HERAT ANATOMY

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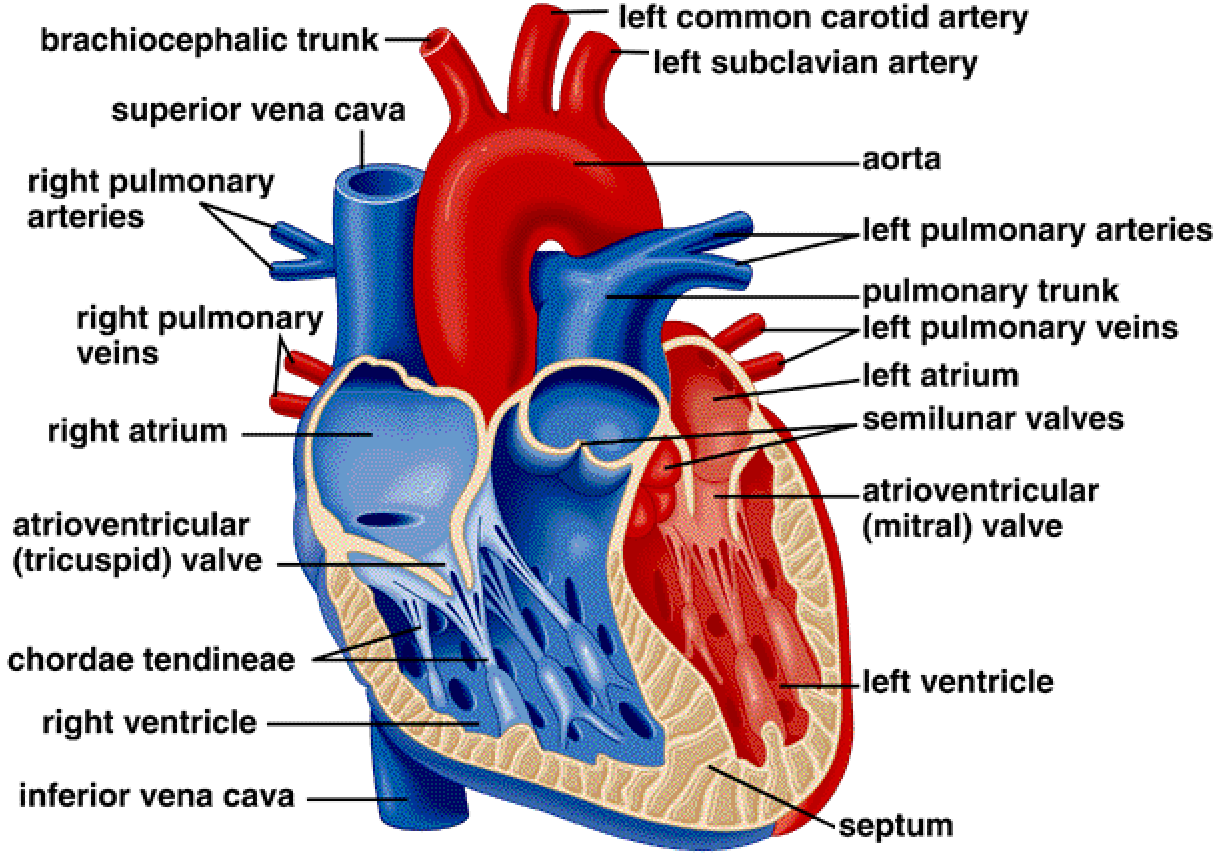
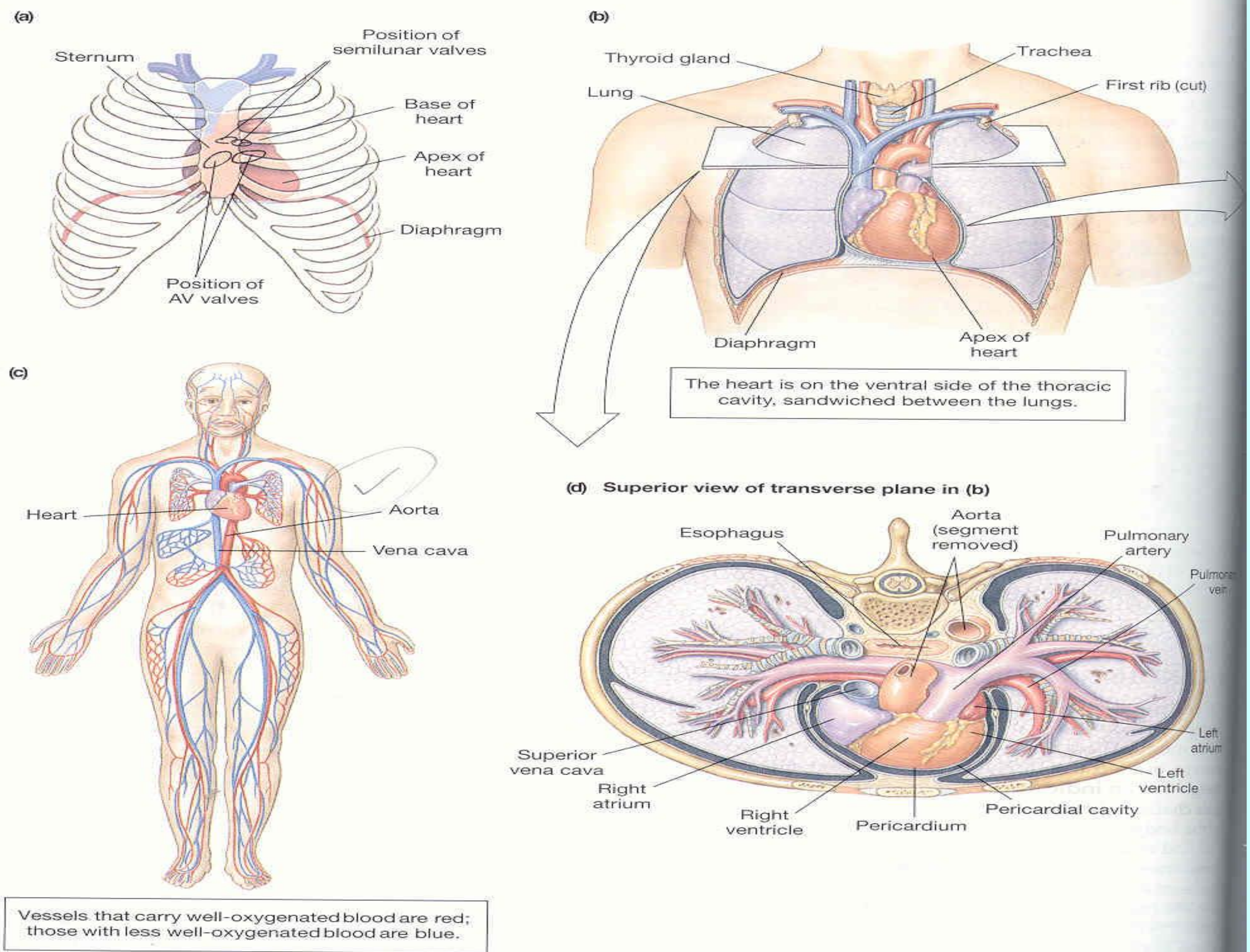
Internal View of Heart



ANATOMY SUMMARY The Cardiovascular System

■ Figure 14-7



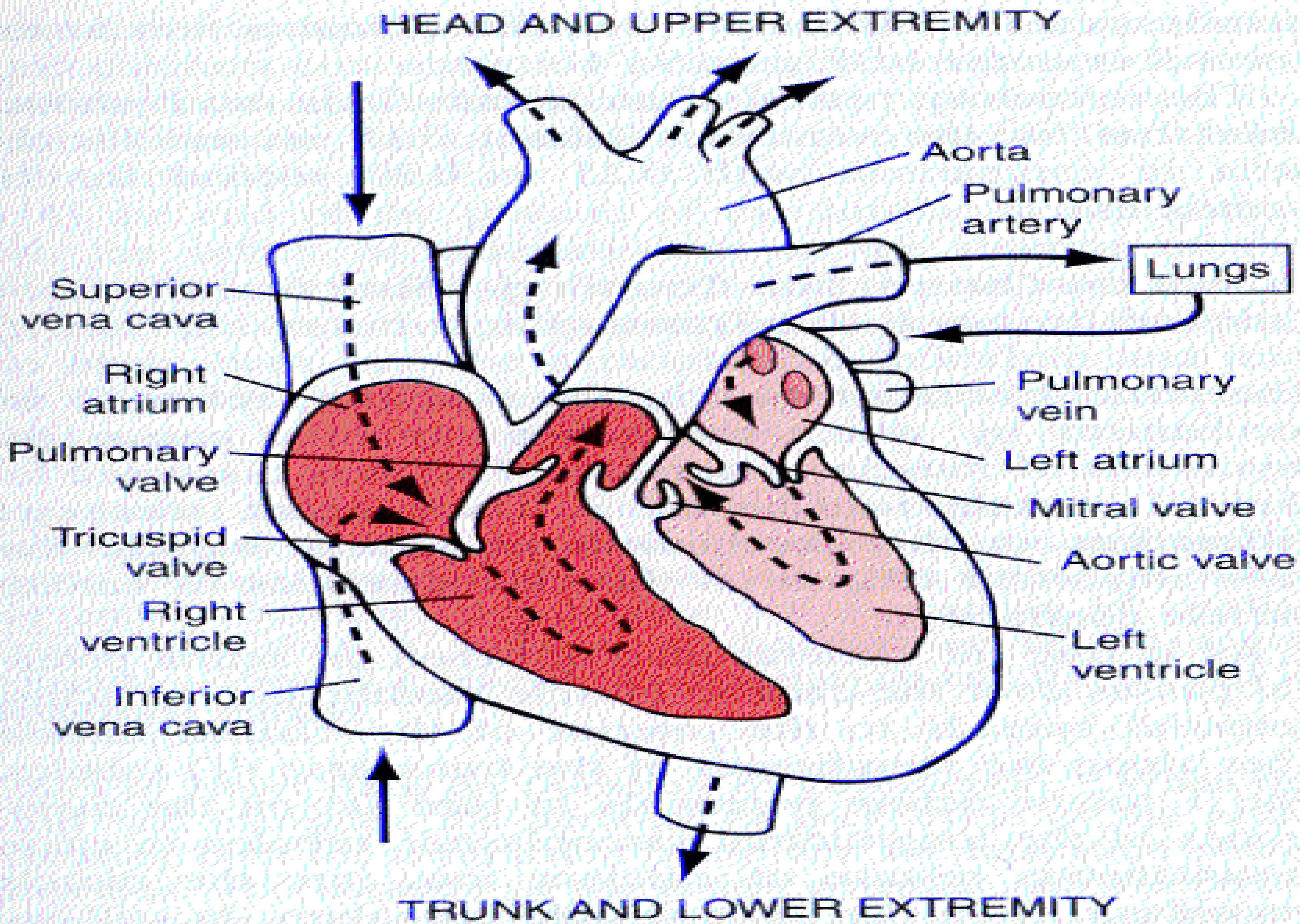
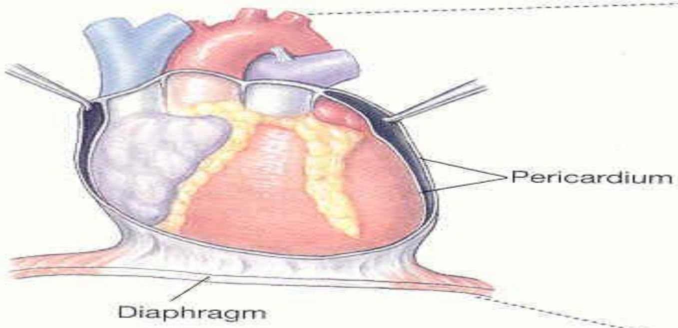


FIGURE 9 – 1

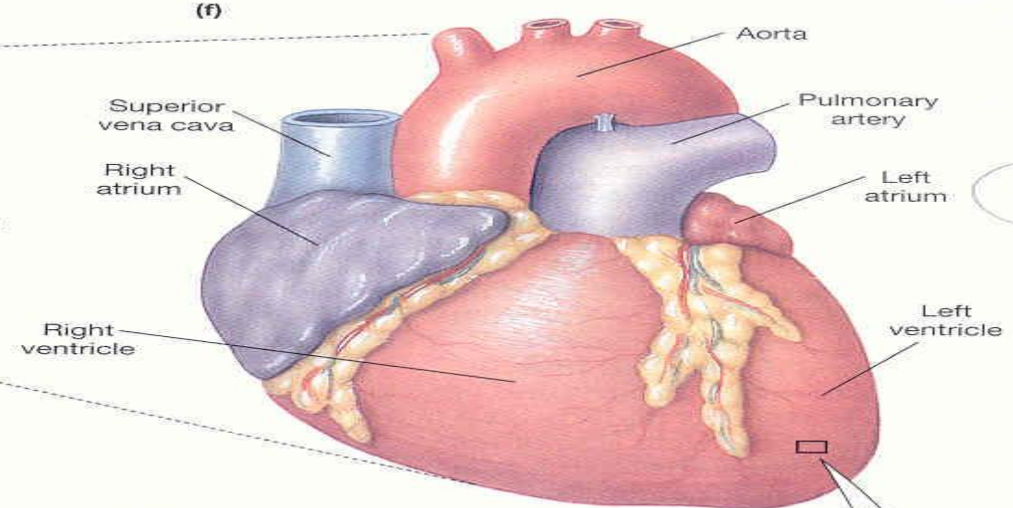
Structure of the heart and course of blood flow through the heart chambers.

(e)



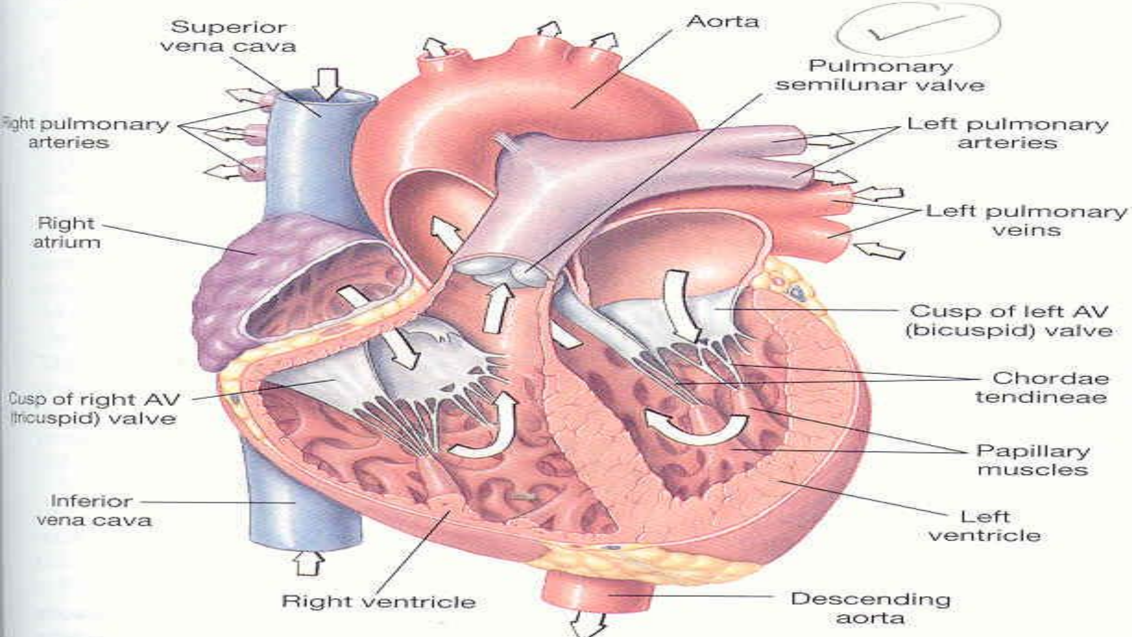
The heart is encased within a membranous fluid-filled sac, the pericardium.

(f)



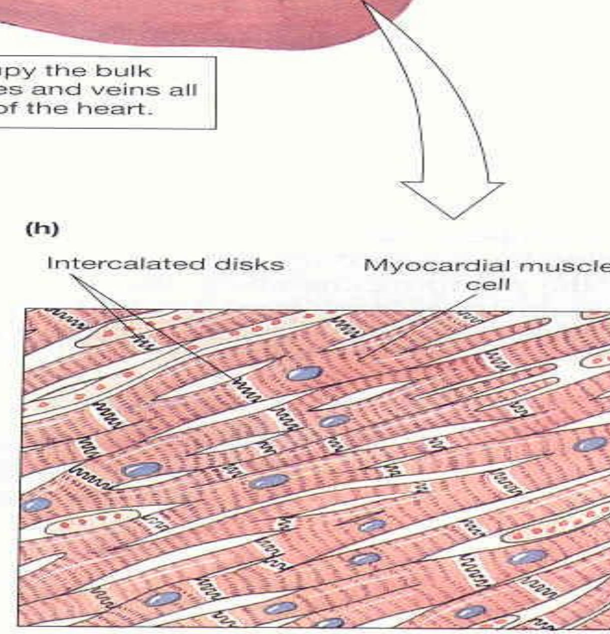
The ventricles occupy the bulk of the heart. The arteries and veins all attach to the base of the heart.

(g)

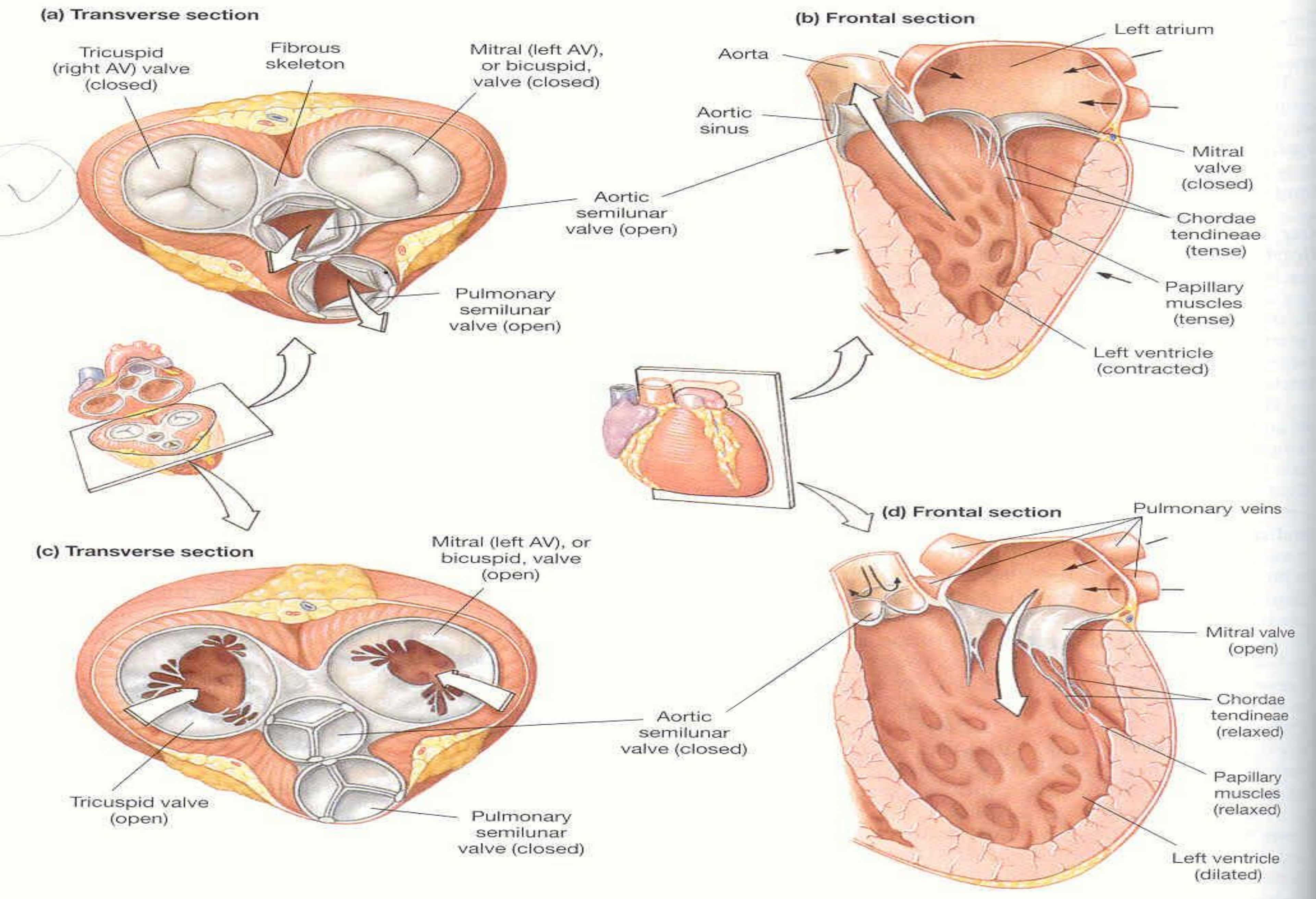


One-way flow through the heart is ensured by two sets of valves.

(h)



Myocardial muscle cells are branched, have a single nucleus, and are attached to each other by specialized junctions known as intercalated disks.



■ **Figure 14-9 Heart valves** The atrioventricular (AV), or cuspid, valves separate the atria from the ventricles. During ventricular contraction, these valves remain closed to prevent blood flow backward into the atria. The semilunar valves prevent blood that has entered the arteries from flowing back into the ventricles during ventricular relaxation. Views (a) and (c) show the valves as viewed from the atria and from inside the arteries.

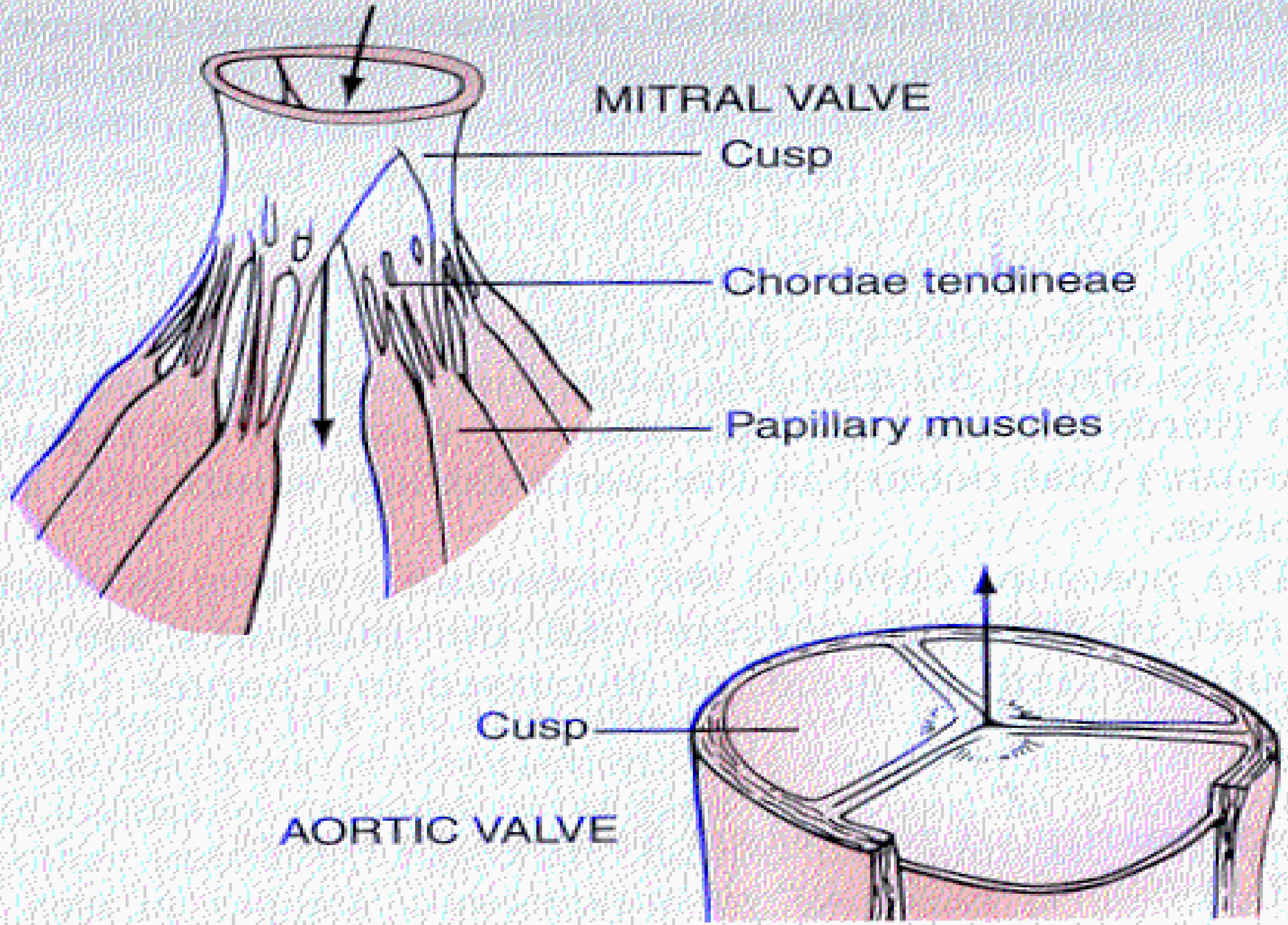
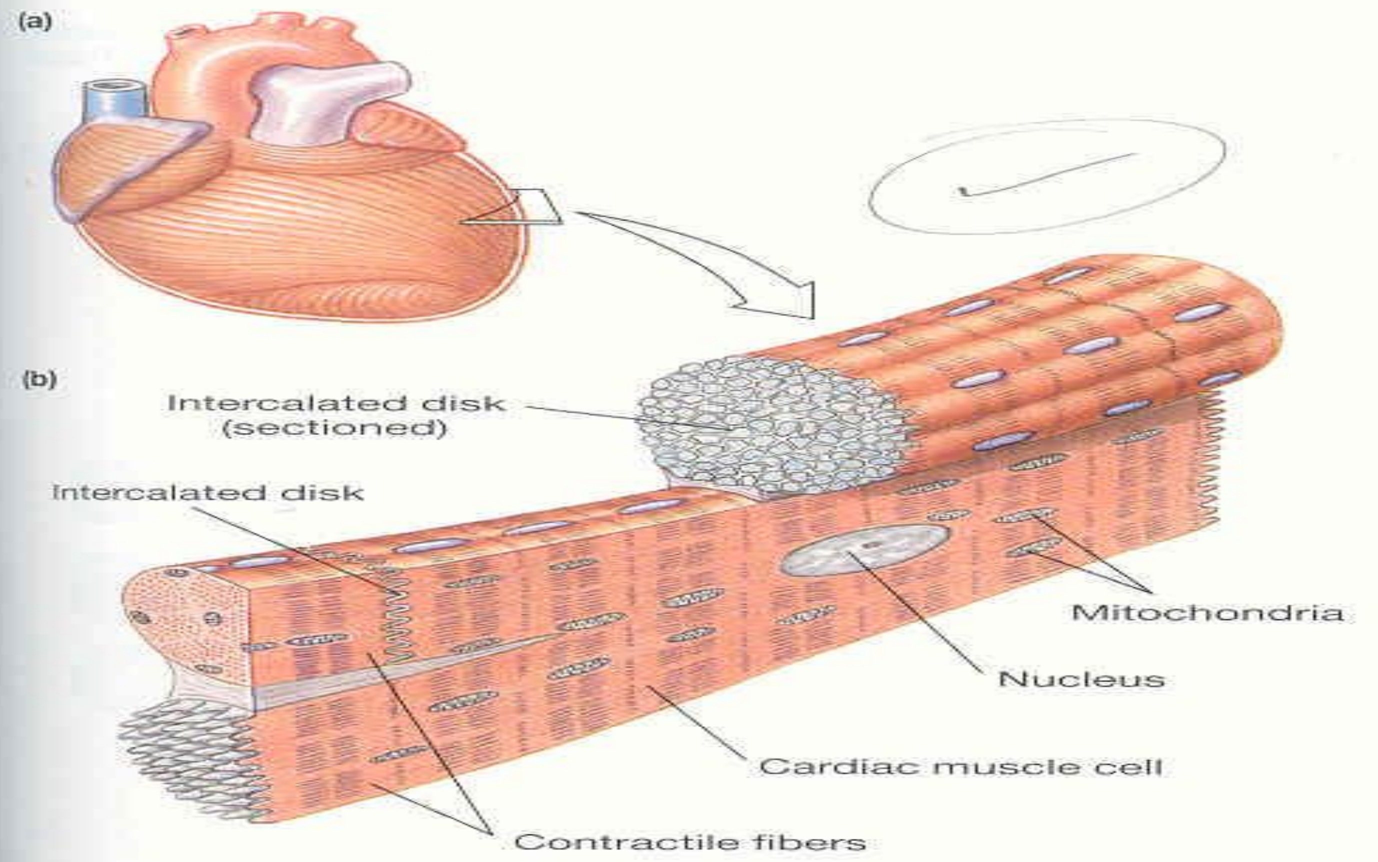
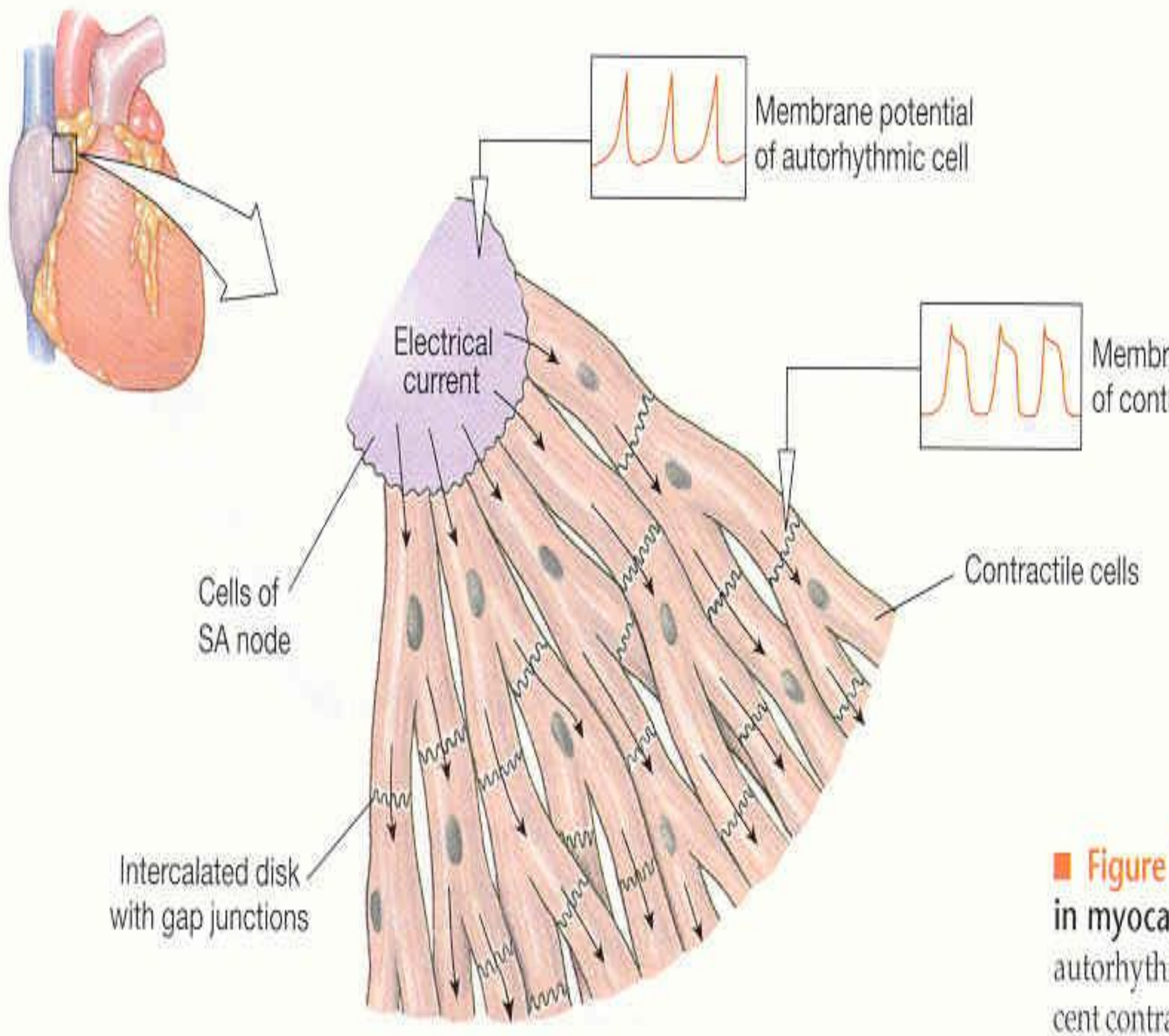


FIGURE 9–6

Mitral and aortic valves.



■ Figure 14-10 **Cardiac muscle** (a) The spiral arrangement of ventricular muscle allows ventricular contraction to squeeze the blood upward from the apex of the heart. (b) Intercalated disks contain desmosomes that transfer force from cell to cell and gap junctions that allow electrical signals to pass rapidly from cell to cell.



■ Figure 14-18 **Electrical conduction in myocardial cells** Depolarizations of autorhythmic cells rapidly spread to adjacent contractile cells through gap junctions.

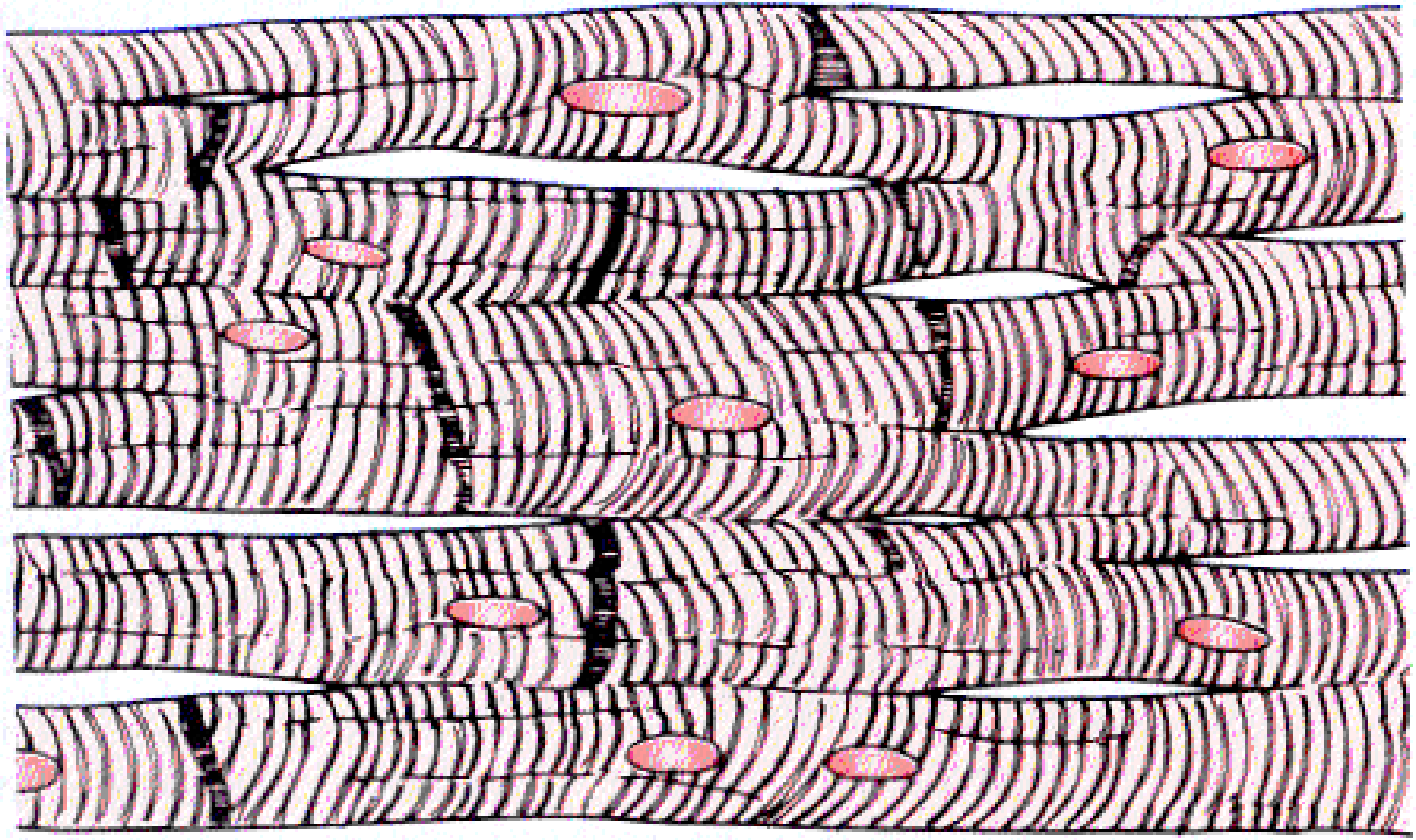


FIGURE 9–2

"Syncytial," interconnecting nature of cardiac muscle fibers.

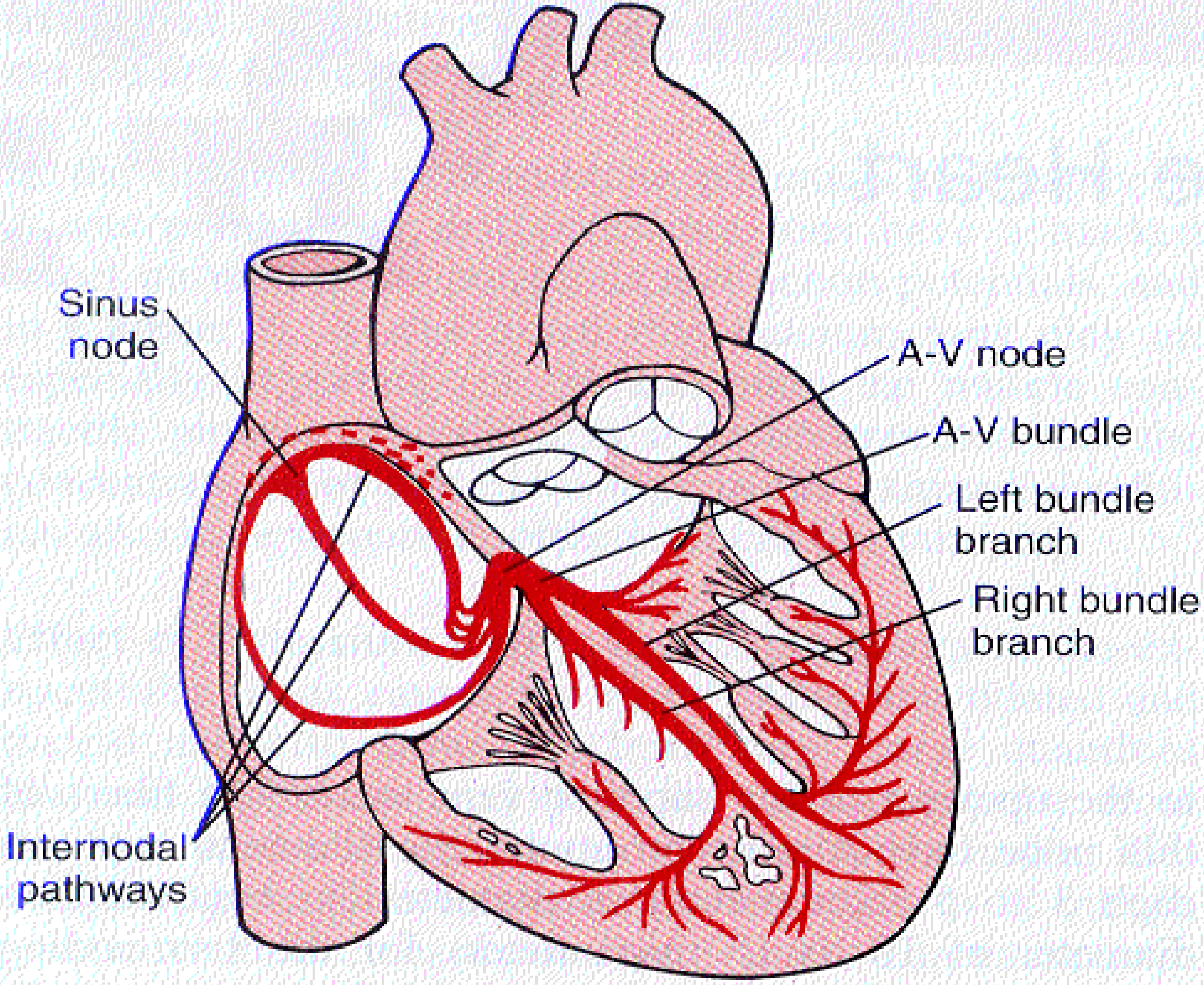


FIGURE 10–1

Sinus node and the Purkinje system of the heart, showing also the A-V node, atrial internodal pathways, and ventricular bundle branches.

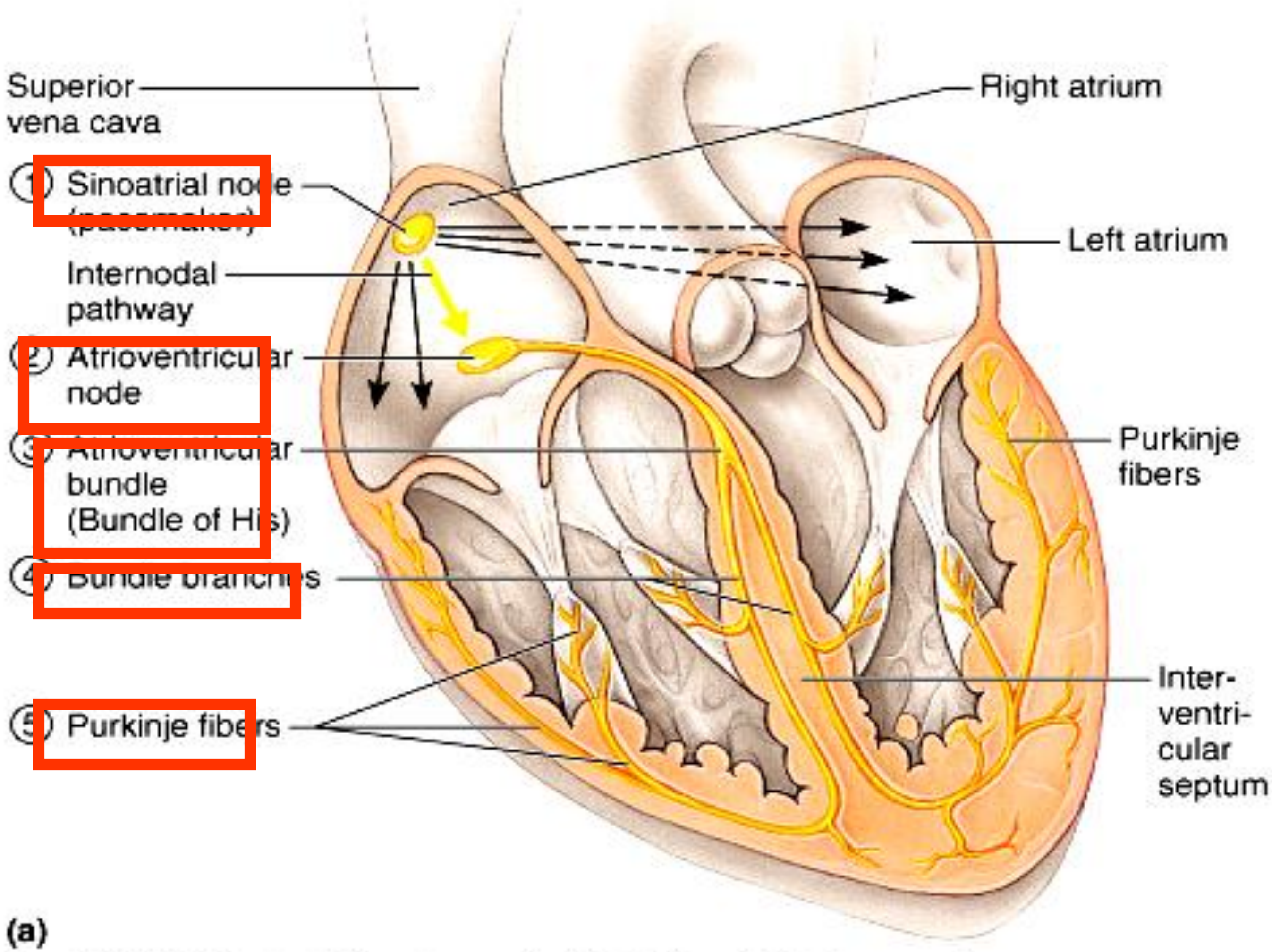
Intrinsic Cardiac Conduction System

Approximately 1% of cardiac muscle cells are autorhythmic rather than contractile

75/min

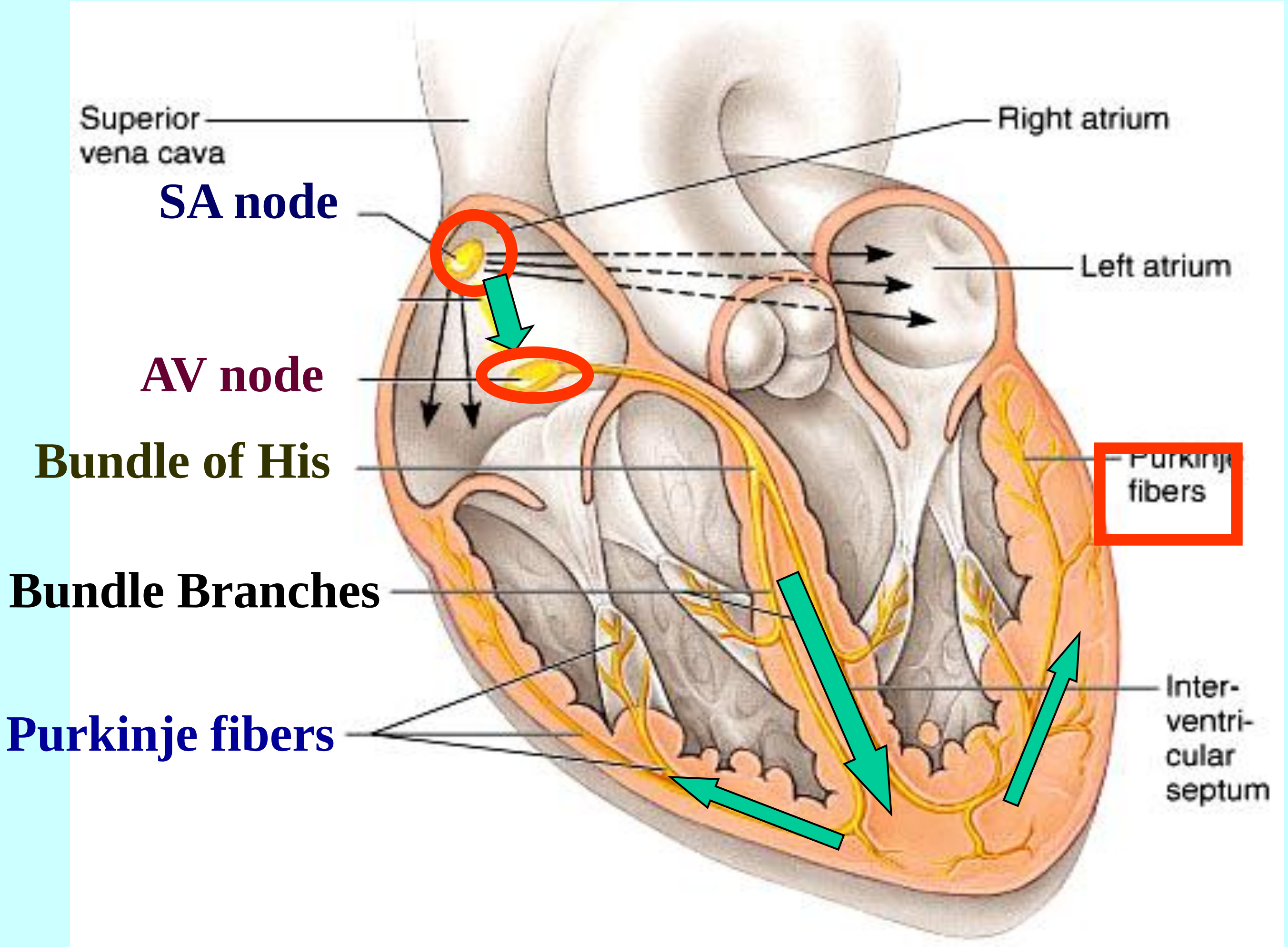
40-60/min

30/min



Intrinsic Conduction System

Function: initiate & distribute impulses so heart depolarizes & contracts in orderly manner from atria to ventricles.



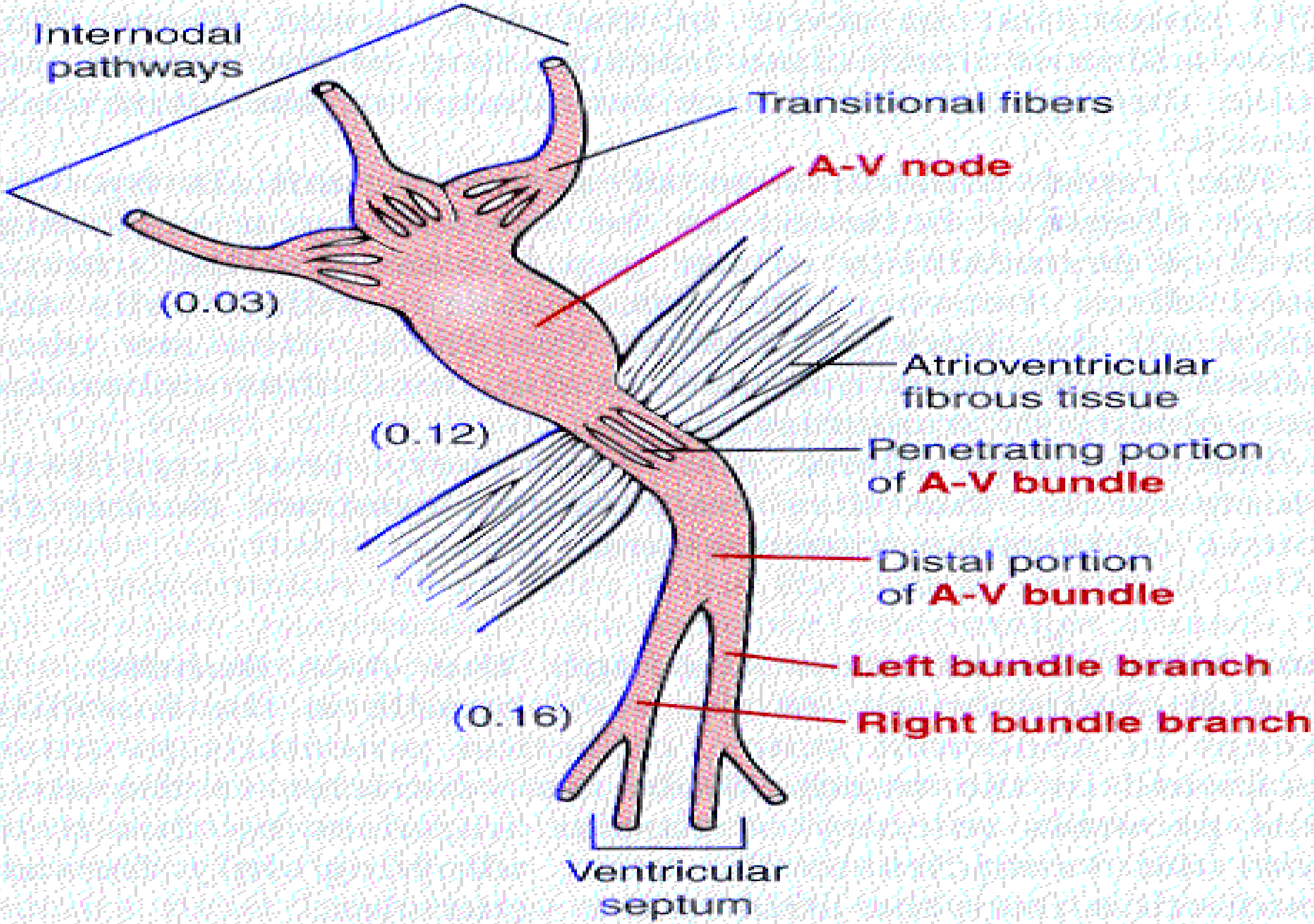


FIGURE 10 – 3

Organization of the A-V node. The numbers represent the interval of time from the origin of the impulse in the sinus node. The values have been extrapolated to humans.

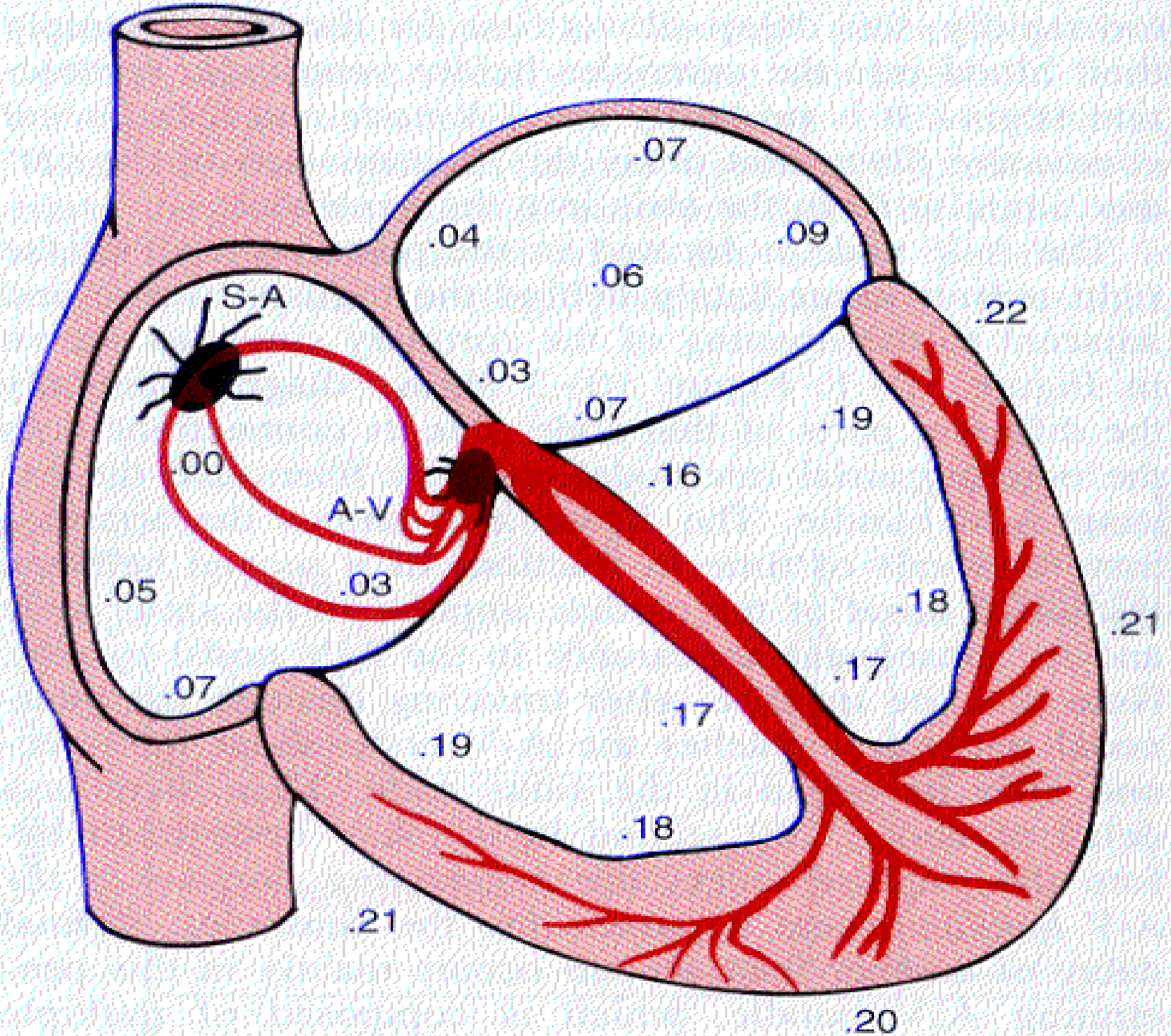


FIGURE 10–4

Transmission of the cardiac impulse through the heart showing the time of appearance (in fractions of a second after initial appearance at the S-A node) in different parts of the heart.

Propagation of the Cardiac Action Potential

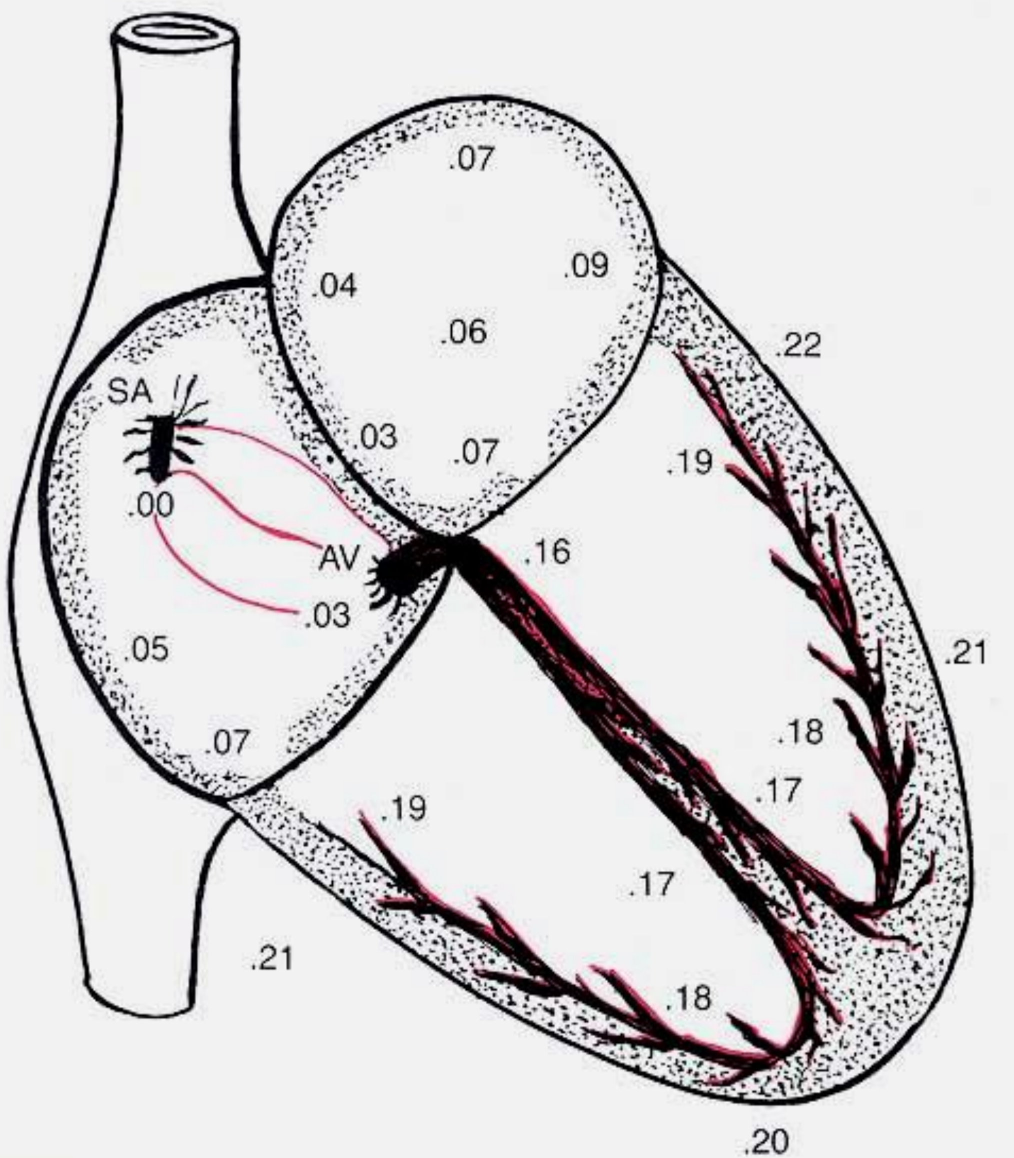


Figure 10 – 4. Transmission of the cardiac impulse through the heart, showing the time of appearance (in fractions of a second) of the impulse in different parts of the heart.

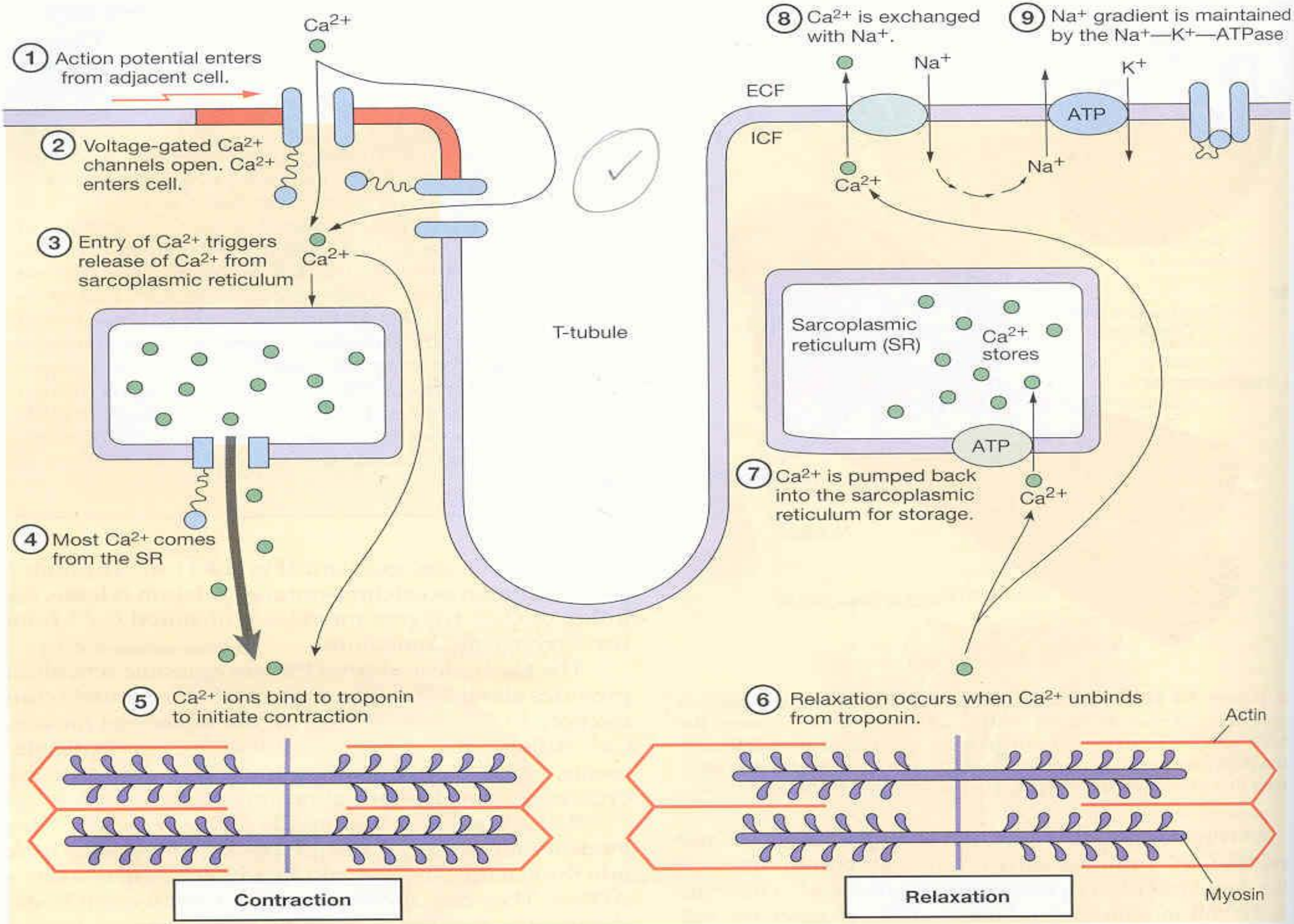
Action potential (AP) starts at SA node.

AP conducted through atrial muscle, interatrial band and internodal pathways.

The AP is delayed at the AV node before entering the Bundle of His.

Conduction through the Bundle of His and Purkinje fibres is extremely rapid.

The ventricles depolarise from endo to epicardium and from apex to base.



■ **Figure 14-11** **Role of calcium in cardiac muscle contraction**

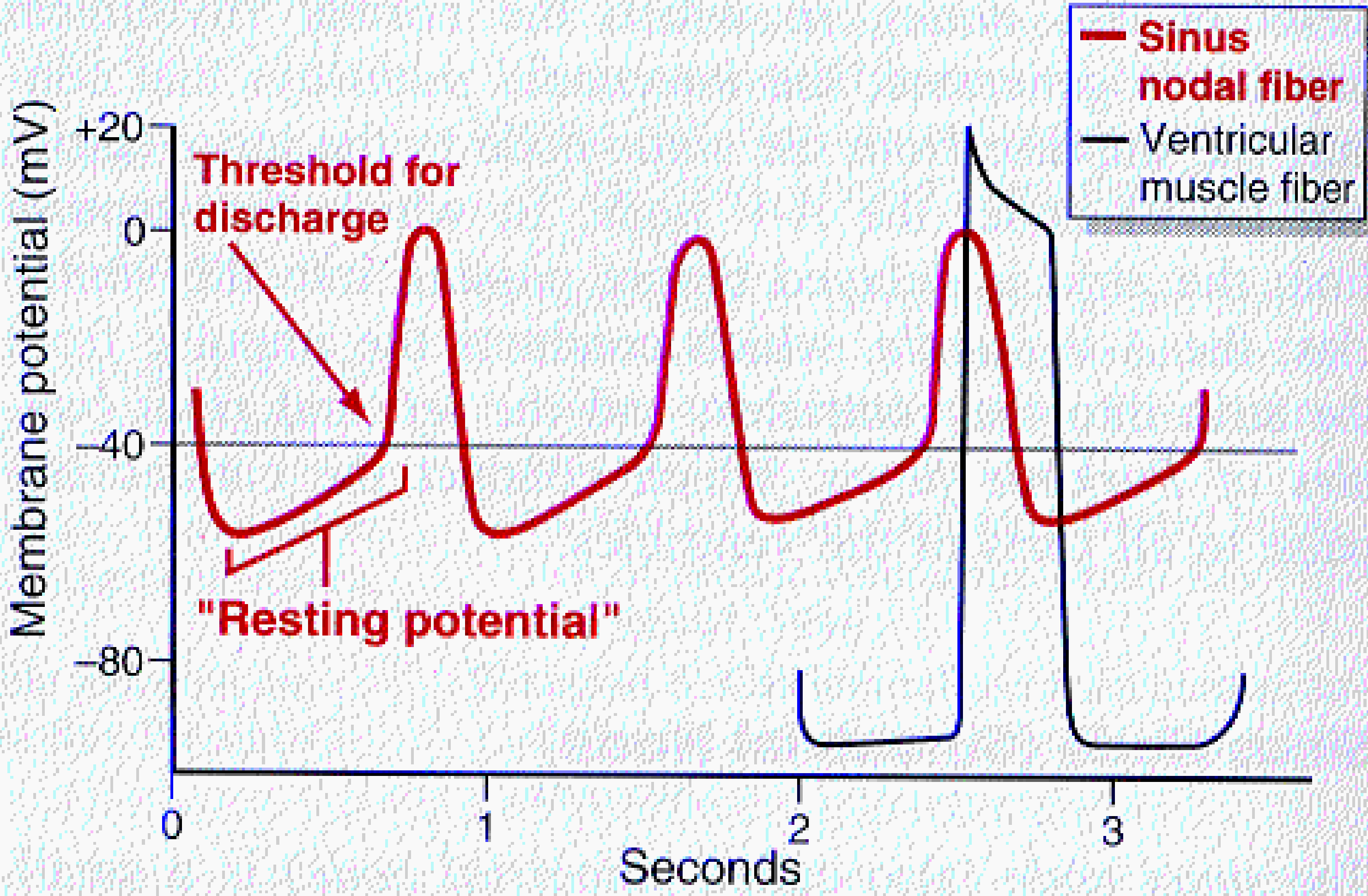
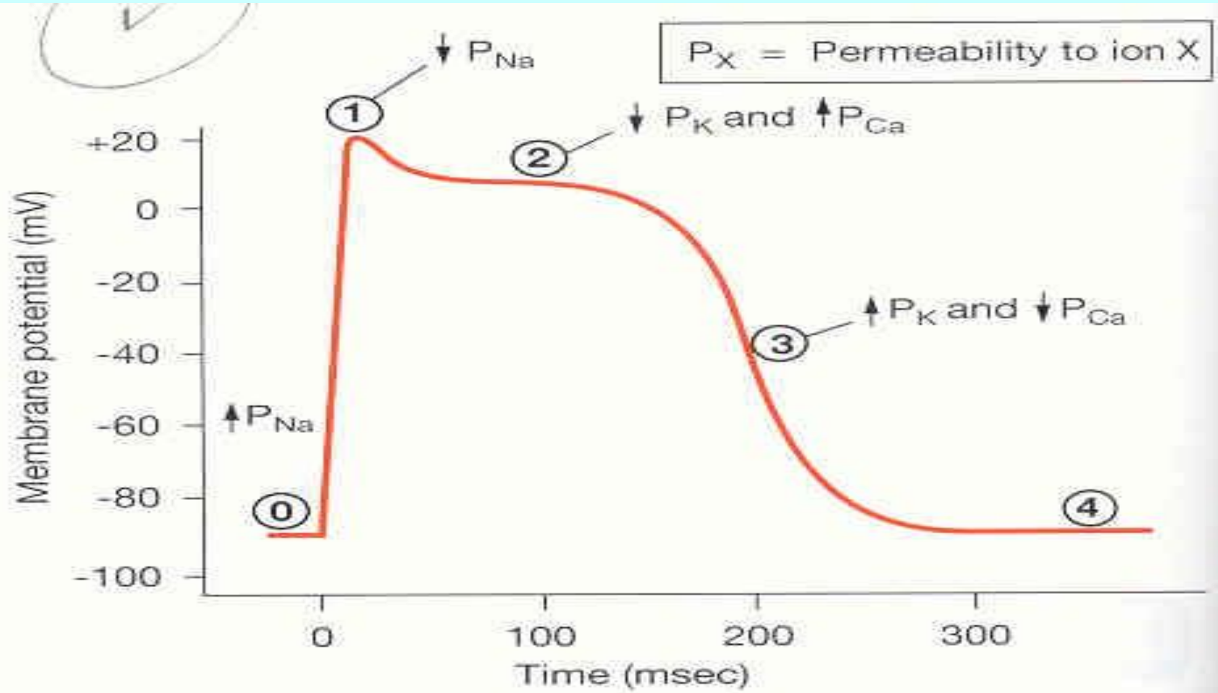


FIGURE 10–2

Rhythmical discharge of a sinus nodal fiber. Also, the sinus nodal action potential is compared with that of a ventricular muscle fiber.



Phase	Membrane channels
0	Na^+ channels open
1	Na^+ channels close
2	Ca^{2+} channels open; fast K^+ channels close
3	Ca^{2+} channels close; slow K^+ channels open
4	Resting potential

Figure 14-14 Action potential of a cardiac contractile cell

Excitation - Contraction Coupling in Cardiac Muscle

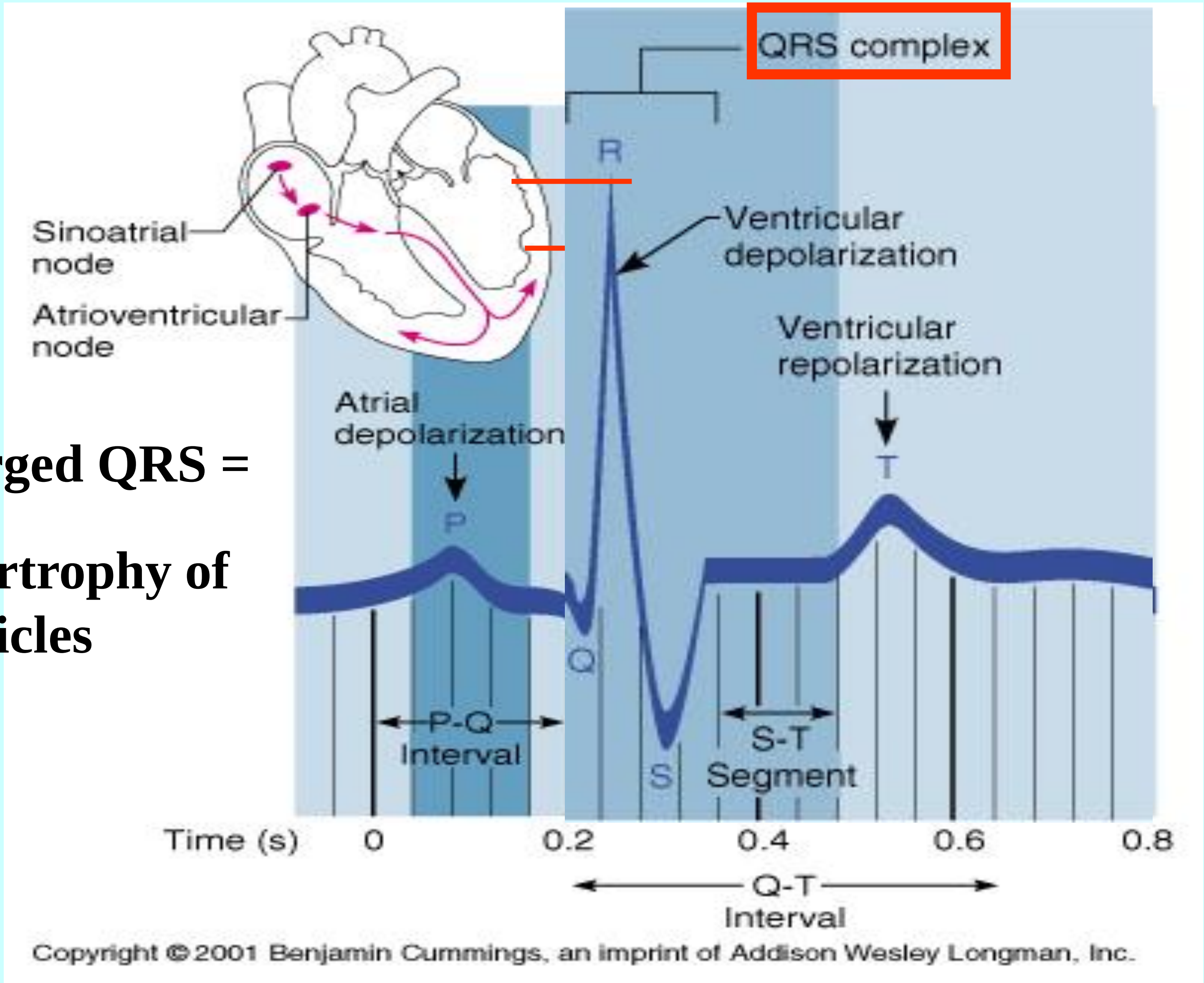
- **Contraction occurs by same sliding filament activity as in skeletal muscle**

some differences:

- **AP opens Ca^{2+} channels in cell membrane**
- **Ca^{2+} induced Ca^{2+} release from SR stores**
- **Ca^{2+} removal requires Ca^{2} -ATPase (into SR) & Na^{+}/Ca^{2+} indirect active transporter (antiport!!) (into ECF)**
- **Na^{+} restored via??**

Fig 14-11

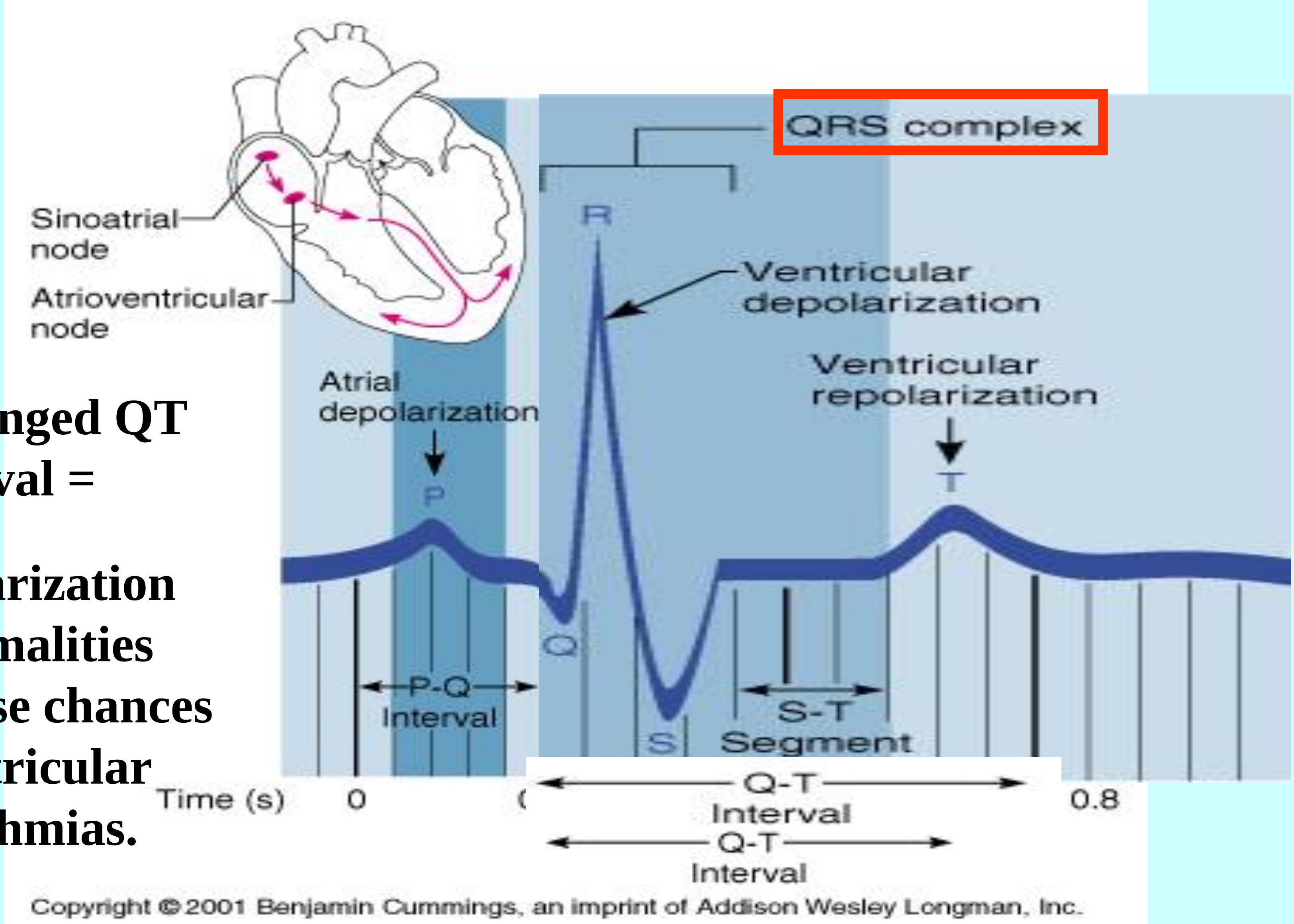
ECG Deflection Wave Irregularities



Enlarged QRS =

Hypertrophy of ventricles

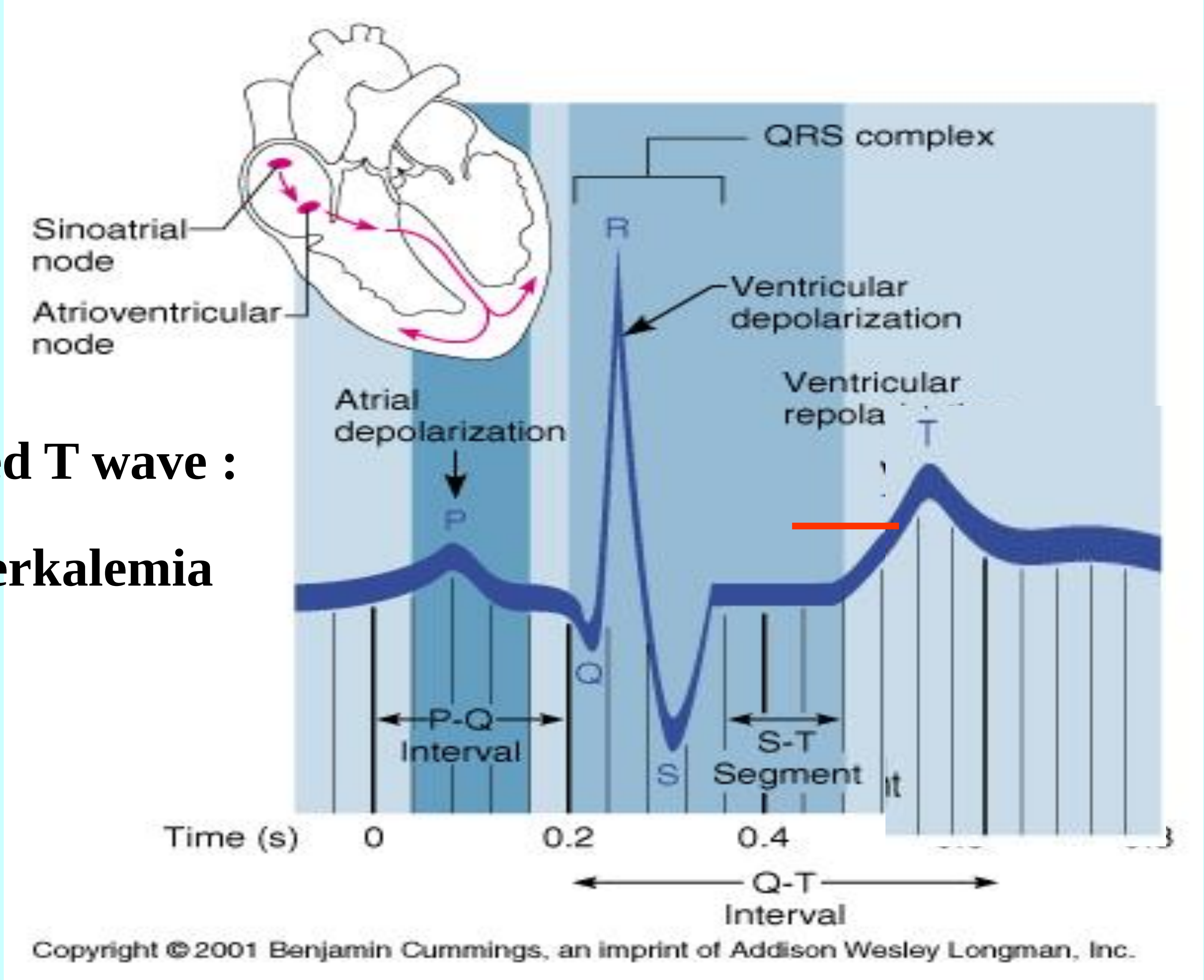
ECG Deflection Wave Irregularities



Prolonged QT Interval =

Repolarization abnormalities increase chances of ventricular arrhythmias.

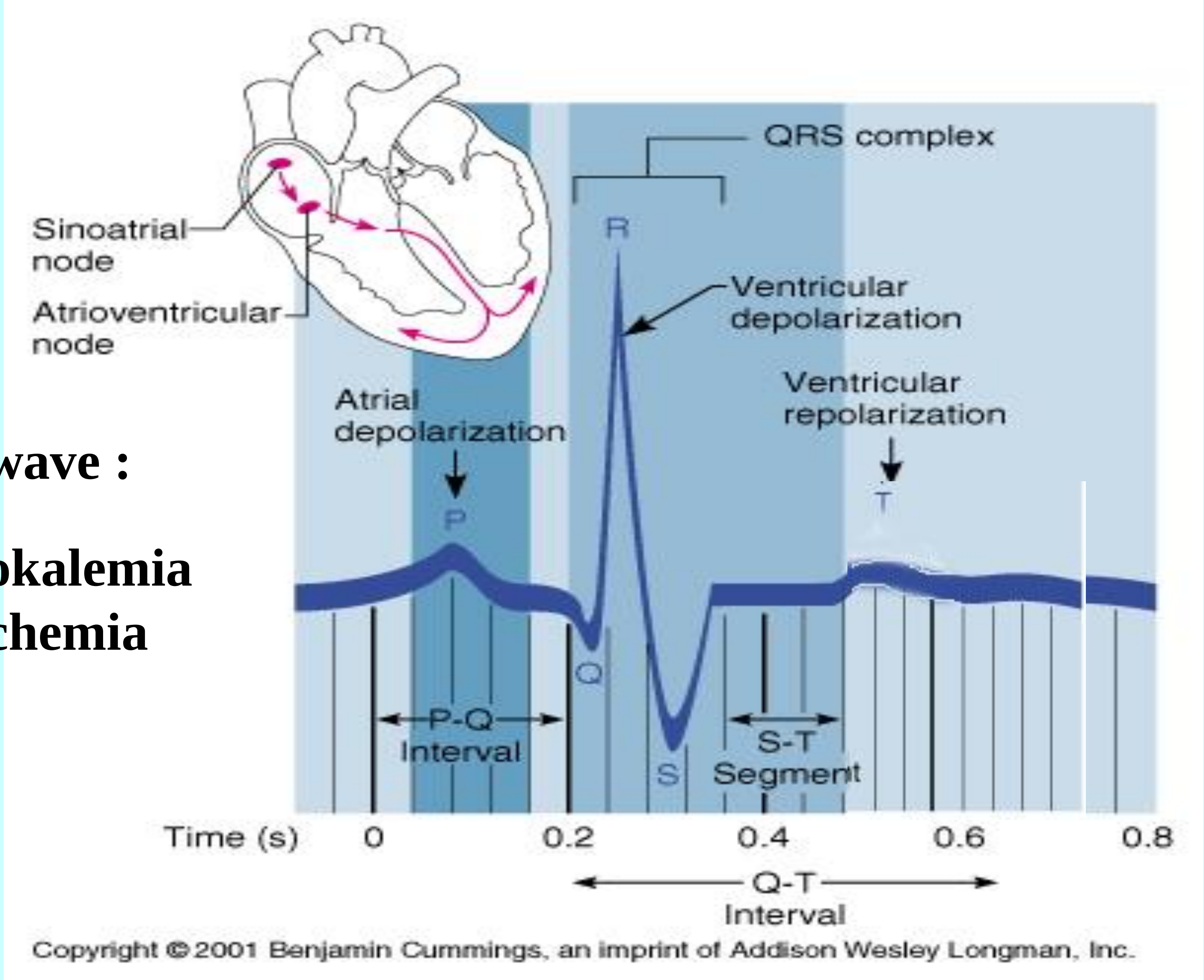
ECG Deflection Wave Irregularities



Elevated T wave :

Hyperkalemia

ECG Deflection Wave Irregularities



Flat T wave :

Hypokalemia or ischemia

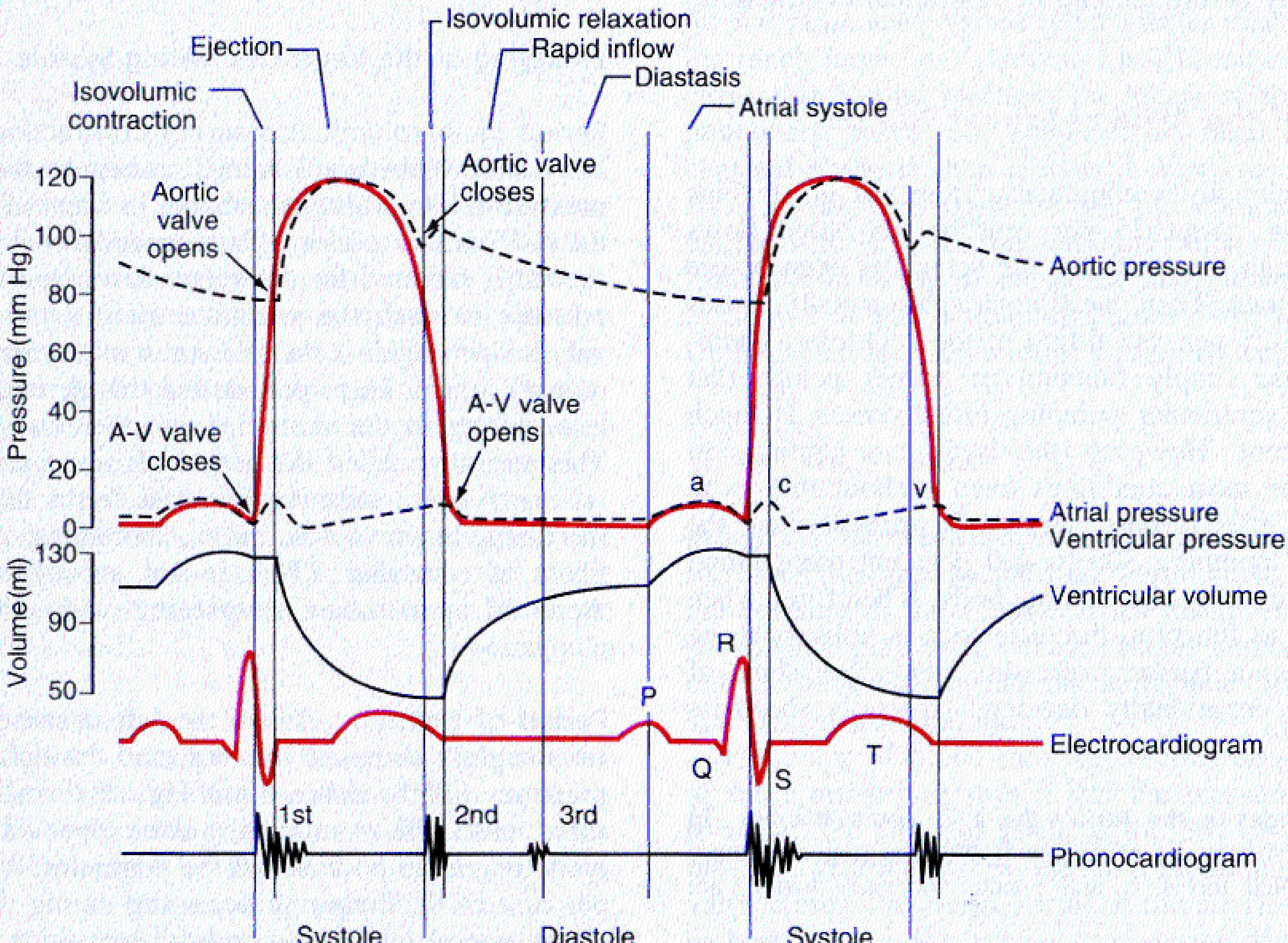


FIGURE 9–5

Events of the cardiac cycle for left ventricular function, showing changes in left atrial pressure, left ventricular pressure, aortic pressure, ventricular volume, the electrocardiogram, and the phonocardiogram.

Frank Starling Law of the Heart

- The more cardiac muscle is stretched within physiological limits, the more forcibly it will contract.
- Increasing volumes of blood in ventricles increase the stretch & thus the force generated by ventricular wall contraction.
- Greater stretch means more blood volume is pumped out, up to physical limits.

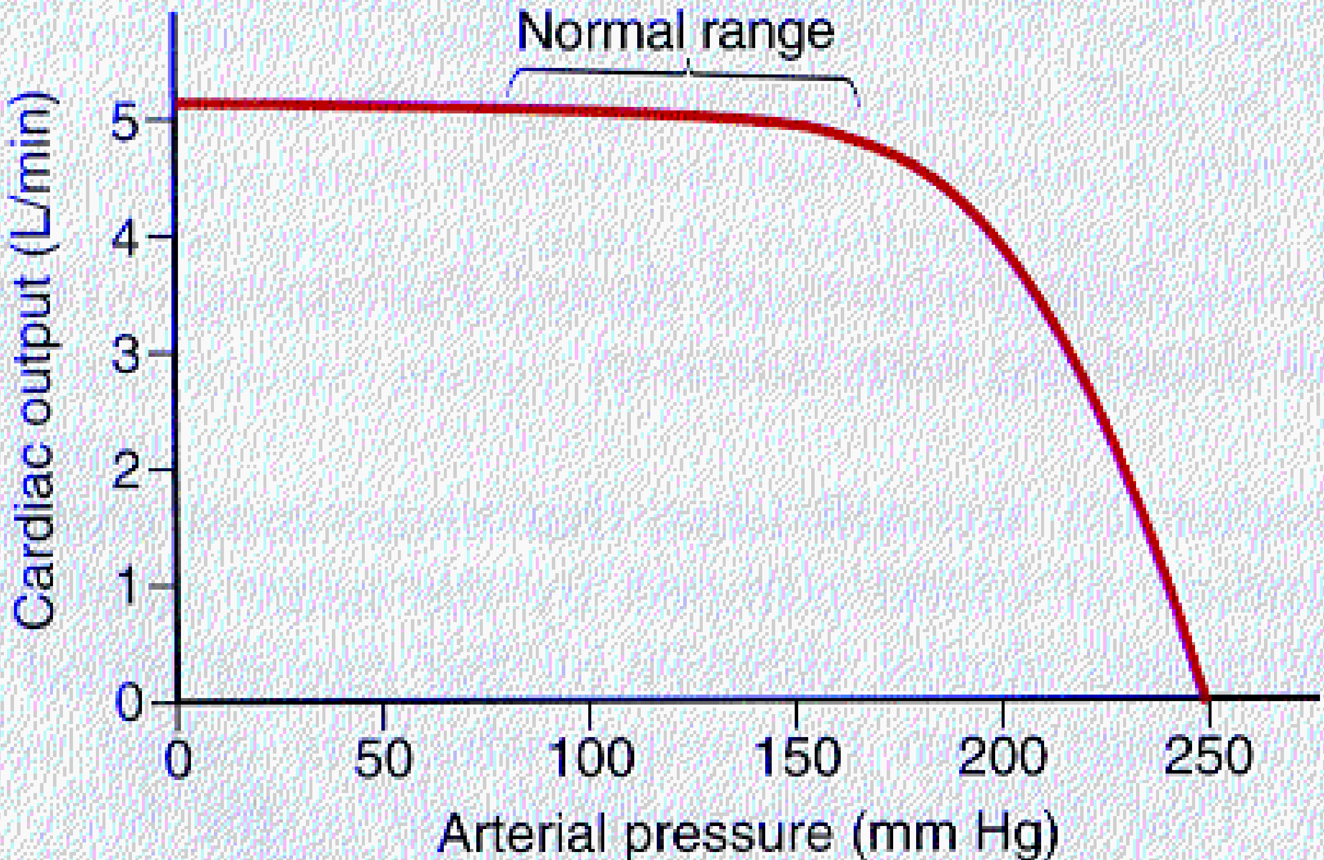


FIGURE 9–8

Constancy of cardiac output (even in the presence of extensive changes in arterial pressure) up to a pressure level of 160 mm Hg. Only when the arterial pressure rises above the normal operating range does the pressure load cause the cardiac output to fall.

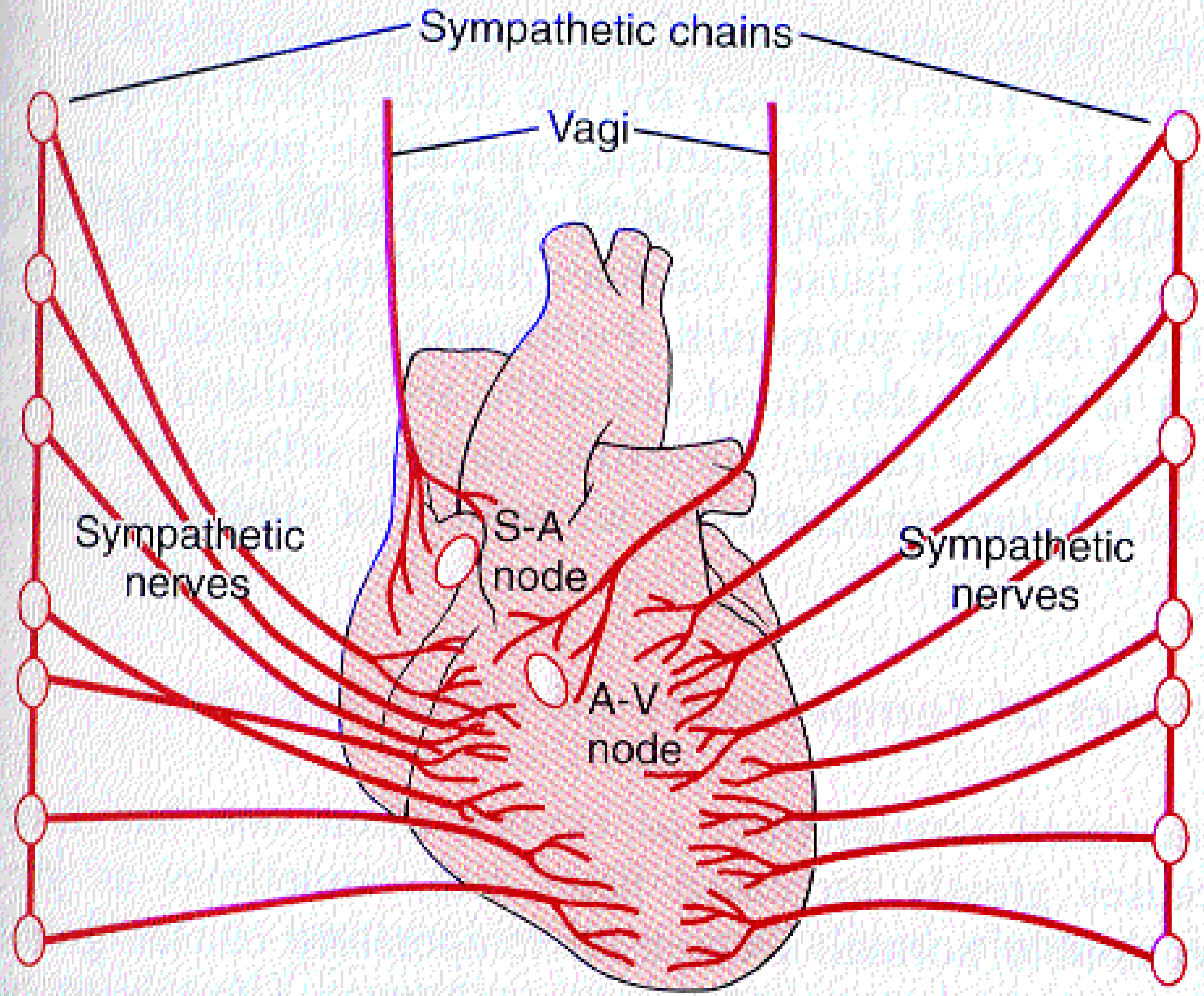
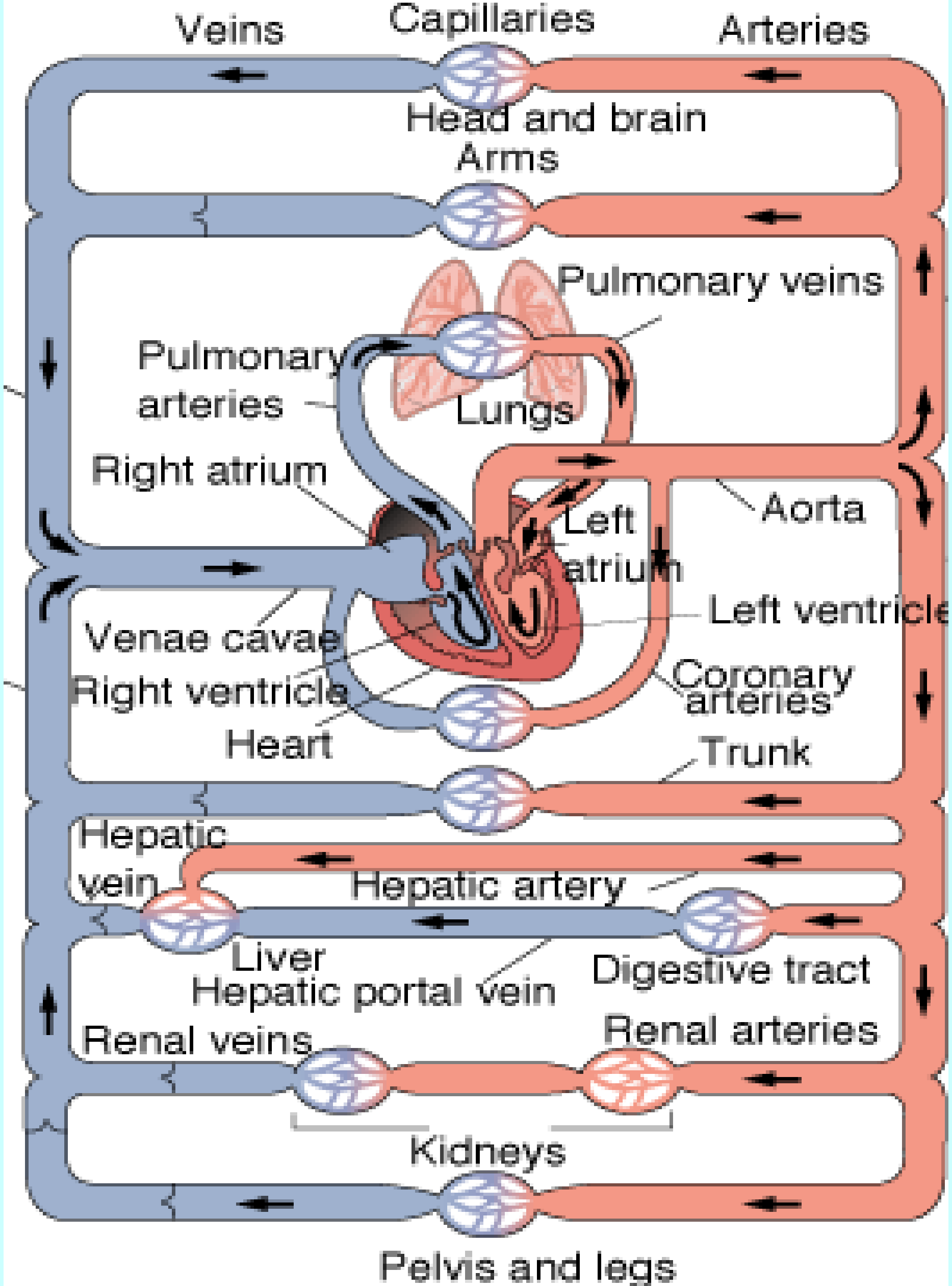
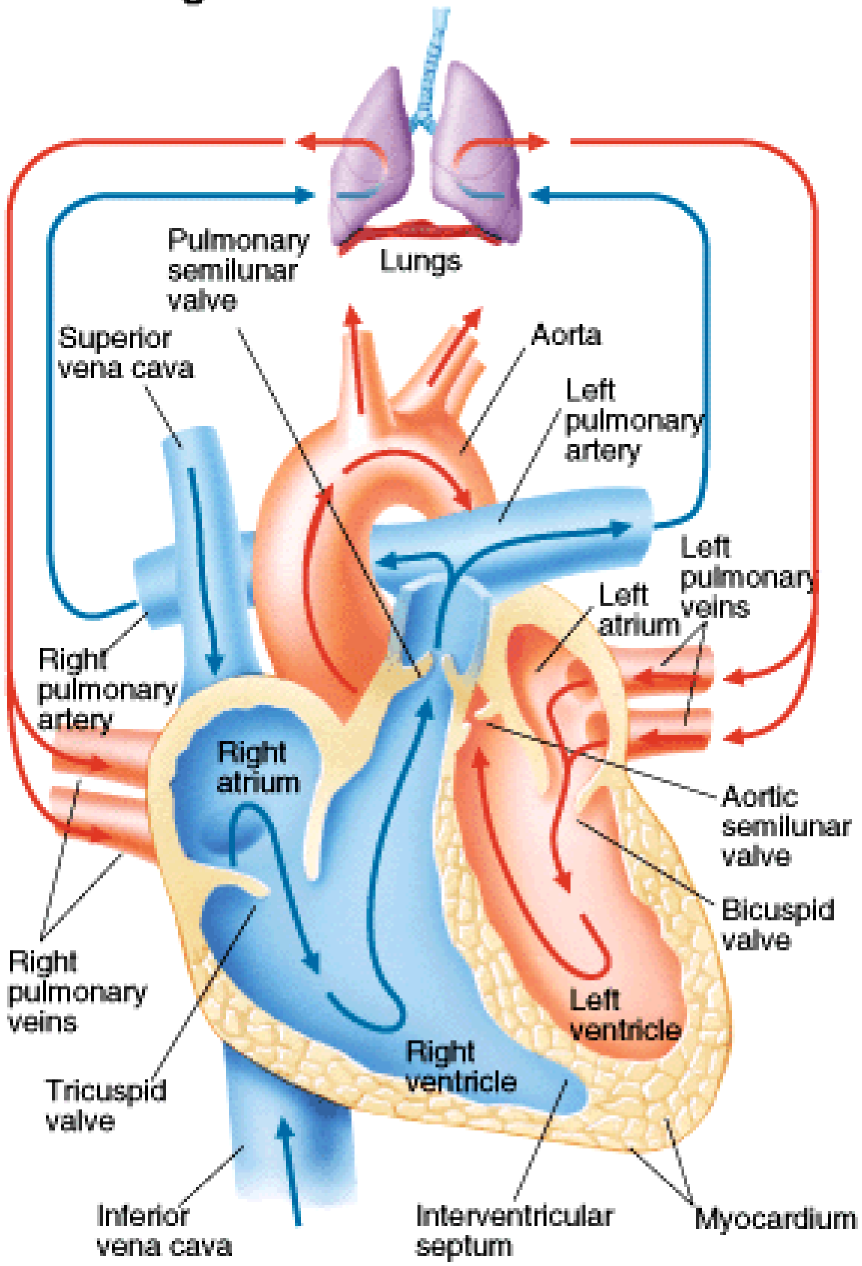


FIGURE 9–11

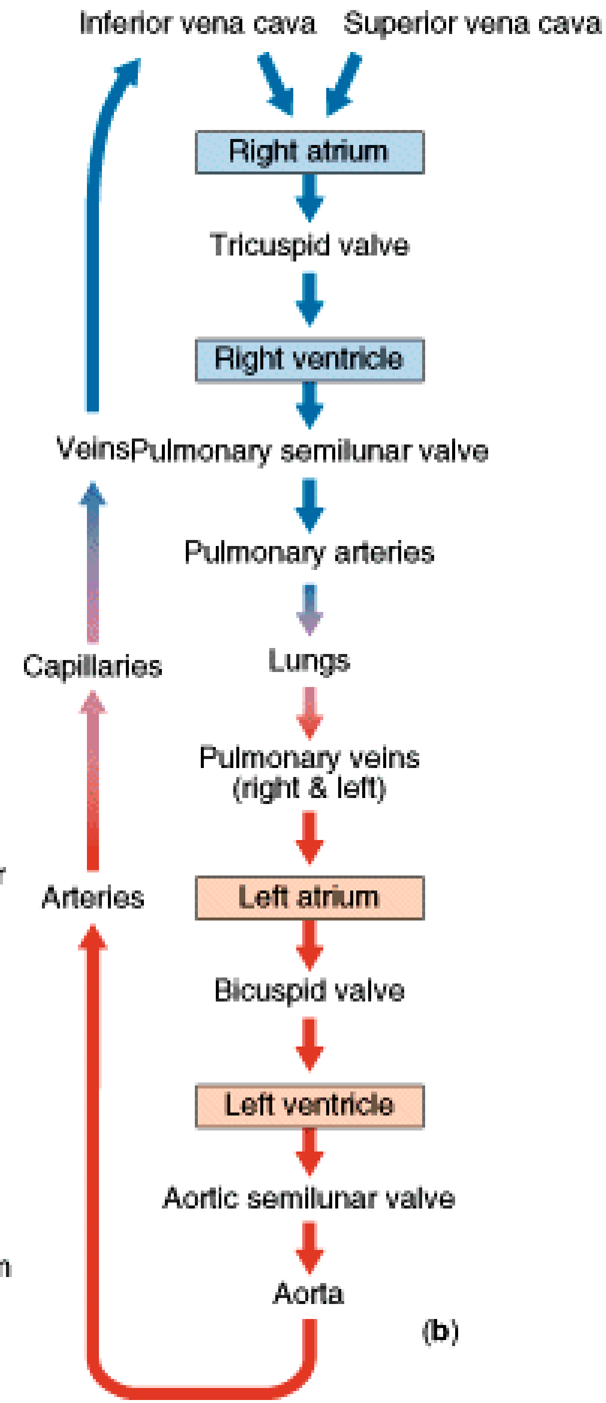
Cardiac nerves. (The vagus nerves to the heart are *parasympathetic nerves.*)


Veins
Capillaries
Arteries
Head and brain
Arms
Pulmonary veins
Pulmonary arteries
Lungs
Right atrium
Aorta
Left atrium
Left ventricle
Venae cavae
Right ventricle
Coronary arteries
Heart
Trunk
Hepatic vein
Hepatic artery
Liver
Hepatic portal vein
Digestive tract
Renal veins
Renal arteries
Kidneys
Pelvis and legs

▶ Blood Flow Through the Heart

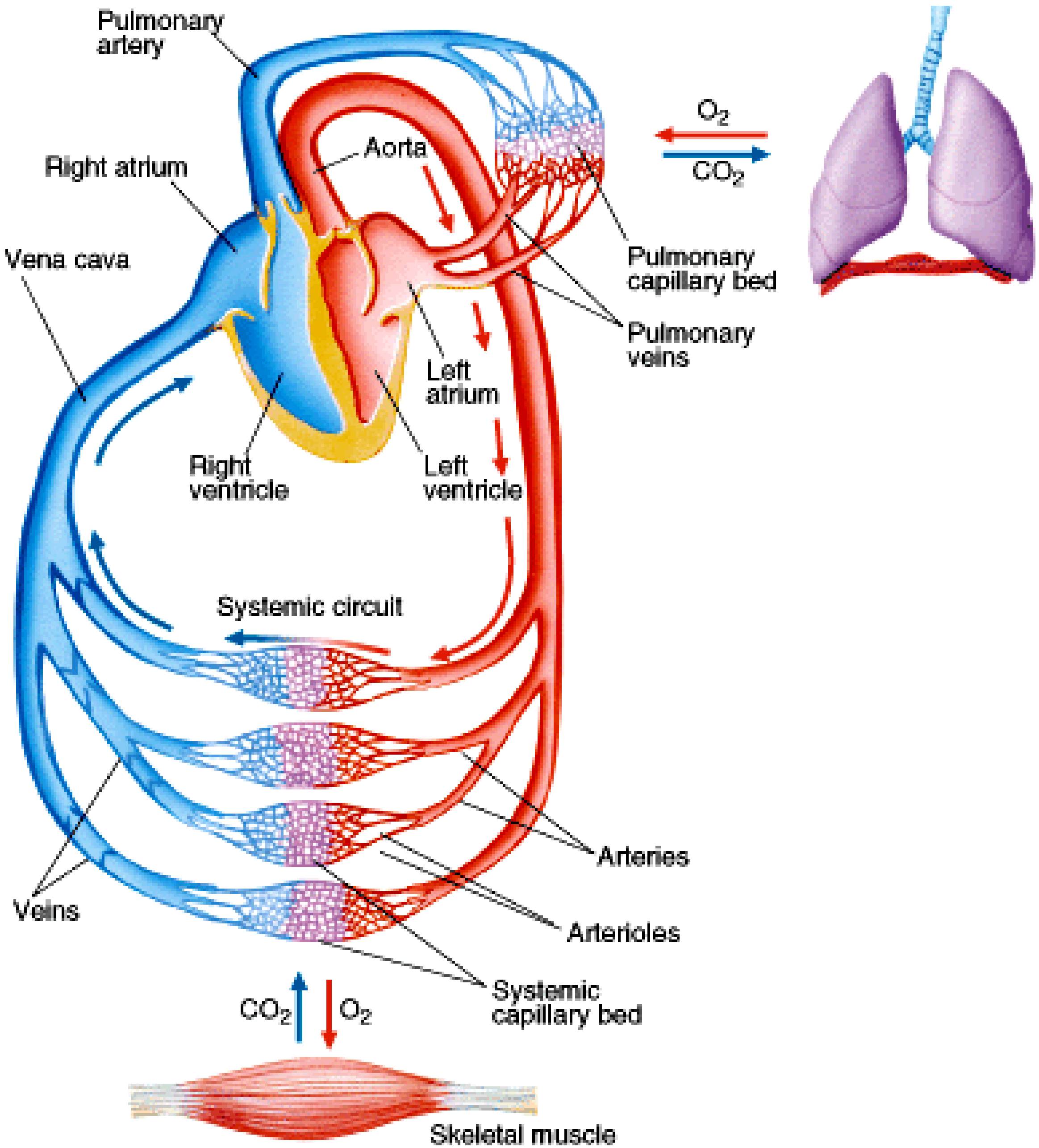


(a)

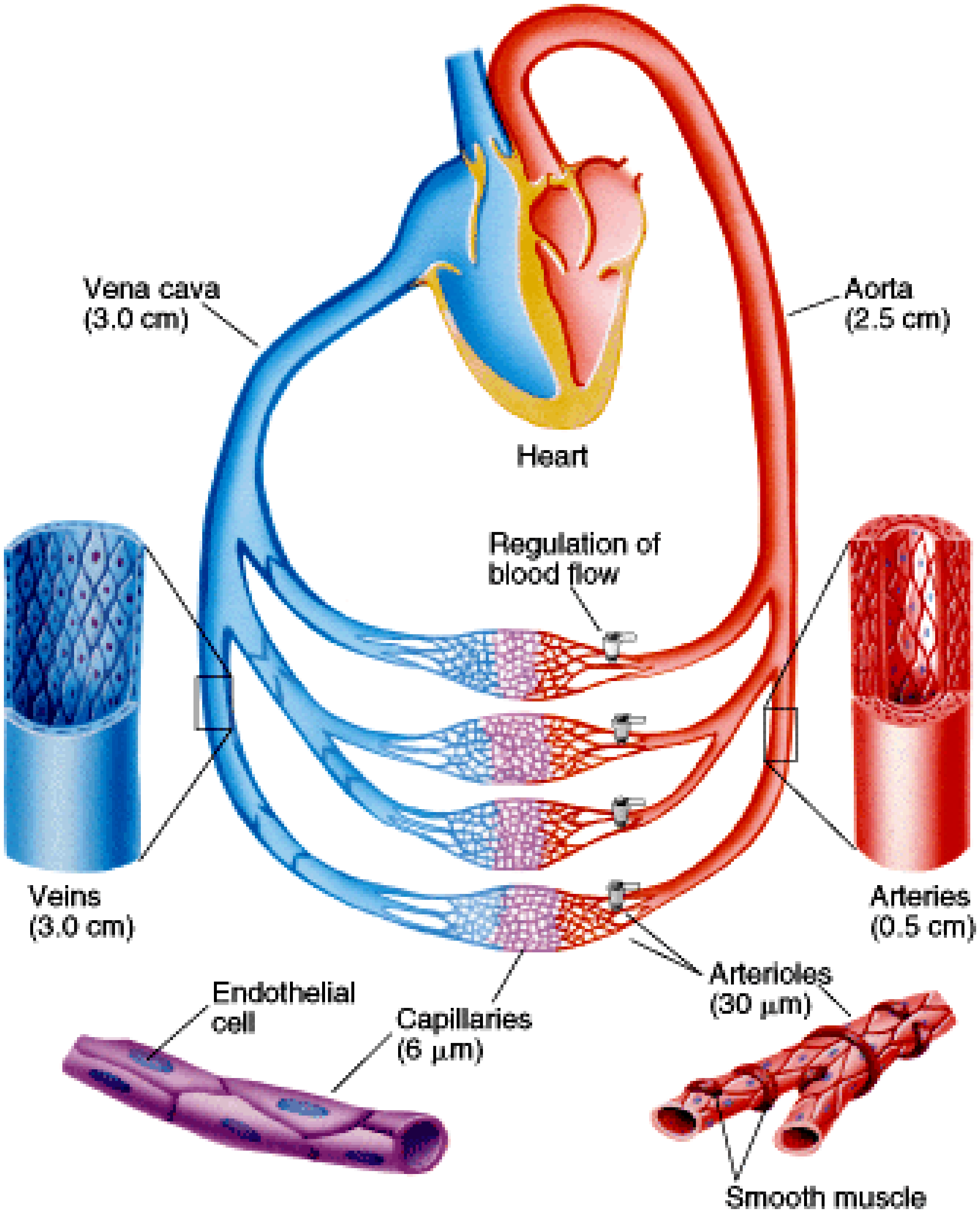


(b)

▶ Overview of the Cardiovascular System



► Vascular System



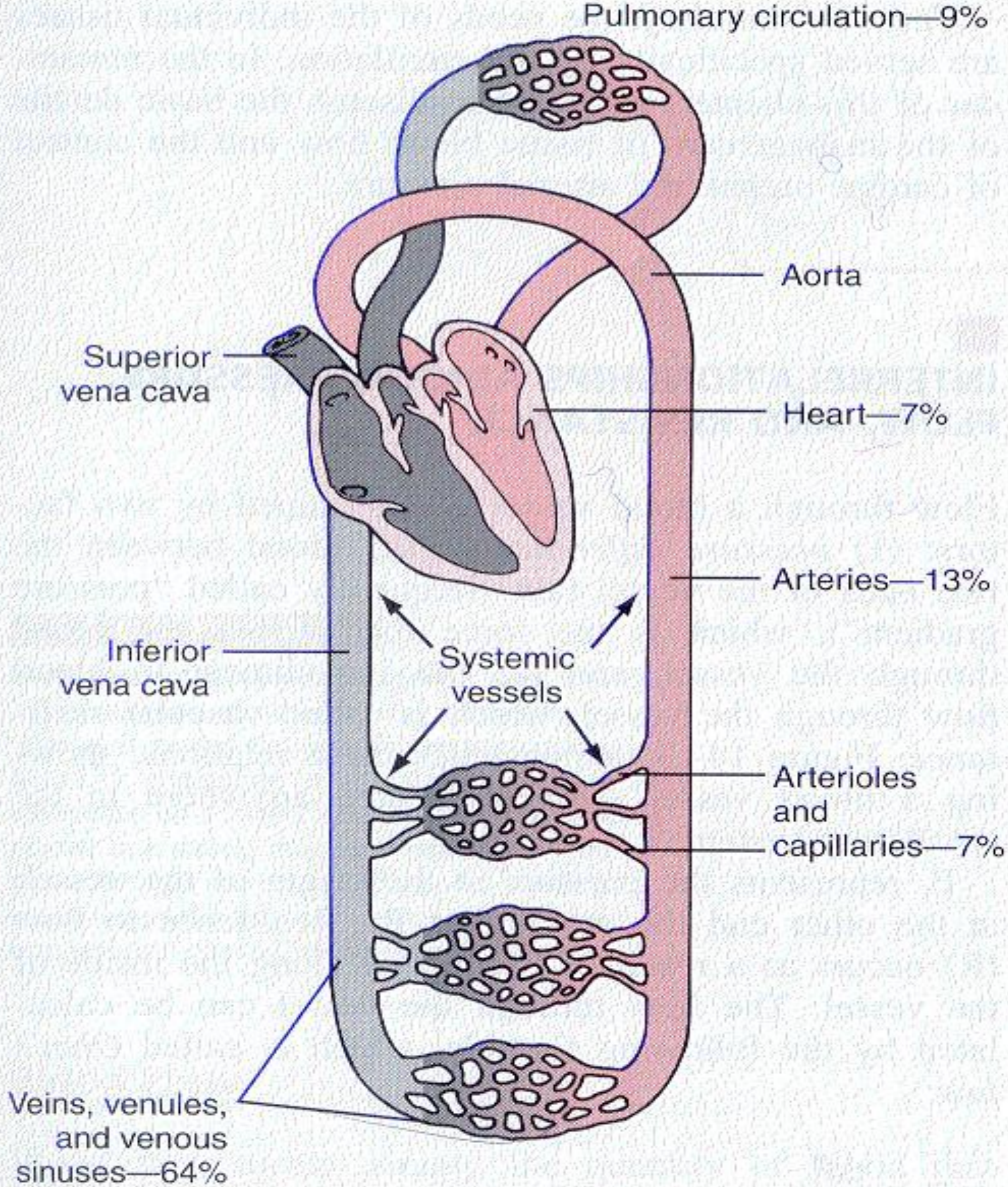


FIGURE 14–1

Distribution of blood (in percentage of total blood) in the different parts of the circulatory system.

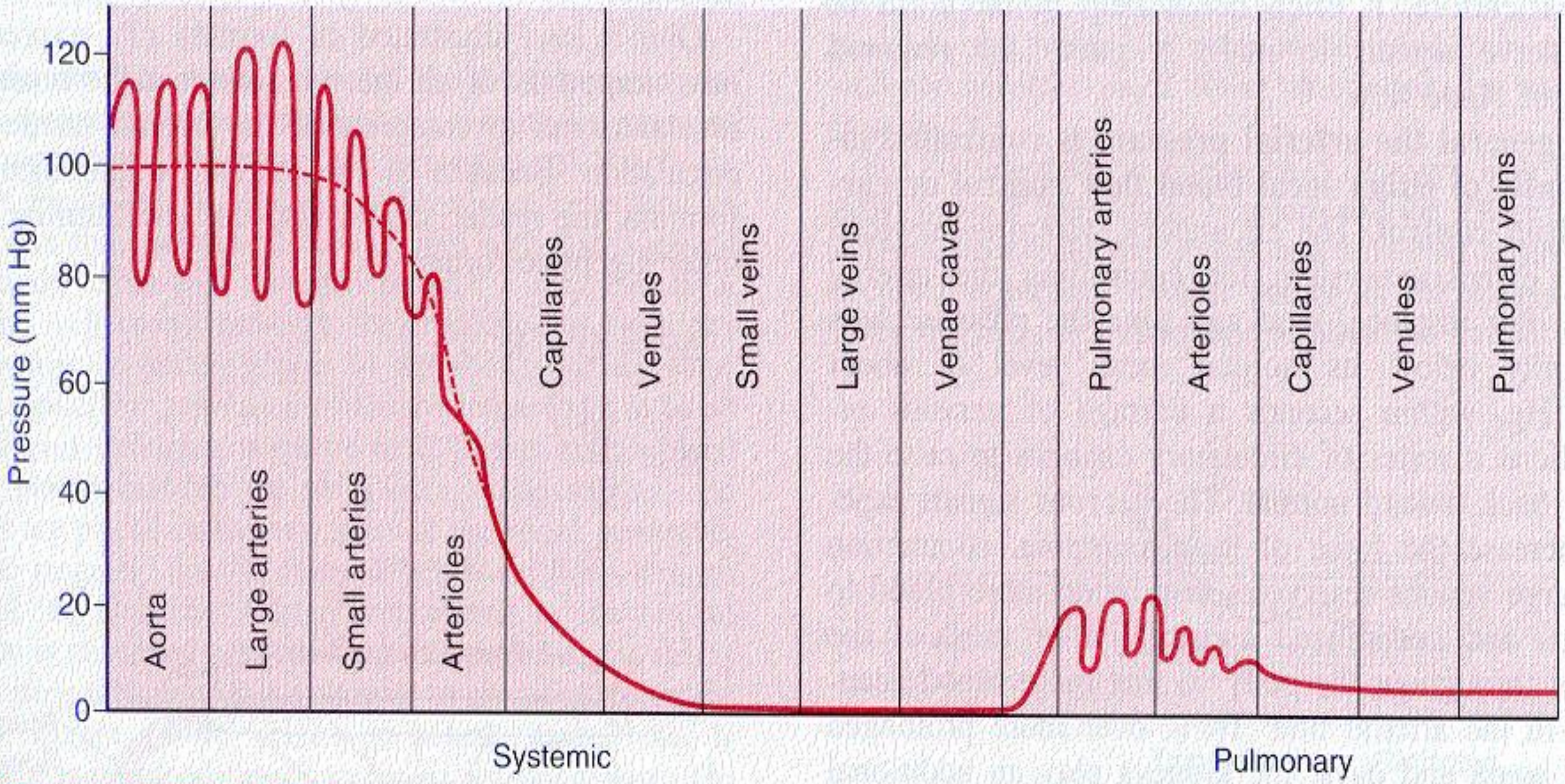
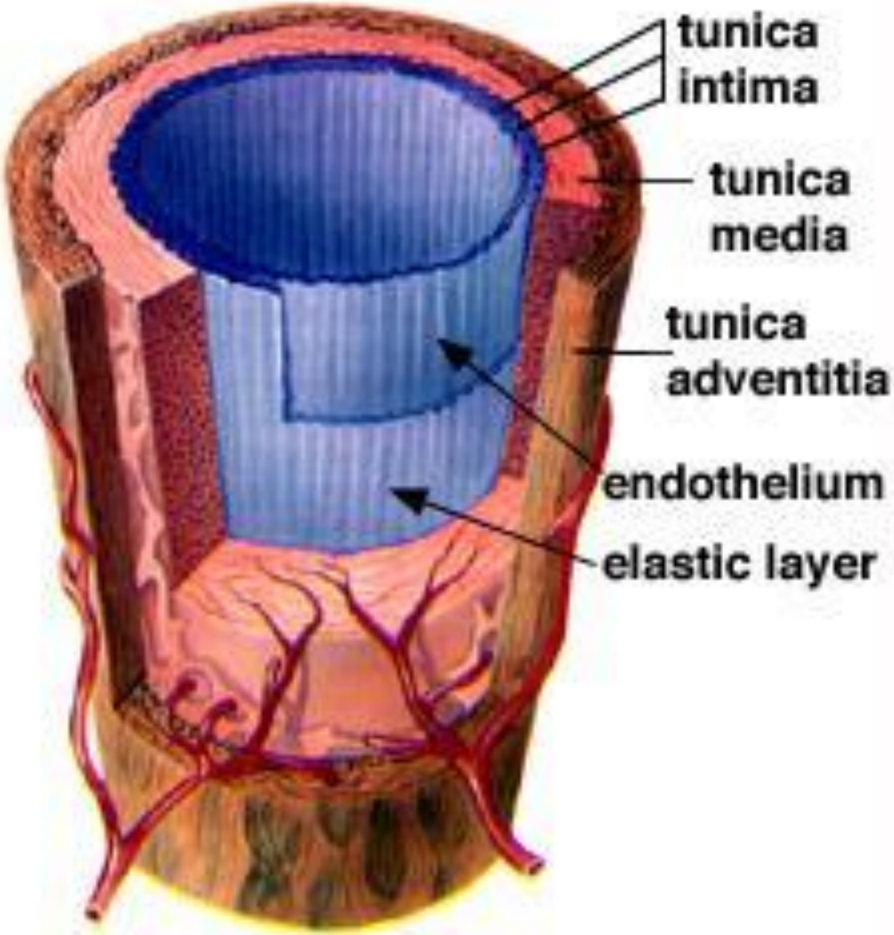
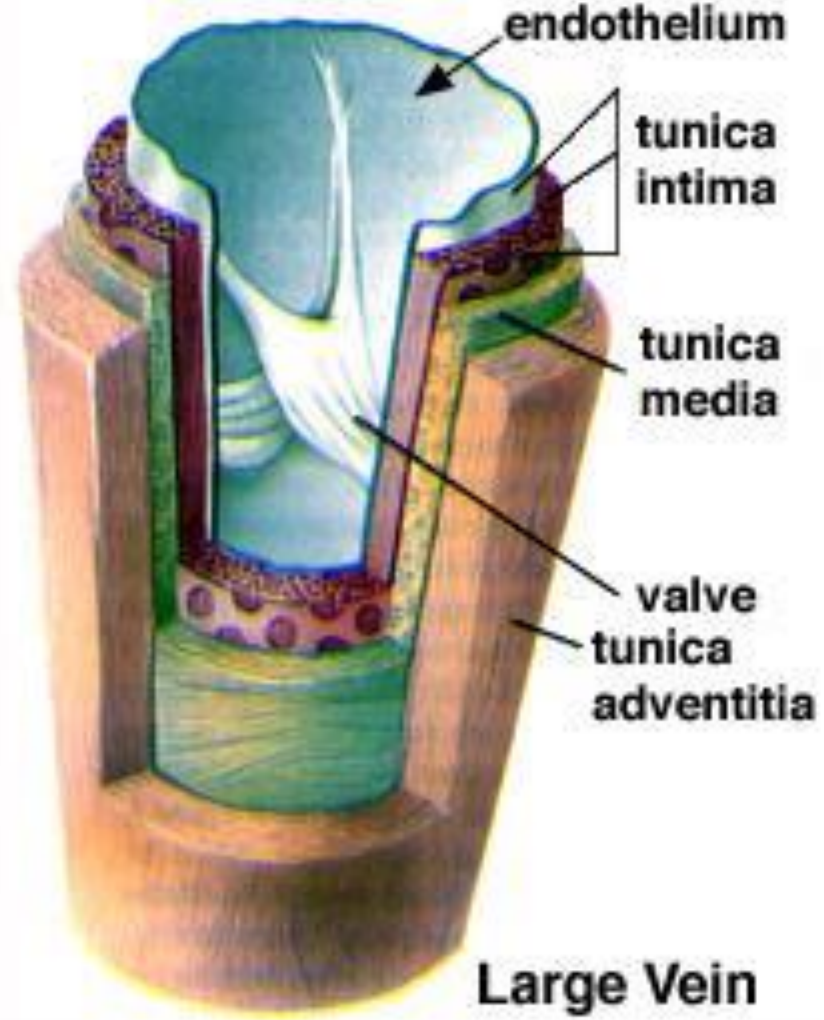


FIGURE 14–2

Normal blood pressures in the different portions of the circulatory system when a person is lying in the horizontal position.



Muscular Artery



Large Vein

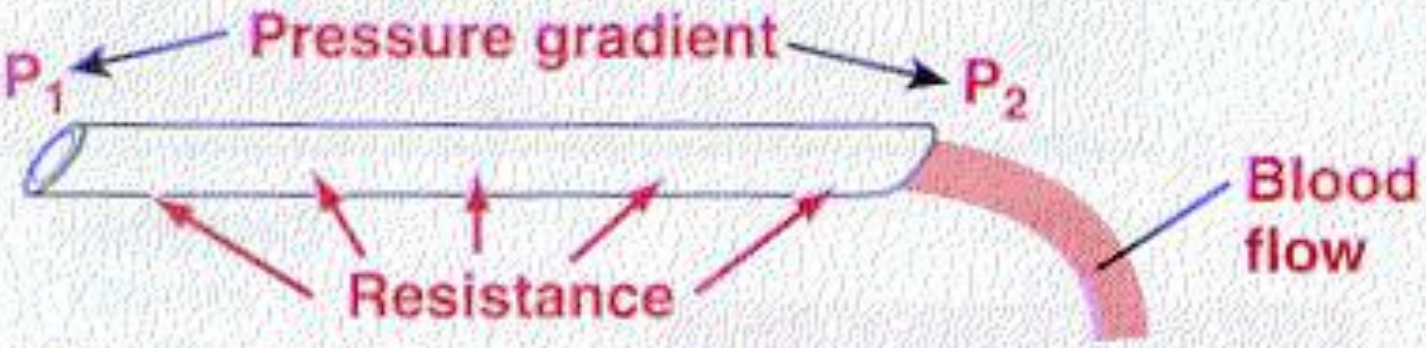


FIGURE 14-3

Relations among pressure, resistance, and blood flow.

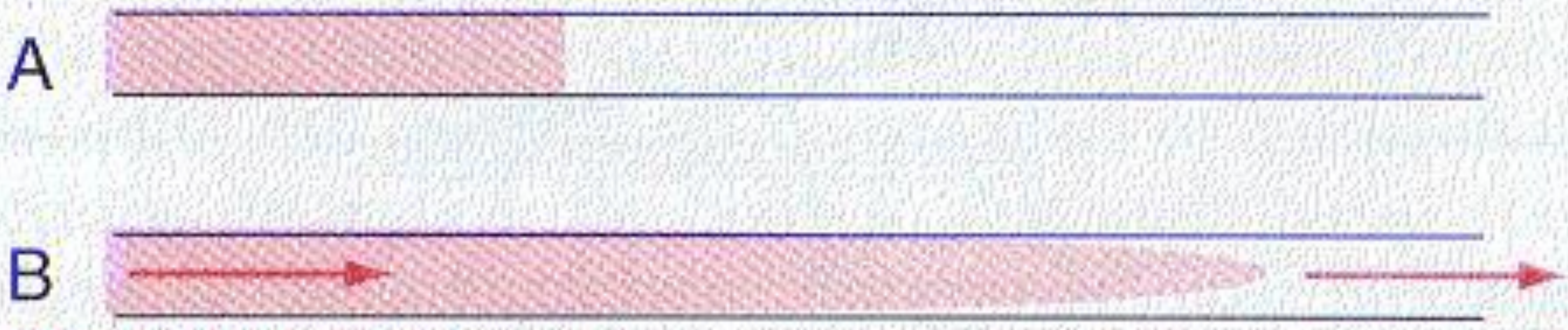
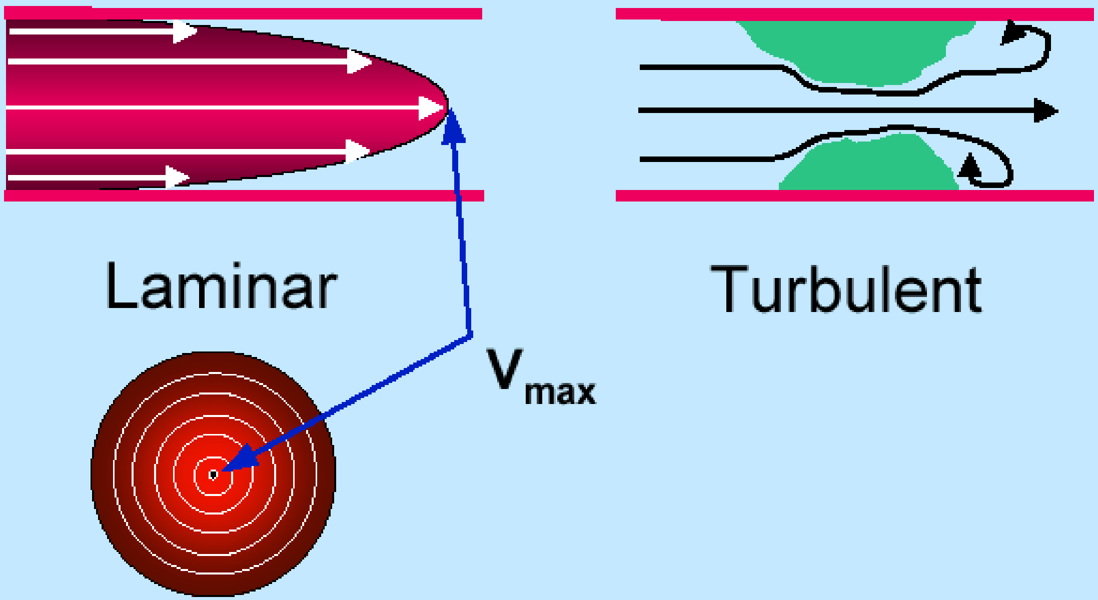
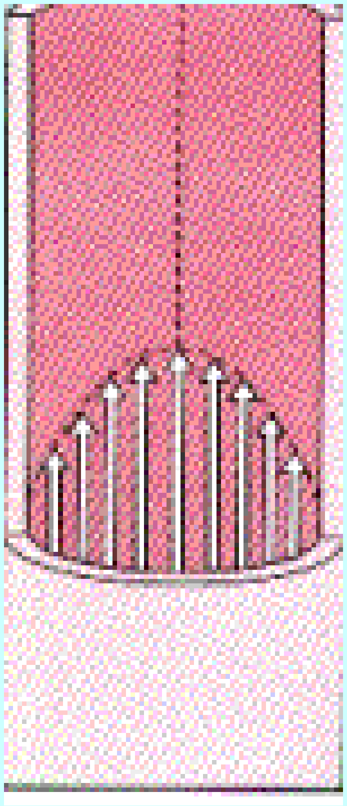


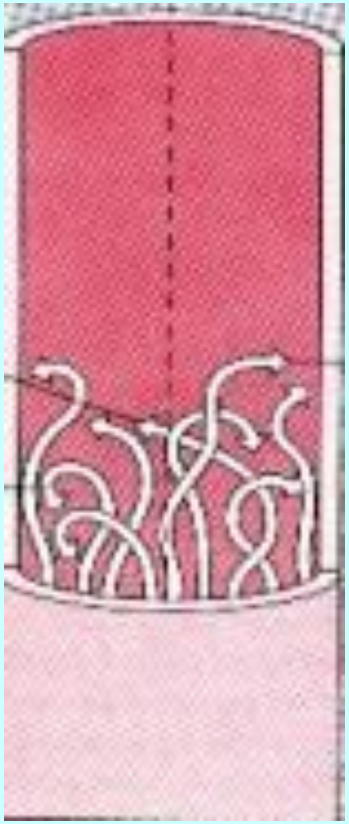
FIGURE 14-6

Experiment demonstrating parabolic blood flow with much faster flow in the center of a vessel. *A*, Two fluids (shaded and unshaded) before flow begins; *B*, the same fluids 1 second after flow begins.

Laminar vs. Turbulent Flow







$$Nr = pDv / n$$

laminar = 2000 or less

p = Density

D = Diameter

v = Velocity

n = Viscosity

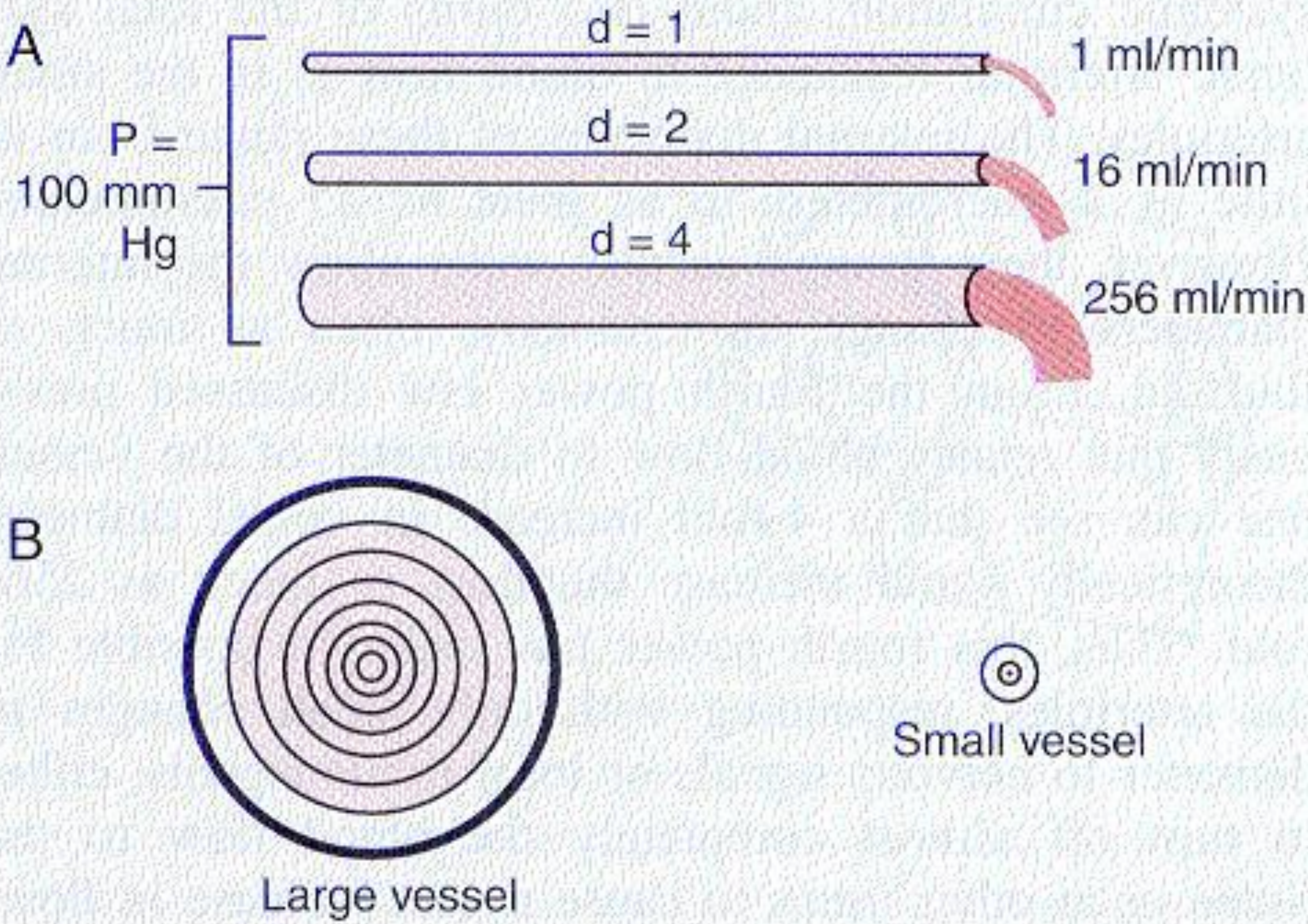


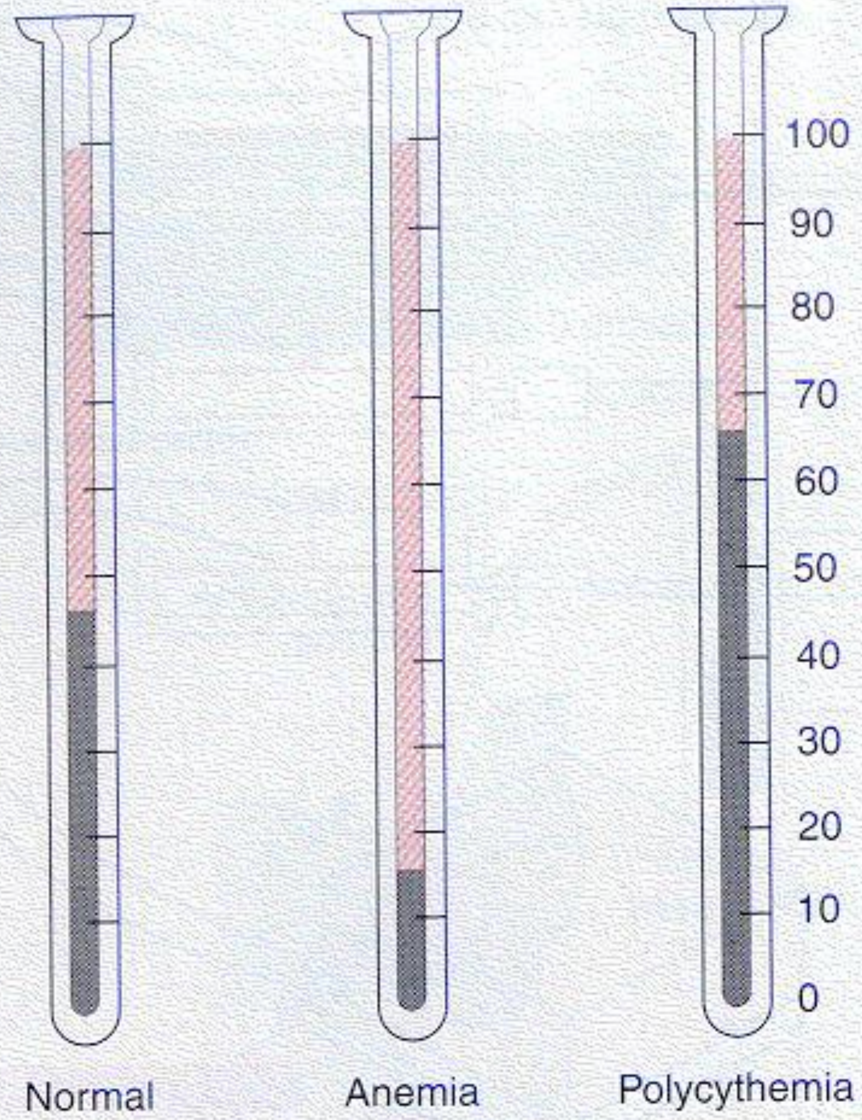
FIGURE 14-9

A, Demonstration of the effect of vessel diameter on blood flow. *B*, Concentric rings of blood flowing at different velocities; the farther away from the vessel wall, the faster the flow.

Pressure, Flow, and Resistance *cont.*

Poiseuille's Equation

$$R \propto \frac{\eta \, L}{r^4} \qquad \textit{therefore} \qquad F \propto \frac{\Delta P \; r^4}{\eta \, L}$$



IGURE 14–10

ematocrits in a healthy (normal) person and in patients with anemia
d polycythemia.

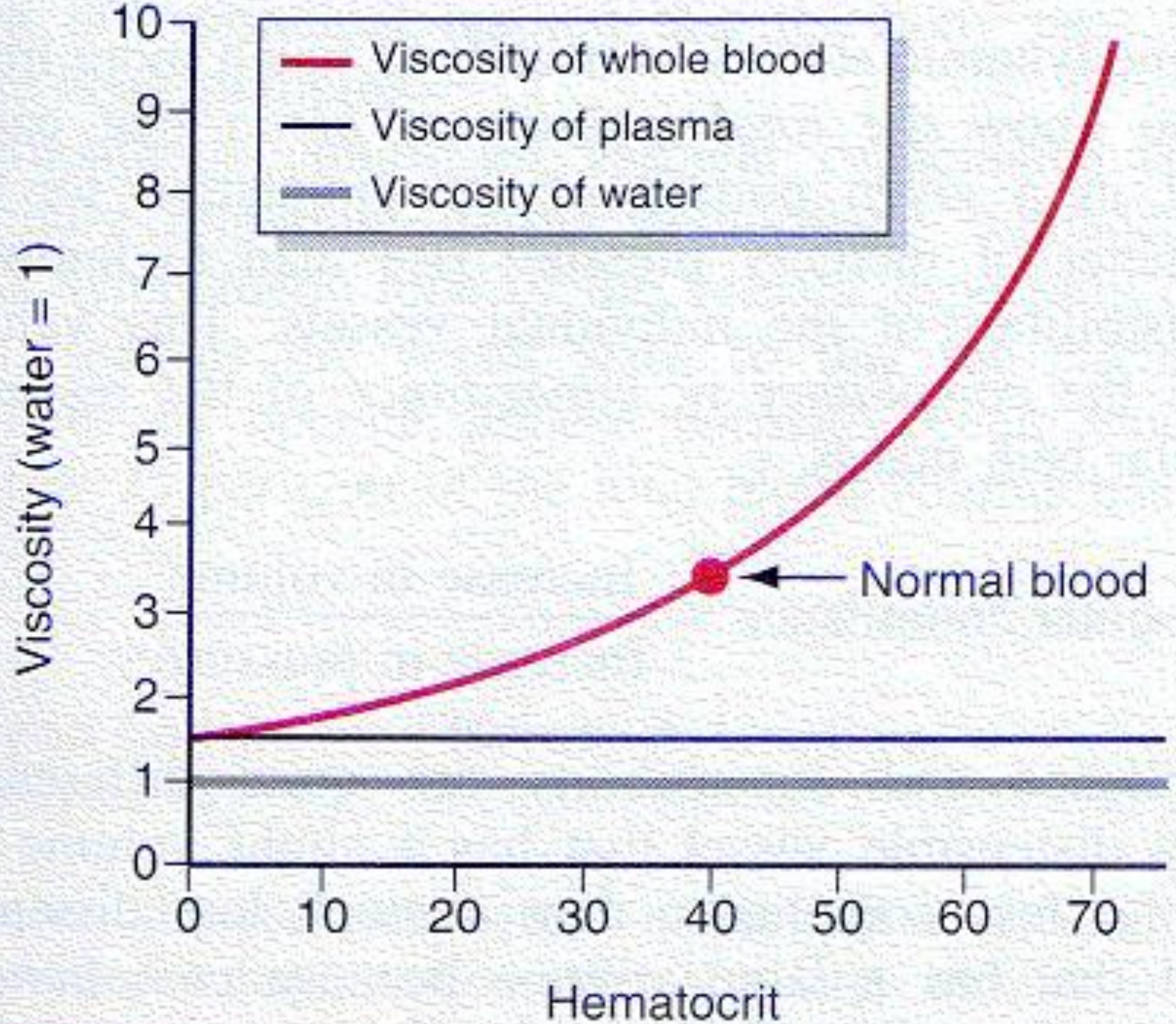


FIGURE 14–11

Effect of hematocrit on blood viscosity. (Water viscosity = 1.)

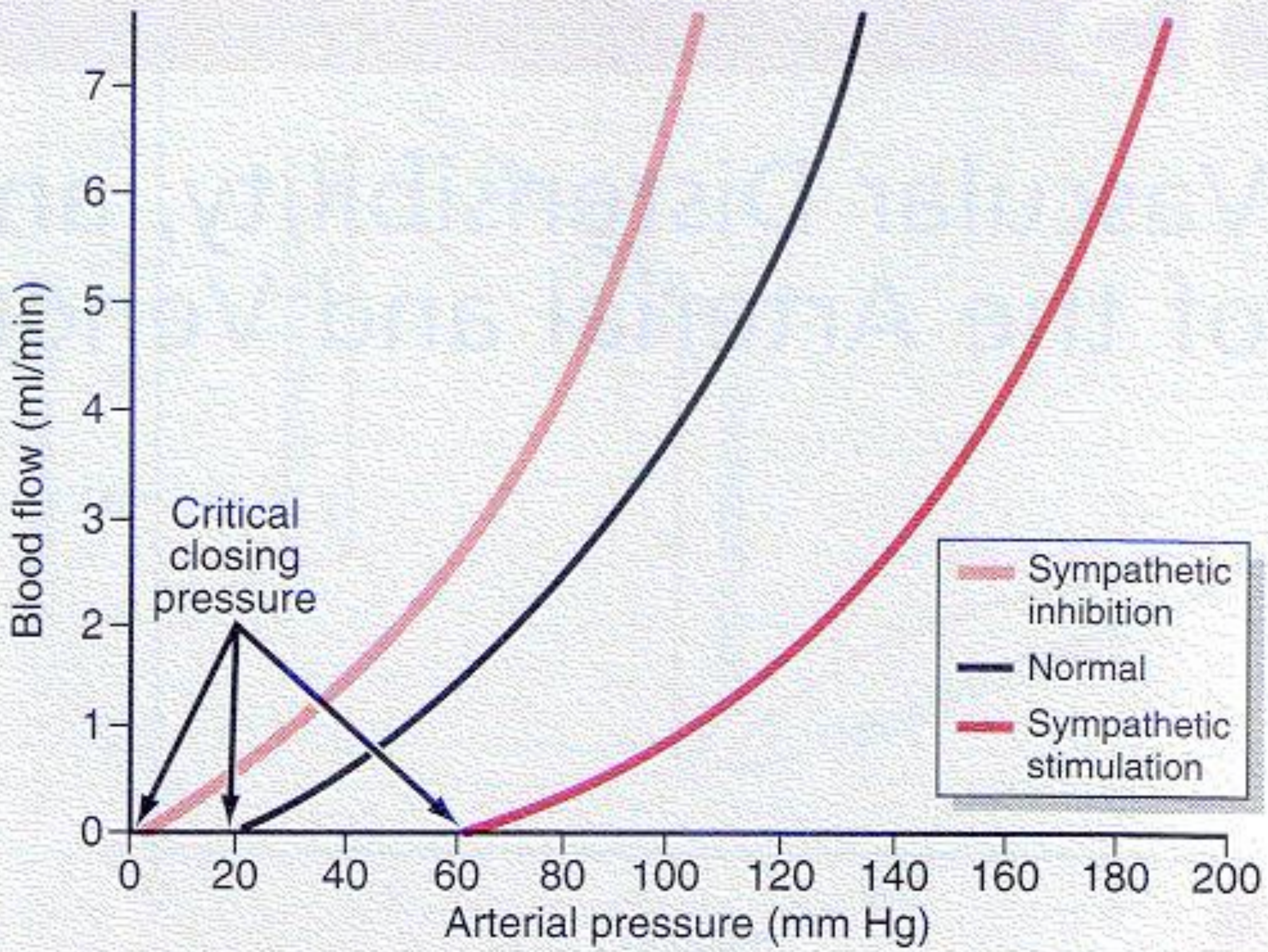


FIGURE 14-12

Effect of arterial pressure on blood flow through a blood vessel at different degrees of vascular tone caused by increased or decreased sympathetic stimulation of the vessel.

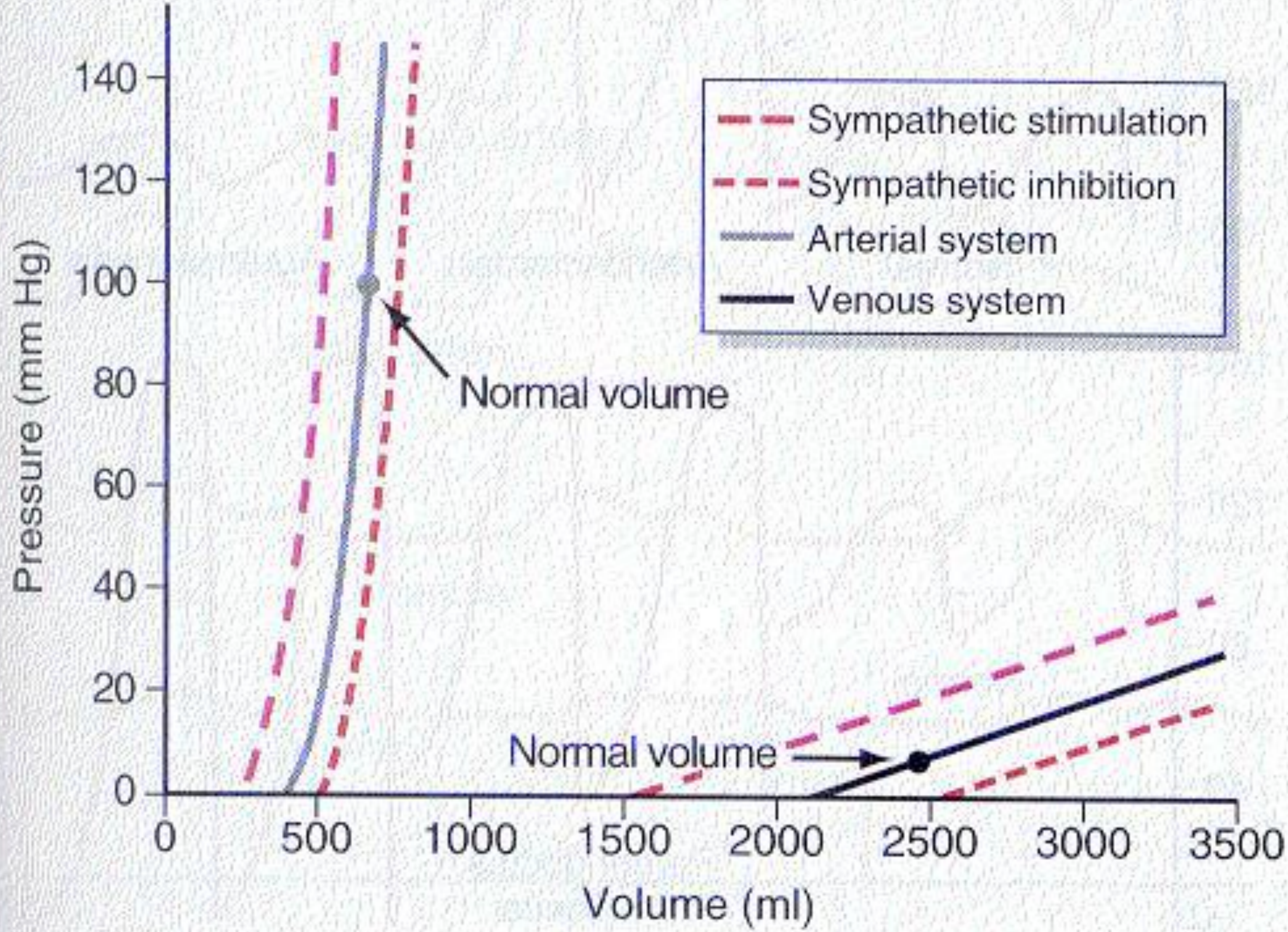


FIGURE 15–1

Volume-pressure curves of the systemic arterial and venous systems, showing also the effects of sympathetic stimulation and sympathetic inhibition.

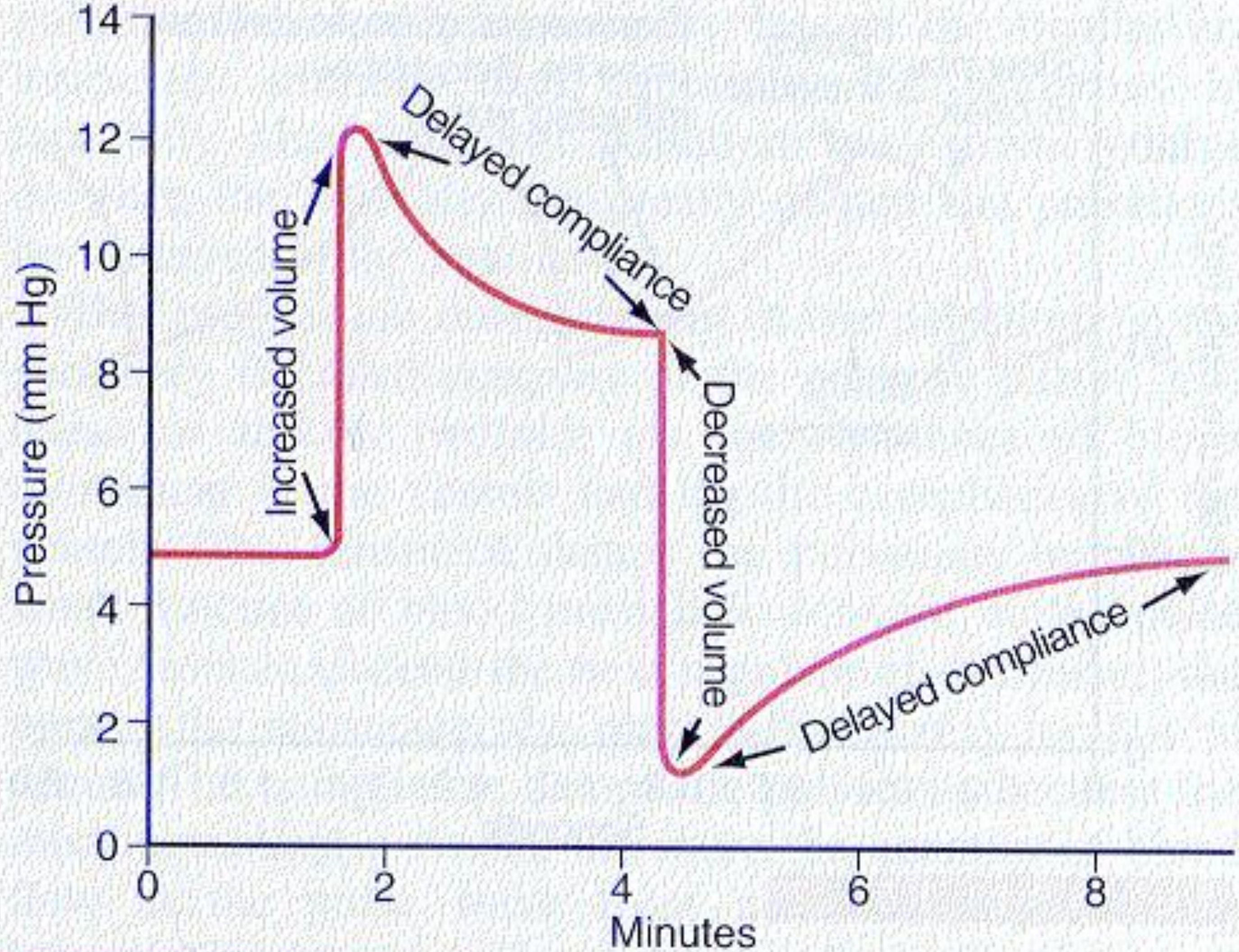


Figure 15-2

Effect on the intravascular pressure of injecting a small volume of blood into a venous segment and a few minutes later removing the excess blood, demonstrating the principle of delayed compliance.

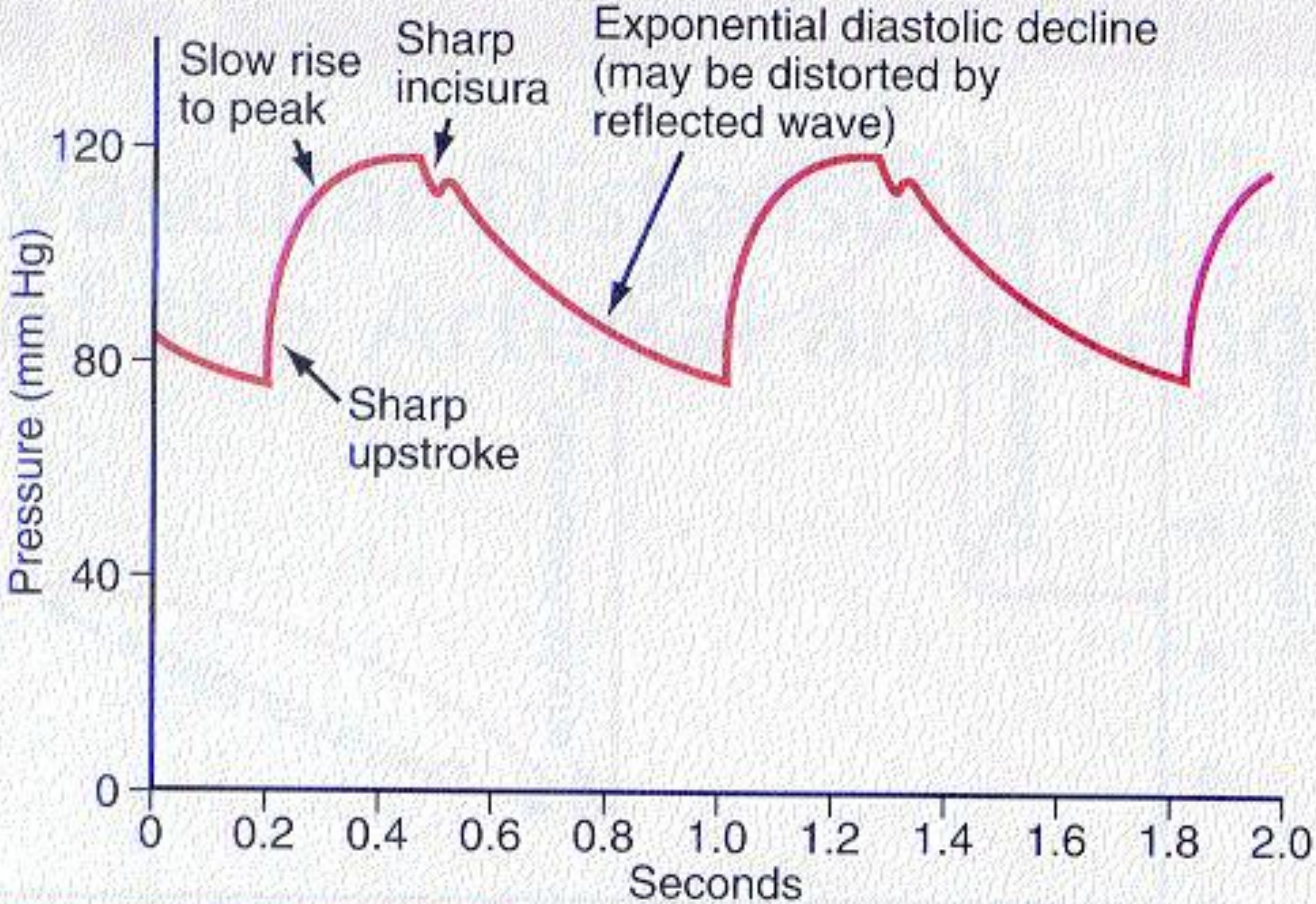


FIGURE 15-3

Pressure pulse contour recorded from the ascending aorta. (Redrawn from Opdyke DF: Fed Proc 11:734, 1952.)

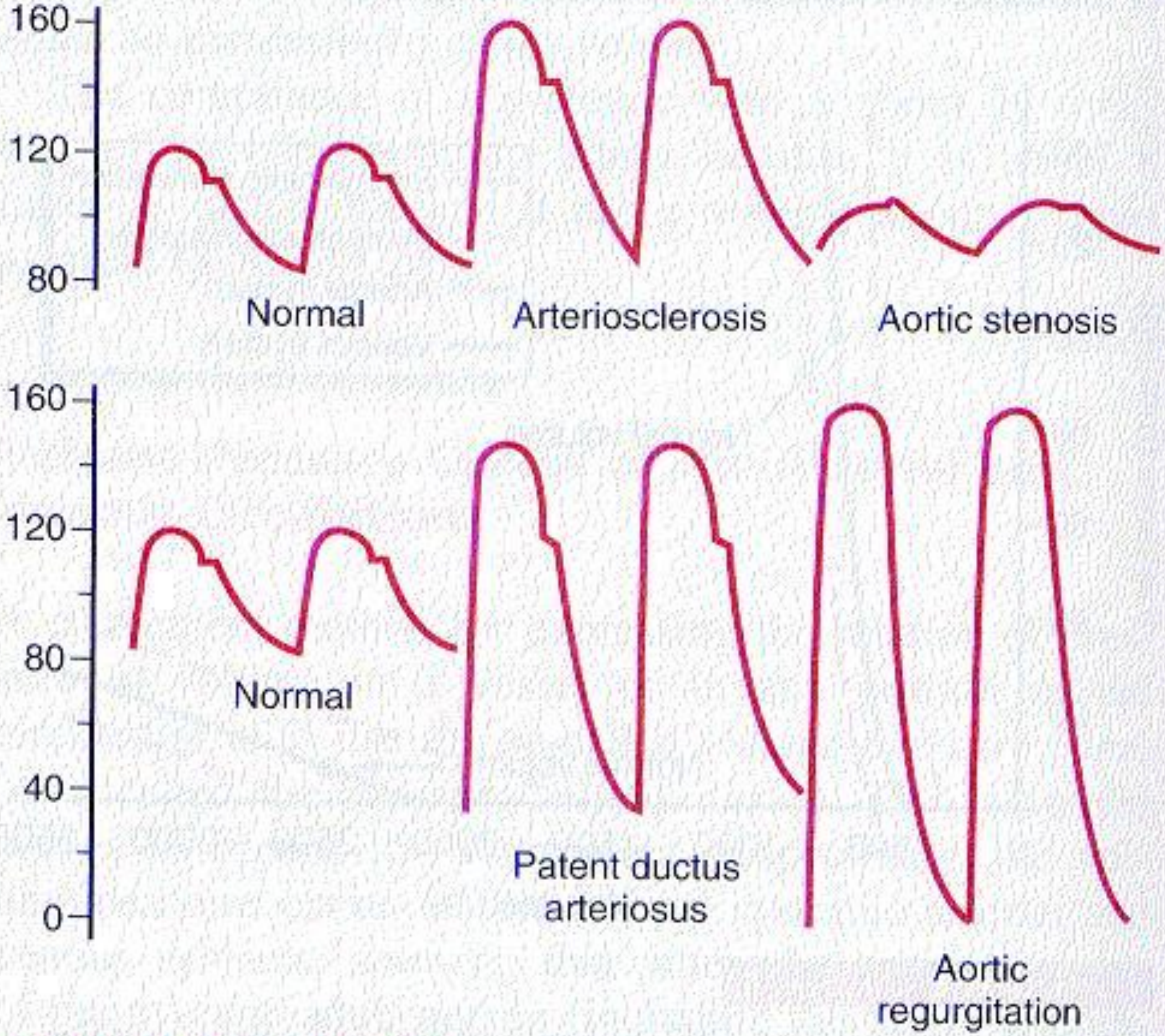


FIGURE 15–4

Aortic pressure pulse contours in arteriosclerosis, aortic stenosis, patent ductus arteriosus, and aortic regurgitation.

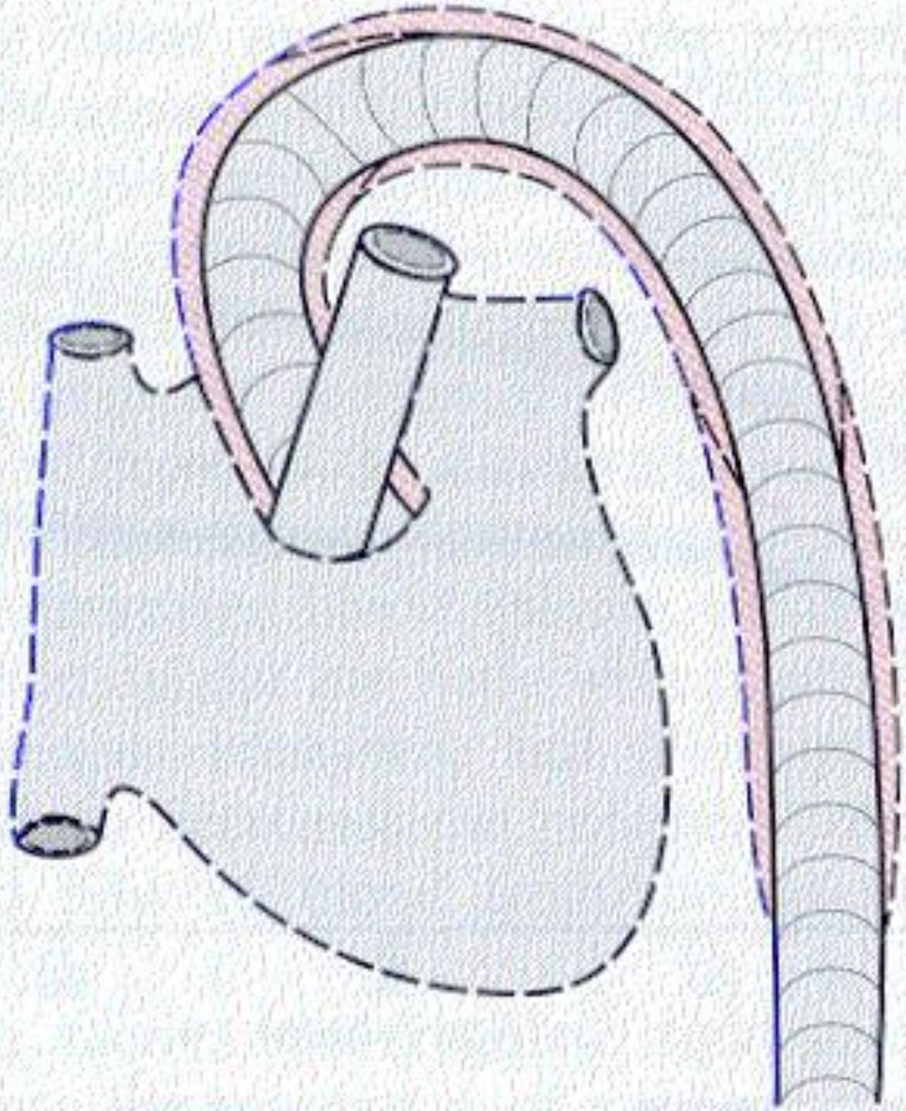


FIGURE 15–5

Progressive stages in the transmission of the pressure pulse along the aorta.

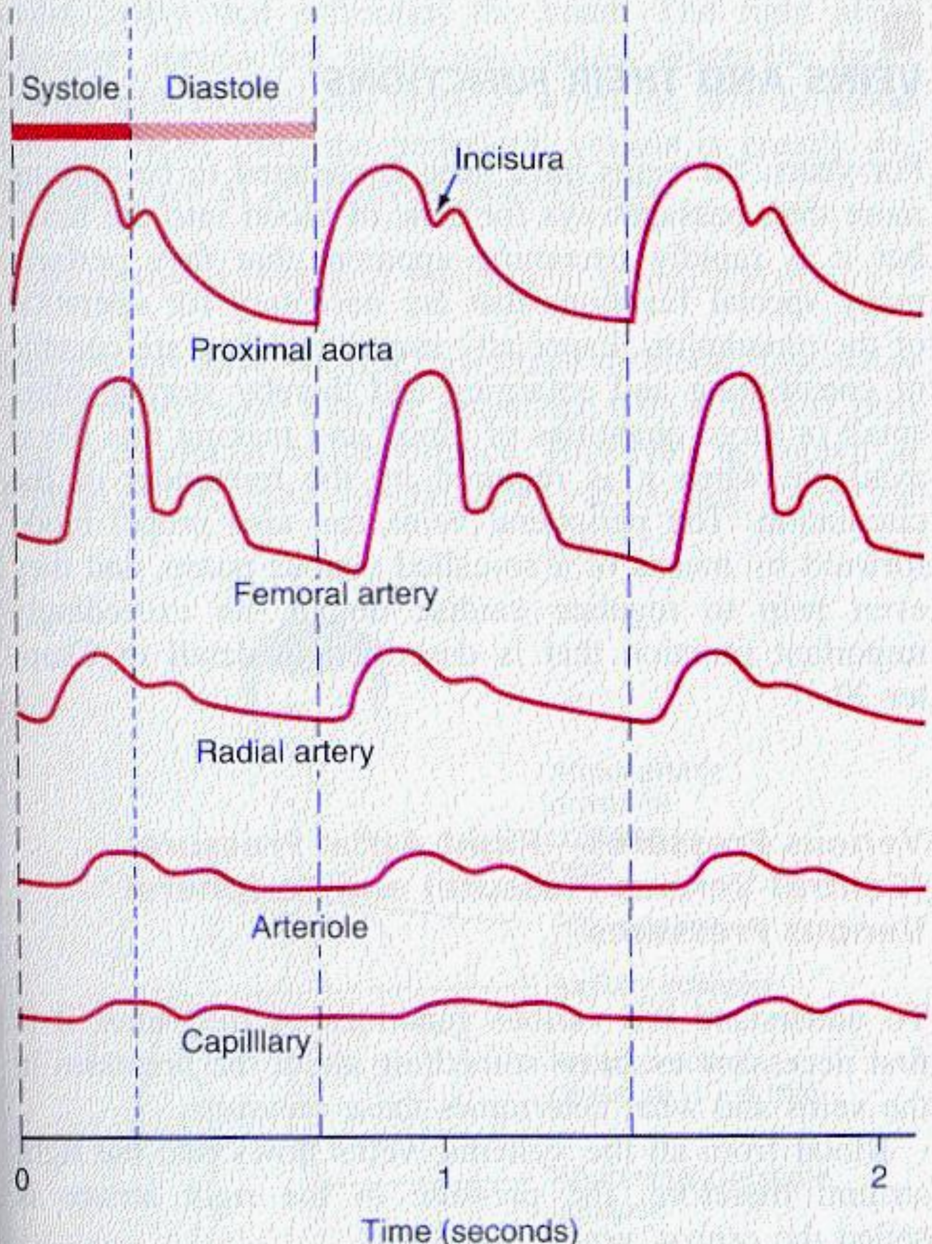
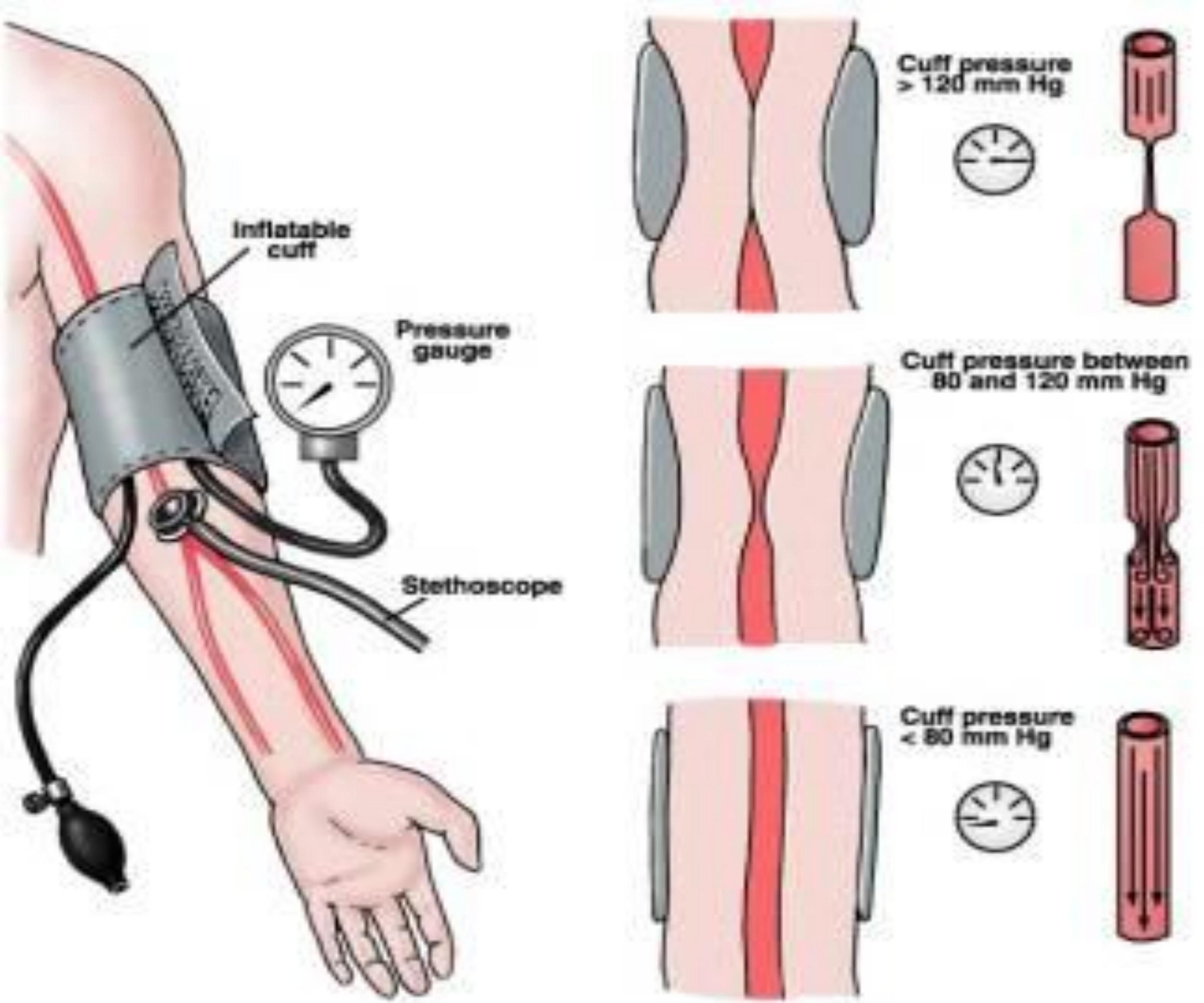


FIGURE 15 – 6

Changes in the pulse pressure contour as the pulse wave travels toward the smaller vessels.


Sedona


SHARPER IMAGE
MEMORY RECALL
MODE
SET


Inflatable cuff
Pressure gauge
Stethoscope
Cuff pressure > 120 mm Hg
Cuff pressure between 80 and 120 mm Hg
Cuff pressure < 80 mm Hg

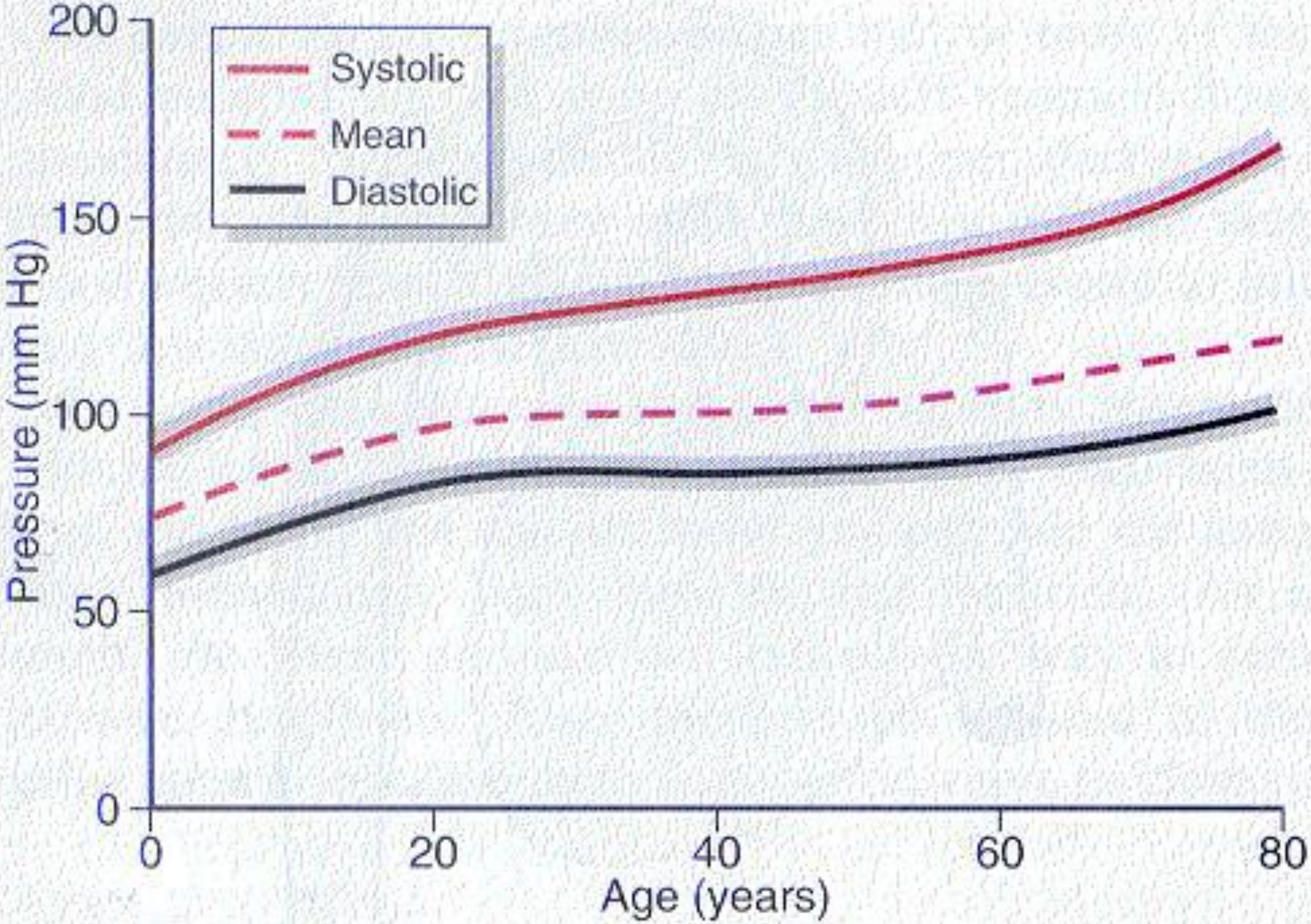


FIGURE 15-8

Changes in systolic, diastolic, and mean arterial pressures with age. The shaded areas show the approximate normal range.

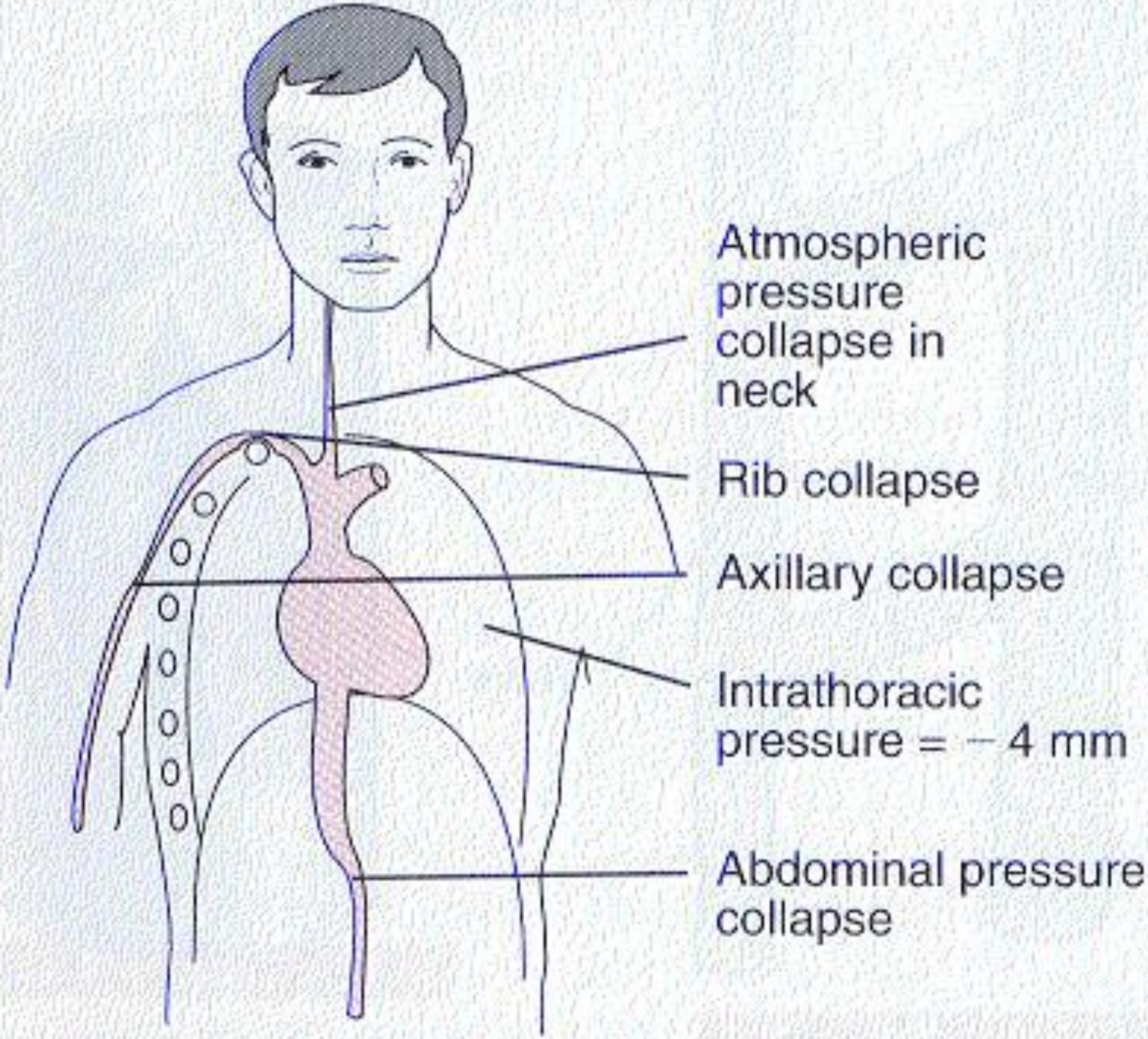


FIGURE 15–9

Factors that tend to collapse the veins entering the thorax.

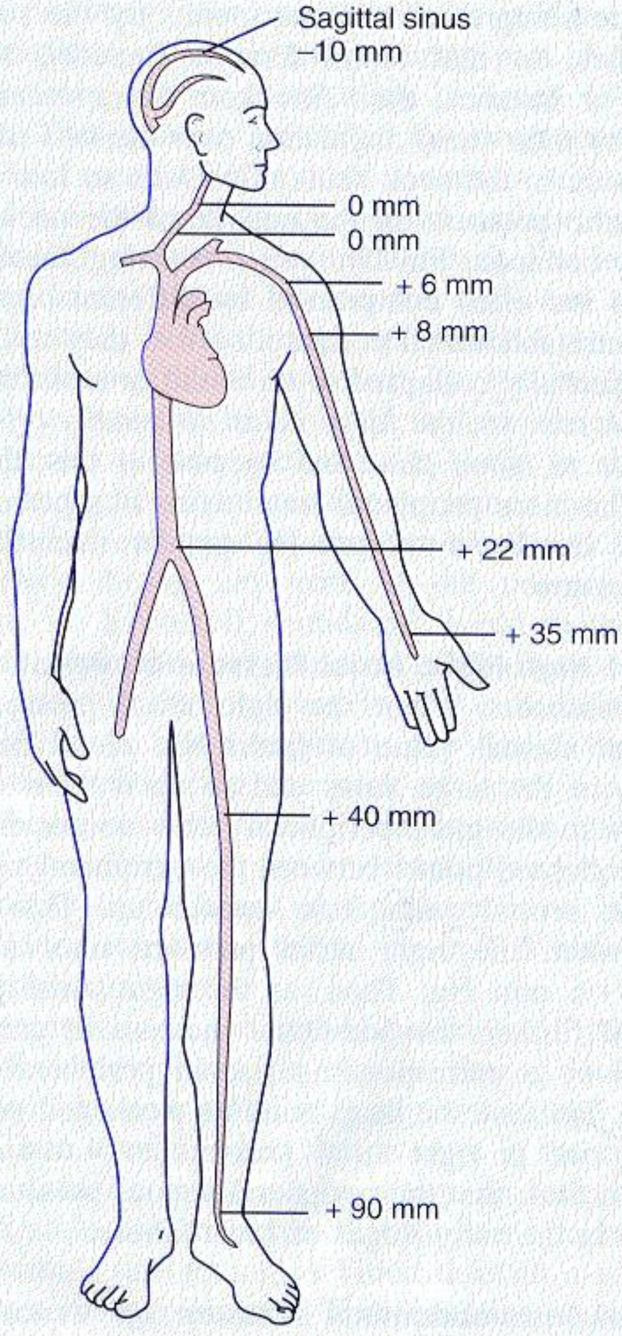


FIGURE 15–10

Effect of gravitational pressure on the venous pressures throughout the

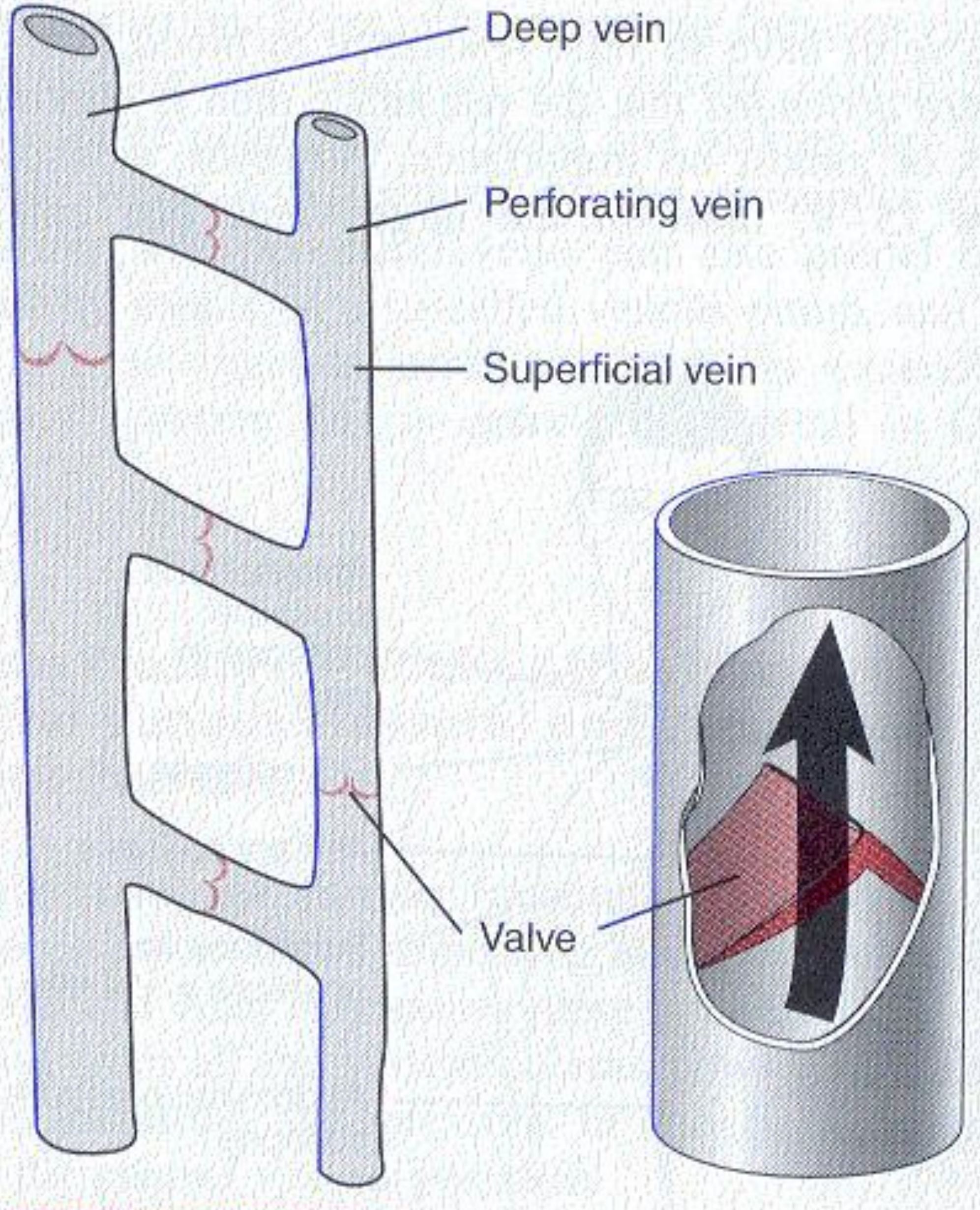
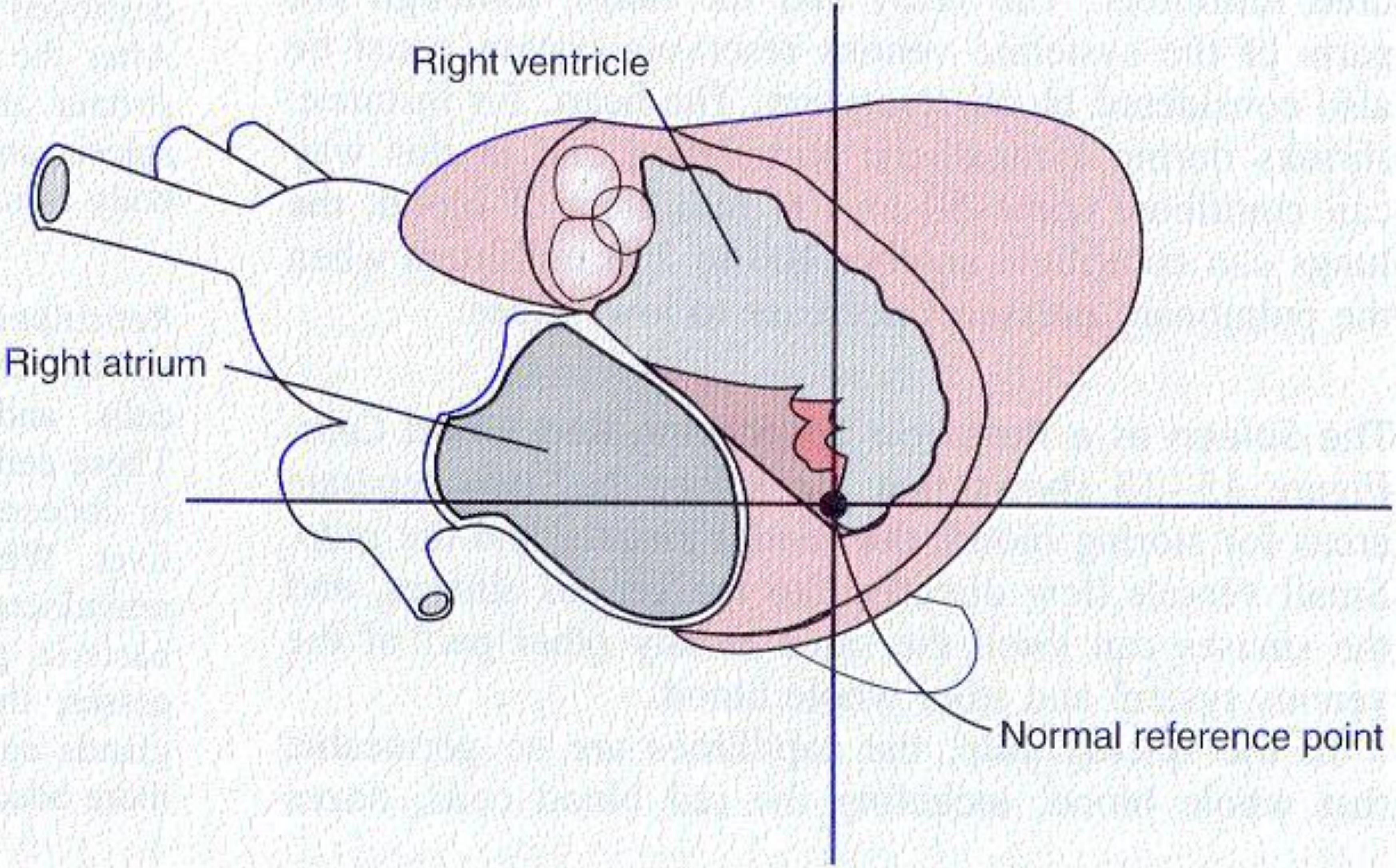


FIGURE 15–11

Venous valves of the leg.



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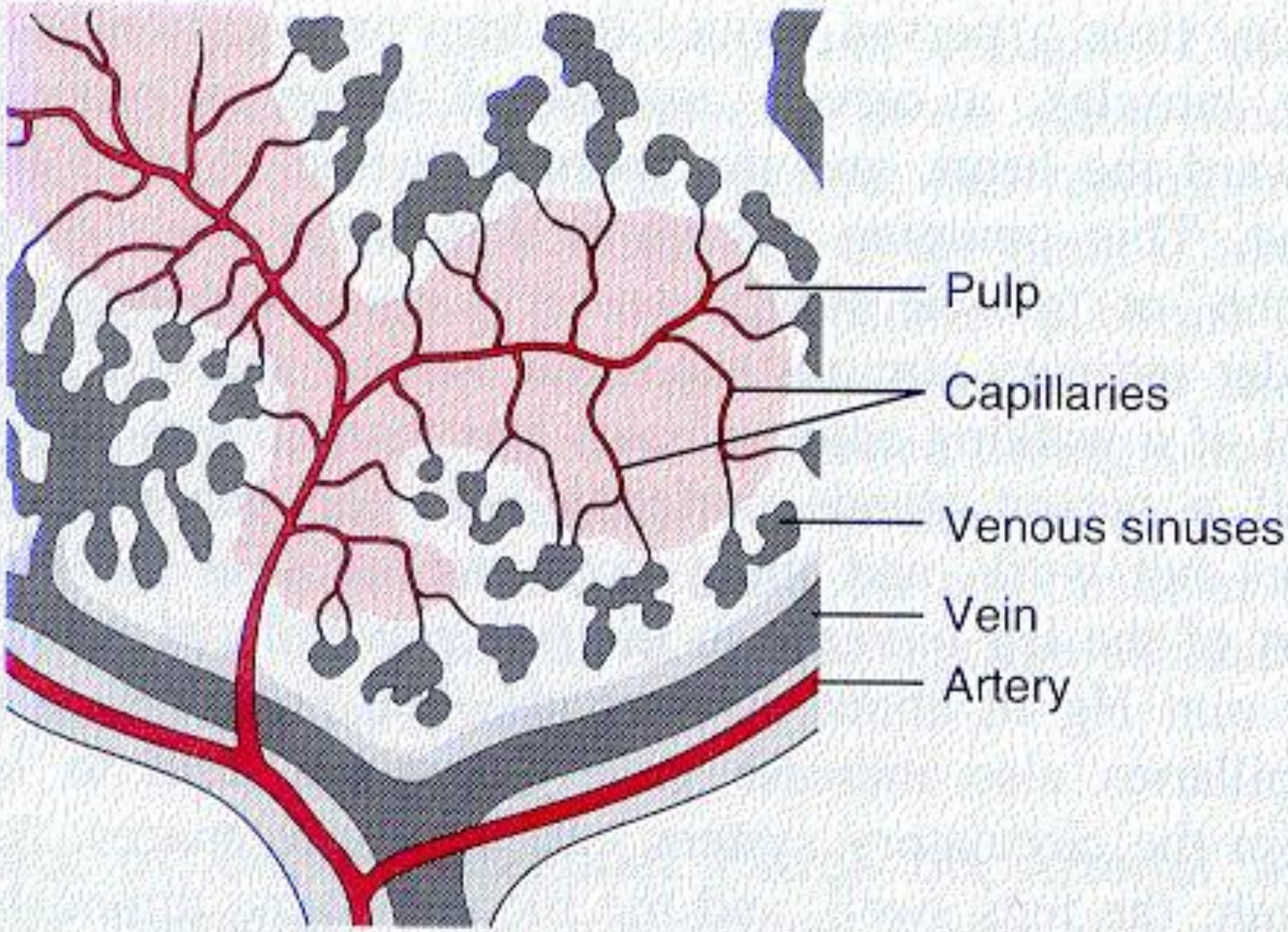


FIGURE 15-13

Functional structures of the spleen. (Modified from Bloom W, Fawcett DW: A Textbook of Histology. 10th ed. Philadelphia: WB Saunders Co, 1975.)

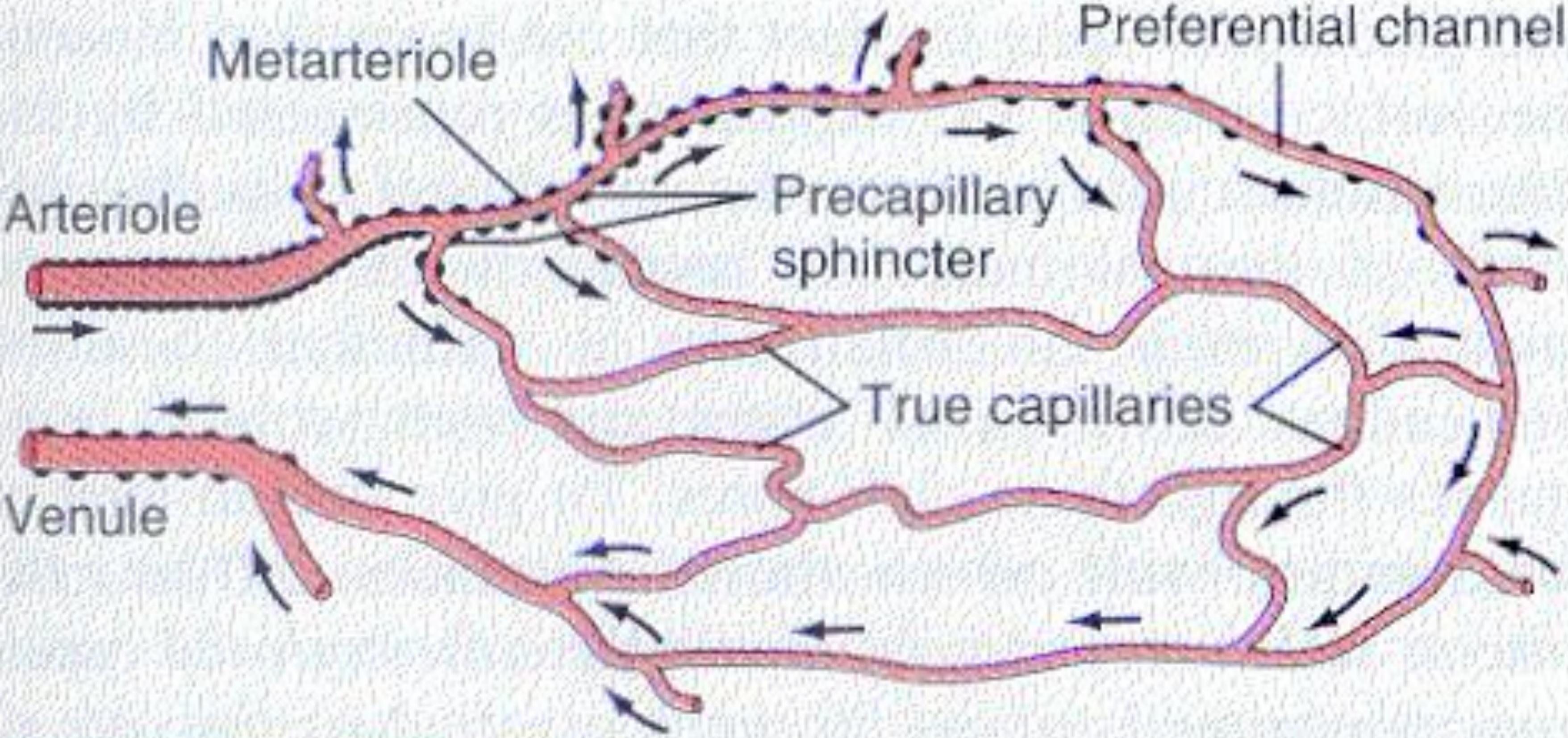


FIGURE 16–1

Structure of the mesenteric capillary bed. (Redrawn from Zweifach: Factors Regulating Blood Pressure. New York: Josiah Macy, Jr., Foundation, 1950.)

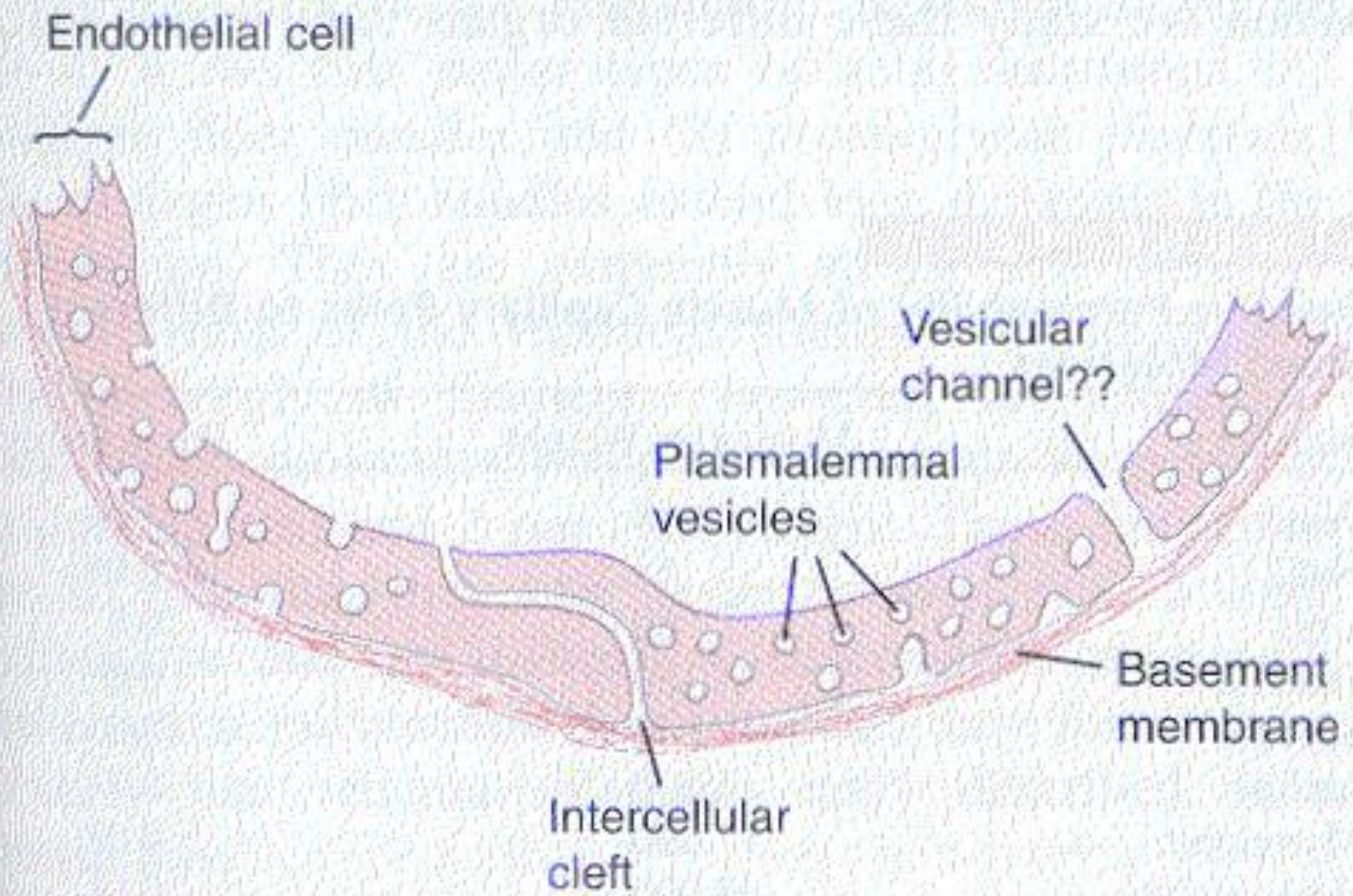


FIGURE 16-2

Structure of the capillary wall. Note especially the *intercellular cleft* at the junction between adjacent endothelial cells; it is believed that most water-soluble substances diffuse through the capillary membrane along this cleft.

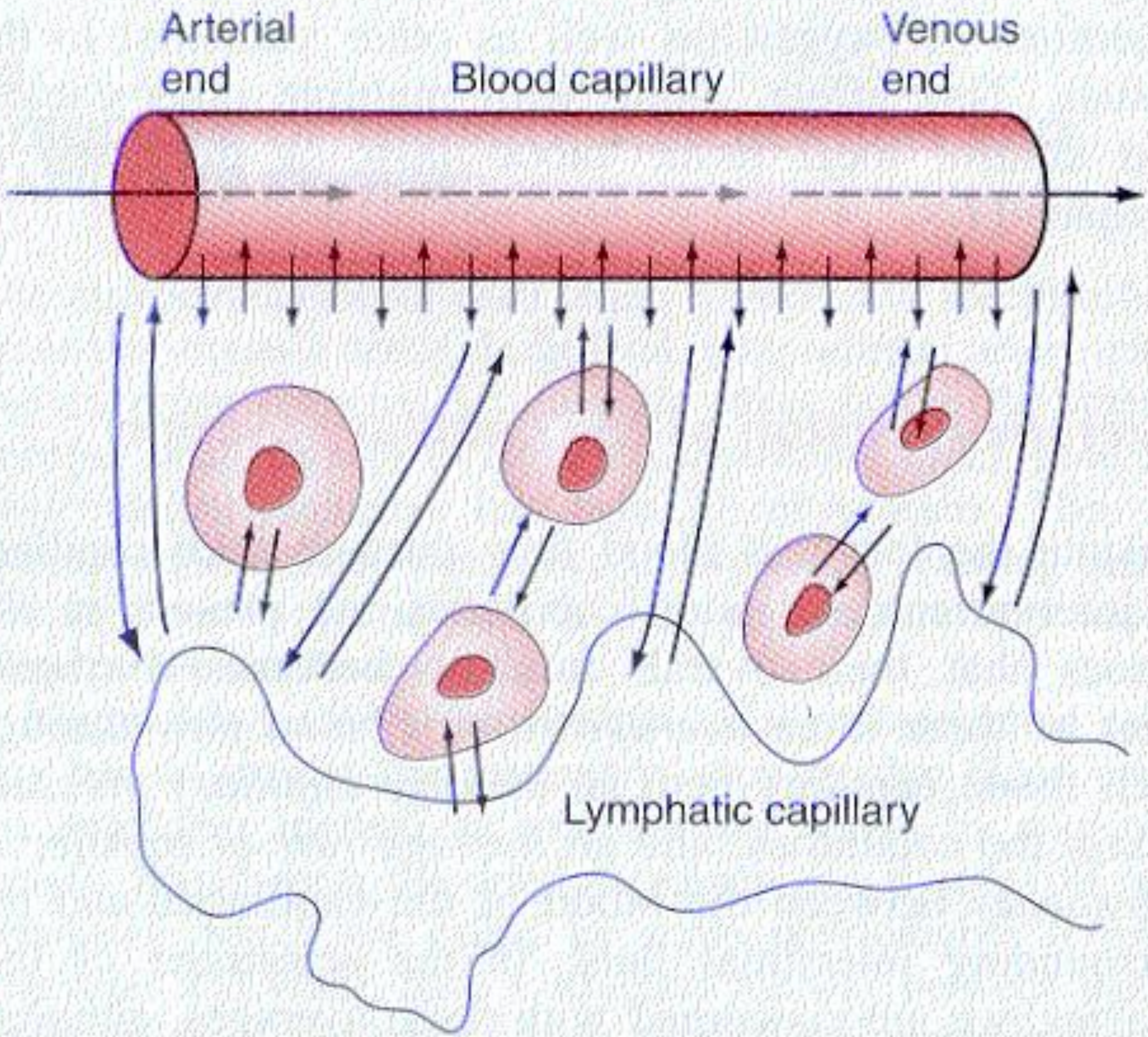


FIGURE 16-3

Diffusion of fluid molecules and dissolved substances between the capillary and interstitial fluid spaces.

TABLE 16-1

Relative Permeability of Muscle Capillary Pores to Different-Sized Molecules

Substance	Molecular Weight	Permeability
Water	18	1.00
NaCl	58.5	0.96
Urea	60	0.8
Glucose	180	0.6
Sucrose	342	0.4
Inulin	5,000	0.2
Myoglobin	17,600	0.03
Hemoglobin	68,000	0.01
Albumin	69,000	0.001

Modified from Pappenheimer JR: Passage of molecules through capillary walls. Physiol Rev 33:387, 1953.

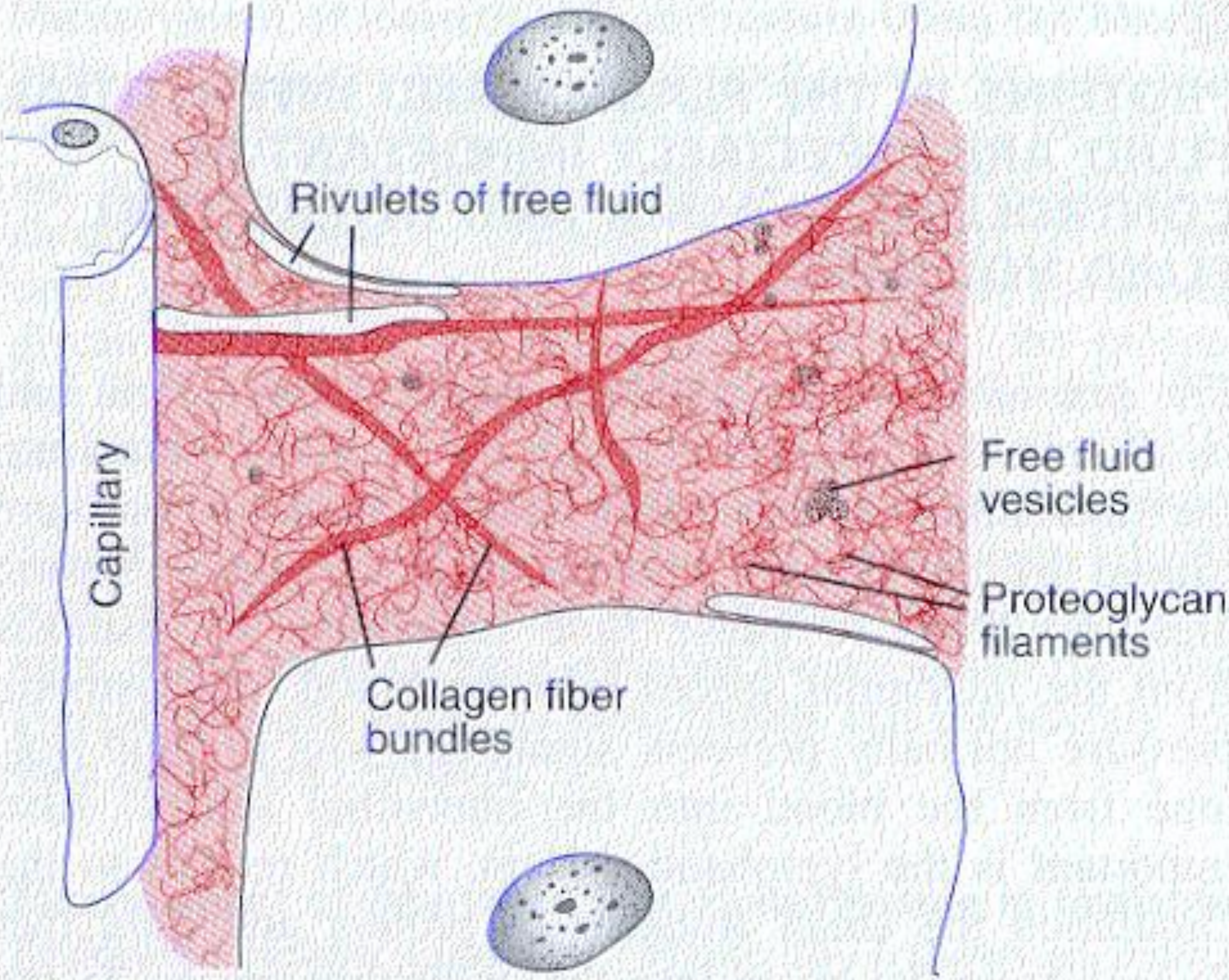


FIGURE 16–4

Structure of the interstitium. Proteoglycan filaments are everywhere in the spaces between the collagen fiber bundles. Free fluid vesicles and small amounts of free fluid in the form of rivulets occasionally also occur.

Capillary Pressure

Two experimental methods have been used to estimate the capillary pressure: (1) *direct micropipette cannula-*

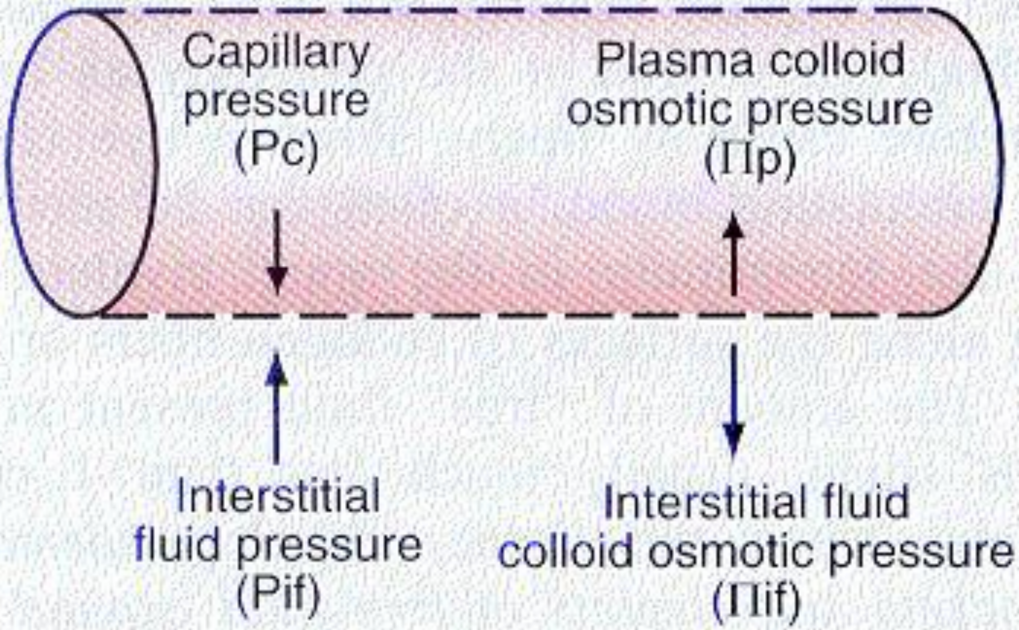
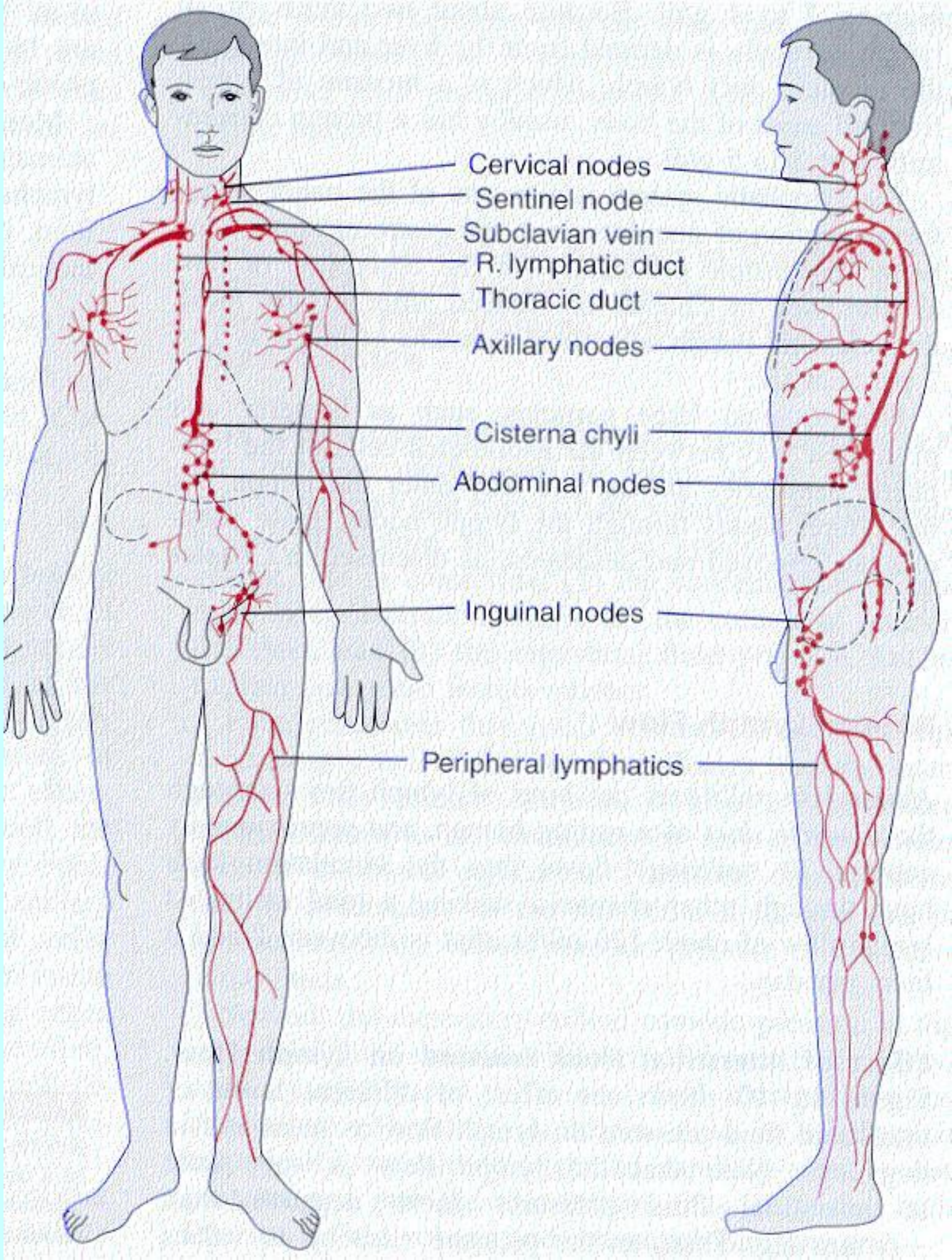


FIGURE 16–5

Fluid pressure and colloid osmotic pressure forces operate at the capillary membrane, tending to move fluid either outward or inward through the membrane pores.


Cervical nodes
Sentinel node
Subclavian vein
R. lymphatic duct
Thoracic duct
Axillary nodes
Cisterna chyli
Abdominal nodes
Inguinal nodes
Peripheral lymphatics

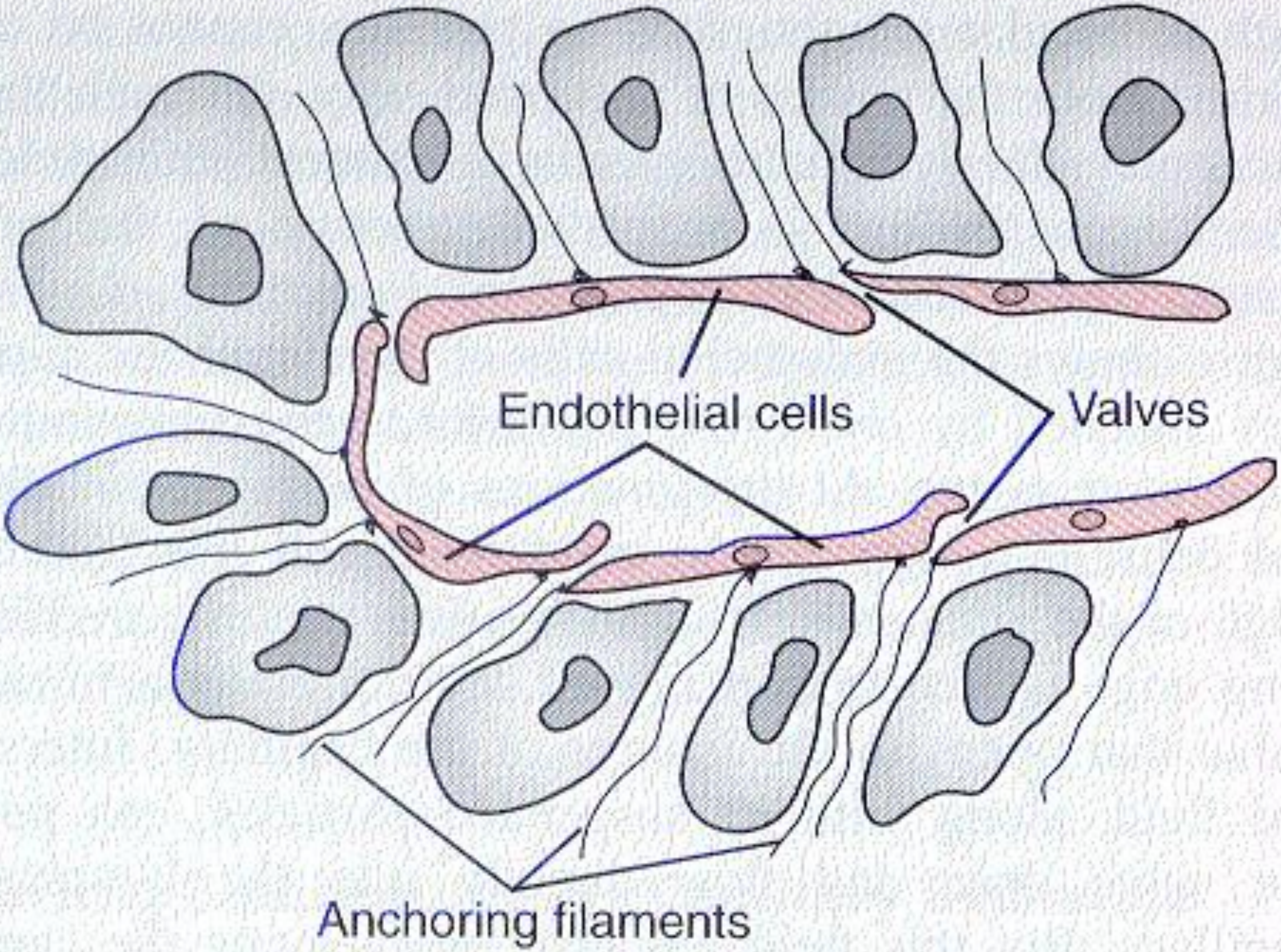
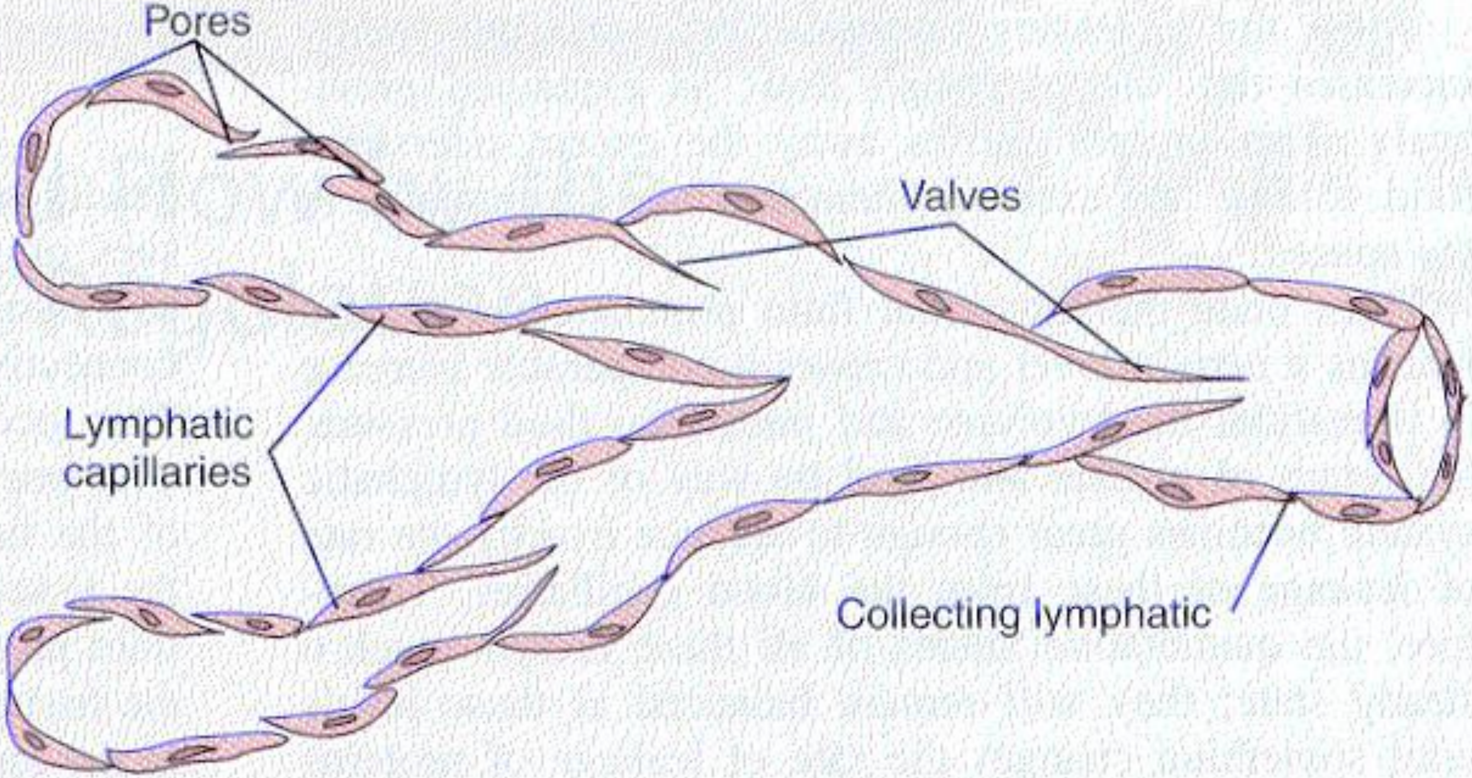


FIGURE 16–9

Special structure of the lymphatic capillaries that permits passage of substances of high molecular weight into the lymph.



and a collecting lym-
c valves.

TABLE 17 – 1

Blood Flow to Different Organs and Tissues Under Basal Conditions

	Per cent	ml/min	ml/min/100 g
Brain	14	700	50
Heart	4	200	70
Bronchi	2	100	25
Kidneys	22	1100	360
Liver	27	1350	95
Portal	(21)	(1050)	
Arterial	(6)	(300)	
Muscle (inactive state)	15	750	4
Bone	5	250	3
Skin (cool weather)	6	300	3
Thyroid gland	1	50	160
Adrenal glands	0.5	25	300
Other tissues	3.5	175	1.3
Total	100.0	5000	—

Based mainly on data compiled by Dr. L. A. Sapirstein.

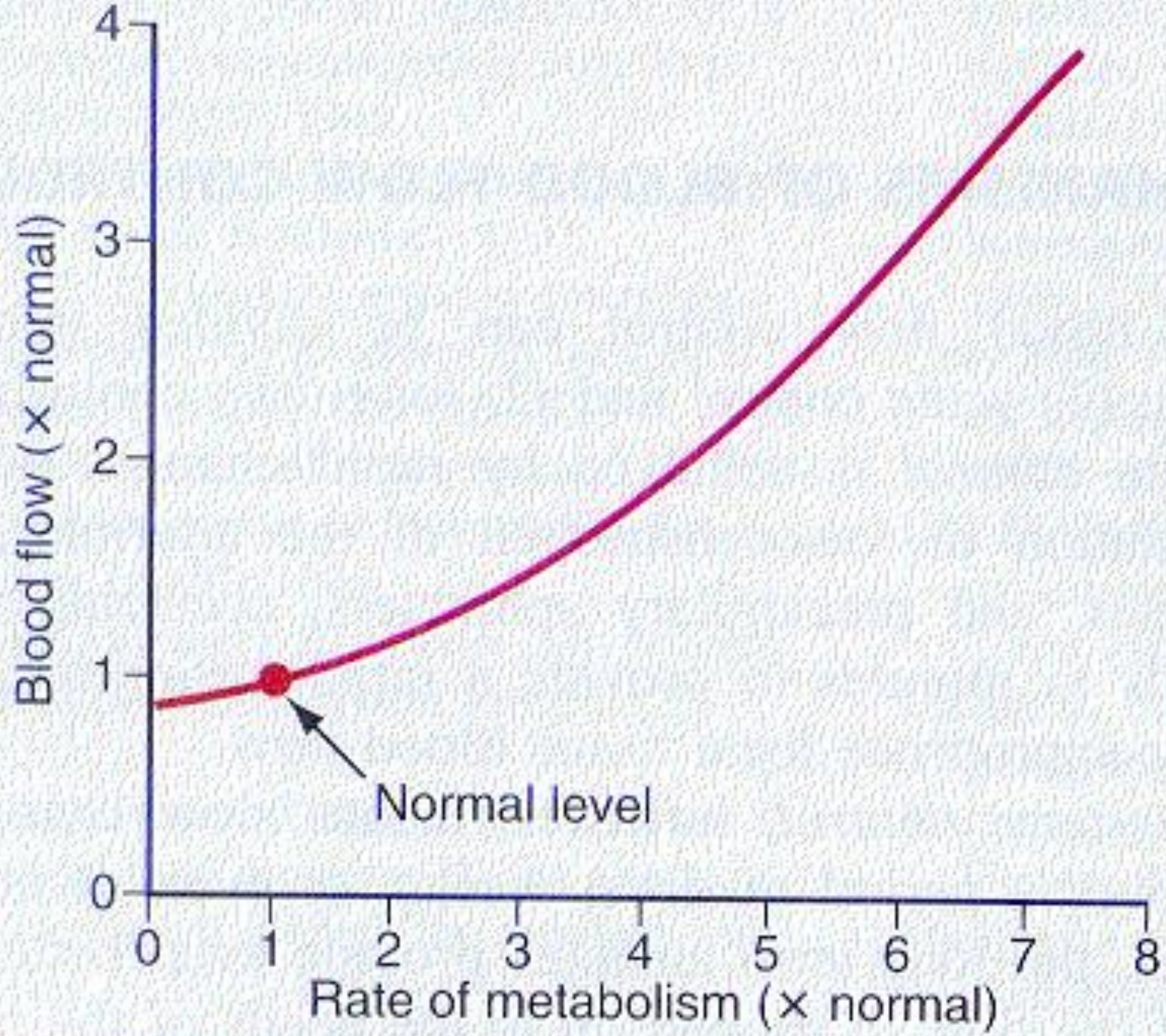


FIGURE 17-1

Effect of increasing rate of metabolism on tissue blood flow.

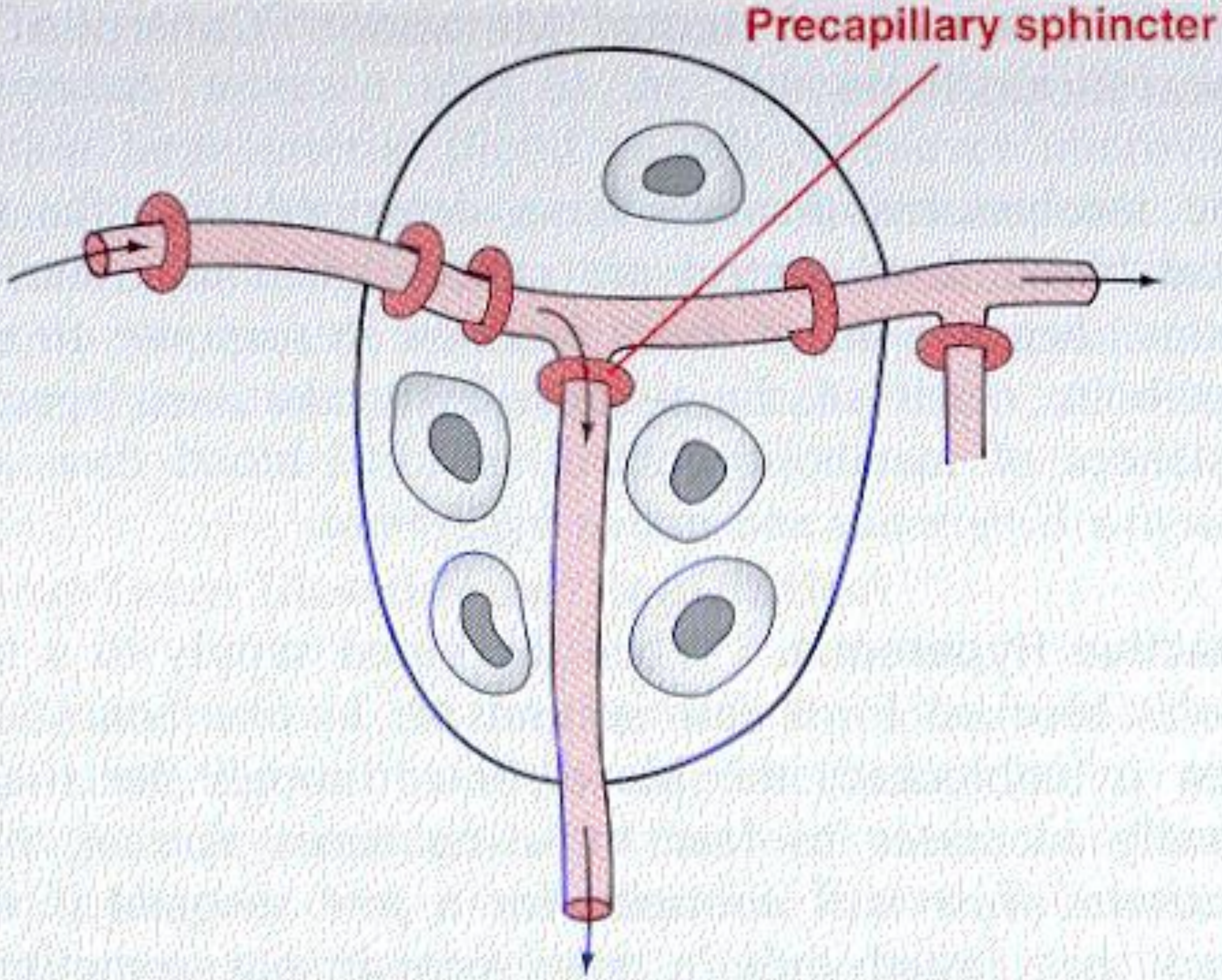


FIGURE 17–3

Diagram of a tissue unit area for explanation of acute local feedback control of blood flow, showing a *metarteriole* passing through the tissue and a sidearm *capillary* with its *precapillary sphincter* for controlling the capillary blood flow.

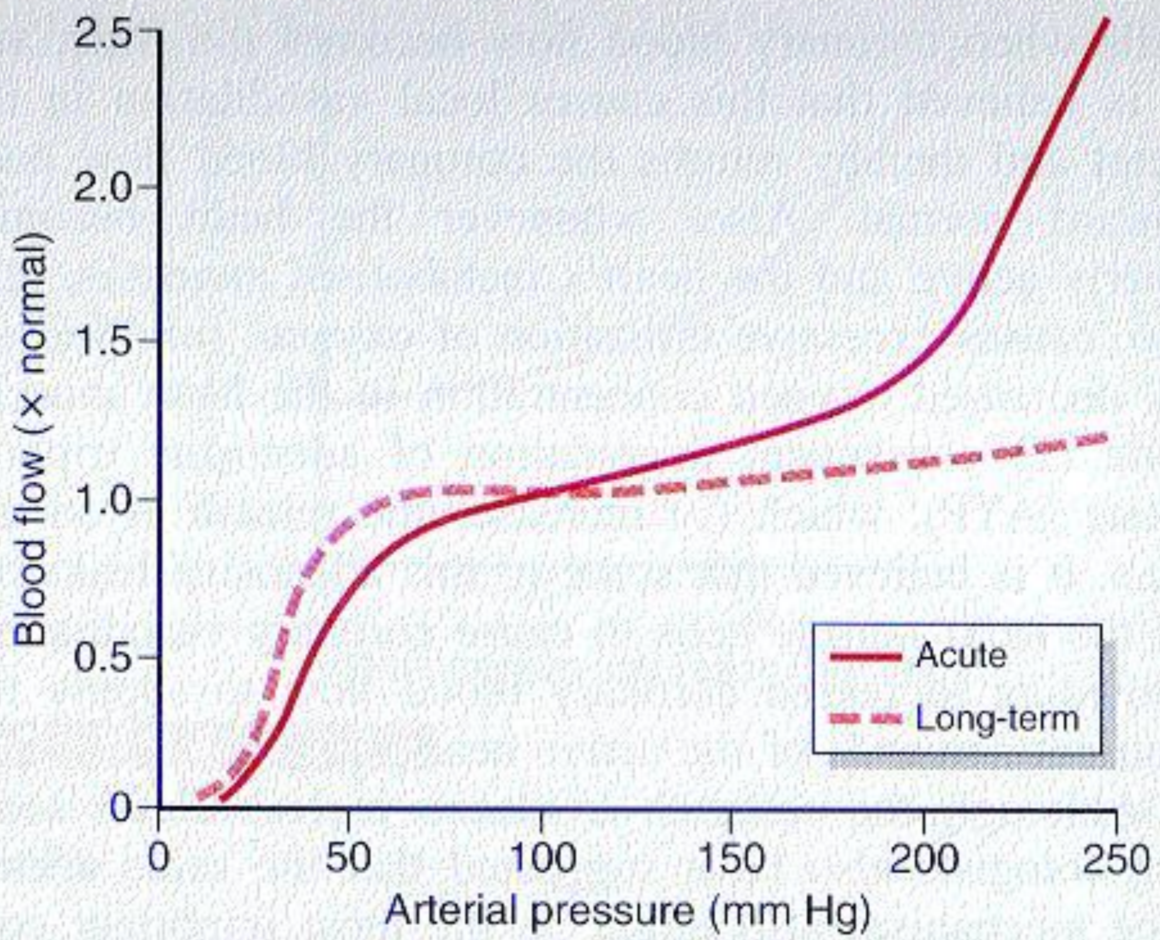


FIGURE 17–4

Effect of different levels of arterial pressure on blood flow through a muscle. The solid curve shows the effect if the arterial pressure is raised over a period of a few minutes. The dashed curve shows the effect if the arterial pressure is raised extremely slowly over a period of many weeks.

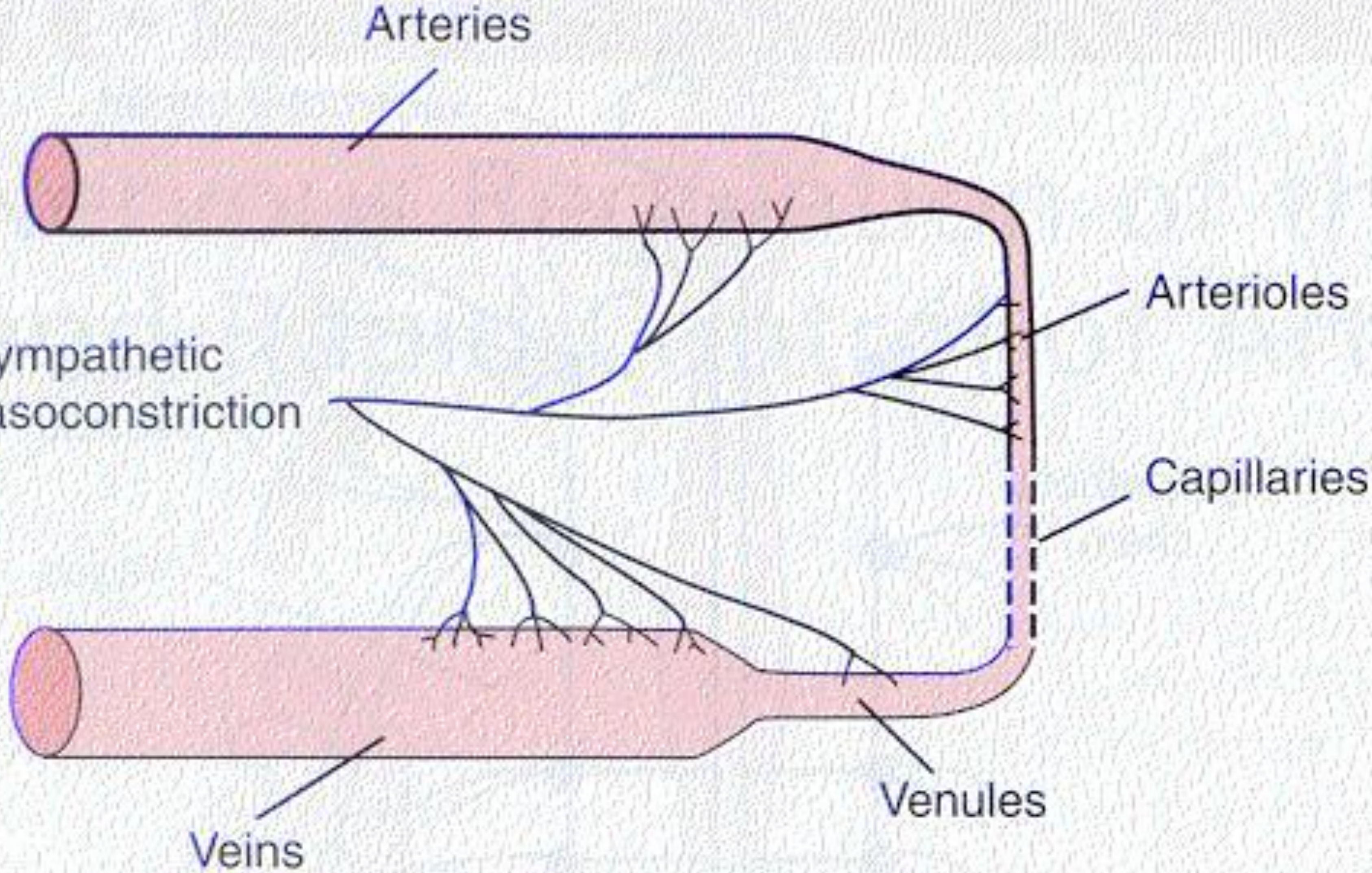


FIGURE 18–2

Sympathetic innervation of the systemic circulation.

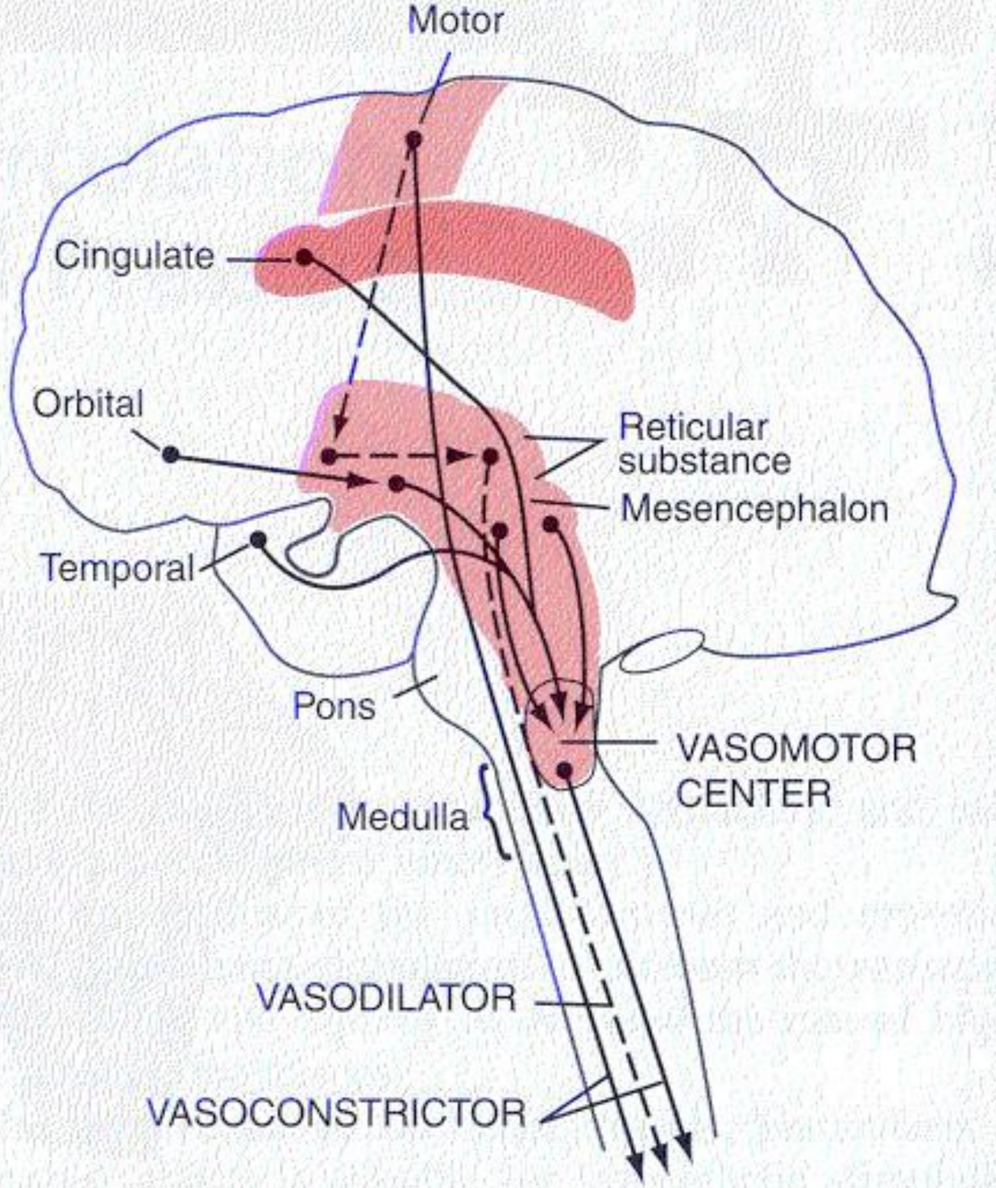
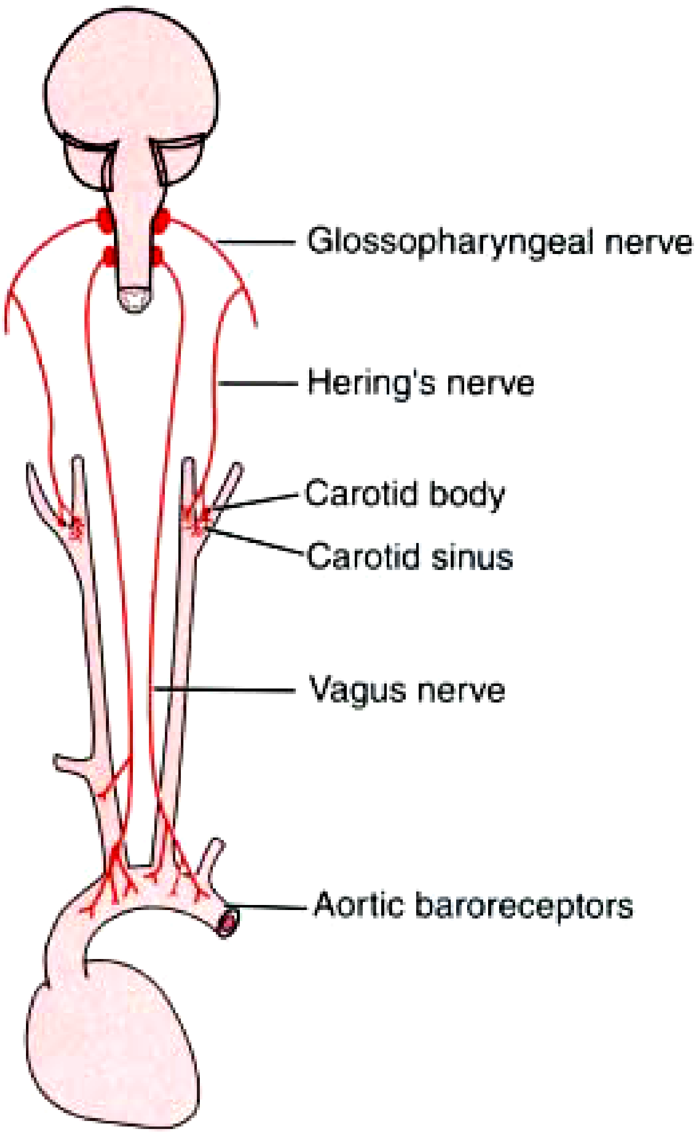


FIGURE 18–3

Areas of the brain that play important roles in the nervous regulation of the circulation. The dashed lines represent inhibitory pathways.



Baroreceptor reflex

- Stretch baroreceptors are located in the wall of almost every large artery of the thoracic and neck region. They are especially abundant in the wall of carotid artery (carotid sinus) and the wall of aortic arch.
- Baroreceptors are stimulated by stretch not pressure.
- Signals from the carotid sinus and aortic baroreceptors are transmitted into the vasomotor center in the medulla.

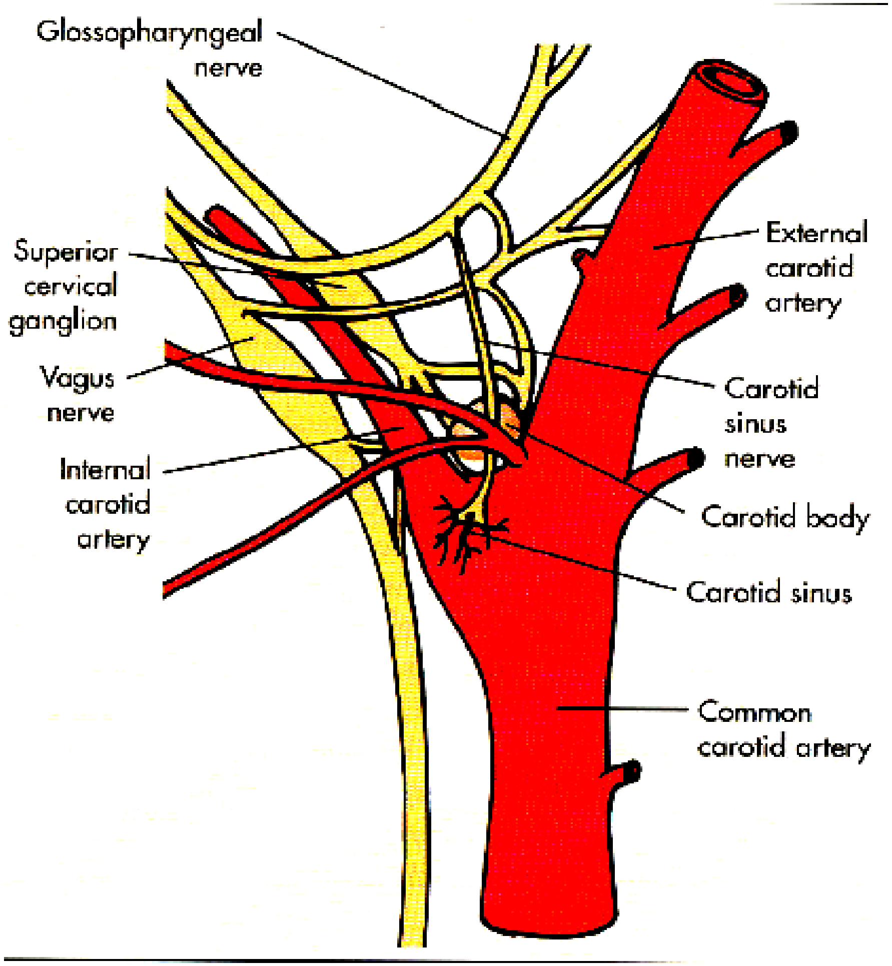
3.Chemoreceptor Reflexes

Peripheral chemoreceptors in Pressure Control

- located in two carotid bodies and several aortic bodies (under arch).

- stimulated by low arterial PO2 and also by arterial pressure below 60 mmHg

- stimulation leads to increased sympathetic tone and increased vagal tone (bradycardia).



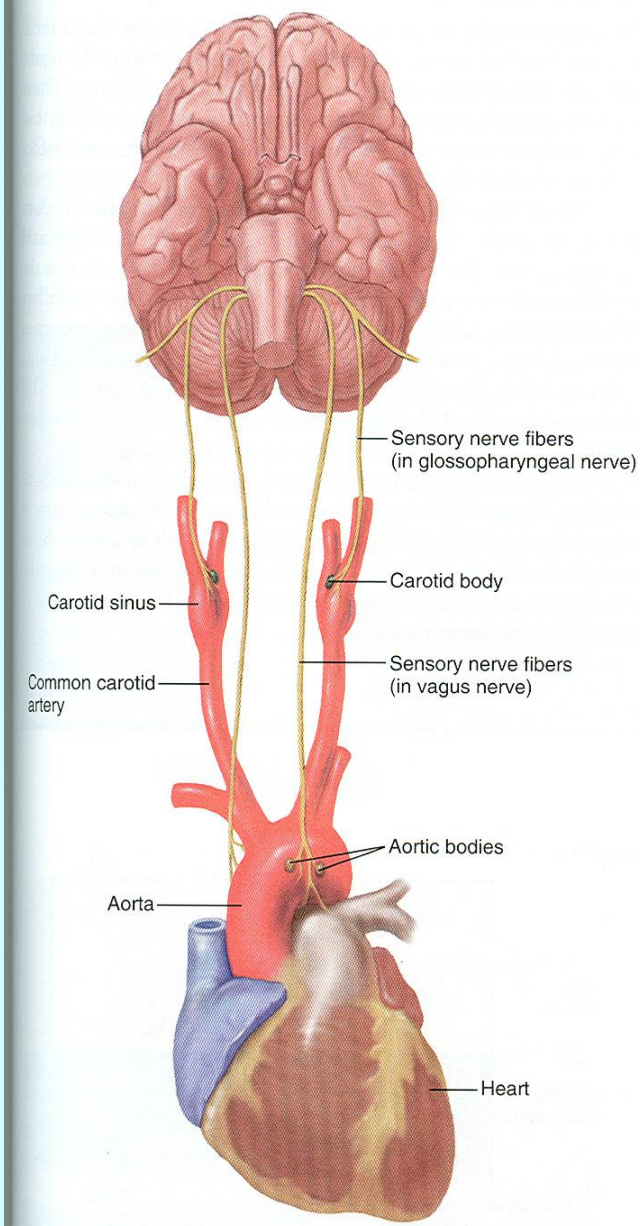


Figure 16.27 **Sensory input from the aortic and carotid bodies.** The peripheral chemoreceptors (aortic and carotid bodies) regulate the brain stem respiratory centers by means of sensory nerve stimulation.

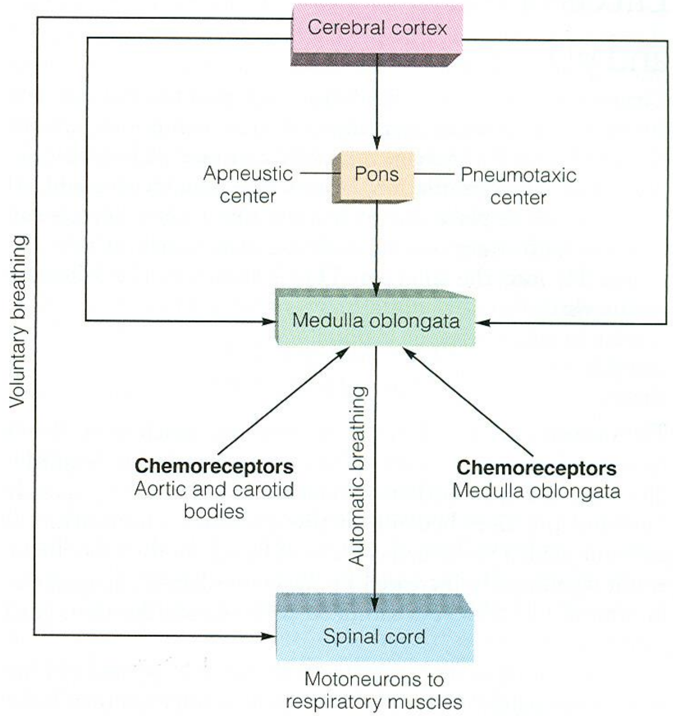
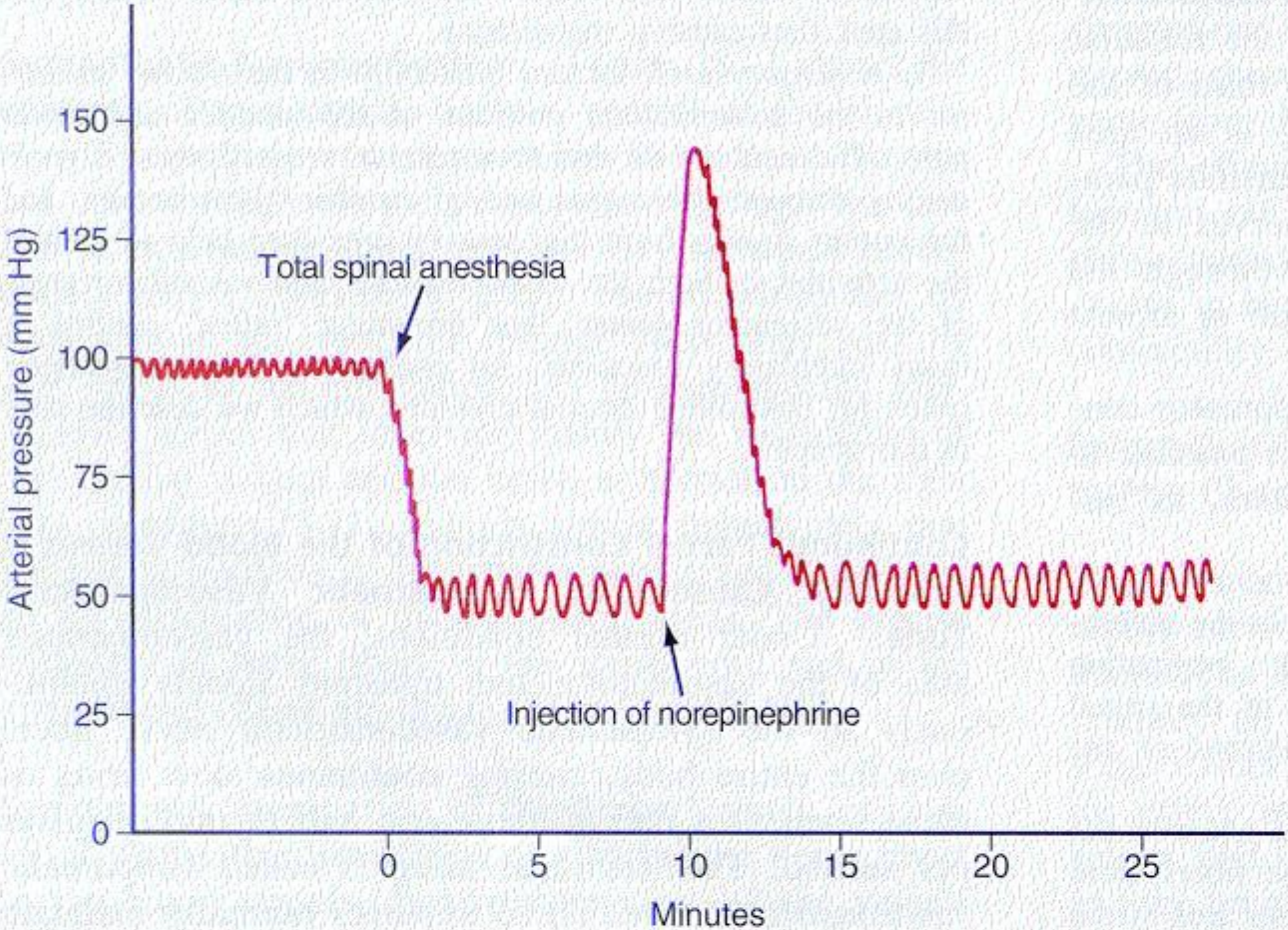


Figure 16.28 **The regulation of ventilation by the central nervous system.** The feedback effects of pulmonary stretch receptors and "irritant" receptors on the control of breathing are not shown in this flowchart.

confused with the aortic and carotid sinuses (chapter 14) that are located within these arteries. The aortic and carotid sinuses contain receptors that monitor the blood pressure.

The peripheral chemoreceptors control breathing indirectly via sensory nerve fibers to the medulla. The aortic bodies send sensory information to the medulla in the vagus nerve (X); the carotid bodies stimulate sensory fibers in the glossopharyngeal nerve (IX). The neural and sensory control of ventilation is summarized in figure 16.28.

The automatic control of breathing is regulated by nerve fibers that descend in the lateral and ventral white matter of the spinal cord from the medulla oblongata. The volun-



150
125
100
75
50
25
0
Arterial pressure (mm Hg)
Total spinal anesthesia
Injection of norepinephrine
0
5
10
15
20
25
Minutes

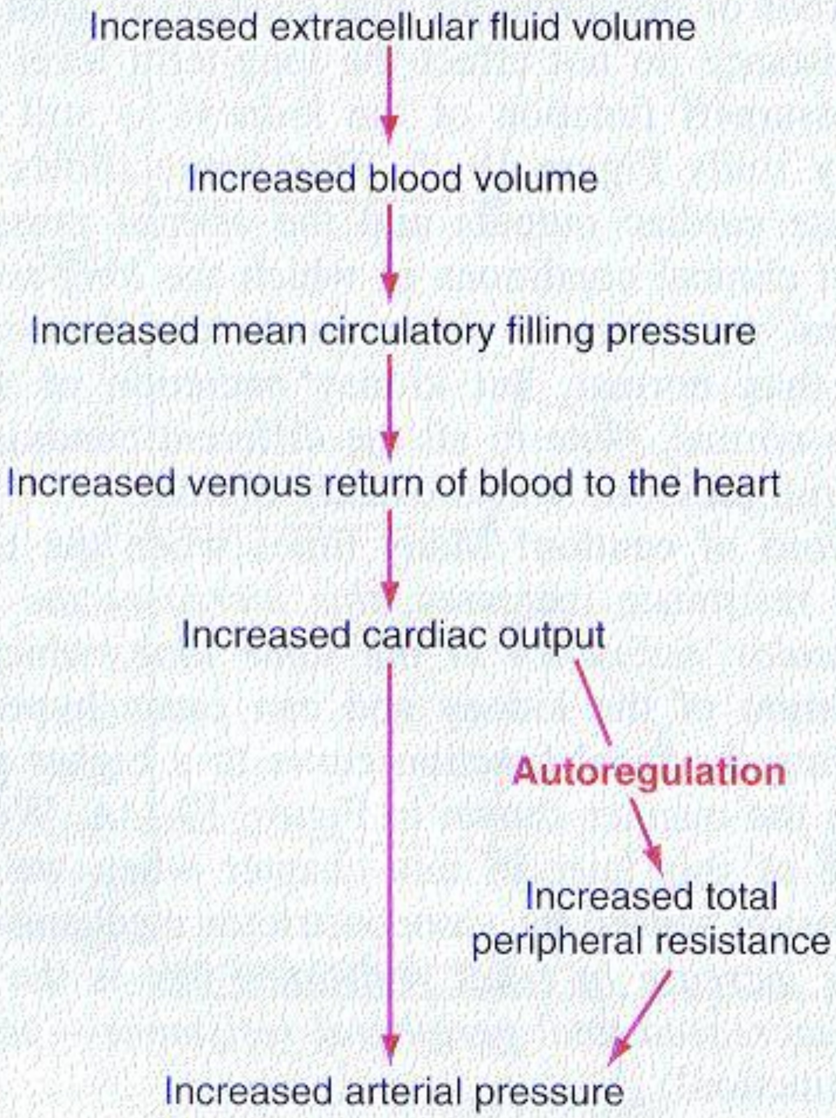


FIGURE 19-6

Sequential steps by which increased extracellular fluid volume increases the arterial pressure. Note especially that increased cardiac output has both a direct effect by increasing arterial pressure and an indirect effect by increasing the total peripheral resistance.

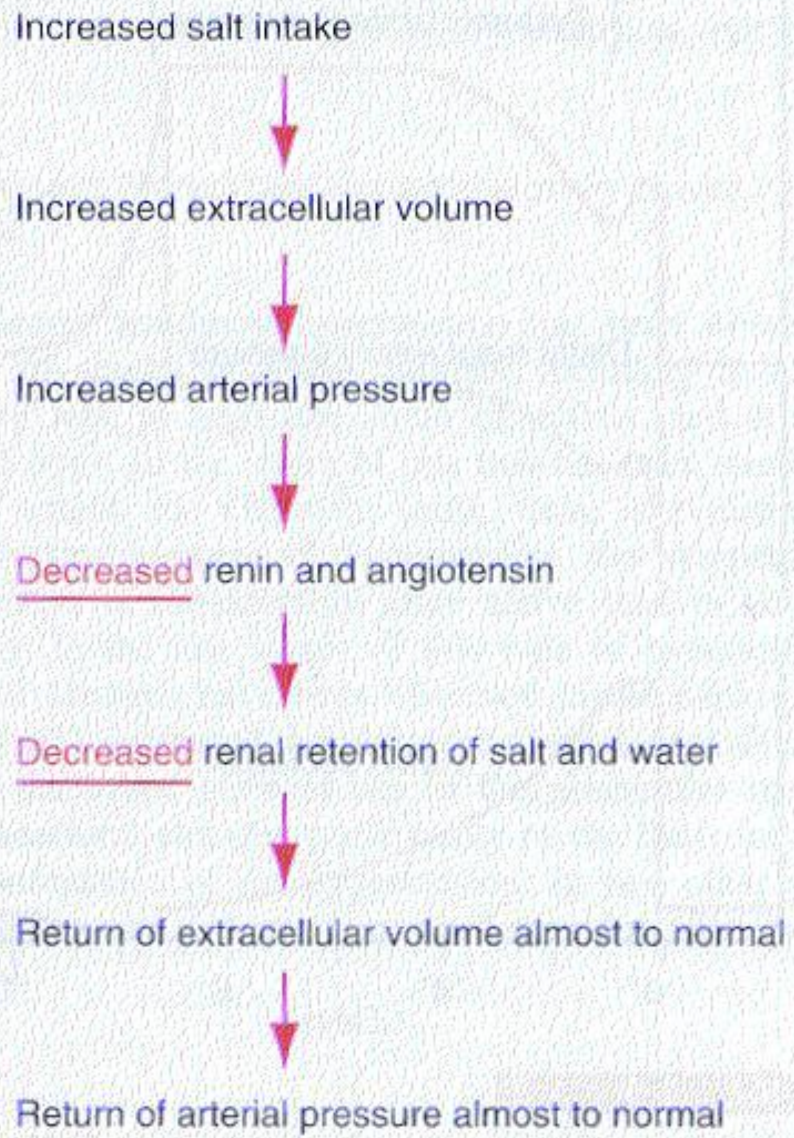


FIGURE 19–12

Sequential events by which increased salt intake tends to increase the arterial pressure, but feedback decrease in activity of the renin-angiotensin system returns the arterial pressure almost to the normal level.

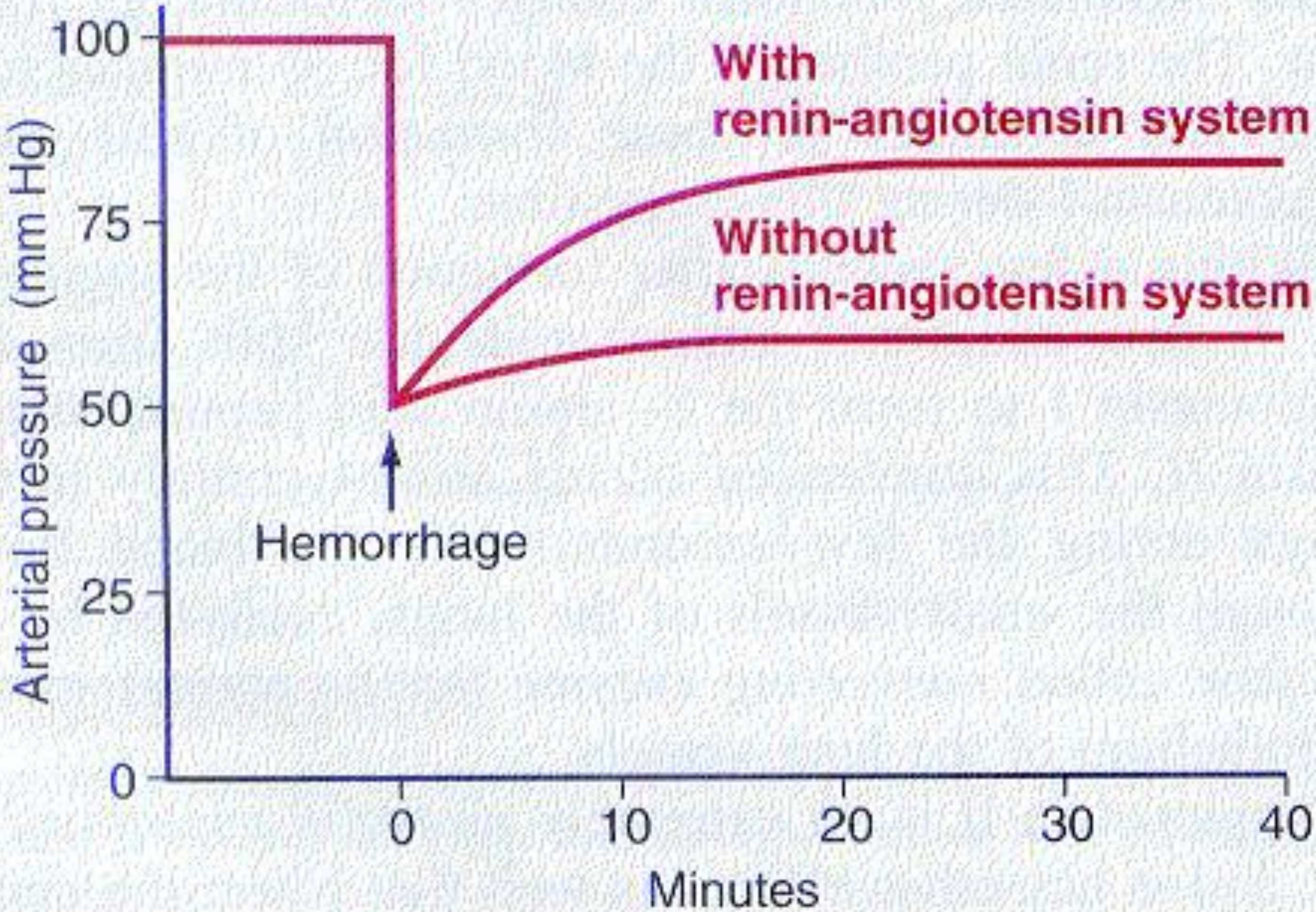


FIGURE 19–10

Pressure-compensating effect of the renin-angiotensin-vasoconstrictor system after severe hemorrhage. (Drawn from experiments by Dr. Royce Brough.)

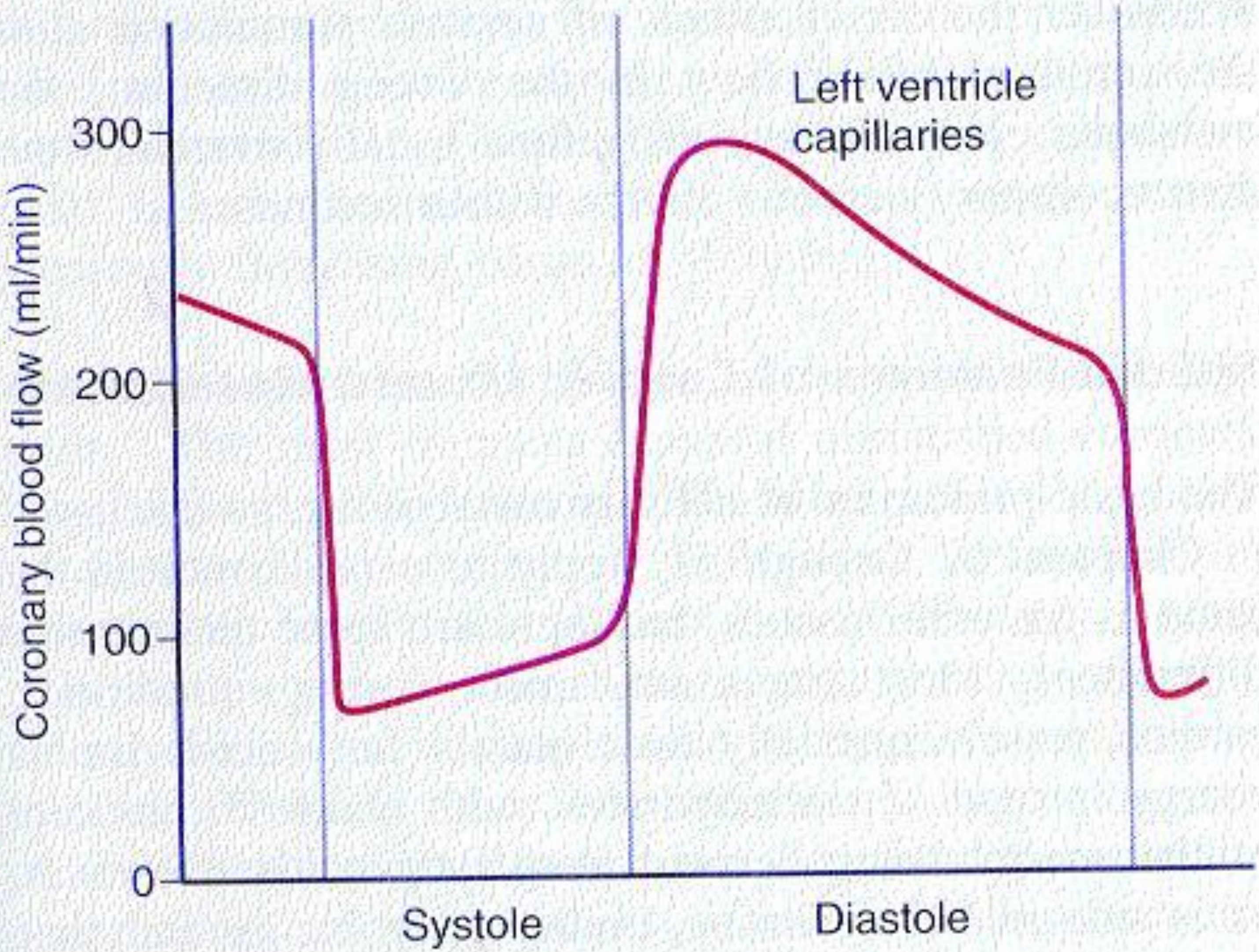


FIGURE 21-4

Phasic flow of blood through the coronary capillaries of the human left ventricle during cardiac systole and diastole (as extrapolated from studies in dogs).

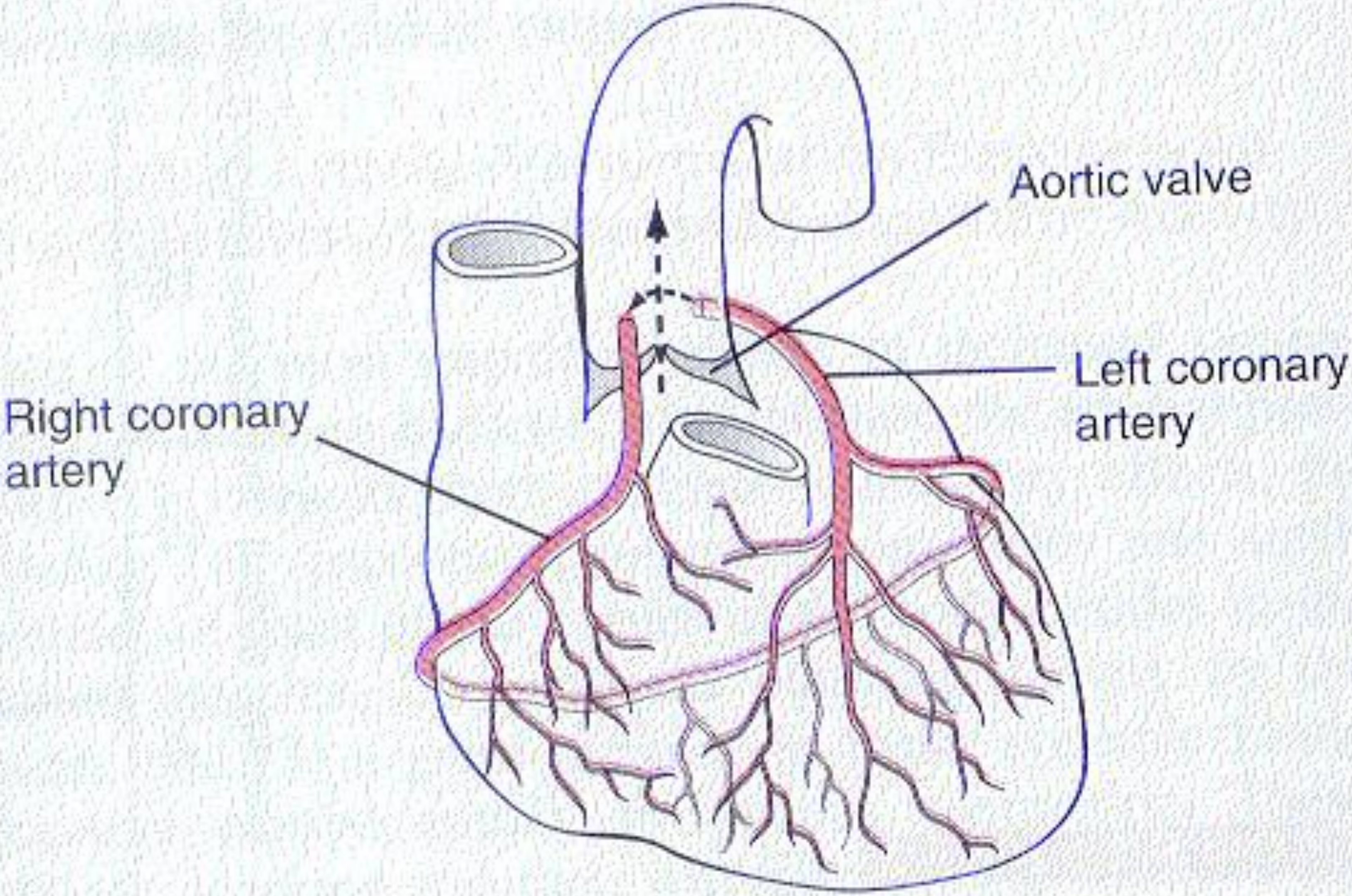


FIGURE 21–3

Coronary arteries.

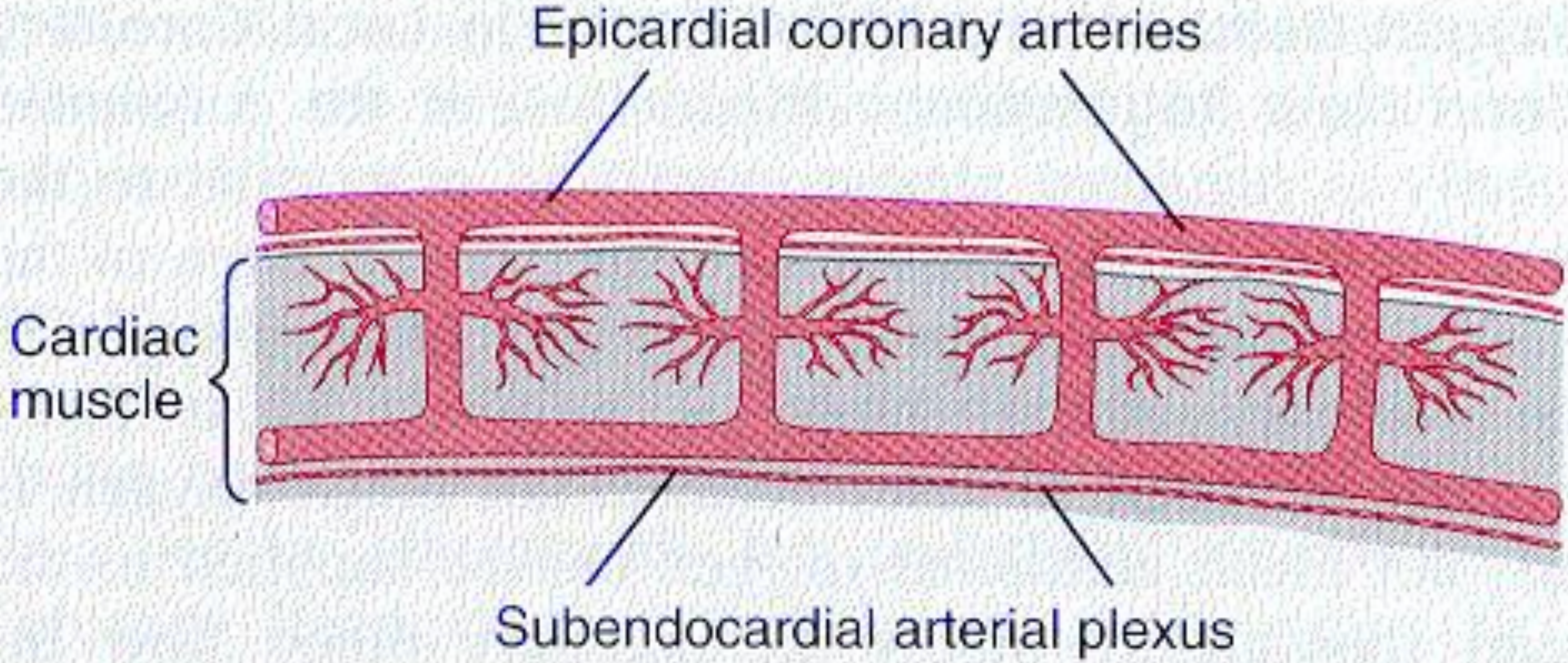


FIGURE 21–5

Diagram of the epicardial, intramuscular, and subendocardial coronary vasculature.

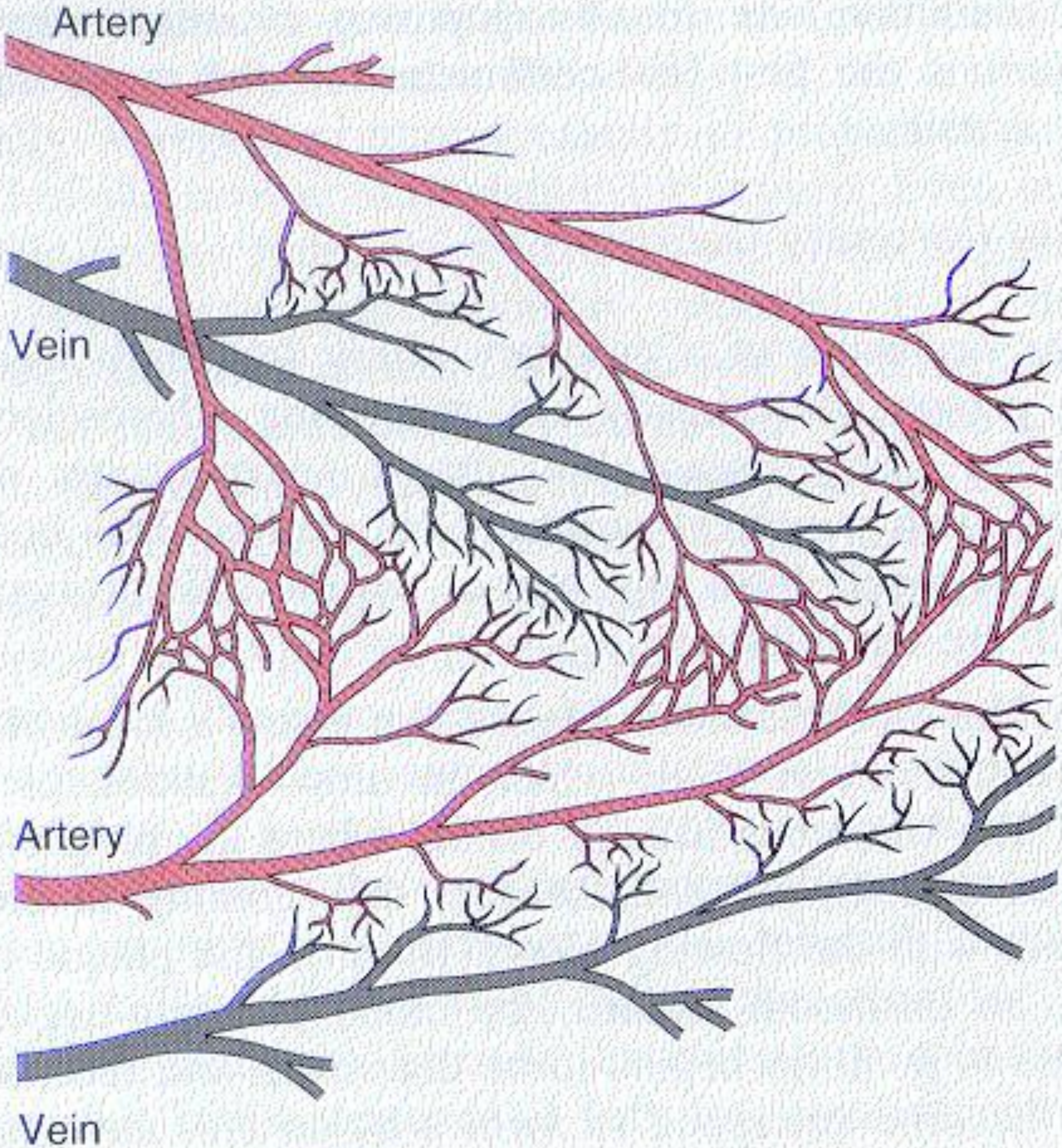


FIGURE 21–6

Minute anastomoses in the coronary arterial system.

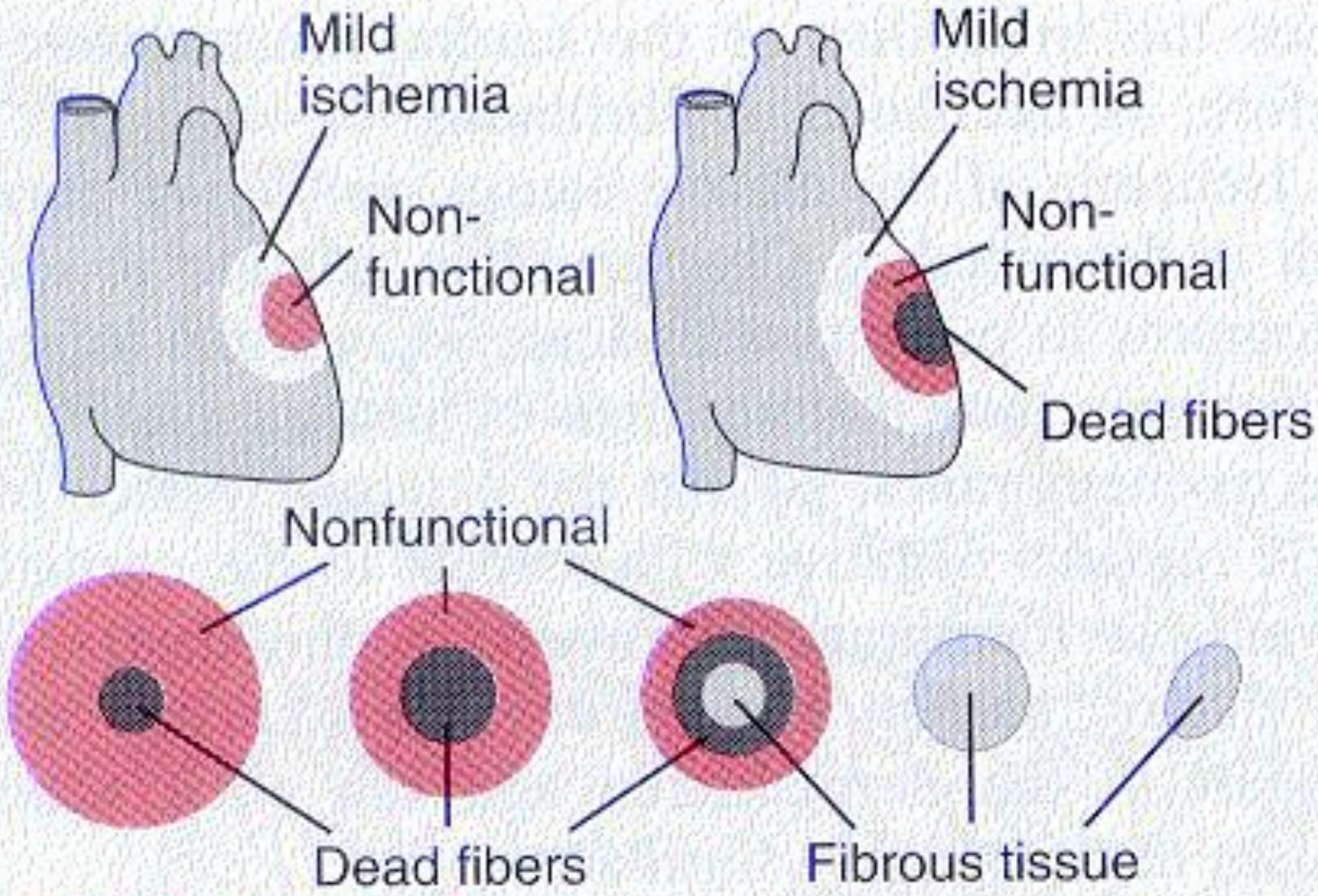


FIGURE 21–8

Top, Small and large areas of coronary ischemia. *Bottom*, Stages of recovery from myocardial infarction.