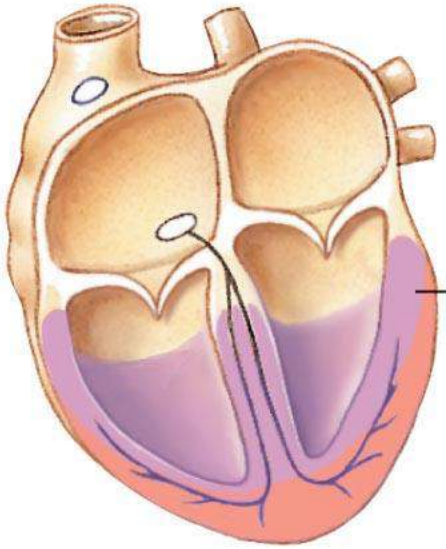
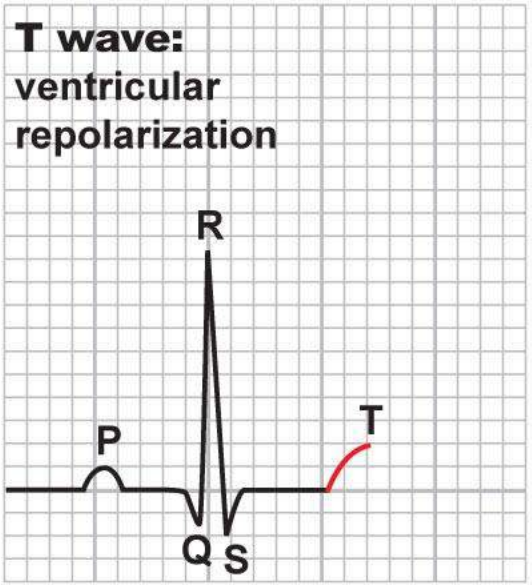
ELECTRICAL EVENTS OF THE CARDIAC CYCLE





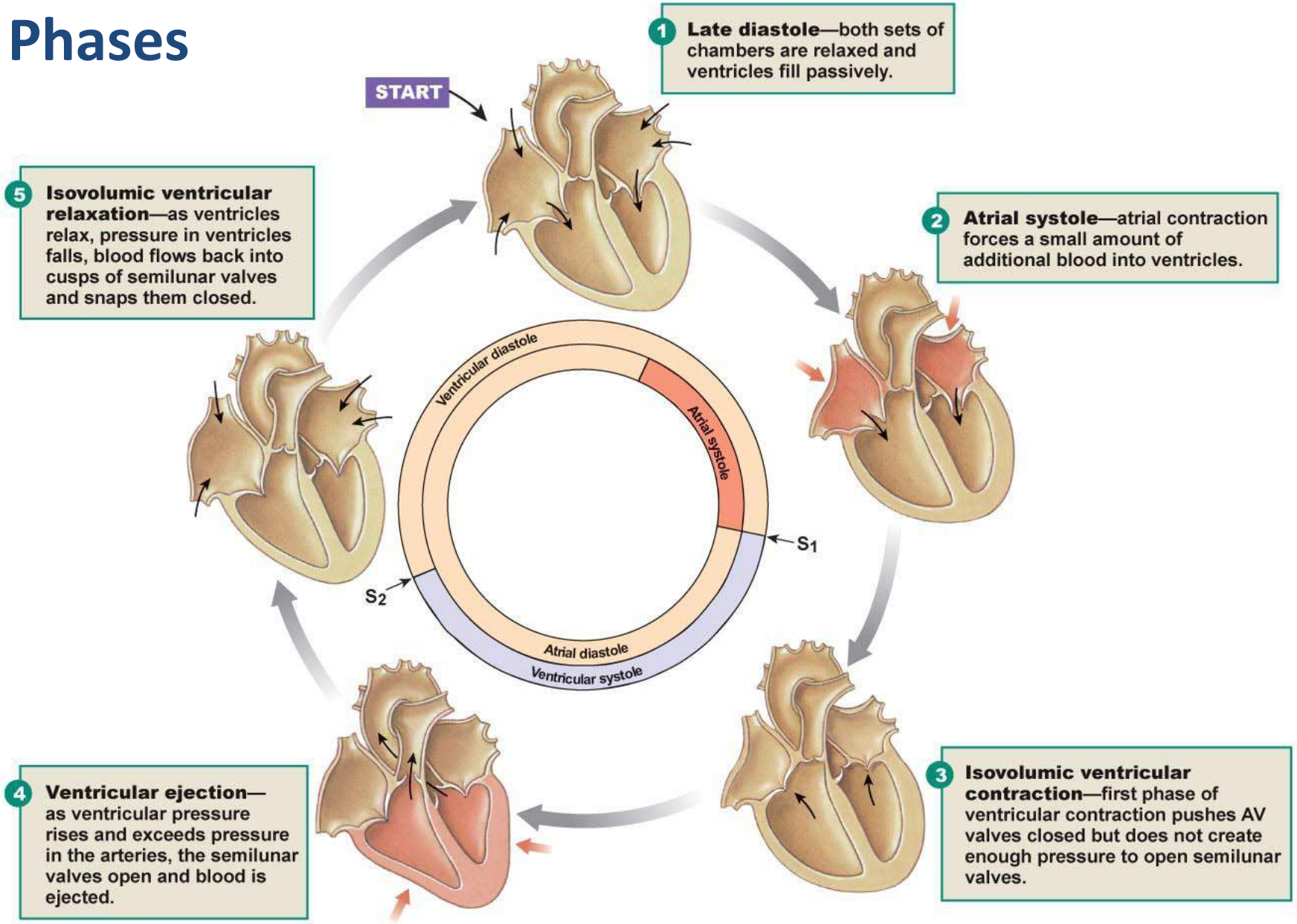
Cardiac Cycle Phases

- Systole = period of contraction Diastole = period of relaxation
- Cardiac Cycle is alternating periods of systole and diastole
- **Phases of the cardiac cycle**
  1. **Rest (Atrial & Ventricular Diastole)**
     - Both atria and ventricles in diastole
     - Blood is filling both atria and ventricles due to low pressure conditions
  2. **Atrial Systole**
     - Completes ventricular filling
  3. **Isovolumetric Ventricular Contraction**
     - Increased pressure in the ventricles causes the AV valves to close… why?
       - Creates the first heart sound (lub)
     - Atria go back to diastole
     - No blood flow as semilunar valves are closed as well
  4. **Ventricular Ejection**
     - Intraventricular pressure overcomes aortic pressure
       - Semilunar valves open
       - Blood is ejected
  5. **Isovolumetric Ventricular Relaxation**
     - Intraventricular pressure drops below aortic pressure
       - Semilunar valves close = second heart sound (dup)
     - Pressure still hasn't dropped enough to open AV valves so volume remains same (isovolumetric)

Back to Atrial & Ventricular Diastole

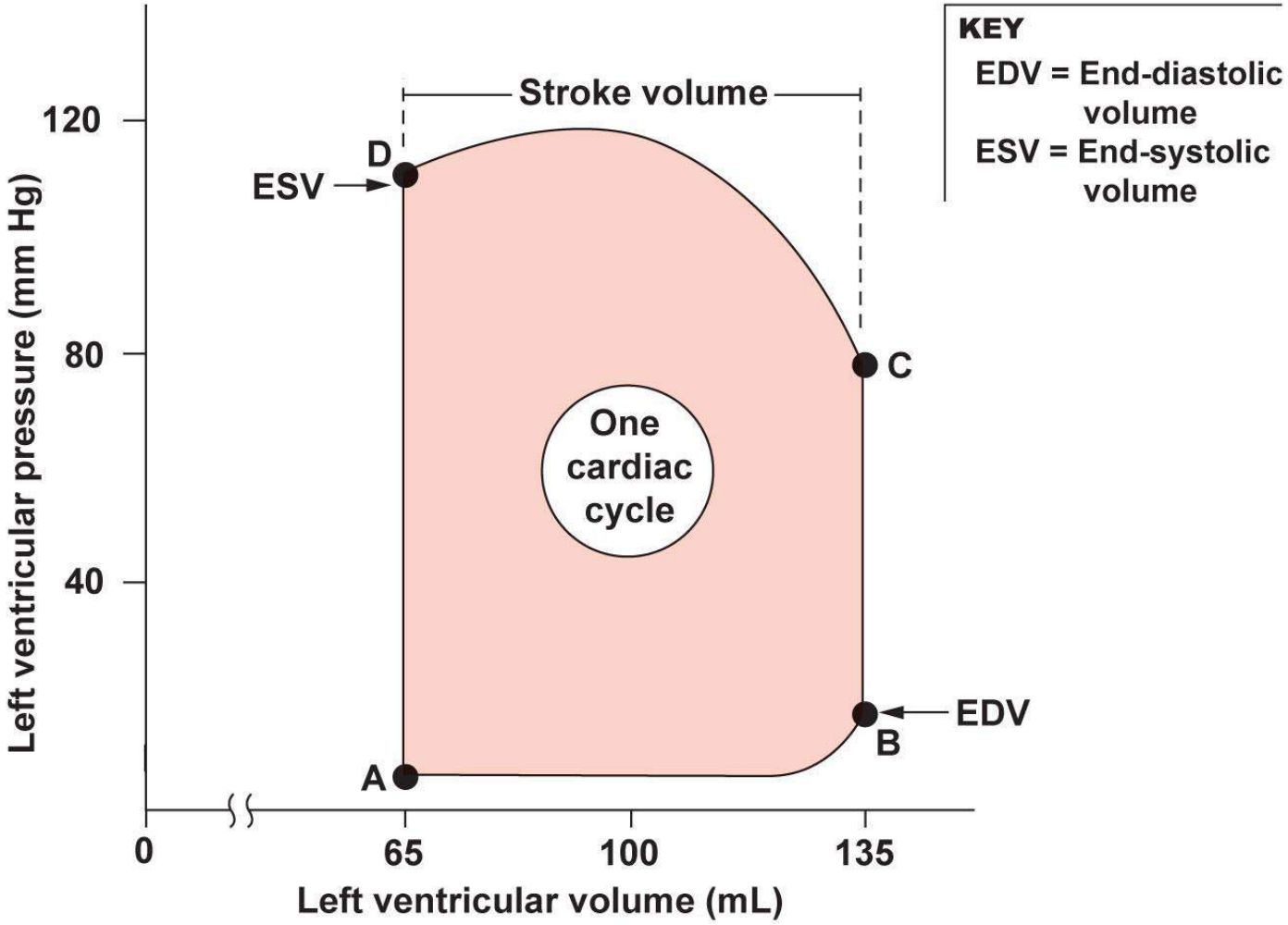
Cardiac Cycle

Phases



Cardiac Cycle

Blood Volumes & Pressure



The Heart: Cardiac Output

- **Cardiac output (CO)**
  - Amount of blood pumped by each side of the heart in one minute

    CO ml/min = (heart rate [HR]) Beats/min x (stroke volume [SV]) ml/beat

  CO = 70mL/beat x75beats/min = 5250 mL/min = 5.25 L/min
- **Stroke volume**

Volume of blood pumped by each ventricle in one contraction.

Stroke volume remains relatively constant

Starling's law of the heart – the more that the cardiac muscle is stretched, the stronger the contraction

- **Heart Rate**

Changing heart rate is the most common way to change cardiac output

- **Increased heart rate**
  - Sympathetic nervous system a. Activated in a Crisis b. Low blood pressure
  - Hormones a. Epinephrine b. Thyroxine
  - Exercise
  - Decreased blood volume
- **Decreased heart rate**
  - Parasympathetic nervous system
  - High blood pressure or blood volume
  - Decreased venous return

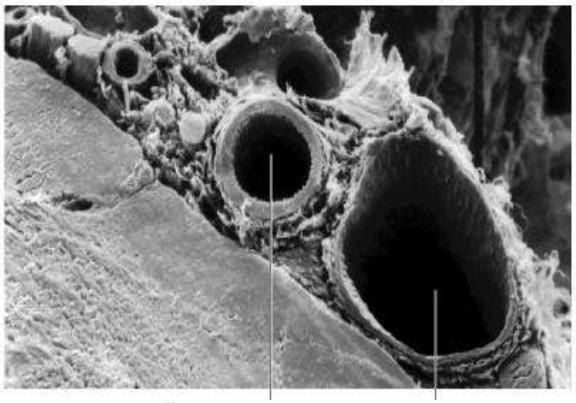
Blood Vessels: The Vascular System

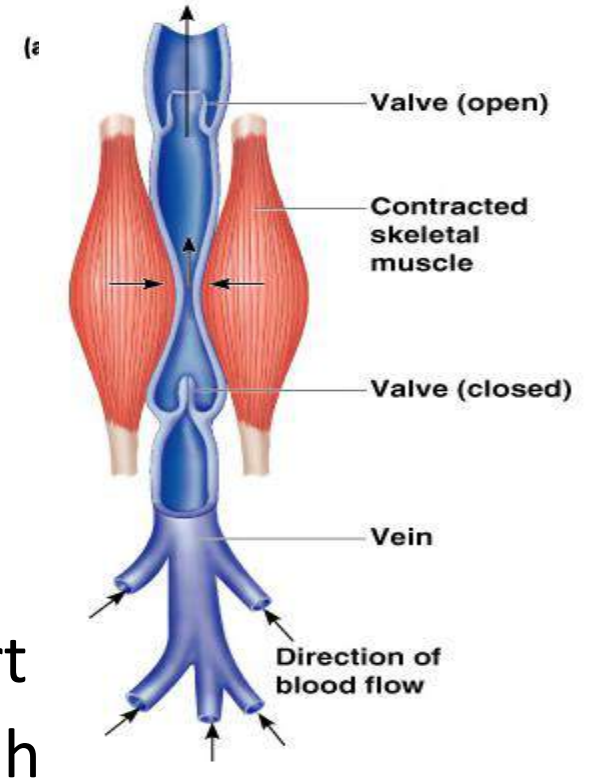
- Taking blood to the tissues and back

Arteries – Arterioles -Capillaries -Venules -Veins

Differences Between Blood Vessel Types

1. Walls of arteries are the thickest
2. Lumens of veins are larger
3. Skeletal muscle “milks” blood in veins toward the heart
4. Walls of capillaries are only one cell layer thick to allow for exchanges between blood and tissue





Movement of Blood Through Vessels

- Most arterial blood is pumped by the heart
- Veins use the milking action of muscles to h

Capillary Beds

- Capillary beds consist of two types of vessels
  - Vascular shunt – directly connects an arteriole to a venule
- True capillaries – exchange vessels
  - Oxygen and nutrients cross to cells
  - Carbon dioxide and metabolic waste products cross into blood

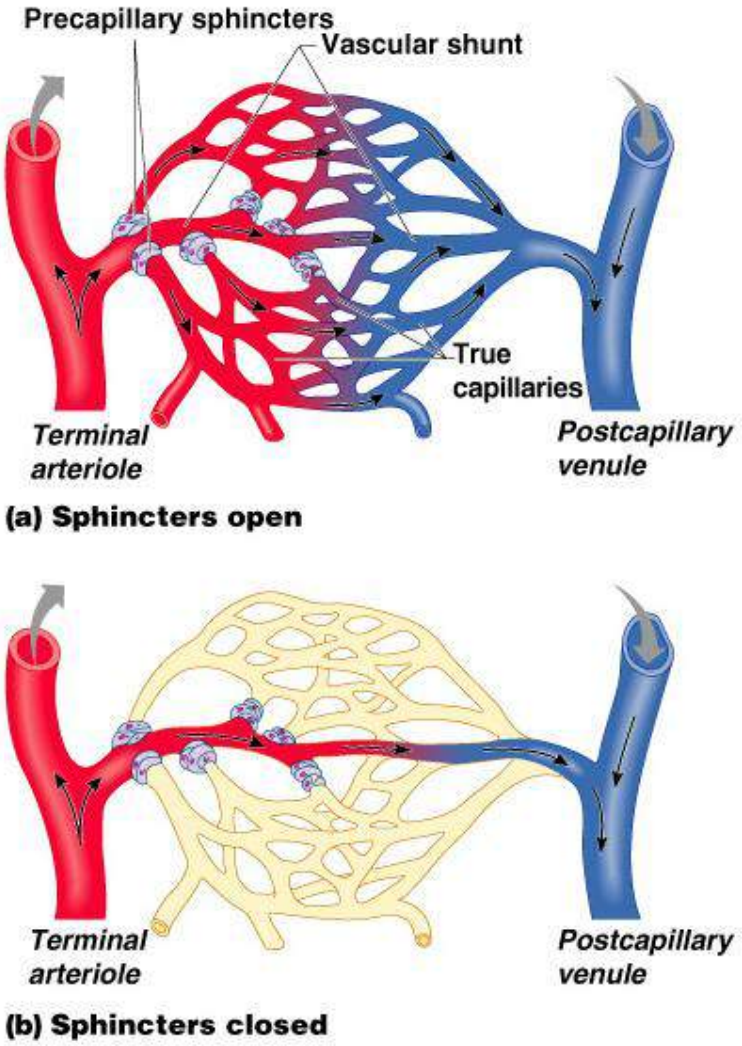


Figure 11.10

Capillary Exchange

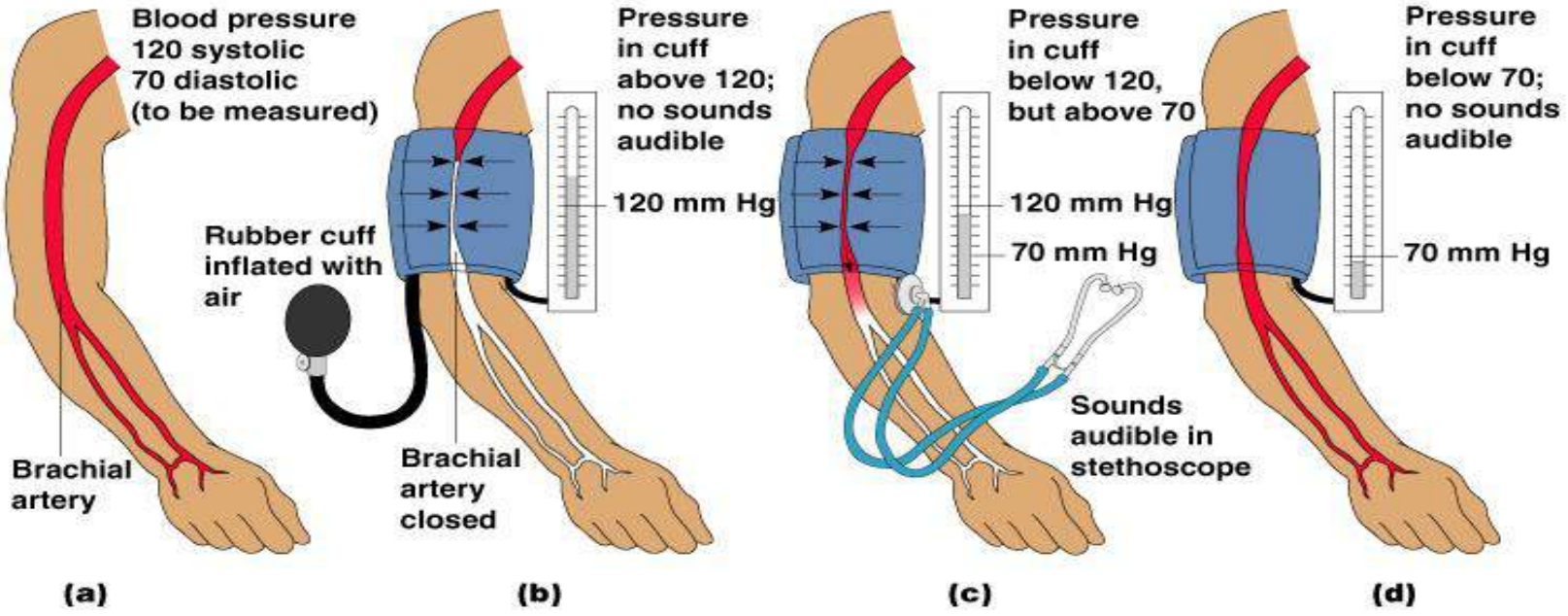
- **Substances exchanged due to concentration gradients**
  - Oxygen and nutrients leave the blood
  - Carbon dioxide and other wastes leave the cells

Capillary Exchange Mechanisms

- Direct diffusion across plasma membranes
- Endocytosis or exocytosis
- Some capillaries have gaps (intercellular clefts)
  - Plasma membrane not joined by tight junctions
- Fenestrations of some capillaries
  - Fenestrations = pores

Blood Pressure

- Measurements by health professionals are made on the pressure in large arteries
  - Systolic – pressure at the peak of ventricular contraction
  - Diastolic – pressure when ventricles relax
  - **Pulse Pressure -- Difference between Systolic & Diastolic Pressure**
- Pressure in blood vessels decreases as the distance away from the heart increases



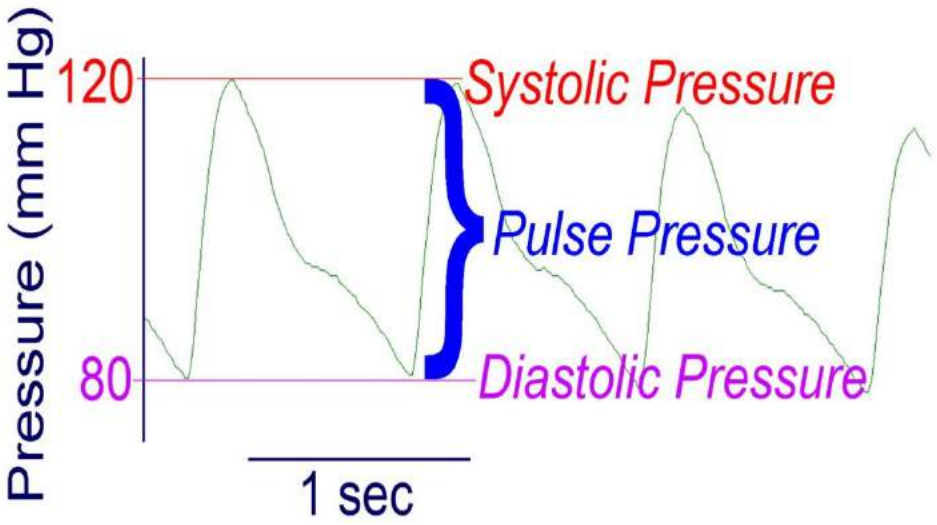
Blood Pressure

- **Effects of Factors**

1. **Neural factors**: Autonomic nervous system adjustments (sympathetic division)
2. **Renal factors**: Regulation by altering blood volume –Renin hormonal control
3. **Temperature**: Heat has a vasodilation effect - Cold has a vasoconstricting effect
4. **Chemicals**: Various substances can cause increases or decreases
5. **Diet**

- **Human normal range is variable**
- Normal

140–110 mm Hg systolic
80–75 mm Hg diastolic
Hypotension
Low systolic (below 110 mm HG)
Often associated with illness
Hypertension
High systolic (above 140 mm HG)
Can be dangerous if it is chronic



What Factors Can Affect Pulse Pressure?

Compliance *(distensibility)* of Arteries and Stroke Volume

The ability of the arterial tree to store potential energy depends on its compliance (C), which can be defined as the tendency of a hollow organ to resist recoil toward its original dimensions. If the vessels were completely rigid (compliance = zero) all of the energy of contraction would appear as kinetic energy.

Normal Cardiovascular Values

Condition	Normal (20 year-old)	Highest Normal	Normal (70 year-old)
Systolic Pressure	120 mm Hg	140 mm Hg	145 mm Hg
Diastolic Pressure	80 mm Hg	90 mm Hg	82 mm Hg
Mean Pressure	93 mm Hg	107 mm Hg	103 mm Hg

Typical Heart Rate ranges from 60-100 beats per minute (bpm) at rest (average of 70 bpm)

Typical Cardiac Output at rest is approximately 5 liters/min

HEART SOUNDS

- PRODUCED FROM BLOOD TURBULENCE CAUSED BY CLOSING OF HEART VALVES
- S1 – ATRIOVENTRICULAR VALVE CLOSURE
- S2 – SEMILUNAR VALVE CLOSURE
- S3 – RAPID VENTRICULAR FILLING
- S4 – ATRIAL SYSTOLE

Developmental Aspects of the Cardiovascular System

- A simple “tube heart” develops in the embryo and pumps by the fourth week
- The heart becomes a four-chambered organ by the end of seven weeks
- Few structural changes occur after the seventh week

Heart Failure

- The volume of blood leaving the left and right heart per unit time must be precisely matched. Otherwise, fluid would accumulate in one system, resulting in serious clinical disease.
- For example, if the myocardium of the left ventricle is severely damaged by a myocardial infarction, the amount of blood leaving the left heart could be less than that leaving the right heart. As a result, blood would accumulate in the vessels of the pulmonary circulation, leading to an impairment of gas exchange in the lungs.