Topic 21: Cardiovascular: Study Guide

Functions and Components of the Circulatory System

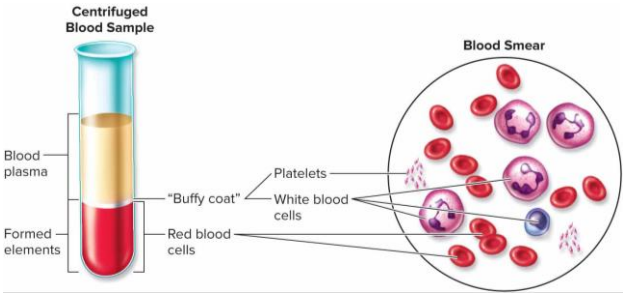
- Transportation
  - Respiratory gases, nutrients, and wastes
- Regulation
  - Hormonal and temperature
- _____
  - Clotting and immunity

Major Components of the Circulatory System

- Cardiovascular system
  - Heart: _____-chambered pump to the pulmonary and systemic circulations
  - Blood vessels: arteries (away from the heart), arterioles, capillaries, venules, and veins (toward the heart)
  - Blood: cells and plasma
- Lymphatic system
  - Lymphatic vessels, lymphoid tissues, lymphatic organs (spleen, thymus, tonsils, lymph nodes)
  - _____: fluid of the lymphatic system that originated from the blood and returns to the blood

Composition of the Blood: Introduction: Blood Composition

- Average adult volume is about _____ liters
- Arterial blood – leaving the heart; bright red, oxygenated except for blood going to the lungs
- Venous blood – entering the heart; dark red, deoxygenated except for blood coming from the lungs
- Made of _____% formed elements and _____% plasma (by volume – hematocrit)



Measurement	Normal Range
Blood volume	80 to 85 ml/kg body weight
Blood osmolality	285 to 295 mOsm
Blood pH	7.38 to 7.44
Enzymes	
Creatine phosphokinase (CPK)	Female: 10 to 79 U/L
	Male: 17 to 148 U/L
Lactic dehydrogenase (LDH)	45 to 90 U/L
Phosphatase (acid)	Female: 0.01 to 0.56 Sigma U/ml
	Male: 0.13 to 0.63 Sigma U/ml
Hematology Values	
Hematocrit	Female: 36% to 46%
	Male: 41% to 53%
Hemoglobin	Female: 12 to 16 g/100 ml
	Male: 13.5 to 17.5 g/100 ml
Red blood cell count	4.50 to 5.90 million/mm3
White blood cell count	4,500 to 11,000/mm3

Measurement	Normal Range
Hormones	
Testosterone	Male: 270 to 1,070 ng/100 ml
	Female: 6 to 86 ng/100 ml
Adrenocorticotropic hormone (ACTH)	6 to 76 pg/ml
Growth hormone	Children: over 10 ng/ml
	Adult male: below 5 ng/ml
Insulin	2 to 20 µU/ml (fasting)
Ions	
Bicarbonate	24 to 30 mmol/l
Calcium	9.0 to 10.5 mg/dl
Chloride	98 to 106 mEq/L
Potassium	3.5 to 5.0 mEq/L
Sodium	135 to 145 mEq/L
Organic Molecules (Other)	
Cholesterol, desirable	under 200 mg/dl
Glucose	75 to 115 mg/dl (fasting)
Lactic acid	5 to 15 mg/dl
Protein (total)	5.5 to 8.0 g/dl
Triglyceride	under 160 mg/dl
Urea nitrogen	10 to 20 mg/dl
Uric acid	Male: 2.5 to 8.0 mg/dl
	Female: 1.5 to 6.0 mg/dl

Plasma: Straw-colored fluid part of blood

- Water
- Dissolved solutes
  - Major solute by concentration is Na+
  - Many other ions and organic molecules such as metabolites, hormones, enzymes, antibodies, and other proteins

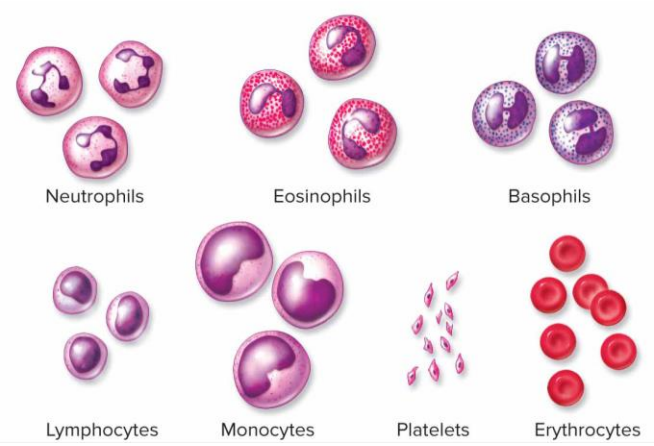
Plasma proteins

- Make up 7 to 9% of the plasma
- _____: creates osmotic pressure to help draw water from tissues into capillaries to maintain blood volume and pressure
- _____
  - Alpha and beta globulins – transport lipids and fat-soluble vitamins
  - Gamma globulins – antibodies that function in immunity

- Fibrinogen: helps in clotting after becoming fibrin
    - Serum – blood without fibrinogen

Plasma volume

- Regulatory mechanisms maintain plasma volume to maintain blood pressure
- Osmoreceptors in the hypothalamus cause the release of _____ from the posterior pituitary gland if fluid is lost



Formed Elements of the Blood: Erythrocytes (red blood cells – RBCs)

- Flattened, biconcave discs
- Carry _____
- Lack nuclei and mitochondria
- Count – approximately 5 million/mm3 blood
- Have a 120-day life span; removed by phagocytic cells in the liver, spleen, and bone marrow
- Each contain about 280 million hemoglobin molecules
- Heme iron is recycled from the liver and spleen; carried by transferrin in the blood to the red bone marrow
- Anemia – abnormally low hemoglobin or RBC count
    - Iron-deficiency anemia – most common; insufficient iron
    - Pernicious anemia – lack of intrinsic factor; Vitamin B12 deficiency
    - Aplastic anemia – damage to bone marrow

Component	Description	Number Present	Function
Erythrocyte (red blood cell)	Biconcave disc without nucleus; contains hemoglobin; survives 100 to 120 days	4,000,000 to 6,000,000/mm^3	Transports oxygen and carbondioxide
Leukocytes (white blood cells)		5,000 to 10,000/mm^3	Aid in defense against infections by microorganisms
Granulocytes	About twice the size of red blood cells; cytoplasmic granules present; survive 12 hours to 3 days		
1. Neutrophil	Nucleus with 2 to 5 lobes; cytoplasmic granules stain slightly pink	54% to 62% of white cells present	Phagocytic
2. Eosinophil	Nucleus bilobed; cytoplasmic granules stain red in eosin stain	1% to 3% of white cells present	Helps to detoxify foreign substances; secretes enzymes that dissolve clots; fights parasitic infections
3. Basophil	Nucleus lobed; cytoplasmic granules stain blue in hematoxylin stain	Less than 1% of white cells present	Releases anticoagulant heparin
Agranulocytes	Cytoplasmic granules not visible; survive 100 to 300 days (some much longer)		
1. Monocyte	2 to 3 times larger than red blood cell; nuclear shape varies from round to lobed	3% to 9% of white cells present	Phagocytic
2. Lymphocyte	Only slightly larger than red blood cell; nucleus nearly fits cell	25% to 33% of white cells present	Provides specific immune response (including antibodies)
Platelet (thrombocyte)	Cytoplasmic fragment; survives 5 to 9 days	130,000 to 400,000/mm^3	Enables clotting; releases serotonin, which causes vasoconstriction

Formed Elements of the Blood: Leukocytes (White Blood Cells – WBCs)

- Have nuclei and mitochondria
- Move in amoeboid fashion
- Diapedesis (_____) – movement through the capillary wall into connective tissue
- Count – approximately 5000 to 9000/mm^3 blood
- Types of leukocytes
    - Granular leukocytes (granulocytes): neutrophils, eosinophils, and basophils
    - Agranular leukocytes (agranulocytes): monocytes and lymphocytes

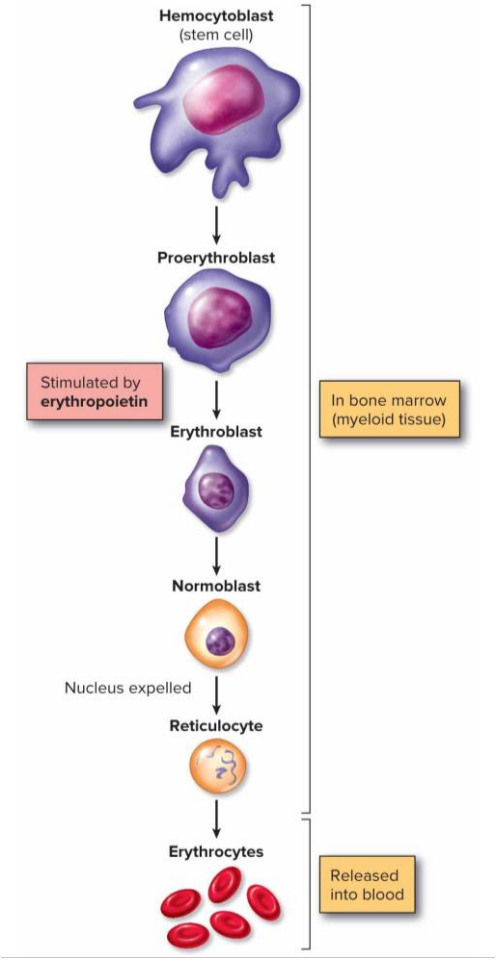
Formed Elements of the Blood: Platelets (thrombocytes)

- Smallest formed element, fragments of large cells called megakaryocytes
- Lack _____
- Very short-lived (5 to 9 days)
- Forms fibrin to clot blood with several other chemicals and fibrinogen
- Release serotonin that stimulates vasoconstriction; secrete growth factors
- Count: 130,000 to 400,000/mm3 blood

Abnormal blood cell counts

- Anemia – abnormally low RBCs
- Polycythemia – abnormally high RBCs

- Leukopenia – abnormally low _____
- Leukocytosis – abnormally high _____
- Leukemia – cancer of the bone marrow that causes high numbers of abnormal, immature WBCs



Hematopoiesis (Hemopoiesis): Process of blood cell formation

- Hematopoietic stem cells – embryonic cells that give rise to all blood cells that originate in the yolk sac of the human embryo; they are self-renewing, dividing by mitosis
- The _____ is the major hematopoietic organ of the fetus; process occurs in myeloid tissue (red bone marrow) and lymphoid tissue after birth
- As cells differentiate, they develop membrane receptors for chemical signals

Hematopoiesis (Hemopoiesis): Erythropoiesis

- Formation of red blood cells from erythroblasts
- Red bone marrow produces about 2.5 million RBCs/sec
- Regulation of erythropoiesis
- Process stimulated by erythropoietin from the kidneys that respond to low blood O2 levels
- Process takes about _____ days
- Most iron is recycled from old RBCs, the rest comes from the _____
    - Intestinal iron secreted into blood through ferroportin channels
    - All iron travels in blood bound to transferrin
    - Major regulator of iron homeostasis is the hormone hepcidin which removes ferroportin channels to promote cellular storage of iron and lowers plasma iron levels

Hematopoiesis (Hemopoiesis): Leukopoiesis

- Formation of white blood cells from myeloblasts, lymphoblasts, and monoblasts
- _____ stimulate the production of the different subtypes
    - Multipotent growth factor-1, Interleukin-1, Interleukin-3, Granulocyte colony stimulating factor, Granulocyte-monocyte colony-stimulating factor

Hematopoiesis (Hemopoiesis: Thrombopoiesis

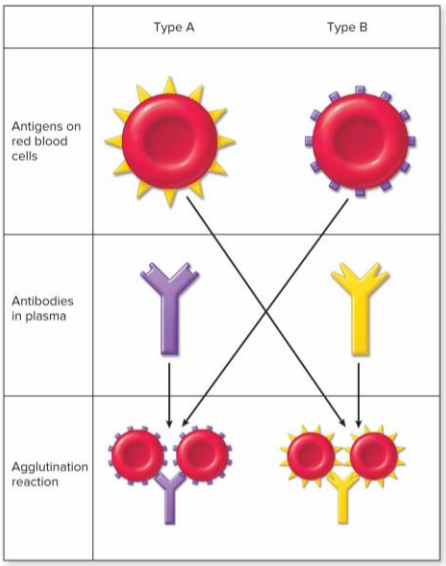
- Thrombopoietin stimulates growth of megakaryocytes and maturation into platelets.
- Thrombocytosis is an abnormally elevated platelet count. This occurs when conditions such as acute blood loss, inflammation, cancer, and others stimulate the liver to produce an excess of thrombopoietin.
- Thrombocytopenia – _____ platelet count

Red Blood Cell Antigens and Blood Typing

- Antigens: found on the surface of cells to help immune system recognize self cells
- Antibodies: secreted by lymphocytes in response to foreign cells
- ABO system: antigens on erythrocyte cell surfaces
    - Type A - has the A antigen (I^A)
    - Type B - has the B antigen (I^B)
    - Type AB - has both the A and B antigens
- Type O - has neither the A nor the B antigen (i)

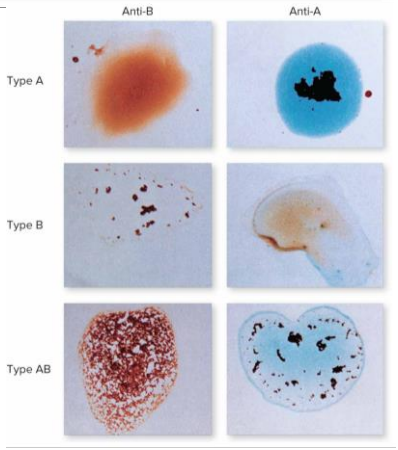
Genotype	Antigen on RBCs	Antibody in Plasma
I^AI^A; I^Ai	A	Anti-B
I^BI^B; I^Bi	B	Anti-A
ii	O	Anti-A and anti-B
I^AI^B	AB	Neither anti-A nor anti-B

- The plasma contains antibodies against the antigens not present on the RBC
    - Type A – has anti-B antibodies
    - Type B – has anti-B antibodies
    - Type AB – has no antibodies (universal recipient)
    - Type O – has anti-A and anti-B antibodies (universal donor)
- Transfusion reaction - If a person receives the wrong blood type, antibodies bind to erythrocytes and cause agglutination.



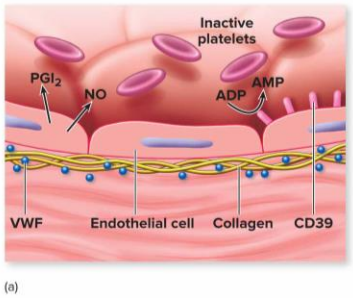
Red Blood Cell Antigens and Blood Typing: Rh factor

- Antigen D or Rho(D)
- Rh-positive has the _____
- Rh-negative does not have the antigen; will not have antibodies unless exposed to Rh+ either through a blood transfusion or pregnancy
- Issues in pregnancy– An Rh– mother exposed to Rh+ fetal blood produces antibodies. This may cause erythroblastosis fetalis in future pregnancies as antibodies cross the placenta and attack fetal RBCs. Rh- mother is treated with RhoGAM that inactivates the antigens



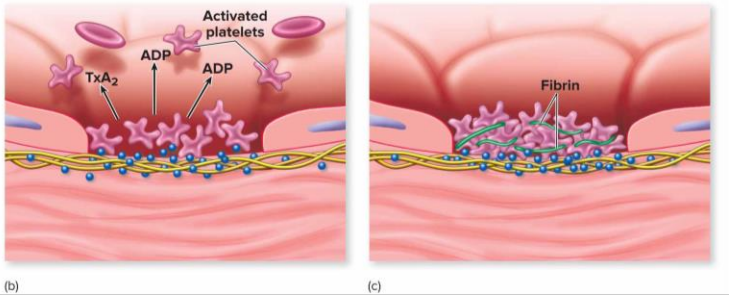
Blood Clotting

- _____: cessation of bleeding when a blood vessel is damaged
- Damage exposes collagen fibers to blood, producing:
    - Vasoconstriction
    - Formation of platelet plug
    - Formation of fibrin protein web
- Platelets and blood vessel walls
    - Intact endothelium secretes prostacyclin (PGI2) and nitric oxide, which:
        - Vasodilate
        - Inhibit platelet aggregation
    - Intact endothelium also secretes CD39, which breaks down ADP into AMP and Pi to inhibit further platelet aggregation



(a)

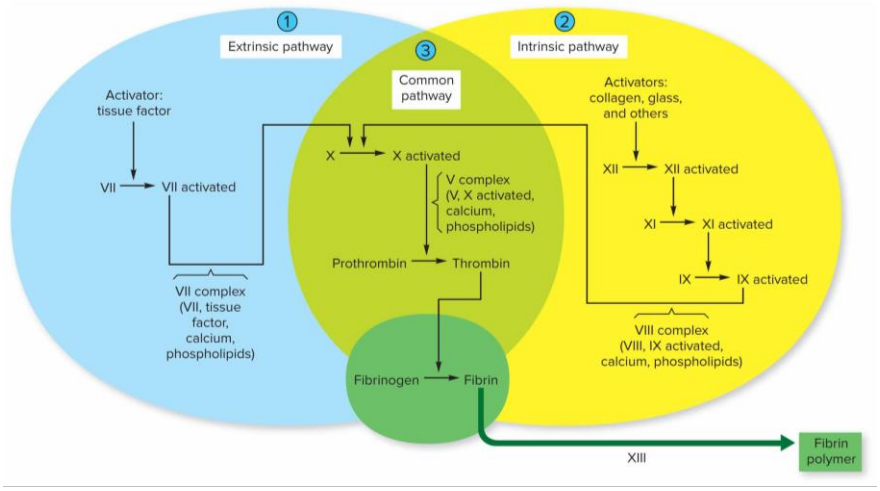
- Damaged endothelium exposes collagen
    - Glycoproteins on platelet membranes bind to _____
    - Von Willebrand factor (VWF) holds them there
    - Platelets recruit more platelets and form a platelet plug by secreting: (Platelet release reaction)
        - ADP (sticky platelets)
        - Serotonin (vasoconstriction)
        - Thromboxane A2 (sticky platelets and vasoconstriction)
    - Activated platelets also activate plasma clotting factors



(b) (c)

Blood Clotting: Clotting factors:

Formation of Fibrin



- Fibrinogen is converted to fibrin via one of two pathways:
  - _____ (contact pathway): Activated by exposure to collagen, polyphosphates and NETS. Factor XII activates a cascade of other blood factors. Amplifies the extrinsic pathway.
  - _____: Initiated by tissue thromboplastin (factor III). This is a more direct, shorter pathway.
- Next, calcium and phospholipids (from the platelets) convert prothrombin to the active enzyme thrombin, which converts fibrinogen to fibrin.
- Vitamin _____ is needed by the liver to make several of the needed clotting factors
- Dissolution of clots
  - Factor XII converts an inactive plasma molecule to kallikrein which catalyzes conversion for plasminogen to plasmin
  - Plasmin digests fibrin
- Anticoagulants - clotting can be prevented with certain drugs:
  - Calcium chelators (sodium citrate or _____)
  - Heparin: inactivates thrombin
  - Warfarin (Coumadin): inhibits vitamin K production
  - Rivaroxaban (Xarelto): inhibits Factor X

Category	Cause of Disorder	Comments
Acquired clotting disorders	Vitamin K deficiency	Inadequate formation of prothrombin and other clotting factors in the liver
Inherited clotting disorders	Hemophilia A (defective factor	Recessive trait carried on X chromosome; results in delayed formation of fibrin
	von Willebrand's disease (defective factor	Dominant trait carried on autosomal chromosome; impaired ability of platelets to adhere to collagen in subendothelial connective tissue
	Hemophilia B (defective factor IX); also called Christmas disease	Recessive trait carried on X chromosome; results in delayed formation of fibrin
Anticoagulants		
Aspirin	Inhibits prostaglandin production, resulting in a defective platelet release reaction	
Coumarin	Inhibits activation of vitamin K	
Heparin	Inhibits activity of thrombin	
Citrate	Combines with Ca^{2+}, and thus inhibits the activity of many clotting factors	

Hemophilia – clotting disorders

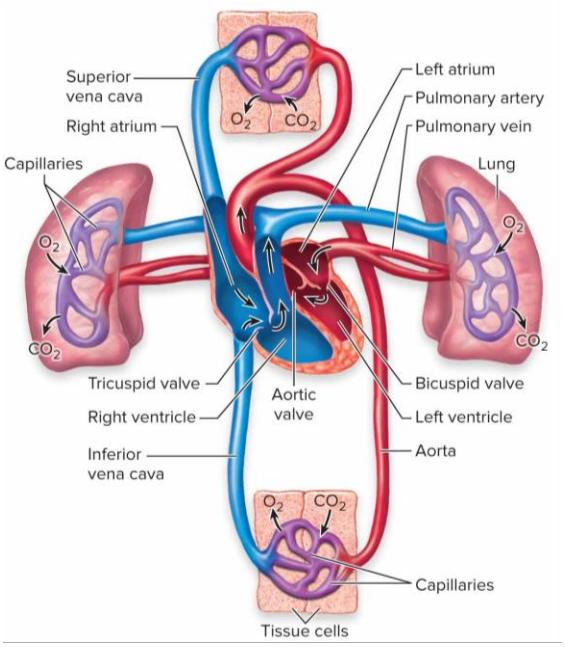
- Hemophilia A – X-linked recessive trait prevalent in European royal families; a subunit of factor VIII prevents participation in the intrinsic pathway
- Von Willebrand's disease – defect in a different subunit of factor VIII; most common bleeding disorder
- Hemophilia B – defective X-linked gene for factor IX

Factor	Name	Function	Pathway
I	Fibrinogen	Converted to fibrin	Common
II	Prothrombin	Converted to thrombin (enzyme)	Common
III	Tissue thromboplastin	Cofactor	Extrinsic
IV	Calcium ions (Ca^{2+})	Cofactor	Intrinsic, extrinsic, and common
V	Proaccelerin	Cofactor	Common
VII*	Proconvertin	Enzyme	Extrinsic
VIII	Antihemophilic factor	Cofactor	Intrinsic
IX	Plasma thromboplastin component; Christmas factor	Enzyme	Intrinsic
X	Stuart-Prower factor	Enzyme	Common
XI	Plasma thromboplastin antecedent	Enzyme	Intrinsic
XII	Hageman factor	Enzyme	Intrinsic
XIII	Fibrin stabilizing factor	Enzyme	Common

Structure of the Heart

- Four chambers
  - Right atrium: receives deoxygenated blood from the body
  - Left atrium: receives oxygenated blood from the lungs
  - Right ventricle: pumps deoxygenated blood to the lungs
  - Left ventricle: pumps oxygenated blood to the body

- The right and left sides are separated by a muscular wall (septum) that prevents the mixing of oxygen rich and oxygen poor blood
- Fibrous skeleton
    - Separates atria from ventricles. The atria therefore work as one unit (myocardium), while the ventricles work as a separate unit.
    - Forms the annuli fibrosi rings, which support the heart valves



Pulmonary: between heart and _____

- Blood pumps to lungs via pulmonary arteries.
- Blood returns to heart via pulmonary veins.

Systemic: between heart and _____

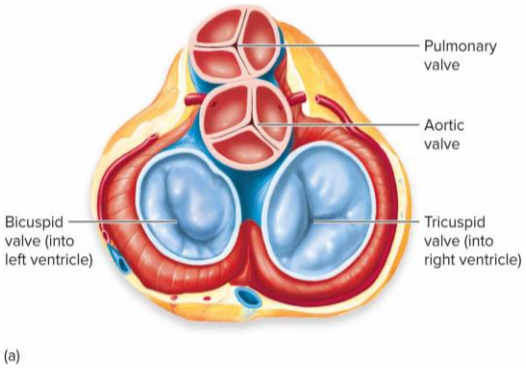
- Blood pumps to body tissues via aorta.
- Blood returns to heart via superior and inferior venae cava.

	Source	Arteries	O_2 Content of Arteries	Veins	O_2 Content of Veins	Termination
Pulmonary Circulation	Right ventricle	Pulmonary arteries	Low	Pulmonary veins	High	Left atrium
Systemic Circulation	Left ventricle	Aorta and its branches	High	Superior and inferior venae cavae and their branches*	Low	Right atrium

*Blood from the coronary circulation does not enter the venae cavae, but instead returns directly to the right atrium via the coronary sinus.

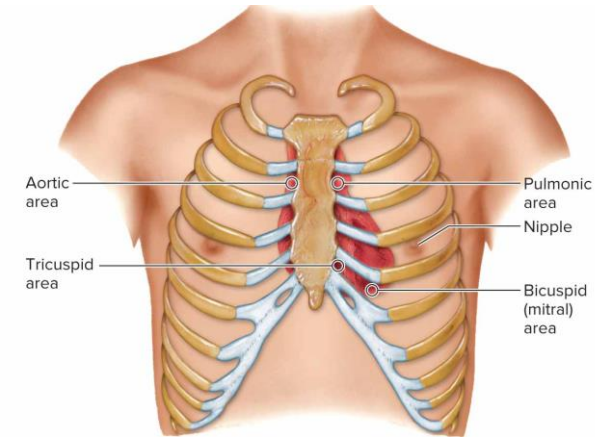
Atrioventricular and Semilunar Valves

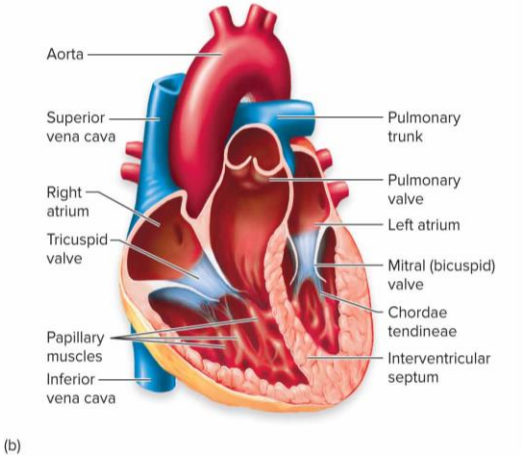
- _____ (AV) valves: located between the atria and the ventricles; prevent backflow
    - Tricuspid: between right atrium and ventricle
    - Bicuspid or mitral: between left atrium and ventricle
    - Papillary muscles and chordae tendineae prevent the valves from everting
- _____ valves: located between the ventricles and arteries leaving the heart; prevent backflow
    - Pulmonary: between right ventricle and pulmonary trunk
    - Aortic: between left ventricle and aorta



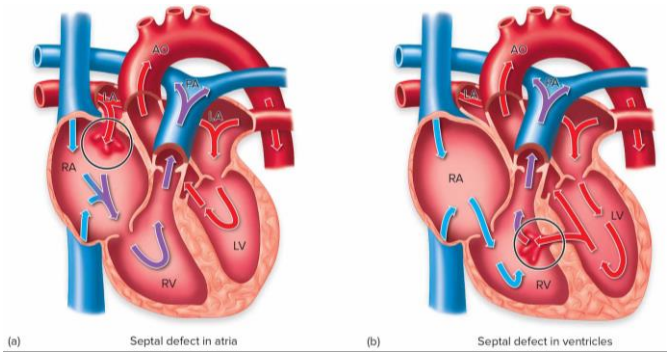
Heart Sounds

- Produced by closing valves
- "_____" = closing of AV valves; occurs at ventricular systole
- "_____" = closing of semilunar valves; occurs at ventricular diastole

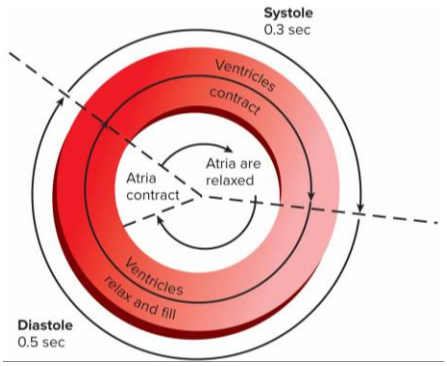




Heart Sounds: Heart Murmur

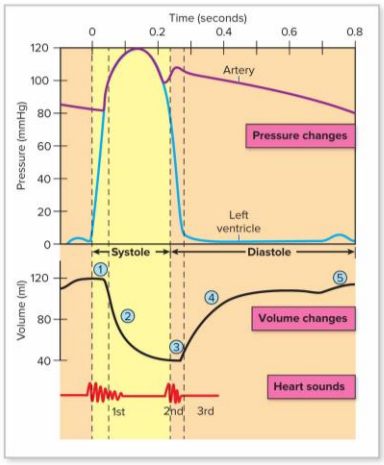


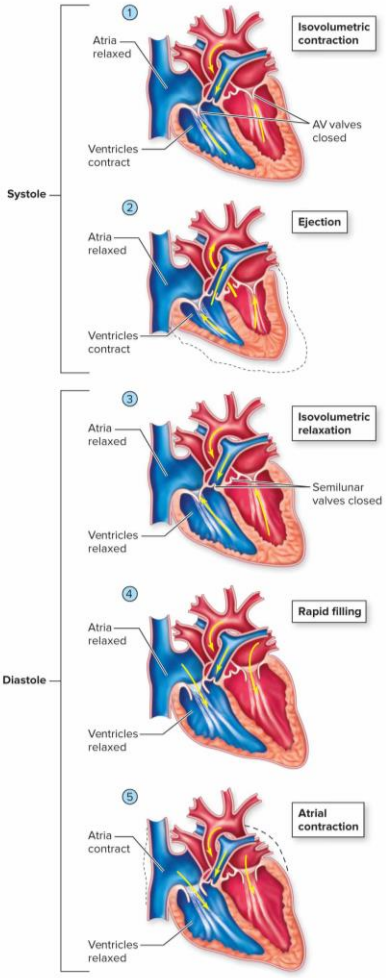
- Abnormal heart sounds produced by abnormal blood flow through heart.
  - Many caused by defective heart valves.
  - May be congenital or from rheumatic endocarditis
- _____ stenosis: Mitral valve calcifies and impairs flow between left atrium and ventricle.
  - May result in pulmonary hypertension.
- Incompetent valves: do not close properly
  - May be due to damaged papillary muscles
  - Mitral valve prolapse – most common cause of chronic mitral regurgitation
- _____ defects: holes in interventricular or interatrial septa which allows blood to cross sides.
  - Patent ductus arteriosus results from a failure of the foramen ovale to close after birth.
- Access the text alternative for slide images.



Cardiac Cycle: Introduction to the Cardiac Cycle

- Repeating pattern of contraction and relaxation of the heart.
- _____: contraction of heart muscles
- _____: relaxation of heart muscles
- End-diastolic volume – total volume of blood in the ventricles at the end of diastole
- End-systolic volume – the amount of blood left in the left ventricle after systole (1/3 of the end-diastolic volume)
- The amount ejected is the <u>stroke volume</u> (ejection fraction)
  - At the average cardiac rate of 75 beats/min, each cycle lasts 0.8 sec
- Ventricles begin contraction, pressure rises, and AV valves close (lub); isovolumetric contraction
- Pressure builds, semilunar valves open, and blood is ejected into arteries.
- Pressure in ventricles falls; semilunar valves close (dub); isovolumetric relaxation; both sets of valves now closed; Dicrotic notch – slight inflection in pressure during isovolumetric relaxation;
- Pressure in ventricles falls below that of atria, and AV valve opens. Ventricles fill.
- Atria contract, sending last of blood to ventricles



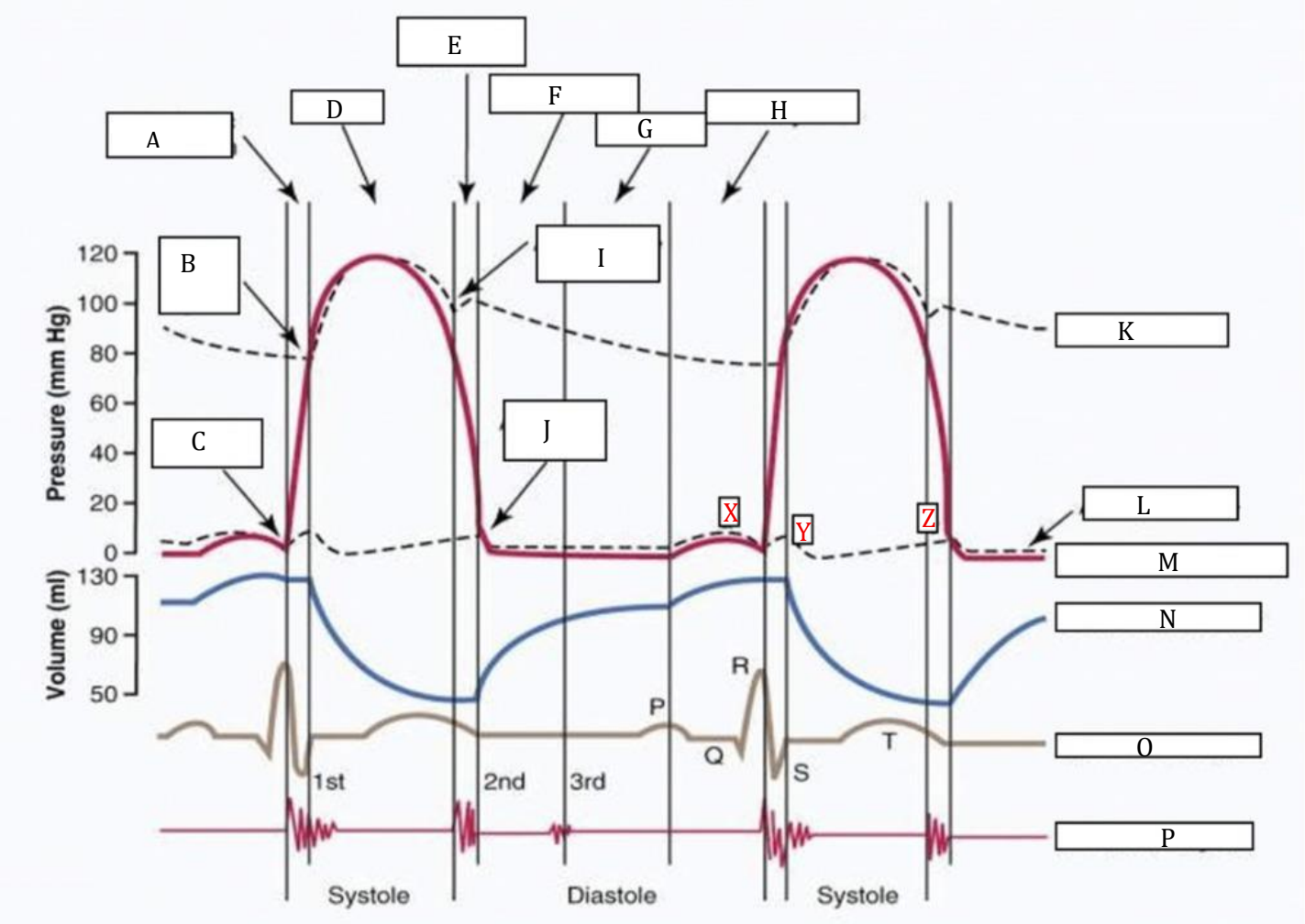


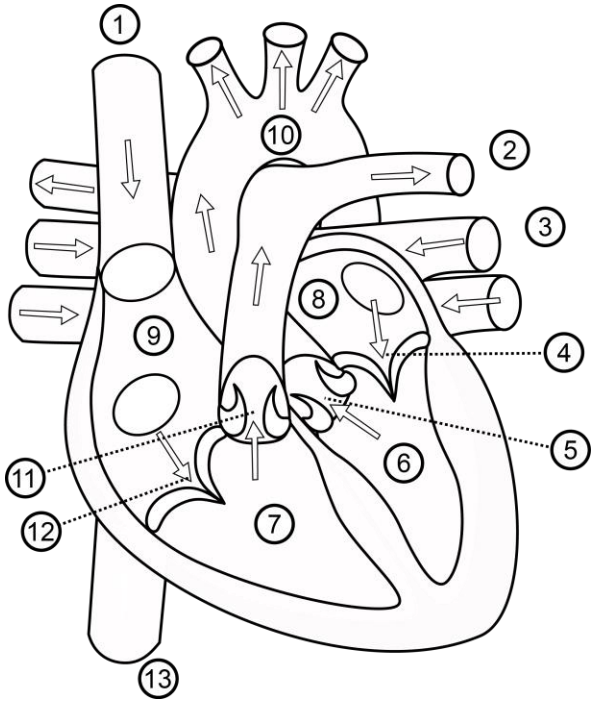
Topic 21: Cardiovascular Part 1 Study Guide Questions (preppages)

1. Which of the following is NOT a function of the circulatory system?
   a. transportation of gases
   b. protection via immunity
   c. hormone secretion by the adrenal cortex
   d. regulation of temperature
2. Arteries always:
   a. carry deoxygenated blood
   b. carry blood toward the heart
   c. carry blood away from the heart
   d. contain valves to prevent backflow
3. Which component makes up the majority of plasma by concentration?
   a. potassium
   b. sodium
   c. calcium
   d. glucose
4. Albumin's primary role is to:
   a. act as an antibody
   b. form fibrin clots
   c. create osmotic pressure to maintain blood volume
   d. transport lipids
5. Gamma globulins are responsible for:
   a. blood pressure regulation
   b. lipid transportation
   c. immunity (antibodies)
   d. osmotic balance
6. Venous blood is typically:
   a. bright red and oxygenated
   b. dark red and deoxygenated
   c. colorless
   d. blue due to lack of iron
7. Which formed element lacks nuclei and mitochondria?
   a. monocytes
   b. erythrocytes
   c. platelets
   d. lymphocytes
8. Anemia is defined as:
   a. high wbc count
   b. low hemoglobin or rbc count
   c. low platelet count
   d. high rbc count
9. Pernicious anemia results from a deficiency in:
   a. iron
   b. vitamin c
   c. vitamin b12 due to lack of intrinsic factor
   d. erythropoietin
10. Leukopoiesis is stimulated primarily by:
    a. adh
    b. cytokines
    c. erythropoietin
    d. fibrinogen
11. Thrombopoietin stimulates production of:
    a. rbcs
    b. wbcs
    c. platelets
    d. antibodies
12. A universal donor in the ABO system is blood type:
    a. a
    b. b
    c. ab
    d. o
13. Rh-negative individuals produce anti-Rh antibodies:
    a. naturally at birth
    b. only after exposure to rh+ blood
    c. only after age 50
    d. regardless of exposure
14. The first step in hemostasis after vessel damage is:
    a. fibrin formation
    b. vasoconstriction
    c. platelet plug dissolution
    d. activation of plasmin
15. The intrinsic clotting pathway is triggered by:
    a. tissue thromboplastin
    b. exposure to collagen
    c. vitamin k deficiency
    d. lack of adp
16. The chamber that pumps oxygenated blood to the body is the:
    a. right atrium
    b. right ventricle
    c. left atrium
    d. left ventricle
17. AV valves prevent backflow between:
    a. atria and ventricles
    b. ventricles and arteries
    c. veins and atria
    d. arteries and capillaries
18. The “lub” heart sound corresponds to:
    a. closing of semilunar valves
    b. opening of av valves
    c. closing of av valves at ventricular systole
    d. blood entering the ventricles
19. Stroke volume represents:
    a. blood remaining after systole
    b. total blood entering the atria
    c. volume ejected by ventricles each beat
    d. total blood volume in the heart
20. A septal defect results in:
    a. blood bypassing the lungs
    b. backflow into veins
    c. mixing of oxygenated and deoxygenated blood
    d. failure of av valves to close

Fill in the missing blanks below:

Terms to use: Aortic pressure, ventricular pressure, atrial pressure, isovolumetric contraction, ventricular ejection, isovolumetric relaxation, aortic pressure, left ventricular pressure, left atrial pressure, end diastolic volume (EDV), end systolic volume (ESV), aortic valve opens/closes, mitral (AV) valve opens/closes, stroke volume, QRS complex, S1=lub, S2=dub, T wave, P wave. Don't forget to identify the parts of the heart at the bottom (identify #1-13).





Helpful images below: