# Cardiovascular Physiology


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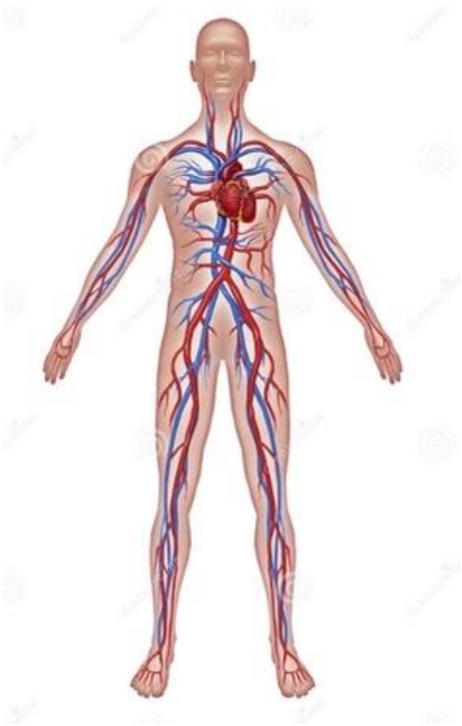
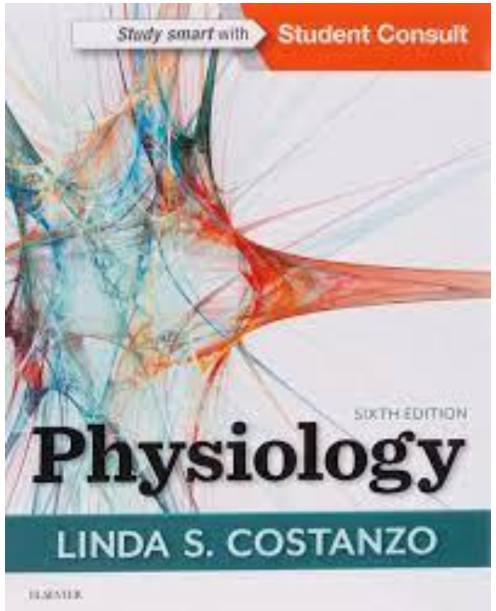


# References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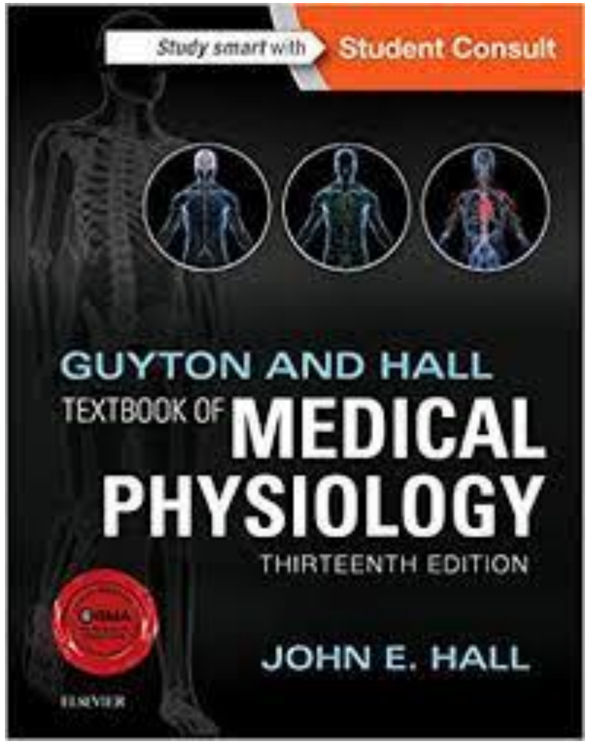
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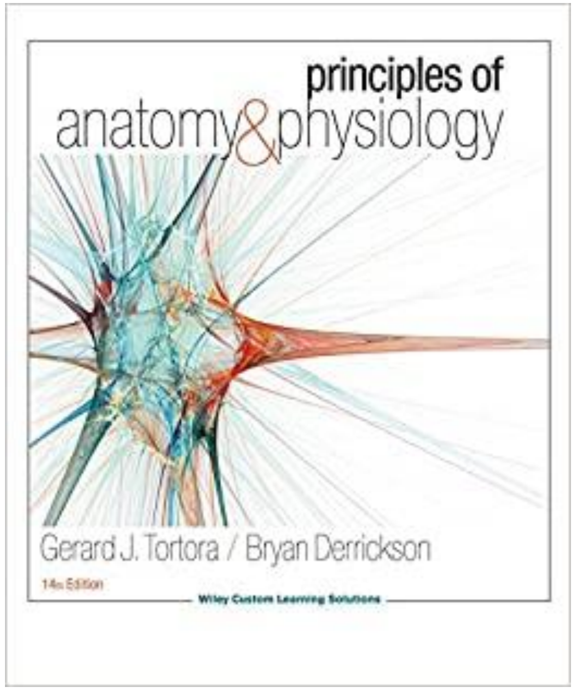
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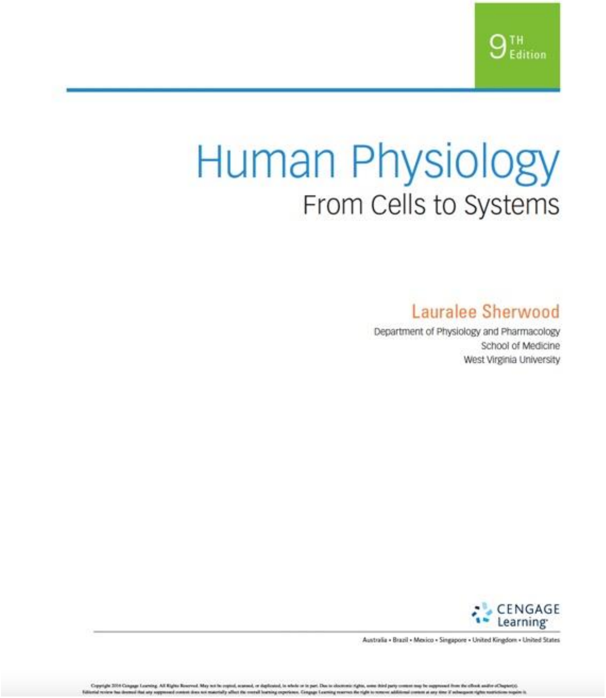
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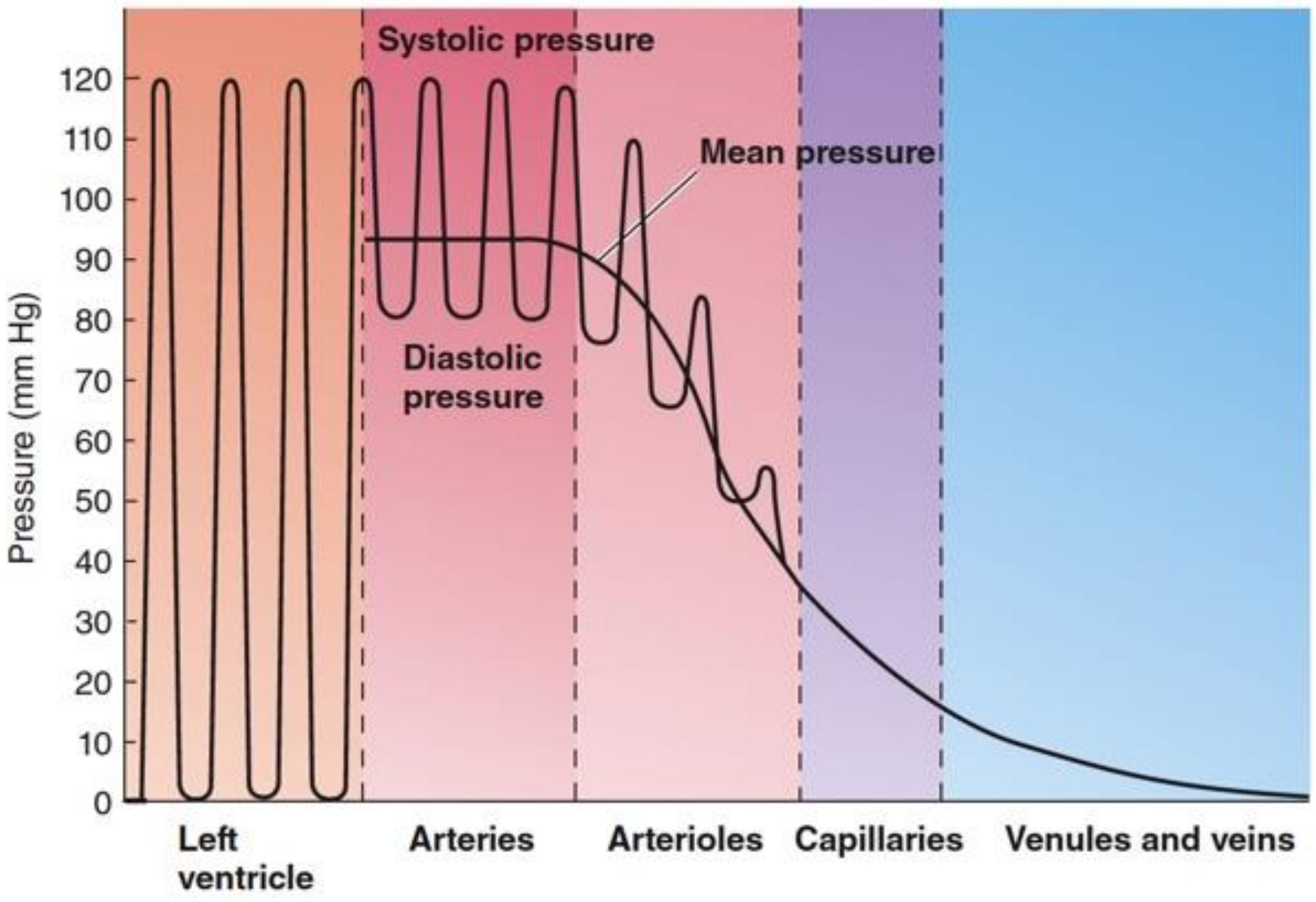
# Vascular hemodynamics-3



Systolic pressure
Mean pressure
Diastolic pressure
Pressure (mm Hg)
120
110
100
90
80
70
60
50
40
30
20
10
0
Left ventricle
Arteries
Arterioles
Capillaries
Venules and veins

# Arteries

- Because arteries offer little resistance to flow, only a negligible amount of pressure energy is lost in them because of friction.
- Therefore, arterial pressure—systolic, diastolic, pulse, or mean—is almost the same in all arteries.

# Pulsation of arterial pressure

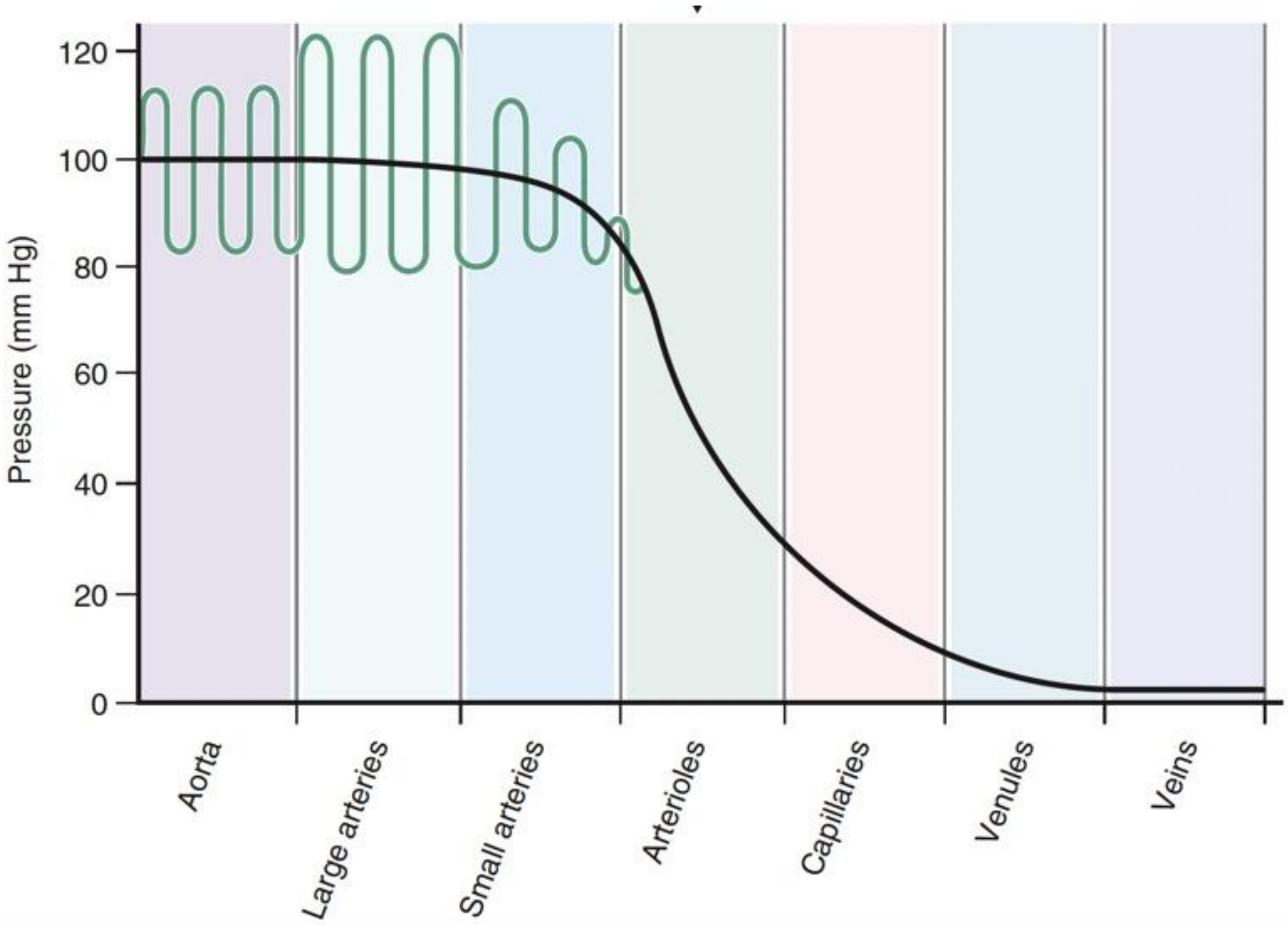
- pulsations of arterial pressure reflect the pulsatile activity of the heart.
- Each cycle of pulsation in the arteries coincides with one cardiac cycle.

# Pulse pressure

- Pulse pressure is the difference between systolic pressure and diastolic pressure.
- Two major factors affect the pulse pressure:
- (1) the stroke volume
- (2) the compliance of the arterial tree.

# Pulse pressure

- In general, the greater the stroke volume output, the greater the amount of blood that must be accommodated in the arterial tree with each heartbeat and, therefore, the greater the pressure rise and fall during systole and diastole, thus causing a greater pulse pressure.
- Conversely, the less the compliance of the arterial system, the greater the rise in pressure for a given stroke volume of blood pumped into the arteries.



120
100
80
60
40
20
0
Pressure (mm Hg)
Aorta
Large arteries
Small arteries
Arterioles
Capillaries
Venules
Veins

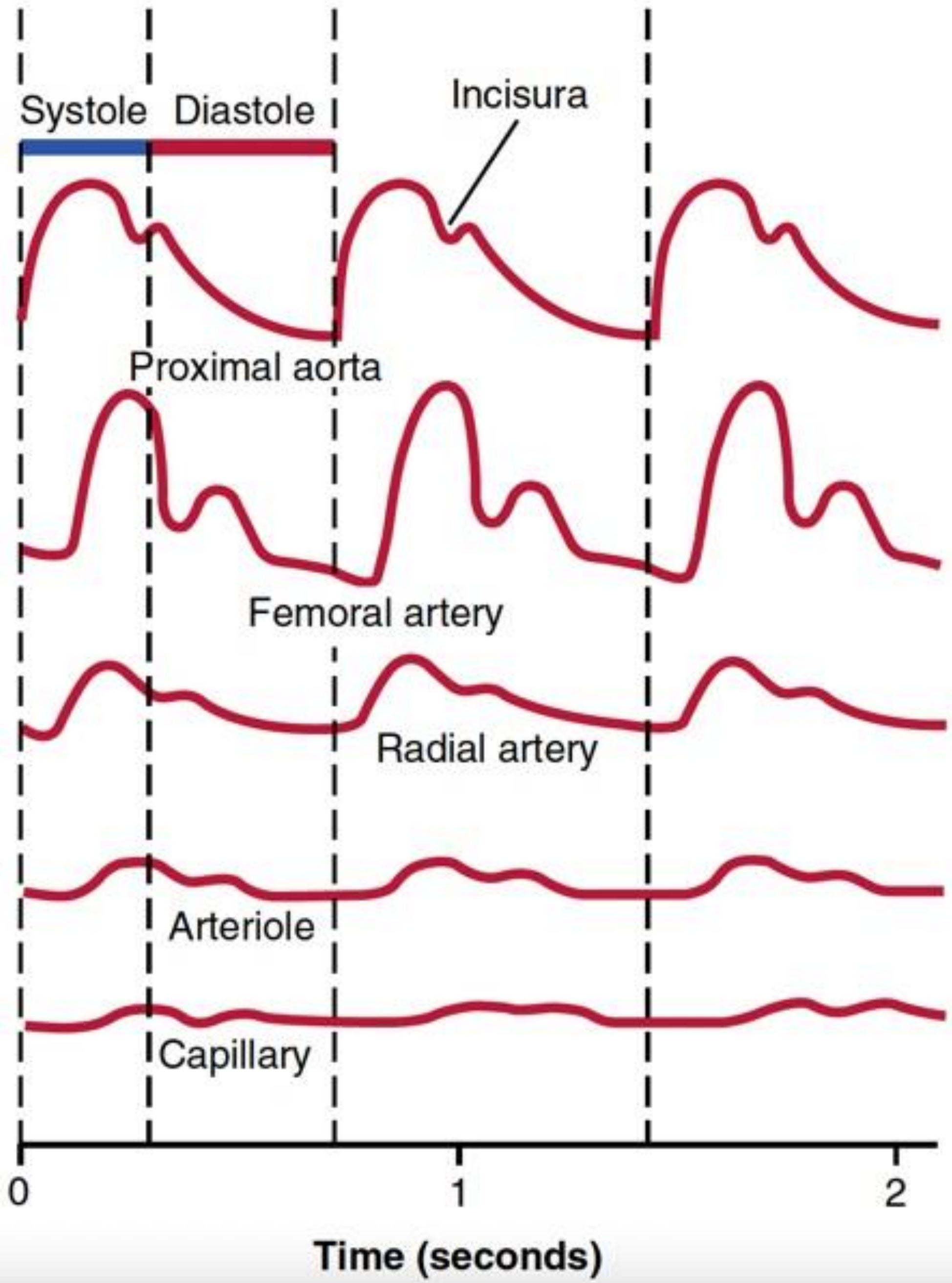
# Pulsations in large arteries

- pulsations in large arteries are even greater than the pulsations in the aorta.
- following ejection of blood from the left ventricle, the pressure wave travels at a higher velocity than the blood itself travels (due to the inertia of the blood), augmenting the downstream pressure.
- Furthermore, at branch points of arteries, pressure waves are reflected backward, which also tends to augment pressure at those sites.

# Mean arterial pressure

- the driving force for blood flow in the arteries is the mean arterial pressure, which is influenced more by diastolic pressure than by systolic pressure.

- While systolic pressure is higher in the large arteries than in the aorta, diastolic pressure is lower; thus mean arterial pressure is lower downstream.



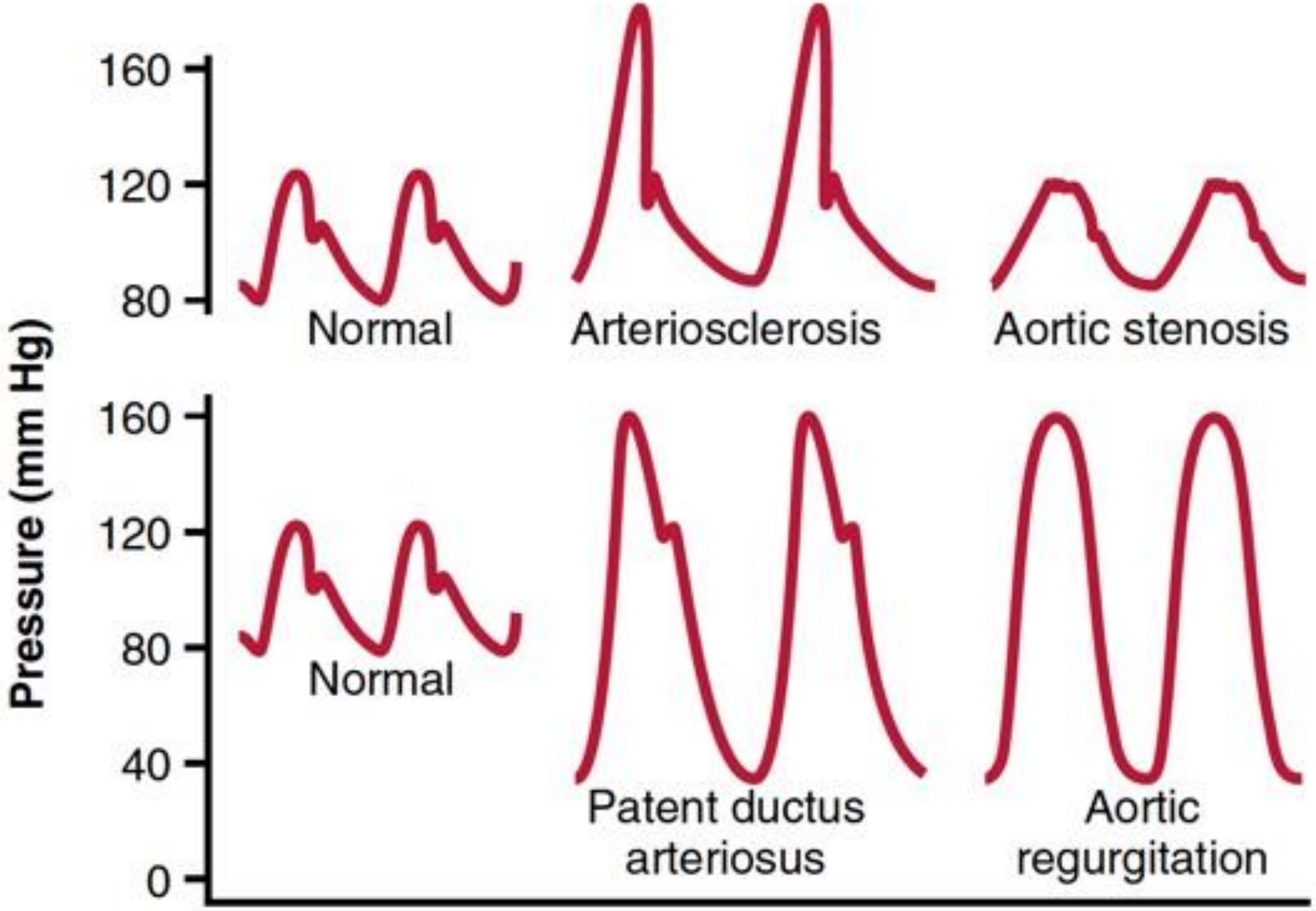
Systole
Diastole
Incisura
Proximal aorta
Femoral artery
Radial artery
Arteriole
Capillary
0
1
2
Time (seconds)

# Damping of pulse pressure

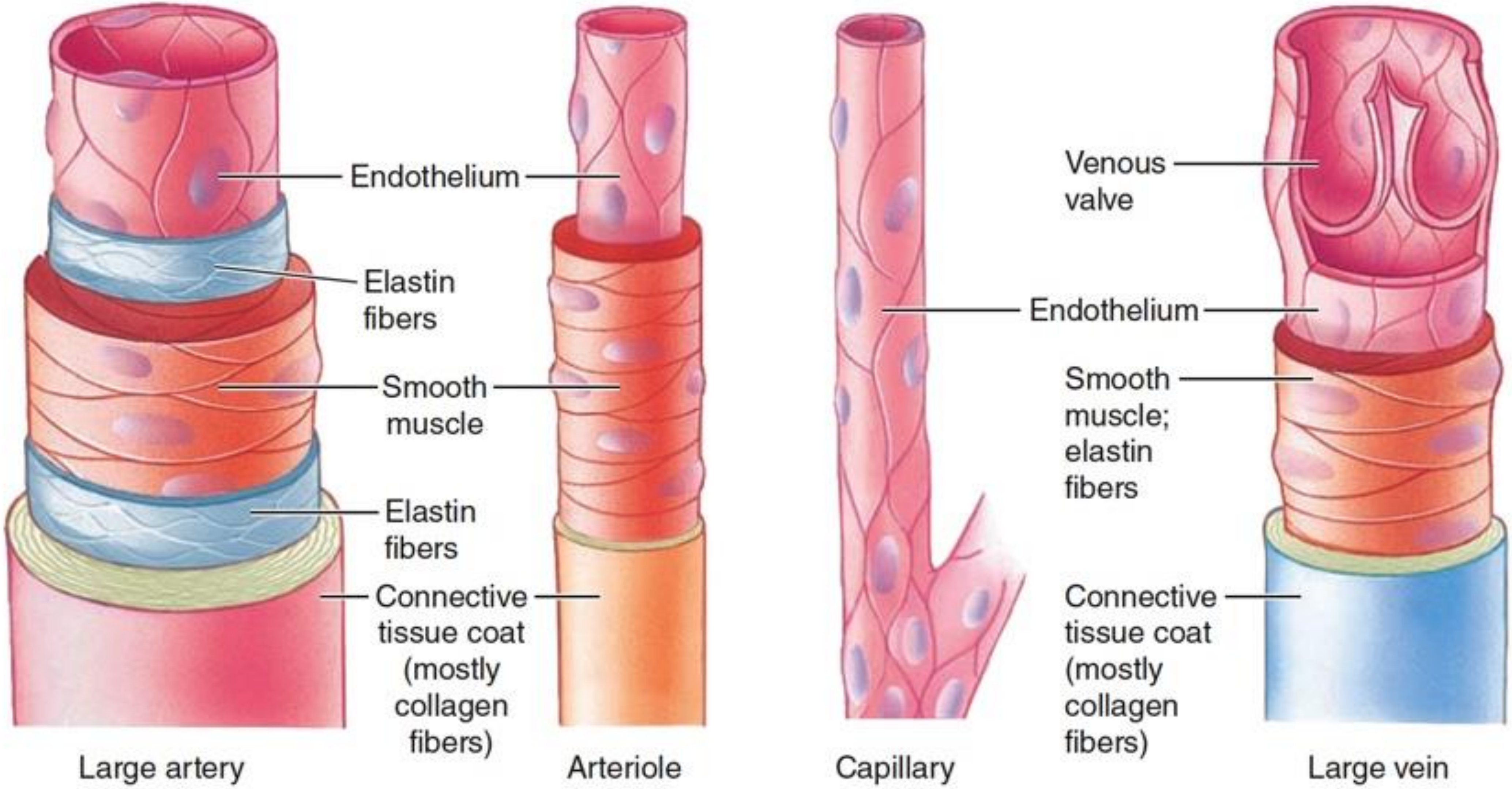
- The progressive diminution of the pulsations in the periphery is called damping of the pressure pulses.
- The cause of this damping is twofold:
- (1) resistance to blood movement in the vessels
- (2) compliance of the vessels.

# Aortic dicrotic notch

- dicrotic notch (or incisura), is produced when the aortic valve closes.
- Aortic valve closure produces a brief period of retrograde flow from the aorta back toward the valve, briefly decreasing the aortic pressure below the systolic value.



Pressure (mm Hg)
160
120
80
Normal
Arteriosclerosis
Aortic stenosis
160
120
80
40
0
Normal
Patent ductus arteriosus
Aortic regurgitation



Endothelium
Elastin fibers
Smooth muscle
Elastin fibers
Connective tissue coat (mostly collagen fibers)
Large artery
Arteriole
Capillary
Venous valve
Endothelium
Smooth muscle; elastin fibers
Connective tissue coat (mostly collagen fibers)
Large vein

# Arterioles

- Arterioles are the main resistance vessels in the vascular tree because their radius is small enough to offer considerable resistance to flow.

- arterioles are also the site where resistance can be changed by alterations in local, humoral, and neural factors.

# Arterioles

the high degree of arteriolar resistance causes a marked drop in mean pressure as blood flows through these small vessels.

- This pressure differential that encourages the flow of blood from the heart to the various organs downstream.

- Arteriolar resistance also converts the pulsatile systolic-to-diastolic pressure swings in the arteries into the nonfluctuating pressure present in the capillaries.

$$R = \frac{8\eta l}{\pi r^4}$$

# Arterioles

- The radius (and, accordingly, the resistances) of arterioles supplying individual organs can be adjusted independently to accomplish two functions:
- (1) to variably distribute the cardiac output among the systemic organs, depending on the body's momentary needs,
- (2) to help regulate arterial blood pressure.

# Arterioles

- Unlike arteries, arteriolar walls contain little elastic connective tissue.
- However, they do have a thick layer of smooth muscle that is richly innervated by sympathetic nerve fibers.
- The smooth muscle layer runs circularly around the arteriole; so when the smooth muscle layer contracts, the vessel’s circumference (and its radius) becomes smaller, increasing resistance and decreasing flow through that vessel.

# Arterioles

- The smooth muscle in the arteriole is sensitive to:
- 1. local chemical changes.
- 2. circulating hormones.
- 3. mechanical factors such as stretch.
- 4. sympathetic nerve stimulation.

# Arterioles

- Vasoconstriction is the term applied to such narrowing of a vessel.
- Vasodilation refers to enlargement in the circumference and radius of a vessel as a result of its smooth muscle layer relaxing.
- Vasodilation leads to decreased resistance and increased flow through that vessel.

# Vascular tone

- Arteriolar smooth muscle normally displays a state of partial constriction known as vascular tone, which establishes a baseline of arteriolar resistance.
- Two factors are responsible for vascular tone. First, arteriolar smooth muscle is tonic smooth muscle that has sufficient surface-membrane voltage-gated Ca channels open even at resting potential to trigger partial contraction.
- This myogenic activity is independent of any neural or hormonal influences, leading to self-induced contractile activity.
- Second, the sympathetic fibers supplying most arterioles continually release norepinephrine, which further enhances vascular tone.
- This ongoing tone makes it possible to either increase or decrease contractile activity to accomplish vasoconstriction or vasodilation, respectively.

# Sympathetic innervation of arterioles

- It is  extensively innervated by sympathetic adrenergic nerve fibers. α1-Adrenergic receptors are found on the arterioles of several vascular beds.
- When activated, these receptors cause contraction, or constriction, of the vascular smooth muscle.
- Constriction produces a decrease in the diameter of the arteriole, which increases its resistance to blood flow.
- Less common, β2-adrenergic receptors are found in arterioles of skeletal muscle. When activated, these receptors cause dilation, or relaxation, of the vascular smooth muscle, which increases the diameter and decreases the resistance of these arterioles to blood flow.

# Vascular tone

- A variety of factors can influence the level of contractile activity in arteriolar smooth muscle, thereby substantially changing resistance to flow in these vessels.
- Unlike skeletal and cardiac muscle in which action potentials trigger muscle contraction, vascular smooth muscle can undergo graded changes in force in response to chemical, physical, and neural factors without undergoing action potentials.
- These agents largely act via second-messenger pathways.
- The extent of contraction of arteriolar smooth muscle depends on the cytosolic Ca concentration.
- The factors that cause arteriolar vasoconstriction or vasodilation fall into two categories: local (intrinsic) controls, which are important in determining distribution of cardiac output, and extrinsic controls, which are important in blood pressure regulation.

Thank you