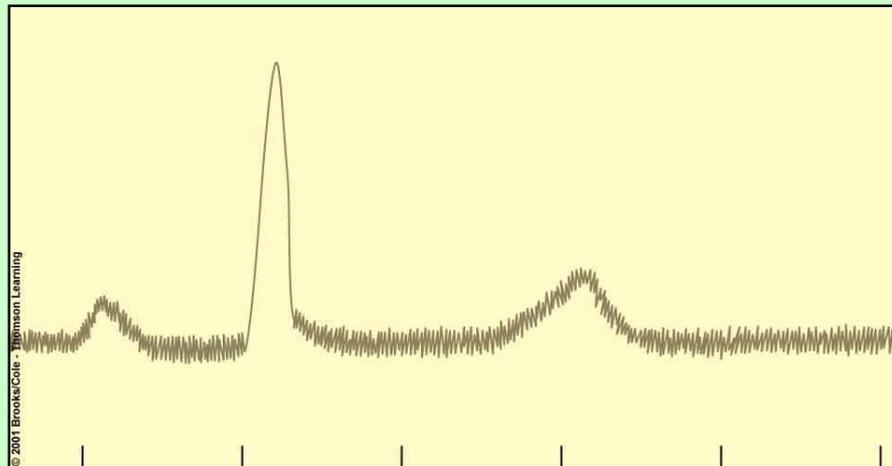


# Circulation

## The Cardio Vascular System Chapters 19 - 21



# Key Concepts:

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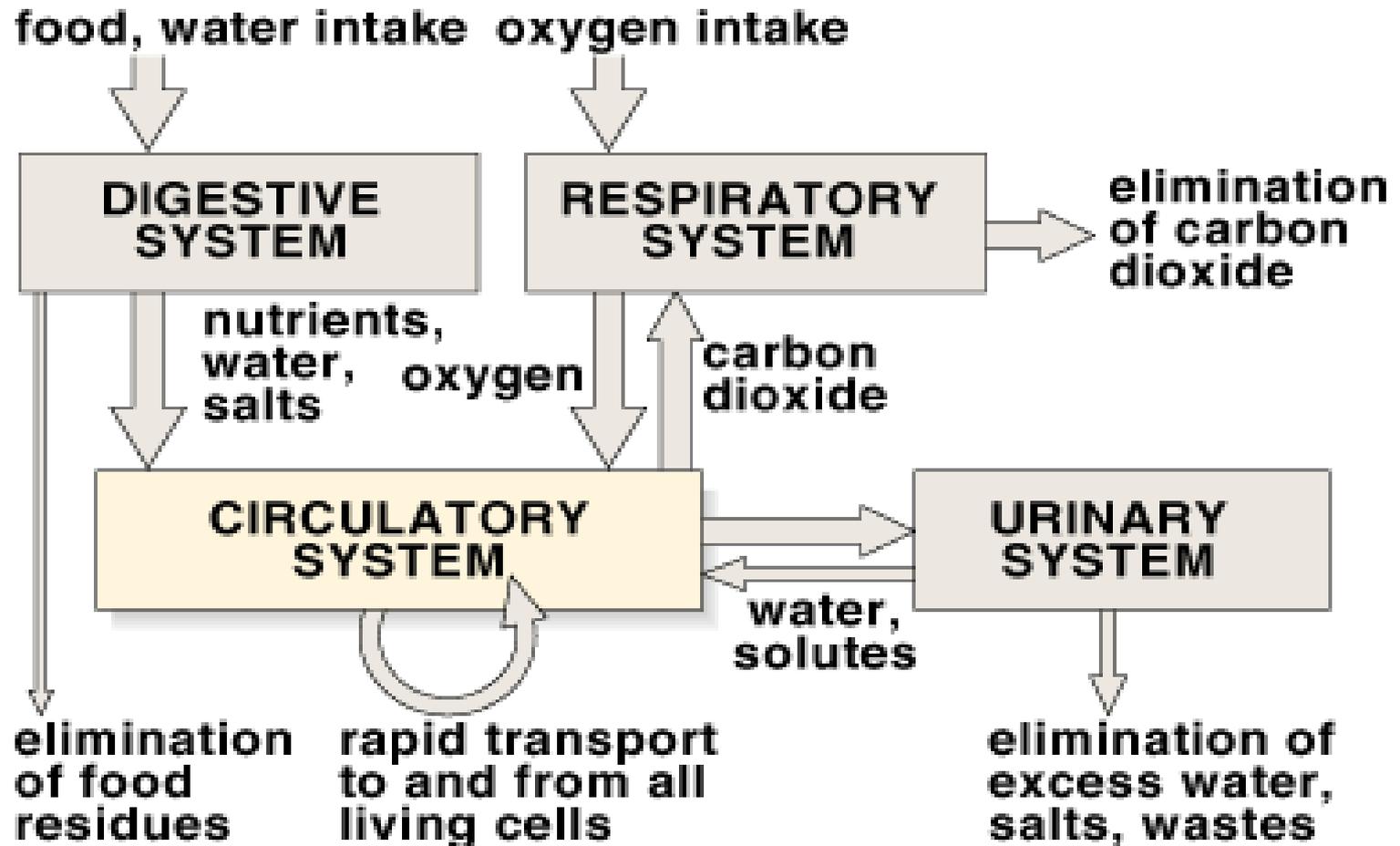
- ⌘ **All cells survive by exchanging substances with their surroundings**
- ⌘ **Blood is the transport medium of the circulatory system**
- ⌘ **A four-chambered heart pumps blood through the body**
- ⌘ **The circulatory circuits are the pulmonary and systemic circuits**

# Key Concepts:



- ⌘ **Arteries transport blood away from the heart whereas veins transport blood to the heart**
- ⌘ **Arterioles control blood-flow through each organ**
- ⌘ **Capillaries are the vessels where diffusion takes place**

# Circulatory, Respiratory and Digestive Systems



# **General Characteristics of the Cardiovascular System**



## **⌘ Interstitial fluid**

**☒ The fluid found between cells.**

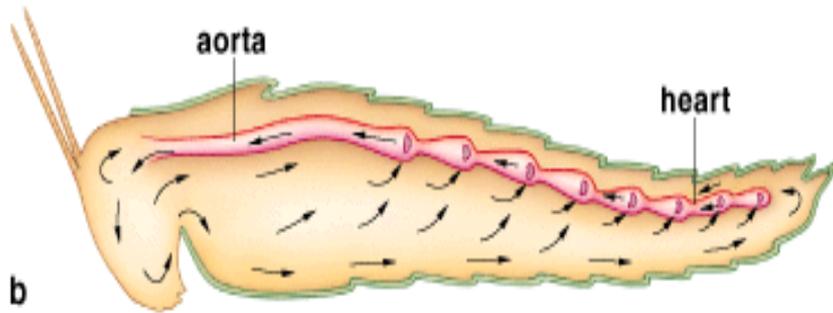
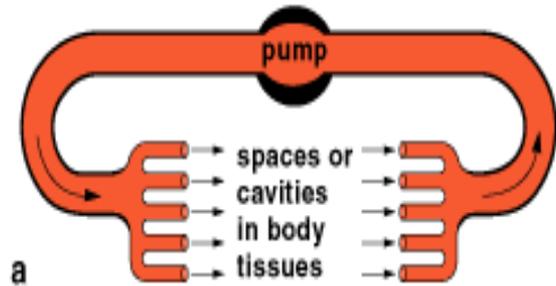
**⌘ Blood interacts with this fluid**

**⌘ The heart is a pressure pump for blood flow**

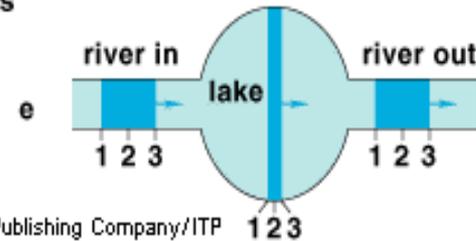
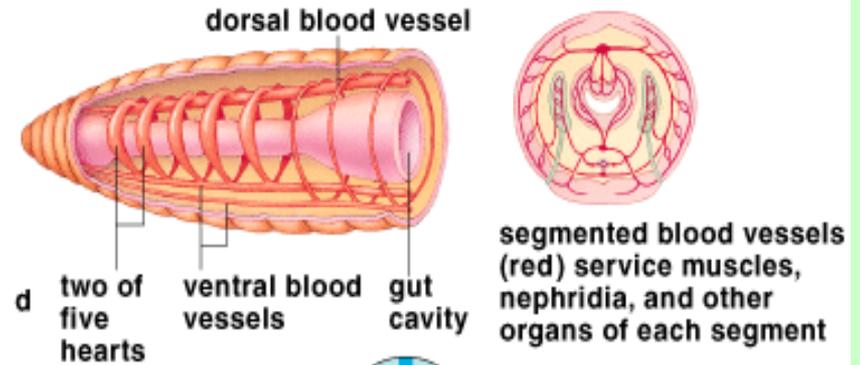
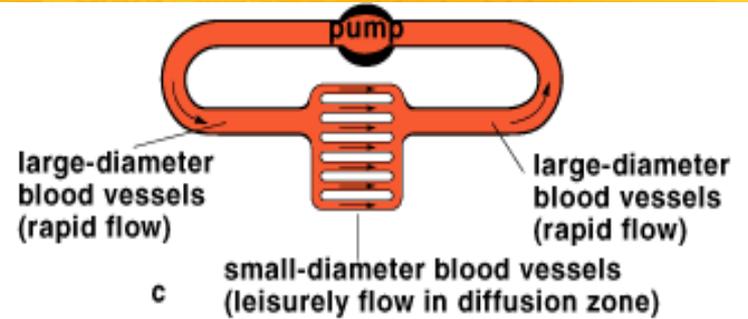
**⌘ “Closed” system (ours)**

**⌘ “Open” system (most invertebrates)**

# Flow Through Open and Closed Circulatory Systems



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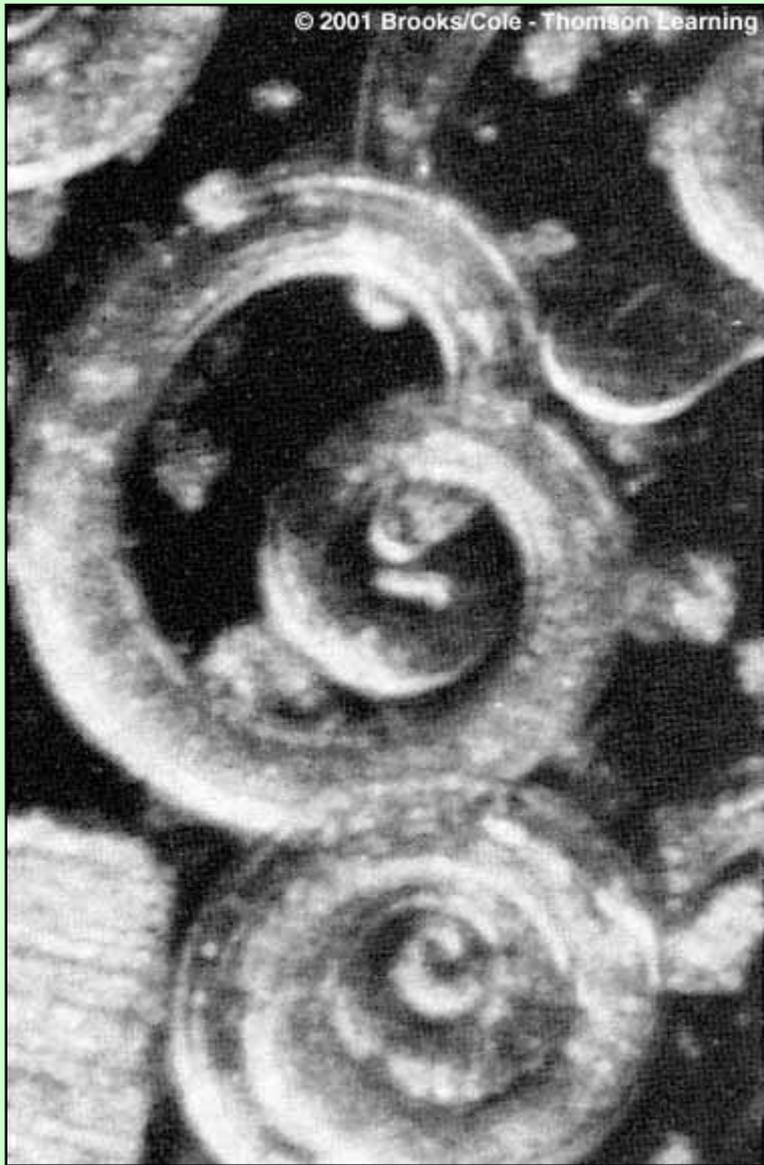
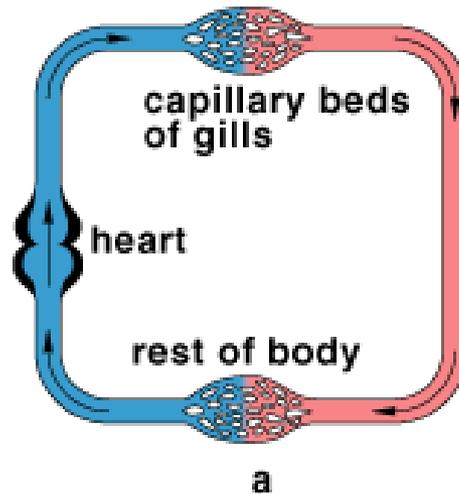


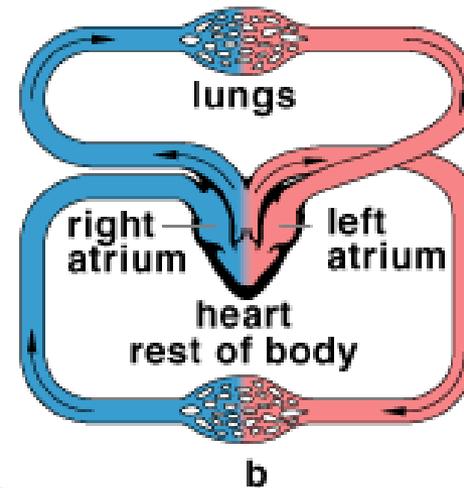
Fig. 26.21, p. 435

# Closed Circulatory Systems of Vertebrates

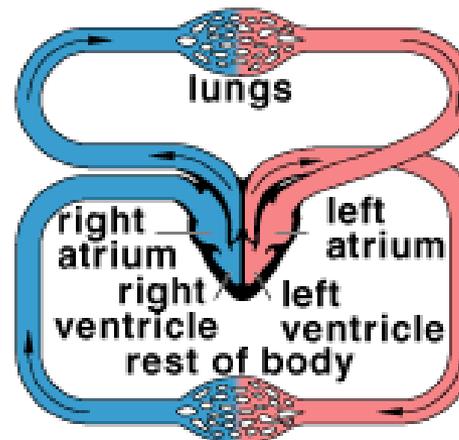
Fish



Amphibian

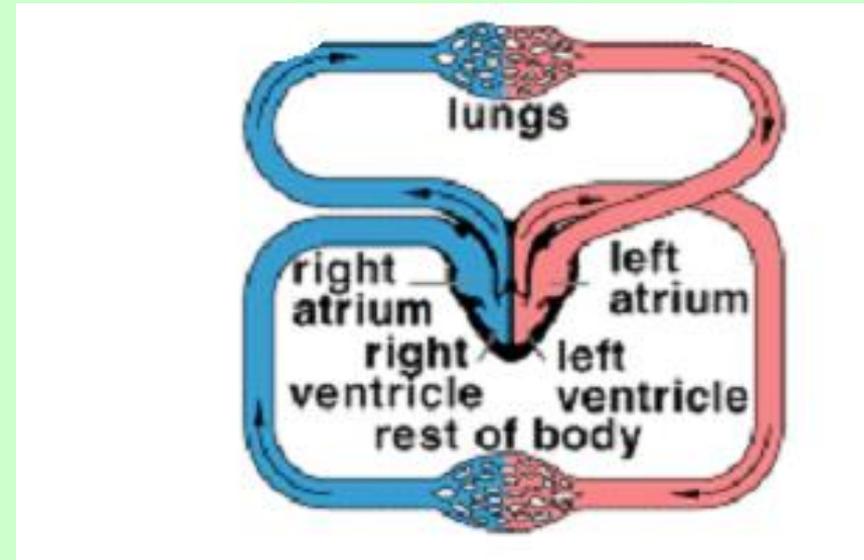


Birds and Mammals



# Two Circuits

- ⌘ Pulmonary: The right half of the heart pumps oxygen poor blood to the lungs
- ⌘ Systemic: The left half of the heart pumps oxygen rich blood to the body



# Functions of Blood



## ⌘ Transport

### ☒ Oxygen

**Nutrients**

**Solutes**

**Metabolic wastes**

**Secretions**

## ⌘ Maintain pH

## ⌘ Phagocyte transport

## ⌘ Maintain body temperature

# Blood Volume and Composition

⌘ **4-6 liters in volume (4 – 6 quarts)**

⌘ **Plasma 50 - 60 % total volume**

☒ **Water 91 - 92 %**

☒ **Protein 7 - 8 %**

☒ **Solutes 1 - 2 %**

☒ **Cellular portion (40-50%)**

☒ **Red blood cells**

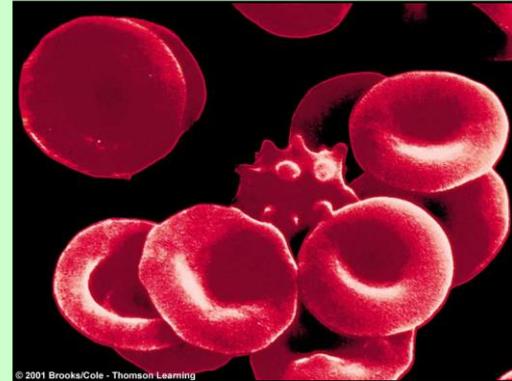
**5.4 million/ml**

☒ **White blood cells**

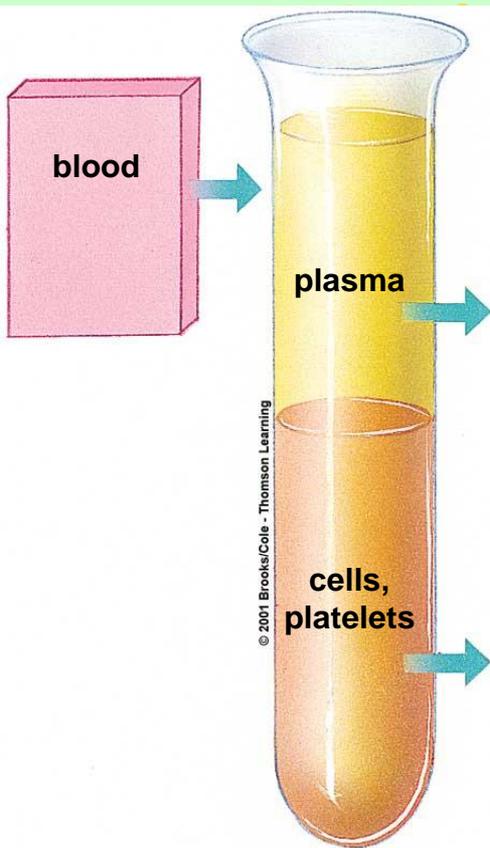
**5,000 - 10,000**

☒ **Platelets**

**250,000 - 300,000**



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Components	Relative Amounts	Functions
<b>Plasma Portion (50%–60% of total volume):</b>		
1. water	91%–92% of plasma volume	Solvent
2. Plasma proteins (albumin, globulins, Fibrinogens, etc.)	7%–8%	Defense, clotting, lipid transport, roles in extracellular fluid volume, etc.
3. Ions, sugars, lipids, amino acids, hormones, vitamins, dissolved gases	1%–2%	Roles in extracellular fluid volume, pH, etc.
<b>Cellular Portion (40%–50% of total volume):</b>		
1. Red blood cells	4,800,000–5,400,000 per microliter	Oxygen, carbon dioxide transport
2. White blood cells:		Phagocytosis during inflammation
Neutrophils	3,000–6,750	Immune responses
Lymphocytes	1,000–2,700	Phagocytosis in all defense responses
Monocytes (macrophages)	150–720	Defense against parasitic worms
Eosinophils	100–360	Secrete substances for inflammatory response and for fat removal from blood
Basophils	25–90	
3. Platelets	250,000–300,000	Roles in clotting

Fig. 39.5, p. 670

# Blood Cells



- ⌘ Red Blood Cells (RBCs): are biconcave disks that transport oxygen. The oxygen binds with **hemoglobin**, an iron-containing pigment that gives red blood its color.
- ⌘ White Blood Cells (WBCs): Also called leukocytes. They are used in body defense.

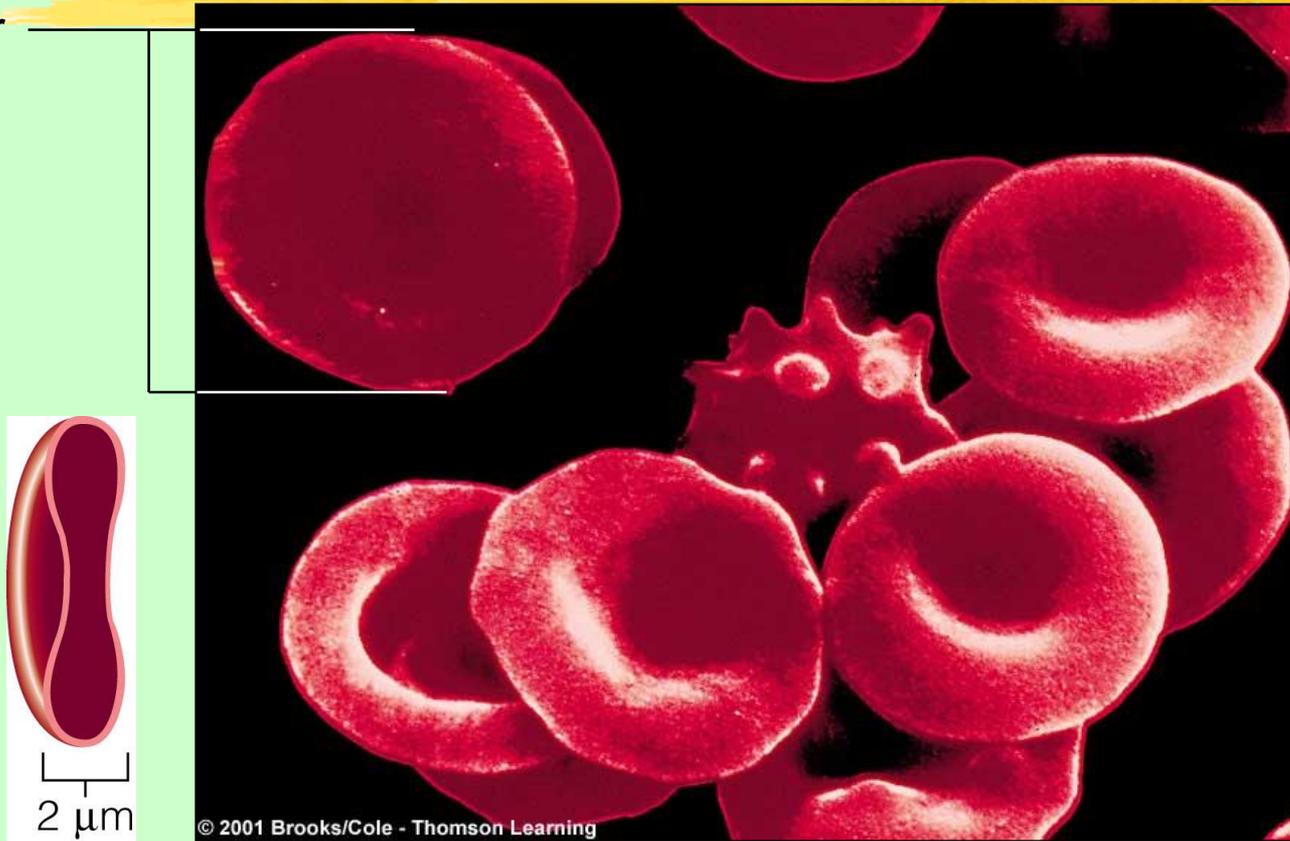
# Blood Cells Continued



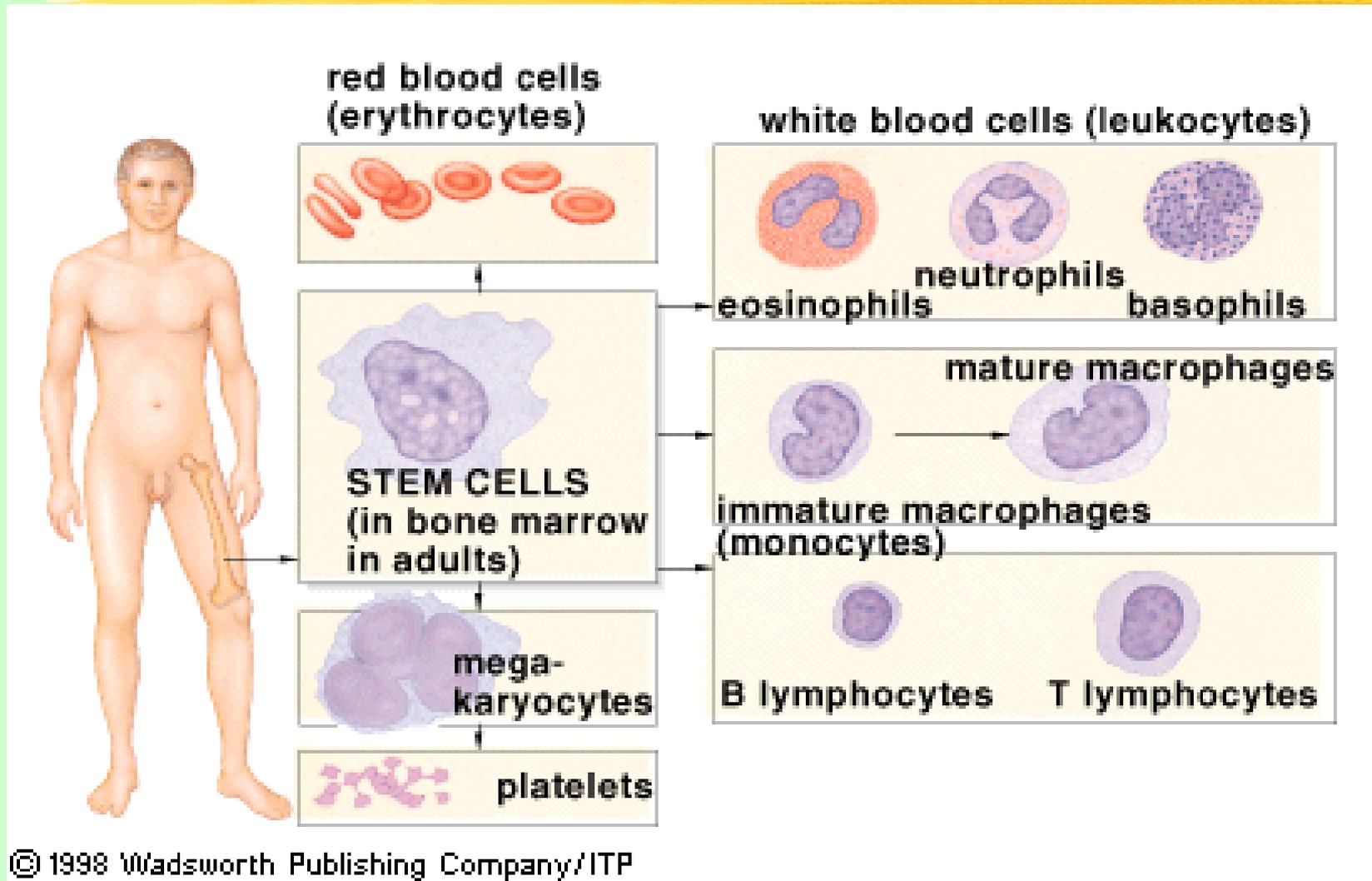
⌘ Platelets: Not cells but parts of cells. They are used in blood clotting.

# Red Blood Cells

8  $\mu\text{m}$   
average  
diameter



# The Cellular Components of Blood



# Blood Typing

⌘ **Based on protein “self” markers on red blood cells**

⌘ **Blood Type**

☒ **A**                      **anti B antibodies**

☒ **B**                      **anti A antibodies**

☒ **AB**                    **none**

☒ **O**                      **anti A and anti B antibodies**

# Blood Transfusion

⌘ **Agglutination of incompatible blood**

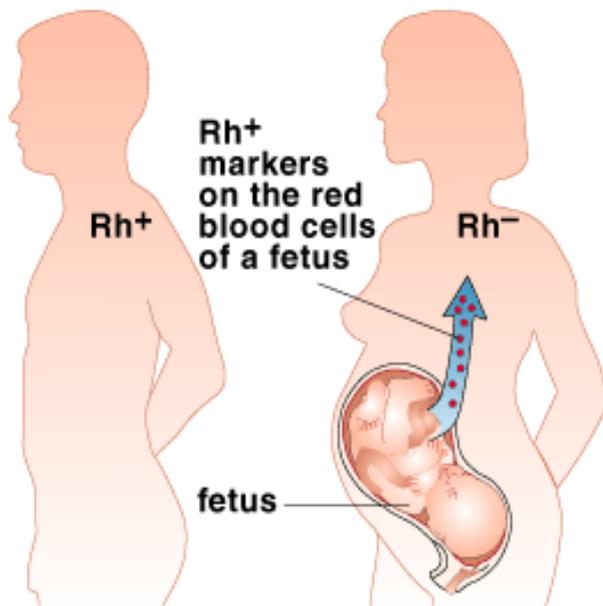
⌘ **Antibodies**

		Blood Type of Donor			
		O	A	B	AB
Blood Type of Recipient	O				
	A				
	B				
	AB				

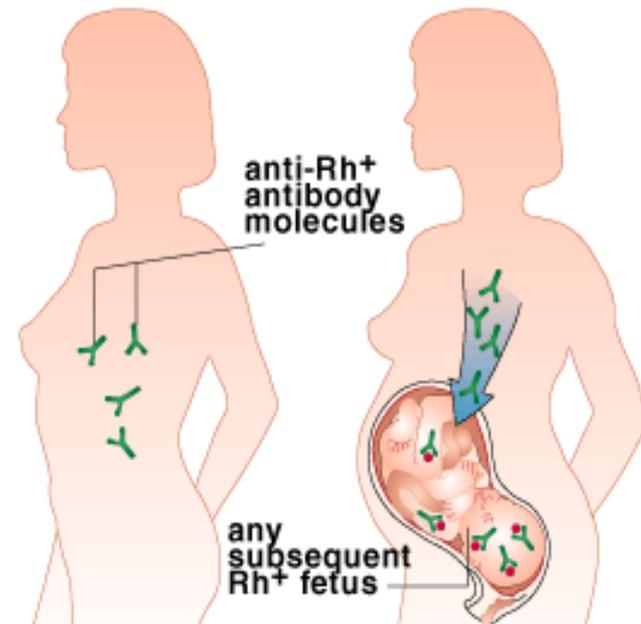
# Rh Blood Typing

⌘ Presence or absence of Rh markers

⌘ Erythroblastis fetalis



a A forthcoming child of an Rh<sup>-</sup> woman and Rh<sup>+</sup> man inherits the gene for the Rh<sup>+</sup> marker. During pregnancy or childbirth, some of its cells bearing the marker may leak into the maternal bloodstream.



b The foreign marker stimulates her body to make antibodies. If she gets pregnant again and if this second fetus (or any other) inherits the gene for the marker, the circulating anti-Rh<sup>+</sup> antibodies will act against it.

# Human Cardiovascular System

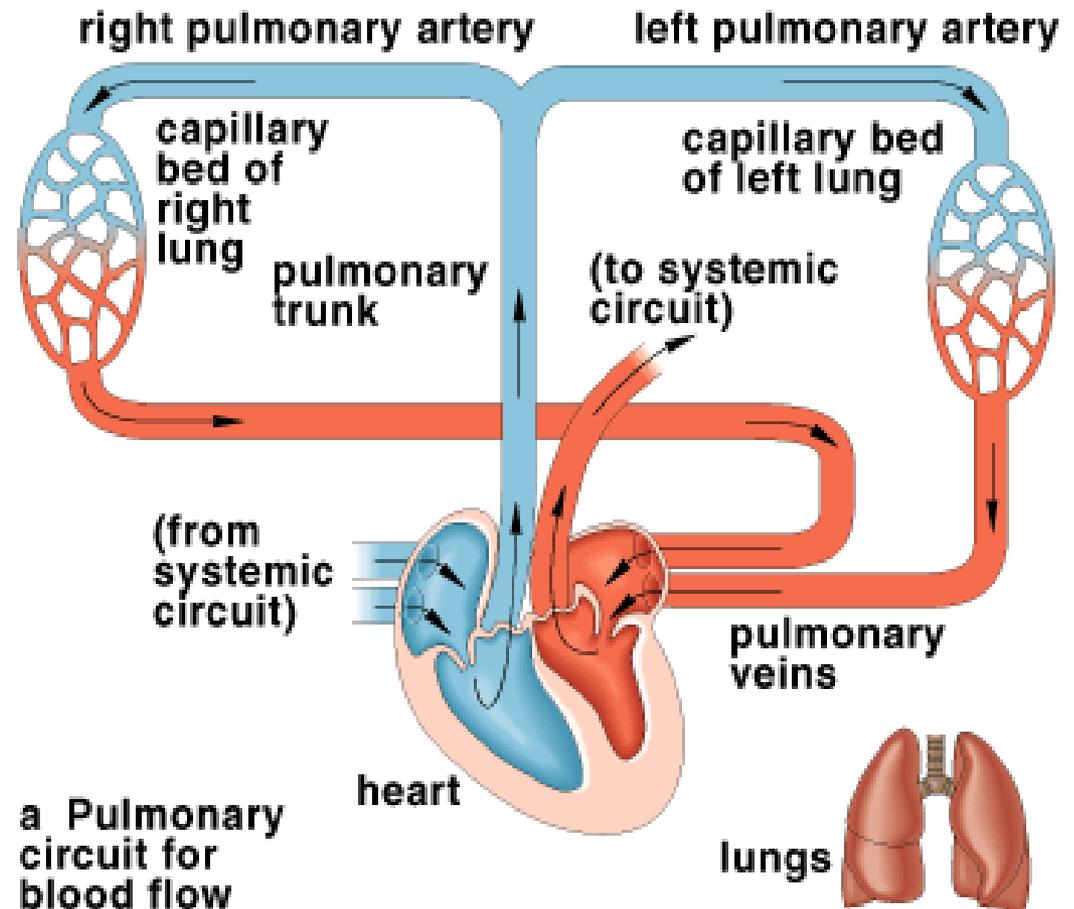
## ⌘ Heart

⊞ Double pump

## ⌘ 2 circuits

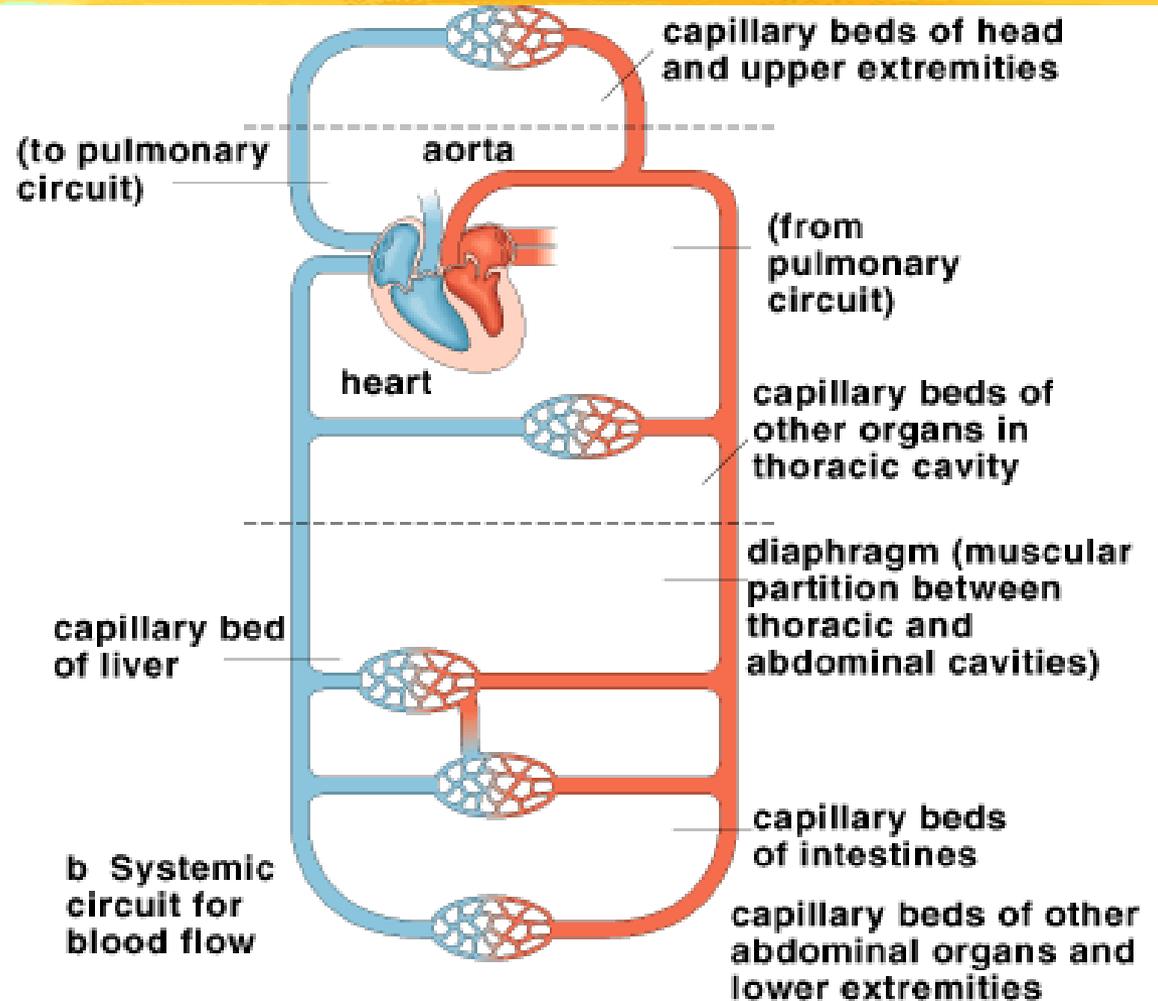
⊞ Pulmonary

⊞ Systemic

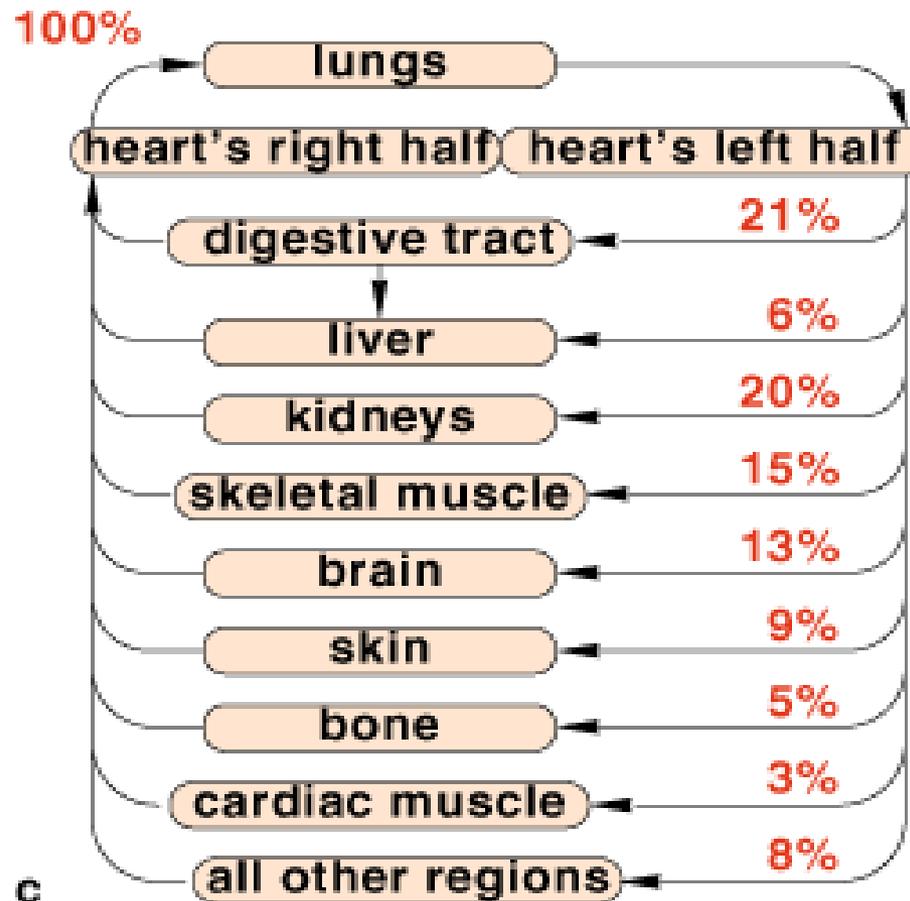


# Systemic Circuit for Blood Flow

- ⌘ Aorta
- ⌘ Arteries
- ⌘ Arterioles
- ⌘ Capillaries
- ⌘ Venules
- ⌘ Veins
- ⌘ Superior & Inferior Vena Cava



# Distribution of Blood - Heart Output



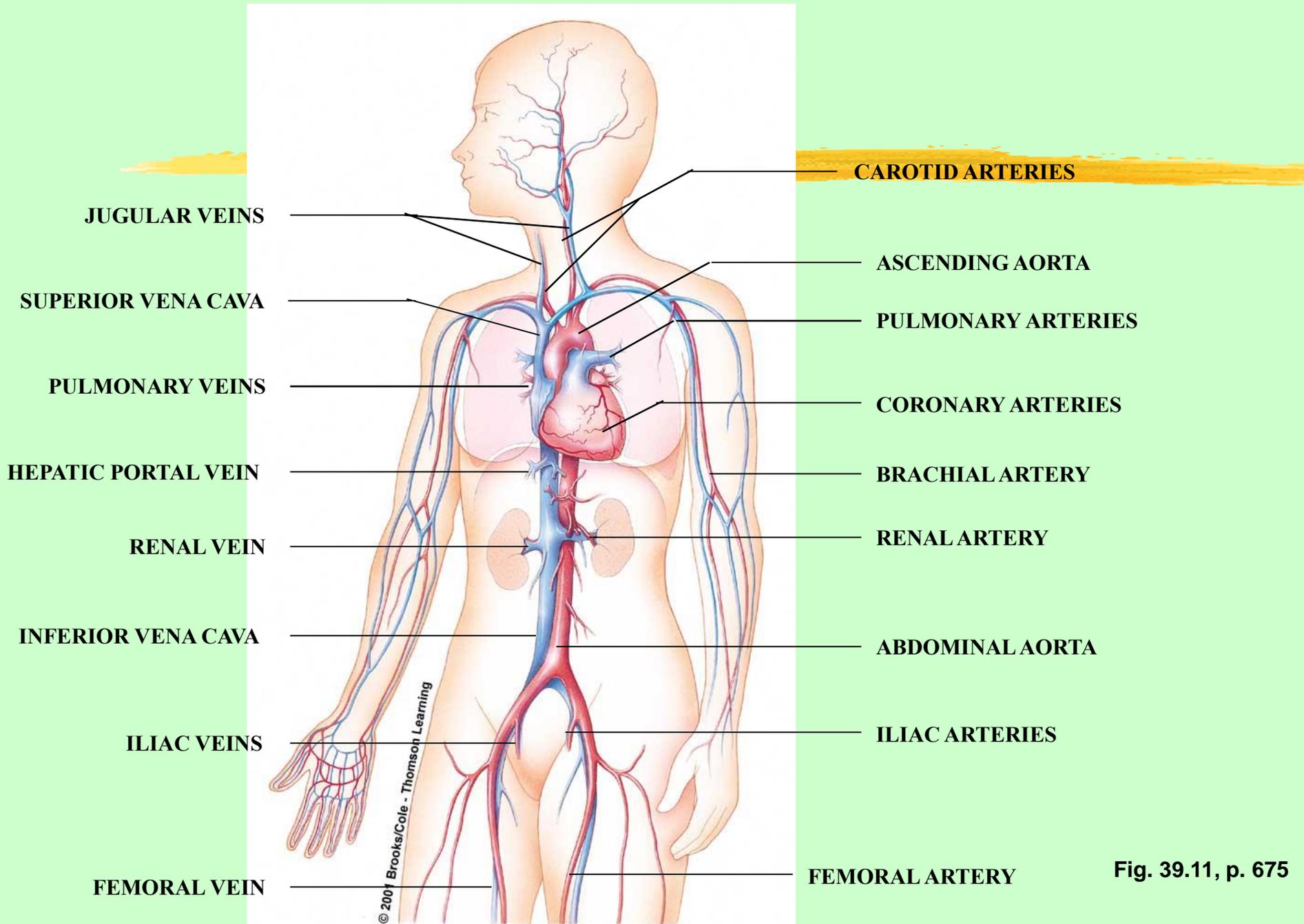
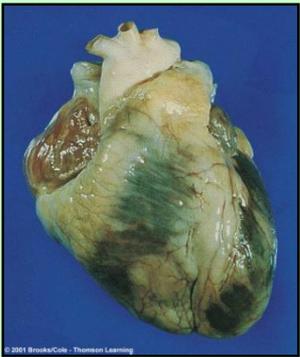
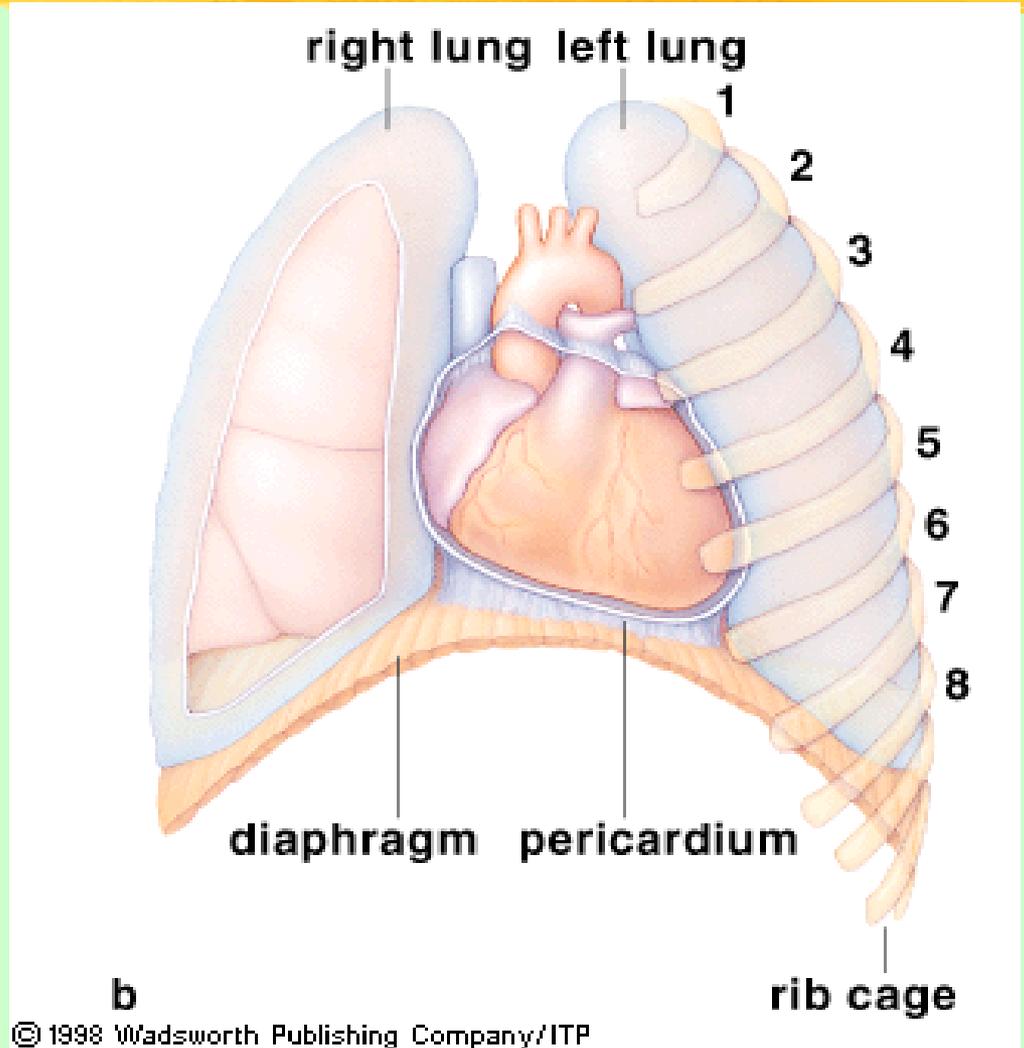


Fig. 39.11, p. 675



# Heart Structure

- ⌘ **Thoracic cavity**
- ⌘ **Pericardium (double sac of tough connective tissue)**
- ⌘ **Endothelium (found in the hearts inner layer – only found here and in blood vessels)**



# Structures in the Heart



## ⌘ 4 Chambers

- ☑ 2 Atria

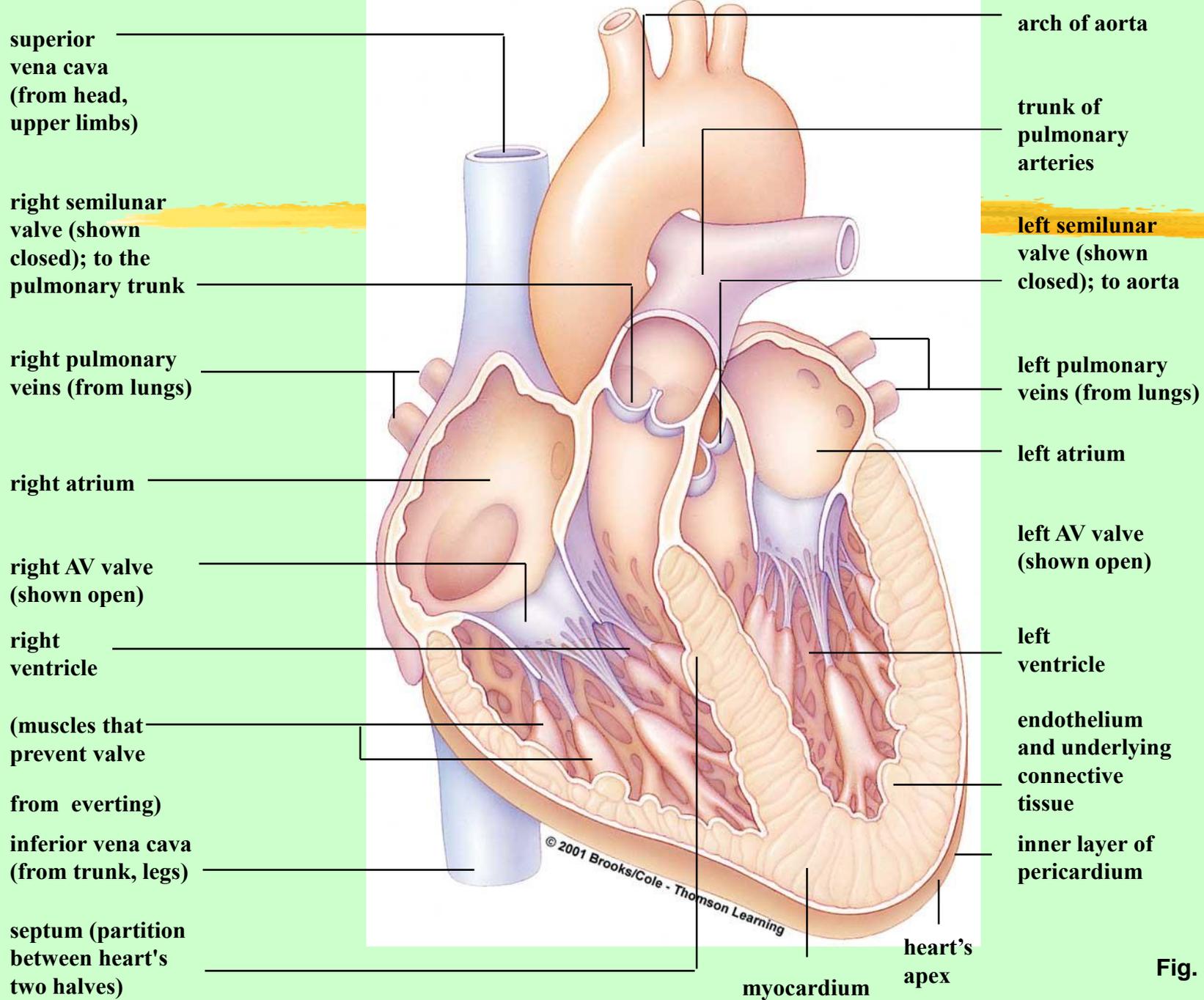
- ☑ 2 Ventricles

- ☑ AV valves

- ☑ Semilunar valves

- ☑ Septum

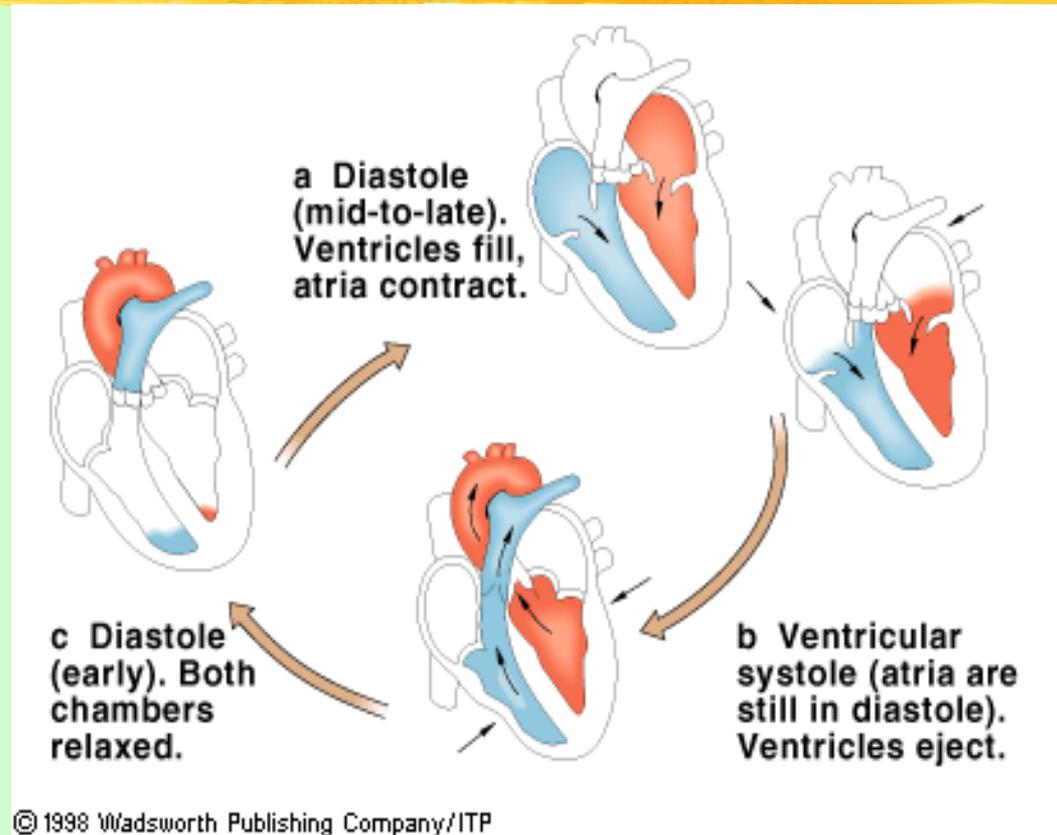
- ☑ Myocardium



**Fig. 39.12b, p. 676**

# Cardiac Cycle

- ⌘ **Systole**  
**(contraction)**
- ⌘ **Diastole**  
**(relaxation)**
- ⌘ **Closure/Opening of valves**



**Contraction of Ventricles is the force for blood flow**

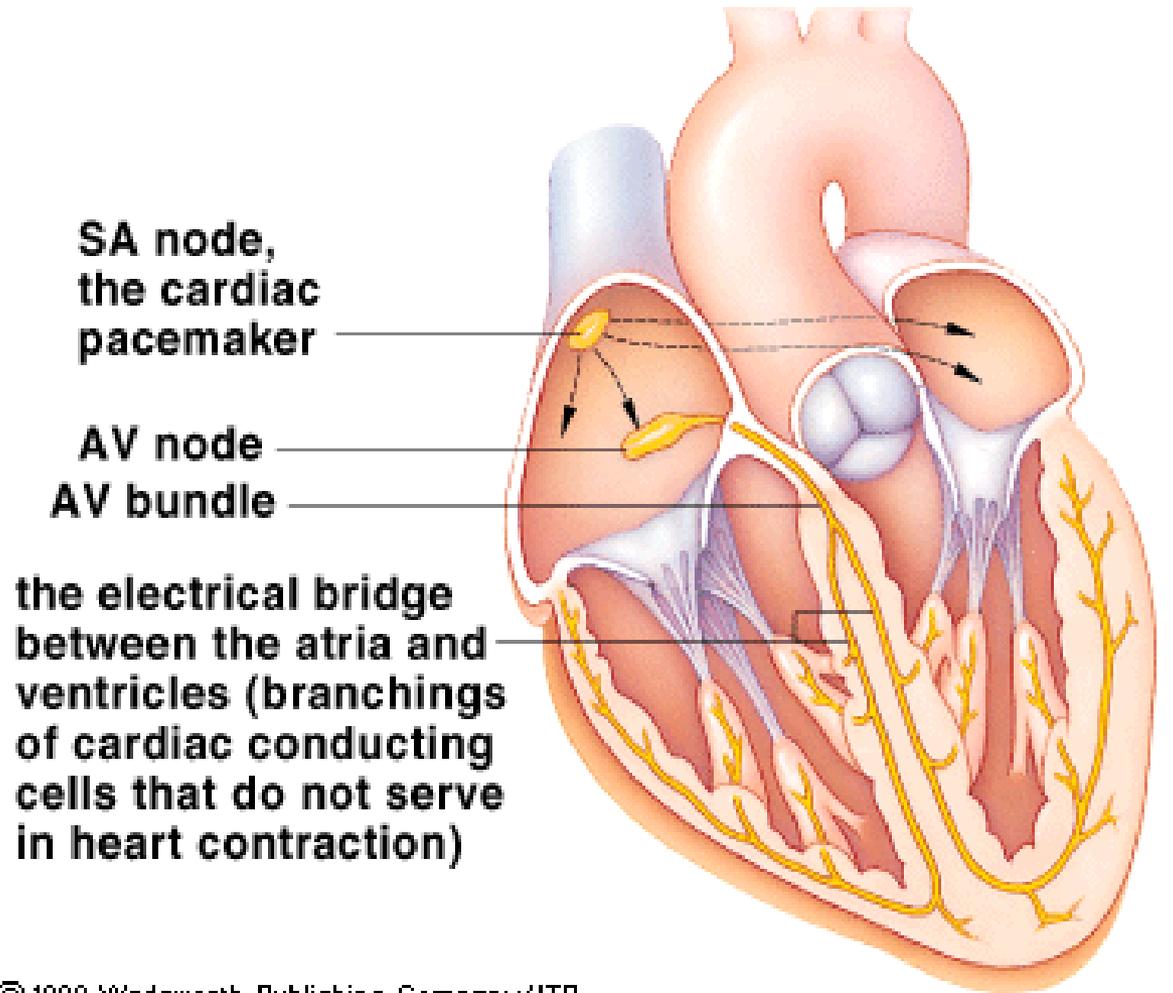
# Cardiac Conducting System

⌘ SA node

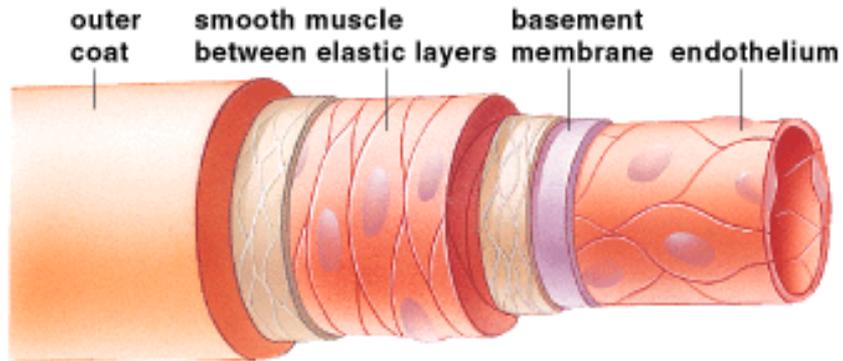
☑ Pacemaker

⌘ AV node

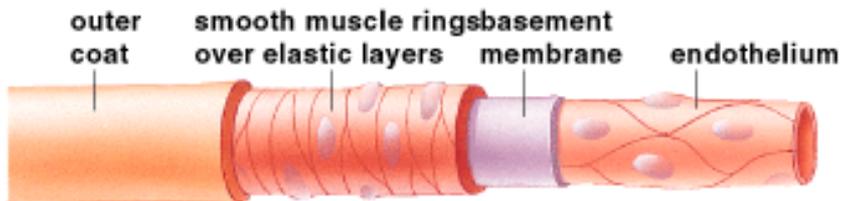
⌘ AV bundle



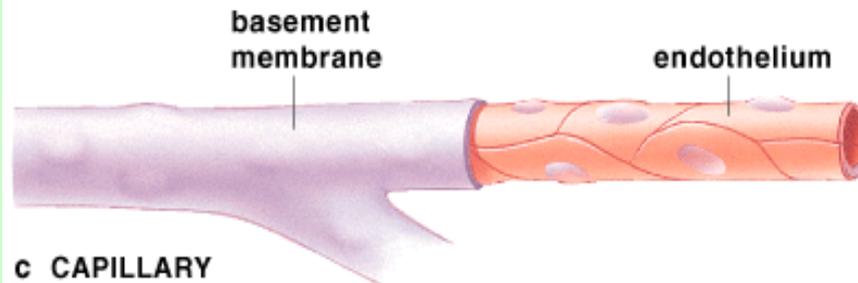
# Structure of Blood Vessels



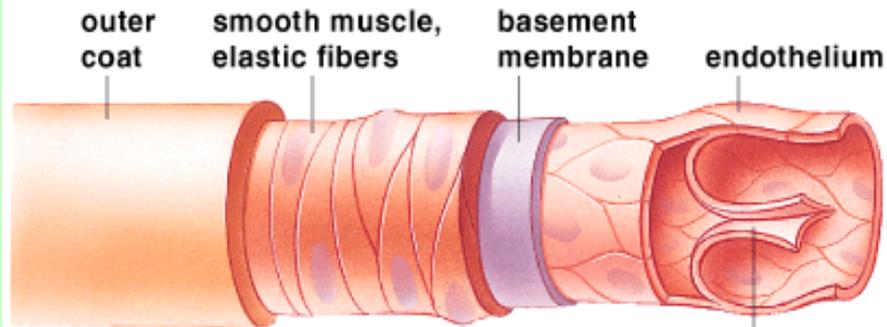
a ARTERY



b ARTERIOLE



c CAPILLARY



d VEIN

# Blood Pressure



## ⌘ Rate of Flow

- ☑ Pressure gradient

- ☑ Resistance

⌘ **Blood Pressure: the pressure to blood created by heart contractions.**

## ⌘ Flow

- ☑ High pressure area to low pressure area

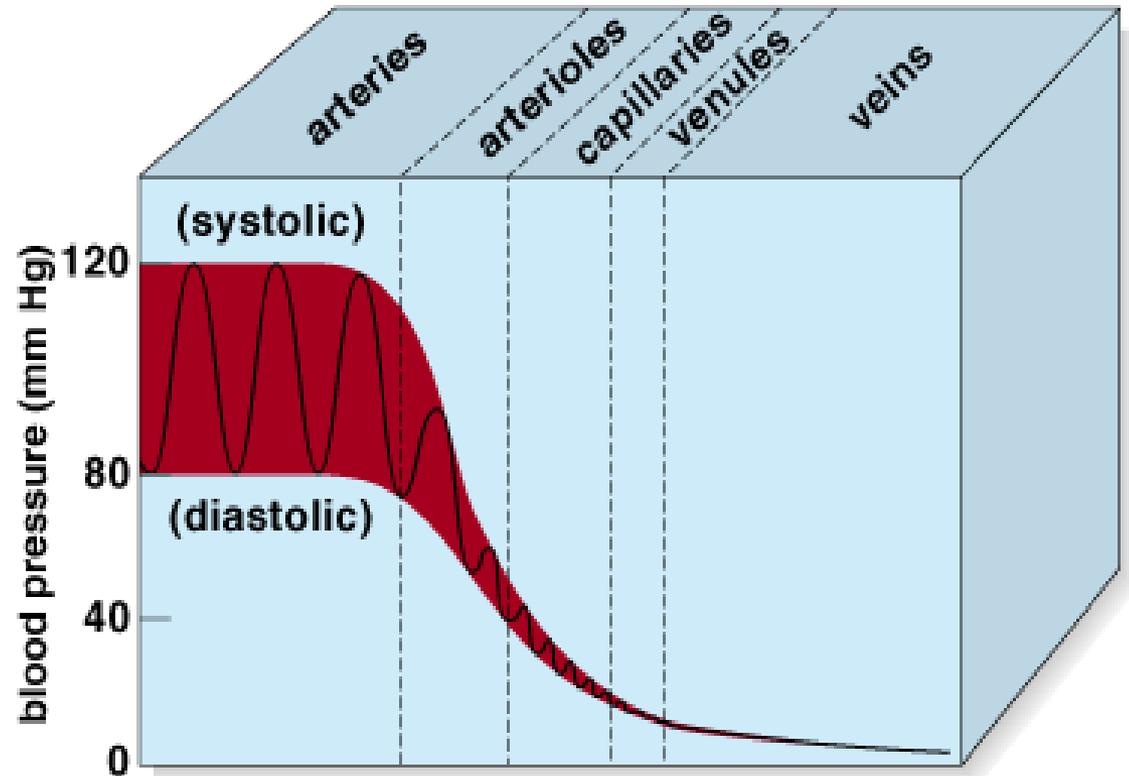
# Blood Pressure

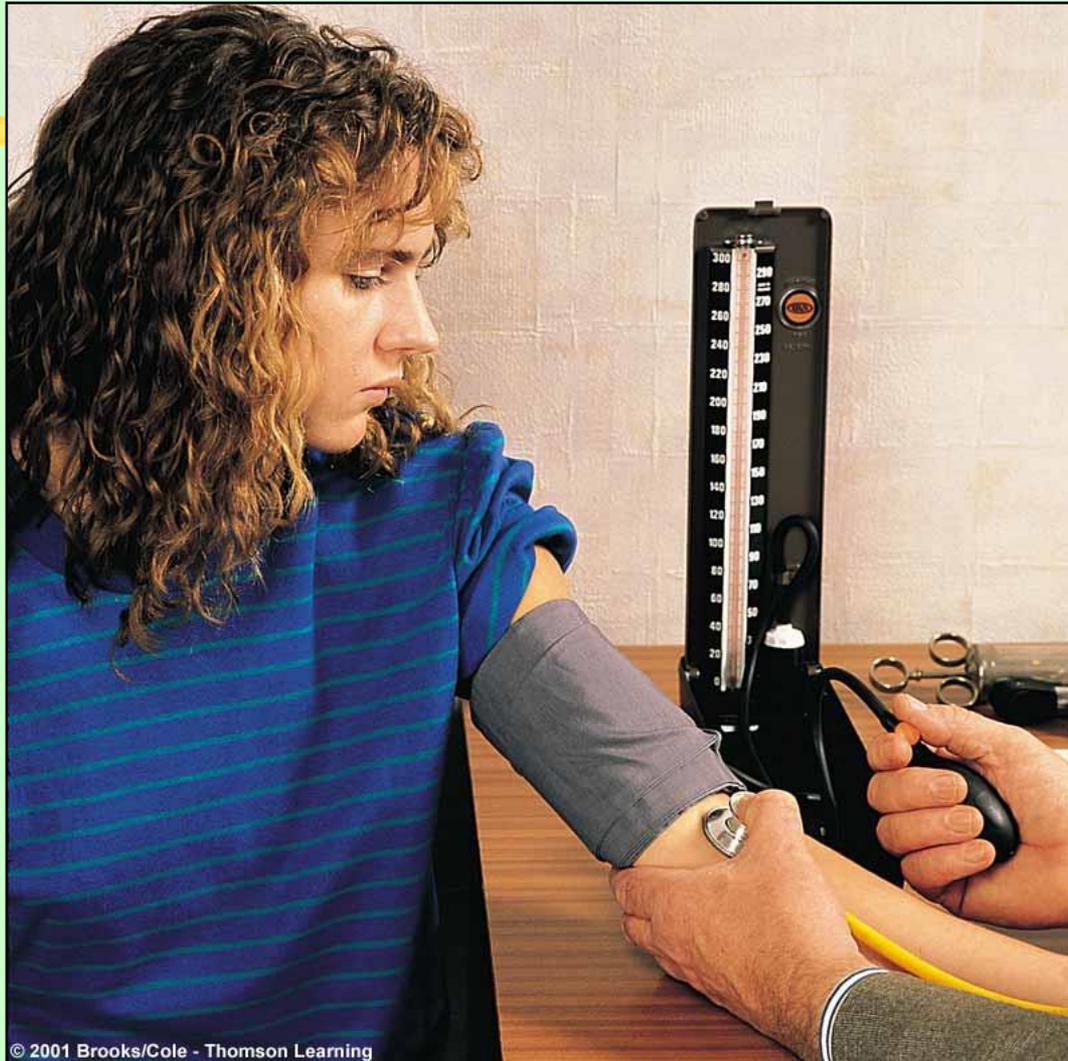
⌘ **Systolic (highest pressure)**

⊞ **Contracting ventricles**

⌘ **Diastolic (lowest pressure)**

⊞ **Ventricles at rest**





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Fig. 39.18, p. 679

# Control of Flow

- ⌘ **Nervous and Endocrine**

- ⌘ **Blood vessel diameter**

  - ⊞ **Vasodilation**

  - ⊞ **Vasoconstriction**

- ⌘ **Baroreceptors** (detect fluctuations in pressure)

  - ⊞ **Carotid arteries and aortic arch**

- ⌘ **Medulla oblongata: receive impulses from baroreceptors**

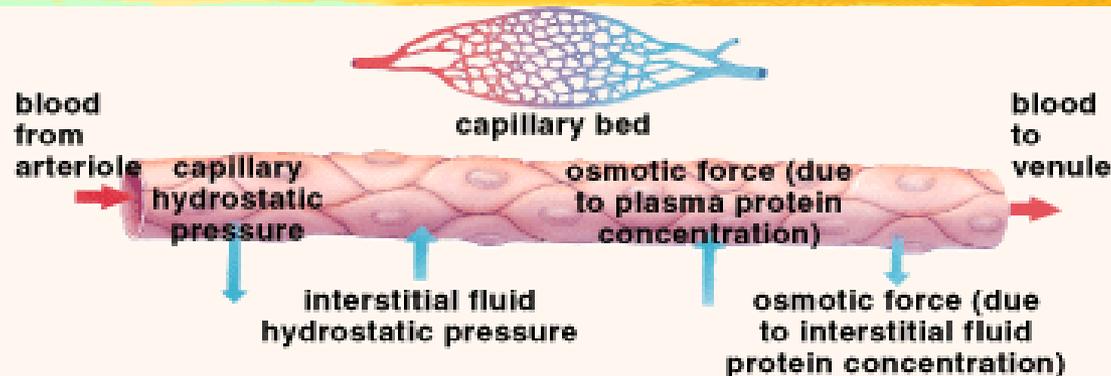
- ⌘ **Kidneys (long-term): adjust volume of the blood**

# Capillary Function



- ⌘ **Capillary beds are zones of diffusion between blood and interstitial fluid.**
- ⌘ **They are the functional unit of the cardiovascular system**
- ⌘ **Almost every cell in the body is close to a capillary.**

# Bulk Flow in a Capillary Bed



## PRESSURES (mm Hg) AT ARTERIOLE END OF CAPILLARY BED

hydrostatic pressure of blood in capillary	35
hydrostatic pressure of interstitial fluid	0
osmotic force due to plasma proteins	28
osmotic force due to interstitial proteins	3

net filtration pressure  
 $(35 - 0) - (28 - 3)$       10

**OUTWARD-DIRECTED FILTRATION IS FAVORED**

## PRESSURES (mm Hg) AT VENULE END OF CAPILLARY BED

hydrostatic pressure of blood in capillary	15
hydrostatic pressure of interstitial fluid	0
osmotic force due to plasma proteins	28
osmotic force due to interstitial proteins	3

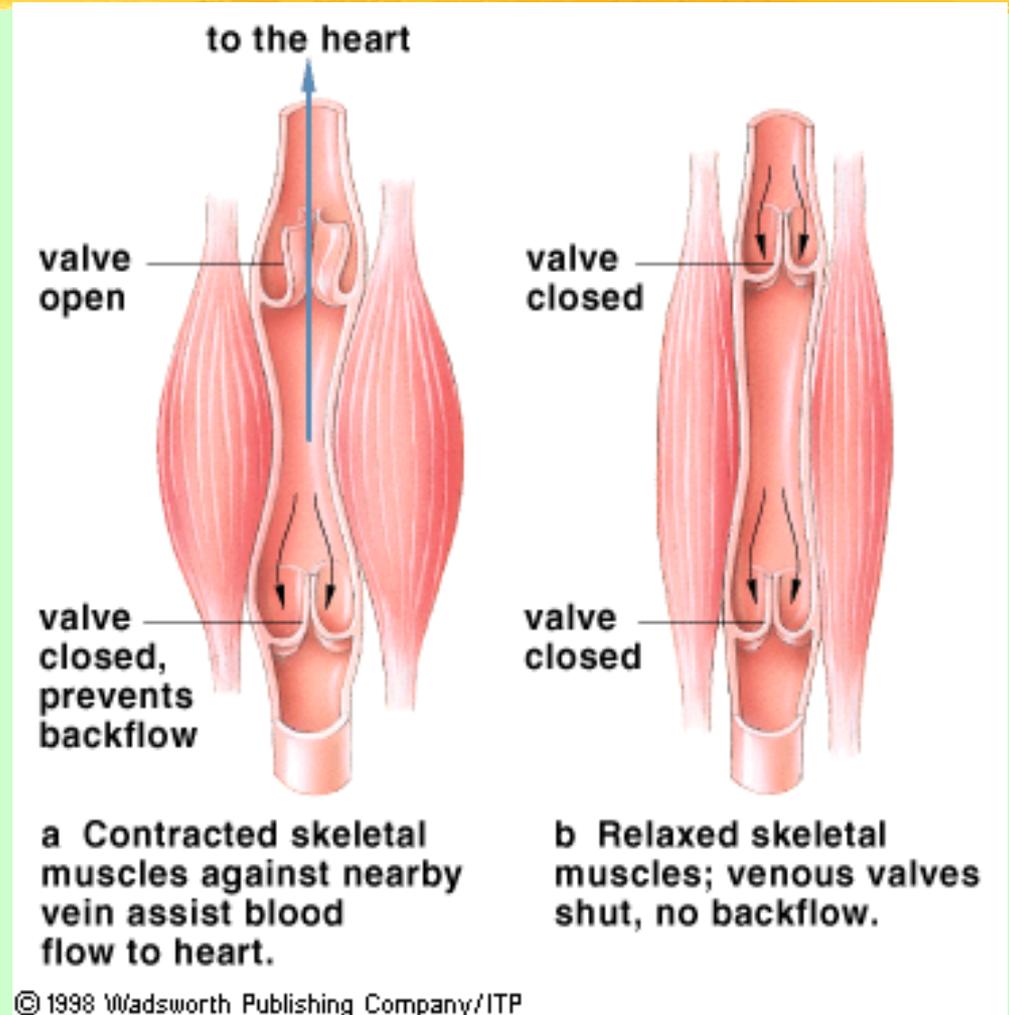
net filtration pressure  
 $(15 - 0) - (28 - 3)$       -10

**INWARD-DIRECTED ABSORPTION IS FAVORED**

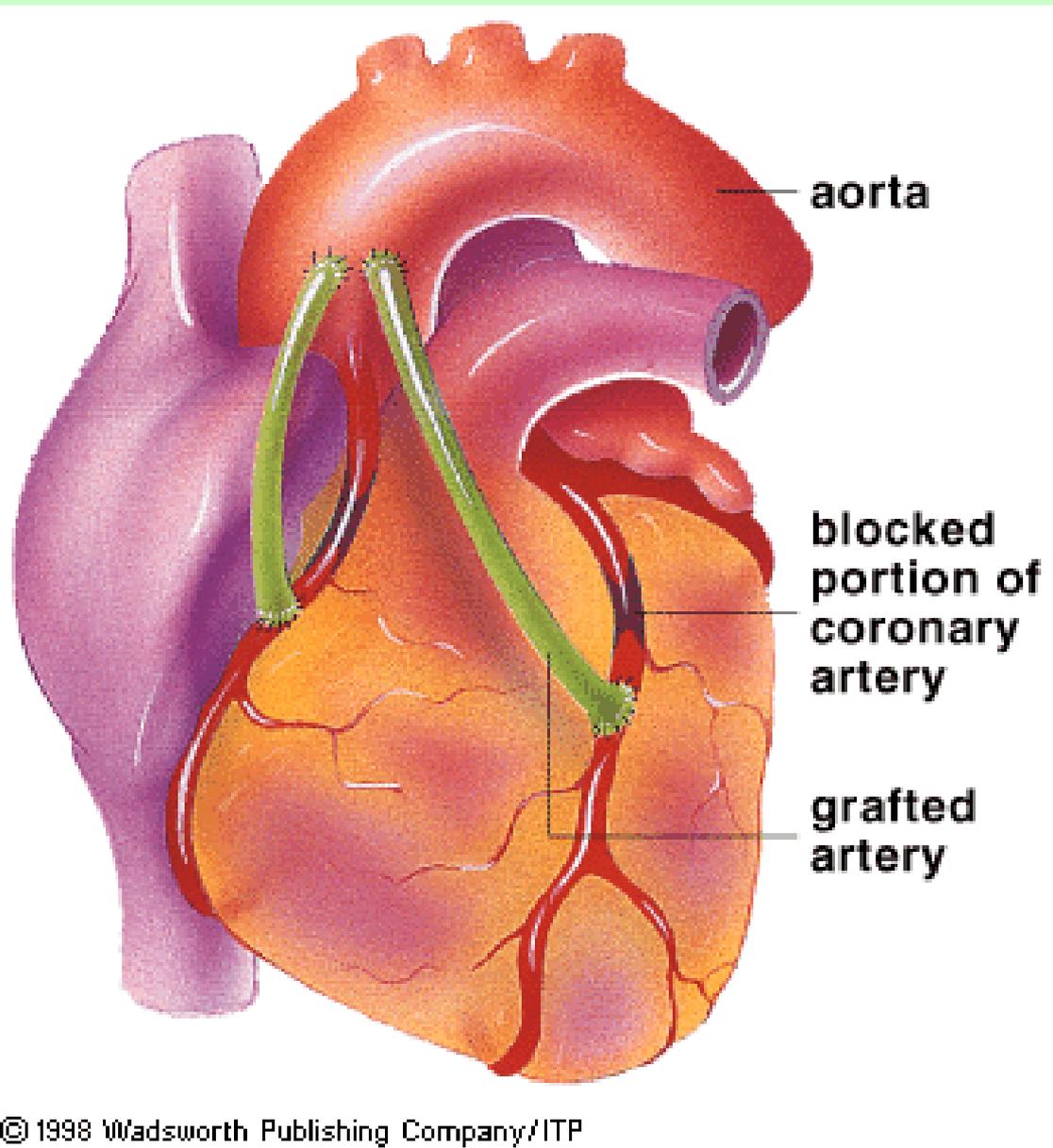
# Venous Pressure

## ⌘ Veins (blood carried to the heart)

- ⊞ Large diameter
- ⊞ Low resistance
- ⊞ Valves (one way)
- ⊞ Blood Reservoir
  - ⊞ 50 - 60% or total blood volume



# Coronary Bypass



# Electrocardiogram

## ⌘ Arrhythmias

☑ Bradycardia  
(slow beat)

☑ Tachycardia  
(high beat)

☑ Ventricular  
fibrillation

