I. There are three components to the cardiovascular system
   a) Blood, Heart, Vessels

II. Blood (Chapter 18)
   a) Blood is a fluid connective tissue that consists of a fluid portion, plasma, and a cellular portion consisting of red blood cells, white blood cells, and platelets.
   b) Interstitial Fluid: the fluid outside the cardiovascular system that bathes the body’s cells.
   c) 3 Functions of Blood
      i) Transportation: Carries oxygen from the lungs to the cells and carbon dioxide from the cells to the lungs. Carries nutrients from the GI Tract to the cells and heat and waste products away from the cells. Also carries hormones from glands to their target cells.
      ii) Regulation: Helps regulate pH to avoid acidosis and/or alkalosis. Helps regulate temperature with the coolant properties of the water component of blood plasma. Blood osmotic pressure helps control the water content of cells.
      iii) Protection: Clotting protects against excessive loss of blood, white blood cells protect against disease.
   d) Blood Plasma: 91.5% Water and 8.5% solutes, mostly known as plasma proteins.
      i) Plasma proteins, mostly synthesized by the liver, play an important role in blood osmotic pressure (responsible for the gradient that allows the exchange of fluids through the capillary walls).
         (1) Albumin is the most significant
      ii) Electrolytes: non-proteins found in the blood plasma that include salts, ions (Na, K, Cl, Mg, etc) help maintain the osmotic pressure and are essential in the functions of cells.
      iii) Hematocrit: the percentage of blood that is made up of formed elements (mostly RBCs).
         (1) Formed Elements: red blood cells (erythrocytes), white blood cells (leukocytes), platelets.
            (a) Erythropoiesis: red blood cell production, takes place in the red bone marrow of long bones.

III. Formed Elements
   a) Red Blood Cells (erythrocytes)
      i) The most abundant of the formed elements (4.5 to 5.0 million cells per cubic ml of blood)
      ii) Have a biconcave-disk shape them
      iii) No nucleus, therefore unable to reproduce or repair damage
      iv) 100-120 day lifespan
      v) Are sacs of hemoglobin molecules, which are responsible for oxygen transport in the bloodstream.
         (1) Hemoglobin: a molecule of iron and protein that can bind and release oxygen.
            (a) Normal: 12-18g Hemoglobin per 100ml of blood.
      vi) RBCs function to carry oxygen from the lungs to the tissues of the body.
         (1) They also carry some of the carbon dioxide waste from the tissues back to the lungs to exhale out.
         (2) Most is dissolved in the blood plasma
   b) White blood cells (leukocytes)
      i) Less numerous (4000 – 11000 per cubic ml of blood) and nucleated
      ii) Protective, pathogen-destroying cells that are transported in blood or lymph to everywhere in the body.
      iii) Can travel through the bloodstream or out of the bloodstream in interstitial fluid
      iv) Two Main classes of WBC:
         v) Granulocytes (presence of conspicuous granules in the cytoplasm)
            (1) Neutrophils: the most abundant WBC (40-70% of WBCs)
            (2) Functions as an active phagocyte (destroys foreign particles)
            (3) Increases concentration at sites of inflammation or infection
            (4) Eosinophils: (1-4% of WBCs)
               (5) play a role in counteracting parasitic worms and lessening allergic reactions by phagocytizing antigen-antibody complexes and inactivating some inflammatory chemicals.
               (6) Basophils: (<1% WBCs)
                  (7) Contain histamine, a vasodilator, released in response to antigens, creating an inflammatory response (allergic reaction)
         vi) Agranulocytes: no granules in the cytoplasm
            (1) Lymphocytes: smallest WBC, 20-45% of WBCs
(a) Function in immunologic responses
(b) B-lymphocytes oversee production of antibodies released in the blood
(c) T-lymphocytes help destroy tumors and virus-infected cells.

(2) **Monocytes**: largest WBC (4-8% of WBCs)
(a) Convert to “macrophages” for long-term phagocytosis
(b) Associate with the “clean-up” of chronic infections, such as tuberculosis.

c) **Platelets**
i) Cell fragments formed in the bone marrow
ii) 250K to 500K platelets per cubic ml of blood
iii) responsible for the clotting aspect of blood when blood vessels rupture.

IV. **Blood type**
a) A way to classify blood based on the presence of certain antigens.
b) These antigens (determined genetically) are often accompanied by antibodies that react with RBC’s bearing different antigens and causing them to **agglutinate and hemolyze** (clump up and disintegrate).
c) Blood types:
   i) Type A blood has A-antigens and Anti-B antibodies
      (1) 40% of white pop., 27% of black pop., 28% Asian pop.
   ii) Type B blood has B-antigens and Anti-A antibodies
      (1) 11% white, 20% black, 26% Asian
   iii) Type AB blood has A- & B-antigens and no antibodies
      (1) 4% white, 4% black, 5% Asian
   iv) Type O blood has no antigens and Anti-A & Anti-B antibodies
      (1) 45% white, 49% black, 40% Asian
d) The antibodies (i.e. anti-A) present in certain types of blood will attack and reject the specific antigens (i.e. A) of blood received.
   i) This will cause the blood to agglutinate, or clump up and clog up the circulatory system possibly causing blockages and sludge in the blood vessels.
   ii) It’s ok to receive blood in a transfusion that has antibodies against your own blood because the antibodies of the donor’s blood become diluted in the plasma and it’s not enough to attack all of your blood and make a big difference.
e) **Compatibility:**
   i) Type A blood patient can receive type A blood and Type O blood
   ii) Type B blood patient can receive Type B and type O blood
   iii) Type AB blood has no antibodies so can receive all blood types
   iv) Type O blood has both A & B antibodies, so can receive only type O
f) **Rh Type**
   i) People who have Rh antigens in their blood are considered Rh+
   ii) People who do not are considered Rh-
   iii) People who do not have Rh antigens, but are then exposed to Rh+ blood will develop anti-Rh antibodies to the antigen that remain in the blood
   iv) A second exposure to Rh+ blood will cause the anti-Rh antibodies to attack and agglutinate the donor blood.

V. **The Heart (all of Chapter 19)**
a) The heart lies on top of the diaphragm, near the midline of the thoracic cavity in a space known as the **mediastinum**.
   i) 2/3 of the heart lies left of the midline.
   ii) The pointed, inferior end of the heart is known as the **Apex**.
   iii) The flat, superior surface is known as the **Base**.
b) **Pericardium**: The membrane that surrounds and protects the heart
   i) Keeps the heart in position, but allows movement for vigorous and rapid contraction
   ii) The pericardium is has many layers. The layer closest to the heart is called the **epicardium**.
   iii) The layers are separated by a fluid known as **pericardial fluid**, which reduces friction between the membranes.
   iv) **Cardiac Tamponade**: A buildup of pericardial fluid compressing the heart.
c) **Chambers of the Heart**
i) The heart is a strong organ made of cardiac muscle tissue that is responsible for pumping blood throughout the body so it can be used by all the tissues for gas and nutrient exchange.

ii) The human heart consists of four chambers (or muscular cavities that hold blood) and four valves that make sure the blood is being pumped in the proper direction.

iii) **Atria:** two upper chambers

iv) **Ventricles:** two lower chambers

v) **Right Atrium:** Receives blood from the body via the superior and inferior vena cava and pumps it through the tricuspid valve to the right ventricle

vi) **Right Ventricle:** Receives blood from the right atrium and pumps blood through the pulmonary valve to the lungs via the pulmonary trunk.

vii) **Left Atrium:** Receives blood from the lungs via the pulmonary veins and pumps blood through the mitral valve to the left ventricle.

viii) **Left Ventricle:** Receives blood from the left atrium and pumps blood through the aortic valve to the body via the ascending aorta.

d) **Circulation:**

i) Blood starts, fully oxygenated (ready to deliver oxygen to the body’s cells) in the Left Atrium.

ii) The left atrium contracts and pumps blood through the mitral valve into the left ventricle.

iii) When the left ventricle is full, it contracts, pumping blood through the aortic valve, into the ascending aorta, which branches out, allowing blood to travel to all the arteries of the body.

iv) Blood travels to the tissues that need nutrients and gas exchange (oxygen for carbon dioxide). Arteries branch out in to arterioles, which branch out into capillaries (very small, permeable vessels).

v) Oxygen and nutrients leave the blood and carbon dioxide and waste products enter the blood (blood is now deoxygenated).

vi) Capillaries converge to form venules, which converge to form veins, which carry deoxygenated blood back to the heart.

vii) The veins converge to become the superior and inferior vena cava and carry blood into the right atrium.

viii) The right atrium fills up and contracts, pumping blood through the tricuspid valve into the right ventricle.

ix) The right ventricle fills up and pumps blood through the pulmonary valve into the pulmonary trunk.

x) The pulmonary trunk branches out into right and left pulmonary arteries, which carry deoxygenated blood to the bilateral lungs, respectively.

xi) The pulmonary arteries branch out into pulmonary arterioles, which branch out into pulmonary capillaries, where carbon dioxide leaves the blood into the lungs and oxygen leaves the lungs and enters the blood (blood is now oxygenated).

xii) The pulmonary capillaries converge and become pulmonary venules, which converge and become pulmonary veins, eventually the superior and inferior left and right pulmonary veins, which eventually will carry oxygenated blood from both lungs into the left atrium, to start all over again.

e) **Contraction of the heart**

i) The heart contains its own electrical system without the use of nerves.

ii) This is because of specific cardiac muscle fibers called autorhythmic cells.

iii) These cells repeatedly generate spontaneous action potentials that trigger heart contractions.

iv) They act as both, a pacemaker of the heart (sets the heart’s rhythm) and a conduction system making sure the action potentials are propagated throughout the heart muscle.

v) Both of these things make sure the chambers of the heart contract in an orderly manner, making the heart an efficient pump.

vi) Cardiac excitation of the normal heart:

1) It all begins in the Sinoatrial Node (aka SA Node). The SA Node is located on the outer wall of the right atrium, just inferior to the opening of the superior vena cava. It sets off an action potential that travels throughout the right atrium and to the left atrium via gap junctions.

2) **Gap junctions:** connections in muscle tissues that allows action potentials to travel from one muscle fiber to another.

vii) In response to the action potential, the atria contract, forcing blood to push open the respective valves and rush into the respective ventricles.

viii) The action potential propagates through the atria and reach the atrioventricular (AV) node and then to the AV Bundle (aka Bundle of His).
This is the only electrical connection between the atria and ventricles. Elsewhere, the ventricles are insulated by a structure known as the fibrous skeleton of the heart.

From the AV Bundle, the action potential enters the right and left bundle branches that travel through the interventricular septum toward the apex of the heart.

Finally, the large-diameter conduction myofibers (aka Purkinje Fibers), rapidly conduct the action potential from the apex and then upward to the remainder of the ventricular heart muscle (or myocardium).

If a site other than the SA Node initiates cardiac contraction, it is known as an ectopic pacemaker or ectopic foci.

This may be serious or not serious, depending on how often it happens.

Causes the blood to not be pumped in an organized, efficient manner.

If it keeps up, an artificial pacemaker may be necessary to regulate the heart’s contraction.

Systole: the phase of the heart during contraction

Diastole: the phase of the heart during relaxation.

Heart Sounds

Ausculation: the act of listening to the sounds of the heart

Four different heart sounds occur in the normal cardiac cycle.

Only 2 (S1 & S2) can be heard with stethoscope

S1 is known as the lub: generated by the blood turbulence caused by the closure of the tricuspid and mitral valves

S2 is known as the dupp: generated by the blood turbulence caused by the closure of the aortic and pulmonary valves.

Heart Murmur: an abnormal sound consisting of a “gurgling” or “rushing” noise before, in between, or after the normal heart sounds.

Not always associated with a heart problem, but often indicates a valve disorder.

Causes of murmurs:

Mitral Valve Stenosis: narrowing of the mitral valve by scar tissue or congenital defect

Mitral Valve Insufficiency: backflow (regurgitation) of blood from the left ventricle into the left atrium due to damage mitral valve

Aortic Stenosis: narrowing of the aortic valve

Aortic Insufficiency: backflow (regurgitation) of blood from the aorta into the left ventricle due to damage aortic valve

Mitril Valve Prolapse (MVP): one or both of the cusps protrude into the left atrium and allow some backflow of blood. Not always a serious threat. Hereditary. 10-15% of the population.

Cardiac Output (CO): volume of blood ejected from one of the ventricles each minute

Stroke Volume (SV): volume of blood ejected from the ventricle in one contraction.

Heart Rate (HR): the number of heartbeats per minute (aka pulse, normal pulse is approx. 70-80 bpm).

CO = SV x HR

Frank-Starling Law of the Heart: The higher the volume of blood entering the ventricle, the stronger the contraction.

During exercise, stroke volume increases as well as heart rate. This increases the cardiac output.

Heart rate is regulated by the Autonomic nervous system and hormones from the adrenal medulla (norepinephrine and epinephrine).

Coronary Arteries: the arteries that are responsible to carrying blood to the heart muscle itself.

Common Heart Conditions:

Coronary Artery Disease (CAD): #1 cause of death in US.

Atherosclerosis: hardening and narrowing of the arteries by plaque formation in the walls of large and medium-sized arteries.

The endothelial lining of the inside of the arterial wall is damaged and a plaque formation begins as a result of cholesterol, lipid, platelet, and WBC build-up.

The plaque formation narrows the lumen and decreases blood flow within the artery, resulting in insufficient blood flow to the target cells and increasing the risk that a small blood clot could block the whole artery.

Modifiable risk factors include: high blood cholesterol, high blood pressure, cigarette smoking, obesity, diabetes (type II), sedentary lifestyle, and “type A” personality.
(5) Unmodifiable risk factors: family history, age, gender (CAD kills males earlier than females, but it is the #1 cause of death in both).

ii) **Myocardial Infarction** (aka heart attack): by definition means “death of heart muscle tissue”.
   1. Occurs when a coronary artery is obstructed and cannot bring sufficient blood to a section of the heart. This results in myocardial ischemia (decreased blood flow) and eventually hypoxia (reduced oxygen supply). As a result, that particular section of myocardial tissue cannot survive, which can throw off the electrical activity of the heart and/or the blood pumping capability of the ventricle. May or may not result in death.

iii) **Arrythmia**: an irregularity in the heart rhythm
   1. Tachycardia: the heart is beating more than 100x/minute.
   2. Bradycardia: the heart is beating less than 60x/minute.
   3. **AV Heart Block**: The action potential does not travel from the atria to the ventricles and the ventricles do not contract properly or at all.
   4. **Atrial Flutter**: the atria contract at an abnormally rapid rate (usually about 300x/minute)
   5. **Fibrillation**: There is complete asynchronous contraction of muscle fibers and can be as high as 400-600x/minute. Blood cannot be pumped because some fibers are contracting while others are relaxing.
      a) Fibrillation can happen in the atria or ventricles.
      b) A strong heart with atrial fibrillation may only result in a decrease in pumping effectiveness of about 20-30%, which is enough to sustain life.
      c) **Ventricular Fibrillation** must be corrected immediately with electrical shock paddles (defibrillator) or the person will die from a complete lack of blood ejection from the ventricles.

VIII. **Blood Vessels (Chapter 20)**
   a) Blood vessels all work together to deliver blood to all the tissues of the body. From the left ventricle, blood vessels start as the aorta (carrying oxygenated blood), which branches in many arteries, branching out further into many arterioles, and then branching microscopically into many, many permeable capillaries, which allow for gas and nutrient exchange (aka capillary exchange).
   b) After gas and nutrient exchange, capillaries converge into many small venules (carrying deoxygenated blood back to the right atrium), which converge into many veins, which eventually lead to the superior or inferior vena cava and bring blood into the right atrium.
   c) **Lumen**: the hollow center of the vessel.
   d) **Arteries**: carry blood from the heart to the body
      i) Contain three layers:
         1. **Tunica Interna**: the innermost layer consisting of a lining of epithelium, a layer of connective tissue, and a layer of elastic tissue giving it flexibility.
         2. **Tunica Media**: the middle, thickest layer consists of elastic fibers and a layer of smooth muscle that contracts to constrict the artery (decreasing the lumen’s diameter) and relaxes to dilate the artery (increasing the lumen’s diameter).
         3. **Tunica Externa**: the outer layer that consists of elastic and collagen fibers (connective tissue).
         4. The more muscular arteries have an extra layer elastic tissue between the media and the externa.
      ii) **Arterioles**: arteries branch out into smaller vessels called arterioles.
   e) **Veins**: carry blood from the body back to the heart.
      i) Contain Three Layers
         1. Three layers are named as in arteries and are similar to arteries but without the elastic tissue and a much thinner layer of smooth muscle.
         2. The epithelium on the inside of the vein is arranged into valves that prevent blood from flowing in the wrong direction.
      iii) **Venules**: as blood leaves the tissues to head back to the heart, they first enter a multitude of small venules before converging into individual veins.
   f) **Capillaries**: many, many microscopic vessels between arterioles and venules.
      i) Only wide enough for one red blood cell to fit through at a time
      ii) Walls are permeable to fluids, electrolytes, molecules, etc.
      iii) This is where the exchange of oxygen and nutrients for waste products and carbon dioxide takes place.
      iv) Frequently arranged in beds of mesh-like vessels in the tissue.
      v) Layers: simply a layer of epithelium and its basement membrane of connective tissue.
g) **Blood Pressure:** 1) necessary to make sure blood gets to everywhere in the body it needs to be despite gravity and 2) to facilitate capillary exchange.
   i) **Blood Hydrostatic Pressure (BHP):** pressure of blood generated by volume and the force of the pumping action of the heart (higher BHP pushes fluid away from itself).
   ii) **Blood Colloid Osmotic Pressure (BCOP):** a force produced by the presence of large plasma proteins (higher BCOP draws fluid toward itself)
   iii) **Interstitial Fluid (ISF) Pressures:**
       1) **Interstitial Fluid Hydrostatic Pressure:** the pressure created by the presence of the interstitial fluid (opposes BHP by pushing fluid out of the ISF)
       2) **Interstitial Fluid Osmotic Pressure:** the pressure created by presence of proteins in the interstitial fluid (opposes BCOP by drawing fluid toward the ISF)
   (a) very low and almost insignificant
   iv) Blood pressure is regulated by the endocrine system (norepinephrine, epinephrine, and ADH), the nervous system (medulla oblongata is the cardiovascular center of the brainstem), and locally by the capillaries to meet their demand for nutrients.
   1) Blood pressure is measured using a sphygmomanometer and a stethoscope to determine the pressure during systole and the pressure during the diastole
   2) Normal = 100-140 systole and 70-89 diastole.
   3) Termed as systole over diastole.

h) The mission of the cardiovascular system is to keep blood flowing through the capillaries so that the movement of substances in and out of the capillaries can occur.
   i) There are three methods in which substances move in and out of capillaries.
   1) **Diffusion:** simple diffusion states that substances flow down their concentration gradient.
      (a) i.e.: O₂ will flow from high concentration of O₂ to low concentration O₂, as will CO₂, steroid hormones, and other lipid-soluble substances flow down the gradient of their own concentrations.
      (b) Water soluble substances can flow through cellular spaces in the capillaries called fenestrations or intercellular clefts.
   2) **Transcytosis:** substances are enclosed inside vesicles and enter the outer capillary wall and are exocytosed from the inner capillary wall into the vessel.
      (a) Insulin uses this mode
   3) **Bulk Flow:** large numbers of molecules, ions, and particles suspended in fluid move together in the same direction from an area of higher pressure to an area of lower pressure.
      (a) **Filtration:** Pressure-driven movement of fluids out of the capillaries and into the interstitial fluid.
      (b) **Reabsorption:** Pressure-driven movement of fluids into the capillaries from the interstitial fluid.
   (c) **Net Filtration Pressure (NFP):**
      (i) If BHP + IFOP > BCOP + IFHP, the result is a positive NFP resulting in Filtration
      (ii) If BCOP + IFHP > BHP + IFOP, the result is a negative NFP resulting in Reabsorption
      (iii) In a normal system, the arteriole end of the capillary has a positive NFP (so nutrients and oxygen can leave the capillary and enter the ISF) and at the venule end of the capillary, there is a negative NFP (so waste products and CO₂ can leave the ISF and enter the capillary to return to the heart).
   (iv) **Capillary Filtration and Absorption summary:**
      1. Hydrostatic pressure is the pressure exerted by fluid inside a vessel. i.e. water in a hose exerts pressure on the inside walls on the hose. If the water pressure inside the hose is greater than the pressure outside the hose and there were small holes in the hose, water would flow out of the holes (high pressure to low pressure). If you submerge that same hose in water so that the pressure outside is greater than the pressure inside, than water would flow into the hose through the holes.
      2. Osmotic pressure is the pressure at which water moves to balance out the concentration of a solution. i.e. if the concentration of solutes in the blood's plasma is higher than the concentration of solute in the interstitial fluid of the tissues, than water will flow from the tissues into the blood's plasma in an attempt to equalize that concentration, and vice versa. That is osmotic pressure.
3. Filtration and absorption is a result of the NET PRESSURE created in the capillary.
4. If the Hydrostatic Pressure inside the capillary (forcing water out) plus the Osmotic Pressure of the interstitial tissues (pulling water out of the capillary) is GREATER than the Hydrostatic pressure of the interstitial tissues (pushing water into the capillary) plus the Blood colloid Osmotic Pressure (pulling water into the capillary) than the net movement of water is OUT of the capillary (aka filtration).
5. If the Hydrostatic Pressure inside the capillary (forcing water out) plus the Osmotic Pressure of the interstitial tissues (pulling water out of the capillary) is LESS than the Hydrostatic pressure of the interstitial tissues (pushing water into the capillary) plus the Blood colloid Osmotic Pressure (pulling water into the capillary) than the net movement of water is INTO of the capillary (aka absorption).

i) **Venous Return**: how blood is forced through the veins back to the heart
   i) Besides the pumping action of the heart, there are two other methods of venous return
   ii) **The Skeletal Muscle Pump**: contraction of skeletal muscles compresses the vein, forcing blood through a proximal venous valve toward the heart (aka milking).
   iii) Immobilized people do not contract their skeletal muscles enough to force venous return and therefore blood can pool in a certain area.
   iv) **The Respiratory Pump**: during inhalation, the diaphragm contracts and flattens, causing increased pressure in the abdominal cavity and compressing the veins. The result is similar to milking.

IX. **Major Arteries**: All arteries are branches of the aorta in some way (except pulmonary arteries)
   i) **Pulmonary Trunk**: emerges from the right ventricle and carries blood to the lungs
      (1) Pulmonary arteries: split into left and right to bring blood to the lungs.
   ii) **Aorta**: *Ascending* from heart, *arch, descending (thoracic)* until diaphragm, *abdominal inferior to diaphragm*.
   iii) Major arteries and the region of the body they supply blood to:
   iv) **From Ascending Aorta**
      (1) **Coronary Arteries**: branches off of the ascending aorta that are responsible for carrying blood to the heart muscle itself.
      (2) **Left coronary artery**: inferior to the left atrium and branches in the anterior interventricular and circumflex branches
         a) **Anterior Interventricular branch**: between the left & right ventricle on the anterior
            i) aka left anterior descending (LAD) branch
         b) **Circumflex branch**: between the left atrium and left ventricle
      (3) **Right Coronary Artery**: comes off the aorta and passes between the right atrium and right ventricle
         a) gives small branches that immediately supply the right atrium.
         b) **Posterior interventricular branch**: between the ventricles on the posterior of the heart
         c) **Right marginal branch**: between the right atrium and right ventricle (inferiorly)
         d) The arteries continue to branch and then reconnect throughout the heart to supply all of the heart’s muscle with oxygenated blood.
            i) **anastomosis**: when two arteries converge to supply a common tissue.
   v) **From Arch of the Aorta**
      (1) **Brachiocephalic trunk, left common carotid artery, left subclavian artery**
      (2) From Brachiocephalic trunk
         a) **Right common carotid**: right side of head and neck
         b) **Right vertebral**: brain
         c) **Right subclavian**: right upper limb
            i) This is the continuation of the brachiocephalic trunk as it passes below the clavicle
      (3) **Left common carotid**: Left side of head and neck
      (4) **Left subclavian**: left upper limb
   vi) **From Thoracic Aorta**
      (1) **Pericardial arteries**: tiny arteries that supply the pericardium
      (2) **Bronchial arteries**: lungs
      (3) **Esophageal arteries**: four or five branches from the aorta that supply the esophagus
(4) Mediastinal: supply structures of the mediastinum
(5) Posterior intercostal arteries: 9 pairs of arteries bilaterally that travel between the ribs that supply multiple muscles of the thoracic region, the mammary glands, the vertebrae, the meninges (three-layered covering of the spinal cord) and the spinal cord.
(6) Subcostal arteries: similar to intercostals
(7) Superior Phrenic Arteries: superior to the diaphragm and supply the diaphragm

vii) From Abdominal Aorta
(1) Right & Left inferior phrenic arteries: supply the diaphragm from the inferior.
(2) Celiac Trunk: large anterior branch just inferior to the diaphragm.
(3) Superior Mesenteric: anterior branch of abdominal aorta inferior to the celiac trunk.
   (a) Travels inferiorly and branches into several arteries that anastomose with each other and supply the pancreas and portions of the small and large intestine.
(4) Right & Left suprarenal arteries: supply the adrenal glands
(5) Left & Right Renal arteries: kidneys & ureters
(6) Left & Right Gonadal arteries: supply the gonads in males & females as well as the uterine tubes and ureters in females.
(7) Inferior mesenteric: large anterior branch at about the 3rd lumbar vertebra. Travels leftward and branches into arteries that anastomose with each other and the branches of the superior mesenteric artery to supply portions of the large intestine.
(8) Right & Left Lumbars: posterior branches that supply the lumbar vertebrae.
(9) Right & Left Common Iliac arteries: the abdominal aorta terminates at about the L4 vertebral level and bifurcates into the common iliacs.
   (a) External iliac: lower limbs
   (b) Internal Iliac: uterus, prostate, urinary bladder, gluteal muscles

X. Major Veins: most arteries have an accompanying vein that returns the blood to the heart after it’s been used by the tissues.
   a) Coronary sinus: returns blood from the heart muscle to the right atrium
   b) Superior Vena Cava: all blood from superior to the heart returns to the heart via this vein
   c) Internal and external jugular veins: return blood from the brain via the lateral anterior neck bilaterally.
   d) Left & right subclavian veins return blood from the upper limbs (shoulder, arm, and forearm)
   e) Azygous and Accessory hemiazygous veins return blood from the thoracic cavity’s structures.
   f) Inferior Vena Cava: found lateral to the abdominal aorta. All blood from inferior to the heart returns to the heart via this vein
   g) Right & Left renal veins return blood from the kidneys.
   h) 3 Hepatic veins: from the liver
   i) Right & Left gonadals: from the gonads
   j) Hepatic Portal: a large vein that brings blood returning from the digestive system to the liver for detoxification and processing of nutrients, vitamins, minerals, and other molecules absorbed from digestion.
   k) Superior Mesenteric vein returns blood from the right side of the large intestine and all of small intestine to the hepatic portal.
   l) Inferior mesenteric vein: returns blood from the left side of the large intestine to the hepatic portal.
   m) Left & Right gastric vein: returns blood from the stomach to the hepatic portal
   n) Splenic vein: returns blood from the spleen to the hepatic portal
   o) Bilateral common iliac veins
   i) Bilateral internal iliac veins: returns blood from each pelvic region
   ii) Bilateral external iliac veins: return blood from each lower limb