Haemodynamics and capillary filtration

Cardiovascular Module
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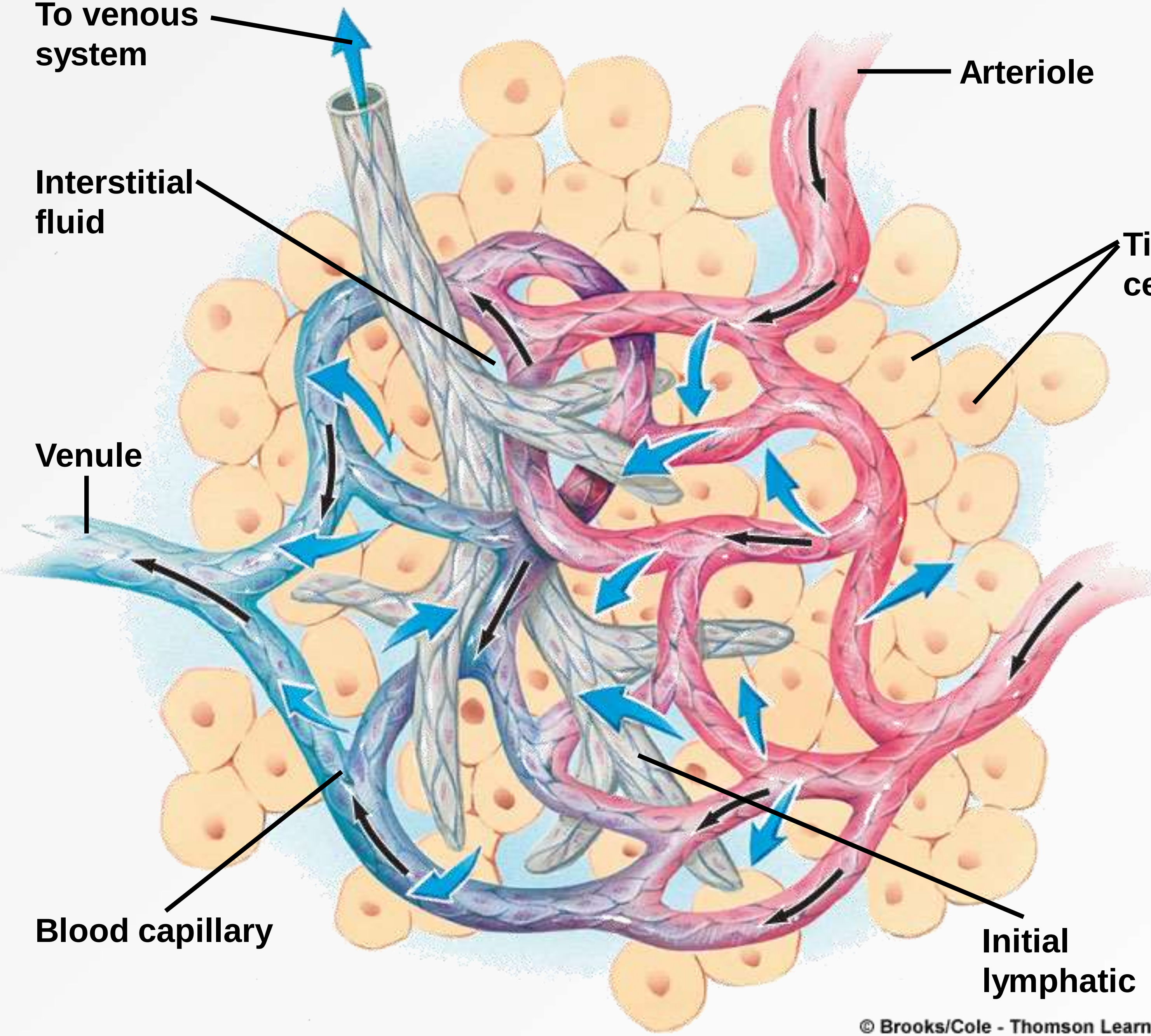


 Fig. 10-20a, p. 296

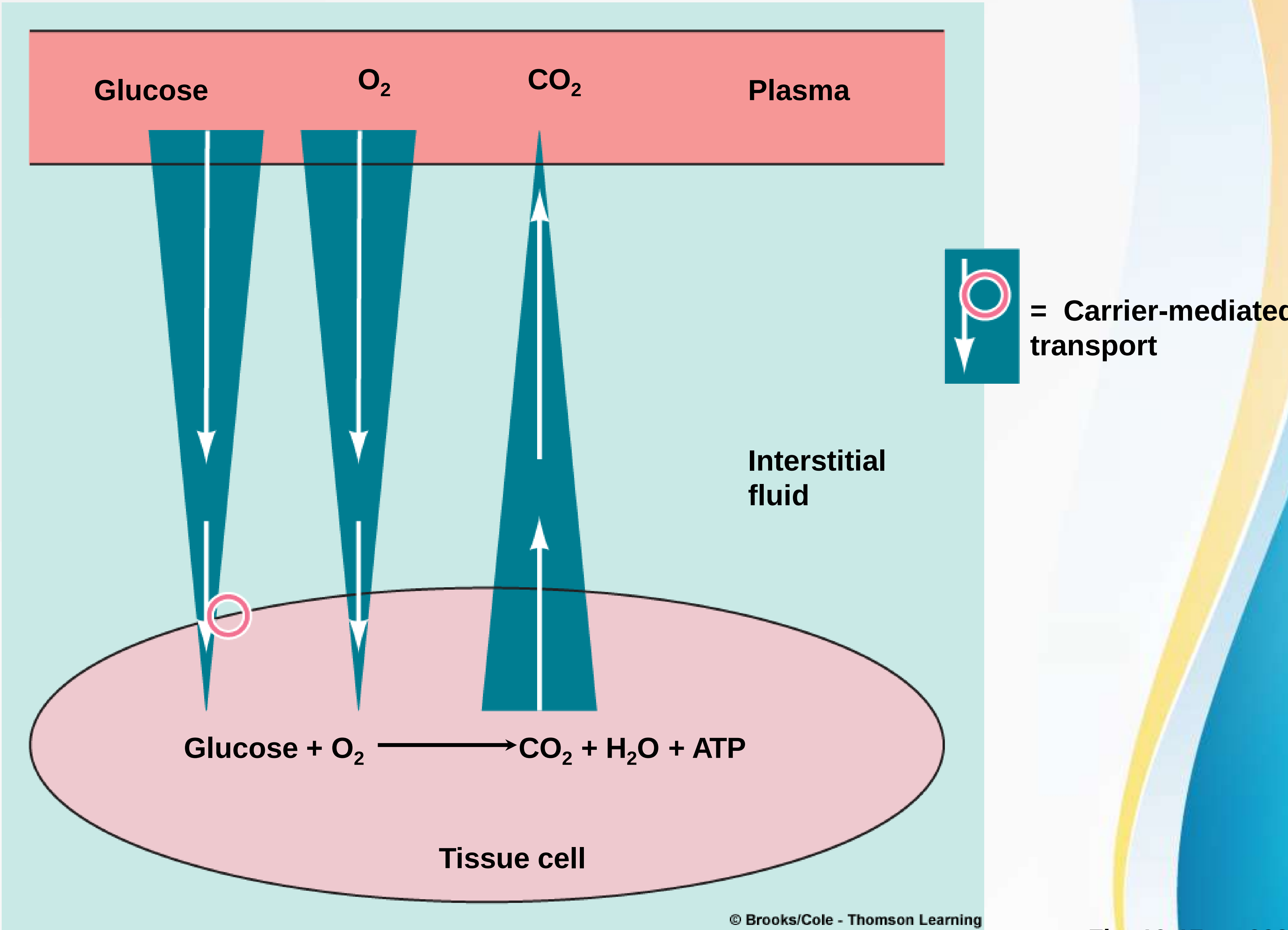


Fig. 10-17, p. 293

Capillary

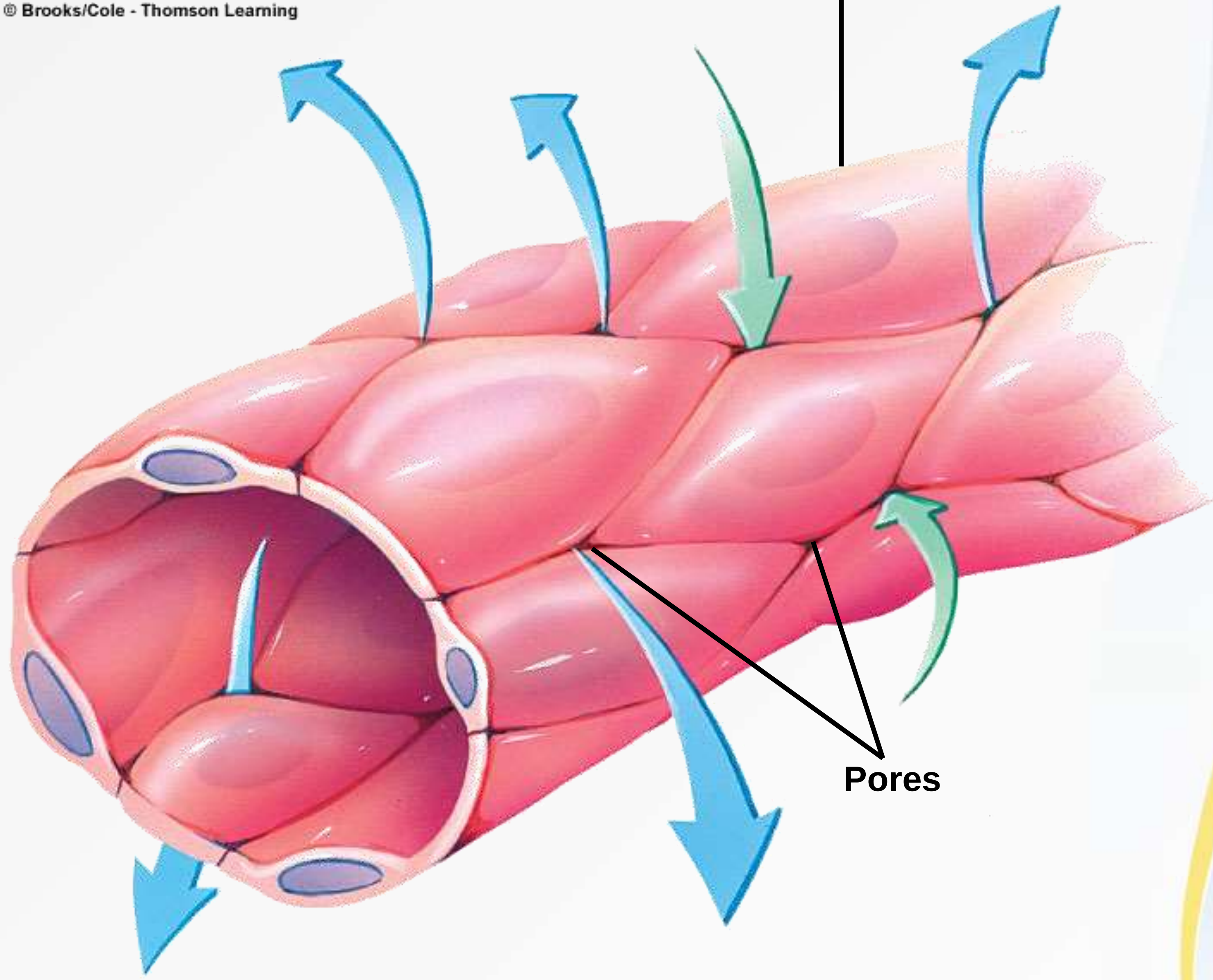


Fig. 10-16a, p. 292

Types of pores:

In some organs the pores in the capillaries have special characteristics .

1- In ***Brain*** the junctions between the capillary endothelial cells are tight junctions allowing only very small molecules to pass into brain cells, e.g oxygen CO_2, glucose and water

2- In ***liver*** the clefts between the endothelial cells are wide open to allow almost all plasma components to pass including large molecular weight proteins

3- In ***Kidney*** the glomerular tufts have large number of oval like windows called “ ***fenestrae***” which penetrate all through the endothelial wall which allows all components of plasma to filter out except large molecular weight proteins (albumin) and blood elements (blood white and red cells)

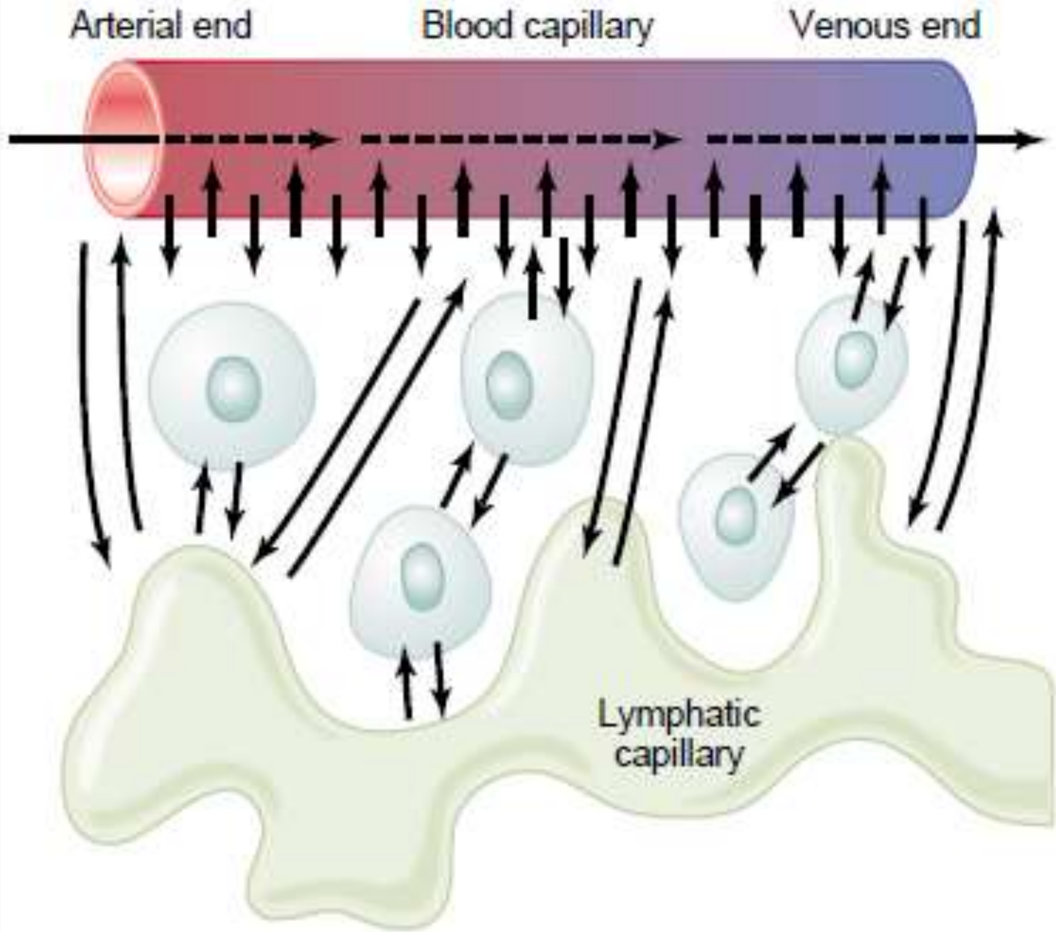


Figure 16–3

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

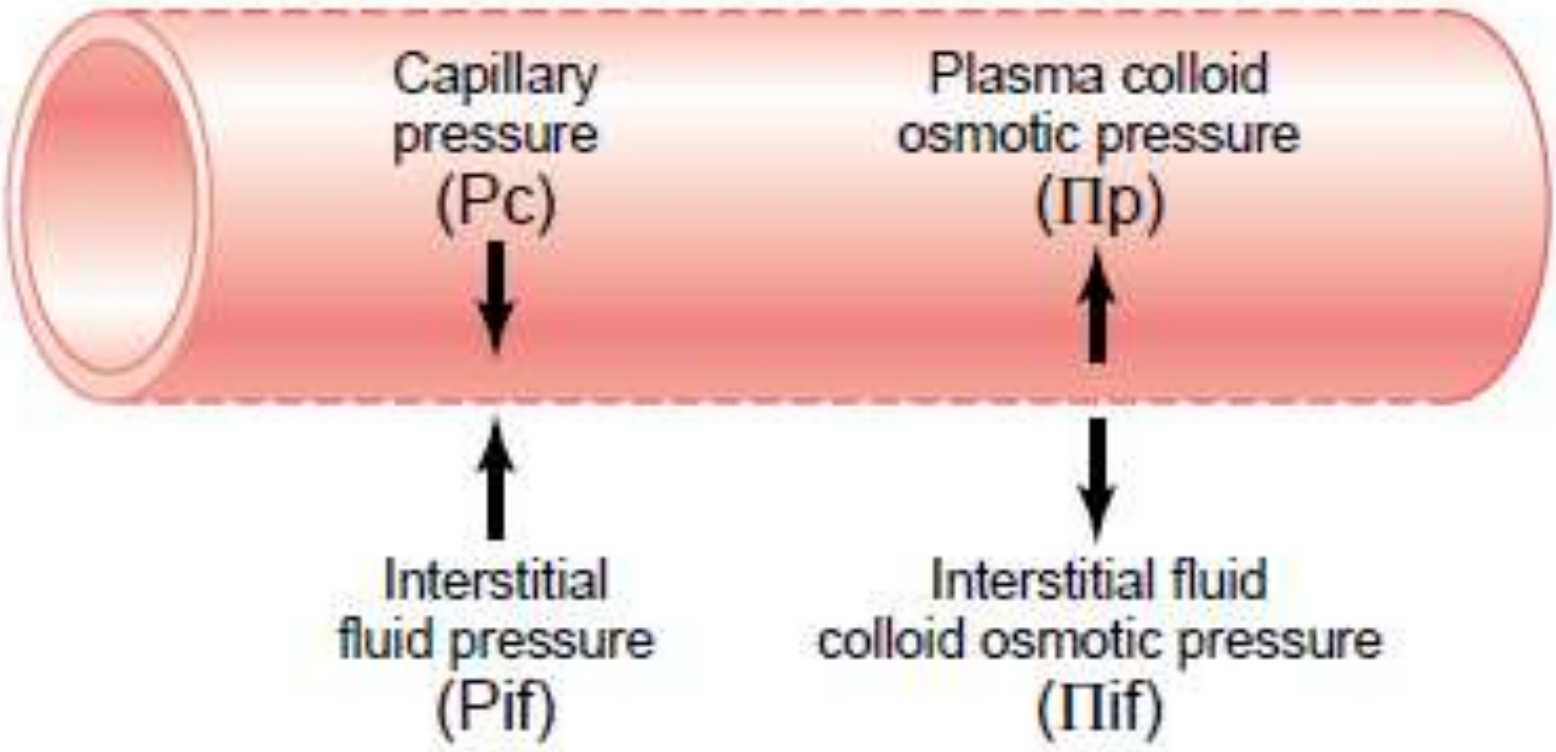
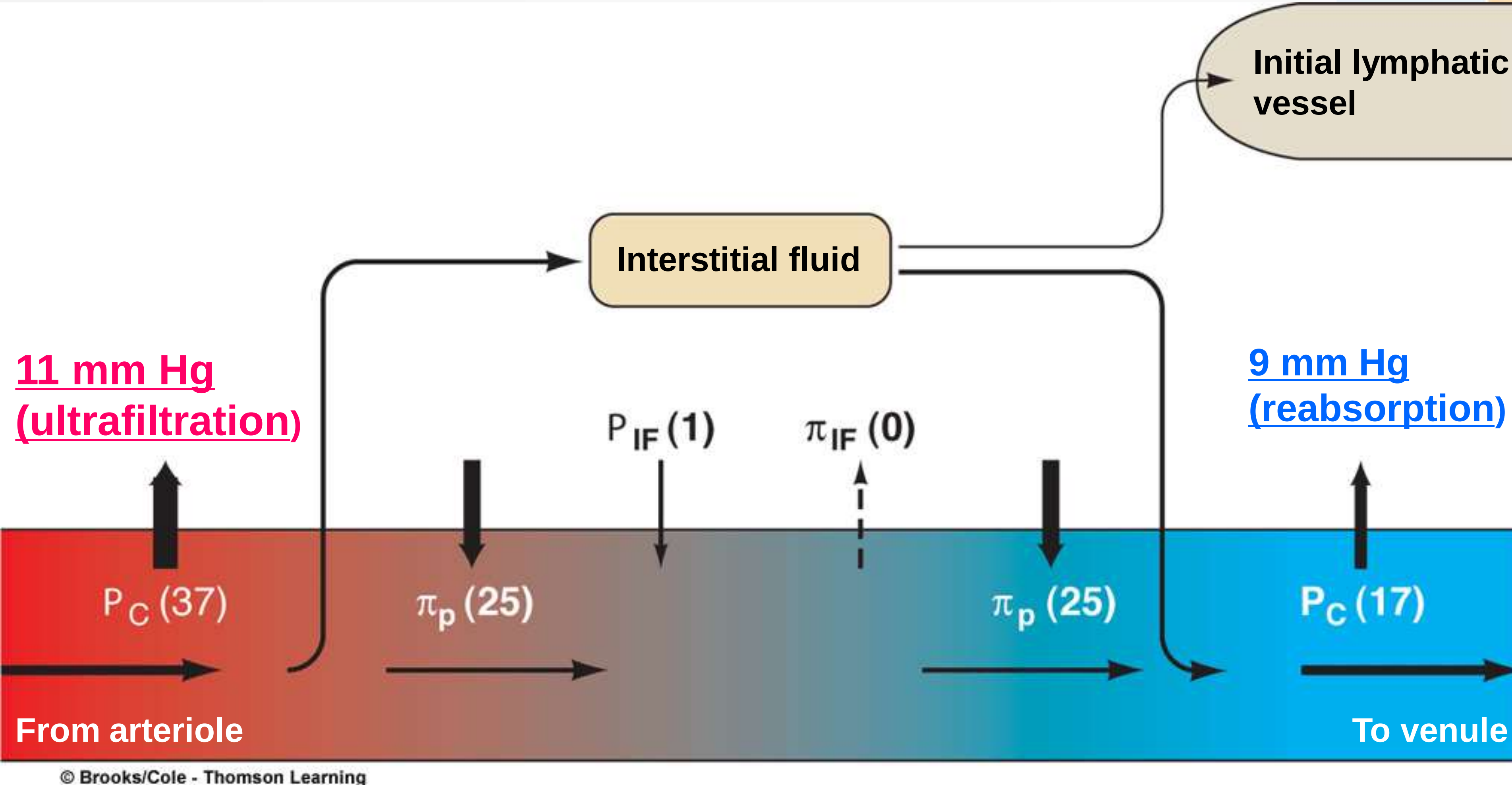


Figure 16–5

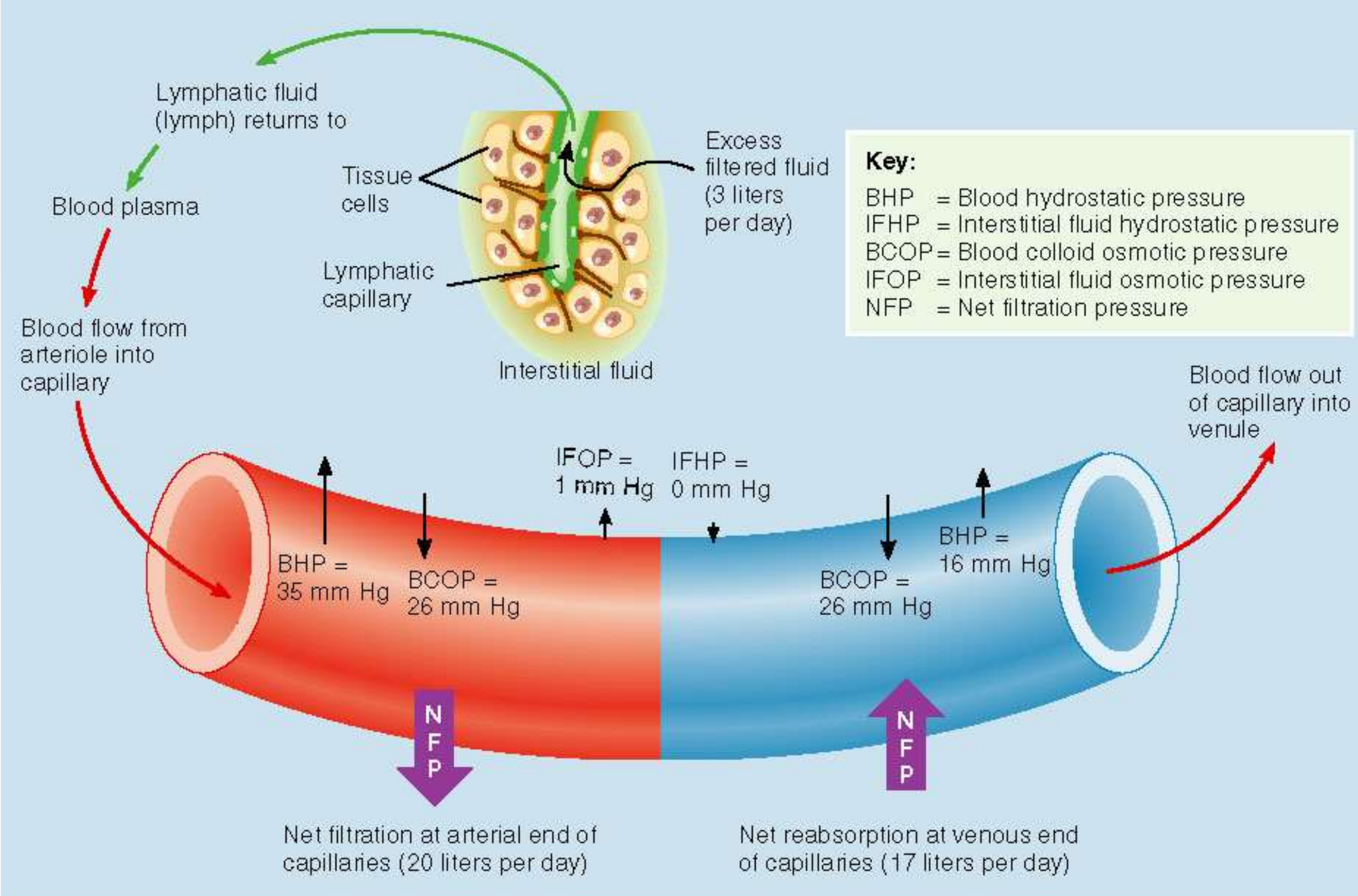
Fluid pressure and colloid osmotic pressure forces operate at the capillary membrane, tending to move fluid either outward or inward through the membrane pores.



Blood capillary

(See next slide)

Fig. 10-18 (middle), p. 294



Net filtration pressure (NFP) = (BHP + IFOP) – (BCOP + IFHP)

Pressures promoting filtration — Pressures promoting reabsorption

	Arterial end	Venous end
	NFP = (35 + 1) – (26 + 0) = 10 mm Hg	NFP = (16 + 1) – (26 + 0) = – 9 mm Hg
Result	Net filtration	Net reabsorption

21.07

Forces at arteriolar end of capillary

- **Outward pressure**

P_C	37
π_{IF}	0
	37

- **Inward pressure**

π_P	25
P_{IF}	1
	26

Net outward pressure of 11 mm Hg = Ultrafiltration pressure

(See next slide)

All values are given in mm Hg.

Fig. 10-18 (left), p. 294

Forces at venular end of capillary

- **Outward pressure**

P_C	17
π_{IF}	0
	17

- **Inward pressure**

π_P	25
P_{IF}	1
	26

Net inward pressure of 9 mm Hg = Reabsorption pressure

Fig. 10-18 (right), p. 294

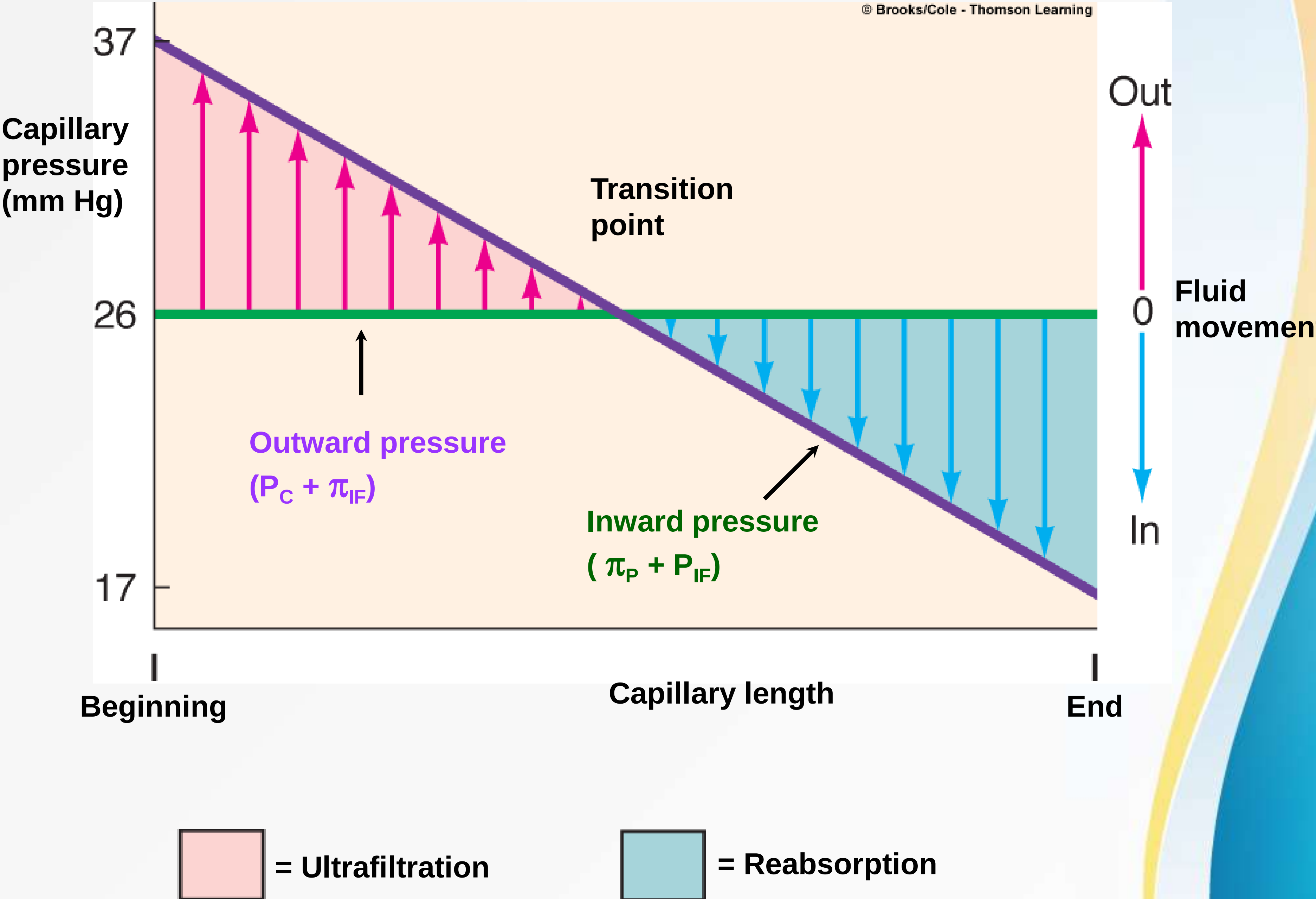
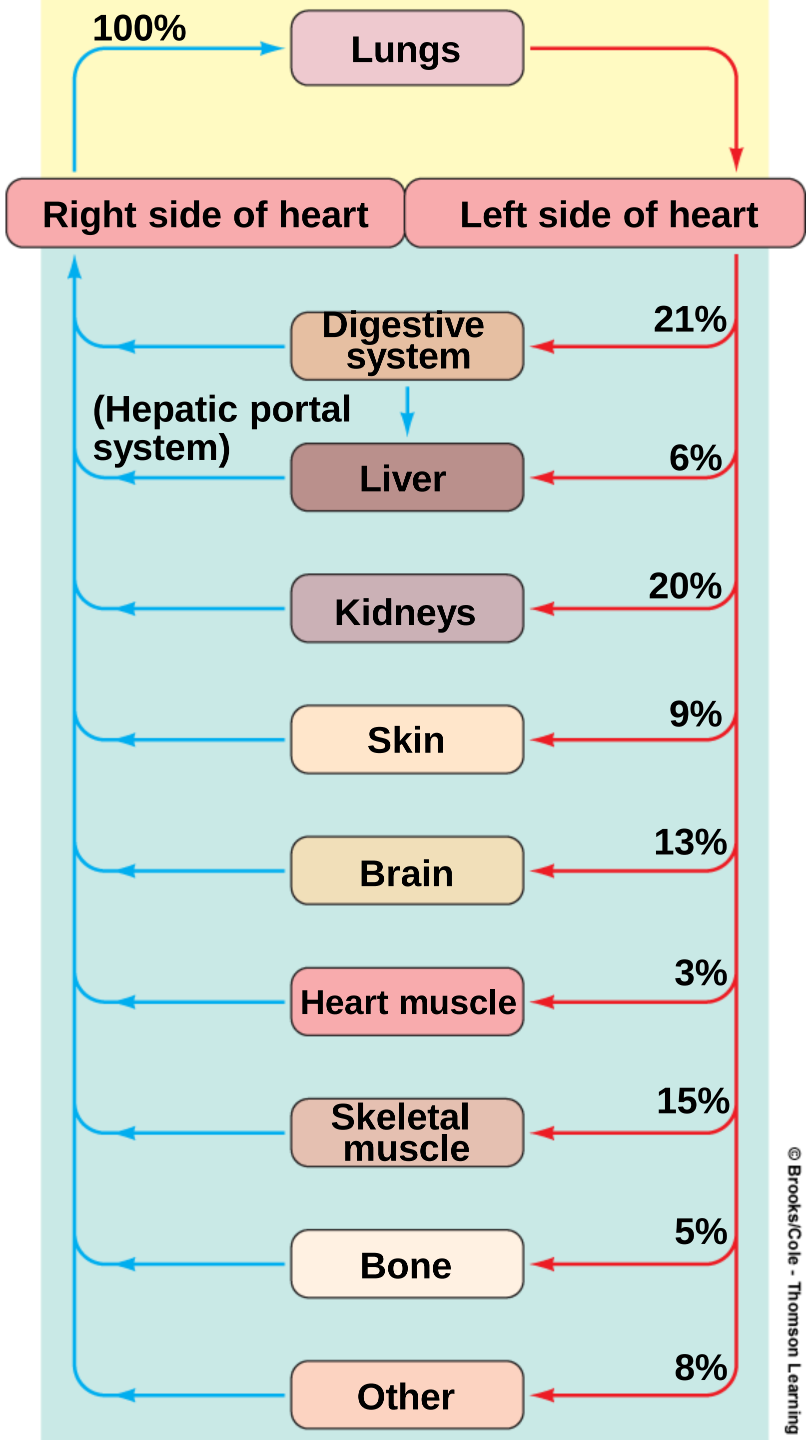


Fig. 10-19, p. 295



100%
Lungs
Right side of heart
Left side of heart
21%
Digestive system
(Hepatic portal system)
6%
Liver
20%
Kidneys
9%
Skin
13%
Brain
3%
Heart muscle
15%
Skeletal muscle
5%
Bone
8%
Other

Fig. 10-1, p. 276

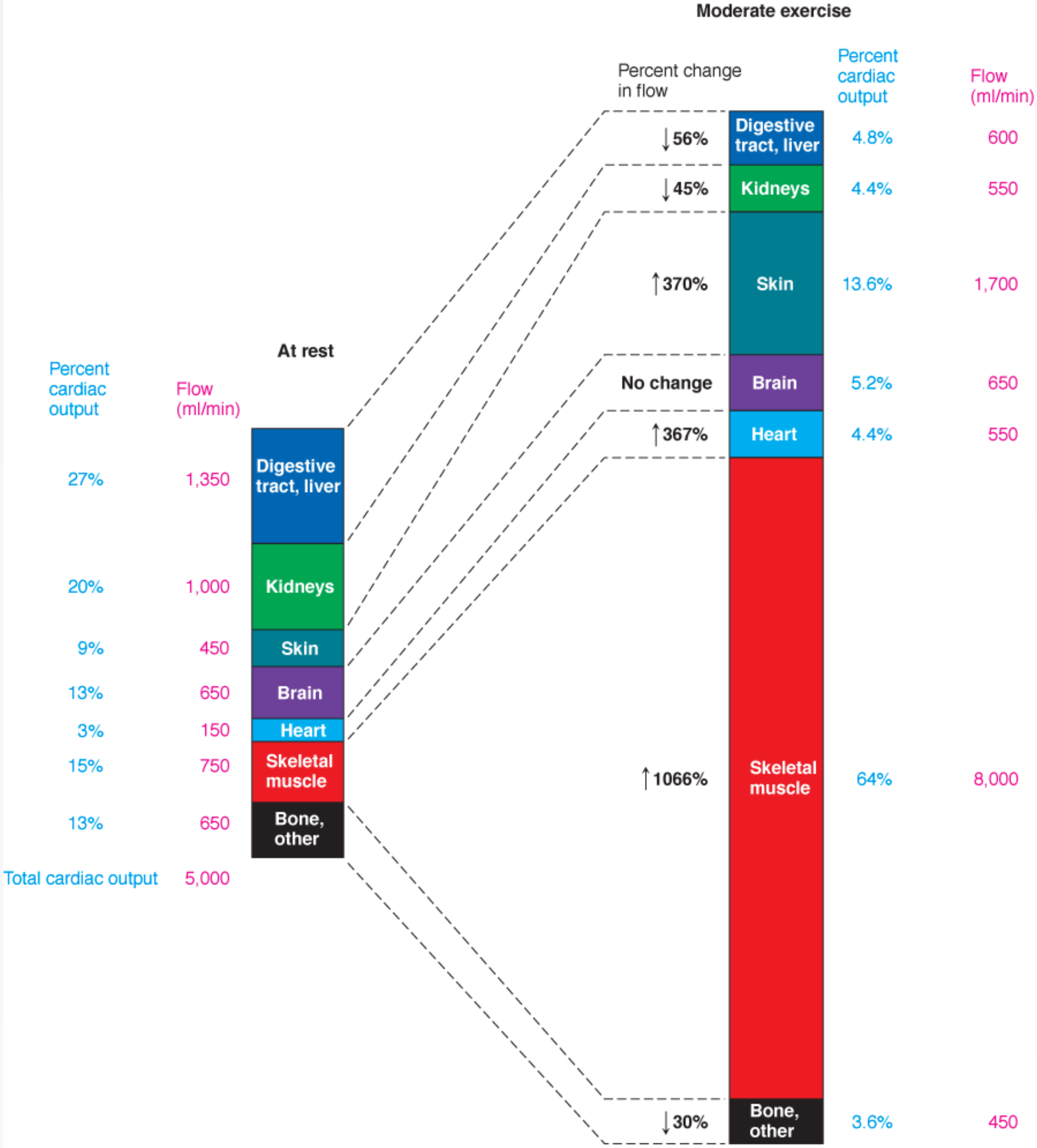


Fig. 10-11, p. 286

Determinants of Blood Flow

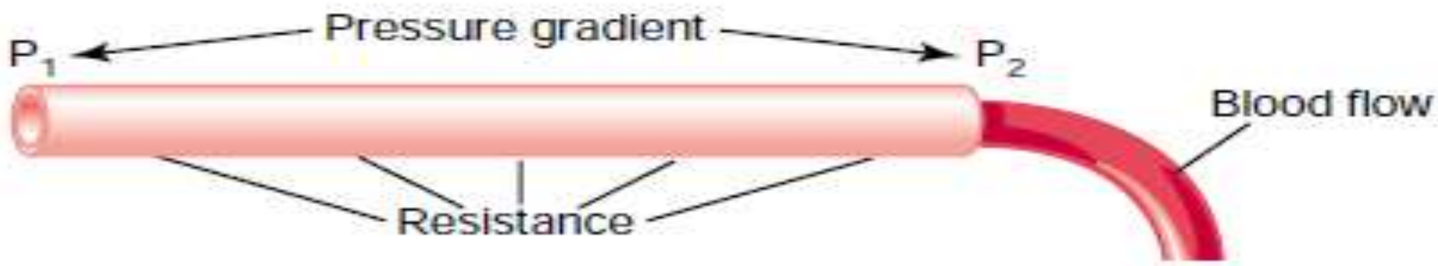
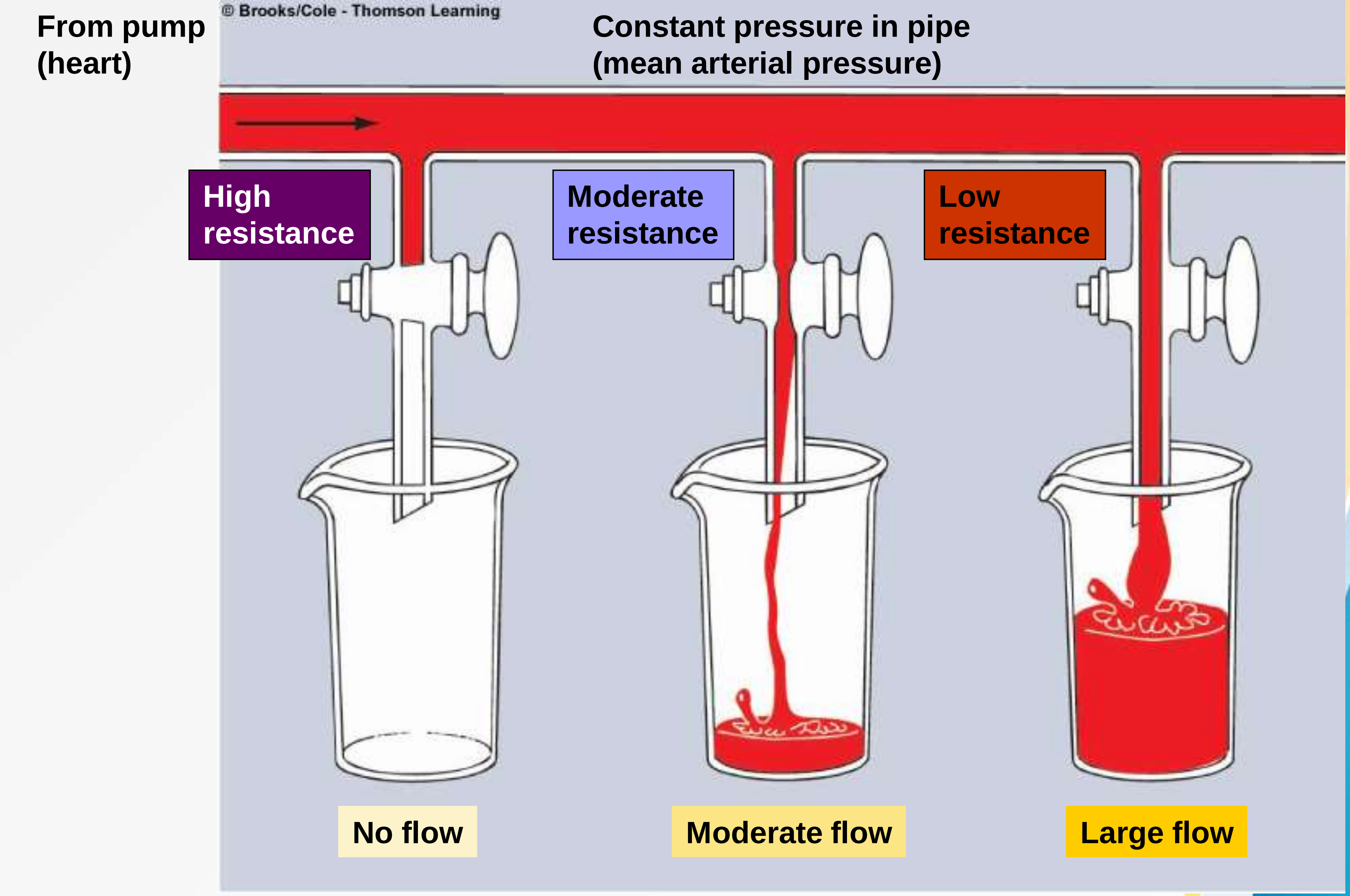


Figure 14–3

Interrelationships among pressure, resistance, and blood flow.

- Blood flow is determined by pressure gradient and peripheral resistance, therefore: $F = \frac{(P_A - P_V)}{R}$
- Arterioles play a major role in blood distribution & control of BP.
- Arteriolar smooth muscles determine the resistance to blood flow to the tissues it supplies.

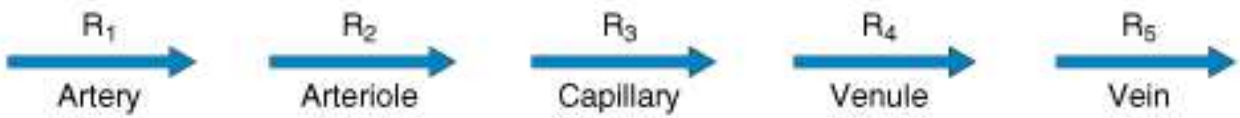


Control valves = Arterioles

Fig. 10-10, p. 285

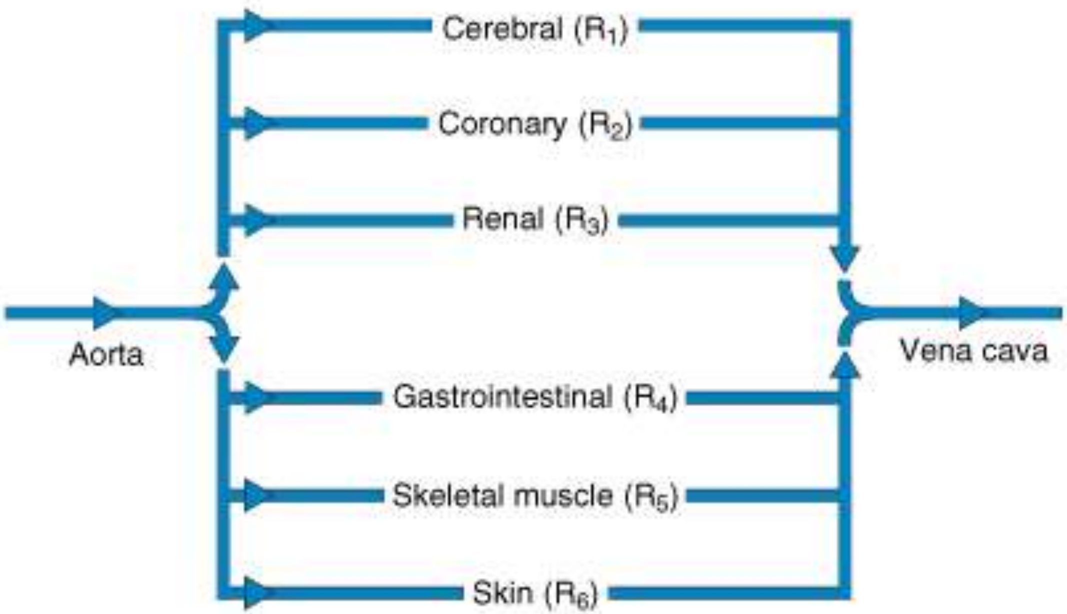
SERIES RESISTANCES

$$R_{total} = R_1 + R_2 + R_3 + R_4 + R_5$$



PARALLEL RESISTANCES

$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5} + \frac{1}{R_6}$$



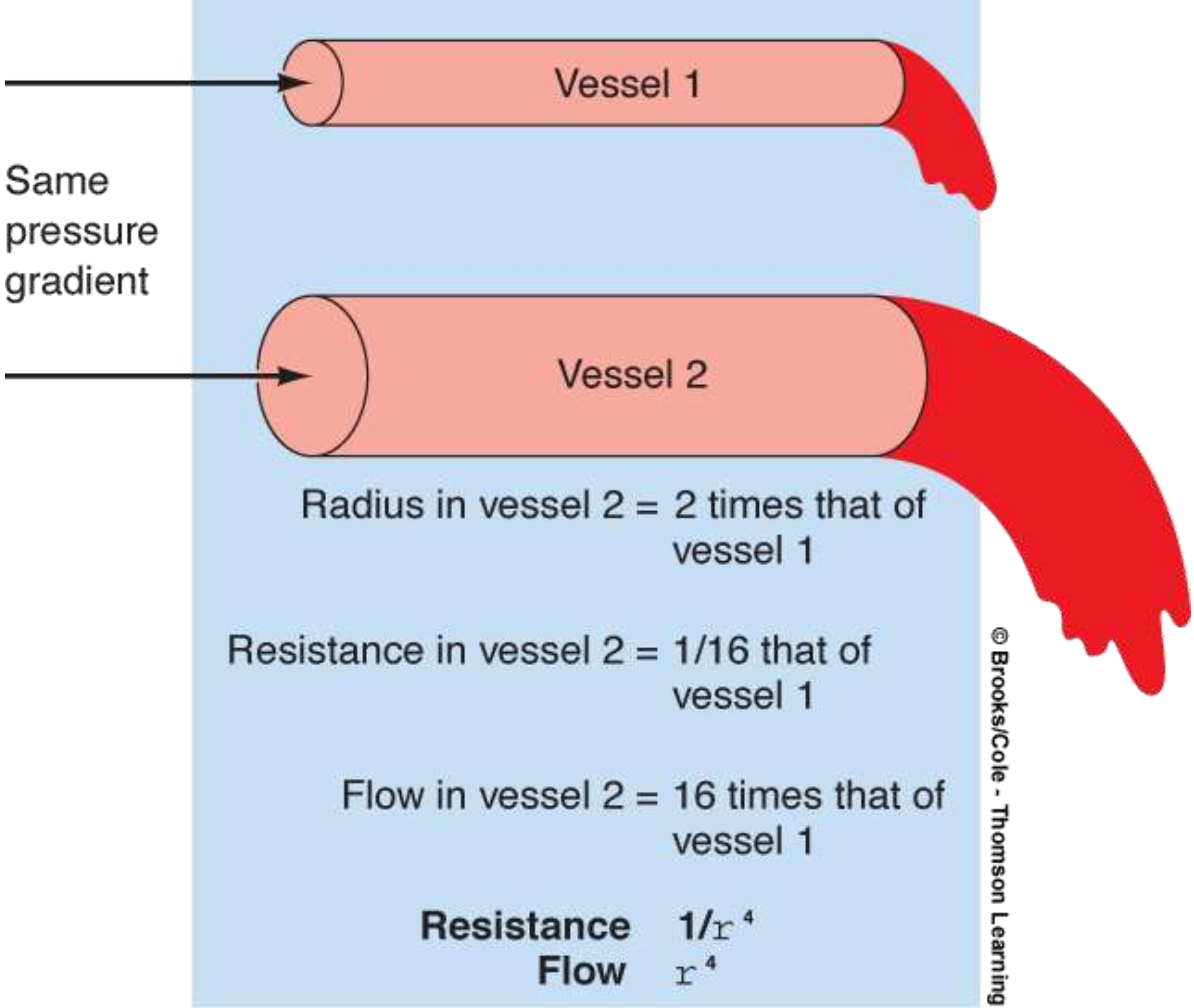
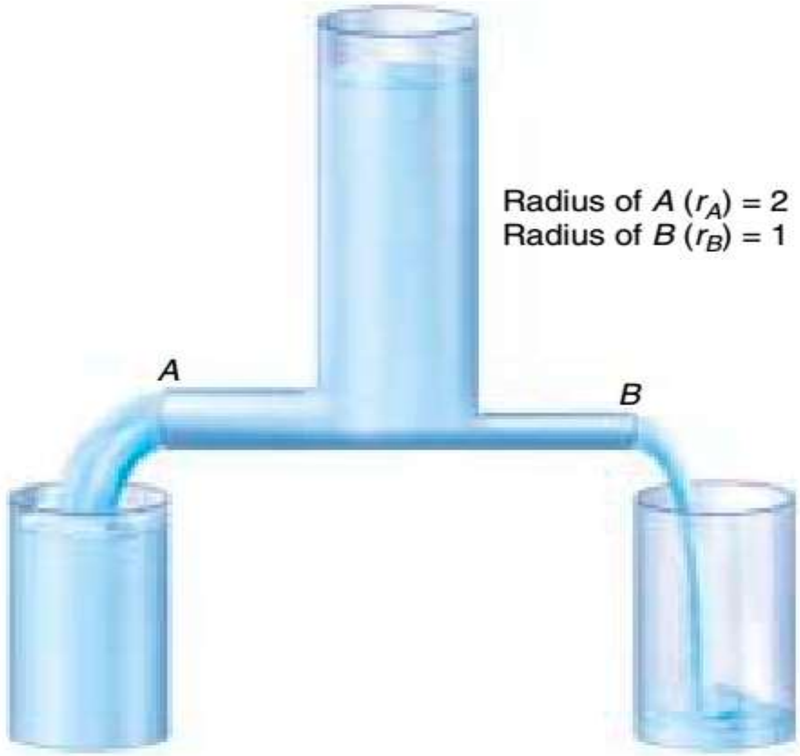


Fig. 10-3b, p. 278



$$R \propto \frac{1}{r^4}$$

$$R_A \propto \frac{1}{(r_A)^4} = \frac{1}{2^4} = \frac{1}{16} = 0.0625$$

$$R_B \propto \frac{1}{(r_B)^4} = \frac{1}{1^4} = \frac{1}{1} = 1.0$$

Therefore $R_B = 16\ R_A$

$$\text{Flow} = \frac{\Delta P}{R}$$

Therefore flow in $B = \frac{1}{16}$ th of flow in A

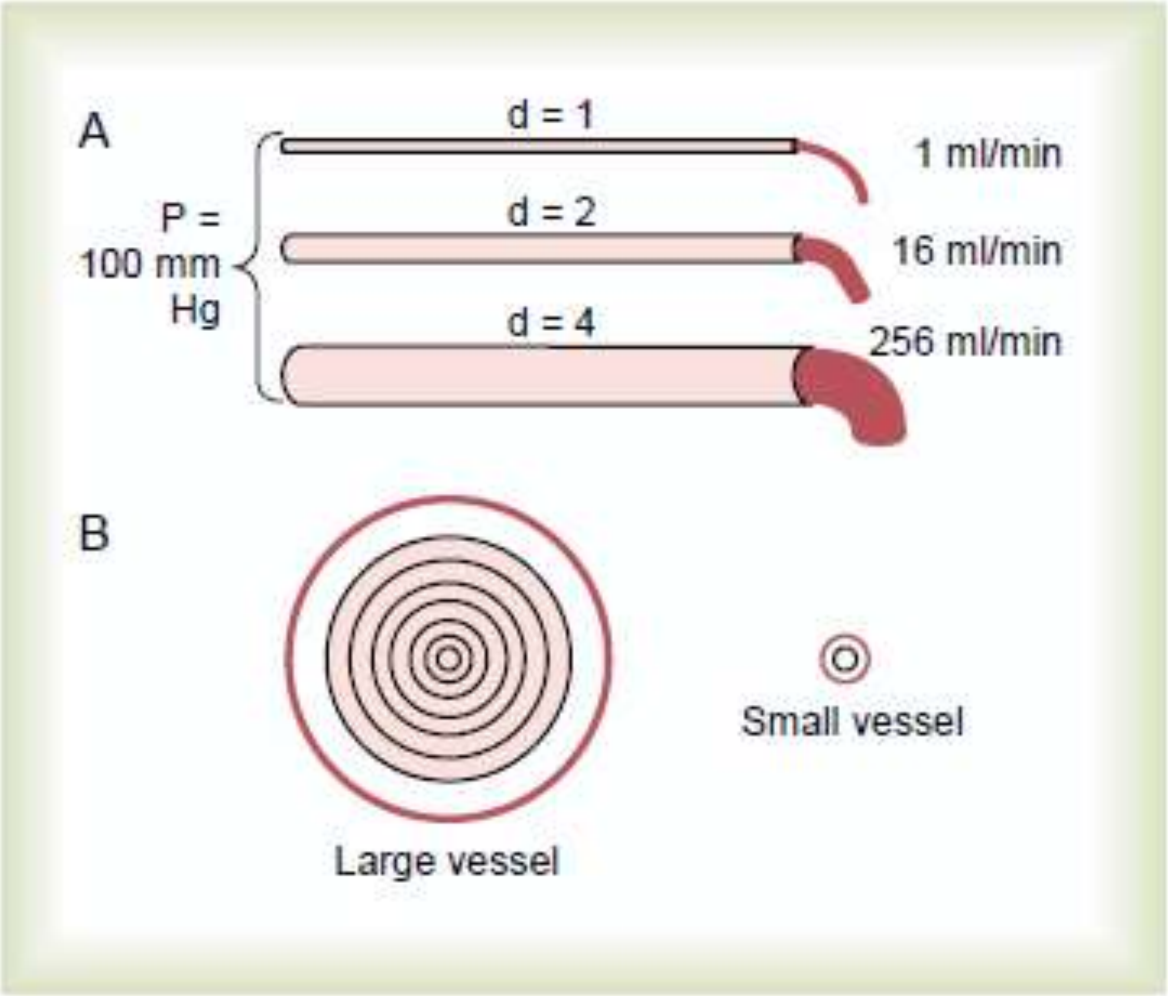


Figure 14–9

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.

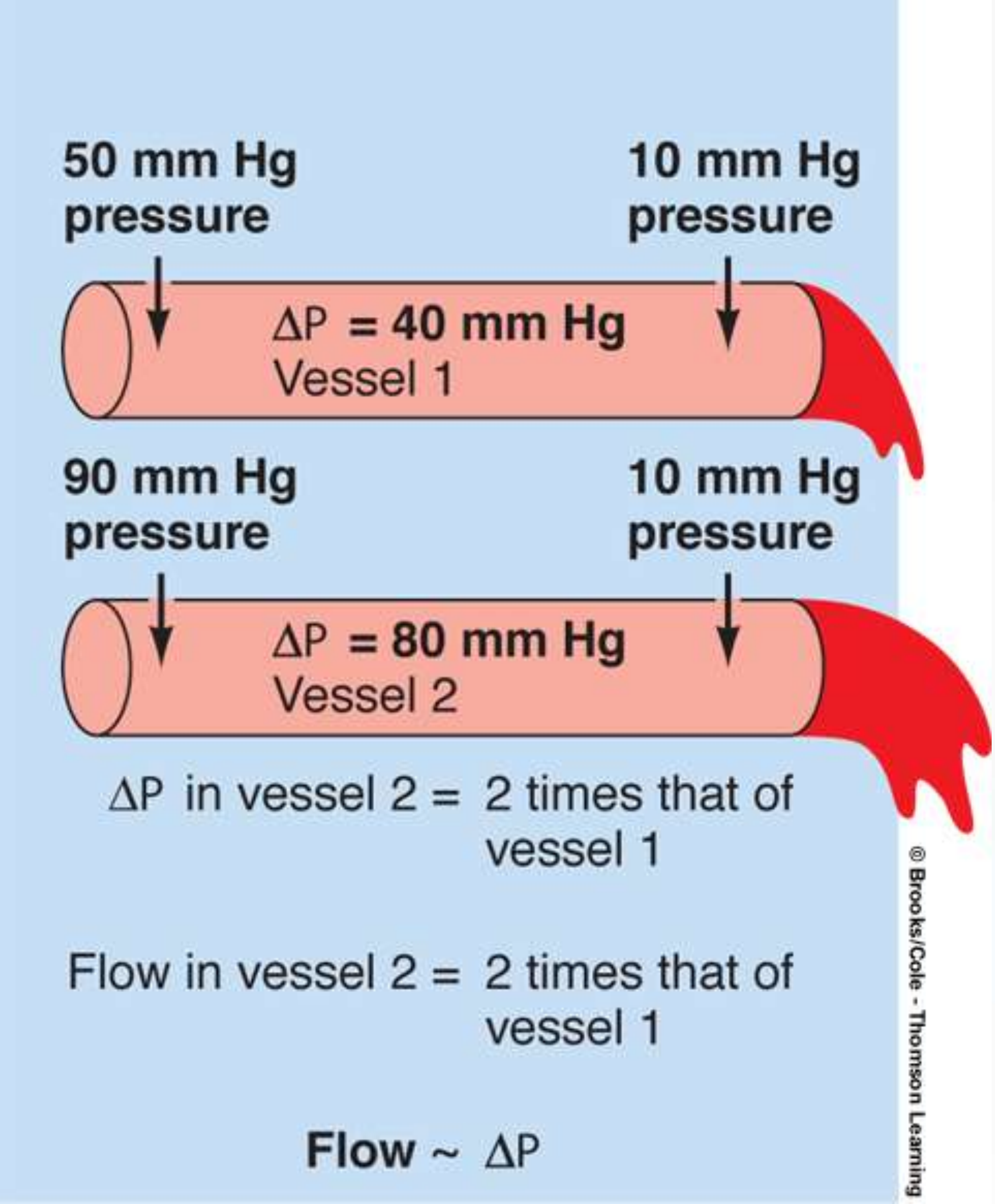


Fig. 10-2a, p. 277

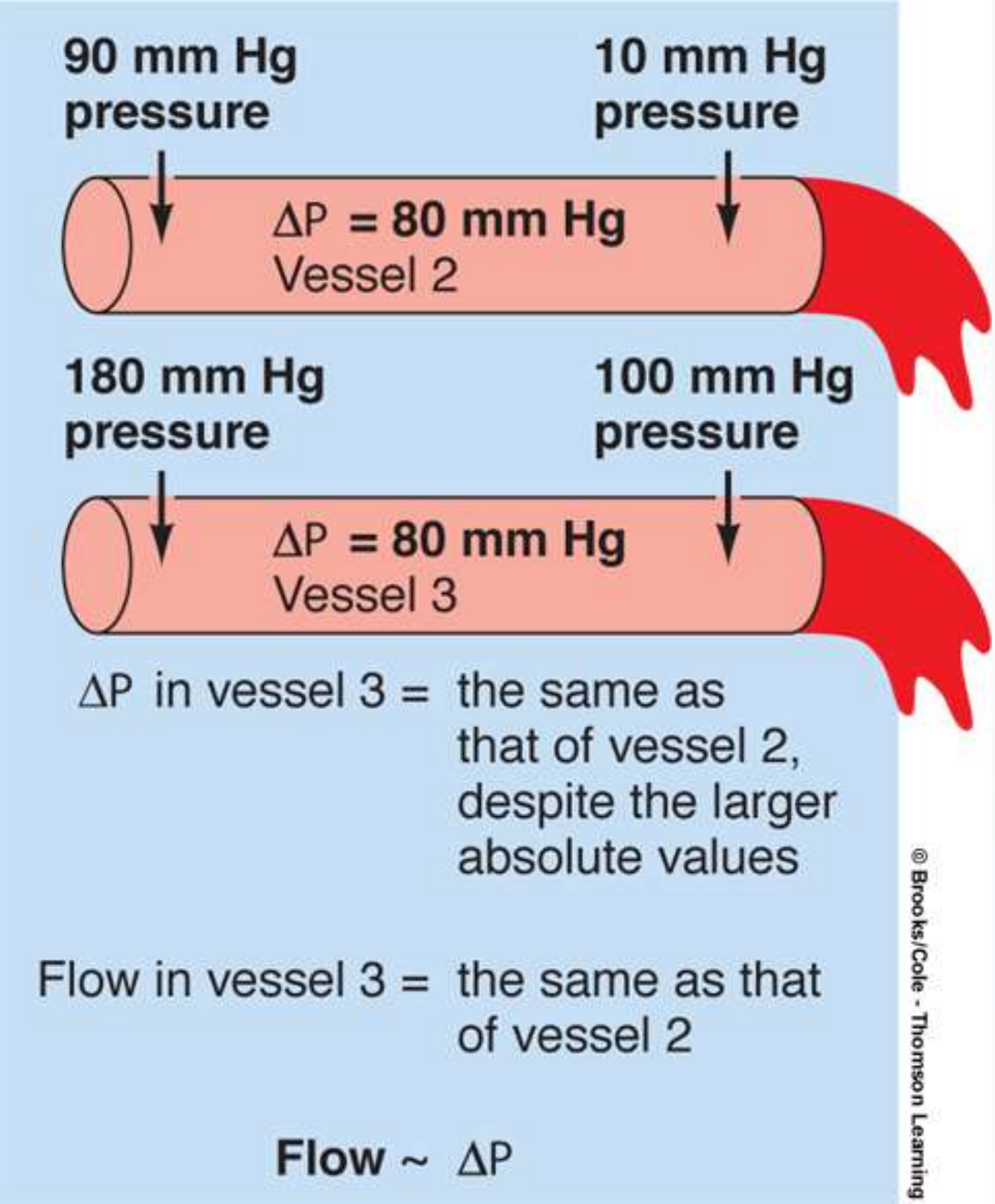


Fig. 10-2b, p. 277

$$F = \frac{\Delta P}{R}$$

Since **R**esistance α 1/r4 (radius to power 4)…r = radius

R inversely proportional to r4

Therefore **F = ΔP x r4**

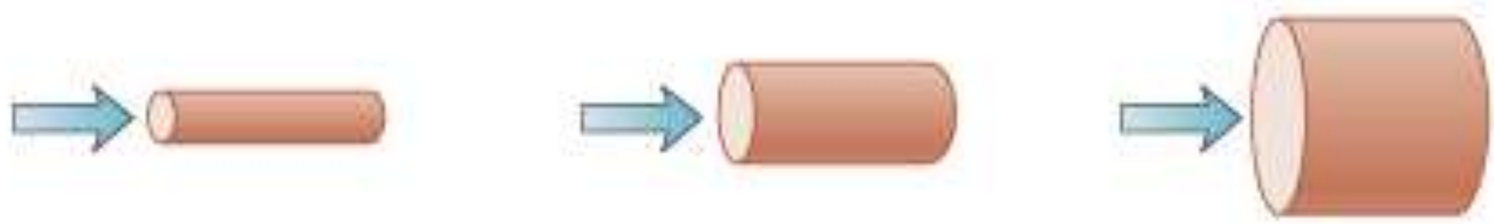
Hence: If the **radius is doubled** the **flow will increase by 16 times**

The relationship between velocity, flow and cross sectional area

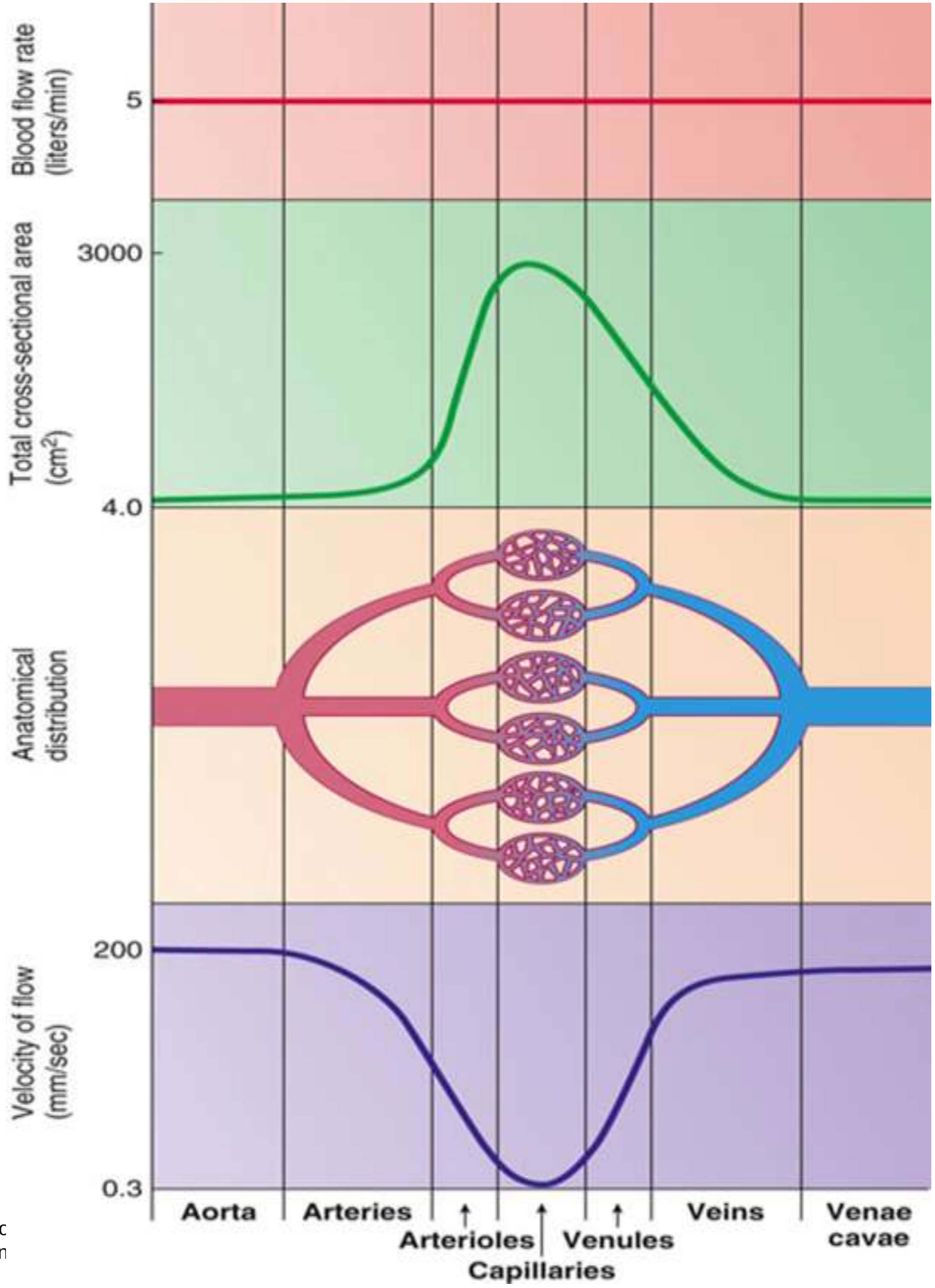
V = velocity cm/sec, Q = flow ml/sec, A = cross sectional area

$$v = Q/A$$

10 mL/sec



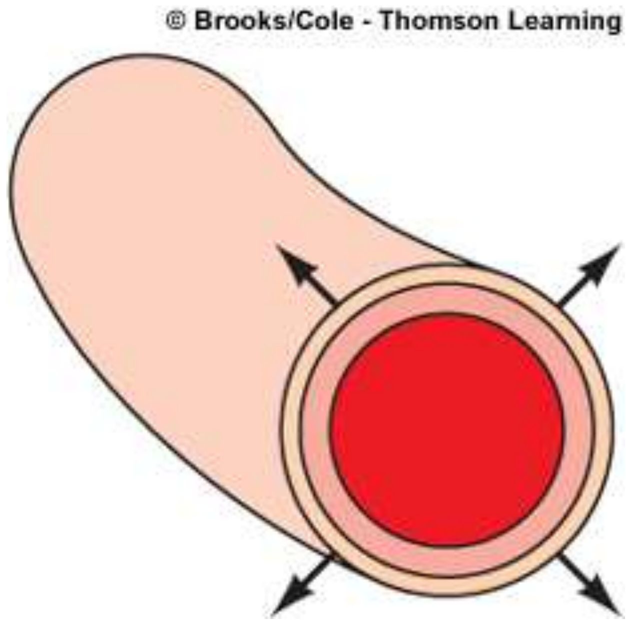
Area (A)	1 cm^2	10 cm^2	100 cm^2
Flow (Q)	10 mL/sec	10 mL/sec	10 mL/sec
Velocity (v)	**10 cm/sec**	**1 cm/sec**	**0.1 cm/sec**



Chapter 9 Cardiac Physiology
Human Physiology by Lauralee Sherwc

Vasodilation

(decreased contraction of circular smooth muscle in the arteriolar wall, which leads to decreased resistance and increased flow through the vessel)



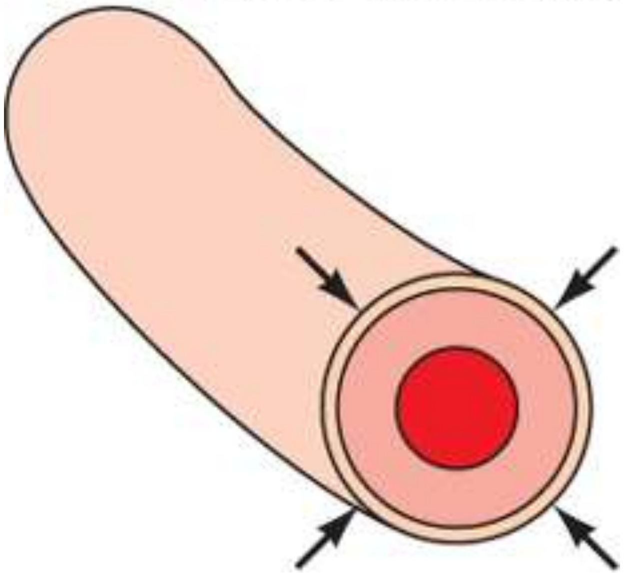
Caused by:

- ↓ Myogenic activity
- ↓ Oxygen (O_2)
- ↑ Carbon dioxide (CO_2) and other metabolites
- ↑ Nitric oxide
- ↓ Sympathetic stimulation
- Histamine release
- Heat

Fig. 10-9d, p. 284

Vasoconstriction

(increased contraction of circular smooth muscle in the arteriolar wall, which leads to increased resistance and decreased flow through the vessel)



Caused by:

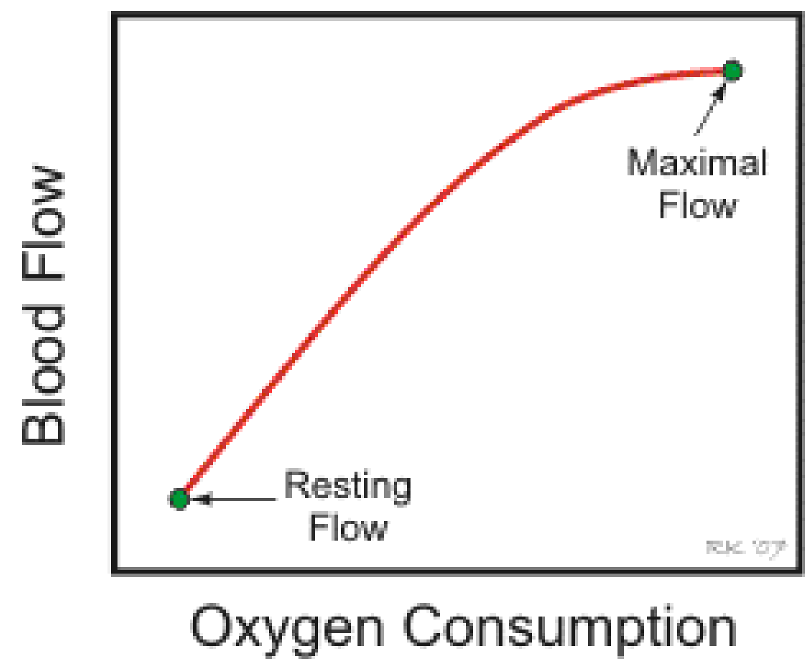
- ↑ Myogenic activity
- ↑ Oxygen (O_2)
- ↓ Carbon dioxide (CO_2) and other metabolites
- ↑ Endothelin
- ↑ Sympathetic stimulation
- Vasopressin; angiotensin II
- Cold

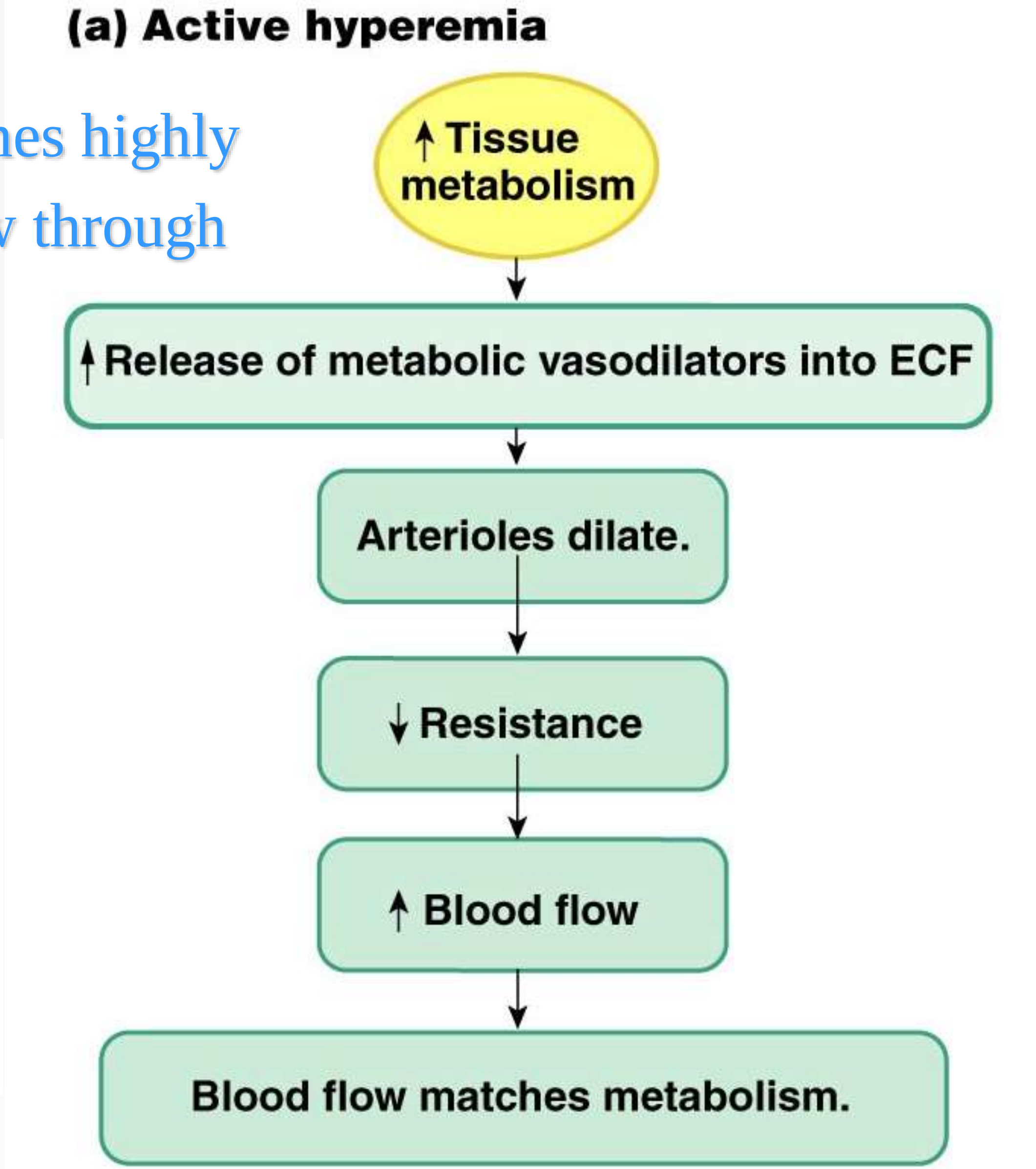
Fig. 10-9c, p. 284

Neural Regulation

Active Hyperemia (Metabolic activity)

- When a certain tissue becomes highly active, the rate of blood flow through the tissue increases.

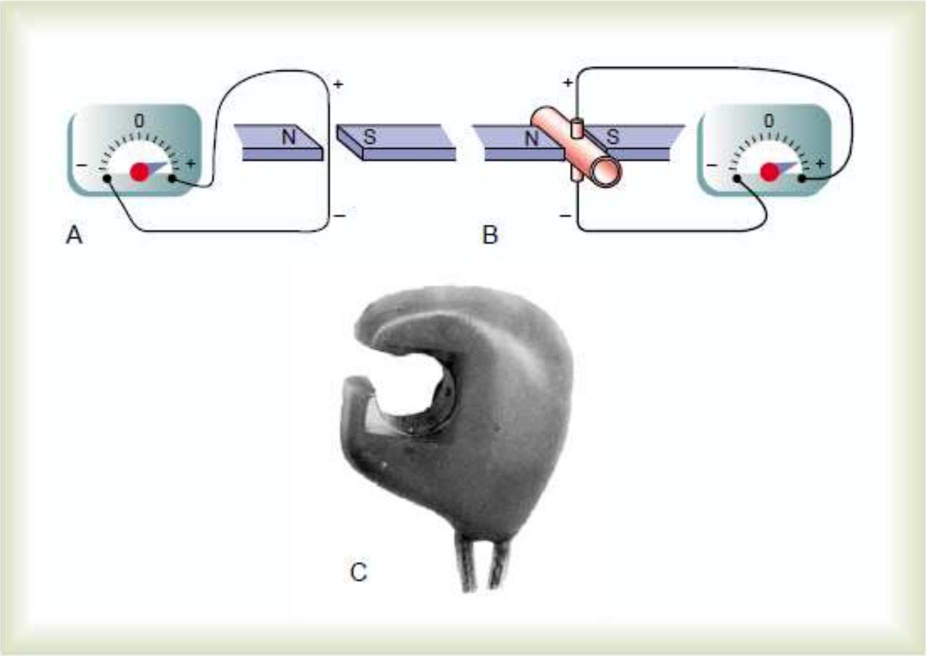




End of lecture

Electro-magnetic flow meter - doppler

to measure blood flow in blood vessels



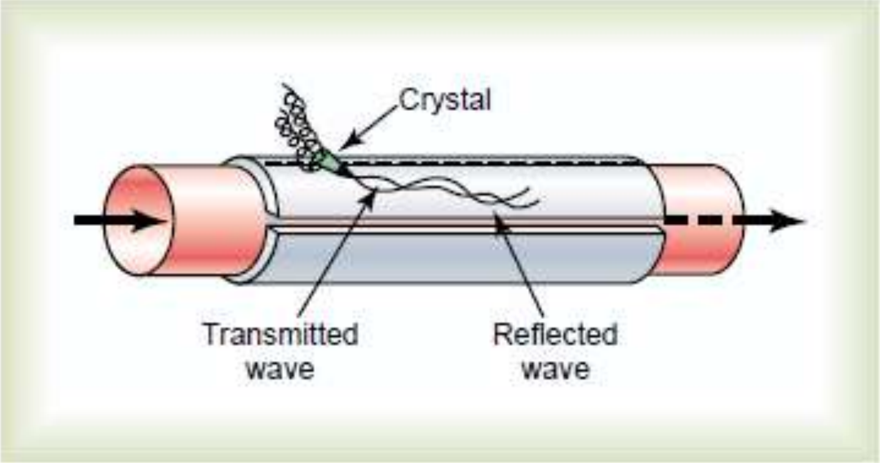
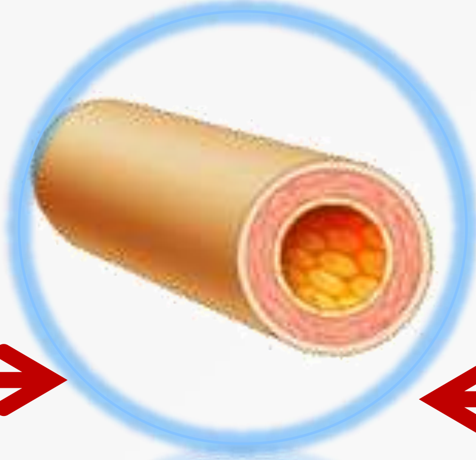


Figure 14–5

Ultrasonic Doppler flowmeter.

Control of blood flow

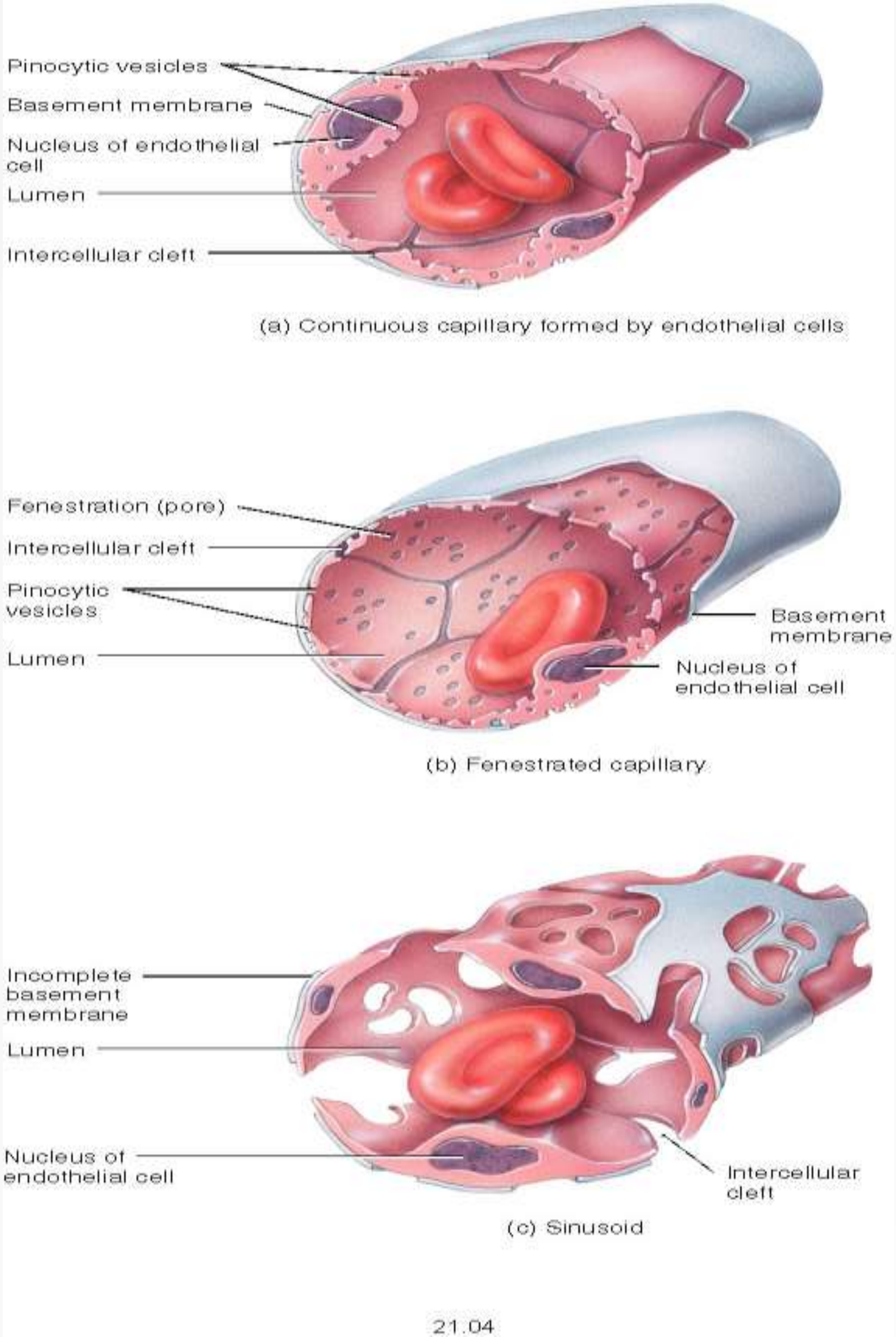


Local (intrinsic) control
- Myogenic response.
- Metabolic response.
- Endothelial response.
- Humoral mechanisms.

Extrinsic control
- Neural mechanisms.
- Humoral mechanisms

Blood flow to capillaries is controlled by caliber of arterioles.

In kidney


Pinocytic vesicles
Basement membrane
Nucleus of endothelial cell
Lumen
Intercellular cleft
(a) Continuous capillary formed by endothelial cells
Fenestration (pore)
Intercellular cleft
Pinocytic vesicles
Lumen
Basement membrane
Nucleus of endothelial cell
(b) Fenestrated capillary
Incomplete basement membrane
Lumen
Nucleus of endothelial cell
Intercellular cleft
(c) Sinusoid
21.04