BIOLOGY MID-TERM Study Guide

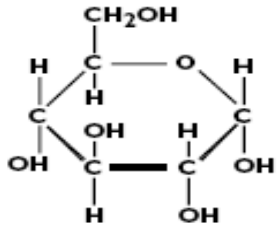
- Structure and Functions of Organic Molecules (carbohydrates, proteins, lipids, nucleic acids)
- Structure and Functions of Cells, Cellular Organelles, Cell Specialization, Communication Among Cells
- Cell as a Living System, Homeostasis, Cellular Transport, Energy Use and Release in Biochemical Reactions
- Structure and Function of Enzymes, Importance in Biological Systems
- Bioenergetic Reactions, Aerobic / Anaerobic Respiration, Photosynthesis

ORGANIC MOLECULES:

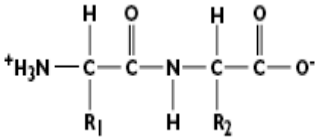
Organic compounds contain carbon and are found in all living things.

- ***Carbohydrates***
  - major source of energy and include sugars and starches
  - made up of carbon, hydrogen, and oxygen with a 2:1 ratio of hydrogen to oxygen
  - 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, cushion internal organs, found in biological membranes
  - saturated (with hydrogen, single bonds, see example →) 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)

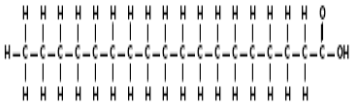
CARBOHYDRATE
(Sugar – Glucose)



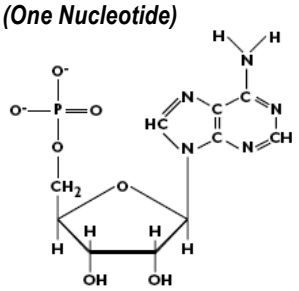
PROTEIN
(One Amino Acid)



LIPID



NUCLEIC ACID
(One Nucleotide)



CELL ORGANELLES:

- ***Chloroplast*** – capture solar energy for photosynthesis (plant cells, some algae)
- ***Golgi Body*** – package, distribute products
- ***Lysosomes*** – digests excess products and food particles
- ***Mitochondria*** – transform energy through respiration
- ***Nucleus*** – contains DNA which controls cellular activities
- ***Ribosome*** – produce proteins
- ***Vacuole*** – store substances
- ***Cell (plasma) membrane*** – phospholipid bilayer that protects and encloses the cell; controls transport; maintains homeostasis
- ***Cell wall*** – rigid second layer that protects and encloses the cell (plant cells and some bacteria)
- ***Cytoplasm*** – fluid-like substance that contains various membrane-bound structures (organelles) that perform various functions
- ***Endoplasmic Reticulum*** – site of chemical reactions
  - ROUGH: contains ribosomes
  - SMOOTH: lipid production
- ***Cytoskeleton*** – provides internal structure
  - MICROFILAMENTS: fibers
  - MICROTUBULES: cylinders

CELL TYPES:

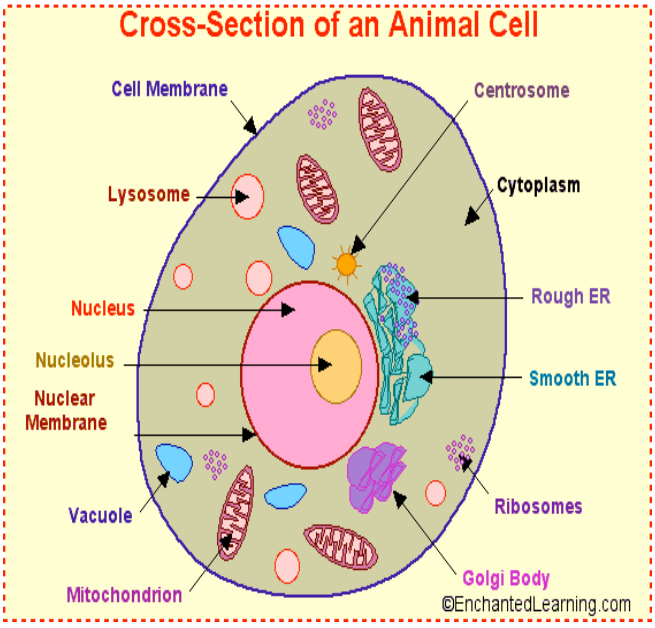
- ***Unicellular*** – organism that exists as a singular, independent cell
- ***Multicellular*** – organism that exists as specialized groups of cells; cells are organized into tissues that perform the same function; tissues form organs and organs make up an organ system
- ***Prokaryote*** – has nuclear material in the center of the cell, but is not enclosed by a nuclear membrane; no membrane-bound organelles; found in bacteria and blue-green bacteria
- ***Eukaryote*** – contain a clearly defined nucleus enclosed by a nuclear membrane and membrane-bound organelles; found in plants, animals, fungi, and protists

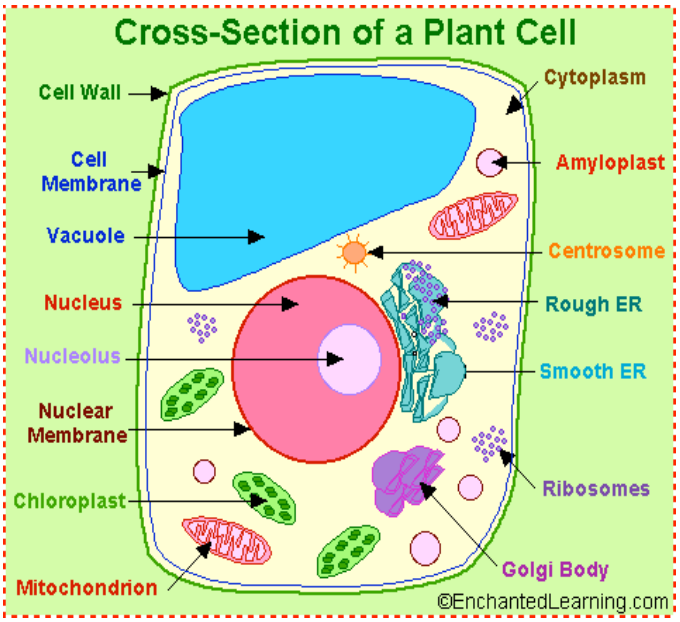
CELL THEORY:

- The cell is the basic unit of life.
- All organisms are composed of cells
- All cells come from pre-existing cells.

CELL SPECIALIZATION:

- cells >>>> tissues >>>> organs >>>> organ systems >>>> organism
- each cell performs a specific function for each tissue or organ
- as cells mature, they shape and contents change
- as cells become specialized they may contain organelles that are NOT common to all cells (for example: plastids, cell wall, vacuole, centriole)
- design and shape of a cell is dictated by its function and the conditions under which it works
- multicellular organisms exhibit greater cellular specialization, such as red blood cells, nerve cells, and gland cells





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
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)

1. ENDOCYTOSIS – large particles are brought into the cell
2. 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 to pass through
- ***Effect of Concentration on a Cell***

1. HYPOTONIC – water moves in; cell bursts
2. HYPERTONIC – water moves out; cell shrivels
3. ISOTONIC – no net movement; cell maintains equilibrium

HOMEOSTASIS: Self-regulating mechanism that maintains internal conditions (with individual cells and within organs, systems) Example: body temperature, respiration, nutritional balance, etc. Cells communicate their needs to each other mainly through their cell membranes by releasing chemical messengers that, ultimately, tell the hypothalamus gland in the brain that a change needs to be made in the interstitial fluid. Since it is the ruler of homeostasis, the hypothalamus sends neural and chemical signals to other glands, tissues, organs, and organ systems to adjust the internal environment, the interstitial fluid, so that it is more suitable for all the cells at that particular time. And since we are always changing what we are doing, homeostasis needs to change along with our activities, both day and night. This constantly changing internal environment is the process of homeostasis.

- Negative Feedback: Glucose / Insulin levels in cells
- Positive Feedback: Blood platelets / Blood clotting

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); the next two stages are called the citric acid cycle and the electron transport chain and are aerobic (oxygen is required)

  $C_6H_{12}O_6 + 6O_2 \Rightarrow 6CO_2 + 6H_2O + \text{ENERGY (36 ATP)}$

- ***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)

  $6CO_2 + 6H_2O + \text{ENERGY(from sunlight)} \Rightarrow C_6H_{12}O_6 + 6O_2$

- ***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

  $ATP \Leftrightarrow ADP + P + \text{ENERGY}$

- ***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) $\quad \text{Glucose} \Rightarrow \text{Lactic Acid} + 2ATP$

  Alcoholic Fermentation (plant cells) $\quad \text{Glucose} \Rightarrow CO_2 + \text{Alcohol} + 2ATP$

AEROBIC AND ANAEROBIC RESPIRATION:

Aerobic Respiration –

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

Anaerobic Respiration –

- 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
- seen as an adaptation for organisms that live in environments that lack oxygen

COMPARISON OF CELLULAR RESPIRATION, PHOTOSYNTHESIS AND CHEMOSYNTHESIS

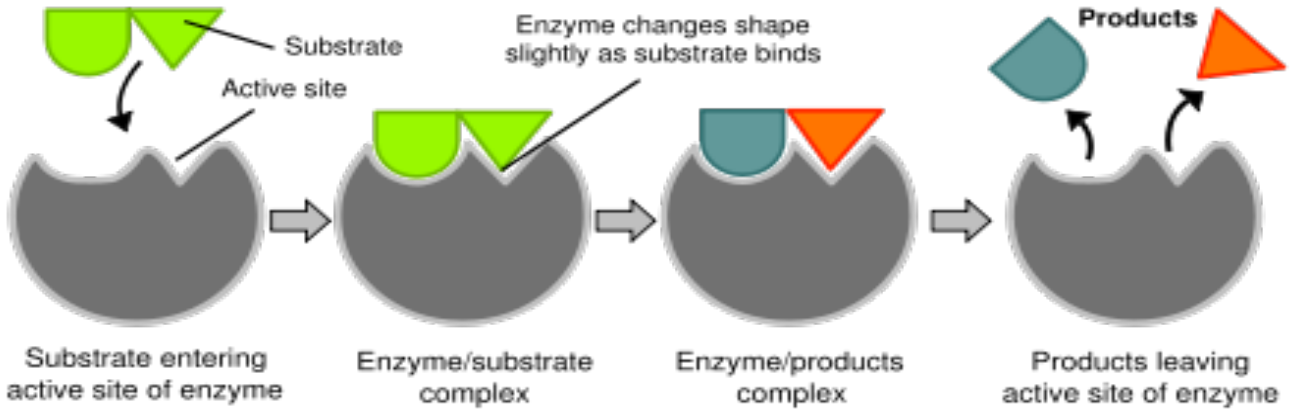
CELLULAR RESPIRATION	***PHOTOSYNTHESIS***	***CHEMOSYNTHESIS***
Food Broken Down	Food Synthesized	Food Synthesized
Energy from Glucose Released	Energy from Sun stored in Glucose	Energy from Methane or Inorganic Material
Carbon Dioxide given off	Carbon Dioxide taken in	(ex: H gas or Hydrogen sulfide)
Oxygen taken in	Oxygen given off	Organisms often called chemotrophs
Produces Carbon Dioxide and Water	Produces Sugars (Glucose) from PGAL	Organisms called extremophiles
Does not require Light	Requires Light	Live in environments without oxygen
Occurs in ALL Living Cells	Occurs only in presence of Chlorophyll	Anaerobic Bacteria
Organisms often called Heterotrophs	Organisms called Autotrophs	Habitats: hydrothermal vents

ENZYMES:

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

Enzymes function to:

- Provide energy to cells
- Build new cells
- 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

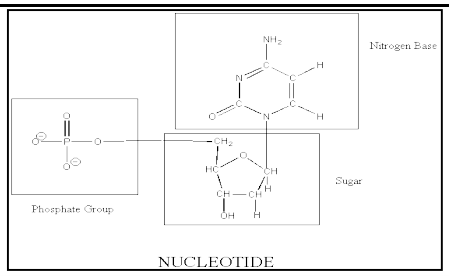


DNA

- Molecular Basis of Heredity, DNA Replication, Protein Synthesis (Transcription, Translation), Gene Regulation
- Characteristics of Sexual and Asexual Reproduction
- Patterns of Inheritance, Dominant / Recessive / Intermediate Traits, Multiple Alleles, Polygenic Inheritance, Sex-Linked Traits, Independent Assortment, Test Cross, Pedigrees, Punnett Squares
- Impact of Advances in Genomics on Individuals and Society, Human Genome Project, Applications of Biotechnology

DNA & RNA:

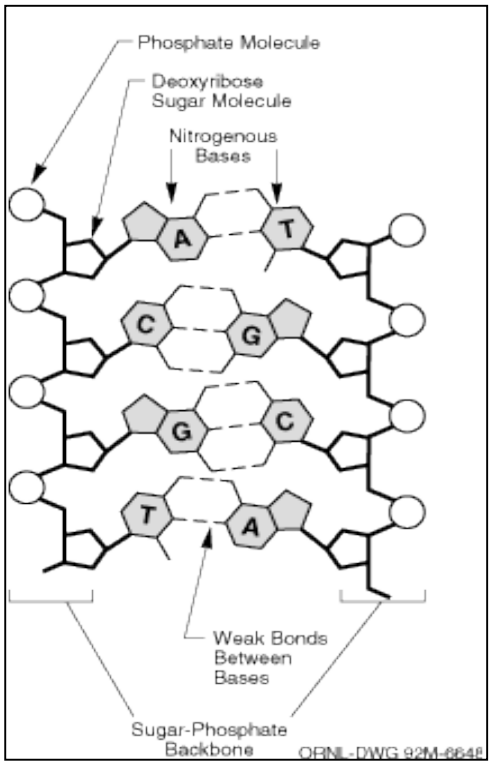
- Nucleic acids composed of nucleotides
- Nucleotides composed of:
  - Phosphate group
  - Sugar
  - Nitrogenous base

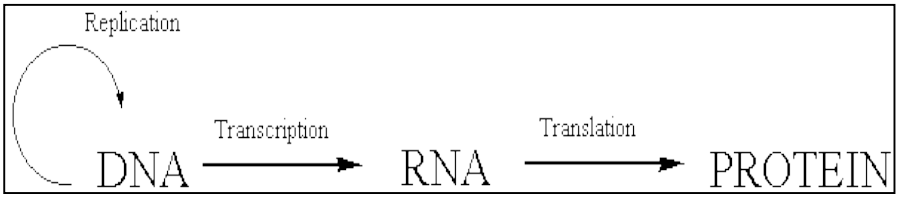


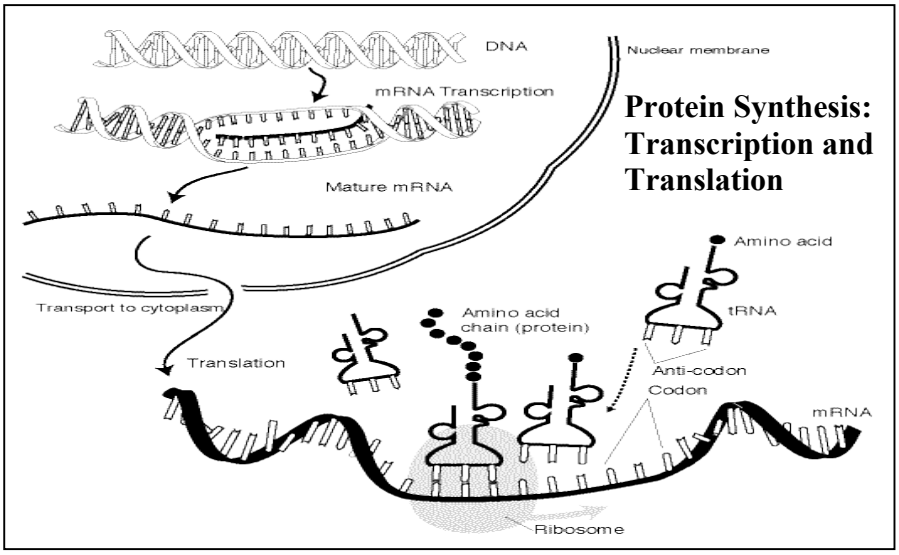
NUCLEOTIDE

COMPARISON OF DNA AND RNA

DNA	***RNA***
Deoxyribonucleic acid	Ribonucleic acid
Double-stranded, twisted helix	Single-stranded
Never leaves the nucleus	Leaves the nucleus
Nitrogenous bases: adenine, thymine, guanine, cytosine	Nitrogenous bases: adenine, uracil, guanine, cytosine
(Guanine w/Cytosine, Adenine w/Thymine)	(Guanine w/Cytosine, Adenine w/Uracil)
(Purines opposite the Pyrimidines)	Sugar: ribose
(held together by weak hydrogen bonds)	Three major types of RNA
Sugar: deoxyribose	(Ribosomal – rRNA; Messenger – mRNA; Transfer – tRNA)
Controls production of all proteins	Leaves the nucleus to carry out functions in cytoplasm
DNA Replication:	***Transcription:***
(DNA unravels and each strand makes a new exact copy so that when mitosis takes place, each cell has the exact copy of DNA)	(mRNA is made from one strand of DNA, carries message to ribosomes)
DNA coiled into chromosomes in nucleus	***Translation:***
Tiny sections of DNA are called genes	(mRNA translated into a protein at the ribosomes; tRNA transfers amino acids from cytoplasm to ribosomes)
Sequence of bases determines sequence of amino acids in proteins	







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

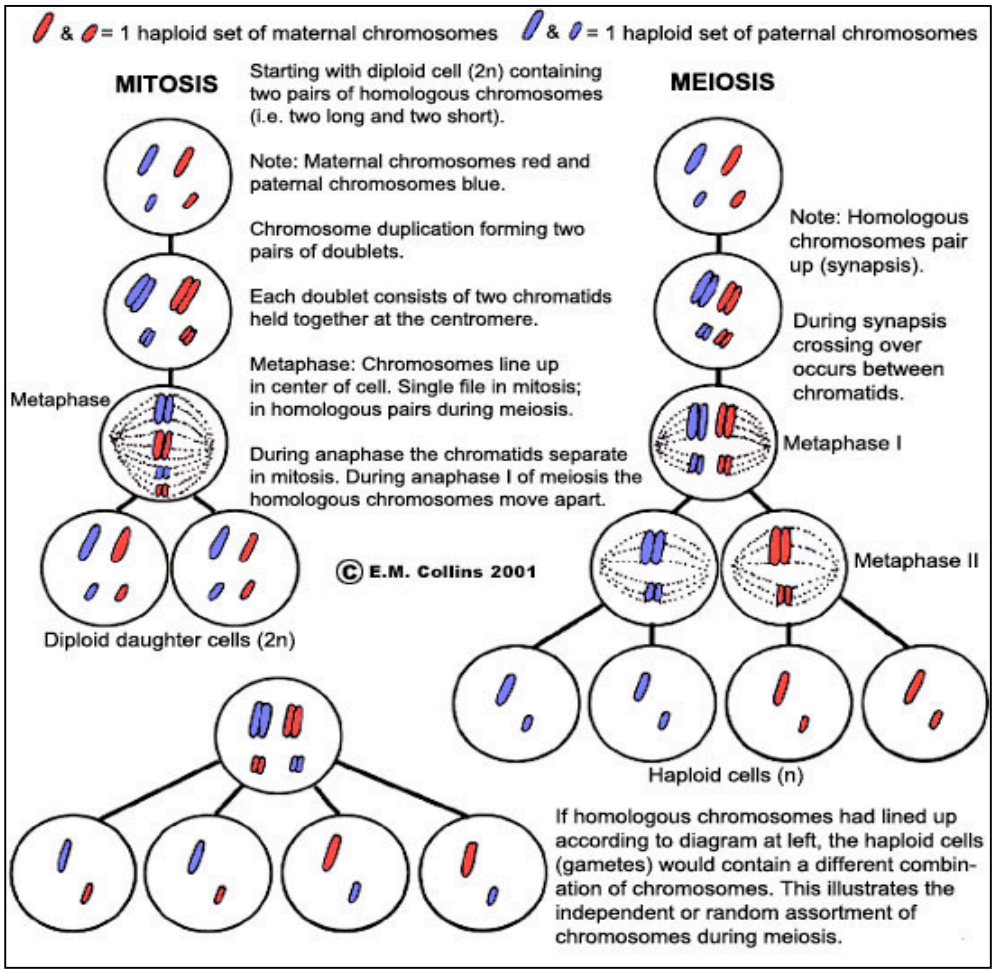
- results in genetic variation (diversity)
- common in multicellular organisms (external or internal fertilization); good for changing environments
- slow process (high energy requirement) – produces low number of offspring
- meiosis = formation of sex cells (gametes)

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

COMPARISON OF MITOSIS AND MEIOSIS

MITOSIS	***MEIOSIS***
Cell cycle consists of interphase, mitosis, and cytokinesis ***Interphase*** – longest part of cell cycle Growth, metabolism, and preparation for division occurs Duplicates chromosomes (DNA Replication) ***Mitosis*** – division of nucleus of the cell - ***Prophase -*** duplicated chromosomes and spindle fibers appear - ***Metaphase*** – duplicated chromosomes line up randomly in center of cell between spindle fibers - ***Anaphase*** – duplicated chromosomes pulled to opposite ends of cell - ***Telophase*** – nuclear membrane forms around chromosomes at each end of cell; spindle fibers disappear; chromosomes disperse ***Cytokinesis*** – division of plasma membrane; two daughter cells result with exact genetic information *(in plant cells a "cell plate" forms along the center of the cell and cuts the cell in half; cell plate forms new cell walls once the plasma membrane divides)* ***RESULTS:*** Two daughter cells (body cells) Same number of chromosomes as original cell (humans = 46) Cells are diploid (human diploid # = 46 or 23 homologous pairs)	Consists of two cell divisions, but only one chromosome replication (sometimes called reduction division) Each cell division consists of prophase, metaphase, anaphase, and telophase Occurs only in sex cells – to produce more sex cells (gametes) ***First Meiosis Division*** Produces cells containing ½ # of double stranded chromosomes ***Second Meiosis Division*** Results in formation of four cells Each cell w/ ½ # of single-stranded chromosomes (haploid cells) --- ***Sperm*** Each primary sperm cell develops into four haploid cells of equal size. As cells mature, the cells lose most of their cytoplasm and develop a long whip-like tail for movement. ***Egg*** Each primary egg cell develops into one large haploid cell and three smaller haploid cells called polar bodies. The first meiosis division produces one large cell and one polar body. The second meiosis causes the large cell to produce one egg cell and a polar body; the original smaller polar body divides into two polar bodies. The polar bodies eventually disintegrate. The final egg cell is provided with the larger supply of stored nutrients ***RESULTS:*** Four daughter cells (sex cells) ½ # of chromosomes (haploid) with genetic variation (n = 23) Sex cells combine during ***sexual reproduction*** to produce a diploid individual



GENETICS:

- branch of biology that deals with heredity
- 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
- ***Recessive*** – hidden allele; designated with lower-case letters
- ***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
- ***Karyotype*** – chart of metaphase chromosome pairs to study chromosome number / diseases
- ***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

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 when gametes are formed (Anaphase II in Meiosis)

PATTERNS OF INHERITANCE:

Sex Chromosomes
- 23rd pair of chromosomes; Males = XY; Females = XX

Sex-Linked Traits
- traits associated with particular sexes
- X-Linked Traits inherited on X chromosome from mother (ex: colorblindness, baldness, hemophilia)

Linked Traits
- genes are linked on chromosomes; genes on same chromosome are inherited together; ex: red hair and freckles
- one trait controlled by many genes (ex: hair color, eye color, skin pigment)

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 (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)

Dominance / Recessive ness
- observed trait is controlled by a homozygous genotype
- ex: dominance disease – Huntington's; ex: recessive disease – Cystic Fibrosis and Tay Sach's

SOURCES OF VARIATION:

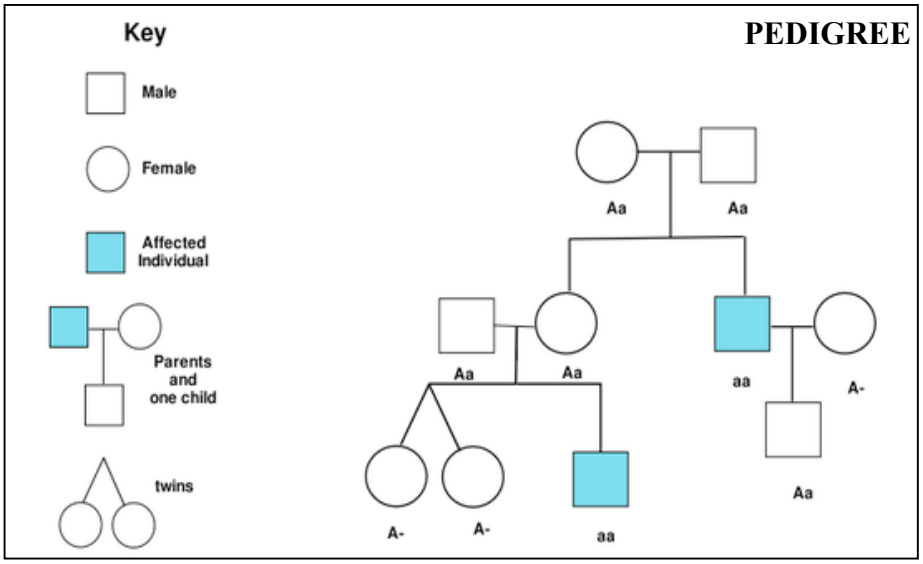
Crossing Over
- genes from one chromosome are exchanged with genes from another chromosome
- occurs regularly during meiosis and leads to greater genetic variation
- many different phenotypes are a result of the random assortment of genes that occurs during sexual reproduction

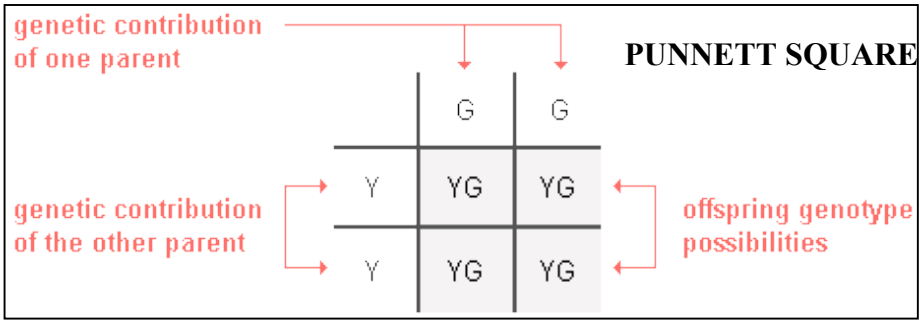
Nondisjunction
- during meiosis, homologous pairs of chromosomes don't separate
- results in half the sex cells having an extra chromosome and the other half having one less chromosome
- if fertilization occurs with an abnormal sex cell, zygote formed will have either one extra (***trisomy***) or one less (***monosomy***) than the diploid number (ex: Down's Syndrome caused by extra 21st chromosome)

Genetic Variation
- influenced by crossing over, mutations, genetic engineering, random assortment of genes, natural selection
- genetic variation controlled by sexual reproduction (does not occur in asexual reproduction)
- gene regulation vs. gene expression – the expression of genes is regulated by turning genes on / off or amount of action
- environment can influence magnitude of gene expression (ex: improper nutrition can prevent proper bone growth)

GENETIC ENGINEERING (GENOMICS):
- sometimes called biotechnology
- process of transferring a gene (DNA) from one organism to another
- Organisms with transferred gene now produce "recombined" genetic code (called "recombinant DNA")
- Ex: insulin produced through bacteria
- Ex: oil-eating bacteria
- Has application in medicine, environment, industry, agriculture, selective breeding
- Human Genome Project
- DNA Fingerprinting

KARYOTYPE: to identify gender or chromosomal abnormalities





SCIENCE, PSEUDOCIENCE & NON SCIENCE
science encompasses all the observable, verifiable knowledge of the human race.
non-science either encompasses subjective knowledge (such as history, phylosophy, economics, which, although it's not science, it isn't junk either)
pseudoscience (junk science) are myths and beliefs that pose as observable and verifiable facts in order to further an agenda (ex. astrology, psychic readings)

PLANT CELL TYPES

Parenchyma Cells
- Least specialized plant cells
- Thin and somewhat flexible cell walls
- Living at maturity
- Carry on most of the plant's metabolic functions
- Generally have a large central vacuole
- Most parenchyma cells have the ability to differentiate into other cell types under special conditions ex. during repair and replacement of organs after injury

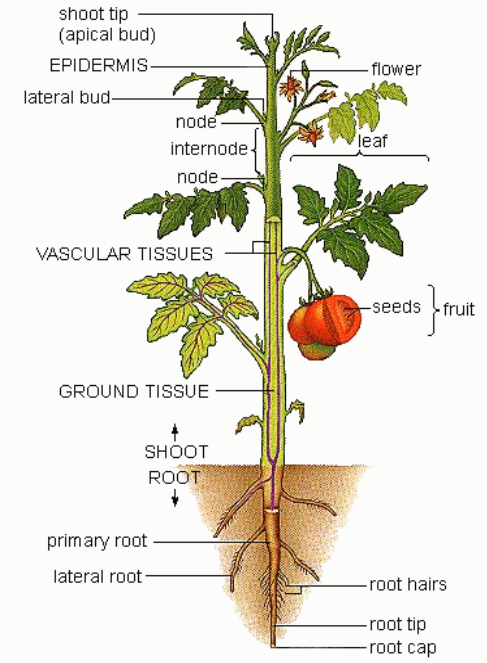
Collenchyma Cells
- Thicker primary cells walls (usually with uneven thickness)
- Living at maturity
- Role in support of herbaceous plants. *Example* - the "strings" of celery

Schlerenchyma Cells
· Thick secondary cell walls
· Dead at functional maturity
· Cannot increase in length - occur in parts of the plant which have quit growing in length

Xylem
· Thick secondary cell walls, often deposited unevenly in a coil-like pattern so that they may stretch
· Dead at functionally maturity.
· Involved in conduct of water and ions in the plant

Phloem
Involved in transport of sucrose, other organic compounds, and some ions
Living at functional maturity
Endwalls connect to each other via sieve-plates
Two types of cells in the phloem - sieve-tube members and companion cells
Sieve-tube members - actual conduit for sucrose transport
Companion cells - has a nucleus that may also control the sieve-tube element and may aid in sucrose loading

ANGIOSPERMS (Flowering Plants)

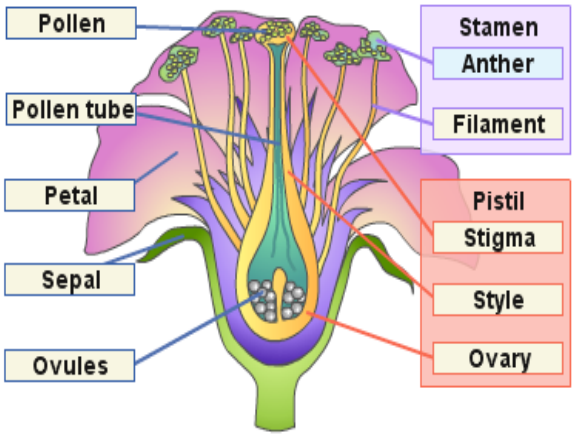


PLANT GROWTH
- The plant retains areas where rapidly dividing, undifferentiated cells remain all through the life of the plant . These areas are called **meristems**
- Meristematic tissue continues to rapidly divide producing undifferentiated cells which may eventually differentiate to form the tissue and cell types discussed above
- Plants do not have a pre-programmed body plan
  There are constants like leaf shape and branching patters (opposite, alternate, etc.) but you can never predict where a new branch will come about on a tree...
  Plants continue to grow throughout their life

Meristems
- pattern of plant growth depends upon the location of meristems

Apical Meristems
- located at the tips of roots and shoots
- supply cells for the plant to increase in length (grow up for shoots and down for roots)
- growth in this direction is known as **primary growth**
  primary growth found in herbaceous and woody plants
  primary growth found in monocots and dicots

Lateral Meristem
- located near the periphery of the plant, usually in a cylinder
- supply cells for the plant to increase in girth
  growth in this direction is known as secondary growth
  found in all woody and some herbaceous plants
  lateral meristems and secondary growth found only in dicots



Anther - structure that contains pollen
Filament - stalk that supports the anther
Stigma - sticky top surface of the pistil
Style - tube part of the pistil between the stigma and the ovary
Ovary - part of the pistil that contains ovules, turns into fruit after fertilization
Ovules -structures in the ovary that contain egg cells, develop into seeds once fertilized
Sepal - small leaves at base that protects the flower before it blooms
Petals - brightly colored part of the flower that attracts insects
Pollen Tube - tube that grows from a pollen grain to an ovule
Pollen - tiny grains that contain sperm cells

TISSUE ORGANIZATION IN ANGIOSPERMS

Dermal Tissue
- Generally a single layer of cells
- The "skin" of the plant
- Primarily parenchyma cells
- Main role is protection of the plant

Ground Tissue
- Makes up the bulk of the plant
- Predominately parenchyma, but collenchyma and schlerenchyma cells are found
- Diverse functions including photosynthesis, storage, and support

Vascular Tissue
- Involved in the transport of water, ions, minerals, and food
- Also has a secondary role in support
- Composed of xylem, phloem, parenchyma, schlerenchyma