



**HOLY TRINITY
ACADEMY**

Veritas: Christo et Ecclesiae
"Truth: for Jesus and His People"

**Mrs. Paulgaard
Biology 20
Notes & Diagrams**

**Organic Chemicals, Enzymes, Cells, Cellular Respiration,
Photosynthesis, Muscles, Digestion, Kidney, & Pulmonary
Systems**

Unit 1: Energy Flow and Cellular Matter

Cellular Chemistry:

- **Metabolism:** sum of all chemical reactions that occur within the cell.
- **Catabolism:** chemical reactions in which complex molecules are broken down into smaller compounds.
- **Anabolism:** chemical reactions where simple molecules are combined together to form more complex compounds.

Organic Chemistry:

- Chemistry of carbon ~ hydrocarbons (HC's)
- Simplest compounds that are classified based on the number of carbons.
- Consist of carbohydrates, lipids, and proteins

Carbohydrates: sugars (CHO) ending of OSE

- **Role:** Structure: cell wall in plant cells ~ cellulose.
Function: energy ~ rapidly available energy.
- **Monosaccharides:** simple single sugars ~ C3 to C10
 - Glucose, Fructose, and Galactose.
- **Disaccharides:** double sugars that are combinations of single sugars.
 - Sucrose, Maltose
 - Example: $C_6H_{12}O_6 + C_6H_{12}O_6 \longrightarrow C_{12}H_{22}O_{11} + H_2O$
Glucose + Glucose Maltose + Water
- **Polysaccharides:** many sugars. General formula ($C_6H_{10}O_5$).
 - Polymers: molecules composed of 3 to several million sub-units.
 - Examples:
 - Cellulose ~ 1000 to 2000 glucose units. (dietary fibre)
 - Starch ~ plant storage carbohydrate.
 - Glycogen: animal starch ~ animal storage carbohydrate that is stored in the liver and muscles.

Chemical Tests:

- **Starch Test:** drops of iodine solution; blue or black color indicates presence of starch.
- **Reducing (mono & disaccharide) Sugar:** drops of Benedict's solution. Heat to boiling point but don't boil. Color indicates the % of sugar.

Lipids: (CHOP) ending of OL

- **Role:** Structural: phospholipids in cell membranes and fat deposits for physical protection.
Functional: fat deposits for heat insulation and long term storage of energy.
- **Triglycerides:** union of glycerol and three fatty acids.
 - **Fats:** animal lipids composed of glycerol and saturated fatty acids.
 - **Oils:** plant lipids composed of glycerol and unsaturated fatty acids.
- **Phospholipids:** phosphate molecule is attached to the glycerol molecule making the molecule polar. Major components to cell membranes in animals and plants.

Chemical Test:

- **Lipids Test:**
 1. Grease spot test on **brown paper**, translucent result indicates fat or oil.
 2. Add a trace of **Sudan IV** stain that is only soluble in lipids: color will show.

Proteins: structural components of cells. (CHONS) ending of IN

- **Roles:** Structural: cell membrane and determine the shape of cells.
Functional: enzymes control all chemical reactions, hormones, and energy.
- Very large macromolecules composed of **Amino Acids**.
 - 20 types of amino acids that are joined together by **peptide bonds**, as a result proteins are often called **polypeptides**. Most proteins have up to 3000 amino acids.

Amino Acid ~~~ peptide bond ~~~~ Amino Acid

- **Primary Structure:** polypeptide chain O-O-O-O
- **Secondary Structure:** coil made of weak hydrogen bonds
- **Tertiary Structure:** unique 3-dimensional structure allows proteins to become very specific.
 - As a result of its structure, each protein has a unique configuration (surface shape) which determines largely the properties of that protein.
 - If environmental factors change this shape then the protein cannot carry out its proper role. This process is called **Denaturation** ~ uncoiling the protein shape.
 - Caused by environmental agents:
 - Heavy metals ~ Pb and Hg.
 - Electricity ~ electrocution
 - Heat ~ cooking eggs or fever
 - pH
 - Sometimes if the agent is removed the protein can recapture its shape, if not the permanent change is referred to **Coagulation**.
- **Nucleic Acids:** hereditary material found within the genes of chromosomes.
 - Deoxyribonucleic Acid ~ DNA.
 - **Nucleotides:** the functional units of nucleic acids.
 - **A and T together**
 - **G and C together**

Chemical Test:

- **Protein Test:** drops of Biuret Reagent (test for the peptide bond), a violet color indicates the presence of protein.

Chemical Processes:

- **Dehydration Synthesis:** combination of simple molecules to form larger, macro-molecules which yields a water molecule.

- **Hydrolysis:** breaking down of a macromolecule to form simpler, micro-molecules through the addition of water.

Review:

Organic Compound	Elements	Types	Examples	Processes	Chemical Test
Carbohydrates (sugars)	Carbon Hydrogen Oxygen	Monosaccharides Disaccharides Polysaccharides	Glucose Sucrose Cellulose	Dehydration synthesis & Hydrolysis	Benedict's Solution Iodine
Lipids	Carbon Hydrogen Oxygen Phosphate	Triglycerides: <ul style="list-style-type: none"> • Fat • Oils Glycerol and Fatty Acids Phospholipids: Glycerol and phosphate	Fats, Cholesterol, Steroids, Wax	Dehydration synthesis & Hydrolysis	Paper Test Sudan IV
Proteins	Carbon Hydrogen Oxygen Nitrogen Sulphur	Amino Acids Polypeptides Chains Coils 3-D Proteins	Enzymes, Haemoglobin, Antibodies	Dehydration synthesis & Hydrolysis Denaturation Coagulation	Biuret Reagent
Nucleic Acid	Carbon Hydrogen Oxygen Nitrogen Phosphate	Nucleotides DNA and RNA	DNA		

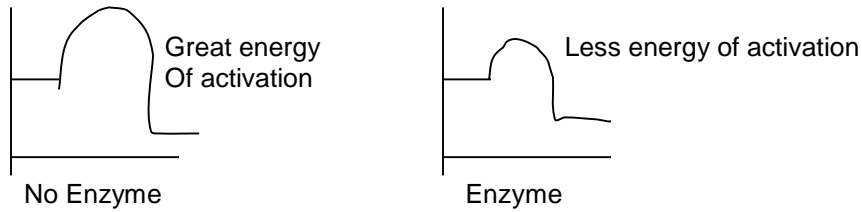
Enzymes: "lock and key" hypothesis. **Suffix ~ ase**

Induced fit hypothesis.

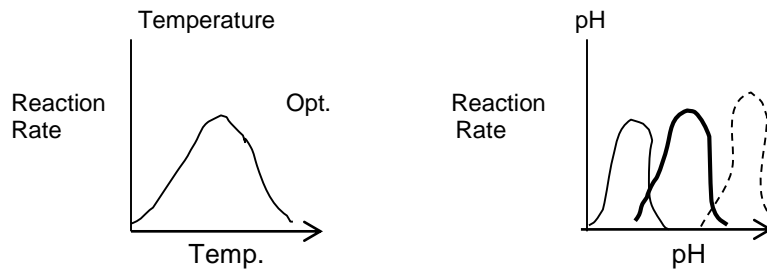
Substrate and enzyme must stretch and strain to fit.
The strain breaks the bonds.

Characteristics of Enzymes:

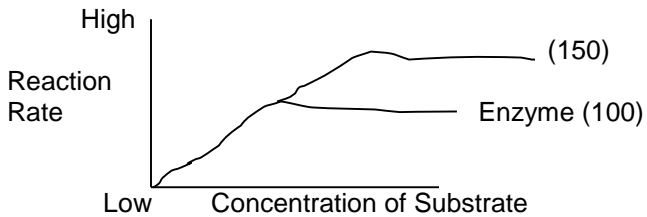
- Proteins
- Needed in small quantities (reusable)
- Substrate specific
- Action is reversible
- Organic catalysts



- Allow chemical reactions to proceed under “milder” conditions in terms of temperature and pH.
- Have optimum pH and temperature where they are most effective or work the best.



- Rate is regulated by the relative amounts of enzyme and substrate.



Co-Enzyme:

- Chemical molecules, such as a vitamin, which are needed to alter the active site of enzymes to correctly fit it with the substrate.

Competitive Inhibition:

- Interference, caused by a non-substrate, with the active site of an enzyme or a specific site on a substrate.
- This chemical interference prevents the normal chemical reaction that involves that enzyme.

Non-Competitive Inhibition:

- A process where a substance that doesn't resemble the substrate at all attaches to the enzyme (not on its active site) which rearranges the enzyme rendering it useless.

Negative Feedback ~ Homeostasis:

- The ability of the body to keep the normal internal body environment in a stable state even as the external environment is changing.
- Stops a process

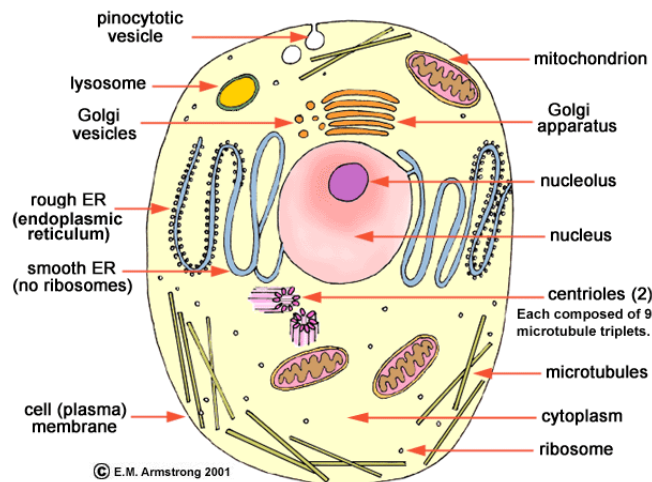
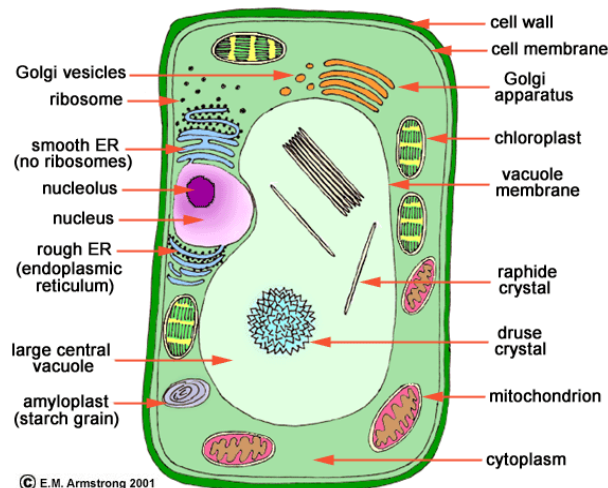
Positive Feedback ~ Precursor Activity:

- Activation of the last enzyme in a pathway due to a build-up of the initial substrate.
- Starts a process

Biology 20: Unit 2 Cellular Respiration and Photosynthesis

Cell Organelles:

- **Cell membrane:** controls what comes in and out of the cell.
- **Cytoplasm:** solution within the cell.
- **Endoplasmic reticulum (ER):** contain ribosomes which are responsible for protein synthesis.
- **Golgi Apparatus:** prepare materials for secretion (proteins or enzymes).
- **Lysosomes:** Digestive enzymes
- **Mitochondria:** produces most of the cell's energy, has its own DNA.
- **Plastids:** plants only, sites of photosynthesis, has its own DNA.
- **Vacuoles:** storage deposits
- **Cilia and Flagella:** movement of the cell.
- **Microfilaments and Microtubules:** movement of materials within the cell and movement of the cell itself.
- **Cell Wall:** plants only, supports the cell.
- **Nucleus:** determines the shape, metabolism, and heredity of the cell (DNA).

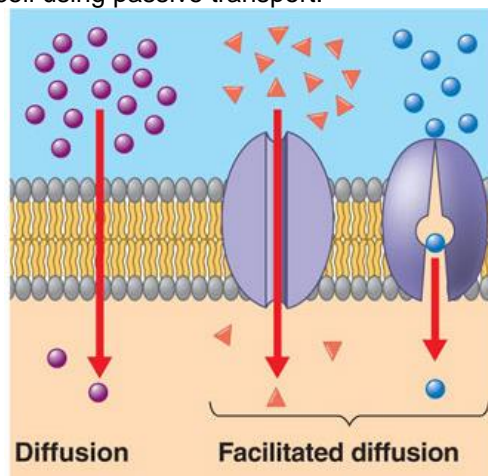


Movement through the Cell Membrane:

- Bilayer of phospholipids that have hydrophilic head and hydrophobic tails.
- Proteins found on the surface and embedded through the membrane.
- Membrane is selectively permeable.

Passive Transport:

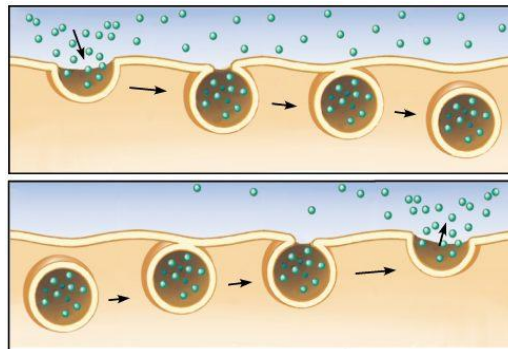
- **Diffusion:** movement of materials from an area of high concentration to an area of low concentration.
- **Facilitated diffusion:** macromolecules that are recognized by proteins on the membrane guide the molecules into the cell using passive transport.



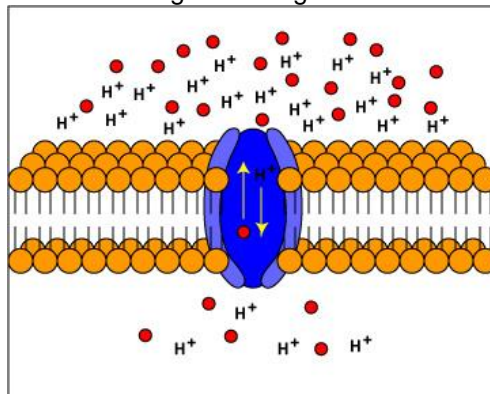
- **Osmosis:** movement of water across a semi-permeable membrane from an area of low solute concentration to high solute concentration.
 - **Isotonic** – solution on both sides have the same concentration of water.
 - **Hypotonic solution:** solution with less solute concentration and more water.
 - **Hypertonic:** solution with more solute and less water

Active Transport: similar to facilitated diffusion but the movement of the molecules requires the cell to use energy.

- **Endocytosis:** large particle is engulfed by the cell
 - **Pinocytosis:** small particles engulfed by the cell
 - **Phagocytosis:** large particles engulfed by the cell.
- **Exocytosis:** vacuole moves toward the cell membrane and dumps the contents out.

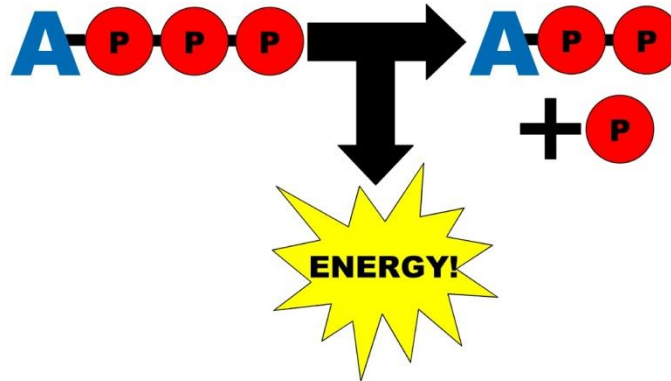


- **Ion Pump:** small ions move against the gradient

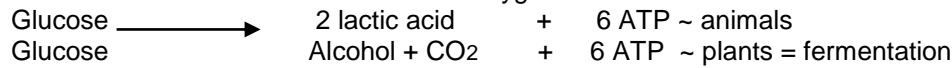


ATP:

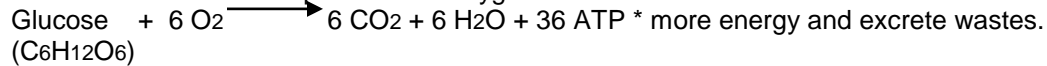
- Adenosine Triphosphate (ATP) is the storage form of energy for cellular activity.
- High energy bond between the second and third phosphate group. Once broken the energy released is transformed and used within the cell.



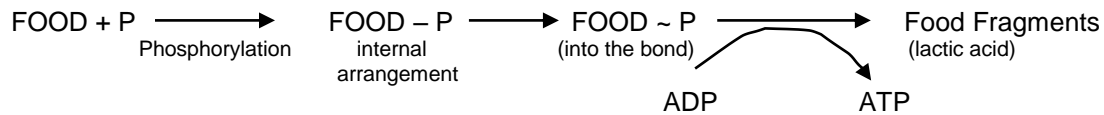
Anaerobic Metabolism: ~ absence of oxygen



Aerobic Metabolism: ~ presence of oxygen



Phosphorylation: the process of adding a phosphate to a molecule.

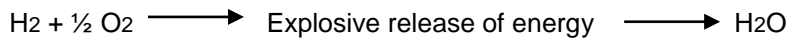


Oxidation and Reduction:

- Oxidation: release energy when a compound loses electrons.
- Reduction: absorb energy when a compound gains electrons.

• **Hydrogen or Electron Transport:**

- Hydrogen electrons in hydrogen gas or in organic molecule have a great deal of energy.
- Hydrogen electrons in water have low energy.



*if our bodies used this pathway we would burn up.

- Electron transport releases the energy step by step so that the cells can convert the energy into ATP.

H₂ ~ hydrogen is separated

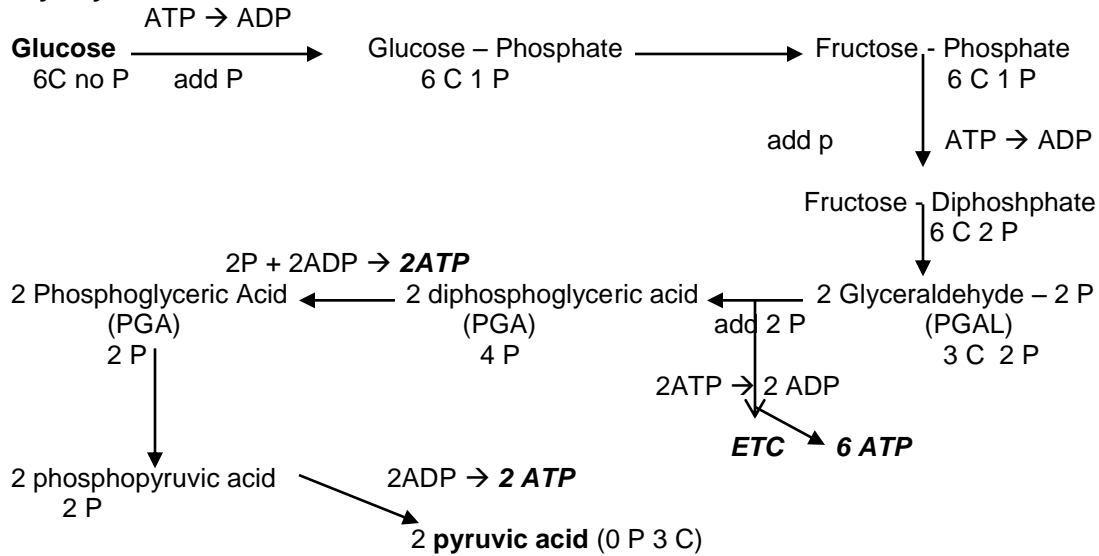
Advantage: lots of energy and easily excrete wastes (water and carbon dioxide).
 Disadvantage: needs oxygen.

Electron Transport Inhibitors:

- Certain chemicals can block the chain so that the complete reduction cannot occur.
- Ex: carbon monoxide, cyanide, and hydrogen sulfide.

Cellular Respiration:

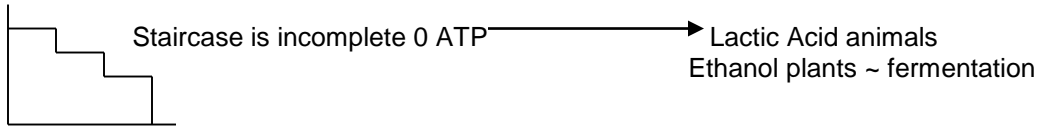
Glycolysis: Outside of the mitochondria



Used 4 ATP
 Gained 10 ATP
 Net gain of 6 ATP

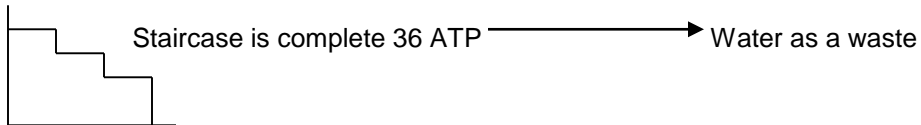
Fate of Pyruvic Acid:

- **Without Oxygen: Anaerobic**

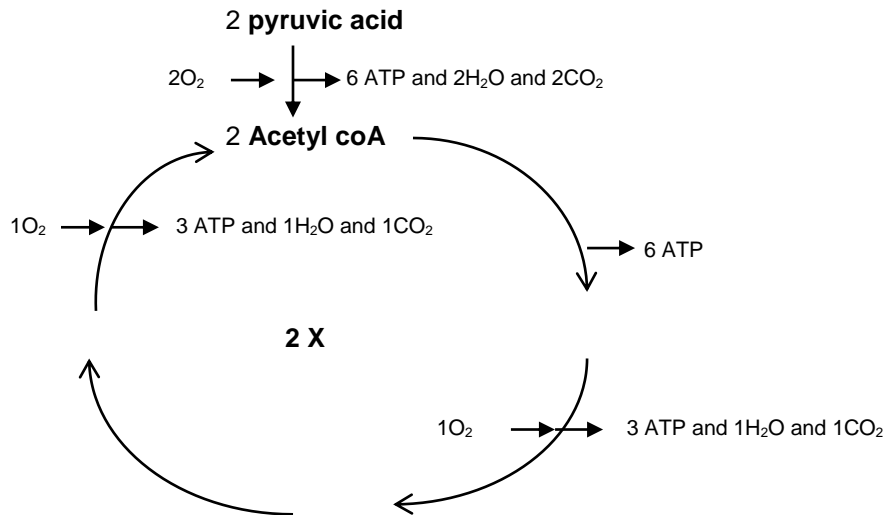


Amount of ATP = 6 ATP due to glycolysis

- **With Oxygen: Aerobic**

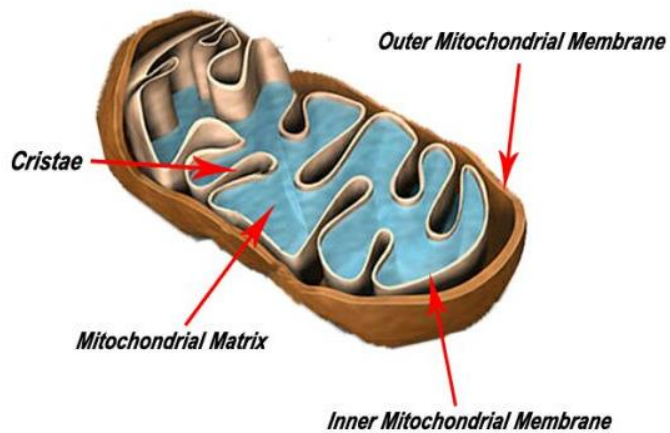


Citric Acid/Krebs Cycle: within mitochondria



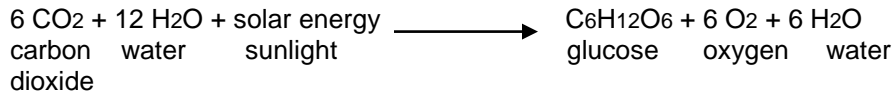
The cycle is repeated 2 times.

Total ATP produced = 6 + (2 x 12) + 6 (from glycolysis) = 36



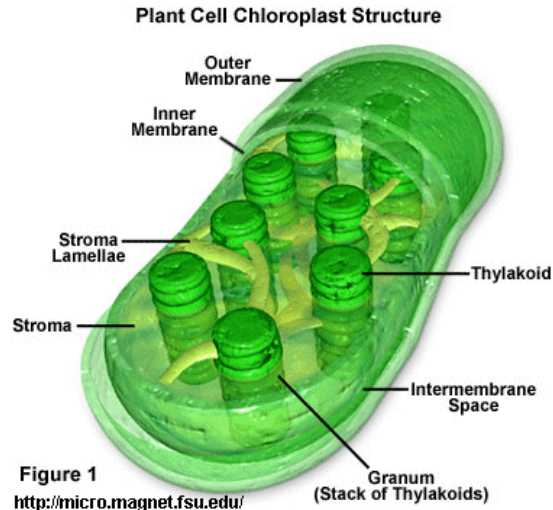
Photosynthesis:

- The process whereby plants store solar energy into organic compounds.

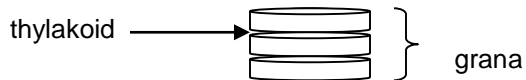


(Leaf) (Roots)

(Root/Leaf) (Leaf) (Leaf)



- Takes place in the **chloroplasts** of plant cells.
 - Contains cellulose and chlorophyll which is the pigment that traps sunlight.
 - Photosynthesis takes place within specialized membranes called **thylakoid** membranes.
 - These membranes are stacked one upon another to form stacks known as **grana**
 - The fluid surrounding the grana is called **stroma**.



Chemiosmosis:

- Different pigments absorb different wavelengths of light that provide the right amount of energy to the electrons within them.
 - Ex: chlorophyll a, chlorophyll b, carotenoid
 - See colours not absorbed by the object (Chloroplasts absorb red and blue)
- The trapped energy excites the electrons and boosts them to a higher energy level.

The reactions of photosynthesis occurs in two phases:

- Photosystems
- Carbon-Fixing Cycle or Calvin-Benson Cycle

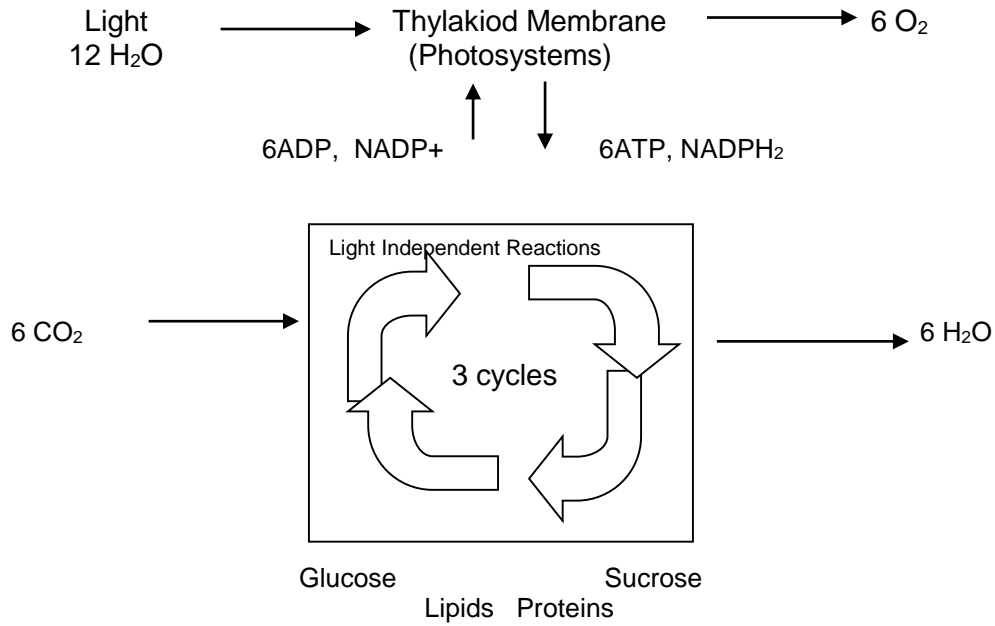
Photosystems:

- Energy capturing phase ~ light dependent
- The thylakoid membrane appears to have two systems that operate at the same time.

Photolysis: splitting of water by light energy

Calvin-Benson Cycle:

- Carbon fixing phase ~ light independent
- Occurs in the stroma



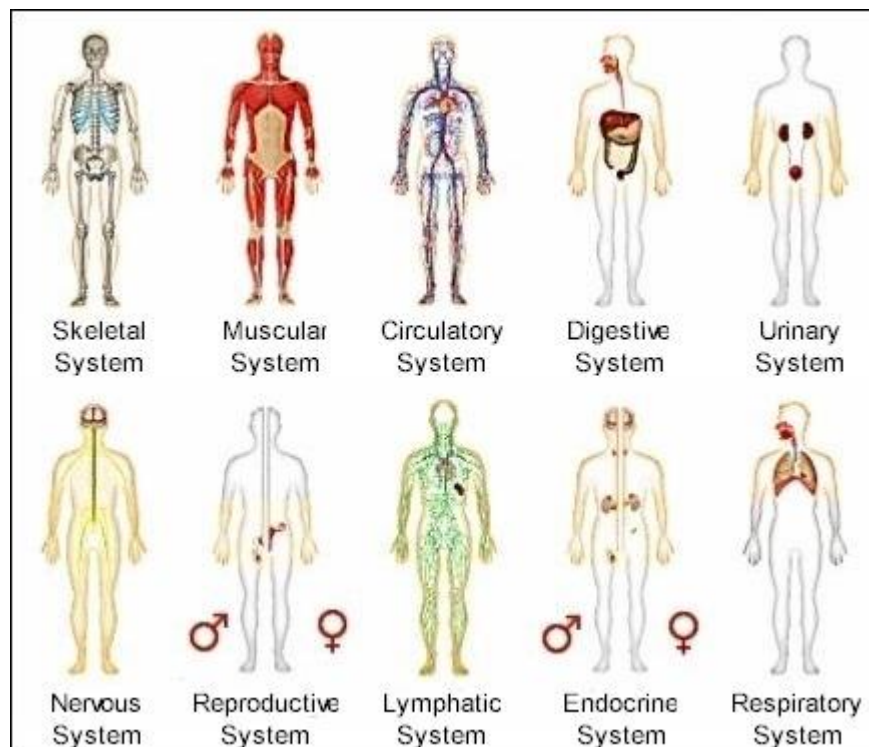
Comparison between Cellular Respiration and Photosynthesis:

Cellular Respiration	Photosynthesis
Energy produced (36 ATP)	Energy required (6 ATP)
Oxidation	Reduction
High energy reactants (glucose)	Low energy reactants (CO ₂ and H ₂ O)
Oxygen required (aerobic)	Oxygen released
CO ₂ and H ₂ O produced	Glucose produced
Processes: Phosphorylation Kreb's Cycle (2)	Processes: Photosystems Calvin-Benson Cycle (3)
Mitochondria	Chloroplasts

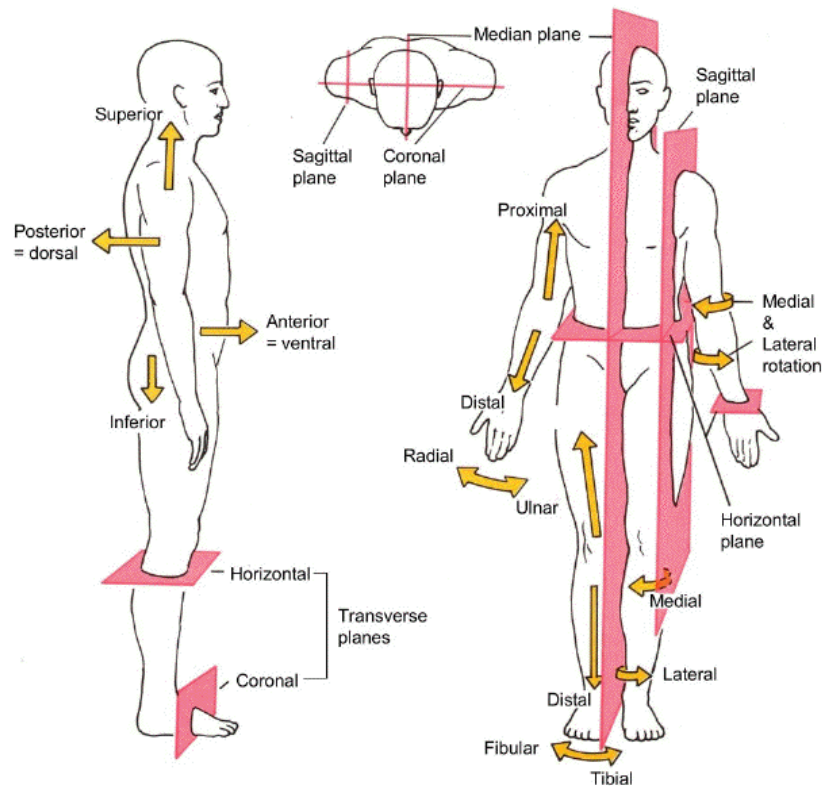
Unit 3: Energy and Matter Flow in the Human Body

The human body is made up of a various systems responsible for specific functions:

- Muscular System: movement and heat production
- Digestive system: nutrients
- Respiratory system: gas exchange
- Circulatory system: blood transport
- Urinary system: excretion



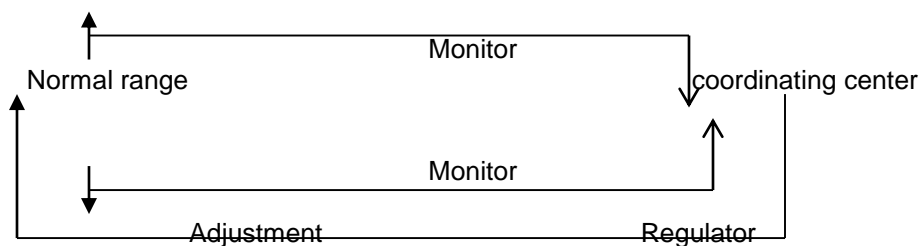
Anatomy Terms:



- **Cavities:**
 - Cranial – brain
 - Spinal – back
 - Thoracic – lungs and chest
 - Abdominal – digestive system
 - Pelvic – lower part of the digestive system
- **Planes:**
 - Anterior (Ventral) – front section of the body, from the face to the feet.
 - Posterior (Dorsal) – back section of the body.
 - Superior – upper part of the body.
 - Inferior – lower part of the body.
 - Medial – close to the midline of the body.
 - Lateral – away from the midline of the body
 - Distal – toward the end of the structure or limb
 - Proximal – towards the beginning of the structure or limb

Homeostasis and Control Systems:

A process by which a constant internal environment is maintained despite changes in the external environment.



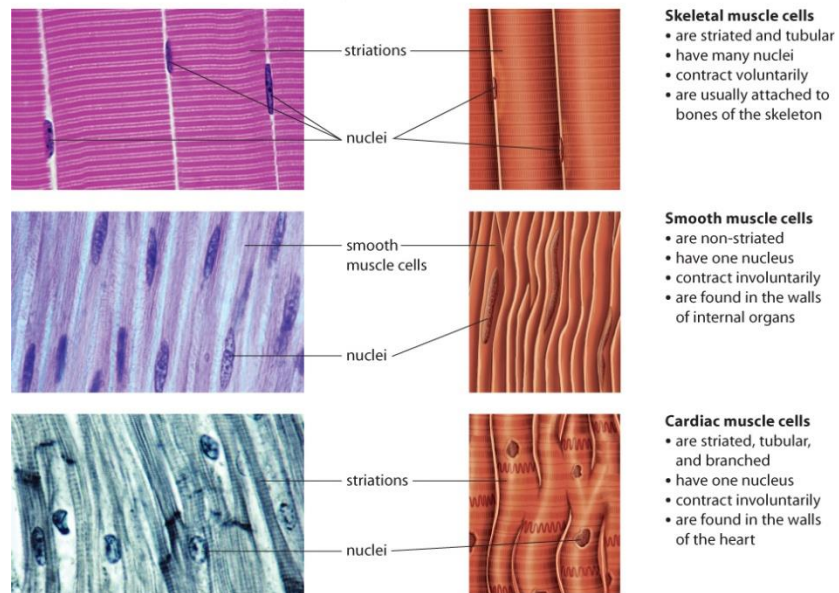
Muscles:

- Tissue designed to convert chemical energy (ATP) into kinetic energy (movement & heat).
- Supports body functions
- Responsible for locomotion (bones), heat production, peristalsis, breathing etc.

Types of Muscle Tissue:

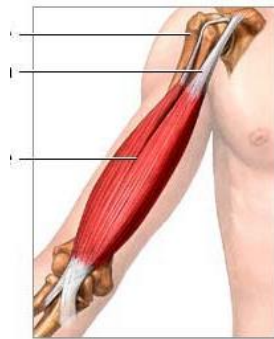
- **Smooth Muscle:** non-striated, one nucleus, contracts involuntarily, slow and long contracts, don't fatigue easily, and found along the wall of internal organs.
- **Cardiac Muscle:** striated, tubular and branched, one nucleus, contracts involuntarily, found in the walls of the heart.
- **Skeletal Muscle:** striated and tubular, contain many nuclei, contracts voluntarily, attached to bones of the skeleton.

Figure 10.1 Comparing and contrasting skeletal, smooth, and cardiac muscle cells.



Functions of Skeletal Muscle:

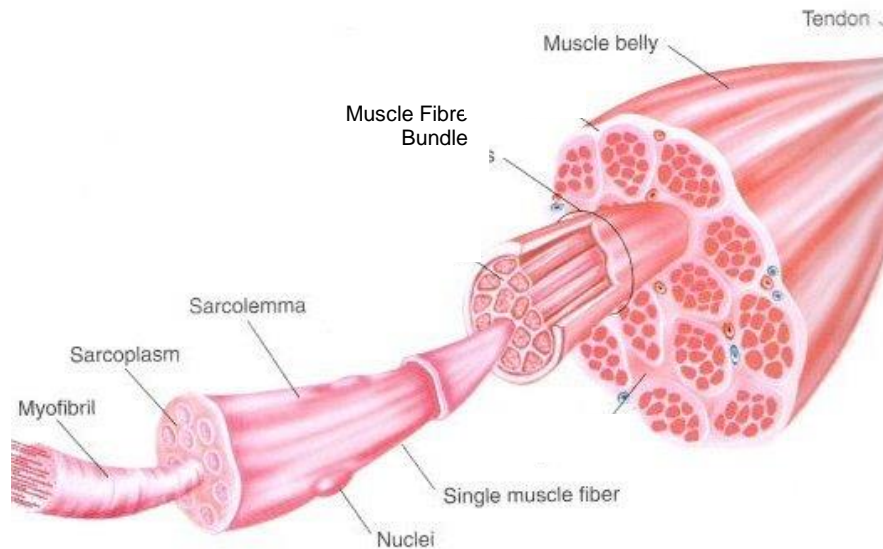
- Opposes the force of gravity and enables standing
- *Constant temperature* by releasing of metabolic heat is distributed to the body (shivering)
- *Protects internal organs and stabilizes joints:*
 - Ligaments hold bones (cartilage in between) together at the joints.
 - Tendons attach muscle to bones



Cooperation of Skeletal Muscle:

- All muscle tissue contracts (shortens) and relaxes (lengthens).
- Muscles can only pull on a bone when they contract but there must be a force that stretches the muscle after it has stopped contracting and relaxes
- Flexing causes the bone or limb to move away from its original position. Extension is when the bone or limb moves towards its original position.
- Muscles are allows in pairs: antagonistic
 - Bicep causes the arm to flex as the muscle shortens
 - Triceps causes the arm to extend as the muscle shortens.

Hierarchy of Muscle Structure:



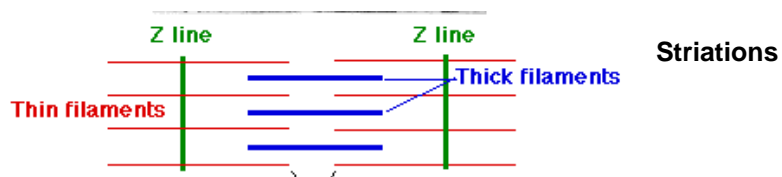
- **Muscle** (Tendon is heavy tissue that attaches to bone)
- **Muscle-Fibre Bundle** (connective tissue surrounds each muscle fibre with nerve and blood vessel running between each bundle of fibres)
- **Muscle Fibre** (single muscle cell)
 - **Myoglobin** (stores oxygen)
 - **Sarcoplasm** (cytoplasm of the muscle fibre, contains myoglobin & glycerine)
 - **Sarcolemma** (membrane of the muscle fibre that regulates movement of material)
 - **Sarcoplasmic Reticulum** (stores calcium ions)
 - **Myofibrils** (cylindrical sub-units that make up a muscle fibre)
 - **Myofilaments** (protein structures responsible for muscle contractions)
 - **Thick Filaments:** composed of myosin(heads)
 - **Thin Filaments:** composed of actin

Mechanisms of Muscle Contractions:

1. Myosin head attaches to actin
2. Myosin head flexes, advancing the actin filament
3. Myosin head releases and unflexes, powered by ATP.
4. Myosin reattaches to actin farther along the fibre.

Sliding Filament Model of the Sarcomere

1. The heads of the two ends of myosin filament are oriented in opposite directions. When the heads attach to the actin, they bend towards the centre of the myosin.
2. As one end of the myosin filament draws the actin filament and its attached Z line towards the centre, the other end of the myosin filament does the same.
3. Both Z lines move towards the centre, and contraction occurs.



Role of Calcium Ions in Muscle Contraction:

1. Muscle is at rest: A long filament, composed of the protein molecule **tropomyosin**, blocks the myosin binding sites of the **actin** molecule. Without these sites exposure, muscle contraction will not occur.

2. Calcium ions bond with a molecule called **troponin**, which results in exposing the myosin binding sites of **actin** so now muscle contraction can occur.

Sequence in Muscle Contraction:

1. Nerve impulse travels to the muscle fibre bundle (stimulus)
2. Ca ions are released from the sarcoplasmic reticulum into the sarcoplasm.
3. Ca ions attach to the troponin (Ca receptor site) thereby causing the tropomyosin to release from the actin.
4. Myosin heads can now attach, release, and reattach using ATP thereby causing muscle contraction (z-lines move together).

Sequence in Muscle Relaxation:

1. Nerve impulse stops
2. Ca ions reabsorbed from sarcoplasm into the sarcoplasmic reticulum.
3. Absence of the Ca ions on the troponin allows tropomyosin to reattach to the actin preventing the binding of myosin.
4. Myosin and actin just slide away from each other (z-lines move away).

Rigor Mortis

After death, calcium levels inside the muscle cells rise and the body's level of ATP drops. Inside the muscles, myosin binds to actin and the muscles contract. However, with no ATP to reset the crossbridges and release the myosin, all of the muscles remain contracted and stiff -- this state is called **rigor mortis**.

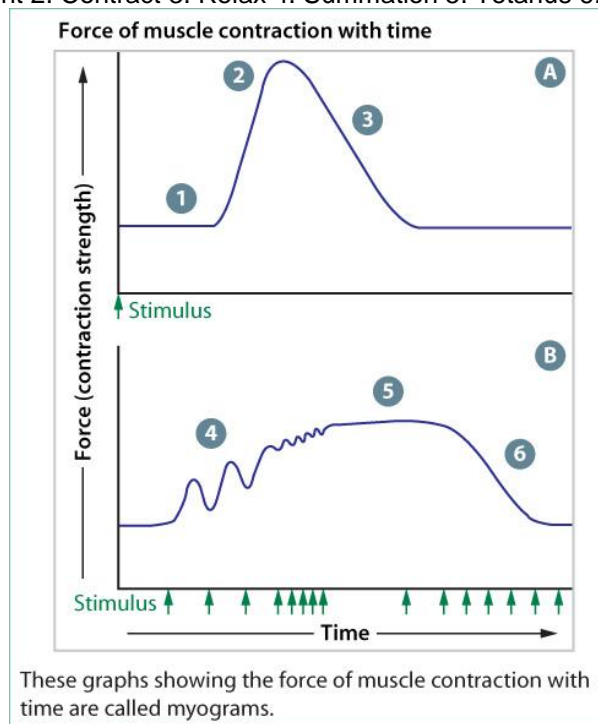
Energy for Muscle Contractions:

- Stored Energy in a Resting Muscle:
 1. Creatine Phosphate is built up and stored in a resting muscle.
 2. Glucose and Glycogen is stored in muscle to be used during cellular respiration.
- Release Energy (make ATP) and Contract the Muscle:
 1. Breaks down **creatine phosphate**, adding the phosphate to ADP to create ATP for immediate use.
 2. Carries out **anaerobic respiration**, by which glucose is broken down to lactic acid and ATP is formed.
 - Lead to fermentation (another way of providing ATP without oxygen which causes cramping and muscle fatigue)
 - Oxygen Debt (replenish creatine phosphate and remove lactate)
 - More in shape a person is the more mitochondria he or she has the less oxygen debt.
 3. Carries out **aerobic respiration**, by which glucose, glycogen, fats and amino acids are broken down in the presence of oxygen to produce ATP.

Muscle Contractions or Twitches:

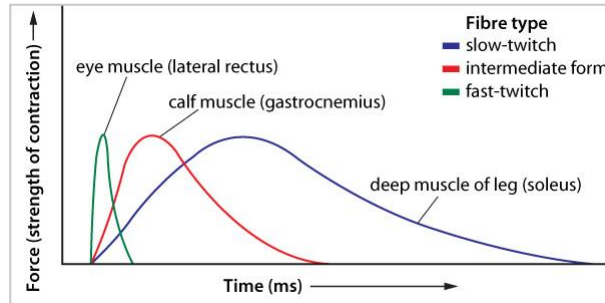
- Muscles require a stimulus (nerve) to contract, latent period, contraction period (muscle shortens), and a relaxation period (when the muscle returns to its former length).
- All or none response (one muscle fibre will contract).
- When there is a short relaxation period, the muscle will fatigue due to a lack of glycogen and excess lactic acid.
- More stimulus is received, more 100% fibres bundles contract

1. Latent 2. Contract 3. Relax 4. Summation 5. Tetanus 6. Fatigue



Types of Muscle Twitches:

- Classified based on how fast the muscle fibres contract.
- **Slow-Twitch:** smaller, contract slow, produce energy aerobically, rich in mitochondria, many blood vessels, and are resistant to fatigue (endurance)
- **Fast-Twitch:** larger, contract fast, use a lot of ATP, rich in glycogen, low in mitochondria, less blood vessels, produce energy anaerobically, and fatigue faster (power)
- **Intermediate –Twitch:** fast twitch but have a high oxidative capacity. Can increase the proportion of these fibers by training but also heredity.



Exercise:

- Limited by amount of glycogen stored and buildup of lactate.
- Adaptation to muscles that stores, utilizes, or spares glycogen and removes lactate efficiently improves endurance.
- **Hypertrophy:** exercised induced increase in muscle mass
- **Atrophy:** reduction in muscle mass
 - Loss of muscle mass as one ages

Endurance	Power
<ul style="list-style-type: none"> • Focus on aerobic respiration • Slow-twitch muscles • Increased density of blood vessels • Many mitochondria • Lower heart rate and breathing rate 	<ul style="list-style-type: none"> • Focus on anaerobic respiration • Fast-twitch muscles increase • Muscle enlargement due to high frequency and intensity resistant training. • Increase in the amount of myosin and actin.

Disorders of Skeletal Muscles:

- *Muscular Dystrophy:* hereditary condition that results in atrophy and replacement of muscle with fatty and fibrous tissues.
- *Botulism:* toxin produced by a bacteria that prevents muscle contraction
- *Cramps:* muscle spasms triggered by strenuous exercise, cold, dehydration, salt imbalance, low glucose, or reduced blood flow
- *Contracture:* abnormal muscle shortening due to inability to remove Ca
- *Fibromyalgia:* chronic muscle pain and tenderness
- *Crush Syndrome:* shock like state that follows after muscles have been crushed (collapsed building)
- *Delayed Onset Muscle Soreness:* muscle fatigue after exercise
- *Strain:* tearing of muscle or ligament tissue
- *Tendonitis:* overuse of the tendon

Technologies to treat muscle condition:

- **Cold:** reduces swelling after a tearing
- **Heat:** encourages blood flow to healing area (reduces pain and muscle stiffness)
- **Ultrasound:** sound waves heat up the tissue (speeds healing) and increases blood flow
- **Massage:** increased blood flow and breaks down lactic acid
- **Strengthening & Stretching Exercises**

Drugs:

- **Anabolic steroids**
- **Creatine Phosphate**
- **Athletic Drinks**

Unit 4 Digestion

Digestive System:

- The organs which collectively perform the task of breaking down nutrients or organic molecules for the use of cell (digestion).

Digestive Processes:

1. **Ingestion:** taking food into the body (eating).
2. **Movement:** propels food through the digestive system.
3. **Secretion:** release of digestive juices in response to a specific stimulus.
4. **Digestion:** breakdown of food into molecular components through the use of chemical and mechanical means.
5. **Absorption:** passage of the molecules into the body's blood stream and movement into the cells.
6. **Egestion:** removal of undigested food and wastes.

Mechanical Digestion versus Chemical Digestion:

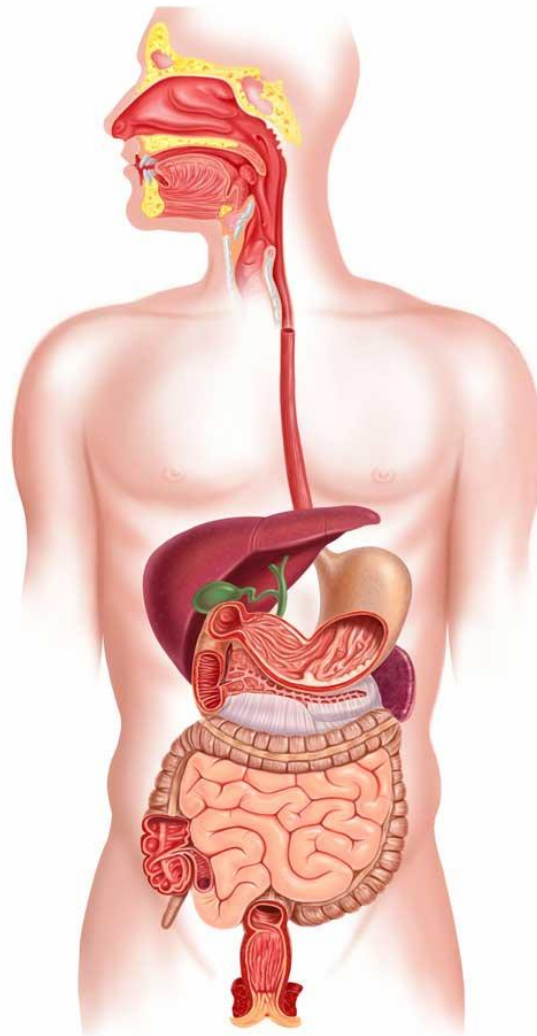
Mechanical Digestion: molecules stay the same size and the physical motions break big pieces into smaller pieces. Ex: chewing.

Chemical Digestion: molecules change and different molecules are produced. Ex: enzyme action.

Factors that stimulate ingestion:

- Habit
- Hunger caused by low blood glucose levels.
- Brain stimulation

Organs of Digestion:



Organs are classified into two groups:

- **Gastrointestinal (GI) Tract:**
 - Tube
 - Oral cavity, pharynx, epiglottis, esophagus, stomach, the small and large intestines, appendix, and the rectum/anus.
- **Accessory Structures:**
 - Teeth, tongue, salivary glands, liver, gallbladder, and the pancreas.
 - Digestive secretions.
- Attached by the **mesentery** ~ tissue that attaches various organs to the body cavity

Organs of Digestion:

Mouth: moistens food with secretions of saliva, grinds food which increase the surface area for chemical digestion, and directs the food down the esophagus. Chewing or **mastication** food creates **bolus**.

Salivary Glands: secretes saliva into food, contains amylase (enzyme) that begins the digestion of starch.

Epiglottis: a flap of skin in the pharynx region that closes off the trachea when swallowing food.

Esophagus: a large muscular tube that carries food to the stomach. It is made of smooth muscle that contracts in a peristaltic wave motion, pushing the bolus of food along.

Peristalsis – squeezing, pushing down

Vomiting – reverse wave pushing up

Stomach:

1. Provides storage for 1 to 2 litres of material for 3 to 5 hours.
2. Mixes organic juices with a muscular wave-like motion.
3. Starts protein digestion.
4. Sets the rate of digestion between 4 to 24 hours.

Cardiac sphincter

chyme

Pyloric sphincter

Liver:

Chemistry lab of the body and is the largest gland

Produces bile (breaks down fats and neutralizes strong acids) which is stored in the gall bladder.

Dual blood supply (poison smasher).

Hepatic Vein
(deoxygenated)
toward the heart

Hepatic Artery (oxygenated)
from the heart

Hepatic Portal Vein (deoxygenated)
From intestine

Pancreas:

- Endocrine gland that produces and secretes hormones into the blood stream. (Insulin and Glucagon)
- Exocrine gland that releases chemicals into the small intestine.

Small Intestine:

Six meters long.

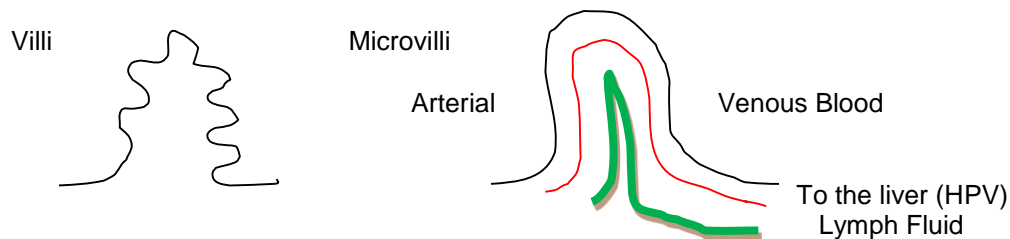
Majority of digestion and absorption occurs in this area.

Movement through active transport.

Three sections: duodenum (shortest), jejunum, and the ileum (longest)

Absorption:

- **Villus Structure:**



- Uses active transport so the cells contain a large number of mitochondria.
- A capillary net supplies the microvilli with oxygenated blood (arterial) and removes carbon dioxide and organic molecules (amino acids, glucose, fatty acids) through the venous vessels (deoxygenated) toward the liver.
- Glycerol and more fatty acids are removed via the lacteal vessel that transports the materials to the lymphatic system.
- **Adaptations for Absorption:**
 1. Villi and Microvilli – increased surface area
 2. Length – buys time and provides more opportunity for digestion.
 3. Water is secreted – moistens the contents
 4. Peristalsis – digested food contacts the absorptive surface faster.
 5. Narrow diameter – molecules are closer to the absorptive surface.

Appendix:

Stores beneficial bacteria which assists in the digestion of organic material.

Large Intestine:

Colon that is three meters long and has three sections: ascending colon, transverse colon, descending colon.

1. Absorbs water, minerals, and salts.
2. Decomposes left-over organic material with the help of resident bacteria (e-coli) which produces vitamin B, K, and Folic acid.

Rectum & Anus:

Stores feces (undigested cellulose and matter) until it is appropriate to eliminate.

Digestion of Carbohydrates

Digestion of Lipids

Digestion of Proteins

Enzyme Summary:

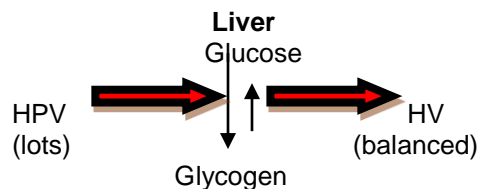
Organ	Digestive Secretion	Active Digestive Agent	Action on Food
Salivary Glands	Saliva	<ul style="list-style-type: none"> • Amylase 	<ul style="list-style-type: none"> • Breaks down starch into maltose
Stomach	Gastric Juice	<ul style="list-style-type: none"> • Pepsinogen (+HCL) into Pepsin • Rennin • Lipase • Mucin 	<ul style="list-style-type: none"> • Protein to peptide chains • Clots milk • lipids into 3 fatty acids and 1 glycerol • protective mucus secretion
Liver	Bile (gall bladder)	<ul style="list-style-type: none"> • Bile Salts 	<ul style="list-style-type: none"> • Emulsifies fats • Neutralizes acids
Pancreas	Pancreatic Juice	<ul style="list-style-type: none"> • Sodium Bicarbonate • Lipase • Amylase • Peptidase <ul style="list-style-type: none"> • Trypsin (active) • Chymotrypsin (active) 	<ul style="list-style-type: none"> • Neutralizes acids • Breaks down fats to fatty acids and glycerol • Breaks down starch to maltose • Continues the protein breakdown of amino acids.
Small Intestine	Intestinal Juice (intestinal glands)	<ul style="list-style-type: none"> • Carbohydrase <ul style="list-style-type: none"> ○ Maltase ○ Sucrase ○ Lactase • Mucin • Erepsin 	<ul style="list-style-type: none"> • Completes digestion of sugars to glucose. • protective mucus secretion • Continues the protein breakdown of amino acids.

Absorption:

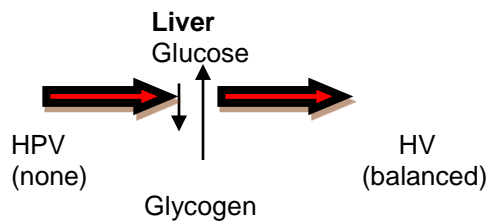
- Stomach: alcohol and drugs
- Small Intestine: organic compounds
- Large Intestine: water, minerals, salts, vitamins

How the liver handles excessive material:

- Glucose is stored in the liver and muscle in the form of glycogen controlled by insulin. Insulin is produced by the pancreas.



- Glycogen is released by the liver and muscles in the form of glucose controlled by glucagon. Glucagon is produced by the pancreas.



- Glycerol and fatty acids are converted into lipids and is stored as fat.
- Amino acids broken down (**deamination**) into fatty acids that is stored in the liver or in fatty tissue and urea which is excreted via the kidney.
- Water and minerals are stored in the blood and excess goes through kidneys.
- Vitamins that are water soluble goes through kidneys and vitamins that are fat soluble are stored in fatty tissue.

Glands are stimulated by:

- Neural control: senses
- Hormonal control: hormones in the blood
- Mechanical control or Movement: peristalsis and other movement

The hormonal control of digestion:

Gastrin:

Trigger: presence of undigested food in the stomach

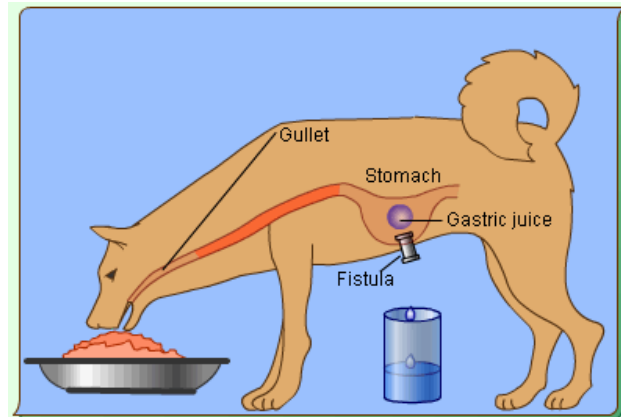
Produced by: cells lining the stomach

Released into: blood

Travels to: gastric glands

Cause: release of HCl, pepsinogen, and lipase

Effect: digests proteins and lipids



Cholecystokinin (CCK) and Secretin:

Trigger: food in the small intestine

Produced by: cells lining the duodenum

Released into: blood

Travels to: gall bladder and pancreas

Cause: release of bile to emulsify fat and the release of pancreatic juice (protease, amylase, and lipase)

Effect: neutralizes acids and digests fats, starch, and proteins

Technologies:

- Endoscope: tube-shaped camera that is inserted into the abdominal cavity.

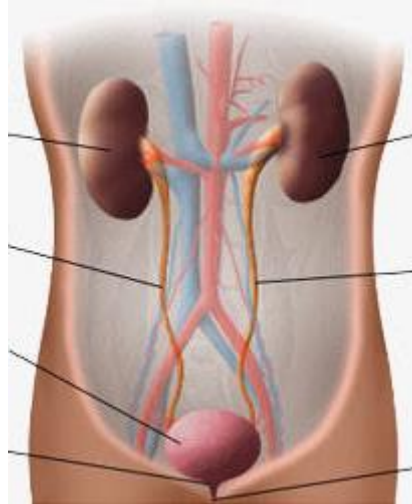
Unit 5: Excretion & Pulmonary Systems

Excretion:

Location of the Kidney: *Renal*

- Abdominal cavity towards the back
- Right kidney is slightly higher than the left kidney.

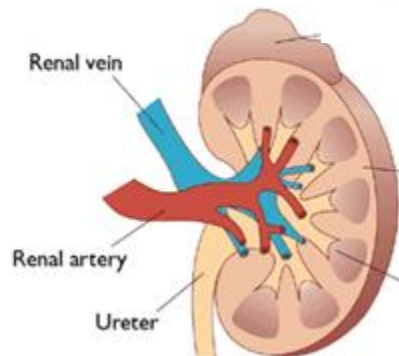
Diagram of the Urinary System:



Role of the Kidney:

- Remove “waste”
- Remove any chemical that is present in the blood in amounts greater than the body needs. (water, salt, glucose, etc.)
 - I.e., the kidney is an organ of homeostasis

Structure of the Kidney:



Nephron:

Deamination: Removal of amino group from an organic compound which forms one molecule of urea and one fatty acid.

- Urea ~ two molecules of ammonia and one molecule of carbon dioxide (less toxic)
- Uric Acid ~ waste from breakdown of nucleic acid

Processes of the Kidney:

1. **Force or Glomerular Filtration:**

- Movement of fluids (exception of proteins) from the **glomerulus** (blood) into the **Bowman's capsule** due to blood pressure to become apart of the nephric filtrate.

2. **Tubular Reabsorption:**

- Selective transfer of essential solutes back into the blood through active transport. Molecules the body still needs.
- **Proximal tubule, ascending loop of Henle, and distal tubule**

3. **Tubular Secretion:**

- Movement of wastes from the blood into the nephron through diffusion.
- 15% of the molecules stay within the nephric filtrate and are removed via the bladder.
- **Proximal tubule, distal tubule**

4. **Water Reabsorption:**

- Removes water from the filtrate and returns it to the blood.
- **Proximal tubule, descending loop of Henle, distal tubule, and collecting tube.**

Kidney Reabsorption:

- Glucose, amino acids, vitamins, and minerals are absorbed by active transport.

- Change in solute concentration as Cl⁻ is attracted to the + blood causes the tubule to become **hypotonic** and the blood **hypertonic**.

Hormonal Control of Water Reabsorption: Urine Formation.

Hormone: Aldosterone

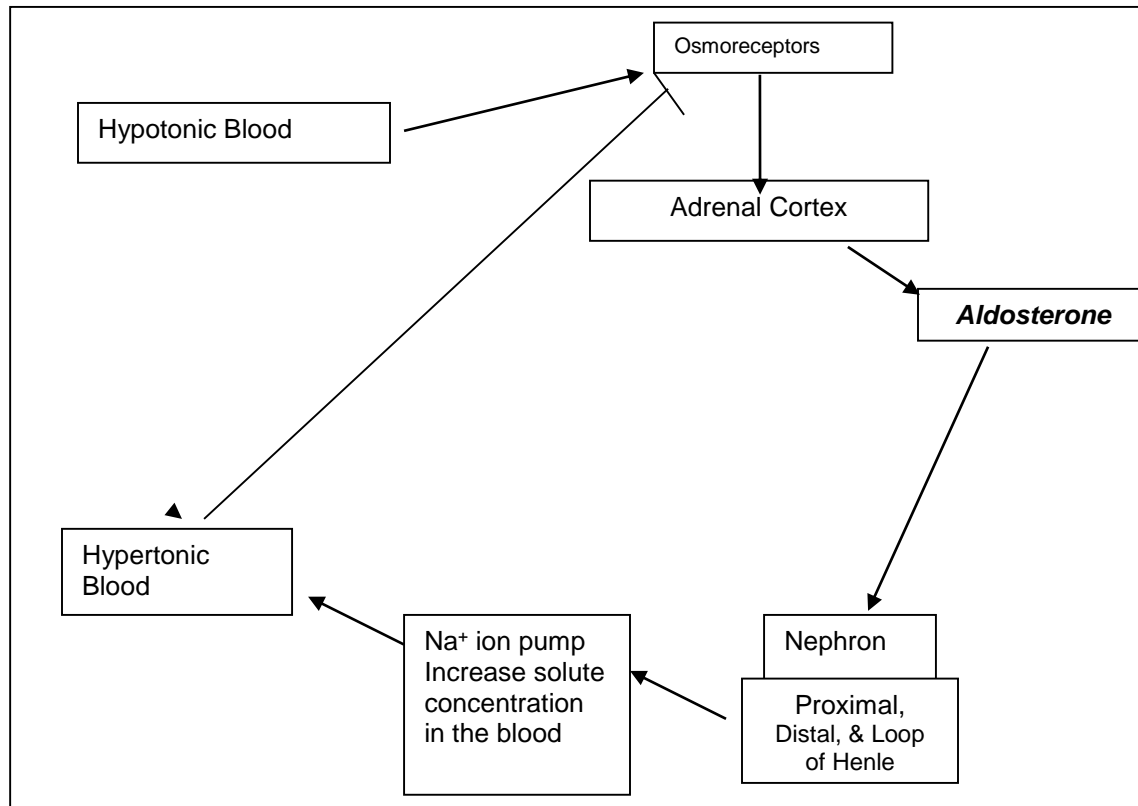
Source: Adrenal Cortex

Trigger: Decreased solute concentration in the blood and increased osmotic pressure.

Released: blood

Target: Proximal tubule, ascending loop of Henle, and distal tubule

Effect: Reabsorbs Na ions (Na pump) into the blood



Hormone: Anti Diuretic Hormone (ADH)

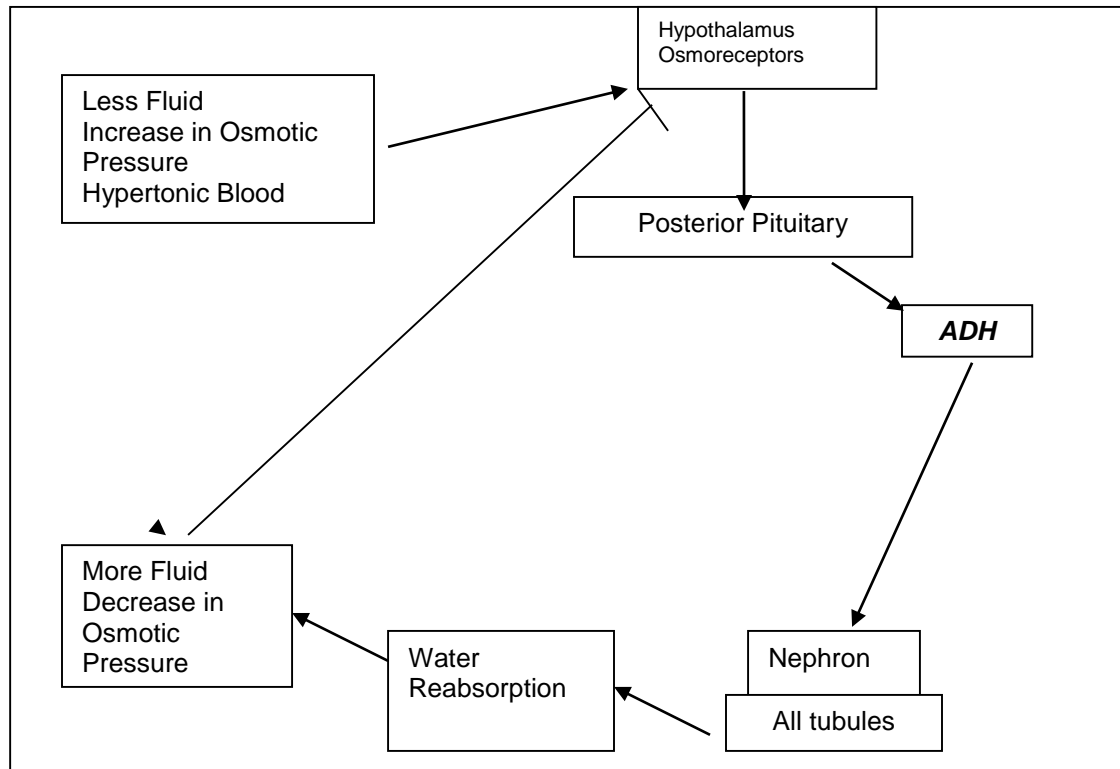
Source: Posterior end of the Pituitary Gland

Trigger: increased solute concentration in the blood and decreased osmotic pressure.

Released: blood

Target: Proximal tubule, descending loop of Henle, distal tubule, and collecting tube.

Effect: increased water reabsorption.



Kidney Diseases:

- *Diabetes Mellitus:* sugar diabetes, body is not producing enough insulin, sugar is not reabsorbed, causing a greater loss of water.
- *Diabetes Insipidus:* cannot produce ADH to regulate water reabsorption.
- *Kidney stones:* precipitation of mineral solutes in the blood break the kidney tissue.
- *Bright's disease:* protein found in the urine

Case Study: Comparing Solutes in Plasma, Nephron, and Urine

Micropipettes were used to draw fluids from the Bowman's capsule, the glomerulus, the loop of Henle, and the collecting duct. Solutes in the fluids were measured. The resulting data are displayed in Table 1.

Table 1 Solute Concentrations in Various Parts of the Kidney

Solute	Bowman's Capsule	Glomerulus	Loop of Henle	Collecting Duct
Protein	0	0.8	0	0
Urea	0.05	0.05	1.50	2.00
Glucose	0.10	no data	0	0
Chloride Ions	0.37	no data	no data	0.6
Ammonia	0.0001	0.0001	0.0001	0.04
Substance X	0	9.15	0	0

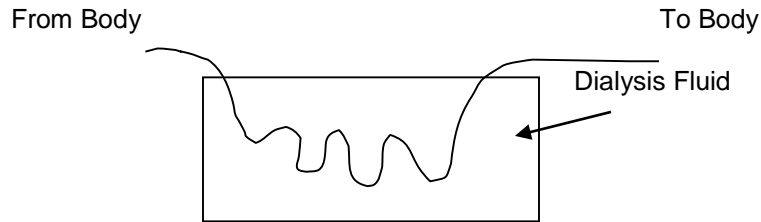
Quantities are in g/100ml

Application Questions:

1. Which of the solutes was not filtered into the nephron? Explain your answer.
2. The test for glucose was not completed for the sample taken from the glomerulus. Predict whether glucose would be found in the glomerulus. Provide reasons for your prediction.
3. Why do urea and ammonia levels increase after filtration occurs?
4. Chloride ions, Cl^- , follow actively transported sodium ions, Na^+ , from the nephron into the blood. Therefore, you would expect the Cl^- concentration to decrease as fluids are extracted along the nephron. What causes this discrepancy?
5. Is it correct to say that veins carry blood with high concentrations of waste products and arteries carry blood with high concentrations of nutrients? Explain.
6. Compare the blood found in a renal artery and a renal vein with respect to urea and glucose.

Technologies:

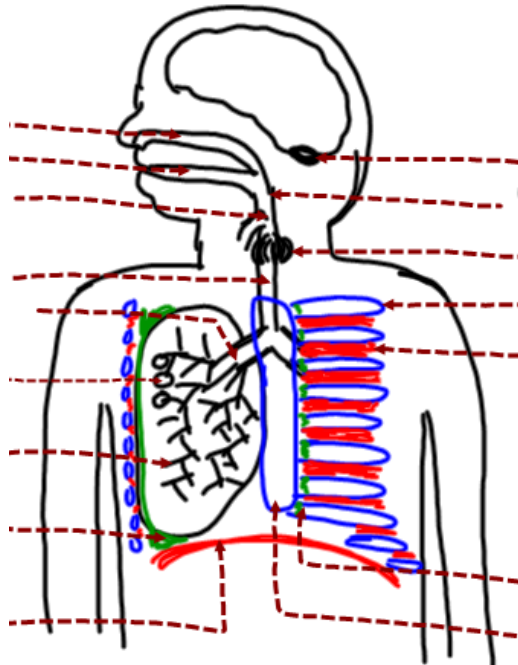
- **Dialysis:**



- Solution is maintained at body temperature, contains no urea, and has a balanced concentration of glucose, amino acids, minerals, vitamins, and fatty acids.

Breathing and Gas Exchange:

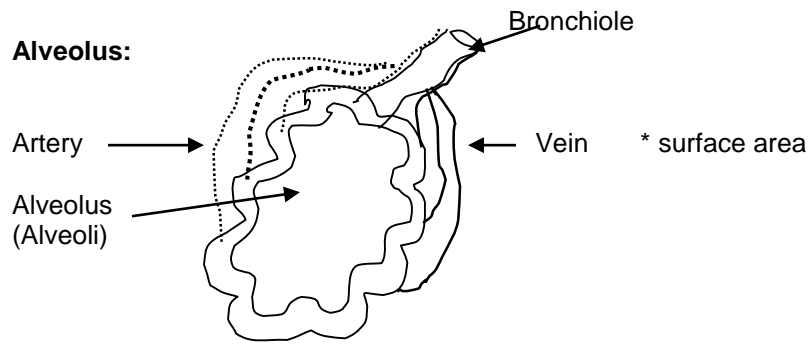
Pulmonary System:



Bronchiole:

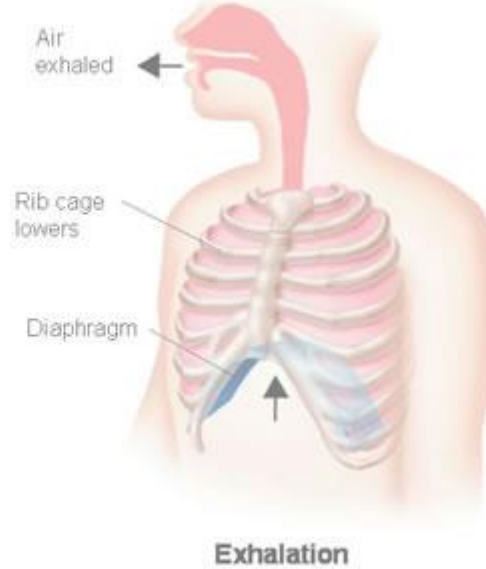
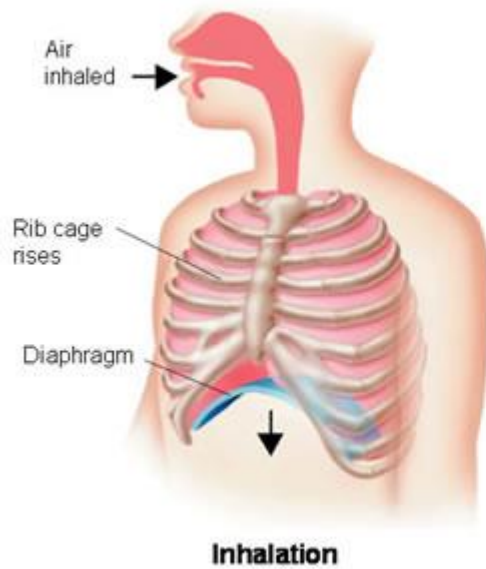


Beating cilia move a river of mucus up so we can clear our throat and swallow. Cleaning of our bronchus of dust particles.



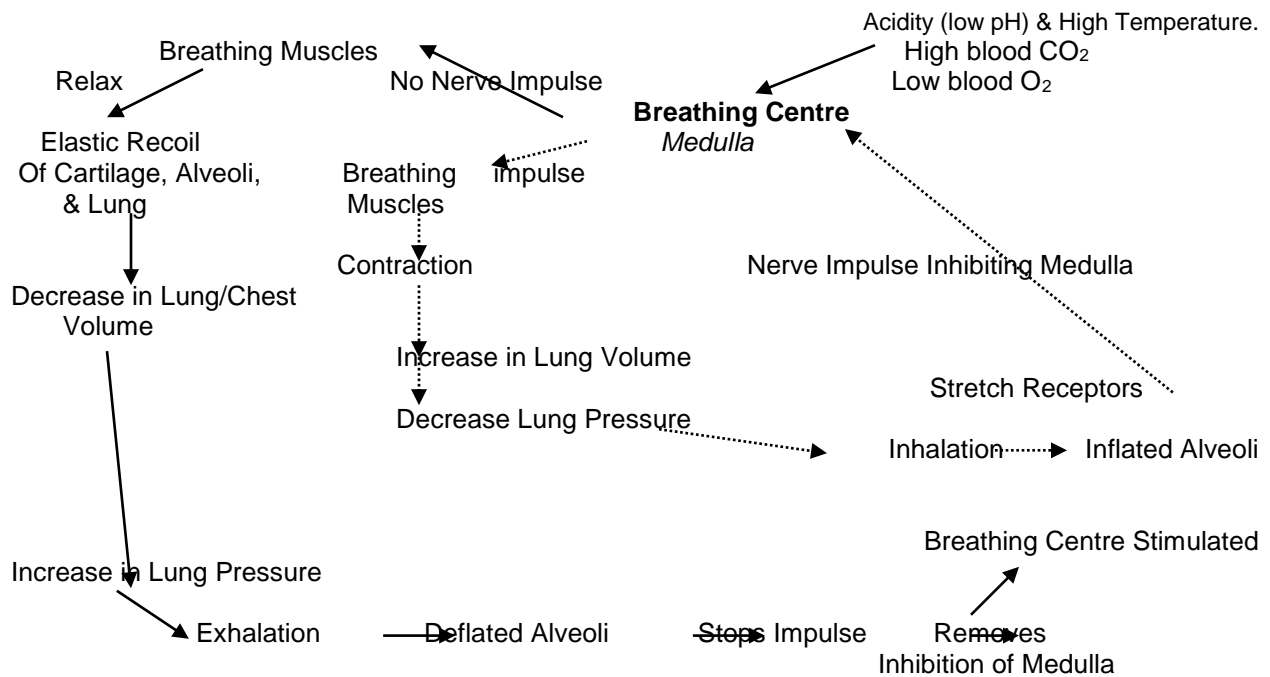
Composition of Air:

Compound	Inhaled Air	Exhaled Air
N ₂	78%	78%
O ₂	21%	16%
CO ₂	0.04%	5%



High pressure to Low pressure
Forces air into the lungs

Breathing Centre:



Chemoreceptors: send an impulse to the medulla initiating the breathing process.

Stretch Receptors: (inflated) inhibit the nerve impulse to the ribs. (deflated) enables chemoreceptors to signal the medulla

Breathing Volumes

Residual (Dead) Air: air needed to maintain the inflation of the lung

Tidal Volume: normal breathing (10%)

Inspiratory Reserve Volume: inhale deeply as much as one can

Expiratory Reserve Volume: exhale deeply as much as one can

Vital Lung Capacity: Tidal, inspiratory, and expiratory reserve volumes.

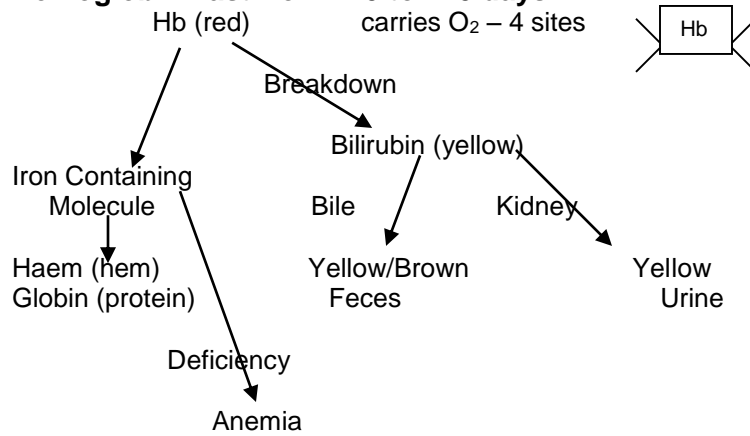
Total Lung Capacity: All capacities together.

Case Study: Measuring Respiratory Volumes

Patient	Tidal Volume (mL)	Vital capacity (mL)	Respiratory rate of patients at rest (breaths/min)
1 (normal)	500	5 000	18
2	500	4 000	20
3	400	3 000	38
4	550	5 000	17
5	550	6 000	17

1. Distinguish between tidal volume and vital capacity.
2. What is the relationship between vital capacity and respiratory rate?
3. Which patient is likely a long distance runner? How do you know?
4. Which patient is likely suffering from pneumonia? How do you know?
5. A ventilator is a piece of medical equipment that maintains respiratory movements in a person who is unable to breathe. Consider a young, otherwise healthy person who is paralyzed as a result of a car crash. Would it be a good idea to adjust a ventilator to maximize the volume of air inhaled and exhaled? Explain.

Hemoglobin: last from 110 to 120 days



Gas Exchange:

Lung – Blood Exchange:

Hb – Hemoglobin

HHb – Reduced Hb – dull red

HbO₂ – Oxyhemoglobin – bright red

Tissue – Blood Exchange

Oxygen Deficiency:

Short Term:

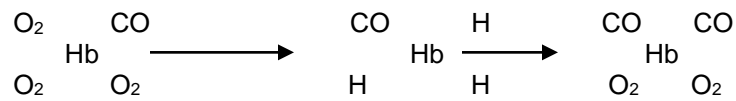
1. Increased breathing rate and depth
2. Increased heart rate

Long Term

1. Increased Hb production (red blood cells).

Carbon Monoxide Poisoning:

Hb picks up CO easier than O₂ and has a stronger bond.
One dies of a lack of oxygen.



Bends:

Gases in the body are dissolved into the blood. At a low altitude (underwater) the blood has more gas can dissolve. However, once one rises to the top (higher altitude) the gases become insoluble and bubbles form.

Diseases of the Pulmonary System:

1. **Tonsillitis:** infection of tonsils
2. **Laryngitis:** inflammation of the larynx
3. **Bronchitis:** bronchi become inflamed and filled with mucus
4. **Pneumonia:** alveoli fills with liquid due to inflammation
5. **Pleurisy:** swelling and irritation of the pleura
6. **Emphysema:** over-inflation of the alveoli. Continued over-inflation can lead to the rupture of the alveoli.
7. **Cystic Fibrosis:** genetic condition that causes the mucus in the lung to become sticky
8. **Asthma:** reduced air flow due to inflammation.
9. **Lung Cancer:** most common death of Canadians. Uncontrolled growth of cells that decreases the surface area for diffusion.

Technologies:

- CT scan- specialized X-ray can be used to detect lung cancer.