Circulatory System

1. Function
2. Components
   - Heart
   - Blood
   - Vessels (vein & arteries)
   - Lungs
   - Lymphatic system

Functional Connections

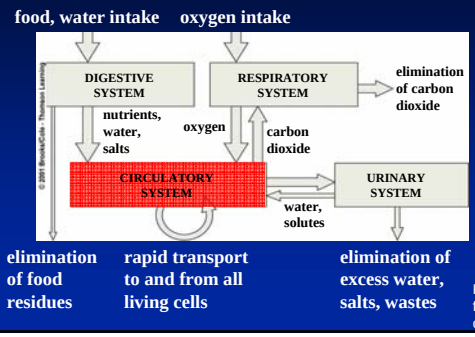


Figure 33.10 from page 559 of your text

Circulatory System

1. Accepts oxygen, nutrients, and other substances from the respiratory and digestive systems and delivers them to cells
2. Accepts carbon dioxide and wastes from cells and delivers them to respiratory and urinary systems for disposal
3. Also functions in temperature and pH control.

Parts of the Circulatory System

- Fluid – blood, hemolymph, coelomic fluid
- Tubes – arteries go away from heart; veins return to heart
- Pump – heart or pulsating vessel

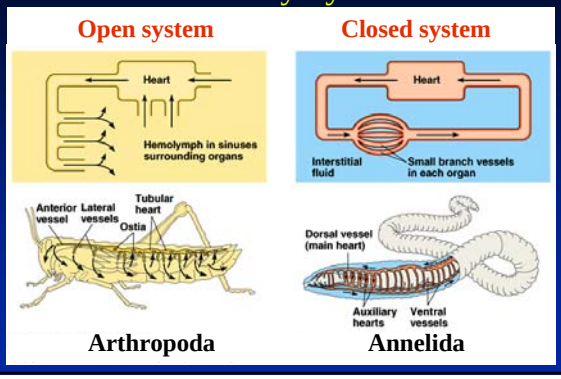
Circulatory Systems in Various Phyla

No Circulatory System
Porifera
Cnidaria
Playthelminthes
Nematoda

Open Circulatory System
Arthropoda
Mollusca (except squid and octopuses)
Echinodermata
Chordata (tunicates)

Closed Circulatory System
Annelida
Mollusca (squid and octopuses)
Chordata (cephalochordates and vertebrates)

Circulatory Systems

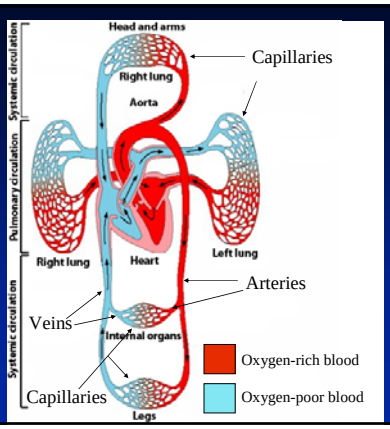


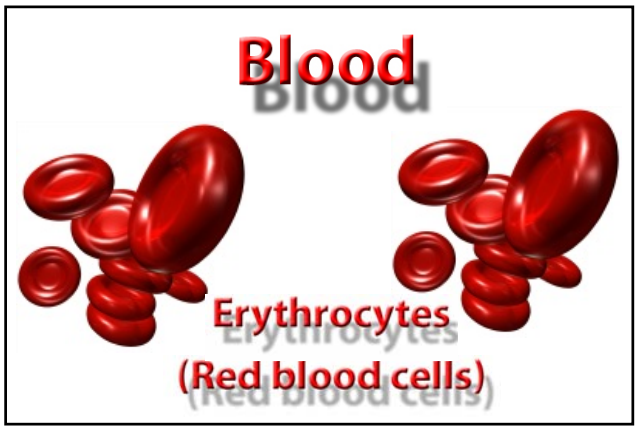
Closed Circulatory System

- Heart pumps blood in large arteries away from your heart. Diffusion occurs in tiny capillaries. Blood returns to heart in large veins.
- Large vessels for bulk transport
  - fast flow (2-4 cm/sec)
  - large diameter (10-12 mm diameter)
  - thick walls (muscular)
- Capillaries for diffusion
  - Slow flow (<1 mm/sec)
  - Small diameter (0.008 mm)
  - Very thin walls (single cell layer)
  - Fit one RBC through at a time. RBCs scrape walls.

Circulation

involves a pump (heart), arteries, veins, capillaries





Blood Volume and Composition

Blood is alive! Blood is 90% water.

1. Plasma portion
   - 50-60 percent of volume
   - Water, plasma proteins, dissolved ions and molecules
2. Cellular portion
   - 40-50 percent of volume
   - Red cells, white cells, and platelets

Erythrocytes

1. Red blood cells transport oxygen from lungs to aerobically respiring cells and carry carbon dioxide wastes from them.
2. Red blood cells have no nucleus (no DNA). They are created in bone marrow with enough proteins to last about 120 days.
3. Phagocytes engulf old cells.

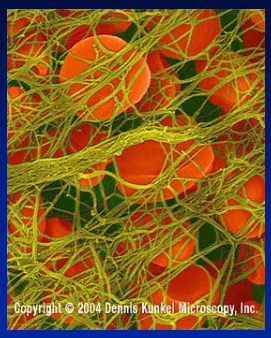
Leukocytes (White Blood Cells)

1. Cleaners and defender – engulf damaged and dead cells and anything tagged as foreign.
2. Some signal the immune system to mount a defense.
3. Elevated levels of white blood cells indicate to physicians that there is an infection.

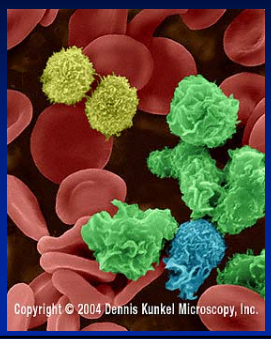
Megakaryocytes (Platelets)

1. There are hundred of thousands of platelets circulating in blood.
2. They live for about 8 days.
3. They respond to injury by releasing chemicals that initiate blood clotting

Red Blood Cells in a Clot



Macrophages, Lymphocytes, and Red Blood Cells

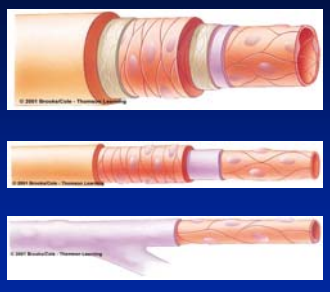


Sickle Cell Anemia

Blood Vessels

Figure 33.14 from page 562 of your text

1. Arteries: main transporters of oxygenated blood
2. Arterioles: diameter is adjusted to regulate blood flow
3. Capillaries: diffusion occurs across thin walls



The Venous System

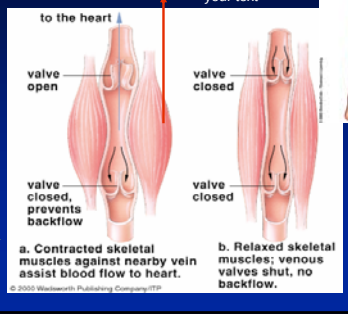
1. Blood flows from capillaries into venules, then on to veins
2. Veins are large-diameter vessels with some smooth muscle in wall
3. Valves in some veins prevent blood from flowing backward

Figure 33.14 from page 562 of your text

Venous Pressure

1. Veins
   - Large diameter
   - Low resistance
   - Valves
   - One-way flow
   - Blood Reservoir
     - 50-60% or total blood volume

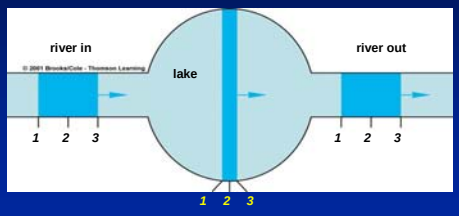
Figure 33.19 from page 565 of your text



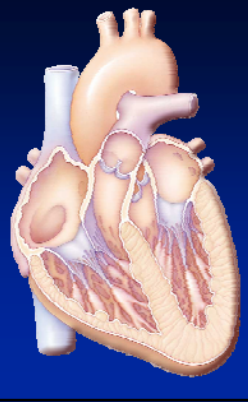
Vessel Sizes and Flow Rates

Vessel	Diameter (mm)	Number	Cross-sectional Area (cm^2)	Velocity (cm/sec)
Aorta	10	1	0.8	40
Large Arteries	3	40	3	
Capillaries	0.008	10-300 Billion	600	<0.1
Large Veins	6	40	20	
Vena Cava	12.5	1	1.2	5-20

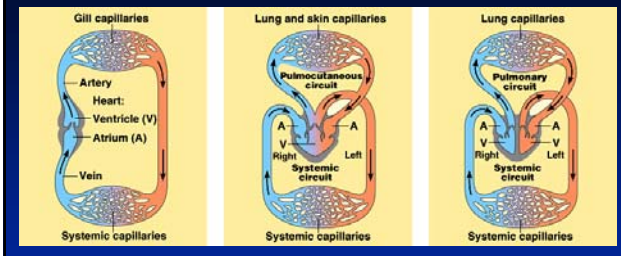
Flow Analogy



The Heart



Vertebrate Hearts and Circulation

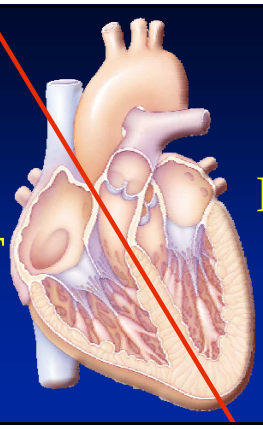


2-chambered heart	3-chambered heart	4-chambered heart
Fishes	Amphibians, Reptiles	Birds, Crocodiles, Mammals

Vertebrate Systems

1. Fish
   - Two-chamber heart pumps blood through one circuit
2. Amphibians
   - Heart pumps blood through two partially separate circuits
3. Birds and mammals
   - Four-chamber heart pumps blood through two entirely separate circuits

The Heart

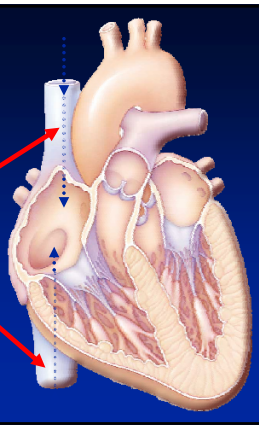


RIGHT

LEFT

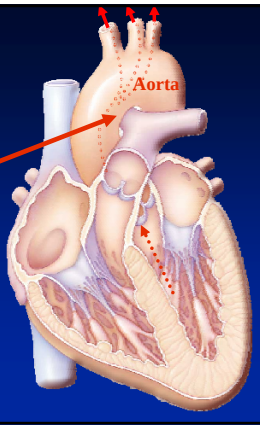
The Heart

Vena Cava
Delivers
oxygen-poor
blood to heart



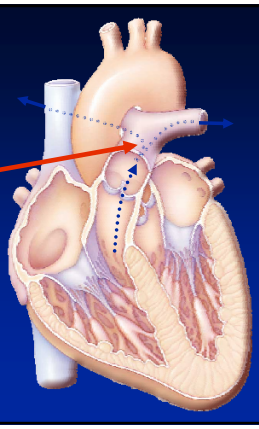
The Heart

Aorta
Delivers
oxygen-rich
blood to body

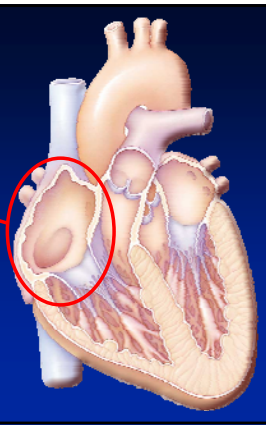


The Heart

Pulmonary Artery
Delivers
oxygen-poor
blood to lungs



The Heart



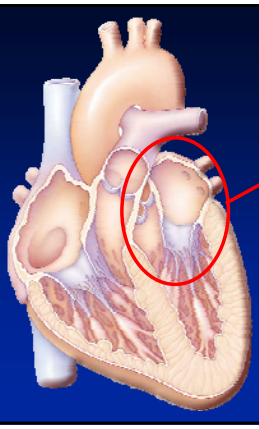
Left atrium

Right atrium

Left ventricle

Right ventricle

The Heart



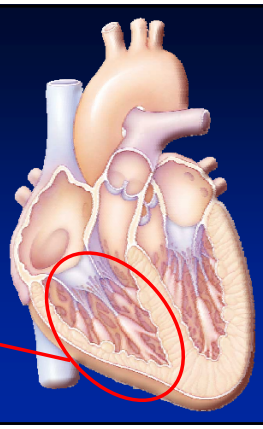
Left atrium

Right atrium

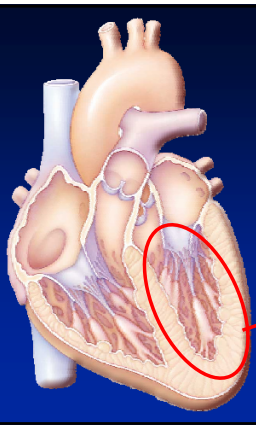
Left ventricle

Right ventricle

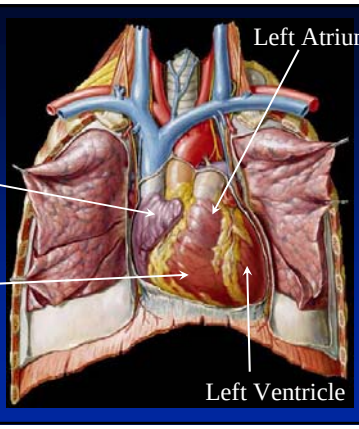
The Heart



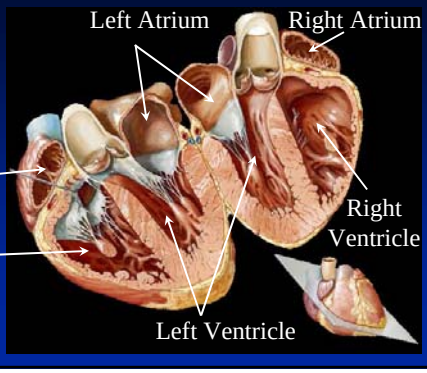
The Heart



Human Heart in Chest



Human Heart



Conduction and Contraction

1. SA node in right atrium is pacemaker
2. Electrical signals cause contraction of atria
3. Signal flows to AV node and down septum to ventricles

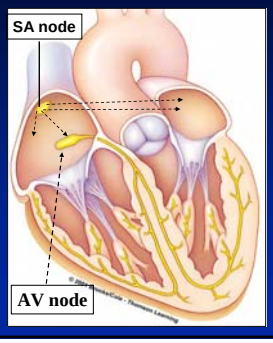
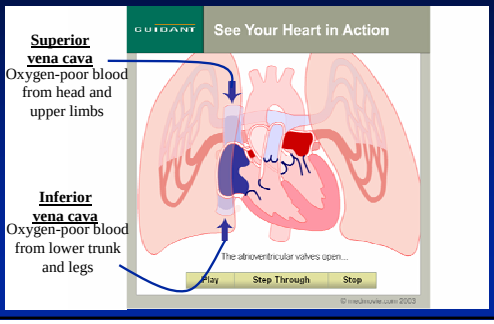
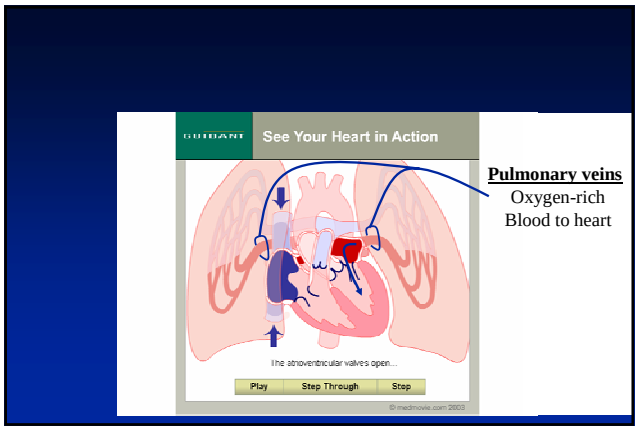


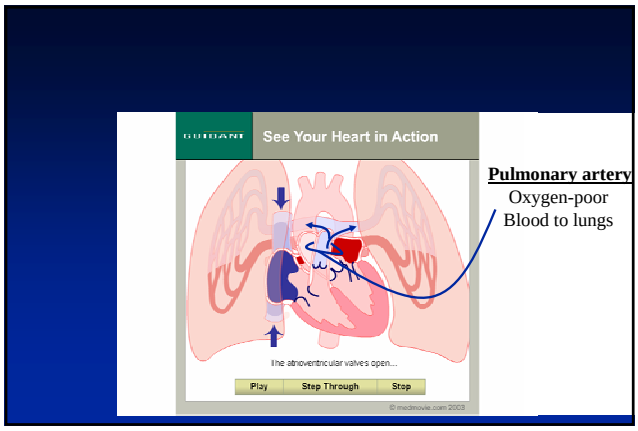
Figure 33.13(b) from page 561 of your text

Heart Contraction Animation

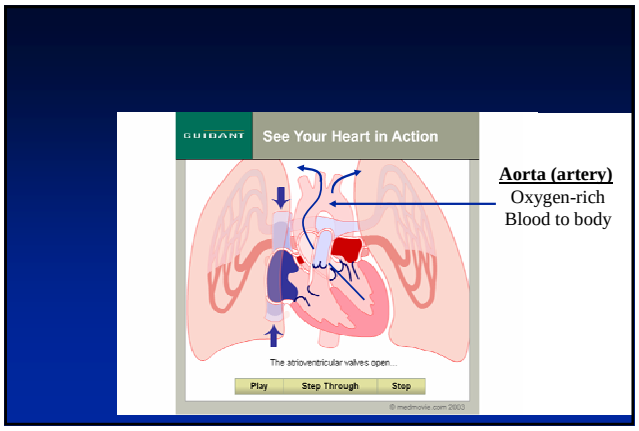




Pulmonary veins
Oxygen-rich
Blood to heart



Pulmonary artery
Oxygen-poor
Blood to lungs



Aorta (artery)
Oxygen-rich
Blood to body

Heart Contraction Animation

Pulmonary Circuit

Short loop that oxygenates blood

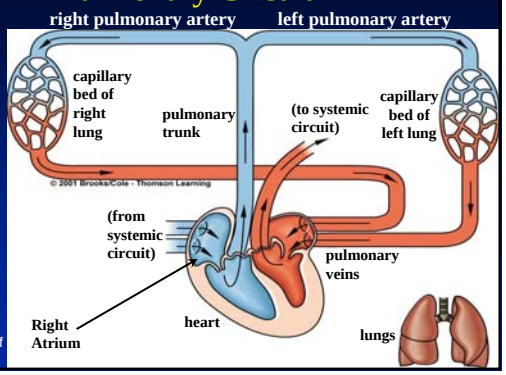
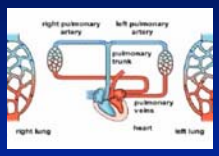


Figure 33.9(b) from page 559 of your text

Circulation Animation



Systemic Circuit

Longer loop that carries blood to and from body tissues

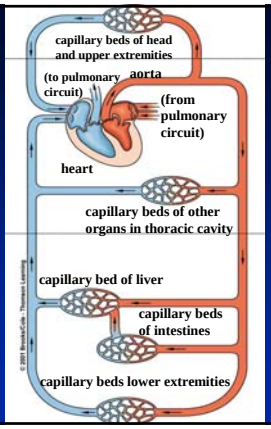
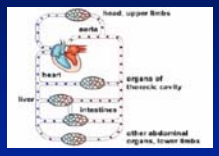


Figure 33.9(a) from page 559 of your text

Circulation Animation



Direction of Blood Flow

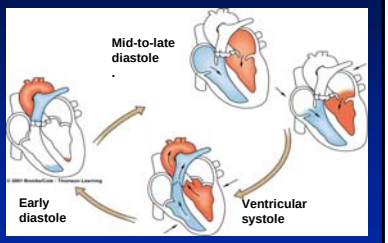
1st Pump
- LUB
  1. Superior and inferior vena cava
  2. Right atrium
  3. Right ventricle
- DUB
  4. Pulmonary artery

2nd Pump
- LUB
  5. Pulmonary veins
  6. Left atrium
  7. Left ventricle
- DUB
  8. Aorta

Cardiac Cycle Blood Pressure

1. Contraction phase is **systole** – when ventricles are fully contracted.
2. Relaxation phase is **diastole** – when ventricles are relaxed.

Figure 33.12 from page 561 of your text



Arteriole Blood Pressure

1. Resting blood pressure measures maximum systolic pressure and diastolic blood pressure (most relaxed ventrical state).
2. An average measure of 120/80 mm Hg is systolic pressure over diastolic pressure in millimeters of mercury (how far the pressure pushes Hg in a glass column.

Measure Blood Pressure

Blood pressure is measured using an inflatable cuff wrapped around the biceps. The cuff is attached to a pressure gauge. A stethoscope is placed over the brachial artery.

Blood Doping

Athletes withdraw and save blood just before an event. Withdrawal triggers manufacture of new RBCs. Athlete then adds original blood back into body. Extra RBCs increase O_2 carrying capacity.

Arteriosclerosis and Atherosclerosis

Arteriosclerosis – hardening of the arteries – arteries thicken and lose elasticity

Atherosclerosis – deposition of fatty substances inside artery walls and narrow the vessels.

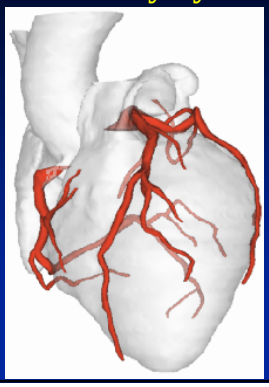
Both cause high blood pressure, chest pain, heart attack, stroke, or death.

Cholesterol

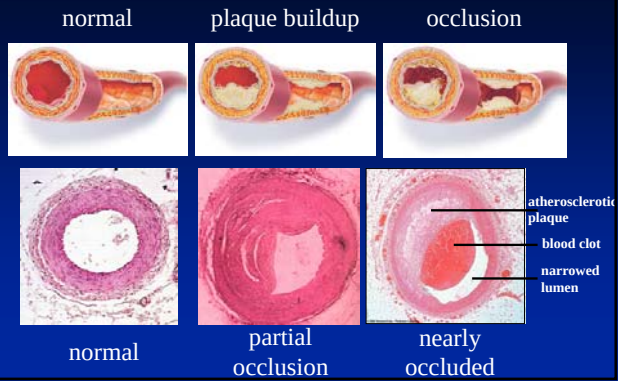
1. Cholesterol is used to make cell membranes, myelin sheaths, bile salts, and steroid hormones.
2. The liver makes enough cholesterol for all of these, but we ingest extra cholesterol and the body has to deal with it.
3. Most cholesterol in the blood is bound to proteins as low-density lipoproteins (LDLs). A small amount is bound to high-density lipoproteins (HDLs).
4. HDL is taken up and metabolized by the liver.
5. Over time LDL deposits cholesterol on artery walls and can lead to atherosclerosis.

Circulatory System

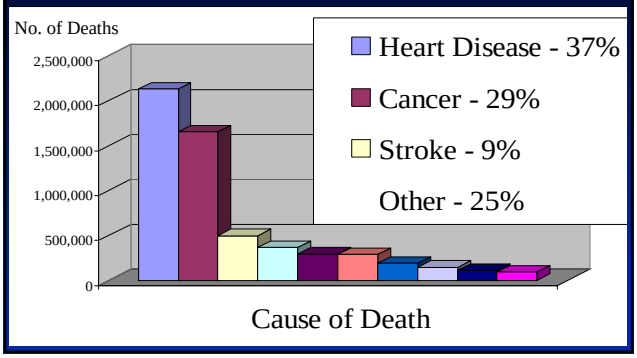
Human heart with coronary arteries in red



Atherosclerosis in Arteries



10 Leading Causes of Death, United States, 1999 - 2001, All Races, Both Sexes



Risk Factors for Cardiovascular Disease

- Smoking
- Genetic factors
- High cholesterol
- Obesity
- Lack of exercise
- Diabetes mellitus
- Gender (maleness)
- Old age

New Heart Bypass Surgery Method Video Clip

Lymphatic System

1. The circulatory system is leaky
2. Some fluid is forced out of the smallest vessels and into the interstitial fluid
3. Vessels of the lymphatic system pick up this fluid, filter it, and return it to the circulatory system

Lymph Vascular System

1. Fluid enters lymph capillaries
2. Capillaries merge into lymph vessels
3. Lymph vessels converge into ducts that funnel fluid into veins in the lower neck

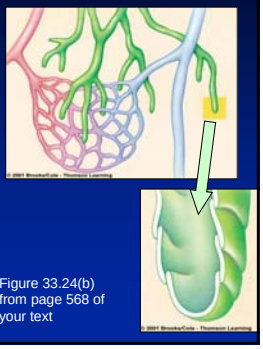


Figure 33.24(b) from page 568 of your text

Lymph Nodes

1. Located at intervals along lymph vessels
2. Act as a filter for lymph
3. Contain lymphocytes that can recognize a foreign invader

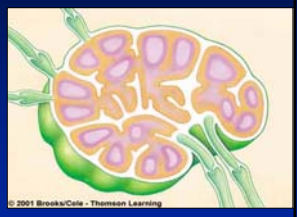


Figure 33.24(c) from page 568 of your text

Lymphoid Organs

1. Central to the body's defense
2. Tonsils
3. Spleen
4. Thymus gland

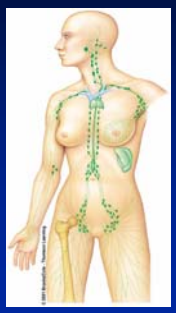


Figure 33.24 from page 568 of your text