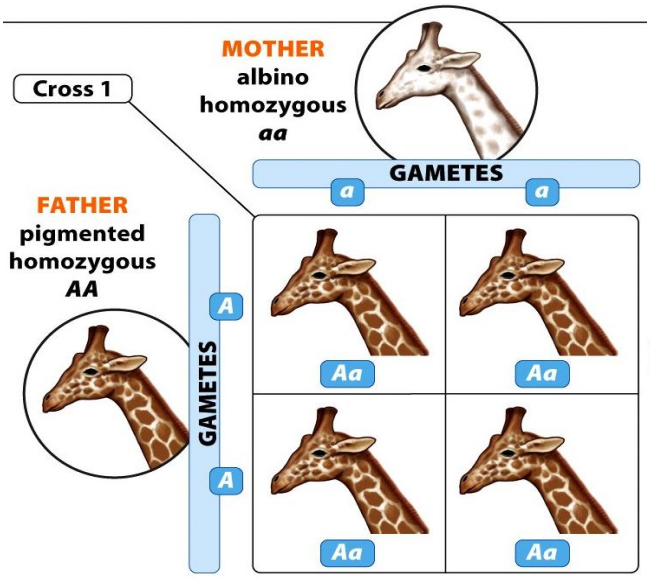
1. In sexually reproducing organisms, individuals have an equal chance of passing the genes given to them by their father into the next generation as they do those given to them by their mother.
    a. Mendel predicted that each individual carries two copies (alleles) for a given gene and that they pass one of these copies to their offspring in the form of a haploid gamete; these two haploid gametes combine to form a diploid zygote cell that contains two copies of each gene.
    b. Mendel also demonstrated that the result (phenotype) of certain gene combinations (genotype) will often follow a pattern of simple dominance; in other words, one version of a gene (the dominant allele) will often cover up the presence of another version of that same gene (the recessive allele).

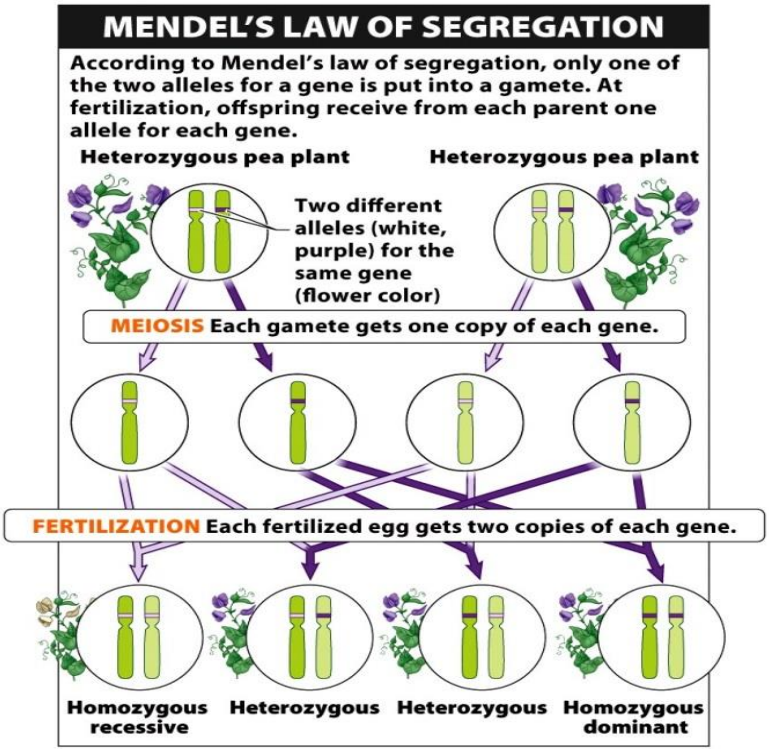
2. Punnett square analysis may be used to predict the probability that the offspring of a given mating pair will show a specific phenotype.
    a. The offspring that are identified are simply predictions, and will vary according to the laws of probability.
    b. The probability of two events occurring simultaneously (this AND that) is equal to the product of their individual probabilities (Product rule), whereas the probability of two events occurring interchangeably (this OR that) is equal to the sum of their individual probabilities (Sum rule).
    c. Each parent in a cross will have one of the following combinations of alleles (letters are picked based upon the phenotypes involved such that "H" might signify a "hairy" phenotype):
        - Homozygous dominant (HH): Two copies of the dominant allele; phenotypically dominant.
        - Homozygous recessive (hh): Two copies of the recessive allele; phenotypically recessive.
        - Heterozygous: (Hh): One copy of each allele; phenotypically dominant.
    d. A Mendelian cross consists of a homozygous dominant parent crossed with a homozygous recessive parent.
        - The first generation (F_1) of offspring will have a heterozygous genotype (Hh) and the dominant phenotype.
        - The next generation (F_2) in which the F_1 offspring are crossed with one another will show the following ratios: Genotype = 1 homozygous dominant (HH): 2: heterozygous: 1 homozygous recessive (hh), Phenotype = 3 dominant (2 Hh, 1 HH): 1 recessive (hh).
    e. Dihybrid crosses track the inheritance of 2 traits at once.

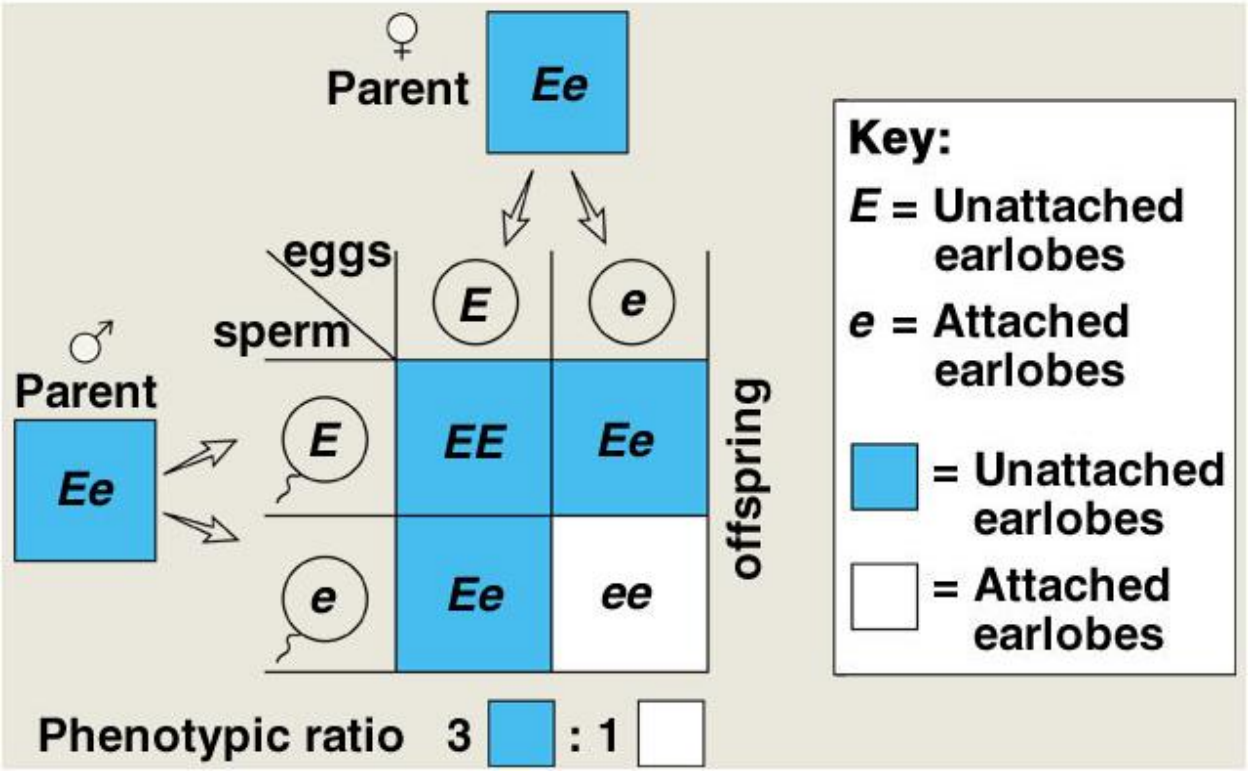
After completing Unit 8, students should be able to…

1. Calculate the probabilities of chance events.
2. Use a Punnett square to accurately predict the probability of traits appearing in the F_1 generation.
3. Explain the effect that special patterns of inheritance have on the inheritance of some traits.
4. Solve problems concerning special patterns of inheritance.

After completing Unit 8, students should be able to interpret and explain the following diagrams:







Unit 9: Mechanisms and Evidence of Evolution

After completing Unit 9, students should understand…

1. Darwin developed his theory of evolution by making observations of natural environments (e.g. Galapagos finches), studying model systems (e.g. pigeons breeding) and reading extensively on topics ranging from geology (Lyell's idea on uniform environmental change) to economics (Malthus' work on limiting factors).
    a. Although organisms are said to adapt to their environment, this process occurs on the population level with no change in individual organisms; this change is not directed towards a particular end result, but rather a reflection of the stresses of the environment.
    b. Evolution does not create new forms of life, but rather relies upon existing variation in a species as fuel for change.

2. Five evolutionary forces work to cause the gradual change in the gene pool of a species.
    a. Natural selection is a change in the frequency of alleles present in a population due to the differential reproduction of organisms with favorable traits as compared with those possessing unfavorable ones; the favorability of traits is relative to the selection pressures and may change along with the environment; an advantage today, might be disadvantage in the future.
    b. Mutations in the master control genes of existing species may cause radical new forms of life to appear.
    c. The frequencies of alleles in a gene pool change as organisms enter or leave the population (gene flow).
    d. Since many species do not mate at random, but rather based upon selection of mates who have desired characteristics, allele frequencies in a gene pool may change (non-random mating).
    e. When populations are re-shaped by chance events like natural disasters, the gene pool of the survivors may be very different than the ancestral populations (genetic drift).

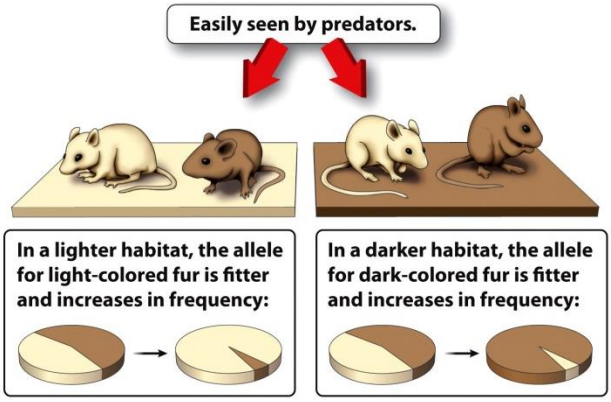
3. Evolutionary forces may change a population so much so that it becomes reproductively isolated from other populations of its species; once mating is no longer possible between populations, we say that speciation has occurred and a new species has formed.
    a. The term microevolution is often used to describe the gradual changes within a population, while macroevolution describes the speciation process.
    b. While Darwin described the evolutionary process as one of gradual change (gradualism), more recently, scientists have proposed that populations exist for long periods of time without noticeable change prior to sudden periods of rapid evolution (punctuated equilibrium).

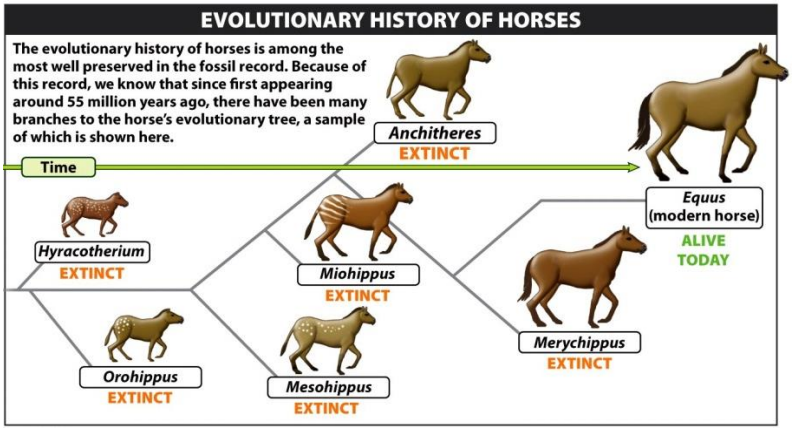
4. Strong evidence exists that today's varied forms of life have evolved from a common ancestor that lived 3.5 billion years ago; this evolutionary process can account for both the unity and diversity of life.
    a. Organisms most closely resemble those organisms that live in adjacent areas, even if those areas present life with very different selection pressures (biogeography).
    b. Developmental and anatomical homologies help us to identify relationships that exist between organisms that seem very different; these differences resulted from divergent evolution driven by different selection pressures within the environments of modern organisms.
    c. The presence of vestigial structures that no longer serve a function in modern organisms provides evidence that modern organisms have evolved from ancestral forms that were adapted to different habitats (e.g. the modern human appendix, an ostrich's wings, eye sockets in blind cave fish).
    d. A comparison of the DNA and proteins of different organisms helps us to measure the differences between groups and track how long ago they became reproductively isolated.
    e. Observations of populations allows scientists to measure the changes that occur as populations respond to evolutionary forces (e.g. artificial selection, antibiotic resistance)

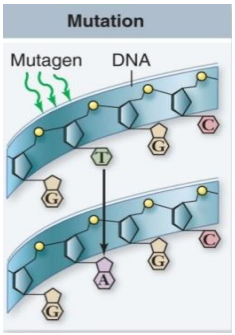
After completing Unit 9, students should be able to…

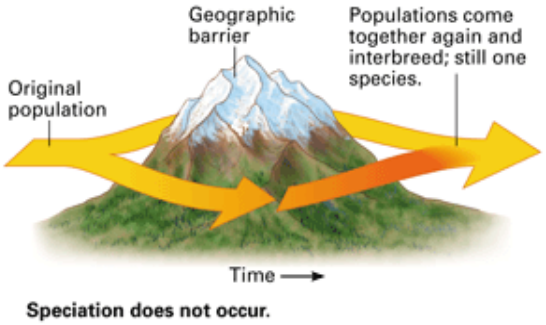
1. Describe how natural selection and other evolutionary forces change the gene pool of a population.
2. Collect and analyze data related to a changing population.
3. Predict how the characteristics of a population will change as a result of natural selection or other evolutionary forces.

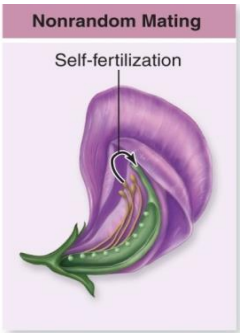
After completing Unit 9, students should be able to interpret and explain the following diagrams:

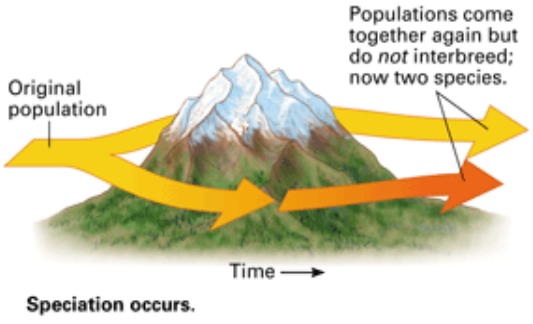


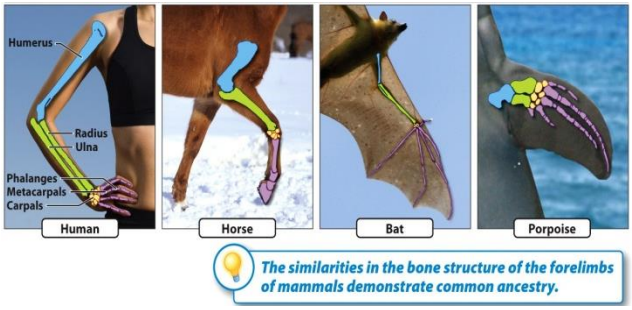












Unit 10: Populations and Communities

After completing Unit 10, students should understand…

1. A population is defined as all of the members of a species that live in one place, at one time.
    a. The health of a population may be understood by studying its size, density and dispersion.
    b. A population's growth rate will be influenced by the natality, mortality, immigration, and emigration of its members.
    c. Although ever increasing rates of growth (exponential) would be expected, real populations undergo logistic growth which is influenced by limiting factors that may be either biotic (living) or abiotic (nonliving).
        - Density-independent factors like weather affect populations regardless of their size.
        - Density-dependent factors only affect a population's growth rate once the population size reaches its carrying capacity.
    d. Populations that grow slowly due to small numbers of offspring and slow generation times often exists at or below the carrying capacity (K); these are known as K-strategists (e.g. primates, elephants)
    e. Populations whose sizes expand and contract according to the availability of density-dependent resources are known as r-strategists (e.g. germs, weeds and other pests)

2. Populations of different species often co-evolve in symbiotic relationships.
    a. Mutualism occurs when both species benefit from the relationship.
    b. Commensalism occurs when one species benefits while the other is unaffected.
    c. Parasitism occurs when one species benefits while the other is harmed.
    d. Predator-prey relationships often result in rapid evolution in what has been described as an "arms race" (e.g. as antelope populations become faster, so does the cheetah population)

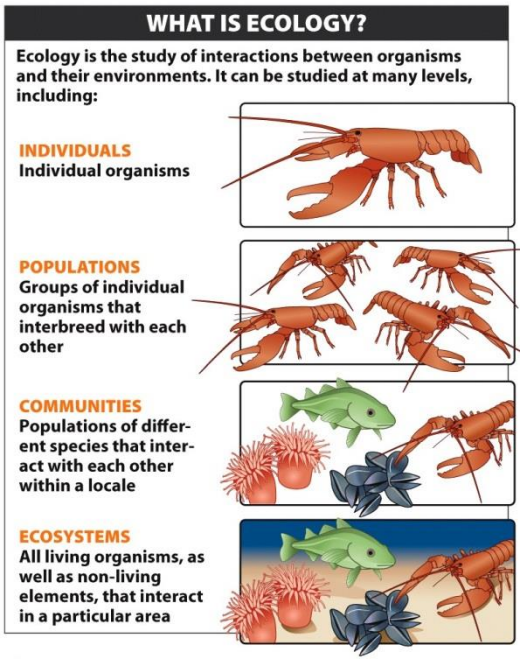
3. The role that an organism plays in its community is referred to as an ecological niche.
    a. Competition between species hoping to fill a niche (the fundamental niche) may result in the exclusion of one species from a community, or the partitioning of the niche into several smaller realized niches.
    b. When predation of the species in competition keeps their numbers low, the competition may be reduced such that both species can exist and biodiversity remains strong.

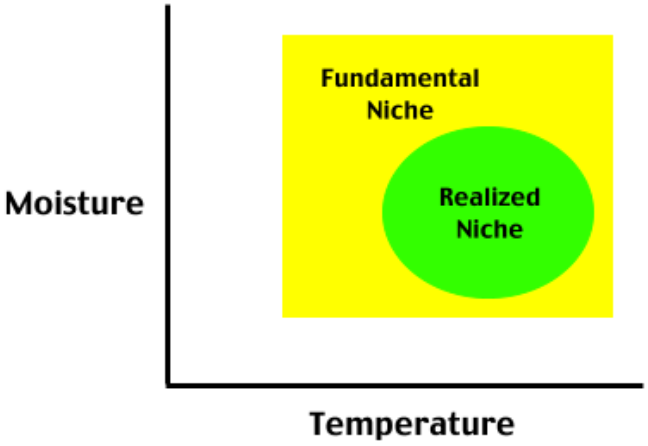
4. A biome is the typical ecological community that exists within a habitat that has specific climate patterns related to temperature and yearly rainfall.
    a. The level of biodiversity that exists within a biome is consistent globally, but the organisms that fill the typical niches may vary from place to place.
    b. Aquatic biomes vary not by temperature and rainfall, but by temperature and available sunlight.

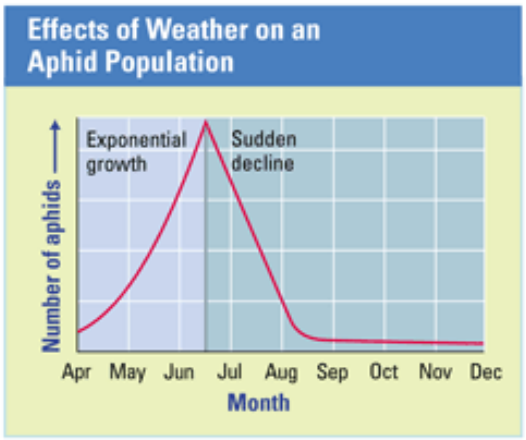
After completing Unit 10, students should be able to…

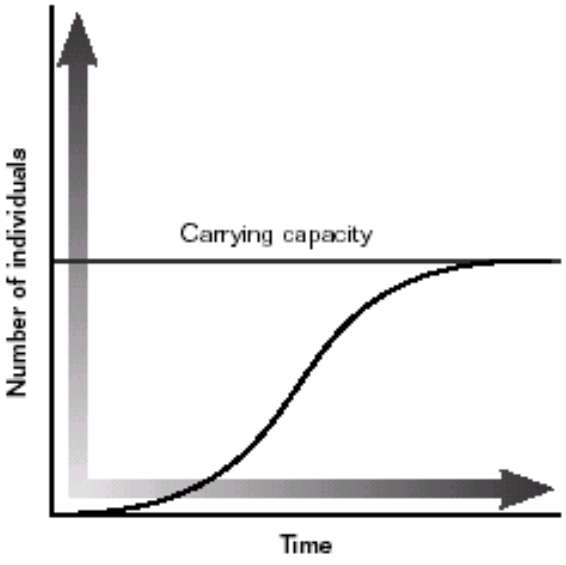
1. Explain how a population's health may be determined by analyzing its size, density and dispersion.
2. Explain how and why density-dependent limiting factors affect populations differently than density-independent limiting factors.
3. Explain how competition may affect populations and the biodiversity of a community.

After completing Unit 10, students should be able to interpret and explain the following diagrams:









Logistic Growth

Unit 11: Ecosystems

After completing Unit 11, students should understand…

1. Ecosystems are composed of biological communities (biotic component) as well as abiotic components such as climate and geologic features.
    a. The study of the interactions between the biotic and abiotic components of an ecosystem is known as ecology.
    b. Biodiversity is a measure of the number of populations within a biological community; generally speaking, the more populations there are, the more stable a community is thought to be.

2. The productivity of a community is determined by the abiotic resources available to the producers (e.g. plants, algae, chemosynthetic bacteria); since these resources are more prevalent in tropical areas, the productivity is generally high which may support large number of consumers.
    a. A food web is used to describe the flow of energy through different trophic levels of a population (e.g. producers, primary consumers, secondary consumers, tertiary and possibly quaternary consumers).
    b. Since the energy that an autotroph produces or a heterotroph consumes is used to sustain growth and the ongoing life of the organisms themselves, only 10% of the energy that is put into a trophic level is stored and therefore available to the level above (the 10% rule).
    c. The dry weight of a community is known as its biomass, and may be used to determine its productivity.

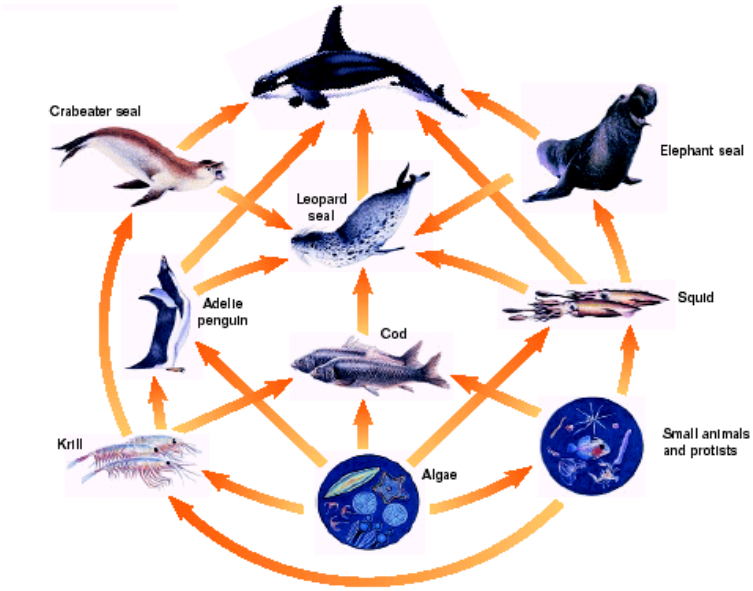
3. Matter flows between the biotic and abiotic components of an ecosystem in biogeochemical cycles.
    a. The Water cycle is driven by heat from the sun.
    b. The Carbon cycle is linked to the flow of energy since it is stored during photosynthesis and released by cellular respiration.
    c. The Nitrogen cycle is maintained by bacteria in the soil which allow plants to take in nitrogen, an essential component in several macromolecules (i.e. nucleic acids, proteins).

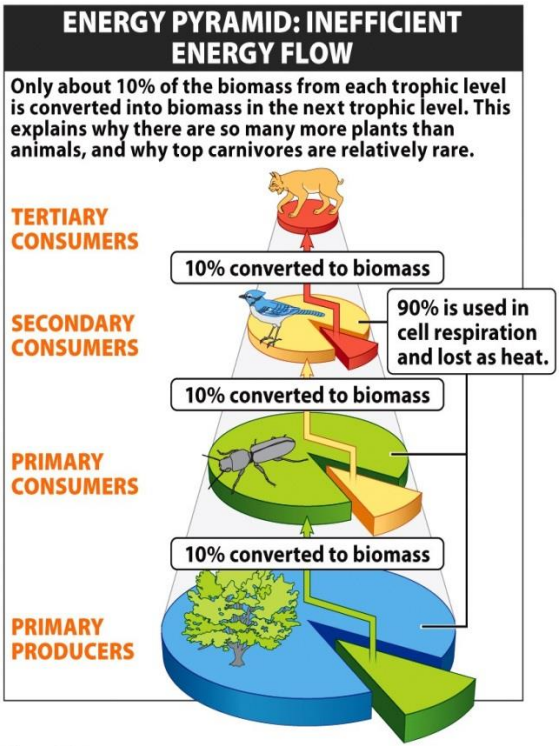
4. Succession is the somewhat regular progression of species replacement that occurs in an ecosystem over time.
    a. Primary succession occurs when life gradually modifies and colonizes rocky surfaces by gradually producing and improving the soil.
    b. Secondary succession occurs when wild populations reclaim land that already has a supply of soil.
    c. Since the harvesting of crops on farmland disrupts the biogeochemical cycles that are normally present, fields that are no longer farmed may become barren deserts that are inhospitable to future colonists.

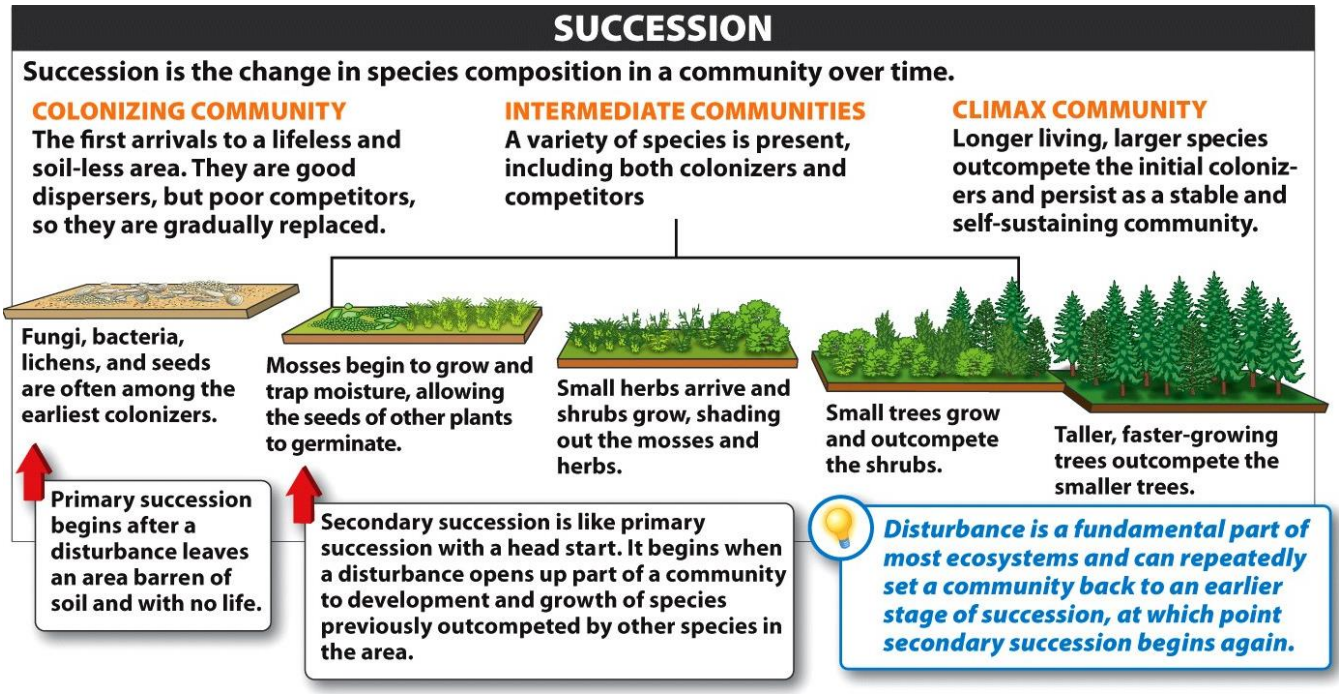
After completing Unit 11, students should be able to…

1. Identify the biotic and abiotic components of a given ecosystem.
2. Construct a food web that accurately shows the passage of energy through at least three trophic levels.
3. Describe how biotic and abiotic processes are present within a biogeochemical cycle.

After completing Unit 11, students should be able to interpret and explain the following diagrams:







Unit 12: Origin and Diversification of Life

After completing Unit 12, students should understand…

1. The classification of life on Earth (taxonomy) is accomplished by organizing organisms into groups based upon their evolutionary history (phylogeny).
    a. Because convergent evolution has caused distantly related species to acquire the same characteristics, it is not always easy to determine the relationships between modern life forms (e.g. the wings of insects, birds and mammals).
    b. Organisms that are placed in the same kingdom have less in common than those placed in the same species, which must be in fact be members of an *actually or potentially interbreeding population*.
    c. Viruses are not classified among living things since they depend on living things for reproduction and other critical life processes.

2. The fossil record confirms the pattern that evolutionary biologist have predicted using evolutionary theory as a guide; the first organisms on Earth were very simple, with increasingly complex organisms occurring over the years that followed.
    a. Prokaryotic cells, such as bacteria and Achaeans, were the first forms of life to appear on Earth 3.85 billion years ago (bya); these primitive cells combined to form the first Eukaryotic cells in a process called endosymbiosis.
    b. The first Eukaryotes diverged into today's Protists, Fungi, Plants and Animals during a slow process that began in the water and eventually spread to dry land.
    c. Fungi combined with algae to form a symbiotic form of life called a lichen, which was probably the first living thing to colonize the land; as these lichens digested rocks and contributed their own organic material to the mix, the first soil was formed.
    d. As soil developed, so did early plant life, allowing insects to colonize new terrestrial habitats.
    e. The symbiotic relationship between flowering plants and their pollinators has allowed them to become the Earth's dominant terrestrial photosynthesizers.

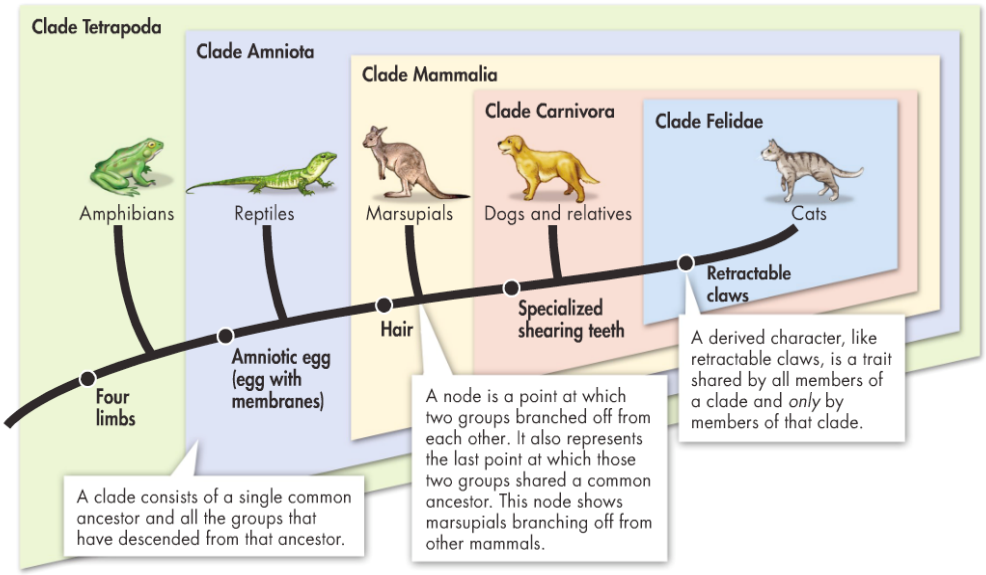
3. The diversity of life on Earth has evolved through repeating series of divergence and extinction.
    a. All modern animals have ancestors that appeared during the Cambrian Explosion.
    b. The bodies of animals follow one of several basic plans (e.g. radial symmetry, bilateral symmetry).
    c. Four legged animals called tetrapods evolved from fish into Amphibians which are still tied to the water for reproduction.
    d. Reptiles adapted to life on the land and then diverged into Dinosaurs, modern reptiles and early mammals.
    e. Approximately 8 million years ago, human ancestors diverged from the other primates and utilized increasingly larger and more powerful brains to establish language and cultural traditions (e.g. use of tools, teaching, cooperation).

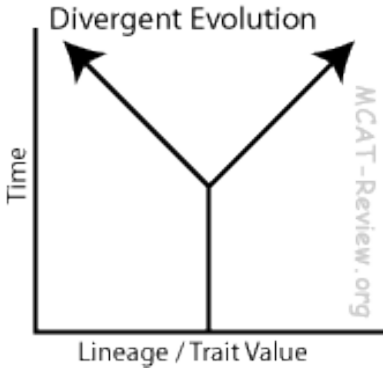
4. During five periods of mass extinction, abiotic factors such as collisions with rocks from space and climate changes, as well as increasingly more complex ecological relationships (biotic factors), stressed many species to the point of failure; these extinctions reduced the biodiversity of life dramatically and fueled new periods of divergence for the survivors.
    a. The most recent mass extinction, which was at the end of the Cretaceous period, saw the end of the age of the Dinosaurs and ushered in the age of the mammals.
    b. The sixth mass extinction is under way, and appears to be caused by human actions such as:
        - Destruction or division of habitat
        - Pollution
        - Over-harvest of species for food, fiber, etc.

After completing Unit 12, students should be able to…

1. Create a cladogram that compares organisms based upon their derived characteristics.
2. Explain the common features of organisms in various levels of taxonomic classification.
3. Explain the pattern of emergence of the major forms of life on Earth.
4. Relate the loss of species and the divergence of new ones to mass extinctions.

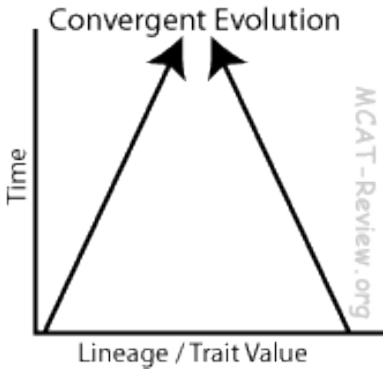
After completing Unit 12, students should be able to interpret and explain the following diagrams:





Classification of Living Things

DOMAIN	Bacteria	Archaea	Eukarya			
KINGDOM	Eubacteria	Archaebacteria	"Protista"	Fungi	Plantae	Animalia
CELL TYPE	Prokaryote	Prokaryote	Eukaryote	Eukaryote	Eukaryote	Eukaryote
CELL STRUCTURES	Cell walls with peptidoglycan	Cell walls without peptidoglycan	Cell walls of cellulose in some; some have chloroplasts	Cell walls of chitin	Cell walls of cellulose; chloroplasts	No cell walls or chloroplasts
NUMBER OF CELLS	Unicellular	Unicellular	Most unicellular; some colonial; some multicellular	Most multicellular; some unicellular	Most multicellular: some green algae unicellular	Multicellular
MODE OF NUTRITION	Autotroph or heterotroph	Autotroph or heterotroph	Autotroph or heterotroph	Heterotroph	Autotroph	Heterotroph
EXAMPLES	*Streptococcus, Escherichia coli*	Methanogens, halophiles	*Amoeba, Paramecium,* slime molds, giant kelp	Mushrooms, yeasts	Mosses, ferns, flowering plants	Sponges, worms, insects, fishes, mammals



Trait	Ancestry	Adaptation	Evolution
Analogous	Different	Same	Convergent
Homologous	Same	Different	Divergent