Cardiovascular System

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Objective

- Describe the organ inside cardiovascular system and its functions.
- Discuss cardiac cycle and how it been controlled.
- Differenciate structure and function of blood vessels.
- Identify types the pattern of ECG .
- Discuss the control of blood pressure

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Cardiovascular Function

- Delivers oxygen to muscles and tissues
- Removes CO2 and metabolic waste
- Transports hormones from endocrine glands to their primary receptors
- Maintains body temp and blood pH
- Prevents dehydration by maintaining fluid levels in addition to preventing infection

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Structure of the CV system

- Has a pump (the heart itself)
- Has a system of channels (vessels)
- Has a fluid medium (blood)

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The Heart

- Has two atria
  - act as receivers of blood
  - pumps into ventricles
- Has two ventricles
  - sends or pumps blood out
    - left ventricle sends O2 rich blood to the periphery
    - right ventricle sends O2 poor blood to the lungs

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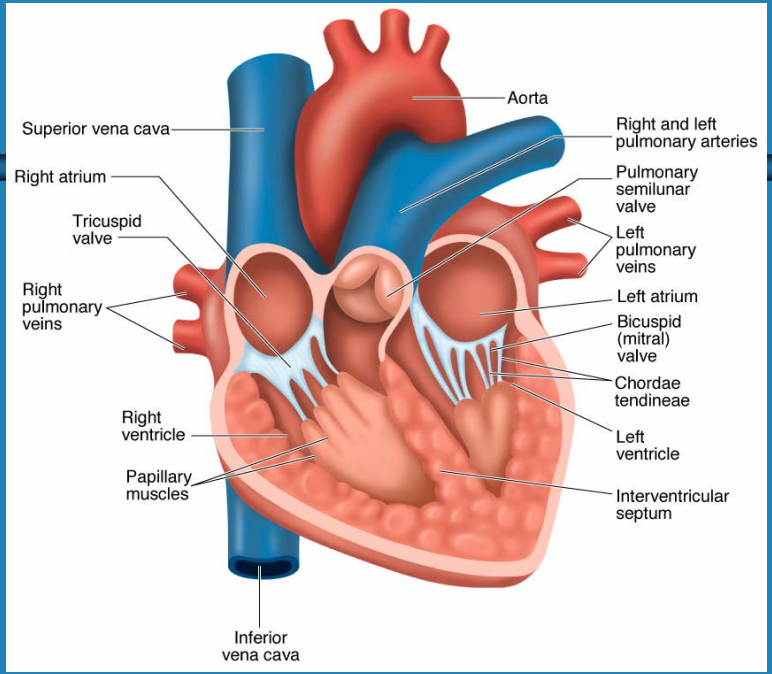

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Blood flow

- Let's trace the blood from the right atrium
  - thru the tricuspid valve into right ventricle
  - pulmonary semilunar valve into the pulmonary artery-only artery with O2 poor blood
  - right and left lung (diffusion)
  - pulmonary veins (only veins with O2 rich blood)
  - back to the heart into the left atrium
  - thru the bicuspid valve (mitral) into the left ventricle
  - passes thru the aortic semilunar valve into the aorta.
  - Aorta sends to all parts of the body (periphery)
  - inferior and superior vena cava back to right atrium
- right side is pulmonary; left is systemic

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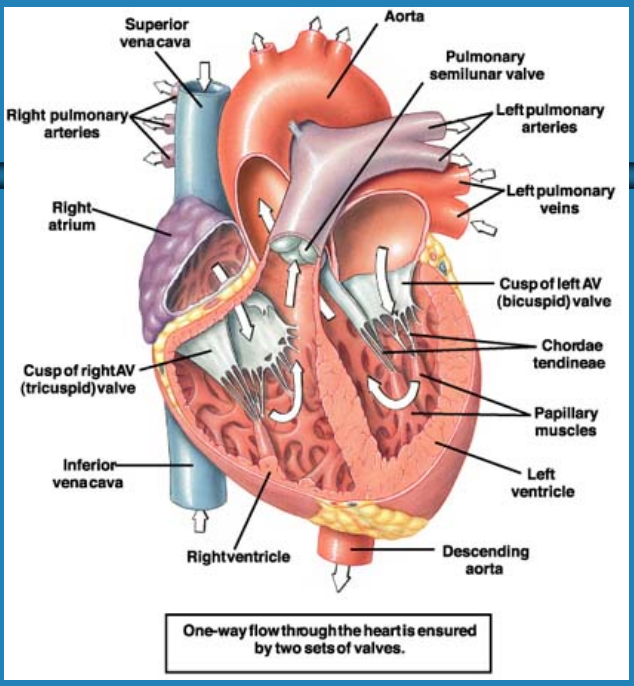

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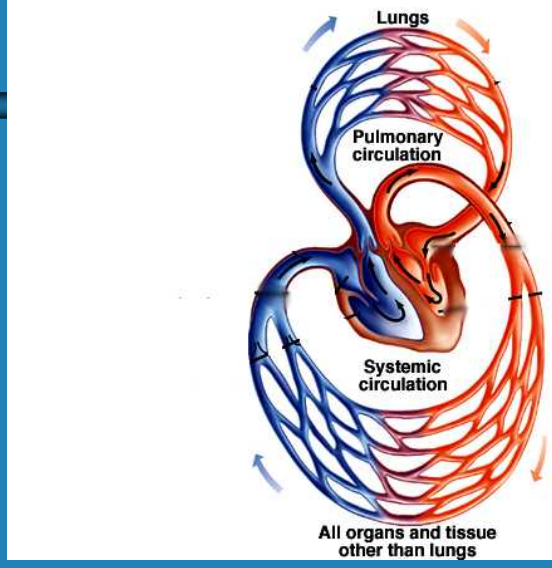

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Myocardium

- Is called cardiac muscle
  - Left ventricle is most powerful and has to overcome gravity to pump to the rest of the body.
  - Left ventricle has greater hypertrophy
- has striated appearance but has intercalated disks
- don't pull away when contracting (gap junctions)
  - this allows rapid transmission
  - All chambers act as one and contract together as one muscle fiber.

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Atrio-ventricular conduction

- Has autoconduction…the ability to generate its own electrical signal
  - contracts rhythmically without neural stimulation.
- Without neural or hormonal influence, the heart rate is 70-80 bts/min.
  - Trained individuals are lower.
- Sinoatrial node (SA node)-initiates impulse-pacemaker
- Atrioventicular node (AV node)-if SA fails, it takes over
- Atrioventricular (AV bundle or bundle of his)
- Purkinje fibers

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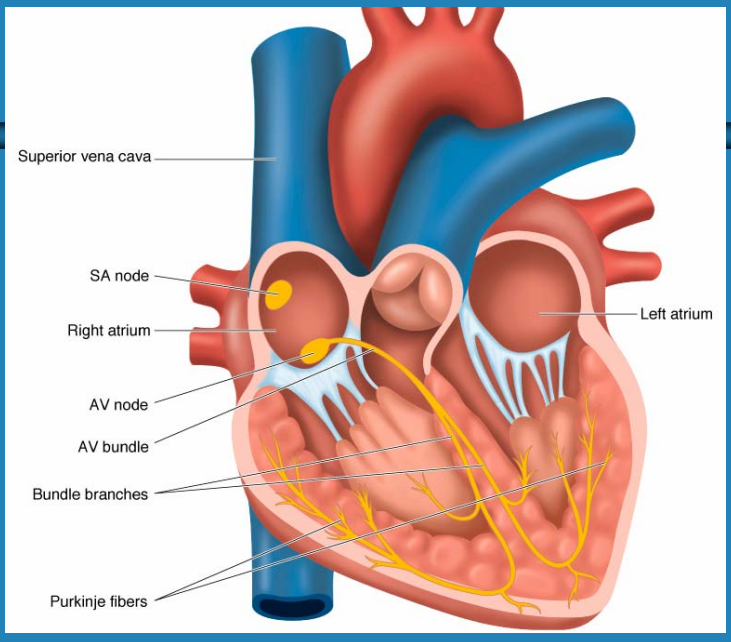

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AV conduction (cont'd)

- SA node (located in right atrium) initiates the electrical signal
- spreads thru both atria into the AV node (located in the right atrial wall in center)
- Conducted from AV node into the ventricles by way of Bundle of His.
  - Atria contract before ventricles, thus allowing ventricles to fill to maximum.
- Travels along ventricular septum to the right and left bundle brancehes into both ventricles.
  - These send impulses to the apex-then outward
  - Purkinje fibers spread the impulse throughout heart
  - 6X faster than other parts of conduction system

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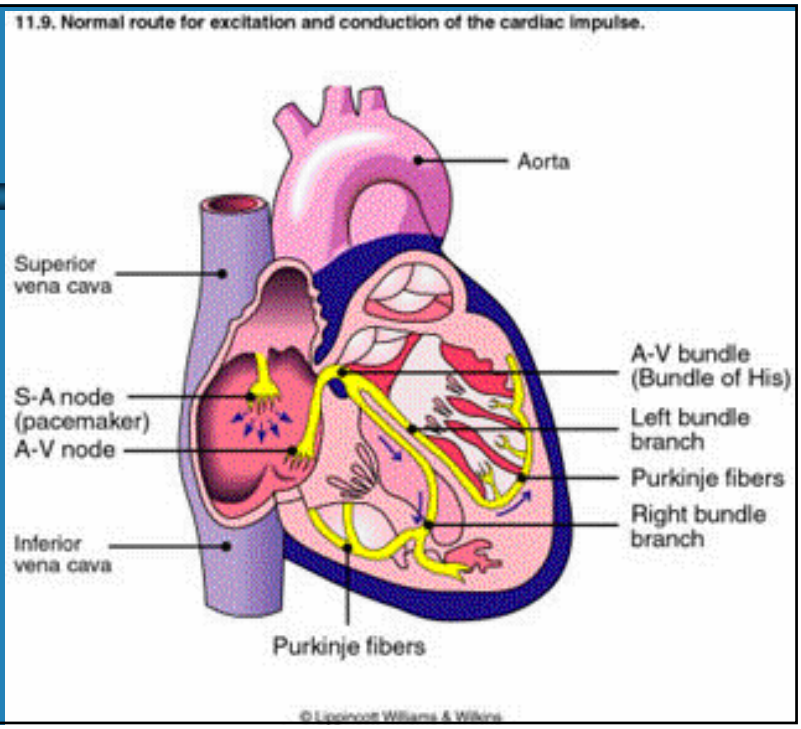

Extrinsic control of heart

- Intrinsic-heart initiates its own electrical impulses.
  - Timing and effect can be altered, however.
- 3 extrinsic methods
  - parasympathetic system-regulated by vagus nerve. Rest - vagal tone. Vagus nerve is a depressant effect. Slows impulse and decreases HR. Max vagal- 20 to 30 bts/min
  - sympathetic system-increases conduction speed. Max stim-250 bts/min. Also increases contraction force. These work together in regulating HR
  - endocrine system-changes HR thru release of hormones by the adrenal medulla. Norepinephrine & epinephrine or catecholamines. Increases HR.
  - Training can cause a decrease in HR over months.

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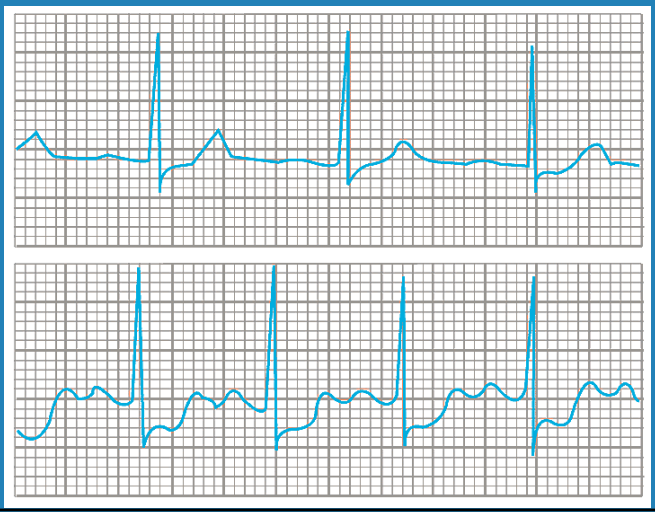
Electrocardiogram (ECG)



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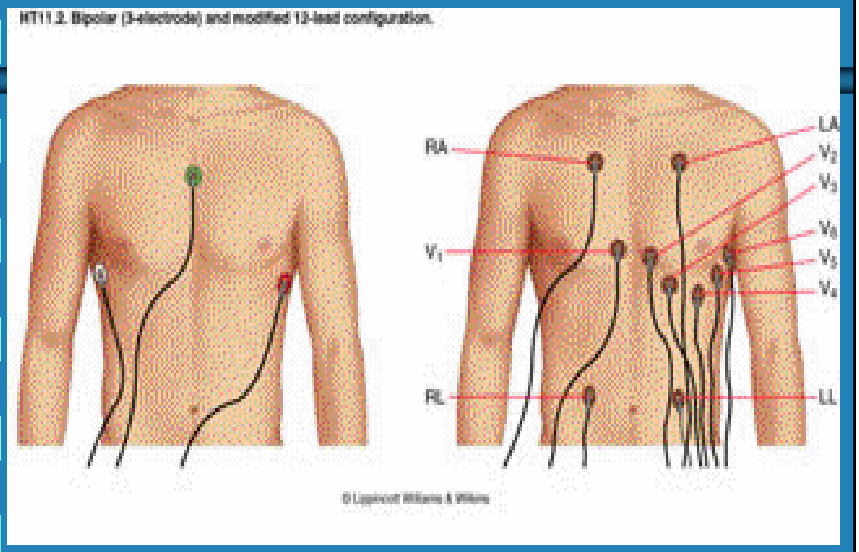

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ECG-electrocardiogram

- P wave- atrial depolarization
- QRS complex- ventricular depolarization-atrial repolarization
- T wave-ventricular repolarization
- Determined by electrocardiogram
- Can be done during exercise
- Common arrhythmias-
  - sinus bradycardia-<60 bts/min
  - sinus tachycardia->100 bts/min
  - others: supraventicular tachycardia (SVT), premature ventricular contraction, atrial fibrillation
  - Ventricular fib is not good-heart quivers-MI is imminent

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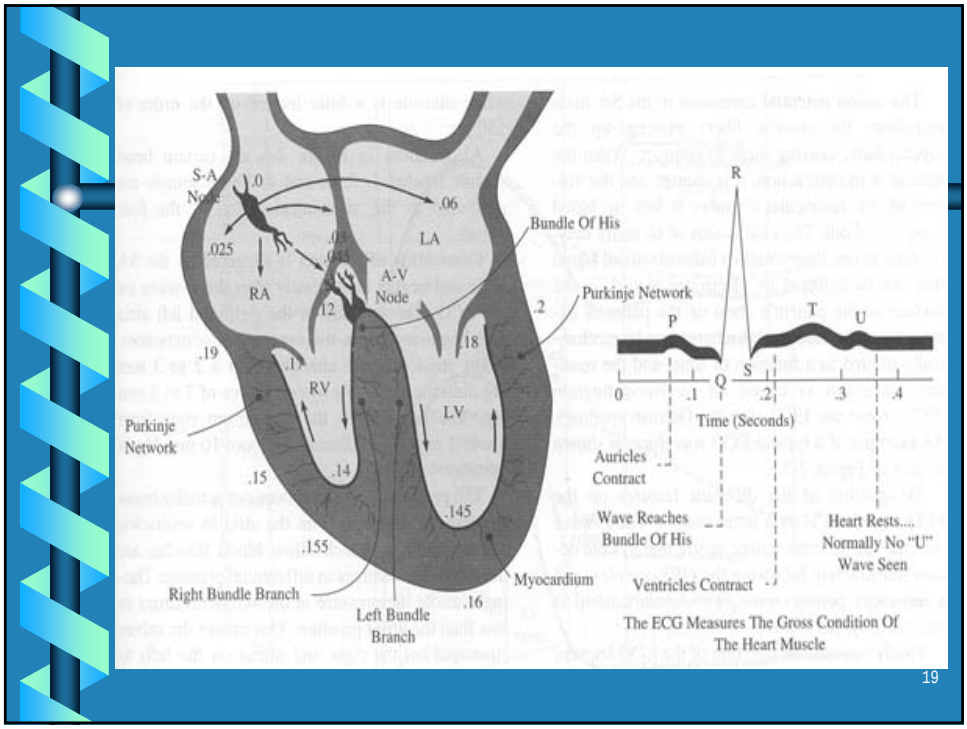
S-A Node
.0
.06
LA
.025
RA
A-V Node
.12
Bundle Of His
.2
Purkinje Network
.19
.18
RV
LV
Purkinje Network
.15
.14
.145
.155
Myocardium
Right Bundle Branch
.16
Left Bundle Branch
R
P
T
U
Q
S
0
.1
.2
.3
.4
Time (Seconds)
Auricles Contract
Wave Reaches Bundle Of His
Heart Rests.... Normally No "U" Wave Seen
Ventricles Contract
The ECG Measures The Gross Condition Of The Heart Muscle

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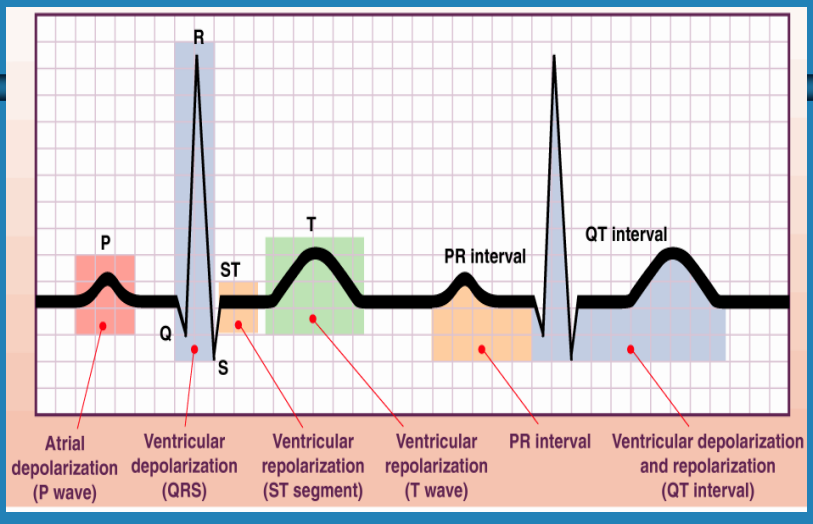
R
P
T
ST
PR interval
QT interval
Q
S
Atrial depolarization (P wave)
Ventricular depolarization (QRS)
Ventricular repolarization (ST segment)
Ventricular repolarization (T wave)
PR interval
Ventricular depolarization and repolarization (QT interval)

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The blood vascular system

- Composed of:
  - arteries-the largest, muscular, elastic-carry blood away from the heart to the arterioles
  - arterioles-small arteries
  - capillaries-very small, one cell thick-exchange between blood and tissues
  - venules-starts the return trip back to heart.
  - Veins-larger venules- carry blood back to heart.

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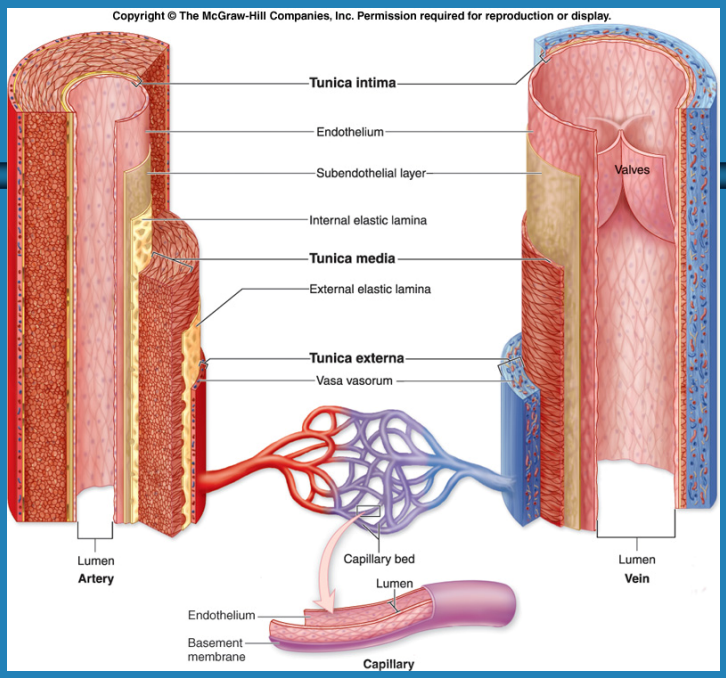

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Classification of blood vessels

- Elastic arteries eg aorta
  - wide lumen, elastic wall
  - damp pressure variations
- Muscular arteries eg other arteries
  - wide lumen, strong non-elastic wall
  - low resistance conduit
- Resistance vessels eg arterioles
  - narrow lumen, thick contractile wall
  - control resistance & therefore flow
  - allows regional redirection of blood
- Exchange vessels eg capillaries
  - narrow lumen, thin wall
- Capacitance vessels eg venules & veins
  - wide lumen, distendable wall
  - low resistance conduit, & reservoir
  - allows fractional distribution of blood

Redistribution of venous blood

- At rest, the blood volume is distributed.....
  - Majority is in veins, see diagram
  - veins are a large reservoir
- When more blood is needed elsewhere.....
  - The sympathetic nervous system stimulates the vessels causing vasoconstriction supplying blood to other parts of the body.
  - This causes an increased avenue back to the heart and shunted to the area in need.

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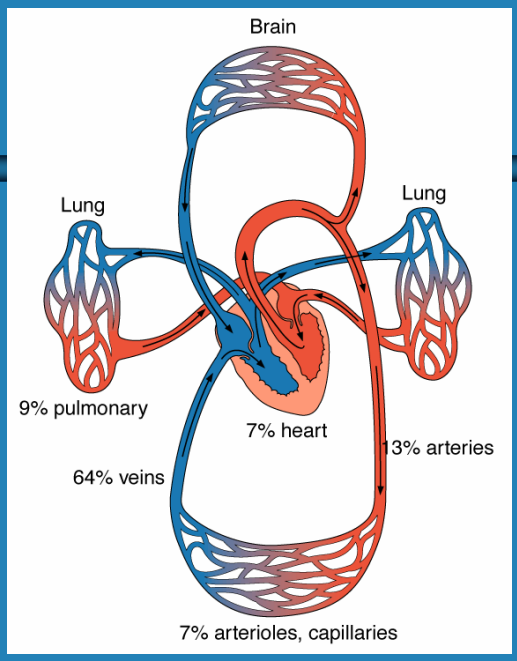

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Blood pressure

- It is the pressure exerted by the blood on the vessel walls. Arterial blood pressure.
- 120/80- systolic (during contraction) /diastolic (rest)
- systolic-pressure against the arterial wall
- diastolic-during rest. Blood moving thru the artery is not pressurized as great. Not moving by a forceful contraction.
- Mean arterial pressure=diastolic+(.333 (systol-diast)
- 120/80 is equal to 93mmHg.
- Blood pressure changes due to alterations in the arterioles, veins, and capillaries.
- Constriction increases; dilation decreases

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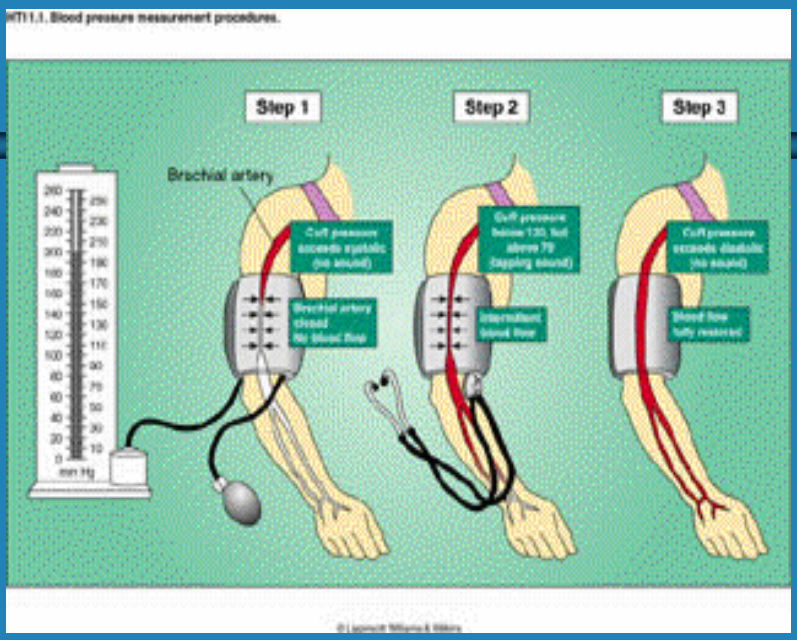

The Blood

- The third component in this system.
- Blood and lymph system
- Are the actual transportation of materials from the heart and tissues.
- Blood plasma filter out of the capillaries into the tissues becoming interstitial fluid. It returns to the capillaries after exchange, but less is returned to the capillaries. This is referred to as lymph cause the fluid enters the lymph capillaries.
  - Maintains proper body fluid.
  - During ex, increase in blood flow and pressure lead to more interstitial fluid.

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The blood (cont'd)

- Transportation
- temperature regulation
- acid base (pH) balance)

- We know about the transportation
- Blood picks up heat from the body core and directs it to the periphery or skin.
- Blood buffers the acid produced during anaerobic metabolism, maintaining the proper pH for efficient activity in metabolism.

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Blood volume and composition

- Depends on the size and training status
- Larger volumes assoc. With larger individuals and higher endurance
- 5-6 L in men; 4-5 L in women
- plasma 55-60% but can decrease 10% due to intense heat and exercise (dehydration, also) 90% of plasma is H20, 7% is plasma proteins, 3% is cellular nutrients (electrolytes, etc)
- Formed elements-40 to 45%: red blood cells (erythrocytes-make up 99% of element volume), white blood cells (leukocytes), and platelets (thrombocytes).
- WBC and platelets make up the remaining 1% of the element volume

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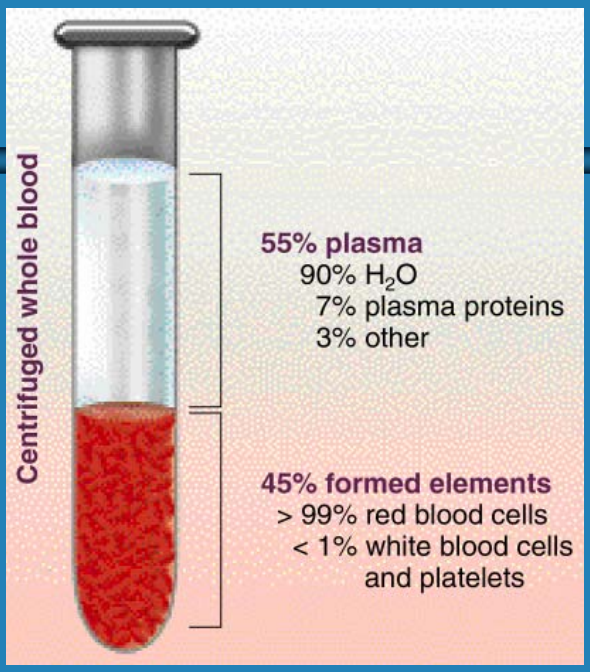

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Red blood cells

- Mature RBC have no nucleus and can't reproduce.
- Life span is 4 months but reproduction=destruction rate
- RBC carry O2 in the blood. Decreases in this cause major O2 function problems.
- Increased circulation and intense heat causes the cell to become destroyed during exercise.
- RBC transport O2 via hemoglobin. Globin is a protein. Hemo is pigment. Heme contains iron which binds O2.
- Each RBC has 250 million hemoglobin molecules each able to bind 4 O2 molecules. This equal 1 billion O2 molecules for 1 red blood cell. Carbon monoxide can affect this binding process.

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Blood viscosity

- Thickness of the blood.
- More viscous=greater resistance to flow.
- Normally 2X greater than water
- Higher hematocrits = greater resistance to flow.
- We would suspect O2 transport to increase with greater RBC, however if plasma doesn't increase, blood viscosity will decrease O2 transport.
  - This only occurs when hematocrit is ~60%
- When RBC count is down but plasma volume is up, this enhances the ability to transport O2 due to the decrease in viscosity. Unfortunately, anemia disrupts this once the RBC is down to a certain percentage.

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Cardiovascular Response to Exercise

- In intense exercise, pH decreases while H ions increase
- The CV system changes for supply and demand.
- Here is a look at the components of the CV system during exercise
  - HR
  - SV
  - Q
  - blood flow
  - blood pressure
  - The blood (itself)

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Heart rate

- Measure at the radial or carotid site.
- Reflects the amt of work that it is performing to meet the demands of the body with increasing work.
- Resting HR
  - 60 to 80 bts/min. Normally
  - sedentary canreach >100 bts/min
  - 28-40 bts/min in conditioned athletes (endurance)
- Anticipatory response-prior to starting exercise just knowing that you are going to have to start exercise.

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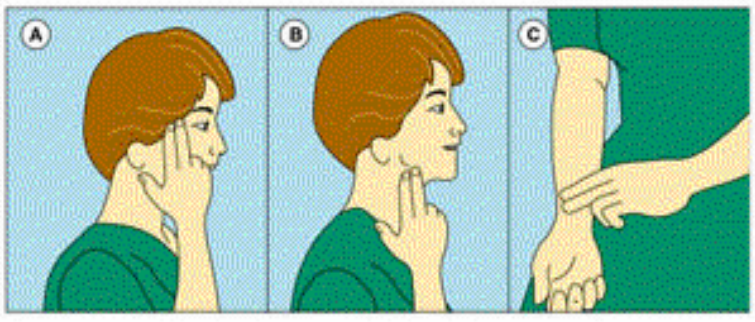
11.5A-C. Pulse rate taken.



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Stroke volume

- Changes to allow the heart to conduct more efficiently.
- It is determined by 4 factors:
  - volume of venous blood
  - ventricular distensibility
  - contractility of the ventricle
  - aortic or pulmonary artery pressure

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SV (cont'd)

- First two factors influence the filling capacity of the ventricle- How much blood is available for filling the ventricle and the ease at which it is filled at the available pressure.
- The last two deal with the ventricles' ability to empty determining the force the blood is ejected and the pressure against the walls of the arteries.
  - SV increases above resting values.
  - Increases to 40 to 60% of max
  - untrained- 60 ml to 120 ml
  - trained- 110 ml to 200 ml
- upright-SV is less, supine is greater (easier to heart)

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