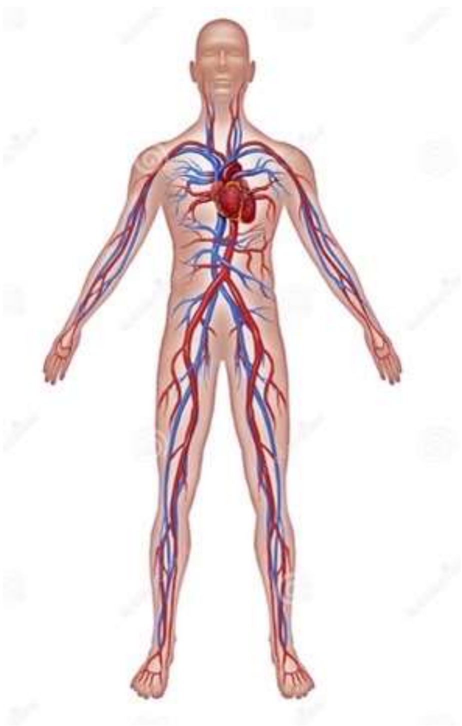
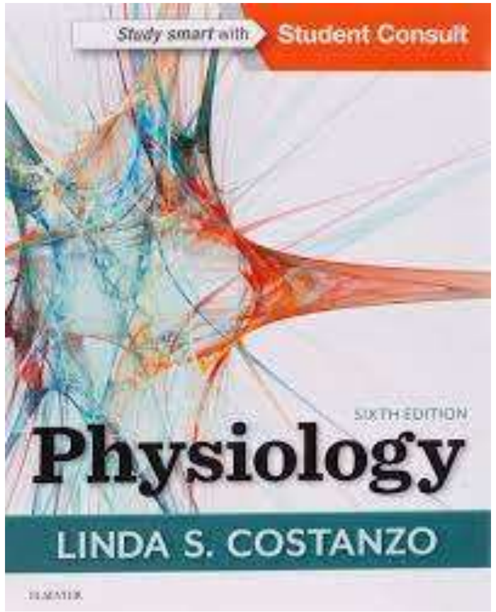
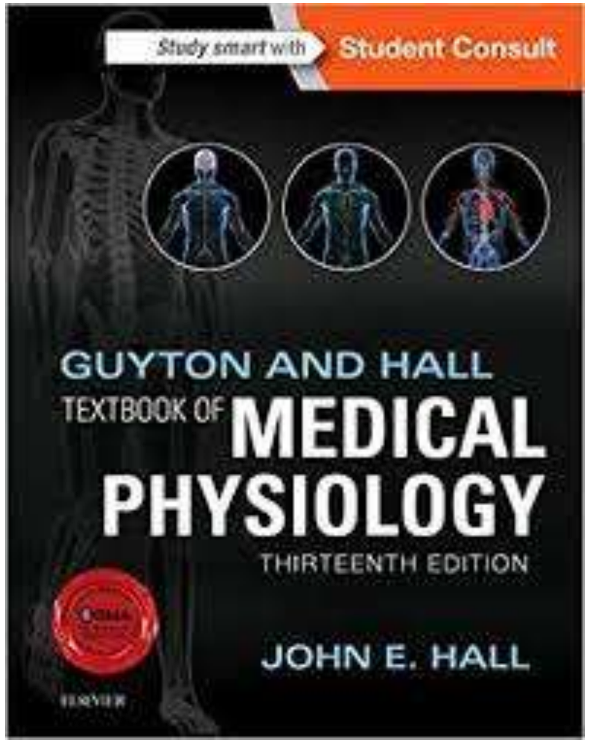
Vascular Physiology

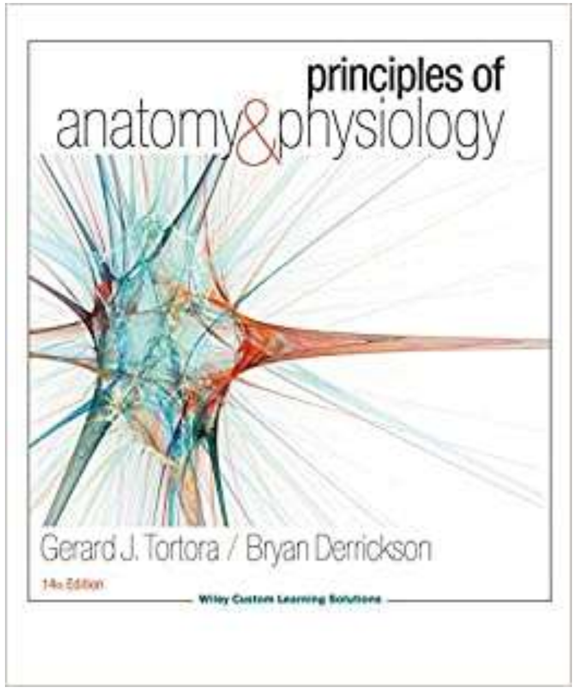
Fatima Ryalat, MD, PhD
Assistant Professor, Physiology and Biochemistry Department
School of Medicine, The University of Jordan



References


Study smart with
Student Consult
SIXTH EDITION
Physiology
LINDA S. COSTANZO
ELSEVIER

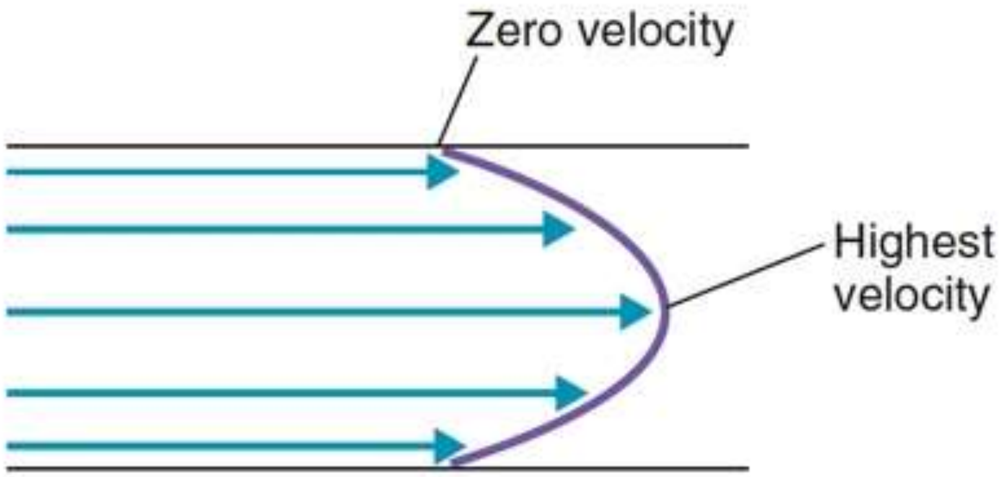

Study smart with
Student Consult
GUYTON AND HALL
TEXTBOOK OF MEDICAL PHYSIOLOGY
THIRTEENTH EDITION
JOHN E. HALL
ELSEVIER


principles of
anatomy&physiology
Gerard J. Tortora / Bryan Derrickson
14th Edition
Wiley Custom Learning Solutions

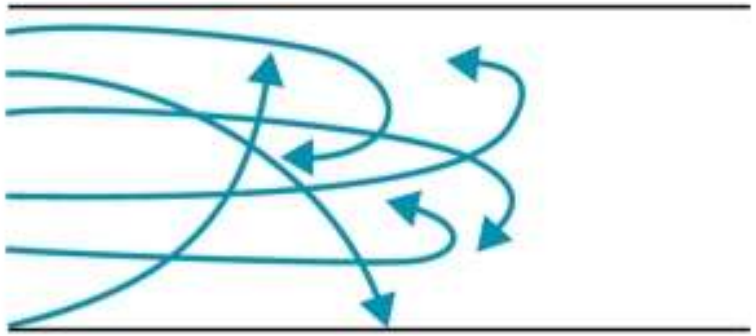

Human Physiology
From Cells to Systems
Lauralee Sherwood
CENGAGE Learning

Vascular hemodynamics-2

Laminar flow



Turbulent flow



Reynolds number

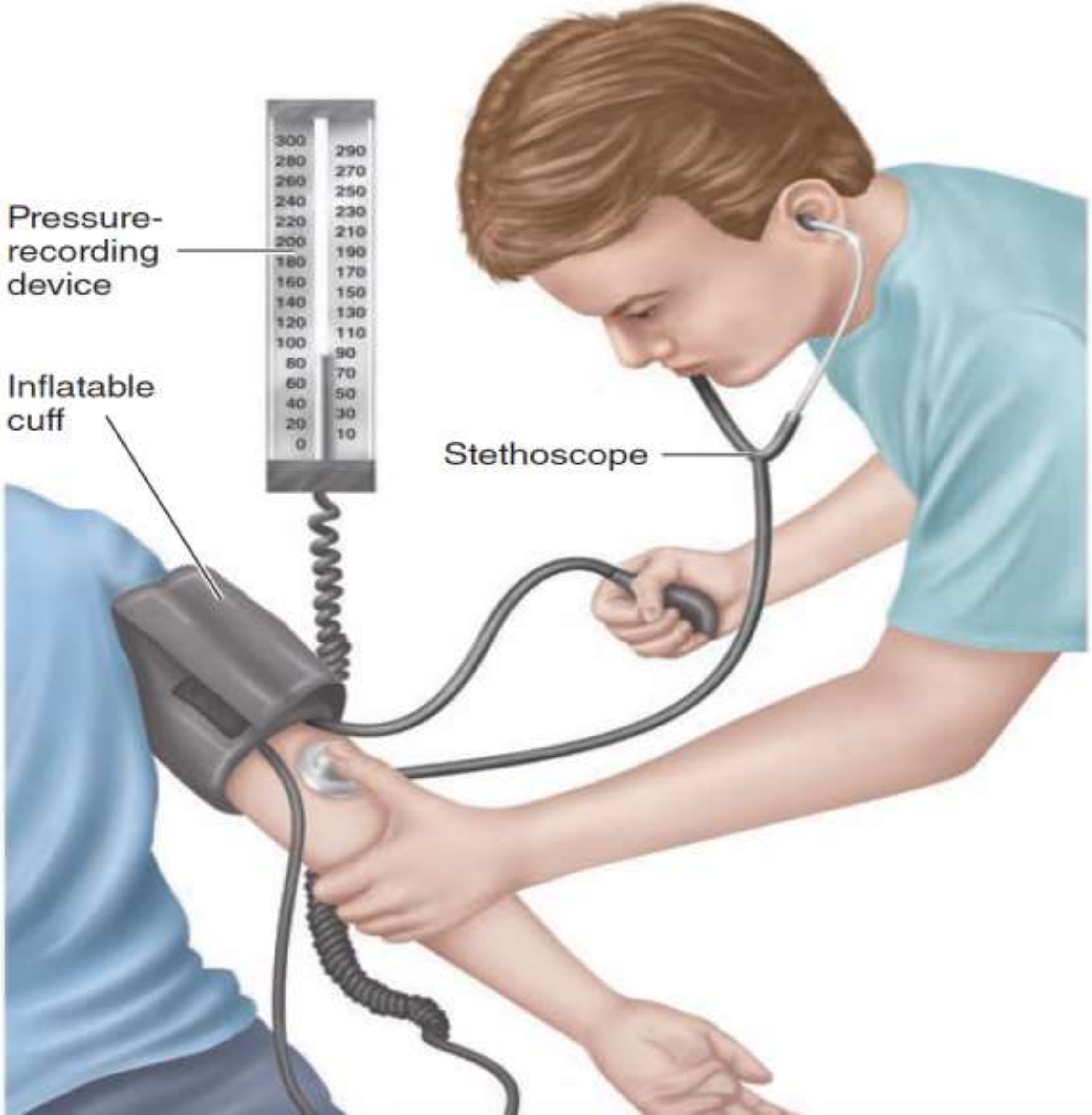
- Rn : Inertia / Friction

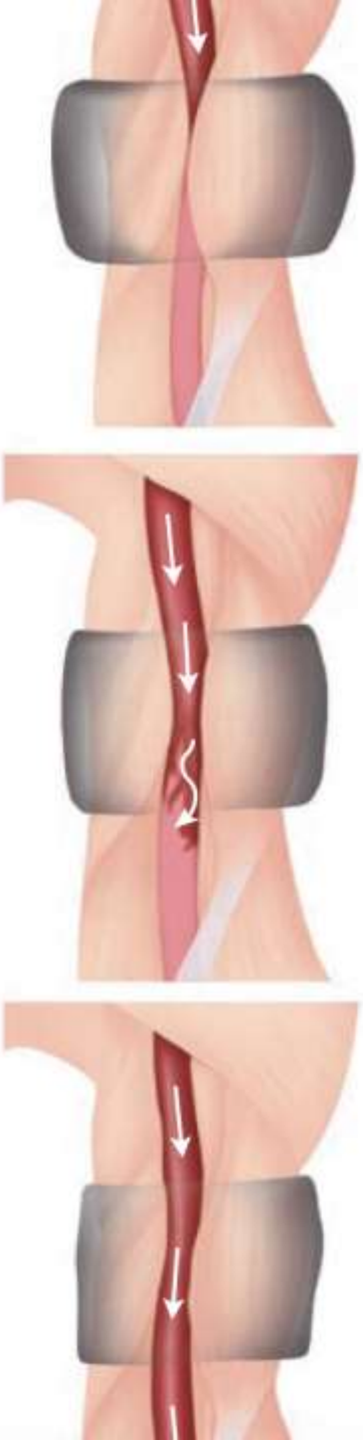
$$N_R = \frac{\rho d v}{\eta}$$

where

$$\begin{aligned} N_R &= \text{Reynolds number} \\ \rho &= \text{Density of blood} \\ d &= \text{Diameter of blood vessel} \\ v &= \text{Velocity of blood flow} \\ \eta &= \text{Viscosity of blood} \end{aligned}$$

Reynolds number





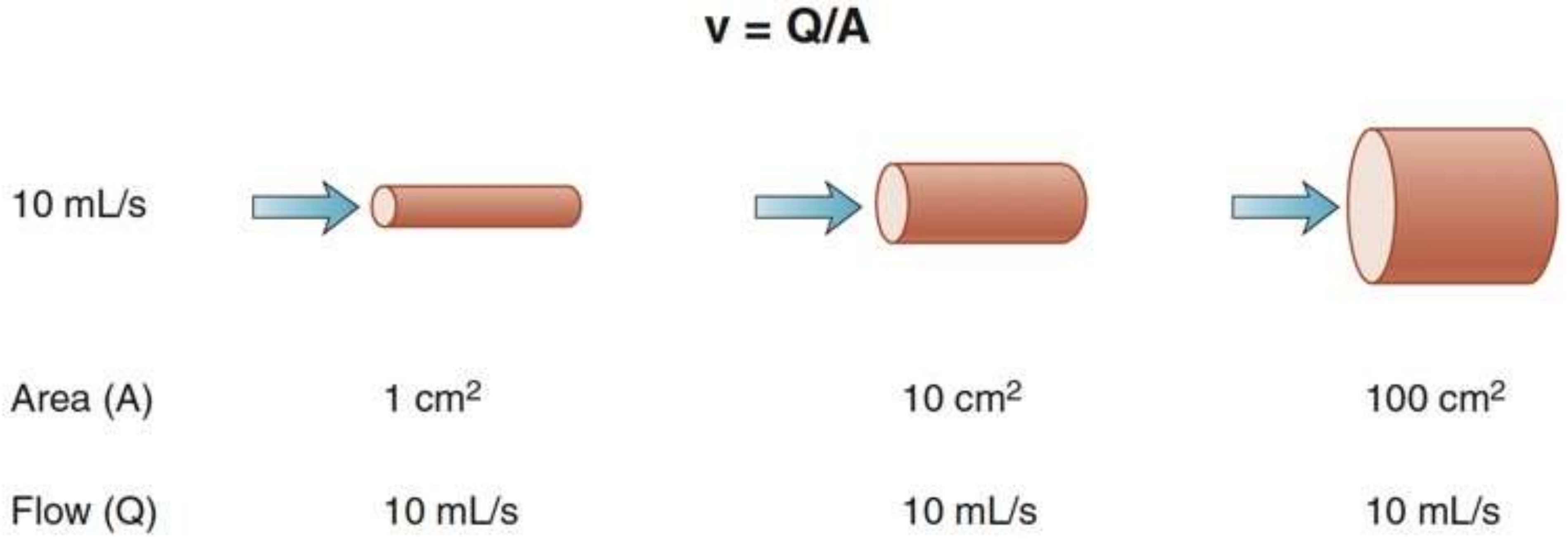
Sherwood textbook

Reynolds number clinical implications

- Anemia
- Polycythemia
- Pregnancy
- Thrombus
- Shock
- Stenosis
- Hyperthyroidism

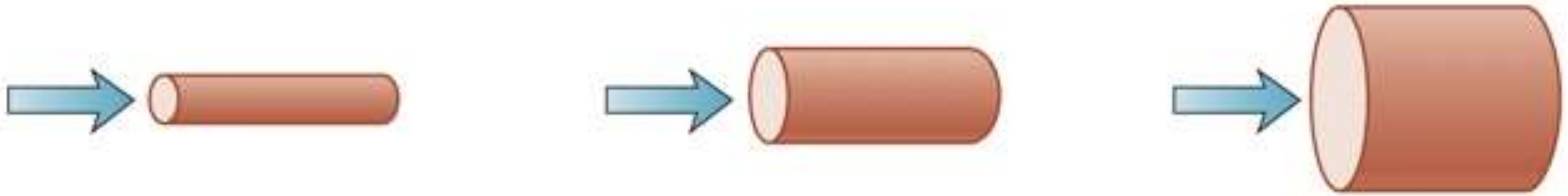
Velocity of blood flow

- $V = F/A$

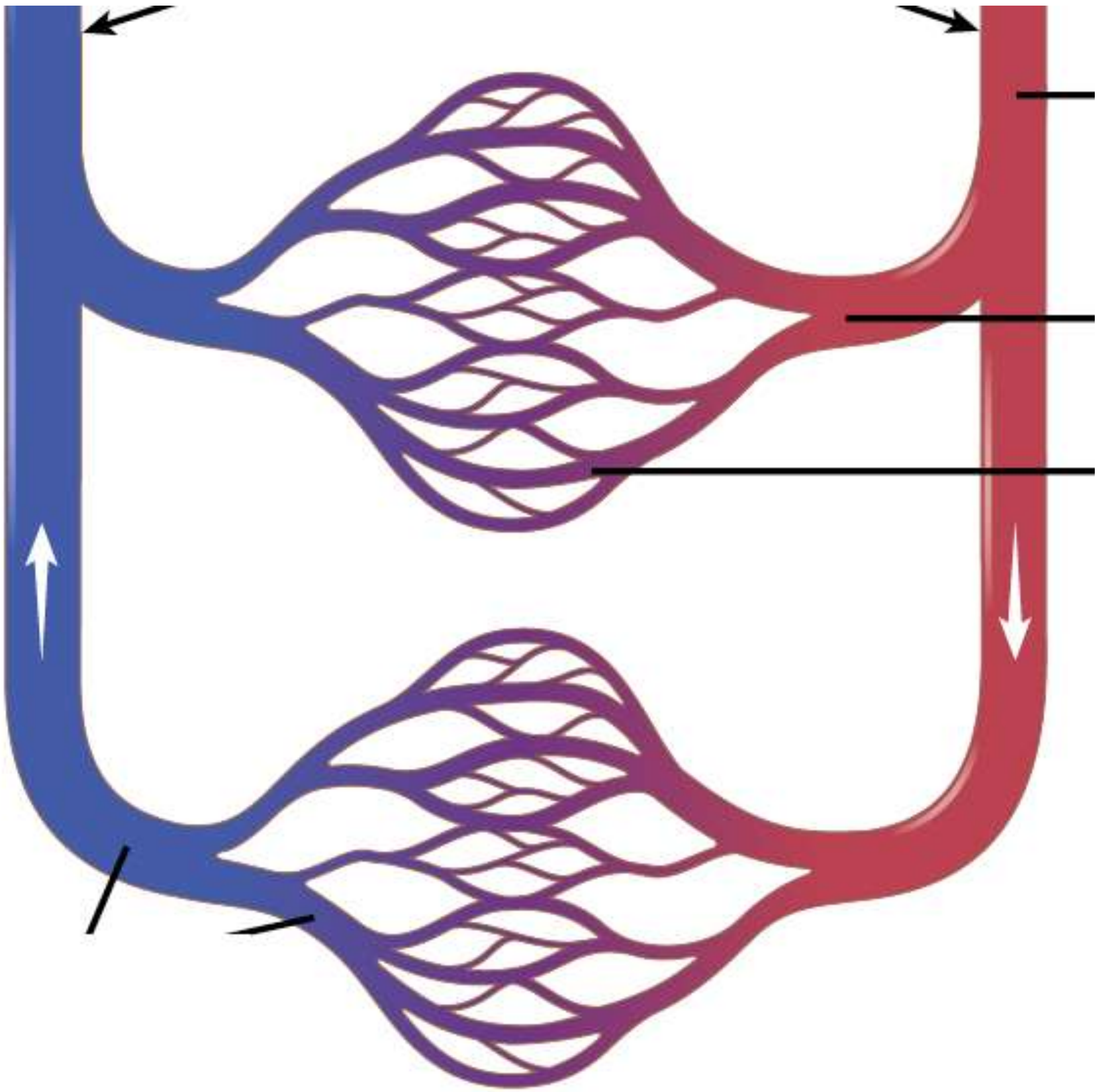

v = Q/A
10 mL/s
Area (A)
1 cm2
10 cm2
100 cm2
Flow (Q)
10 mL/s
10 mL/s
10 mL/s

$$v = Q/A$$

10 mL/s

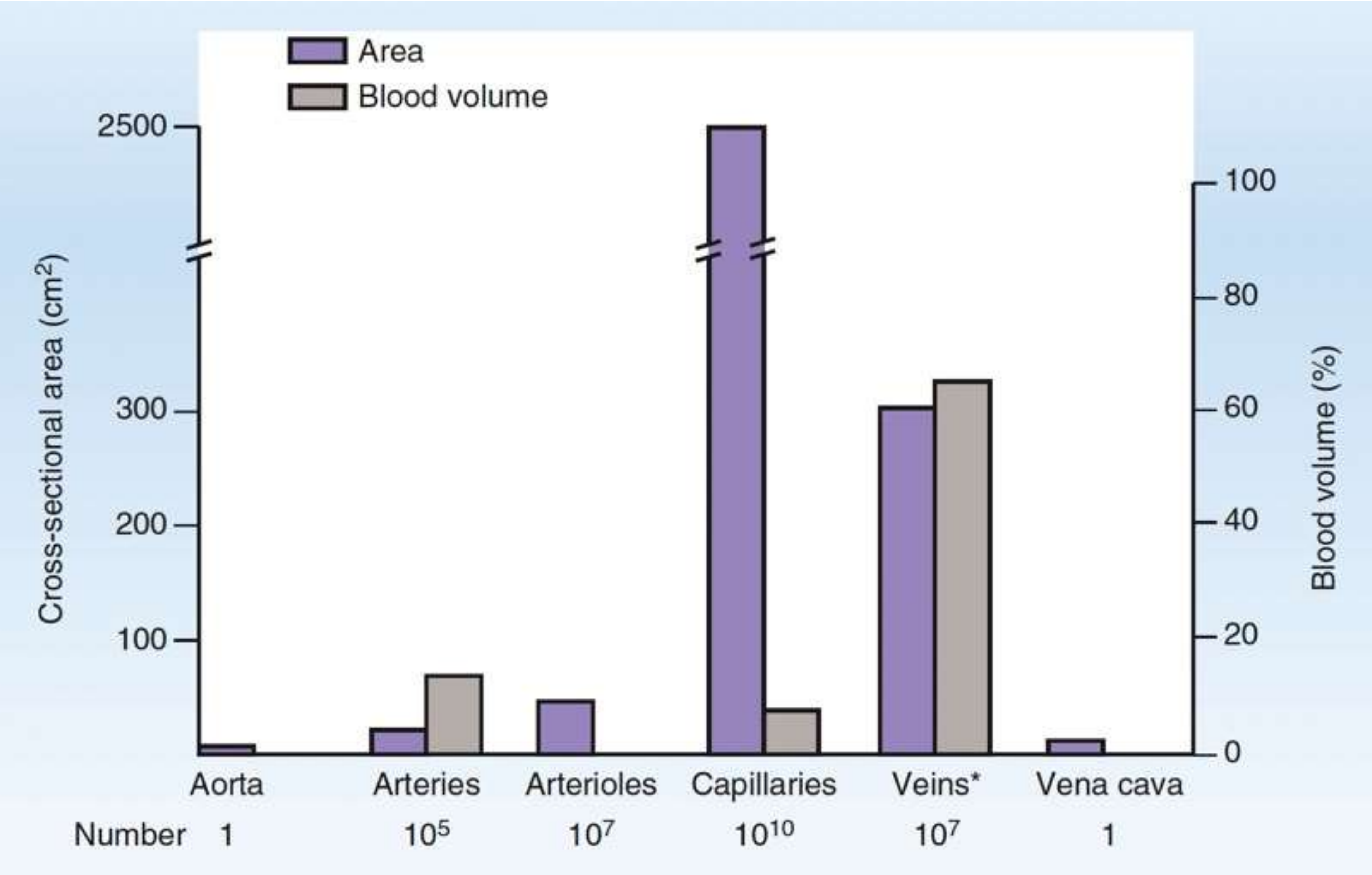


Area (A)	1 cm²	10 cm²	100 cm²
Flow (Q)	10 mL/s	10 mL/s	10 mL/s
Velocity (v)	**10 cm/s**	**1 cm/s**	**0.1 cm/s**



Velocity of blood flow

- Because of the **inverse relationship between velocity and total cross-sectional area**, the velocity of blood flow will be highest in the **aorta** and lowest in the **capillaries**.
- From the standpoint of capillary function (i.e., exchange of nutrients, solutes, and water), the low velocity of blood flow is advantageous, as it maximizes the time for exchange across the capillary walls.



Area
Blood volume
2500
300
200
100
Cross-sectional area (cm²)
100
80
60
40
20
0
Blood volume (%)
Aorta
Arteries
Arterioles
Capillaries
Veins*
Vena cava
Number
1
10⁵
10⁷
10¹⁰
10⁷
1

Vessel	Cross-Sectional Area (cm^2)
Aorta	2.5
Small arteries	20
Arterioles	40
Capillaries	2500
Venules	250
Small veins	80
Venae cavae	8

Series resistances

- Within organ.
- The total resistance of the system arranged in series is equal to the sum of the individual resistances.
- The total resistance of a vascular bed is determined in large part by the arteriolar resistance.
- When resistances are arranged in series, the total flow at each level of the system is the same.

SERIES RESISTANCES

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

Series resistances

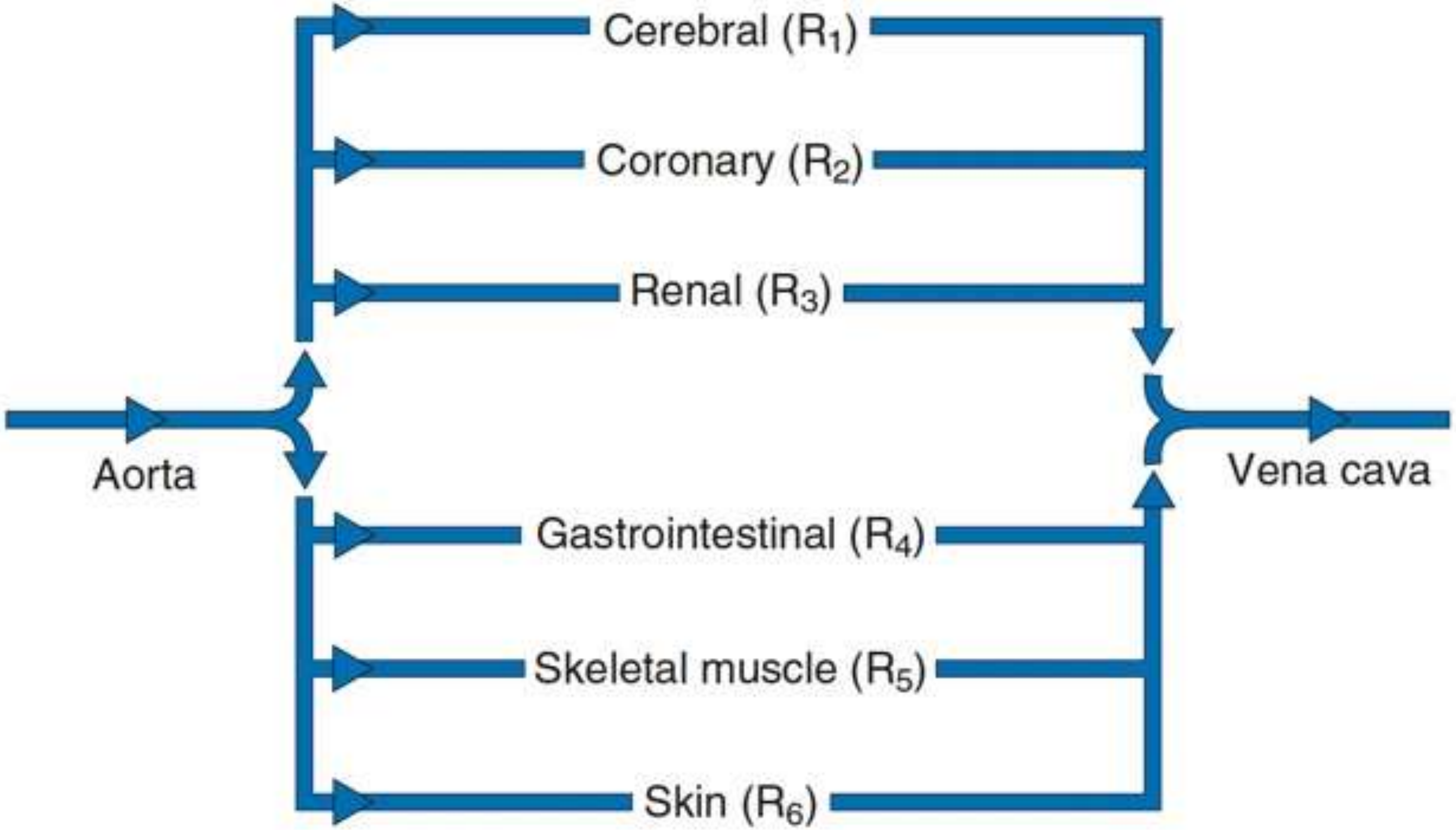
- Although total flow is constant at each level in the series, the pressure decreases progressively as blood flows through each sequential component.
- The greatest decrease in pressure occurs in the arterioles because they contribute the largest portion of the resistance.

Parallel resistances

- the total resistance in a parallel arrangement is less than any of the individual resistances.
- When blood flow is distributed through a set of parallel resistances, the flow through each organ is a fraction of the total blood flow.
- The effects of this arrangement are that there is no loss of pressure in the major arteries and that mean pressure in each major artery will be the same and be approximately the same as mean pressure in the aorta.

PARALLEL RESISTANCES

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

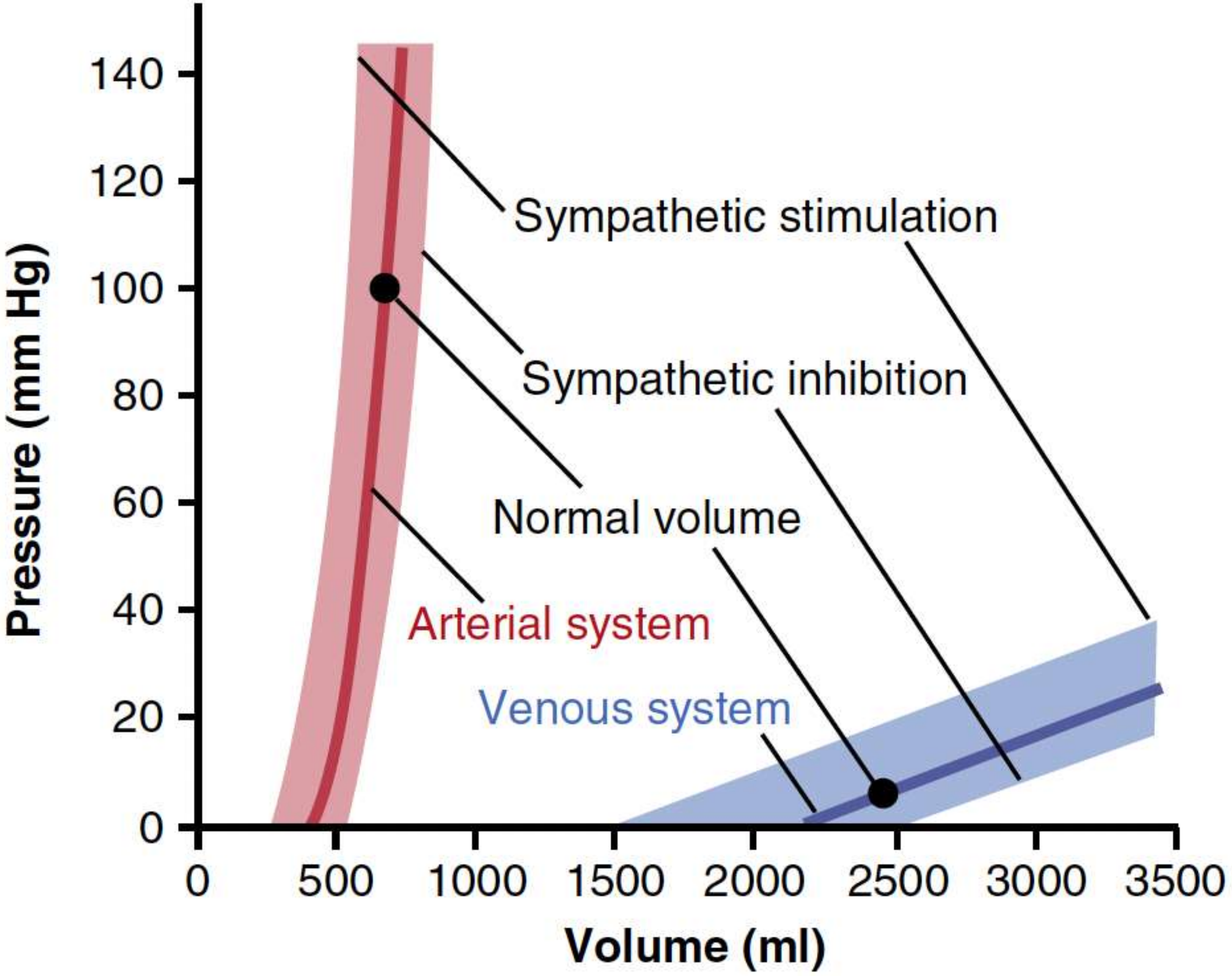


Parallel resistances

- Another predictable consequence of a parallel arrangement is that adding a resistance to the circuit causes total resistance to decrease.
- if the resistance of one of the individual vessels in a parallel arrangement increases, then total resistance increases.

Compliance

Volume-Pressure Curve



Compliance

- increase in vascular smooth muscle tone caused by sympathetic stimulation increases the pressure at each volume of the arteries or veins, whereas sympathetic inhibition decreases the pressure at each volume.
- For example, an increase in vascular tone throughout the systemic circulation can cause large volumes of blood to shift into the heart, which is one of the principal methods that the body uses to rapidly increase heart pumping.
- Sympathetic control of vascular capacitance is also highly important during hemorrhage.

Thank you