Human Anatomy & Physiology

15

# Cardiovascular System

Unit Four

*Karen Webb Smith*

**Cardiovascular System URLs**

http://www.accessexcellence.org/AE/AEC/CC/heart_background.html

http://www.accessexcellence.org/AE/AEC/CC/heart_anatomy.html

http://www.tmc.edu/thi/anatomy1.html

http://www.intelihealth.com/IH/ihtIH/WSIHW000/8059/8049/152179.html?d=dmtContent

http://www.siumed.edu/peds/teaching/Cardiology/conduct.htm

## I. Introduction

A functional cardiovascular system is vital for supplying oxygen and nutrients to tissues and removing wastes from them.

*The heart is the strongest muscle in the body

*The heart must pump blood throughout the body day & night

*The heart is 2 pumps working side by side; on your right side is the heart that pumps blood to your lungs where it picks up O2; on your left side is the heart that pumps this O2-soaked blood out to your body; pumps 45 million gallons blood in a lifetime

*Both pumps are divided into 2 spaces called chambers so your heart is actually a 2-barreled, 4-chambered pumper

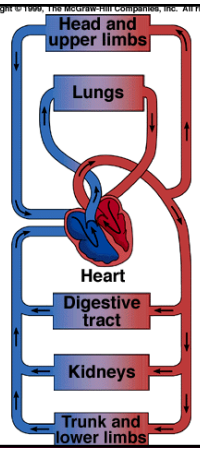
*The 2 sides do not work independently; they are precisely timed as a team to make the best use of their pumping power (quite efficient!)

*As the heart pumps it makes a variety of clicks and thumps; these are the sounds of the heart valves as they click open & shut; each sound has a special meaning (lubb-dupp); lubb is the sound of the tricuspid & mitral (bicuspid) heart valves (on the top chambers) shutting; dupp is the sound of the semilunar heart valves closing (these heart valves shut off the big vessels leaving the heart)

*The heart hangs in the center of the chest (mediastinum)

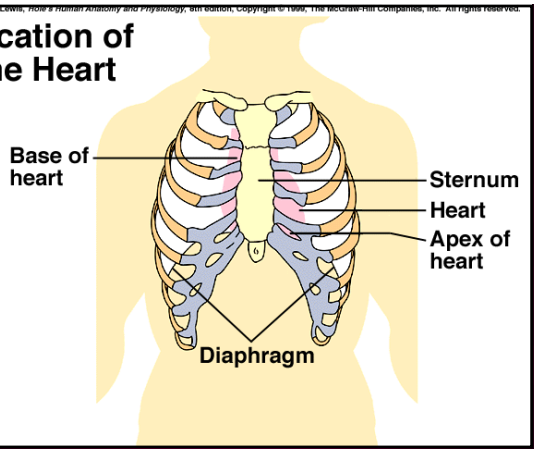


## Cardiovascular System Schematic






## Location of the Heart




## II. Structure of the Heart

A. The heart is a hollow, cone-shaped, muscular pump located within the mediastinum of the thorax & resting upon the diaphragm.

B. Size and Location of the Heart

*heart size varies with body size = 14cm long & 9cm wide

*bordered laterally by lungs, posteriorly by spinal cord, anteriorly by sternum; downward to the left as an apex

C. Coverings of the Heart

*pericardium – covers the heart; fibrous pericardium is the outer layer; visceral pericardium is a double layer that covers the heart – it turns back upon itself to form the parietal pericardium

*pericardium is tough, white fibrous connective tissue

*pericardial cavity (space) – between the parietal & visceral layers

*pericardial membranes secrete serous fluid that reduces friction between the pericardial membranes as the heart moves inside

D. Wall of the Heart

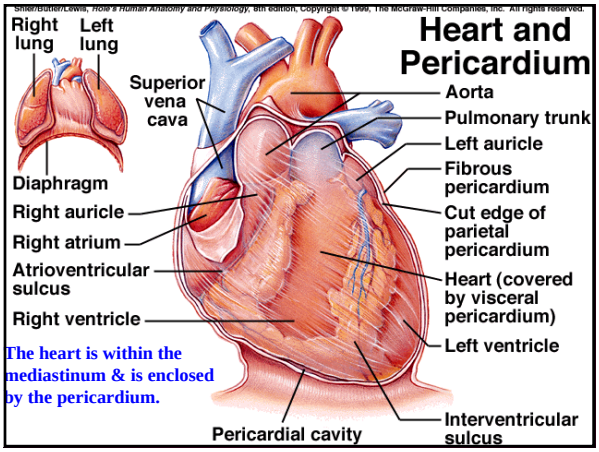
3 distinct layers:

*epicardium – outer covering (visceral pericardium); protective layer; consists of connective tissue covered by epithelium, blood & lymph capillaries, nerve fibers, some fat, & coronary arteries & veins which provide blood flow through the myocardium

*myocardium – middle layer; thick & consists of muscle tissue that pumps blood out of the heart chambers; pumps 70 ml blood with each contraction

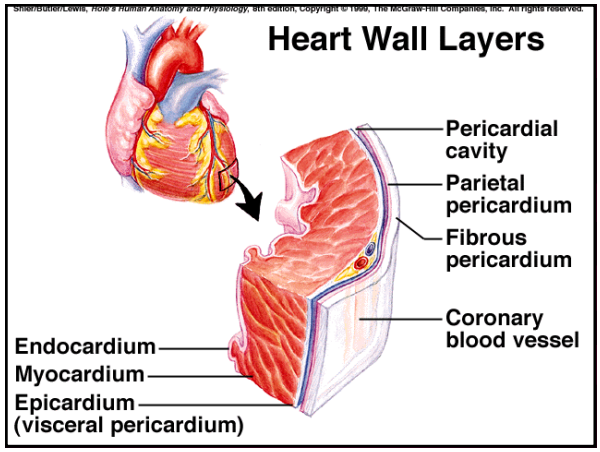
*endocardium – contains blood vessels & specialized cardiac muscle fibers called Purkinje fibers; forms a protective inner lining of chambers & valves; is also continuous with the inner lining of blood vessels attached to the heart






The heart is within the mediastinum & is enclosed by the pericardium.






Other pertinent cardiovascular facts:

*double circulation – 2 pathways that blood leaving the heart may go:
1) pulmonary circulation – leading to lungs
2) systemic circulation – leading to rest of body

*four chambered heart – is really 2 separate pumps; one side of heart circulates blood through the lungs where it takes up O2 and releases CO2 & is called pulmonary circulation; other side of heart circulates blood to the rest of the body & is called systemic circulation

*right atrium collects blood from the veins (superior & inferior vena cavae)& the right ventricle pumps it into the lungs (left pulmonary artery)

*left atrium fills with blood from the lungs & the left ventricle pumps this O2 rich blood into systemic circulation; this ensures:
1) all blood that returns to the heart is pumped through the heart
2) all O2 rich blood returning from the lungs is immediately pumped into systemic circulation

*atrium – chamber through which blood enters the heart

*ventricle chamber through which blood leaves the heart

*if a septum doesn't close can cause problems at birth & cells don't get enough O2 = "hole in heart" condition

E. Heart Chambers and Valves

V

*the heart is divided into 4 hollow chambers-2 atria (upper) & 2 ventricles (lower)

*atria – thin walls & receive blood returning to the heart

*auricles – small earlike projections that extend from the atria & form the wall of the atria

*ventricles – force blood out of the heart into arteries

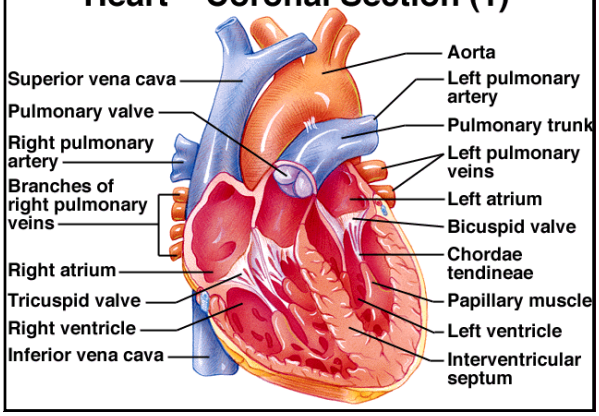
*interatrial septum – separates right & left atria

*interventricular septum – separates the 2 ventricles

*atrioventricular orifice – opening in which the atria communicates with its corresponding ventricle; opening is guarded by the atrioventricular valve (A-V valve)

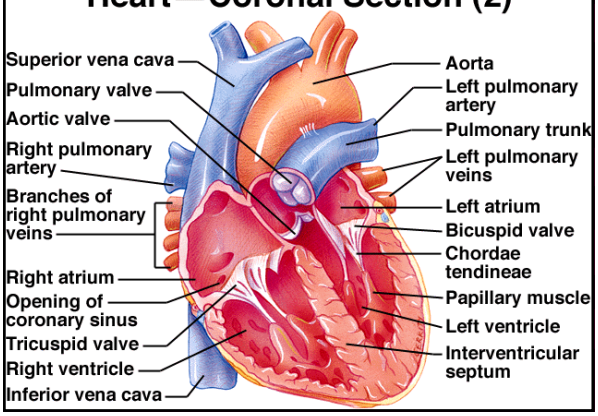
*atrioventricular & interventricular sulci - form separations that mark the 4 chambers

## Heart—Coronal Section (1)






## Heart—Coronal Section (2)




**Right chambers & valves:**

1) receives blood from 2 large veins called the superior vena cava & the inferior vena cava; coronary sinus also drains blood into the right atrium from the myocardium
2) tricuspid valve (3 cusps) guards the atrioventricular orifice between the right atrium & the right ventricle; it permits blood to move from the right atrium into the right ventricle & doesn't allow it to move in the opposite direction;
   papillary muscles – extends inward from the ventricular walls of the heart & to which the chordae tendinae (fibrous strings) attach which prevent the cusps from swinging back into the atrium
3) right ventricle (thinner muscular wall than left ventricle); pumps blood a short distance to the pulmonary trunk (lungs); (left ventricle must force blood to all parts of the body against resistance); blood goes to pulmonary trunk which divides to form the left & right pulmonary arteries (deoxygenated blood)
4) pulmonary valve (3 cusps) – guards the base of the pulmonary trunk; opens as the right ventricle contracts

**Left chambers & valves:**

1) left atrium receives blood from the lungs through 4 pulmonary veins – 2 from right & 2 from left lungs
2) the blood passes from the left atrium into the left ventricle through the atrioventricular orifice; bicuspid or mitral valve guards the left atrioventricular orifice; it prevents blood from flowing back into the left atrium from the ventricle when the ventricle contracts
3) the left ventricle pumps blood by way of the aorta (large artery) into systemic circulation
4) an aortic valve guards the base of the aorta

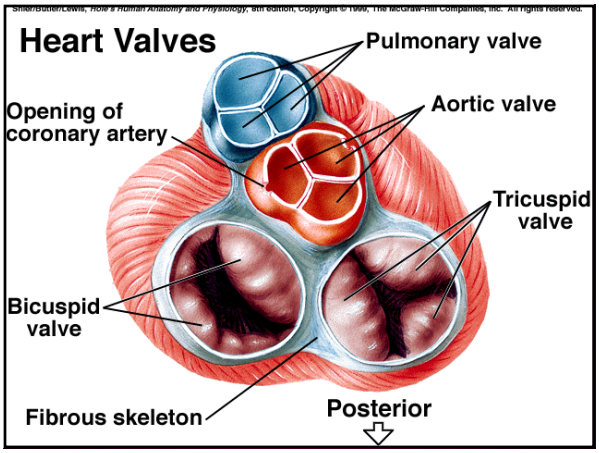
**F. Skeleton of the Heart**

*consists of fibrous rings that enclose the bases of the pulmonary artery, aorta, & atrioventricular orifices

*fibrous rings provide attachments for valves & muscle fibers & prevent the orifices from excessively dilating during ventricular contractions



## Heart Valves




## II. Structure of the Heart

**G. Path of Blood through the Heart**

*blood that is low in $O_2$ and high in $CO_2$ enters the right atrium through the venae cavae & coronary sinus; next is pumped into the pulmonary circulation

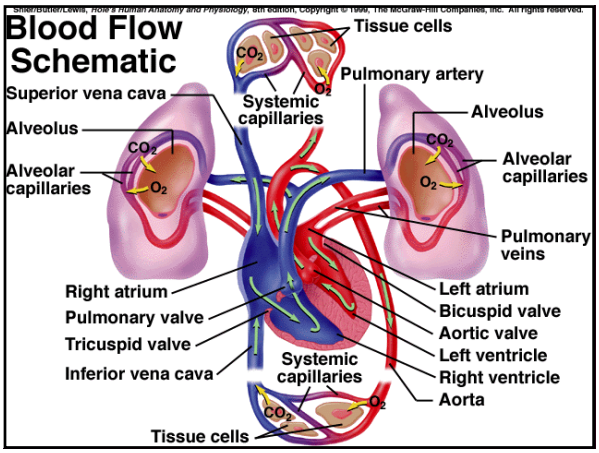
*after blood is oxygenated in the lungs & some of the $CO_2$ is removed, it returns to the left side of the heart through the pulmonary veins

*from the left ventricle, it moves into the aorta

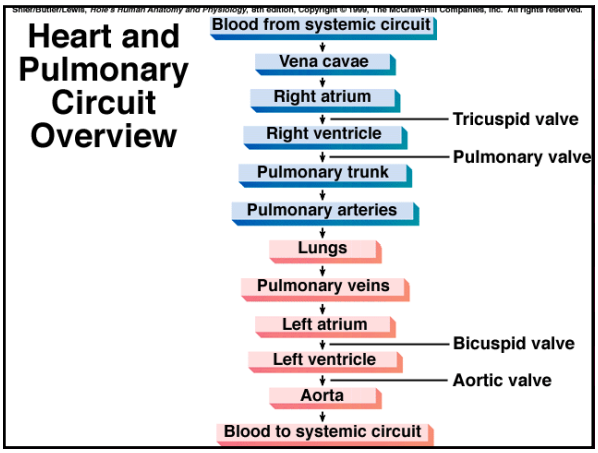
**gas exchanges occur between the blood in the capillaries and the air in the alveoli of the lungs**

**ORDER IN WHICH BLOOD FLOWS:**

1. venae cavae & coronary sinus
2. right atrium > tricuspid valve
3. right ventricle > pulmonary valve > pulmonary trunk
4. pulmonary artery
5. pulmonary vein
6. left atrium > bicuspid (mitral) valve
7. left ventricle > aortic valve
8. aorta





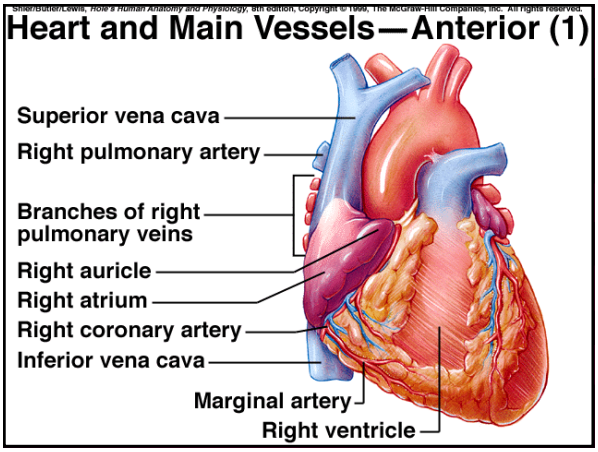




H. Blood Supply to the Heart

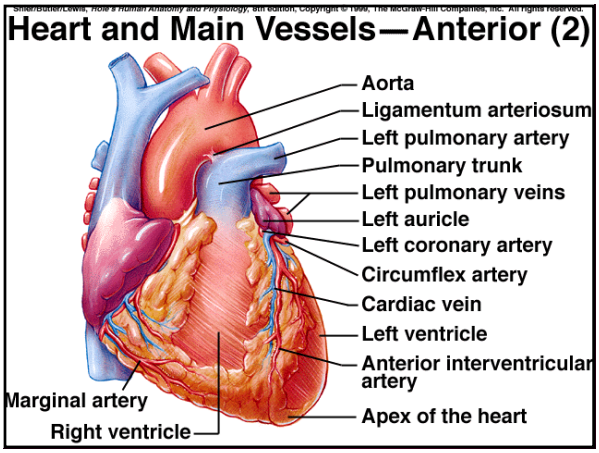
*heart muscle (myocardium) needs blood
*coronary arteries branch off from systemic circulation & feed capillaries that permeate the heart muscle (myocardium)

*when blockage of O2 to heart muscles occur cardiac muscles begin to die & a heart attack (myocardial infarction) can occur if blockage is extensive

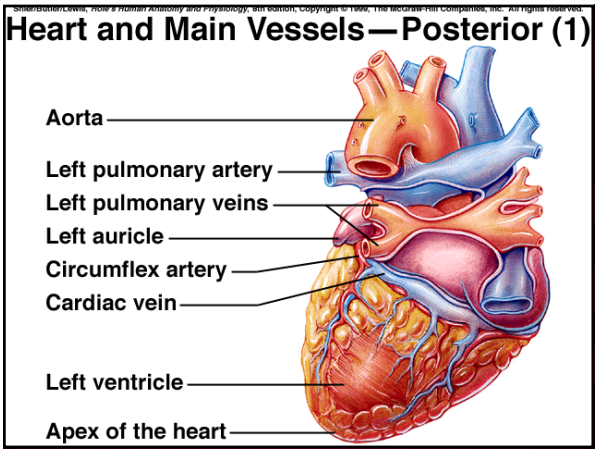




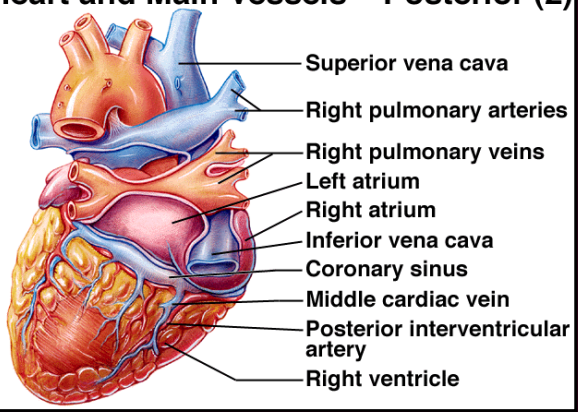


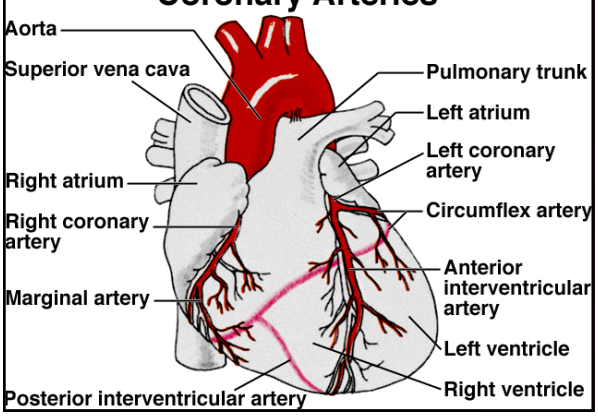


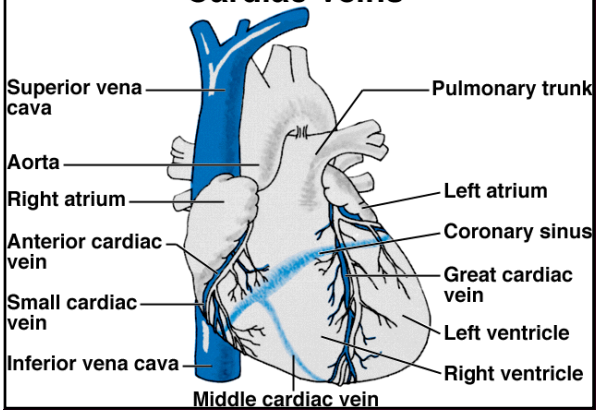
## Heart and Main Vessels—Posterior (2)



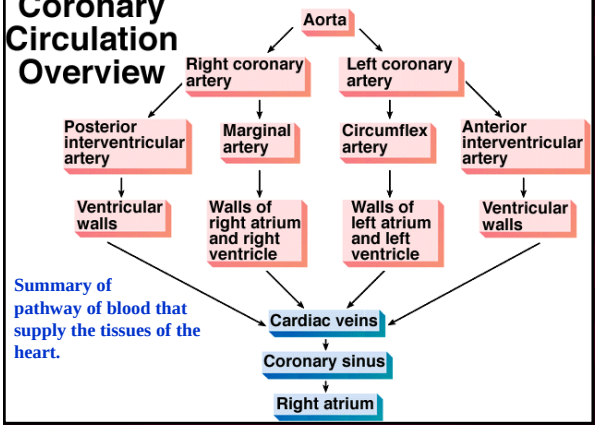

## Coronary Arteries




## Cardiac Veins




## Coronary Circulation Overview




Summary of pathway of blood that supply the tissues of the heart.

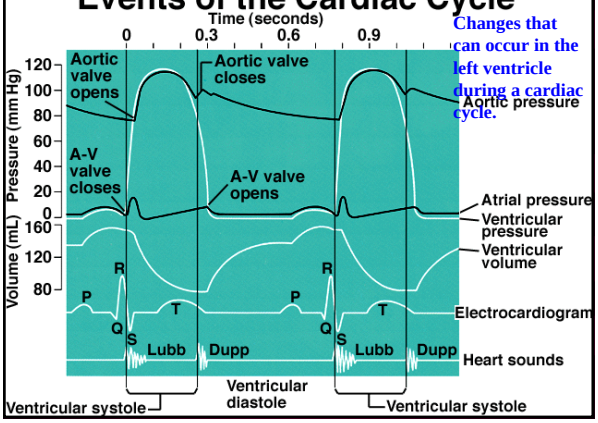
## III. Heart Actions

systole – atria contract; diastole – ventricles relax; then
ventricular systole followed by atrial diastole = a complete heartbeat or cardiac cycle

Cardiac Cycle = a complete heartbeat
- *the atria contract while the ventricles relax; the ventricles contract while the atria relax
- *pressure within the chambers rises & falls in repeated cycles

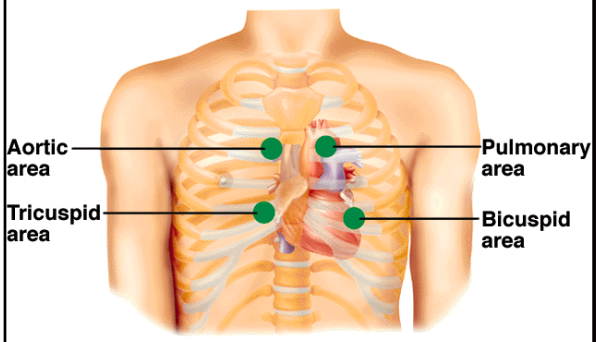
Heart Sounds
- *sounds due to vibrations in the heart tissues produced as the blood flow is speeded or slowed with the contraction & relaxation of the atria & ventricles
- *lubb-dupp sound due to vibrations that the valve movements make & changes in velocity of blood flow
- *lubb sound occurs when A-V valves (tricuspid & bicuspid valves) close; dupp sound occurs with closing of the pulmonary & aortic valves

## Events of the Cardiac Cycle



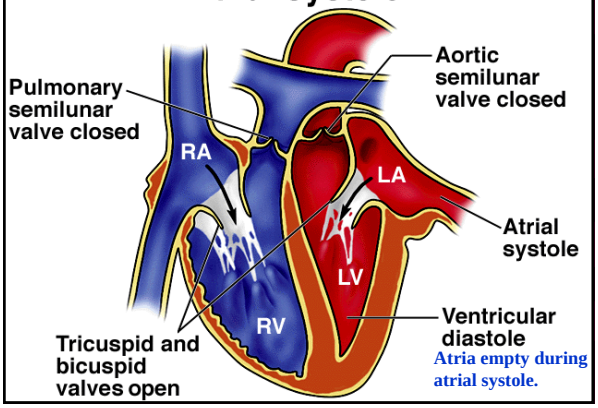

Changes that can occur in the left ventricle during a cardiac cycle.

## Sites of Heart Valve Sounds





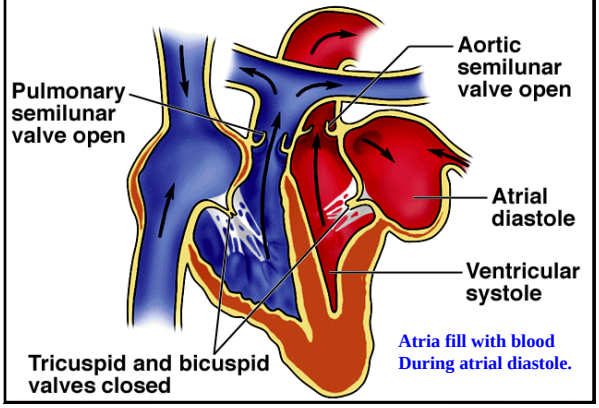

## Atrial Systole




Atria empty during atrial systole.



## Atrial Diastole




Atria fill with blood During atrial diastole.

**Cardiac Muscle Fibers:**

Cardiac muscle fibers are connected by intercalated discs that allow the fibers to connect in branching networks. Stimulation to any part of the network sends impulses throughout the heart, which contracts as a unit.

*syncytium – a mass of merging cells
*cardiac muscle fibers connect to form a functional syncytium
*if any part of the syncytium is stimulated, the whole structure contracts as a unit

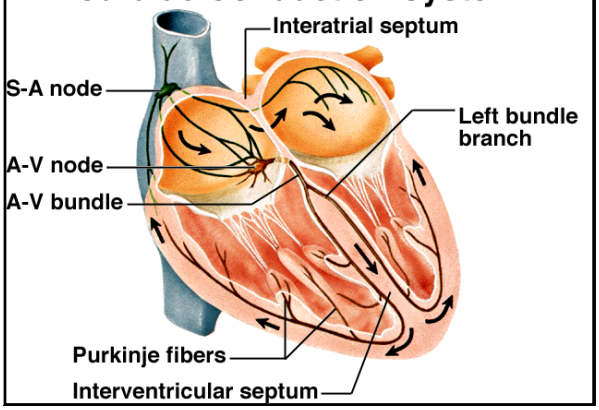
*the fibrous skeleton separates the atrial syncytium from the ventricular syncytium except for a small region in the floor of the right atrium where the atrial syncytium & the ventricualr syncytium are connected by fibers of the Cardiac Conduction System.

**Cardiac Conduction System**

Specialized cardiac muscle tissue whose fibers have only a few myofibrils are located throughout the heart. They initiate & distribute impulses throughout the myocardium. They are the cardiac conduction system of the heart.

D. Cardiac Conduction System
- *heart muscle beats on its own without external stimulation from the nervous system; cardiac muscle cells can do it on their own (hormones can however alter it)
- *the beat starts in an area of the heart called the SA (sino-atrial) node or pacemaker region – upper corner of right atrium – node is sight of a wave of contractions that spread through both atria via the gap junctions linking cardiac muscle cells
- *there is a flow of current in the form of ions that accompanies each contraction
- *A-V node (atrioventricular node) – a region of connective tissue that has a special bundle of conducting fibers that conduct the impulse to the lower regions of the ventricles at A-V bundle & Purkinje fibers which then contract smoothly to force blood up & out through semilunar valves
- *muscle fibers in the ventricular walls area arranged in whorls that squeeze blood out of the contracting ventricles
- *takes 1/10$^{th}$ of a second for an impulse to go from A-V node to ventricles
- *normal heartbeat = 60 – 80 beats/min @ rest

## Cardiac Conduction System



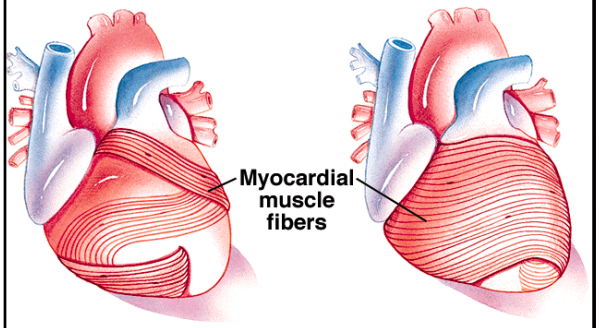



## Cardiac Conduction System Overview

Sinoatrial node
↓
Atrial syncytium
↓
Junctional fibers
↓
Atrioventricular node
↓
A-V bundle
↓
Bundle branches
↓
Purkinje fibers
↓
Ventricular syncytium



## Ventricular Wall Muscle Fibers




**E. Electrocardiogram**

*an ECG records electrical changes in the myocardium during a cardiac cycle

**F. Regulation of the Cardiac Cycle**

*physical exercise, body temperature, & concentration of various ions affect heartbeat; branches of the sympathetic & parasympathetic nerve fibers innervate the S-A & A-V nodes; parasympathetic impulses decrease heart action; sympathetic impulses increase heart action

*the cardiac center in the medulla oblongata regulates autonomic impulses to the heart

*there is a flow of current in the form of ions that accompanies each contraction

*A-V node (atrioventricular node) – a region of connective tissue that has a special bundle of conducting fibers that conduct the impulse to the lower regions of the ventricles at A-V bundle & Purkinje fibers whic then contract smoothly to force blood up & out through semilunar valves

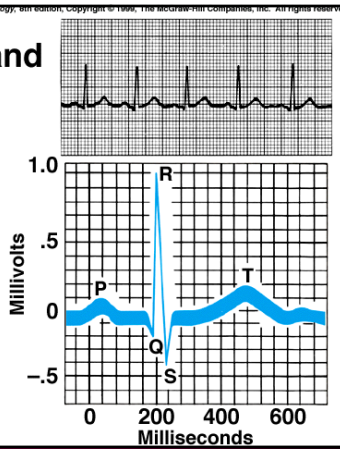
*muscle fibers in the ventricular walls area arranged in whorls that squeeze blood out of the contracting ventricles

*takes 1/10th of a second for an impulse to go from A-V node to ventricles

*normal heartbeat = 60 – 80 beats/min @ rest

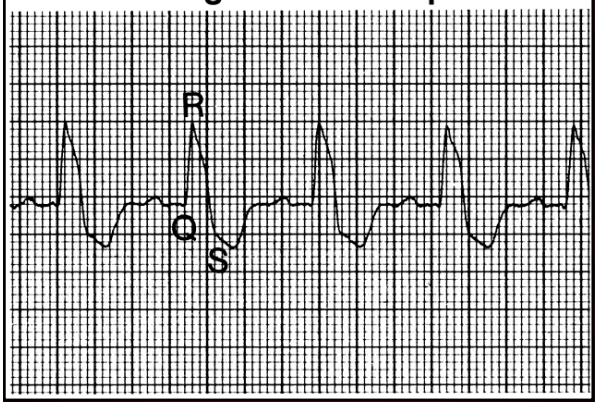


## Normal ECG and Its Pattern

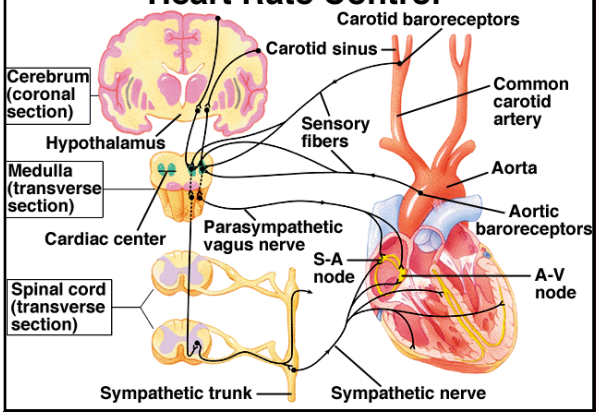





## Prolonged QRS Complex



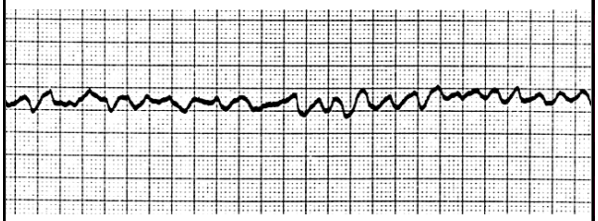
## Heart Rate Control






Fibrillation is rapid, uncoordinated depolarization of the ventricles.

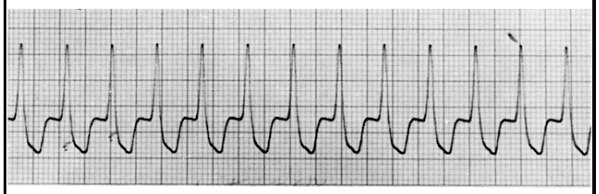
## Ventricular Fibrillation





Rapid heartbeat

## Tachycardia





Slow heartbeat

## Bradycardia



Abnormally rapid rate of atrial depolarization

## Atrial Flutter

### IV. Blood Vessels

BLOOD – a living tissue composed of specialized cells

*Functions of blood:

1) to carry nutrients, gases, & wastes
2) to maintain a proper internal environment
3) to protect organisms from disease

A. The blood vessels (arteries,arterioles, capillaries, venules, and veins) form a closed tube that carries blood away from the heart to the the cells and back again. Blood vessels are organs.

B. Arteries and Arterioles

*arteries – vessels that carry blood away from the heart; are thick walled, have 3 layers of tissues that are flattened cells, smooth muscle, & connective tissue on outer layer; layers tough & elastic; this allows vessels to expand & accommodate surges of blood; blood in arteries closest to heart & are under increased pressure

*because of blood surges, blood flows to smaller vessels called arterioles

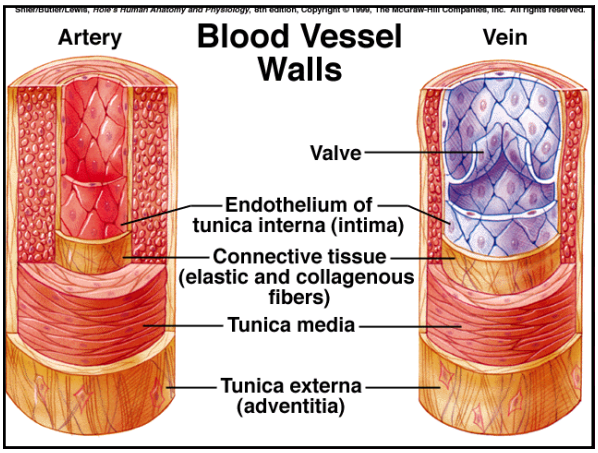
***Arteries and veins consist of 3 distinct layers called tunics.

1. tunica interna – layer of simple squamous epithelium, called endothelium, is rich in elastic & collagenous fibers, provides a smooth surface that allows blood cells & platelets to flow through without being damaged, help prevent blood clotting

2. tunica media – thicker in arteries than veins, includes smooth muscle fibers, has elastic connective tissue so vessel can dilate if needed

3. tunica externa (adventitia) – thin & consists of connective tissue with irregular elastic & collagenous fibers; this layer attaches to surrounding tissues

***Autonomic fibers that can stimulate vasoconstriction or vasodilation innervate smooth muscles in vessel walls.




C. Capillaries - smallest blood vessels; connect smallest arterioles & the smallest venules

*are blood vessels whose walls are 1 cell thick & they form a network that brings blood to the body tissues

*materials are able to diffuse across the wall of the capillary in both directions in & out of the blood

*the capillary interior wall is just thick enough for blood cells to slip through one at a time

D. Exchanges in the Capillaries

*gases, nutrients, & metabolic by-products are exchanged between the capillary blood & the tissue fluid

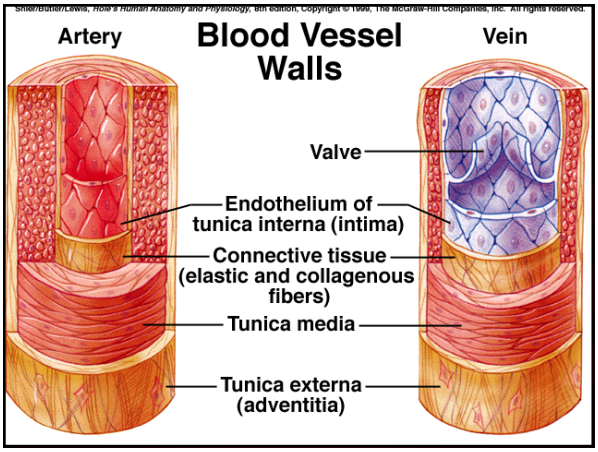
*diffusion provides the most important means of transport

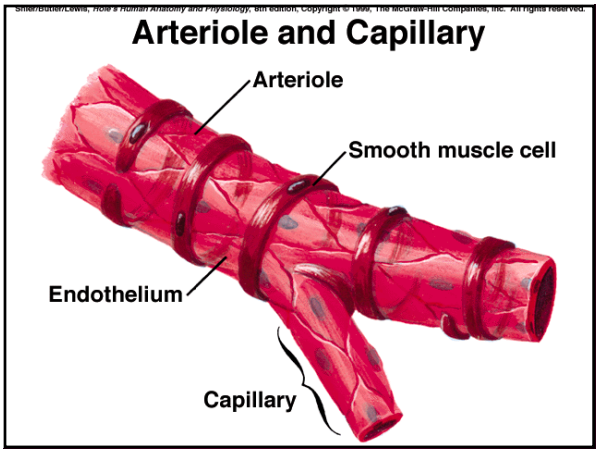
*also flitration & osmosis

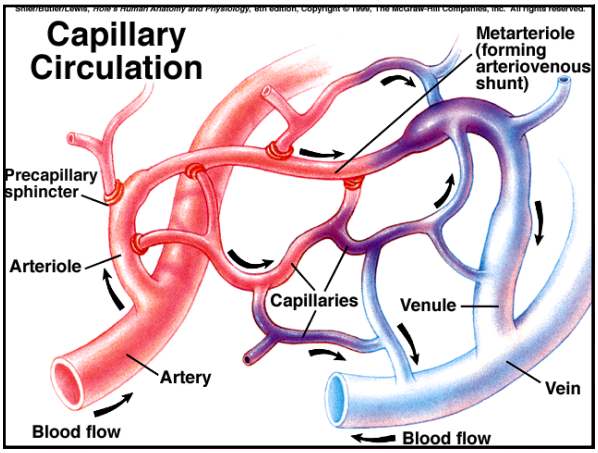
E. Venules and Veins

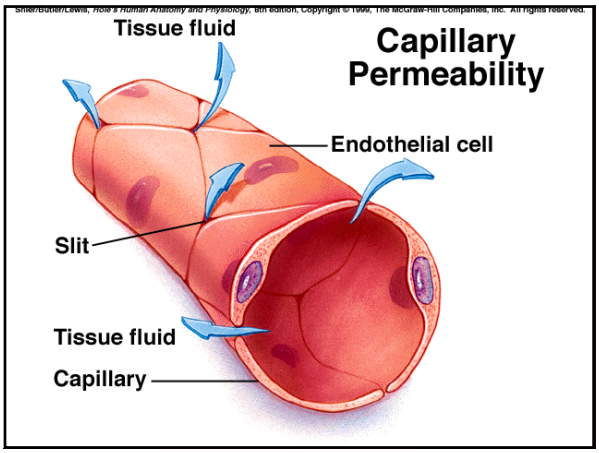
*near the end of capillary circulation blood collects in vessels called venules & they lead the blood to larger vessels called veins that carry blood back to the heart (similar to arteries with smooth & connective tissue but no elastic tissue)

*because venous blood has traveled a great distance from the heart (which is the pressure source for the fluid) there is much less pressure than in arteries; veins have valves which prevent blood from flowing in a reverse direction

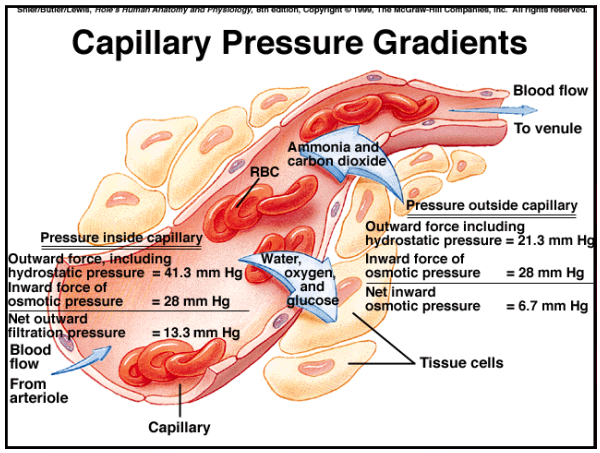


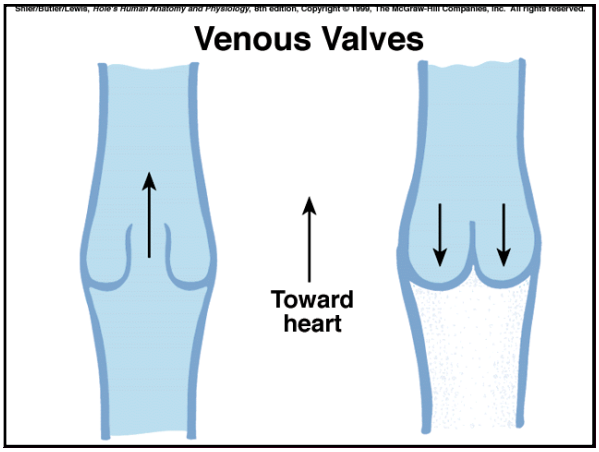





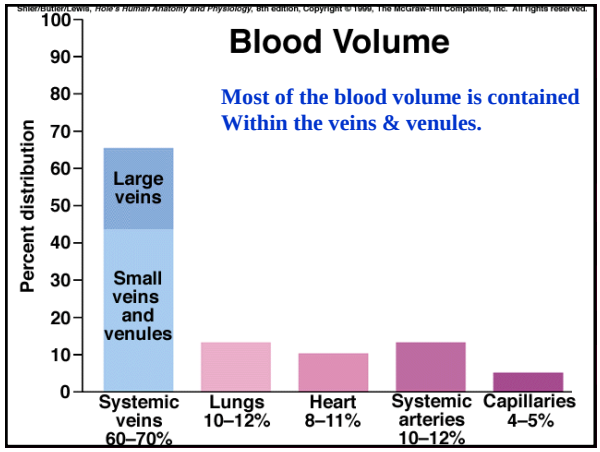







## V. Blood Pressure

A. Blood pressure is the force of blood against the inner walls of blood vessels anywhere in the cardiovascular system, although the term "blood pressure" usually refers to arterial pressure. (pressure exerted against walls of blood vessels when heart beats); it rises & falls with contractions of the heart

*pulse – caused by expansion & contraction of arterial vessels & the rise & fall of pressure

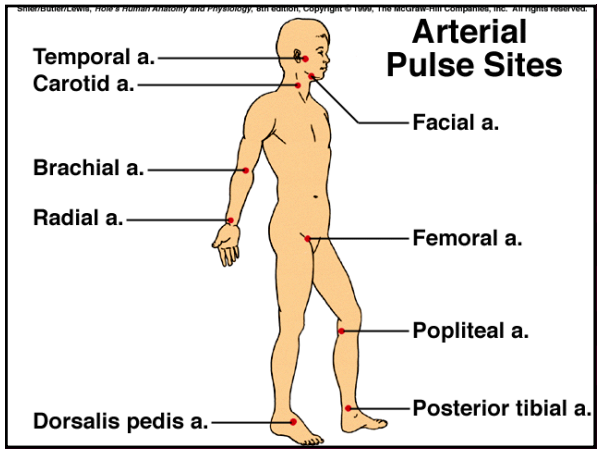
B. Arterial Blood Pressure

*when blood pressure is measured, 2 values are required

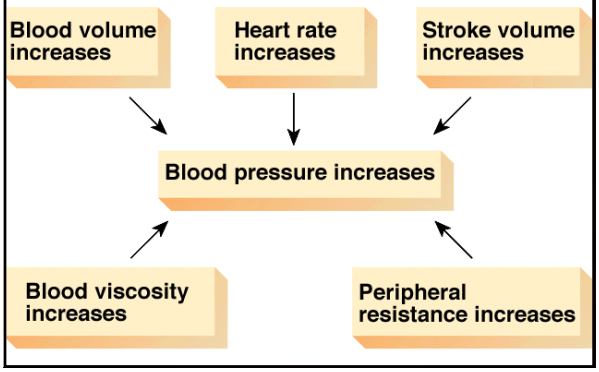
1) systole – when the ventricles of the heart contract, blood pressure reaches a maximum in the aorta & major arteries = systolic pressure (top #)
2) diastole – when the ventricles relax blood pressure drops to a minimum in the vessels = diastolic pressure (bottom #)

*sphygmomanometer – device that measures Bp in mm of Hg



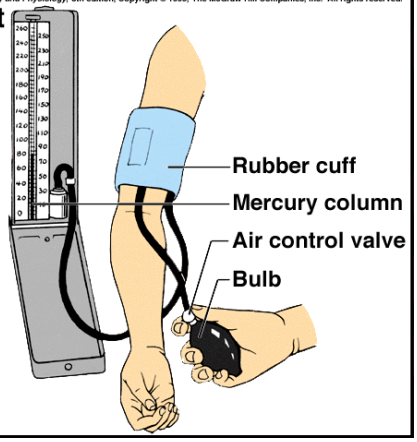


## Arterial Blood Pressure Factors






## Measurement of Blood Pressure



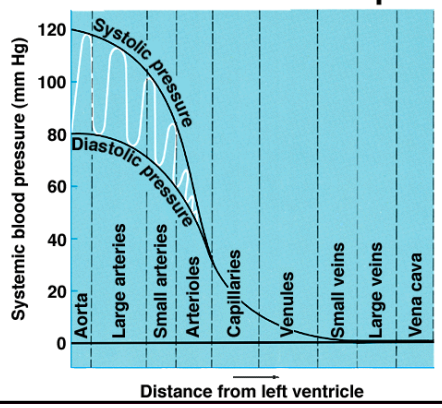

C. Factors that Influence Arterial Blood Pressure

1)as heart rate increases Bp increases because more blood is forced into system
2) when the volume of circulatory vessels is decreased because smooth muscles contract this causes an increase in Bp
3) amount of volume of blood in circulatory system
-more fluid in blood Bp rises
-fluid in blood lost Bp drops
We need these changes to meet the needs of exercise & physiology

D. Control of Blood Pressure
E. Venous Blood Flow
F. Central Venous Pressure

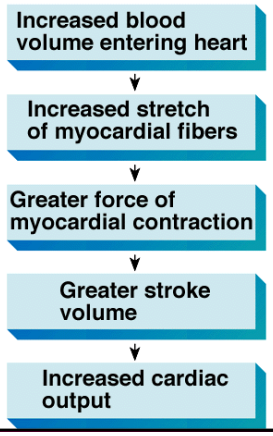


## Blood Pressure Graph



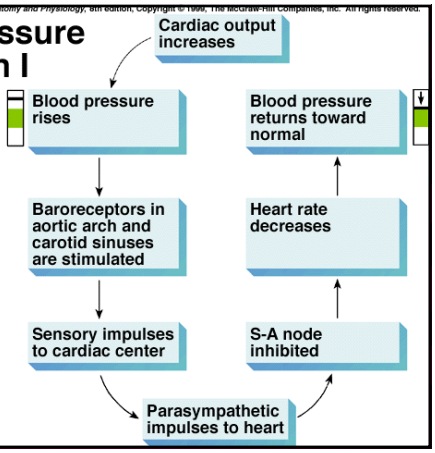


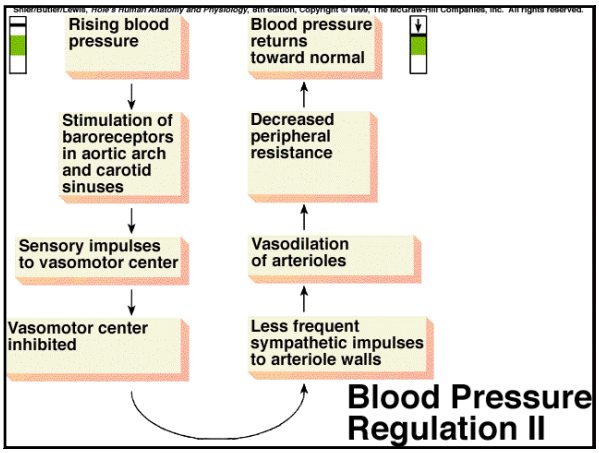

## Blood Volume-Cardiac Output Relationship

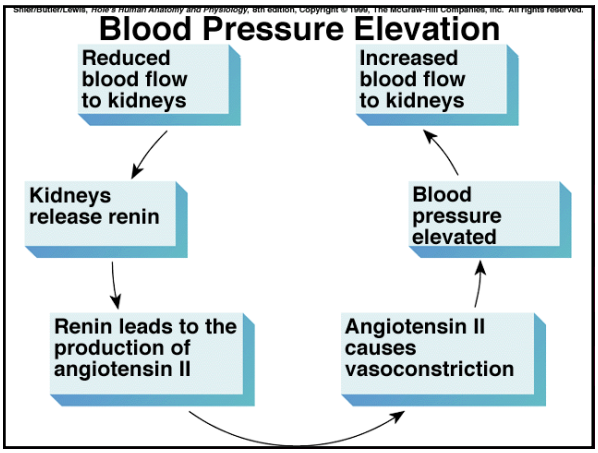


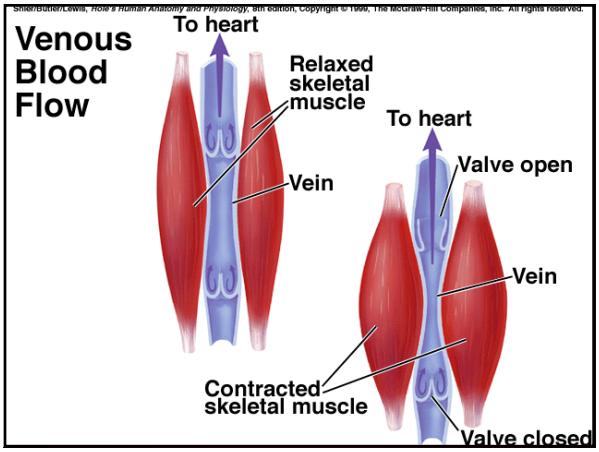



## Blood Pressure Regulation I






## VI. Paths of Circulation

A. The body's blood vessels can be divided into a pulmonary circuit, including vessels carrying blood to the lungs and back, and a systemic circuit made up of vessels carrying blood from the heart to the rest of the body and back.

B. Pulmonary Circuit

*blood passes from right ventricle to lungs via pulmonary arteries & returns to left atrium via pulmonary veins

*pulmonary arteries carry O2 poor blood

*pulmonary veins carry O2 rich blood

*gas exchange takes place between the blood & air that has been inhaled

C. Systemic Circuit

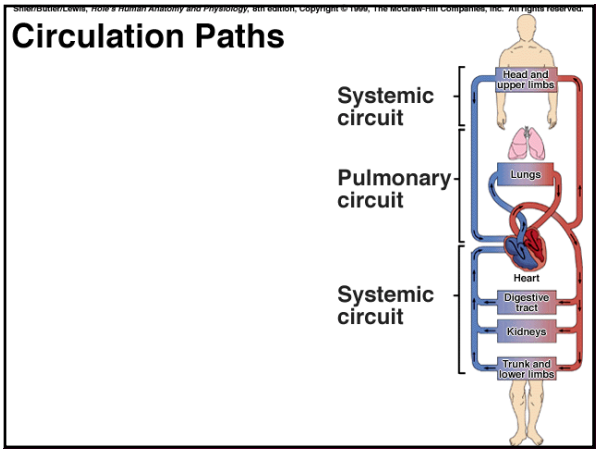
*blood leaves heart through largest artery, the aorta – has opening 1" in diameter; arteries branch from aorta & then become arterioles & thin tiny capillaries & carry blood to organs & tissues

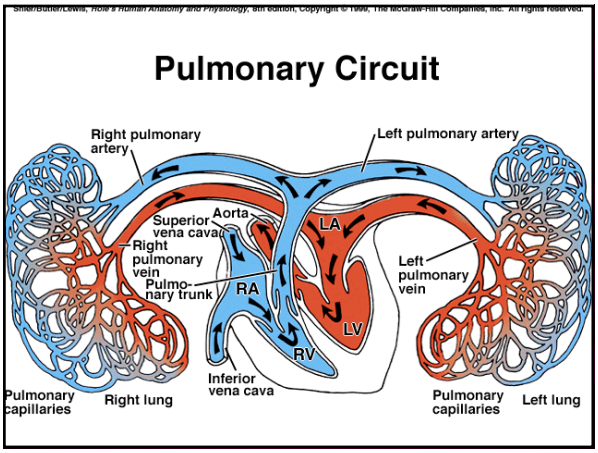
*after blood goes through capillary networks it is collected by venules that lead into larger veins that lead into 2 major vessels:

superior vena cava – collects blood from head, neck, & arms

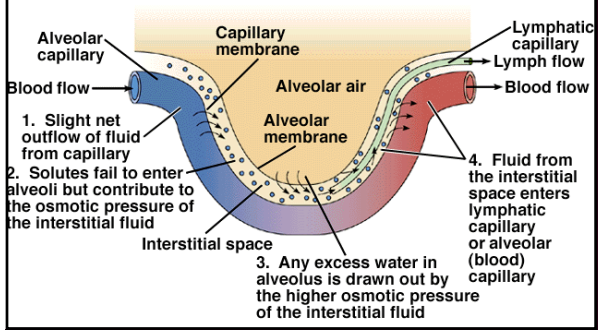
inferior vena cava – collects blood from rest of body

the 2 cavas lead to the right atrium of the heart



## Blood Flow through an Alveolar Capillary




## VII. Arterial System

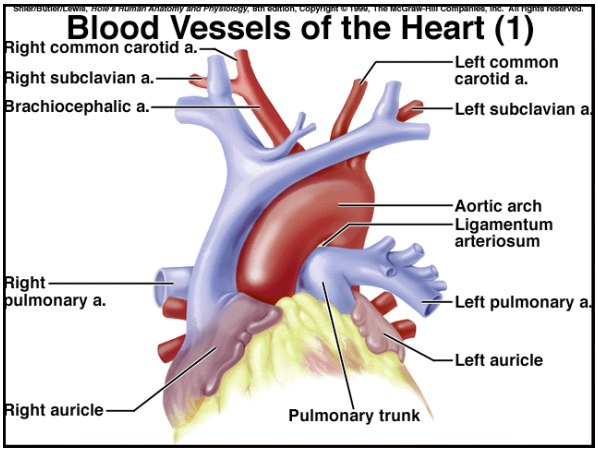
A. The aorta is the body's largest artery.
B. Principal Branches of the Aorta
C. Arteries to the Head, Neck, and Brain
D. Arteries to the Shoulder and Upper Limb

## VII. Arterial System

E. Arteries to the Thoracic and Abdominal Walls
F. F. Arteries to the Pelvis and Lower Limb

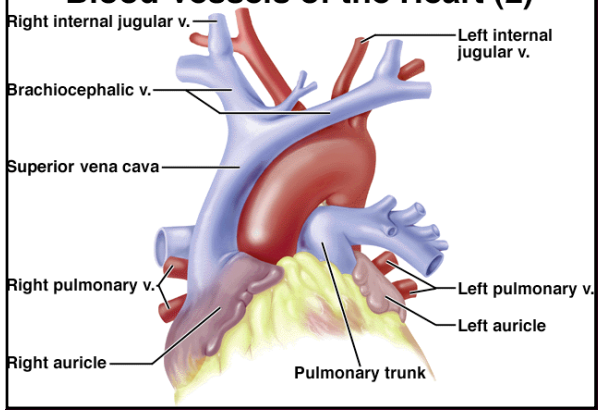


## Blood Vessels of the Heart (1)



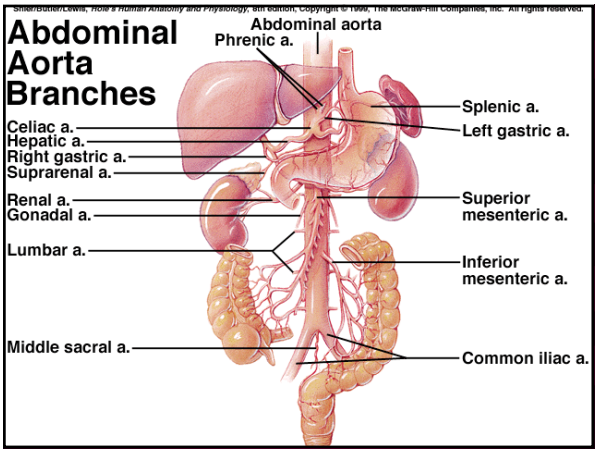



## Blood Vessels of the Heart (2)

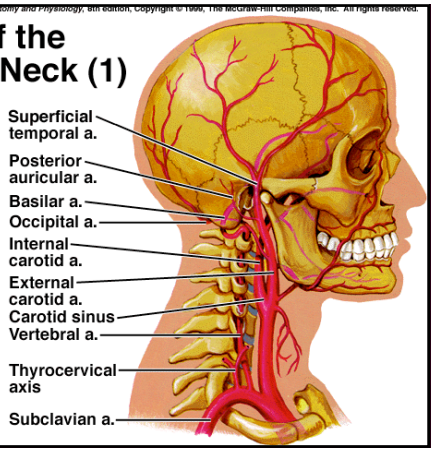





## Abdominal Aorta Branches

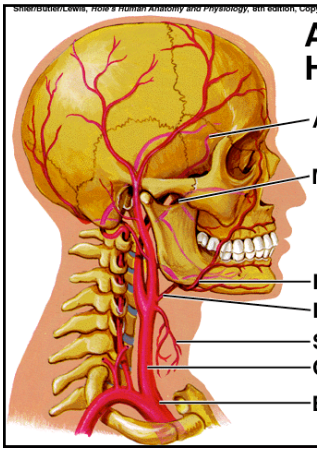


## Arteries of the Head and Neck (1)



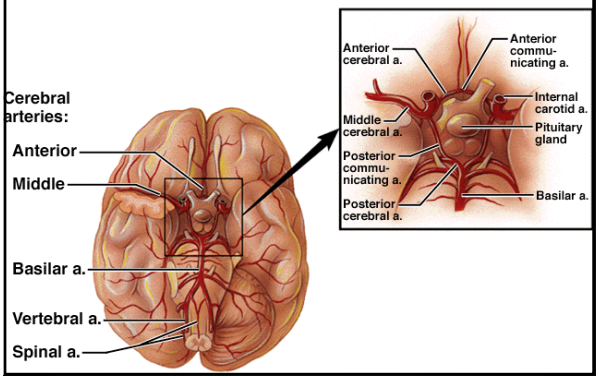



## Arteries of the Head and Neck (2)

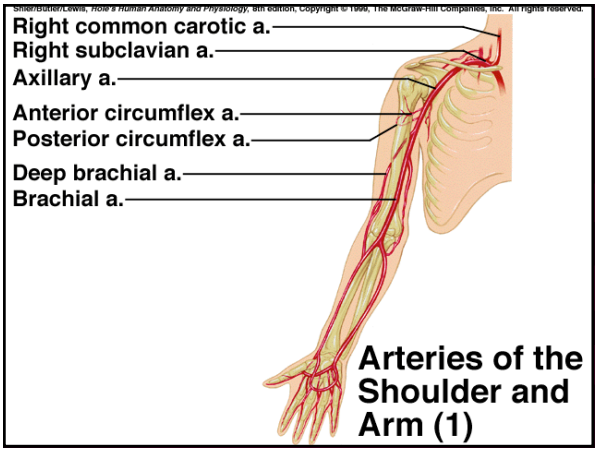





## Circle of Willis



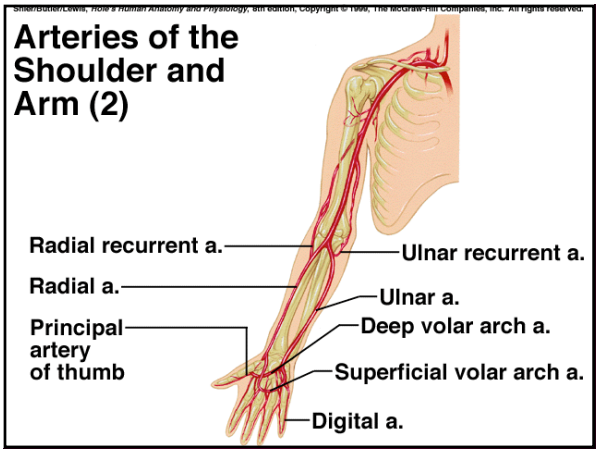



## Arteries of the Shoulder and Arm (1)

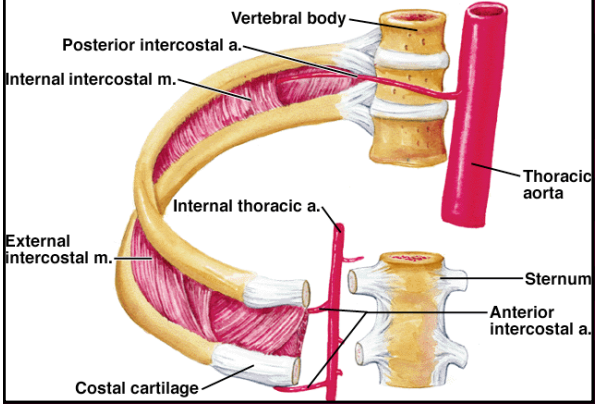


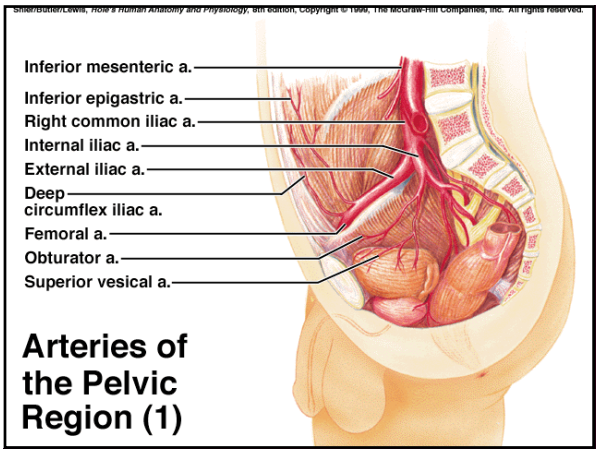
## Arteries of the Shoulder and Arm (2)





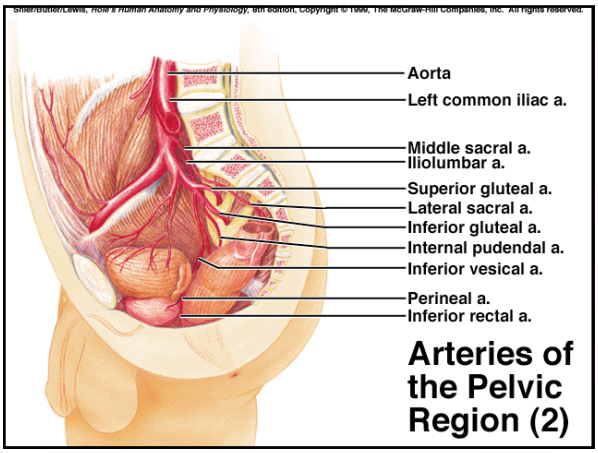

## Arteries of the Thoracic Wall





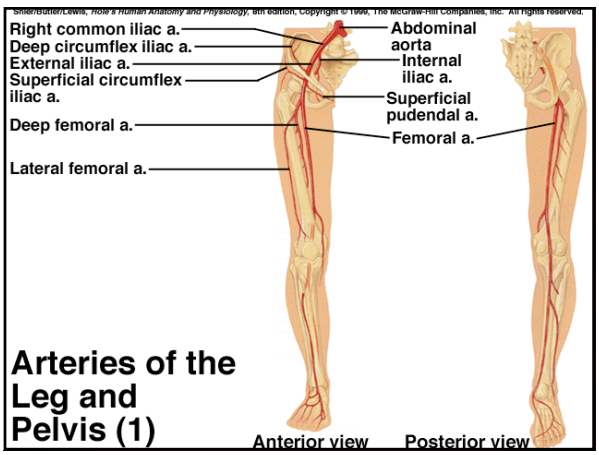

## Arteries of the Pelvic Region (1)





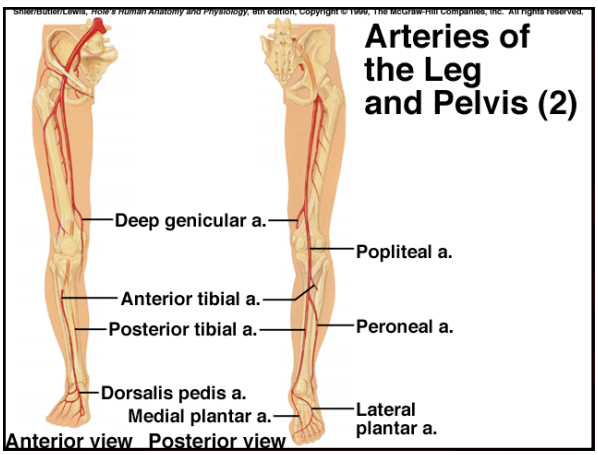

## Arteries of the Pelvic Region (2)





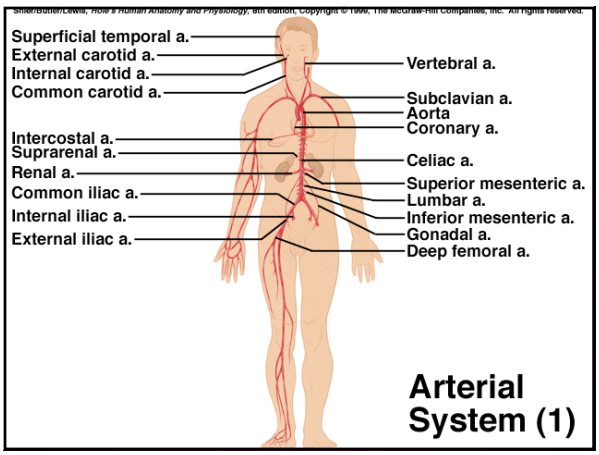

## Arteries of the Leg and Pelvis (1)





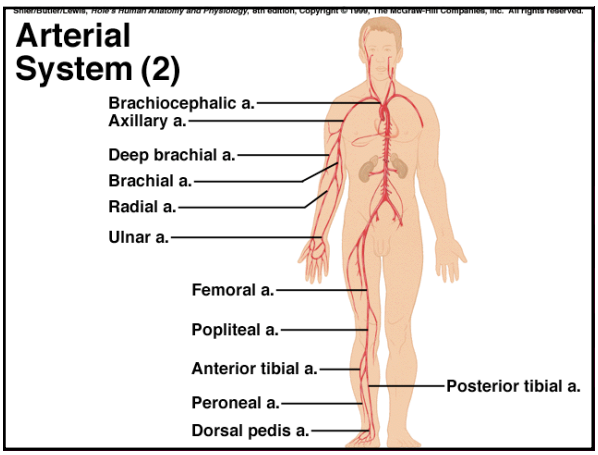

## Arteries of the Leg and Pelvis (2)






## Arterial System (1)






## Arterial System (2)

## VIII. Venous System

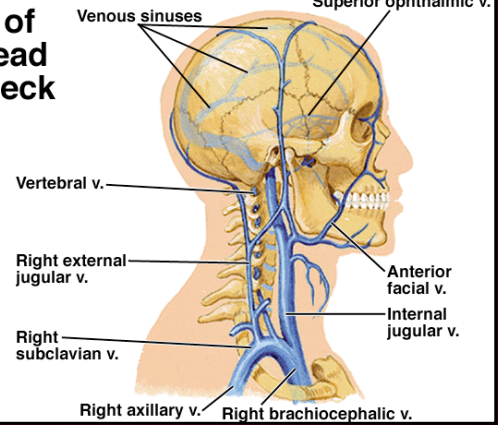
A. Veins return blood to the heart after the exchange of substances has occurred in the tissues.
B. Characteristics of Venous Pathways
C. Veins form the Head, Neck, and Brain
D. D. Veins from the Upper Limb and Shoulder

## VIII. Venous System

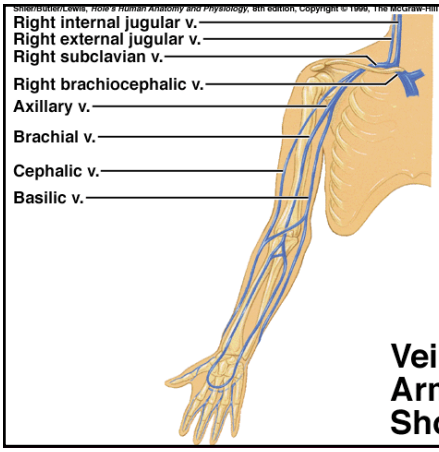
E. Veins from the Abdominal and Thoracic Walls
F. Veins from the Abdominal Viscera
G. Veins from the Lower Limb and Pelvis



## Veins of the Head and Neck



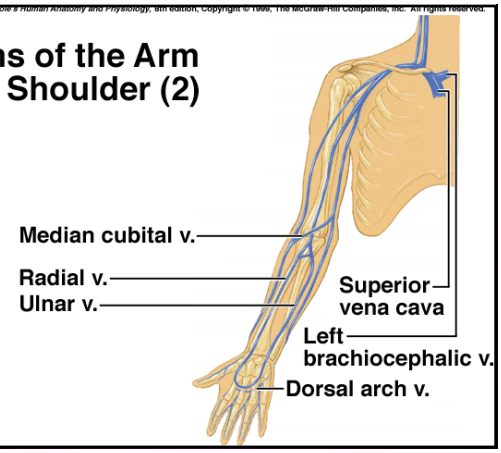



## Veins of the Arm and Shoulder (1)

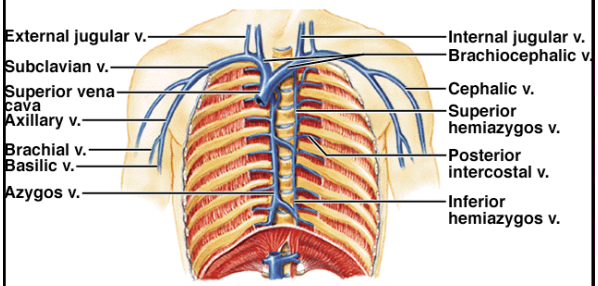


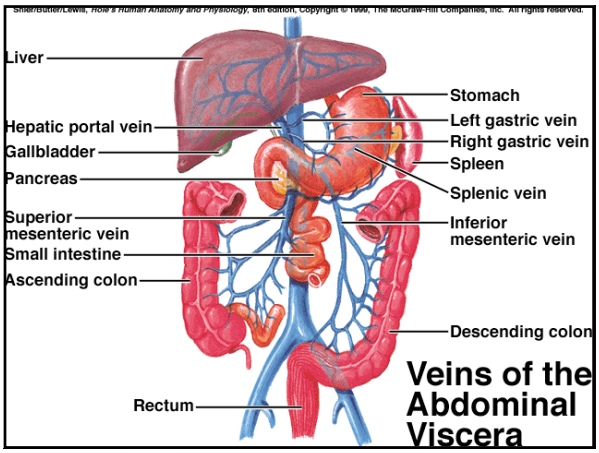
## Veins of the Arm and Shoulder (2)

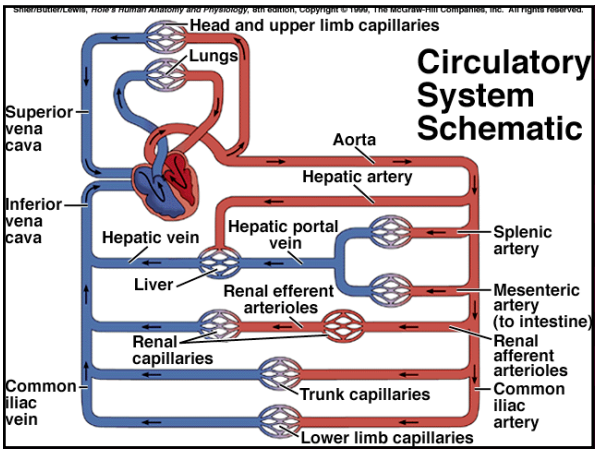


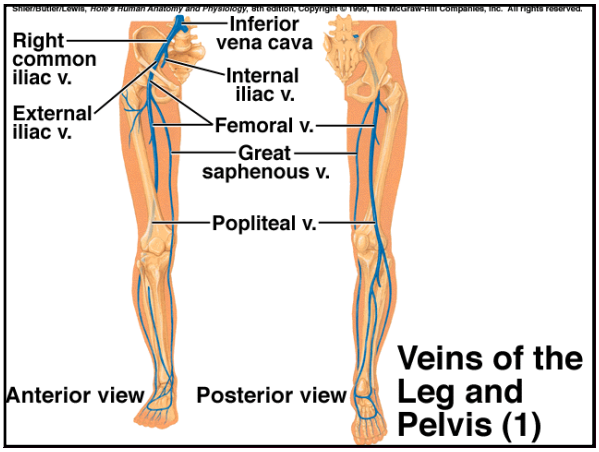


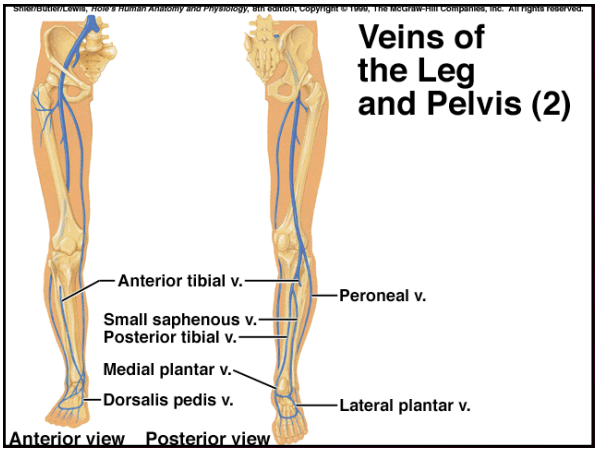

## Veins of the Thoracic Wall

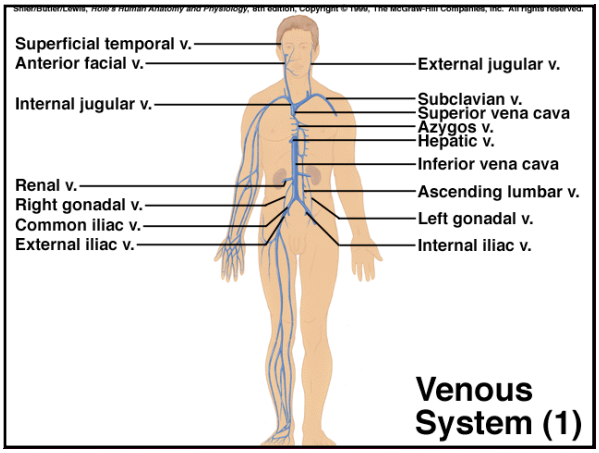


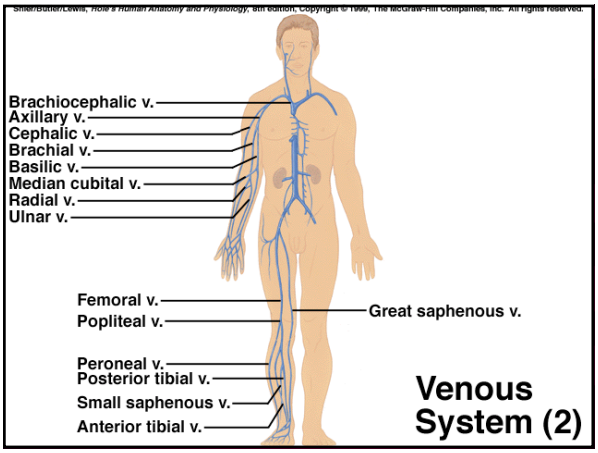


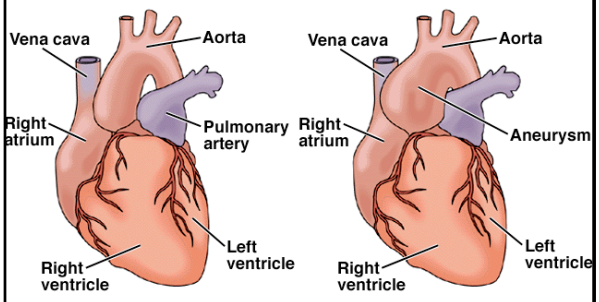



## Aortic Aneurysm




**Disorders of the Circulatory System**

***hypertension – very high Bp; requires heart to work harder to pump blood→damage to blood vessels→hemorrhage→stroke; can be caused by arteriosclerosis or hardening of the arteries caused by diets high in cholesterol & saturated fat; fat layers inside vessel walls & it becomes too rigid & lose elasticity also becoming resistant to good blood flow**

***stroke – condition results from a blockage in circulation to a part of the brain**

***atherosclerosis – result of fatty deposits called plaque lining the walls of the arteries, cholesterol accumulates of the inside of the arterial walls**

***hypertension – condition known as high Bp, is related to stress & diets high in salt**

***myocardial infarction – term for heart attack condition that occurs when the heart muscle is deprived of O2**

***coronary thrombus – a small blood clot becomes lodged in one of the coronary arteries, blocking blood flow to the heart**

# FINI

**Remember – At the end of the chapter is a Chapter Summary that is your Study Guide for the Chapter 15 test.**