BLOOD
&
BLOOD VESSELS

Cardiovascular System -- Blood

1. CV System: Blood, Heart and Blood Vessels

2. Blood: the red body fluid that flows through all the vessels EXCEPT the lymph vessels

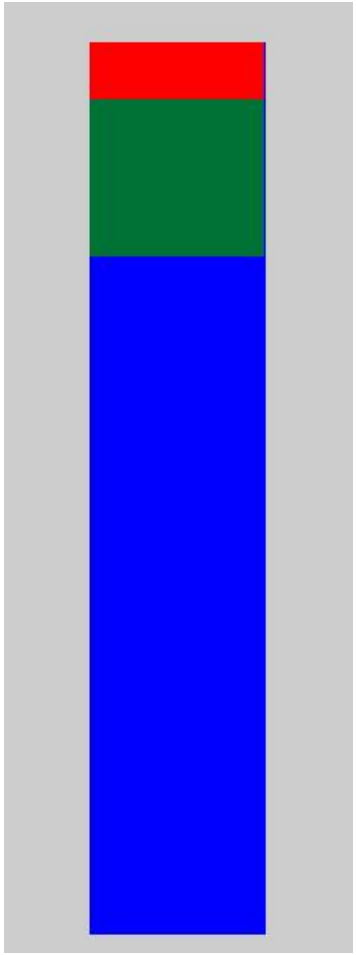
Blood: Physical Characteristics

1. Blood is viscous (“sticky”) – about 5 X > than water, i.e., blood flows at about 1/5 the rate of water flow
2. Requires physiological temperature for proper activity – about 37°C (98.6 °F), more or less
3. Arterial pH of 7.35-7.45 for optimal activity
4. Between 0.85% and 0.9% NaCl
5. Constitutes about 8% of BW_T
6. Males: 5-6 L; Females: 4-5 L

Blood Function

1. Transports oxygen from lungs to all cells in the body
2. Transports carbon dioxide from cells to lungs
3. Transports nutrients from digestive organs to cells
4. Transports waste products from cells to kidneys, lungs and sweat glands
5. Transports hormones from endocrine glands to target cells
6. Regulates pH via buffers and amino acids
7. Transports enzymes to specific cells
8. Regulates body temperature due to the volume of water (heat absorber/coolant)
9. Regulates water content of cells (1° via dissolved Na^+)
10. Prevents body fluid loss through clotting
11. Protects against toxins and foreign microbes via special combat unit cells

Blood Composition -- Plasma



- Plasma = the liquid containing dissolved substances – about 55% of blood
- Composition:
- Inorganic (1%): Na^+, K^+, Cl^-, HCO_3^-, Ca^{2+} -- Na^+ and Cl^- are the most plentiful
- Plasma Proteins (7-9%) – contribute to the viscosity of plasma, maintains dispersion of material, amino acid reserve (very unusual, but available), provides buffers
- Water (90%) – major constituent of plasma

Kinds of Plasma Proteins

Albumins	Globulins			Fibrinogens
Most plentiful	α	β	γ	Least plentiful
55-64%	~2%; 2-3 g/100mL of blood; largest proteins			~0.3%
~4-5 g/ 100 mL blood	General protein functions; bind molecules for transport		Immunoglobulins (antibodies; Ig's; Ab's)	0.15-0.3 g/100 mL blood
SOLUBLE in water	Lipids, T_4, Cu, Cortisol	Fe and cholesterol	Protect body from chemical challenges	Converted to Insoluble fibrin as blood coagulates
Smallest of the proteins	**Produced in liver**	**Produced in liver**	**Produced in plasma cells**	**Produced in liver**
Serves to bind substances for transport through plasma: drugs (barbiturates), hormones (thyroxine, T_4)			IgA: Secretions IgM: 1st to appear IgG: Natural/ acquired Ab (anti-HIV) IgD: Unknown IgE: Allergies	
Produced in liver				

Plasma Protein Concentrations

- Vary little in good health
- A/G ratio is approximately 2
- Protein concentrations decrease due to starvation, liver damage, renal disease

- The primary sign of decreased protein concentration is EDEMA
- Albumin helps to “carry” filtered plasma water back to the blood stream instead of remaining in the interstitial compartment (between the cells)
- Albumin serves to INCREASE the osmotic pressure of the blood
- In starvation, protein intake is decreased with secondary decreases in circulating amino acids’ concentration which leads to decreased plasma proteins
- Decreased plasma albumin results in plasma water staying out of the blood causing edema

Constituents Delivered to Blood Stream by Body Cells

Water and Electrolytes	Come from absorption across the gut
Amino acids	Due to protein digestion – also absorbed across the gut
ASIDE	“OPEN GUT” – alcoholics and newborns to about 2 weeks’ of age
Simple Sugars	From carbohydrate digestion, e.g., sucrose hydrolyzed to glucose and fructose

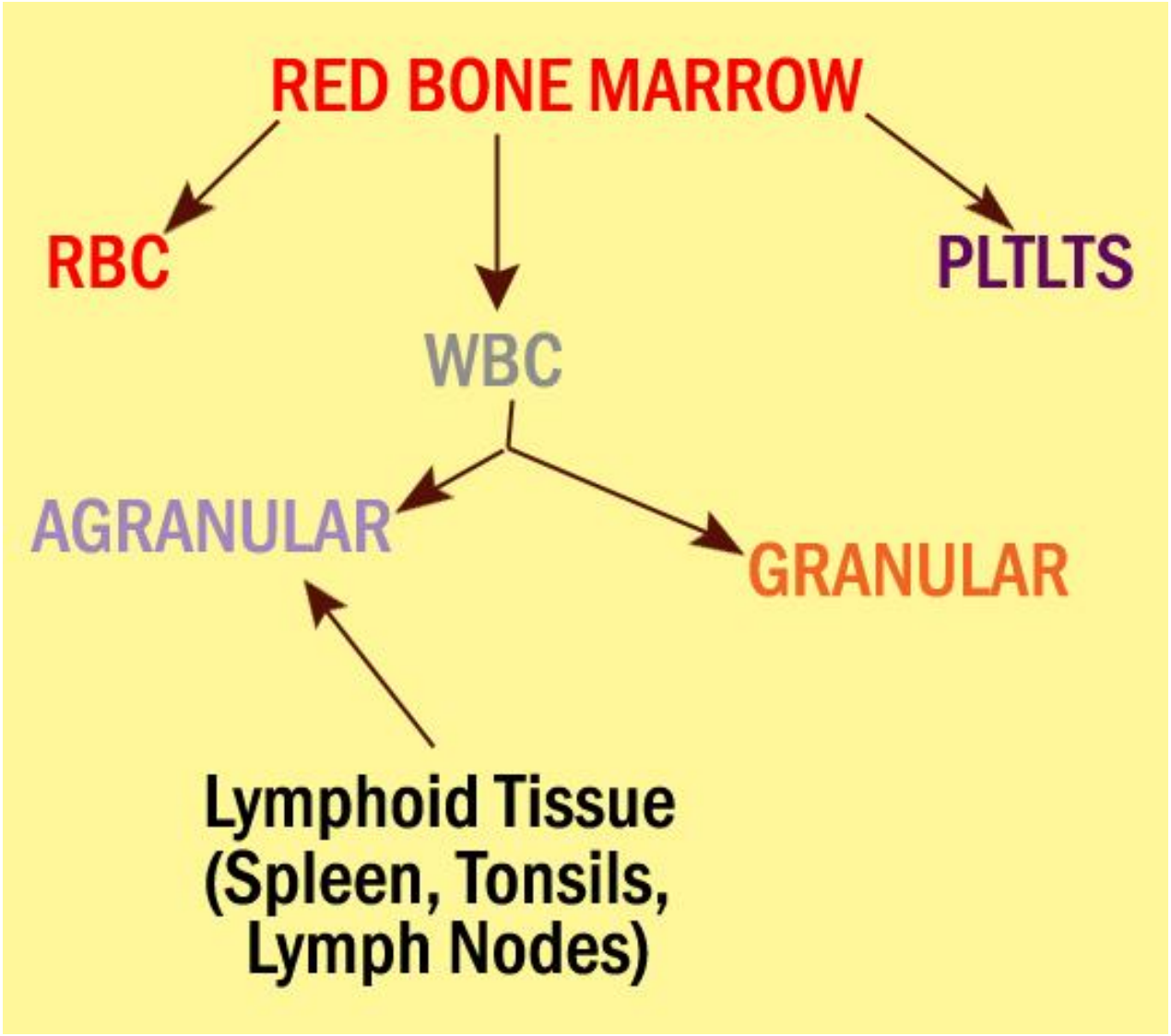
Blood Composition – Formed Elements

- Formed elements are cells and cell-like bodies suspended in the plasma – makes up about 45% of blood
- The process by which blood cells are produced is called hemopoiesis or hematopoiesis
- Red blood cell synthesis is called erythropoiesis
- White blood cell synthesis is called leuk(c)opoiesis

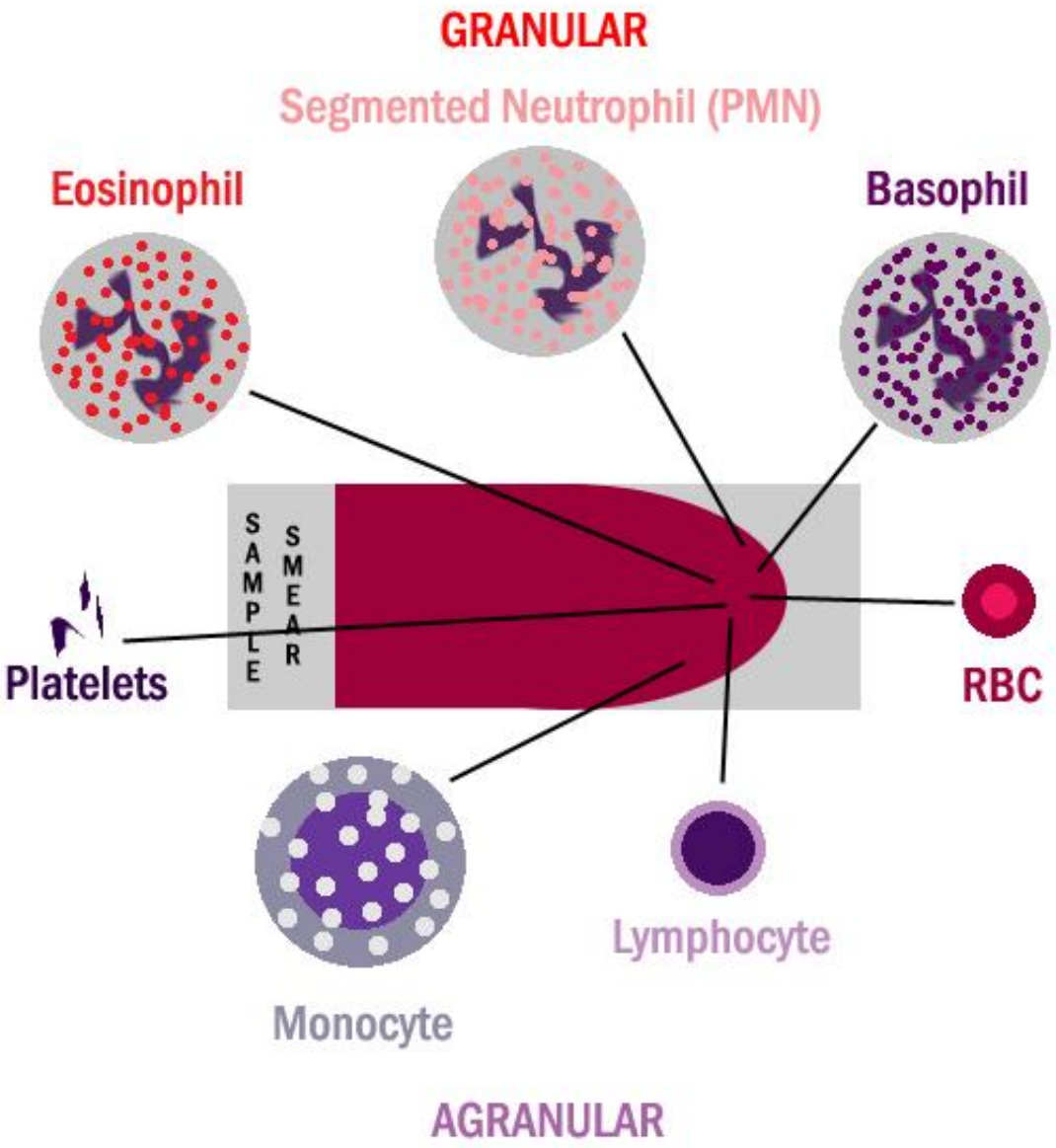
Blood Composition – Formed Elements -- 2

<table>
<tr><th colspan="4">Clinically Relevant Formed Elements</th></tr>
<tr><th>Formed Element</th><th colspan="2">Concentration or Amount</th><th>Notes</th></tr>
<tr><td rowspan="2">RBC
(Erythrocytes)</td><td colspan="2">♂ 5.4 X 10^6/mm^3</td><td rowspan="2">Differences due to ↑ metabolic rate in males and monthly blood loss via menses in females</td></tr>
<tr><td colspan="2">♀ 4.8 X 10^6/mm^3</td></tr>
<tr><td rowspan="2">WBC
(Leukocytes)</td><td><u>Granular WBC's</u></td><td colspan="2">Neutrophils: 60-70%
Eosinophils: 2-4%
Basophils: 0.5-1%</td></tr>
<tr><td><u>Agranular WBC's</u></td><td colspan="2">Lymphocytes: 20-25%
Monocytes: 3-8%</td></tr>
<tr><td>Thrombocytes
(platelets)</td><td colspan="3">250-400 X 10^3/mm^3</td></tr>
</table>

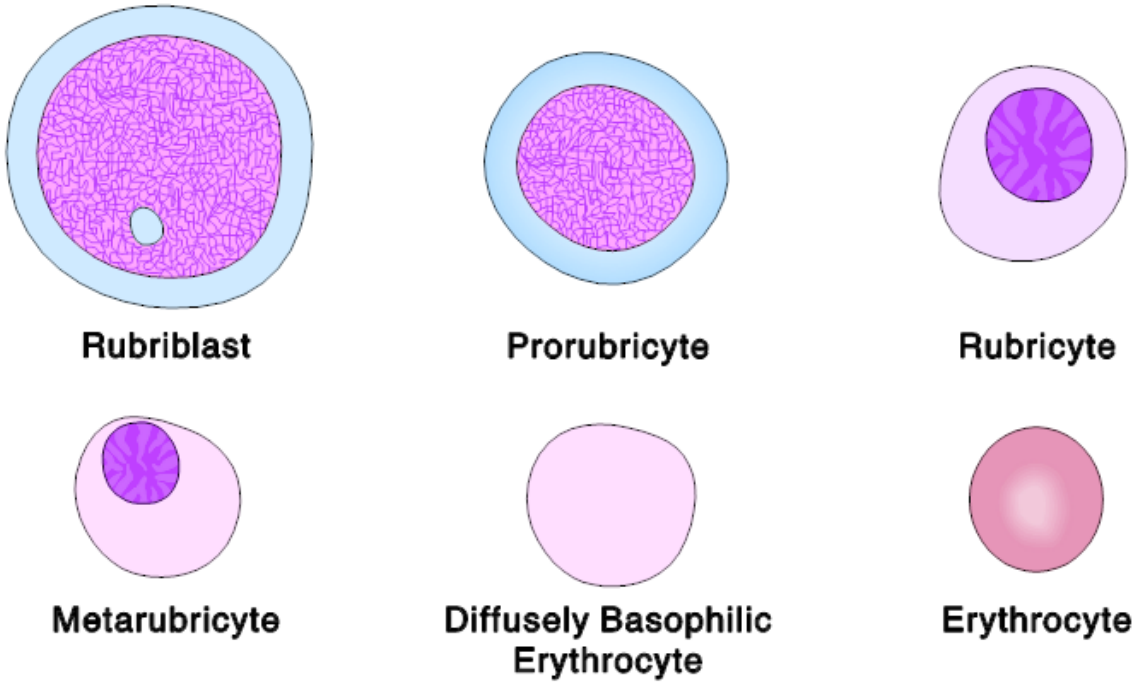
Hematopoiesis



Hemopoiesis



Erythropoiesis



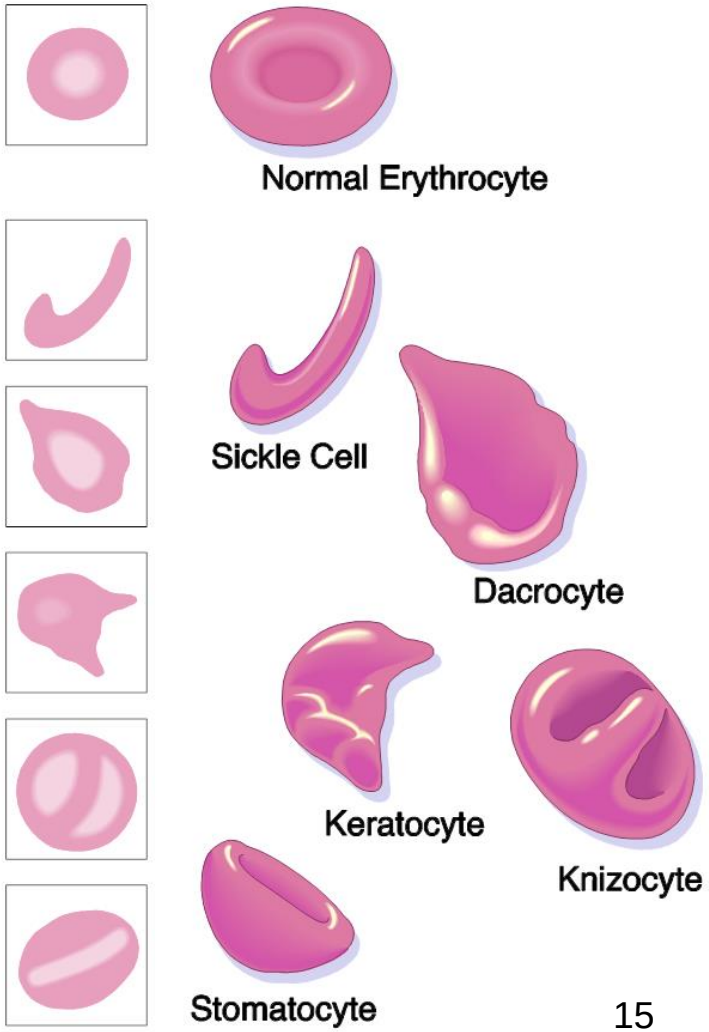
- In general, undifferentiated cells in red bone marrow are transformed into hemocytoblasts (stem cells) which develop into mature blood cells eventually
- Rubriblasts (proerythroblasts) differentiate into RBC at an ~ rate of 2 X 10^6 produced every second

Reticulocyte Count

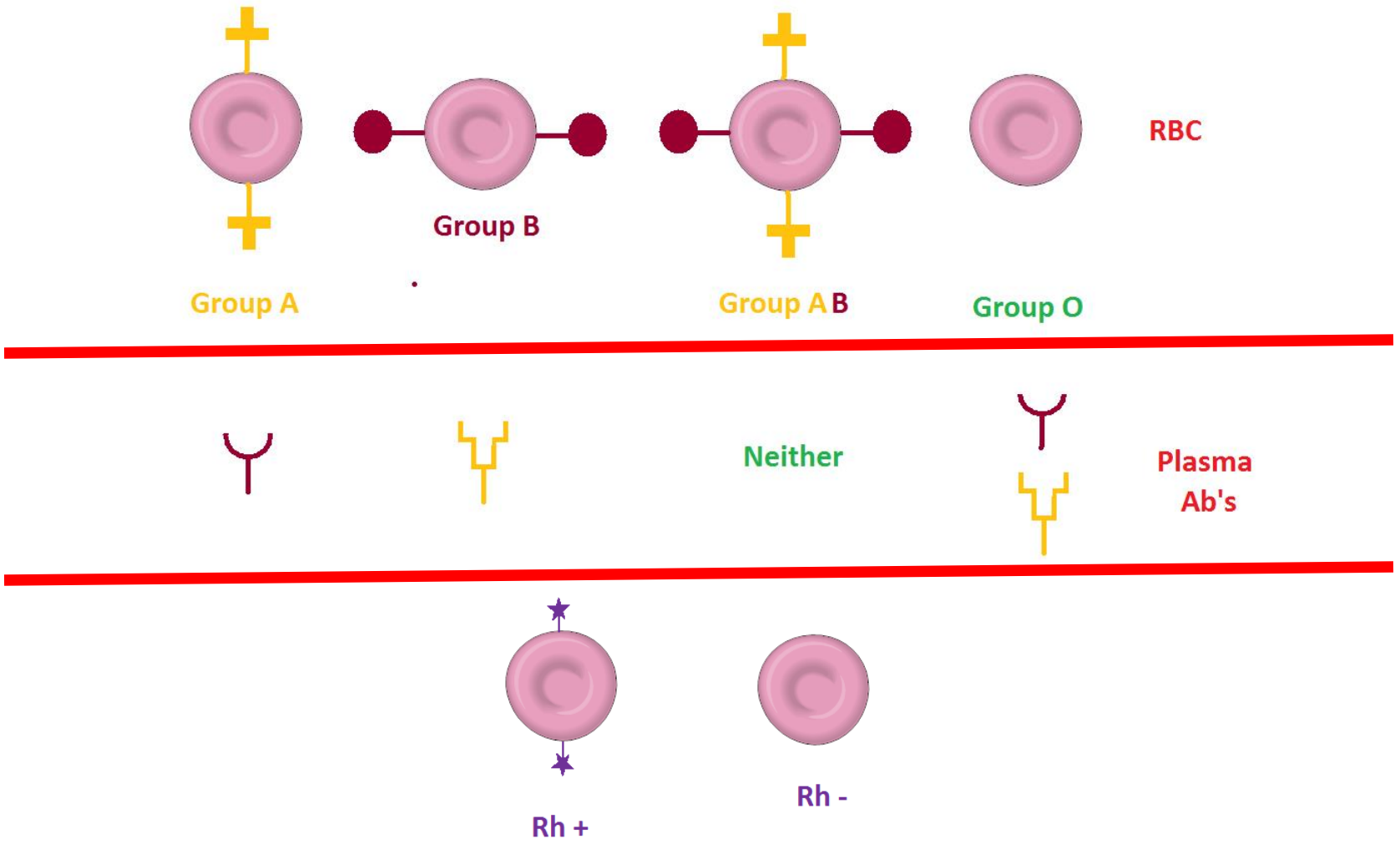
aka “stipled” RBC; gives information about the rate of erythropoiesis		
	< 0.5% total RBC (decreased erythropoiesis)	Anemia (pernicious or aplastic); kidney disease which effects production of erythropoietin. (B_{12} deficiency because are unable to absorb across gut due to no secretion of intrinsic factor from stomach.)
	> 1.5% total RBC (increased erythropoiesis)	Indicative of anemia, oxygen deficiency (COPD), bone marrow CA with secondary increase in erythropoiesis, hemorrhage, hemolysis; MAY be used to check on pernicious anemia after receiving B_{12} parenterally, i.e., the marrow is making up for lost time (peaks in 4-5 days – max production within 7 days)

RBC: Some Abnormalities

- Dacrocyte: A deformed RBC which is tugged to a nipple at one end, having squeezed through a reticuloendothelial system with increased connective tissue; also seen in normal peripheral blood smears as an artifact of slide preparation; such dacrocytes are usually easily recognized as their 'tails' all point in the same direction
- Keratocyte: An erythrocyte formed when haemoglobin denatures—as occurs in alpha-thalassemia or G6PD deficiency—and precipitates—due to oxidation—into clumps that stick to the red cell membrane
- Knizocyte: a red blood cell with two or more concavities (triconcave erythrocyte); associated with hemolytic anemia
- Stomatocyte: an abnormal red blood cell in which a slit or mouthlike area replaces the normal centra circle of pallor, often caused by edema

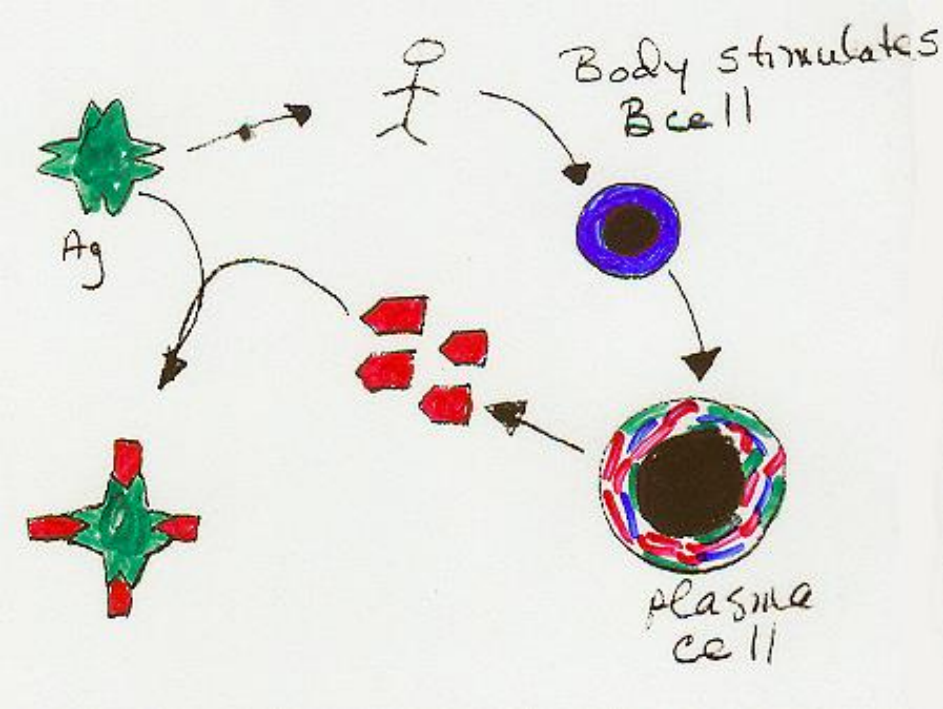


Blood Groups – A, B, AB, O

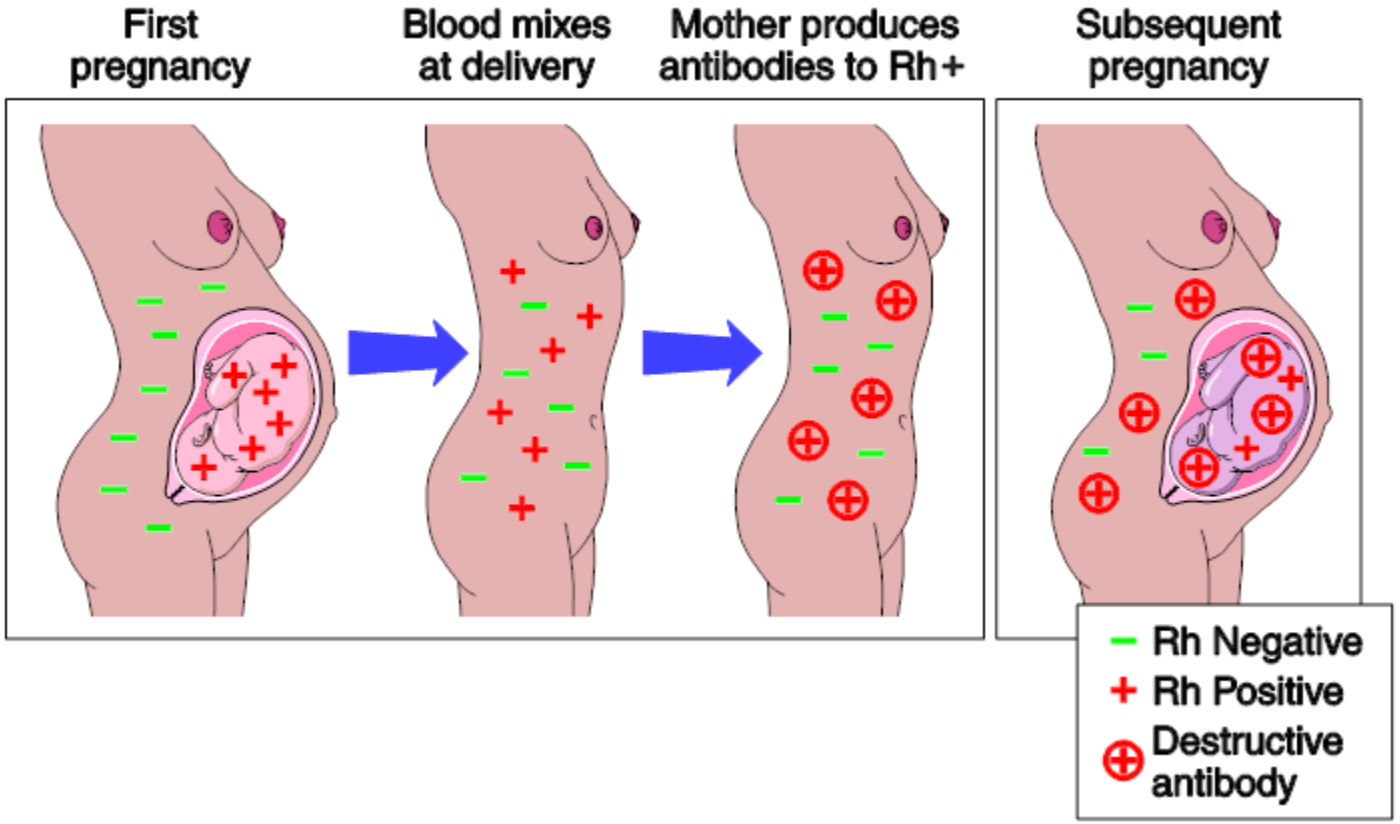


Blood Types

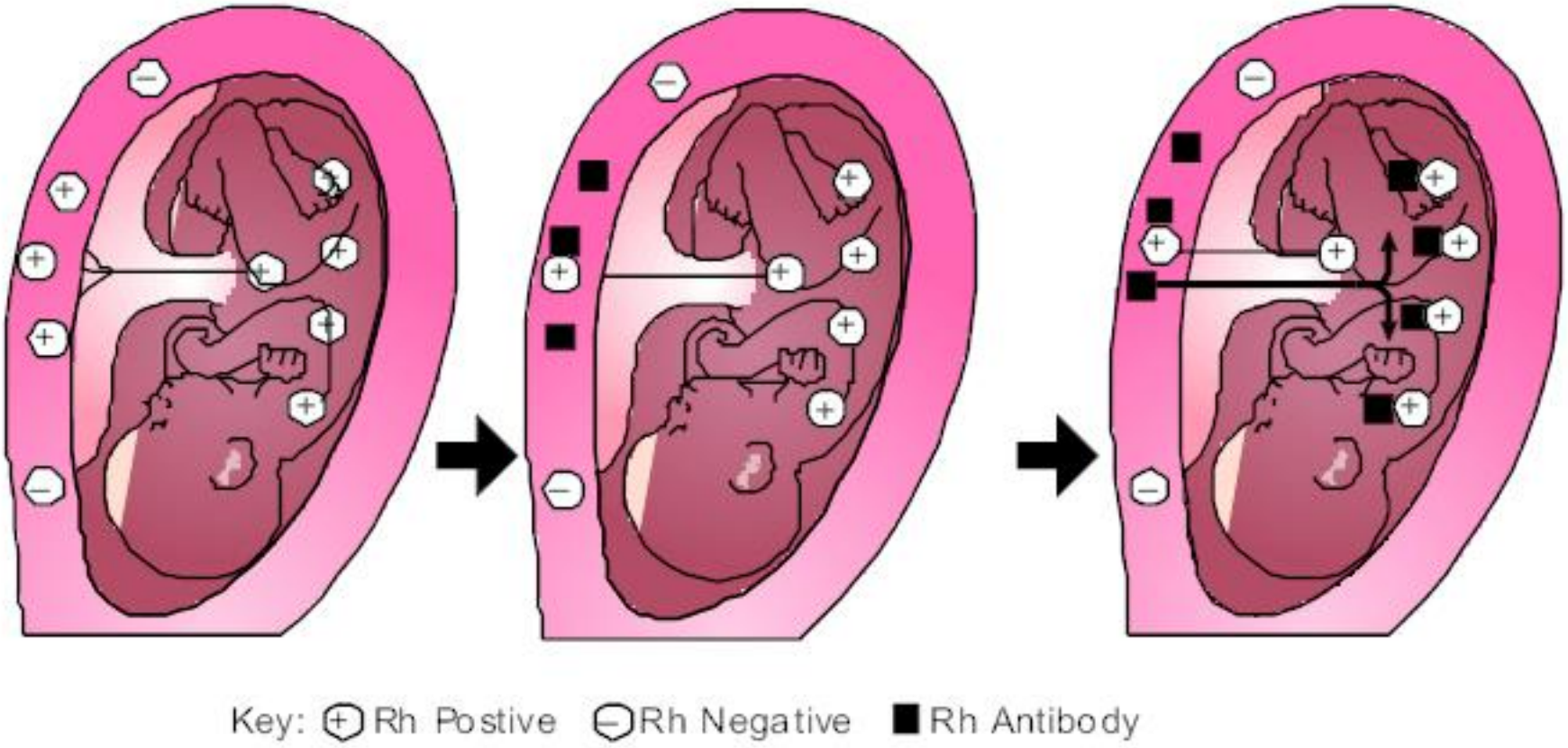
Ag-Ab Response



HDN: Erythroblastosis Faetalis



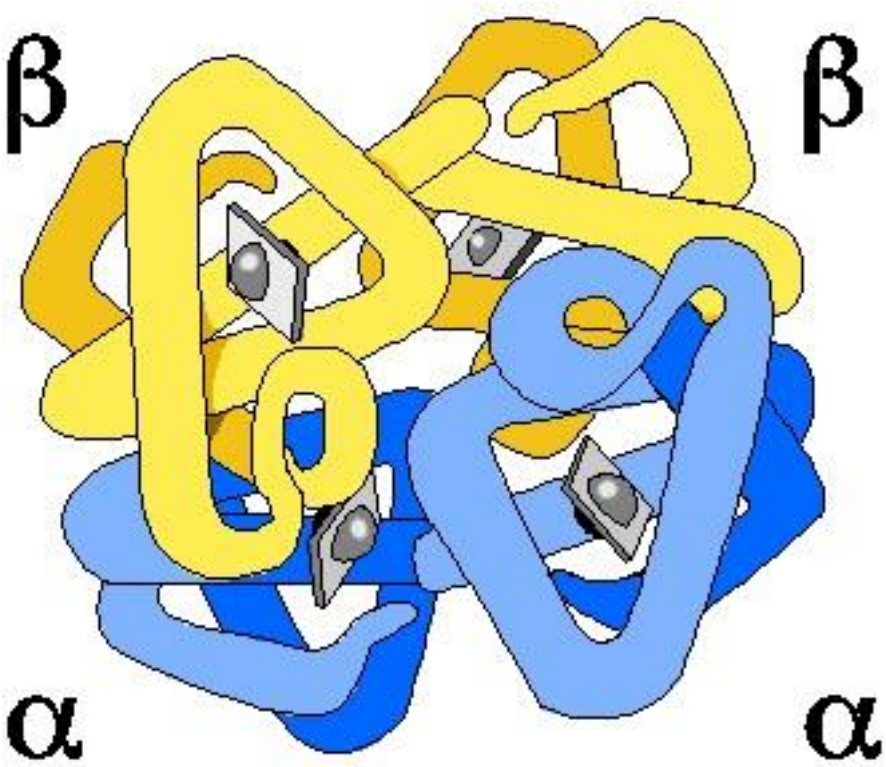
HDN 2



Red Blood Cells: Erythrocytes

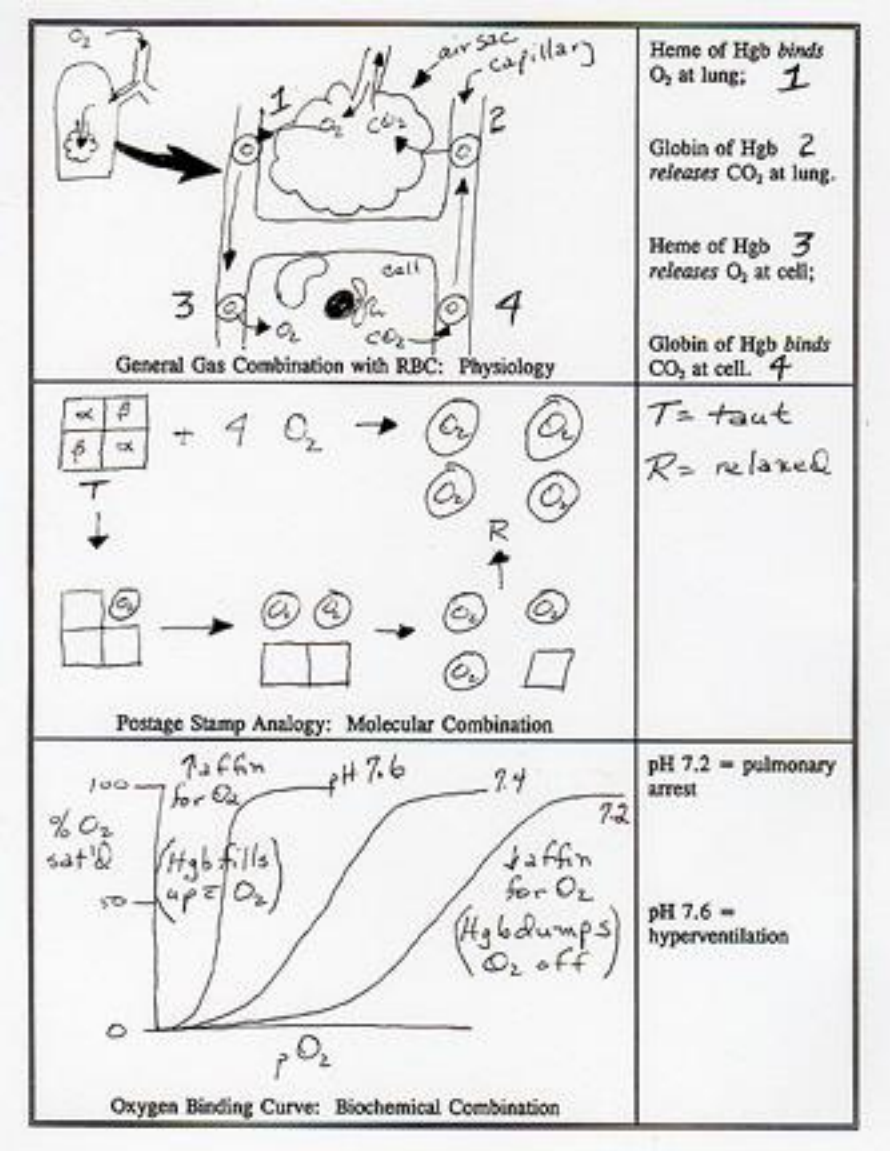
1. Biconcave discs (donut-like without the hole); increases the surface area for diffusion of gases.
2. Mature cells are very simple: LACK a nucleus, are not able to reproduce.
3. No complex metabolic activities.
4. Cell death occurs at about 120 days.
5. Mature RBC contain protein (stroma – network), some cytoplasm, lipids (including cholesterol) and a red pigment (hemoglobin; Hb or Hgb)
6. Hgb makes up about 33% of the cell volume and gives the red color to blood.
7. There are 280 X 10^6 molecules of Hgb/RBC
8. RBC combines with oxygen and carbon dioxide. HOW??????

Hemoglobin

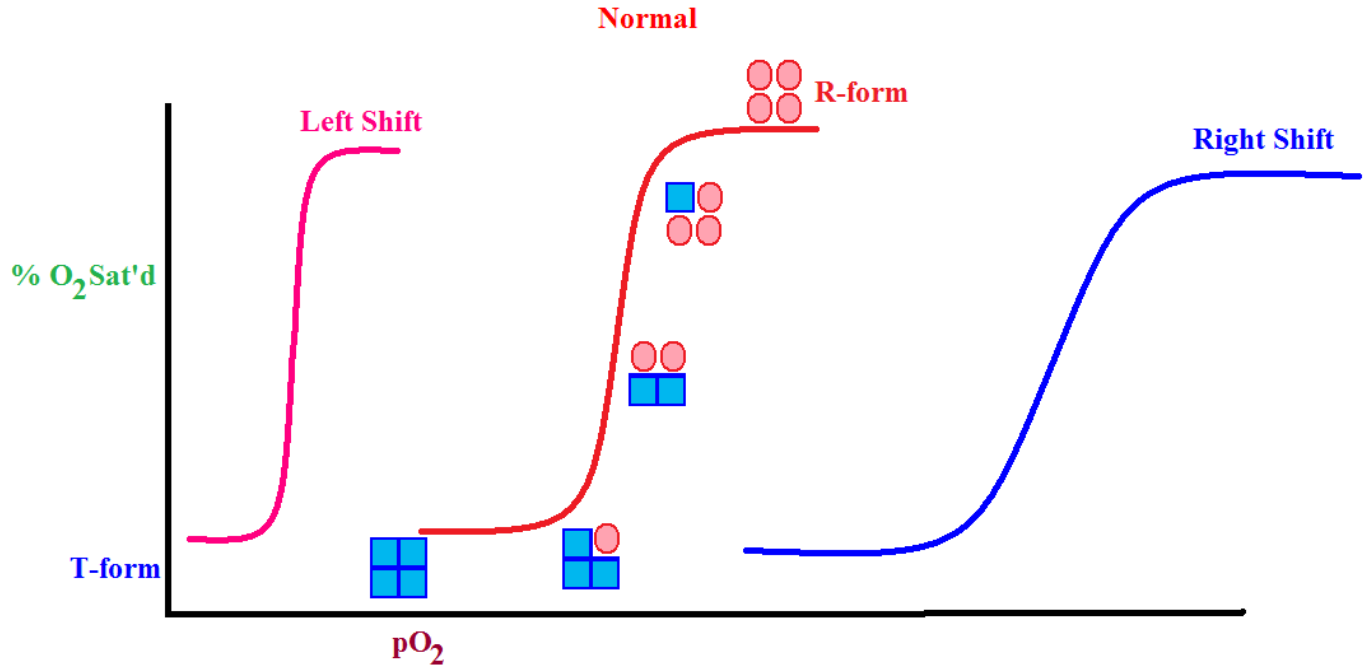


- Tetramer – salt-linked
- Each protein contains a heme group
- Each heme group binds Fe^{2+}
- NOT Fe^{3+}

How Does Hemoglobin (Hb or Hgb) Bind Oxygen?



How Does Hemoglobin (Hb or Hgb) Bind Oxygen and Act as a Buffer?



Oxygen Binding Curve Shift Factors – 1: "Bohr Effect"

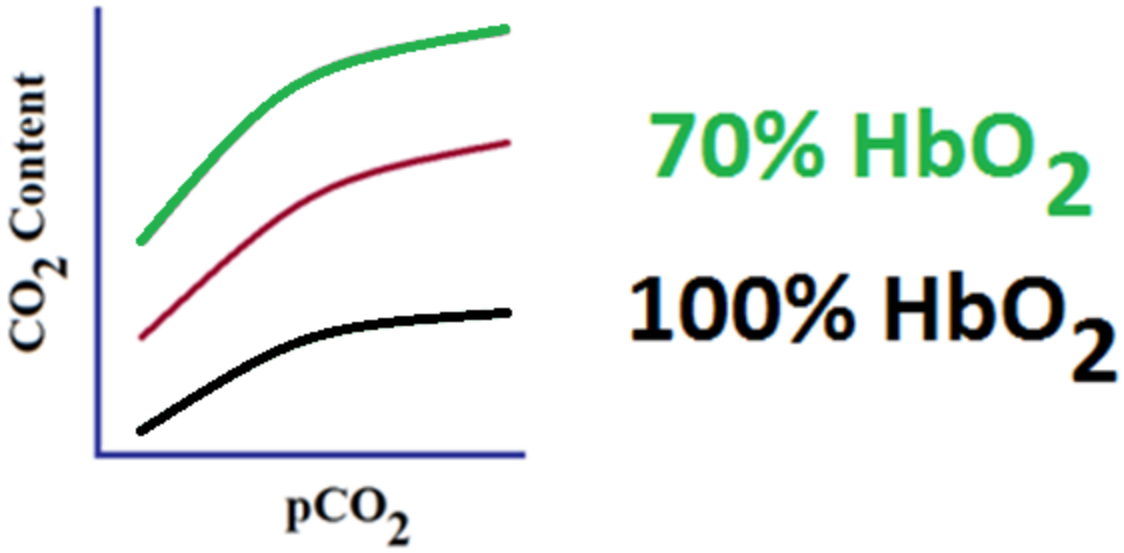
Left Shift

- Alkalosis
- ↓ 2,3-BPG
- Hypothermia
- Fetal Hb (> affinity for oxygen than adult Hb)
- ACD-preserved blood (acid citrate dextrose: ↑ O_2 carrying capacity of RBC >2-3 days old (in bag) with ↑Hb – PROBLEM: doesn't release O_2 to tissues for 18-24 hours after infusion)

Right Shift

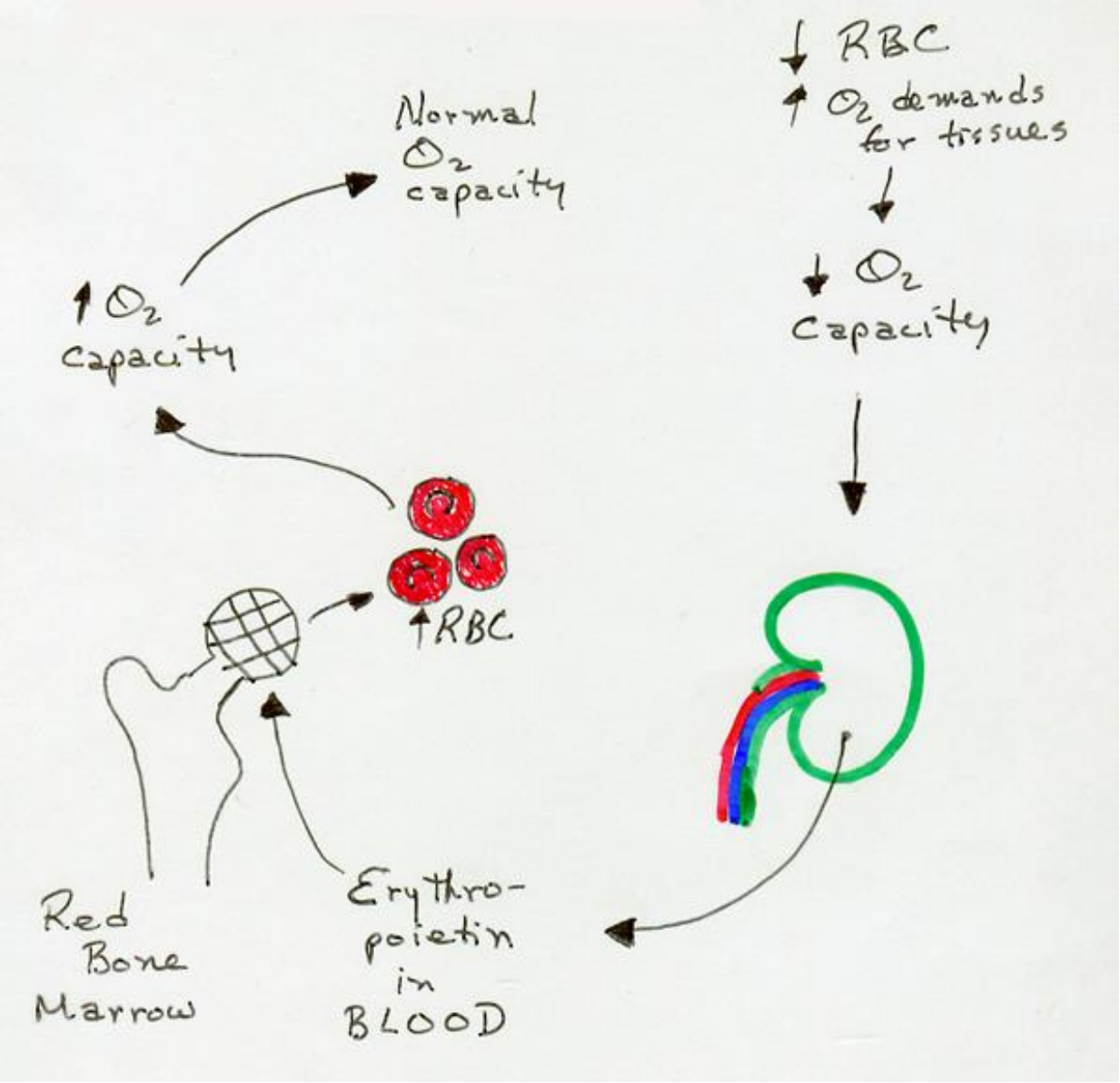
- Acidosis
- ↑ 2,3-BPG
- Fever
- Anemia
- Hypoxia

Haldane Effect

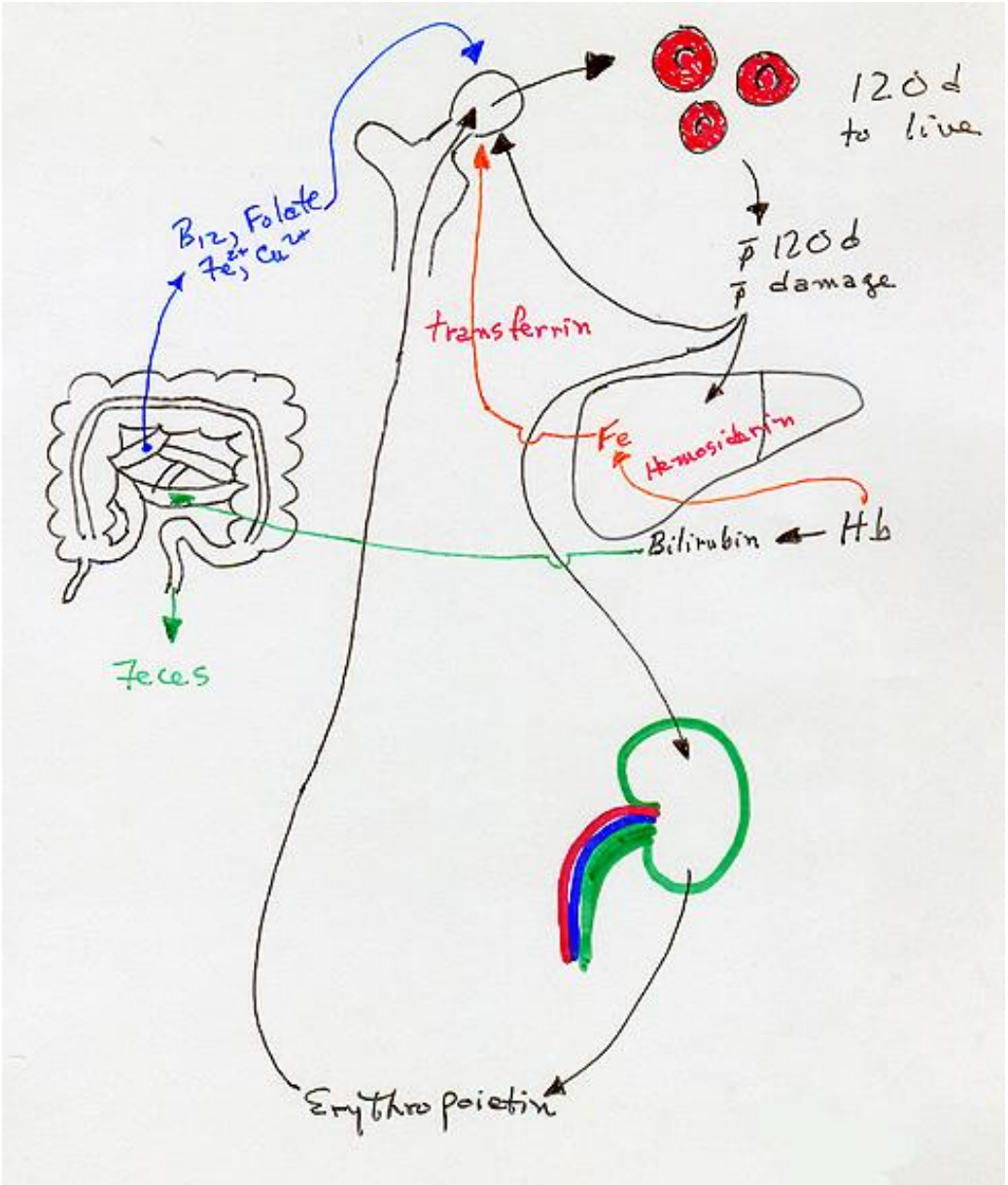


- With ↑$Hb(O_2)_4$, at some pCO_2 → ↓CO_2 content of blood
- With ↓ $Hb(O_2)_4$ at some pCO_2 → ↑CO_2 content of blood
- "Back side of Bohr effect" – greater effect than the Bohr effect on gas transport.

Regulation of Erythropoiesis



Erythrocyte Life Cycle



Hemoglobin A1c

Derivatives of hemoglobin

- **Oxyhemoglobin** (oxyHb) = Hb with O_2
- **Deoxyhemoglobin** (deoxyHb) = Hb without O_2
- **Methemoglobin** (metHb)= Fe^{3+} instead of Fe^{2+} in heme groups
- **Carbonylhemoglobin** (HbCO) =
  CO binds to Fe^{2+} in heme in case of CO poisoning or smoking.
  CO has 200x higher affinity to Fe^{2+} than O_2.
- **Carbaminohemoglobin** (HbCO2) =
  CO_2 is non-covalently bound to globin chain of Hb.
  $HbCO_2$ transports CO_2 in blood (about 23%).
- **Glycohemoglobin** (HbA1c) is formed spontaneously by nonenzymatic reaction with Glucose. People with DM have more HbA1c than normal (› 7%). Measurement of blood HbA1c is useful to get info about long-term control of glycemia.

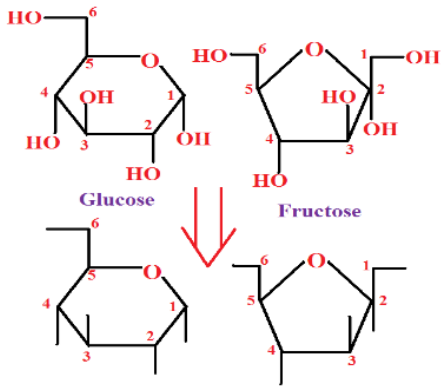
Source: https://slideplayer.com/slide/4463168/ accessed 11 Jan 2019

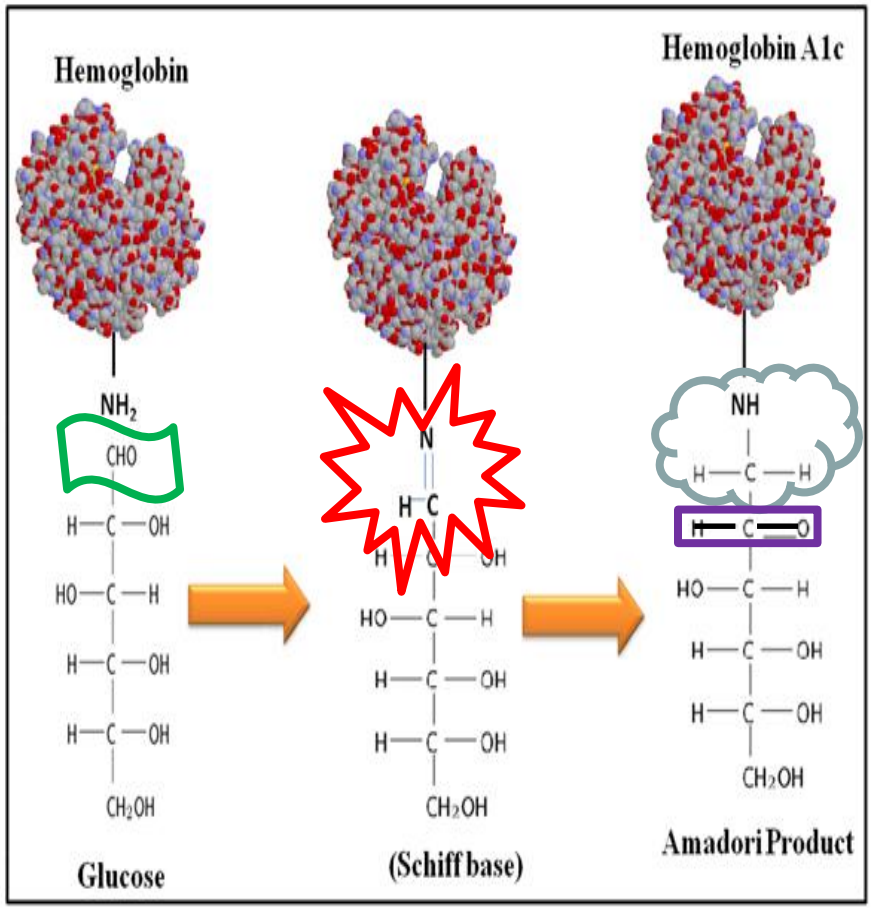
Hemoglobin A1c

- The origin of the naming derives from Hemoglobin type A being separated on cation exchange chromatography.
  - The first fraction to separate, probably considered to be pure Hemoglobin A, was designated HbA_0, the following fractions were designated HbA_{1a}, HbA_{1b}, and HbA_{1c}, respective of their order of elution.
- Hemoglobin A1c is the most abundant minor hemoglobin component in human erythrocytes, and is formed by the condensation of glucose with the N-terminal amino groups of the beta-chains of Hb A.
  - A1c is a specific glycated hemoglobin (Hb) that is modified at the N-terminal valine residue of each ß-chain of Hb A.
  - HbA_{1c} is a measure of the beta-N-1-deoxy fructosyl component of hemoglobin.
- Hb A1c is slowly formed during the 120-day life-span of the erythrocyte
- Patients with shortened erythrocyte life-span due to hemolysis had markedly decreased levels of Hb A1c.

- Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4368825/ accessed 11 Jan 2019
- Source: https://www.aacc.org/publications/cln/articles/2015/april/considerations-in-choosing-hemoglobin-a1c-methods accessed 11 Jan 2019
- Source: https://en.wikipedia.org/wiki/Glycated_hemoglobin **accessed 11 Jan 2019**
- Source: *Miedema K (2005). "Standardization of HbA1c and Optimal Range of Monitoring". Scandinavian Journal of Clinical and Laboratory Investigation.* ***240****: 61–72*

- **Schiff Base: A Schiff base is a compound with the general structure $R_2C=NR'$ ($R' \neq H$).**
- Amadori Product: The Amadori rearrangement is an organic reaction describing the acid or base catalyzed isomerization or rearrangement reaction of the N-glycoside of an **aldose** or the glycosylamine to the corresponding **1-amino-1-deoxy-ketose**.
- Fisher vs Hayworth projections



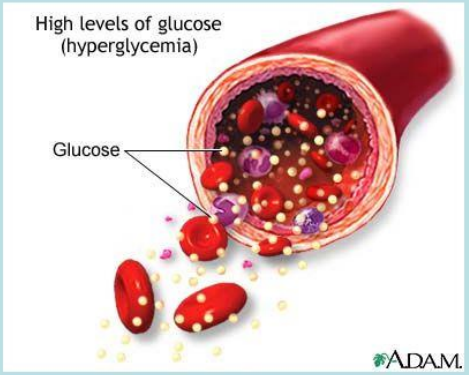


- Resource: http://www.drcarman.info/kem220lx/2akem220.pdf, Slides 12-13
- Source: https://en.wikipedia.org/wiki/Schiff_base, Accessed 16 Jan 2019, 0935 hours PDT
- Source: https://en.wikipedia.org/wiki/Amadori_rearrangement, Accessed 16 Jan 2019, 0936 hours PDT
- Source: https://www.slideshare.net/shrekym/fructosamine-and-hg-a1c, Accessed 16 Jan 2019, 0939 hours PDT

- NOTE: “Too much **GLUCOSE**” …

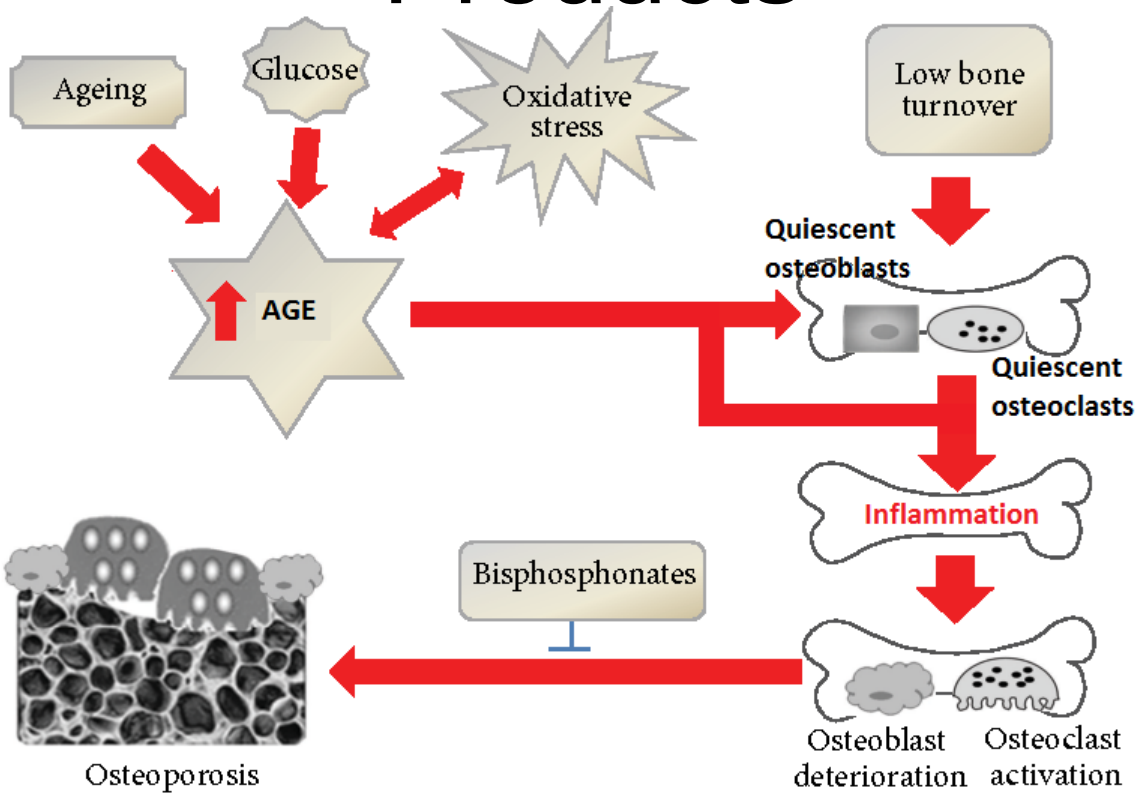
High Blood Sugar

- If there is too much sugar, it sticks to the hemoglobin in the blood, creating jagged red blood cells which damage the blood vessels as they flow through the body.

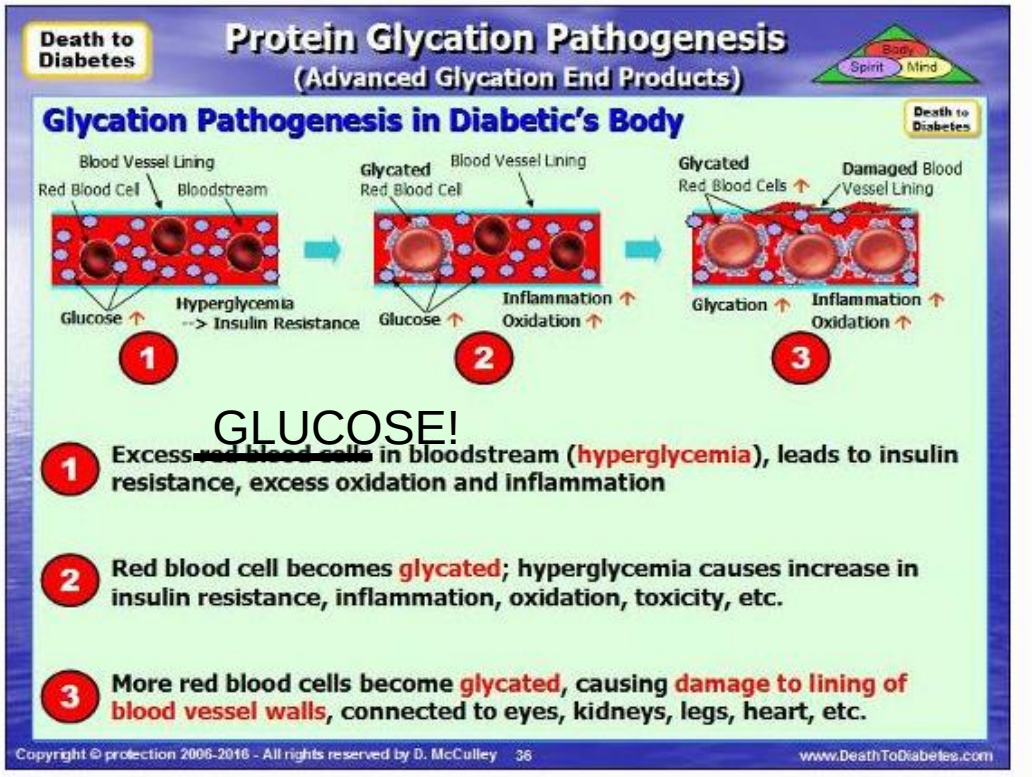


- Source: https://slideplayer.com/slide/4463074/, Accessed 16 Jan 2019, 1406 hours PST

AGE: Advanced Glycation Products



https://www.semanticscholar.org/paper/Advanced-Glycation-End-Products-Play-Adverse-in-Sanguineti-Puddu/d326a259477072ed41b8f6509da3b12dbe28009b , Accessed 16 Jan 2019, 1508 hours, PST



- Source: https://www.deathtodiabetes.com/insulin-resistance-inflammation-oxidation-glycated.php, Accessed 16 Jan 2019, 1413 hours PST

- ROS = reactive oxygen species
- Sarcopenia = loss of muscle tissue as a natural part of the aging process
- RAGE = a single trans-membrane multi-ligand receptor, belongs to the immunoglobulin superfamily; RAGE receptors are physiologically mainly expressed on vascular, endothelial and smooth muscle cells and on monocyte/ macrophage membranes; **Receptor for AGEs**
- A very strong expression of RAGE and high levels of AGEs have been found in inflammatory conditions including osteoarthritis, and rheumatoid diseases such as rheumatoid arthritis and fibromyalgia. Such increase affects especially tissues with a slow turnover, including tendons, bones, cartilage, and skin and could lead to the tissue stiffness and fragility in these structures.
- Moreover, a strong association between RAGE-expression and AGE levels and the severity of Alzheimer's disease has been proposed by different authors.

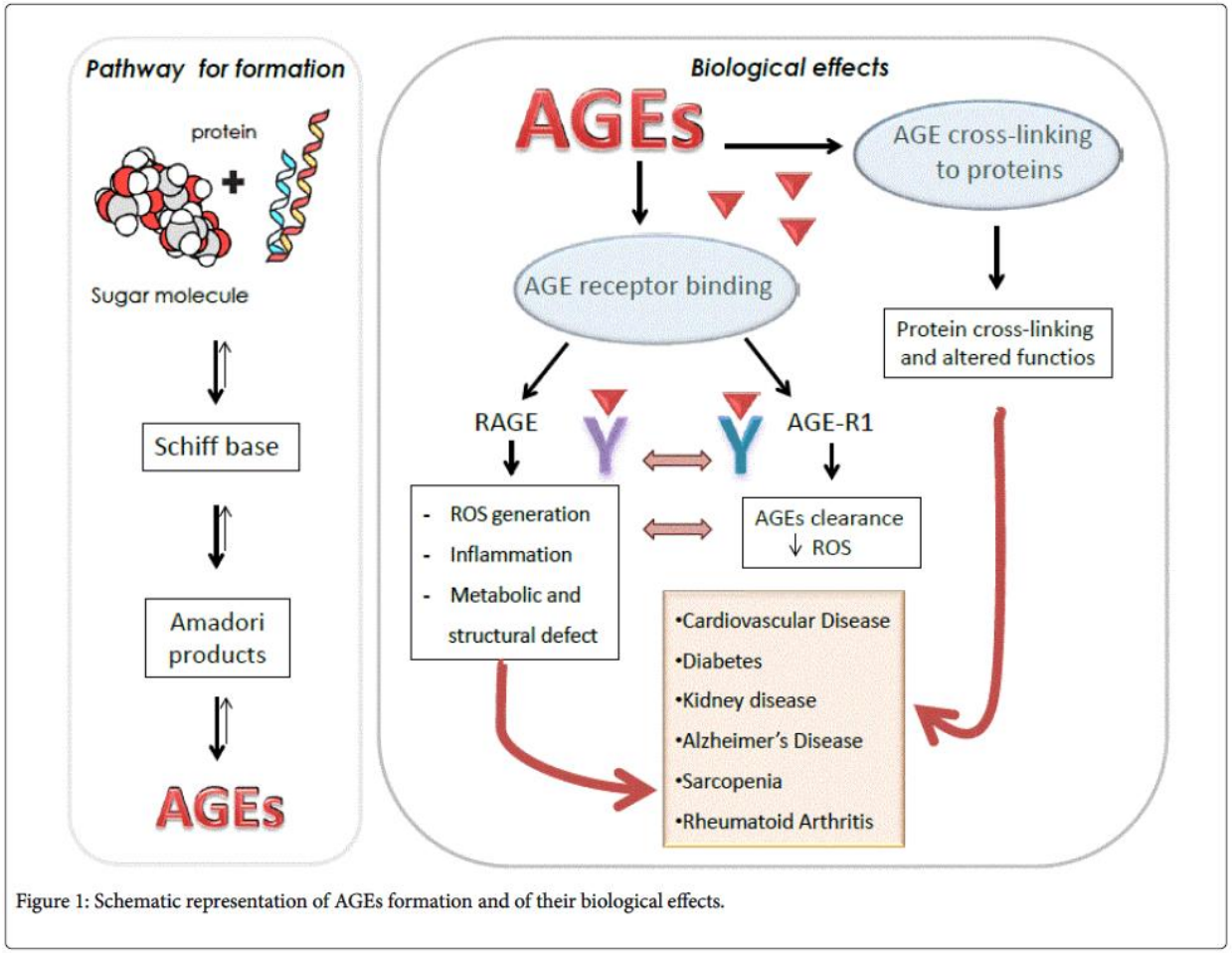


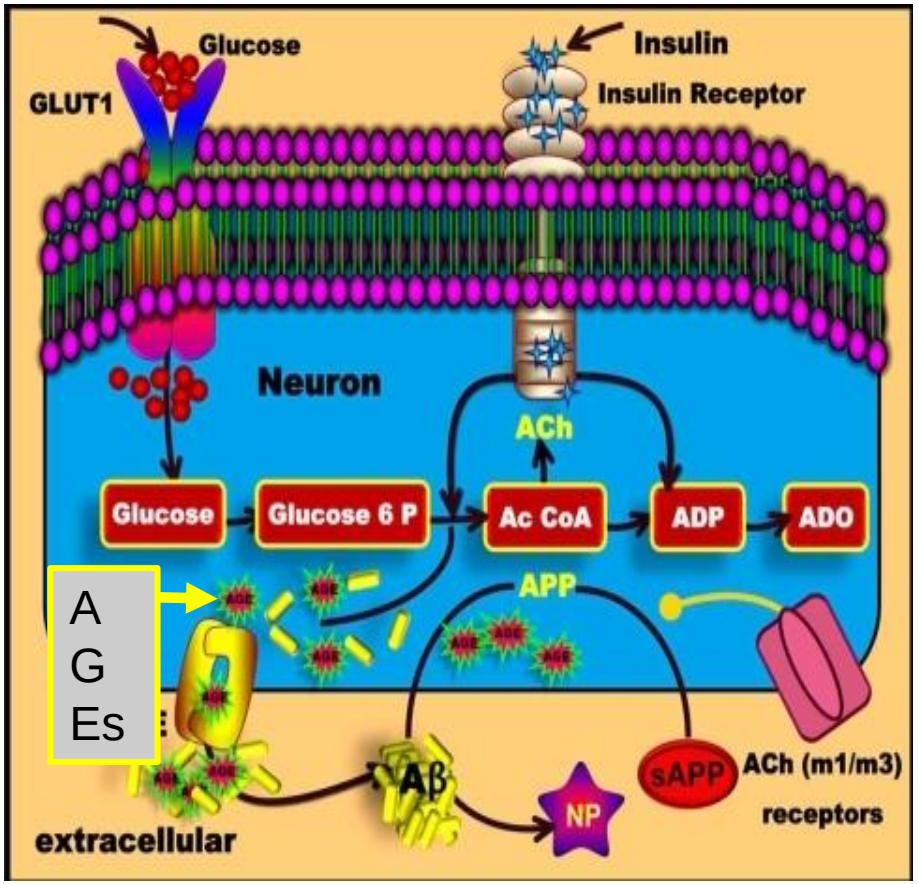
Figure 1: Schematic representation of AGEs formation and of their biological effects.

Source: https://www.omicsonline.org/open-access/advanced-glycation-end-products-ages-in-food-focusing-on-mediterranean-pasta-2155-9600-1000440.php?aid=63980, Accessed 16 Jan 2019, 1517 hours, PST

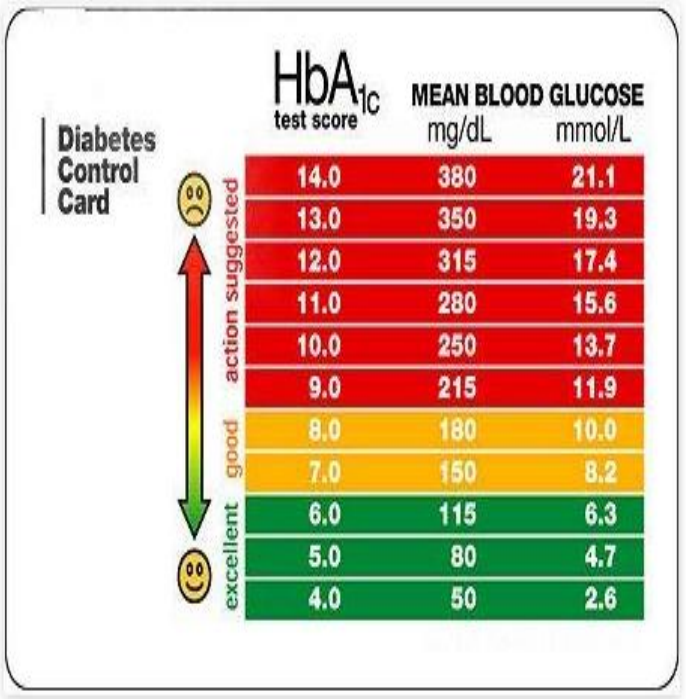
- GLUT1 is a transmembrane protein responsible for the facilitated diffusion of glucose across a membrane.
- This is an example of a membrane protein facilitating passive transport in which net flux can only occur down a concentration gradient of glucose.
- Therefore …, GLUT1 cannot move glucose from a region of low glucose concentration to a region of high glucose concentration.
- GLUT1 is highly abundant in the mammalian erythrocyte membrane where it can rapidly equilibrate glucose between the cytoplasm of the erythrocyte and the blood plasma.
- GLUT1 is also found in brain tissues.
- GLUT1 can also transport mannose, galactose, and glucosamine.
- Aβ = Amyloid beta -- forms neuritic plaques

Source = https://openi.nlm.nih.gov/detailedresult.php?img=PMC2864432_TOBIOCJ-4-29_F6&req=4, Accessed 16 Jan 2019, 1547 hours PST

Source = https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/glut1 , Accessed 16 Jan 2019, 1548 hours PST

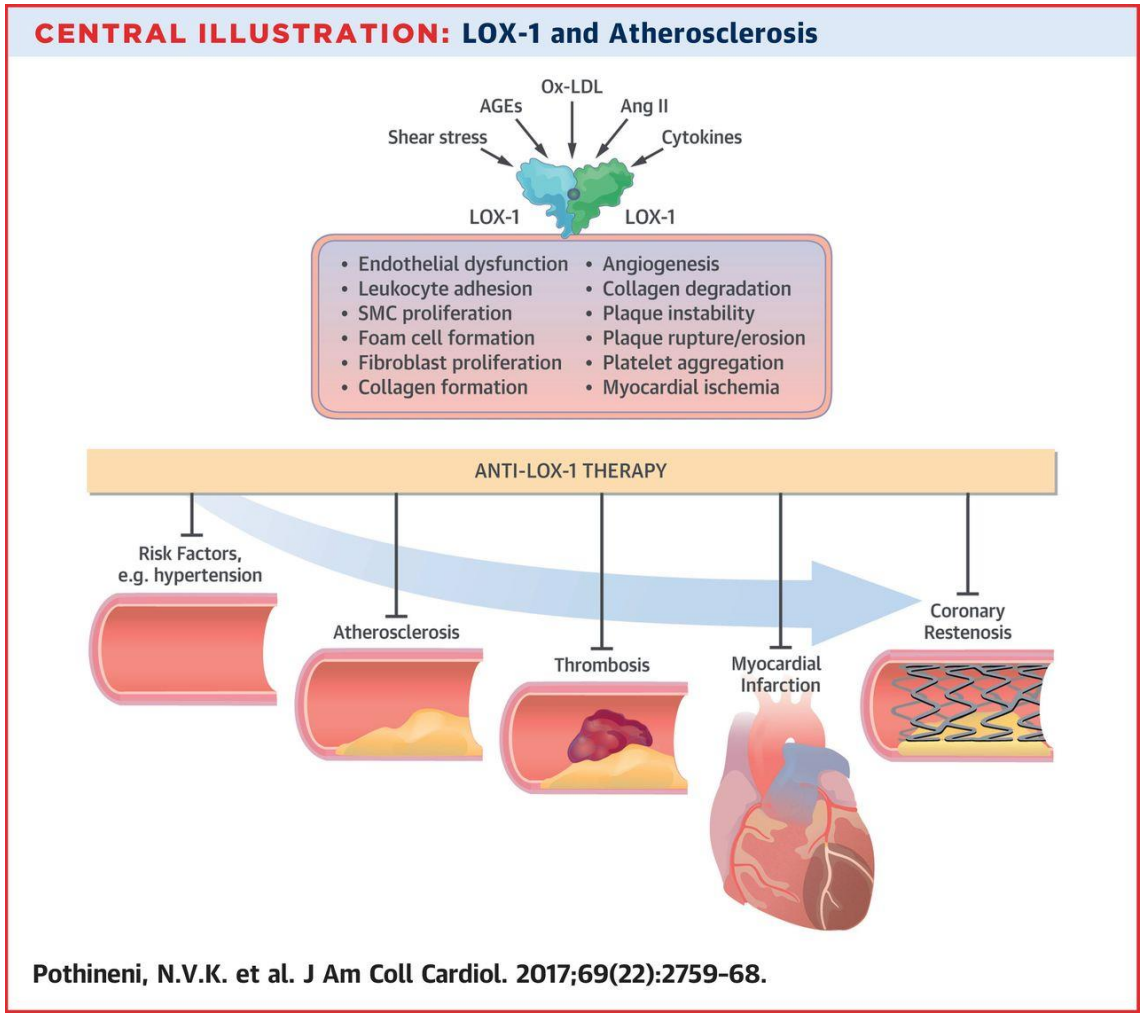


- 5.6 is the upper limit of Excellent (per the graphic) normally;
- For a diabetic, 4.0 can be disastrous
- Normal fasting blood glucose runs around 77-114 mg% -- each lab has its own normal values/ranges



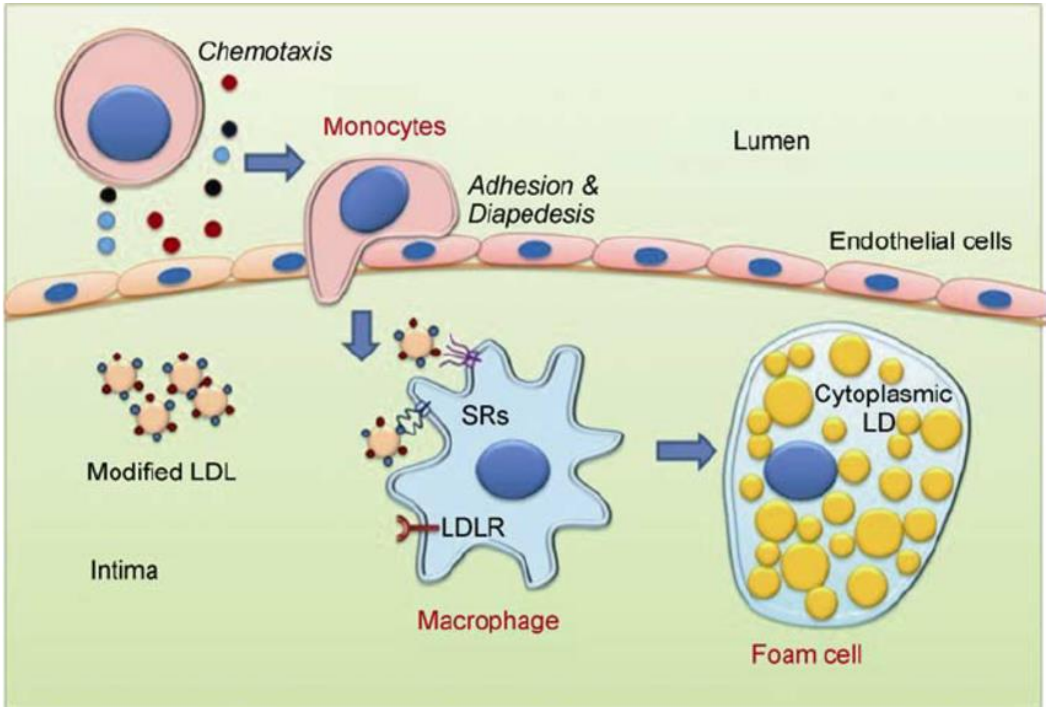
- Source: https://www.diabeticlive.com/diabetes-101/a1c-levels/, Accessed 16 Jan 2019, 1248 hours PST

- LOX = lectin-like oxidized low-density lipoprotein receptor
- Lectin = any of a class of proteins which bind specifically to certain sugars and so cause agglutination of particular cell types
- SMC = smooth muscle cell
- CML = carboxymethyl lysine
- APP = Amyloid precursor protein



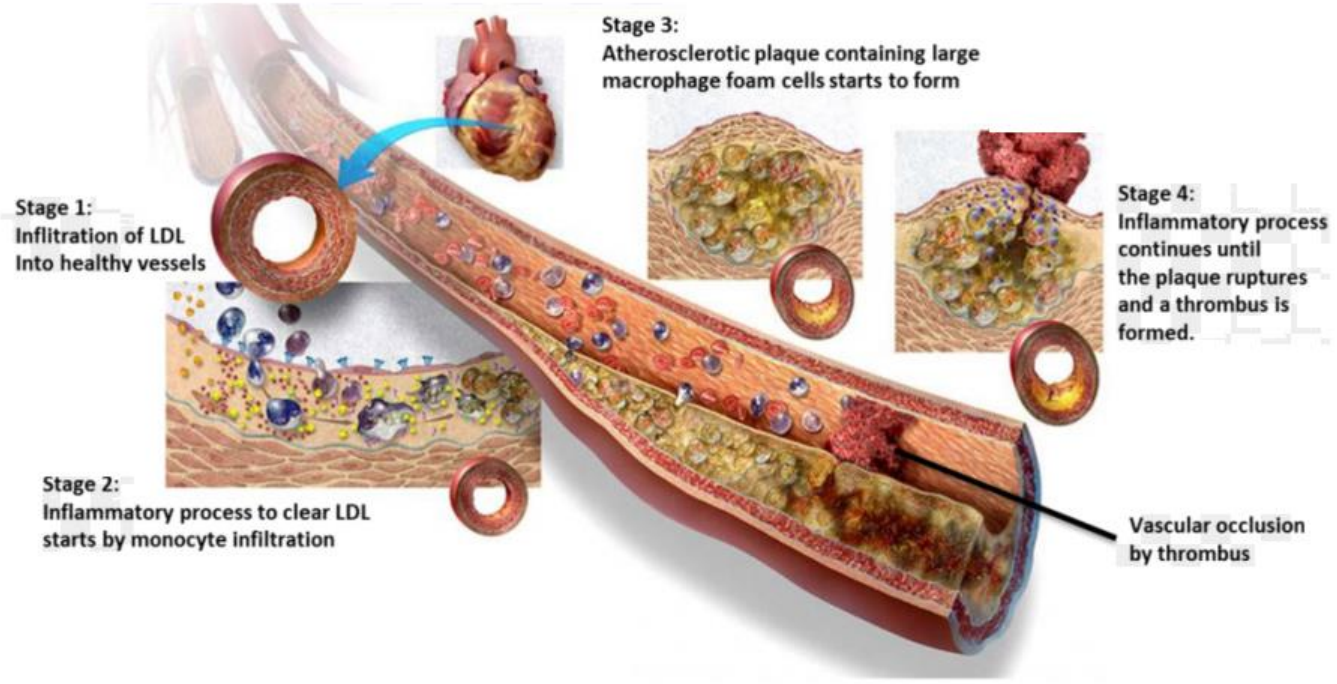
Source: http://www.onlinejacc.org/content/69/22/2759/F5, Accessed 16 Jan 2019, 1527 hours PST

- Structure of the foam cell. Foam cell is a swollen macrophage filled with lipid inclusions. This cell serve as the hallmark of early stage atherosclerotic lesion formation. Cholesterol-loaded cells (foam cells) make plaque unstable, leading to heart attacks and strokes.
- SR = scavenger receptors



- **Source:** https://www.researchgate.net/figure/Schematic-representation-of-sequential-events-involved-in-the-migration-of-monocytes-and_fig1_221976374, **Accessed 16 Jan 2019, 1601 hours PST**
- Source: https://www.123rf.com/photo_100422908_stock-vector-structure-of-the-foam-cell-foam-cell-is-a-swollen-macrophage-filled-with-lipid-inclusions-this-cell-.html, Accessed 16 Jan 2019, 1602 hours PST

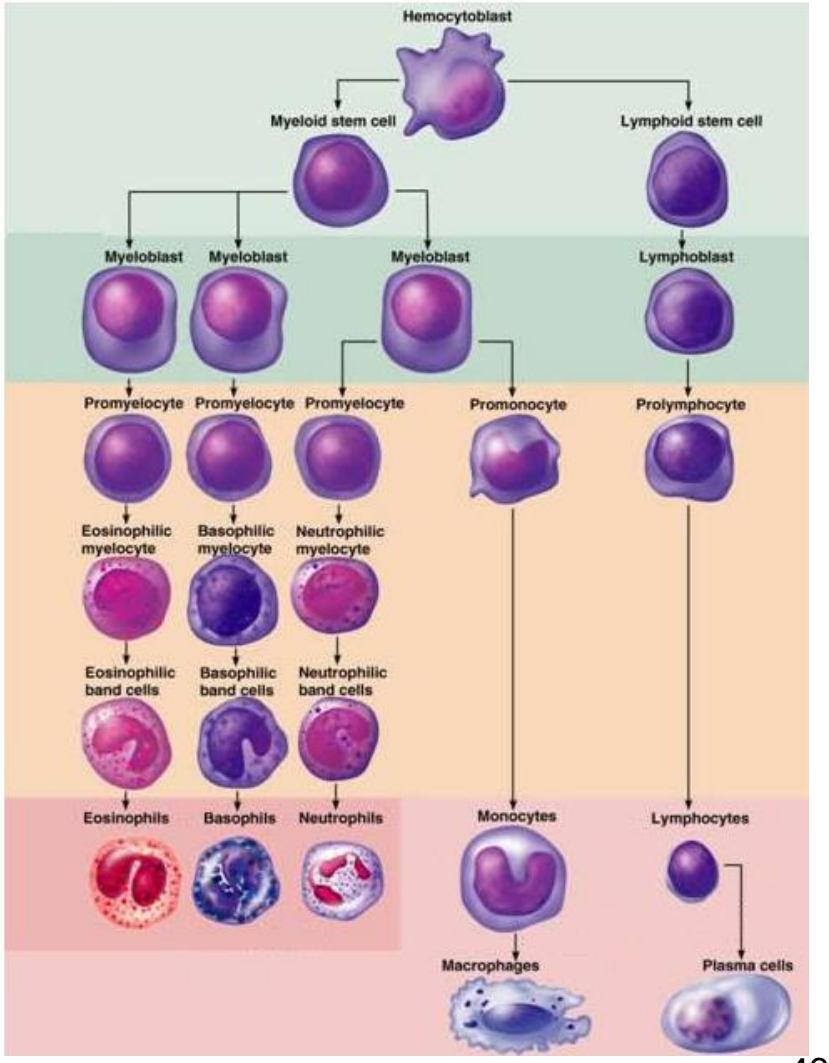
Foam Cells and Vascular Atherogenesis



Source: https://www.kisspng.com/png-arteriosclerosis-low-density-lipoprotein-foam-cell-3902531/ , Accessed 16 Jan 2019, 1608 hours PST

Leukopoiesis

- In general, undifferentiated cells in red bone marrow are transformed into hemocytoblasts (stem cells) which develop into mature blood cells eventually
- Lymphoblasts differentiate into lymphocytes
- Monoblasts differentiate into monocytes
- Myeloblasts differentiate into neutrophils, eosinophils, basophils
- WBC life span is only a couple of days due to the limit on the number of bacteria it phagocytizes.



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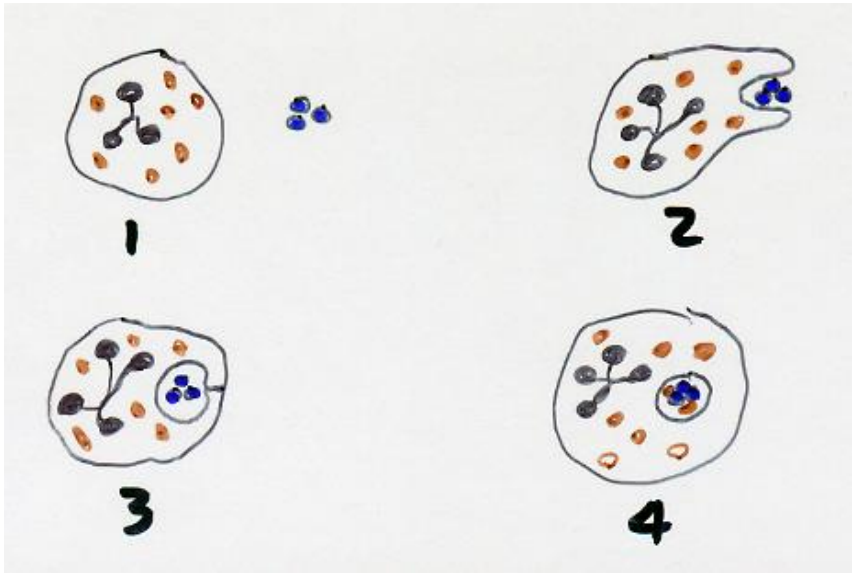
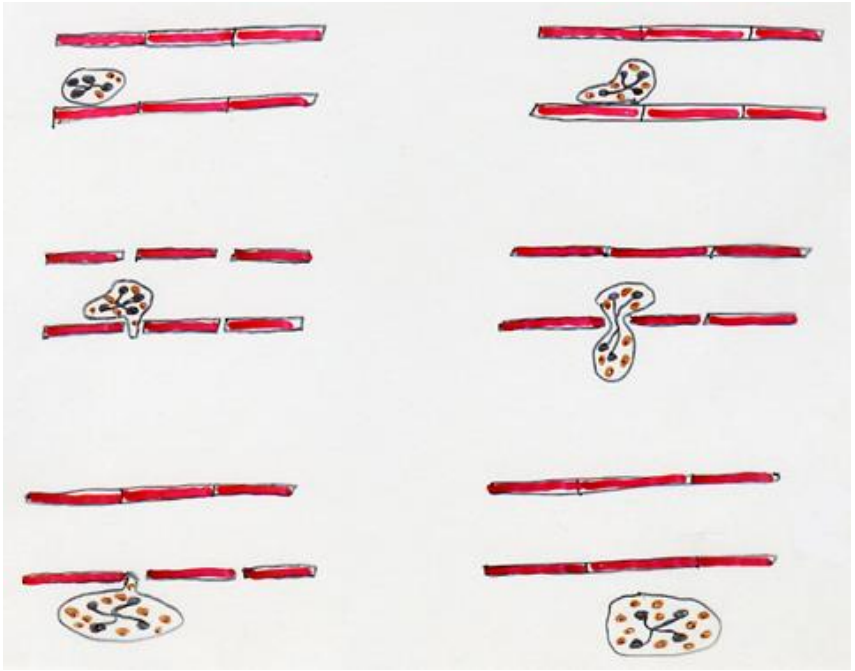
Leuk(c)ocytes

Unlike RBC, WBC HAVE nuclei – DON'T have Hgb. RBC/WBC is about 700/1.	
Granular WBC	Agranular WBC
From red bone marrow	PLUS lymphoid tissues
Cytoplasmic granules	NONE
Lobed nuclei	Spherical nuclei
Neutrophils, eosinophils, basophils	Lymphocytes, monocytes
FUNCTIONS/DEFINITIONS	
Leukocytosis: elevated # of WBC; "usually" >10,000 is pathological	**Leukopenia**: Decreased # of WBC; "usually" < 5000 is pathological
To combat inflammation/infection	Some WBC are actively phagocytic (ingest bacteria and dispose of dead matter).
Most WBC have the ability to crawl through capillary walls and connective epithelial tissue = diapedesis, aka cell walking	

WBC Activities

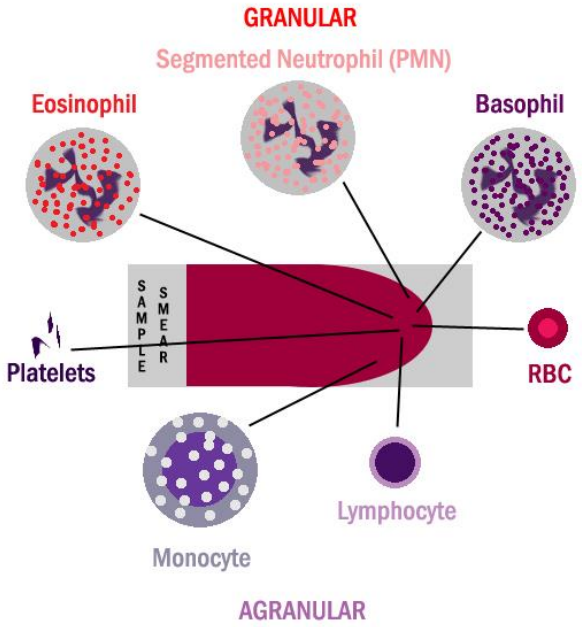


Phagocytosis



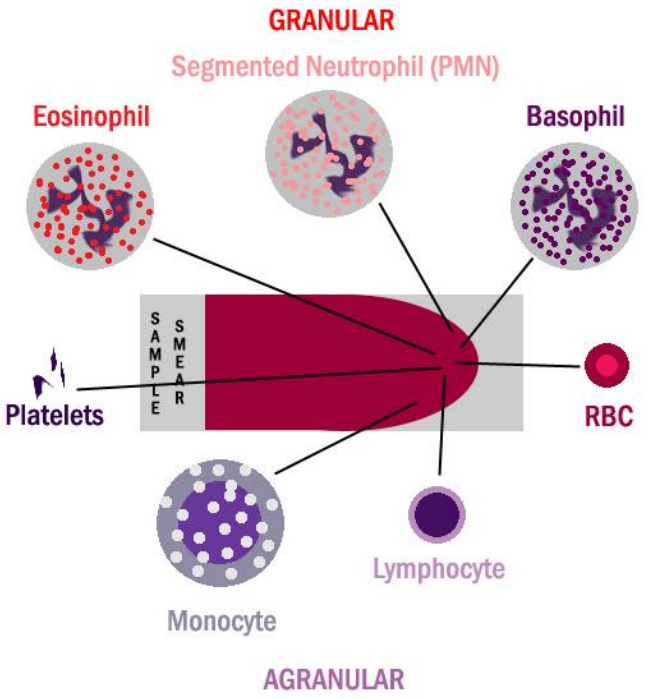
Diapedesis

WBC -- Individually



- Neutrophils: have the greatest activity following bacterially destroyed tissue – primary role is phagocytosis – also releases lysozyme (suicide enzyme) – high neutrophils suggest damage due to invading bacteria

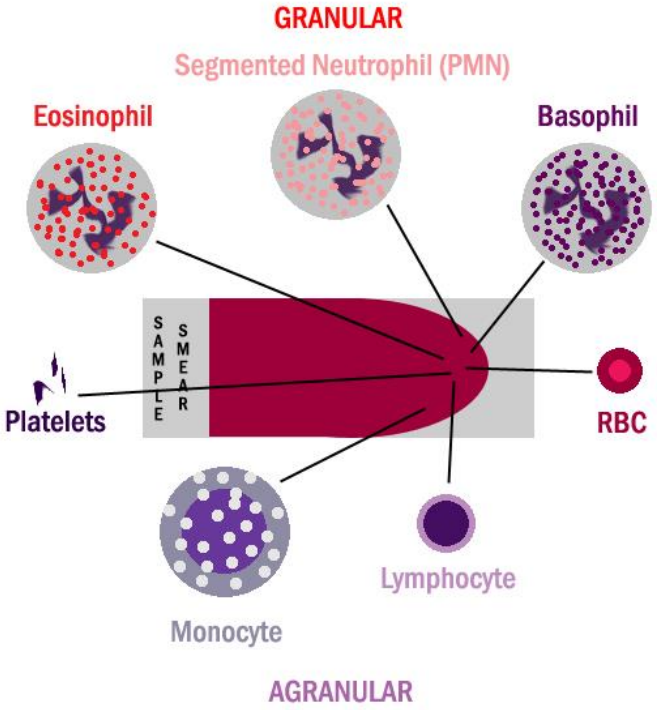
WBC -- Individually



Eosinophils phagocytize the AgAb complex. The AgAb complex combats infection and confers immunity; Ag's are responsible for blood groups, allergies and organ transplant rejections.

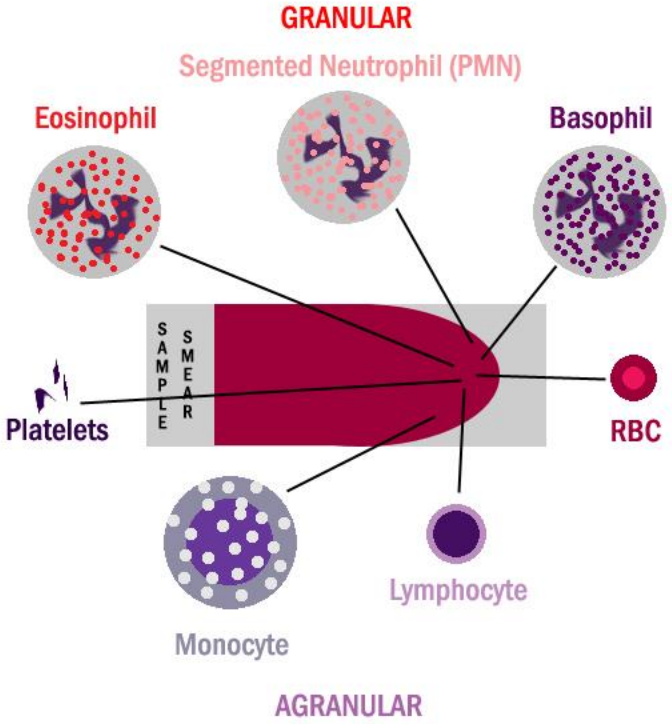
- Eosinophils: high eosinophils suggest allergic conditions – believed to combat allergens which cause allergies; elevated also in cases of porkworm infection, psoriasis, Hodgkin's Disease and some cancers. Decreased numbers after period of stress (cortisol). Eosinophils produce/release antihistamines.

WBC -- Individually



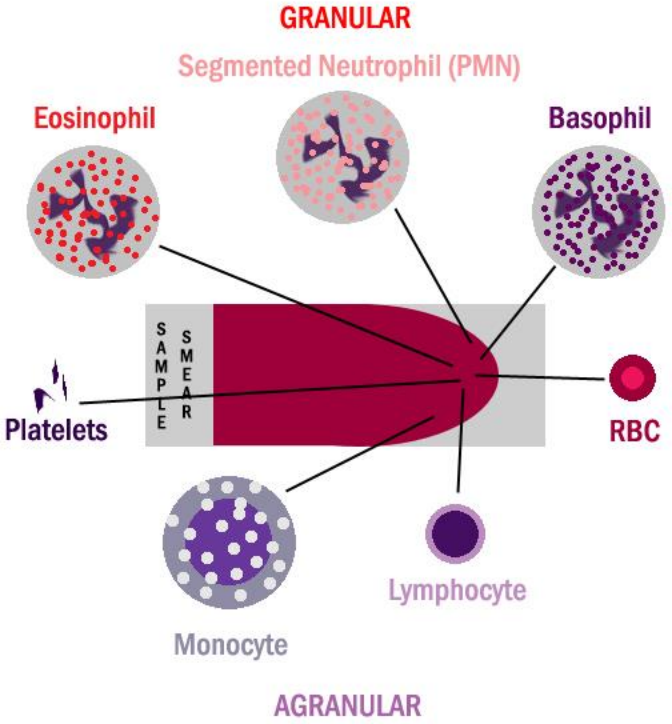
- Basophils: elevated due to allergens, Hodgkin's Disease, smallpox, after splenectomy, chronic hemolytic anemia and some cancers. Elevated also during recovering lobar pneumonia, acute rheumatic fever, anaphylactoid purpura. Decreased in ACUTE phases of same conditions.

WBC -- Individually



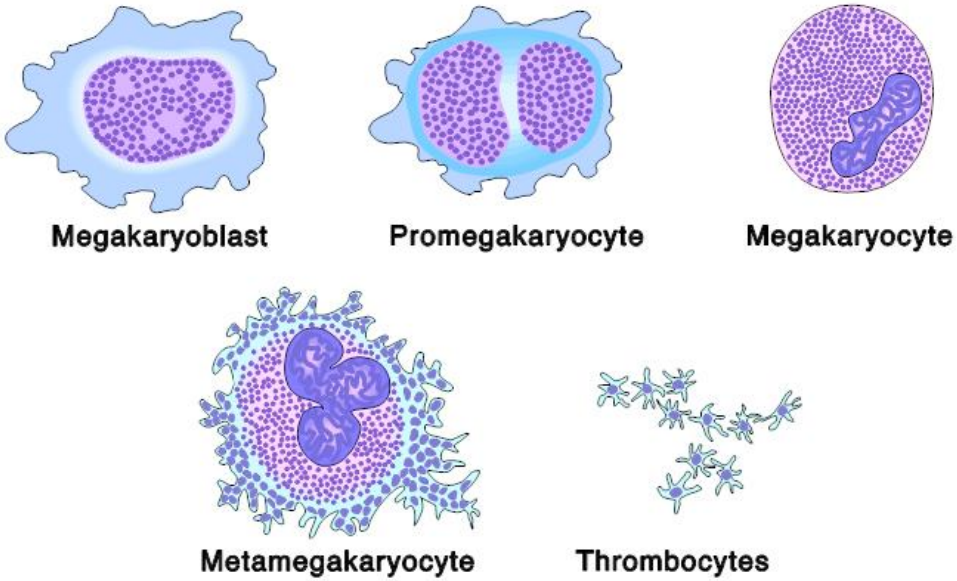
- Monocytes: high monocytes suggest chronic infection, e.g., TB. Take longer than neutrophils to get to damaged site, but arrive in greater numbers and destroy more micro-organisms. Monocytes also phagocytic and clean up cellular debris during an infection.

WBC -- Individually



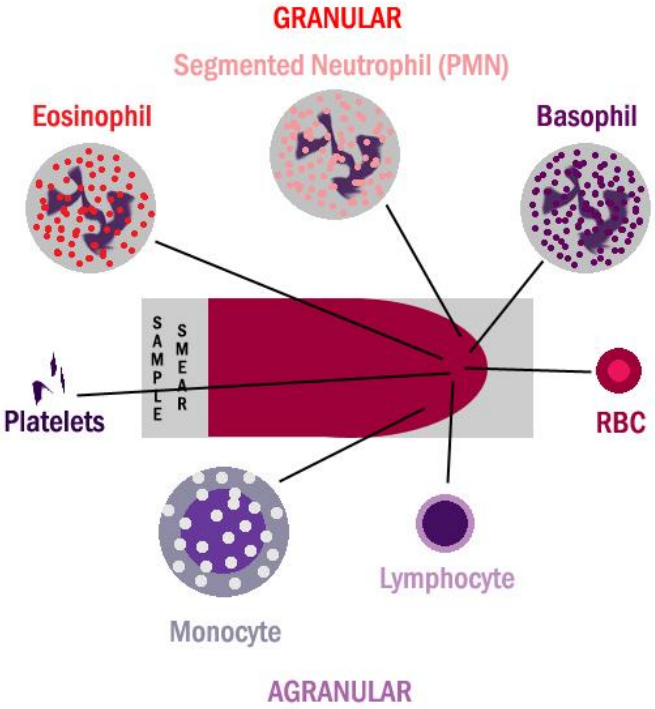
- Lymphocytes: necessary for antibody production
- Antibody (Ab): special proteins which inactivate antigens
- Antigens (Ag): a substance (foreign or otherwise) that will stimulate the production of specific Ab's. Most Ag's are proteins and not synthesized by the body, e.g., pollen

Thrombocytes: Platelets



- In general, undifferentiated cells in red bone marrow are transformed into hemocytoblasts (stem cells) which develop into mature blood cells eventually
- Megakaryoblasts differentiate to generate platelets

Thrombocytes -- Platelets



- Platelets are disc-shaped (more or less) without a nucleus; 2-4 μ in diameter; they initiate a chain of reactions that leads to blood clotting; life span is about a week because they are 1) used up in blood clotting and 2) they are too simple to carry on much metabolism.

Blood Clotting Cascade

It's important to recognize that the liver, while of great digestive importance as a detoxification center, is also important in blood clotting. Figure, right, illustrates the effects of blood clotting after receiving a wound.

1) The skin is sliced by a knife.

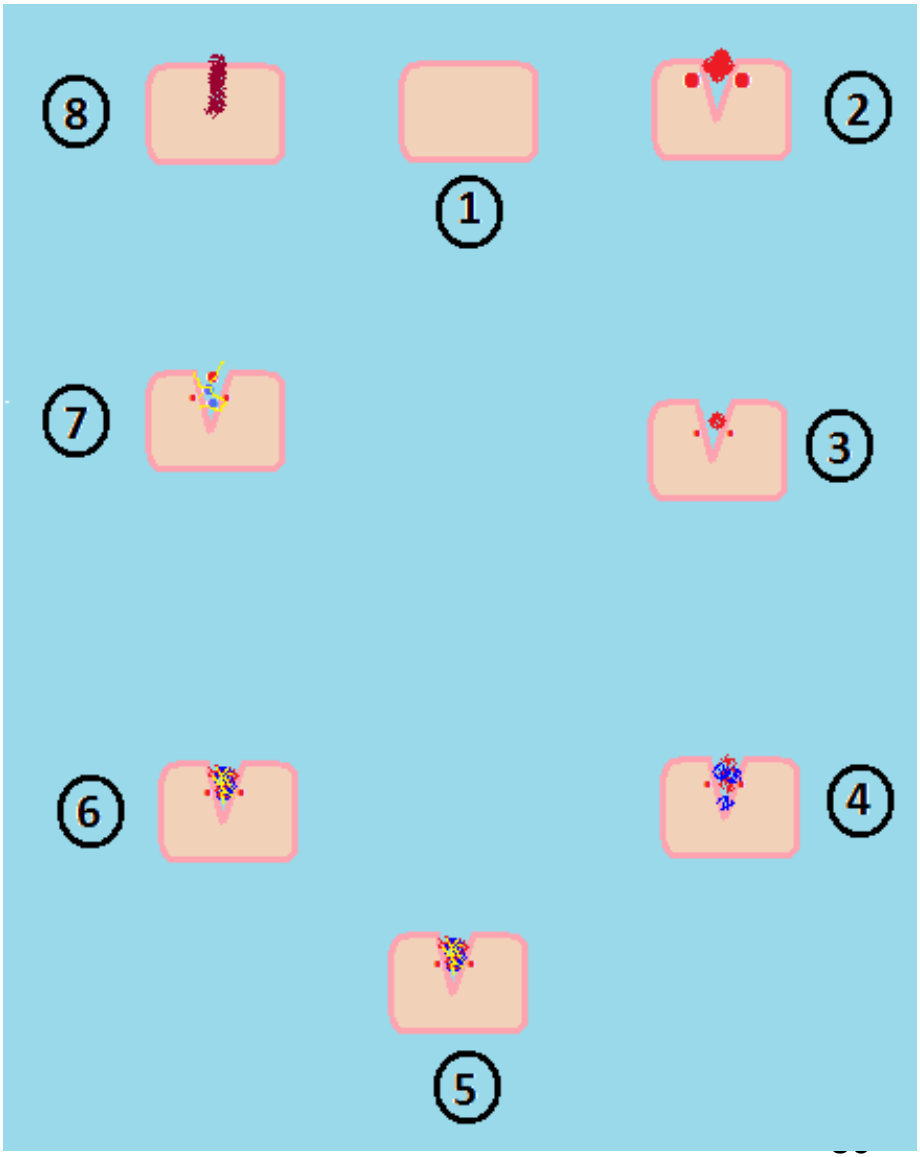
2) The wound fills with blood from the damaged capillaries.

3) The capillaries then constrict to reduce the flow of blood out of the body. In the case of a small injury, this is primary hemostasis.

4) Platelets are then released. Contact between the platelets and the basement membrane causes platelet degranulation which increases the "stickiness" of the platelets that then form a platelet plug with the red blood cells (RBC) in the wound.

5) During secondary hemostasis (or following a larger wound), the next step is to form a fibrin clot.

Clotting factors come from the LIVER! Bile salts are manufactured by the liver for vitamin K absorption. If the liver is shot, expect bleeding disorders.



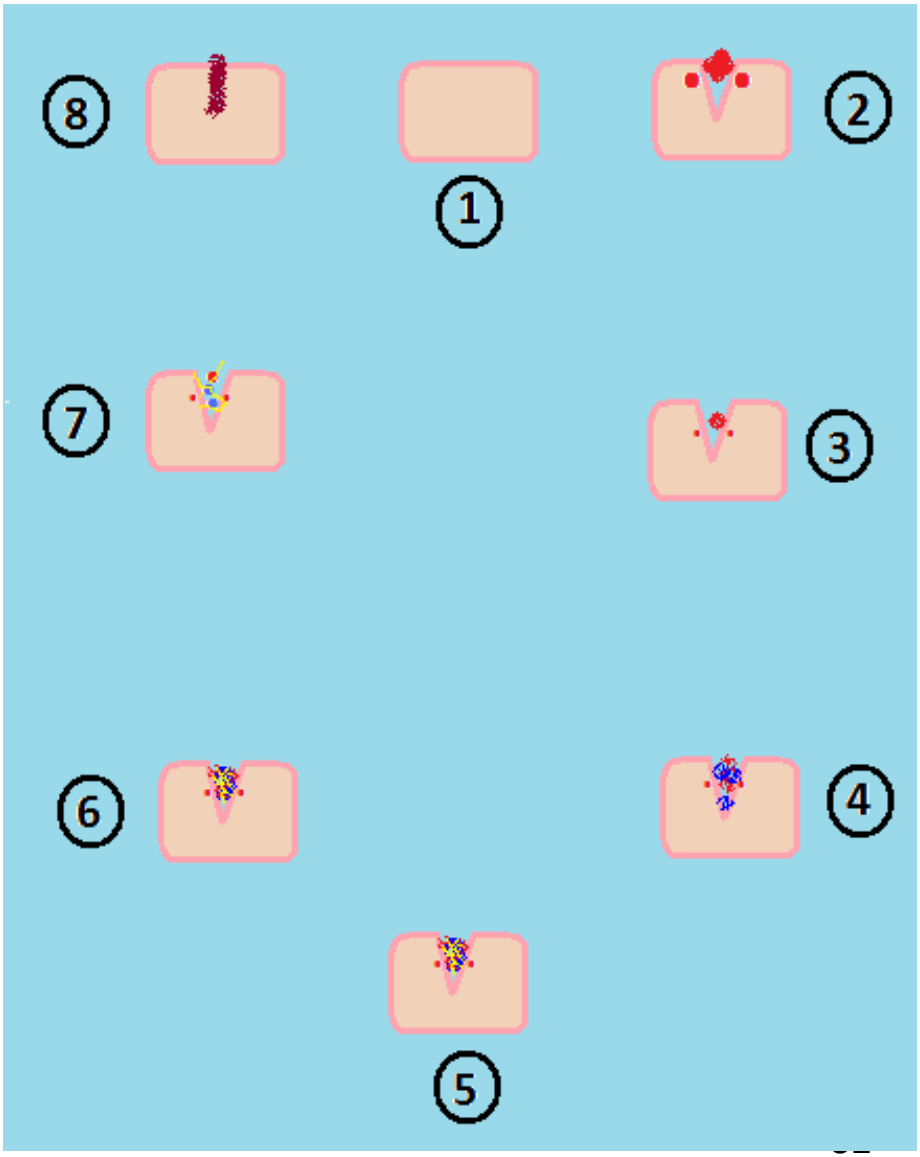
Blood Clotting Cascade

6) A hemostatic plug is formed between the RBC, fibrin and platelets.

7) Once healing begins (review A&P I) or a pathological process is in place, plasmin is released to dissolve the fibrin strands. The degradation products are removed by phagocytosis.

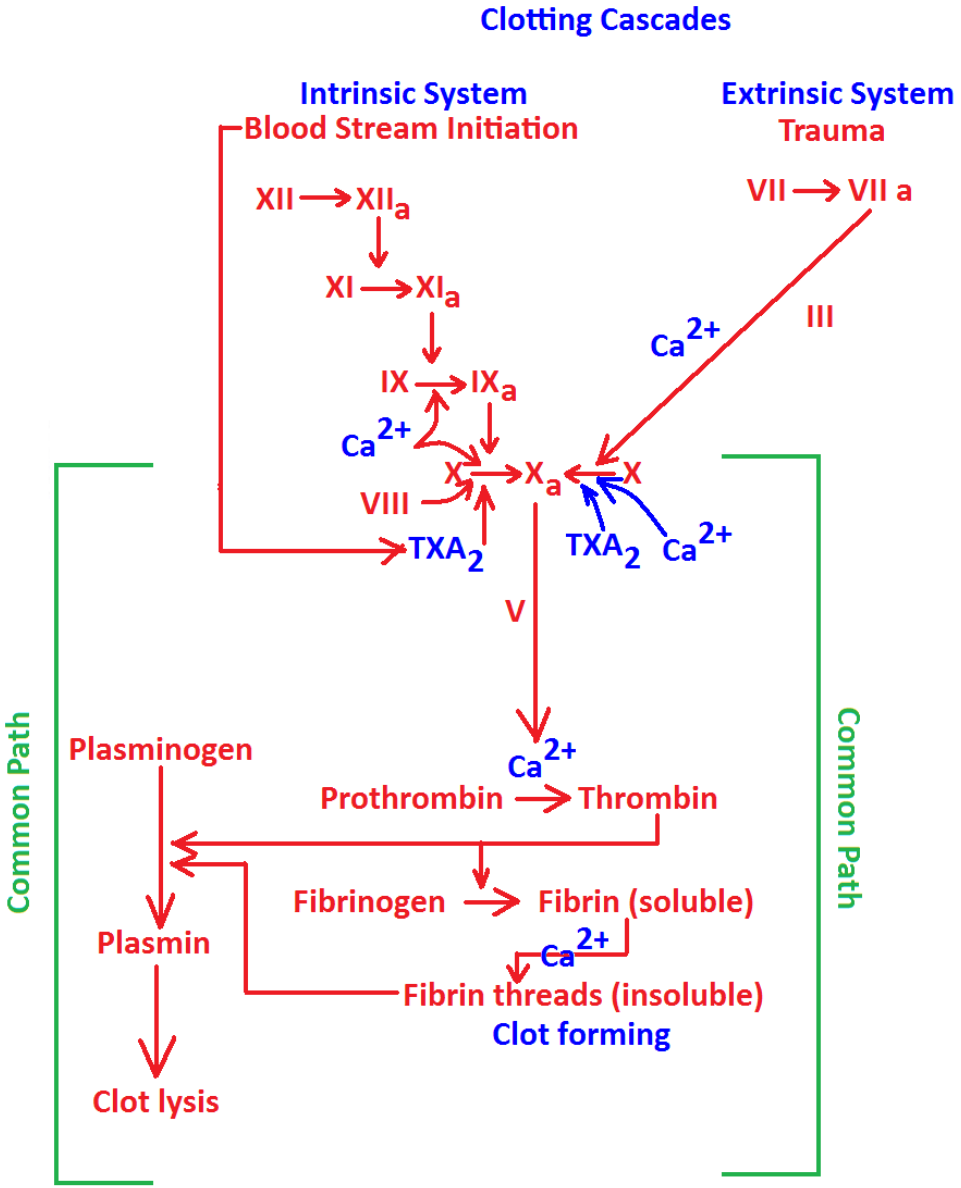
Clinically, "fibrin split products" are measured to determine the extent of blood clotting ability. The higher they are, the less the person may be able to clot effectively, i.e., the higher the fibrin split products, the more thrombin, fibrin polymerization and platelet aggregation are INHIBITED from forming a clot.

8) The wound has healed, more or less with or without scar formation -- review primary, secondary and tertiary wound healing in A&P I.



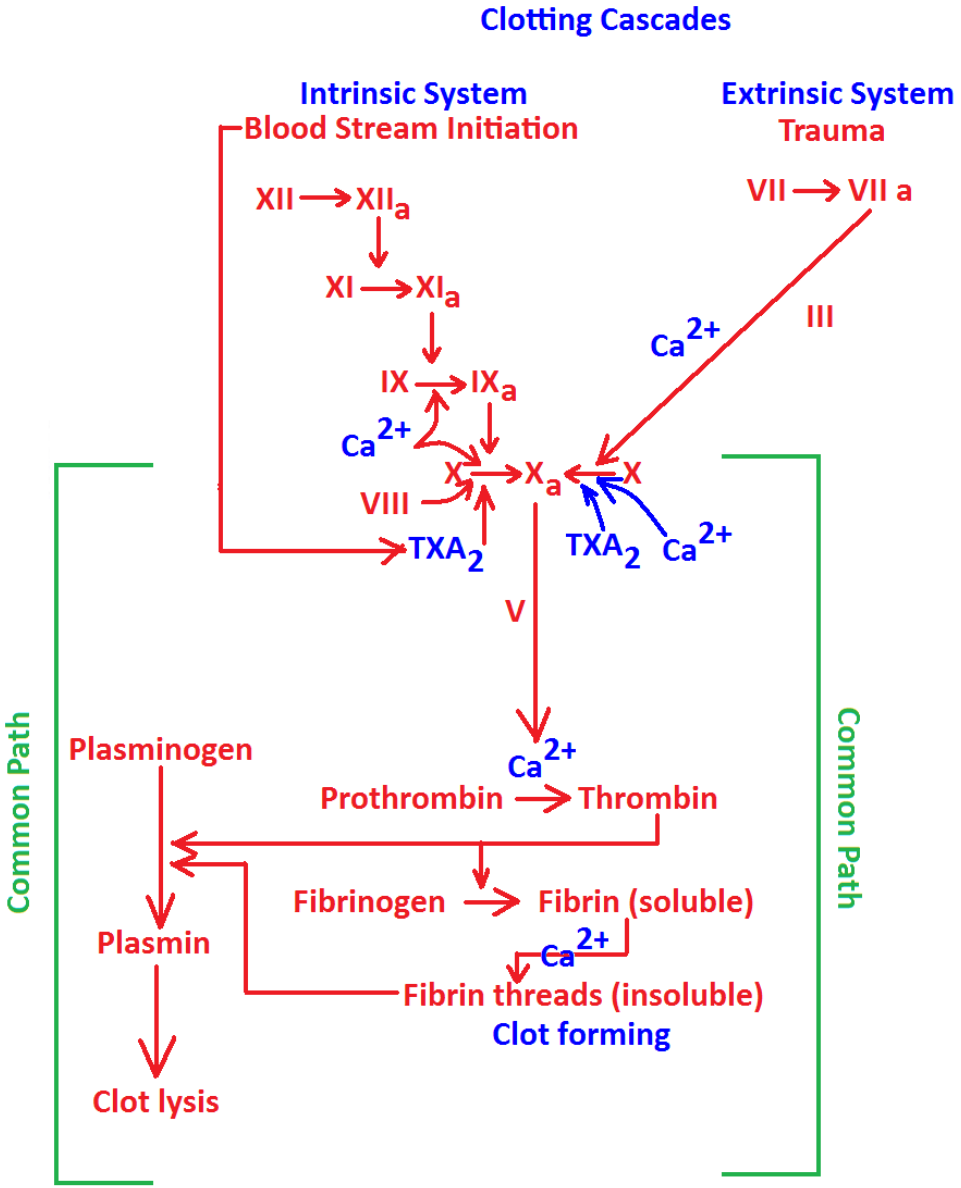
Coagulation and the Liver

- Two pathways are used by the body to produce clots:
  - the extrinsic and
  - intrinsic systems.



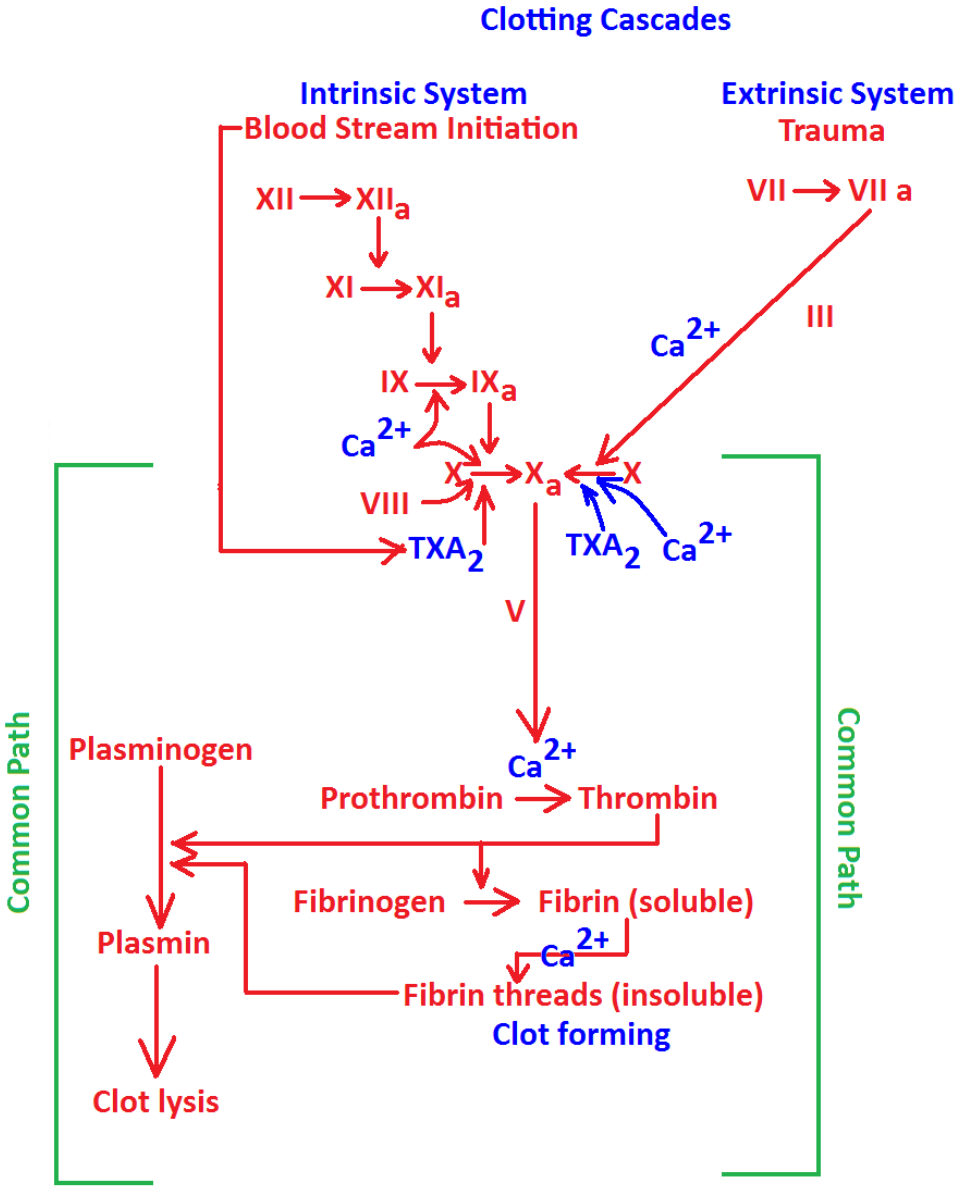
Extrinsic System

•The extrinsic system is generally initiated by some sort of trauma, including venipuncture. Trauma activates factor VII to factor VII_a (the "a" is for "active" factor, in this case, VII). VII_a with calcium ions and III (the factors are usually represented only by their Roman numerals), then activate X to X_a. This latter process also requires the presence of special prostaglandins called thromboxane A_2 (TXA_2; makes the platelets sticky, too). We'll stop here for a moment.



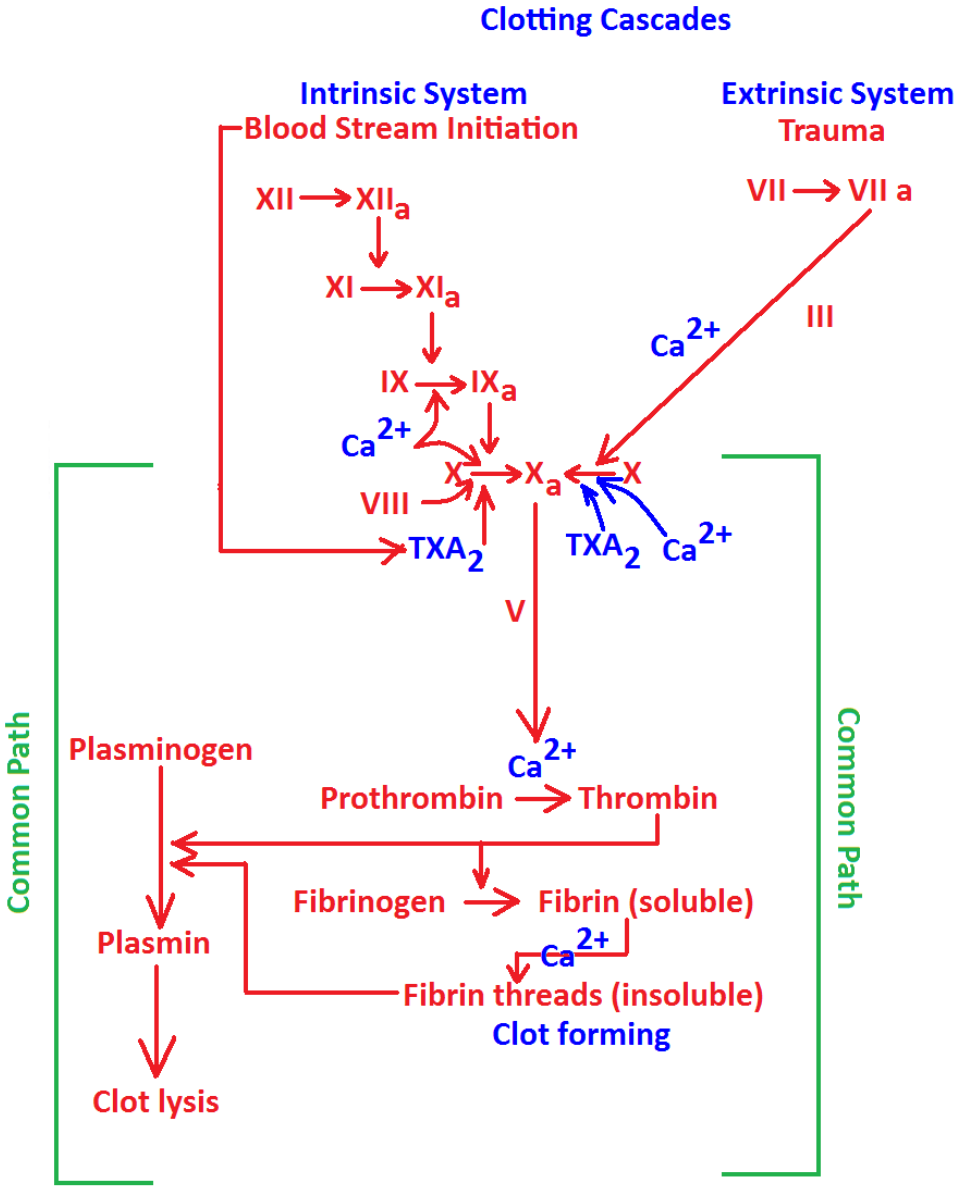
Intrinsic System

- The intrinsic pathway is initiated by the blood stream. That process activates XII to XII_a. XII_a, in turn, activates XI to XI_a, which activates IX to IX_a, which activates X to X_a along with calcium ions and TXA_2.

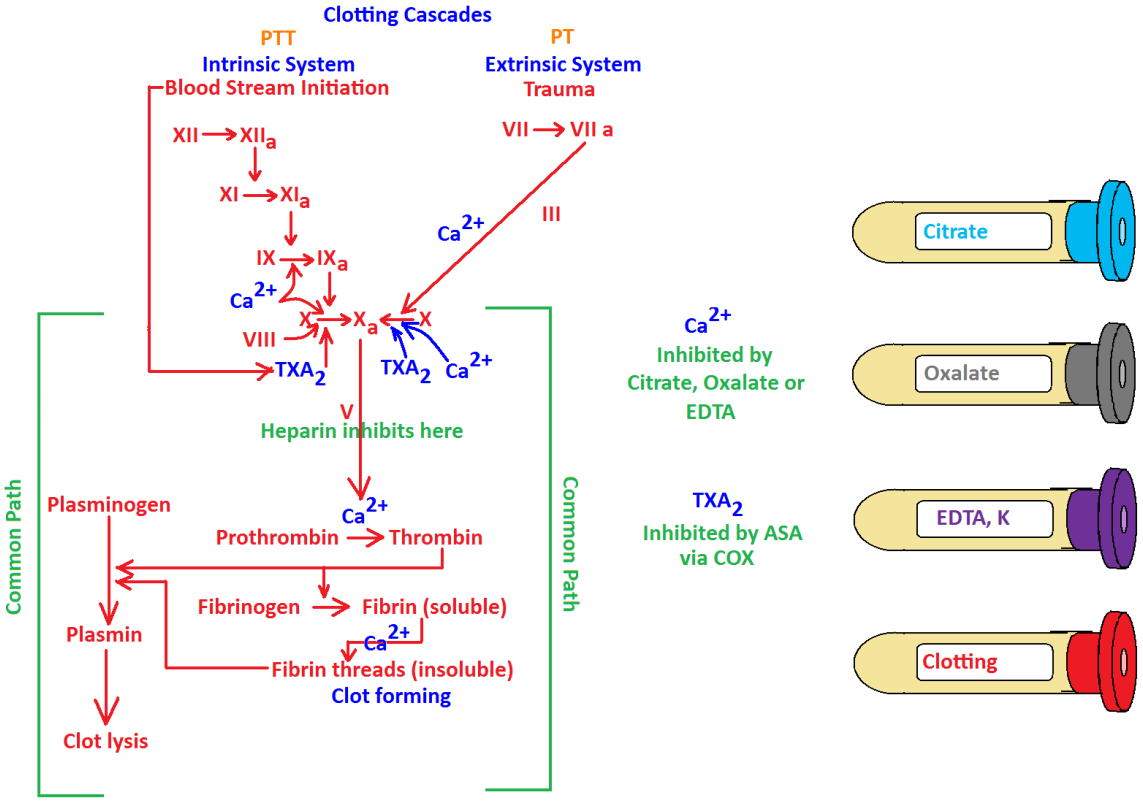


Common Pathwav

- Once factor X_a is formed, the clotting cascade begins the "common pathway".
- It's called the common pathway because both systems utilize the same pathway from X_a on to accomplish coagulation.
- Factor V, with X_a, and calcium ions "convert" prothrombin to thrombin.
- Thrombin causes fibrinogen to "change to" soluble fibrin. Calcium ions causes the soluble fibrin to become insoluble fibrin threads, i.e., clot-forming.
- With either wound healing or a pathological process, the thrombin and insoluble fibrin threads activate plasminogen.
- The active form of this protein is plasmin.
- Plasmin causes clot lysis.
- Plasmin not only causes clot lysis, hematologically, but also causes semen to un-clot, as well, after ejaculation (see A&P II Reproduction lecture for this process).

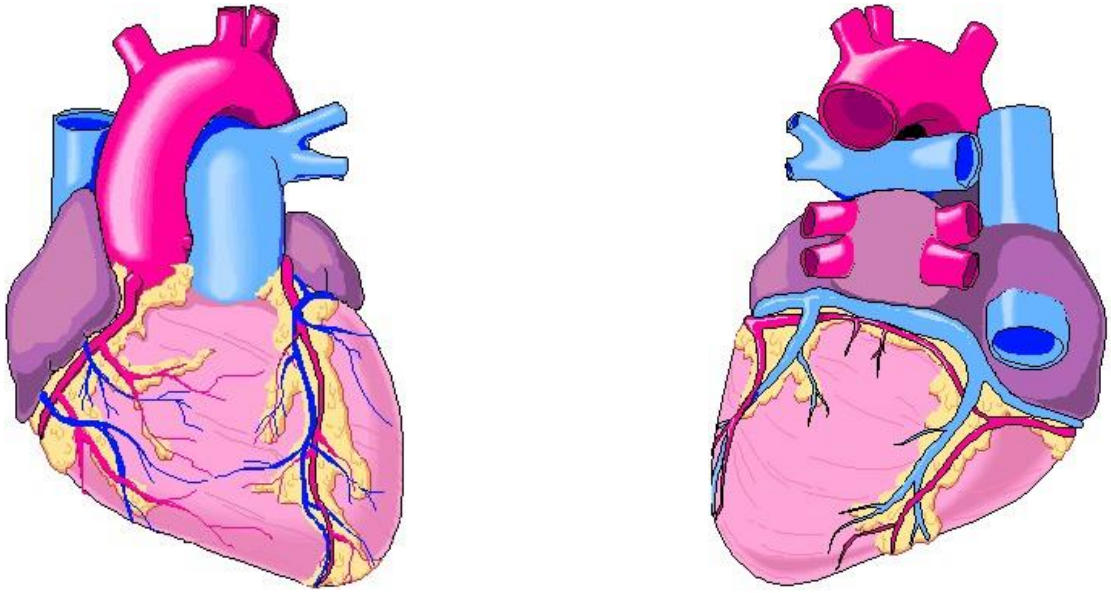


The Clotting Cascade with Anticoagulants



- Note that wherever calcium ions are required to propagate a step in the cascade that it is inhibitable with EDTA, citrate or oxalate -- lavender top tubes, light blue top tubes or gray top tubes, respectively.
- TXA_2 is inhibited by aspirin through the primary enzyme of prostaglandin synthesis, cyclo-oxygenase.
- **Heparin** inhibits the conversion of prothrombin to thrombin.
- Clinically, the partial thromboplastin time (PTT) is used to measure the efficiency of the intrinsic system, while the protime (PT) is used to measure the efficiency of the extrinsic system.
- The PT is used, traditionally, to follow coumadin anticoagulation therapy and the PTT is used, traditionally, to follow heparin therapy for anticoagulation.
- **Coumadin** inhibits II, VII, IX, X, C, S, Z (latter three are clotting proteins) via Vitamin K epoxide reductase

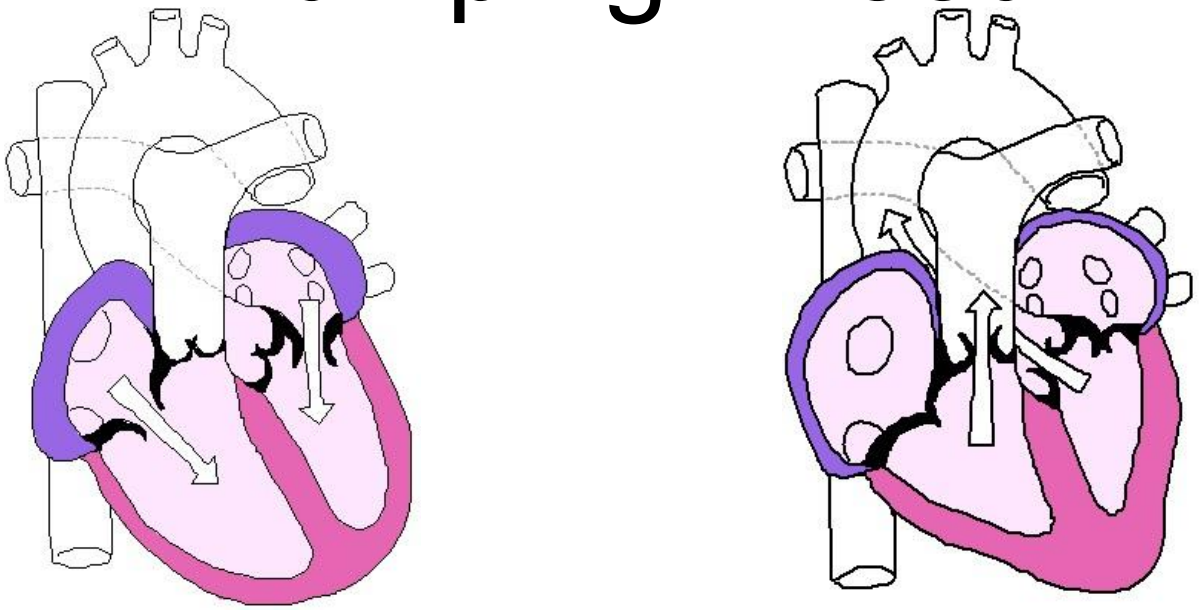
Blood Vessels



- Blood is pumped through blood vessels by the heart.

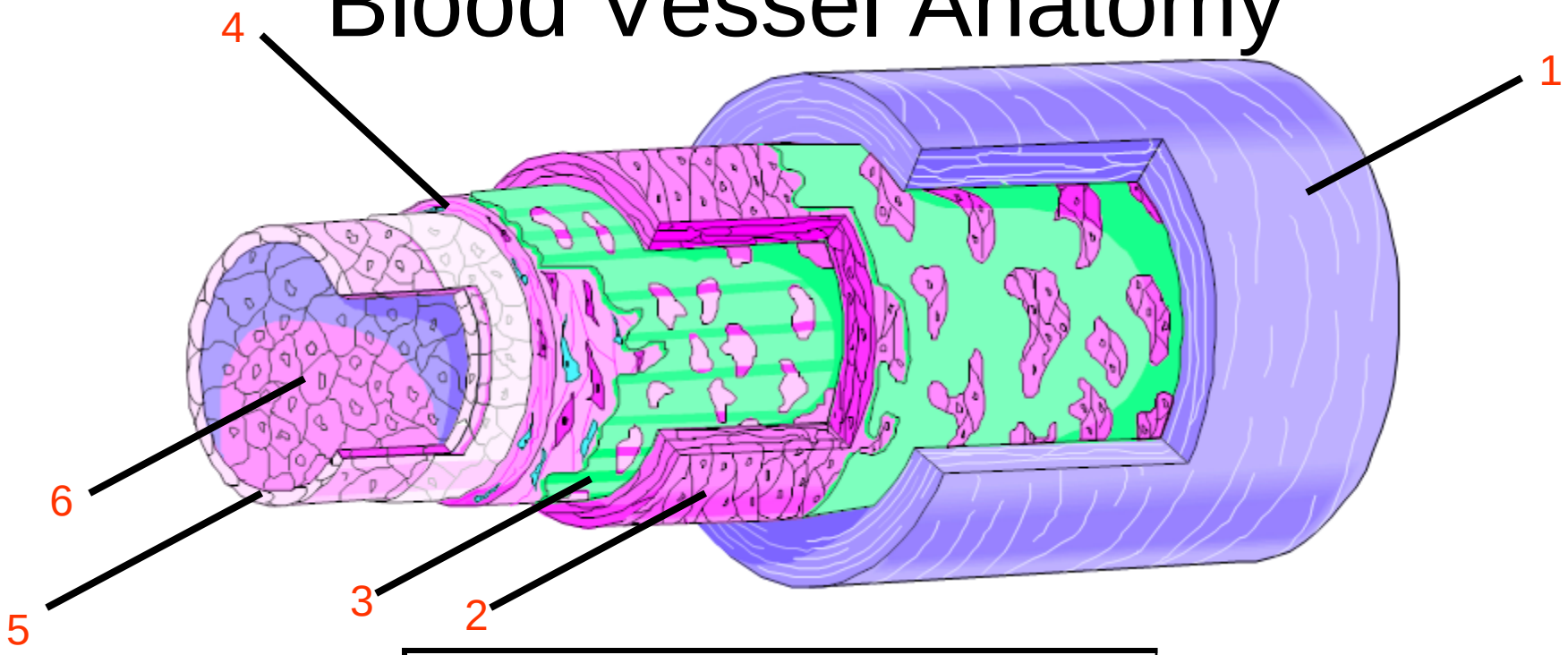
- Heart has its own circulatory system – coronary arteries and veins – RCA, LCA (LADCA and CXA) – Coronary Sinus

“Pumping” Blood



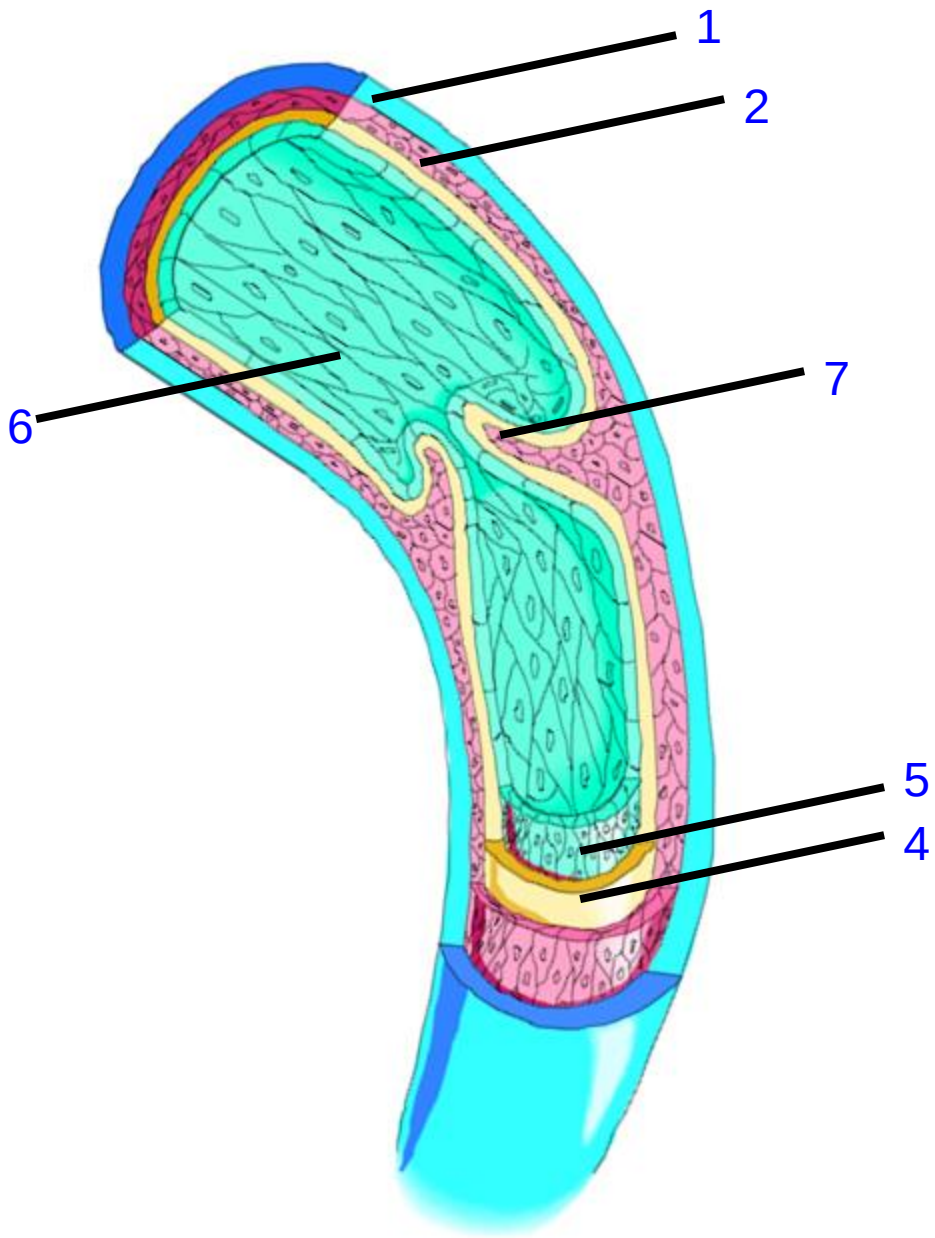
- Atria and ventricles “pump” (contract) opposite to each other
- Relaxation = diastole; contraction = systole
- Chambers fill on diastole; chambers empty on systole

Blood Vessel Anatomy



Arteries
1. Tunica adventia
2. Tunica media
3. Elastic lamina
4. Basement membrane
5. Endothelium
6. Lumen
7. <u>NOT in arteries</u>
4 & 5 = Tunica intima

Blood Vessel Anatomy



Veins
1. Tunica adventia
2. Tunica media
3. <u>NOT in veins</u>
4. Basement membrane
5. Endothelium
6. Lumen
7. Valve
4 & 5 = Tunica intima

Flow of Peripheral Blood -- Circuitry

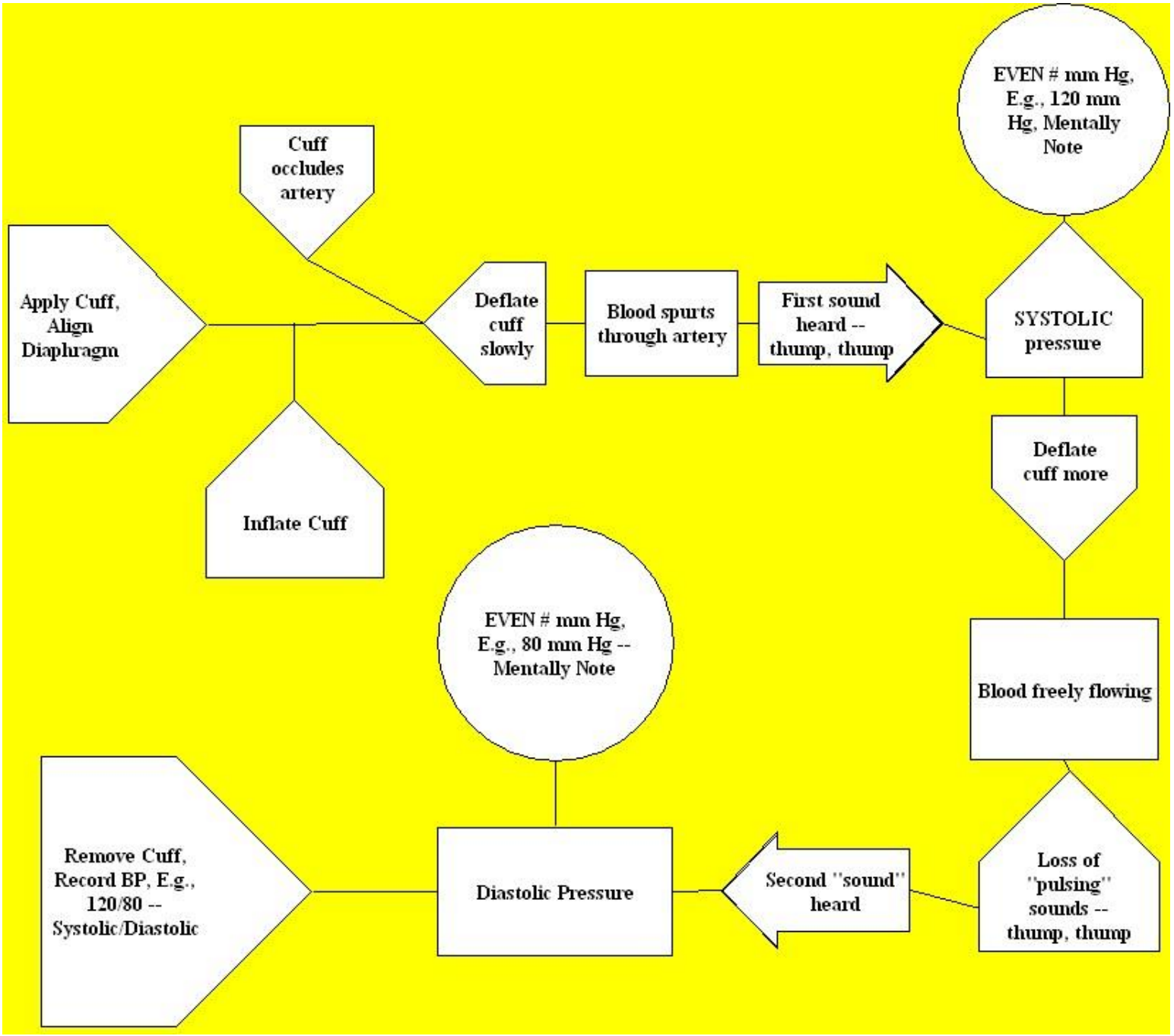
- Blood pumped out of (AWAY from) heart into ARTERIES -- oxygenated
- Arteries branch into arterioles
- Arterioles branch into capillaries
- Nutrients into cells
- Waste out of cells
- Capillaries branch into venules
- Venules expand into veins
- Veins “pour” (“drain”) blood INTO (TOWARDS) heart – de-oxygenated

Blood Pressure Defined

- The pressure exerted by the blood on the wall of any vessel
- A hydrostatic pressure – key for kidneys
- Varies with age, gender, altitude, muscular development, states of mental and physical stress and fatigue
- Measured in an auscultatory manner with sphygmomanometer and stethoscope
- May be measured by palpation – only systolic, though
- May be measured electronically, too

Measuring Blood Pressure

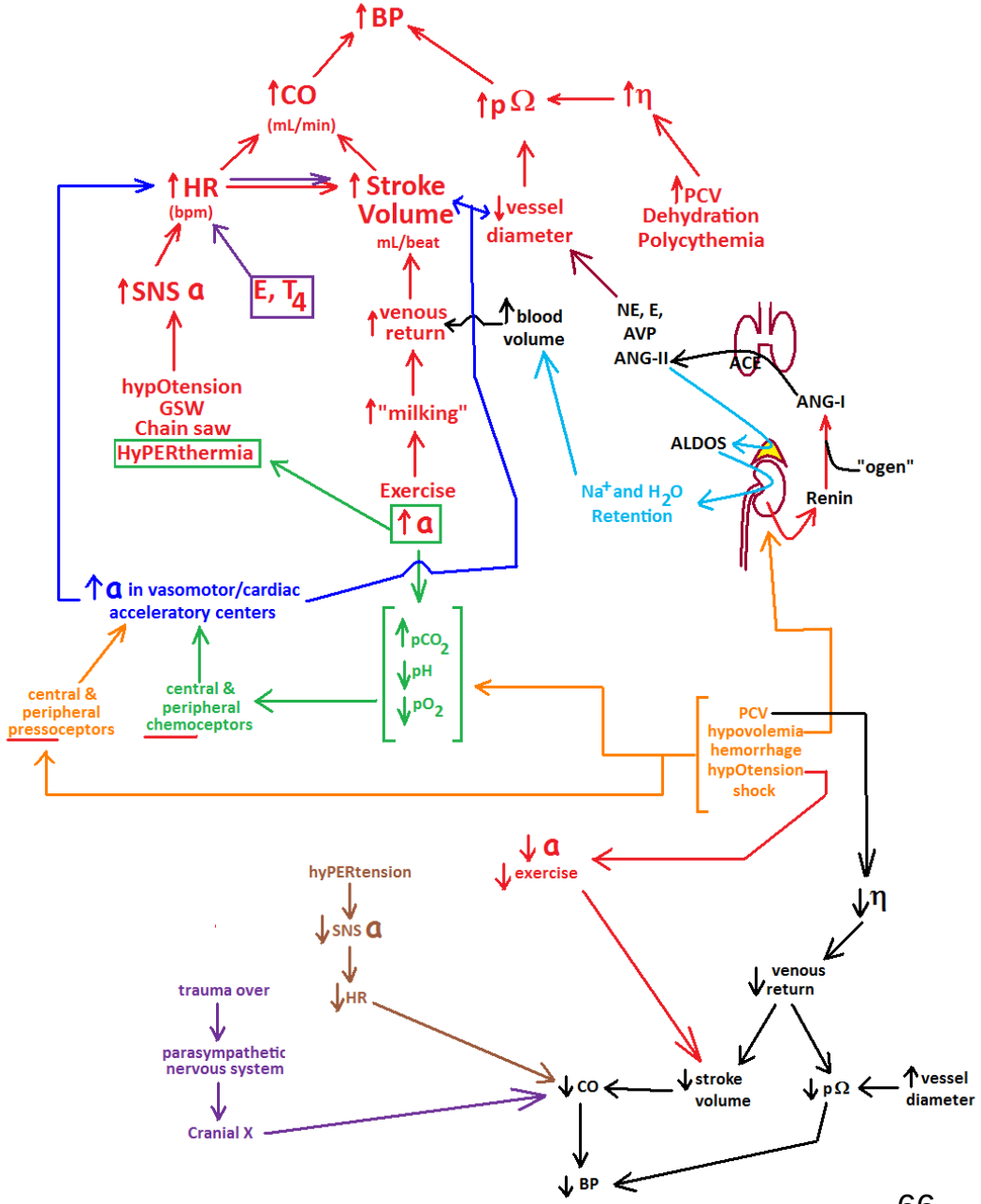
- Put BP cuff over upper arm
- Put diaphragm over brachial artery
- Pump cuff to 160 mm Hg (at least – may need to go higher)
- Deflate cuff slowly, listening to sounds
- Record 1st sound pressure (in even mm Hg)
- Record 2d sound pressure (in even mm Hg)
- Remove apparatus


EVEN # mm Hg, E.g., 120 mm Hg, Mentally Note
Cuff occludes artery
Apply Cuff, Align Diaphragm
Deflate cuff slowly
Blood spurts through artery
First sound heard -- thump, thump
SYSTOLIC pressure
Deflate cuff more
Inflate Cuff
EVEN # mm Hg, E.g., 80 mm Hg -- Mentally Note
Blood freely flowing
Remove Cuff, Record BP, E.g., 120/80 -- Systolic/Diastolic
Diastolic Pressure
Second "sound" heard
Loss of "pulsing" sounds -- thump, thump

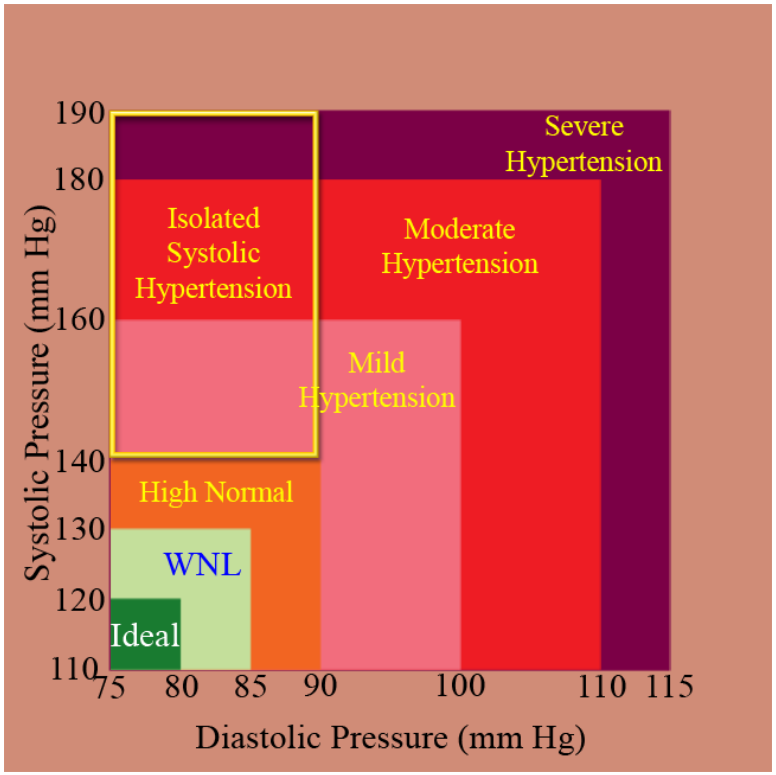
Blood Pressure is Postural AVP involved!

Approximate Values				
Head (mm Hg)	Heart (mm Hg)	Feet (mm Hg)	AVP Levels	Position
110	120	110	⇔	Lying Down
90	120	190	↑	Sitting
90	120	240	↑↑↑	Standing

Blood Pressure Regulation



Hypertension



Pulse Pressure

The numeric difference between your systolic and diastolic blood pressure is the pulse pressure.

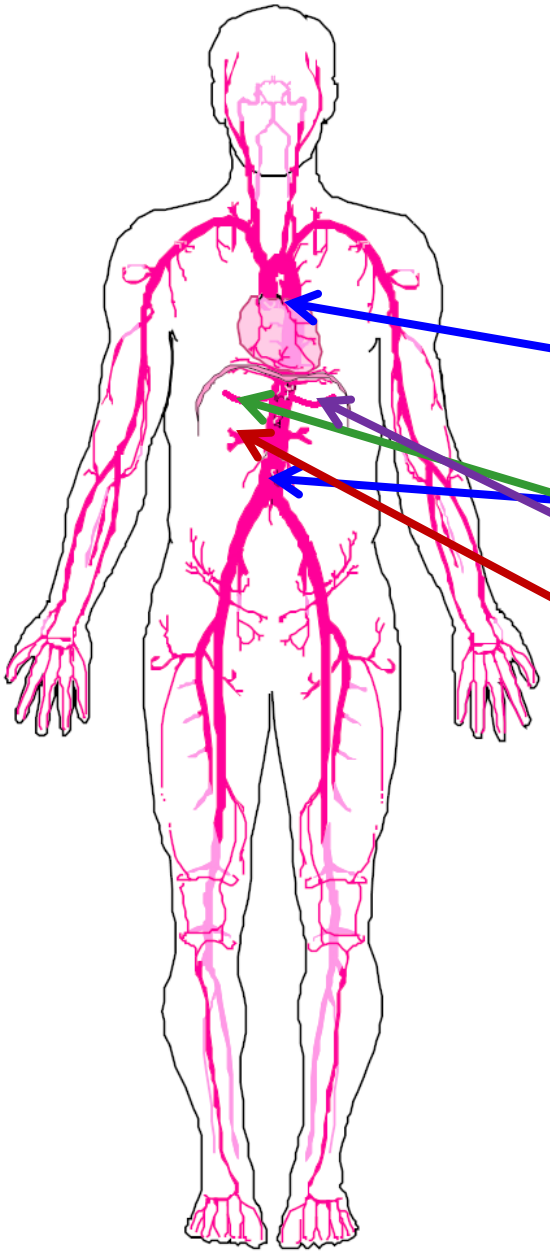
The most important cause of elevated pulse pressure is stiffness of the aorta. The stiffness may be due to high blood pressure or fatty deposits on the walls of the arteries (atherosclerosis). The greater the pulse pressure, the stiffer and more damaged the vessels are thought to be.

Mean Arterial Pressure

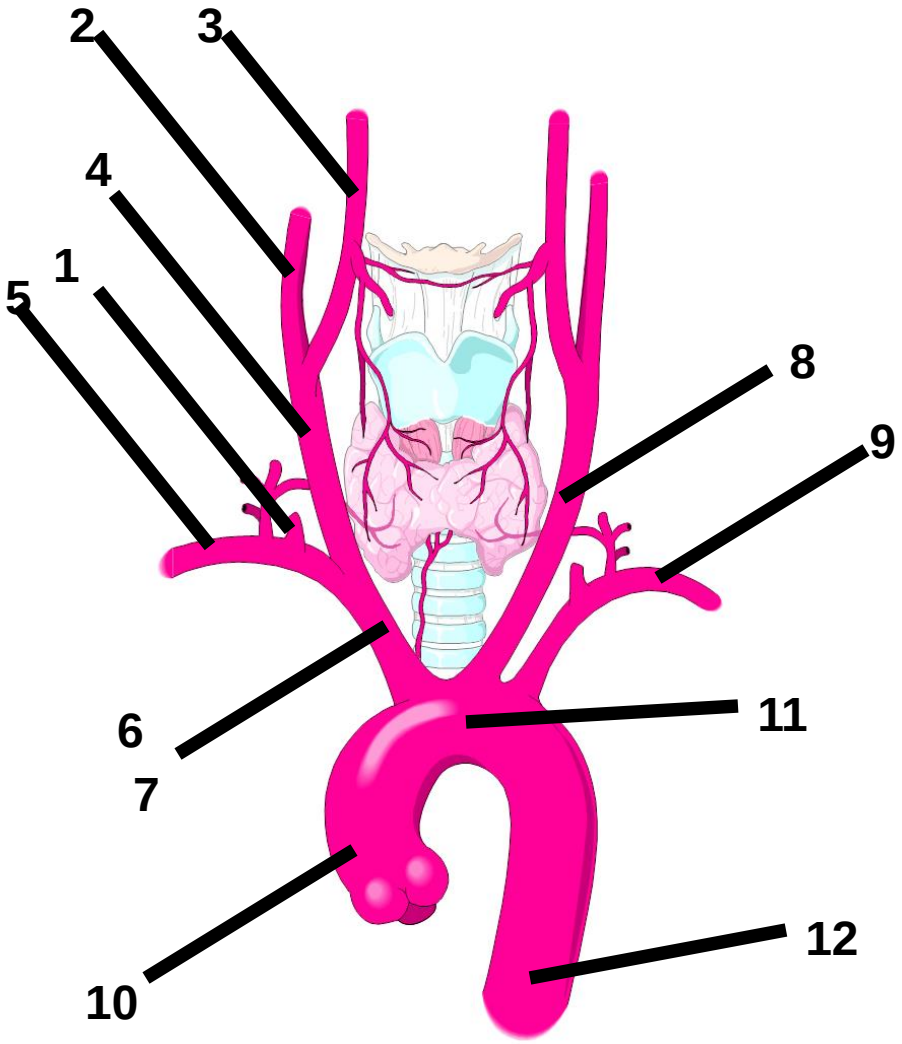
MAP = [(2 x diastolic)+systolic] / 3

Diastole counts twice as much as systole because 2/3 of the cardiac cycle is spent in diastole. An MAP of about 60 is necessary to perfuse coronary arteries, brain, kidneys. Usual range: 70-110; Below this range for any appreciable time, vital organs will not get enough Oxygen, and will become ischemic.

Major Arteries

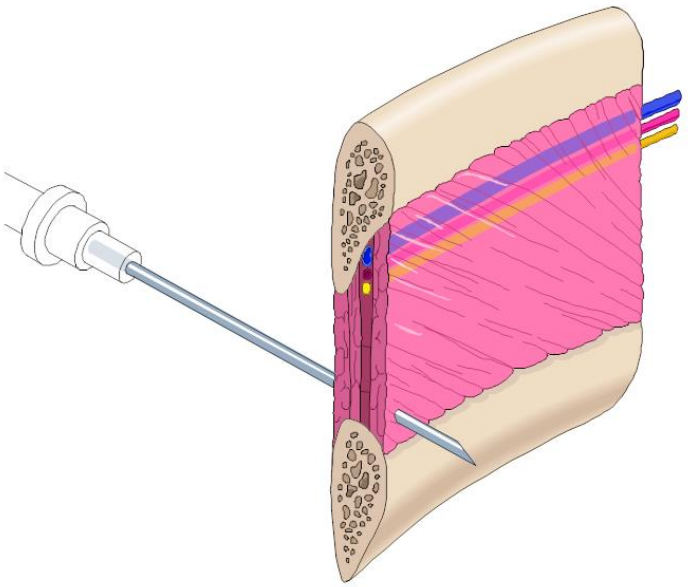


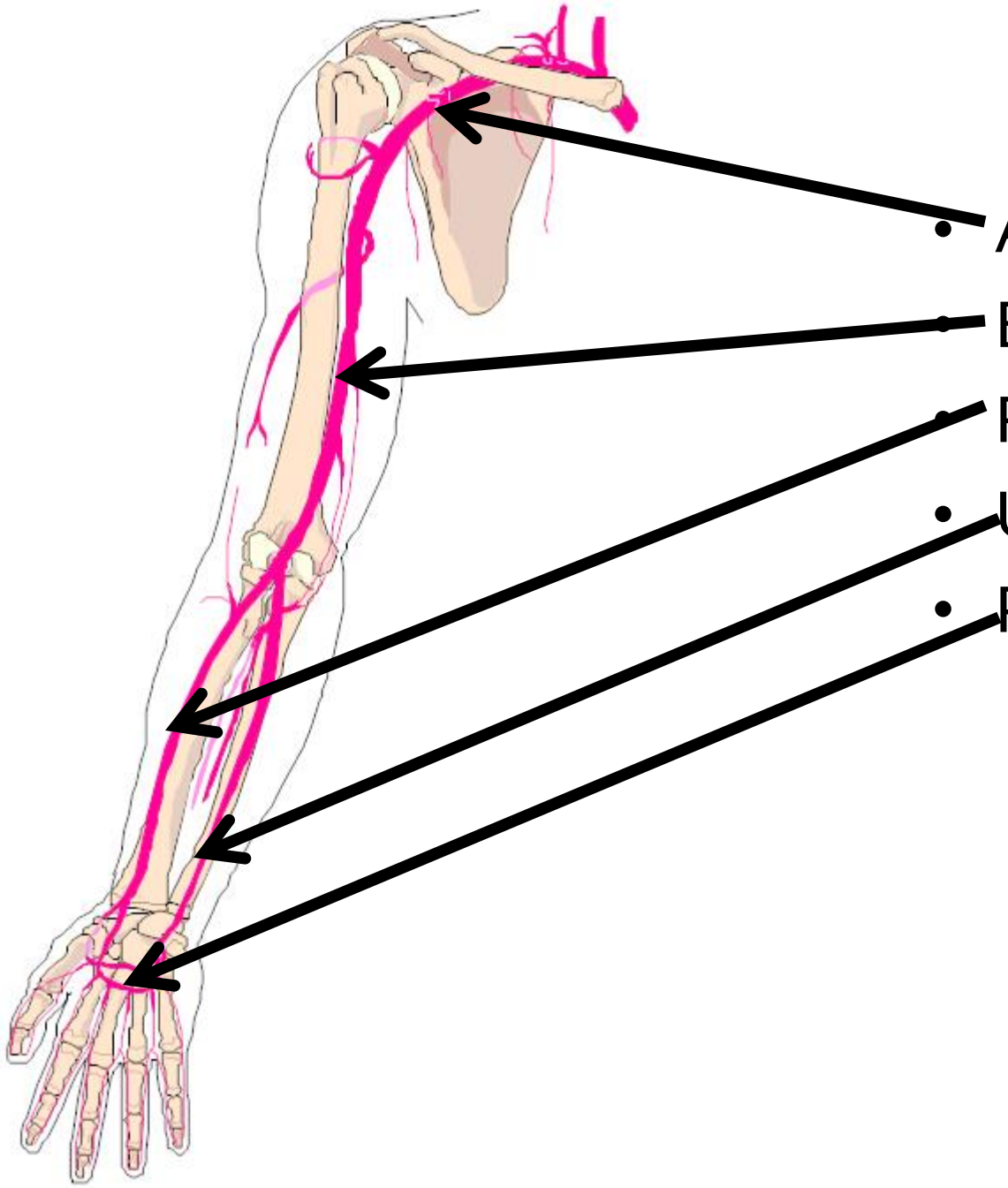
- Aorta
  - Thoracic
  - Abdominal
- Common Hepatic
- Splenic
- Renal



1. Vertebral
2. Internal carotid
3. External carotid
4. Common carotid
5. Subclavian
6. Brachiocephalic
7. Innominate
8. Left common carotid
9. Left subclavian
10. Ascending aorta
11. Aortic arch
12. Descending aorta

- Note nerve, artery and vein location relative to rib.
- Note needle location to MISS the three structures
- Thoracentesis
  - Hemothorax
  - Pneumothorax
  - Chylothorax

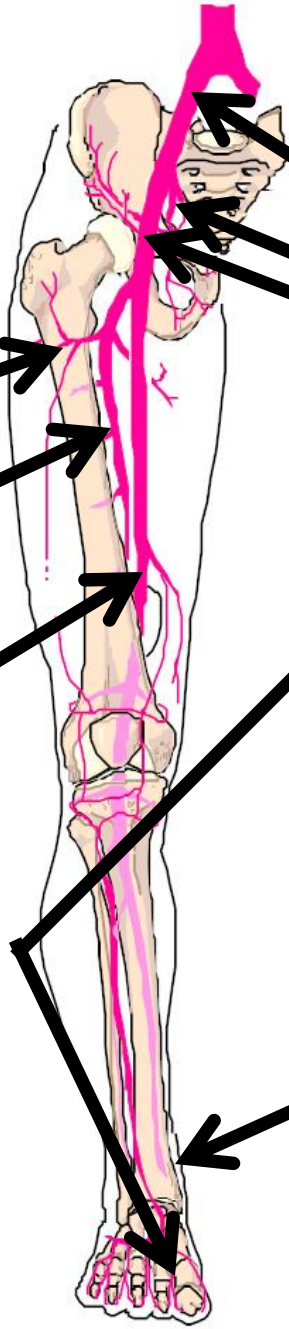




- Axillary Artery
- Brachial Artery
- Radial Artery
- Ulnar Artery
- Palmar Arch

Major Arteries Upper Extremity

Major Arteries



Major Arteries

Common Iliac
Internal Iliac
External Iliac

Dorsalis pedis pulse palpable between flexor tendons of Digits 1 and 2 on anterior foot

Posterior tibial pulse palpable behind the medial malleolus

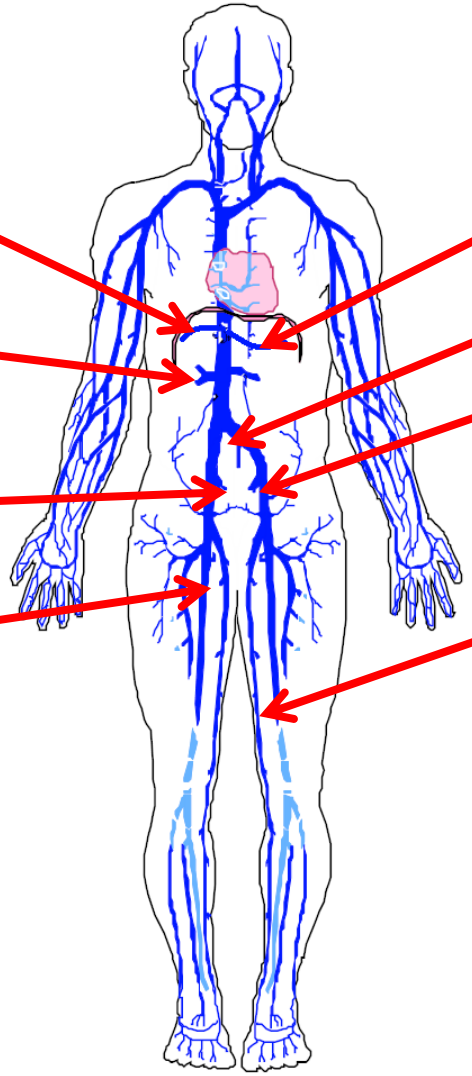
Lateral femoral crosses over anterior femur

Profunda femoris artery crosses behind (posterior) femur

Femoral proper forms popliteal artery

Major Veins – NOT Inclusive

- Hepatic portal
- Renal
- Internal iliac
- Femoral

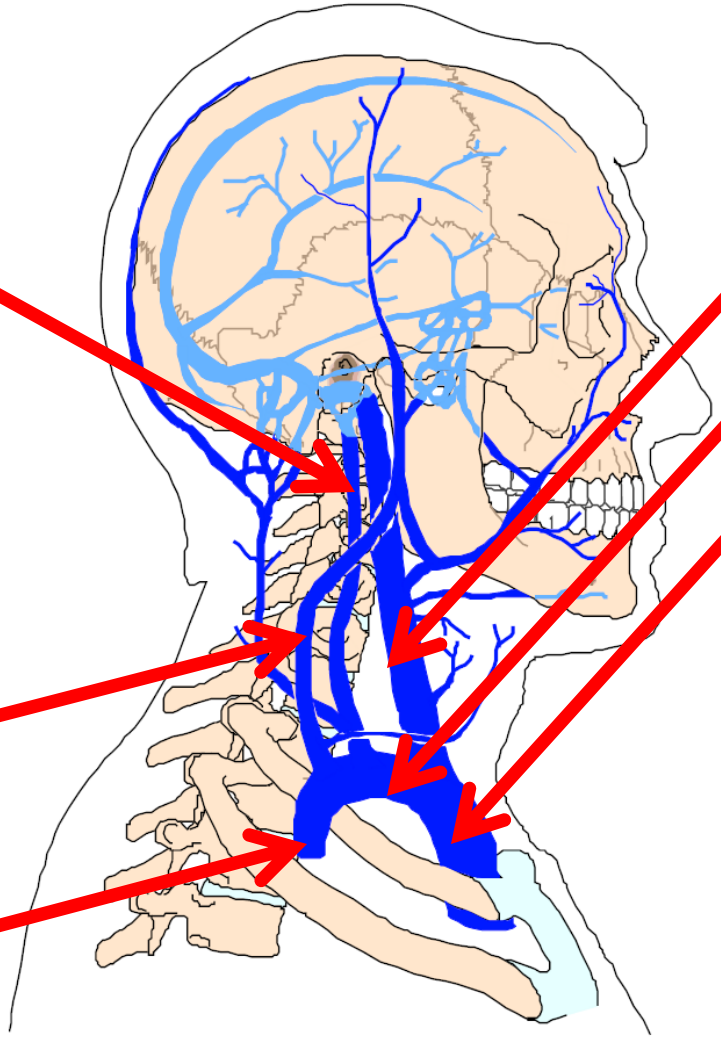


- Splenic
- Common iliac
- External iliac
- Greater saphenous (used for CABG's)

NOTE: veins tend to follow arteries – hence, common names between the two kinds of vessels

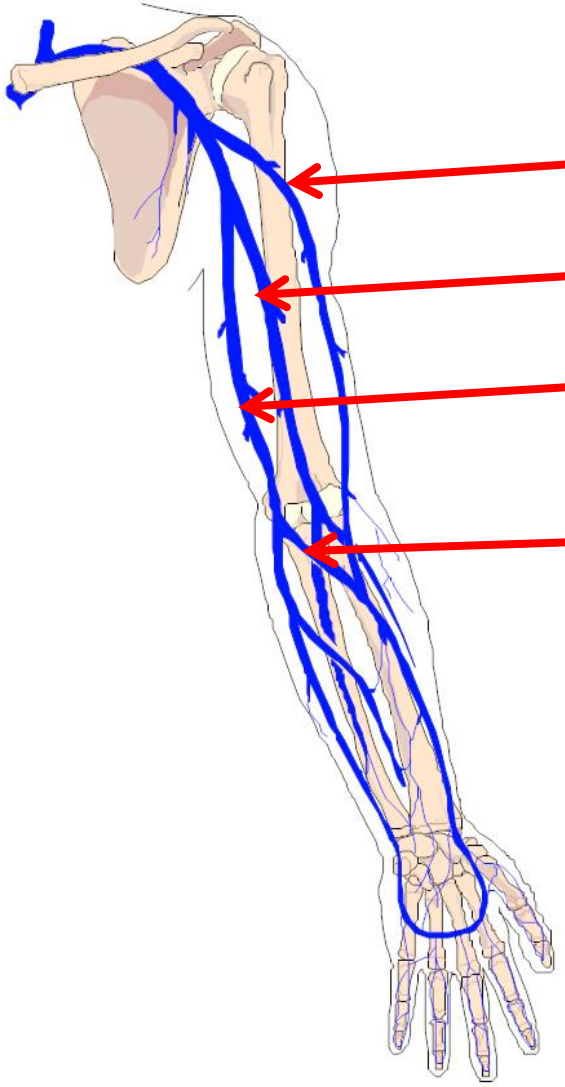
Major Veins – NOT Inclusive

- Vertebral vein
- External jugular vein
- Axillary vein



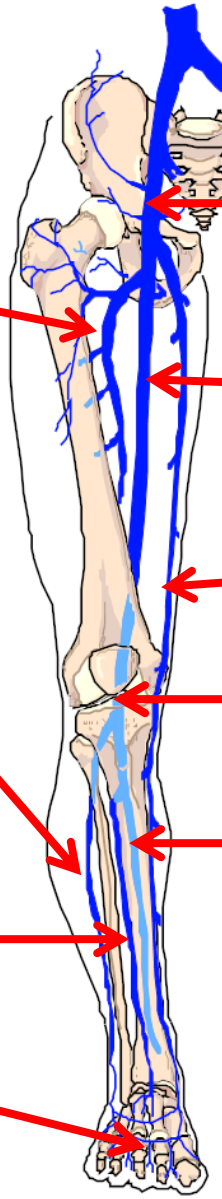
- Internal Jugular Vein
- Subclavian vein
- Brachiocephalic vein

Major Veins – NOT Inclusive



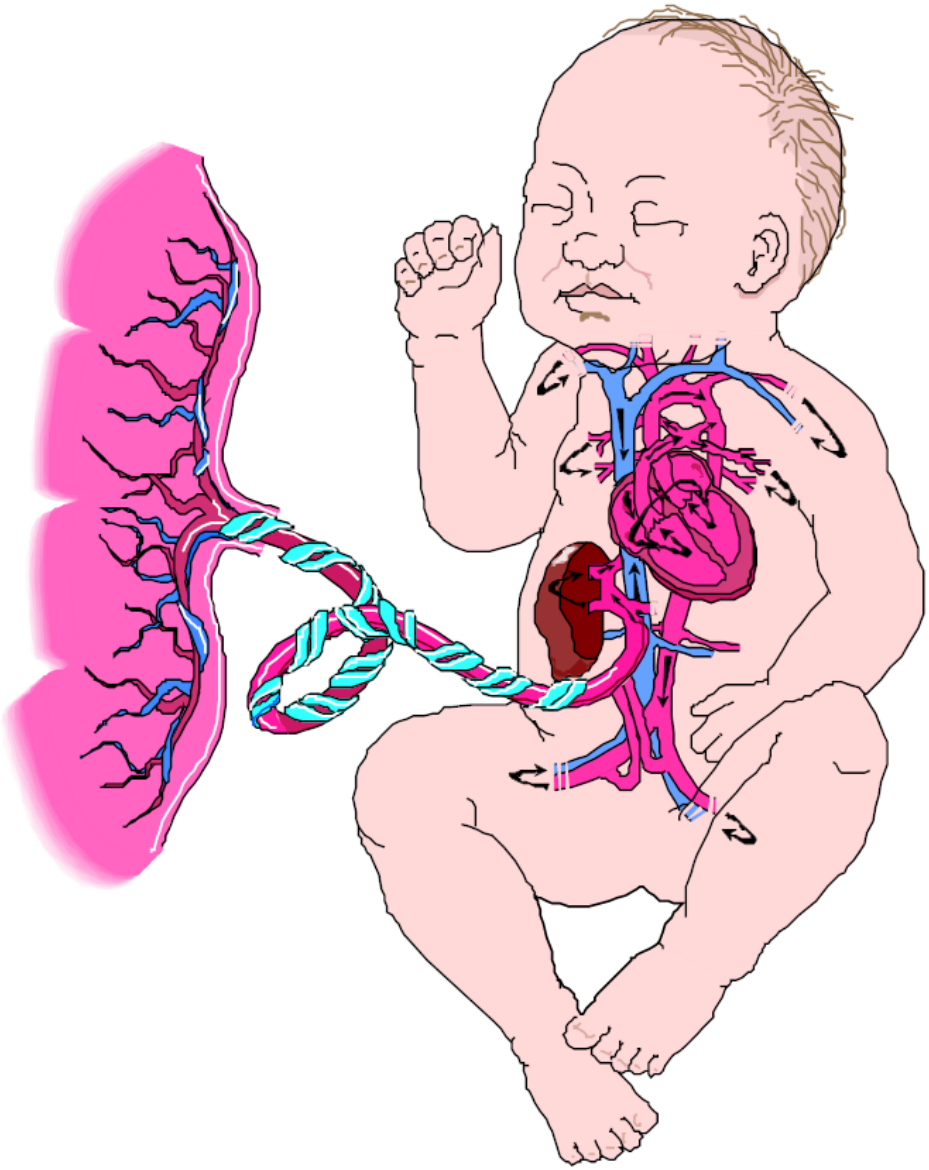
- Cephalic
- Brachial
- Basilic
- Median cubital

Major Veins – NOT Inclusive



- Lateral femoral
- Peroneal
- Anterior tibial
- Dorsal arch
- External iliac
- Femoral
- Great saphenous
- Popliteal
- Posterior tibial

Fetal Circulation – Differences!

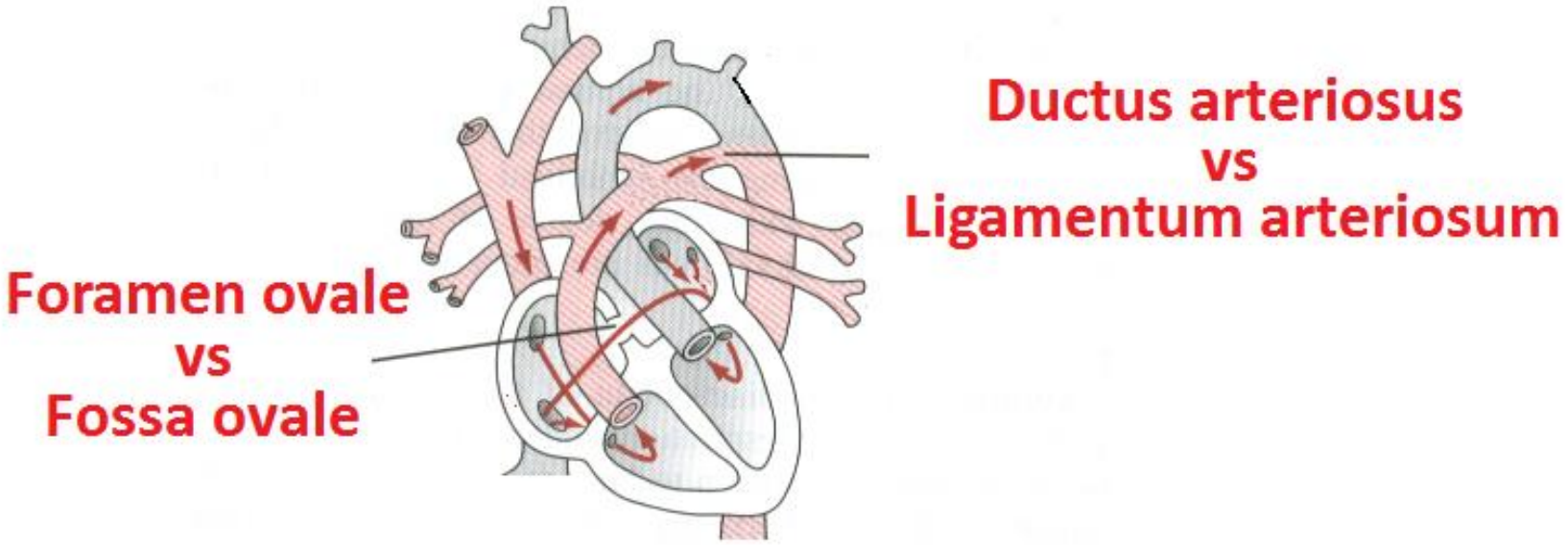


1. Ductus venosus vs Ligamentum venosum
2. Umbilical arteries (2 – DE-oxygenated blood!!!) vs lateral umbilical ligaments
3. Urachus vs medial umbilical ligament – not shown here
4. Umbilical vein (1 – OXY-genated!!!) vs ligamentum teres

Fetal Circulation – Differences!

- Ductus venosus: allows nutrient-rich blood (about 50%) to bypass liver
- Foramen ovale: allows nutrient-rich blood to bypass lungs
- Ductus arteriosus: allows waste-rich blood to bypass lungs and return to placenta via umbilical arteries

Fetal Circulation – Differences!

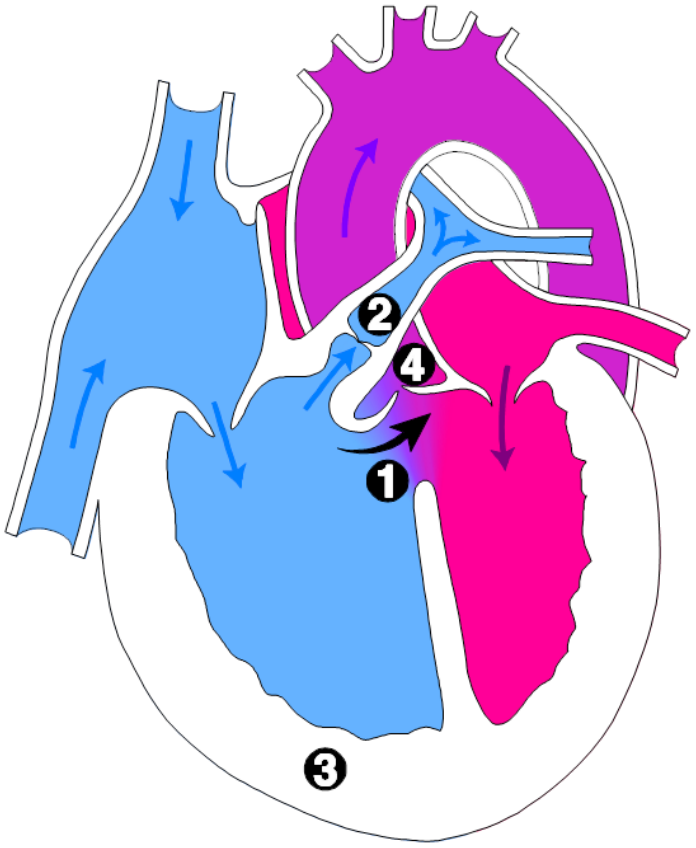


Foramen ovale vs Fossa ovale

Ductus arteriosus vs ligamentum arteriosum

Either PG's or Bradykinin thought to constrict D. arteriosus after birth

Tetralogy of Fallot



1. Interventricular septal defect
2. Stenosed pulmonic valve
3. Right ventricular hypertrophy
4. Biventricular aorta – dextroposed aorta