

Chapter 13 Outline

- ▶ Functions and Components of the Circulatory System
- ▶ Composition of Blood
- ▶ Structure of the Heart
- ▶ Cardiac Cycle and Heart Sounds
- ▶ Electrical Activity of the Heart and the ECG
- ▶ Blood Vessels
- ▶ Atherosclerosis and Cardiac Arrhythmias
- ▶ Lymphatic System

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Functions of Blood

- ▶ **Transportation**
 - ▶ **O₂, CO₂, metabolic wastes, nutrients, & hormones**
- ▶ **Regulation**
 - ▶ **helps regulate pH**
 - ▶ **helps regulate body temperature**
 - ▶ **Vasodilatation/vasoconstriction**
 - ▶ **helps regulate water content of cells by interactions with dissolved ions and proteins**
- ▶ **Protection from disease & loss of blood**

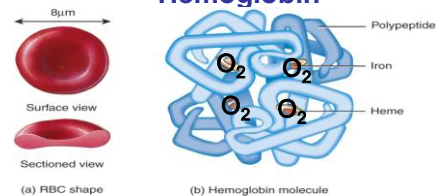
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Plasma Proteins

- ▶ Constitute 7-9% of plasma
- ▶ 3 types of plasma proteins: albumins, globulins, and fibrinogen
 - ▶ **Albumin** accounts for 60-80%
 - ▶ Creates colloid osmotic pressure that draws H₂O from interstitial fluid into capillaries
 - ▶ **Globulins:**
 - ▶ Alpha & beta: prod. by liver - carry lipids (vitamins)
 - ▶ Gamma globulins: prod. by lymphocytes – are antibodies
 - ▶ **Fibrinogen** serves as clotting factor (vs. serum)
- ▶ Plasma regulation: Osmoreceptors in hypothalamus

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Hemoglobin



- ▶ **Globin protein consists of 4 polypeptide chains**
- ▶ **1 Heme (non-protein, C-H-N ring)/polypeptide chain**
- ▶ **Each heme has an iron ion (Fe) that can bond (reversibly) with 1 O₂ oxygen molecule**
- ▶ **Each hemoglobin molecule can carry 4 O₂**
- ▶ **Each RBC ~ 280 million hemoglobin molecules**
- ▶ **300 billion RBCs are produced each day**

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Leukocytes

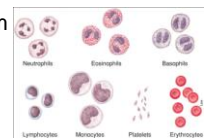
- ▶ Have a nucleus, mitochondria, amoeboid locomotion
- ▶ Can squeeze through capillary walls (**diapedesis**)
 - ▶ **Granular leukocytes:** phagocytic, detoxify foreign substances, release heparin
 - ▶ **Agranular leukocytes:** Provide immune response, phagocytic



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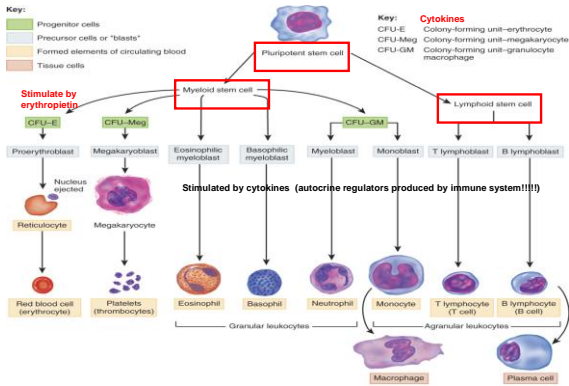
Platelets (thrombocytes)

- ▶ lack nucleus
- ▶ fragments of **megakaryocytes** from bone marrow
- ▶ Constitute most of mass of blood clots
- ▶ Release serotonin vasoconstricts vessels - reduce blood flow to clot area
- ▶ Secrete growth factors to maintain integrity of blood vessel wall
- ▶ Survive 5-9 days
- ▶ Stored in Spleen



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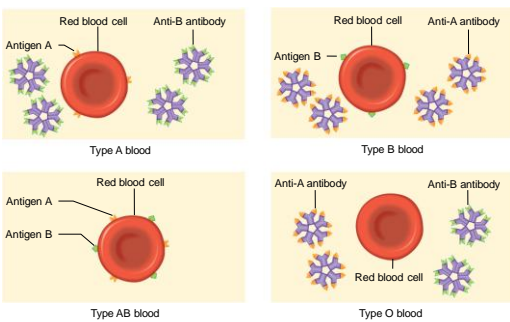
Hematopoiesis (Erythropoiesis/Leukopoiesis)



Terms to become familiar with:

- Agglutination – clumping of red blood cells in response to a reaction between an antibody and an antigen
- Antigens – a unique complex of **self-molecules** on cell surfaces. Foreign antigens (**non-self**) stimulate cells to produce antibodies
- Antibodies – proteins that react against a specific foreign antigen

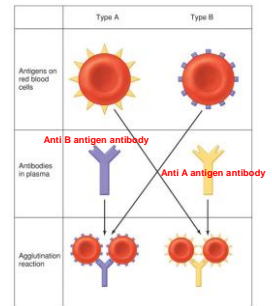
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Transfusion Reactions

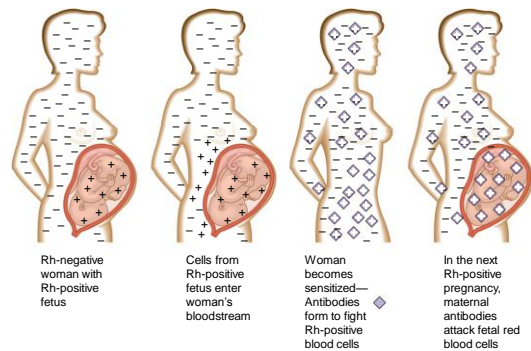
- ▶ Type A blood (A antigens) make anti-B antigen antibodies
- ▶ Type B blood (B antigens) make anti-A antigen antibodies
- ▶ Type AB blood (A & B antigens) doesn't have antibodies
- ▶ Type O (no antigens) has both anti- A & B antigen antibodies



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Rh Blood Group

- The group includes several Rh antigens or factors
- Rh positive – presence of antigen D (or other Rh antigens)
- Rh negative – lack of these antigens
- erythroblastosis fetalis or hemolytic disease of the newborn



Anti-D antibodies not normally in blood – they form only in Rh- who are exposed to Rh+ blood

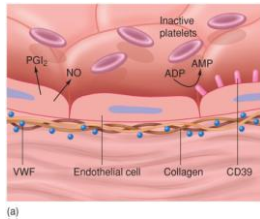
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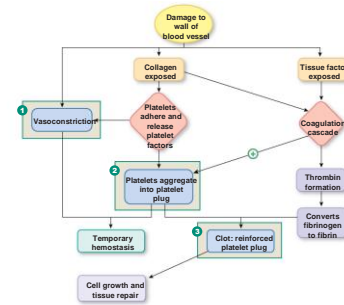
Intact Blood Vessel

Intact blood vessel:

- endothelium
 - Connective tissue collagen
 - Proteins (capable of activating platelets)
1. Endothelium keeps blood away from connective tissue (chemicals could activate platelets)
 2. Endothelium releases Prostaglandin (PGI₁) & Nitric Oxide:
 1. vasodilators
 2. inhibit platelet aggregation
 3. CD39 enzyme (endothelium) breaks down ADP to AMP
 - ADP released by platelets promotes platelet activation

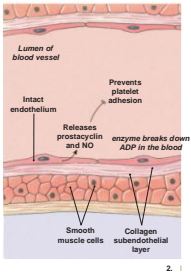


Overview of Hemostasis – 3 major steps



Vasoconstriction – Step 1: endothelial cells of damaged vessel
Releases vasoconstrictive paracrines

Platelet Plug Formation – step 2



2.

Coagulation – Step 3

- ▶ Coagulation (clotting) – last and most effective defense against bleeding
- ▶ Converts a platelet plug into a clot
 - ▶ **insoluble network fibrin threads**

Figure 16-11

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Coagulation – Step 3

Coagulation (clotting) – last and most effective defense against bleeding

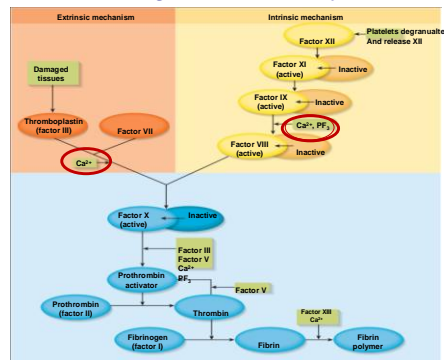
- ▶ Converts platelet plug into a clot (**insoluble network of fibrin threads**)

2 pathways ways to make Fibrin – Both use a number of

- ▶ **Intrinsic (contact) pathway** – exposure of plasma to collagen (or other negatively charged surface, e.g., test tube)
 - ▶ i.e., Damage to tissue exposes collagen
 - ▶ Activates plasma protein Factor XII (Protease)
 - ▶ Activates other Clotting Factors
 - ▶ Fibrinogen turns to Fibrin!!!!!!!
- ▶ **Extrinsic pathway:**
 - ▶ **Tissue Factor III (aka tissue thromboplastin)** released by damaged tissues begin cascade
 - ▶ Activates other clotting Factors
 - ▶ Fibrinogen turns to Fibrin!!!!!!!

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Coagulation Pathways



Overview of Hemostasis and Tissue Repair

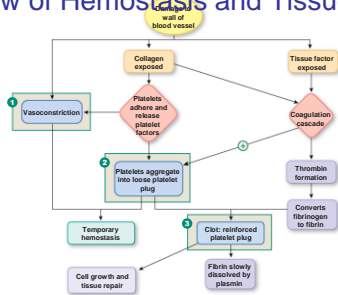
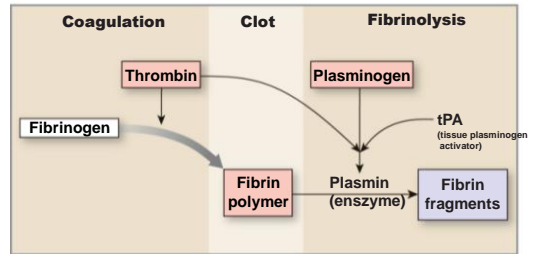


Figure 16-10 (15 of 17)

Coagulation and Fibrinolysis

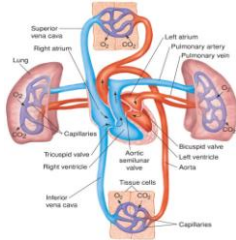


- clot retraction occurs within 30 minutes
- platelet-derived growth factor secreted by platelets and endothelial cells
- mitotic stimulant for fibroblasts and smooth muscle cells

Figure 16-13

Structure of Heart

- ▶ Heart has 4 chambers
 - ▶ 2 **atria** receive blood from venous system
 - ▶ 2 **ventricles** pump blood to arteries
 - ▶ Pulmonary and systemic systems



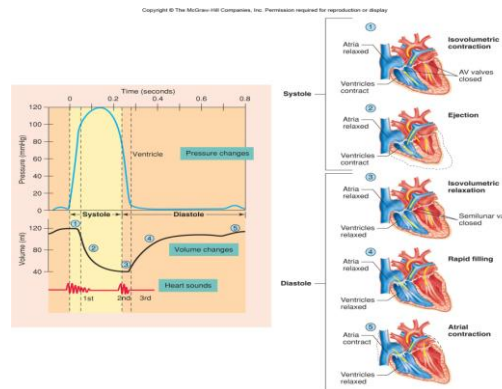
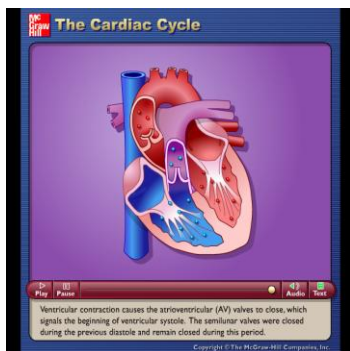
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Cardiac Cycle

- ▶ Is repeating pattern of contraction and relaxation of heart
 - ▶ **Systole** refers to contraction phase
 - ▶ **Diastole** refers to relaxation phase
 - ▶ Atria contract simultaneously; ventricles follow 0.1-0.2 sec later
 - ▶ **Stroke volume** : amount of blood ejected from 1 **ventricles** during systole (~ 70 mL)

$$EDV - ESV = \text{Stroke Volume}$$

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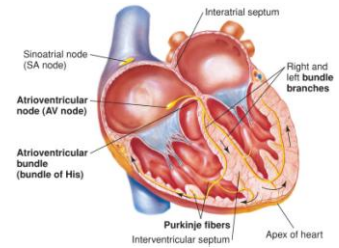


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Electrical Activity of Heart

- ▶ Myocardial cells are short, branched, and interconnected by gap junctions
- ▶ Entire muscle that forms a chamber is called a myocardium
 - ▶ Remember action potentials originating in any cardiac cell are transmitted to all others:
- ▶ Chambers separated by nonconductive tissue

SA Node Pacemaker



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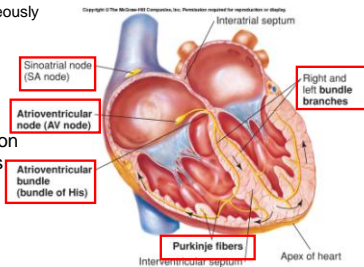
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Conducting Tissues of Heart

- ▶ SA node functions as pacemaker

- ▶ Depolarizes spontaneously (autorhythmic cells)
- ▶ Pacemaker Potential

- ▶ Wave of depolarization moves into ventricles



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Electrical Conduction in the Heart

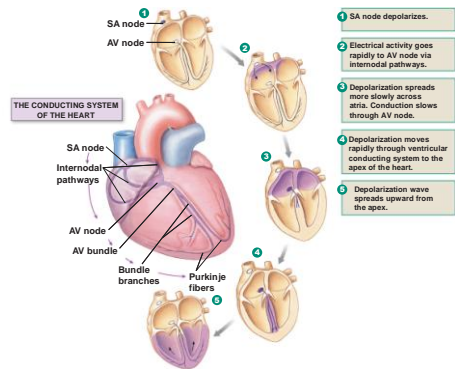
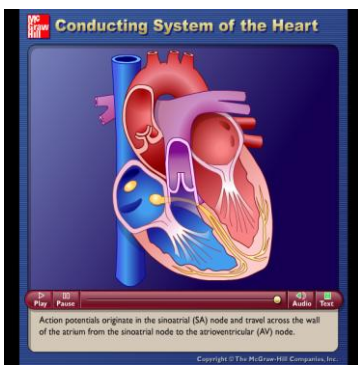
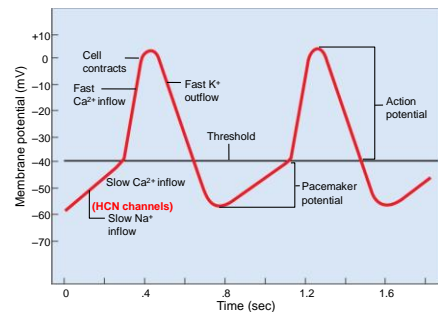


Figure 14-18, steps 1-5



SA Node Pacemaker Potentials



HCN channels = hyperpolarization activated cyclic nucleotide channels – channels open in response to hyperpolarization!!!! Na+ moves in

Action Potential in Myocardial Cells

▶ Action potential of a cardiac contractile cell

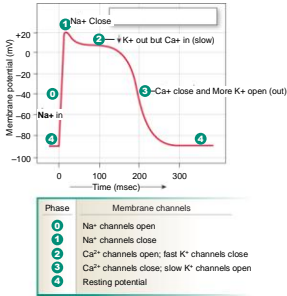


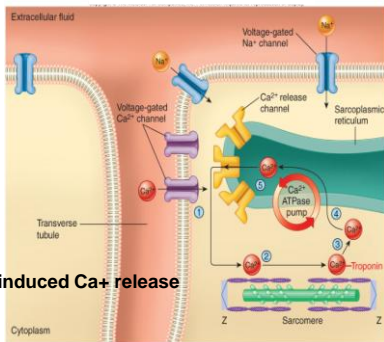
Figure 14-13

Excitation-Contraction Coupling

- ▶ Depolarization of myocardial cells opens V-gated Ca²⁺ channels in sarcolemma
 - ▶ This depolarization opens V-gated and Ca²⁺ release channels in SR (**calcium-induced-calcium-release**)
 - ▶ Ca²⁺ binds to troponin and stimulates contraction (as in skeletal muscle)
 - ▶ During repolarization Ca²⁺ pumped out of cell and into SR

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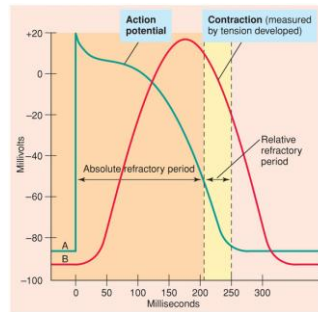
Cardiac Muscle (Myocardium)



▶ Ca⁺ induced Ca⁺ release

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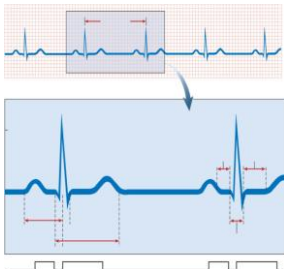
Refractory Periods



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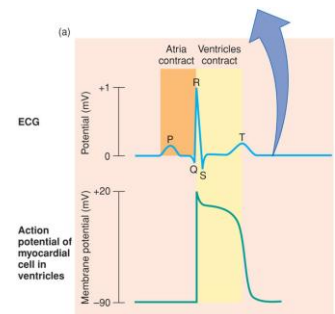
Electrocardiogram (ECG or EKG)

- ▶ Composite of all action potentials/amplified/recorded
- ▶ Recording of electrical activity of heart conducted thru ions in body to surface



Electrocardiogram (ECG/EKG)

- **P wave**
 - SA node fires, **atria depolarize** and contract
 - atrial systole begins 100 msec after SA signal
- **QRS complex**
 - **ventricular depolarization**
 - complex shape of spike due to different thickness and shape of the two ventricles
- **ST segment - ventricular systole**
 - plateau in myocardial action potential
- **T wave**
 - **ventricular repolarization** and relaxation



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Electrical Activity of Cardiac Cycle

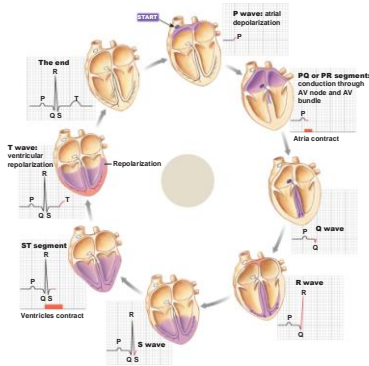
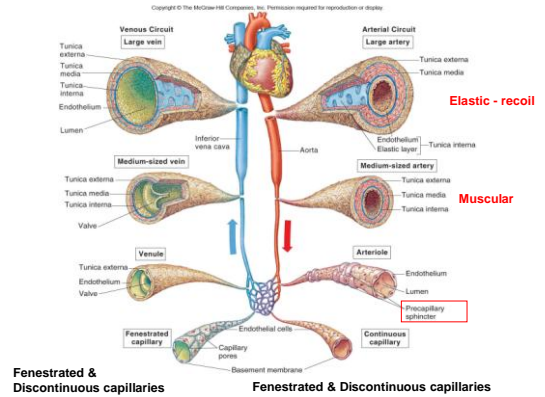


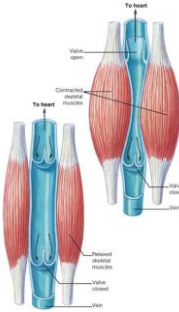
Figure 14-21 (9 of 9)



Fenestrated & Discontinuous capillaries

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Veins

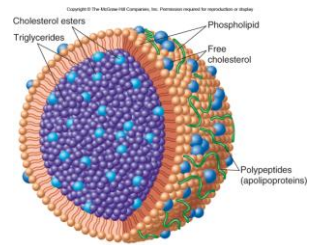


- Valves
- Skeletal muscular pumps
- Diaphragm

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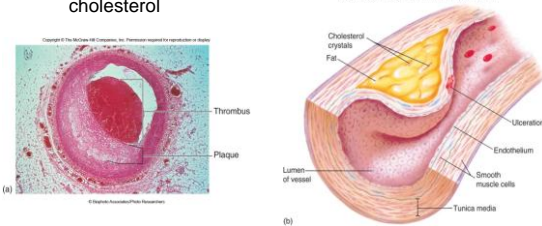
Cholesterol and Lipoproteins

- ▶ Lipids & cholesterol carried in blood by plasma lipoproteins
- ▶ LDLs: produced in liver
- ▶ Many organs cells have receptors for lipoproteins
 - ▶ Cell engulfs it
- ▶ Liver removes LDLs this way
- ▶ HDLs take cholesterol to liver



Atherosclerosis

- ▶ Plaques form in response to damage done to the endothelium of a blood vessel.
- ▶ Caused by:
 - ▶ Damage or "insult" to endothelium
 - ▶ Smoking, high blood pressure, diabetes, high cholesterol



LDL and Plaque

- ▶ The development of atherosclerotic plaques

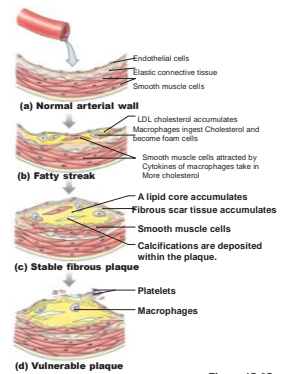


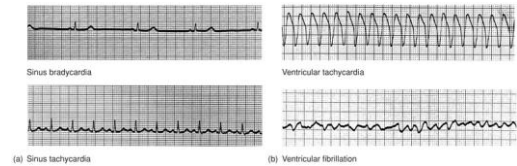
Figure 15-25

Ischemic Heart Disease

- ▶ **Ischemia** = blood supply to tissue is deficient
 - ▶ Causes increased lactic acid from anaerobic metabolism
- ▶ Is most commonly due to atherosclerosis in coronary arteries
- ▶ Often accompanied by **angina pectoris** (chest pain)

Arrhythmias Detected on ECG

- ▶ **Arrhythmias** are abnormal heart rhythms
- ▶ Heart rate <60/min is **bradycardia**; >100/min is **tachycardia**

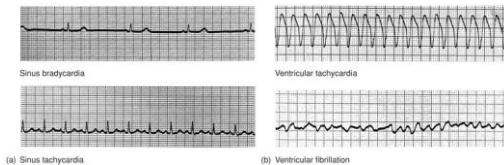


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Arrhythmias Detected on ECG

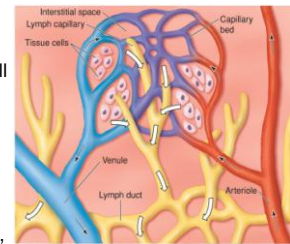
- ▶ In **flutter**, contraction rates can be 200-300/min
- ▶ In **fibrillation**, contraction of myocardial cells is uncoordinated and pumping ineffective
 - ▶ **Ventricular fibrillation** is life-threatening
 - ▶ **Electrical defibrillation** resynchronizes heart by depolarizing all cells at same time



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Lymphatic System

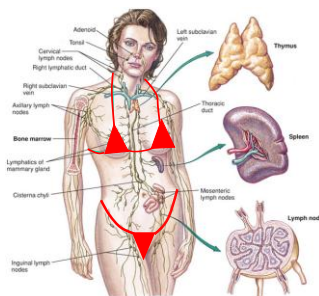
- ▶ 3 basic functions:
 1. Transports interstitial fluid (**lymph**) back to blood
 2. Transports fat from small intestine to blood
 3. Provides immunological defenses against pathogens
- ▶ **Lymphatic capillaries**
 - ▶ Very porous, absorb proteins, microorganisms, fat



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Lymphatic System

- ▶ Lymph nodes filter lymph before returning it to R. & L. subclavian veins via **thoracic duct** or **right lymphatic duct**
- ▶ Nodes contain lymphocytes and phagocytic cells that remove pathogens
- ▶ Tonsils, spleen, thymus (lymphoid organs)



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