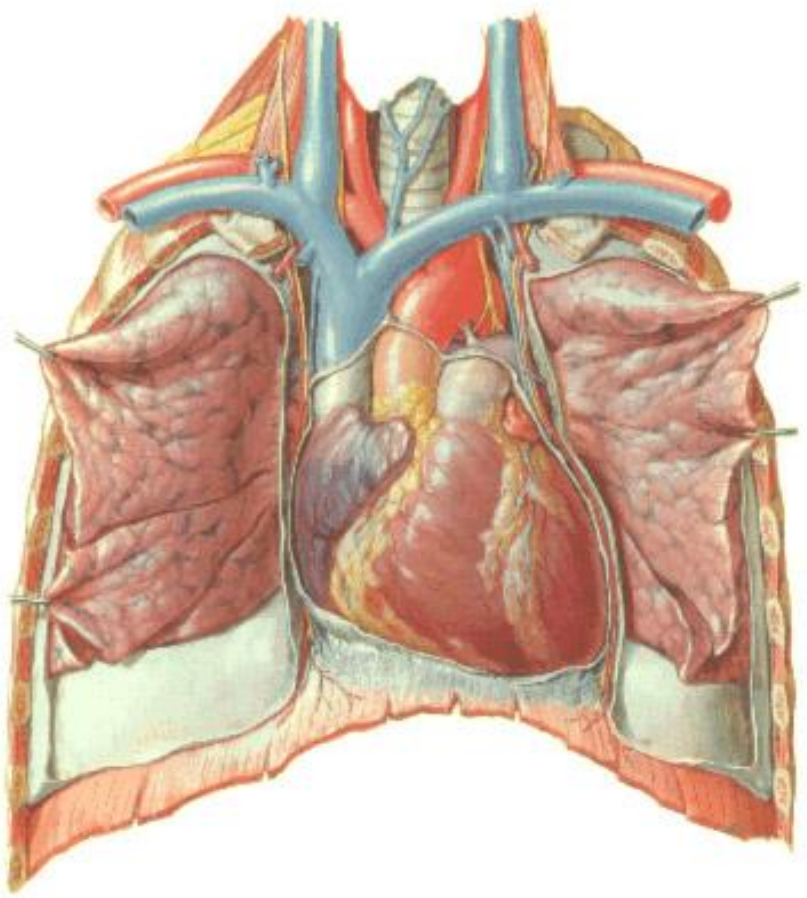
Biology

Human Physiology and Organ Systems

Cardiovascular and Lymphatic System

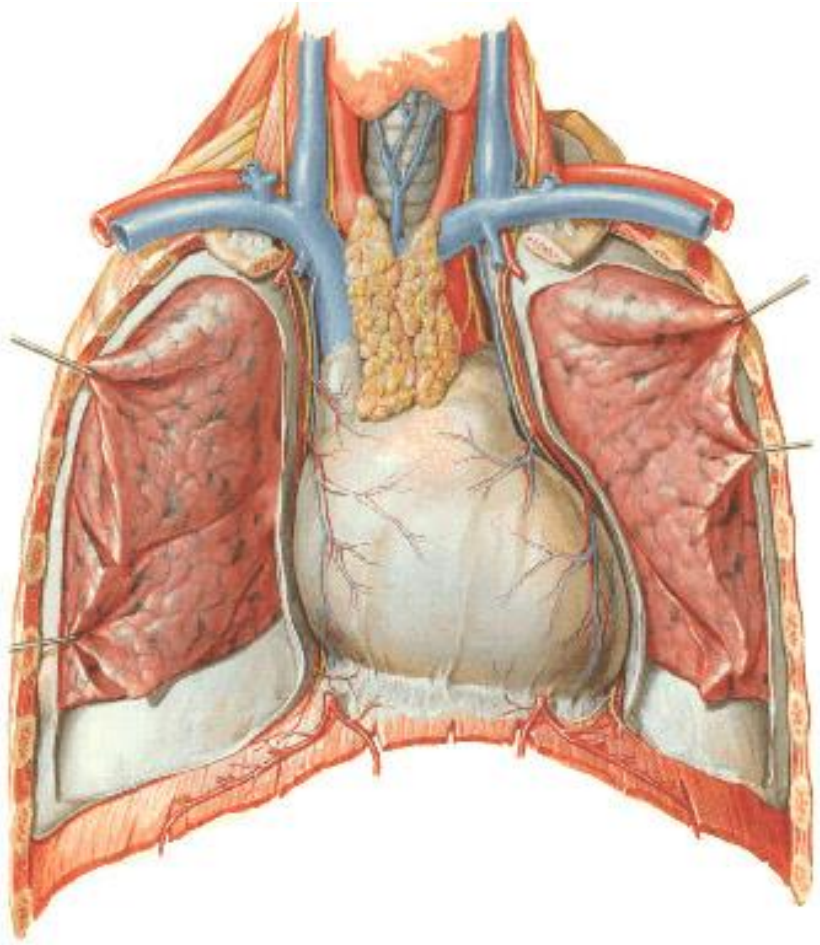
Heart Structure and Circulation

Cardiovascular System



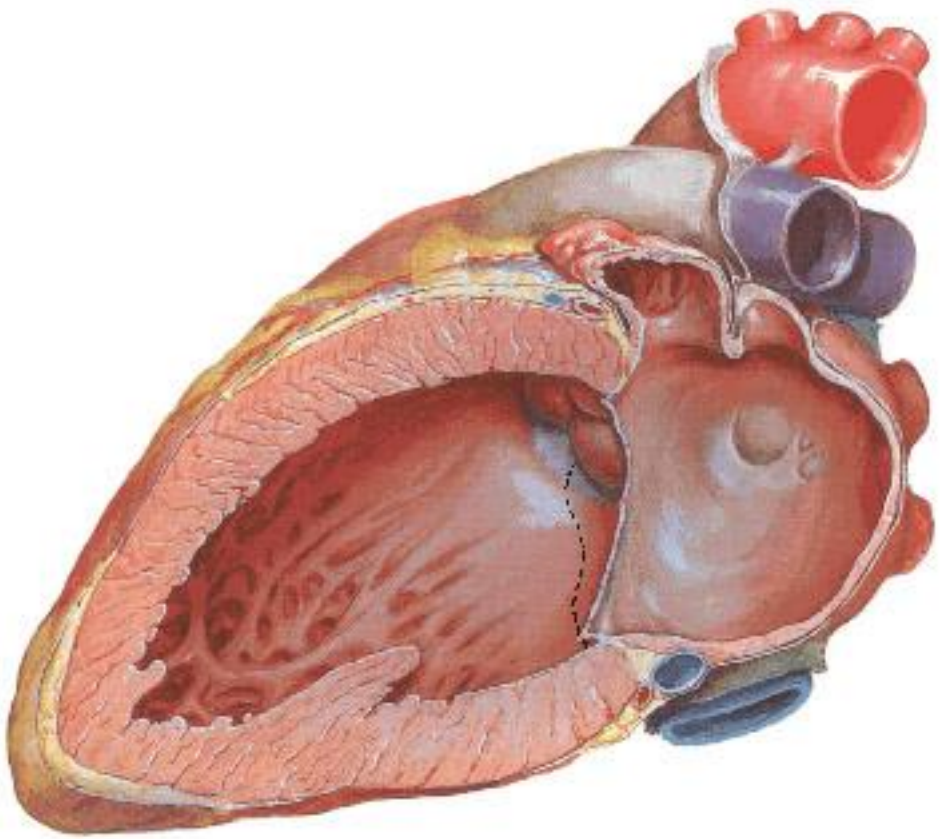
- Cardiovascular system is composed of the
  - Heart
  - Blood vessels
    - Arteries – blood vessels which carry blood away from the heart
    - Veins – blood vessels which carry blood towards the heart
    - Capillaries – exchange vessels
  - Blood
- Its function is to transport nutrients, gases, hormones and other products throughout the body

Pericardium



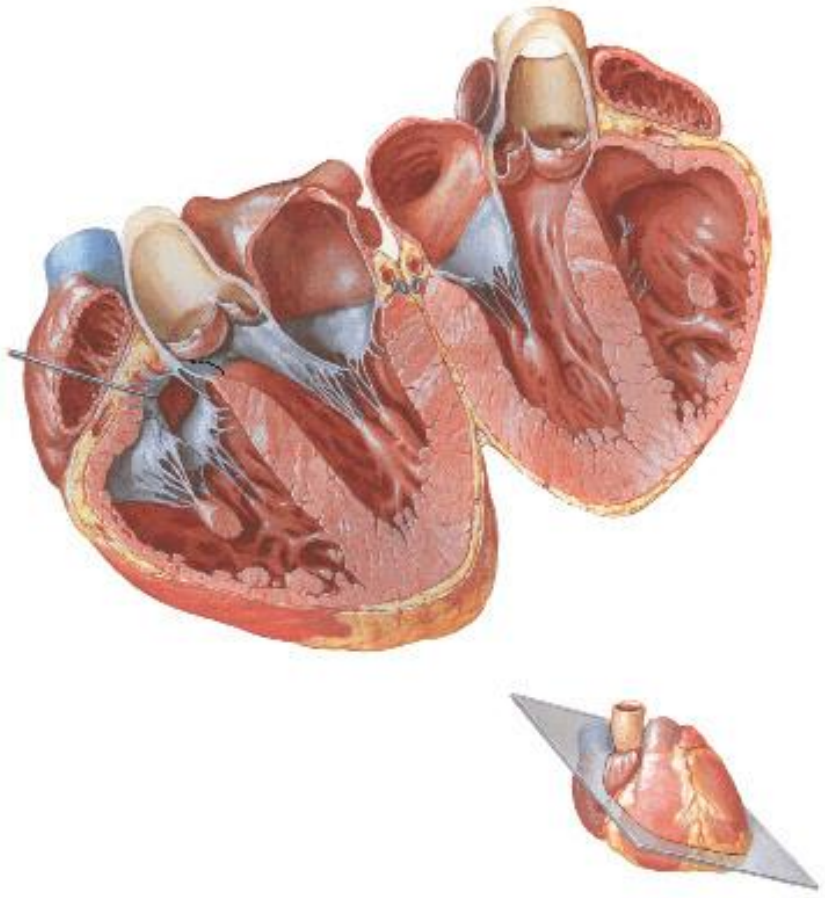
- The heart is surrounded by the pericardium
  - Parietal pericardium is the outer layer. It is a serous membrane
  - The visceral pericardium is the deepest layer and is in contact with the myocardium. It is also a serous membrane

Layers of the Heart



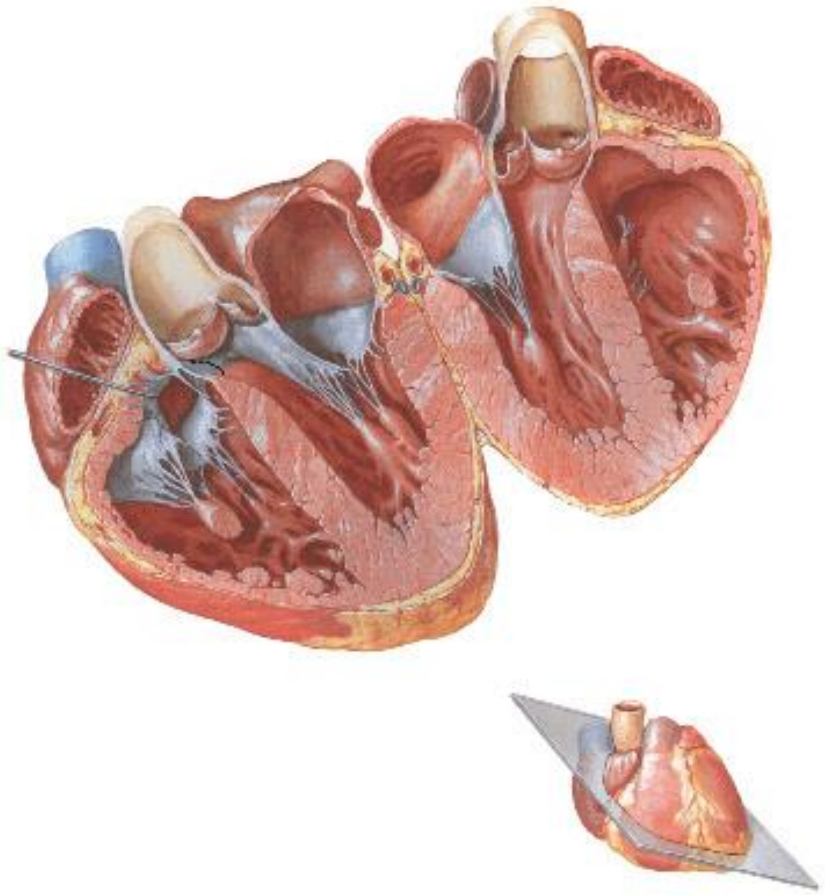
- The heart wall has three layers
  - The epicardium is the outer layer of the heart (it is the same layer as the visceral pericardium)
  - The myocardium is the next muscular layer
  - The endocardium is the inner lining of the heart

Chambers and Valves of the Heart



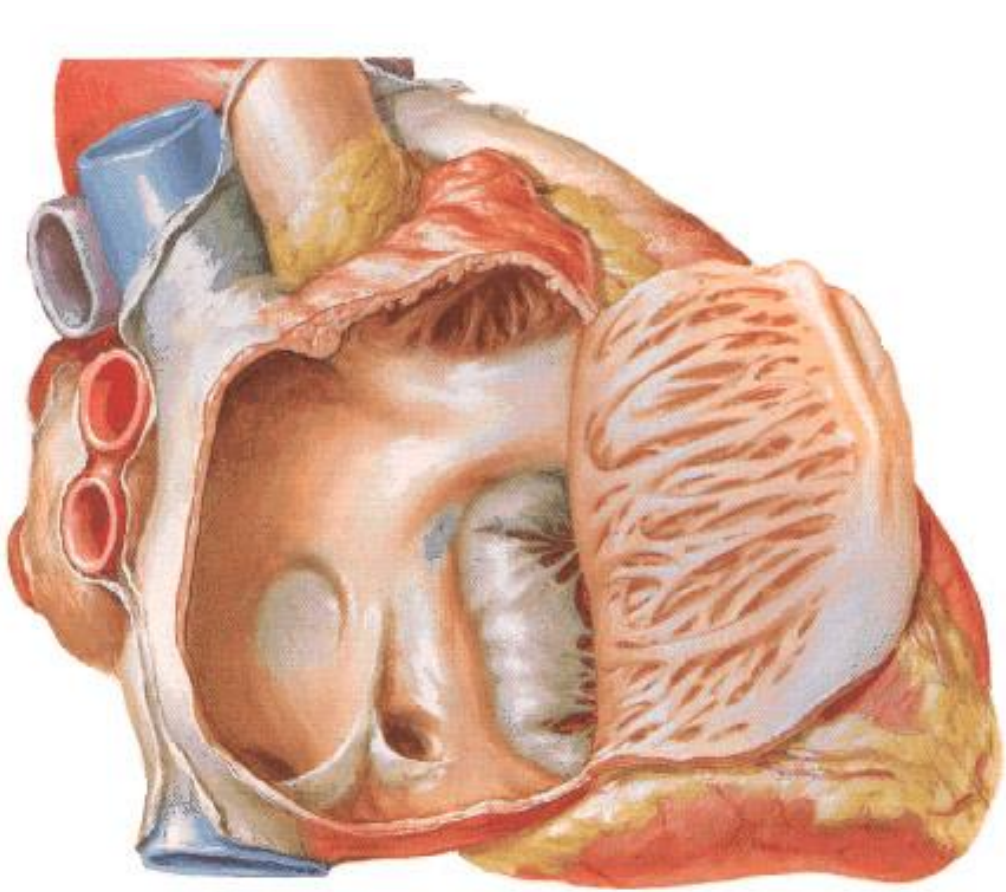
- The heart has 4 chambers and 4 valves
  - Two chambers are receiving chambers which receive blood
    - Right atrium receives blood from the periphery of the body
    - Left atrium receives blood from the lungs
  - Two chamber are discharging chambers
    - Right ventricle discharges blood to the lungs
    - Left ventricle discharges blood to the periphery of the body

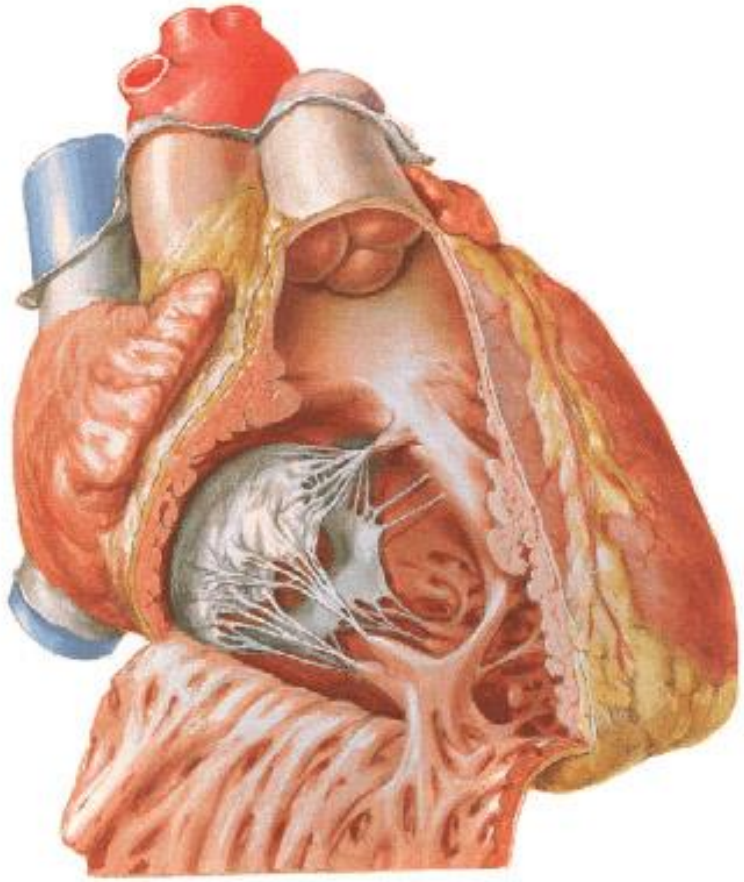
Chambers and Valves of the Heart



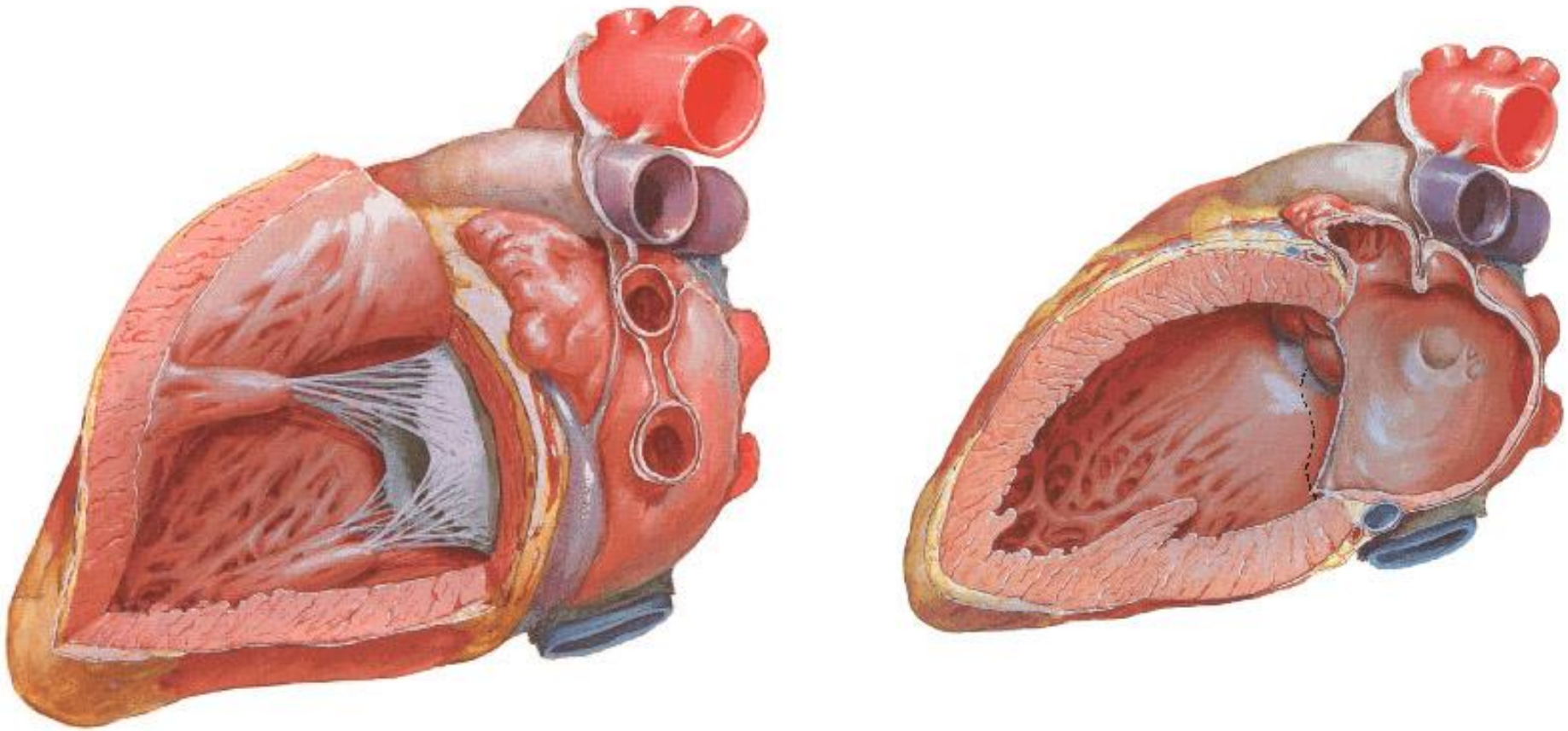
- Two valves are atrioventricular valves
  - The tricuspid valve allows blood to pass from the right atrium to the right ventricle and prevents backflow
  - The bicuspid valve allows blood to pass from the left atrium to the left ventricle and prevents backflow
- Two valves are semilunar valves
  - The pulmonary semilunar valve allows blood to pass from the right ventricle to the pulmonary artery (and to the lungs)
  - The aortic semilunar valve allows blood to pass from the left ventricle to the aorta (and to the periphery of the body)

Right Atrium and Right Ventricle

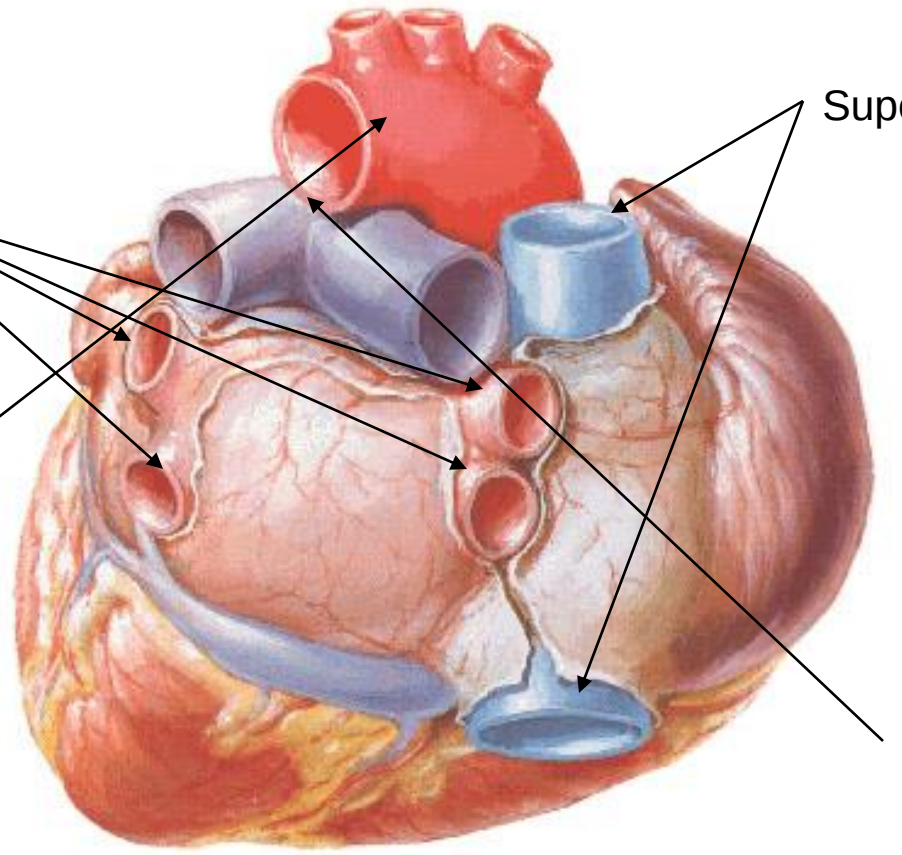




Left Atrium and Left Ventricle



Vessels Related to the Heart



Oxygenated blood from the lungs returns to the heart through….

Pulmonary Veins

Blood enters the left artium, travels through the bicuspid (mitral) valve to the left ventricle

Blood travels through the aortic semilunar valve to the aorta to be sent to the body's tissues

Aorta

Superior and Inferior Vena Cava

Deoxygenated blood from the body enters through these vessels into the right atrium

Blood travels through the tricuspid valve to the right ventricle

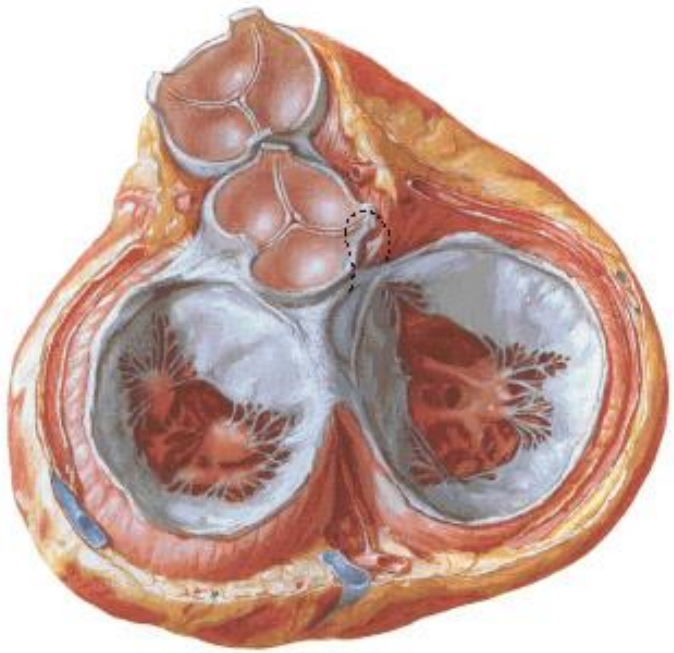
Blood travels through the pulmonary semilunar valve to the pulmonary artery

Pulmonary Artery

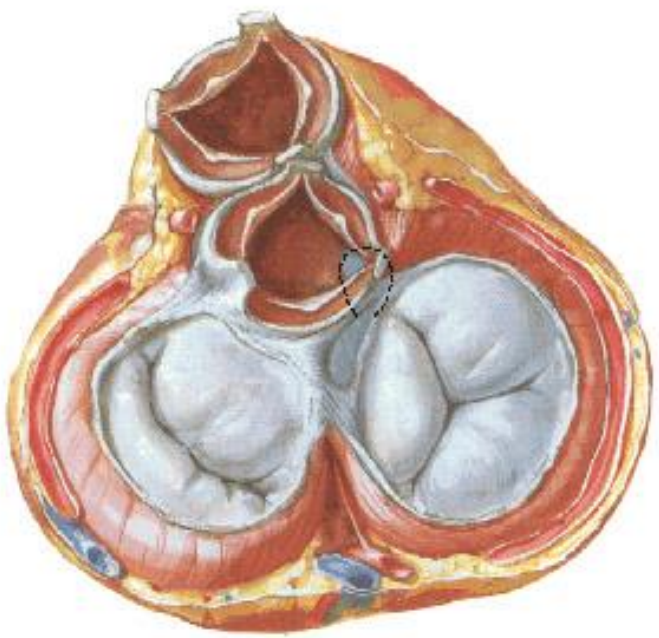
Deoxygenated blood travels to the lungs for gas exchange

Systole and Diastole

Valves of Heart in Diastole



Valves of Heart in Systole



Heart Conducting System

Heart Conducting System

- Heart cells have an inherent rhythmicity, meaning they beat on their own without nervous system or endocrine control. However they are influenced by the nervous system and endocrine system.
- Cardiac muscle cells are bound to each other via proteins and synapse are electrical. If one cell depolarizes, the cells it is in contact with also depolarizes.
- Cardiac muscle cells beat the fastest at the sinoatrial (SA) node. These cells, therefore set the pace.

Heart Conducting System

- From the SA node, the stimulus spreads across the atrial wall and reaches the atrioventricular (AV) node.
- The AV node delays the stimulus. This allows the atria to contract fully and push blood into the ventricles.
- From the AV node, the signal travels along the interventricular septum within the AV bundle (bundle of HIS) and then branches into Purkinje fibers where it spreads to the muscular wall of the ventricles. This causes the ventricles to contract from the inferior end to pump blood out of the ventricles and through the semilunar valves into the aorta and pulmonary artery.

Animations

- http://www.nhlbi.nih.gov/health/health-topics/topics/hhw/electrical.html
- http://highered.mheducation.com/sites/0072495855/student_view0/chapter22/animation__conducting_system_of_the_heart.html

Blood Vessels

Blood Vessels
Arteries

- Arteries – blood vessels which carry blood away from the heart.
- Arteries include:
  - Elastic arteries – largest arteries and very resilient. These arteries expand and their recoiling helps propels blood.
  - Muscular arteries – medium sized arteries which distributes blood to the muscles and organs.
  - Arterioles – smallest arteries. Smooth muscles allow for vasoconstriction andvasodilation which regulates blood flow to capillary beds fed by them.

Blood Vessels
Veins

- Veins – blood vessels which collects blood from the tissues and returns it to the heart.
- Veins include:
  - Venules – smallest veins which collects blood from capillary beds.
  - Medium sized veins
  - Large veins – includes the venae cavae and their tributaries within the abdominal and thoracic cavity.
- Venules and medium sized veins have valves. This is because venous blood pressure is so low that venous return requires both the skeletal and respiratory mechanisms to help. Since this mechanisms do not cause constant movement in the same way as in the arteries, they valves prevent backflow.
- Veins are more expandable than arteries and have higher capacitance (expandability). They store more blood. Tissues such as the liver, bone marrow and skin contain a large amount of veins and store nearly 1/3rd of the bodies blood in the venous system.

Blood Vessels
Capillaries

- Capillaries – exchange vessels.
- These vessels are on layer thick (simple) of endothelial cells. Capillary cell margins can vary, allowing the vessels to be more or less permeable.

Blood

Blood

- Blood contains 46-63% Plasma and 37-54% Formed Elements
  - Formed elements consists of blood cells which include:
    - Red blood cells – Erythrocytes
    - White blood cells – Leukocytes
    - Platelets – Thrombocytes
- Blood is the transporting medium, it transports water, nutrients, wastes, hormones, heat and other materials throughout the body.

Red Blood Cells

- RBCs or Erythrocytes account for 99.9% of formed elements
- They live about 120 days after which time they are removed in the Spleen and their components recycled.
- RBCs do not have a nucleus and carry oxygen and carbon dioxide.

White Blood Cells

- WBCs or Leukocytes are classified by whether the have granules when stained. They are classified as:
  - Granulocytes, Includes:
    - Basophils – essentially circulating mast cells
    - Neutrophils – secrete chemicals that exaggerate the immune response, also phagocytes
    - Eosinophils – secrete chemicals that limit inflammation
  - Agranulocytes, Includes:
    - Lymphocytes -responsible for immunity
    - Monocytes - circulating macrophages

Platelets

- Platelets or thrombocytes are important for clotting

Plasma

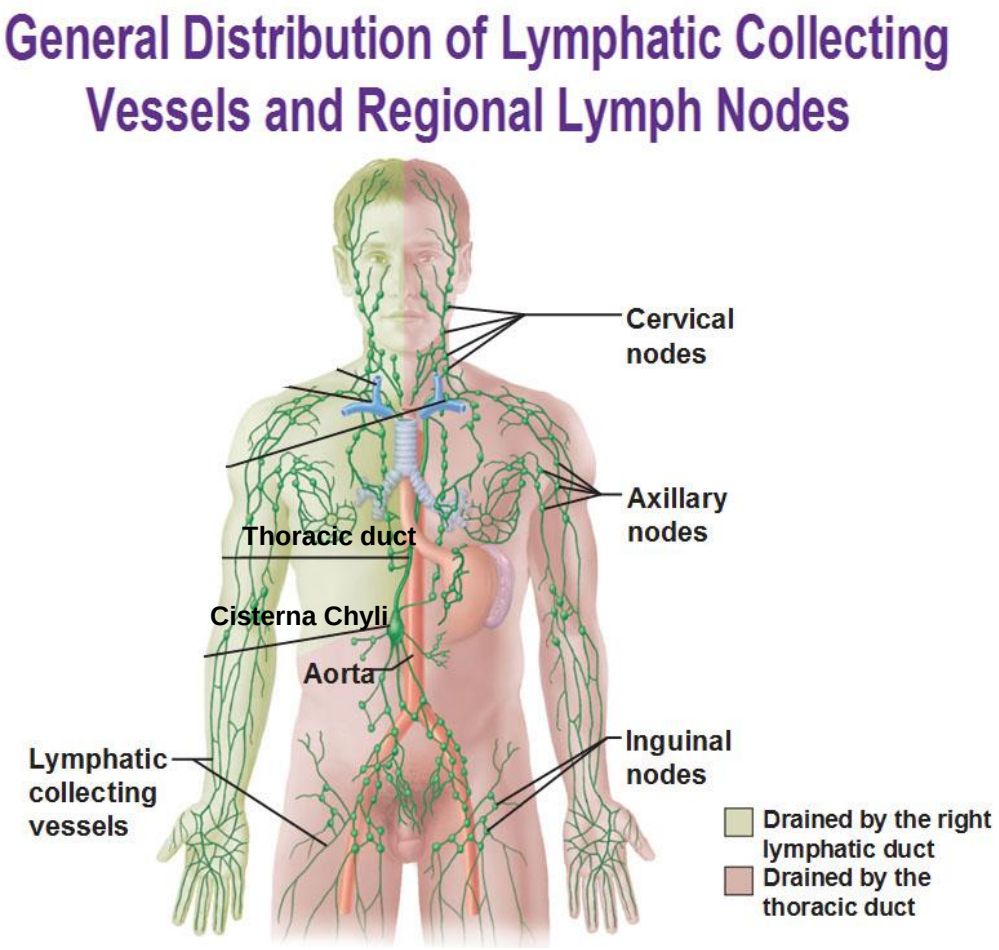
- Contains water, nutrients, electrolytes, hormones, wastes, and plasma proteins

Lymphoid (Immune) System

Lymphoid System

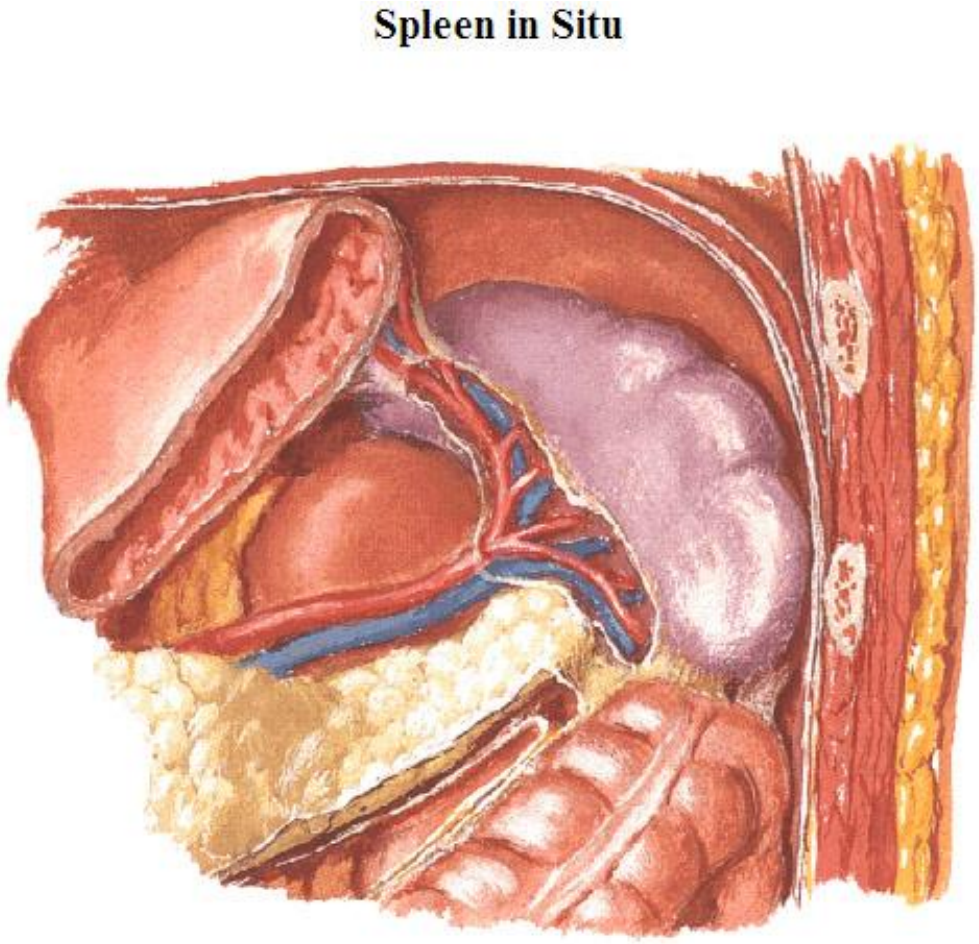
- The lymphoid system consists of:
  - Thymus, Bone marrow
  - Spleen
  - Lymphatic vessels
  - Lymph nodes
  - Other lymphoid tissues such as the tonsils, tissues in the GI tract and respiratory tract
- Its functions are:
  - Defends against infection and disease.
  - Returns tissue fluids to the bloodstream

Lymph and Lymphatic Circulation



- Recall that fluid and solutes from the blood leave at the capillaries and 90% of this flood returns due to osmotic pressure.
- The 10% of fluid that does not return enters the lymphatic vessels. The fluid, which is called lymph, filters through lymph nodes and can stimulate the immune response to antigens
- The lymph also returns plasma proteins that leak from the capillaries to the blood stream
- Lymphatic vessels ultimately drain back into the blood circulation at the subclavian veins

Spleen



- The spleen acts as a large modified lymph node in the circulation of blood instead of lymphatic fluid
- Blood leaves the vessels in the Spleen and allows macrophages to remove antigens and also allows for the removal of old RBC
- Blood then returns to the vessels and exits the spleen
- Since the spleen is full of blood, hemorrage to the spleen can be very dangerous and often requires a splenectomy

Immune Response and Inflammation

Body Defense and Immunity

- Body defense includes two major categories:
  - Nonspecific which are general and act against any pathogen.
    - Includes anatomical barriers, phagocytes, NK cells, complement proteins
  - Specific which involves immunity
    - Includes T- and B-lymphocytes
    - Response is elicited by an antigen
    - Original antigen-antibody reaction is then amplified by the other body defense systems

Leukocytes and the Immune Response

- Leukocytes are classified by whether the have granules when stained. They are classified as:
  - Granulocytes, Includes:
    - Basophils – essentially circulating mast cells
    - Neutrophils – secrete chemicals that exaggerate the immune response, also phagocytes
    - Eosinophils – secrete chemicals that limit inflammation
  - Agranulocytes, Includes:
    - Lymphocytes -responsible for immunity. Includes B- and T-lymphocytes
    - Monocytes - circulating macrophages

Interaction of Leukocytes for Body Defense

- Agranulocytes (lymphocytes and monocytes) are not numerous enough or concentrated enough to deal with body defense on its own.
- Granulocytes are not good at recognition.
- These cells interact to mount a very sophisticated response to defend the body

Immune System Cells (Lymphocytes)

- These are all products of lymphoid tissue.
  - All leukocytes are derived from primitive hematopoietic stem cells originally found in the bone marrow. Lymphocytes also proliferate in other lymphoid tissues such as the lymph nodes, tonsils, spleen, and bone marrow, linings of gastrointestinal tract and respiratory tract.
- Lymphocytes are spherical cells without much cytoplasm. When the become active, they create more structures for protein production.
- Two types of lymphocytes exist
  - B-lymphocytes (B cells)
  - T-lymphocytes (T cells)

Antigens and Lymphocytes

- Antigens cause the proliferation of T-cells and B-cells
- T-cells leave the lymph nodes, enter the systemic circulation and directly attack the foreign invader
  - This is referred to as cell-mediated immunity
- B-cells produce proteins called antibodies which leave the lymph nodes, enters the systemic circulation, and are involved with removing the invader
  - This is referred to as antibody- or humoral-mediated immunity

Inflammation Causes and Events of Inflammation

Inflammation Causes

- Tissue injury
- Presence of immune complexes (antibody-antigen complexes)

Events of Inflammation

- Pronounced arteriolar dilation
- Fluid leaking and sludging

Inflammation and Mast Cells

- Mast cells are found in all connective tissue
- They contain secretory granules
- If they secrete chemicals from these granules, they will cause the events of inflammation. These secretions include histamine, neutrophil chemotaxis factor, Eosinophil chemotactic factor of anaphylaxis, and newly synthesized secretions (leukotrienes and prostaglandins)
- Stimuli that cause mast cells to degranulate:
  - Physical agents (trauma, heat, UV light causing sunburn, X-rays in radiation treatments)
  - Chemical agents (venoms, neutrophil secretions, immune mechanisms)

Inflammation and Plasma Proteins

- Plasma proteins involved in the inflammatory response include:
  - Compliment Proteins
  - Clotting Proteins
  - Kinin System

Inflammation and Compliment Proteins

- Compliment proteins activate in a cascade (compliment A activates B which activates C, etc.). This is an amplifying effect.
- Actions
  - Stimulate mast cell degranulation
  - Directly causes vascular changes (arteriole dilation and capillary endothelial retraction)
  - Cause bacterial lysis
  - Opsonization (increases activity of phagocytes)
- Immune complexes are what set off this compliment

Inflammation and Clotting Proteins

- Clotting proteins include fibrinogen and thrombin. These form clots in the vessels and, when they leave the vessels due to inflammation, in the tissues.
- The clot traps all of the cells and degradation products and prevents a spread if there is an infection.

Inflammation and the Kinin System

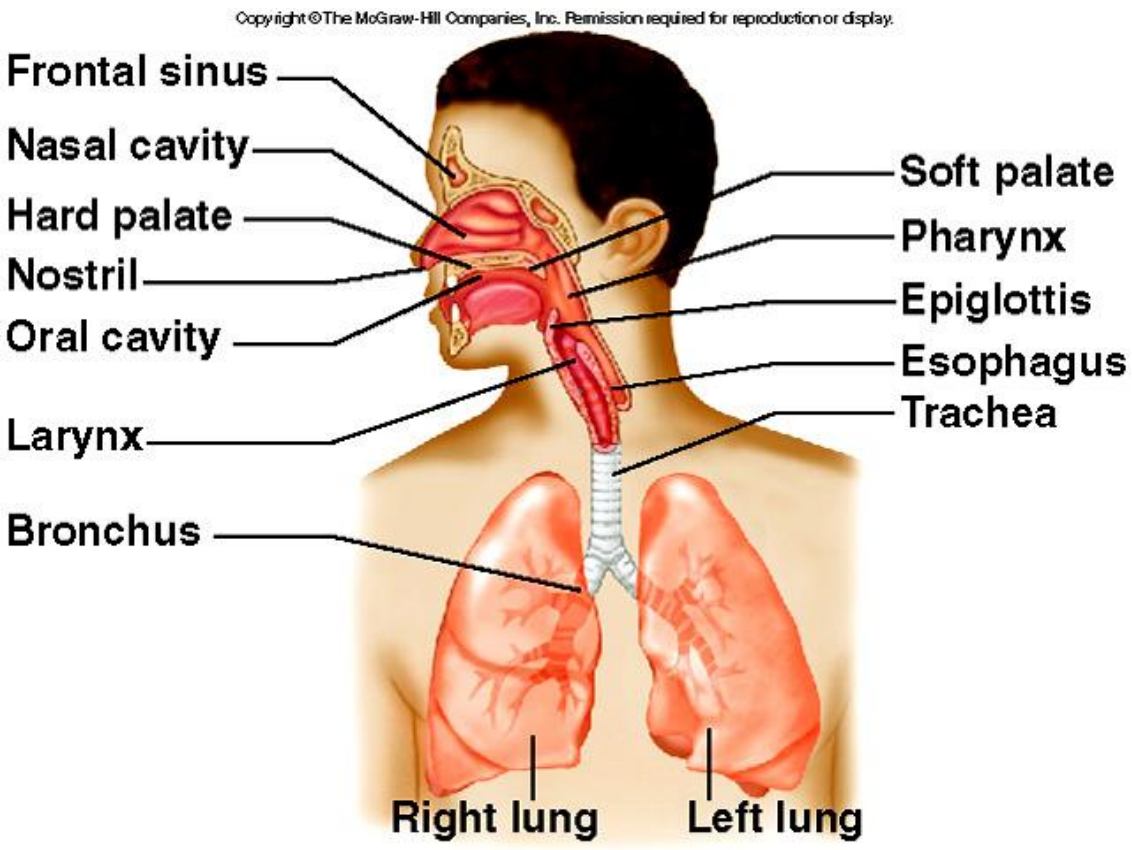
- Bradykinin is the major product. Bradykinin does the following:
  - Stimulates pain (like prostaglandin)
  - Cause extravascular smooth muscle contraction
    - Uterine, intestinal tract, connective tissue
  - Causes increased capillary permeability
  - Causes WBC chemotaxis

Specific Manifestations of Inflammation

- Manifestations of Inflammation are:
  - Fever
  - Leukocytosis
  - Increased plasma protein concentration

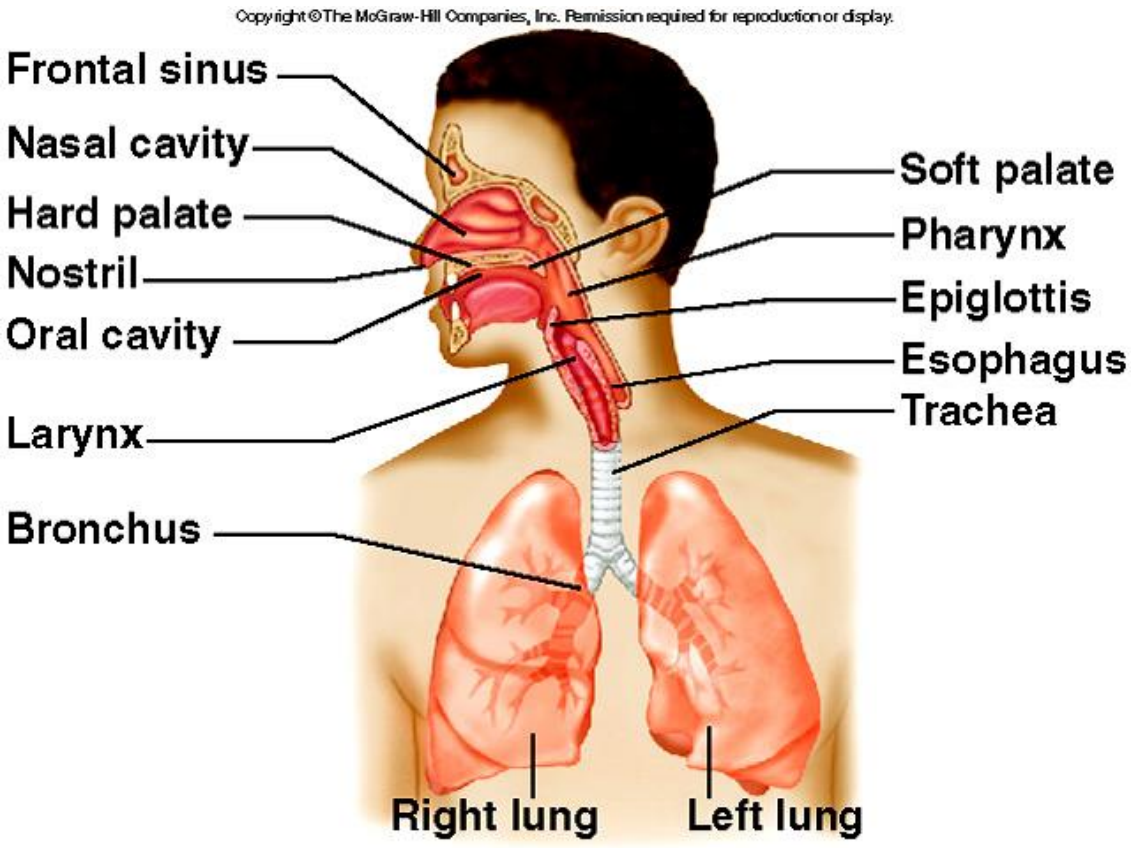
Respiratory System

Respiratory System Structures



- Organs include lungs and the respiratory tract which is divided into upper and lower respiratory tract
  - Upper consists of
    - Nose
    - Naval cavity
    - Sinuses
    - Pharynx
  - Lower consists of
    - Larynx
    - Trachea
    - Bronchial tree (bronchi and bronchioles, alveoli)
    - Lungs

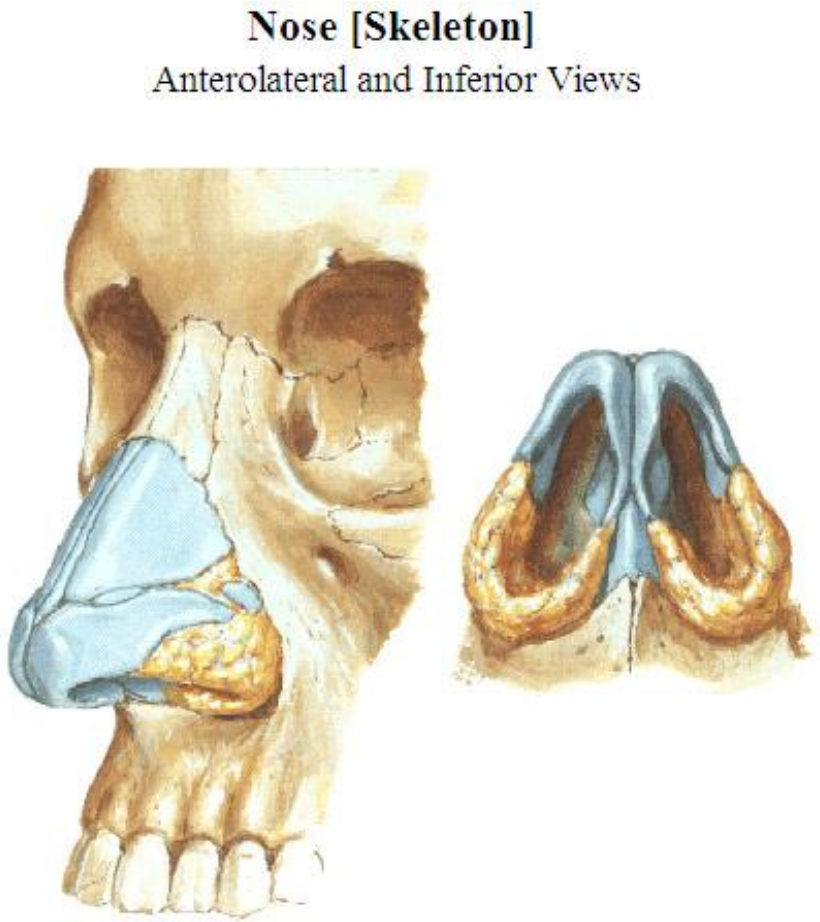
Respiratory Tract Functions



- Pulmonary ventilation – the exchange of gases between external environment to alveoli
- External respiration – the exchange of gases between alveoli and blood stream
- Produces sound for communication

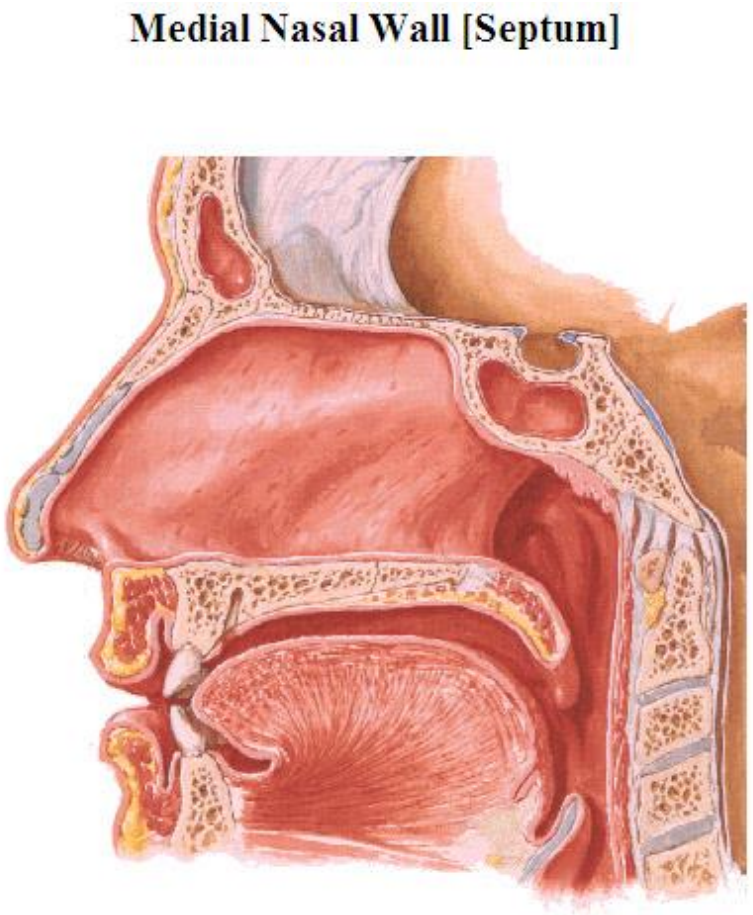
Nose and Paranasal Sinuses

Nose



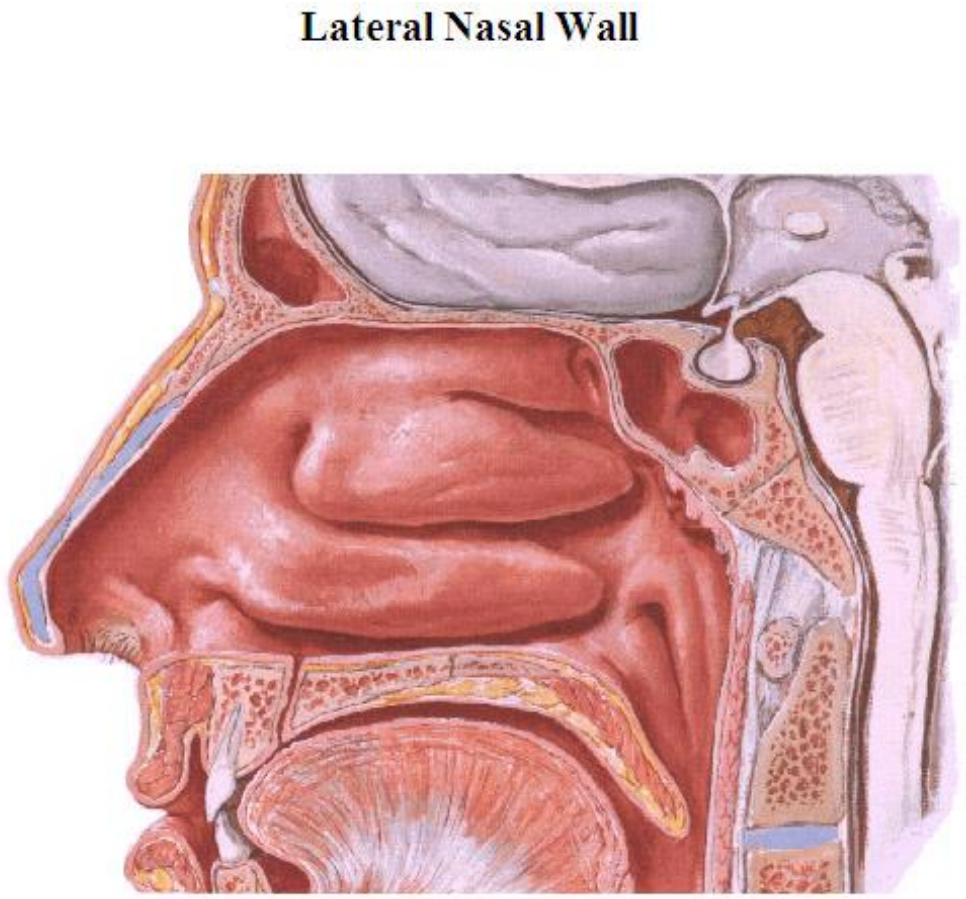
- Lined with mucous membrane
- Supported by bone and cartilage
- Provides an entrance for air in which air is filtered by coarse hairs inside the nostrils

Nasal Cavity

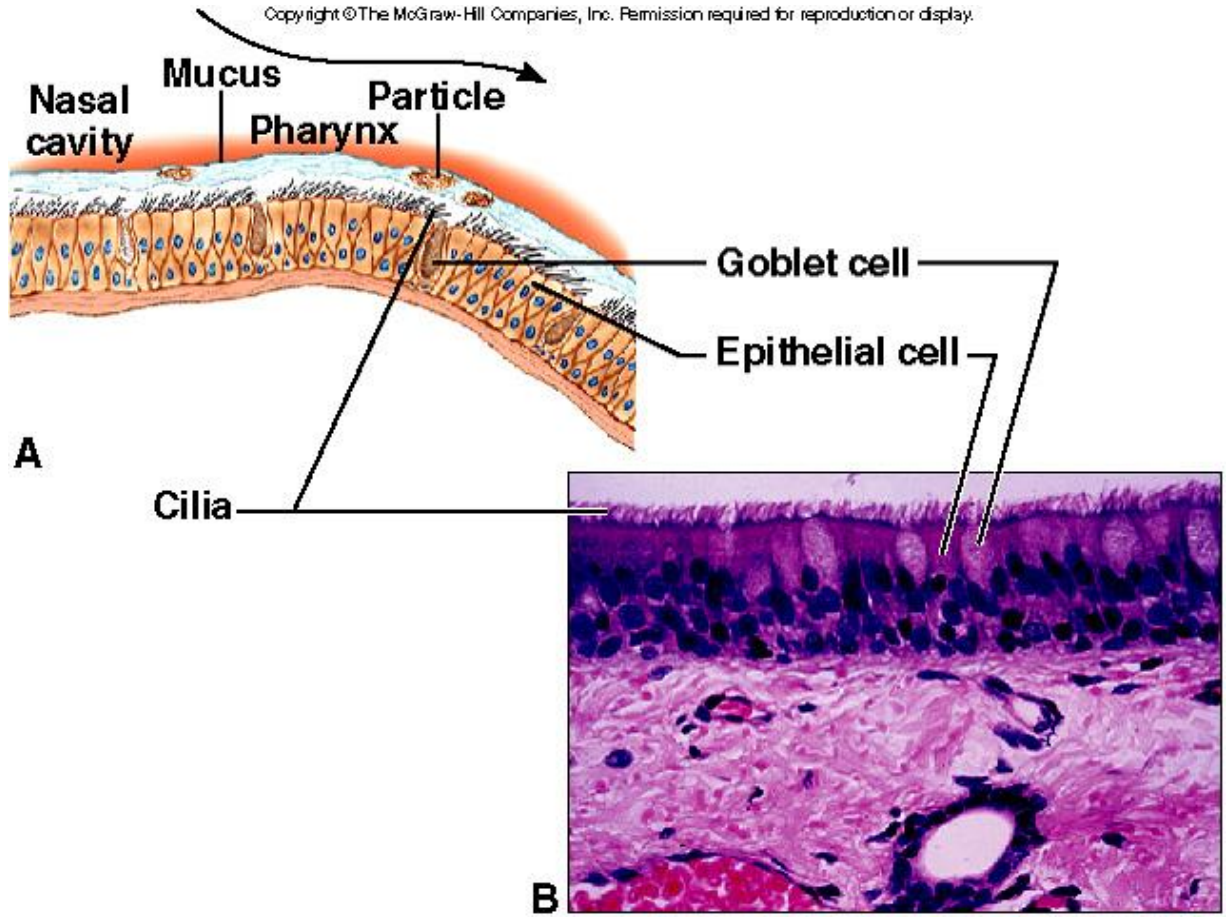


- The nasal cavity is a space posterior to the nose that is divided medially by the nasal septum
- Nasal conchae divide the cavity into passageways that are lined with mucous membrane, and help increase the surface area available to warm and filter incoming air
- Particles trapped in the mucus are carried to the pharynx by ciliary action, swallowed, and carried to the stomach where gastric juice destroys any microorganisms in the mucus

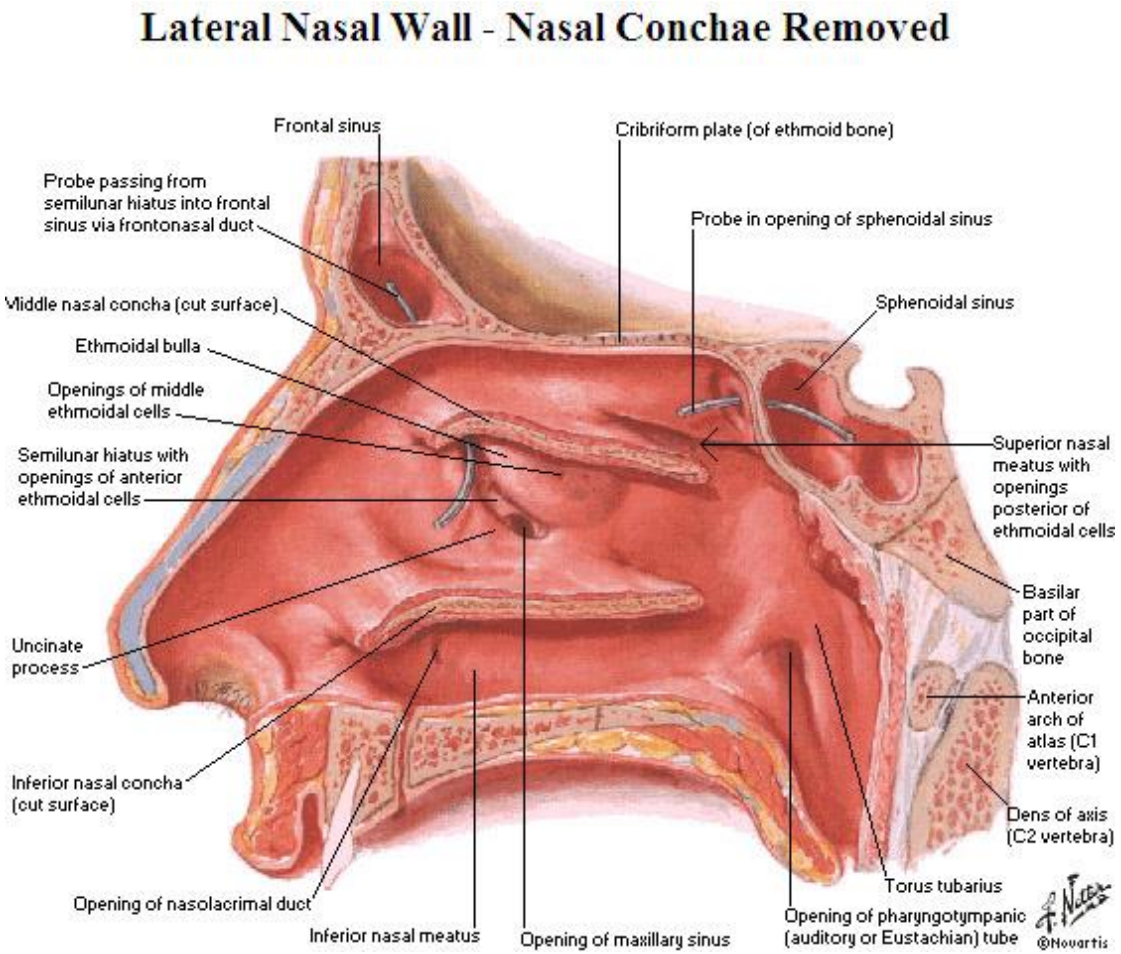
Nasal Conchae



Nasal Mucosa

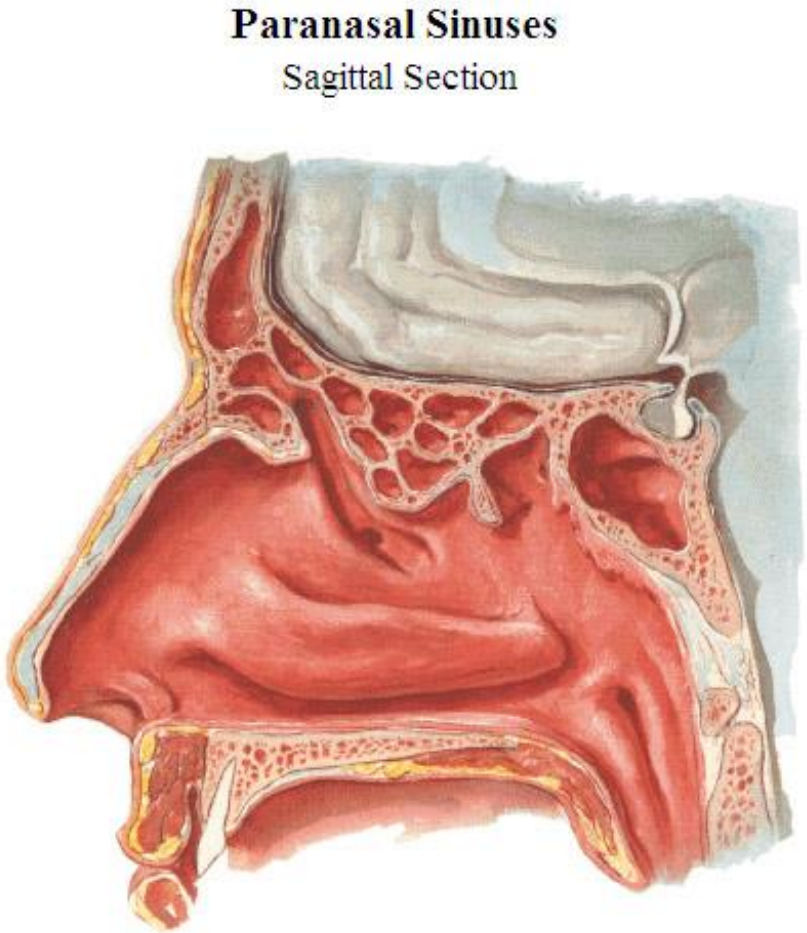


Paranasal Sinuses



- Sinuses are air-filled spaces within the maxillary, frontal, ethmoid, and sphenoid bones of the skull
- These spaces open to the nasal cavity and are lined with mucus membrane that is continuous with that lining the nasal cavity
- The sinuses reduce the weight of the skull and serve as a resonant chamber to affect the quality of the voice

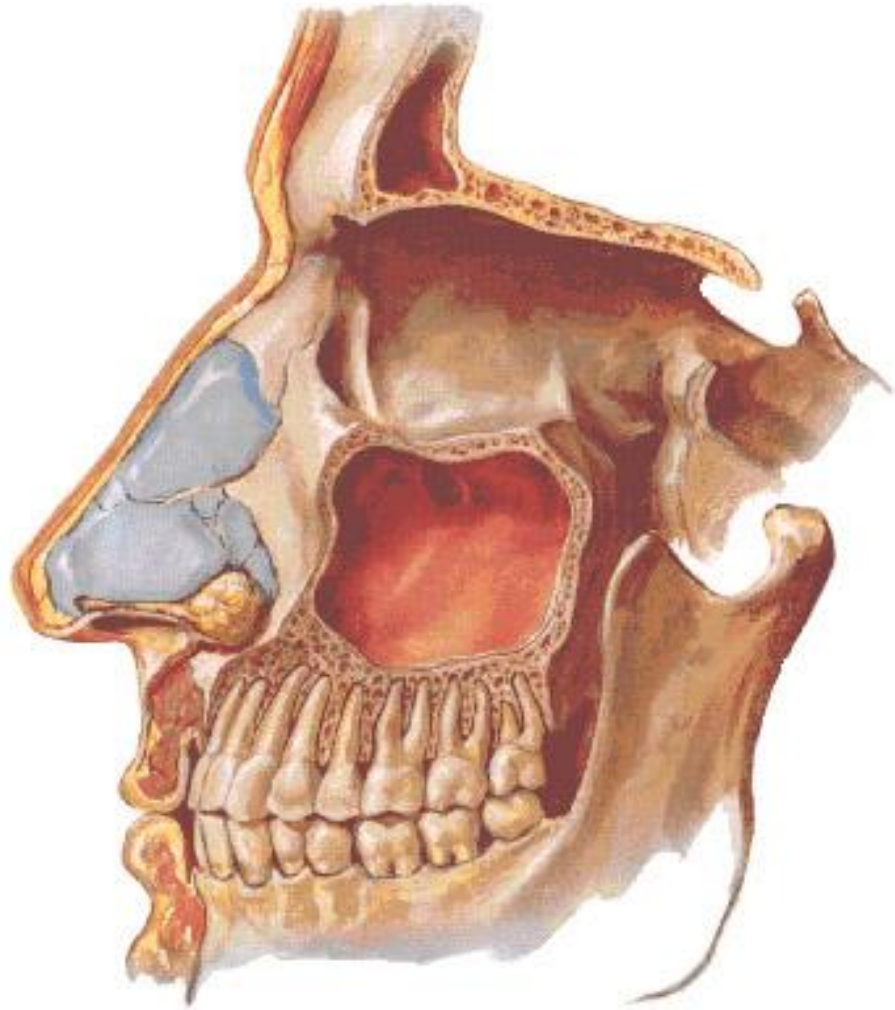
Paranasal Sinuses



- Consists of
  - Frontal sinus
  - Ethmoid Sinus
  - Maxillary Sinus
  - Sphenoid Sinus

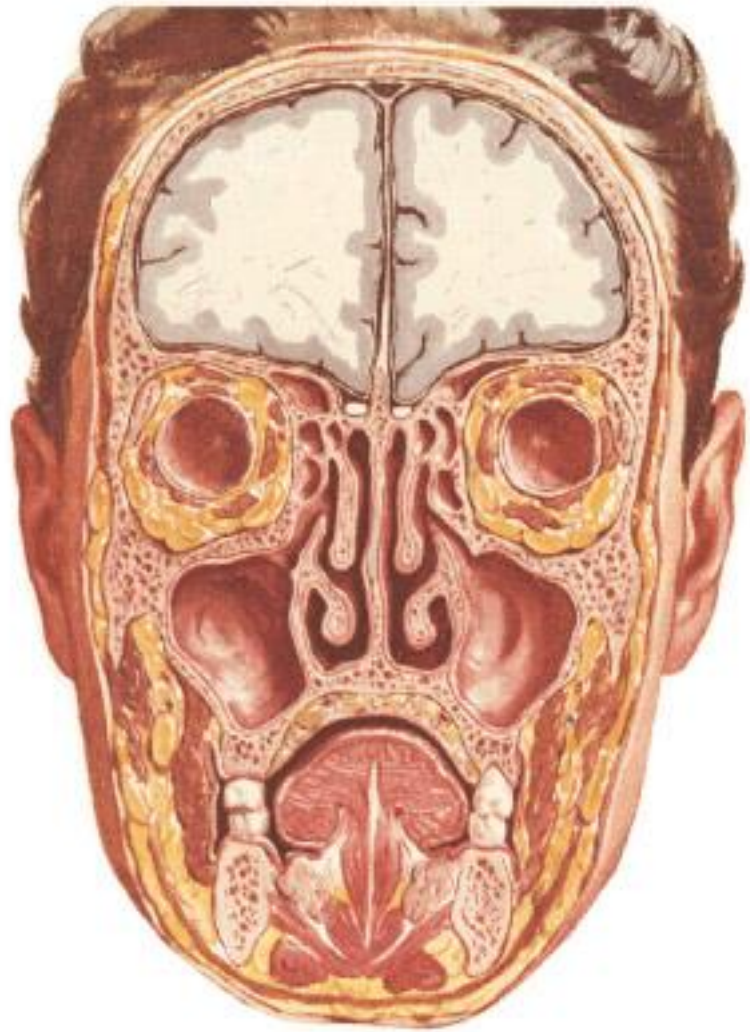
Paranasal Sinuses

Lateral Dissection



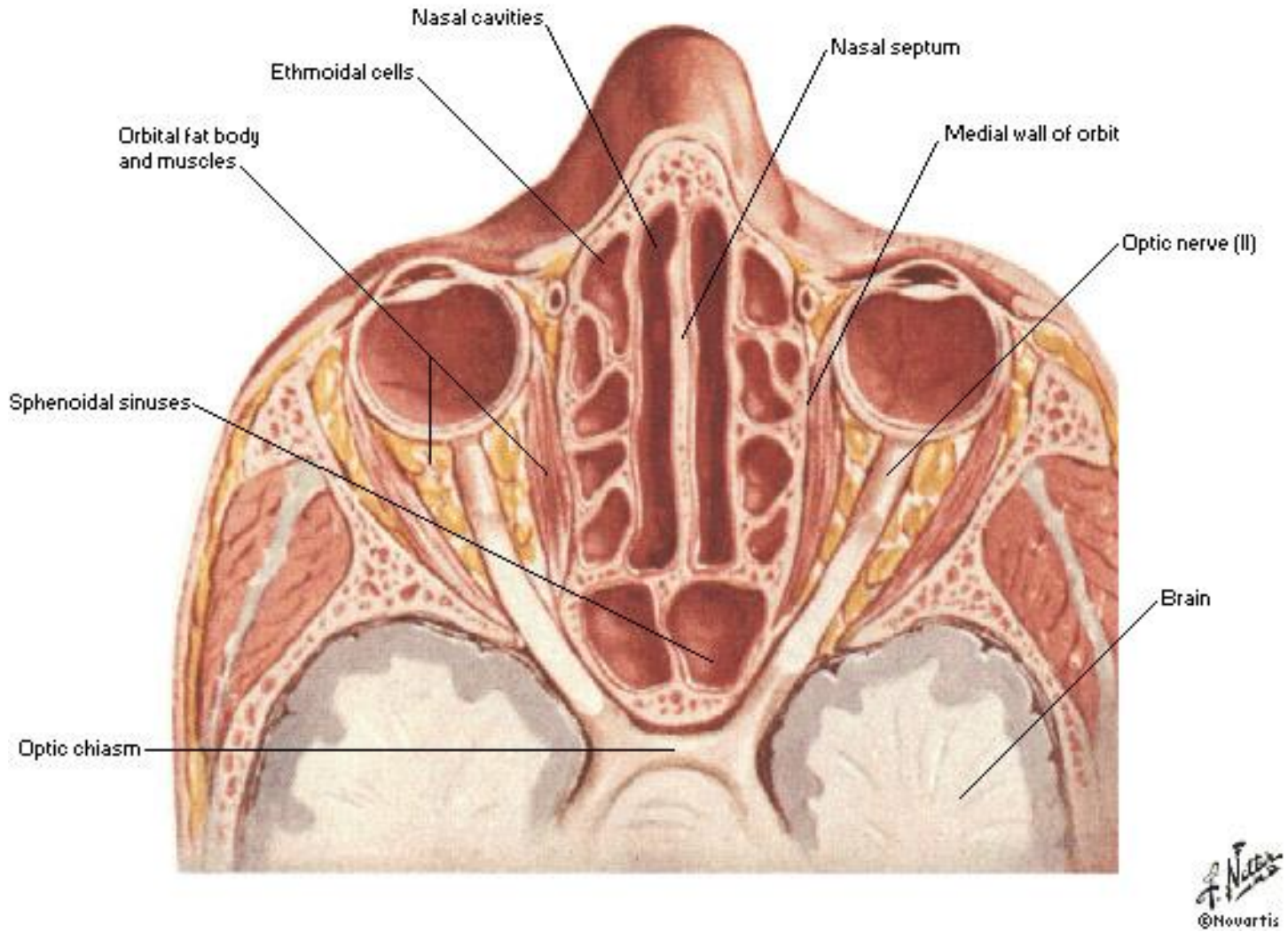
Paranasal Sinuses

Coronal Section



Paranasal Sinuses

Horizontal Section

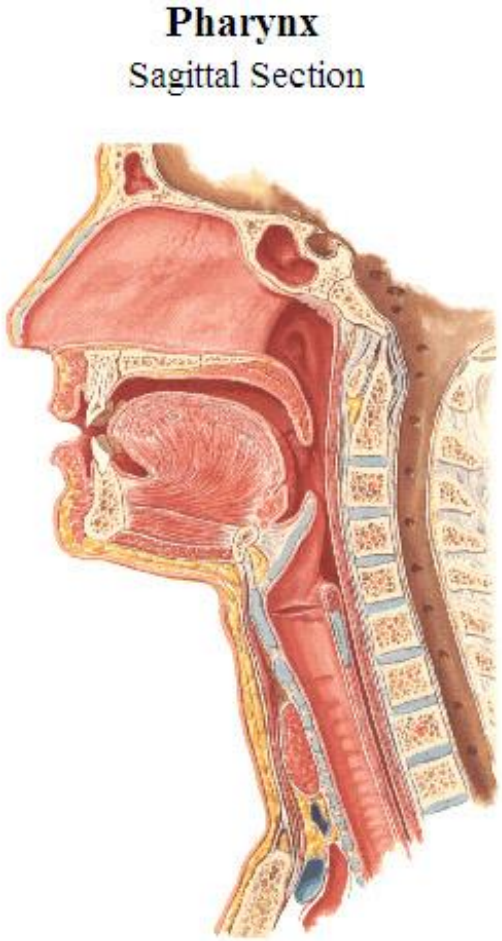


Some Local Points that are Indicated For Sinusitis/Sinus Headache and Rhinitis

- LI-20, Bitong
- Yintang, Yuyao
- UB-2, (Also 3-9)
- GB-14, GB-15
- Du-23, Du-24

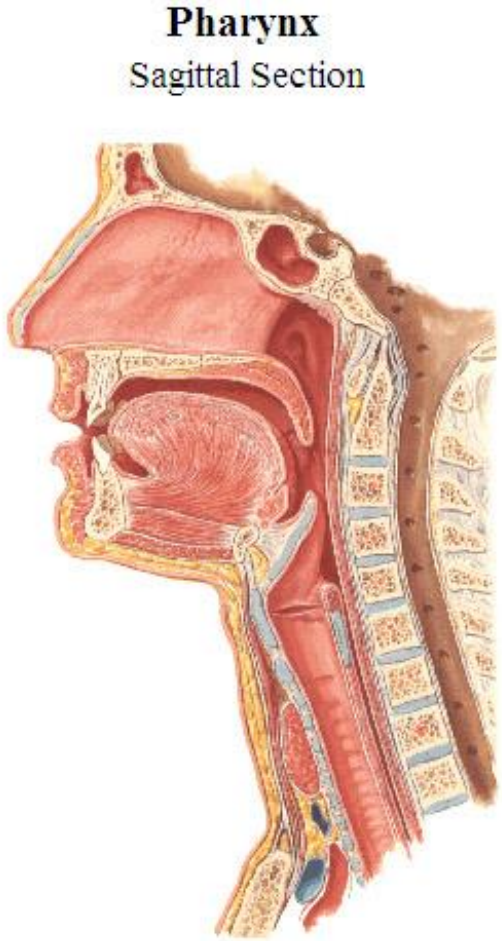
Respiratory Tract and Lungs

The Pharynx



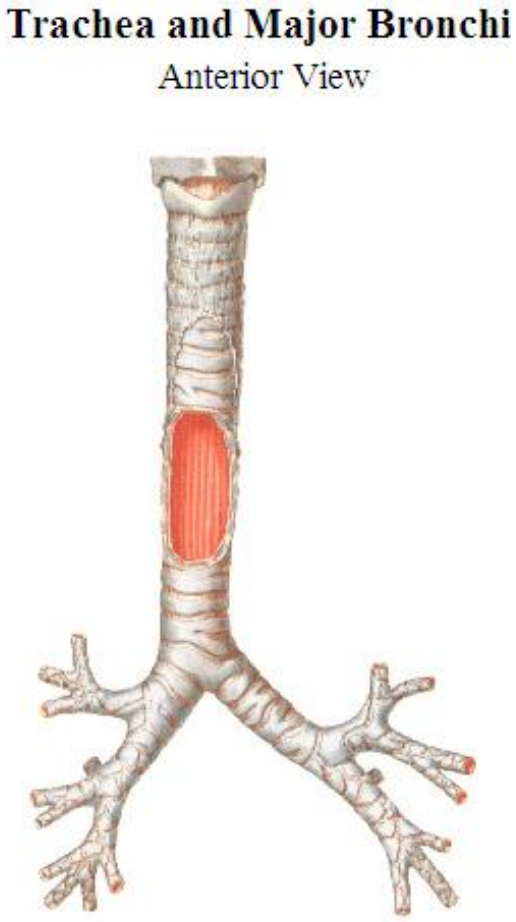
- The pharynx is a common passageway for air and food

The Larynx



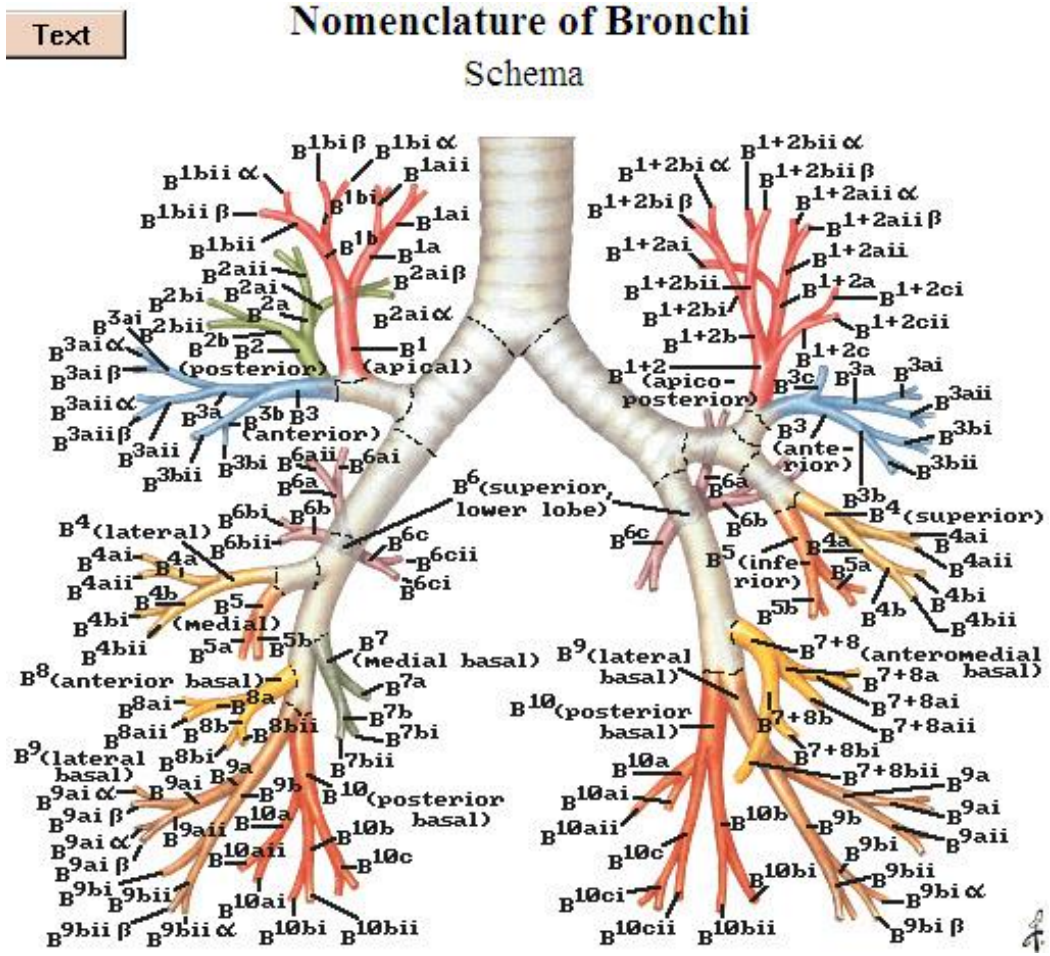
- The larynx is an enlargement in the airway superior to the trachea and inferior to the pharynx
- It helps keep particles from entering the trachea and also houses the vocal cords
- Consists of the vocal cords and the epiglottis
  - During normal breathing, the vocal cords are relaxed and the glottis is a triangular slit.
  - During swallowing, the false vocal cords and epiglottis close off the glottis

The Trachea



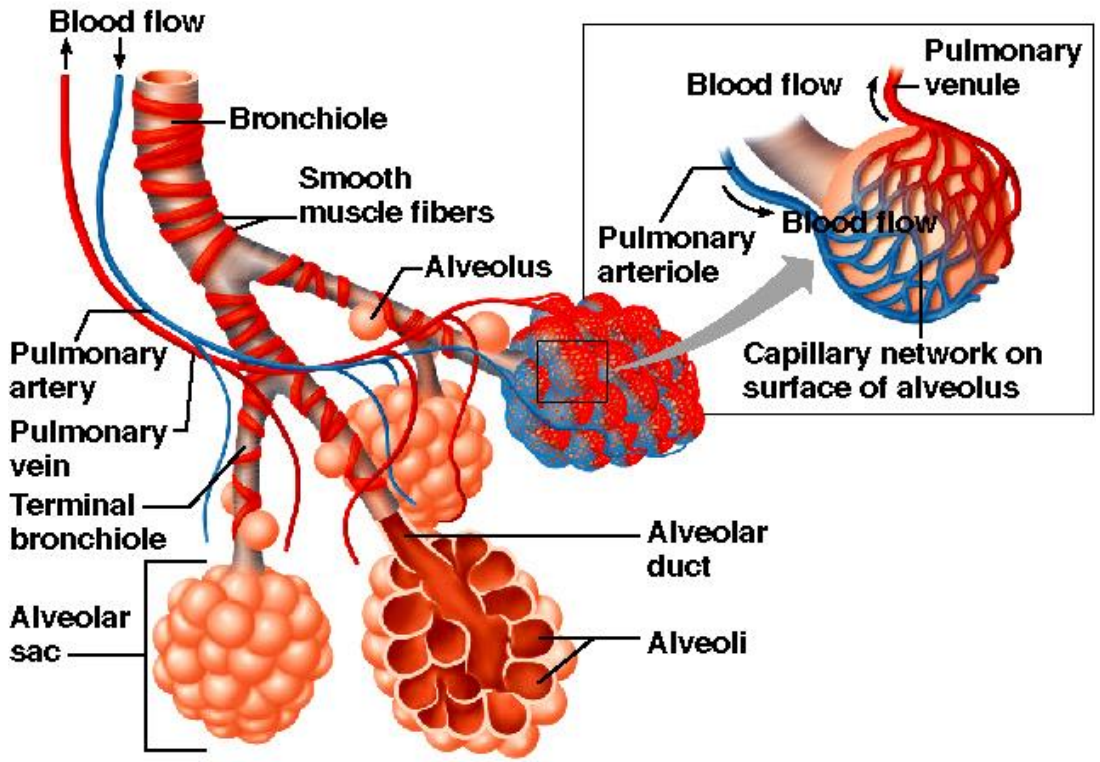
- The trachea extends downward anterior to the esophagus and into the thoracic cavity, where it splits into right and left bronchi
- The inner wall of the trachea is lined with ciliated mucous membrane with many goblet cells that serve to trap incoming particles
- The tracheal wall is supported by 20 incomplete cartilaginous rings

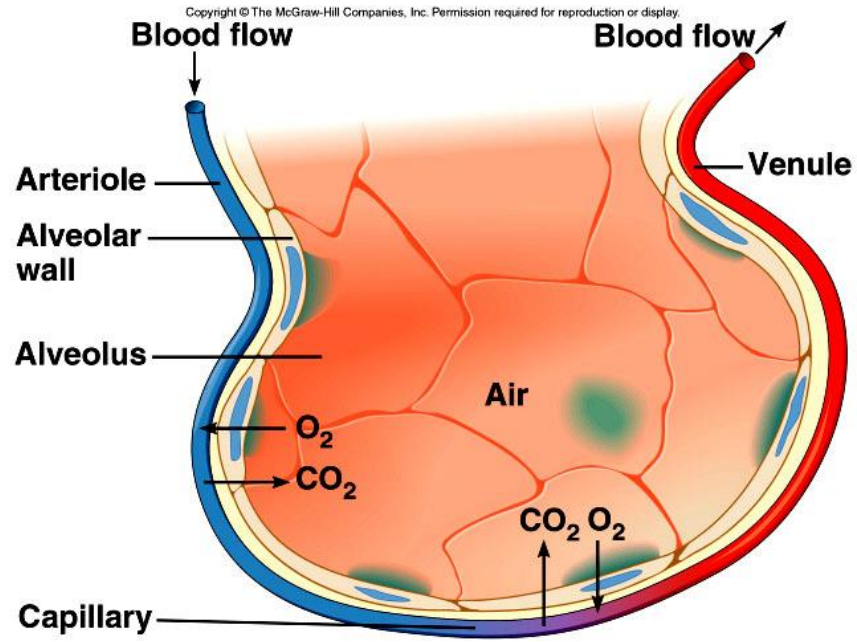
The Bronchial Tree



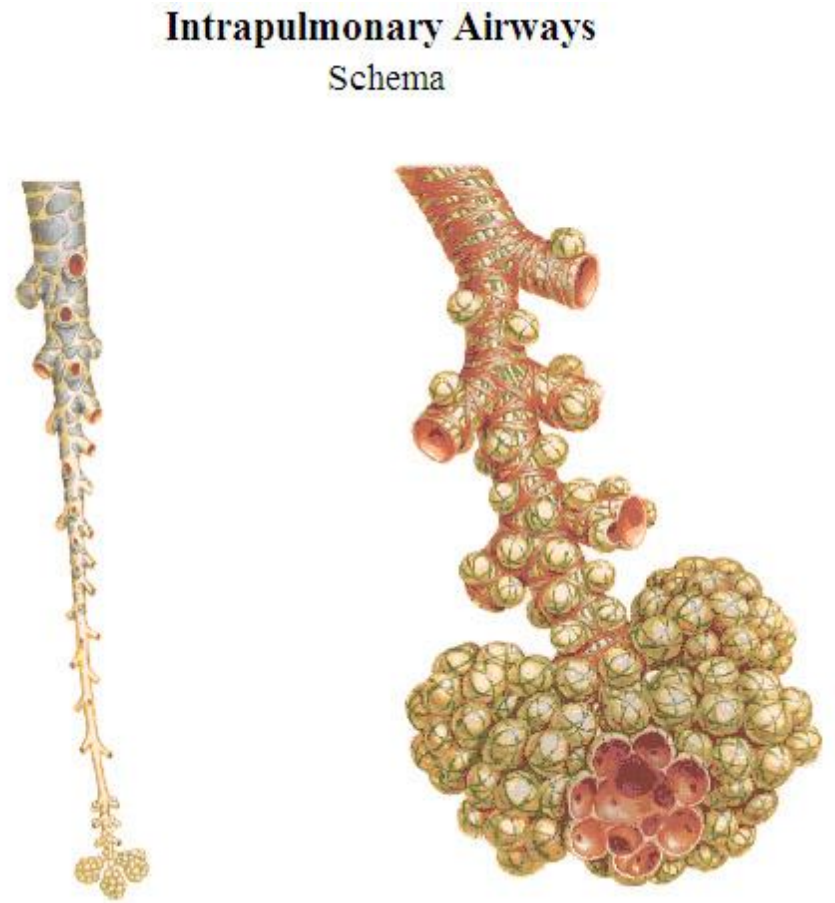
- The bronchial tree consists of branched tubes leading from the trachea to the alveoli
  - The bronchial tree begins with the two primary bronchi, each leading to a lung
  - The branches of the bronchial tree from the trachea are right and left primary bronchi; these further subdivide until bronchioles give rise to alveolar ducts which terminate in alveoli
  - It is through the thin epithelial cells of the alveoli that gas exchange between the blood and air occurs

Gas Exchange Between Alveoli and Capillaries

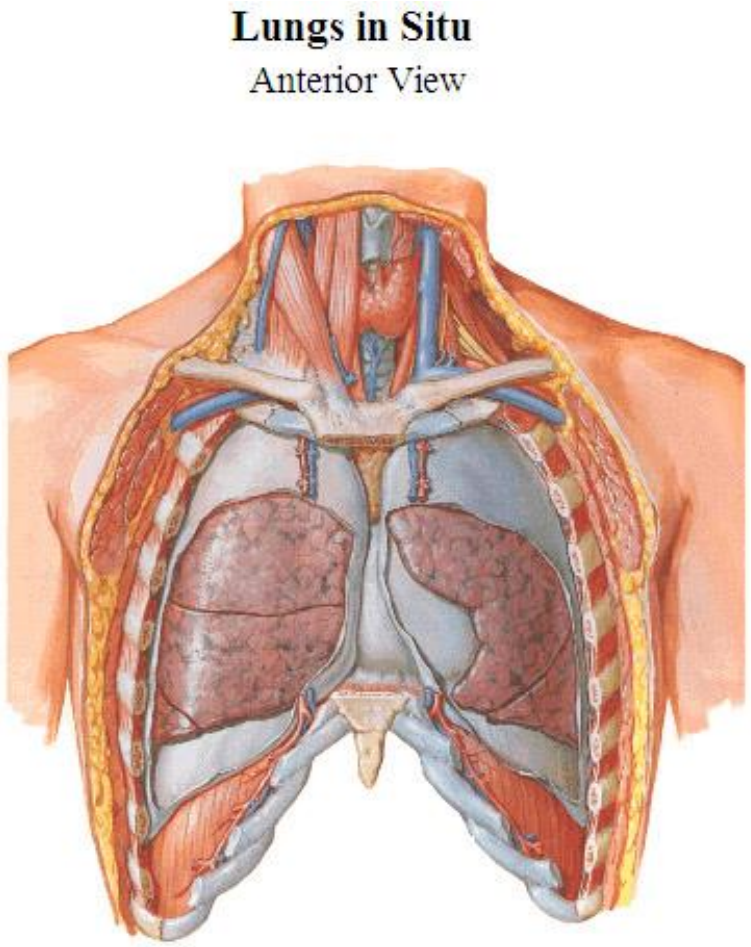




Alveoli

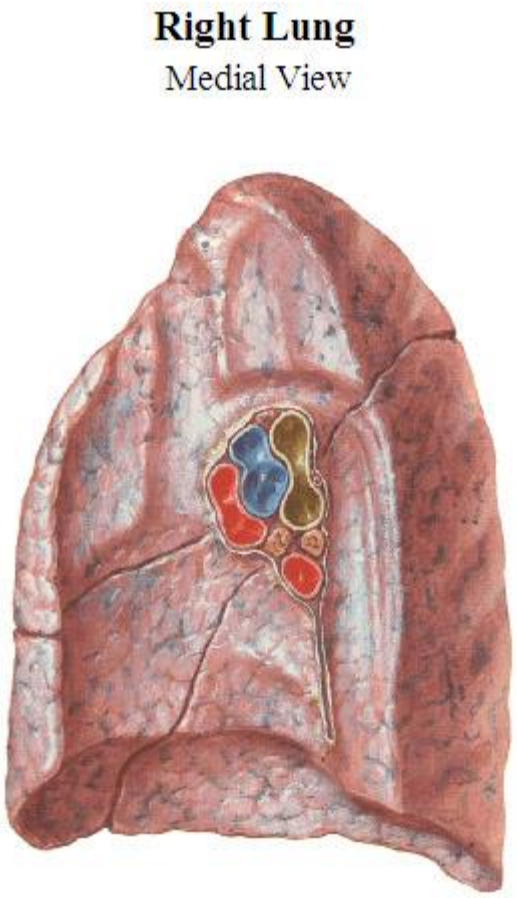


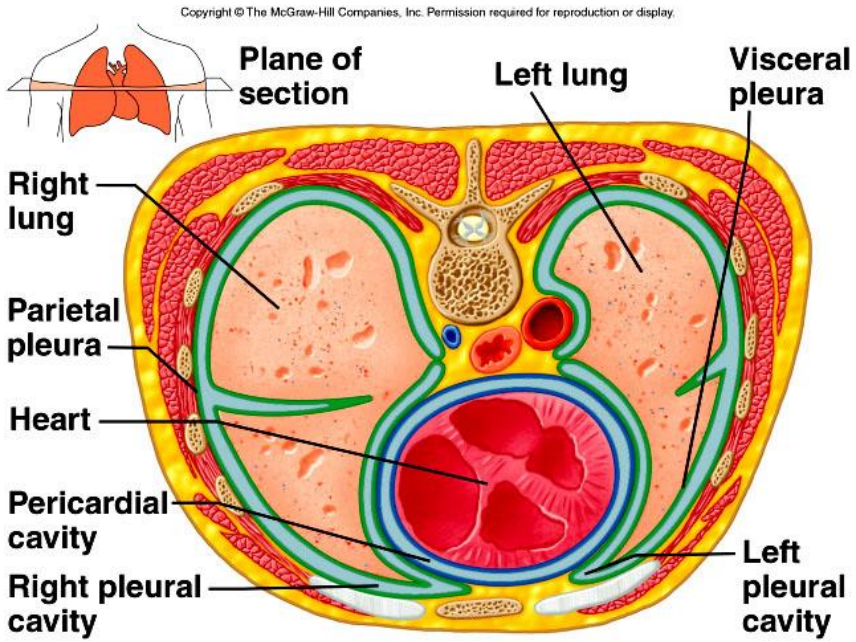
Lungs



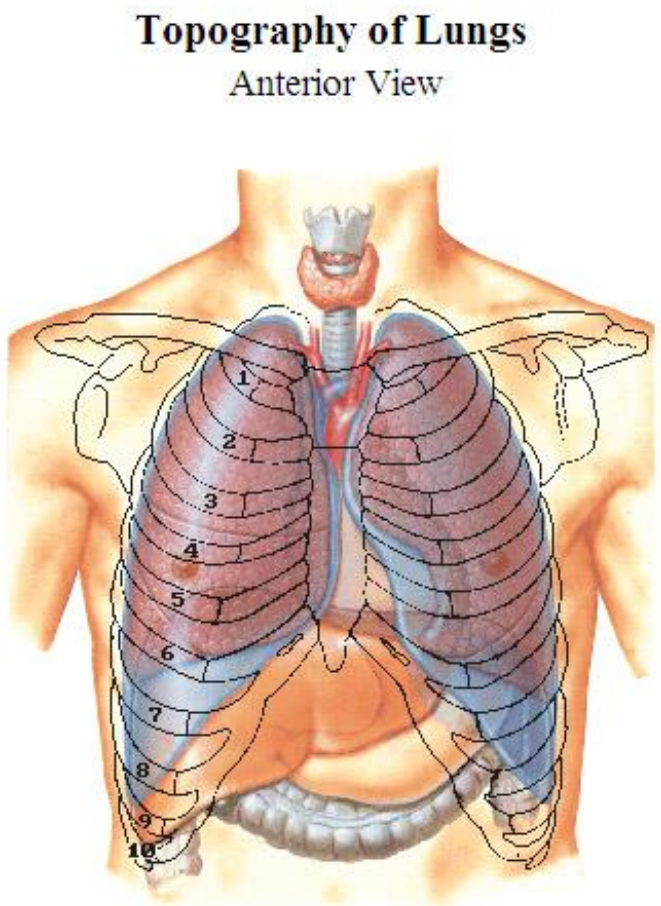
- The right and left soft, spongy, cone-shaped lungs are separated medially by the mediastinum and are enclosed by the diaphragm and thoracic cage
- The bronchus and large blood vessels enter each lung
- A layer of serous membrane, the visceral pleura (pleur/o), folds back to form the parietal pleura
- The visceral pleura is attached to the lung, and the parietal pleura lines the thoracic cavity; serous fluid lubricates the "pleura cavity" between these two membranes
- The right lung has three lobes, the left has two
- Each lobe is composed of lobules that contain air passages, alveoli, nerves, blood vessels, lymphatic vessels, and connective tissues

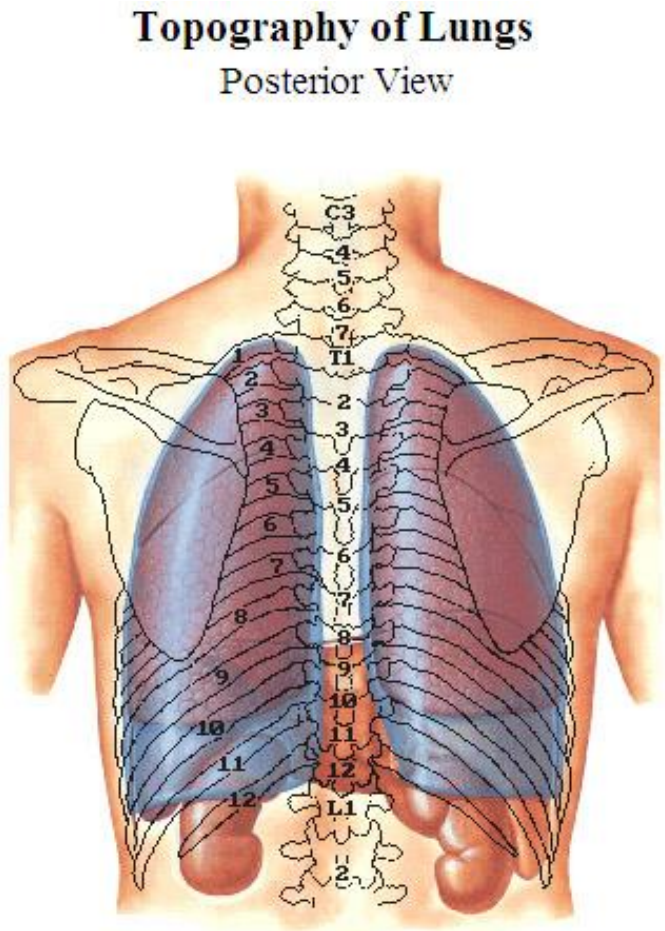
Hilum of Lungs



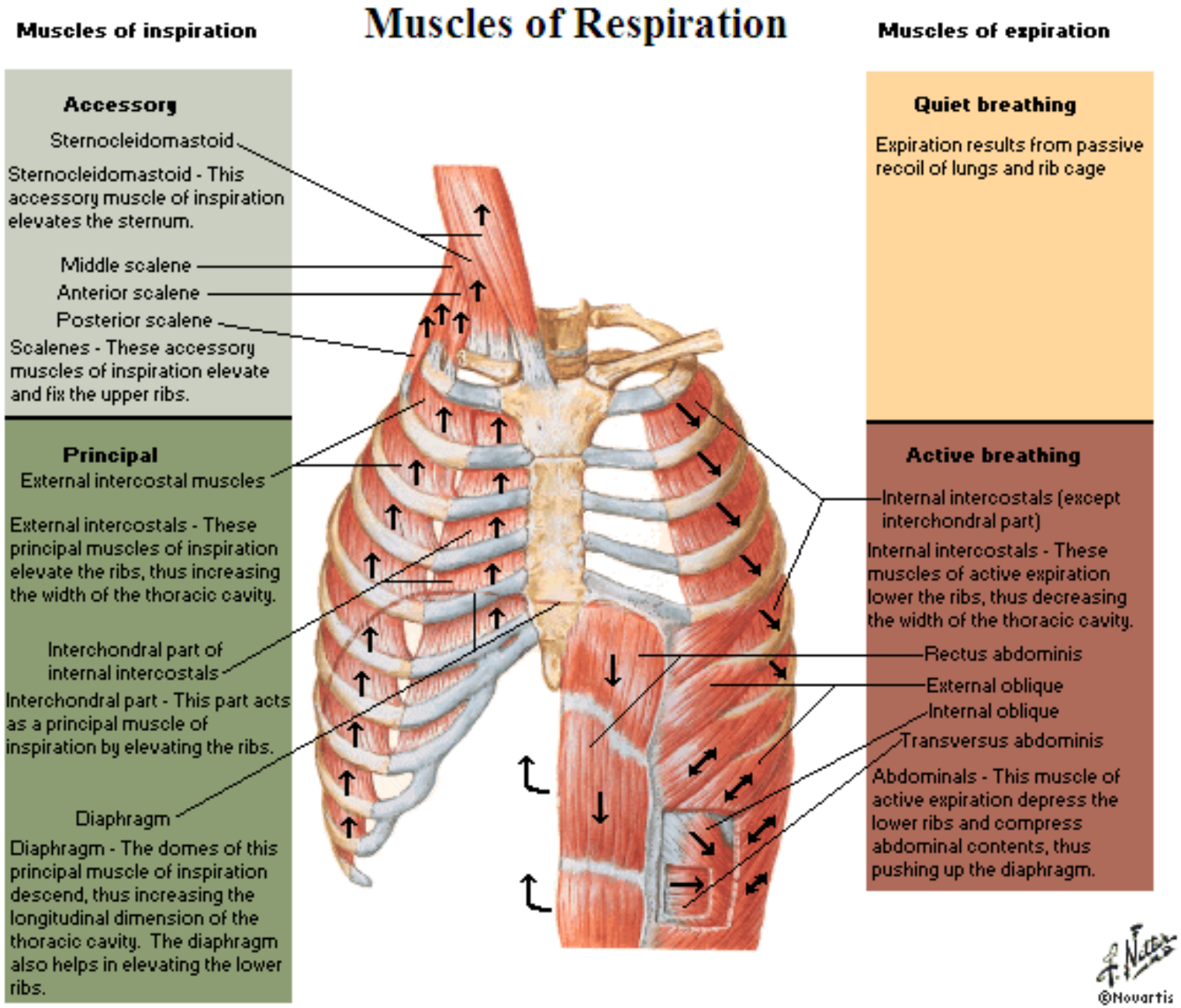


Lung Topography





Muscles of Respiration



Digestive System

Digestive System Structures

- The Digestive System consists of the GI track and accessory organs
- Accessory Organs include mechanical structures such as the teeth and tongue and other organs associated with digestions such as the pancreas, gallbladder and liver.

Digestive System Functions

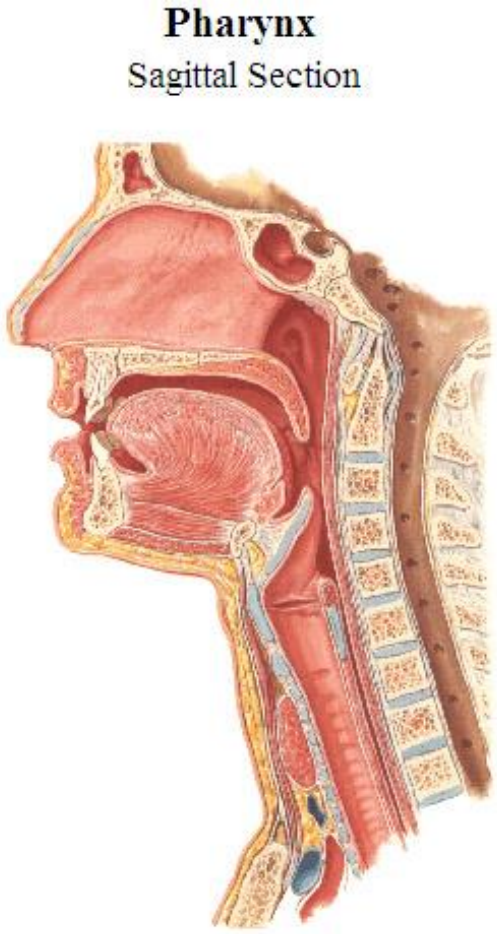
- Processes and digests food
- Absorbs and conserves water
- Absorbs nutrients (ions, water, dietary sugars, proteins and fats)
- Stores energy reserves

Gastrointestinal Track (Alimentary Canal)

Gastrointestinal Tract

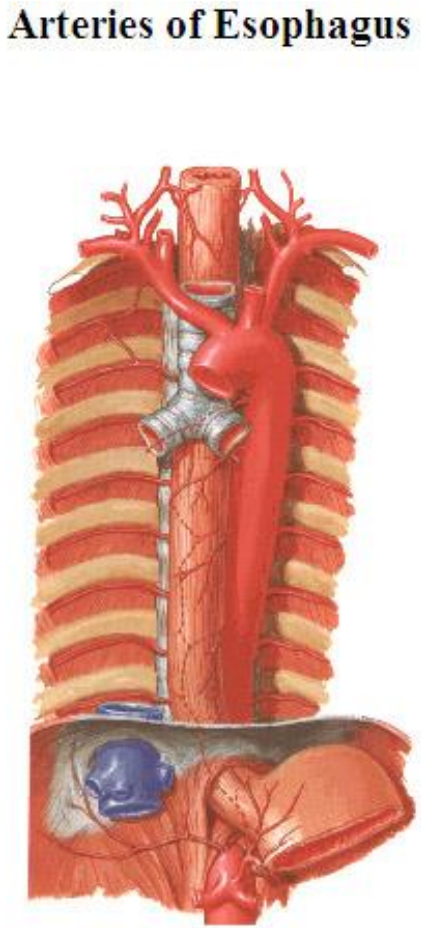
- The GI track consists of:
  - Pharynx
  - Esophagus
  - Stomach
  - Small Intestine
    - Duodenum, jejunum, ileum
  - Large Intestine
    - Cecum, Ascending, Transverse, Descending, Sigmoid Colon, Rectum

Digestive Tract
(aka Alimentary Canal or GI Tract)



- Pharynx
  - Consists or
    - Nasopharynx
    - Oropharynx
    - Laryngopharynx

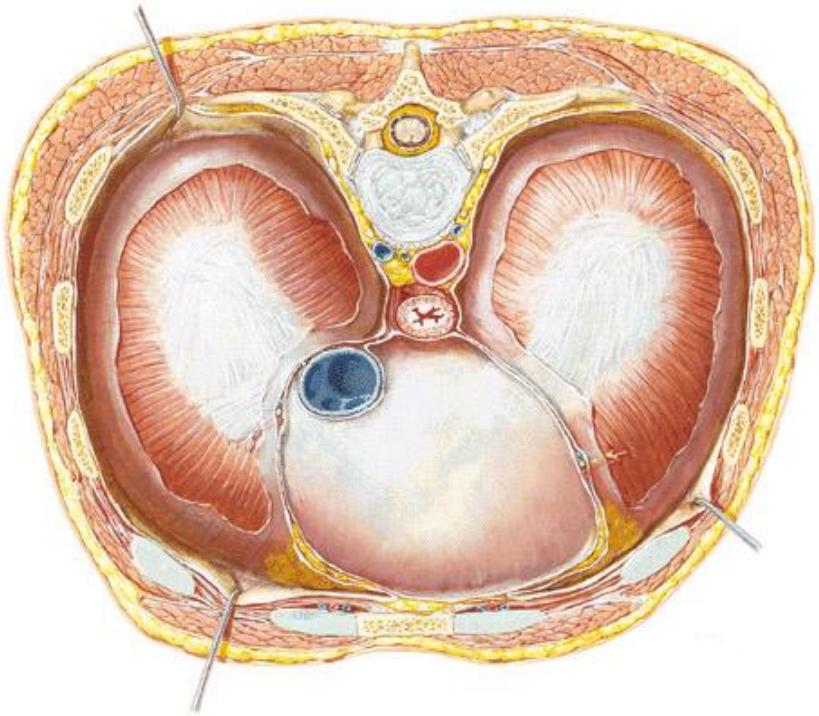
Digestive Tract
(aka Alimentary Canal or GI Tract)



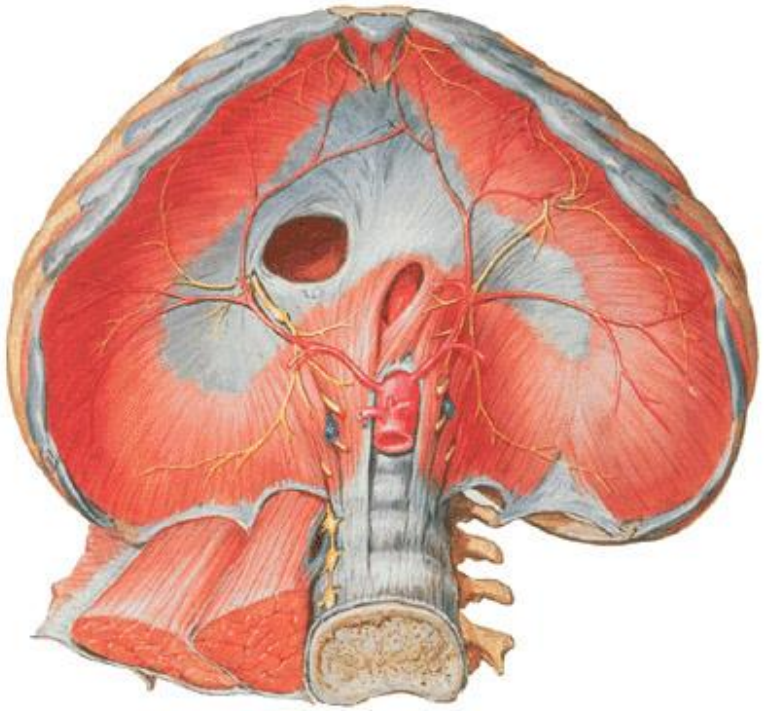
- Esophagus
  - Extends from pharynx to stomach
  - Passes through esophageal hiatus of diaphragm
    - Hiatus serves as a valve to prevent reflux serves

Digestive Tract
(aka Alimentary Canal or GI Tract)

Diaphragm
Thoracic Surface



Diaphragm
Abdominal Surface

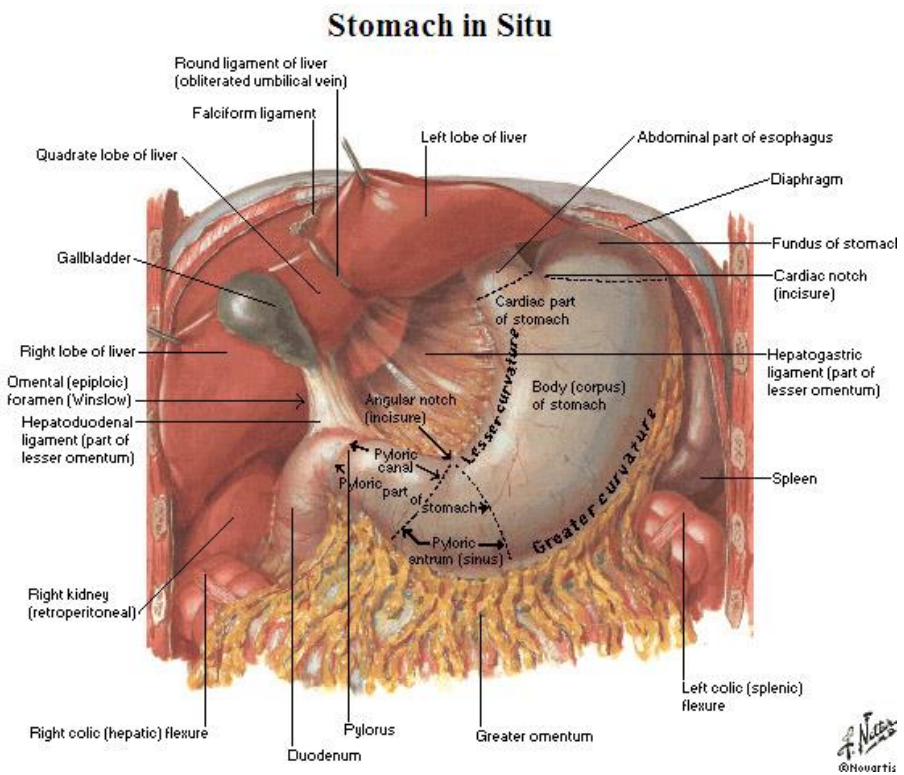


Digestive Tract
(aka Alimentary Canal or GI Tract)

Musculature of Esophagus 1

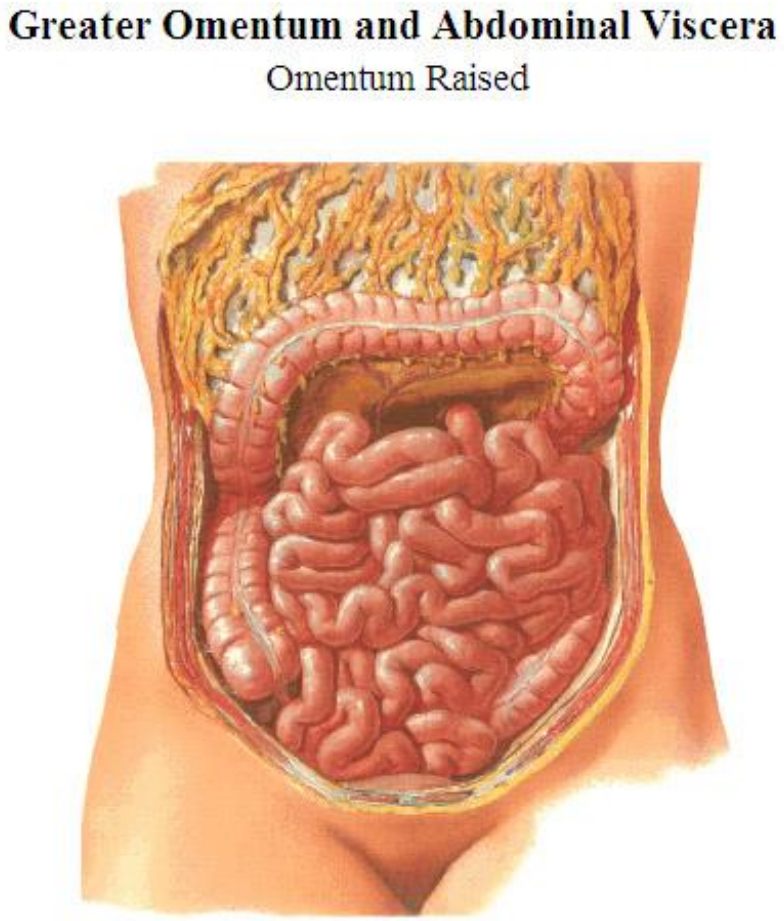
Musculature of Esophagus 2

Digestive Tract
(aka Alimentary Canal or GI Tract)



- Stomach
  - Mixes and stores food. It secretes chemicals for digestion and hormones for local communication control
  - Consists of four regions
    - Cardia
    - Fundus
    - Body
    - Pylorus (pyloric valve regulates passage of bolus to SI)

Digestive Tract
(aka Alimentary Canal or GI Tract)



Small Intestines

- 20 foot canal extending from the pyloric valve to the large intestine
- Consists of three parts
  - Duodenum
  - Jejunum
  - Ileum
    - Connects with the first part of the large intestine (cecum) at the ileocecal valve

Duodenum

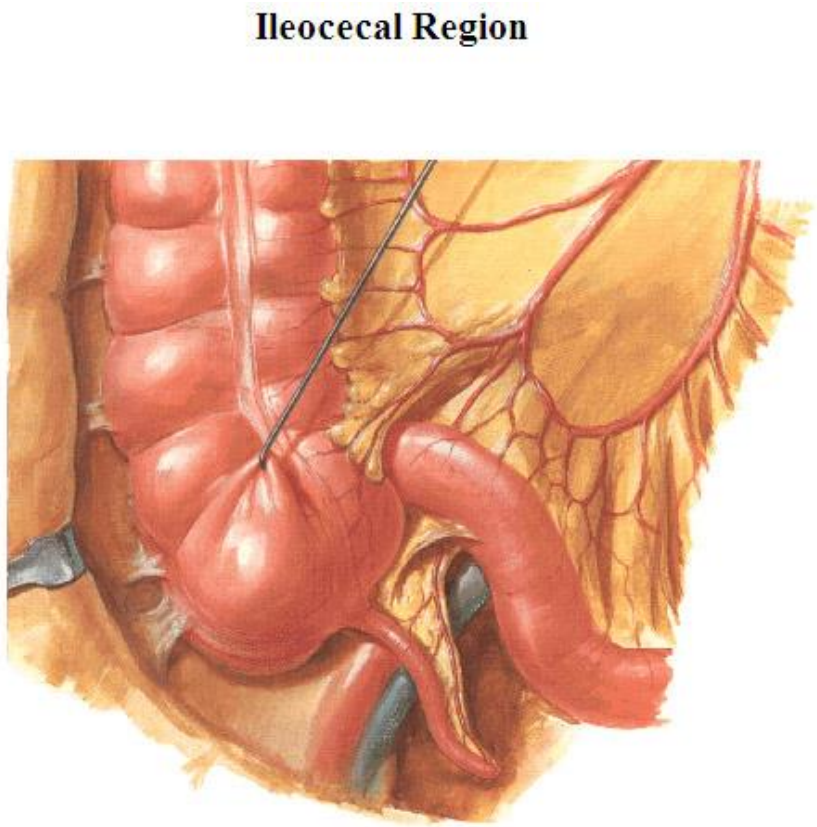
Mesenteric Relations of Intestines

Suspensory Muscle of Duodenum

Exposure of suspensory muscle of duodenum (ligament of Treitz)

- The duodenum receives digestive enzymes from the pancreas (an accessory organ of the digestive system). These are sent through the pancreatic duct into the Sphincter on Oddi.
- Absorption occurs more in the jejunum and ileum

Digestive Tract
(aka Alimentary Canal or GI Tract)



- The ileum meets with the cecum which is the first part of the large intestine at the ileocecal valve

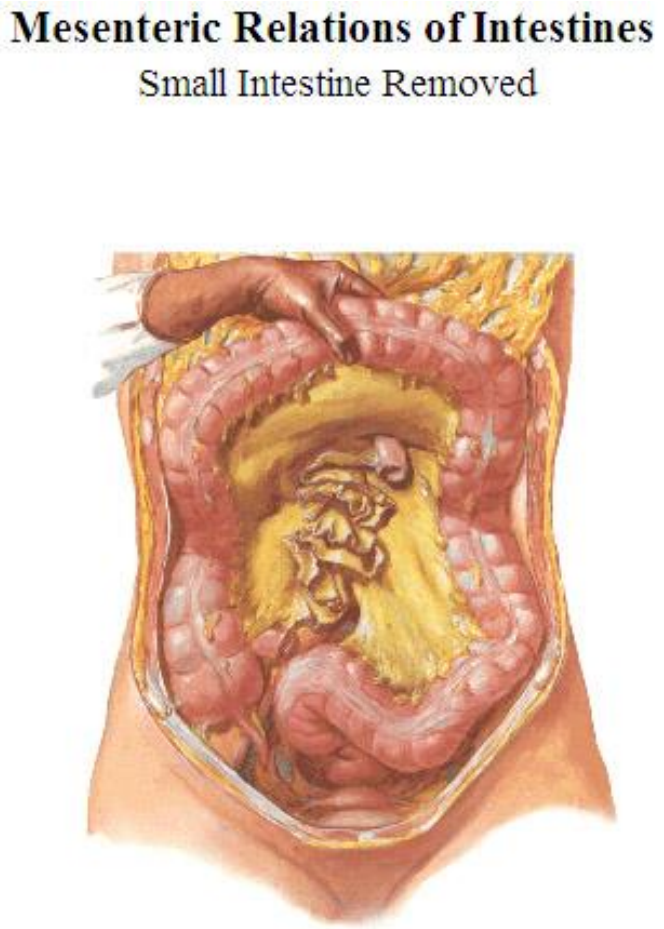
Digestive Tract
(aka Alimentary Canal or GI Tract)

- The large intestine consists of the
  - Cecum
  - Ascending colon
  - Transverse colon
  - Descending colon
  - Sigmoid colon
  - Rectum

The Digestive Organs and the Peritoneum

- The abdominopelvic cavity contains the peritoneal cavity which is lined with serous membrane. It is divided into the parietal peritoneum and visceral peritoneum which contain serous fluid between these layers.
- The peritoneum is a more complex structure than the pleura and peritoneum in shape and contains many folds such which are extensions of the peritoneal structures. These include visceral ligaments, the omentum, and the mesentery.

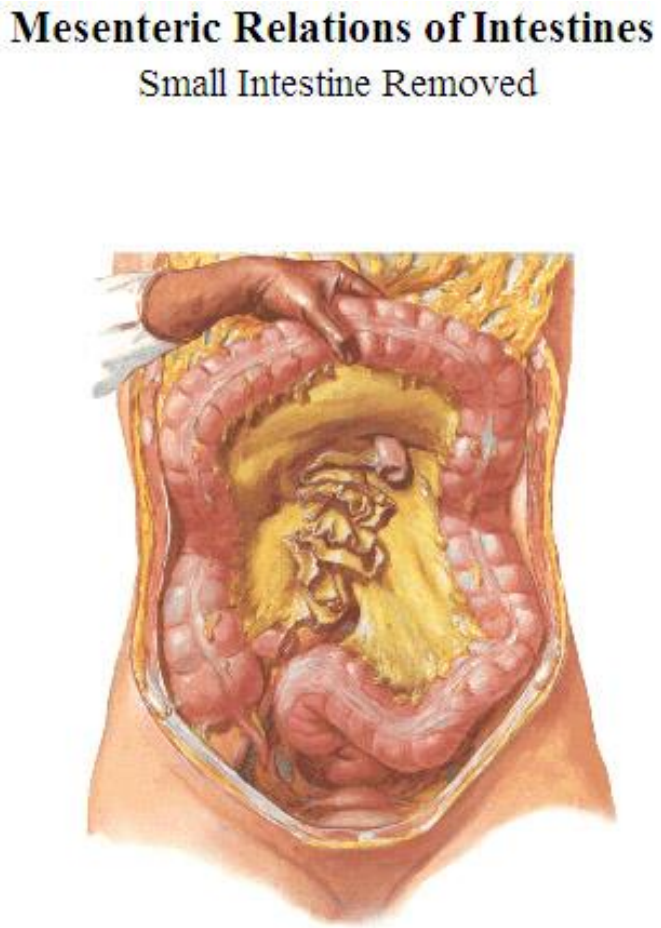
Mesenteries



Connections of the peritoneum that connect the parietal with the visceral peritoneum. They are double sheets of peritoneum and provide passages for blood vessels, nerves, and lymphatic vessels to and from the digestive tract.

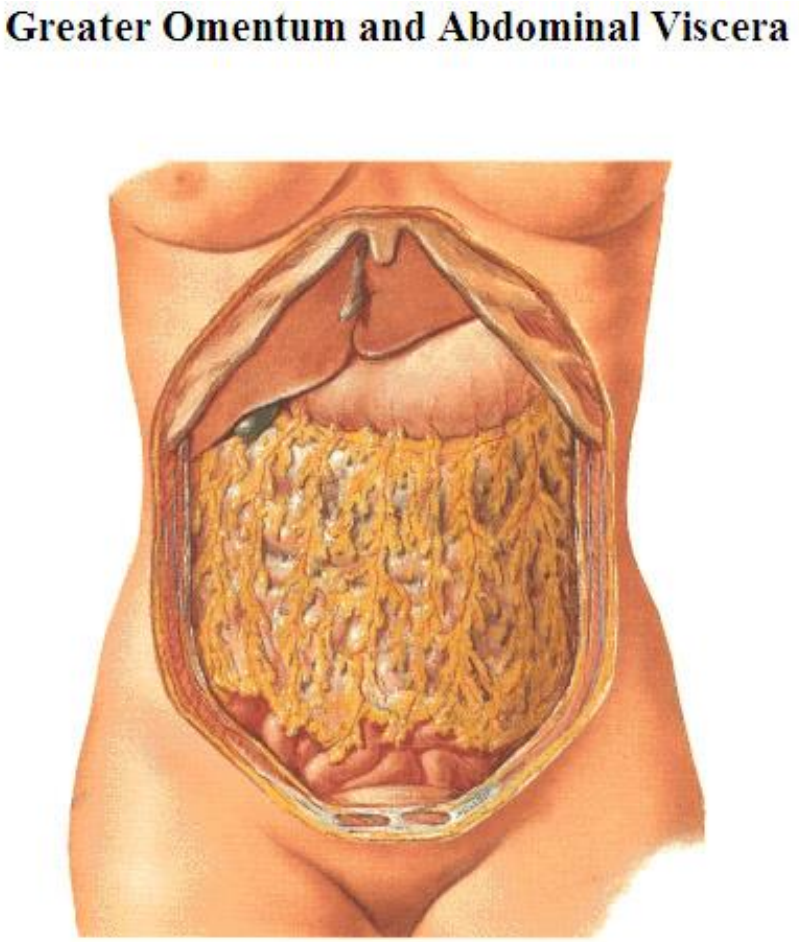
Consists of the mesentery proper, the mesocolon, the omentum and the falciform ligament

Mesenteries



- Mesentery proper
  - The small intestines (especially the jejunum and ileum) are suspended from the posterior peritoneum from the mesentery
  - This permits movement but provides stability

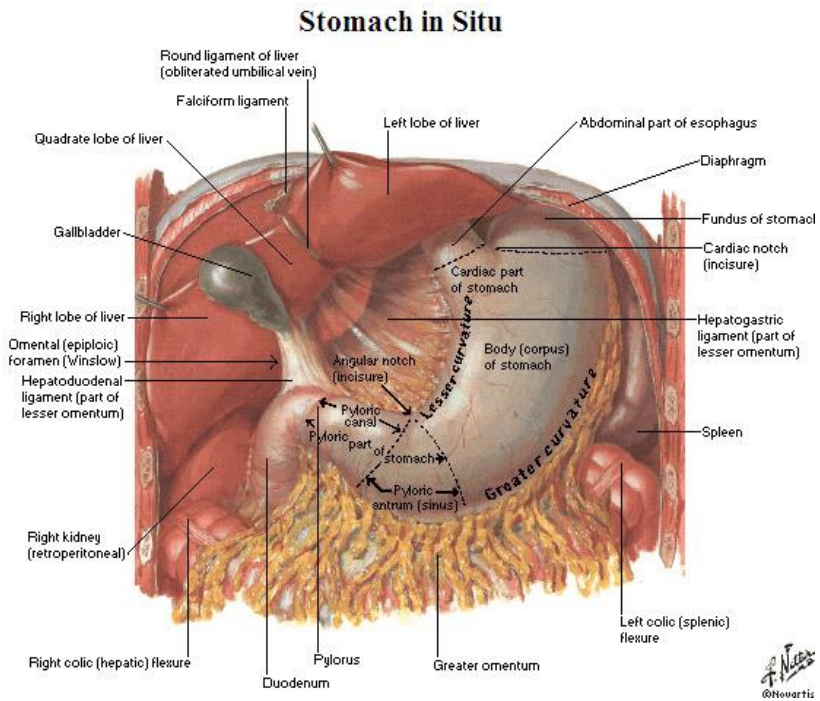
Mesenteries



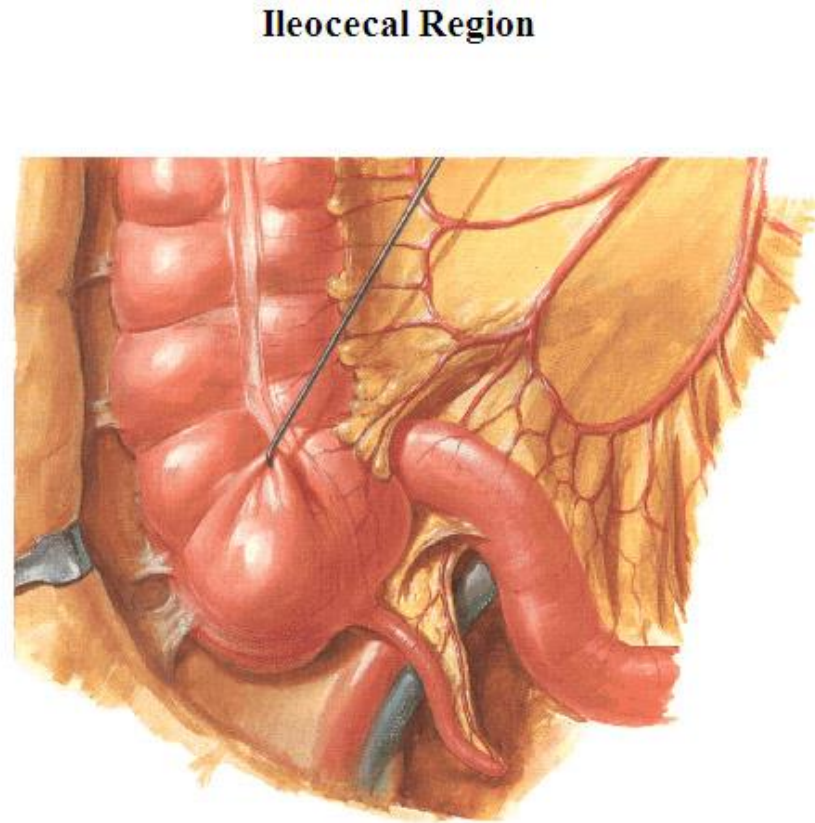
- Greater Omentum
  - Fold of the peritoneum that drapes over the abdominal organs
  - It extends from the greater curvature of the stomach, passing in front of the small intestines and reflects on itself to ascend to the transverse colon before reaching to the posterior abdominal wall

Mesenteries

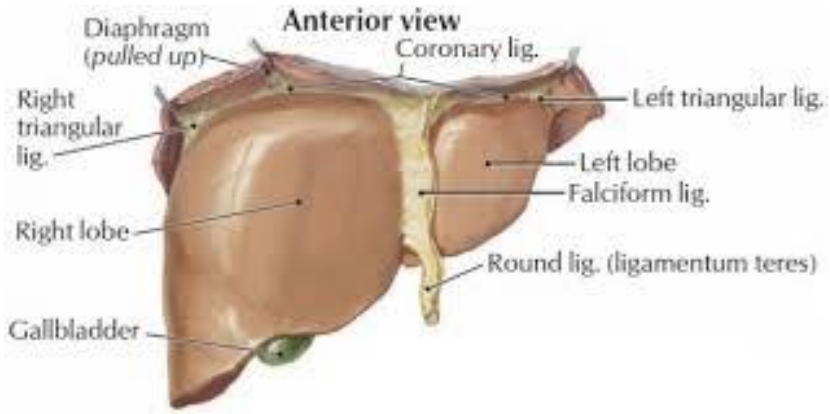
Lesser Omentum

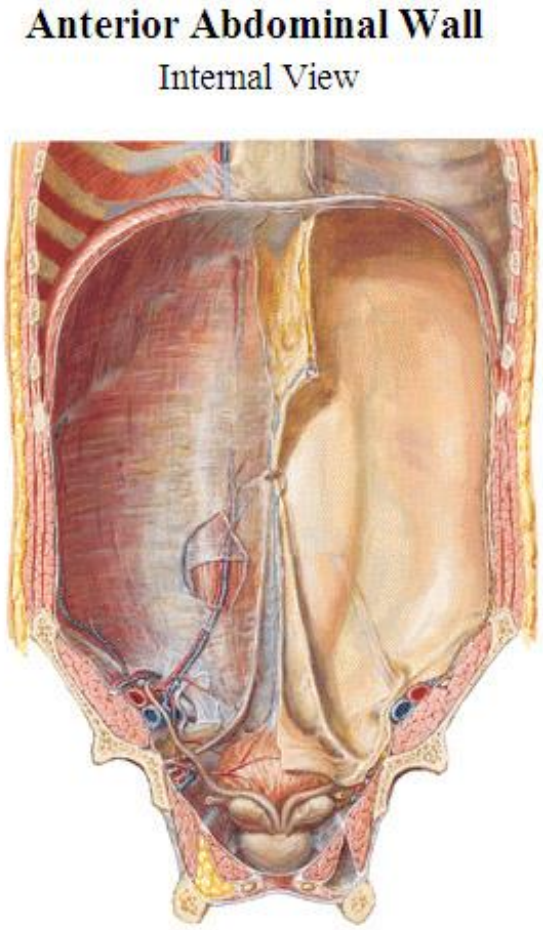


Mesocolon



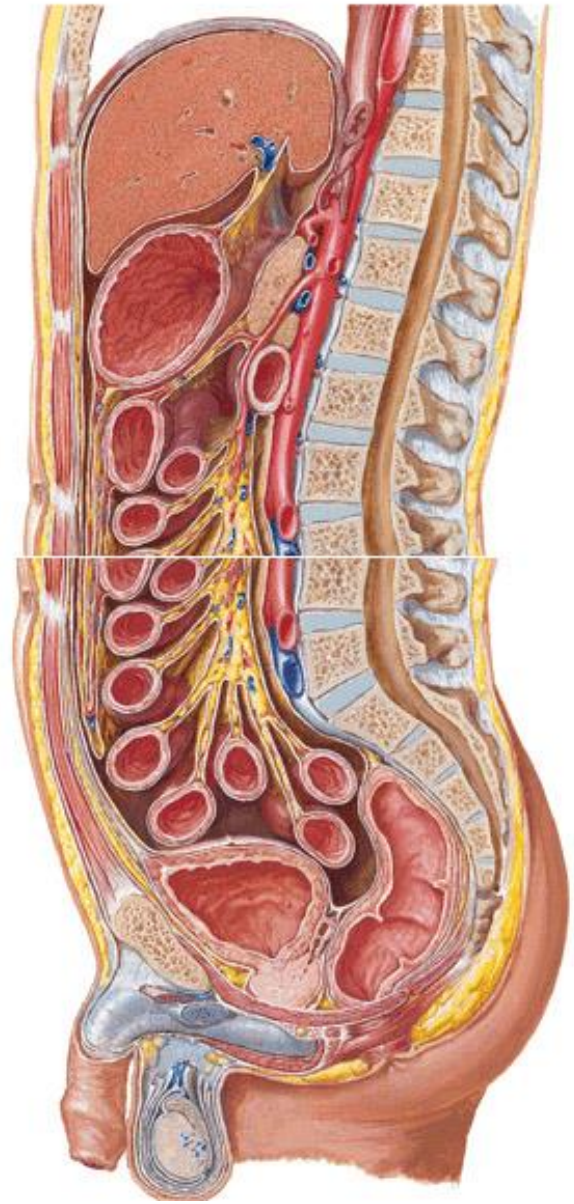
Mesenteries
Falciform Ligament





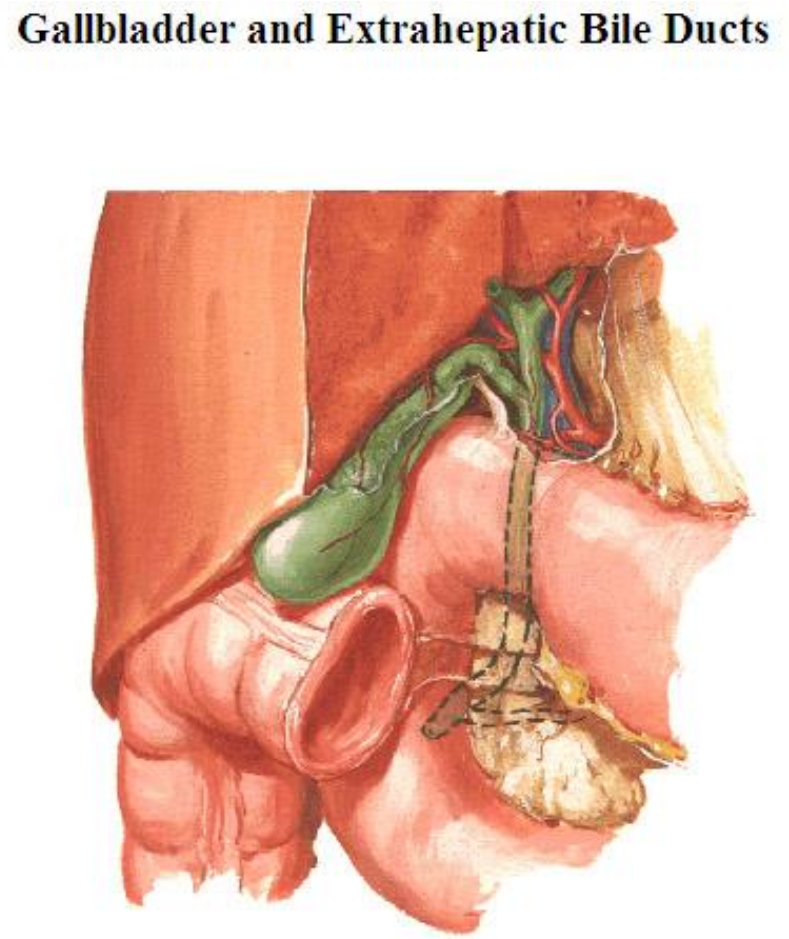
Abdominal Wall and Viscera

Schematic Cross Section Between L2 and L3



Accessory Organs

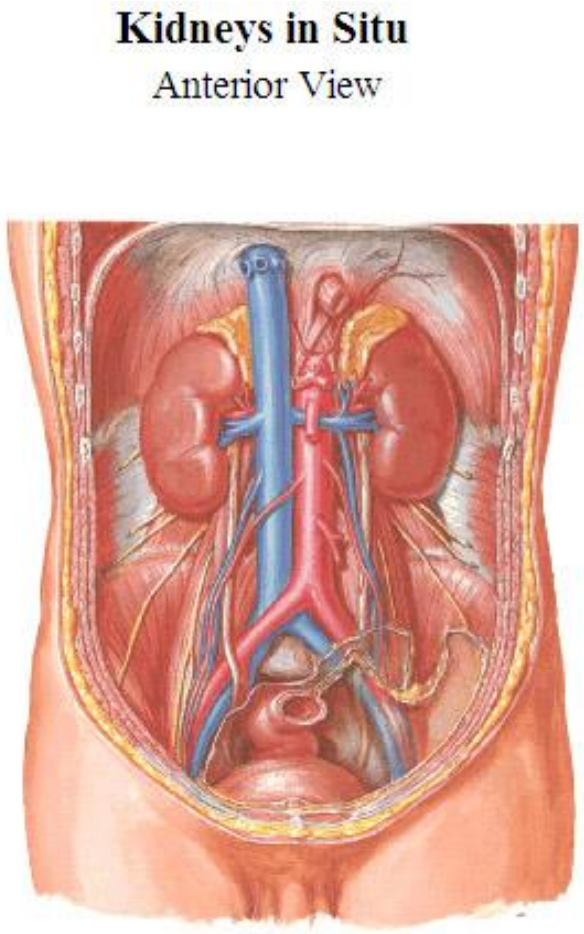
Accessory Organs



- The Liver, Gallbladder, and pancreas are all accessory organs of the digestive system
- The liver manufactures bile, secretes it into the gallbladder, and the gallbladder stores and secretes through the bile duct (joining with the common bile duct) into the duodenum
- Pancreatic digestive enzymes are secreted into the duodenum

Urinary System

Urinary System

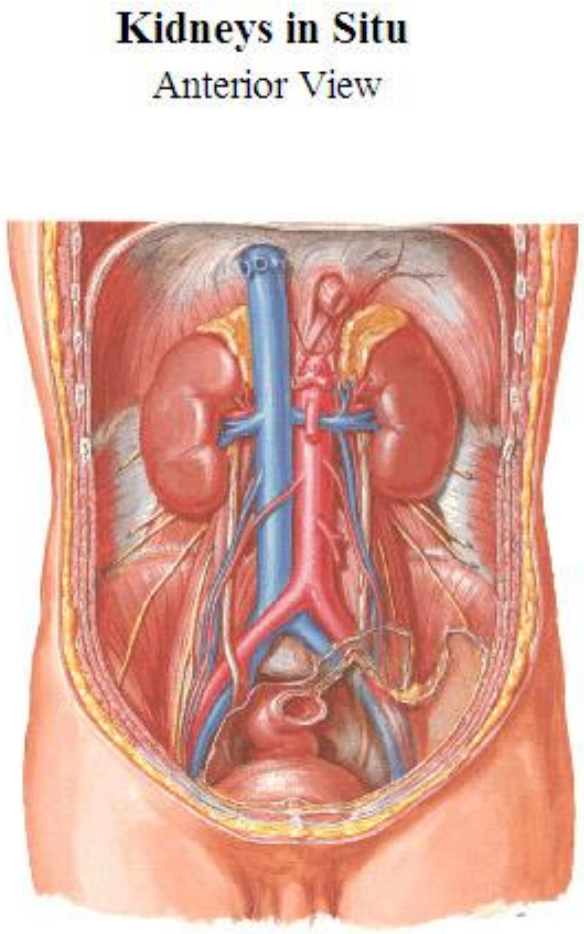


The urinary system removes waste from the blood, regulates fluid volume, and maintains electrolyte concentration in the fluids of the body

Major structures include

- Kidneys
- Ureters
- Urinary bladder
- Urethra

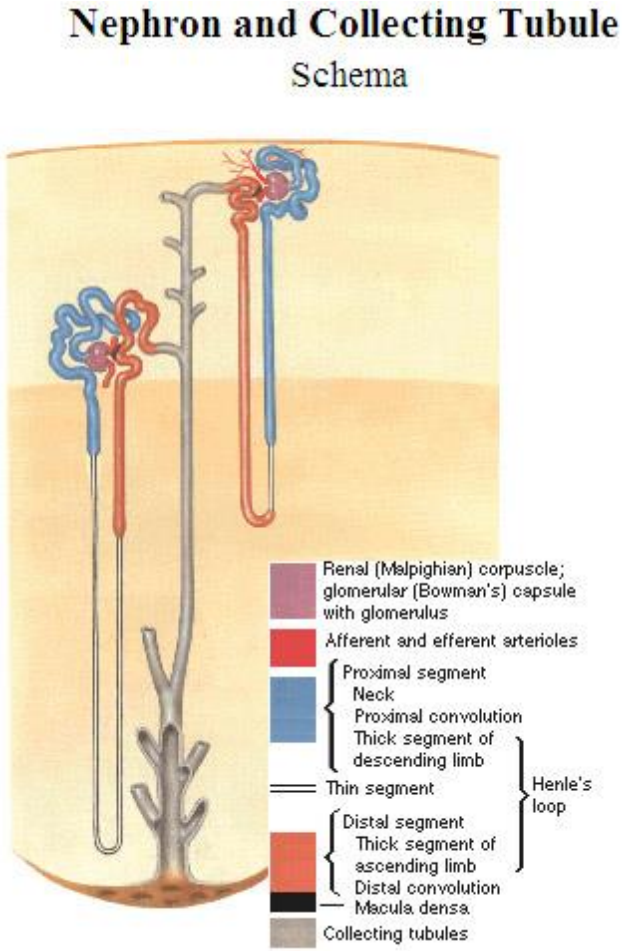
Kidneys



Two organs on either side of the vertebral column. Their function is to remove waste from the blood, and to regulate water and electrolyte balance

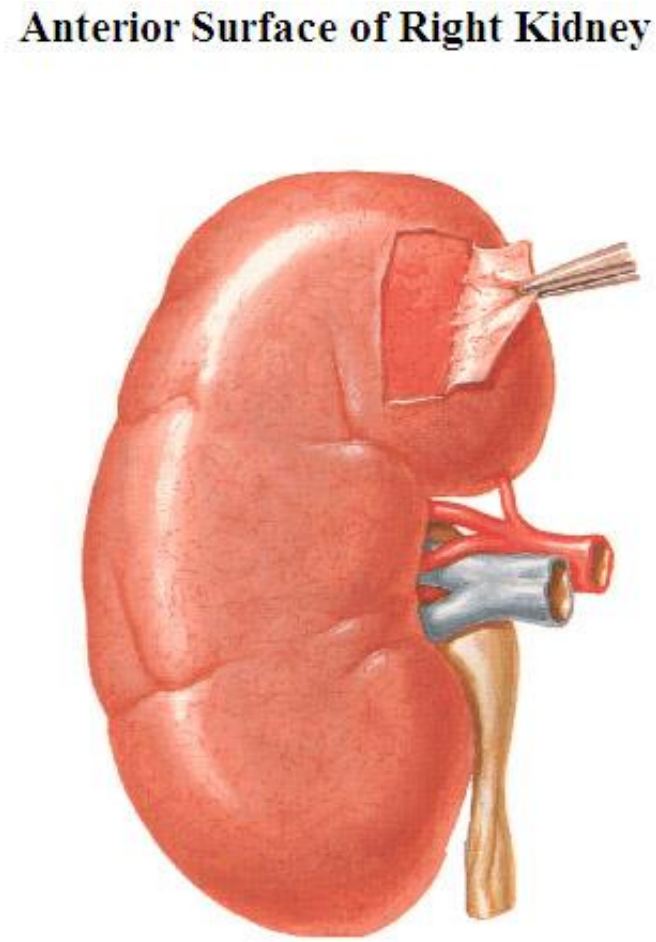
The adrenal gland sits on top of the kidneys

Histology of the Kidneys



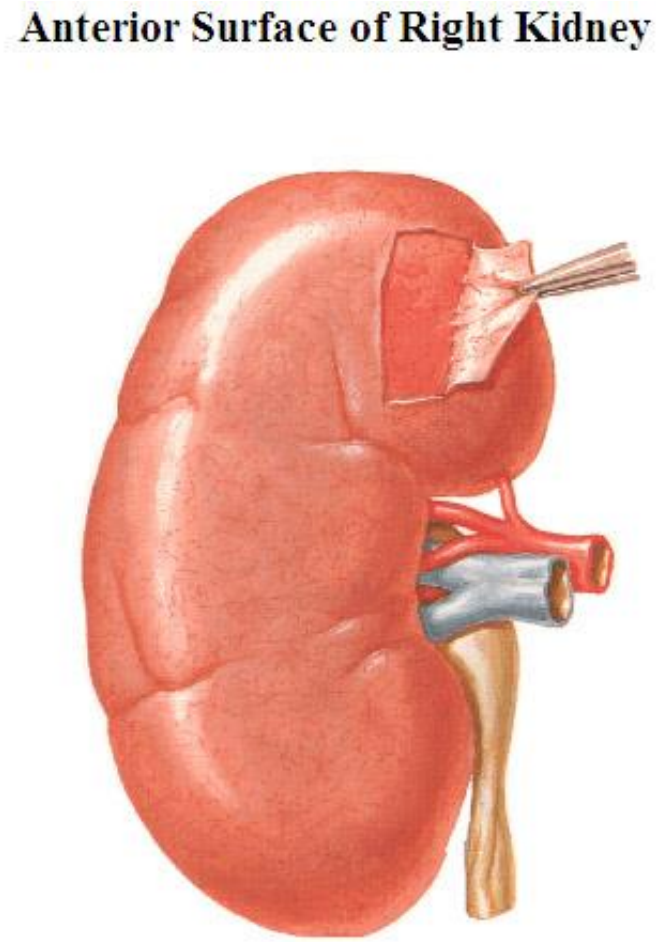
- Nephron
  - The microscopic functional unit of the kidneys which filter wastes and produce urine
- Glomerulus
  - Cluster of arterioles at the entrance of the nephron
  - Contains afferent blood arterioles and efferent arterioles

Fluid Balance



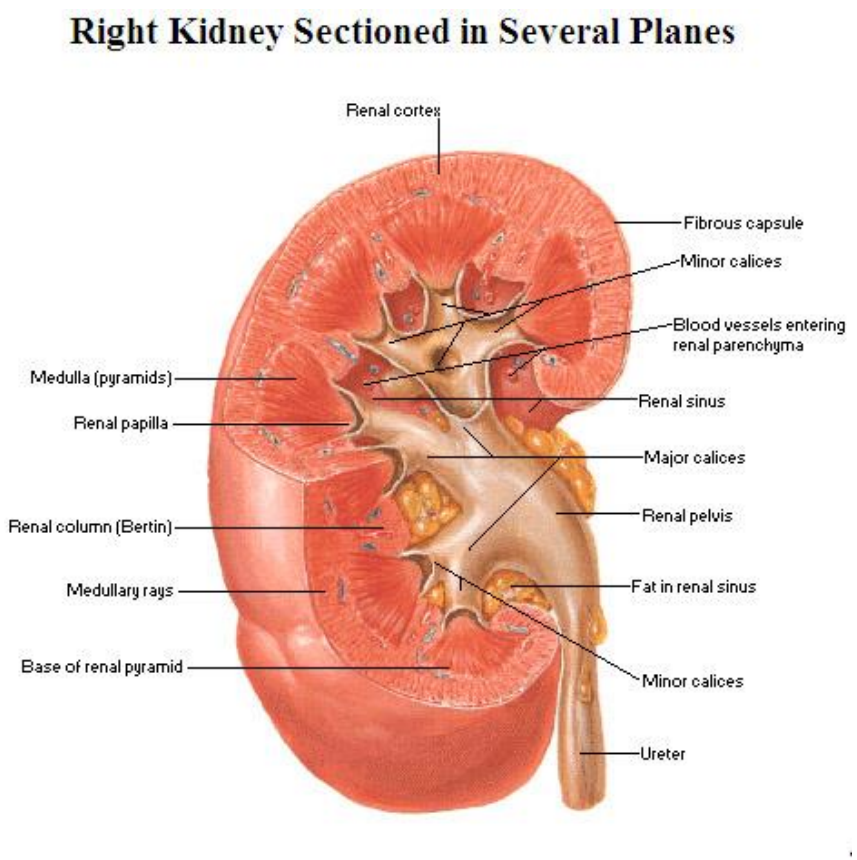
- Vascular supply
  - The kidney is supplied with blood by the renal artery
  - This is a direct branch from the abdominal aorta
  - If someone is volume depleted, the kidneys can initiate the renin-angiotensin mechanism

Fluid Balance



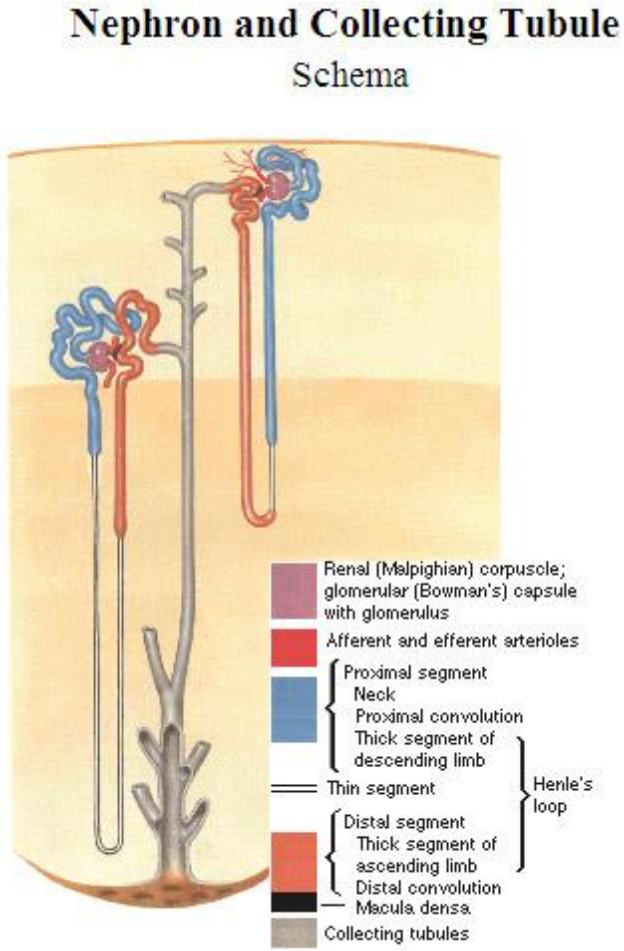
- The renin-angiotensin mechanism regulates blood volume and blood pressure
  - It causes
    - Thirst,
    - Vasoconstriction,
    - Causes adrenal glands to release aldosterone
      - Aldosterone causes more Na (and Water) to be absorbed from the kidneys

Renal Pelvis

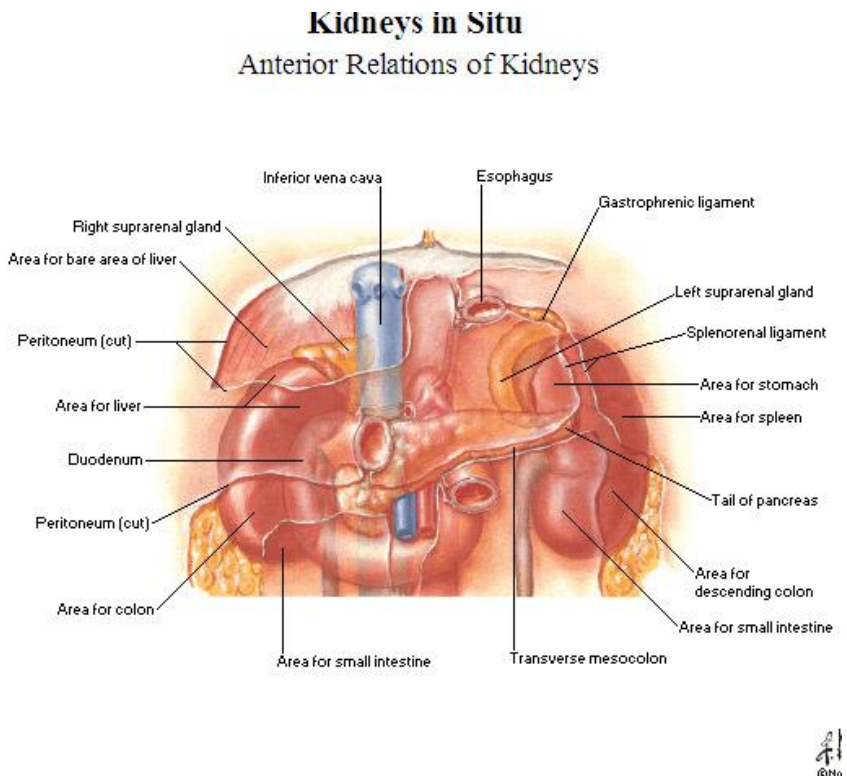


- Renal Pelvis Funnel shaped reservoir that collects the urine from the calices (which are connected to the collecting ducts) and passes it to the ureters
  - Hilum
    - Indentation on the medial side of the kidney where the ureters leave and blood vessels enter and exit the kidneys

Fluid Balance



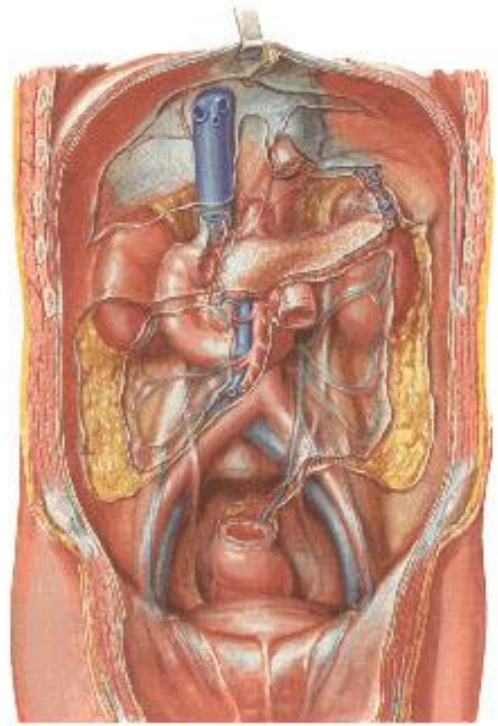
Relation of Kidneys to Peritoneum



- The kidneys are retroperitoneal (behind the peritoneum)
- The right kidney is usually lower than the left due to the size of the liver

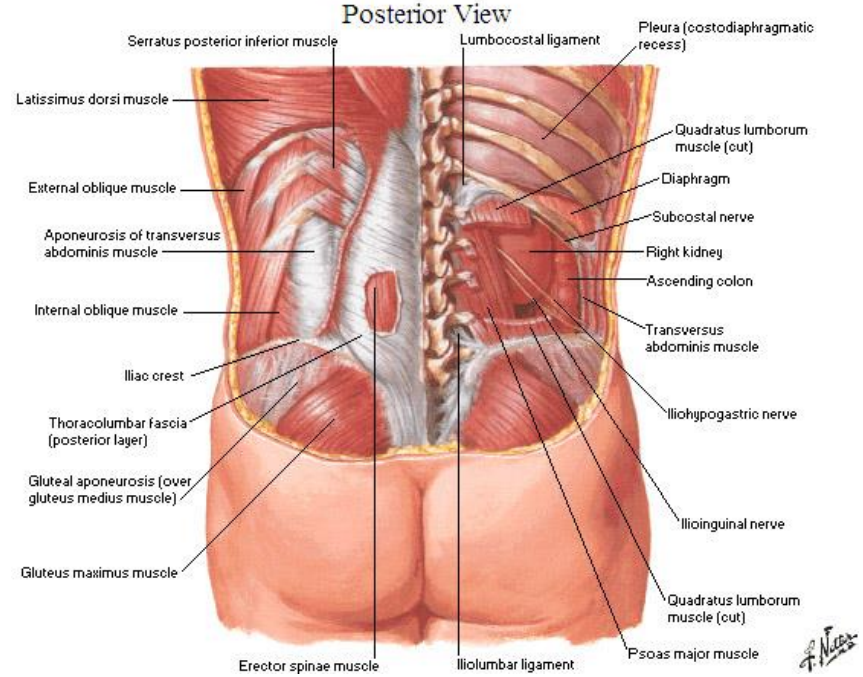
Relation of Kidneys to Peritoneum

Peritoneum of Posterior Abdominal Wall



Kidneys in Situ

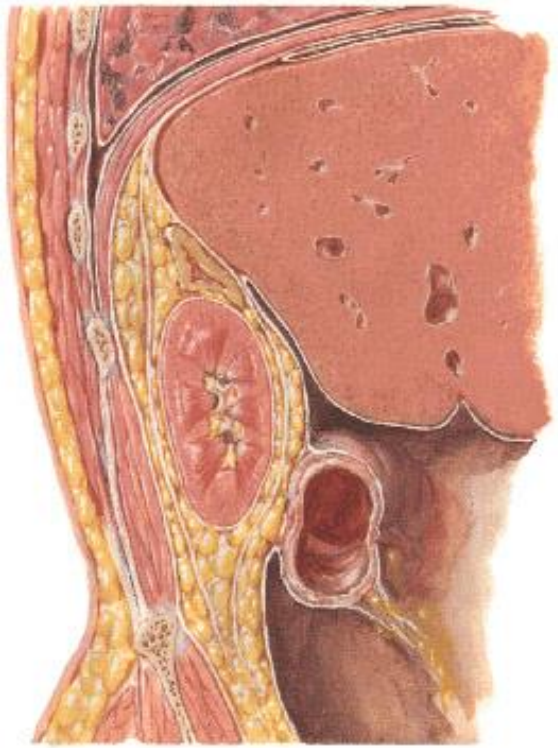
Posterior View



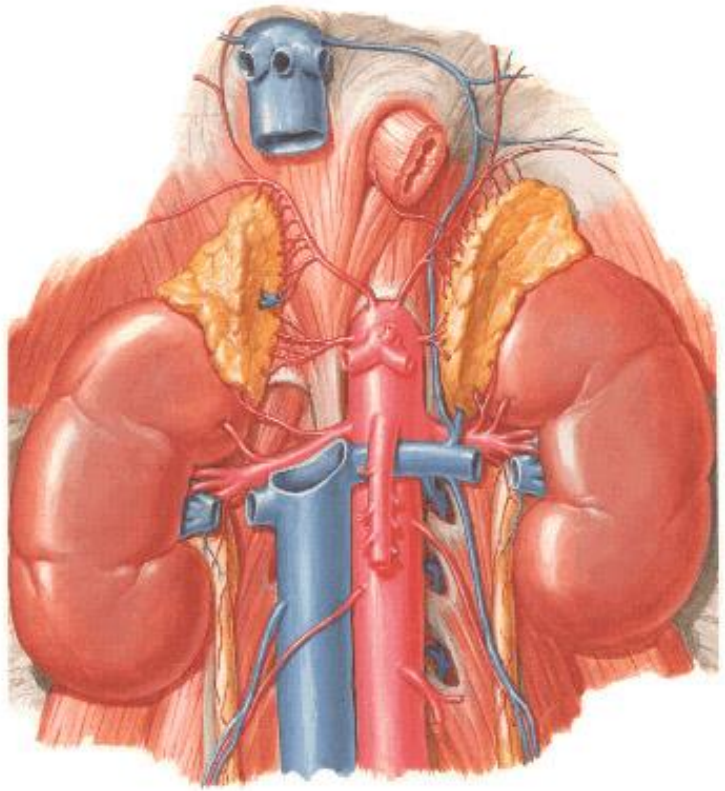
Kidneys

Renal Fascia

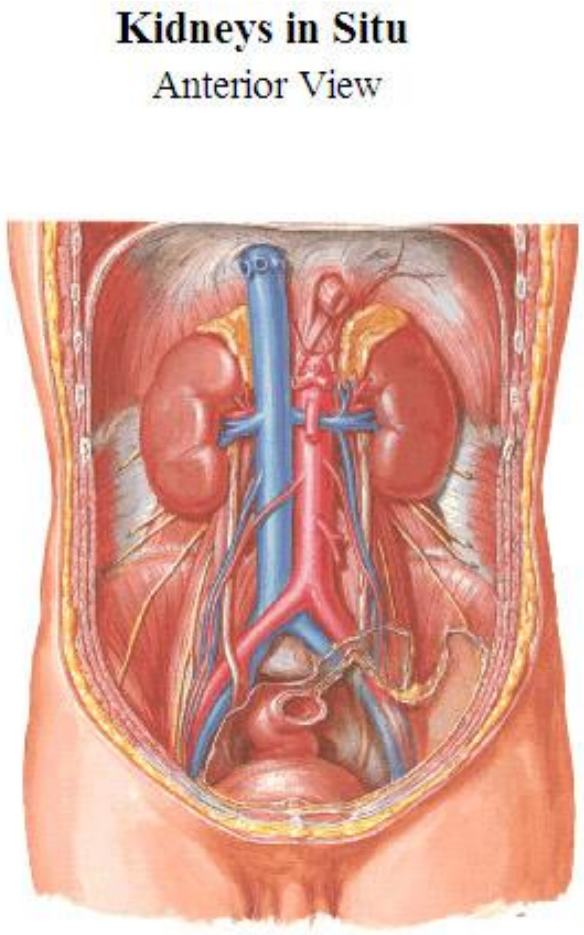
Sagittal Section through Right Kidney



Renal Artery and Vein in Situ



Ureters, Urinary Bladder, Urethra



Ureters

- Slender tubes which receive urine from the kidneys and transport it to the urinary bladder

Urinary bladder

- Muscular, hallow organ that temporarily holds the urine

Urethra

- Transports urine from the bladder to the outside