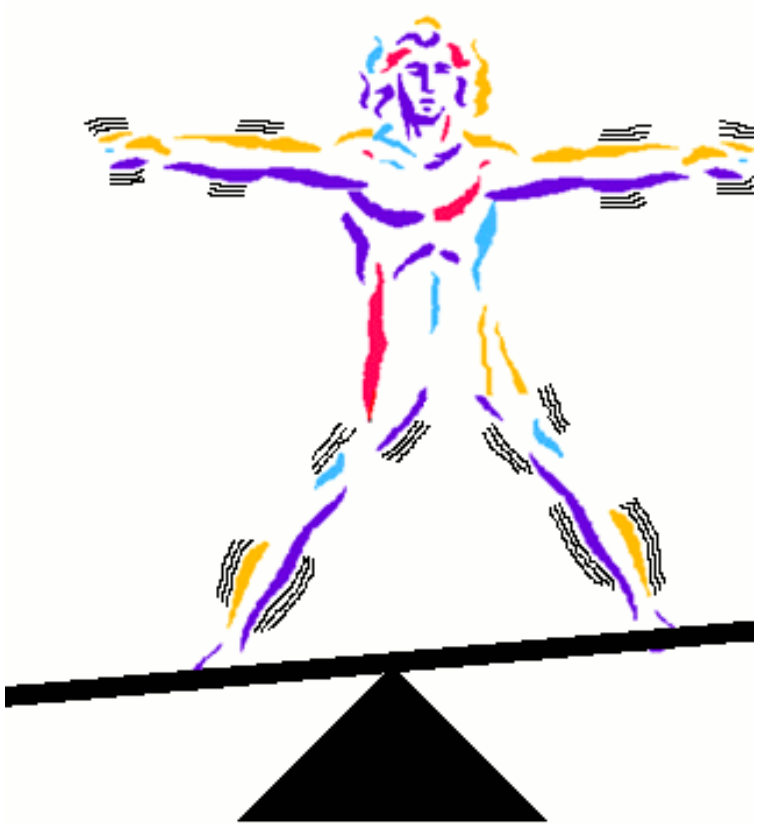
Homeostasis

Unit 3 – Maintaining Dynamic Equilibrium

Homeostasis

- The body's maintenance of a relatively stable internal environment
- Maintaining consistency with varying external environmental conditions
- External environment doesn't always provide the ideal conditions for life
- Body systems must adjust



Dynamic Equilibrium

- A state of balance achieved within an environment as a result of internal controls
- Example of Dynamic Equilibrium:
  - Homeostasis
  - Negative Feedback Loops
  - Temperature regulation

Temperature Regulation

- **Homeotherms** – animals that maintain a constant body temperature
- **Poikilotherms** – body temperature changes to that of the external environment

Temperature Regulation

- Heat is created as a by product of metabolic activity
- Our bodies have several ways to control heat loss
- Can be both:
  1. **Physiological**
  2. **Behavioral**

Temperature Regulation

1. **Behavior Mechanisms**

- Sitting by a fire
- Seeking shade
- Putting a sweater on, or taking a sweater off
- Shipping off to warmer climates

Temperature Regulation

2. Physiological Mechanisms

- Vasoconstriction
  - Capillaries close to skin constrict, limiting blood flow (takes blood away from surface)
  - Heat conservation
- Vasodilation
  - Capillaries close to skin dilate, increasing blood flow near the surface
  - When heat needs to be released

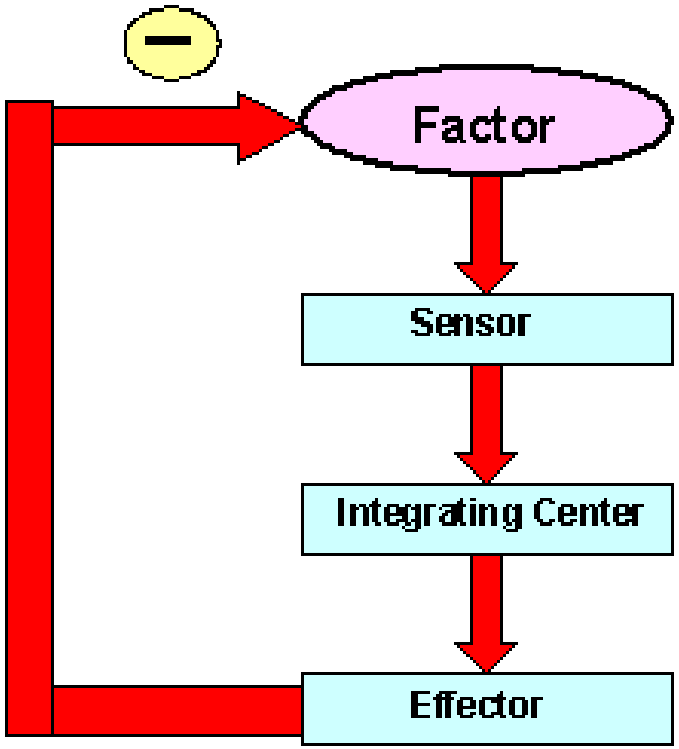
Temperature Regulation

2. Physiological Mechanisms

- Sweating
  - When it's hot, sweat glands are stimulated
  - Perspiration released and evaporates on skin
  - Skin cools down
- Shivering
  - Rapid muscle contractions which help generate heat by body movements

Negative Feedback Loops

- Temperature regulation is an example of a **negative feedback loop**
- NFL's are processes that detect and reverse conditions from normal body constants
- Examples:
  - Blood Glucose
  - Sperm production



Negative Feedback Loops

- NFL's involve three parts:

1. **Receptor**

- Sensory receptors used to detect stimuli and send messages to the brain

2. **Integrator**

- Usually the hypothalamus, it receives information and relays information to effectors

3. **Effector**

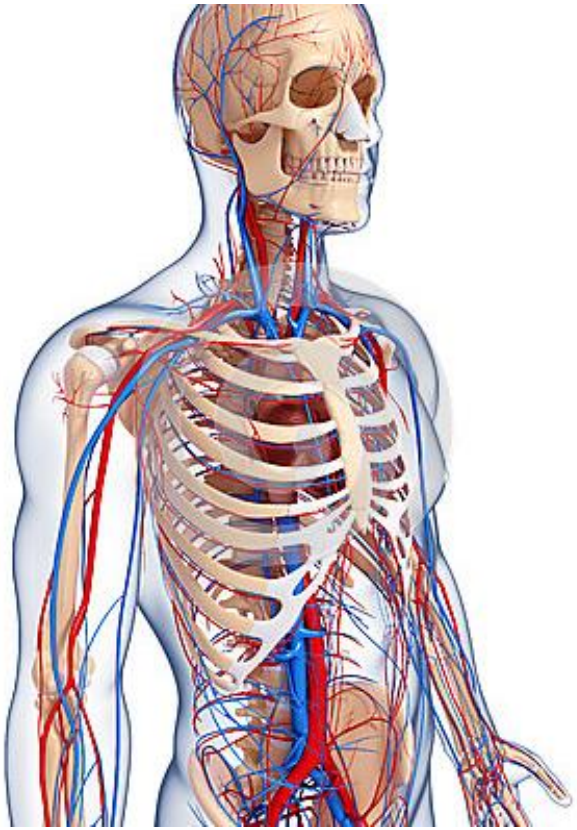
- Cause changes in conditions, they carry out a response
- Typically glands, organs and specialized tissues or muscles

The Circulatory System

Unit 3 – Maintaining Dynamic Equilibrium

Function of the Circulatory System

- Transport blood throughout the body
- Including:
  - Nutrients
  - Oxygen
  - Wasters
  - Hormones
  - Immune System Components



Human Circulatory System

- **Closed circulatory system**
- **4-Chambered Heart**
  - Two Atria – receiving chambers
  - Two ventricle – pumping chambers
- **Two circuit system:**

1. **Pulmonary**
   - Takes deoxygenated blood from the heart through the lungs and to be supplied with oxygen
2. **Systemic**
   - Takes oxygenated blood from the heart to the body and then back to the heart

Human Circulatory System

- Made of three parts:

1. **Vessels**

- Blood carrying arteries, veins, and capillaries

2. **Medium (Blood)**

- Fluid containing ingredients necessary for life

3. **Pump (Heart)**

- Organ that pumps blood into vessels

http://www.youtube.com/watch?v=g0uiDzrGVOI

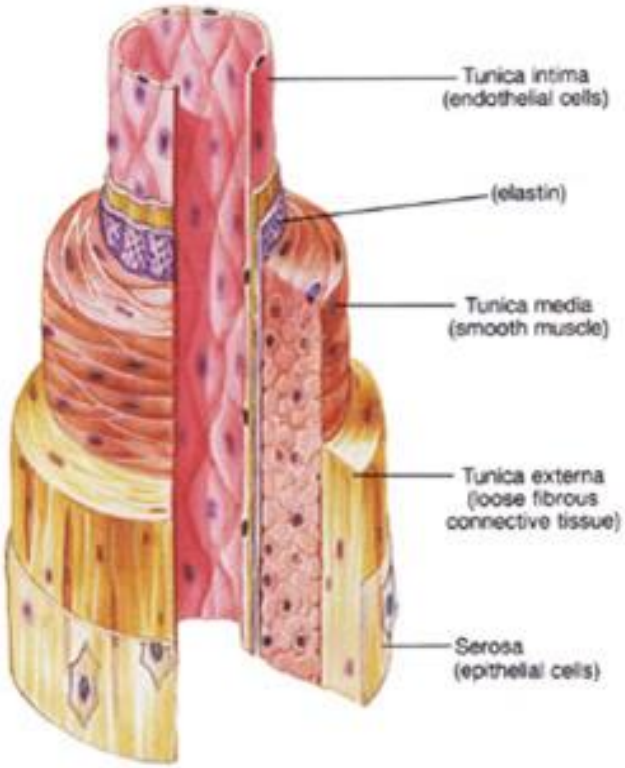
Blood Vessels

- There are three main types of blood vessels:

1. **Arteries**
2. **Veins**
3. **Capillaries**

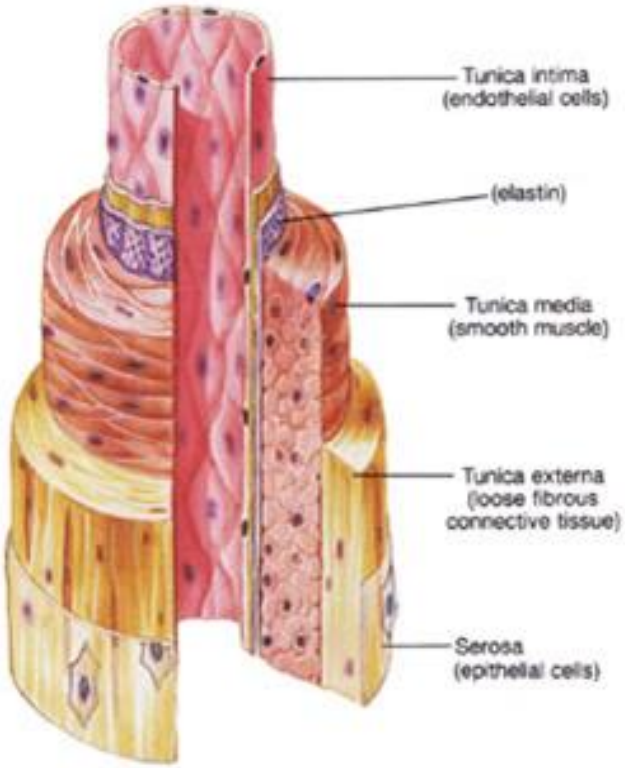
Arteries

- Any blood vessel that carries blood away from the heart
- Smaller arteries known as **arterioles**
- Arteries are made of three layers
  1. **Outer** – connective tissue and elastic fibers
  2. **Middle** – smooth muscle and elastic fibers
  3. **Inner** – single layer of epithelial cells used to reduce friction



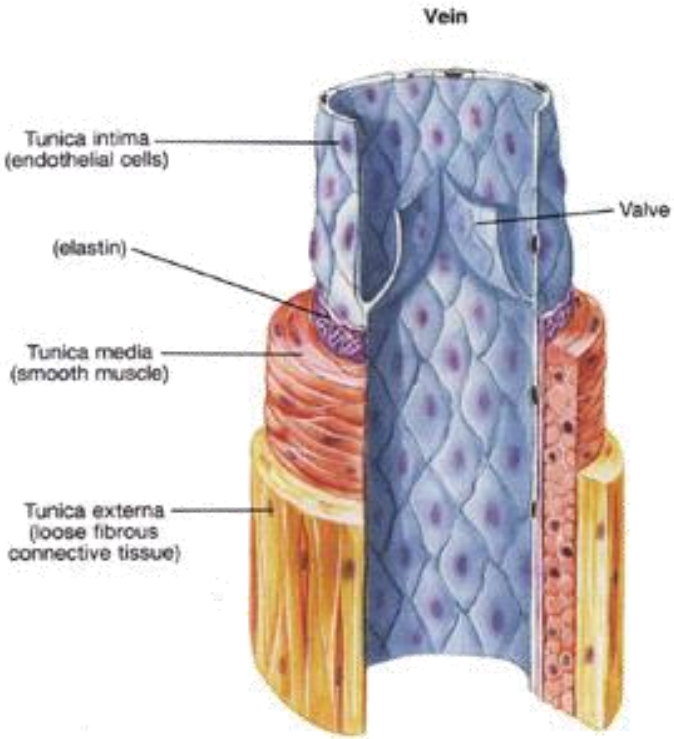
Arteries

- Are designed to handle high-blood pressure straight from the heart
- Thick-walled, strong, and elastic
- Able to expand when blood enters and snap back to normal size, ensuring blood flows in the proper direction
- Arteries hold roughly 30% of systemic blood



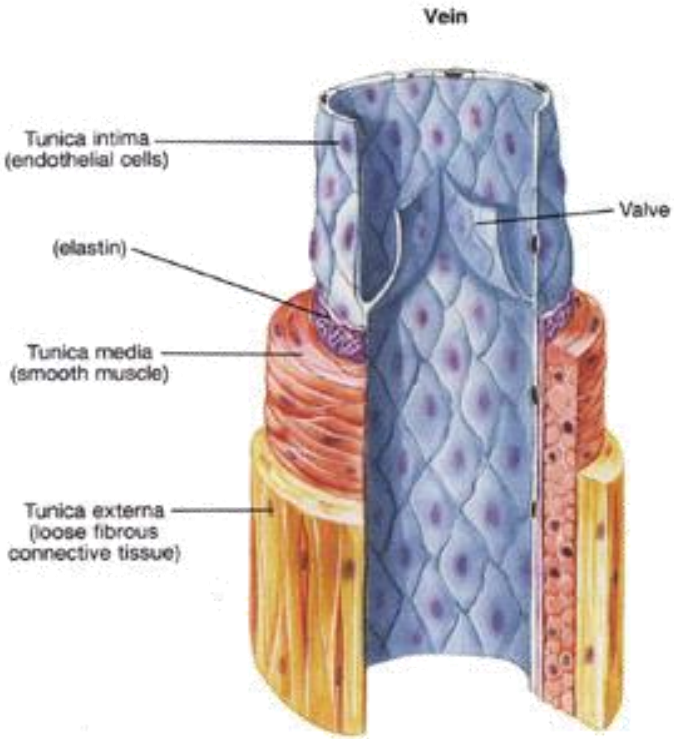
Veins

- Blood vessels that return blood to the heart
- Smaller veins known as **venules**
- Veins contain the same three structural layers as arteries
- Layers are thinner and more flexible
- Blood pressure is much lower than arterial blood, veins do not need to be as rigid



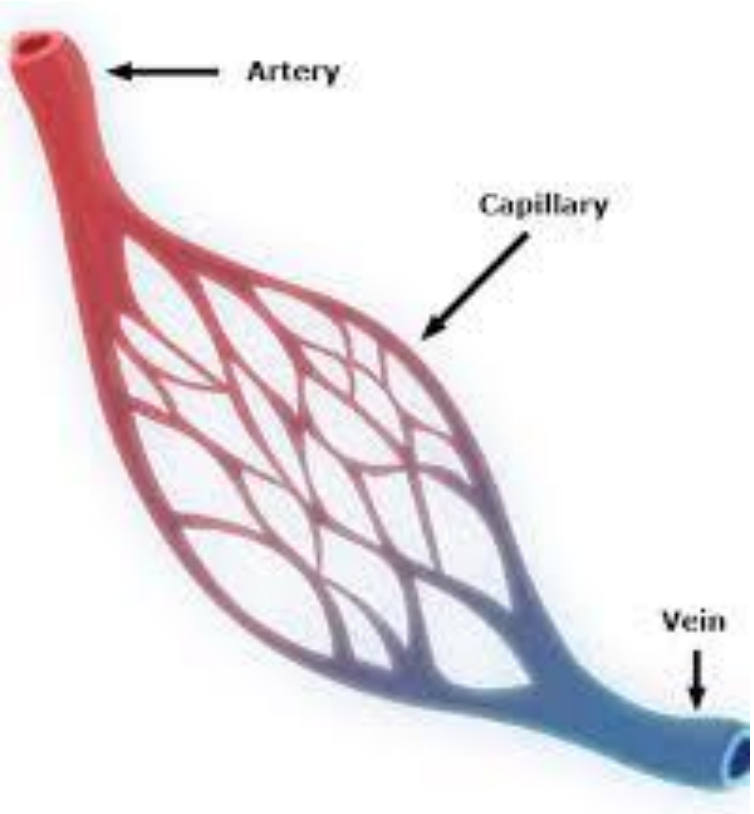
Veins

- Due to lower pressure, venous blood is at more risk to flow backwards
- To solve the problem, venous blood contains **one-way valves** which keep venous blood flowing in the right direction
- Smooth muscle lining veins contract as well
- Veins carry roughly 65% of systemic blood



Capillaries

- Incredibly small blood vessels that connect the circulatory system to body tissues
- Site of nutrient, gas, and waste exchange
- Are one cell layer thick with an average diameter 8 μm
- Small size allows for the diffusion of nutrients, gas, and wastes

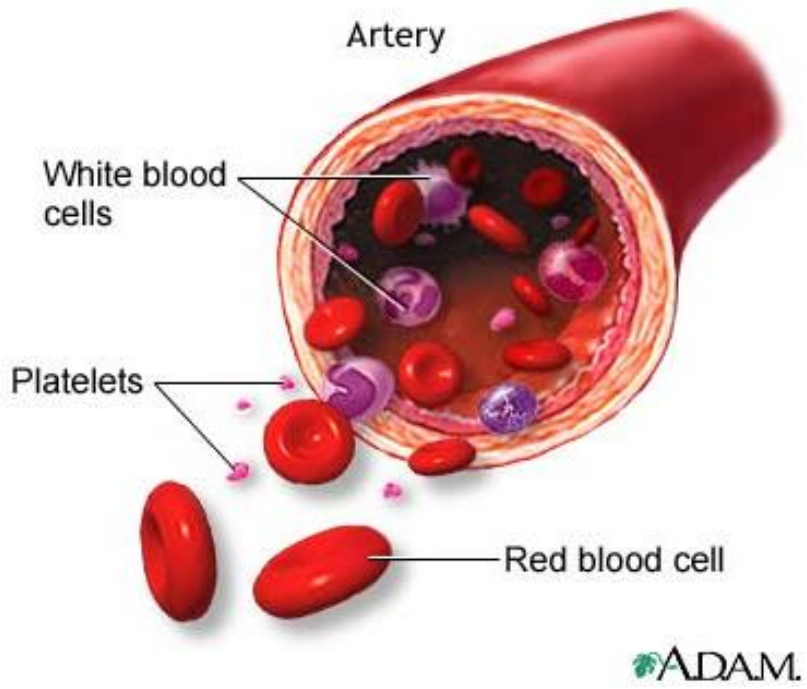


Blood

The Circulatory System

What is the role of blood?

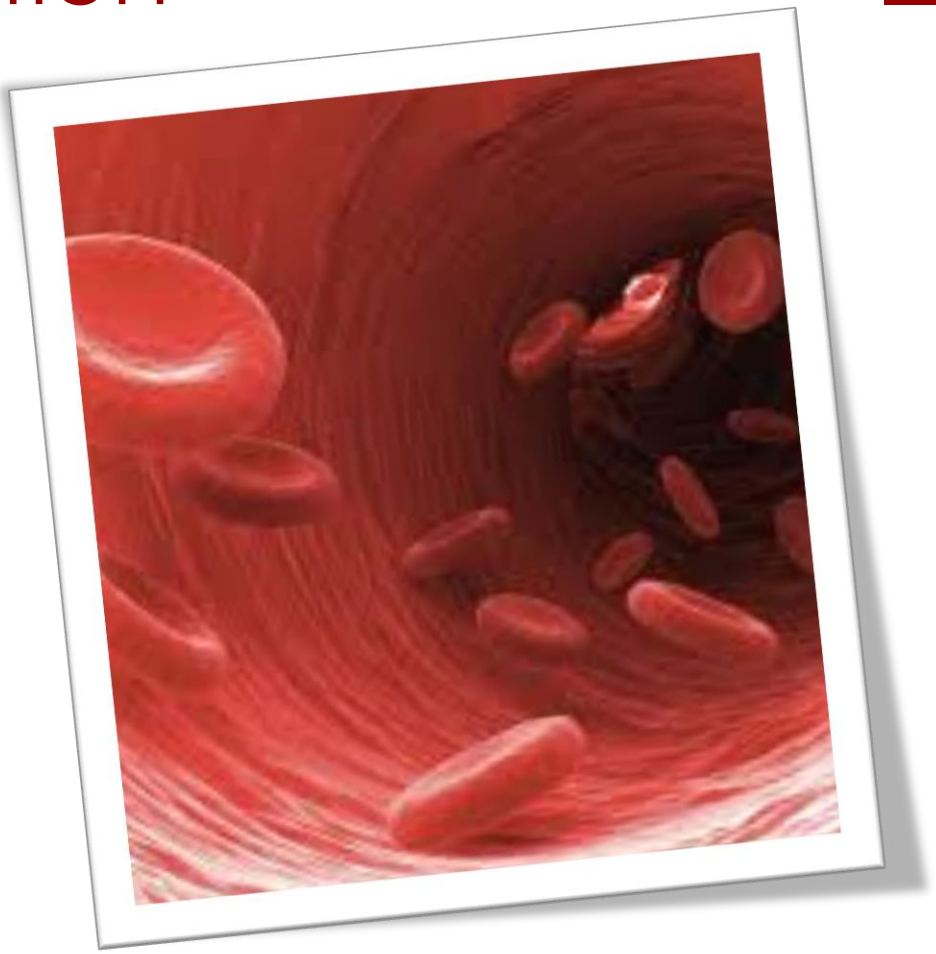
- Nutrient transport
- Immunity
- Distribution of hormones
- Waste removal



Blood Composition

- Consists of two distinct elements:

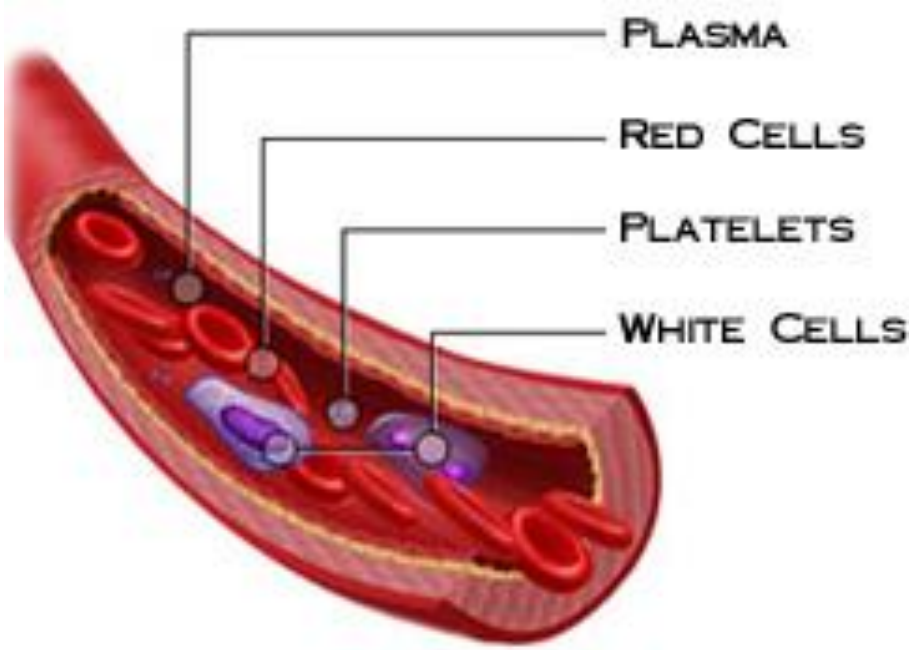
1. **Plasma**
   - Fluid portion
   - 55%
2. **Cellular Component**
   - Formed portion
   - Red and white blood cells, and platelets
   - 45%



Plasma

- Fluid portion of blood
- Carries blood cells, nutrients, and wastes
- Clear fluid composed of water, dissolved substances, and proteins
- Has several functions:

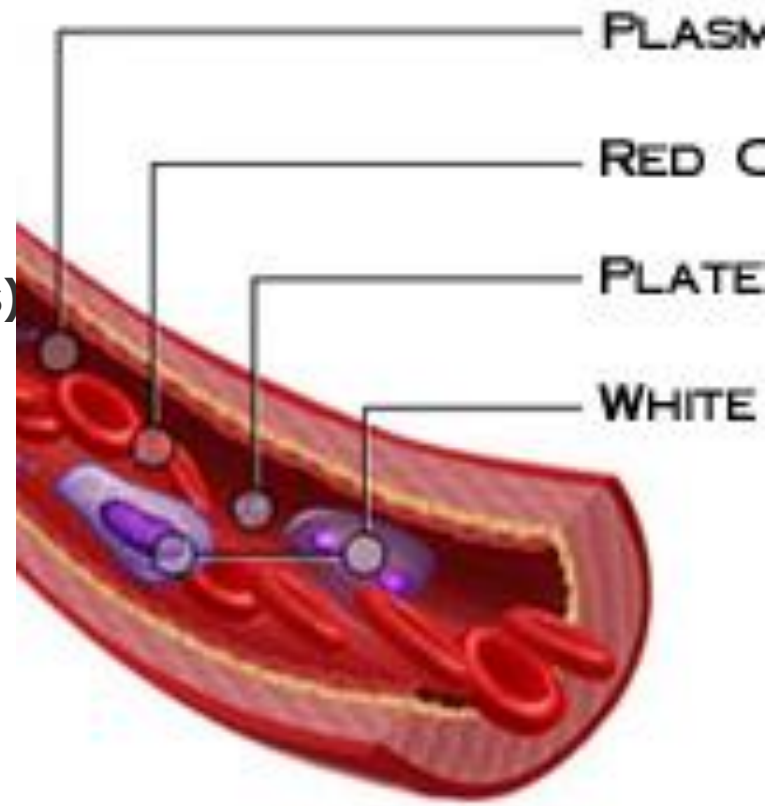
1. Transport small molecules and ions
2. Contains proteins involved in blood clotting
3. Contains antibodies that are involved in disease fighting



Cellular Blood Components

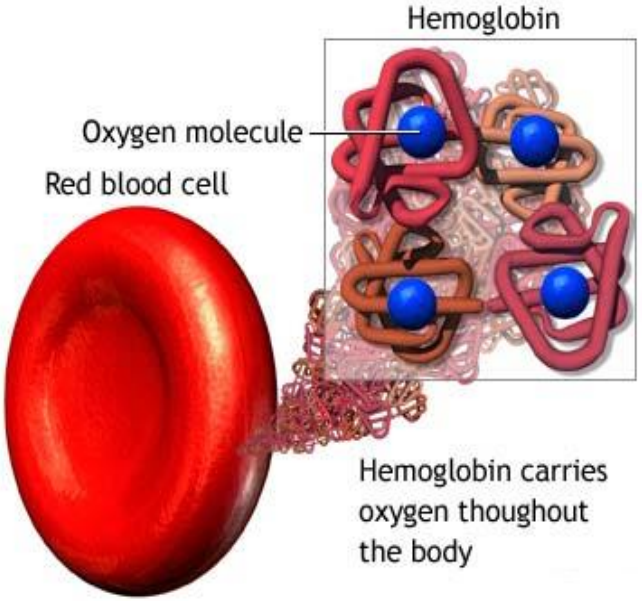
- There are three cellular components to blood:

1. **Red Blood Cells (Erythrocytes)**
2. **White Blood Cells (Leucocytes)**
3. **Platelets**



Red Blood Cells

- Erythrocytes
- On average, people have between **4.5 – 5.5 million per milliliter** of blood
- RBC's are specialized for oxygen transport
- Oxygen transport made possible by **hemoglobin**
- Each hemoglobin proteins contains four oxygen binding sites that allows oxygen to be carried through blood



White Blood Cells

- Leucocytes
- Function to protect the body from infections
- Numbers increase during infection
- Two main types:

1. **Macrophages**

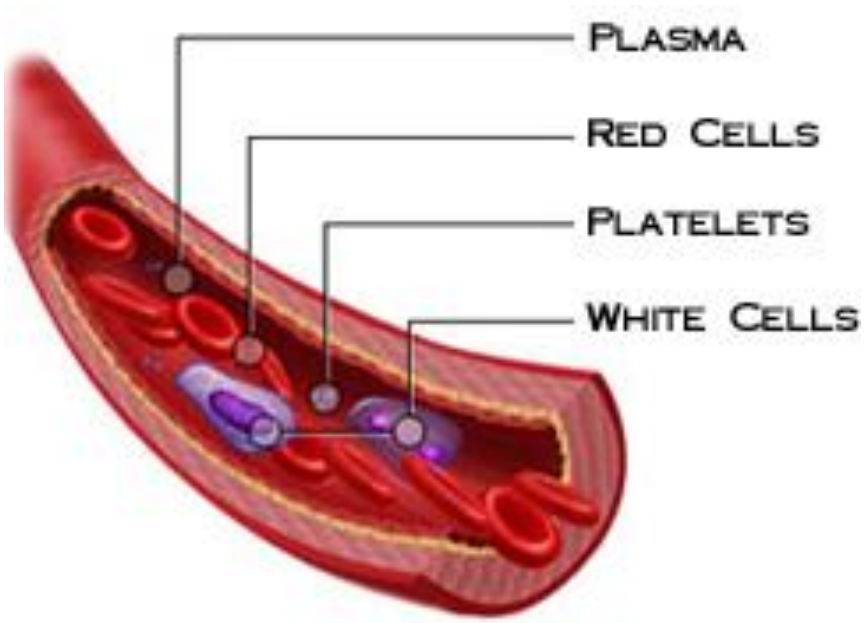
- Phagocytic cells that move out of capillaries and digest foreign materials

2. **Lymphocytes**

- Non-phagocytic cells which manufacture antibodies that fight infection

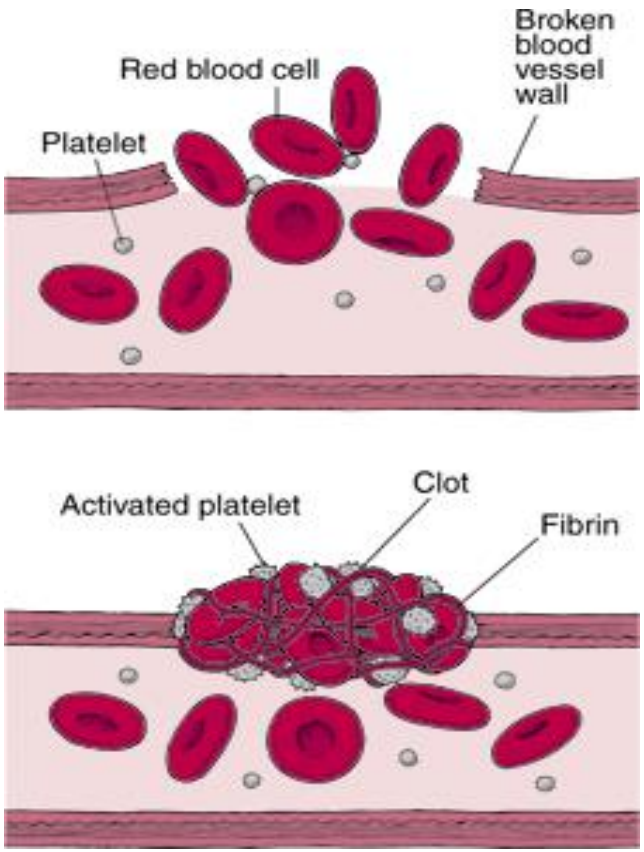
Platelets

- Are not cells, but are fragments of bone marrow cells
- Play an important in blood clotting

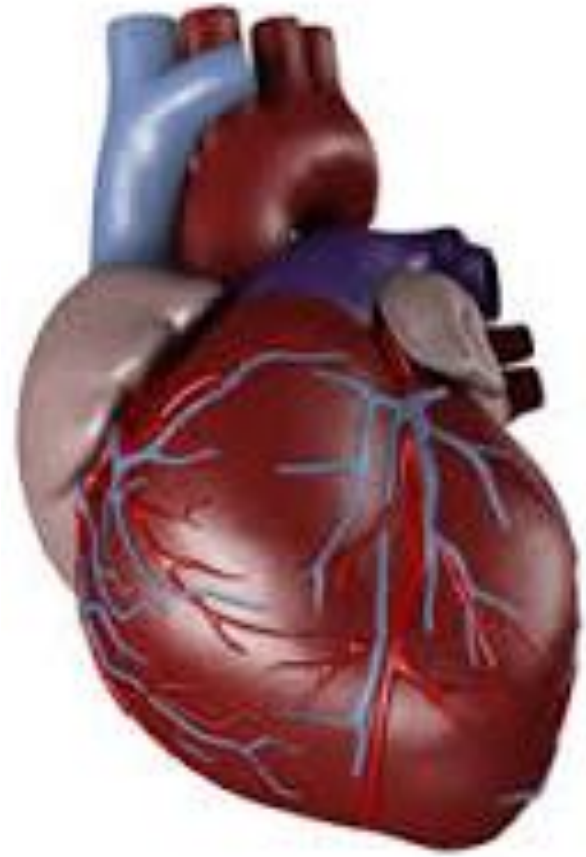


Blood Clotting

1. Broken vessel releases substances which attract platelets
2. Platelets collect and react with each to produce **thromboplastin**
3. **Thromboplastin** reacts with **prothrombin** to produce **thrombin**
4. Thrombin converts fibrinogen into fibrin
5. Fibrin collects to form a mesh strand around the injury



http://adam.about.net/care/Blood-clotting-animation.htm

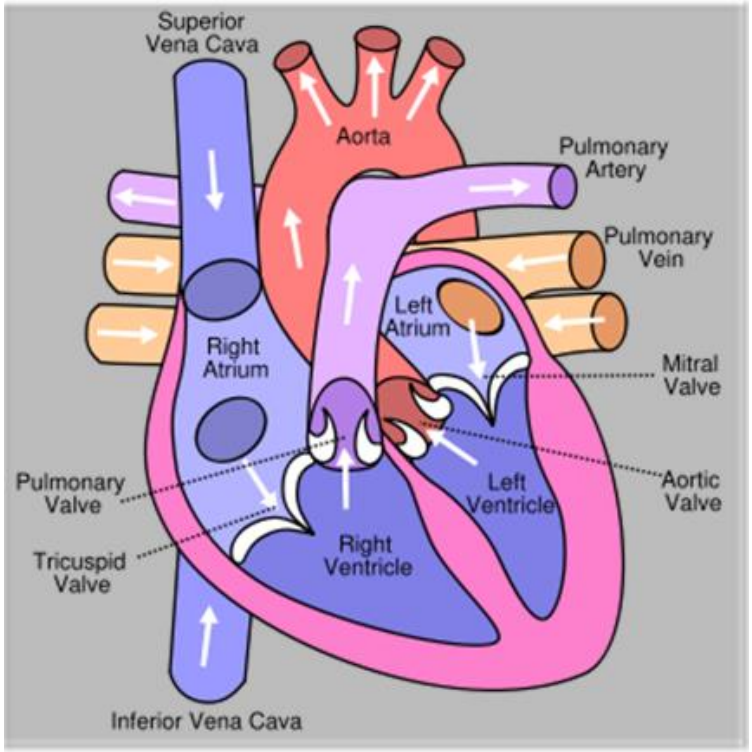


The Heart

The Circulatory System

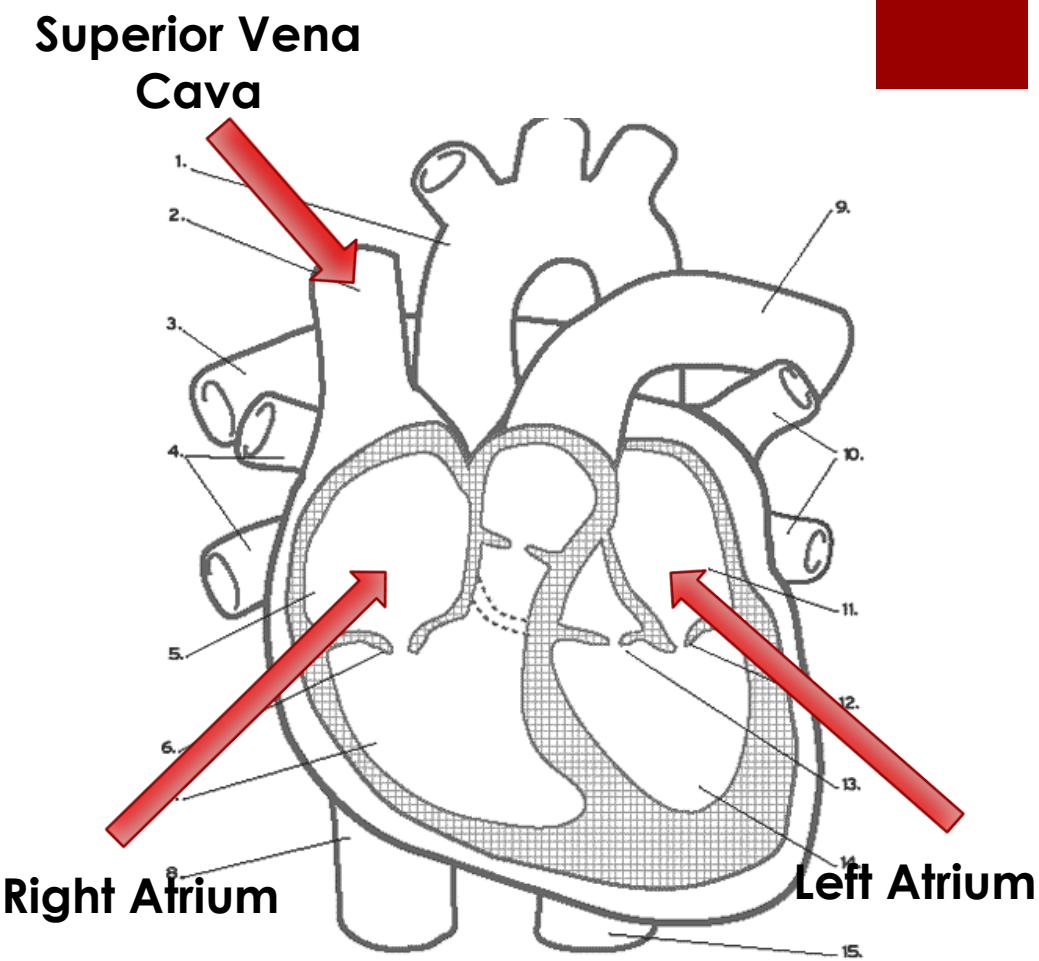
Main Components

- Atria
- Ventricles
- Valves
- Aorta
- Pulmonary Vein
- Pulmonary Artery
- Septum



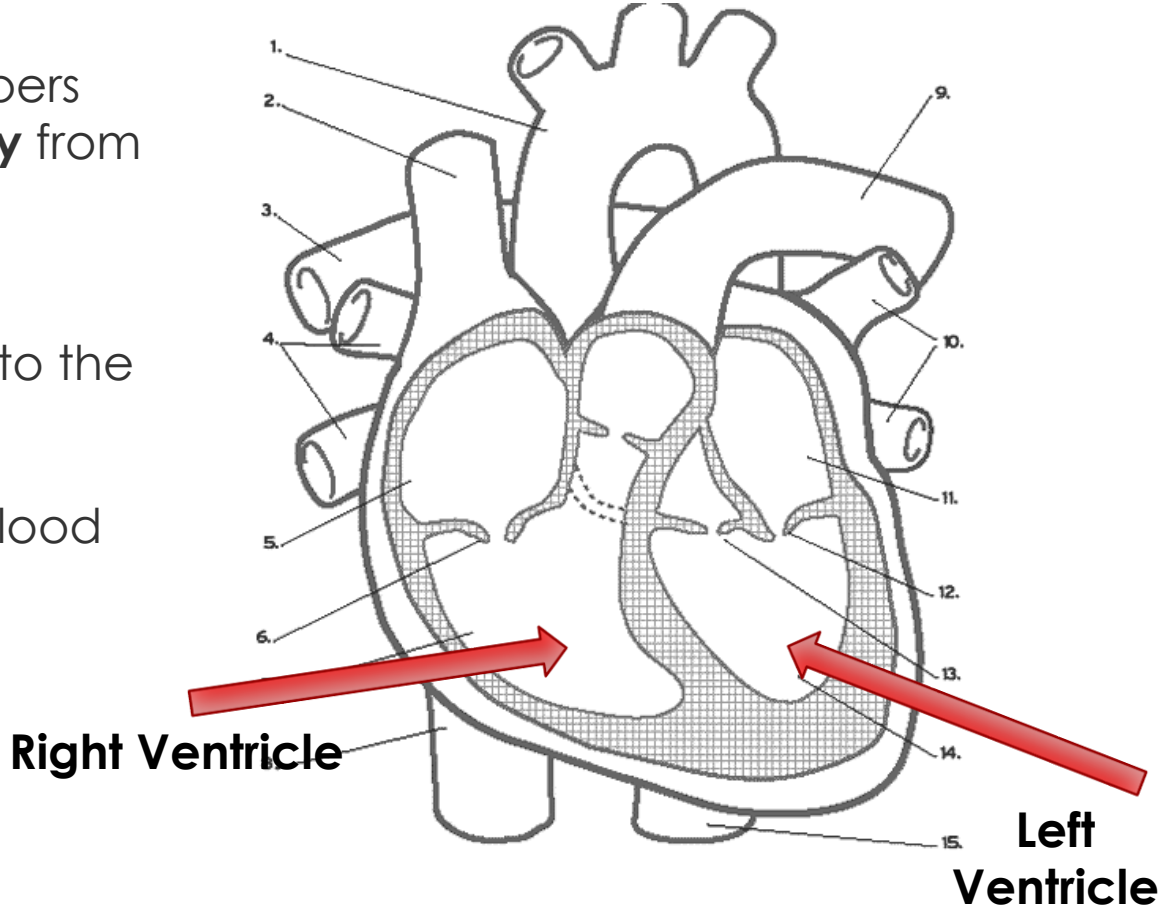
Atria

- Collecting chambers
- **Receive** blood from lungs and body, pump it into ventricles
- Right Atria receives deoxygenated blood from the body
- Left atria receives oxygenated blood from the lungs



Ventricles

- Thick, muscular chambers that pump blood **away** from the heart
- Right ventricle pumps deoxygenated blood to the lungs
- Left ventricle pumps blood to the body



Valves

1. **Bicuspid Valve**

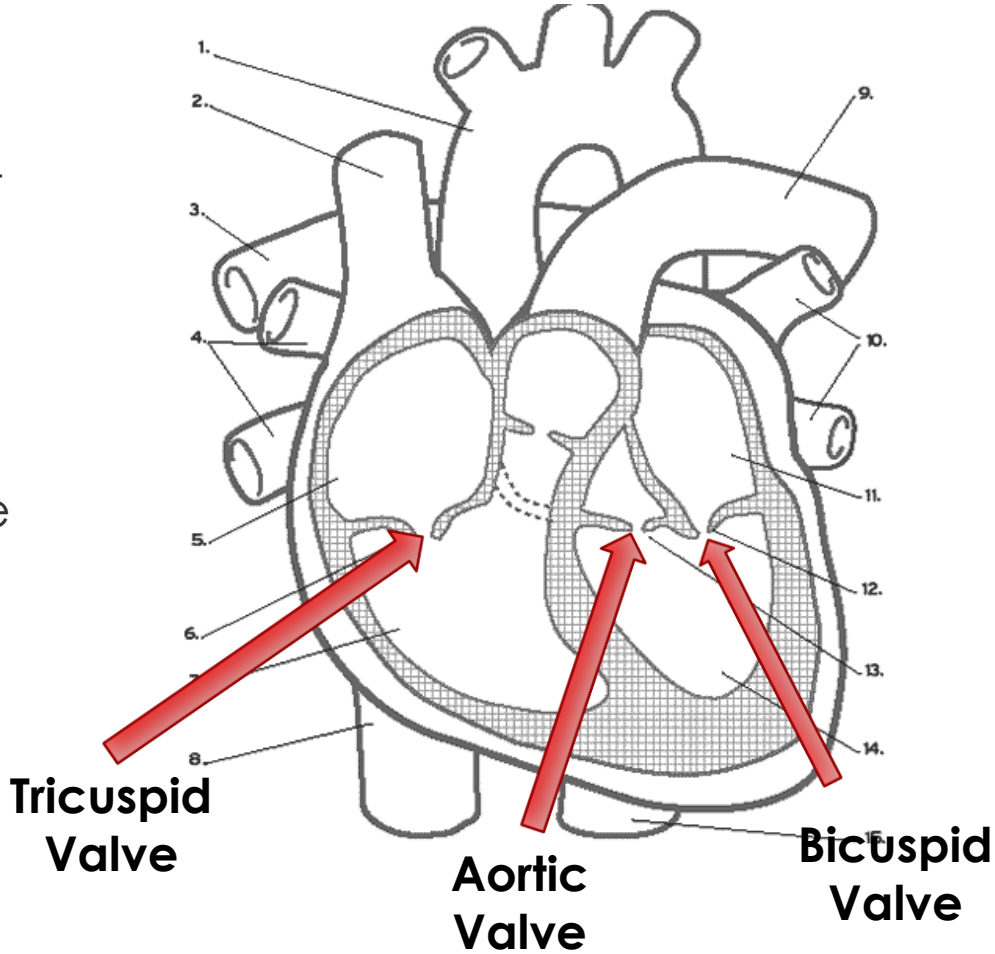
- Regulates flow between left atria and left ventricle

2. **Tricuspid Valve**

- Regulates flow between right atria and right ventricle

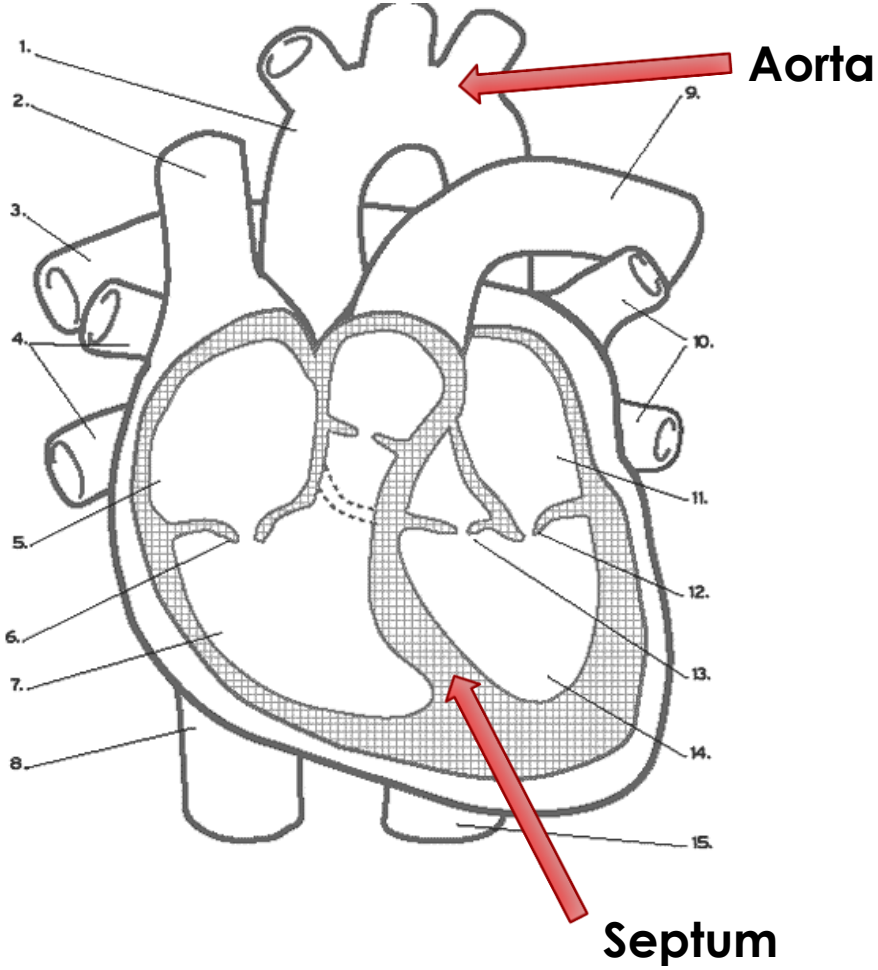
3. **Aortic Valve**

- Regulates flow from the left ventricle into the aorta



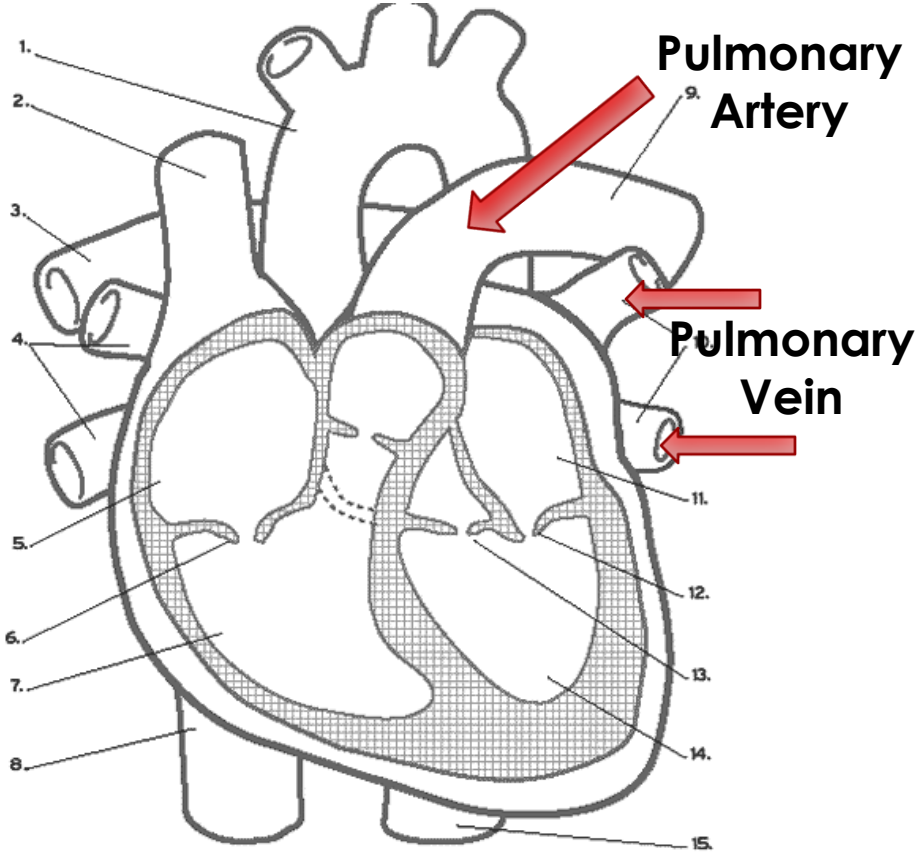
Aorta and Septum

- **Aorta**
  - Largest artery of the body
  - Carries blood from the heart to the rest of the body
- **Septum**
  - Muscular wall of the heart that divides it into two halves



Pulmonary Vein and Pulmonary Artery

- **Pulmonary Vein**
  - Returns oxygenated blood from the lungs to the heart
  - Only vein in the body to carry oxygenated blood
- **Pulmonary Artery**
  - Carries deoxygenated blood from the heart to the lungs
  - Only artery in the body to carry deoxygenated blood



Flow of Blood Through the Heart

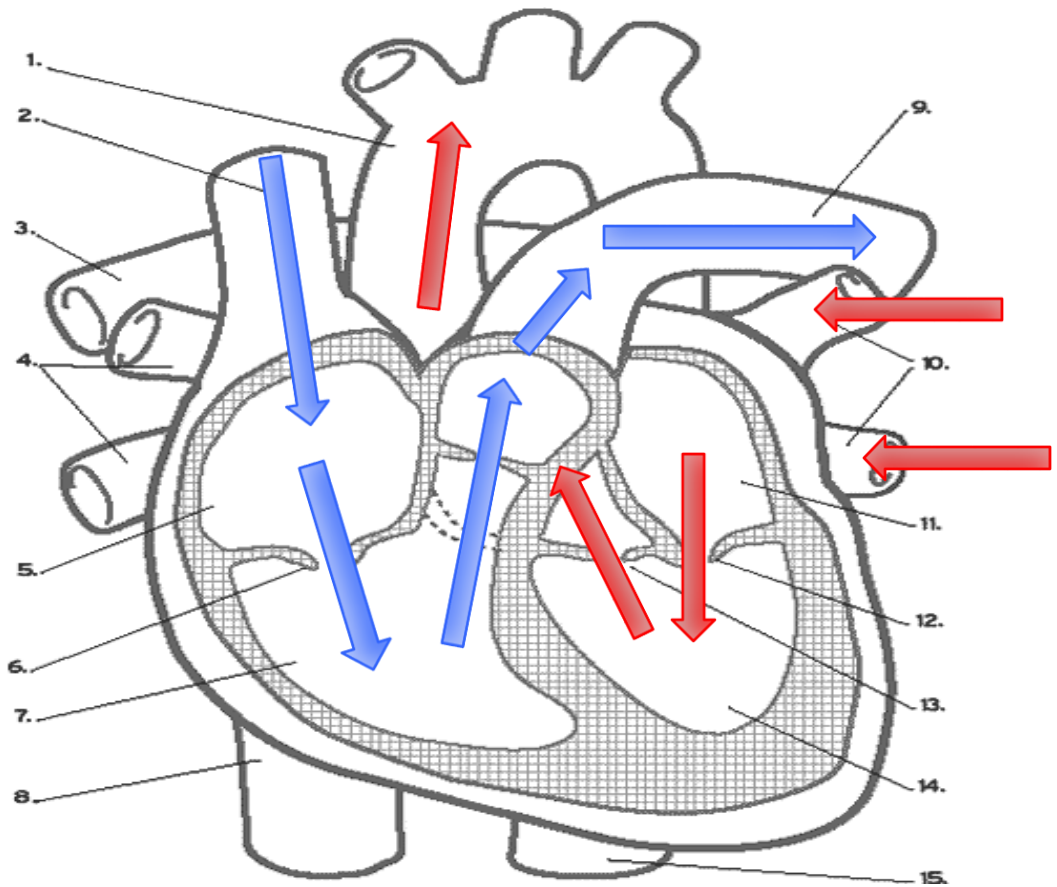
1. Blood from body enters the **superior vena cava**
2. Blood collects in the **right atrium**
3. Right atria contracts, moves blood through the **tricuspid valve** into the **right ventricle**
4. Right ventricle contracts, tricuspid valve closes, blood is forced out of the heart into the **pulmonary artery**
5. Pulmonary artery carries blood to the lungs

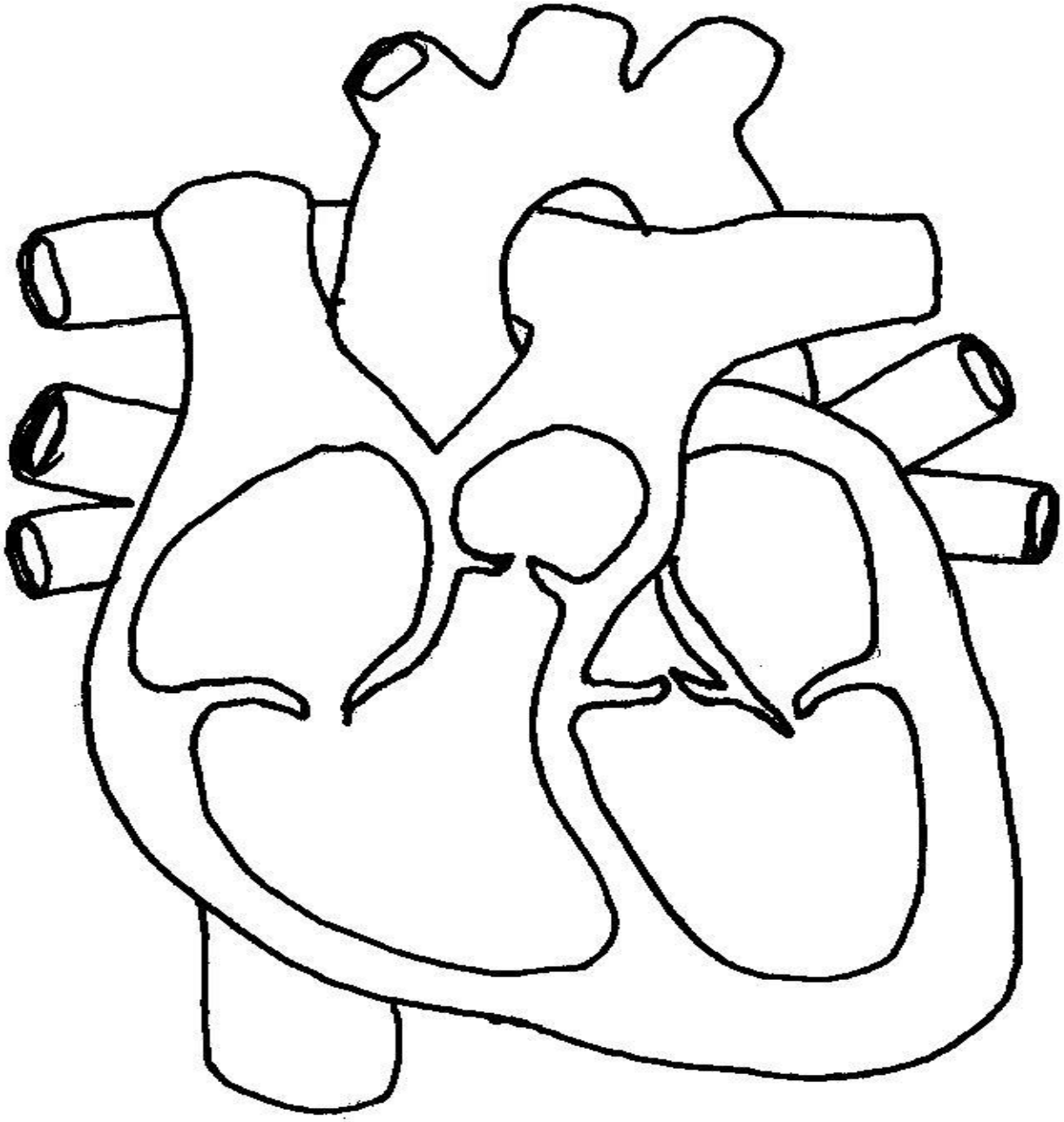
Flow of Blood Through the Heart

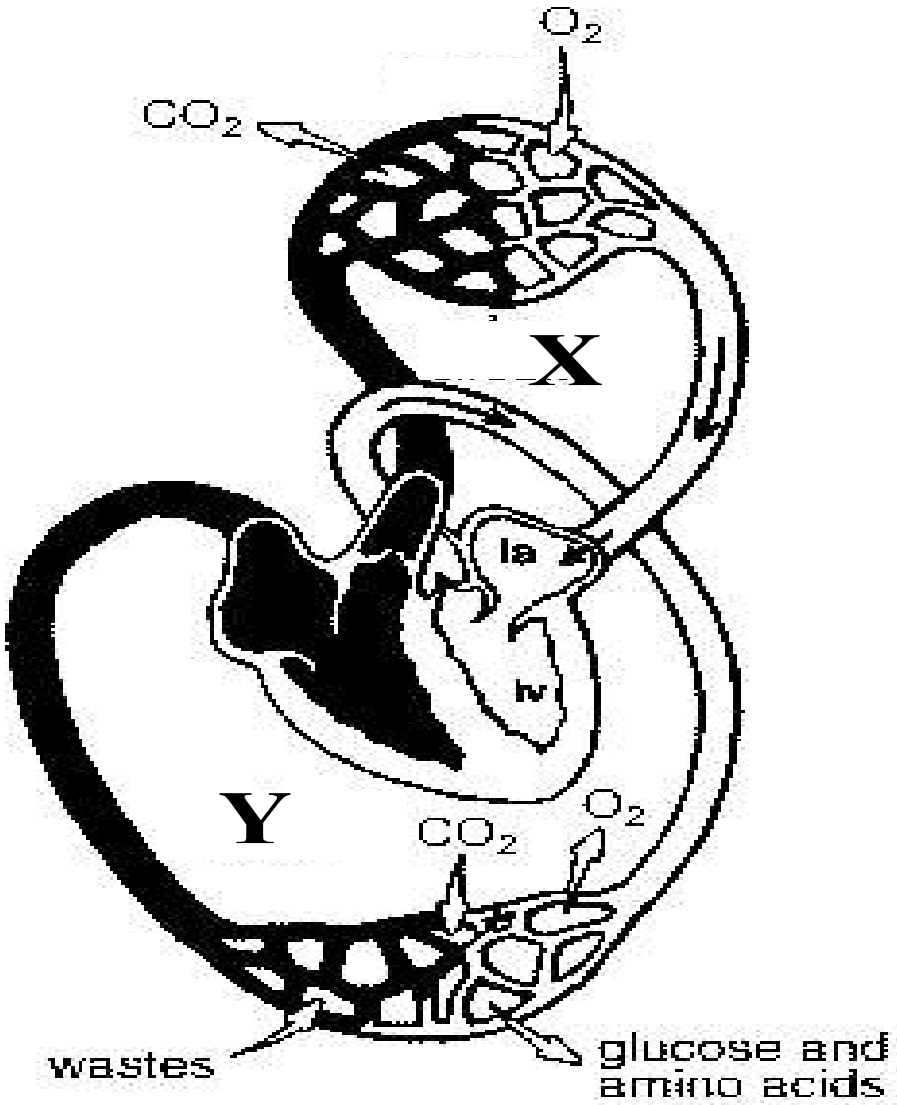
6. Blood returns to the heart, from the lungs, through the **pulmonary vein**
7. Collects in the **left atria**
8. Atria contracts, moves blood through the **bicuspid valve** into the **left ventricle**
9. Ventricle contracts, blood leaves the heart through the **aorta**

http://www.nhlbi.nih.gov/health/health-topics/topics/hhw/contraction.html

Flow of Blood Through the Heart







Pulmonary loop?

Systemic loop?

Heartbeat and Blood Pressure

The Circulatory System

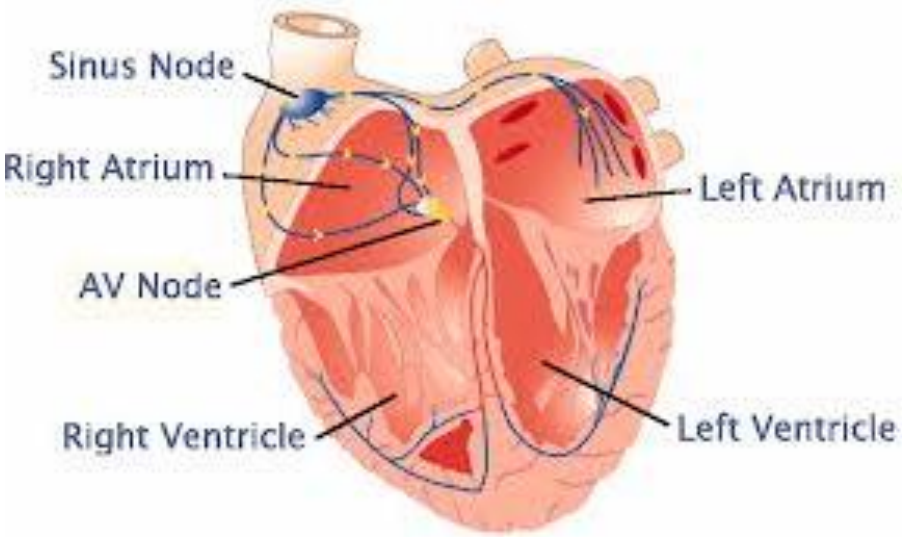
How our Heart Beats?

- The heart beats in response to electrical stimulus and muscle contractions
- Two important structures are responsible for the cardiac cycle of our heart:

1. **Sinoatrial Node**
2. **Atrioventricular Node**

How our are Beats

- **S-A Node**, the pacemaker, stimulates both atria by producing an electrical impulse
- The same impulse reaches the A-V Node
- **A-V Node** transmits the impulse, causing the two ventricles to contract
- The "**lub-dup**" sound associated with heart beat is actually valves opening and closing in the heart



Heart Rate

- Refers to the speed of the heartbeat
- Specifically, the speed of the heartbeat over a unit of time
- Normal human heart rate, at rest, ranges from **60-80 BPM**

Blood Pressure

- Refers to the pressure exerted by circulating blood upon the walls of blood vessels
- Recorded as a ratio of: **systolic pressure over diastolic pressure**
- Average blood pressure for a healthy person is 120/80

Systolic vs. Diastolic Pressure

- **Systolic Pressure**
  - Highest pressure in the cardiac cycle
  - Generated by the contraction of the left ventricle, forcing blood out of the heart
- **Diastolic Pressure**
  - Lowest pressure in the cardiac cycle
  - Heart is relaxed, immediately before another contracton

Circulatory Disorders

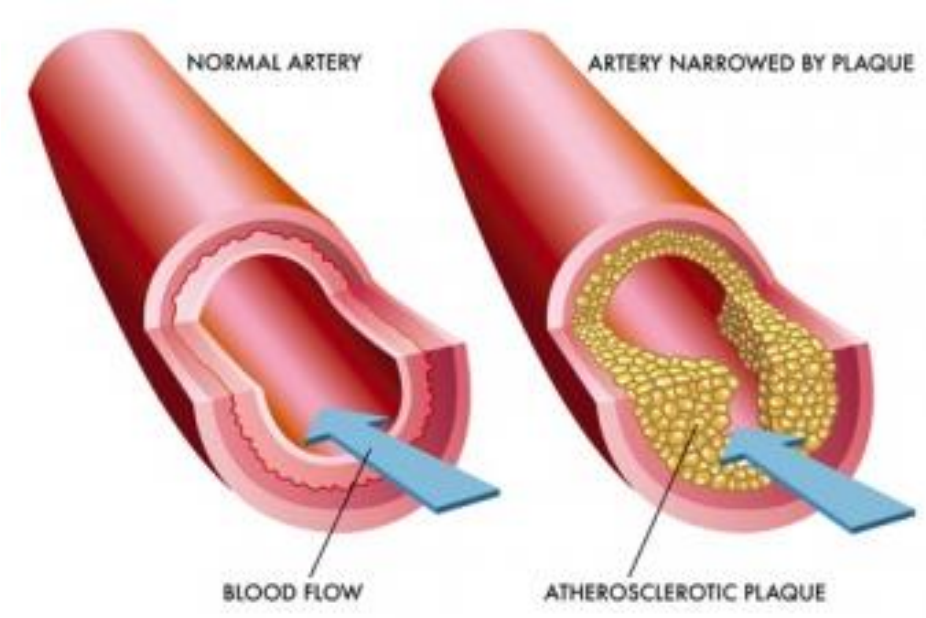
Unit 3: Maintaining Dynamic Equilibrium

Hypertension

- High blood pressure
- Causes can vary:
  - Obesity
  - Diabetes
  - Hereditary
  - Diet
  - Stress
- Puts strain on the heart, forces it to work harder

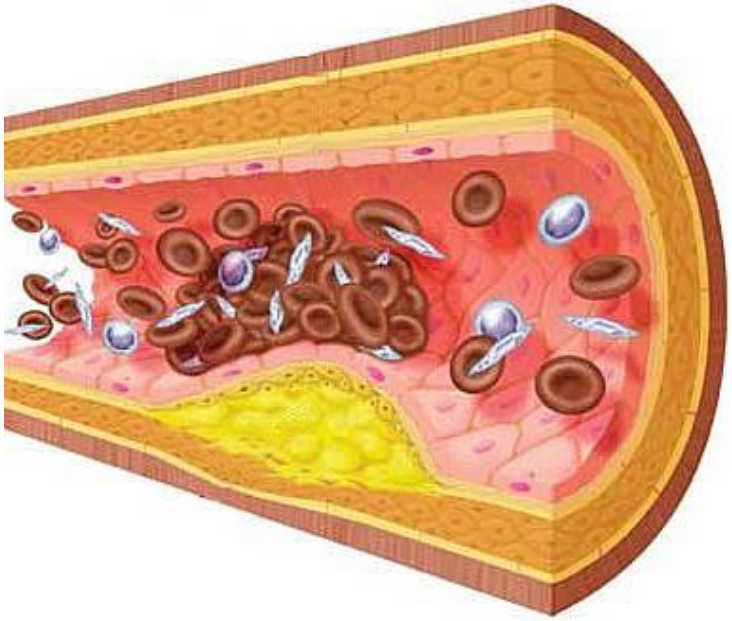
Atherosclerosis

- Deposits of cholesterol build up on the inner walls arteries
- Gradual narrowing of an artery results in decreased blood flow
- Again, heart has to work harder to pump blood
- High cholesterol diets a major cause



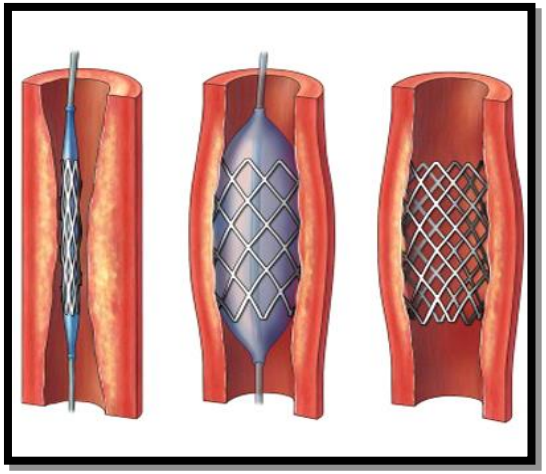
Arteriosclerosis

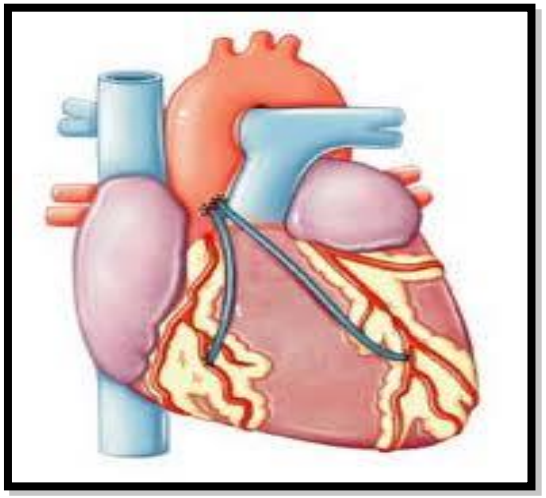
- Deposits of cholesterol buildup on in the inner lining of arteries
- Poor diet another cause
- Plaque blocks flow of blood
- Can lead to heart attack and stroke
- Heart has to work harder



Treatments

- **Angioplasty**
  - Fine tube is inserted into clogged artery
  - Tube contains a balloon which inflates at the site of blockage
- **Coronary Bypass**
  - Healthy blood vessel is transplanted and used to create a pathway of blood around the blocked area near the heart



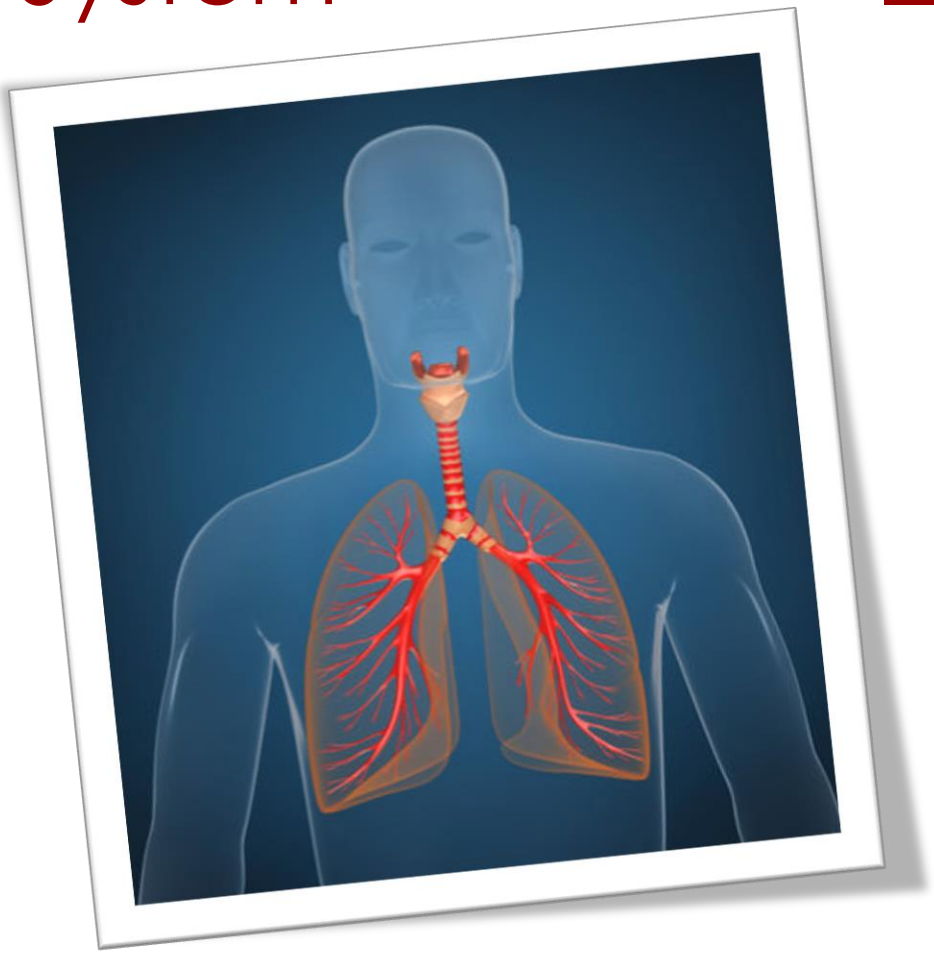


The Respiratory System

Unit 3 – Maintaining Dynamic Equilibrium

The Respiratory System

- Basic function is to **permit gas exchange**
- Oxygen is required for cellular respiration
- Carbon dioxide needs to be removed
- Both gases are carried to their destinations by the **circulatory system**
  - Oxygen diffuses into capillaries
  - CO_2 diffuse out, into air spaces of the lungs



The Lung

- Lung systems vary from species to species
- All systems consists of three elements:

1. **Moist respiratory surface**
2. **Method to forcibly bring in air**
3. **A circulatory system to carry gases between lungs and body cells**

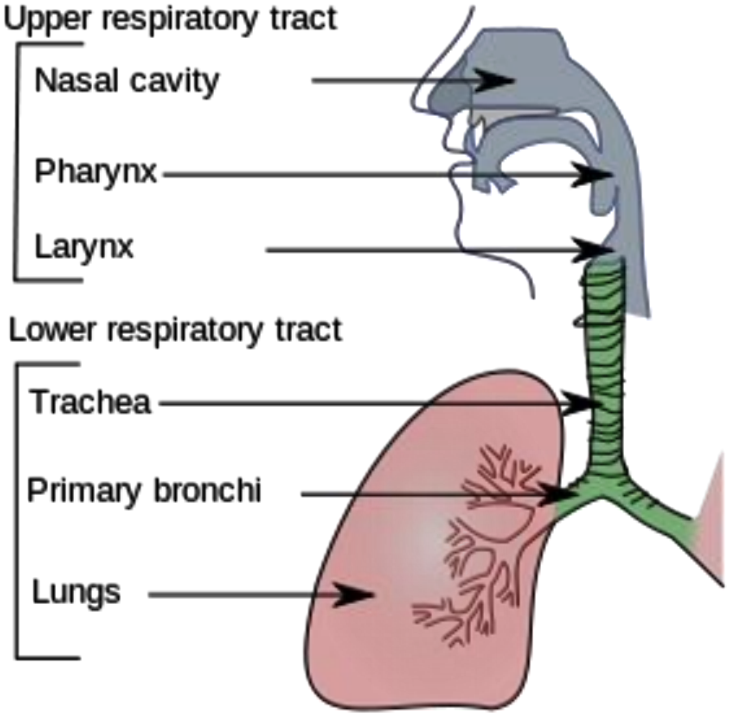
Respiration

- In mammals, can be subdivided into 4 categories:

1. **Breathing**
   - Inhalation and exhalation
2. **External Respiration**
   - Exchange of O_2 and CO_2 between air and blood
3. **Internal Respiration**
   - Exchange of O_2 and CO_2 between blood and and cells of surrounding tissue
4. **Cellular Respiration**
   - Complex reactions that take place in mitochondria

Respiratory Tract

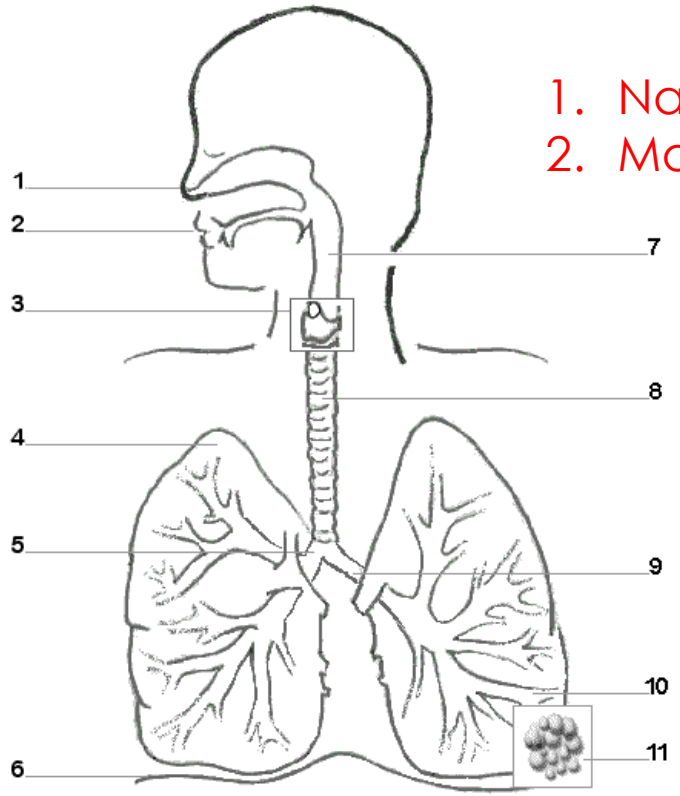
- Lungs are located deep within our bodies
- They're protected by bone and muscle
- A passageway must exist to allow air to to move from the external environment to the respiratory surface of the lungs



Upper Respiratory Tract

1. **Nasal Cavity**

- Air first enters the nostrils, also through the mouth
- Capillaries warm incoming air
- Thin bones, called **turbinates**, secrete mucus which moistens air

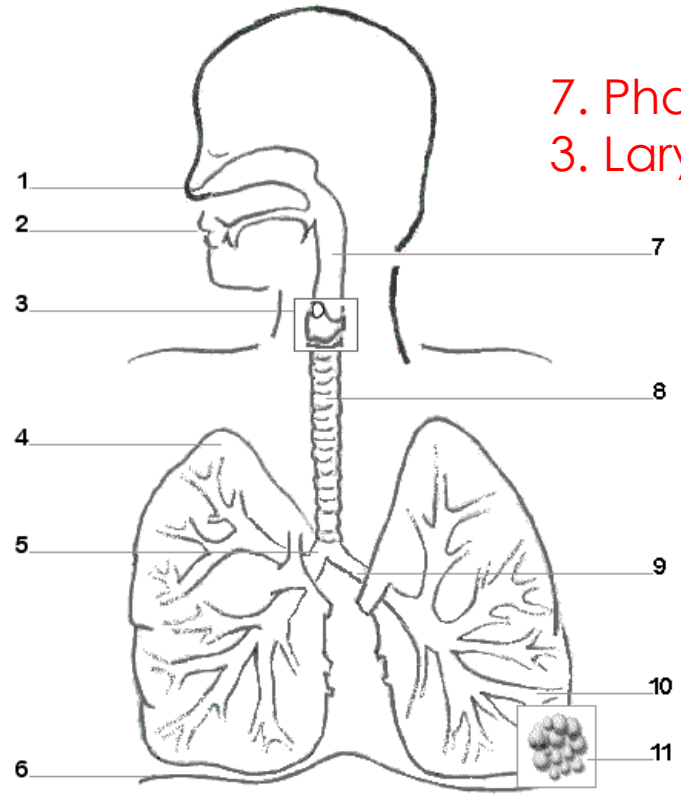


1. Nasal Cavity
2. Mouth

Upper Respiratory Tract

2. **Pharynx and Larynx**

- Air then passes through the pharynx (throat) and larynx
- Section of the alimentary canal that connects the mouth and nasal cavity to the trachea
- Larynx is the "Voice Box", where sound is produced during speech

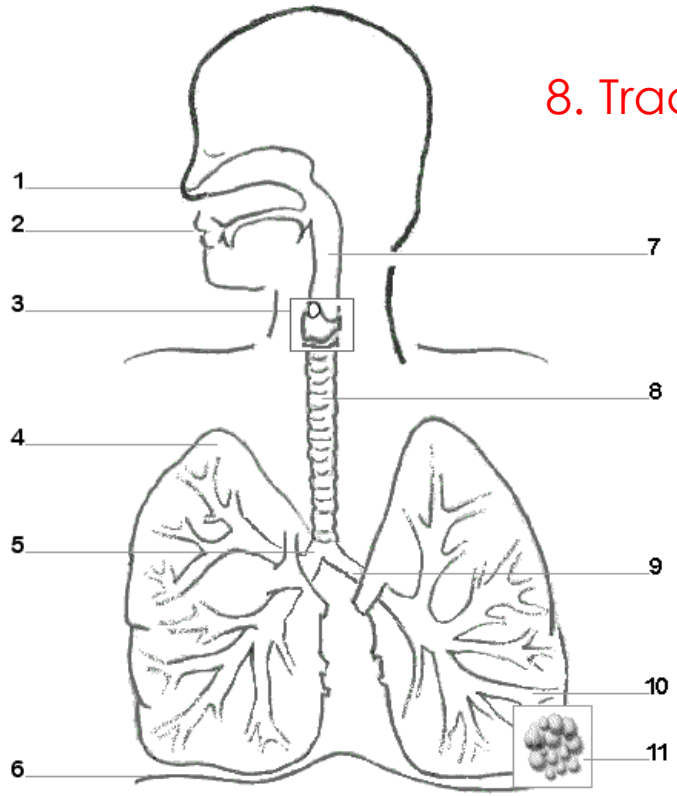


7. Pharynx
3. Larynx

Upper Respiratory Tract

3. Trachea

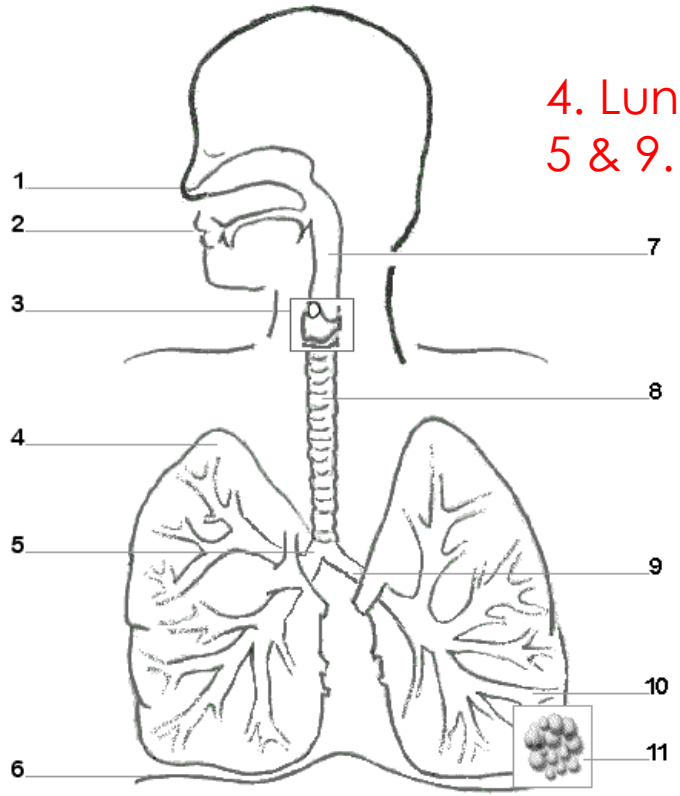
- Air then passes into the trachea (windpipe)
- Trachea is supported by semicircular cartilage rings which prevent the trachea from collapsing



Lower Respiratory Tract

4. Bronchi

- Trachea branches off into two smaller passages called bronchi
- One bronchi enters each lung
- Carries air into each lung

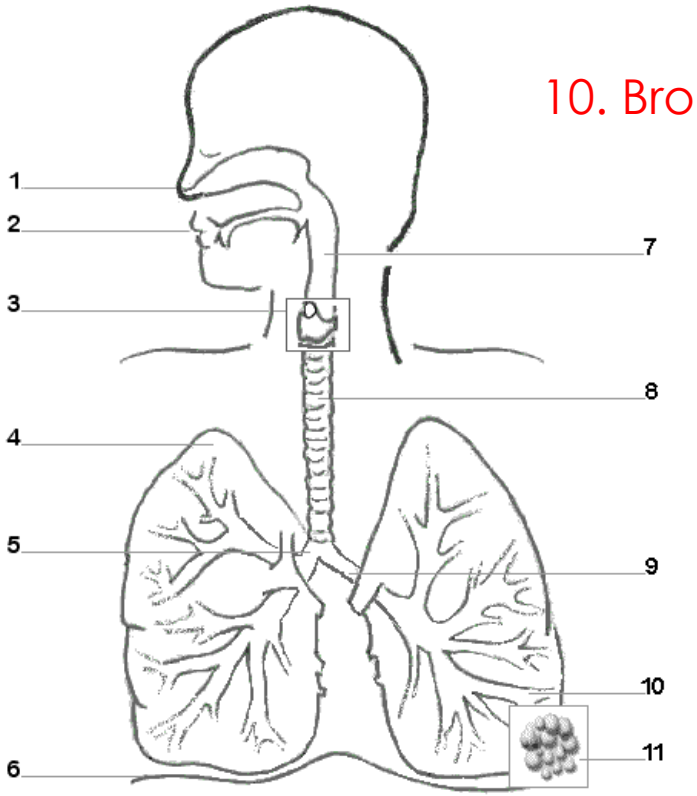


4. Lungs
5 & 9. Bronchi

Lower Respiratory Tract

5. Bronchioles

- Each bronchi subdivides many times to produce a network of finer tubes called bronchioles
- Air passes through bronchioles to reach respiratory air sacs

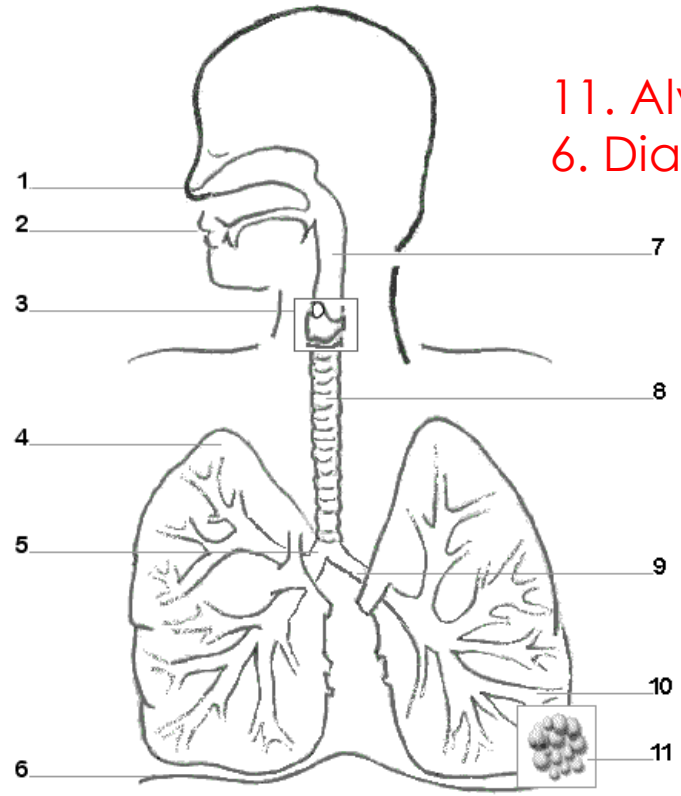


10. Bronchiole

Lower Respiratory Tract

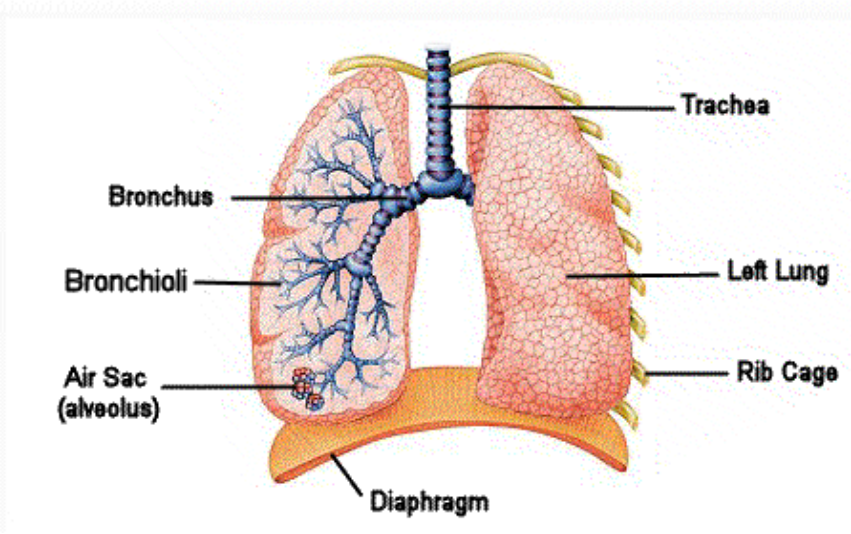
6. Alveoli

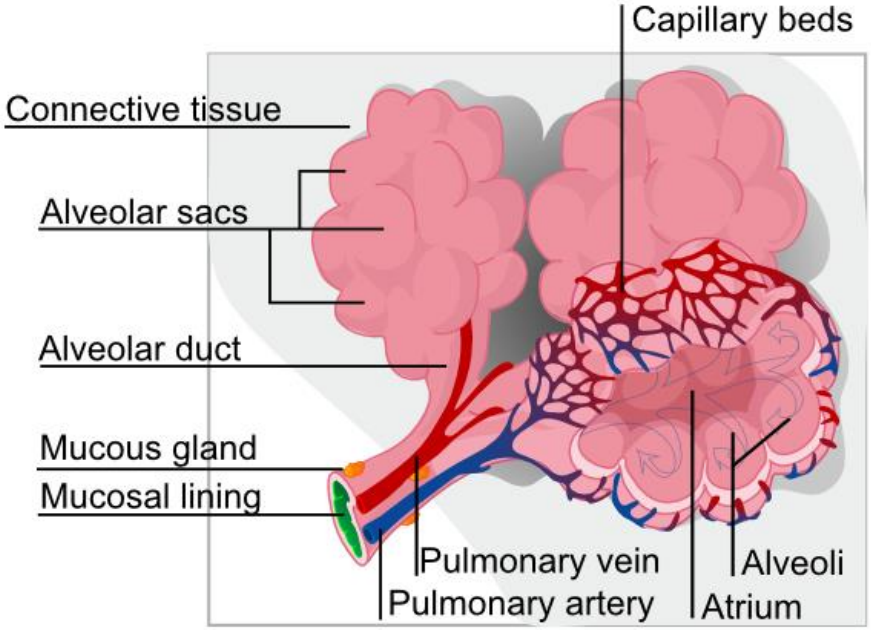
- Each bronchiole ends in a cluster of tiny air sacs called alveoli
- Site of gas exchange
- Each sac is adjacent to a network of capillaries, where O2 and CO2 are exchanged through diffusion



11. Alveoli
6. Diaphragm

Lower Respiratory Tract





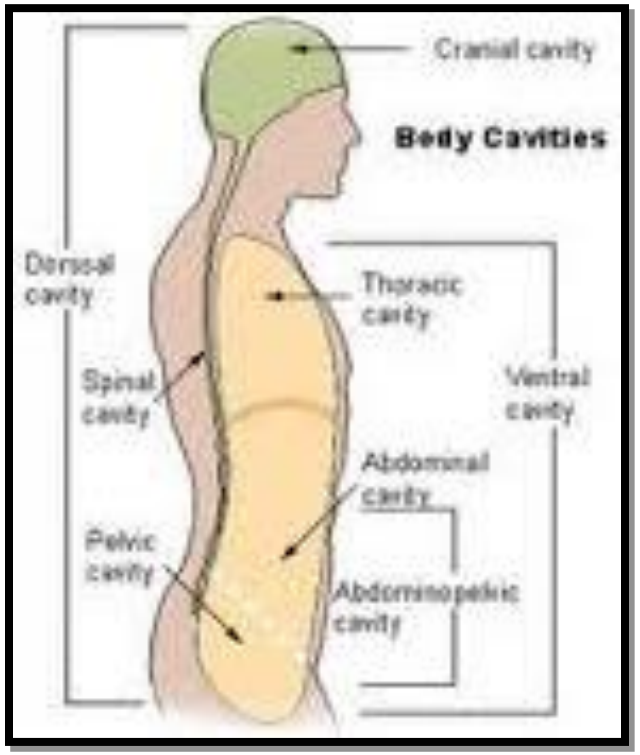
The Mechanics of Breathing

Unit 3: The Respiratory System

Mechanics of Breathing

- When we breathe, we use two muscular structures

1. **Intercostal muscles**
   - Muscles associated with the ventral surface of the rib cage
2. **Diaphragm**
   - Layer of muscle that separates the thoracic cavity from the abdominal cavity

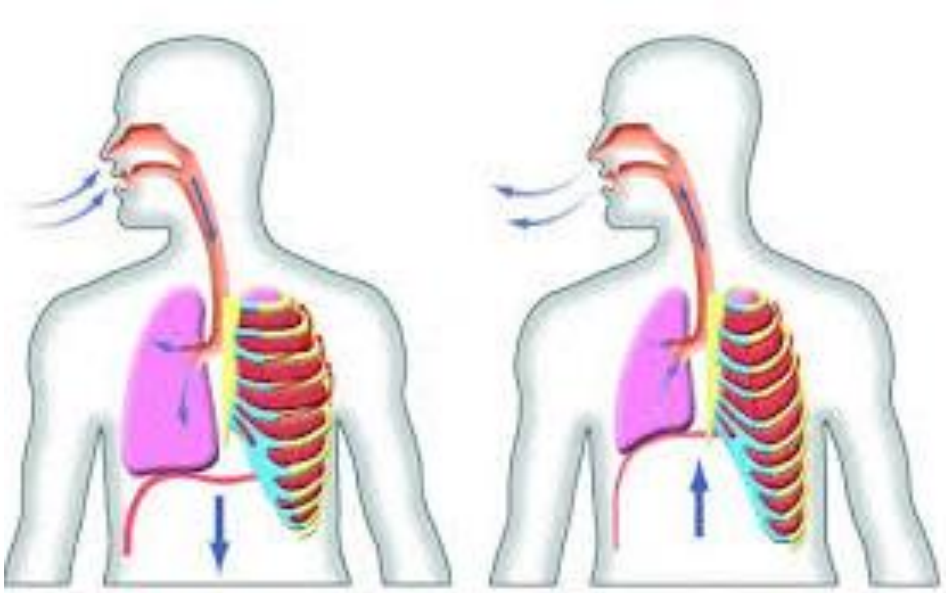


Mechanics of Breathing

- Breathing involves two stages:

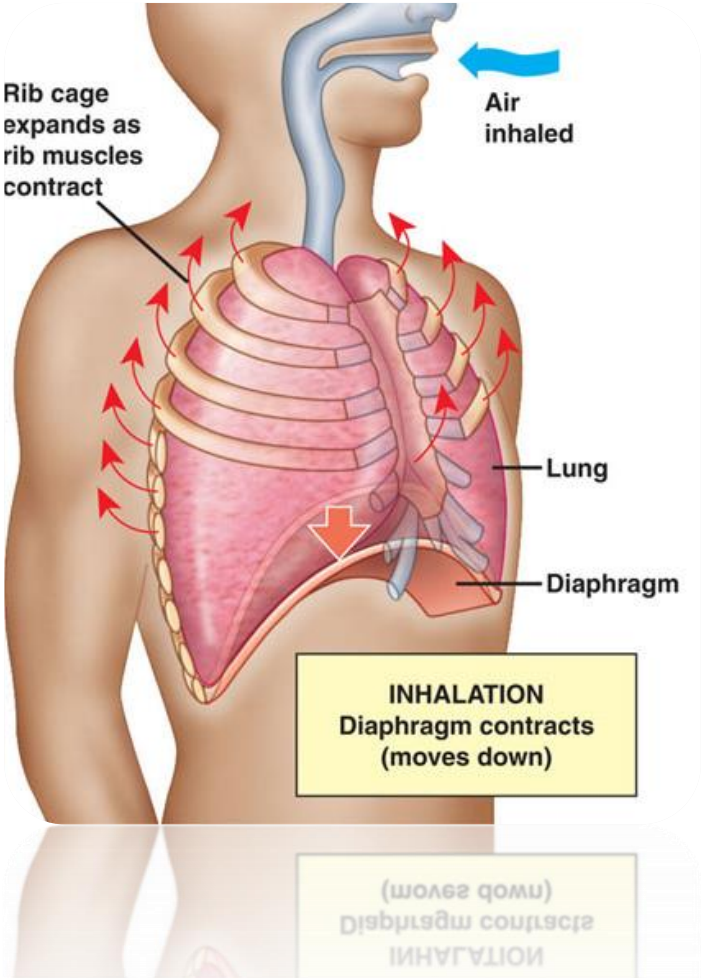
1. **Inhalation**
2. **Exhalation**

- Both aspects of breathing allow for the exchange of gas



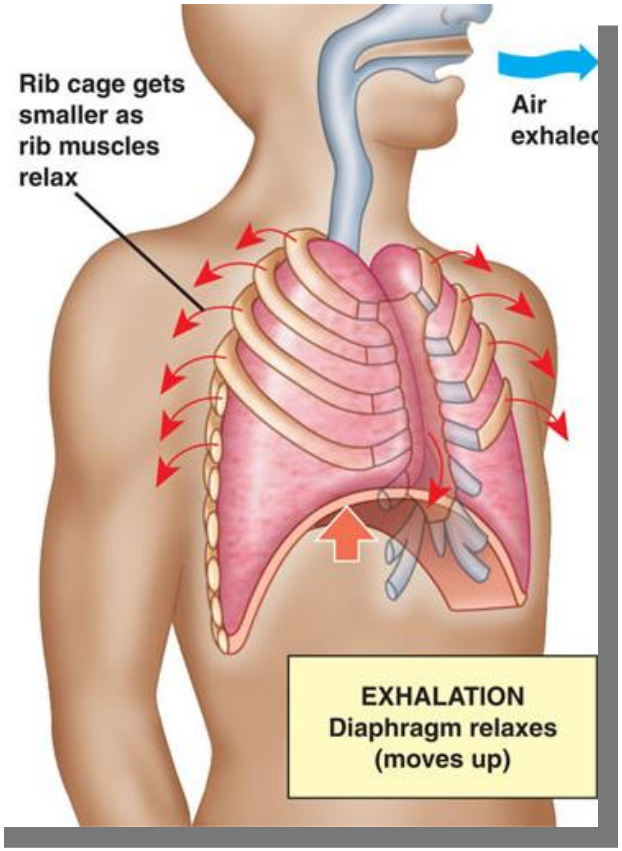
Inhalation

- **Active phase of breathing**
- External intercostal muscles and diaphragm contract
- Rib cage expands, diaphragm moves down
- Chest cavity increases in volume, which decreases air pressure, resulting in the expansion of the lungs
- Air flows into the lungs



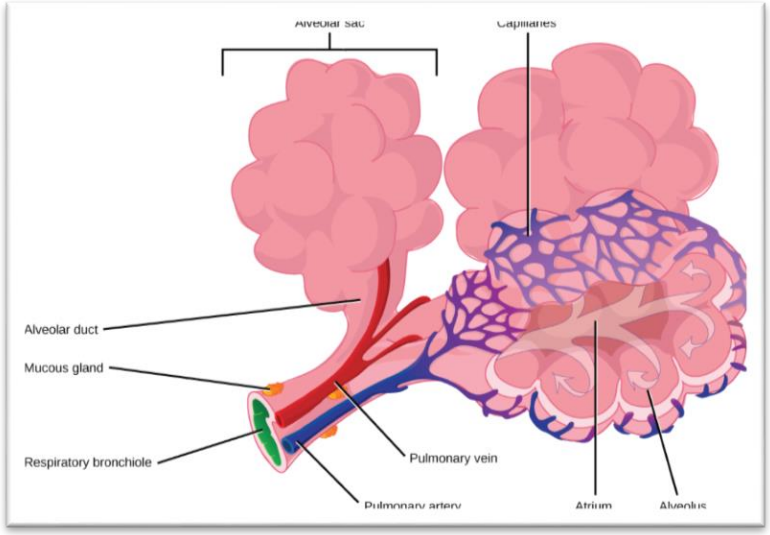
Exhalation

- **Passive phase of breathing**
- Diaphragm and external intercostal relax
- Internals intercostal contract, pulling the rib cage back to its original position
- Chest cavity becomes smaller, increasing air pressure
- Lungs shrink and air flows out



Gas Exchange

- Remember that gas exchange happens at the alveoli
- Alveoli and adjacent capillaries have walls that are a single cell layer thick
- This permits the diffusion of O_2 and CO_2 across membranes



Mechanics of Breathing

- Some useful links;

https://www.youtube.com/watch?v=hp-gCvW8PRY

https://www.youtube.com/watch?v=JrawNbjq91g&feature=related

https://www.youtube.com/watch?v=sU_8juD3YzQ&NR=1&feature=fvwp

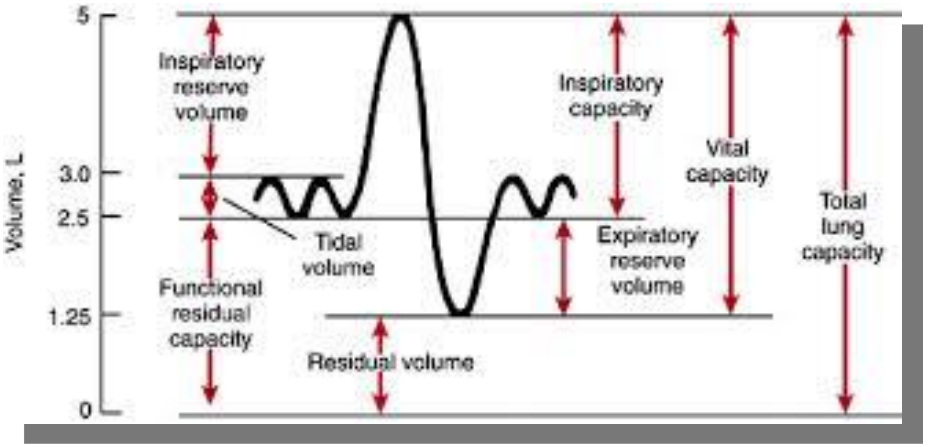
https://www.youtube.com/watch?v=GERsMFWYZrw&feature=related

Lung Capacity

Unit 3: Respiratory System

Lung Capacity

- Refers to the volume of air associated with different phases of the respiratory cycle
- Average lung capacity for men is 5.8 L, for women is 4.2 L
- Different volumes of air drawn in or pushed out are distinguished as follows:
- Some terms to remember…



Tidal Volume

- The volume of air inhaled and exhaled in a normal breathing movement
- For a healthy, young adult, tidal volume is approx. 500 mL of air per inhalation

Inspiratory & Expiratory Reserve Volume

Inspiratory Reserve Volume

- The additional volume of air that that can be taken in beyond a regular tidal inhalation
- Average IRV for men is 3L, for women is 1.9 L

Expiratory Reserve Volume

- The additional volume of air that can be forced out of the lungs beyond regular tidal exhalation
- Average ERV for men is 1.1 L, for women is 0.7 L

Vital Capacity

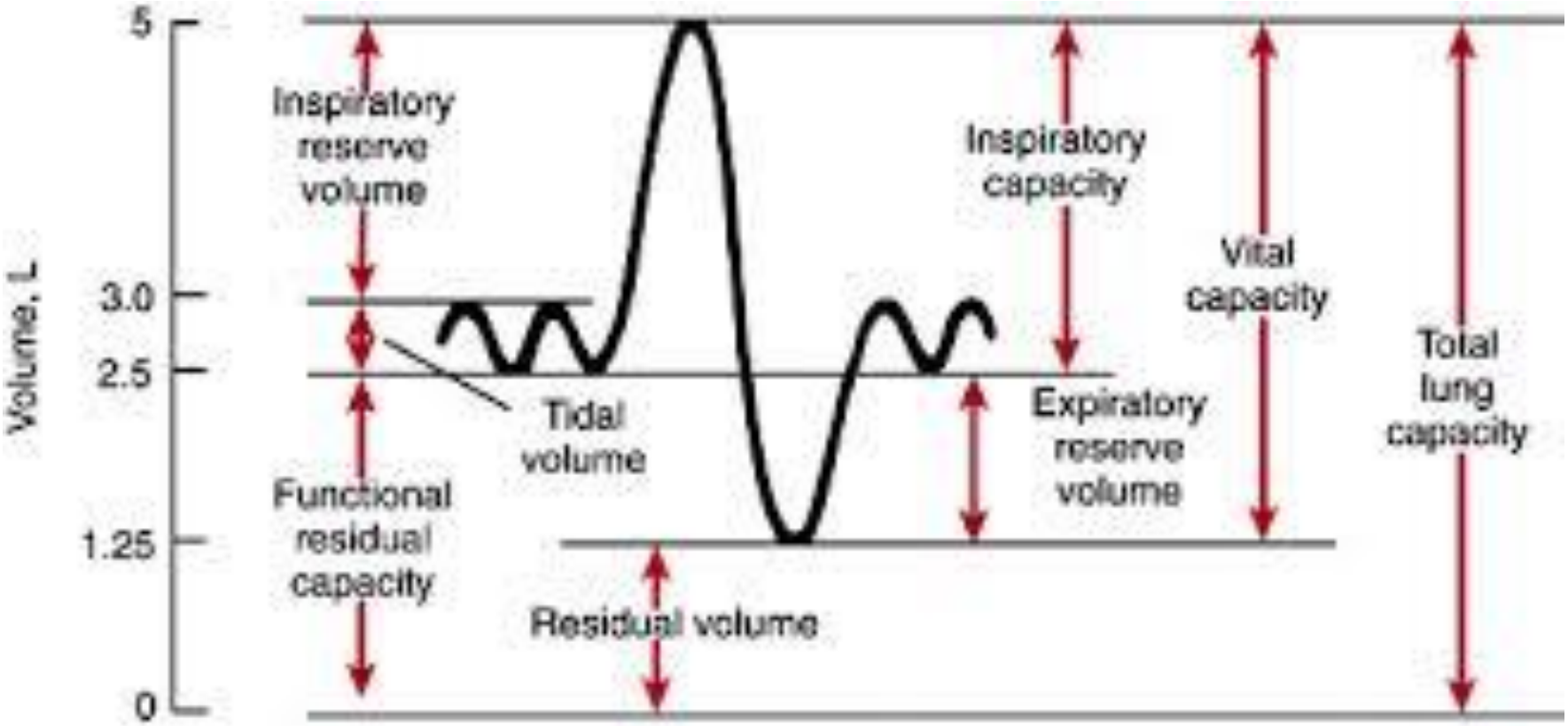
- Total volume of gas that can be moved into or out of the lungs
- Maximum amount of air a person can expel from the lungs following a maximum inhalation
- Can be measured using a spirometer
- Can be calculated:

Vital Capacity = IRV + ERV + Tidal Volume

Residual Volume

- The amount of gas that remains in the lungs and the passageways of the respiratory system after a full exhalation
- This volume never leaves the respiratory system

Lung Capacity



Respiratory Diseases

Unit 3 : Respiratory System

Lung Cancer

- The uncontrolled and invasive growth of abnormal cells in the lungs
- Carcinoma or malignant tumor grows and abnormal cells multiply and take over normal tissue
- Most cases caused by smoking, the inhalation of carcinogens
- Treatments include surgery, chemotherapy, radiation therapy

https://www.youtube.com/watch?v=dd2jYSTi9NM
https://www.youtube.com/watch?v=zcaeSKiZ37Y&feature=related

Pneumonia

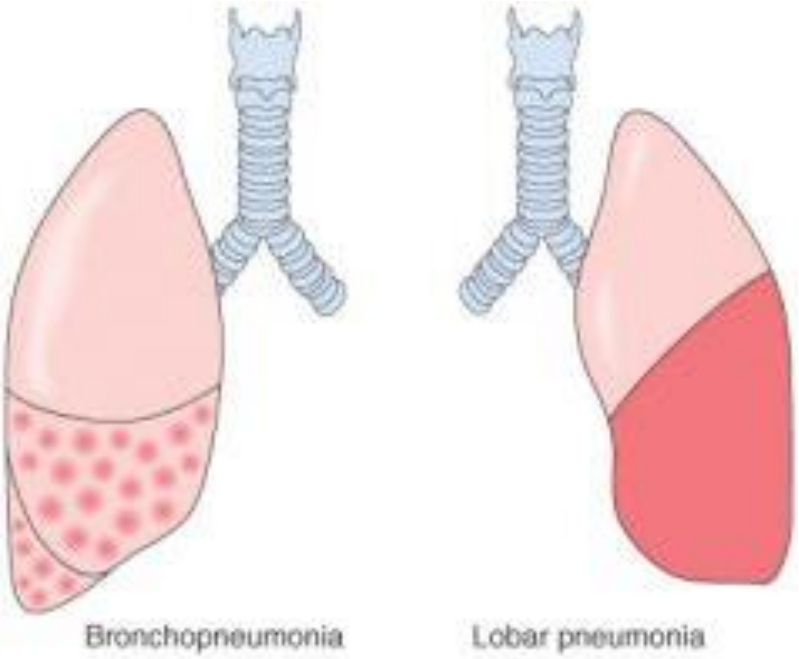
- Infections of the lungs with causes alveoli to become inflamed and fill with liquid
- Treated with antibiotics
- May be caused by bacterial or viral infectious agents
- Two types:

1. **Lobar**

- Affects large lobe of the lung

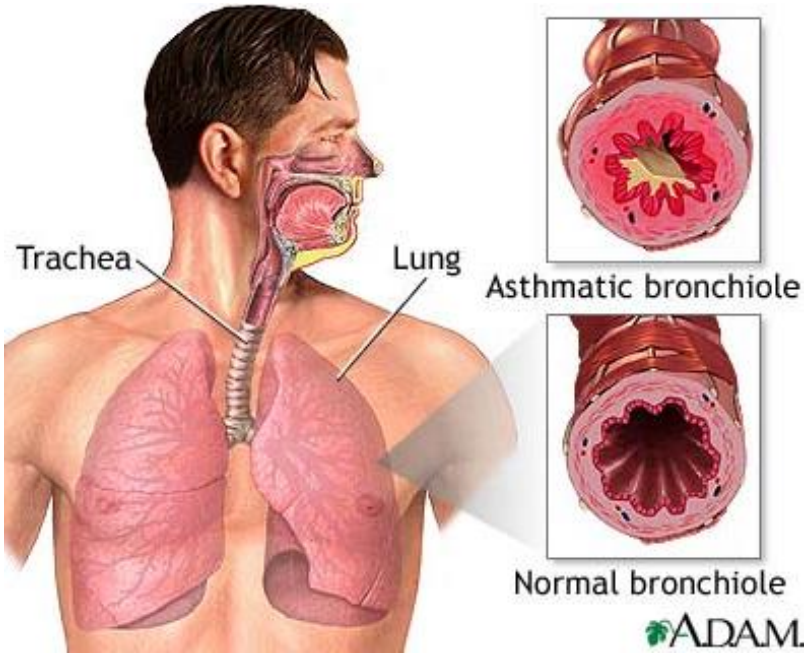
2. **Bronchial**

- Affects patches throughout the llung



Asthma

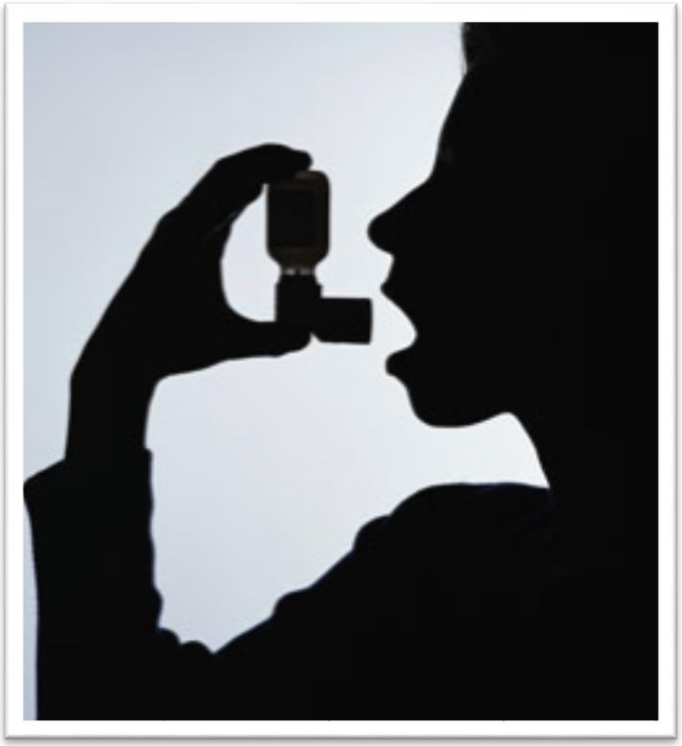
- Chronic lung disease
- Lungs become extremely sensitive to triggers that cause airways to react and become obstructed
- Mild to severe
- Asthmatic episodes can be very detrimental to lung tissue
  - Airways swells
  - Bronchial muscles tighten
  - Mucous secreted
  - Breathing becomes very difficult



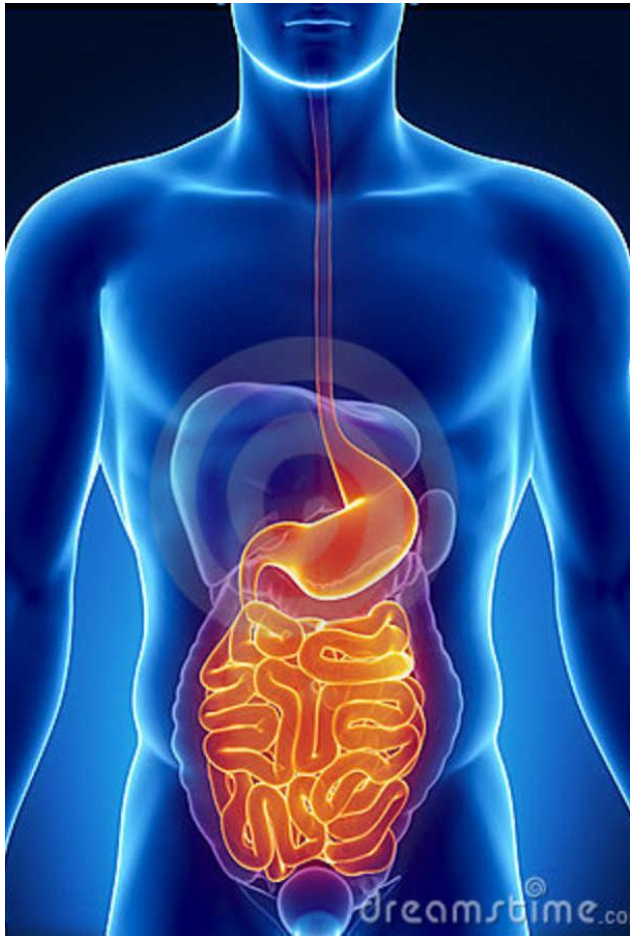
https://www.youtube.com/watch?v=82gn_rDRpHk&feature=fvw

Environmental Factors on Asthma

- The air we breath contain many different particles
- Those with asthma can experience episodes triggered by these particles
- For some, masks must be worn at all time



Environmental Factors on Asthma



The Digestive System

Unit 3: Maintaining Dynamic Equilibrium

Foundation of Digestion

- All organisms, regardless of size, have some method to obtain the essential nutrients required for survival
- Two types of methods to obtain nutrition:

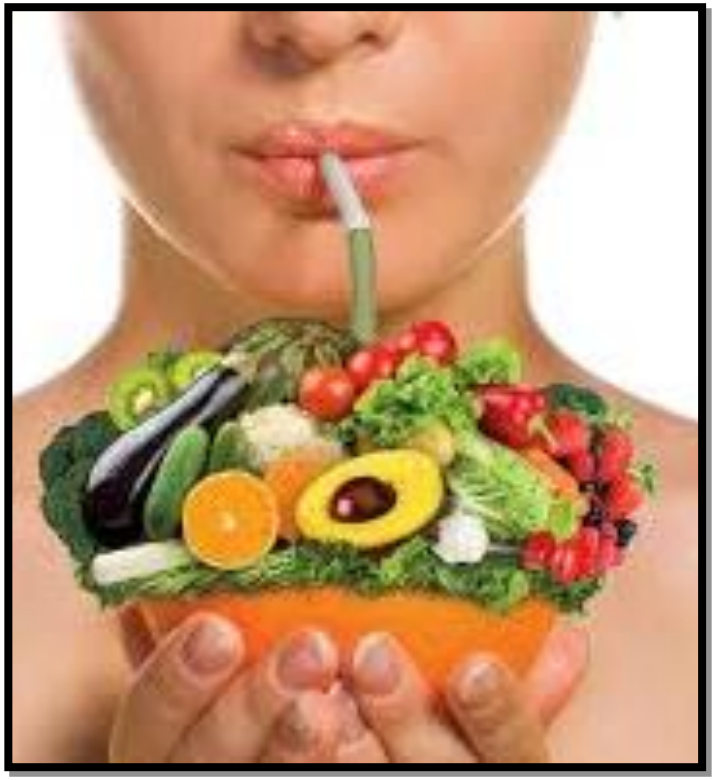
1. **Autotrophs**
2. **Heterotrophs**

Essential Nutrients

- The basic raw materials needed for survival
  - Make new structures
  - Perform cellular functions
  - Obtain energy
  - Provide our bodies with strength

Six Essential Nutrients

1. Carbohydrates
2. Fats (lipids)
3. Proteins
4. Minerals
5. Vitamins
6. Water



Carbohydrates

- Are made of carbon, hydrogen, and oxygen
- Are broken down into simple sugars
- Main function is to provide energy
- Excess carbohydrates are converted to fat
- Sources: Breads, Pasta, Rice

Fats (Lipids)

- Made of fatty acids and glycerol
- Function as a source of energy, insulating the body, and structural materials for cell membranes
- Excess fats aren't broken down and are stored
- Sources: Butter, meat, cheese, eggs

Proteins

- Made of peptides which are made of strings of amino acids
- Are broken down into amino acids which are used to construct newer proteins
- Are essential for the building, repair, and maintenance of cell structure
- Sources: Meat, milk, eggs

Vitamins

- Our bodies require very small amount in diet
- Required for metabolic and enzymatic activity
- Different types serve different functions
  - B_{12}: Vital role in the proper functioning of the brain
  - Vitamin A: Needed for healthy eyes, skin, and hair
- Sources: Variety of foods contain different types
- **See page 358 – Table 11.1**

Minerals

- Inorganic compounds our bodies use for a variety of functions
  - Build bones and teeth – Calcium
  - Construct hemoglobin – Iron
- Source: Variety of food we eat contain minerals

Water

- Act as a solvent in our bodies
- Plays a vital role for most chemical reactions that occur
- Maintains cell structure
- Sources: Various food and drink

Importance of the Digestive System

- Breaks down food into into smaller, simpler units that can be absorbed and used by cells of the body
- There are two basic types of digestion:

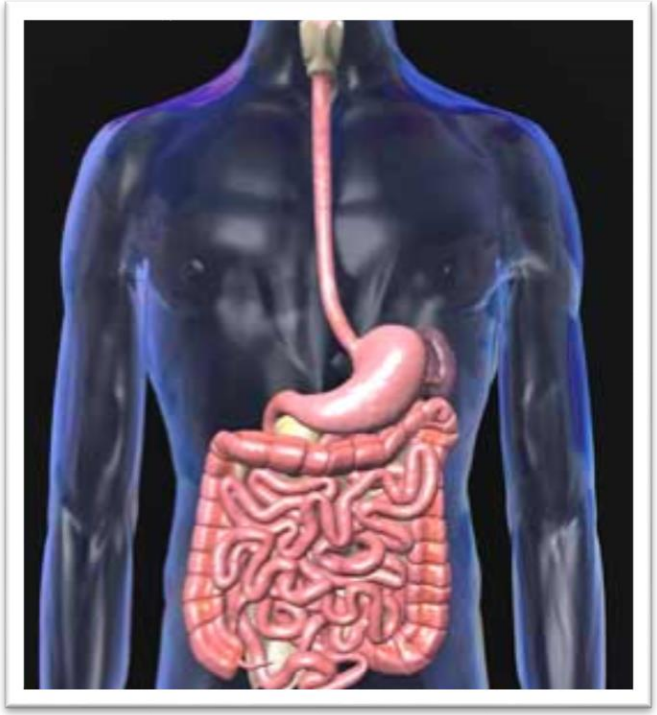
1. **Mechanical Digestion**
2. **Chemical Digestion**

Mechanical Digestion

- The physical breaking down of food
- Initial breakdown of food, occurring mainly in the mouth – Teeth and Tongue
- Teeth of all varieties play an important role in the breakdown of food
- Teeth can tell a story with respect to diet

Chemical Digestion

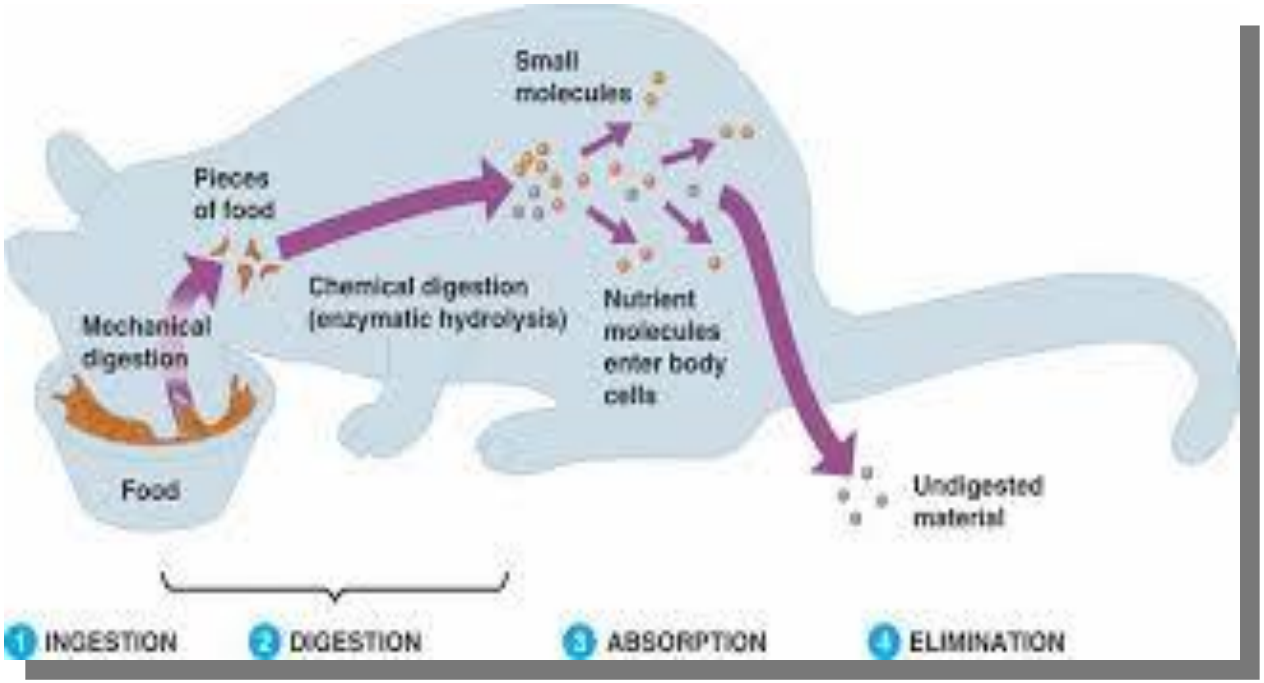
- Breakdown of by chemical means
- Secretions of **enzymes that catalyze the breakdown and absorption** of food into smaller units
- Begins in the mouth, continues in the stomach, and ends in the small intestine



Stages of Food Processing

- There are four stags of food processing:

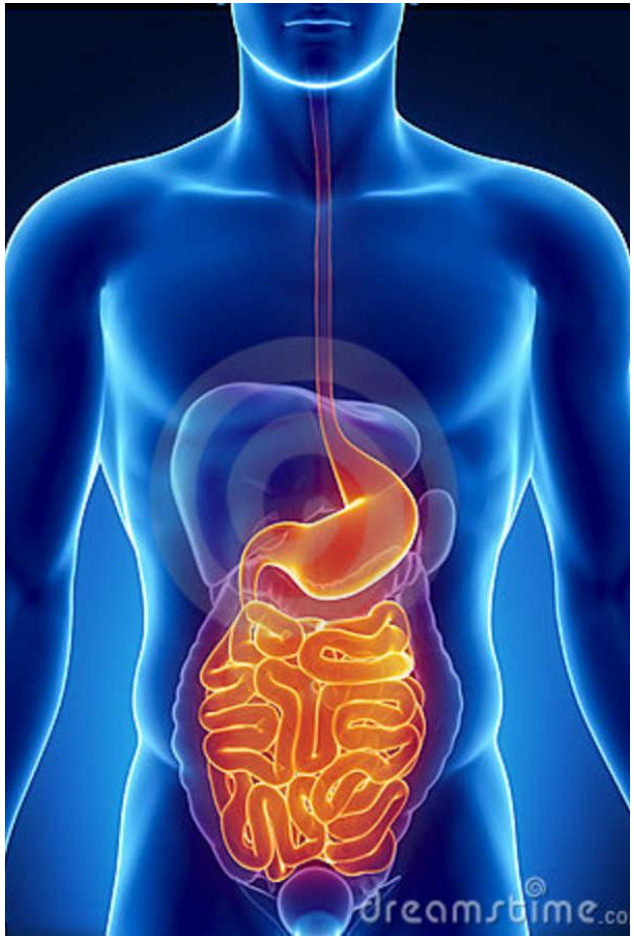
1. **Ingestion**
2. **Digestion**
3. **Absorption**
4. **Elimination**



Parts of the Digestive System

1. **The Alimentary Canal**
   - Food Tube
   - Gastrointestinal Tract (GI Tract)
   - Leads from the mouth to the anus
   - Food is processed here – it passes through
   - **Mouth, Esophagus, Small Intestine, Large Intestine, Rectum**

2. **Accessory Organs**
   - Glands/Organs that assist in digestion but food does not pass through them
   - **Salivary glands, Liver, Gall Bladder, Pancreas**

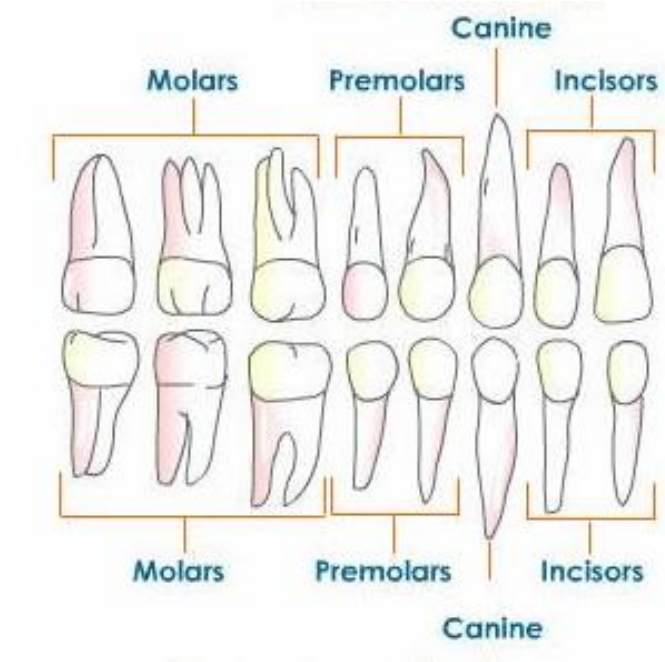


The Digestive System

The Major Organs and Glands

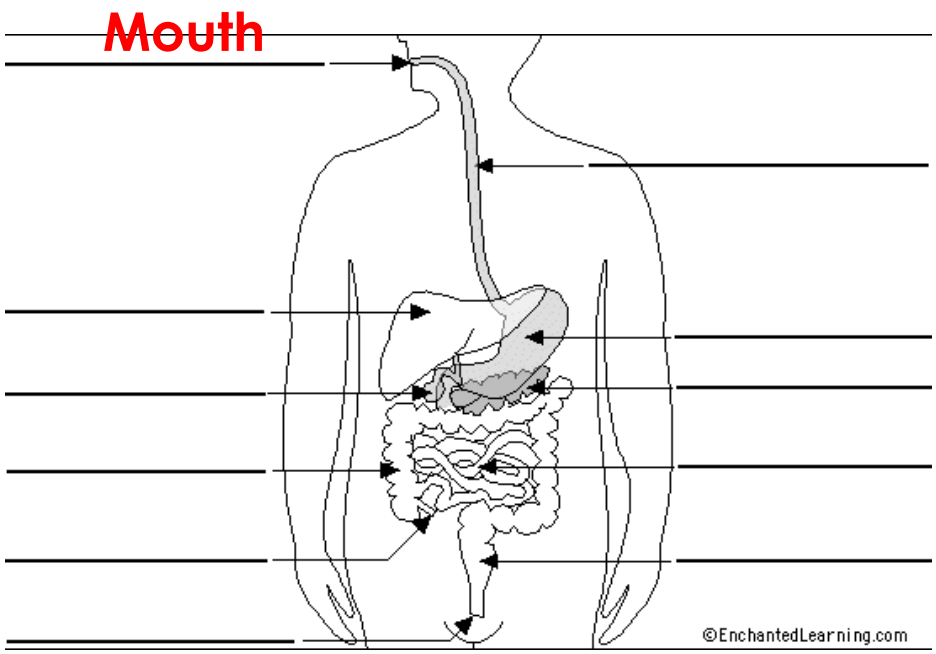
Mouth

- Teeth cut, tear, and grind food
  - Incisors – cutting teeth
  - Canines – Tearing teeth
  - Molars – Grind food
- Tongue manipulates food, is also covered in papillae, i.e. taste buds



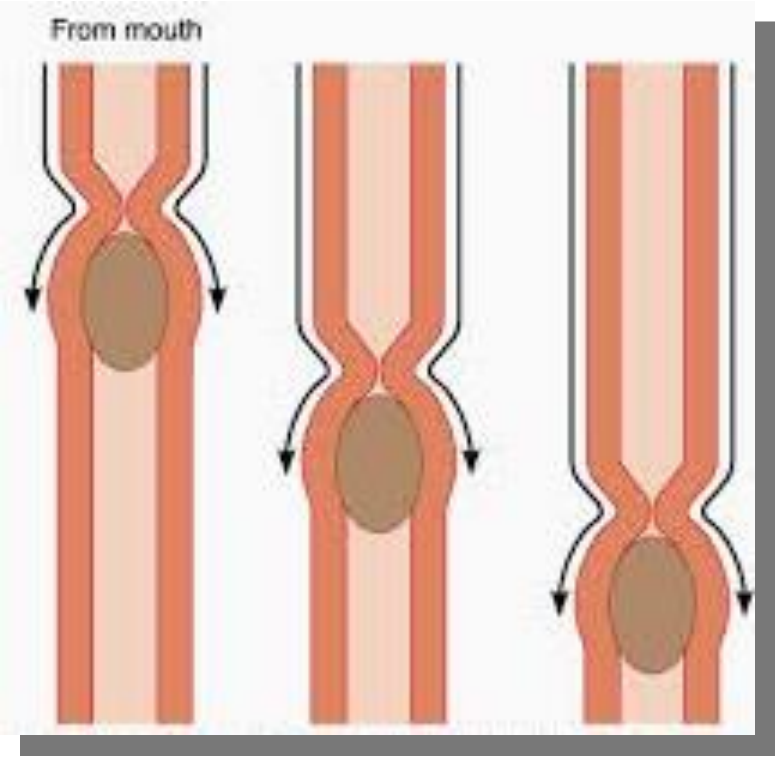
Mouth

- Salivary glands secrete **saliva**
- Saliva lubricates food
- Saliva also contains **salivary amylase** which further breaks food down
- Enzymatic activity breaks starches down into simple sugars
- Food leaves the mouth as a moist ball known as a bolus



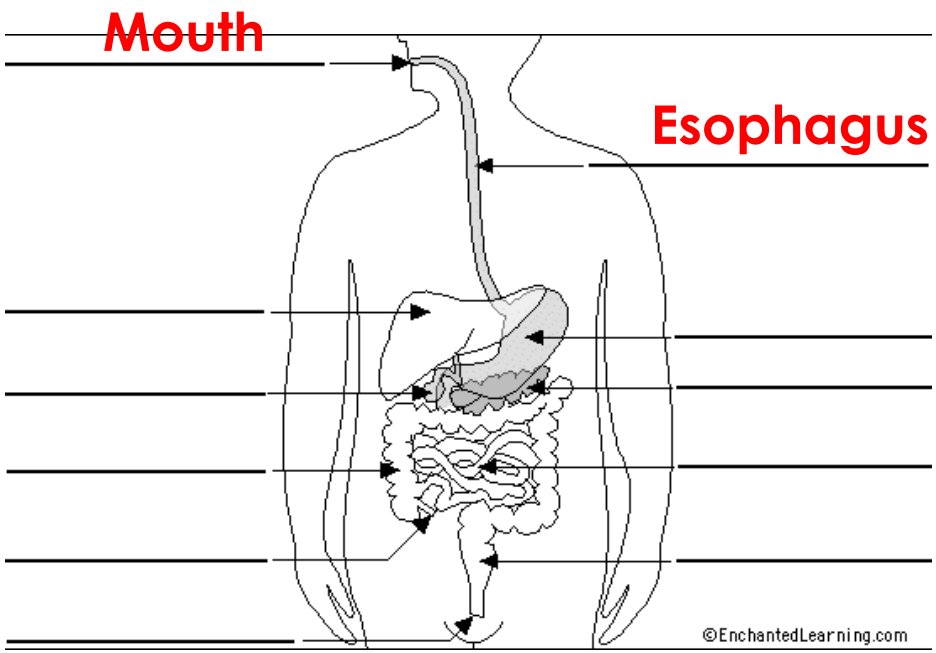
Esophagus

- Muscular tube that moves food to the stomach through peristalsis
- **Peristalsis – waves of rhythmic muscular contractions**
- Side note: Swallowing closes the epiglottis preventing food from entering the trachea



Esophagus

- Walls of the esophagus secrete mucin
- Mucin acts as a lubricant for food
- Eases the passage of food through to the stomach



Stomach

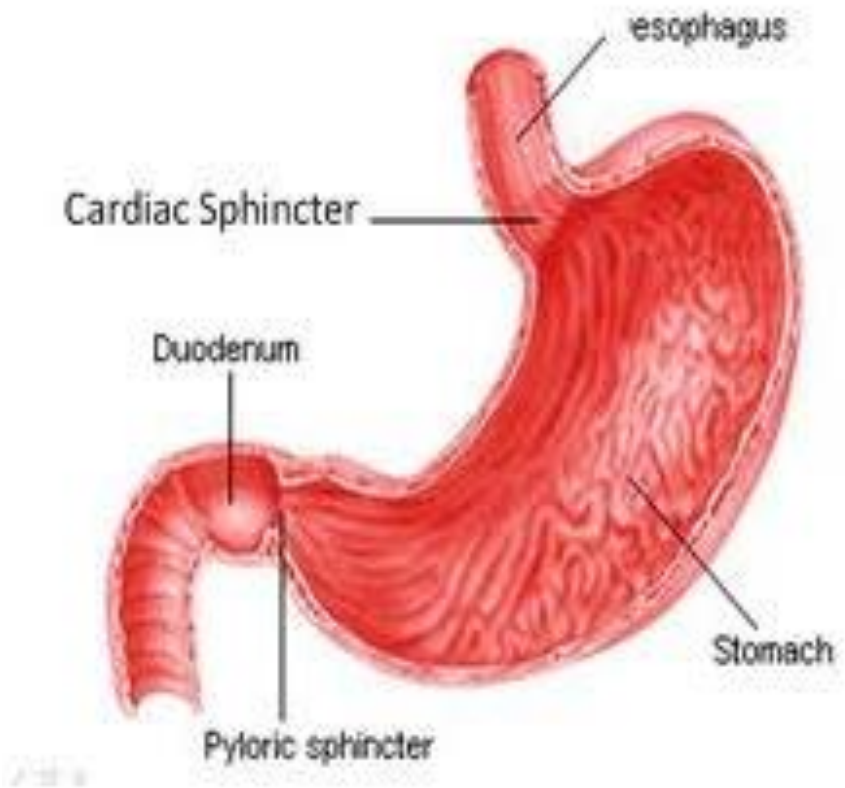
- J-shaped sac-like organ
- Consists of two sphincters:

1. **Cardiac Sphincter**

- Regulates food into the stomach, prevents stomach acids from enter the esophagus

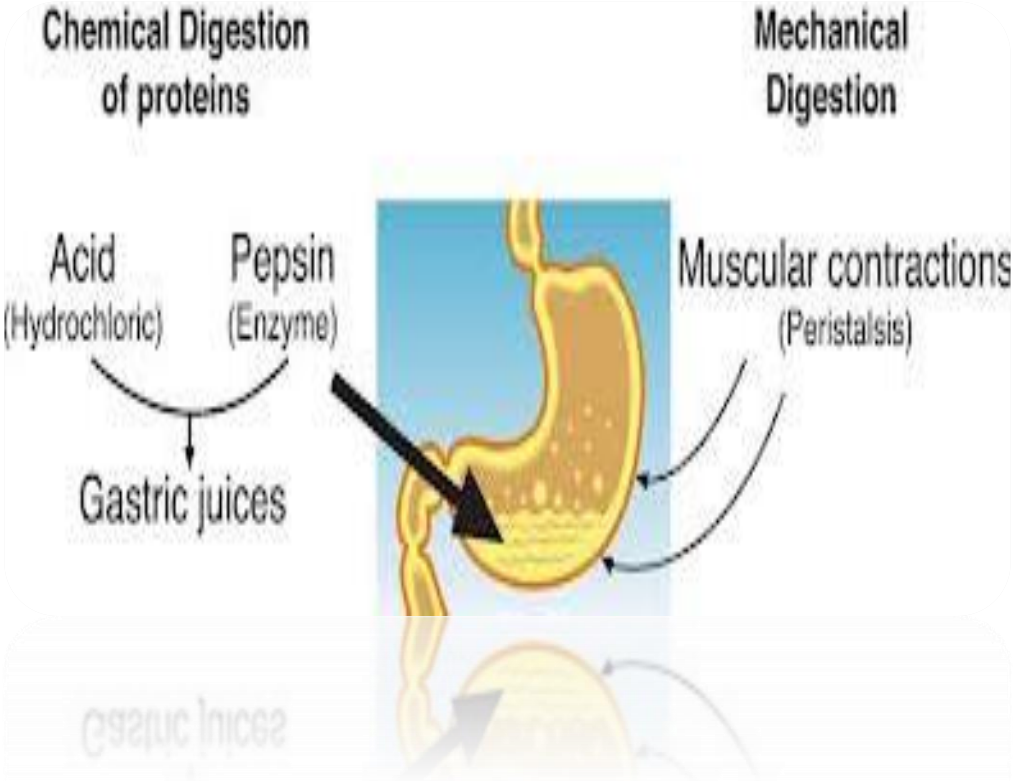
2. **Pyloric Sphincter**

- Regulates and releases food exiting the stomach, entering the small intestine



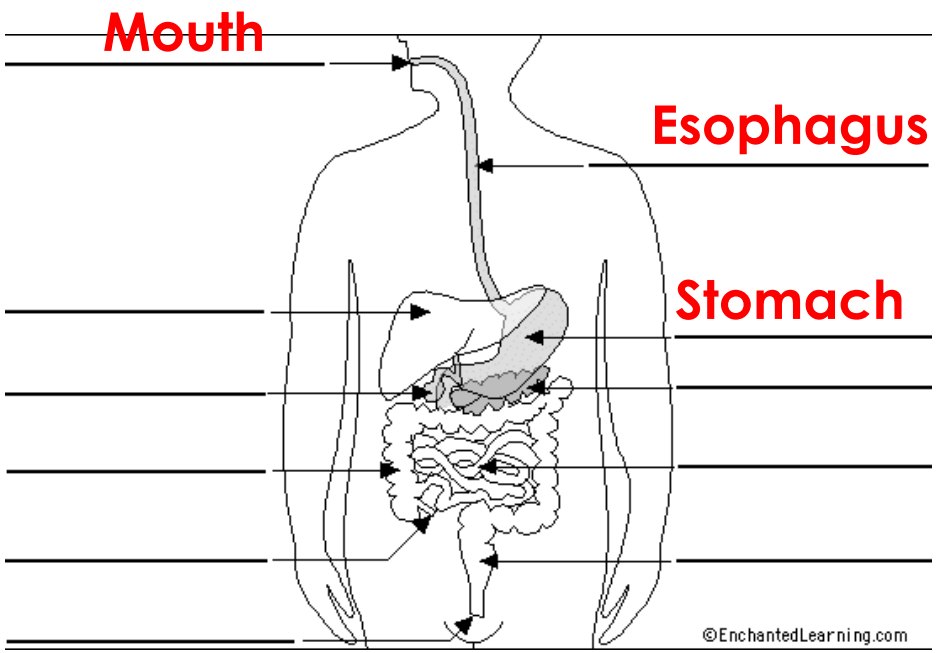
Stomach

- After eating, the stomach walls begin to contract to mix and churn food with **gastric juices**
- **Gastric Juices** are a mixture of:
  1. **Enzymes** – namely Pepsin, breaks proteins into polypeptides
  2. **Water**
  3. **Hydrochloric Acid**



Stomach

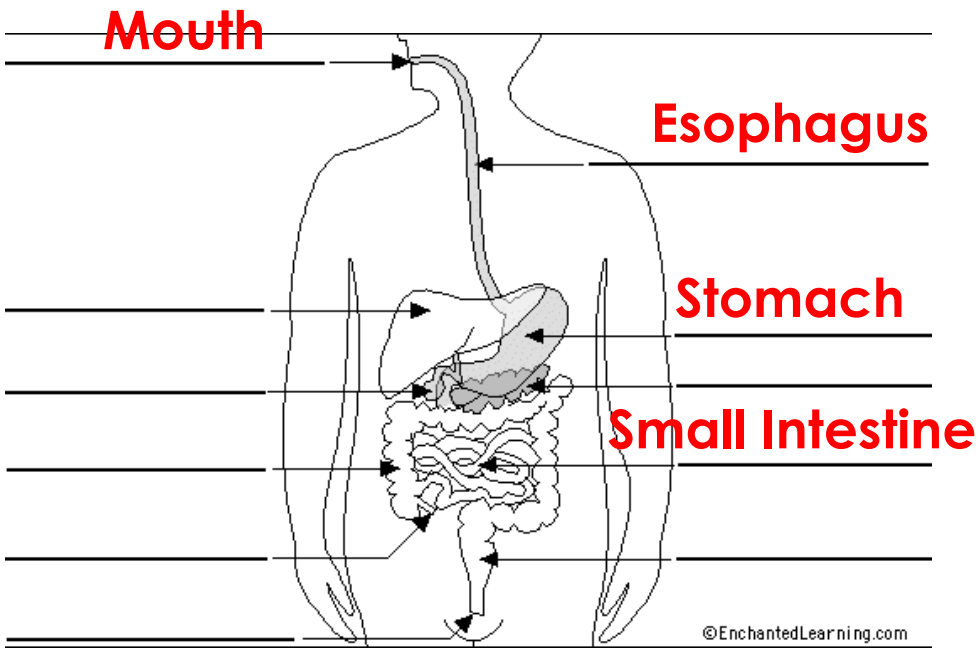
- Gastric juices are secreted by gastric glands
- Production is stimulated:
  - Sight, thought, or smell of food
  - Food entering the stomach
  - Stretching of the stomach wall
- Mixture of food and gastric juices is called **chyme**



Small Intestine

- Measures almost 6 meters in length
- Site of most chemical digestions
- Peristalsis
- Site where food molecules are absorbed into the blood
- Subdivided into three parts:

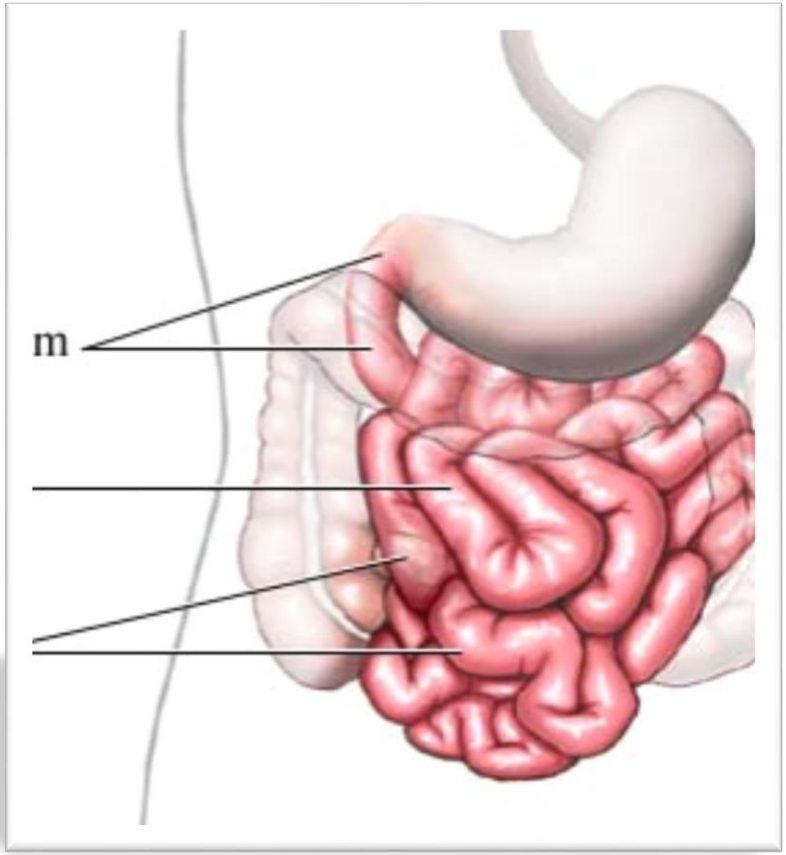
1. **Duodenum**
2. **Jejunum**
3. **Ileum**



Small Intestine

1. **Duodenum**

- First 25 cm of the small intestine
- Pancreatic and bile ducts empty here, important for chemical digestion
- Contains folds known as **microvilli**, which increase surface area of the intestine for better absorption of food
- In between each villi are **intestinal glands**



Small Intestine

2. **Jejunum**

- Roughly 2.5 meters long
- Also contains more folds than the duodenum
- Further break down and absorption of food

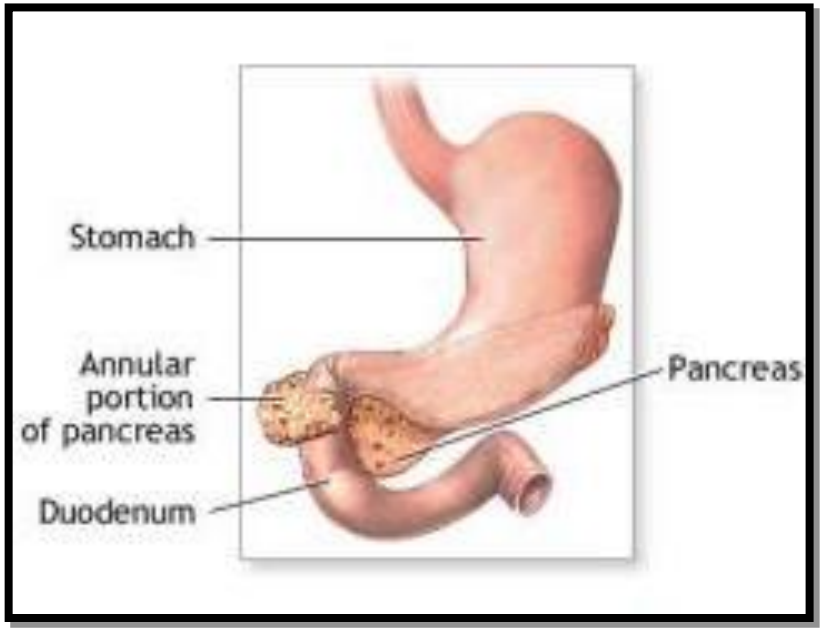
3. **Ileum**

- Last 3 meters
- Contains fewer and small villi
- Responsible for last stages of absorption and to push undigested material through to the large intestine

Small Intestine

- Two glands secrete enzymes into the small intestine:

1. **Pancreas**
2. **Intestinal Glands**



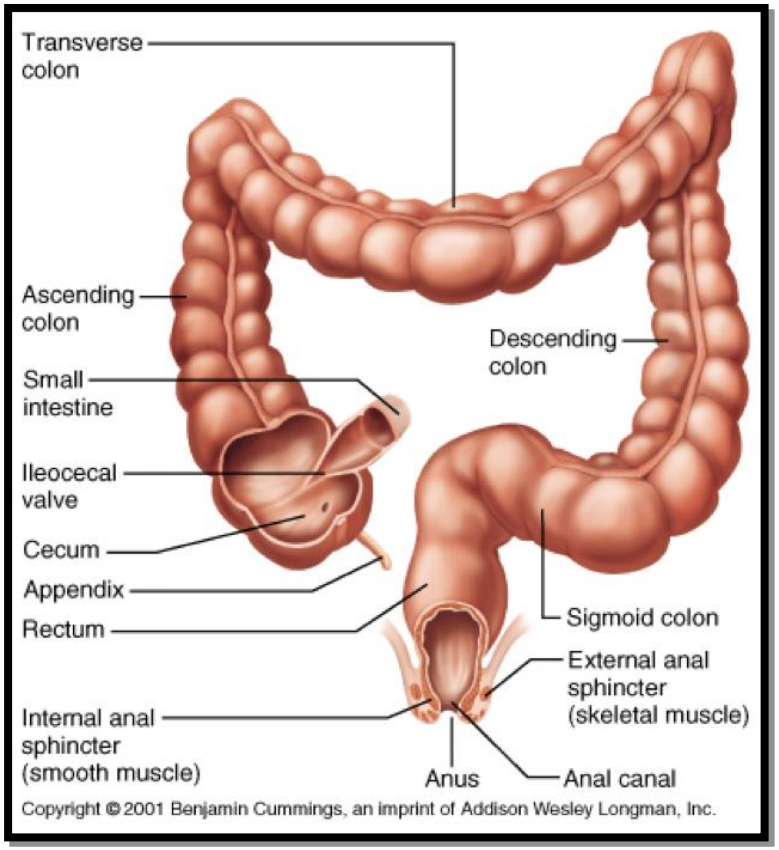
Small Intestine

- Chemical activity of the small intestine involves:

1. **Lipase**
   - Produced by the pancreas
   - Lipids into fatty acid's and glycerol
2. **Carbohydrases**
   - Produced by the pancreas and intestinal glands
   - Complex sugars into simple sugars
   - Ex: Amylase and Maltase
3. **Proteases**
   - Produced by the pancreas and small intestine
   - Proteins into amino acids

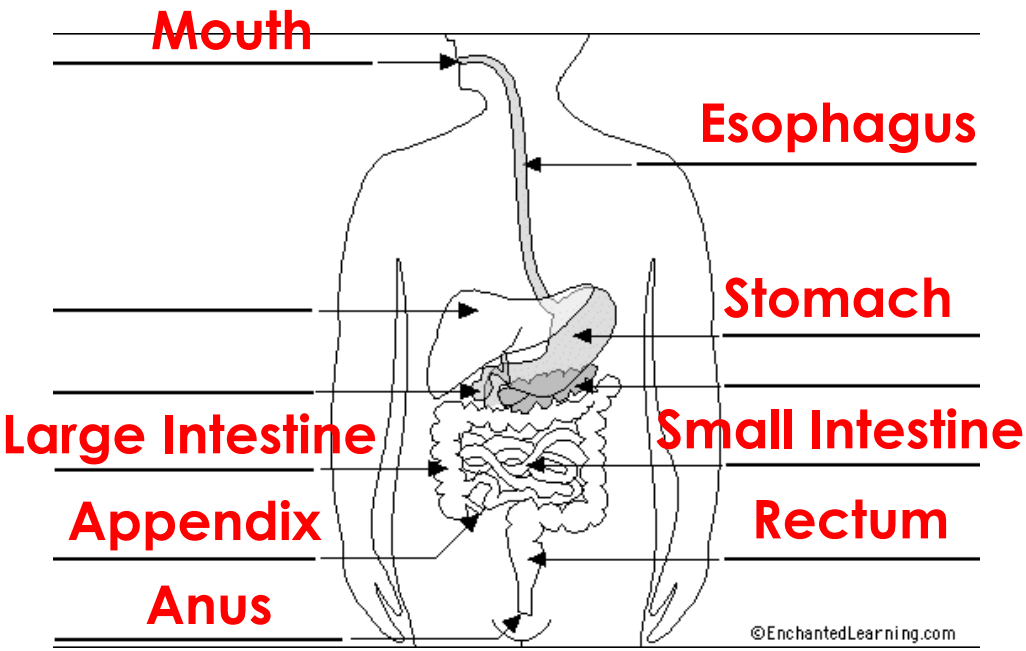
Large Intestine

- Divided into several structures
  - Caecum
  - Colon
  - Rectum
  - Anal Canal
  - Anus
- Much shorter than the small intestine



Large Intestine

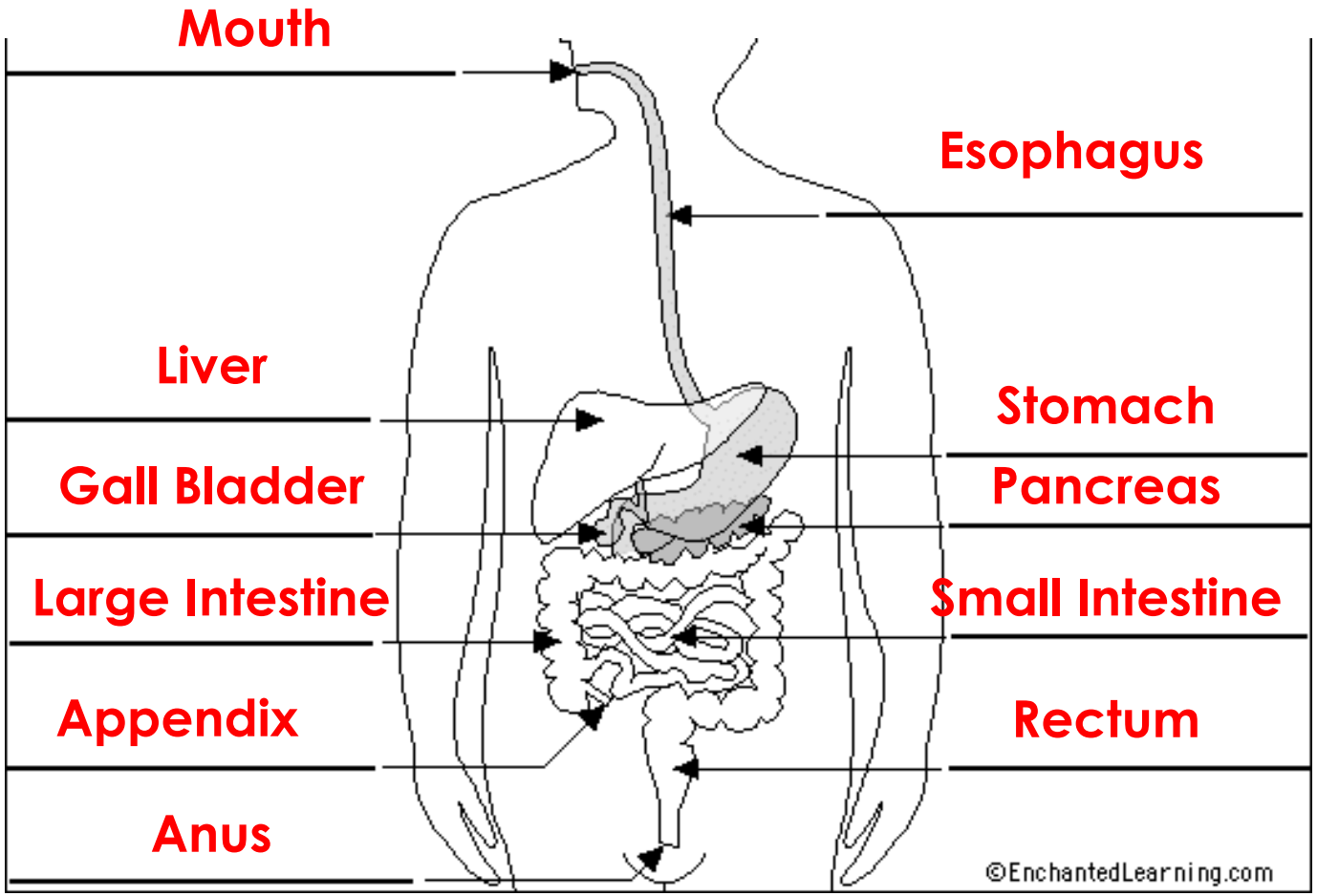
- Site for water and dissolved mineral absorption
- Site where intestinal bacteria further break down food for absorption
- Undigested material passes as feces and is expelled through the anus



Accessory Organs

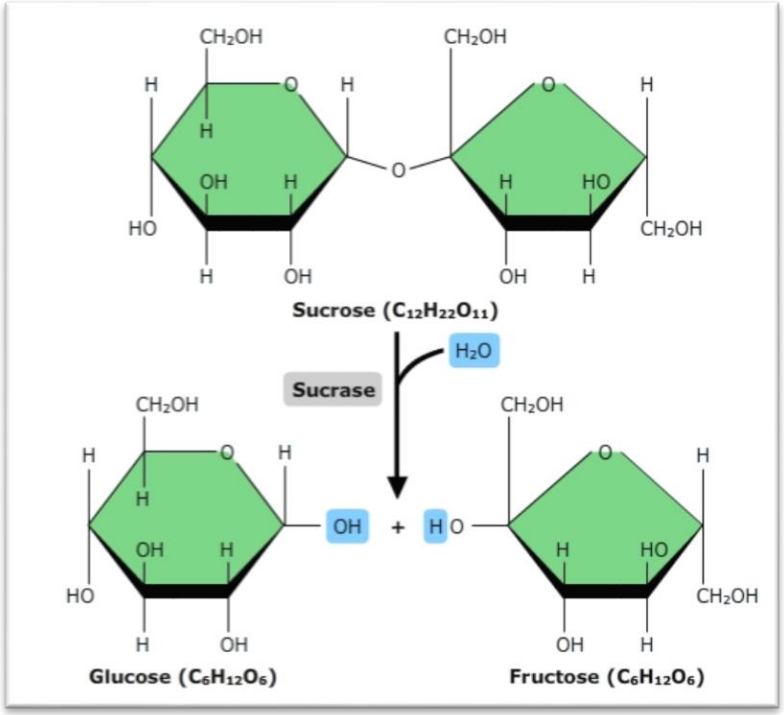
1. **Pancreas**
   - Produces pancreatic juice
   - Secretes digestive enzymes
   - Contains insulin producing cells
2. **Liver**
   - Produces bile which aids in the breaking down of fats and oils
   - Plays a role in the storage of glucose as glycogen in the regulation of blood sugar levels
3. **Gall Bladder**
   - Stores bile and secretes bile into the small intestine

Accessory Organs



Chemical Digestion Detailed

- Is the chemical break down of food, primarily through hydrolysis
- **Hydrolysis** is the chemical break down of macromolecules by the addition of water
- Water is used to break compounds at specific points
- **Enzymes** help speed up the process



Enzymes

- Are chemicals secreted by cells to speed up reaction rates
- Responsible for the breakdown of molecules too large to be absorbed into the blood stream
- There are three types of digestive enzymes:

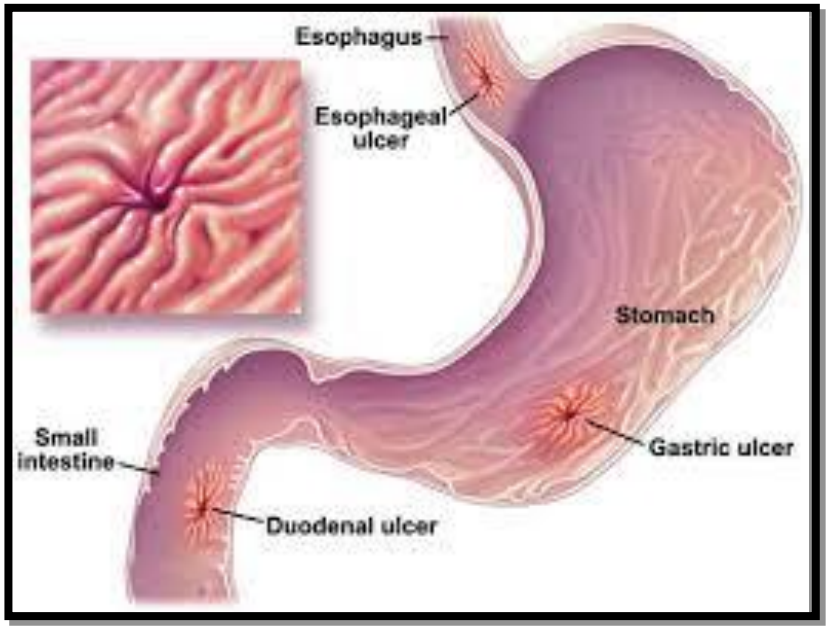
1. **Carbohydrases**
   - Ex: Salivary Amylase
2. **Lipases**
   - Lipase from the Pancreas
3. **Proteinases**
   - Pepsin from the Stomach

Digestive Disorders

Unit 3: Maintaining Dynamic Equilibrium

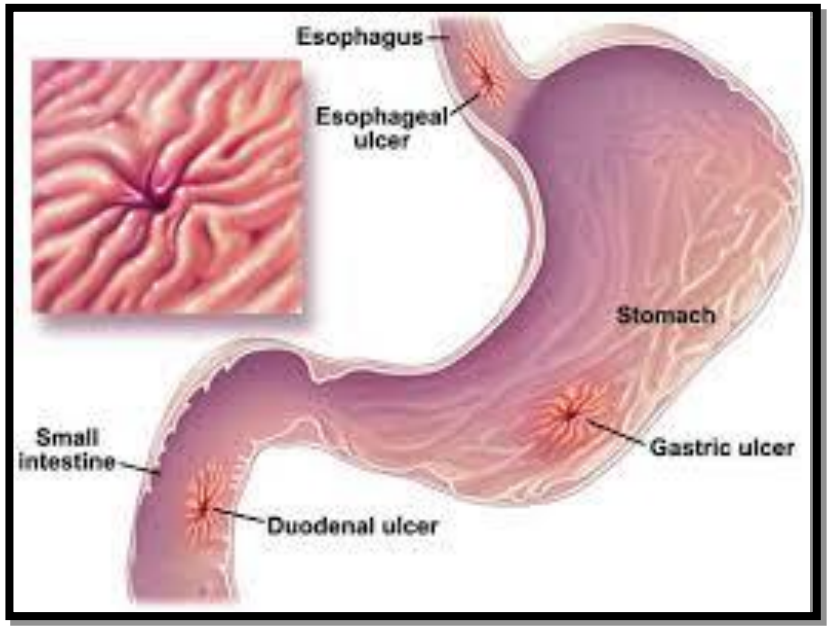
Ulcers

- The stomach is an acidic environment
- The stomach is also covered with a layer of mucous to help protect our it from the acidity of its environment
- When the layer of mucous starts to erode, sores start to form which take time to heal
- Sores are called **ulcers**



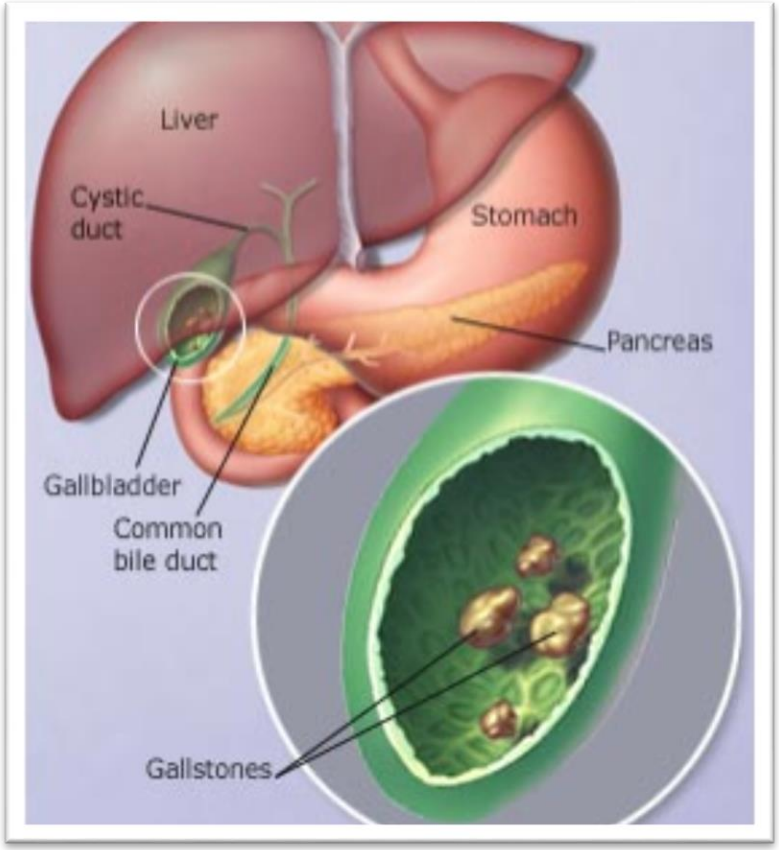
Ulcers

- Most are caused by acid resistant bacteria which prevent mucous secretions
- Other factors include alcohol, smoking, and stress
- Treatments include medication to either reduce acid production or increase mucous secretions



Gallstones

- Small, hard masses that form in the gall bladder
- Stored bile can precipitate to form crystals which can grow to become stones
- Often causes by obesity, alcohol abuse, and heredity
- Treatments include medication or lithotripsy
- High rate of recurrence



Inflammatory Bowel Disease (IBD)

Crohn's Diseases

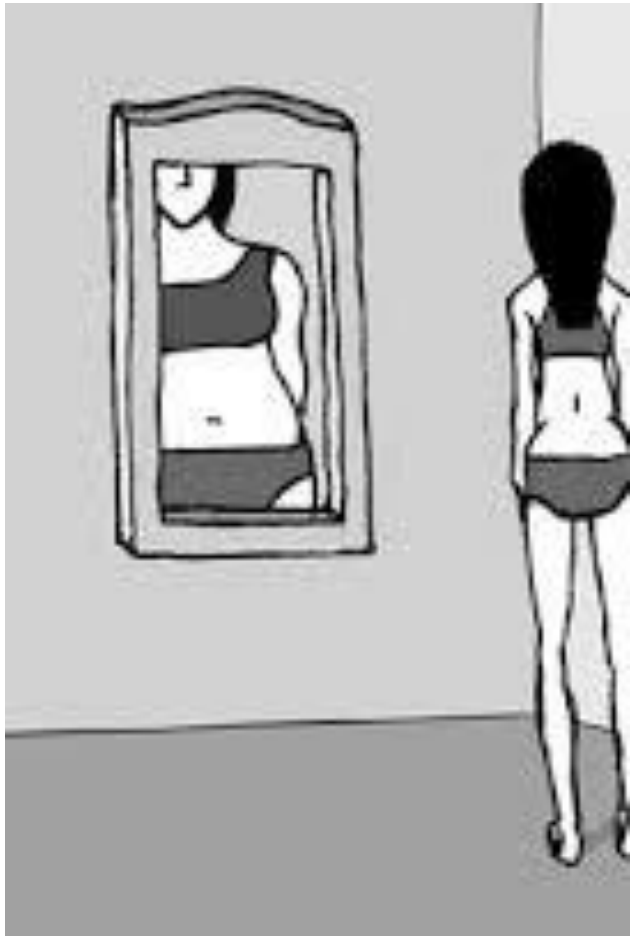
- Inflammation of the ileum lining, ie. **Ileitis**
- Caused by interactions between environmental, immunological and bacterial factors in genetically susceptible individuals
- Pain, diarrhea, fever, and rectal bleeding
- Decrease appetite and weight loss
- Often difficult to diagnose as symptoms are similar to those of irritable bowel syndrome

Colitis

- Ulceration and inflammation of the colon
- Symptoms include loose, bloody stool, cramps
- Treatments include medication or removal of the entire bowel and rectum with an external open for waste removal created - **Ileostomy**

It's No Secret…

- That eating right is important
- Good nutrition provides the energy our bodies need to carry out many metabolic activities
- It also provides the essential raw materials our bodies need as building blocks

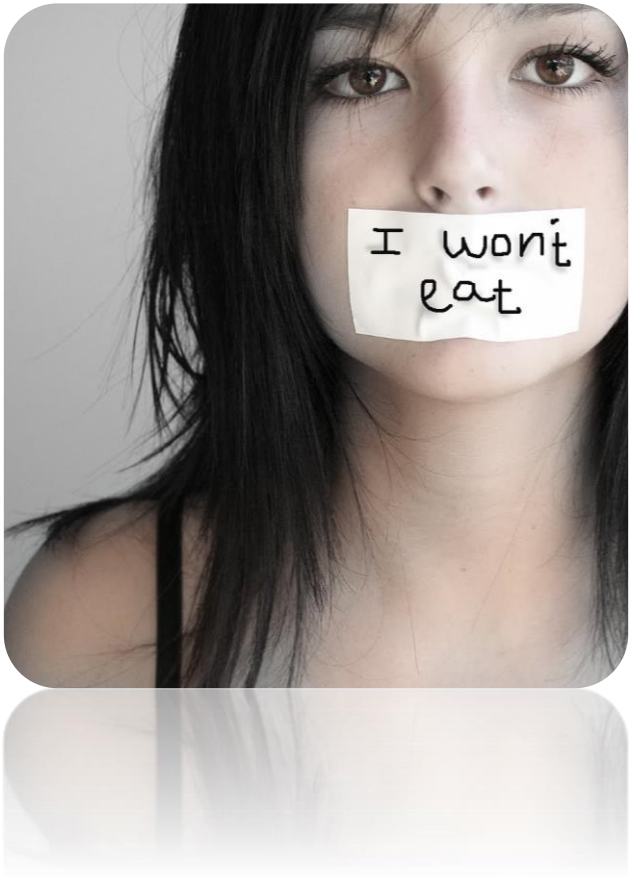


Eating Disorders

The Digestive System

Anorexia Nervosa

- Characterized by a fear of gaining weight, causing a person to go on a very restrictive diet
- Characterized by a body mass of less than 85% of their normal body mass and a distorted image of themselves
- Seeing themselves as overweight even when they clearly are not



Anorexia Nervosa

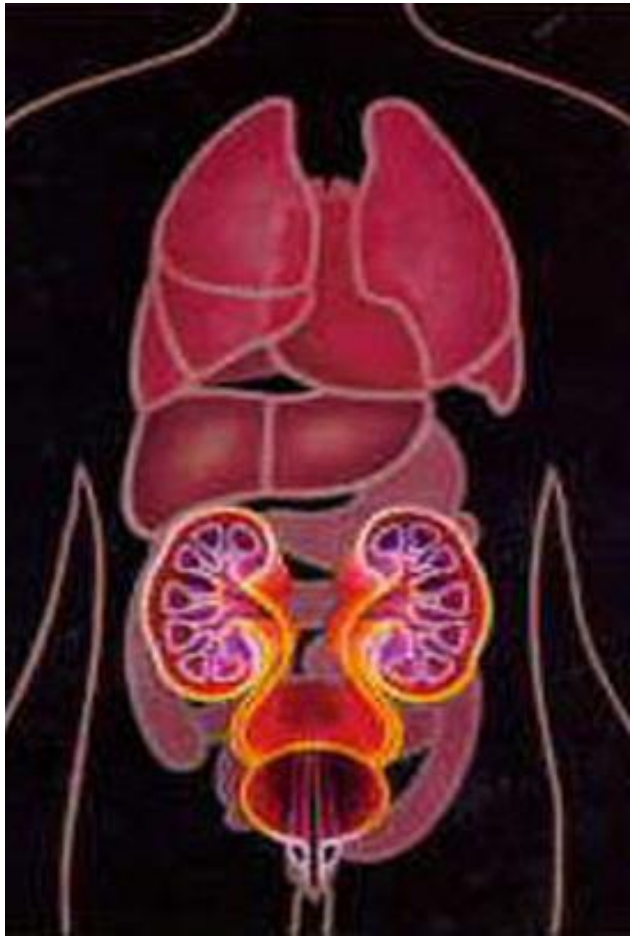
- Symptoms of starvation present include:
  - Low blood pressure
  - Irregular heartbeat
  - Constipation
- Severe cases can lead to:
  - Body shutting down
  - Skin drying out
  - Digestive system shuts off
  - Death
- Psychological therapy and hospitalization are required to help recovery

Bulimia Nervosa

- Eating disorder characterized by episodes of binge eating followed by purging
- Often associated with obesity and anorexia
- Person often has a restrictive diet but loses control, causing them to binge and which they will then purge

Bulimia Nervosa

- Symptoms include:
  - Change in blood composition which can damage the heart and kidneys
  - Vomiting can damage the esophagus, pharynx, and teeth
- Psychological therapy and medication often used to help in recovery

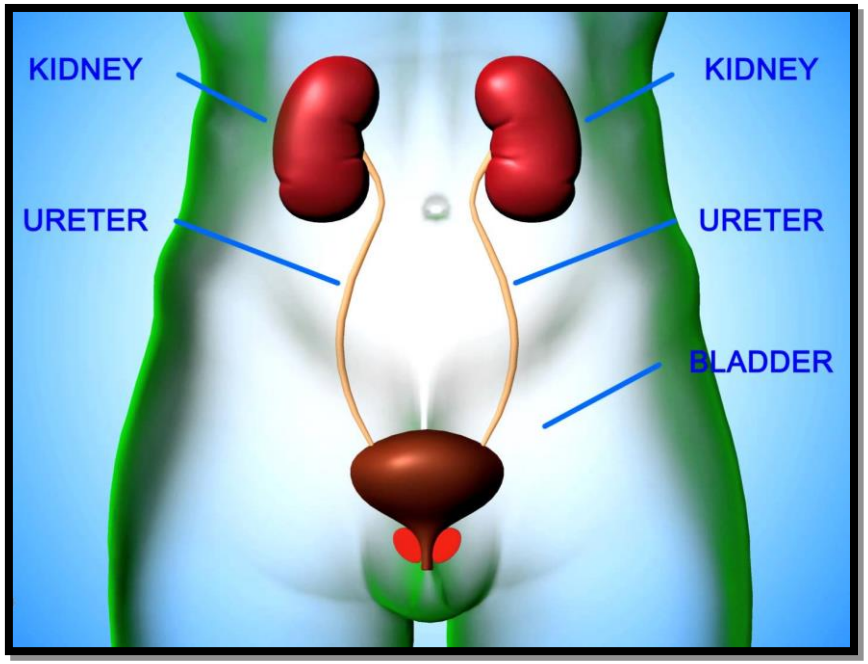


The Excretory System

Unit 3: Maintaining Dynamic Equilibrium

The Excretory System

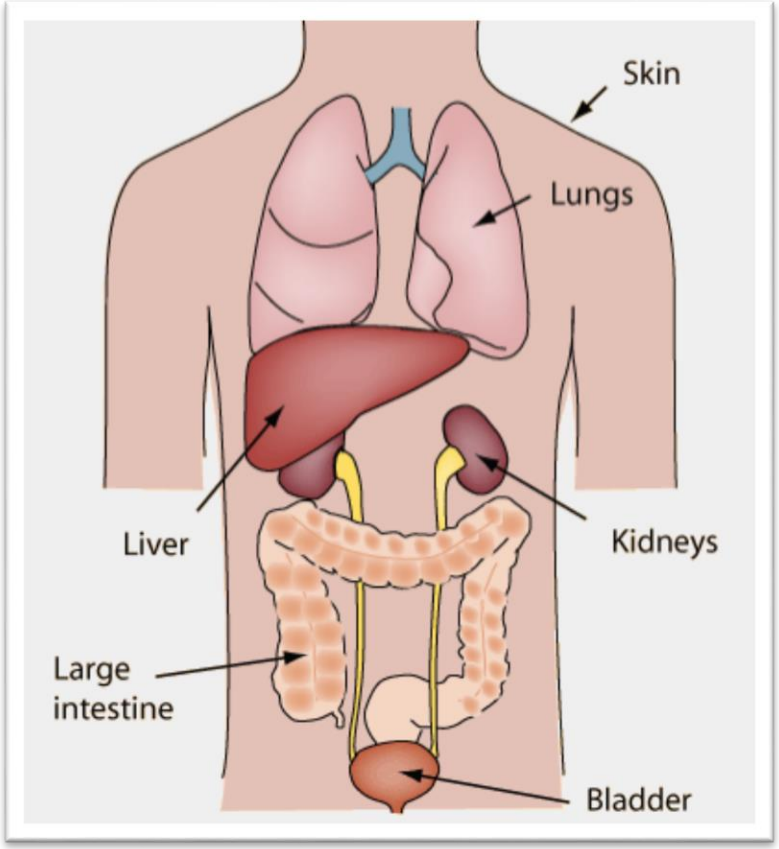
- Human excretory system maintains homeostasis by **removing metabolic wastes** such as water, salt, and metabolic concentrations in the blood



Organs of Excretion

- The excretory system is made of four key components
- There are however other organs that are involved with the removal of wastes

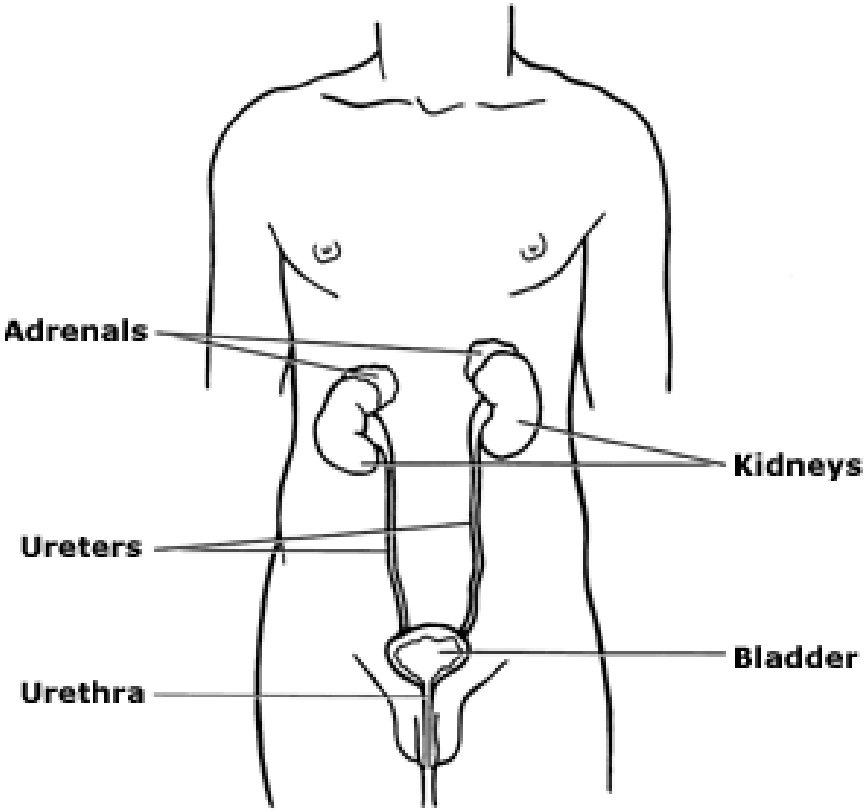
1. **Skin & Associated Glands**
   - Removes water and salt
2. **Lungs**
   - Removes CO_2
3. **Liver**
   - Removes metabolic wastes



The Excretory System

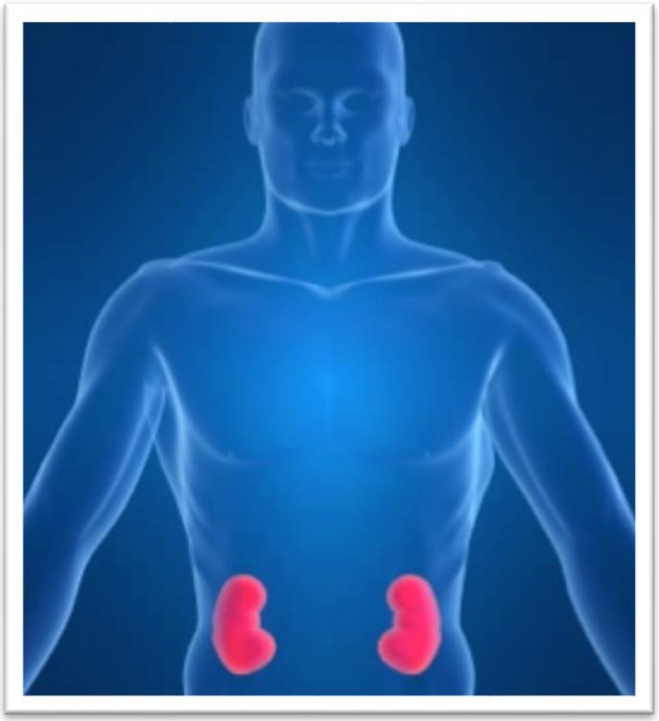
- There are four main parts to the excretory system

1. **Kidneys**
2. **Ureters**
3. **Urinary Bladder**
4. **Urethra**



Kidneys

- Regulate and filter the amount of water, salts, and other metabolic substances in the blood
- They are the bean shaped structures that remove nitrogenous wastes and excess salts from the blood
- Produces urine



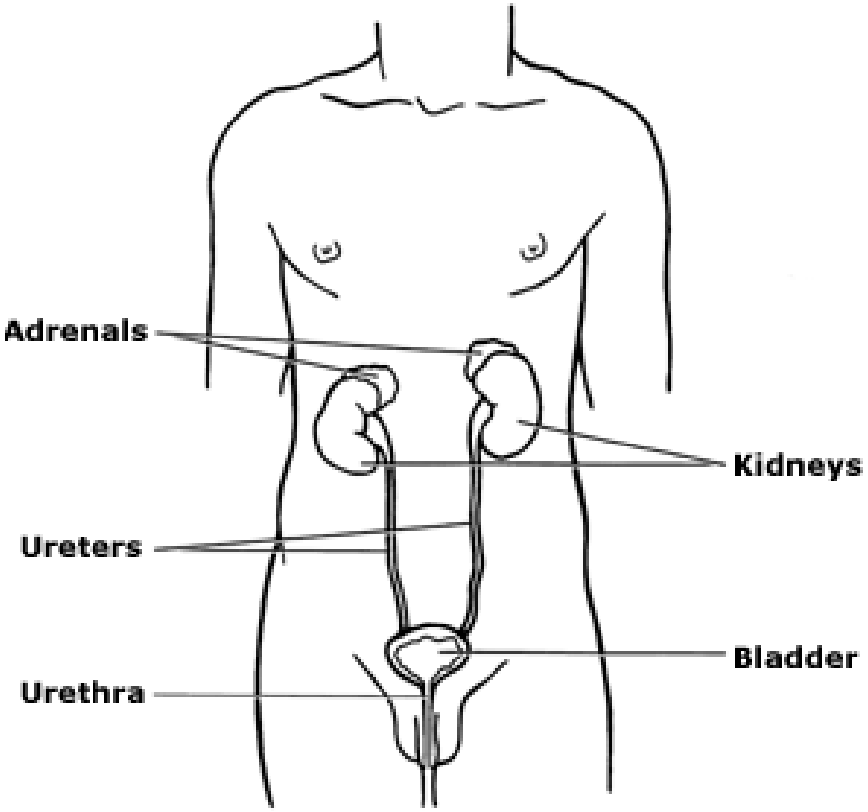
The Others…

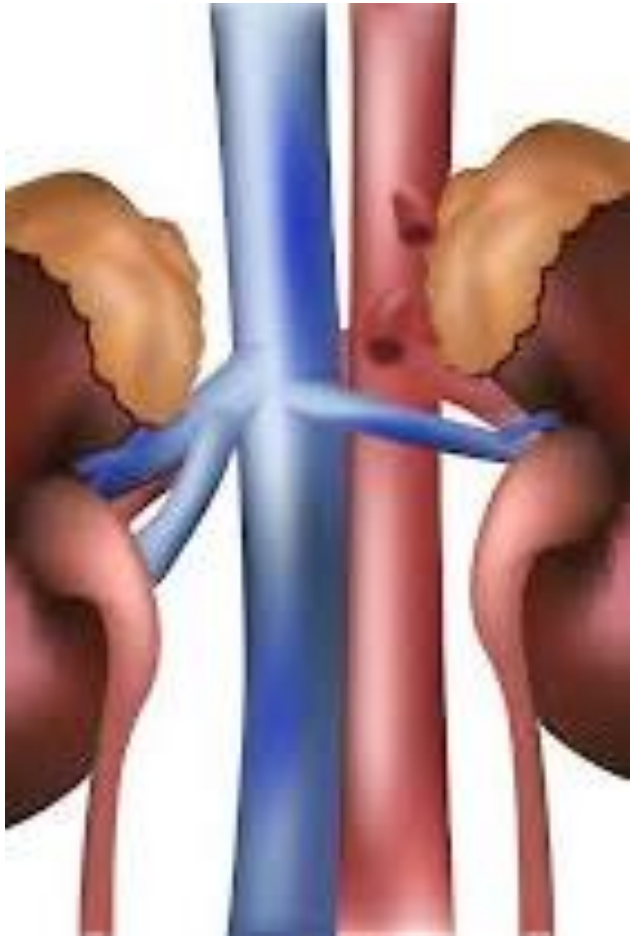
2. **Ureters**

- Tubes that carry urine from the kidney to the urinary bladder

3. **Urinary Bladder**
   - Stores urine until released

4. **Urethra**
   - Tube that carries urine outside of the body



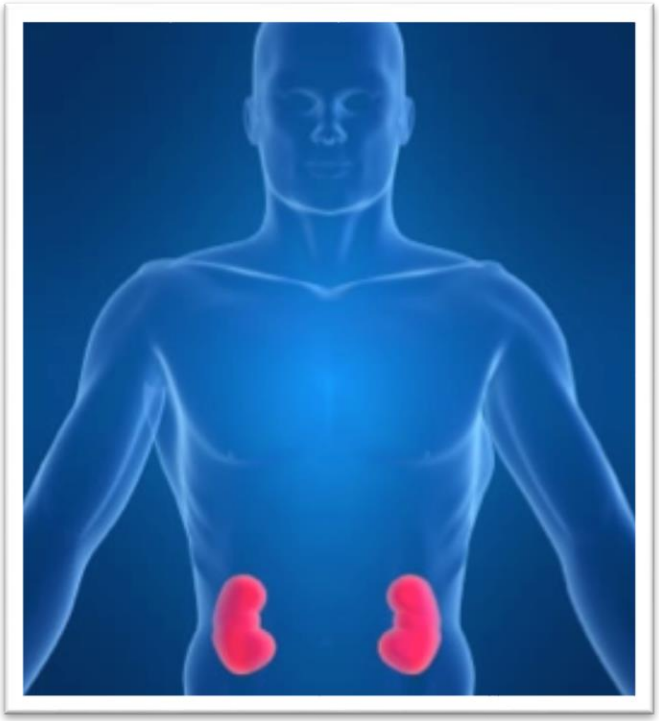


The Kidneys

The Excretory System

The Kidneys

- Regulate and filter the amount of water, salts, and other metabolic substances in the blood
- They are the bean shaped structures that remove nitrogenous wastes and excess salts from the blood
- Produces urine



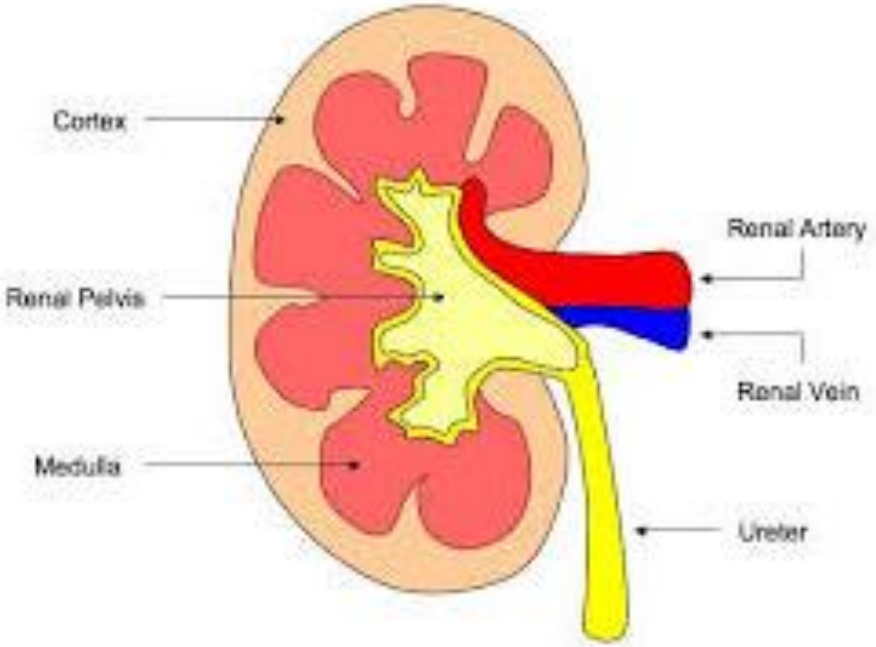
The Kidneys

- Are made of three main sections:

1. **Cortex**
   - Outer layer
   - Where blood is filtered
2. **Medulla**
   - Inner layer
   - Contains collecting ducts which carry filtrate to the pelvis
3. **Pelvis**
   - Inner collecting area
   - Hollow cavity where urine accumulates and drains into the ureter

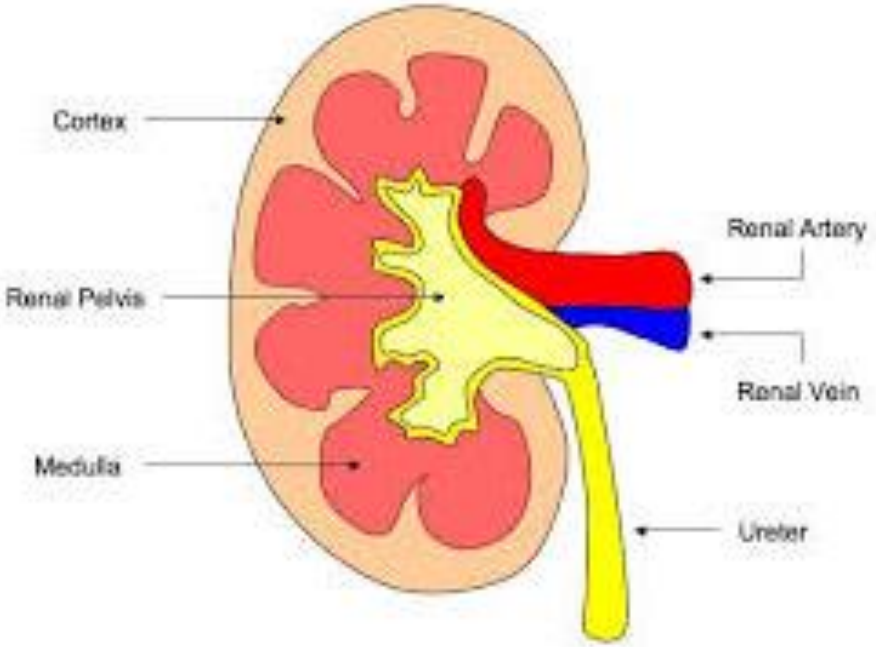
Other Aspects of the Kidney

- **Renal Artery**
  - Supplies blood to the kidney
  - Blood contains glucose and oxygen because the kidney has to work to produce urine
  - Pressure has to be sufficient, high enough, for the kidney to filter blood
  - Blood contains urea which must be removed, may also contain excess salt and water

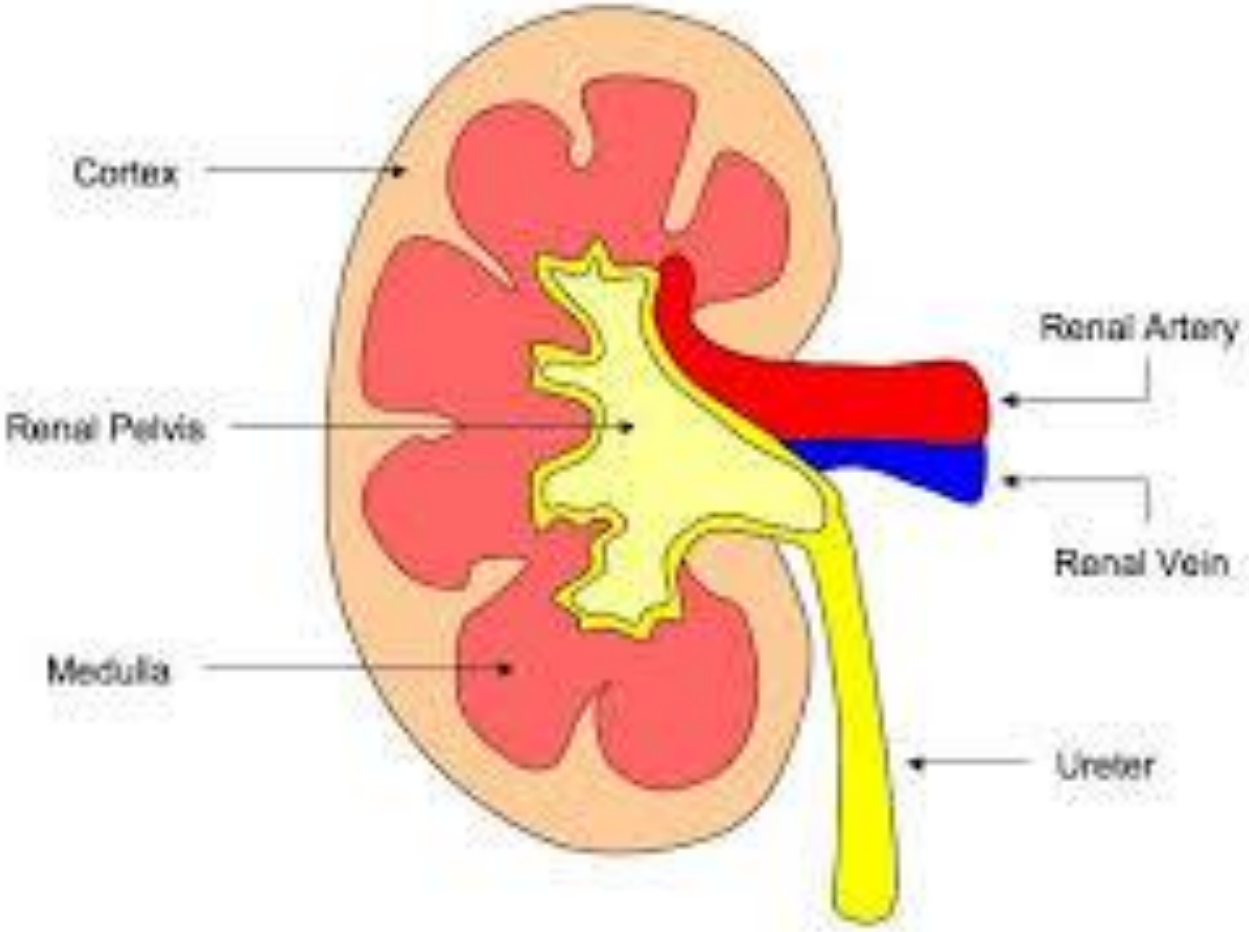


Other Aspects of the Kidneys

- **Renal Vein**
  - Carries blood away from the kidney toward the heart
  - Blood in which urea has been removed
  - Urea is produced in the liver as a byproduct from the breaking down of excess amino acids
  - Blood also has the right amounts of water and salt, as the kidney has filtered the excess

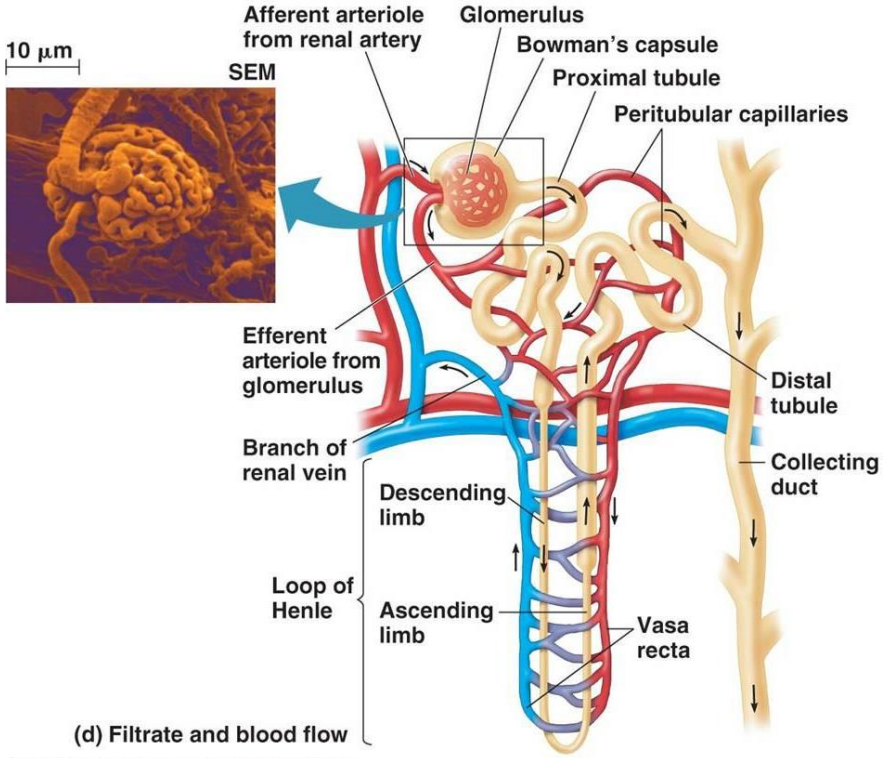


The Kidneys


Cortex
Renal Pelvis
Medulla
Renal Artery
Renal Vein
Ureter

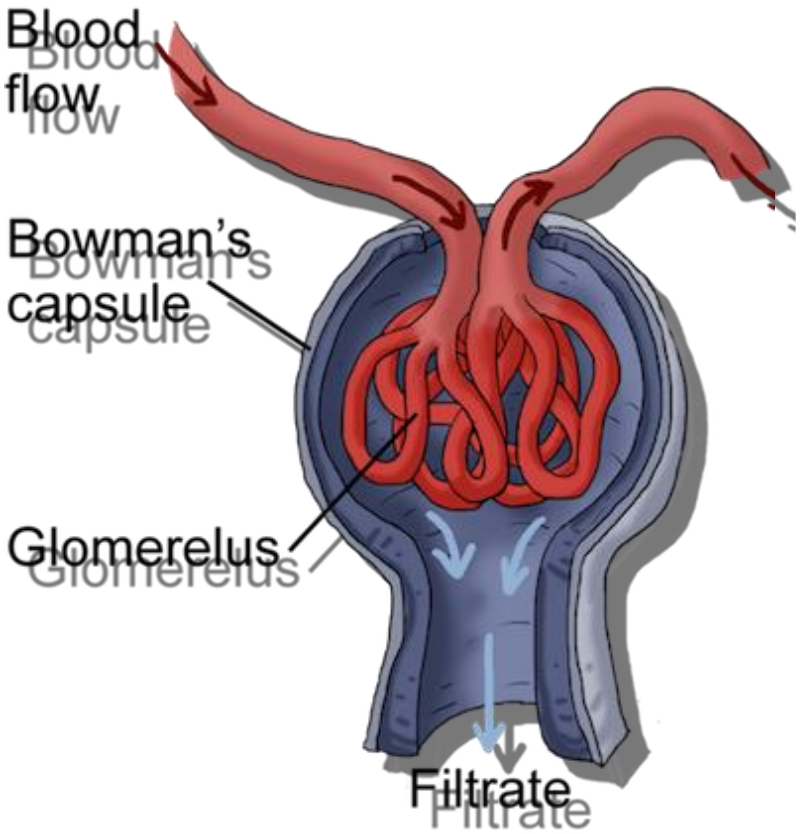
How Blood is Filtered

- Functional units of kidneys are called **nephrons**
- The cortex and the medulla of the kidneys are made of over a million nephrons
- Small branches of the renal artery, **afferent arterioles**, supply nephrons with blood
- Afferent arterioles branch into a capillary bed, called the **glomerulus**



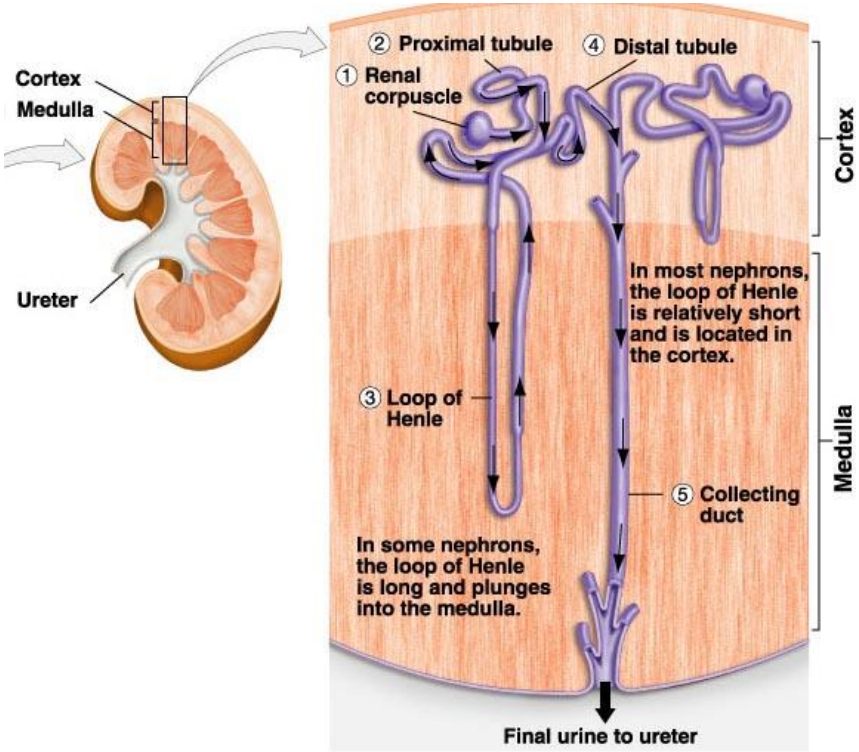
How Blood is Filtered

- The **glomerulus** is the site of **filtration**
- Blood from the renal artery is forced into the glomerulus under high pressure
- Most of this liquid, blood plasma is forced into the **Bowman's Capsule** which surround the glomerulus
- Large particles like blood cells and proteins stay in capillaries



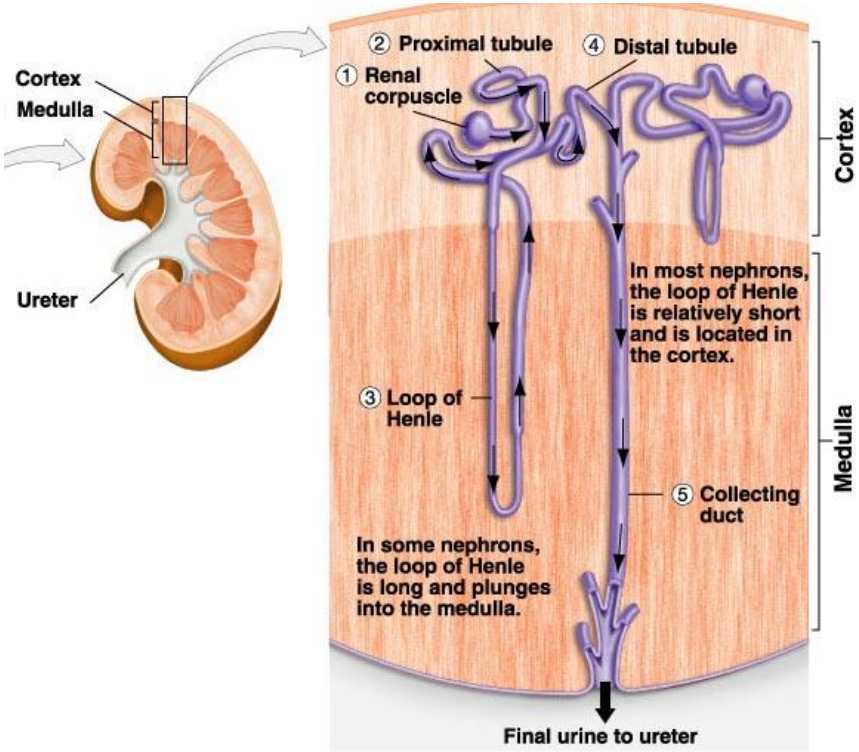
How Blood is Filtered

- Each **Bowman's Capsule** is at the beginning of a long tube called the **Proximal Tube** – site of **Reabsorption**
- As filtrate passes through the proximal tubule materials such as water, glucose, amino acids, and ions that are needed by the body are reabsorbed by the blood stream by osmosis and diffusion



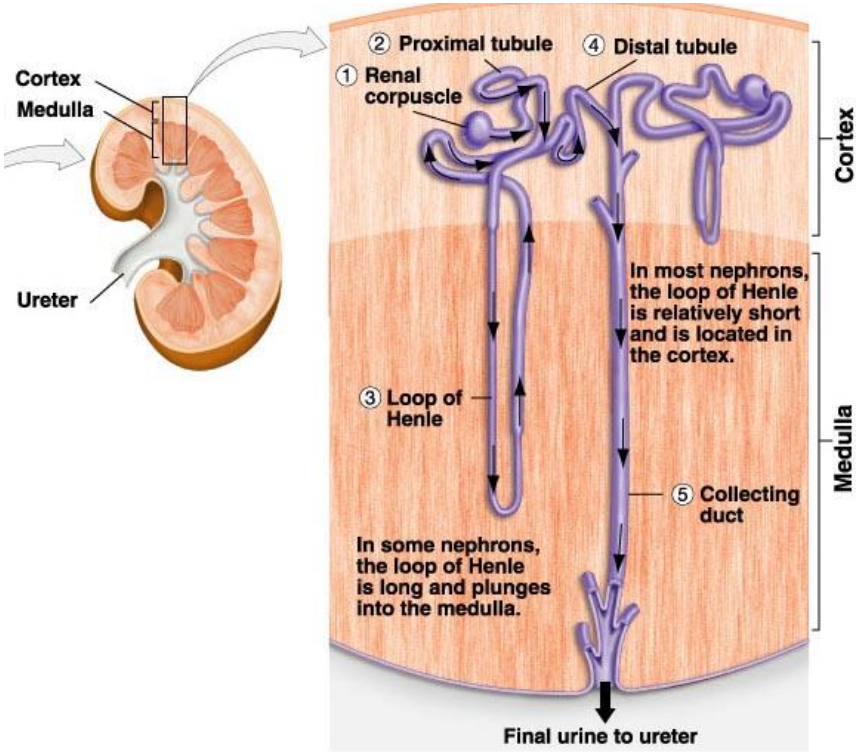
How Blood is Filtered

- Each **Proximal Tube** leads to the **Loop of Henle**
- Loop of Henle is responsible for removing water from the filtrate via osmosis
- This happens because there is a greater salt (Na^+) concentration in the cells of the medulla
- Loop of Henle extends into the medulla and returns to the cortex, at which point it becomes the **Distal Tube**



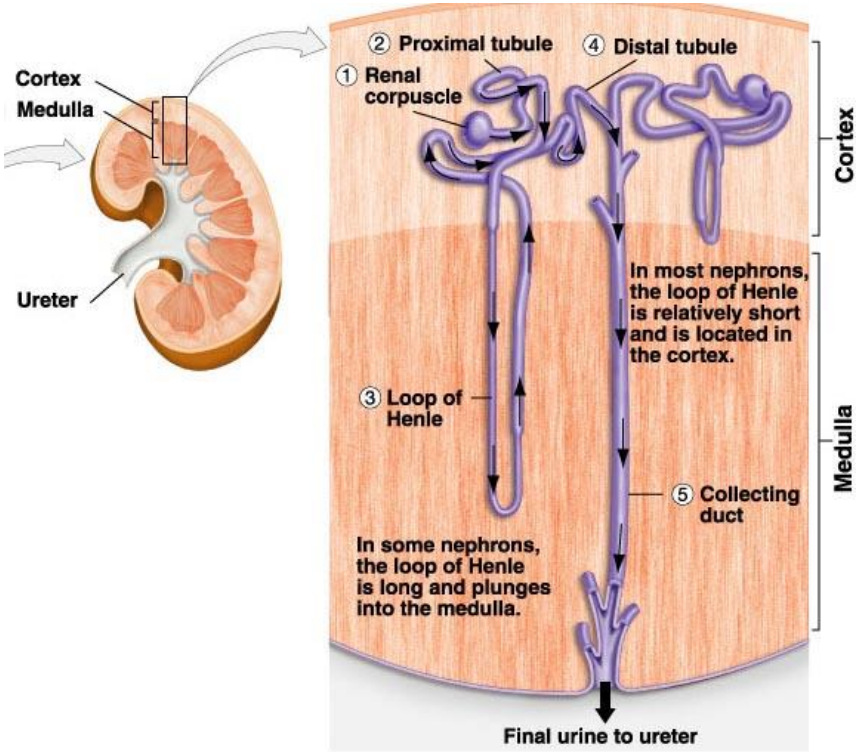
How Blood is Filtered

- **Distal Tube** is the site of **Tubular Secretion**
- Active transport pulls substances such as hydrogen ions, creatinine, and drugs out of the blood and into the filtrate
- **Distal Tube** drains filtrate into **Collecting Ducts** through the medulla into the renal pelvis

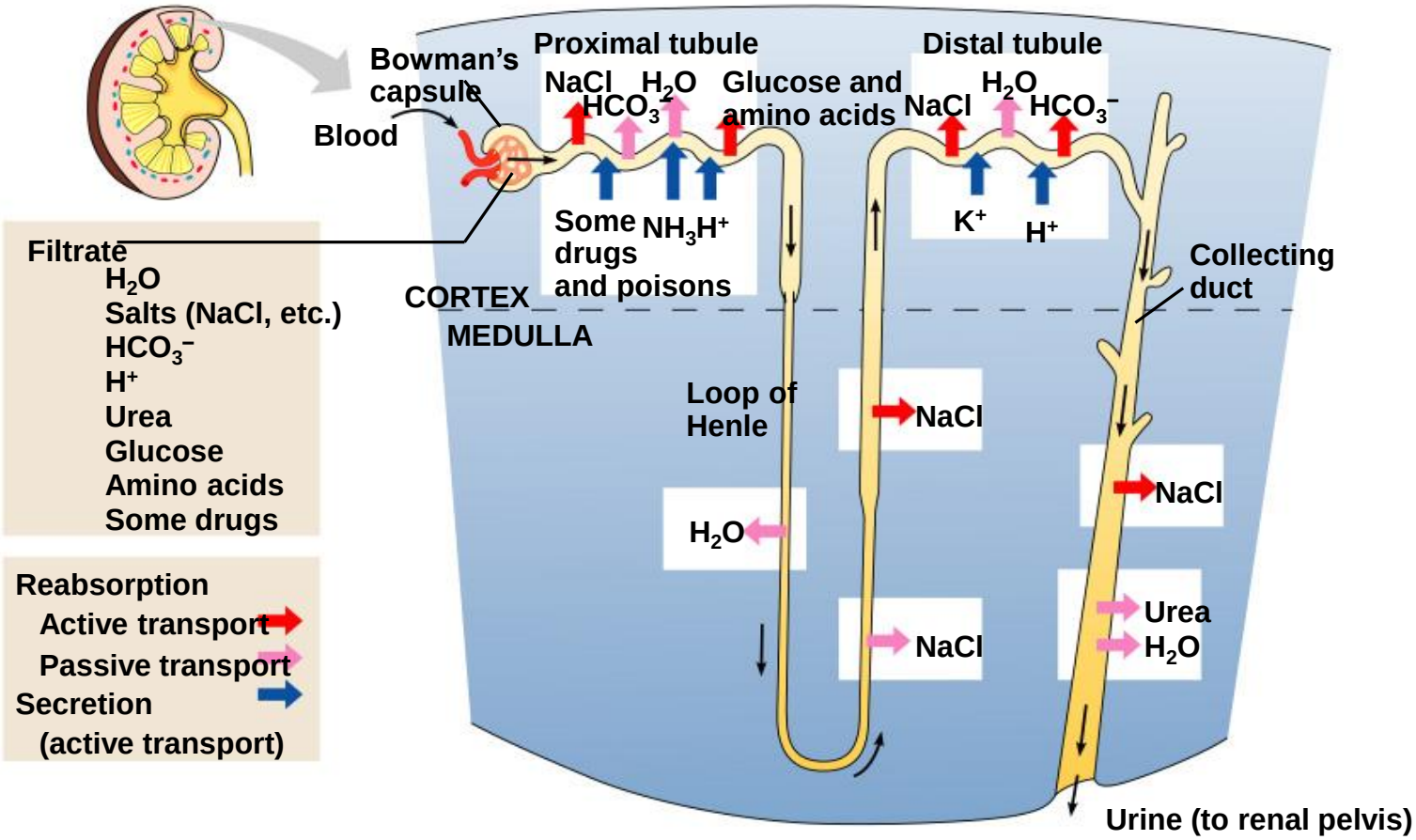


How Blood is Filtered

- Filtrate passes into collecting ducts as urine
- Most water, ions, and useful materials have been reabsorbed
- Urine passes through the pelvis into the ureter



How Blood is Filtered

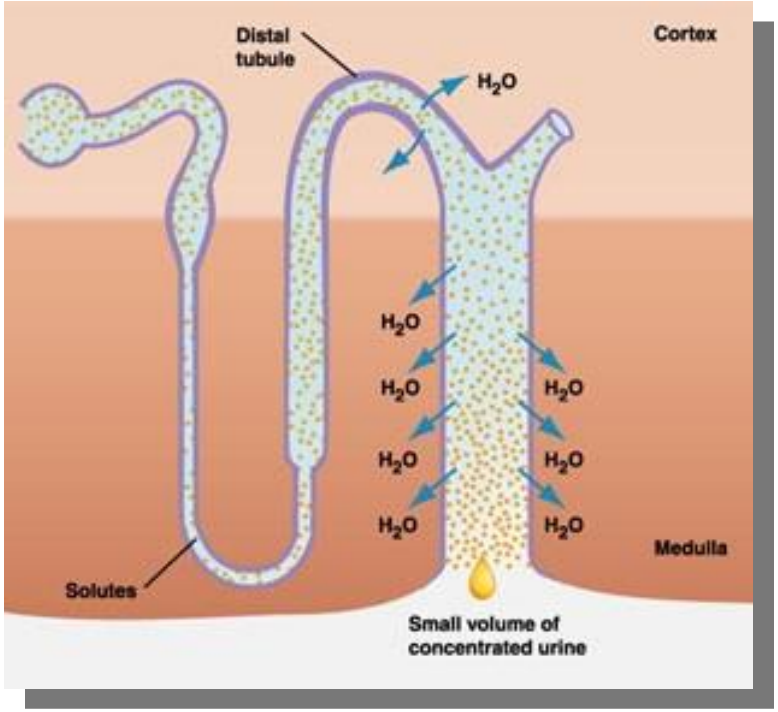


Urine Output

Maintaining Water Volume

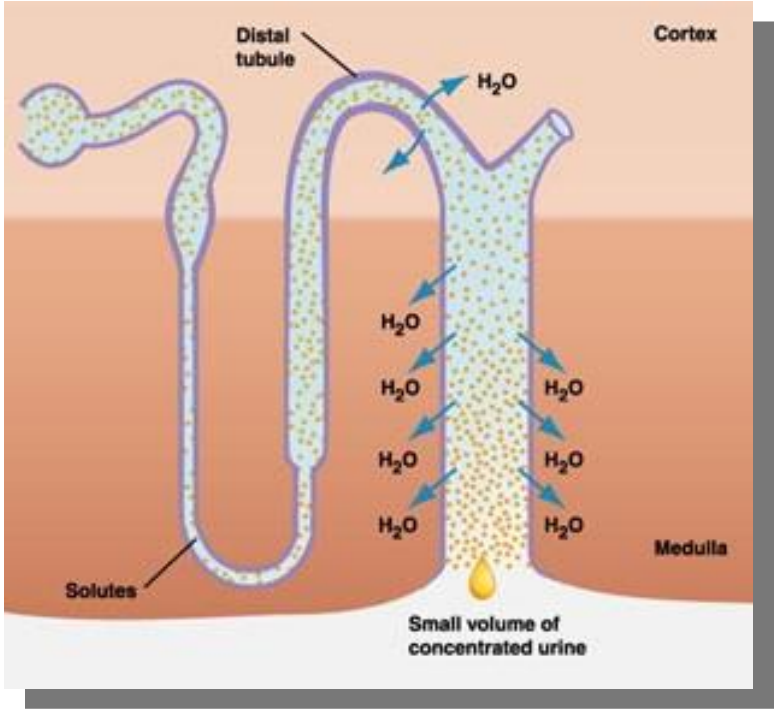
Maintaining Water Volume

- Kidneys have the ability to conserve or waste water
- The permeability of the distal tubule and collecting duct is controlled by **Anti-Diuretic Hormone (ADH)** also known as **Vasopressin**
- ADH is a hormone secreted by the pituitary gland
- It increases the nephrons ability to **conserve water – increases the permeability of the kidneys tubules**



Maintaining Water Volume

- Osmoreceptors in the hypothalamus detect water and salt concentrations in the blood
- When water needs to be eliminated, **ADH secretions are inhibited**, less water is reabsorbed into the blood, more dilute urine is produced
- When water needs to be conserved, **ADH secretions are increased**, more water is reabsorbed into the blood, more concentrated urine is produced

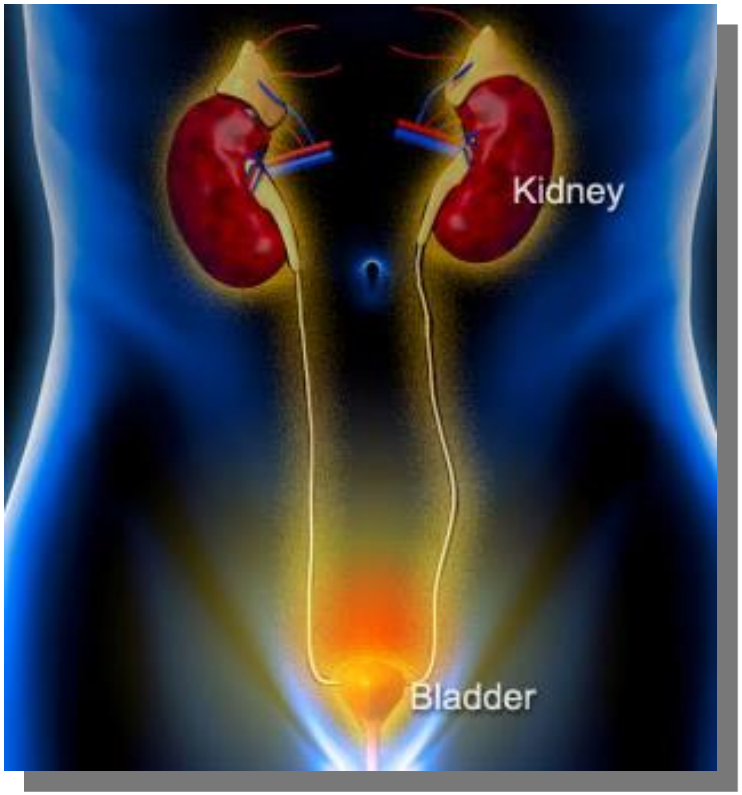


Disorders of the Excretory System

Unit 3

Urinary Tract Infections (UTI)

- Typically caused by bacterial infections
- Generally more common in women
- **Cystitis** – infection in the bladder
- **Urethritis** – infection in the urethra
- **Nephritis** – infection of the kidney

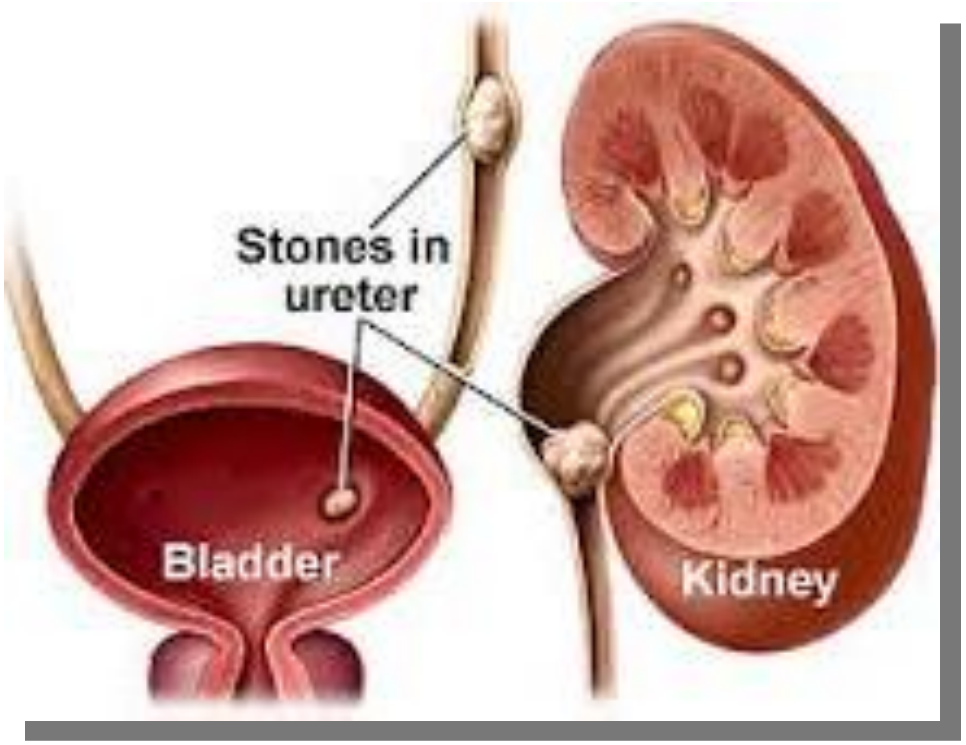


Urinary Tract Infections (UTI)

- **Symptoms**
  - Painful urinations, urge to urinate when there is no urine present, discolored urine
  - Fever, nausea, chills
  - Severity increases if infection reaches the kidneys
- **Treatments**
  - Antibiotics or surgery
- **Prevention**
  - Personal hygiene
  - Drinking lots of water

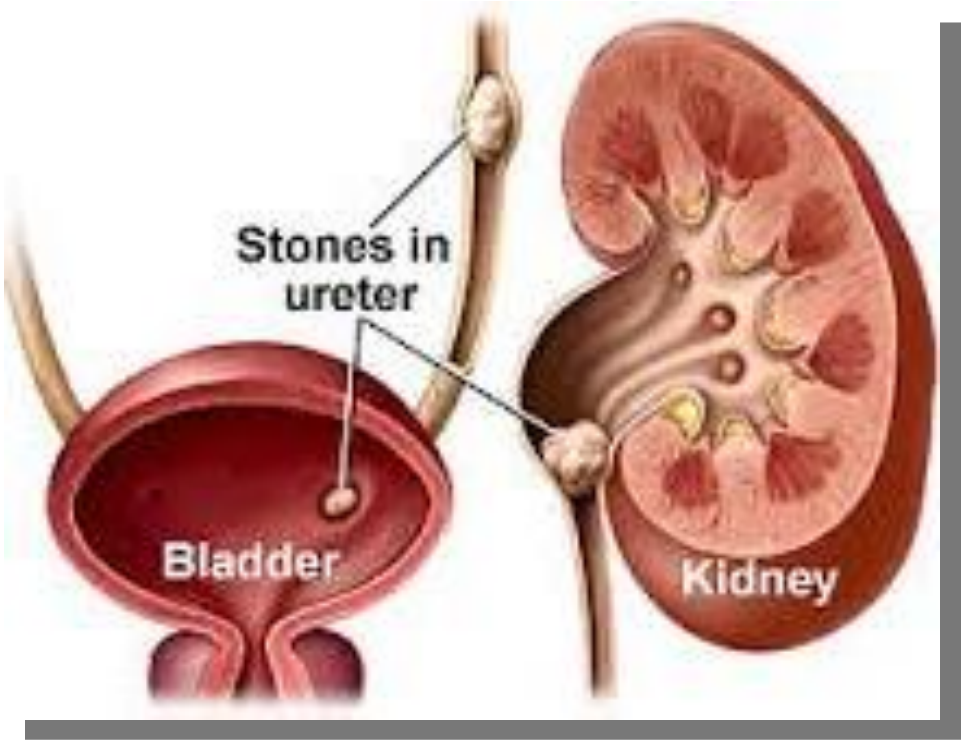
Kidney Stones

- Chemicals in urine precipitate out and form stones
  - Typically: Calcium oxalate, uric acid, or cystine crystals
- **Causes**
  - Recurring UTI's, insufficient water consumption, low activity levels, too much vitamin C and D



Kidney Stones

- **Symptoms**
  - Severe pain in the lower back and abdomen, blood in urine, nausea
- **Treatment and Diagnosis**
  - X-Rays and Urine Testing
  - Medications to break down stones and drinking plenty of water
  - Small stones may be treated with lithotripsy
  - Surgery in some instances



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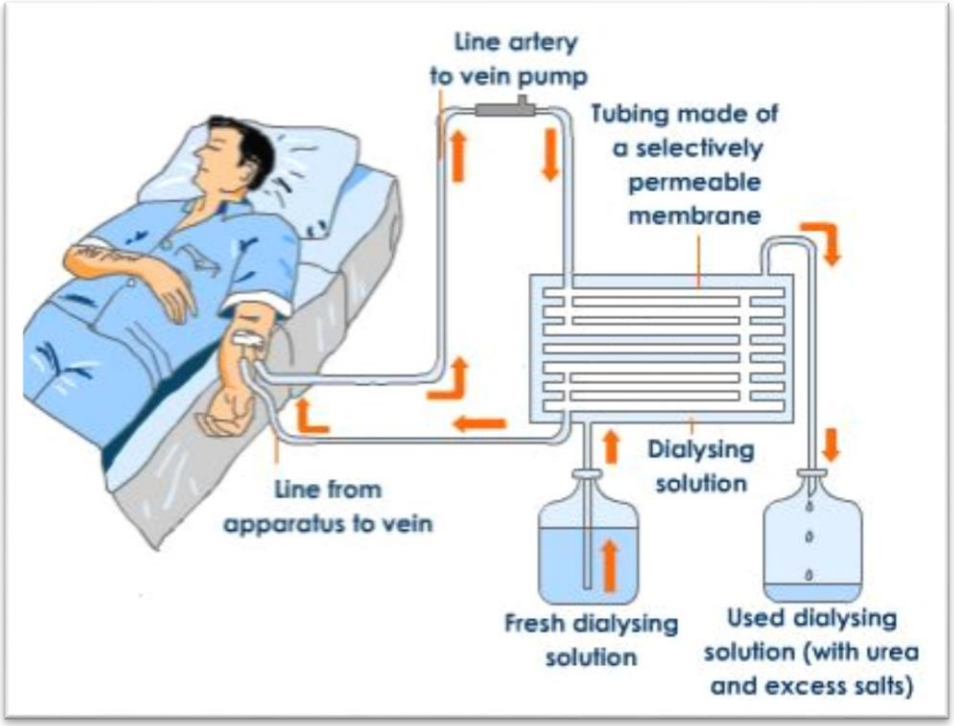
Renal Failure

The Excretory System

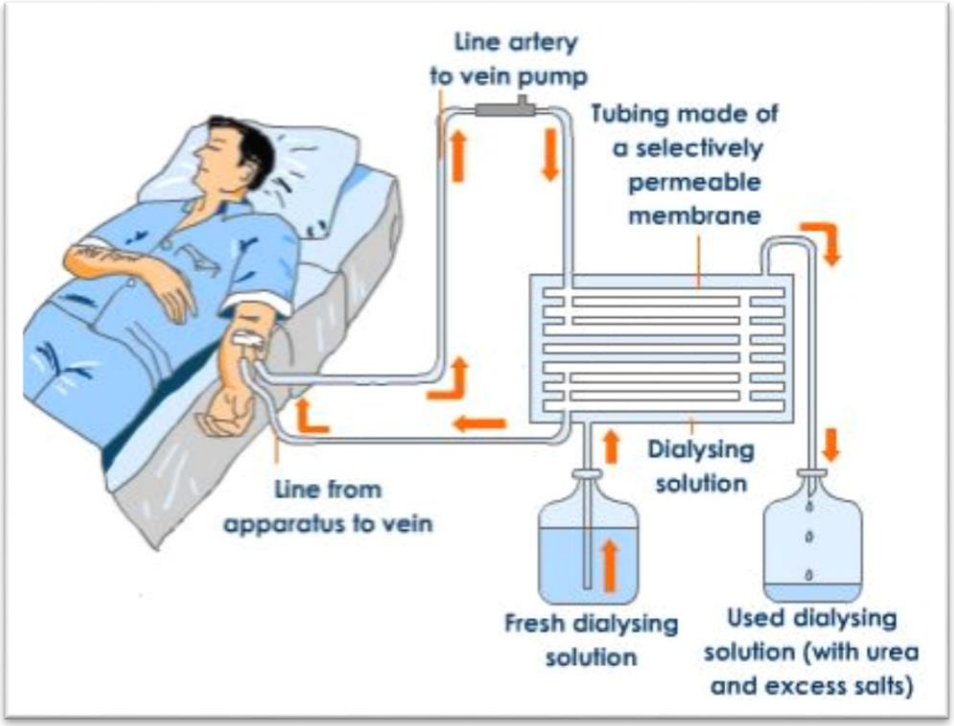
Renal Failure

- When the kidneys no longer work properly or at all
- Wastes begin to accumulate in the blood
- Can lead to heart failure
- Kidney transplants are a must
- While they wait, treatments include **dialysis**



Kidney Dialysis

- Process by which blood is removed from an artery, filtered, vital substances are added, and returning it to a vein
- Process works on the basis of osmosis
- Blood is pumped through dialysis tubing which is submersed in dialysate
- The waste concentrations in the dialysate are lower so waste diffuse out of the semi-permeable tubing



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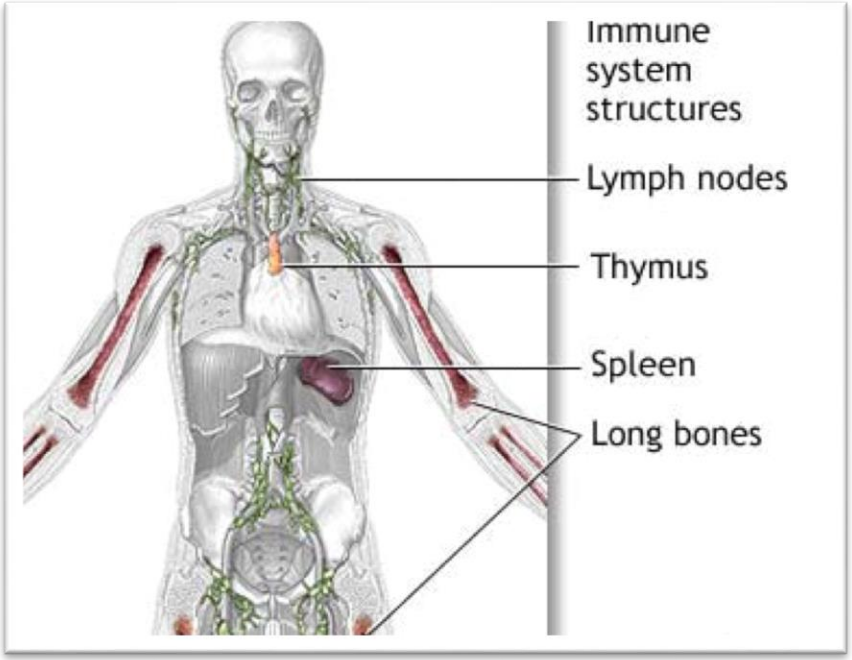
The Immune System

- Functions to provide the body with the ability to fight infection through the production of antibodies and cells that attack pathogens
- It helps to maintain homeostasis by recognizing and destroying harmful organisms or substances that could possible interfere with human health

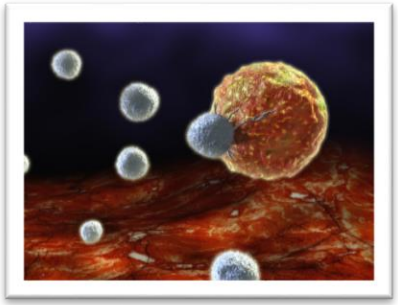


Self vs. Non-Self

- Our bodies, that is **our white blood cells**, can tell the difference between "**self**" and "**non-self**" by the proteins on the outside of cells
- **Major Histocompatibility Complex (MHC)** is the "fingerprint" of proteins on the outside of cells that are identified as "self"
- Normal cells of the body – "self"
- Invading or infected cells – "non-self"

Some Terms…

- **Pathogen** – anything that our immune system attacks
- **Antigen** – Substances on the surface of a pathogen that causes antibodies to be produced
- **Antibodies** – Proteins made by B White Blood Cells which attach to antigens and weaken or kill the pathogen



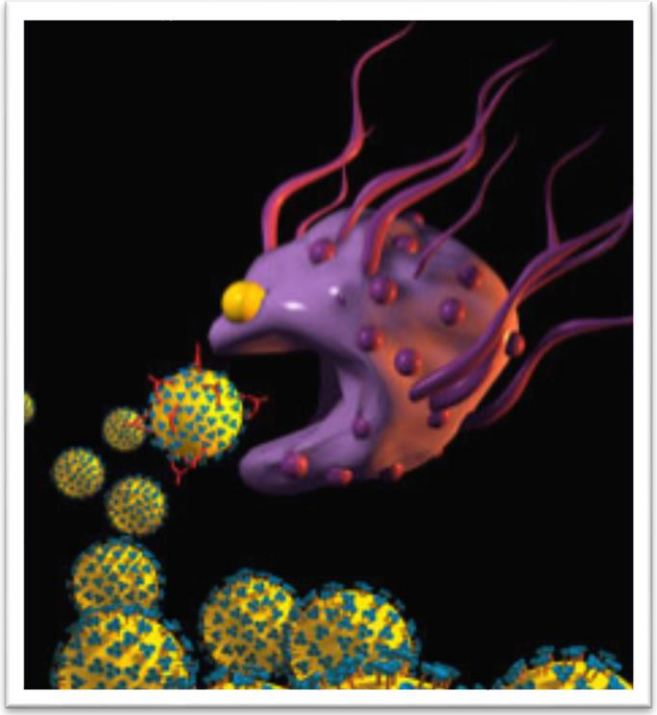
Immunity

- Is the ability of the body to resist a disease
- The immune system is very active in the process of immunity and the body's immune response
- There are two types:

1. **Non-Specific Immunity**
2. **Specific Immunity**

Non-Specific Immunity

- Innate Immune System
- Prior exposure is not necessary for this type of immunity to be effective
- Non-specific immunity includes:
  - **Physical Barriers – The First Line of Defense**
    - Skin, mucus membranes, sweat, saliva, etc…
  - **Phagocytic Cells – The Second Line of Defense**
    - Macrophages, Neutrophils, Monocytes



Non-Specific Immunity

- **Phagocytosis** – Is the process by which a cell ingests bacteria to destroy them

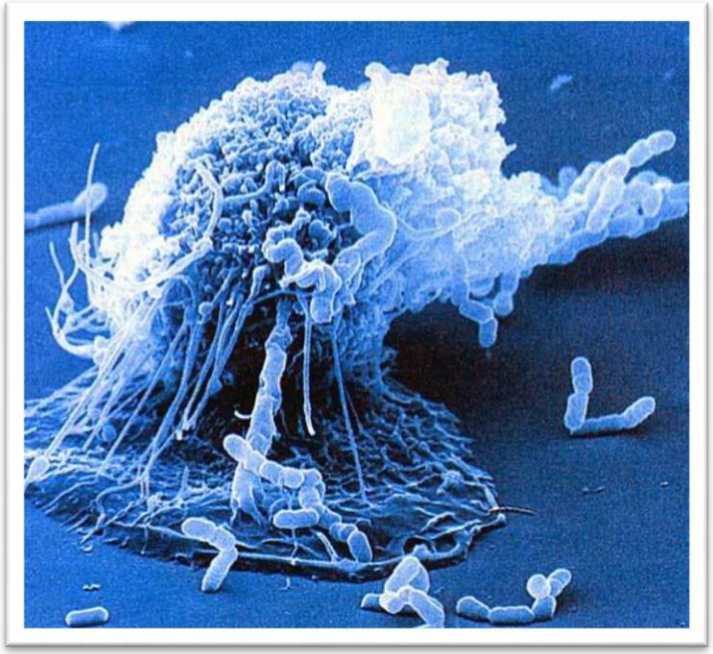
- Non-specific defense are:

1. **Macrophages**
2. **Neutrophils**
3. **Monocytes**
4. **Natural Killer Cells**

Non-Specific Immunity

1. **Macrophages**

- Phagocytic cells produced in bone marrow
- Found in the liver, spleen, brain, and lungs
- Also circulate the bloodstream and interstitial fluid



Non-Specific Immunity

2. **Neutrophils**

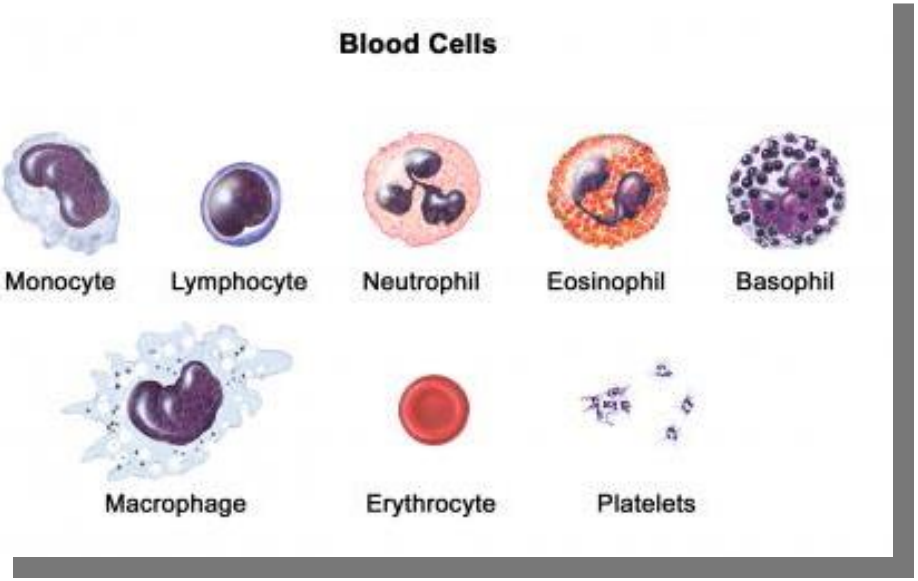
- Are smaller leucocytes or WBC's that engulf bacteria through phagocytosis

3. **Monocytes**

- WBC from which neutrophils and macrophages are derived

4. **Natural Killer Cells**

- WBC's that carry out phagocytosis body cells or body cells infected by viruses



Specific Immunity

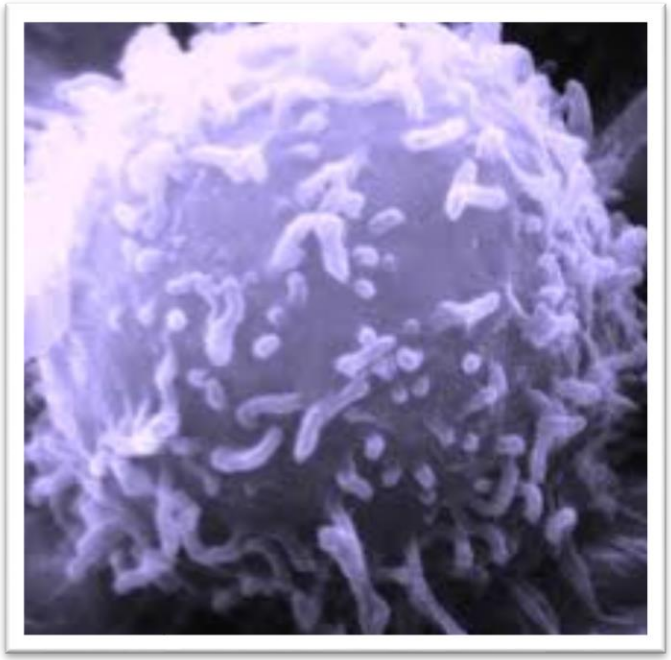
- Non-acquired immune system
- Major functions:

1. **Recognize "non-self"**
2. **Generate a response to eliminate specific "non-self"**
3. **Develop immunological memory**

Specific Immunity

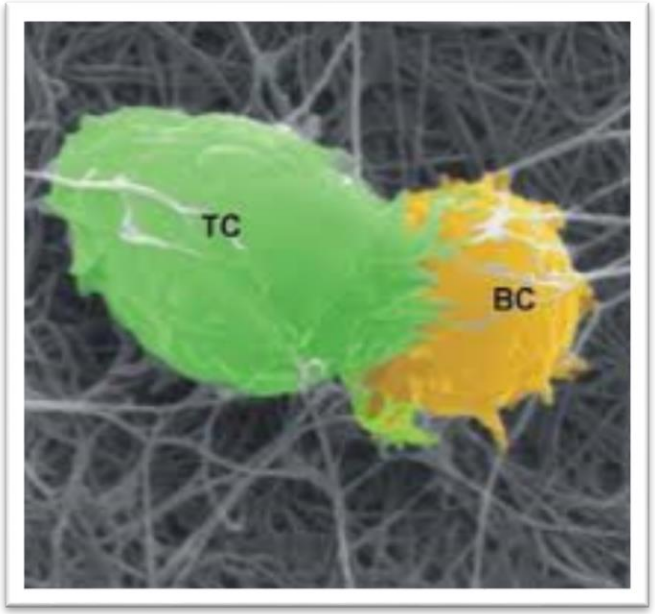
- Primarily a function of the lymphocytes of the circulatory system
- **Lymphocyte**s – are specialized white blood cells produced in bone marrow
- There are two types:

1. **T Lymphocytes (T-Cells)** – mature in bone marrow
2. **B Lymphocytes (B-Cells)** – Mature in the thymus gland

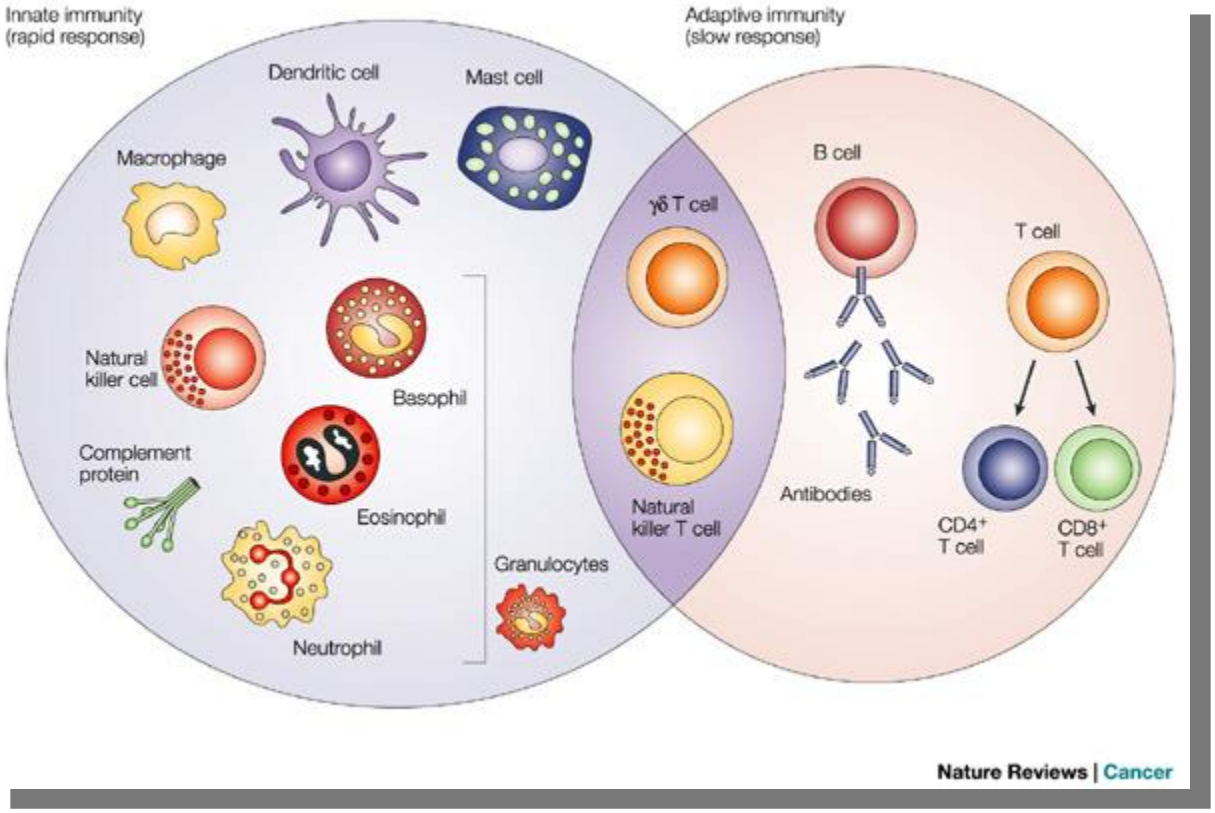


Specific Immunity

- The function of T Cells and B Cells is to recognize specific "non-self" antigens through a process known as **antigen presentation**
- Once identified, the cells generate specific responses that are tailored to eliminate specific pathogens



Acquired vs. Non-Acquired



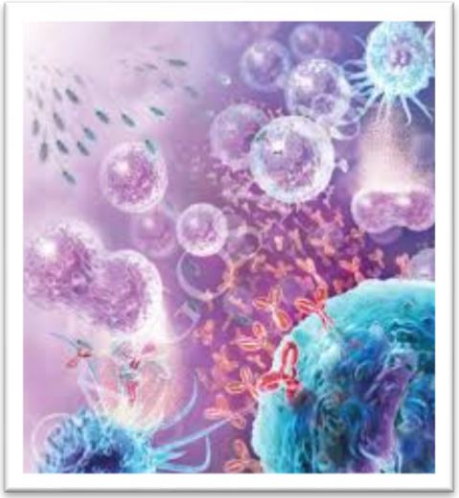
Immune Response

- The immune system reacts to presence of foreign cells or molecules and causes the production of antibodies that bind to hopefully destroy foreign substances

- It involves two types of immune responses:

1. **Complete Immune Response**
   - First Line of Defense
   - Second Line of Defense
   - Third Line of Defense

2. **Antigen/Antibody Reaction**



Complete Immune Response

- **First-Line of Defense – Physical & Chemical Barriers**
- Includes skin, sweat, tears, saliva, mucus, membranes, stomach acids, and urine
- Sweat, tears, and saliva contain chemicals that can kill some bacteria
- Mucus that covers internal membranes traps, prevents penetration, washes bacteria away
- Stomach acid destroys many pathogens
- Skin surface shields the body from pathogen

Complete Immune Response

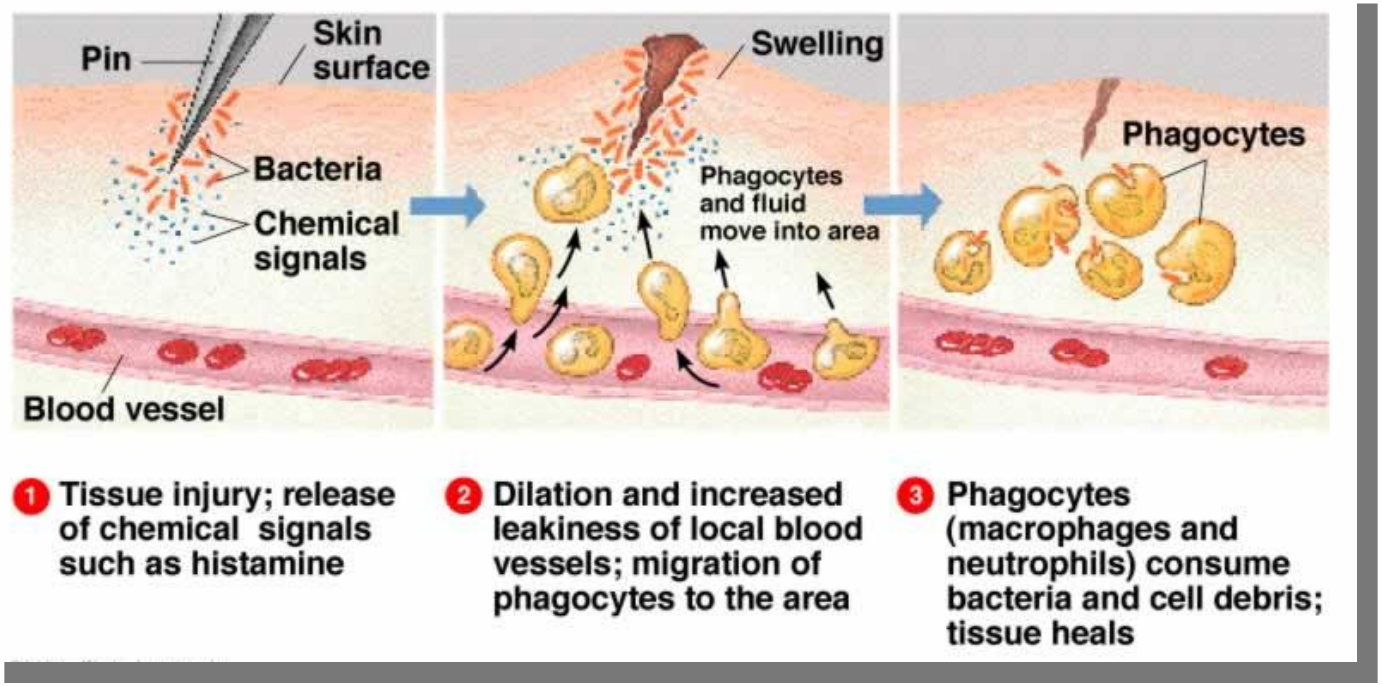
- **Second Line of Defense – The Inflammatory Response**
- The reaction of the body that causes swelling, redness, warmth, and pain in the area of infection
- Cells that are damaged from the infection release certain chemicals called **histamines**
- **Histamines** are chemicals that cause blood vessels to dilate and become more permeable to fluid and leucocytes

Complete Immune Response

- **Second Line of Defense – The Inflammatory Response**
- Increased blood flow and accumulation of fluid causes swelling and warmth in the affected area
- Attracts phagocytic macrophages that ingest and destroy large numbers of bacteria
- Inflammatory response proceeds, phagocytes ingest the pathogens and any damaged tissue
- Eventually pus, a mixture of phagocytes, dead cells, bacteria, and body fluid, collects in the wound
- Pus drains or is absorbed by the body, pathogen is destroyed, inflammations subsides, wound heals

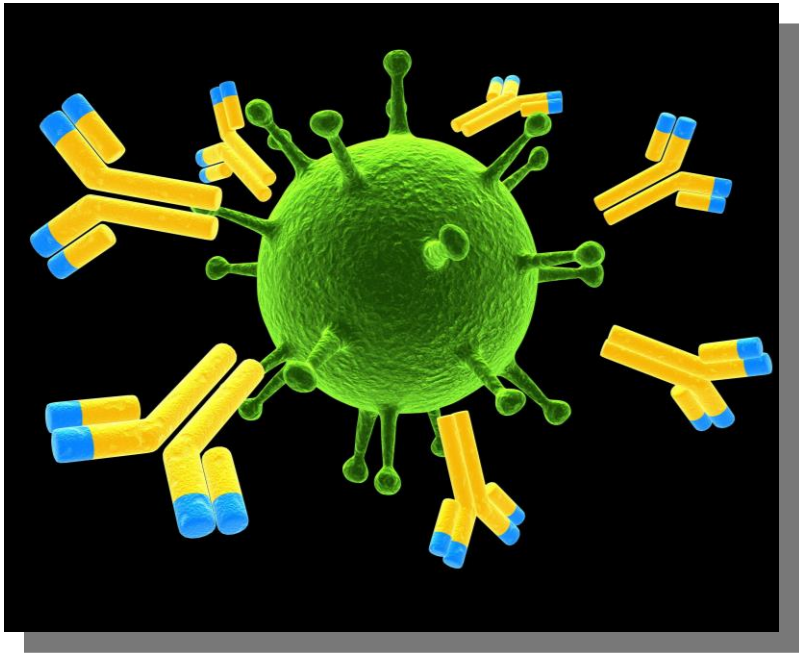
Complete Immune Response

- **Second Line of Defense – The Inflammatory Response**



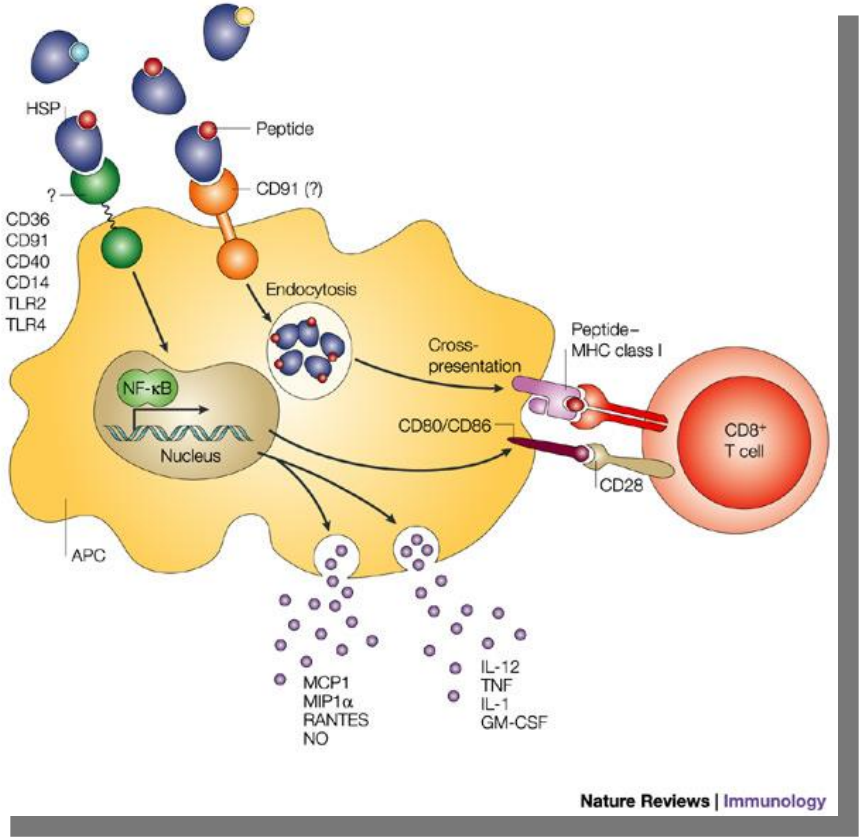
Third Line – The Immune Response

- Begins after the pathogen has been destroyed
- **Antigens** from the pathogen are still present and protrude from the macrophage
- Antigens are easily detected as having **different** genetic markers than our own body



Third Line – The Immune Response

- Antigens signals the production of antibodies
- The attachment of antibodies prevents bacteria or viruses from infecting other healthy cells
- **Antigen presentation** by macrophages signal **Helper T Cells**
- Each **Helper T Cell** is specifically designed to recognize one type of antigen



Third Line – The Immune Response

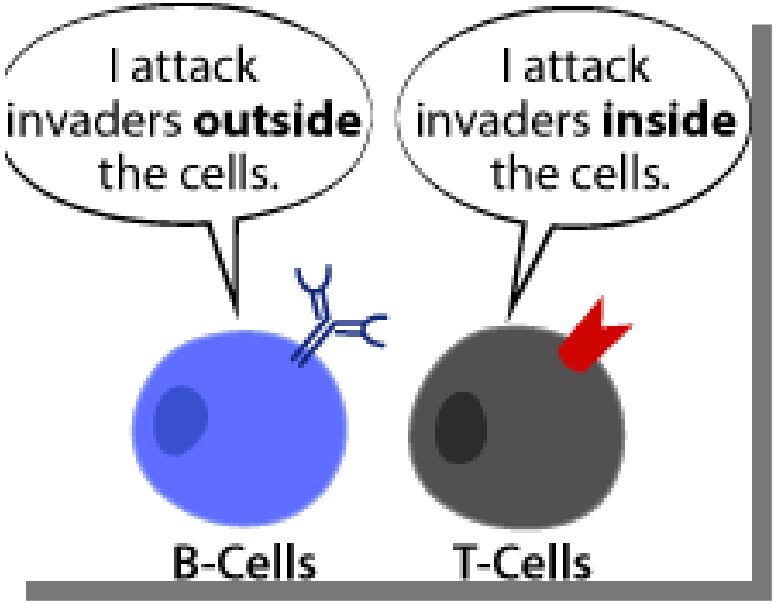
- Linkage between Helper T Cell and an antigen activate two other types od lymphocytes

1. **Killer T Cells**

- Mainly responsible for the destruction of diseased cells

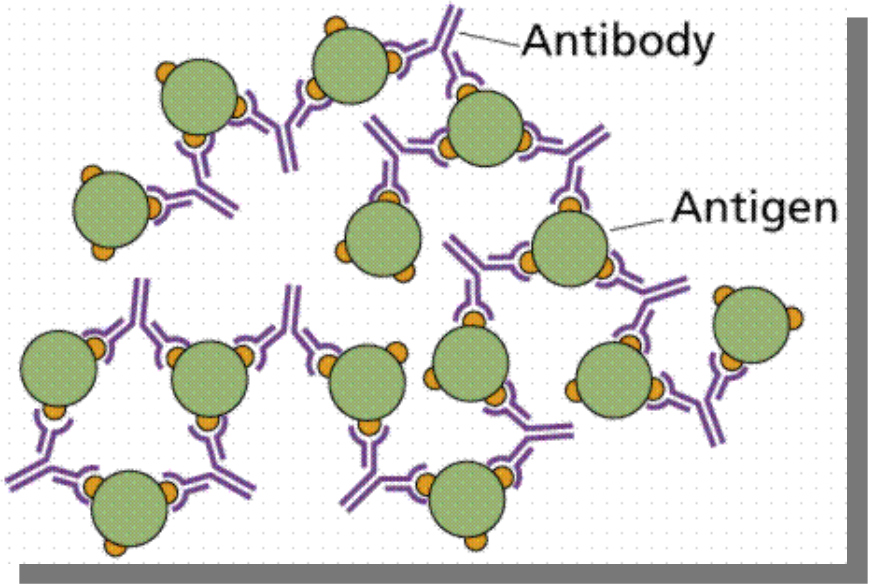
2. **Killer B Cells**

- Make antibodies, each specific to a disease



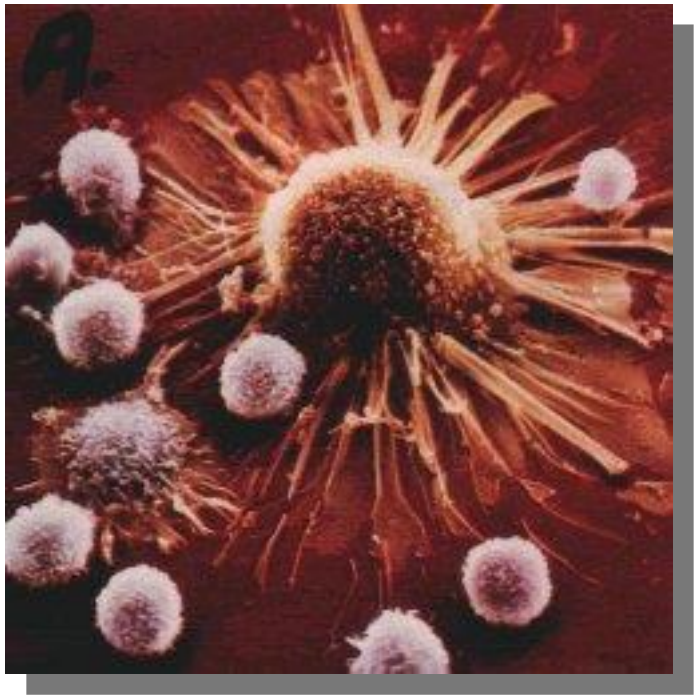
Third Line – The Immune Response

- When the shape of the antibody produced by B Cells matches a pathogen, the **B cell begins to multiply** rapidly
- Cells begin to make and **secrete large amounts of their specific antibody** molecules
- Circulating antibodies **neutralize antigen** molecules



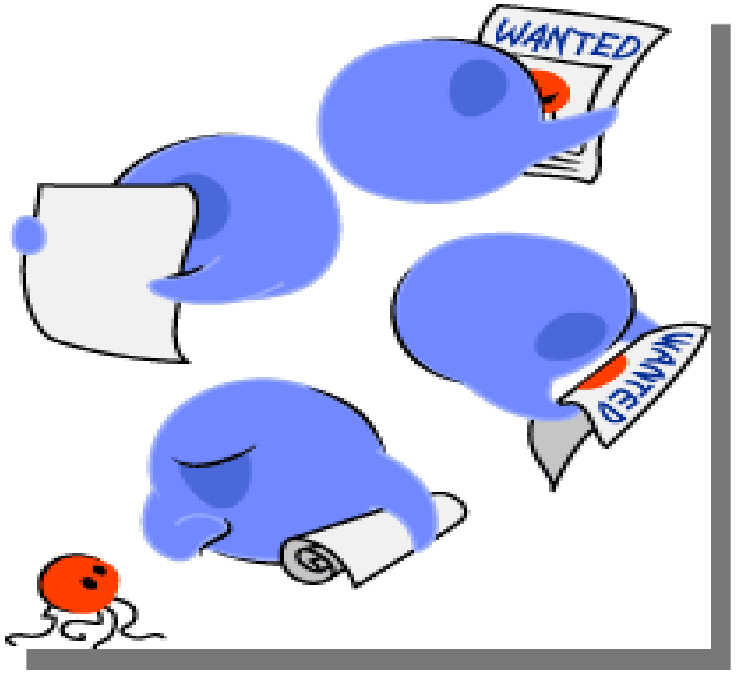
Third Line – The Immune Response

- Meanwhile, **Killer T Cells** are destroying infected body cells
- Once pathogens are neutralized, **Suppressor T Cells** limit the activates of B Cells and other T Cells



Third Line – The Immune Response

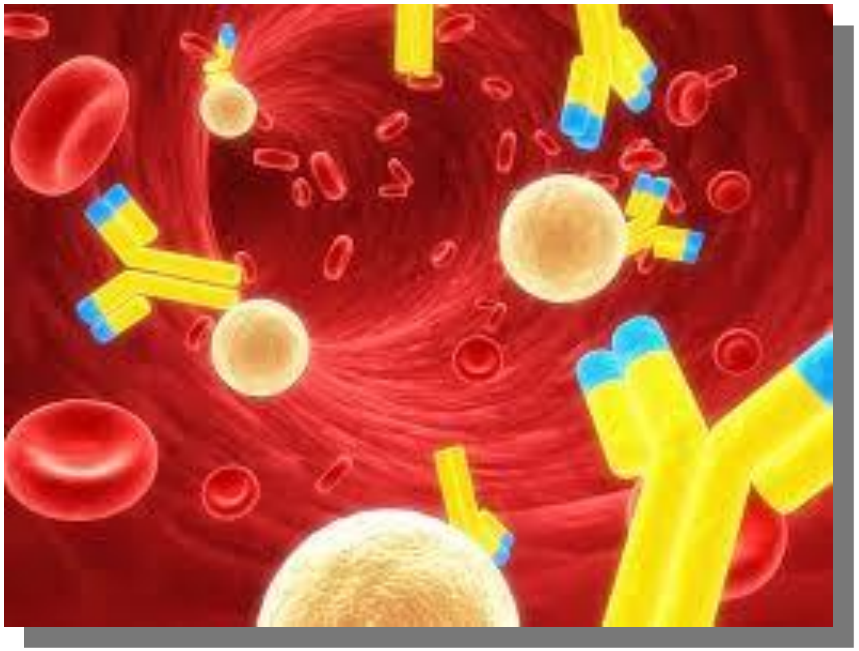
- There exists **Memory B and T cells**
- So that if the same type of antigen gets in the body again, **memory cells secrete large number of antibodies** to destroy the invading antigens
- Do not need to start from scratch



Acquired Immunity

- Immunity can be acquired in two ways:

1. **Passively**
2. **Actively**



Passive Immunity

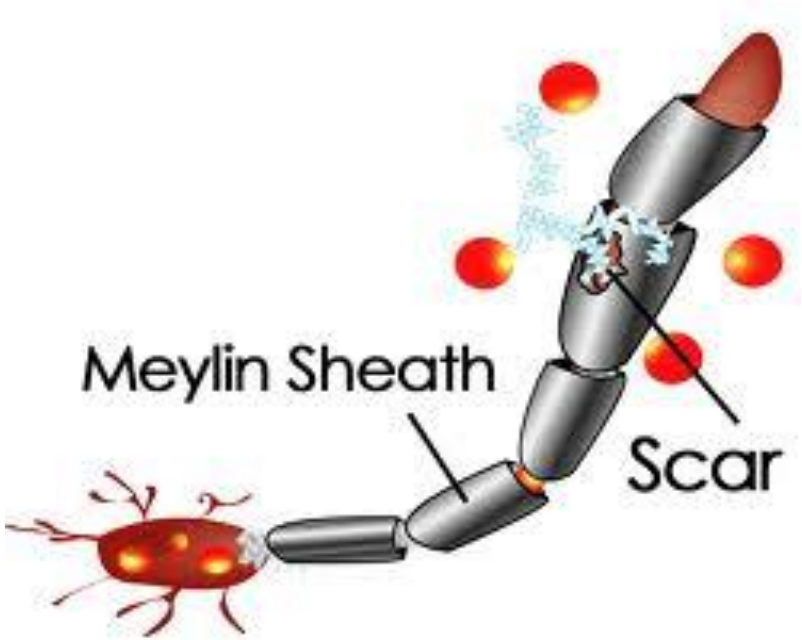
- Occurs when an individual receives antibodies from another person
- Happens during pregnancy, antibodies cross the placenta
- Short term as the antibodies are not being produced by the infant's own immune system
- Breastfeeding can prolong passive immunity – antibodies present in breast milk

Active Immunity

- Antigen/Antibody Response
- Actively gaining immunity through vaccines
- Vaccines are substances that contain an antigen to which the immune system responds
- Vaccines may also contain the antibodies for fighting a particular pathogen

Autoimmune Disorders

- A condition in which the body's own T Cells or antibodies attack body tissues as foreign antigens
- Cause is unknown and there is a tendency for such diseases to be inherited
- Example:
- **Multiple Sclerosis:** autoimmune disorder which affects the myelin sheath covering nerve fibers



Autoimmune Disorders

- **Rheumatoid Arthritis**
- Affects the bone and tissue of joints in the body
- Inflammation of the lining of joints
- Body's immune system attacks the joints causing pain, stiffness, and swelling
- Can affect anyone, most common between ages 25 and 50

Allergies

- Allergies are due to another type of immune malfunction.
- It is an exaggerated response by the immune system to such allergens as pollen, mould or cat dander.
- Allergic reactions to food or to inhaled allergens (as in asthma) are also possible.
- An allergic reaction may be immediate or delayed with the immediate or acute reaction being the most common type. An immediate reaction can occur within 30 seconds and last up to 30 minutes

Allergies

- What happens is that an allergen causes specialized antibodies to trigger certain cells to release histamines.
- The histamines cause the permeability of blood vessels to increase, making the area red or swollen
- It can also cause the release of cellular fluids, resulting in watery eyes and a runny nose
- This is your allergic reaction