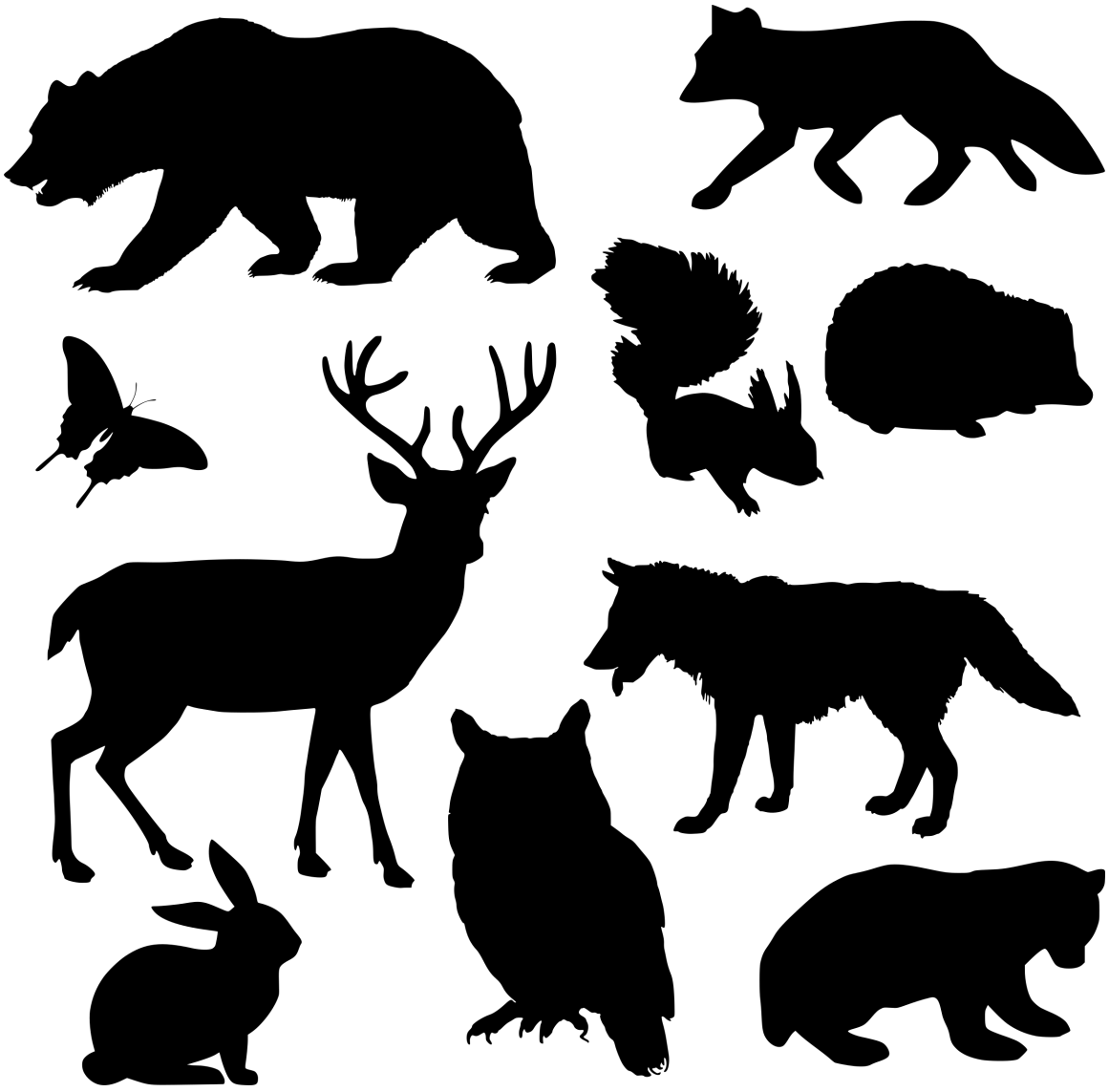
Biology Milestone
EOC Study Guides

Maynard H. Jackson High School



Biochemistry

ORGANIC MOLECULES: 4 Macromolecules

Organic compounds contain carbon and are found in all living things.

- Carbohydrates

- major source of energy(short term) and include sugars and starches
- made up of carbon, hydrogen, and oxygen with a 2:1 ratio of hydrogen to oxygen; monomer: monosaccharide
- plants and animals use carbohydrates for maintaining structure within the cells

- Proteins

- Nitrogen-containing compounds made up of chains of amino acids
- 20 amino acids can combine to form a great variety of protein molecules
- can compose enzymes, hormones, antibodies, and structural components

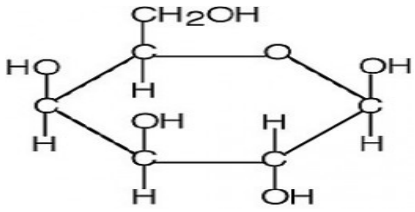
- Lipids

- water-insoluble (fats and oils)
- made up of carbon, hydrogen and oxygen; composed of glycerol and fatty acid
- provide insulation, store energy(long term), and cushion internal organs, found in biological membranes
- saturated (with hydrogen, single bonds) and unsaturated (double bonds)

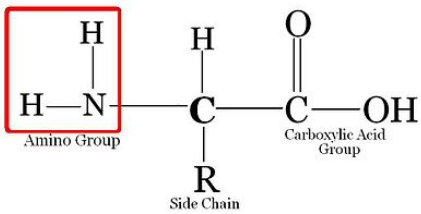
- Nucleic Acids

- direct the instruction of proteins
- genetic information an organism receives from its parents
- two types: DNA (deoxyribonucleic acid) and RNA (ribonucleic acid)

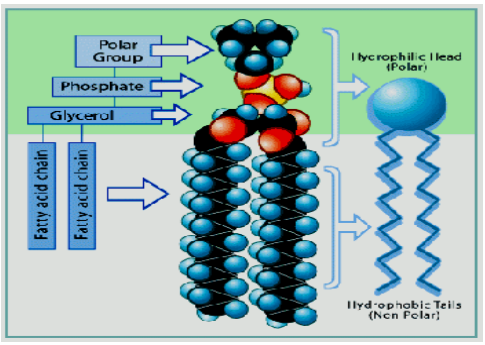
CARBOHYDRATE (monosaccharide – Glucose)



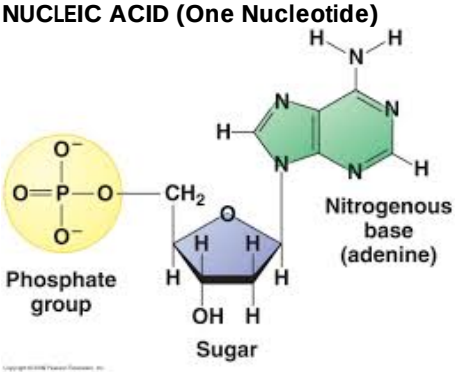
PROTEIN (One Amino Acid)



LIPID (ex: phospholipid/cell membrane)

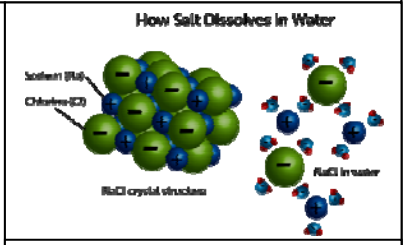


NUCLEIC ACID (One Nucleotide)



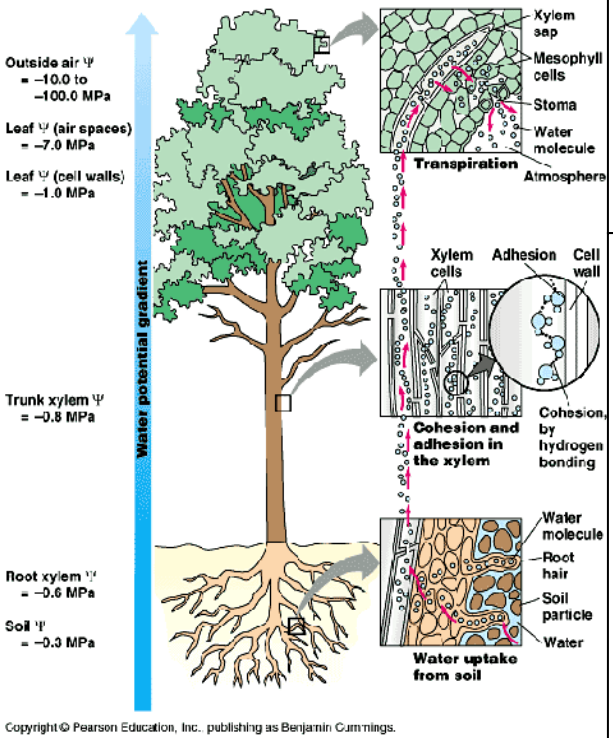
PROPERTIES OF WATER

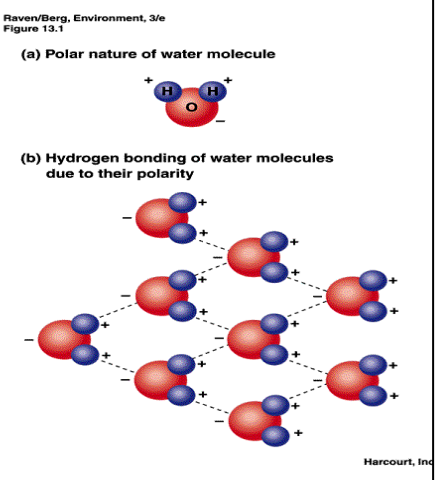
- **Adhesion** -water is attracted to other molecules; **Cohesion**-water is attracted to itself; ex: capillary action-water defies gravity and moves up a tree
- **High heat capacity**- Holds heat to regulate temperature
- **High heat of vaporization** -sweating to cool down
- **Less dense as a solid** than a liquid (ice floats); ex: insulate lakes so that organisms can survive during the winter
- Water is a **great solvent** (good at dissolving things); ex: dissolve nutrients



Water can **dissolve salt** because the positive part of **water** molecules attracts the negative chloride ions and the negative part of **water** molecules attracts the positive sodium ions.

Cohesive property of water in our body (capillary action) -It is the movement of water in and out of your cellular structures that deposits vitamin, nutrients and vital blood plasma.





The uniqueness of water comes from its molecular structure. **Water is polar**; it has a slight positive and slight negative charge on opposite ends.
Oxygen- slight negative charge
Hydrogen- slight positive charge
The polarity of water is responsible for effectively dissolving other polar molecules. This is important to remember because for most biological reactions to occur, the reactants must be dissolved in water.

Cellular Structure and Function

LAW vs. THEORY

Law: Laws are simple and obvious statements about a phenomenon that never require a second guess, or an experiment to verify.

Theory: is a scientific explanation of an observed phenomenon. Unlike laws, theories actually explain why things are the way they are. Theories can never become laws or vice versa.

The Cell Theory was developed from three German scientist's discoveries. They are Matthias Schleiden, Theodor Schwann, and Rudolph Virchow.

- In 1838 the German Botanist Matthias Schleiden discovered that all plants were composed of cells.
- Then only a year later a German zoologist, Theodor Schwann, discovered that all animals were composed of cells.
- Later in 1855 a German physician named Rudolph Virchow was doing experiments with diseases when he found that all cells come from other existing cells.

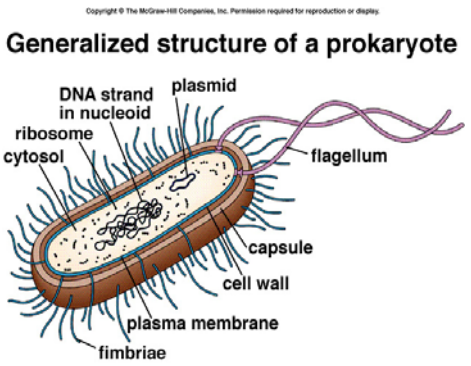
Cells of course were discovered much earlier. The first person to see a cell was Robert Hooke. He used a very primitive microscope, but when he was looking at cork cells under the microscope he saw cells for the first time.

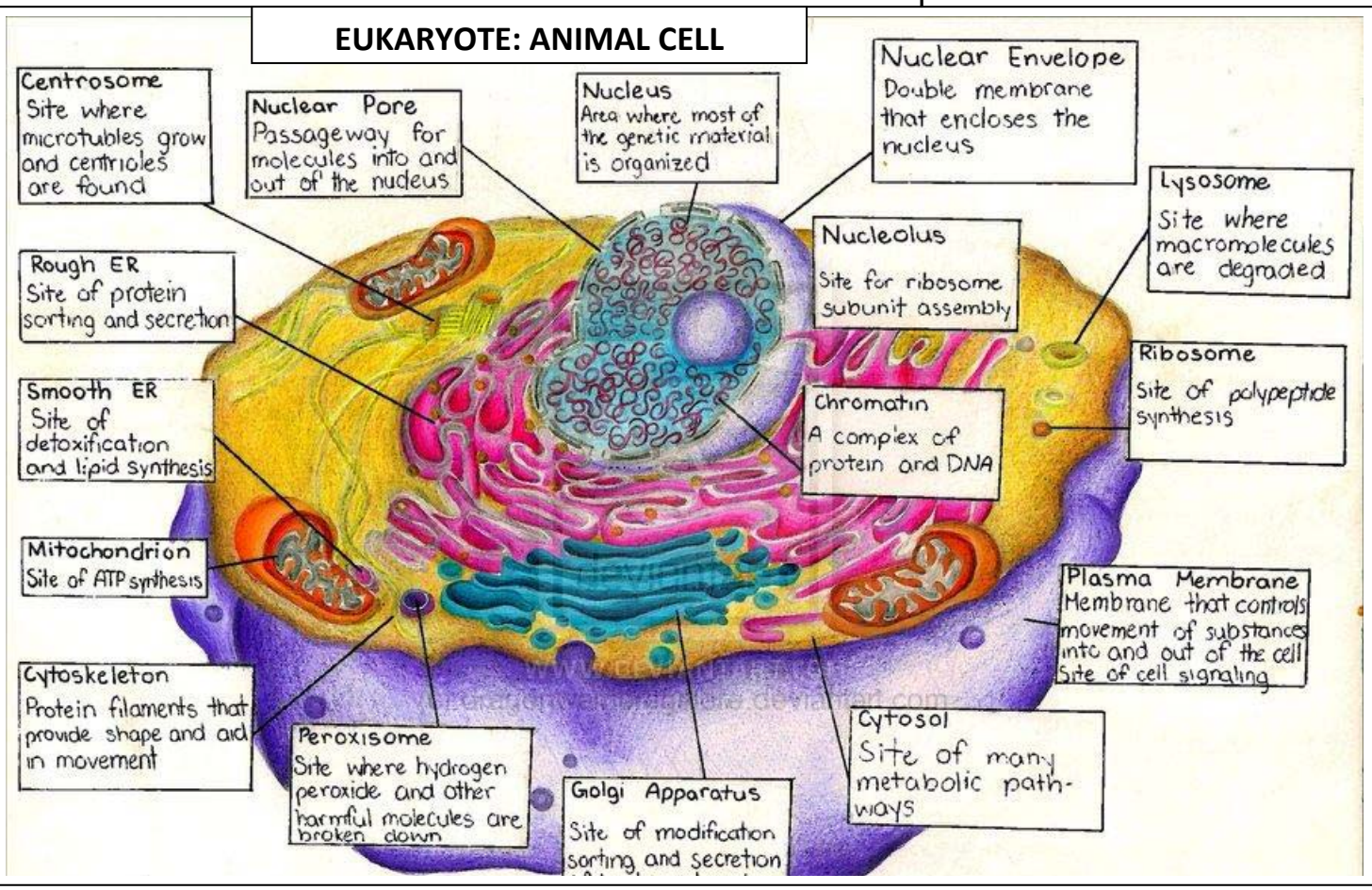
3 PARTS OF THE CELL THEORY:

- Cells are the basic units of structure and function in all living things.
- All organisms/living things are composed of cells.
- All cells come from pre-existing cells.

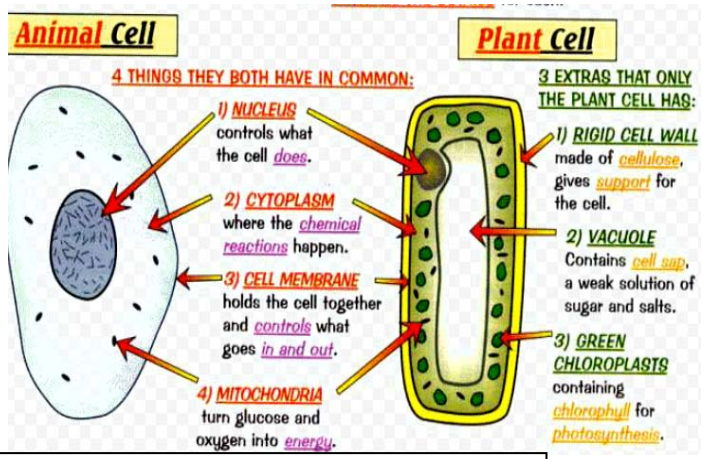
PROKARYOTIC CELLS vs. EUKARYOTIC CELLS

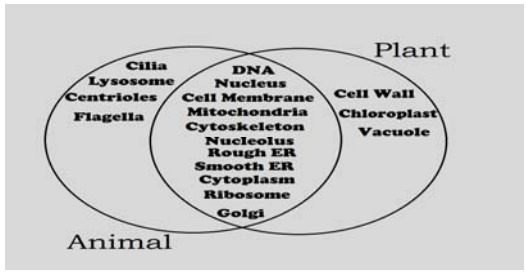
Features	Prokaryotic	Eukaryotic
Nucleus	NO	YES
Membrane-bound organelles	NO	YES
Size	small	large
Organisms	Bacteria, Archaea	Animals, Plants, Fungi, Protists
Ribosome and cell/plasma membrane	YES	YES
Cell wall	YES	Yes, except animals and some protists

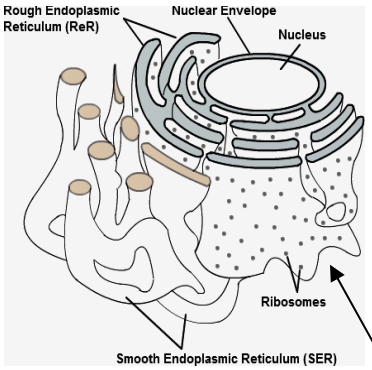


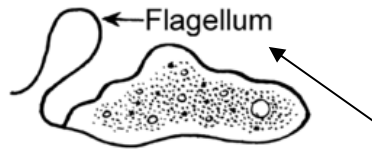


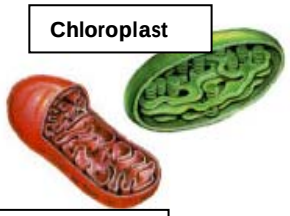
Cellular Structure and Function







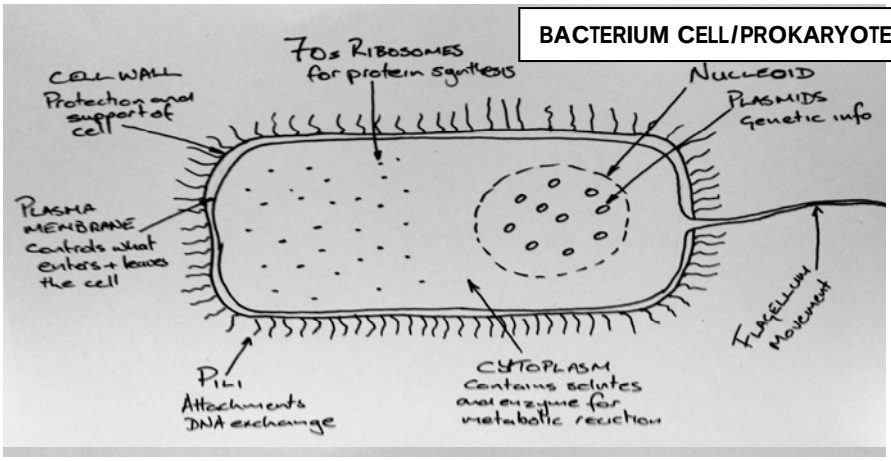


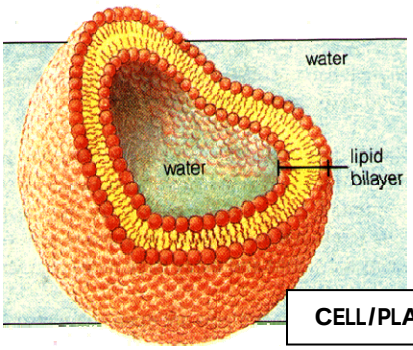


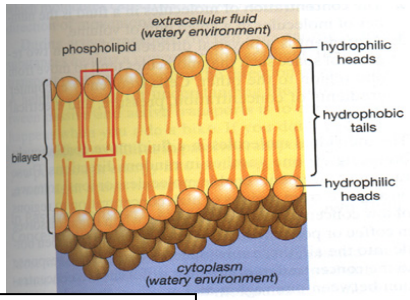
Mitochondria (plants/animals) and Chloroplast (plants) - cell energy.

Rough ER- contains ribosomes; protein synthesis

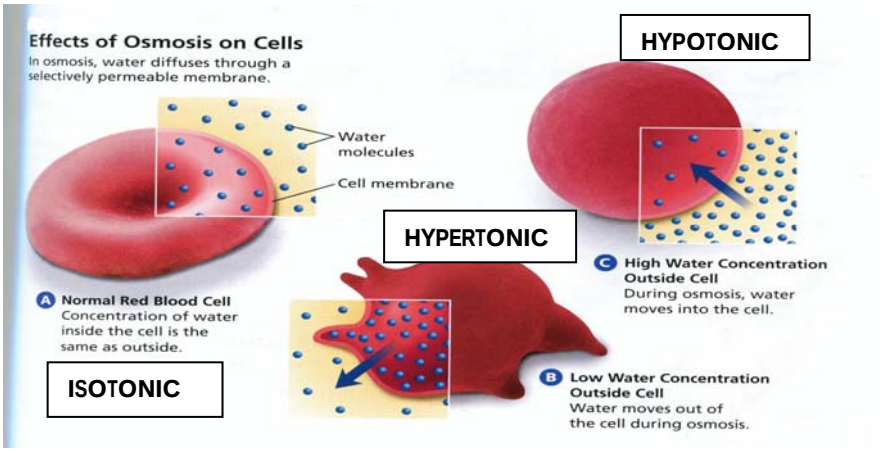
Movement; found in both prokaryotes and eukaryotes.







CELL/PLASMA MEMBRANE



CELL TRANSPORT:

- Passive Transport – movement of substances across the plasma membrane without the use of the cell's energy (with the concentration gradient)

1. DIFFUSION – movement of substances across the plasma membrane from an area of high concentration to an area of low concentration
2. OSMOSIS – diffusion of water across the plasma membrane from areas of high concentration to areas of lower concentration
   - HYPOTONIC – water moves in; cell bursts
   - HYPERTONIC – water moves out; cell shrivels
   - ISOTONIC – no net movement; cell maintains equilibrium
3. FACILITATED TRANSPORT – a carrier molecule embedded in the plasma membrane transports a substance across the plasma membrane following the high-to-low concentration gradient

- Active Transport – movement of substances across the plasma membrane that requires the use of the cell's energy and carrier molecules; substances are moving from an area of low concentration to an area of higher concentration (against the concentration gradient)
- ENDOCYTOSIS – large particles are brought into the cell
- EXOCYTOSIS – large particles leave the cell

- HOMEOSTASIS – internal equilibrium; the plasma membrane regulates what enters and leaves the cell; a selectively permeable membrane only allows certain substances.

CELLULAR ENERGY

BIOCHEMICAL REACTIONS: chemical bonds are formed and broken within living things creating chemical reactions that impact the ability to maintain life and carry out life functions

- **Cellular Respiration** – food molecules are converted to energy; there are three stages to cellular respiration; the first stage is called glycolysis and is anaerobic (no oxygen is required); and are aerobic (oxygen is required)
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + ENERGY (36 ATP)

- **Photosynthesis** – plant cells capture energy from the Sun and convert it into food (carbohydrates); plant cells then convert the carbohydrates into energy during cellular respiration; the ultimate source of energy for all living things is the Sun (in Chemosynthesis, organisms use sulfur or nitrogen as the main energy source)
$6CO_2 + 6H_2O$ + ENERGY (from sunlight) $\rightarrow C_6H_{12}O_6 + 6O_2$

- Interrelated nature of photosynthesis and cellular respiration- the reactants of photosynthesis are the products of cellular respiration and vice versa.

ATP – ATP is a molecule that stores and releases the energy in its bonds when the cell needs it; removing a phosphate group (P) releases energy for chemical reactions to occur in the cell and ATP becomes ADP; when the cell has energy, the energy is stored in the bond when the phosphate group is added to the ADP
ATP $\leftrightarrow$ ADP + P + ENERGY

- ***Fermentation*** – when cells are not provided with oxygen in a timely manner, this process occurs to continue producing ATP until oxygen is available again; glucose is broken down; there are two types of fermentation:

Lactic Acid Fermentation (muscle cells) Glucose $\rightarrow$ Lactic Acid + 2ATP
Alcoholic Fermentation (plant cells) Glucose $\rightarrow$ CO_2 + Alcohol + 2ATP

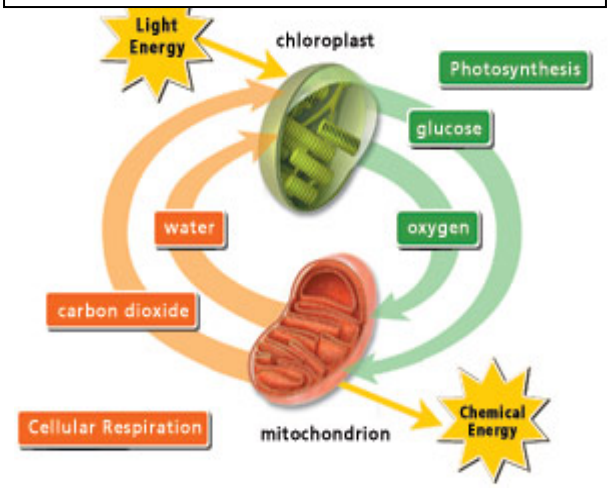
AEROBIC and ANAEROBIC RESPIRATION:
Aerobic Respiration – 3 stages (glycolysis, Krebs cycle and Electron Transport chain)

- requires the presence of oxygen
- release of energy from the breakdown of glucose (or another organic compound) in the presence of oxygen to produce large amounts of energy.
- energy released is used to make ATP, which provides energy for bodily processes
- takes place in almost all living things

Anaerobic Respiration – 1 stage (glycolysis)

- occurs in the absence of oxygen
- breakdown of food substances in the absence of oxygen with the production of a small amount of energy
- produces less energy than aerobic respiration
- often called fermentation: lactic and alcoholic
- seen as an adaptation for organisms that live in environments that lack oxygen

Interrelationship between photosynthesis and cellular respiration

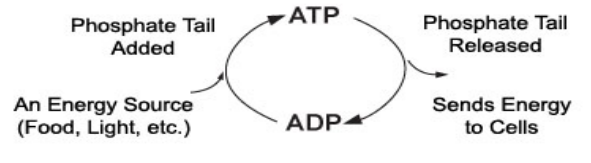


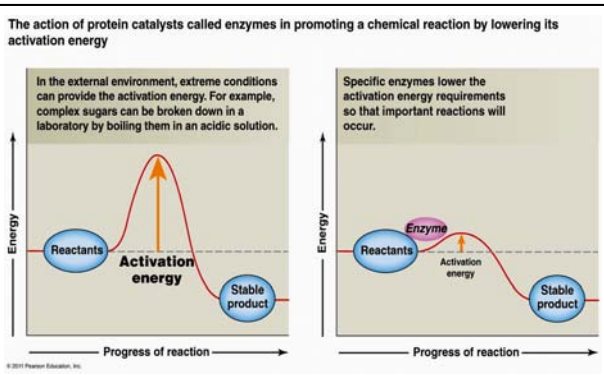
ENZYMES:
Enzymes are special proteins that regulate nearly every biochemical reaction in the cell. Different reactions require different enzymes. Enzymes function to:

- Aid in digestion
- Break down complex molecules ("substrate" = reactant)
- Catalysts (speed up chemical reactions without being used up or altered)
- Factors that affect enzymes: pH, temperature, and quantity
- Lower activation energy for chemical reactions.

- Enzymes are affected by changes in pH. The most favorable pH value - the point where the enzyme is most active - is known as the optimum pH.

- Like most chemical reactions, the rate of an enzyme-catalyzed reaction increases as the temperature is raised. Most animal enzymes rapidly become denatured at temperatures above 40°C, most enzyme determinations are carried out somewhat below that temperature.





Cell Division

Asexual and Sexual Reproduction:

Asexual Reproduction – a single parent produces one or more identical offspring by dividing into two cells - mitosis (protists, arthropods, bacteria by binary fission, fungi, plants); produces large numbers of offspring

- **offspring are clones of parents (genetically identical)**
- common in unicellular organisms, good for stable environments
- budding, binary fission, conjugation
- quick process (low energy requirement) – produces high number of offspring

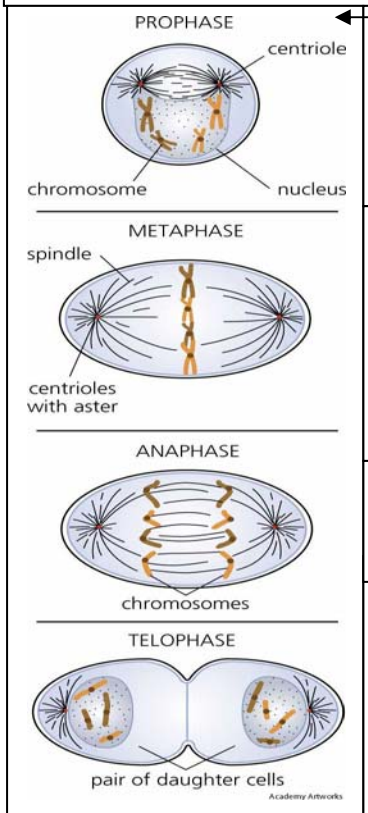
Sexual Reproduction – pattern of reproduction that involves the production and fusion of haploid sex cells; haploid sperm from father fertilizes haploid egg from mother to make a diploid zygote that develops into a multicellular organism through mitosis

- results in **genetic variation (diversity)**
- common in multicellular organisms (external or internal fertilization); good for changing environments
- slow process (high energy requirement) – produces low number of offspring
- meiosis = formation of sex cells (gametes)

CELL DIVISION:

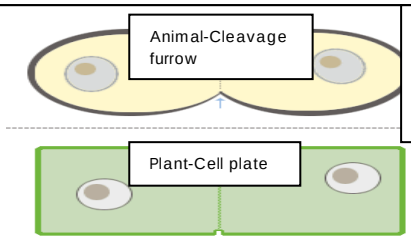
- process of copying and dividing the entire cell
- the cell grows, prepares for division, and then divides to form new daughter cells
- allows unicellular organisms to duplicate in a process called asexual reproduction
- allows multicellular organisms to grow, develop from a single cell into a multicellular organism, make other cells to repair and replace worn out cells
- three types: binary fission (bacteria and fungi), mitosis, and meiosis

Cancers are diseases in which there is a defect in the regulation of the cell cycle; uncontrolled cell division.



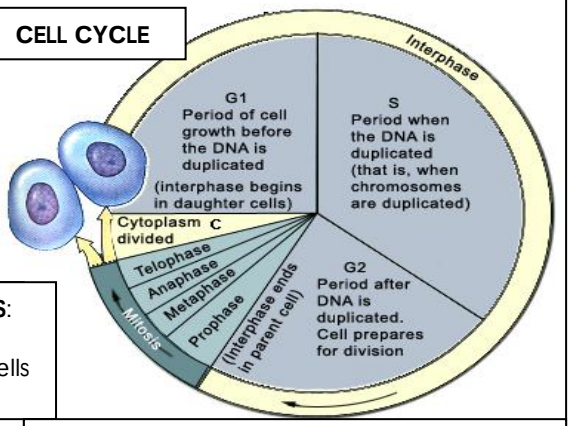
MITOSIS

Prophase- chromosome visible
Metaphase- chromosome line up in the middle
Anaphase- chromosome pulled apart
Telophase- two nuclei

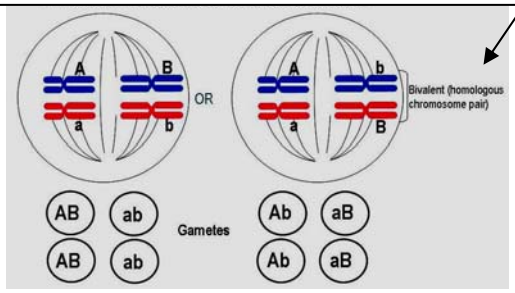


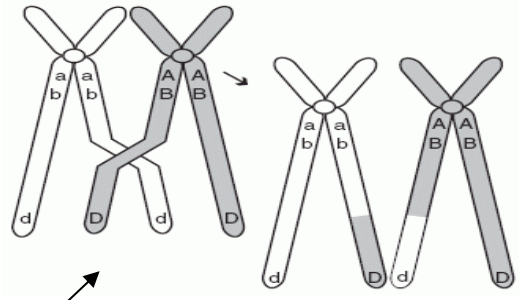
CYTOKINESIS: Animal cells and plant cells

CELL CYCLE



Independent Assortment/MEIOSIS: Metaphase I
random arrangement of pairs of chromosomes which leads to genetic diversity in gametes.





Crossing-over is the process that can give rise to genetic recombination. The duplicated homologous chromosomes pair, and crossing-over (the physical exchange of chromosome parts) occurs during **Prophase I/meiosis**.

Property	Mitosis	Meiosis
DNA Replication	During interphase before mitosis begins	During interphase before Meiosis I only
# of divisions	One	Two
Synapsis of homologous chromosomes	Do not pair.	Pair during Prophase I, with crossing over between non-sister chromatids
# of daughter cells and genetic composition	Two diploid (2n) daughter cells that are genetically identical to the parent cell	Four haploid (n) daughter cells, contain half the # of chromosomes as parents, daughter cells are genetically different from parent cells and each other
Role in animal body	Produces somatic cells for growth and repair	Produce gametes and assure genetic diversity in sexual reproduction

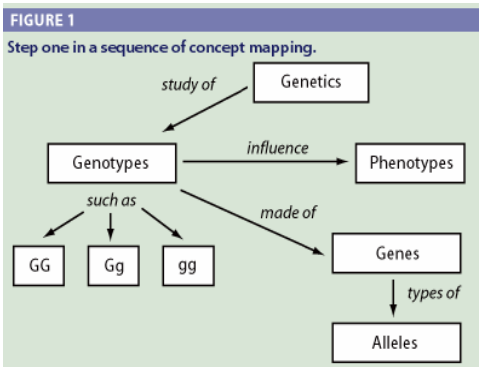
Genetics

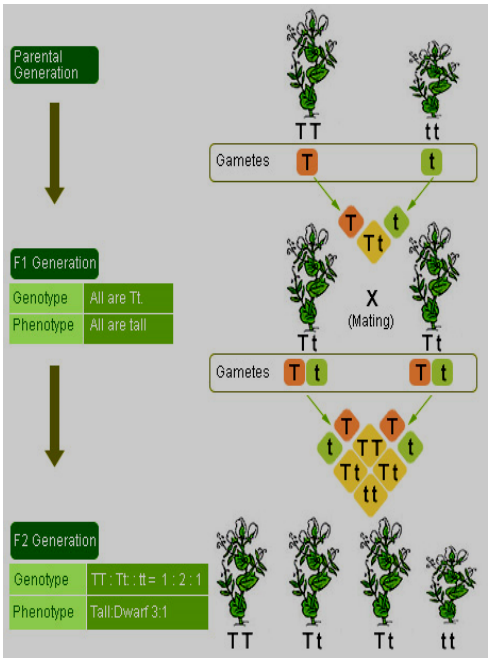
MENDELS LAWS OF HEREDITY:

1. **Law of Dominance**
- the dominant allele will prevent the recessive allele from being expressed
- recessive allele will appear when it is paired with another recessive allele in the offspring

2. **Law of Segregation**
- gene pairs separate when gametes (sex cells) are formed
- each gamete has only one allele of each gene pair

3. **Law of Independent Assortment**
- different pairs of genes separate independently of each other (metaphase I) when gametes are formed (Anaphase II in Meiosis)

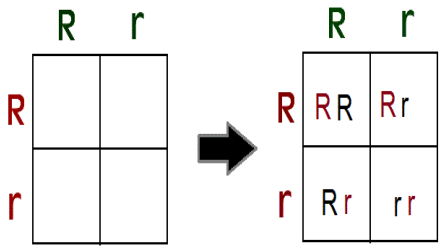




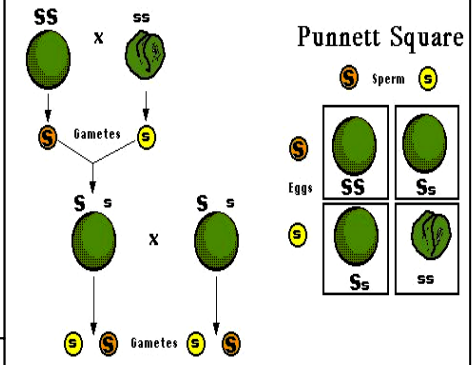
Mendel's experiment
Crossing true-breeding tall plants (homozygous TT) with true-breeding dwarf plants (homozygous tt) produced all tall plants (heterozygous Tt).
Crossing hybrid/heterozygous tall plants (Tt) produced 75% tall plants (1homozygous tall plant and 2 heterozygous tall plants) and 25% dwarf plants.

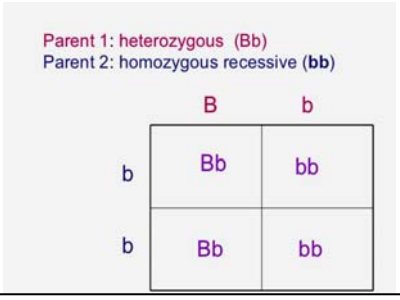
GENETICS:

– Gregor Mendel experimented with sweet pea plants in 1800s
– **Trait** – characteristic an individual receives from its parents
– **Gene** – carries instructions responsible for expression of traits; a pair of inherited genes controls a trait; one member of the pair comes from each parent; often called **alleles**
– **Homozygous** – two alleles of a pair are identical (BB or bb)
– **Heterozygous** – two alleles of a pair are different (Bb); often called "hybrid"
– **Dominant** – controlling allele; designated with a capital letter (RR, Rr)
– **Recessive** – hidden allele; designated with lower-case letters (rr)
– **Genotype** – genetic makeup of an organism (represented by the letters)
– **Phenotype** – physical appearance of an organism (description of the letters)
– **Monohybrid** – cross involving one trait
– **Dihybrid** – cross involving two traits
– **Punnett Square** – graphic organizer used to show the probable results of a genetic cross
– **Pedigree** – graphic organizer to map genetic traits between generations
– **Test Cross** – mating of an individual of unknown genotype with an individual of known genotype; can help to determine the unknown genotype of the parent

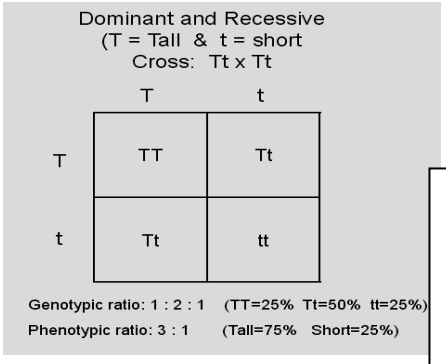


A **monohybrid** cross contains four boxes; a cross between two heterozygous individuals would reveal a 1:2:1 genotype ration and a 3:1 phenotype ratio in the offspring; the probability that the offspring will show a dominant phenotype is ¾, or 75%

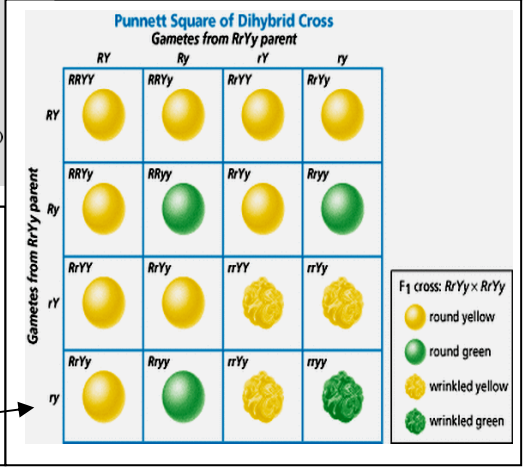




Brown –B Blue-b
Genotype- Bb 50% 2:4, bb 50% 2:4
Phenotype- Brown 50%, blue 50%



A **dihybrid** cross contains sixteen boxes; a dihybrid cross reveals two traits for both parents; a cross between two heterozygous individuals would reveal a 9:3:3:1 phenotype ratio in the offspring.



Genetics

PATTERNS OF INHERITANCE:

Sex-Linked Traits

- traits associated with particular sexes
- 23rd pair of chromosomes; Males = XY; Females = XX
- X-Linked Traits inherited on X chromosome (ex: colorblindness, baldness, hemophilia)

Multiple Alleles

- presence of more than two alleles for a trait (ex: eye color)

Polygenic Inheritance

- one trait controlled by many genes (ex: hair color, skin color); genes may be on the same or different chromosomes

Codominance

- phenotypes of both homozygous parents are produced in heterozygous offspring so that **both alleles are equally expressed/dominant** (ex: black chicken + white chicken = checkered chickens), (ex: sickle cell anemia)

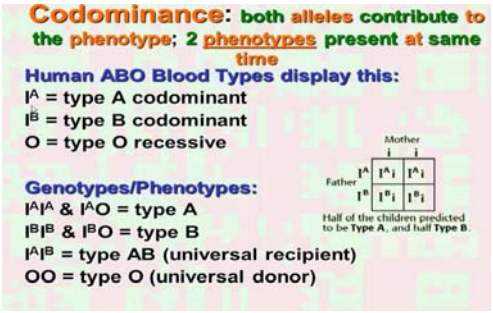
Incomplete Dominance

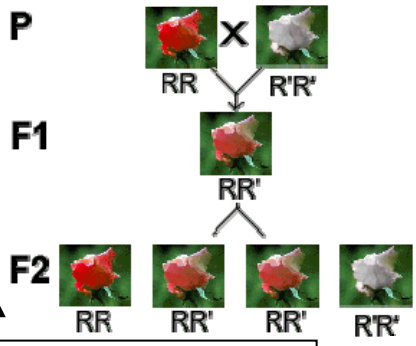
- phenotype of a heterozygote is intermediate between the two homozygous parents; **neither allele is dominant**, but combine to display a new trait (ex: red flower + white flower = pink flower)

Blood type- Multiple Alleles and Codominant

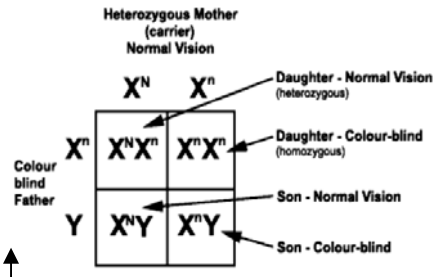
A number of human traits are the result of more than 2 types of alleles (multiple alleles). There are 3 different alleles for blood type (A, B, & O).

Blood type A is dominant to O. B is also dominant to O. A and B are both codominant.

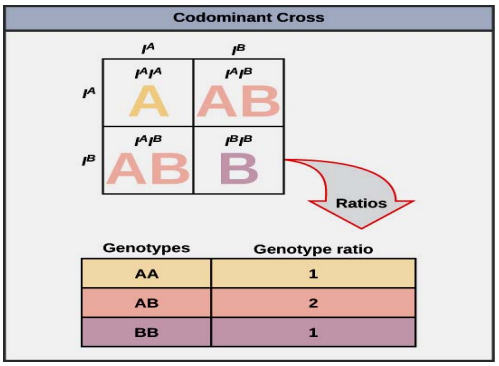


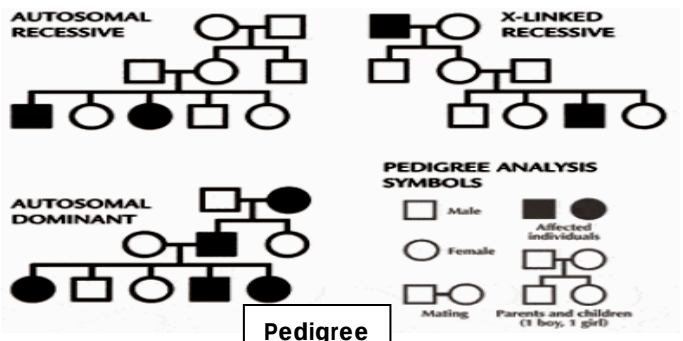


Incomplete Dominance
RR- Red
R'R'-White
RR'- Pink

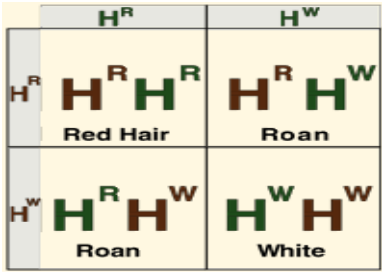


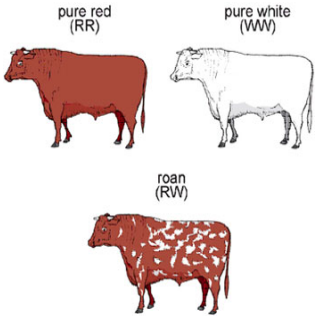
Sex-linked
X^NX^n – normal vision/carrier female
X^nX^n – color blind female
X^nY- color blind male
X^NY- normal vision male



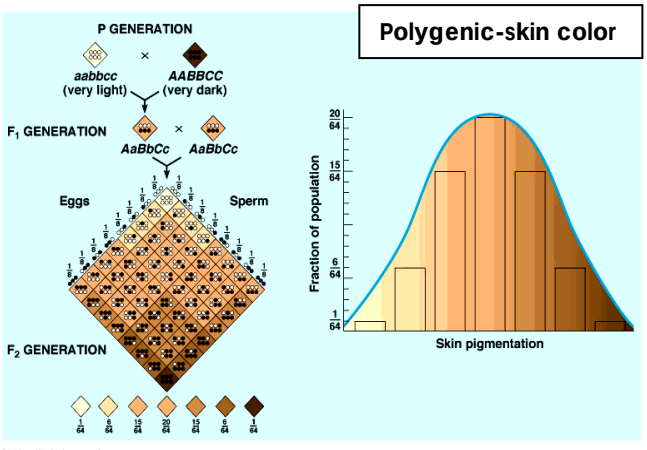


Pedigree





Codominance- red hair and white hair cows will produce roan cows (red and white).



Polygenic-skin color

Dihybrid Cross
Dominant and Recessive
T=Tall, t=short
B=Black, b=white
Cross: TtBb x TtBb

	TB	Tb	tB	tb
TB	TTBB	TTBb	TtBB	TtBb
Tb	TTBb	TTbb	TtBb	Ttbb
tB	TtBB	TtBb	ttBB	ttBb
tb	TtBb	Ttbb	ttBb	ttbb

Genotypic ratio: 1:2:2:1:4:1:2:2:1
Phenotypic ratio: 9:3:3:1

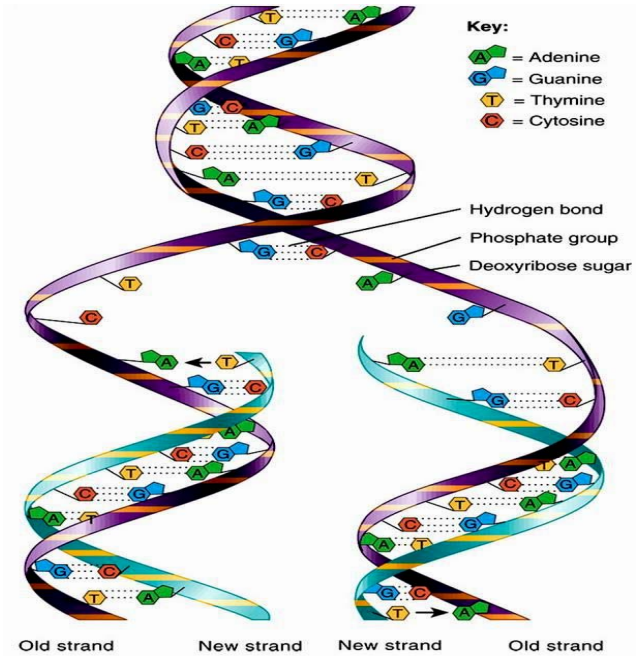
Protein Synthesis

DNA & RNA:
- Nucleic acids composed of nucleotides
- Nucleotides composed of: Phosphate group, Sugar Nitrogenous base

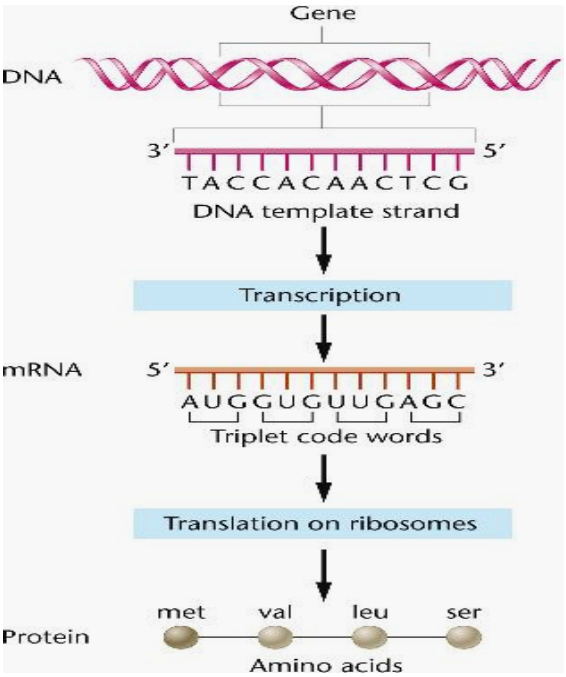
DNA Replication:
Helicase unravels the DNA molecule and each strand serves as a template to make new exact copies (so that when mitosis takes place, each cell has the exact copy of DNA). DNA polymerase is used to add the nitrogenous bases to create the new strands.
Semiconservative model- the two new copies consist of an old strand and a new strand.

Deoxyribonucleic acid
- Double-stranded, twisted helix
- Never leaves the nucleus
- Nitrogenous bases: adenine, thymine, guanine, cytosine(Guanine w/Cytosine, Adenine w/Thymine)- held together by weak hydrogen bonds (A-T, T-A or C-G, G-C)
- Sugar: deoxyribose
- Controls production of all proteins
- DNA coiled into chromosomes in nucleus
- Tiny sections of DNA are called genes
- Sequence of bases determines sequence of amino acids in proteins

Ribonucleic acid
- Single-stranded
- Leaves the nucleus
- Nitrogenous bases: adenine, uracil, guanine, cytosine (A-U, T-A or C-G, G-C)
- Sugar: ribose
- Three major types of RNA (Ribosomal – rRNA; Messenger – mRNA; Transfer – tRNA)
- Leaves the nucleus to carry out functions in cytoplasm



Protein Synthesis- Central Dogma
Transcription: takes place in the nucleus; DNA to mRNA (mRNA is made from one strand of DNA, carries message to ribosomes)
Translation: takes place in the cytoplasm; mRNA to protein (mRNA translated into a protein at the ribosomes; tRNA transfers amino acids from cytoplasm to ribosomes)



The **genetic code is universal** to ALL life and tells us that everything is related. All life regenerates itself by producing offspring and passing on the genetic code. The genetic code is used to produce amino acids, which are the building blocks for proteins (build and construct practically everything in your body). Variations in the genetic code caused by mutations may alter the protein sequence, which can lead to variation in species.

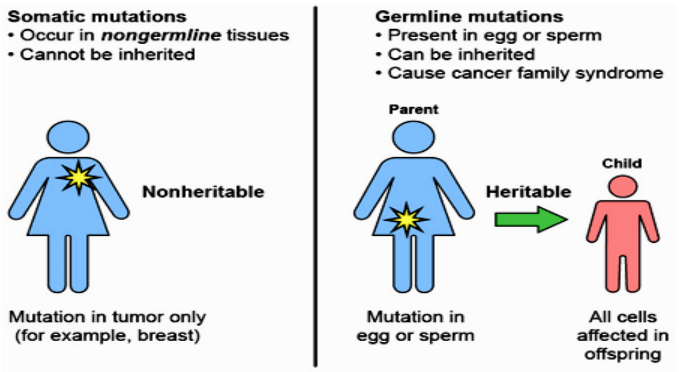
Universal Genetic Code Chart
Messenger RNA Codons and Amino Acids for Which They Code

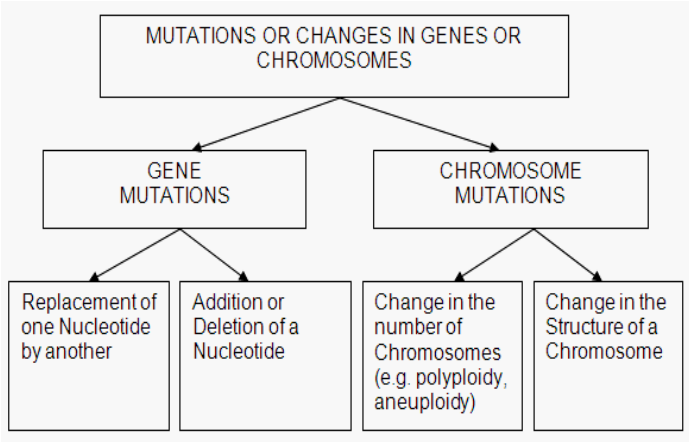
First base	Second base: U	Second base: C	Second base: A	Second base: G	Third base
U	UUU, UUC: PHE; UUA, UUG: LEU	UCU, UCC, UCA, UCG: SER	UAU, UAC: TYR; UAA, UAG: STOP	UGU, UGC: CYS; UGA: STOP; UGG: TRP	U C A G
C	CUU, CUC, CUA, CUG: LEU	CCU, CCC, CCA, CCG: PRO	CAU, CAC: HIS; CAA, CAG: GLN	CGU, CGC, CGA, CGG: ARG	U C A G
A	AUU, AUC, AUA: ILE; AUG: MET or START	ACU, ACC, ACA, ACG: THR	AAU, AAC: ASN; AAA, AAG: LYS	AGU, AGC: SER; AGA, AGG: ARG	U C A G
G	GUU, GUC, GUA, GUG: VAL	GCU, GCC, GCA, GCG: ALA	GAU, GAC: ASP; GAA, GAG: GLU	GGU, GGC, GGA, GGG: GLY	U C A G

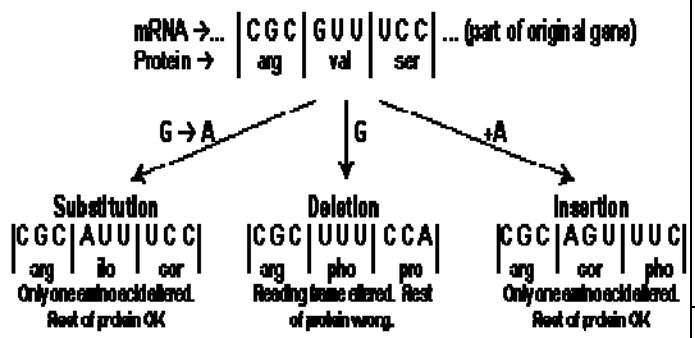
Genetics

MUTATIONS:

- change in genetic code
- passed from one cell to new cells
- transmitted to offspring if occurs in sex cells
- most have no effect
- **Gene Mutation** – change in a single gene; point/substitution or insertion and deletion; occurs during DNA replication.
- **Chromosome Mutation** – change in many genes; occurs during cell division.
- Can be spontaneous or caused by environmental **mutagens** (radiation, chemicals, etc.)





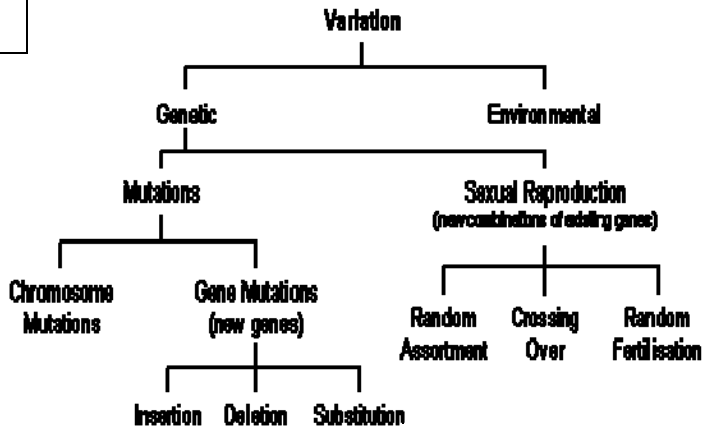


The actual effect of a single gene mutation depends on many factors:

- A substitution on the third base of a codon may have no effect because the third base is less important.
- If a single amino acid is changed to a similar one, then the protein structure and function may be unchanged, but if an amino acid is changed to a very different one, then the structure and function of the protein will be very different.
- Additions and Deletions are Frameshift mutations and are far more serious than substitutions because more of the protein is altered.
- Some proteins are simply more important than others. For instance non-functioning receptor proteins in the tongue may lead to a lack of taste but is not life threatening, whereas non-functioning hemoglobin is fatal.
- Some cells are more important than others. Mutations in somatic cells (i.e. non-reproductive body cells) will only affect cells that derive from that cell, so will probably have a small local effect like a birthmark (although they can cause widespread effects like diabetes or cancer). Mutations in germ cells (i.e. reproductive cells) will affect every single cell of the resulting organism as well as its offspring. These mutations are one source of genetic variation.

As a result of a gene mutation there are three possible phenotypic effects:

- Most mutations have no phenotypic effect. These are called silent mutations, and we all have a few of these.
- Of the mutations that have a phenotypic effect, most will have a negative effect. Most of the proteins in cells are enzymes, and most changes in enzymes will stop them working. When an enzyme stops working, a metabolic block can occur, when a reaction in cell doesn't happen, so the cell's function is changed. An example of this is the genetic disease phenylketonuria (PKU)
- Very rarely a mutation can have a beneficial phenotypic effect, such as making an enzyme work faster, or a structural protein stronger, or a receptor protein more sensitive. Although rare beneficial mutations are important as they drive evolution.

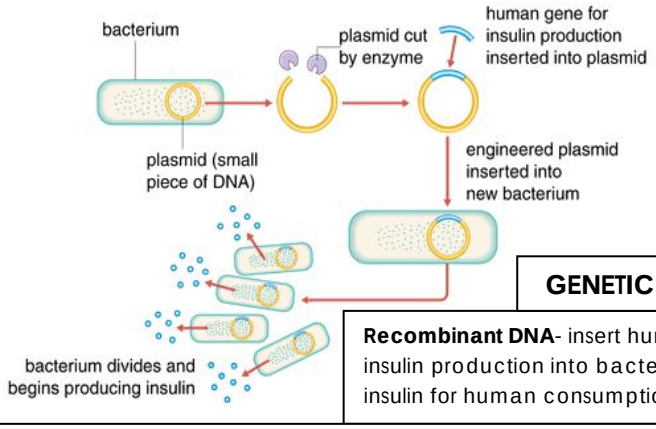


Mutations in chromosomes are different from gene mutations, modification results in more marked phenotypic effects. Mutations in chromosomes occur during the formation of zygote where there are changes in the number of chromosomes; this may result in fission or fusion of chromosomes. Changes in the structure of chromosome can occur in many ways including inversion, duplication, deletion or translocation.

Biotechnology

Biotechnology is the manipulation of organisms or their parts to produce useful products to improve human health and food production.

Genetic Engineering is the process of manually adding new DNA to an organism. Examples of genetically engineered (transgenic) organisms currently on the market include plants with resistance to some insects, plants that can tolerate herbicides, and crops with modified oil content.



GENETIC ENGINEERING

Recombinant DNA- insert human gene for insulin production into bacteria to produce insulin for human consumption.

IMPACT OF BIOTECHNOLOGY ON-

Environment:

- For the most part, crops developed with biotechnology will have many positive impacts on the environment.
- Benefits include reduced pesticide use, improved water and soil conservation and greater safety for workers and the ecosystem.
- Biotechnology has aided in the removal of pollution from our soils, water, and air.
- Also, it has helped us find ways to use our garbage to create new needed products.
- Concerns have been raised that a herbicide tolerant plant could pass that gene responsible for the tolerance on to a weed species, thus conferring herbicide tolerance.

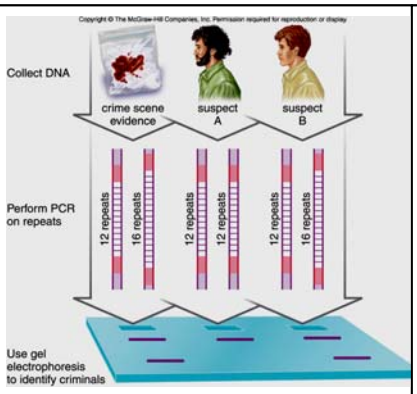
Society:

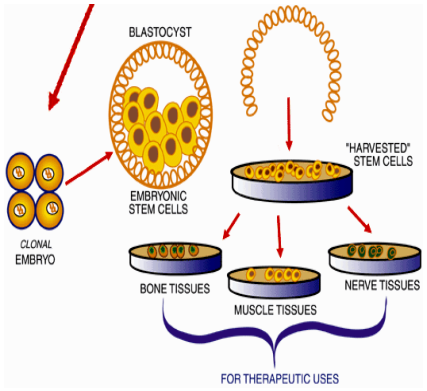
- For developing countries, biotechnology can increase crop yields, thereby helping to address food shortages and hunger.
- In time, biotechnology may produce biodegradable packaging, alternatives to chemical pharmaceuticals, and more healthful food products (e.g. vegetables with increased quantities of antioxidants to reduce the risk of cancer.); as well as foods, when consumed, will deliver vaccines that can currently only be given by injection.
- Also, it is used to solve crimes with DNA and forensic testing.
- Concerns: Accidental immunity of pests, weeds, viruses, and bacteria; biological warfare.

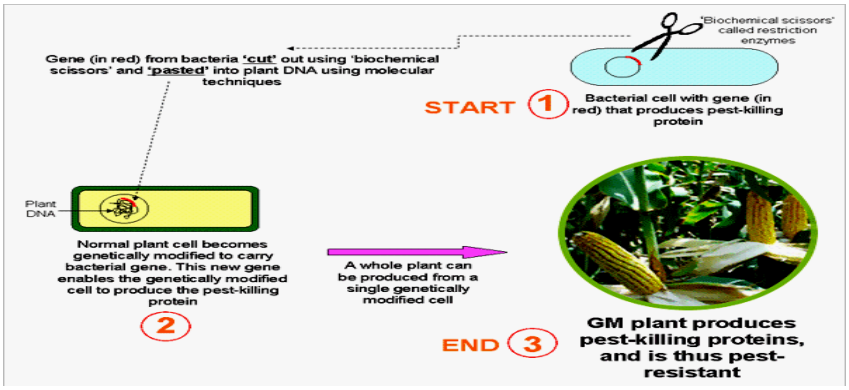
Individual:

- It provides medicine, and can detect and treat diseases: Diabetes, sickle-cell anemia, antibiotics, etc.

Usage	Concerns
• GMOs- genetically modified plants to be pest/disease resistance; to use less water and fertilizers. • Genetically modified bacteria to clean up toxic waste/oil spill. • Biofertilizers- increase fertility of soil. • Gene cloning- specific DNA sequence is isolated and reproduced for medical research, production of insulin and vaccines. • Gene therapy-a nonfunctioning gene in human cells are replaced with a functioning one. • DNA fingerprinting- fragments of DNA are used to identify criminals or to reveal paternity.	• Reduce genetic diversity • Safety of genetic modified foods • Discrimination by DNA • Interference with nature

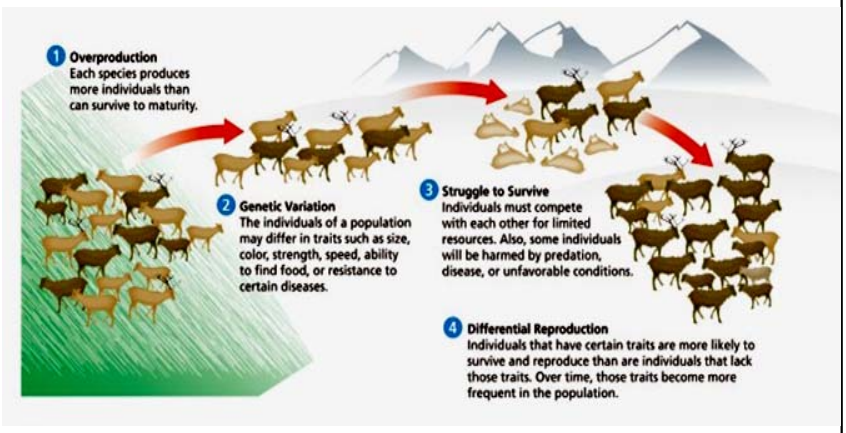






Evolution

THEORY OF EVOLUTION:
- proposed by Charles Darwin
- process by which organisms that are best suited to environment survive and pass genetic traits on to offspring
- **Adaptation** – organisms with the most suited traits will survive
- **Evolution** – change in a species over time (not a single individual, but the group)



The traits that help an organism survive in a particular environment are "selected" in **natural selection.** Overtime, natural selection results in changes in the inherited characteristics of a population. These changes increase species fitness (survival rate).

Conditions required for natural selection:

There is variation in traits.
For example, some beetles are green and some are brown.

There is differential reproduction.
Since the environment can't support unlimited population growth, not all individuals get to reproduce to their full potential. In this example, green beetles tend to get eaten by birds and survive to reproduce less often than brown (camouflage with the bark of trees) beetles do.

There is heredity.
The surviving brown beetles have brown baby beetles because this trait has a genetic basis.

End result
The advantageous trait, brown coloration, which allows the beetle to have more offspring, becomes more common in the population. Eventually, all individuals in the population will be brown.

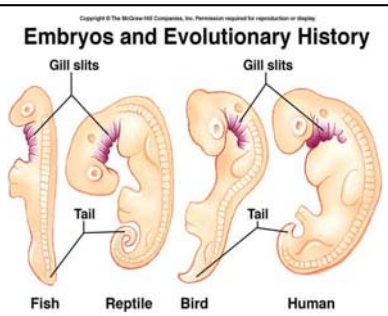
EVIDENCE OF EVOLUTION:
- **Fossils-** may appear in rocks, ice, and amber; when fossils are arranged in order of their age, the fossil record provides a series of changes that occurred over time; comparison of anatomical characteristics reveals shared ancestry/common ancestry
- **Molecular Biology-** comparing DNA/gene or protein sequences from organisms (closely-related organisms will have similar DNA, RNA, and protein (amino acid) sequences). This also gives evidence of a common ancestor
- **Embryology-** embryos of different vertebrates look alike in their early stages, giving the superficial appearance of a relationship
- **Comparative anatomy-** Homologous structures - structures (body parts/anatomy) which are similar in different species because the species have common descent. They may or may not perform the same function. An example is the forelimb structure shared by cats and whales. Vestigial structures are anatomical features that are still present in an organism (although often reduced in size) even though they no longer serve a function. Whales, which evolved from land mammals, have vestigial hind leg bones in their bodies.
- **Biogeography-** patterns of past evolution are found in the natural geographic distribution of related species, similarity of endemic island species to nearby mainland species.

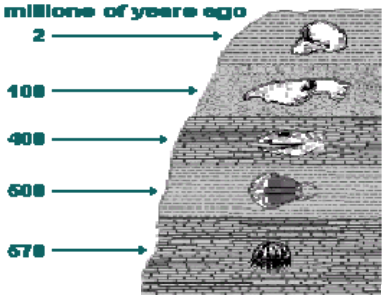
Amino acids reveal evolution

Cytochrome *c* Evolution

	Organism	Number of amino acid differences from humans
	Chimpanzee	0
	Rhesus monkey	1
	Rabbit	9
	Cow	10
	Pigeon	12
	Bullfrog	20
	Fruit fly	24
	Wheat germ	37
A	Yeast	42

Molecular Evidence

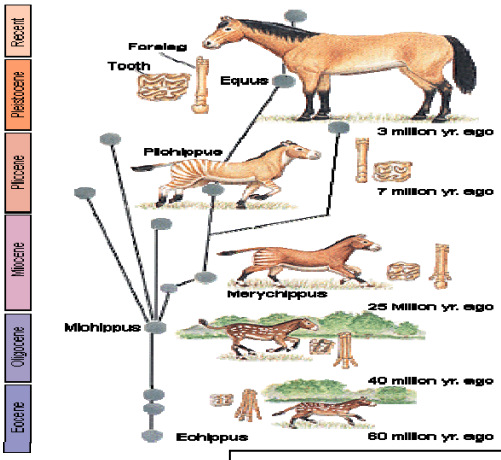




Fossil Evidence- newer to the top

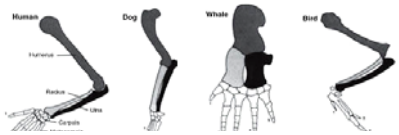
Hominids are the family of organisms that includes humans.

Trends in Hominid Evolution:
- Bipedalism (walk on two legs)
- Increase in brain size
- Smaller teeth and jaw
- Tool usage
- Language development

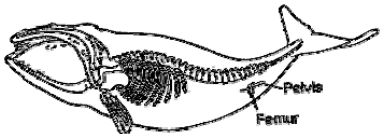


Fossil Evidence - Horse Evolution

Homologous structure- Forelimbs in humans, dogs, whales and birds



Vestigial Structures- Anatomical structures that are not in current use by the species. Example: pelvis and femur bones in whales

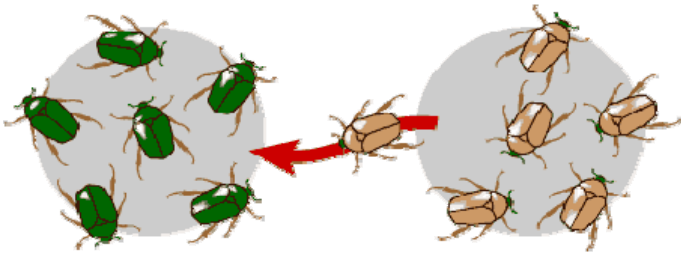


Evolution

Mechanisms of Evolutionary Change

- ***Mutation*** is the change in DNA. Since all cells in our body contain DNA, there are lots of places for mutations to occur; however, not all mutations matter for evolution. Somatic mutations occur in non-reproductive cells and won't be passed onto offspring only those in germ cells/gametes.
- ***Gene Flow/Migration*** is any movement of genes from one population to another. Gene flow includes lots of different kinds of events, such as pollen being blown to a new destination or people moving to new cities or countries. If genes are carried to a population where those genes previously did not exist, gene flow can be a very important source of genetic variation which could potentially lead to the evolution of the species in that population.
- ***Genetic drift*** along with natural selection, mutation, and migration - is one of the basic mechanisms of evolution. In each generation, some individuals may, just **by chance**, leave behind a few more descendents (and genes, of course!) than other individuals. The genes of the next generation will be the genes of the "lucky" individuals, not necessarily the healthier or "better" individuals.
- ***Nonrandom Mating*** mating that has not occurred due to chance (arranged marriages).

Gene Flow



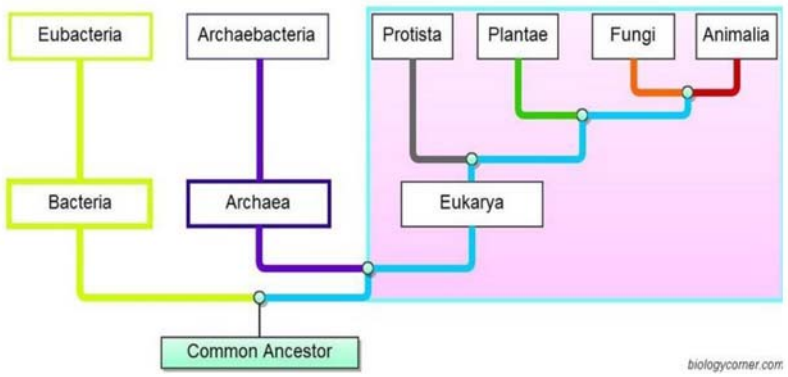
Genetic Drift- random event chance

Classification

CLASSIFICATION:
- process in understanding how organisms are related and how they are different
- It also follows the evolutionary trends
- **taxonomy** – branch of biology that studies grouping and naming of organisms

History of classification systems-
- early 1700s, Carolus Linnaeus developed a system based on physical characteristics; two kingdoms (plants and animals)
- developed "genus" and "species"
- designed system of naming called **binomial nomenclature** ("two names") which gave each organism two names, a genus and a species, Genus always capitalized, both should be underlined or italicized

One of the new reasons why species are being re-evaluated is because of DNA analysis. Basic genetic analysis information can change our ideas of how closely two species are related and so their classification can change.



Organisms are classified into three Domains and into one of six Kingdoms of life. Organisms are placed into these categories based on similarities or common characteristics. Some of the characteristics that are used to determine placement are cell type, metabolism, and reproduction.

Domain: Archaea, Bacteria and Eukarya

Six kingdoms: Archaea/Archaeabacteria, Bacteria/Eubacteria, Protista, Fungi, Plantae, and Animalia

LEVELS OF CLASSIFICATION:
- Kingdom
- Phylum
- Class
- Order
- Family
- Genus
- Species

CLASSIFICATION OF HUMANS:

Kingdom: *Animalia* (multicellular organisms that eat food)
Phylum: *Chordata* (dorsal hollow nerve cord, notochord, pharyngeal slits)
Class: *Mammalia* (hair, mammary glands, endothermic, and four-chambered heart)
Order: *Primates* (nails, clavicle, orbits encircled with bone, enlarged cerebrum, and opposable digits)
Family: *Homidae* (bipedal – walk erect on two feet, advanced tool use)
Genus: *Homo* ("human" like)

Classification of Living Things

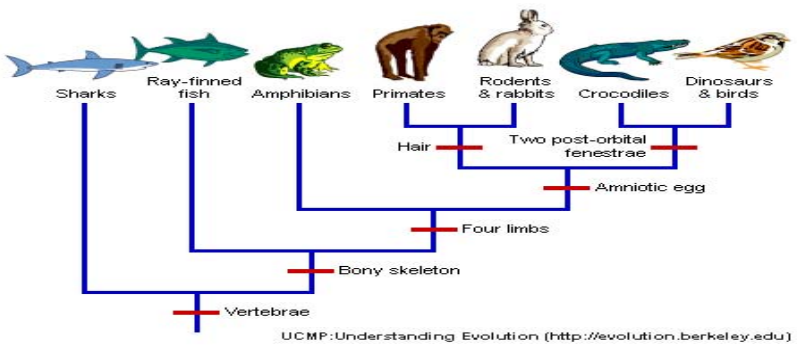
DOMAIN	Bacteria	Archaea	Eukarya			
KINGDOM	Eubacteria	Archaebacteria	Protista	Fungi	Plantae	Animalia
CELL TYPE	Prokaryote	Prokaryote	Eukaryote	Eukaryote	Eukaryote	Eukaryote
CELL STRUCTURES	Cell walls with peptidoglycan	Cell walls without peptidoglycan	Cell walls of cellulose in some; some have chloroplasts	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	Multicellular	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

lassification of Living Things Organisms are grouped in three domains. There is a simple **elationship between the three domains and the six kingdoms.** This table summarizes key evidence used classifying organisms into these major taxonomic groups.

Autotrophs- are organisms that can produce their own food from the substances available in their surroundings using light (photosynthesis) or chemical energy (chemosynthesis); producers.

Heterotrophs- are organisms that cannot produce their own food and rely on other organisms for energy/food; consumers.

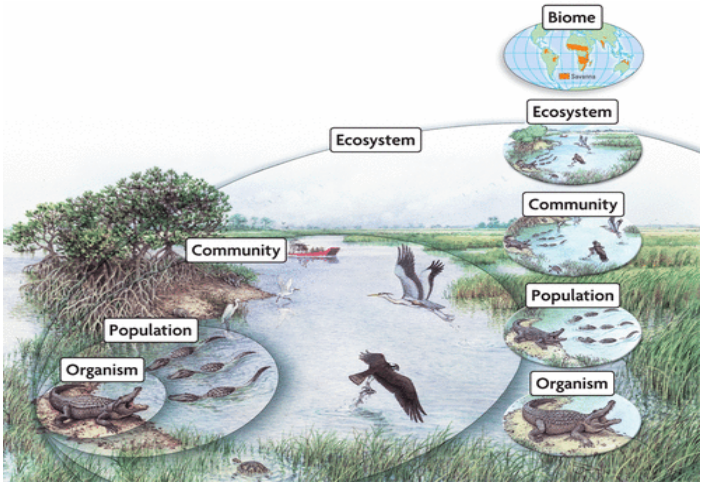
A **cladogram** is another way of representing evolutionary relationships.
Branches represent real lineages that occurred in the evolutionary past.
It includes information about ancestors, duration of evolutionary lineages, amounts of evolutionary change that has occurred.



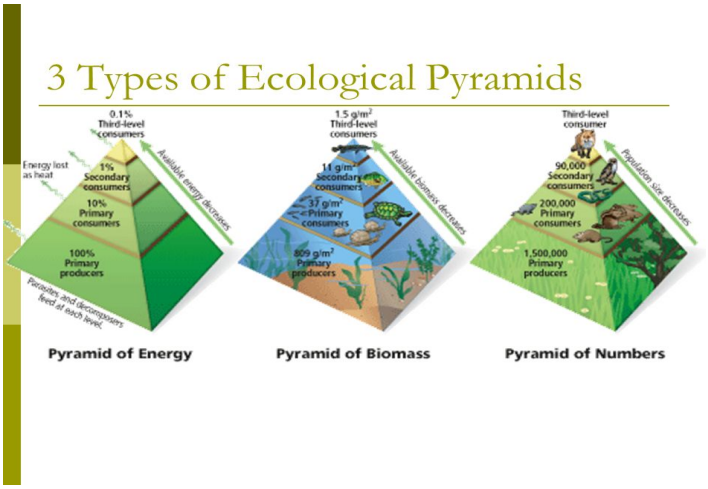
ECOLOGY

Ecology is the study of relationships between organisms and their environment.

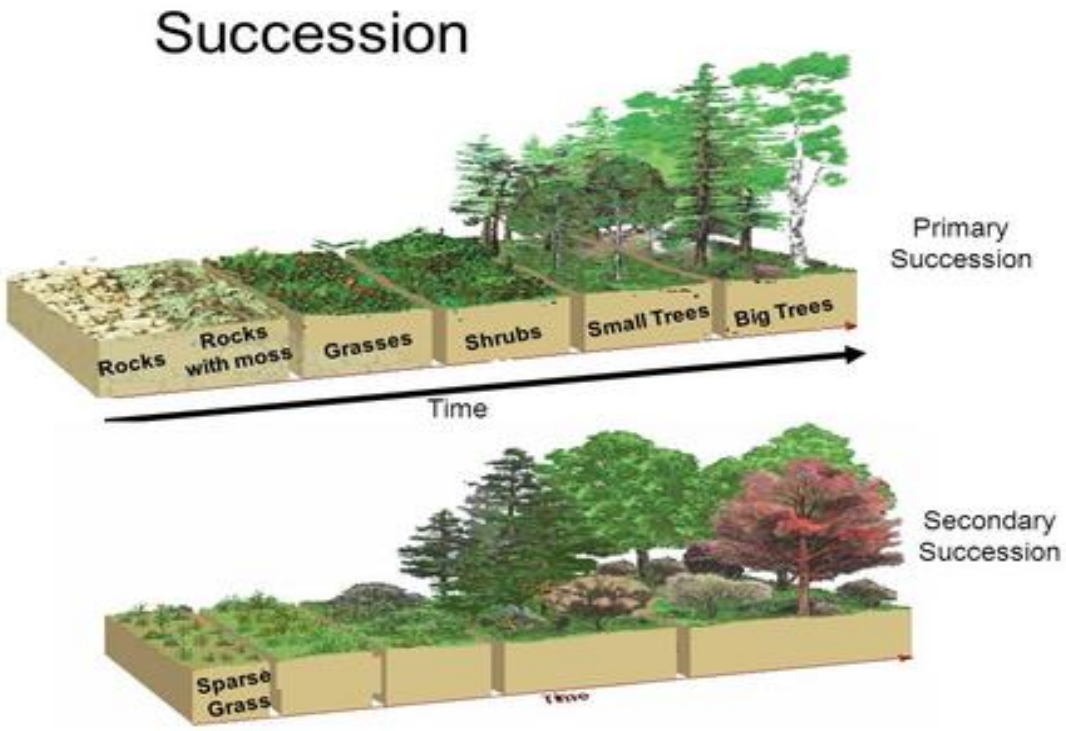
- **Biotic factors**: living things
- **Abiotic factor**: non-living things (rocks, sand, temperature, rainfall…)
- **Levels of Ecological Organization**:
    - Organism, population, community, ecosystem, biomes, biosphere
        - **Organism**: individual
        - **Population**: group of individuals of same species
        - **Community**: groups of populations in an area
        - **Ecosystem**: first level to contain biotic (groups of communities) and abiotic factors
        - **Biomes**: groups of ecosystems with similar climate in different parts of the world
        - **Biosphere**: group of all biomes in the world: Earth.



- **Habitat**: the PLACE where living things inhabit
- **Niche**: the ROLE (job) of the organism in the environment: ex.: predator, prey, producer, etc…
- **Competition**: when organisms that occupy the same NICHE have to share the same resources (food, water, shelter, etc.)
- **Predation**: involves predator killing prey for food
- **Symbiosis**: different species living very closely together
    - Commensalism: one species benefits, the other is neither harmed nor benefitted (ex. Plants that live on top of trees to get closer to sun)
    - Parasitism: one species benefits the other is harmed (mosquito bites humans)
    - Mutualism: both species benefit (birds cleaning alligator's teeth)
- **Food Web**: show flow of energy from food to the organism eating it. (show direction of arrows; organized in trophic levels)
    - **Producers = autotrophs** (photosynthetic organisms): located at the base/beginning of every food chain/web
    - **Consumers = heterotrophs** (must consume food to obtain energy): can be:
        - **Primary**: mandatory HERBIVORES
        - **Secondary**: can be carnivores or omnivores
        - **Tertiary**: can be carnivores or omnivores
        - Top of food chain/web contains **top predators** (will rarely be consumed by any other organism)

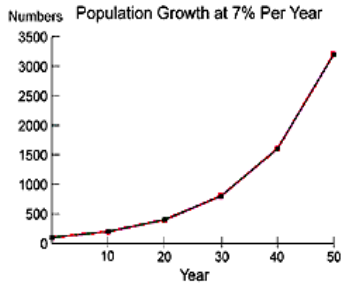


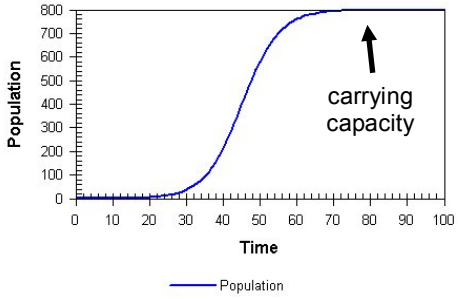
- **Scavengers**: eat already dead organisms (vultures, ravens)
- **Detritivores**: eat pieces of organic material mixed in with the soil (crabs, worms)
- **Decomposers**: absorb nutrients from decaying matter (mushrooms)
- ****Only 10% of energy (and biomass) is transferred from one trophic level to another in the food web (energy decreases as it goes up). 90% is lost as heat while organism performs life functions.**
- **Nutrient cycles**: matter, as opposed to energy, is recycled!
    - Water cycle: transpiration (from living things), precipitation, condensation, evaporation
    - Carbon cycle: one way for carbon to get in living things: through photosynthesis (autotrophs) and then the food web. Several ways it can come out: respiration (CO_2, decomposition, combustion)
    - Nitrogen cycle: nitrogen fixation into living things can only be done by bacteria in the roots of legumes: they convert nitrogen gas (N_2) into ammonium (NH_4^+). Several ways to come out: urine, decomposition
- **Succession**: predictable changes in the environment that will allow a devastated environment to rebuild.
    - Primary succession: No soil is left (ex.: after volcanic eruption). Pioneer species (mosses, lichens, grass) will break down rock to rebuild soil and repopulate area.



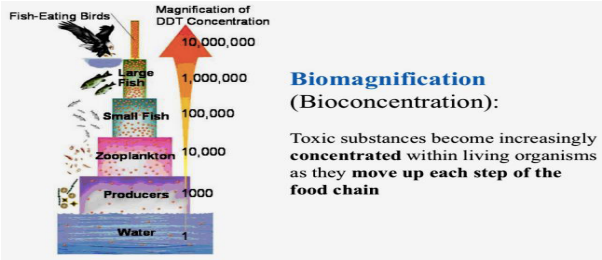
    - Secondary succession: Soil is present (ex.: after fire forest, floods, landslides, earthquakes). Faster than primary succession.
    - Climax community: mature environment, where little change happens in the environment. Contains mature organisms (hardwood trees, for instance)
- **Population Ecology**: Studies the change in size of a population
- Factors that cause increase in population: birth rates, immigration (coming in environment)
- Factors that cause decrease in population: death rates, emigration (moving out of environment)

- **"J"** Curve graphs: **exponential growth**
- **"S"**Curve graphs: **logistical growth** (contain carrying capacity)
    - **Carrying capacity**: number of organisms an environment is able to support (food, water, shelter, density)





- **Limiting Factor**: factors determinging population growth:
    - **Density dependent**: overpopulation, over crowded areas (depends on living things)
    - **Density independent**: natural disasters, disease, food/water availability (does not depend on living things)
- **Human Impact**:
    - Overpopulation, deforestation, extinction, pesticide/chemical use,
    - **Biological Magnification**: toxins such as pesticides accumulate in food chain.



    - **Global Warming/Greenhouse Effect**: caused by pollution trapped in atmosphere, trapping heat around Earth
    - **Acid Rain**: caused by air pollution that causes the acidification of rain, contaminating rivers, lakes and the oceans.
- **Biomes**: Regions with similar climate and precipitation influenced by position on planet: biomes closer to equator are warmer than those away from equator
    - **Rainforest**: hot, humid, high precipitation, most diverse biome (no. of species per area)
    - **Temperate Deciduous Forest**: 4 seasons, mild winters, average precipitation, trees change leaves
    - **Coniferous Forest**: cold winters, short summers, low precipitation. Plant adaptation: connifers (pine trees) needles are modified leaves to prevent loss of water).
    - **Tundra:** polar caps. Very long winters and nights, low rain fall. Permafrost: soil is permanently frozen, even in summer.
    - **Grasslands/Savannah**: mild winters, low precipitation, mostly grass.
    - **Deserts**: very dry, very low precipitation, hot days, cold nights. Cactuses have thorns as modified leaves to avoid moisture loss.