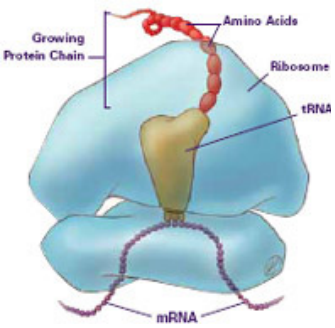
01: Introduction to Molecular Cell Biology

Key Terms

Molecular Biology is the study of the replication, transcription, & translation of genetic material within a cell. Manipulation of these processes is also known as molecular biology or recombinant DNA techniques.
Macromolecules- there are four main classes of macromolecules: lipids, proteins, carbohydrates, and nucleic acids.
Deoxyribonucleic acid (DNA)- double helix chains of paired bases containing thymine, cytosine, guanine, and adenine.
Ribonucleic acid (RNA)- the intermediate between DNA and proteins.
Proteins- chains of amino acids coded for by genes in the DNA.
Carbohydrate: consist of hydrogen, oxygen and carbon. Glucose is the most important carbohydrate in biology.
Proteins: linear polymer the alpha carboxyl group of one amino acid links via a peptide bond to the alpha amino group of another amino acid.
Lipid: amphiphilic having a large organic cation or anion and a long unbranched hydrocarbon chain.

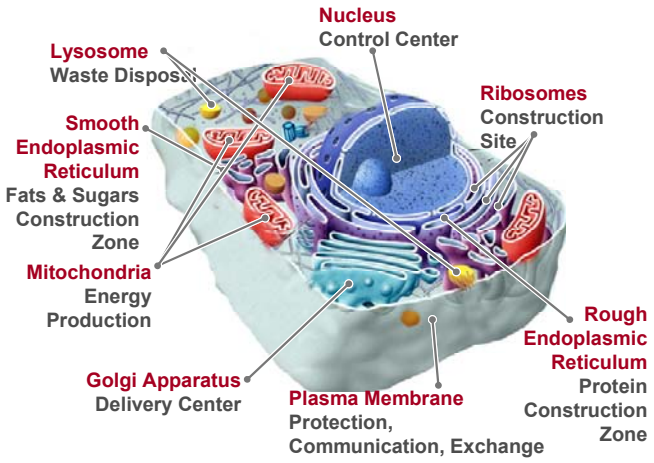
Transcription & Translation

DNA is transcribed into mRNA. mRNA is translated via the ribosome, complexed with rRNA and tRNA, into a protein. A codon consists of three nucleatides that code for an amino acid in a protein.



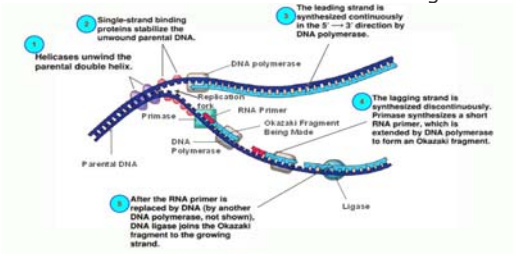
	U	C	G	A
U	UUU Phe UUC Phe UUG Leu UUA Leu	UCU Ser UCC Ser UCG Ser UCA Ser	UGU Cys UGC Cys UGG Trp UGA Stop	UAU Tyr UAC Tyr UAG Stop UAA Stop
C	CUU Leu CUC Leu CUG Leu CUA Leu	CCU Pro CCC Pro CCG Pro CCA Pro	CGU Arg CGC Arg CGG Arg CGA Arg	CAU His CAC His CAG Gln CAA Gln
G	GUU Val GUC Val GUG Val GUA Val	GCU Ala GCC Ala GCG Ala GCA Ala	GGU Gly GGC Gly GGG Gly GGA Gly	GAU Asp GAC Asp GAG Glu GAA Glu
A	AUU Ile AUC Ile AUG Met AUA Ile	ACU Thr ACC Thr ACA Thr ACG Thr	AGU Ser AGC Ser AGG Arg AGA Arg	AAU Asn AAC Asn AAG Lys AAG Lys

Organelles & Functions



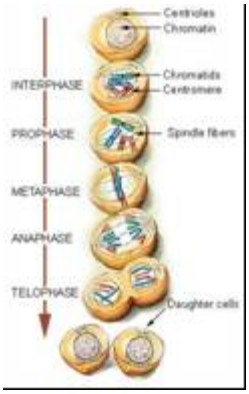
Important DNA Processes

DNA replication- is the process in which a strand of DNA makes an identical copy of itself.
DNA repair- a complex set of enzymes proofread DNA and repair brakes in the double helix.
DNA recombination- is the mixing of genetic material from two chromosomes as a result of crossing over.



Cell Division

Interphase– duplication of genetic material.
Prophase– condensation of chromatin into chromosomes.
Metaphase– binding of chromosomes to mitotic spindle.
Anaphase– separation of chromosomes into opposite sides of the cell.
Telophase– reformation of cell and nuclear membranes.



Cytoskeleton Components

The cytoskeleton gives cells structure and is composed of three types fibers:
Actin– composed of actin polymes, important for cellular locomotion and contraction of muscle cells.
Microtubules– composed of tubulin poymers, important for vesicle motilty and separation of chromosones during cell division.
Intermediate filaments– composed of proteins such as keratin and lamin, important for cell adhesion and signaling.

Membrane Transport

Simple diffusion– passive transport down with rate determined by a molecules permeability, size, and concentration gradient
Facilitated diffusion– carrier protein mediated but does not use energy
Active transport– uses both carrier proteins and metabolic energy, can move molecules against an electrochemical gradient (i.e. uphill)
Cotransport – uses a carrier protein to move two molecules the same direction across a membrane without metabolic energy. One molecule (usually sodium) move "downhill" and the other "uphill"
Countertransport - uses a carrier protein to move two molecules the opposite direction across a membrane without metabolic energy

02: Chemical Basis of Life

Key Terms

Atoms:
- Electrons: both energy and substance particles
- Neutrons
- Protons

Molecules:
- Formed by atoms
- Joined by chemical bonds
- Molecular formula and structure formula

Organic Molecules/macromolecules:
- Amino acids --> proteins
- Monosacchrides --> polysaccharides
- Fatty acids --> lipids
- Nucleotides --> nucleic acids

Isotope: Atoms have same proton numbers but may differ in neutron numbers
Energy shell: Electrons occupy orbital around nucleus, these are called energy shells. The most inner shell (K) contains 2 electron maximum, the L and M shell contain 8 maximum each.
Organic chemicals: Chemicals are made from living organisms and contain carbon backbones.
Isomers: Chemicals that have same molecular formula but different structure formula.
Buffers: Solutions which resist change in pH upon addition of small amounts of acid or base.
Electrolytes: Chemicals that can release ions into solutions
pH: pH represents the concentration of hydrogen ions [H^+] in solution.
pH = -log [H^+]
Enzymes: Proteins that serve as catalysts for biochemical reactions.
Enthropy: A measure for a system's degree of disorder. It increases with increasing disorder.
Law of thermodynamics:
- The first Law: The total energy of the universe is always conserved. Energy can neither be created nor destroyed.
- The second Law: The universe tends towards maximum disorder, or, in other words: the direction of all spontaneous processes is such as to increase the entropy of a system plus its surroundings

ΔG: Change of free energy of a system.
- ΔG negative reaction: spontaneous
- ΔG positive reaction: non-spontaneous

Chemical Bonds

Chemical bonds store energy. For covalent bonds, the more electrons a bond share, the more energy it stores.

Ionic bond: ionic bond forms when atoms lose or gain electrons.
Covalent bond: Covalent bonds form when atoms share electrons, very strong bonds. The major one in organic chemicals.
Hydrogen bond: Weak electrical attraction between the positive end of one molecule and the negative end of another

Organic Chemicals

Classified by the functional groups:
- Alcohols, R-OH
- Aldehydes, R-CHO, R-C=O
  |
  O H
  ||
- Ketones, R-C-R, R-CO-R
  O
  ||
- Carboxylic Acids, R-COOH, R-C-OH
- Amines, R-NH_2, R-N-H
  |
  H
- Organic Phosphates, R-OPO_3^{2-}, R-O-P=O
  O-
  |
  O-
- Thiols, R-SH

Important Biochemical Molecules

Organic Molecules/macromolecules:

- Polysaccharides
  - Monomer unit: monosaccharide
  - Store energy, provide building unit
- Lipids
  - Monomer unit: fatty acids, glycerol
  - Store energy, membrane construction, hormones
- Proteins:
  - Monomer unit: amino acids
  - Structure protein, enzymes
- Nucleic Acids:
  - Monomer unit: nucleotides
  - Genetic material

Chemical Reactions

Coupled reactions: Many biosynthesis reactions are coupled to ATP hydrolysis which can provide energy and therefore the overall reaction can be delta G negative.
- ΔG negative reaction: spontaneous
- ΔG positive reaction: non-spontaneous

Enzyme catalyzed reactions: Lower the activation free energy but do not change the ΔG.

Biochemical Reaction Types and Enzymes

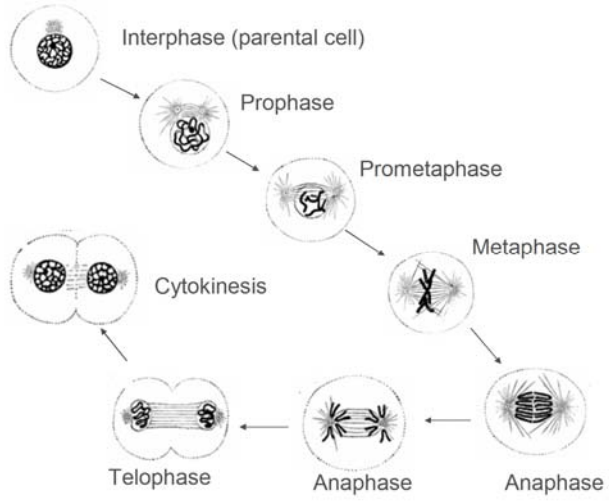
- Oxidation-reduction reactions: oxidoreductase
- Intramolecular or intermolecular functional group-transfer reactions: transfease
- Hydrolysis of esters, ethers, and amides: hydrolase
- Elimination or addition reactions: lyase.
- Isomerization reactions: isomerase
- Formation of ester, thiol ester, and amide linkages: ligase

04: Mitosis and Meiosis

Key Terms

- **C Value**: The total amount of DNA in a haploid cell.
- **Cell cycle:** the series of events between one cell division and the next is termed the cell cycle. It normally contains G1, S, G2 and M (mitosis) phases.
- **Cell skeleton:** Composed of microtubules made of tubulin and actin, plays roles in maintaining cell shape, cell motion, intra-cellular transport and cell division –both mitosis and meiosis.
- **Centrosome:** Made of two centrioles, it is the main microtubule organizing center (MTOC) and a regulator of cell-cycle progression.
- **Cytokinesis**: The division of the cytoplasm in a cell, which usually occurs immediately after nuclear division in mitosis.
- **Diploid Number (2N):** The total number of chromosomes present in a somatic cell containing 1 pair of homologous chromosomes.
- **Kinetochore**: The protein structure assembled on the centromere and links the chromosome to microtubules from the mitotic spindle.
- **Meiosis:** The series of events when a cell divides twice while it's DNA is replicated only once, resulting in4 haploid progeny cells –germ cells.
- **Mitosis:** The series of events when a somatic cell is divided into two identical daughter cells. It normally contains prophase, prometaphase, metaphase, anaphase and telophase.
- **Mitotic spindle:** A dynamic protein structure assembled at early mitosis stage, consisting of a bundle of microtubules joined at the ends but spread out in the middle. The function is to pull chromosomes to two opposite poles.
- **Sister chromatid**: Two identical chromatids after chromosome replication that stay together at the early stage of mitosis but separate later.
- **Synapsis:** a pair of homologous chromosomes lines up closely together
- **Tetrad:** A tetrad is composed of four chromatids, 2 sister chromatids from each of the homologous chromosomes

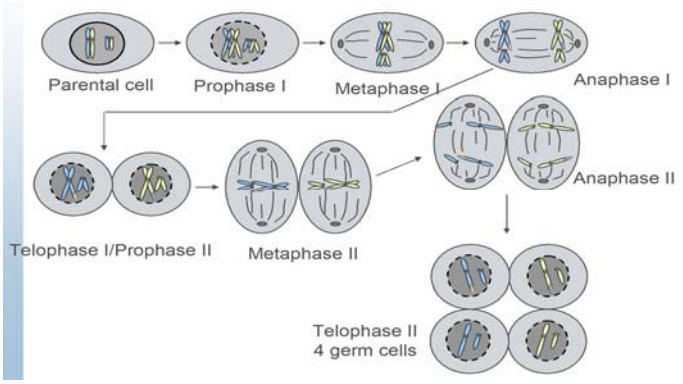
Mitosis



- DNA replicates once and the cell divides once.
- Sister chromosomes separate.
- Resulting daughter cells contain one set of homologous chromosomes each.

Meiosis

- DNA replicates once
- Cell divide twice
- First division results in separation of homologous chromosome.
- Second division results in separation of sister chromosomes.
- Resulting cells contain reduced number of chromosomes (half of the parental cell).



Stages of Mitosis and Meiosis

- **Prophase:**
  - Chromatin condense to form chromosomes
  - Nucleolus disappears
  - Centrosomes are duplicated and begin moving to opposite poles
  - Formation of mitotic spindle
- **Prometaphase (for mitosis only):**
  - The nuclear membrane starts to dissolve
  - Kinetochores formation
  - Microtubules from spindles attach at the kinetochores and the chromosomes begin moving
- **Metaphase:**
  - Chromosomes are aligned on the metaphase plate
- **Anaphase:**
  - The sister chromotids separate at the kinetochores (for mitosis); Homologous chromosome separate (meiosis anaphase I) or sister chromosome separate (meiosis anaphase II)
  - The separated chromosomes move to opposite sides of the cell.
- **Telophase:**
  - New membranes form around the daughter nuclei.
  - The chromosomes disperse and are no longer visible under the light microscope.
  - The spindle dissembles
  - Cytokinesis occurs

The Major Difference

Mitosis:

For somatic cell proliferation

Meiosis:

For germ cell production

07: All about Proteins

Key Terms

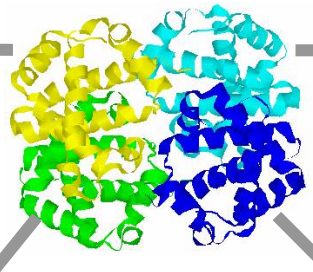
- **Antibody:** A specific protein that interacts with a foreign substance (antigen) in a specific way.
- **Beta-sheet (ß-sheet):** A sheet like structure formed by the interaction between two or more extended polypeptide chains.
- **Cytoskeleton:** The filamentous skeleton, formed in the eukaryotic cytoplasm that is largely responsible for controlling cell shape.
- **Dalton:** A unit of mass equivalent to the mass of a hydrogen atom (1.66 x 10-24 g)
- **Disulfide Bridge:** A covalent linkage formed between two cysteine-SH groups either in the same polypeptide chain or in different polypeptide chains.
- **Enzyme:** A molecule, most often a protein that contains a catalytic site for a biochemical reaction.
- **Globular protein:** A folded protein that adopts an approximately globular shape. May also be called soluble proteins.
- **Glycoprotein**: A protein linked to an oligosaccharide or a polysaccharide. Glycosaminoglycans. Long, unbranched polysaccharide chains composed of repeating disaccharide subunits in which one of the two sugars is either N-acetylglucosamine or N-acetylgalactosamine.
- **Nuclear Magnetic Resonance:** NMR is a phenomenon which occurs when the nuclei of certain atoms are immersed in a static magnetic field and exposed to a second oscillating magnetic field. Some nuclei experience this phenomenon, and others do not, dependent upon whether they possess a property called spin.
- **Polypeptide:** A linear polymer of amino acids held together by peptide bonds.
- **Inducible proteins:** Those which are synthesized in different amounts depending on cellular signals.
- **Isoelectric point or pH**: The pH at which a protein has no net charge.
- **Membrane Protein:** A protein associated with a membrane, rather than found free in the cell. A membrane protein may be integral (embedded or buried) in the membrane, or peripheral (attached more loosely to the membrane.
- **Myosin:** The main protein of the thick filaments in a muscle myofibril. It is composed of two coiled subunits (Mr about 220,000) that can aggregate to form a thick filament, which is globular at each end.
- **Structural Protein:** A protein that serves a structural function.
- **Transport Protein:** A protein whose primary function is to transport a substance from one part of the cell to another, from one cell to another, or from one tissue to another.
- **Unwinding Proteins:** Proteins that help to unwind double-stranded DNA during DNA replication.
- **X-ray crystallography:** is an experimental technique that exploits the fact that X-rays are diffracted by crystals.
- **Zymogen:** An inactive precursor of an enzyme. For example, trypsin exists in the inactive form trypsinogen before it is converted to its active form, trypsin.

Amino Acids – Building Blocks

- **pKa:** is defined as negative logarithm of Ka (the dissociation constant for a acid). Since there are two groups viz. amino and carboxyl. In an amino acid both of them will dissociate at a particular pH. Therefore we get two pKa values (pK1 and pK2).
- **pI:** is the isoelectric point where the net charge on the amino acid is zero and is the average of pK1 and pK2.

The box below explains about the proteins with hemoglobin as example

3D structure of Hemoglobin



- The picture shows the 4 monomeric subunits of Hemoglobin; they are colored differently for clarity.
- The individual subunits are polypeptide chains.
- This picture represents the quaternary structure of the protein.
- There are two alpha and two beta subunits.
- The 3D structure is important for its function.

The main function of Hemoglobin is to transport oxygen to the tissues in the body and to remove the carbon dioxide from them.
The binding of hemoglobin to oxygen is very much related to its native structure.
If there be any change in its structure (e.g. A mutation as in SCA, it results in defective binding of oxygen resulting in severe anemia.

- The 3D structure of the protein is dependent on the amino acids in the sequence.
- The nature of the side chain of the amino acid and its dissociation under a particular pH is also important for the 3D structure.
- If there be any change in its structure (e.g. a mutation as in SCA it results in defective binding of oxygen resulting in severe anemia.
- Four molecules of oxygen bind to hemoglobin.
- The binding of first oxygen enhances the binding of successive molecules – a property called positive cooperativity.

- The angles between various atoms in a peptide bond are important.
- Because those angles and their freedom of rotation only determines the type of secondary structure.
- A typical example is collagen; a triple helical protein is with a predominantly alpha helical structure.
- Its function is fully dependent on its triple helical structure.
- Ramachandran's plot explains about the type of secondary structure formed with given set of psi and phi angles.

How to Use This Cheat Sheet: These are the keys related to this topic. Try to read through it carefully twice then recite it out on a blank sheet of paper. Review it again before the exams.

10: Viruses

Key Terms

Capsid: Protein shell enclosing the nucleic acid.
Nucleocapsid: Composed of the nucleic acid and its surrounding proteins, forming the core of the virus.
Envelope: Glycoproteins embedded in bi-layer lipids surrounding the nucleocapsid (not all viruses have this layer).
Virion: A complete infectious viral particle.
Viroid: An infectious particle made of naked RNA molecules, no protein.
Prion: An infectious particle made of protein molecules, no nucleic acids; can be inherited.
Lytic Cycle: A virus infection cycle that results in virus multiplication and lysis of the host cell.
Lysogenic cycle: Bacteriophage DNA can be integrated into a host genome and replicated with host DNA; no cell lysis occurs.
Latent infection: Virus DNA is incorporated into host cell (usually higher organisms) and replicates with the host DNA. Infection results with no symptoms for a period of time.
Transformation: The modification of the genotype of a cell by introduction of DNA from another source.
Transduction: Transformation mediated by latent infection –the viral DNA becomes part of the host genome.
Cell transformation: The process during which a normal cell becomes cancerous.

Viral Structure and Classification

Two basic structures:
Rod (helical) shape
Isomeric shape

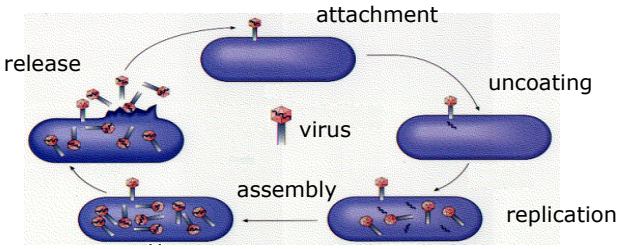
Classification based on the genome:
DNA virus
dsDNA
ssDNA
RNA virus
dsRNA
ssRNA(+)
ssRNA(-)
retrovirus

Virus Multiplication

Based on the genome, virus multiplication requires:

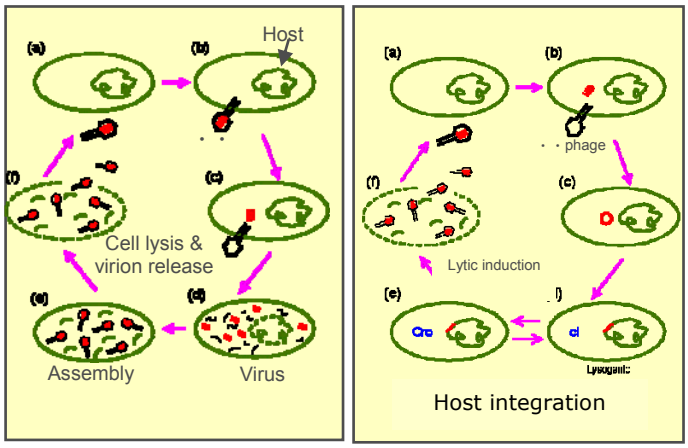
1. replication of viral genome & synthesis of viral structure proteins.

2. utilizes host cell transcriptional and translational machinery.



Virus Genetics & Pathogenesis

Lytic cycle Vs Latent cycle

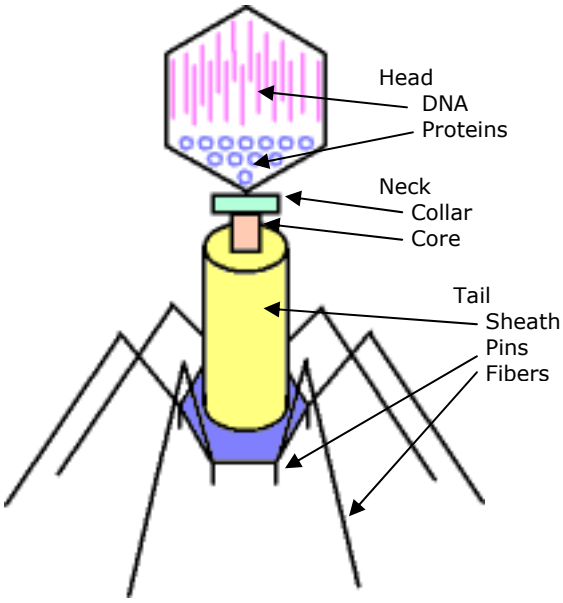


- **Viral genetics:**
  - High mutation rate for RNA virus due to absence of proof-reading mechanism in genome replication.
  - Viral gene recombination due to simultaneous infection of different viruses.

- **Viral pathogenesis:**
  - Implantation of virus at the portal of entry
  - Local replication
  - Spread to target organs (disease sites)
  - Spread to sites or shedding virus into environment

- **Three factors:**
  - Accessibility of virus to tissue
  - Cell susceptibility to virus multiplication
  - Virus susceptibility to host defenses
  - Cellular pathogenesis
  - Direct cell damage or cell death
  - Indirect cell damage such as inflammation

Bacteriophage



12: Nucleic Acids

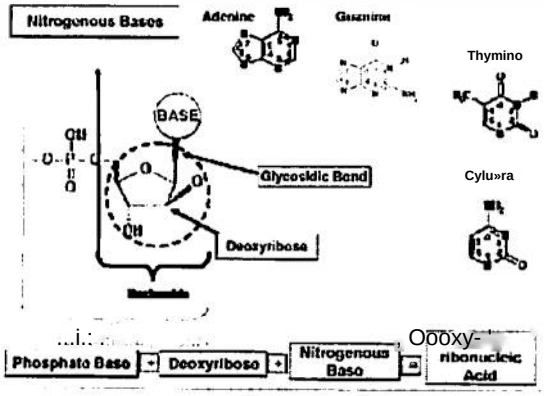
Key Terms

- **Amino acids:** basic building units of proteins.
- **Complementary Base Pairing:** Natural pairing of nucleic acids. Adenine:Thymine, Guanine:Cytosine in ONA. Uracil replaces Thymine in RNA.
- **DNA bases:** Adnenine, Thymine, Guanine, Cytosine.
- **RNA bases:** Adenine, Uracil, Guanine, Cytosine.
- **DNA replication: The** process of copying **a** cell's DNA In order to pass it on to a daughter cell.
- **DNA:** Deoxyribonucleic acid, the genetic material of cells.
- **Double Helix:** The double winding strand shape of DNA.
- **Exons:** A portion of DNA which codes for protein.
- Introns: A portion of DNA which does not code for a product.
- **mRNA:** Messenger RNA which carries DNA code.
- **ncRNA:** non-coding RNA.
- **Promoter:** The DNA region where RNA polymerase binds.
- **Proteins:** a key organic macromolecule, which function as enxymes, tran porters and hormones.
- **RNA polymerase:** An enzyme molecule which makes RNA by copying DNA.
- **rRNA:** Ribosomal RNA is part of ribosomes.
- **Start Codon:** Signal transcription start site.
- **Stop Codon:** A codon that signals transcription stop.
- **The Central Dogma:** States that DNA-»makes RNA->makes protein, Transcrption through translation.
- **Translation:** The process of producing protein from the RNA message.
- **tRNA:** Transfer RNA brings amino acids to the ribosome during translation.

DNA Structure

- Is the cellular genetic material.
- Made up from deoxyribose-phosphate and 4 bases.
- Contains two strands based on base pairing between A and T, C and G.
- The two strands are anti-parallel and form double helix structure
- Highly organized in cells (final form: chromosome)
- One gene is defined as one functional section of DNA

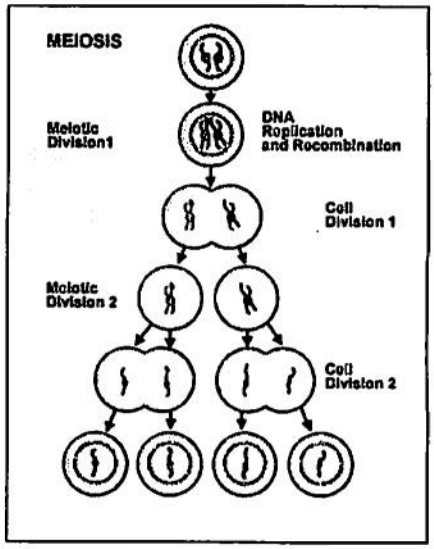
DNA:structure



Translation

- Ribosome binds to mRNA.
- Ribosome reads mRNA one codon at a time, beginning with the start codon AUG.
- For every codon, a tRNA brings the proper amino acid.
- Ribosome holds onto the amino acid chain as it grows.
- When the stop codon is encountered, the mRNA and ribosome disassemble.

Meiosis

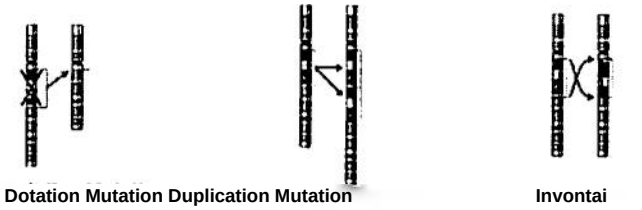


Transcription & Translation

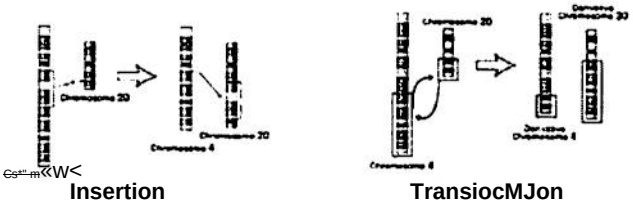
- DNA helicase unwinds the DNA double helix.
- DNA polymerase binds to the promoter on both strands, usually TATA.
- DNA polymerase copies new DNA using both of the original strands.
- DNA polymerase copies from the 3' o S' direction on both the leading and lagging strand.
- On the leading strand DNA polymerase moves continuously to copy.
- On the lagging strand, DNA polymerase copies many backward strips called Okazaki fragments.

Mutations

Mutations: changes in DNA sequence, i.e., insertion/deletion.



Dotation Mutation Duplication Mutation Invontai



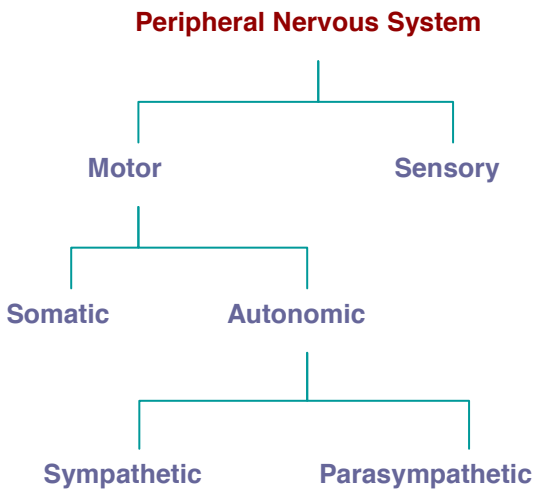
Insertion TransiocMJon

13: The Peripheral Nervous System

Key Terms

Nervous System: The system of cells, tissues, and organs that regulates the body's responses to internal and external stimuli.
Impulse: The electrochemical signal transmitted down a neuron.
Neuron: The basic functional unit of the nervous system, consisting of a cell body, and it's processes: the dendrites, axon, and terminal branches.
Neurotransmitter: Biological molecules released from the terminal branches in response to a propagating action potential.
Axon: The major process that conducts impulses from the dendrites to the terminal branches.
Myelin Sheath: The fatty membranes that cover the axon, allowing for faster electrical conduction.
Nodes of Ranvier: Gaps in the myelin sheath. The electrical impulses jump from one node to the next on an axon.
Electrical Potential: A separation of charge, which gives the ability to send electricity.
Ions: Charged atoms, which give the neuron its potential.
Resting Potential: The potential of an inactive neuron.
Action Potential: The propagated impulse of an excited neuron.
Threshold Potential: The potential at which an action potential can be initiated.
Afferent Neuron: Brings sensory information to the CNS.
Efferent Neuron: Brings motor information from the CNS.
Dorsal Root: contains sensory neurons.
Dorsal Root Ganglia: Bundle of sensory neuron cell bodies outside the spinal cord.
Ventral Root: contains motor neurons.
Mixed Nerves: Nerves that contain both sensory and motor neurons.
Reflex Arc: A simple neural circuit that includes an afferent sensory neuron, an interneuron, and an efferent motor neuron that does not rely on any input from the brain.
Somatic Nervous System: Voluntary motor system
Autonomic System: Involuntary nervous system
Parasympathetic Nervous System: The part of the Autonomic system that inhibits function
Sympathetic Nervous System: The part of the Autonomic system that inhibits function
Sympathetic Ganglion: sympathetic synapses between spinal neurons and efferent neurons

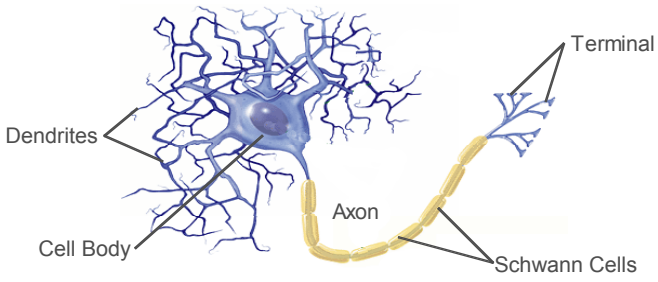
Peripheral Nervous System Organization



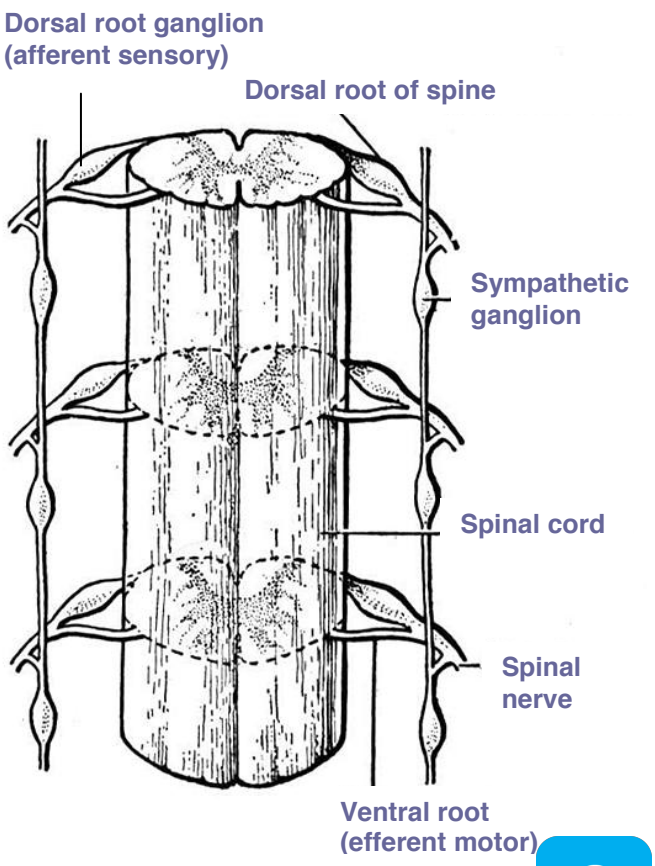
Cell Types

Neurons:
Anaxonic – small neurons with no identifiable axon (interneurons)
Bipolar – small neurons with two processes, one axon and one dendritic (specialized sensory neurons)
Unipolar – large myelinated neurons with a single dendro-axonic process with the cell body off to the side (afferent sensory)
Multipolar – large myelinated neurons with many dentritic processes and an axonal process that can branch (efferent motor neuron)
Glial Cells:
Schwann Cells: scavenging, structural support and source of PNS myelination
Satellite Cells: cells that surround the cell bodies in the dorsal root ganglia

Neurons and Glial Cells



Spinal Nerve Anatomy



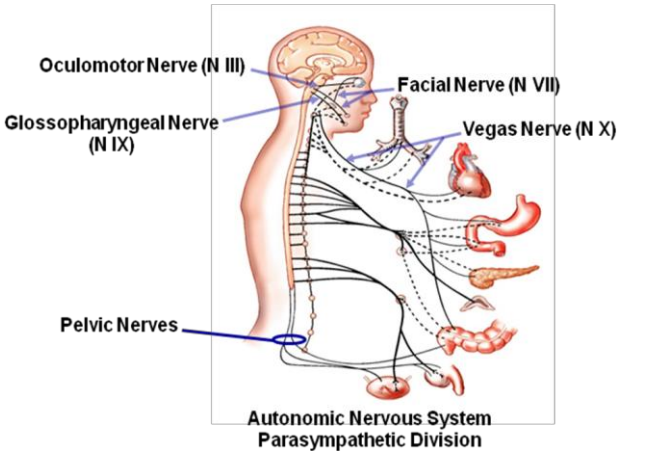
Human Anatomy and Physiology - Core Concept Cheat Sheet

15: The Autonomic Nervous System

Key Terms

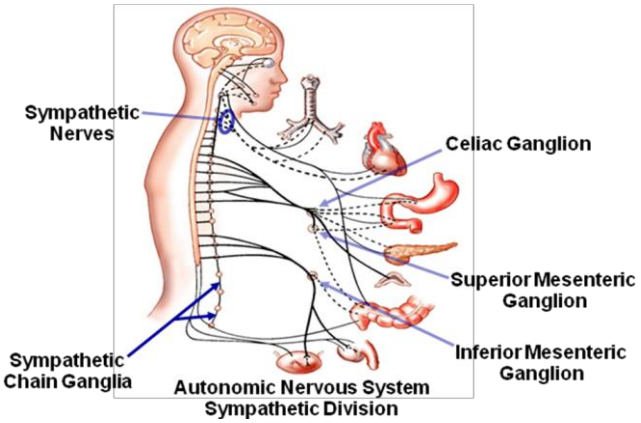
- **Autonomic Nervous System**: The autonomic nervous system is made up of afferent and efferent neurons that connect the autonomic nervous system to visceral effector organs.
- **Parasympathetic Division:** The parasympathetic division of the autonomic nervous system is active during periods of rest and digestion. The parasympathetic division innervation involves the cranial nerves, such as the facial nerve.
- **Sympathetic Division:** The sympathetic division of the autonomic nervous system is active during times of physical or mental stress on the body. As the system`s activity increases, skeletal muscles and heart rate are prepared for a fight-or-flight response.
- **Sensory Information:** The autonomic nervous system generates a response, based on the information received from the sensory branch.
- **Vagus Nerve:** The vagus nerve synapses with the intramural ganglion. There are many targets, including: the visceral organs of the neck, thoracic cavity and most of the abdominal cavity. This leads to stimulation of secretion and an increase in motility in the stomach and intestine.
- **Nicotinic and Muscarinic Receptors:** The nicotinic receptor subtype is located on all the ganglionic neurons. Muscarinic receptors are located at cholinergic neuroeffector junctions (small narrow synaptic clefts).
- **Alpha and Beta Receptors:** Alpha receptors are located primarily on the surface of smooth muscle cells in blood vessels. Beta receptors are located in the heart, liver and skeletal muscles.
- **Autonomic Plexuses**: Within the abdominopelvic cavities, both the parasympathetic and sympathetic fibers mix in special plexuses.
- **Autonomic Control:** The control of the autonomic nervous system can be divided as follows: (1) sympathetic division is controlled from the posterior and lateral hypothalamus, and (2) the parasympathetic division is controlled from portions of the anterior and medial hypothalamus.

Parasympathetic Division

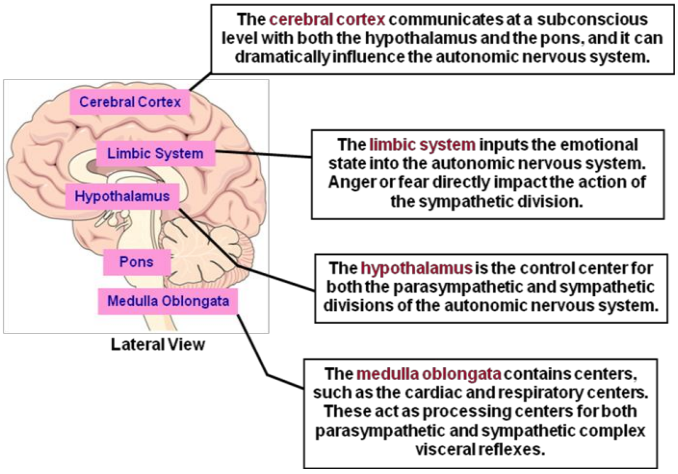


The parasympathetic division of the autonomic nervous system is active during periods of rest and digestion. The parasympathetic division innervation involves the cranial nerves, such as the facial nerve.

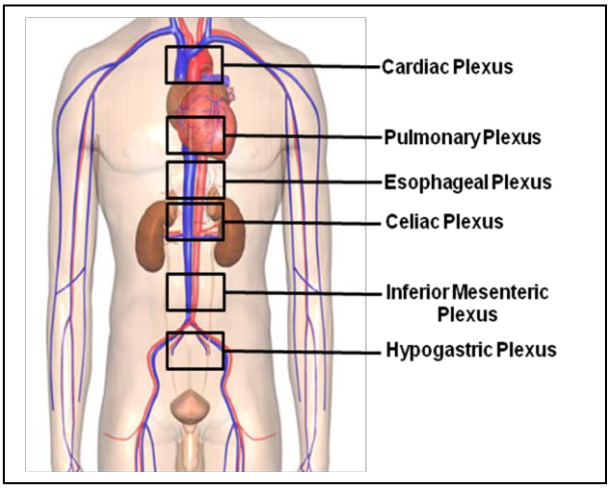
Sympathetic Division



Levels of Autonomic Control



Autonomic Plexuses



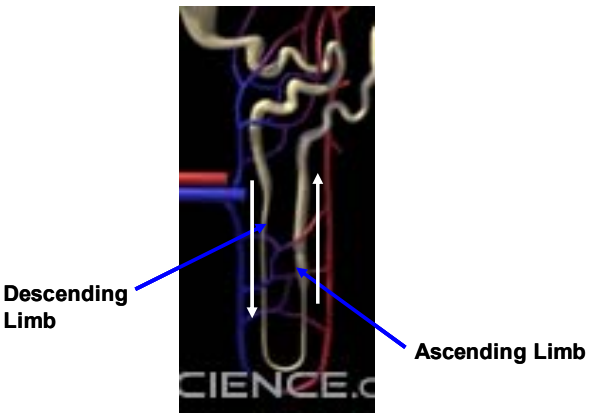
Within the abdominopelvic cavities, both the parasympathetic and sympathetic fibers mix in special plexuses: cardiac, pulmonary, esophagus, celiac, inferior mesenteric and the hypogastric plexus.

17: Kidney and Nephronal Physiology

Key Terms

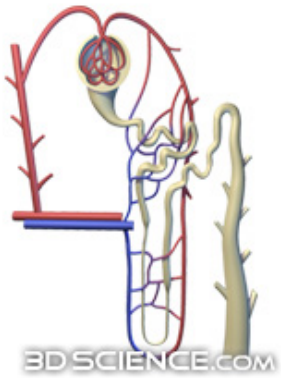
- **Ureter:** are hollow, muscular tubes. The filtrate fluid drains from the kidneys to the bladder.
- **Bladder:** functions by collecting and storing urine until it is eliminated from the body.
- **Urethra:** is a hollow tube leading from the bladder to the body surface, for the external elimination of urine.
- **Nephron:** There are over 1 million in each kidney. All the nephrons drain towards the center of the kidney into the collecting duct system. The nephron perfoms almost all of the kidneys functions, including reabsorption and secretion of certain solutes and ions.
- **Minor calyx:** receives drainage from nephron.
- **Renal pelvis:** gathers fluid from major calyx before draining into ureters.
- **Vasa recta:** blood vessels around Loop of Henle, These vessels function to maintain the gradients necessary for countercurrent exchange.
- **Loop of Henle:** The Loop of Henle can be divided into 2 functional regions: Descending Limb and the Ascending Limb. In the Descending Limb, fluid travels down the descending limb towards the medulla. In the Ascending Limb, fluid travels towards the cortex. In this region of the nephron, Na+ and Cl- are actively transported out of the limb. This leads to dilute or hypo-osmotic fluid entering the collecting tubule.
- **Countercurrent mechanism:** establishes osmolarity gradient from cortex (300 mOsm) to medulla (1200 mOsm); enables urine to be concentrated.
- **Tubular Maximum:** maximal level of a substance to be transported by the nephrons.
- **Micturition Reflex:** emptying of the bladder, involves spinal cord reflex, as well as conscious control.
- **Diabetes:** In uncontrolled diabetes, higher than normal blood glucose levels occur. This leads to greater than normal glucose being filtered in the glomerulus. Therefore, glucose levels in the nephron exceed tubular maximum and this causes glucose to be excreted in the urine. The excreted glucose can be easily detected on urine test strips.
- **Glomerulus:** specialized capillary; filters blood into nephron; pore size determines what passes into nephron.
- **Bowman's Capsule:** membrane surrounding glomerulus; captures all filtrate, which then drains into the proximal tubule

Loop of Henle



- **Filtration:** movement of substances through the glomerular pores into the nephron

Nephron Anatomy and Function



- **Proximal tubule:** primary reabsorption area; has microvilli and protein transporters; 100% of glucose; 60-70% of water and sodium; calcium, magnesium, potassium.
- **Descending limb:** water is reabsorbed; fluid in nephron becomes hyperosmotic.
- **Ascending limb:** sodium and chloride transported from nephron; water can not follow; fluid in the nephron become dilute – can excrete dilute urine.
- **Distal tubule and Collecting ducts:** impermeable to water unless hormones are present.

Hormones and Urine Concentration

- **Anti-diuretic hormone:** inserts water channels in collecting duct; increases water reabsorption and decreases urine volume.
- **Aldosterone:** increases sodium and water reabsorption which increases blood volume and blood pressure.
- **Atrial natriuretic hormone:** released form atria of heart in response to high blood pressure; increases urine output to reduce blood volume and pressure.

Kidney Function Tests and Dialysis

- **Plasma Clearance:** assesses how quickly the kidneys are able to remove or clear a substance from the plasma.
- **Blood Urea Nitrogen (BUN):** measures urea levels in the blood which indicates how well the kidneys are ridding the body of waste products such as urea.
- **Glomerular Filtration Rate (GFR):** an assessment of quickly the blood is being filtered.
- **Urinalysis:** A urinalysis is a common test used in the doctor's office as part of yearly physicals or if a problem is suspected. A urinalysis tests for electrolyte levels and for the presence of proteins, glucose, blood cells, bacteria and immune cells. This test, along with others, can be used to asses overall kidney function.
- **Dialysis:** Dialysis is an artificial means of filtering the blood. Blood flows through specialized membranes, similar in principle to glomerulur filtration. Waste products are filtered out and then the blood is returned into the patient's circulation.
- **Diabetes and Kidney:** increased glucose levels can result in glucose appearing in the urine.
- **Kidney Transplant:** only one kidney needed to maintain life; kidneys can be donated and transplanted; approximately 10,000 kidney transplants per year in U.S.

Biology, 1 of 6

01: The Science of Biology

- **Characeristics of life**

Organization: all lives are well organized
Energy use: all lives need energy to support
Reproduction: all lives should be able to reproduce itself
Growth: all lives grow and develop.
Response to stimuli: all lives can respond to internal or external stimuli
Homeostasis: all lives have the ability to maintain a relatively stable internal environment—self-regulation

- **Basic Theory of modern biology**

Cell Theory
- Cell is the building unit of all living organisms.
- All cells come from pre-existing cells
- All metaboism occur in cells of the body—cells are functional unit for all lives

Gene Theory
- All genetic information is stored in DNA – genes
- Genes control most, if not every, aspects of an organism
- The DNA language can be transcribed into RNA language and then translated into protein language for its final function

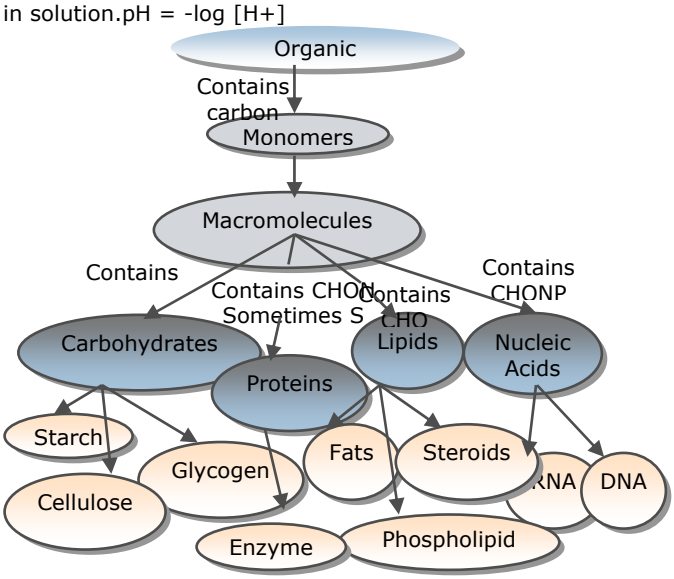
Homeostasis
- All living organisms have the ability to maintain a relatively constant internal environment
- Purpose: to ensure proper function of the body

02: Chemical Basis of Life

Atoms:
- electrons: both energy and substance particles
- neutrons
- protons

Molecules:
- Formed by atoms
- Joined by chemical bonds
- molecular formula and structure formula

Chemical Bond:
Ion bond: ion bond forms when atoms lose or gain electrons.
Covalent bond: Covalent bonds form when atoms share electrons, very strong bonds. The major one in organic chemicals.
Hydrogen bond: Weak electrical attraction between the positive end of one molecule and the negative end of another
Buffers: solutions which resist change in pH upon addition of small amounts of acid or base.
pH: pH represents the concentration of hydrogen ions [H+] in solution.pH = -log [H+]



03: The Cell

Cell organelles and their functions:
- **Nucleus:** the control center
  - Holds all of cell's genetic information
  - Makes decisions about cell needs
- **Ribosome:** the factory
  - Synthesizes proteins
- **Rough Endoplasmic Reticulum**
  - Edits and finalizes proteins made by ribosomes.
- **Smooth Endoplasmic Reticulum**
  - Synthesizes carbohydrates and lipids.
- **Golgi Apparatus:** the post office
  - Tags and ships packages to their destinations
- **Mitochondria:** the power house
  - Produces ATP for the cell's activities.
- **Lysosome:** the recycling center.
  - Recycles waste and foreign bacteria.

The cell membrane: lipid bilayer which envelops the cell. For Protection, Communication, and Selective Exchange

Passive Transport
- Does not use energy
- Osmosis, diffusion, facilitated diffusion
- Natural movement from high concentration to low concentration.

Active Transport
- Uses energy
- Movement from against natural diffusion

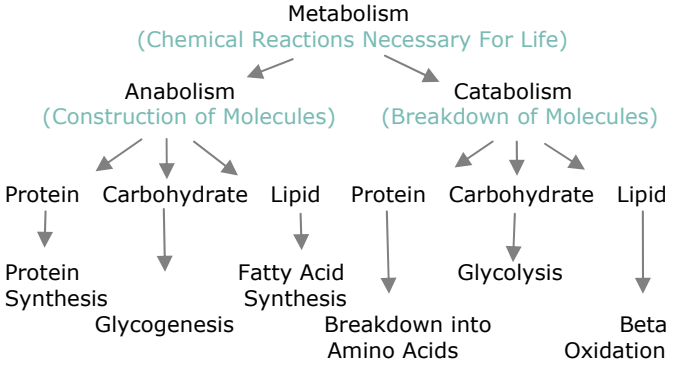
Prokaryotes
- Examples: bacteria, microscopic organisms
- Structure: DNA, ribosomes, and cell membranes.
- Except for ribosomes, prokaryotes DO NOT have organelles.

Eukaryotes
- Animals: with organelles and cell membranes
  - Plants: with organelles and cell membranes like animal cells, but also have chloroplasts and cell walls.

04: Cellular Respiration

Aerobic Resoiration
- **Glycolysis**
  - Glucose is broken down into pyruvate.
  - 2 ATP produced.
- **Krebs Cycle**
  - Acetyl CoA (made from pyruvate) runs a cycle of reactions, regenerating at the end of each cycle.
  - All of the electrons are passed to NADH and $FADH_2$ (electron carriers).
  - 2 ATP produced.
- **Oxidative Phosphorylation**
  - 32 ATP produced.

Anaerobic Resoiration
- **Glycolysis**: Glucose is broken down into pyruvate; 2 ATP produced.
- **Fermentation**: Pyruvate is broken down into ethanol or lactic acid. Glycolysis intermediates produced to allow glycolysis to begin again immediately.



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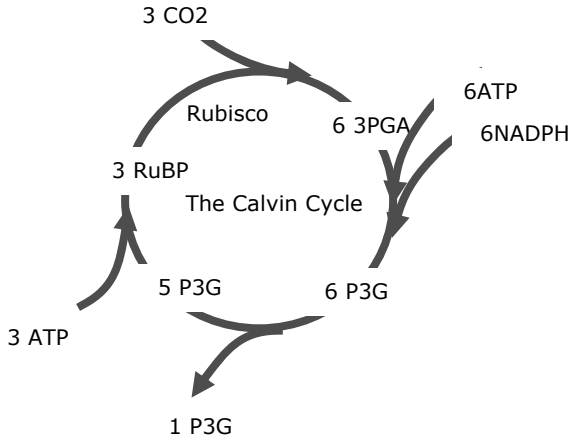
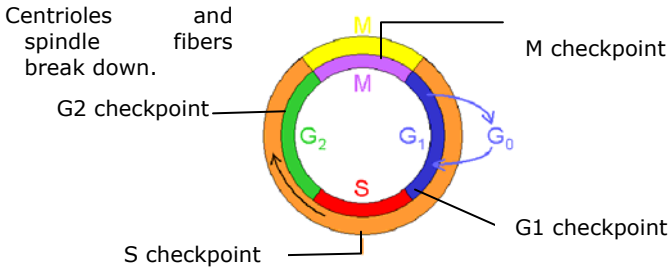
05: Photosynthesis

- **Chloroplast:** An organelle in plant cells where photosynthesis occur.
- **Photophosphorylation:** a process that ATP is generated via light reactions in photosynthesis.
- **Light Reaction:** The first phase of photosysnthesis which light is harvested and the electron transfer occurs, ATP, NADPH and oxygen is generated.
- **Dark Reaction:** The second phase of photosynthesis where crbon dioxide is fixed and carbohydrates are generated by consuming ATP and NADPH.
- **Chloroplasts:** These are organelles which allow the organism to perform photosynthesis, obtaining energy from sunlight.
- **Chlorophyll:** Proteins found in chloroplasts which have the ability to absorb sunlight for photosynthesis.

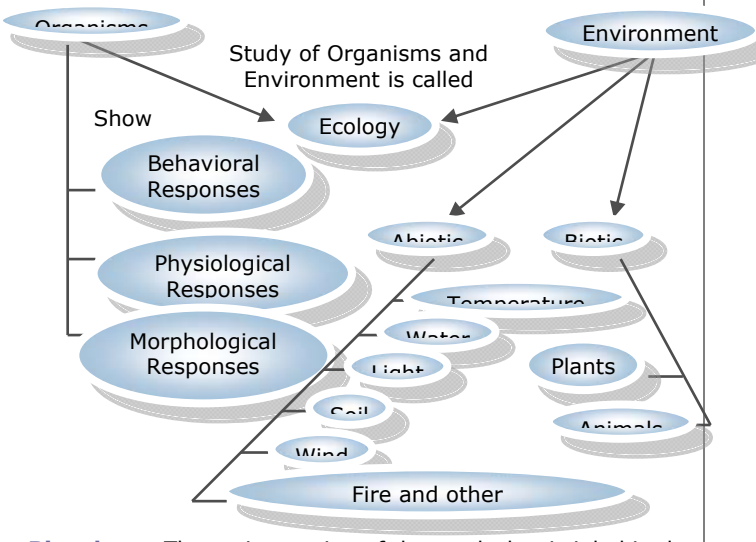


06: The Cell Cycle



- **Prophase**
  - Chromosomes condense and become visible.
  - Nuclear envelope breaks down.
  - Centrioles take positions on opposite sides of nucleus.
- **Metaphase:**
  - Chromosomes line up single-file in the middle of the cell.
  - Spindle fibers from the centrioles attach to each side of the centromeres of the chromosomes.
- **Anaphase:**
  - Sister chromatids are pulled apart to become individual chromosomes.
  - Chromosomes move until they reach centrioles on opposite sides of cell.
- **Telophase:**
  - Chromosomes dissolve.
  - Nuclear envelopes re-form around both sets of chromosomes.

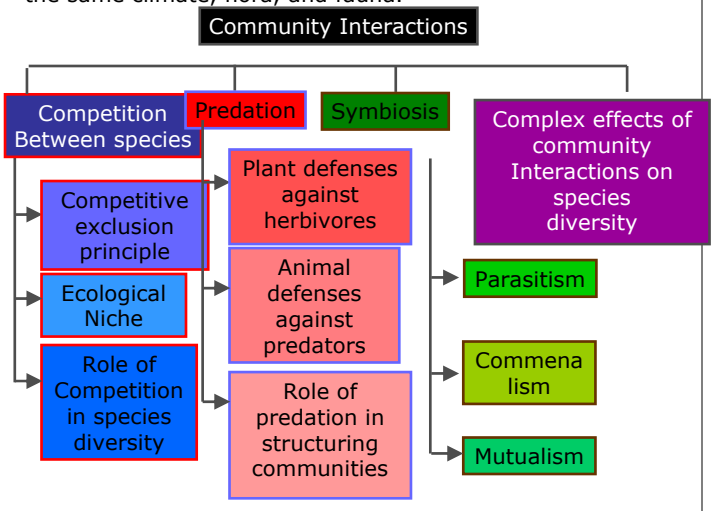
07: Introduction to Ecology



- **Biosphere:** The entire portion of the earth that is inhabited by life. The sum of all the planet's ecosystems.
- **Biomes:** The world's major communities classified according to the predominant vegetation and characterized by adaptations of organisms to that particular environment.
- **Community:** A group of populatins living in the same area.
- **Population:** A group of individuals in a particular geographic area that belong the same species.
- **Producers:** They are primarily green plants that bring energy into the system by capturing sunlight.
- **Consumers:** An organism in an eco system that lives by eating other organisms.
- **Food Web:** A complex interaction of feeding relationships.
- **Chemical Cycling:** Nature's way of allowing life on Earth access to limited resources by continually transferring the energy from one form to the next.

08: Communities, Ecosystems, and Biomes

- **Primary Succession:** An event in which life begins to exist where no life existed previously.
- **Secondary Succession:** The change in composition of the species which live in an area.
- **Aquatic Ecosystems:** Most of life on Earth lives in the oceans, a poorly understand system of oceans, lakes, streams, rivers, and estuaries.
- **Terrestrial Biomes:** The group of ecosystems which share the same climate, flora, and fauna.



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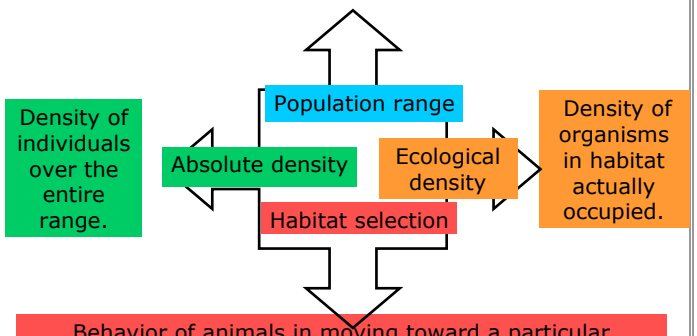
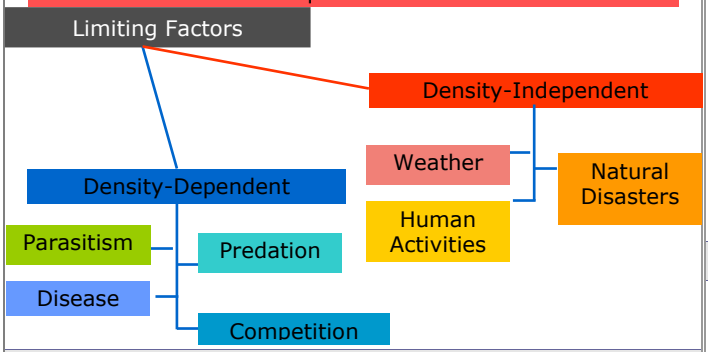
09: Population Ecology

- **Population:** It is a group of individuals of a given species inhabiting a specific geographic area and exhibiting a characteristic density and dispersion.
- **Population Density:** Individuals per unit area or volume.
- **Dispersion:** The pattern of spacing for individuals within the boundaries of the population.

Geographic limits within which a population lives.

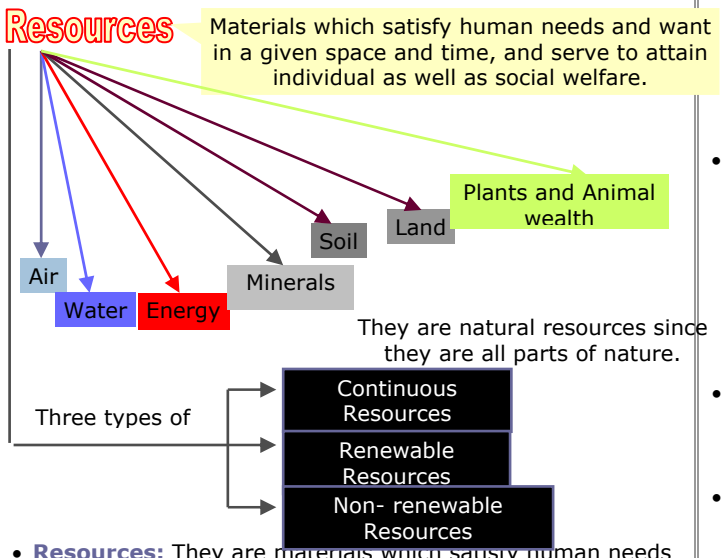


Behavior of animals in moving toward a particular microenvironment within the range that satisfies their requirements.



10: Conservation Ecology

- **Reforestation:** It is the development of a forest in a deforested area to ensure a sustained yield.
- **Conservation:** It is the safeguarding, maintaining or protecting and wise management of natural resources.



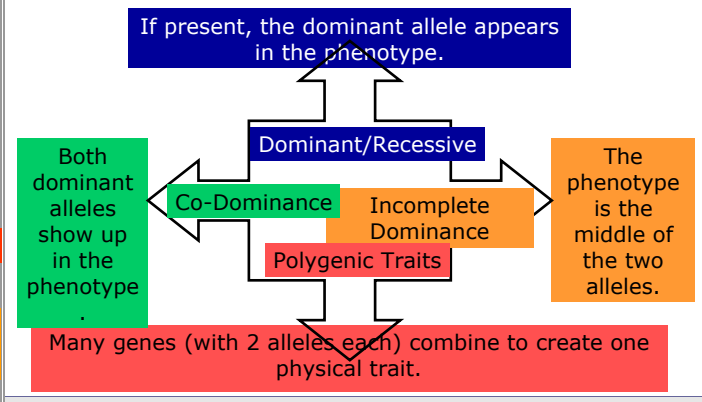
- **Resources:** They are materials which satisfy human needs and wants in a given space and time and serve to attain individuals as well as social welfare.
- **Non Renewable resources:** There is no known process by which they can be renewed quickly. They are available in fixed quantities and too much exploitation would mean their end. Ex: Minerals, ground water.

11: Genetics

- **Chromosome:** where the cell nucleus pack its long stretch of DNA molecule into, it is the functional unit for heredity
- **Meiosis:** A reproductive process which produces two unique haploid cells from one cell. These unique haploid cells are gametes, sex cells for reproduction.
- **Haploid:** Descibing a cell which has one entire set of the oganism's chromosomes.
- **Diploid:** Describing a cell which has two entire sets of the organism's chromosomes.
- **Cross:** The parents which reproduce together.

Aa x aa

	A	a
a	Aa	aa
a	Aa	aa



12: Nucleic Acids

- **DNA**
  - Is the cellular genetic material
  - Contains two strands based on base pairing between A and T, C and G.
  - The two strands are anti-parallel and form double helix structure

- **RNA Classes**:
  - mRNA: Copies information from DNA through base-paring mechanism
  - tRNA: carries amino acids to protein synthesis sites
  - rRNA: component for ribosome
  - ncRNA: regulate cellular processes

- **The Central Dogma**

- **Transcription:** RNA polymerase reads DNA and produces pre-mRNA. The pre-mRNA is edited via splicing of exons together to form the mature mRNA which leaves the nucleus to enter the cytoplasm.
- **Translation:** Ribosomes read the mRNA script and tRNA's bring amino acids in order to produce the final gene product, proteins.
- **Causes of Mutation**
  - Errors during DNA replication
  - DNA damage
  - Chromosome errorss

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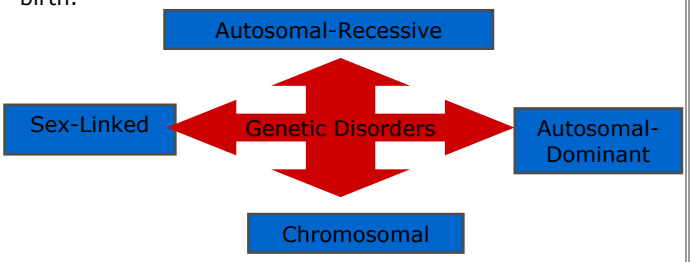
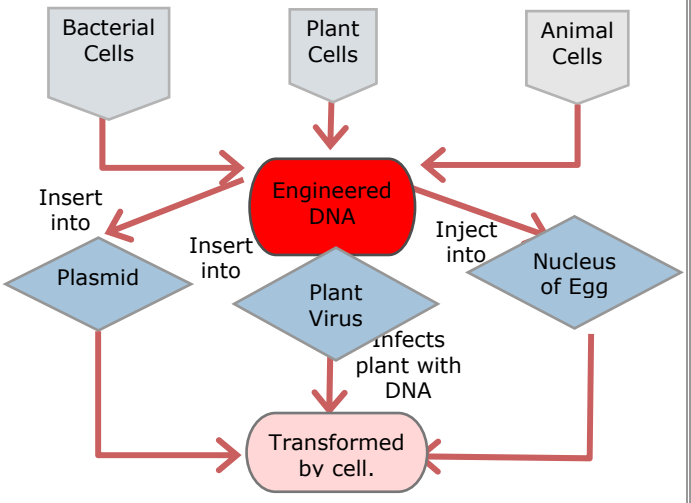
13: The Human Genome

- **Autosomal Chromosomes**: Chromosomes that code for the regular human traits.
- **Sex Chromosomes**: Chromosomes that determine sex.
- **Genetic Disorder**: A disease or sickness caused by DNA at birth.

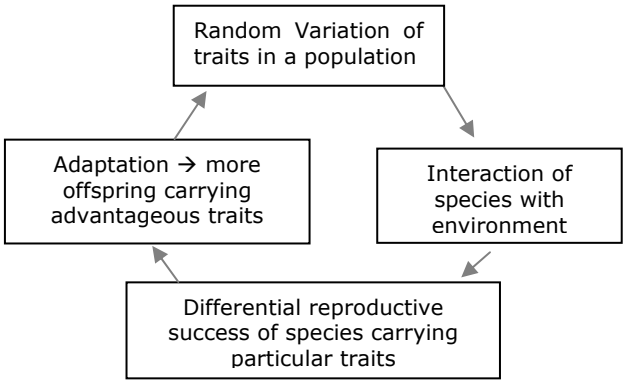


Genetic Engineering



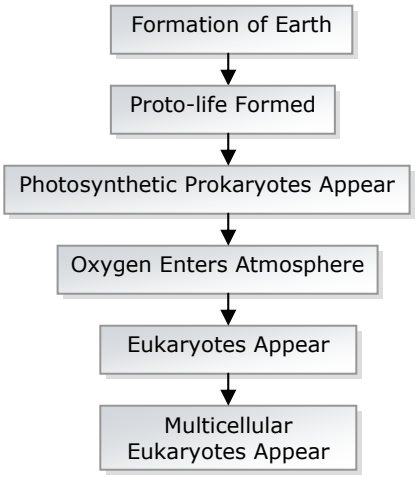
14: Evolution

Heritable Adaptation: Any inherited trait that ultimately leads to a reproductive advantage of a species.
Punctuated Equilibrium: Evolutionary changes occur relatively quickly followed by long periods of stabilization.
Natural selection:
-Natural Selection is a result of a species interaction with the environment, with "selection" being determined by whichever species lives long enough to propagate and thereby be successful.
-Survival of the "Fittest". Fit refers to best fit to environment.



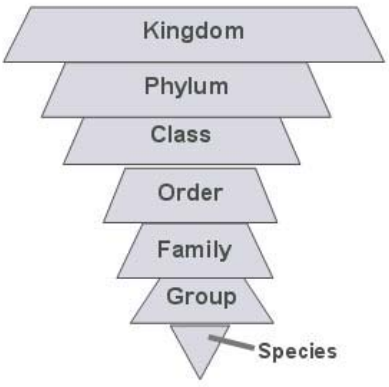
15: Evolutionary History

- **Precambrian Time**: 99% of Earth's history. All of the life history events above happened during this time. Oxygenation of the atmosphere, the first life forms, etc. All life was aquatic.
- **Paleozoic Era**: The first invertebrates and vertebrates. Insects, plants, and reptiles appeared. First movement of organisms onto land.
- **Mesozoic Era**: "The Age of Reptiles." Reptiles became dominant. Mammals appeared. Dinosaurs became extinct.
- **Cenozoic Era**: "The Age of Mammals." Mammals became dominant. Glaciers melted. The climate warmed. Humans appeared.



16: Classification

- **Taxonomy**: The discipline of studying and classifying organisms.
- **Animalia**: A kingdom which includes heterotrophic consumers such as herbivores, carnivores, omnivores, and detritivores.
- **Binomial Nomenclature**: A standard way to refer to the scientific name of an organism by using the genus and species.
- **Phylogeny**: The process of classifying and organizing organisms based on evolutionary relationships.



Five Kingdom System

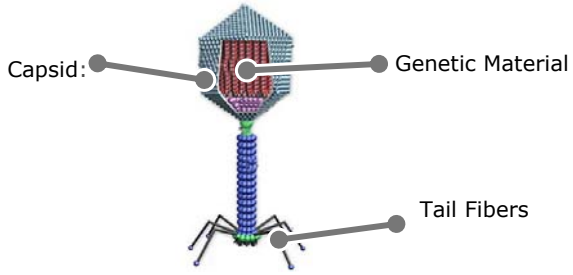
Monera | Protista | Fungi

Plamtae | Animalia

Biology, 5 of 6

17: Bacteria and Viruses

- **Bacteria**: smallest and simplest organisms, scientifically called prokaryotes.
- **Binary Fission:** Asexual reproduction of prokaryotes.
- **Conjugation:** A method of transferring DNA from one bacteria to another using a sex pilus.
- **Transformation:** A method of transferring DNA in which a bacteria picks up DNA from another dead bacteria and integrates the foreign DNA as its own.
- **Transduction:** A method of DNA transfer in which a virus accidentally picks up DNA from one bacteria and injects it into another.
- **Obligate Anaerobes:** bacteria which are unable to grow in the presence of oxygen,
- **Facultative anaerobes:** bacteria which can grow with or without oxygen
- **Aerobic:** bacteria which require oxygen to grow.
- **Lytic Cycle:** A viral life cycle which takes over and kills a host cell in order to make more viruses.
- **Lysogenic Cycle:** A viral life cycle which integrates viral DNA into host DNA in order to be replicated with the host DNA and lie dormant.



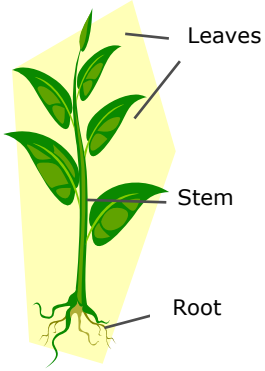
18: Plants

- **Transpiration**: Evaporation via the stomata on the lower surface of leaves pulls up water/minerals from roots. This force makes water to go upwards from root to leaves.

- **Differences between a plant cell and an animal cell**
  - Cell wall: plants have a protective layer of cellulose around the cell membrane known as the cell wall.
  - Large central vacuole: This large organelle maintains the structure of the plant cell by giving a water-filled support.
  - Chloroplast: This organelle allows plants to perform photosynthesis, to absorb sunlight to produce energy.

❖ **Root**
  - Usually under the ground
- **Function**
  - Anchor plants to soil
  - Absorb and transport nutrients

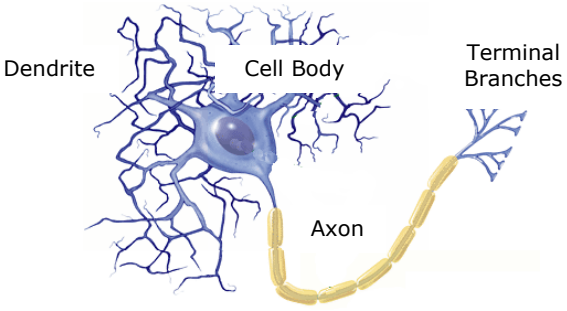
❖ **Stem**
  - The part of a plant from which shoots and buds arise.
- **Function**
  - Structural support
  - Growth through increase in diameter and elongation
  - Transport of fluids between the roots and the leaves.

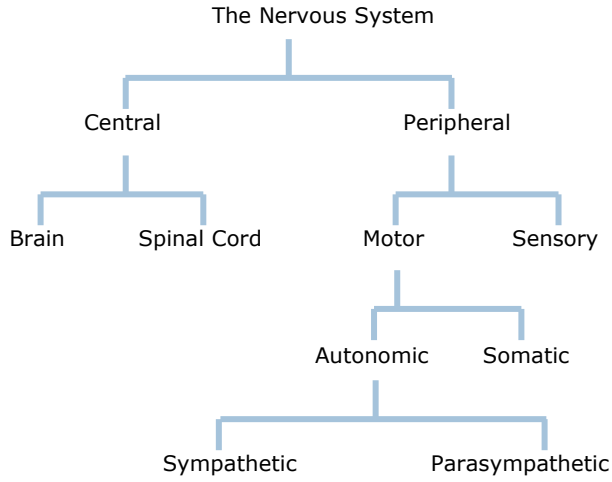


❖ **Leaves**
- **Function**
  - Photosynthesis: to obtain food from light
  - Transpiration: pulling water up from the roots.

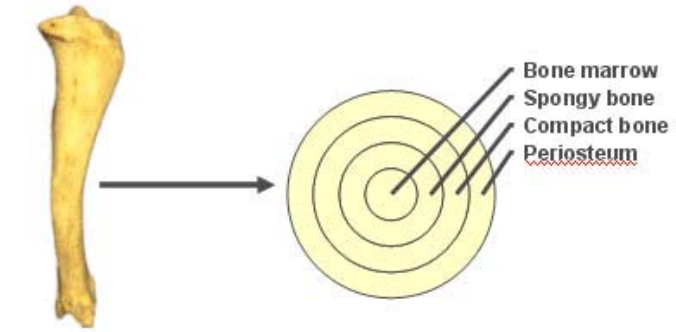
19: The Nervous System

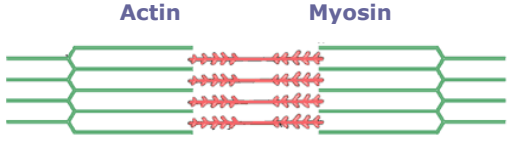
- **Neurotransmitter**: Biological particles which the branches release when an action potential reaches them. Neurotransmitters carry information to the next neuron.





20: The Skeletal, Muscular, and Integumentary Systems





Skeletal Muscle
- Attached to bones
- Has stripes = striated
- Powers voluntary movement

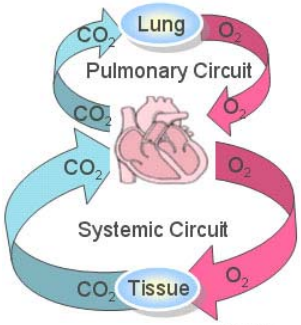
Smooth Muscle
- Used in intestines
- Not striated
- Powers involuntary movements

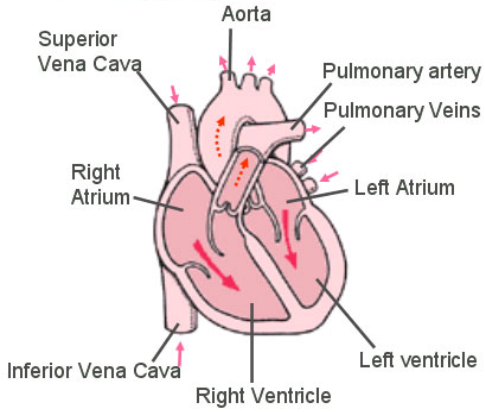
Cardiac Muscle
- Found only in the heart
- Striated
- Powers the heartbeat

Biology, 6 of 6

21: Respiratory and Circulatory Systems

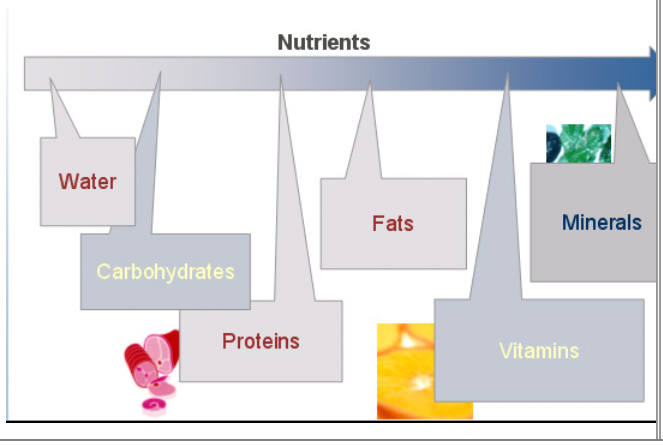
- **Respiratory System**: An organ system designed to pick up needed gas and release waste.
- **Circulatory System**: An organ system designed to deliver oxygenated blood through all of the body's cells.





22: The Digestive and Excretory Systems

- **Ingestion**: The mouth mechanically breaks down food. The esophagus pushes food down with peristalsis.
- **Digestion**: The stomach stores the food and releases enzymes to break it down. The liver releases bile to help with digestion of large fats. The pancreases releases enzymes to help the small intestine digest food.
- **Bladder**: The storage zone for urine, filtrated waste, to leave the body. enzymes to activate digestion overall.
- **Absorption**: The small intestine takes in food molecules into the blood. The large intestine absorbs water.
- **Elimination**: The waste leaves through the rectum.
- **Skin**: Excretes urea through the surface.
- **Lungs**: Excretes carbon dioxide.
- **Liver**: Detoxifies dangerous compounds.
- **Kidneys**: Filters the blood, keeping necessary amounts of minerals and water while discard extraneous amounts.

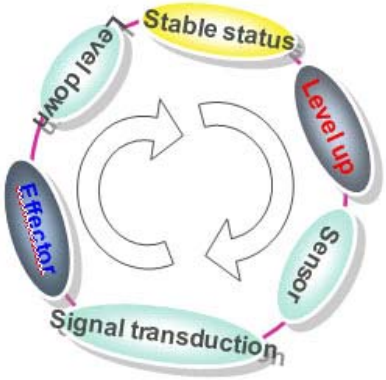


23: Endocrine and Reproductive Systems

- **Endocrine System vs Nervous System**

Slow Response	Fast Response
Hormones	Electrical Impulses
Long-lasting Effects	Short-lasting Effects

- **Hypothalamus:** controls pituitary to release hormones.
- **Pituitary Gland:** signals other glands to release hormones. Growth hormone.
- **Thyroid:** Releases thyroxine to control metabolism.
- **Parathyroid:** Releases parathyroid hormone to regulate levels of calcium.
- **Adrenal:** "Flight or Fight" response.
- **Pancreas:** Release insulin/glucagon to regulate blood-glucose levels.
- **Gonads:** Release testroterone, estrogen, to stimulate reproductive system changes.
- **Homeostasis:** When the stable status of a body is disrupted, the organ systems sense the change, and by activating signals such as through the nervous or endocrine systems, effectors are activated which returns the body back to the original state.



24: The Immune System

- **Humoral Immunity:** B cells become plasma cells and memory B cells. The plasma cells release antibodies into the blood to kill the pathogen cells. Memory B cells remember the specific antibody needed to defend against the same pathogen.
- **Cell-Mediated Immunity:** Helper T cells bind to already infected body cells and then activate killer T cells. Killer T cells bind to the infected cell and destroy its membrane to kill the infected cell.
- **Physical/Chemical Barriers:** The skin and hair in ears and nose prevent pathogens from entering the body. Chemicals such as saliva, sweat, and oil contain enzymes which destroy pathogens before they spread.
- **Inflammatory Response:** Kills any pathogens in area of damage.

		Function
Macrophages	Phagocytes	Ingest and destroy foreign invaders.
B Cells	Plasma Cells	Produce antibodies and release them into blood.
	Memory	Remember specific pathogens.
T Cells	Helper T	Activate Killer T Cells
	Killer T Cells	Destroy infected cells of the body

01: Introduction to Human Physiology

Key Terms

Physiology: Physiology is the study of body function. It is the study of the biochemical, physical and mechanical functions of living organisms. Physiology and anatomy are interconnected; anatomy describes the location and structure of a particular body part, and physiology describes how and what it does.

History of Physiology: Human Physiology dates back to at least 420 B.C., during the time of Hippocrates. Between 380-322 B.C, Aristotle began thinking critically about the relationship between structure and function, which marks the beginning of the discipline of physiology. During the Middle Ages, a physician named Ibn al-Nafis first correctly described the human circulatory system and gas exchange in the lungs. He is credited as being the father of circulatory physiology.

Integumentary System: The skin is the largest organ of the body, covering the entire surface of the body. The skin provides a protective barrier for the human body, as well as playing a key role in body temperature regulation as part of homeostasis. The skin is divided into 2 layers: the epidermis and the dermis.

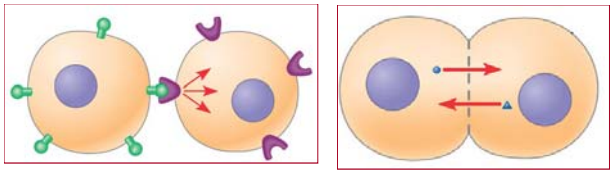
Nervous System: The nervous system controls movement and function through nerve impulses sent to and from the brain. The nervous system is divided into the Central Nervous system and the Peripheral Nervous system.

Cell Communication: Cells within a group of tissue must communicate to support themselves, as well as transmit vital information. Specialized cell junctions, such as gap junctions, provide a direct connection for the transfer of molecules between cells. Cell receptors also provide a major form of cell communication between cells.

Signal Transduction: After the signal reaches the target cells, it must then activate it or stimulate it to respond to the signal. This involves the transduction of the signal from the outside environment to the inside of the cell. Cells have very elaborate intracellular signaling pathways, such as the Epidermal Growth Factor signaling pathway.

Homeostasis: Homeostasis is a vital concept in human physiology. It is the process through which a nearly stable internal environment is maintained in the body so that cellular functions can proceed at maximum efficiency. Every body structure contributes to maintaining the internal environment within a normal range of temperature, pH, oxygenation, etc. Homeostasis is maintained through the regulatory process called "feedback". A feedback loop is a cycle of events in which a body condition (such as blood pressure) is continually monitored and adjusted to be within specific limits.

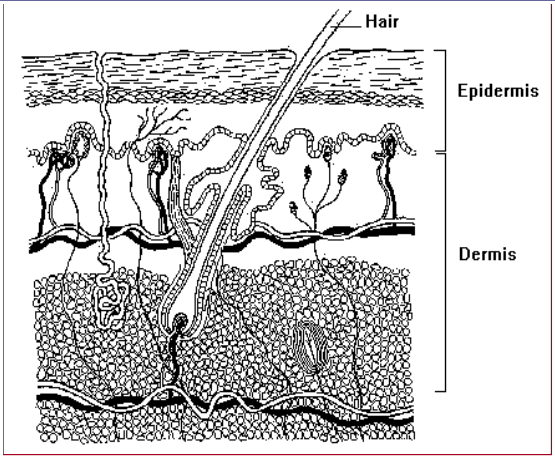
Cell to Cell Communication



Cell Receptors | Gap Junctions

Cells within a group of tissue must communicate to support themselves, as well as transmit vital information. Specialized cell junctions, such as gap junctions, provide a direct connection for the transfer of molecules between cells. Cell receptors also provide a major form of cell communication between cells.

Integumentary System

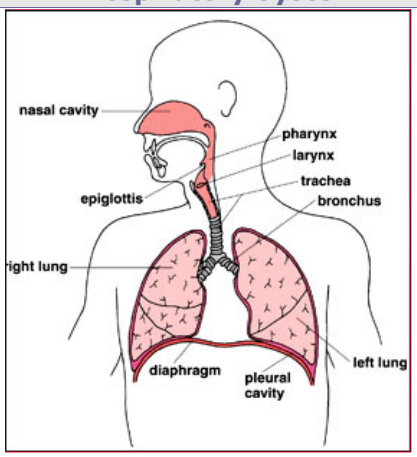


Sex determination in humans takes place around 7-9 weeks of gestation. The Wolffian ducts, which develop in males, and the Mullerian ducts, which develop in females are under the control of a glycoprotein hormone known as Mullerian-inhibiting factor (MIF).

Homeostasis

Homeostasis is a vital concept in human physiology. It is the process through which a nearly stable internal environment is maintained in the body so that cellular functions can proceed at maximum efficiency.

Respiratory System



The Respiratory system's function is gas exchange, including oxygen uptake and carbon dioxide release in the lungs. The respiratory cycle of breathing brings gas into the lungs during inspiration; oxygen and carbon dioxide are exchanged and then the carbon dioxide is blown off during expiration.

01: Introduction to Immunology

Key Immunology Terms

Immune System: It is a unique adaptive defensive system that has evolved in vertebrates to protect them from invading pathogenic microorganisms and cancer.

Immunity: All those physiological mechanisms that endow the animal with the capacity to recognize materials as foreign to itself and to neutralize eliminate or metabolize them with or without injury to its own tissues.

Antigen: Any substance (usually foreign) that bind specifically to an antibody or a T cell receptor.

Antibody: A protein (immunoglobulin) that recognizes a particular antigen and binds specifically to it.

Innate immunity or native immunity: It is the resistance to infections which an individual possesses by virtue of his genetic and constitutional make-up. It is not affected by prior contact with microorganisms or immunization.

Adaptive immunity or acquired immunity: It is the resistance that an individual acquires during life, as distinct from the inborn innate immunity. Adaptive immune responses exhibit four immunological attributes: Specificity, Diversity, Memory, Self and non-self recognition.

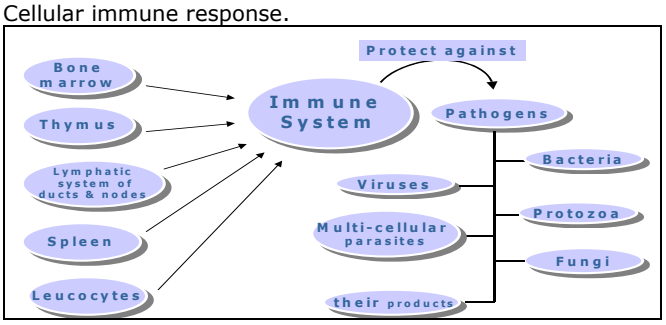
Immune System

Vertebrates have a unique adaptive Immune System that has evolved to protect them from invading pathogenic encounters. We are able to fight against the infectious agents, because of the presence of effective, protective and complex array of Immune System.

Protection against infectious diseases is only one of the consequences of the immune response, which in its entirety is concerned with the reaction of the body against any foreign antigen.

The immune system is composed of many interdependent cell types, organs, and tissues that jointly protect the body from infections.

The immune system comprises of two parallel but interrelated systems: The Humoral immune response and Cellular immune response.



Humoral and Cellular Immunity

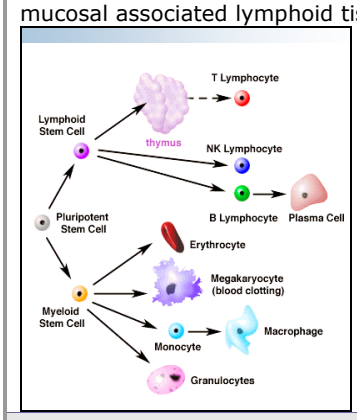
In the humoral immune response, antibodies function as recognition elements and binds specifically to antigens.

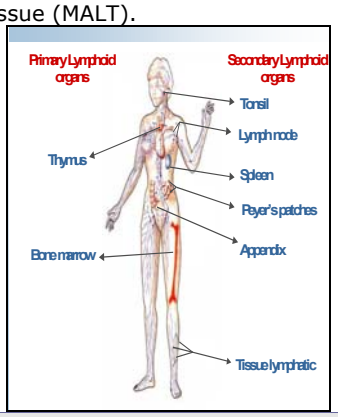
In the Cellular immune response cytotoxic T-lymphocytes kill cells that display foreign motifs on their surfaces. The cellular immune response is mediated by specific receptors that are expressed on the surface of the T cells.

Cells and Organs of Immune System

Immune responses are mediated by variety of cells and by the soluble molecules, which they secrete. Leucocytes (WBCs) are central to all immune responses.

The organs and tissues involved in immune response can be divided as Primary lymphoid organs: Thymus and Bone marrow. Secondary lymphoid organs: Lymph nodes, spleen, & mucosal associated lymphoid tissue (MALT).





Antigen and Antibody

An Antigen (usually foreign) is a substance that binds specifically to an antibody.

Antibody is a protein (immunoglobulin) that recognizes a particular antigen and binds specifically to it.

Innate and Adaptive Immunity

Immune system comprises of two parallel but interrelated systems, known as Innate Immunity and Adaptive immunity.

Innate immunity is the resistance to infections which an individual possesses by virtue of his genetic and constitutional make-up and includes anatomic, physiologic, endocytic and phagocytic and inflammatory barriers that help prevent the entrance and establishment of infectious agents.

Adaptive immunity is the resistance that an individual acquires during life. Adaptive immune responses exhibit four immunological attributes: Specificity, Diversity, Memory, Self & Non-self recognition. Antigen presenting cells, B-lymphocytes and T- lymphocytes are the primary cells of the adaptive immune responses. It is of two types, active and passive.

History of Immunology

The history of immunology can be traced back to 430 BC. Chinese and Turks developed the technique of Variolation.

Edward Jenner, 'father of vaccine', improved the technique of Variolation and his experiments on smallpox turned to be breakthrough finding in the field of immunology.

In 1885, Pasteur administered the first vaccine to a human, a young boy, Joseph Meister, bitten by rabid dog. He also developed the vaccines for anthrax and cholera.

Robert Koch, Elie Metchnikoff, Emil von Behring and Shibasaburo Kitasato are the major contributors in the development of immunology.

The history of Immunology can be traced back to 430 BC. This subject has fetched 16 Nobel Prizes.