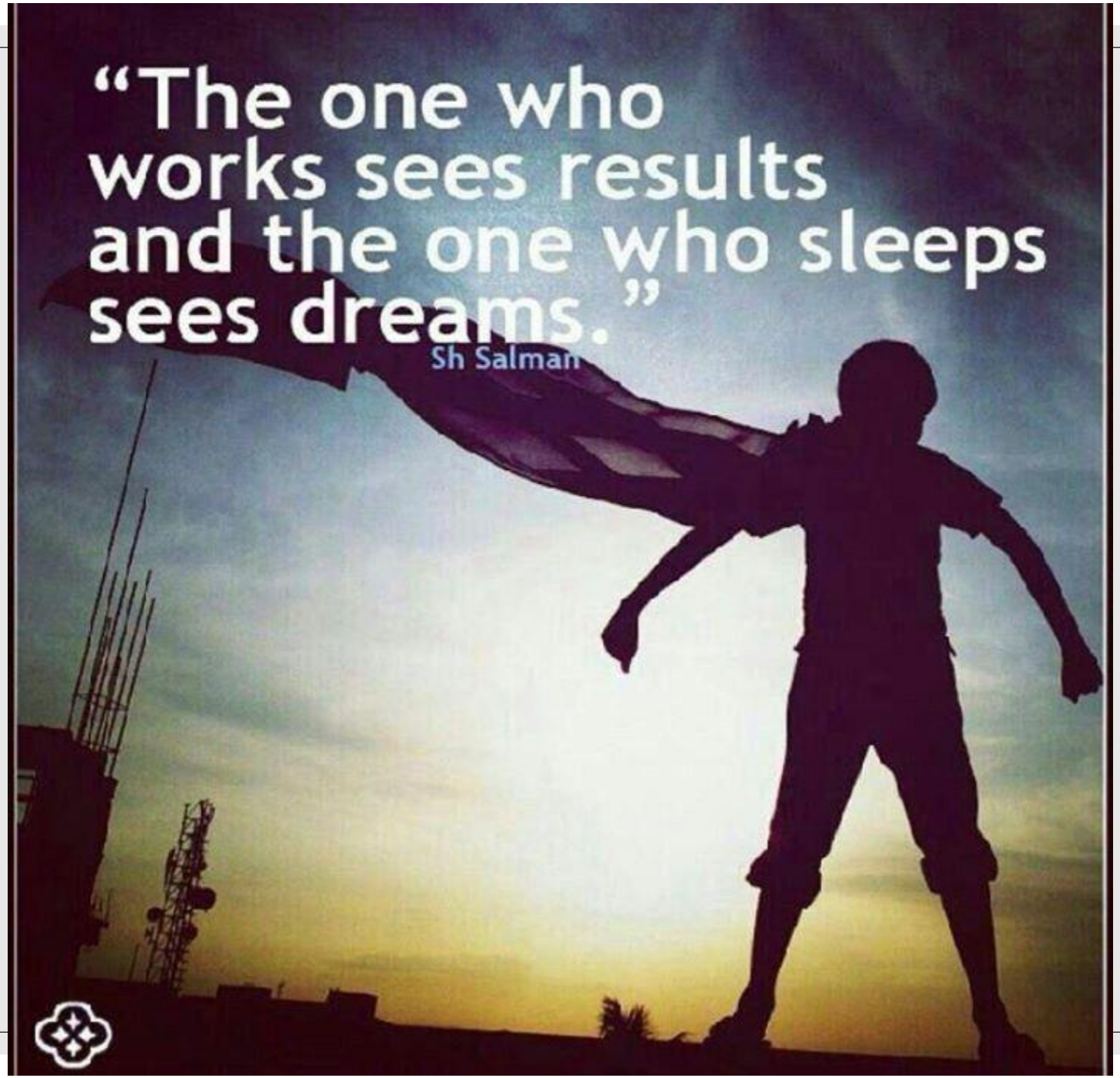

بسم الله الرحمن الرحيم


“The one who works sees results and the one who sleeps sees dreams.”
Sh Salman

THE PULMONARY CIRCULATION-1

Dr Zubia Shah

Learning Objectives

- Describe the **pressures** in the pulmonary circulatory system.
- Describe **blood volume** of the lungs.
- Describe **blood flow** through the lungs and its distribution.
- Compare the **systemic and pulmonary circulations** with respect to pressures, resistance to blood flow, and response to hypoxia.
- Describe the **regional differences** in pulmonary blood flow in an erect position.
- List the **normal airway, alveolar, arterial and mixed venous PO_2 & PCO_2 values.**

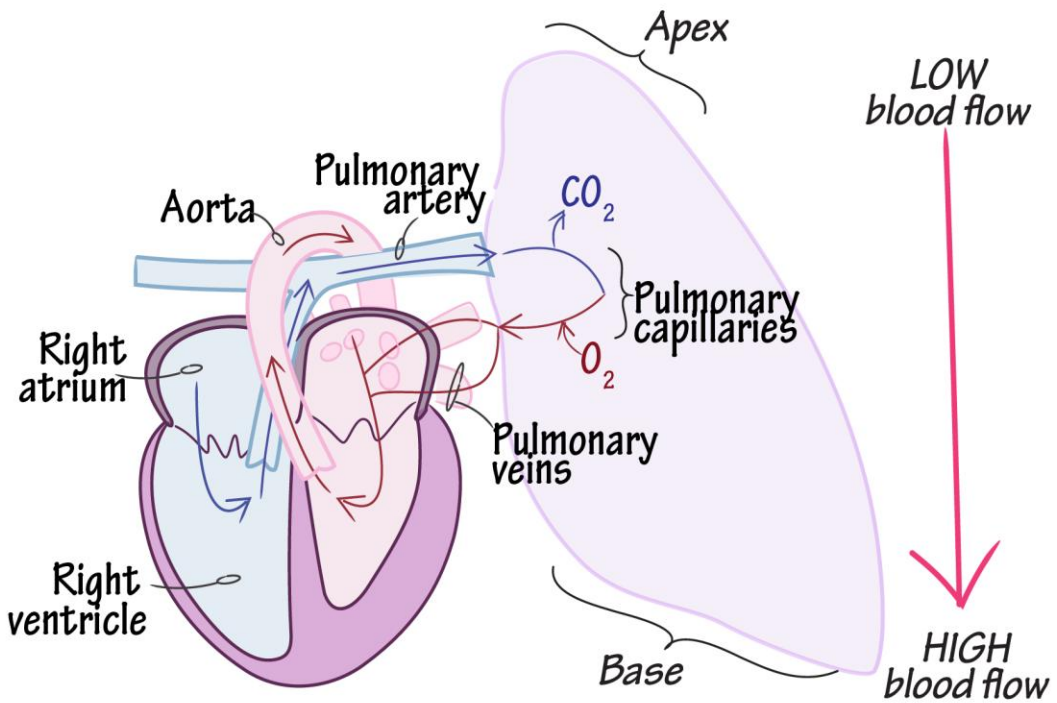
Types of Pulmonary Circulation

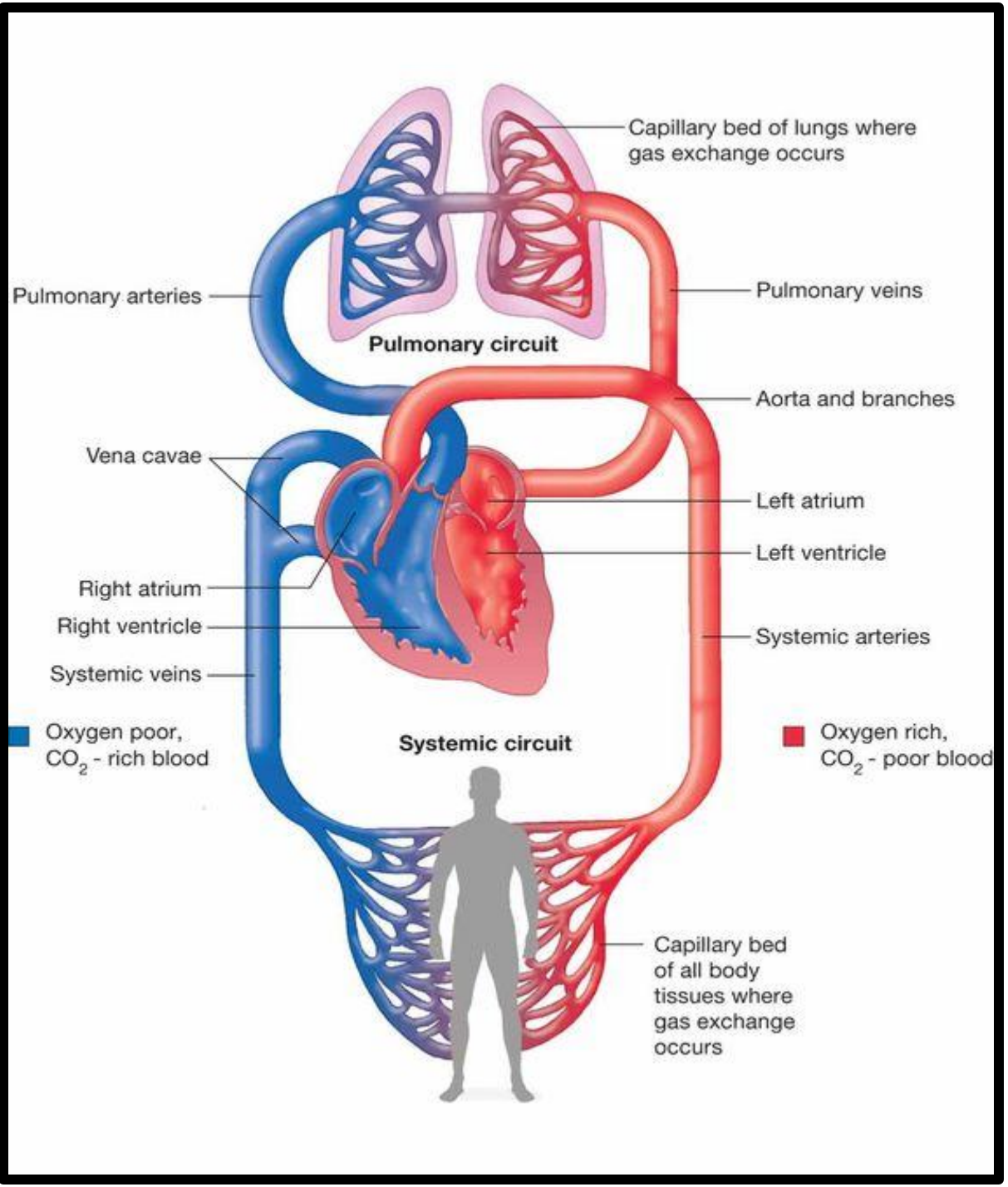
a high-pressure, low-flow circulation → trachea, bronchial tree, supporting tissues of lung, adventitia of pulmonary arteries and veins

Bronchial arteries

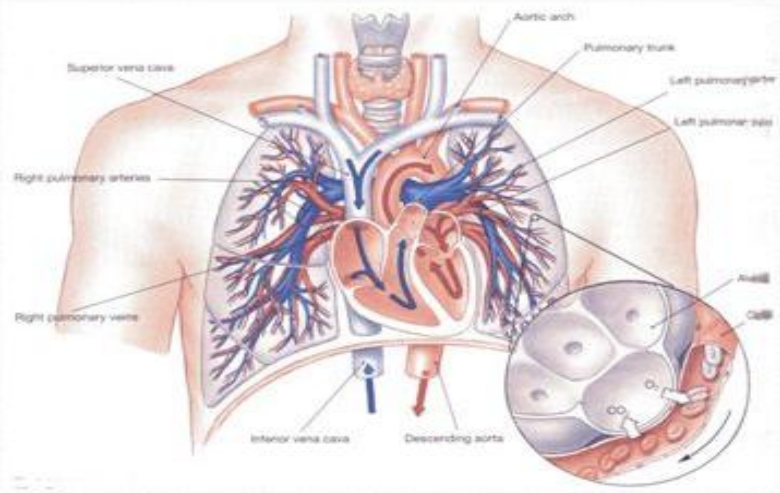
a low-pressure, high-flow circulation → The pulmonary artery and its branches → alveolar capillaries and the pulmonary veins then return the blood to the left atrium

Pulmonary Circulation





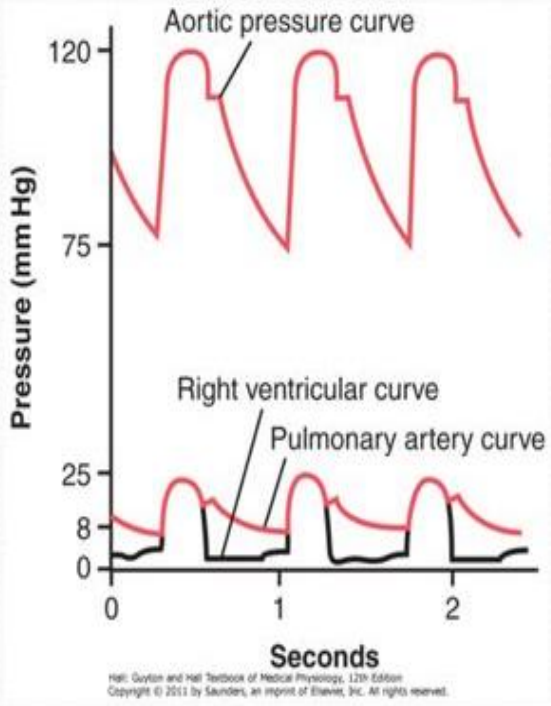
Physiological Anatomy of Pulmonary Circulation



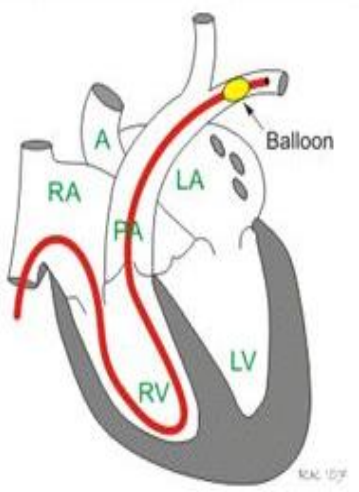
- **Pulmonary vessels**
  - *Low-pressure, high-flow*
  - Thin, distensible – *high compliance*
  - PA: venous, deoxygenated blood!
  - Function: gas exchange
- **Bronchial vessels**
  - *High-pressure, low-flow*
  - Systemic circulation, 1-2% of CO
  - Function: nutritive!
- **Lymphatic vessels**
  - Begin in connective tissue surrounding terminal bronchioles
  - Function: prevention of lung edema, removing particles

7 ml/mmHg

Pressures In the Pulmonary System



- Right ventricle:
  - P_s: 25 mm
  - P_d: 0 mmHg
- Pulmonary artery:
  - P_s: 25 mmHg
  - P_d: 8 mmHg
  - P_{mean}: 15 mmHg
- Left atrium:
  - 1-5 mmHg (2 mmHg)
  - *pulmonary wedge pressure*

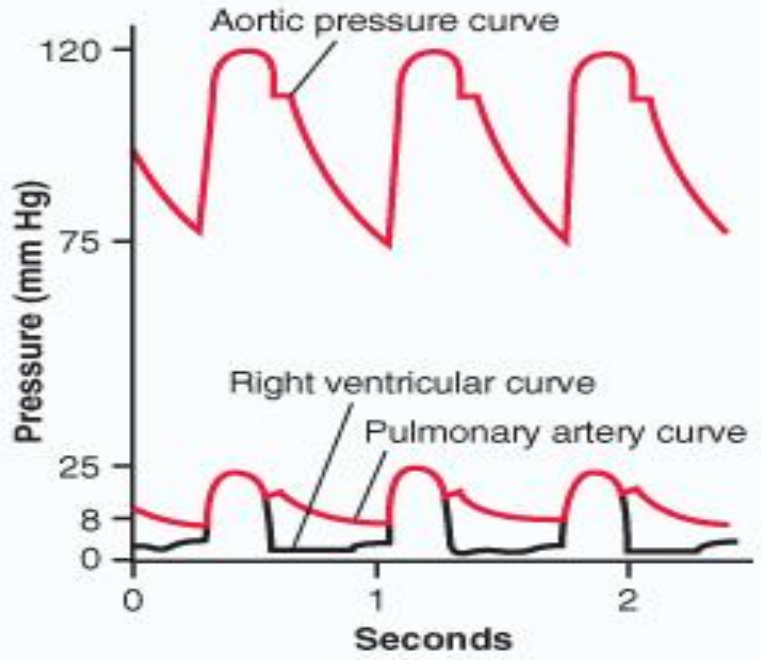


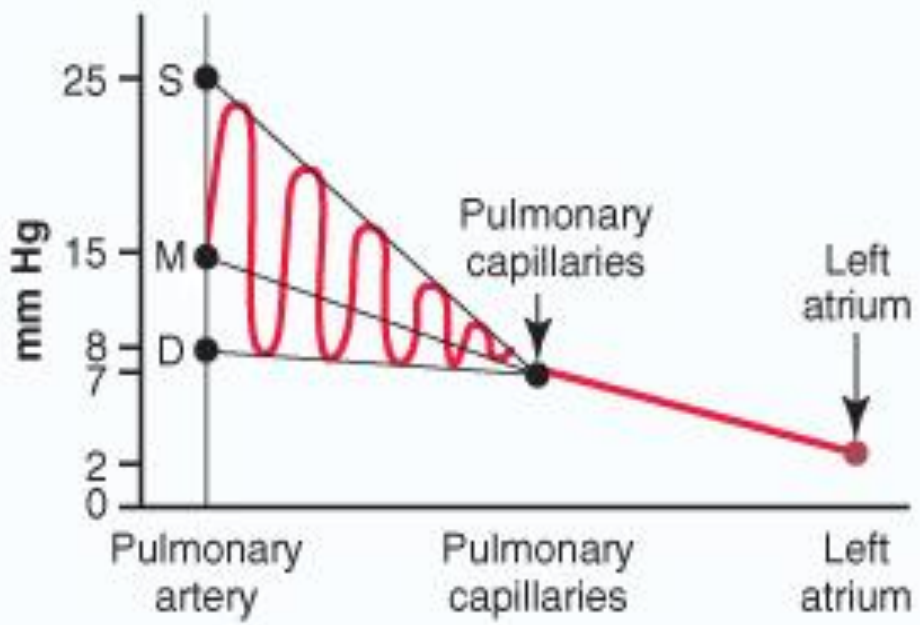
Balloon-tipped, Swan-Ganz catheter for measuring pulmonary capillary wedge pressure (PCWP).

5 mmHg

Mean Pulmonary Capillary Pressure is 7 mmHg

Pressures in the Different Vessels of the Lungs





Blood Volume of Lungs

Blood Volume Of The Lungs

Blood volume of the lungs is about 450 milliliters

about 9% of total blood volume of the entire circulatory system

70 ml of pulmonary blood volume is in pulmonary capillaries, and rest is divided equally between the pulmonary arteries and veins

Lungs Serve as a Blood Reservoir

- can vary from one-half normal up to twice normal
- **blowing a trumpet** → 250 ml of blood can be expelled from pulmonary circulation into systemic circulation
- **loss of blood by hemorrhage** can be partly compensated for by the automatic shift of blood from the lungs into the systemic vessels but that has 9 times more blood

Cardiac Pathology May Shift Blood From the Systemic Circulation to the Pulmonary Circulation

Left heart failure, mitral stenosis or mitral regurgitation →

blood to dam up in the pulmonary circulation sometimes increasing the pulmonary blood volume as much as 100 percent and causing large increases in the pulmonary vascular pressures

Blood Flow Through Lungs And Its Distribution

Blood flow through Lungs = Cardiac Output

Pulmonary Vessels distend with ↑ pressure & narrow with ↓ Pressure

Factors Affecting Blood Flow

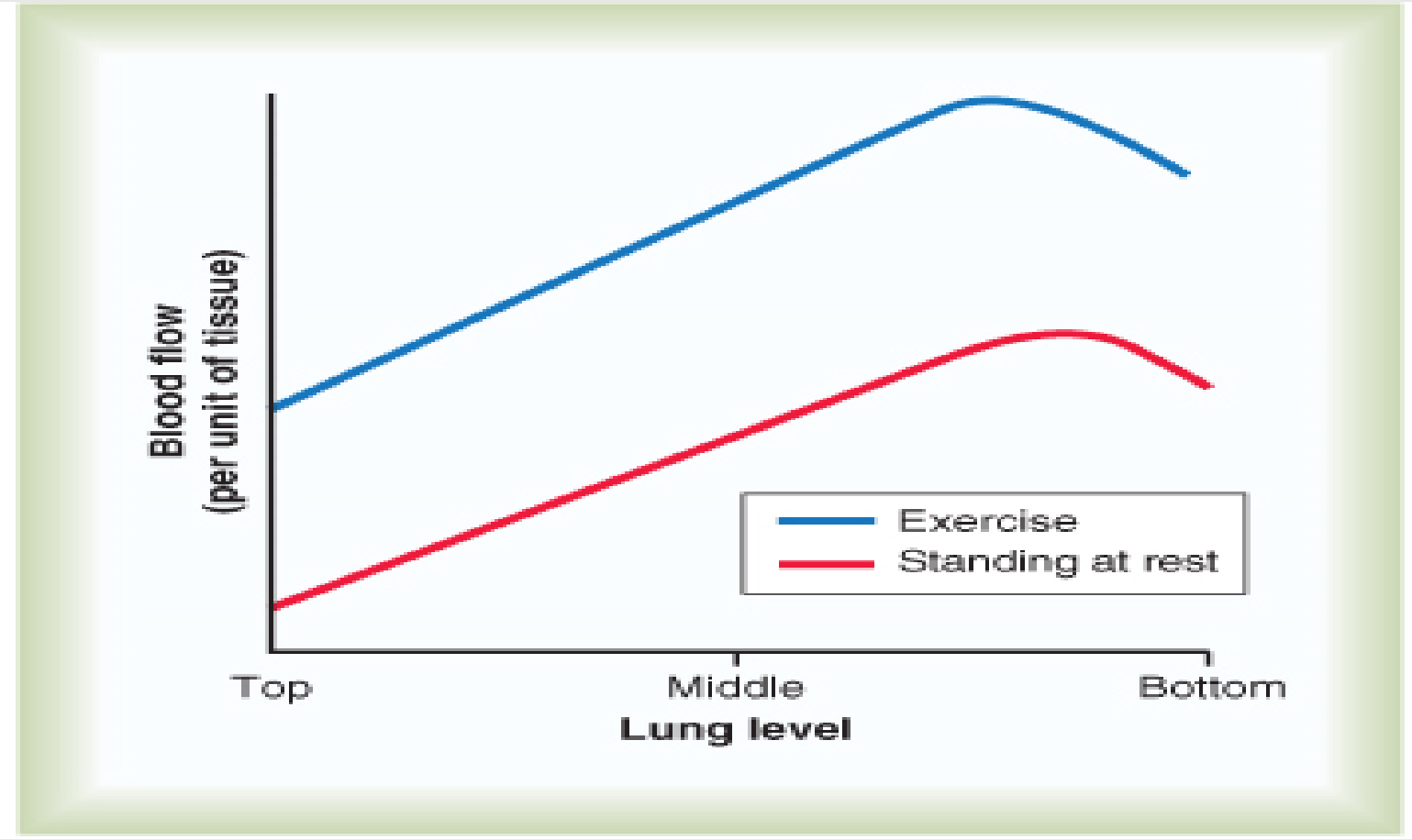
- Autonomic innervation
- Humoral Factors (histamine, bradykinin)

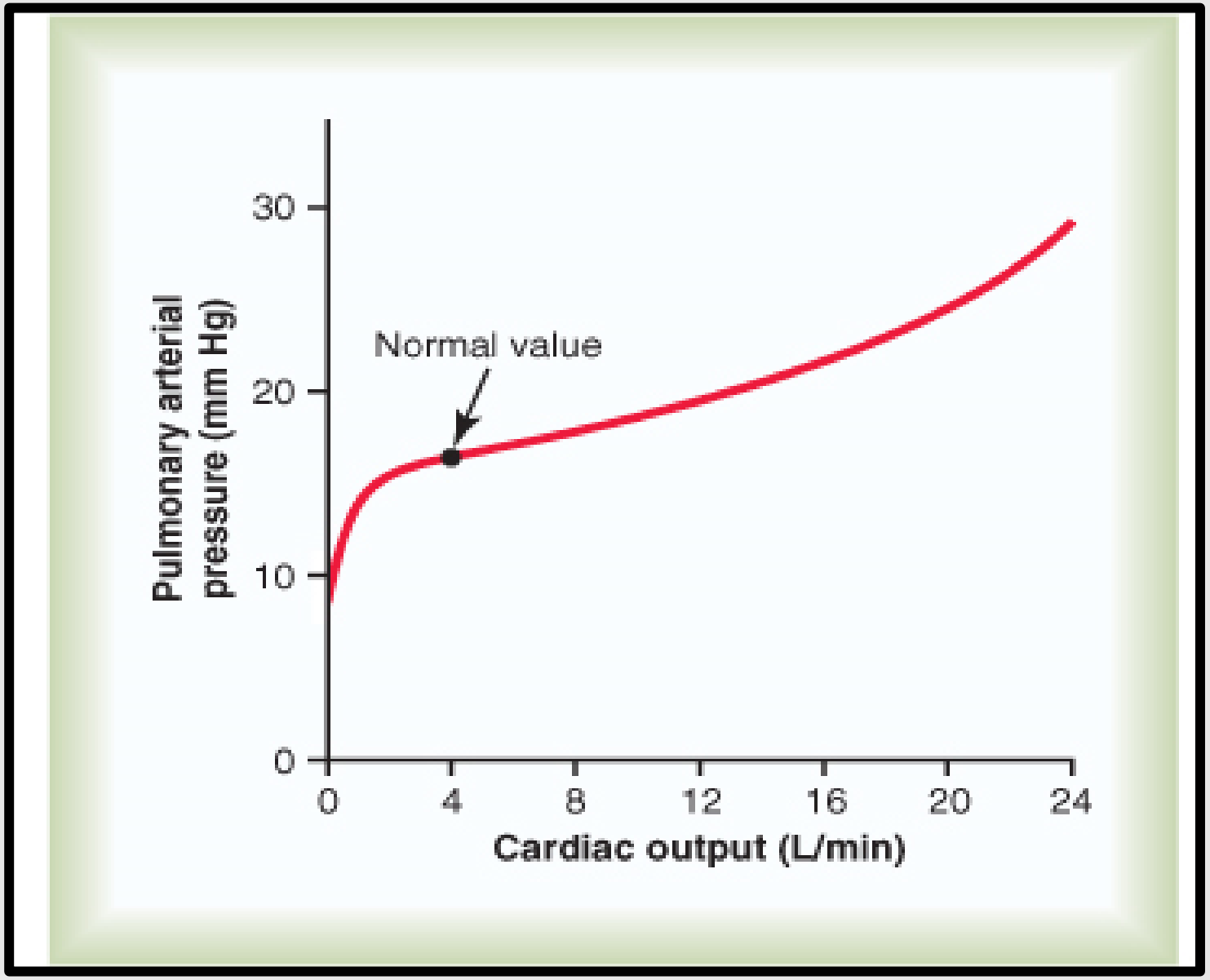
Effect of Hypoxia on Alveolar & Pulmonary Blood Flow

PO_2 falls below 73 mmHg adjacent blood vessels constrict reducing blood flow an effect opposite to systemic circulation

Hypoxia increases the Pulmonary Vascular Resistance

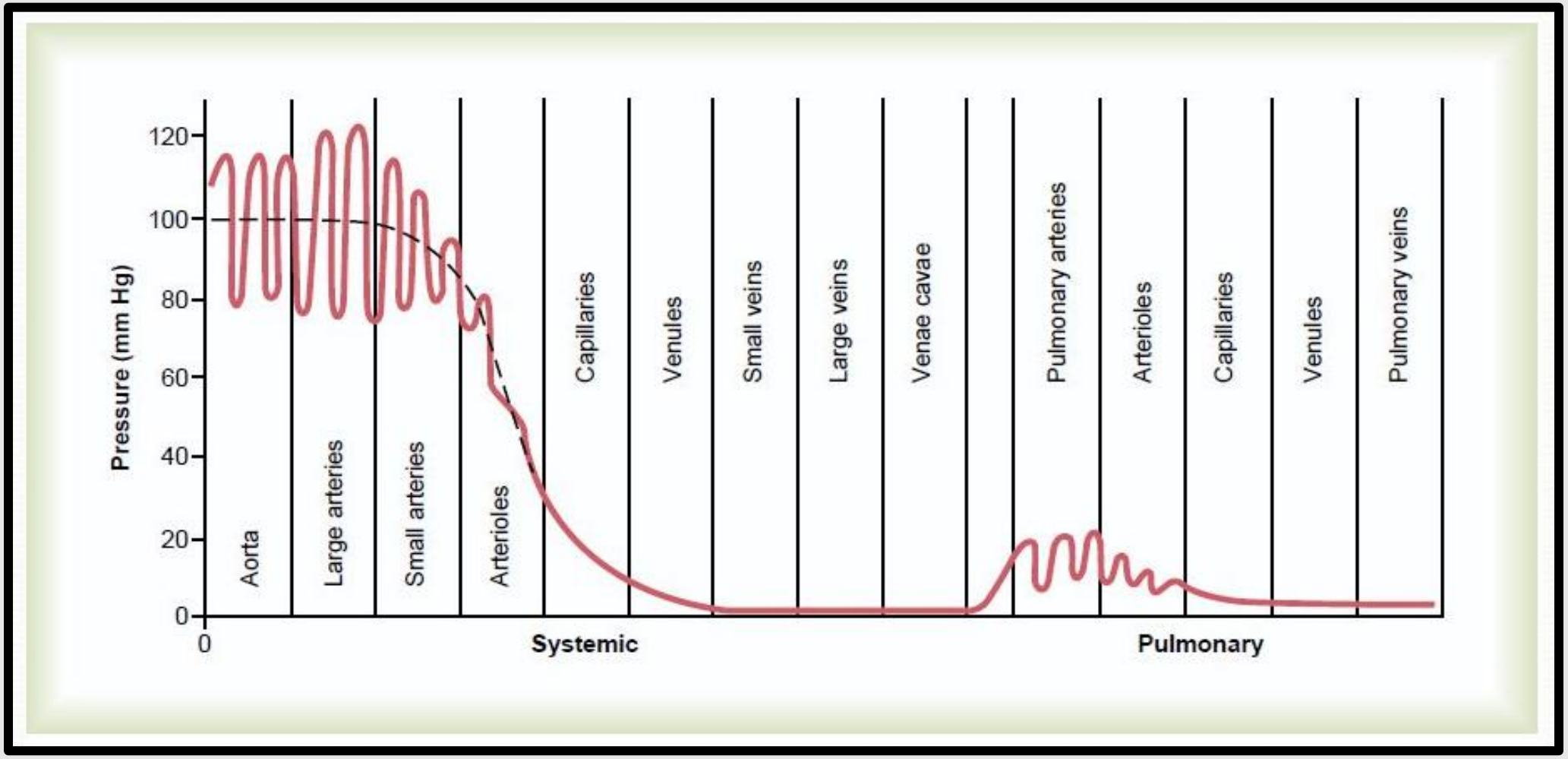
Effect of Hydrostatic Pressures In Lungs on Pulmonary Blood Flow



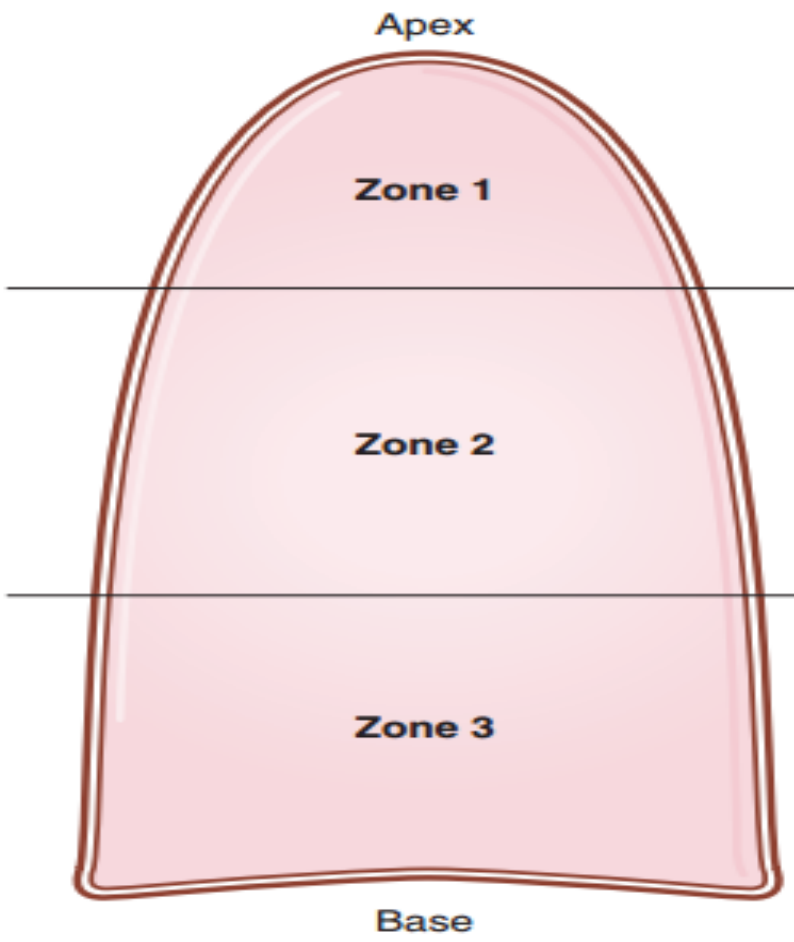


Effect on Mean Pulmonary Arterial Pressure by Increasing Cardiac Output During Exercise

Comparison of Pressures in Systemic & Pulmonary Circulation



BLOOD FLOW DISTRIBUTION IN THE LUNG



	Blood Flow	Pressures Driving Blood Flow
Zone 1	Lowest	$P_A \geq P_a > P_v$
Zone 2	Medium	$P_a > P_A > P_v$
Zone 3	Highest	$P_a > P_v > P_A$

PA= Pulmonary Alveolar Pressure
Pa=Pulmonary arterial Pressure
Pv= Pulmonary Venous Pressure

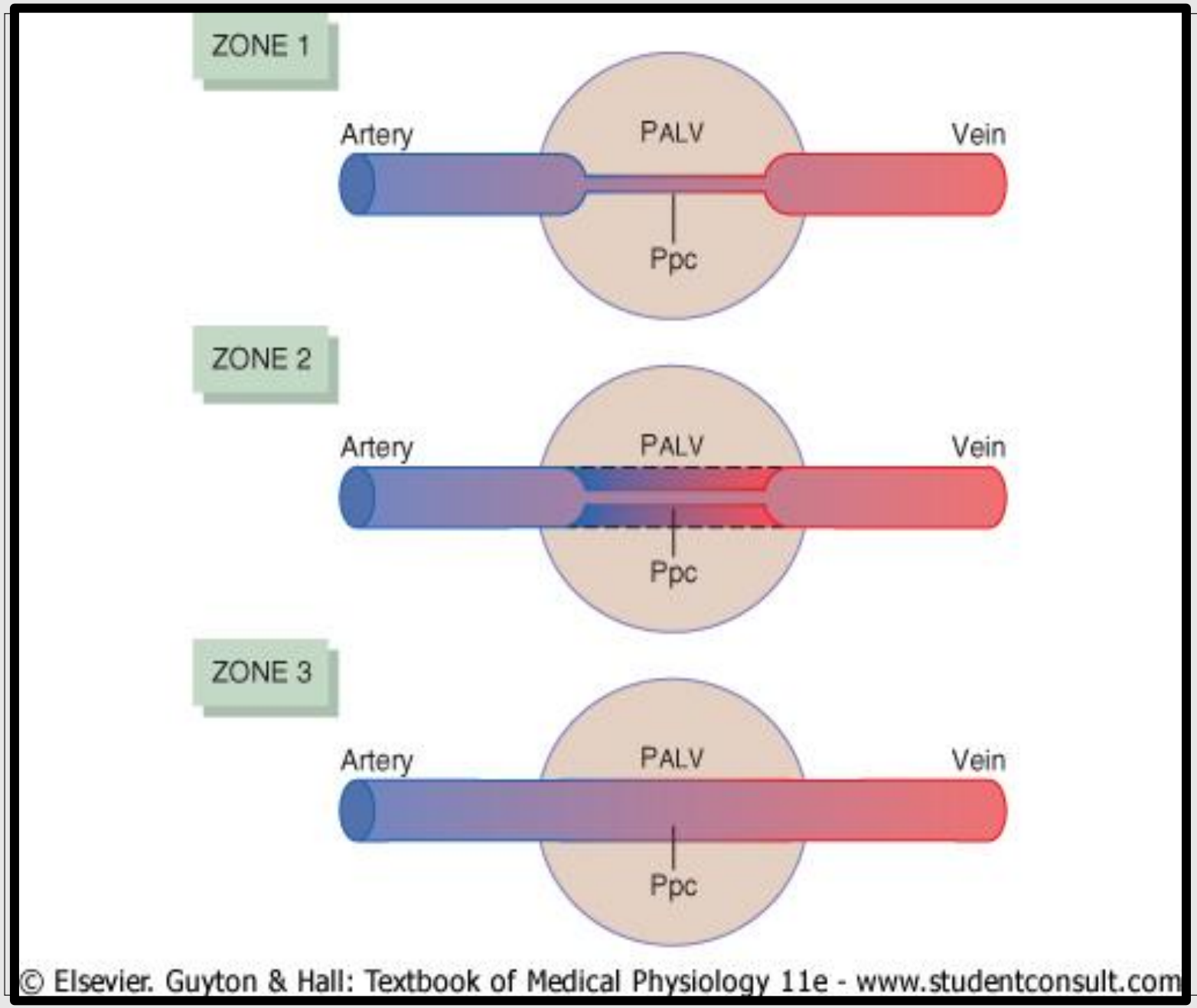
Normal Zones of Perfusion In Lung

Zone 2 **Apex** 10cm above mid level of heart	**Intermittent Blood Flow/Medium** Pa is 15mmHg less than heart level Apical systolic pressure is 10 mmHg (25-15) so blood flows during systole During diastole Pa is 8mmHg so no blood flows
Zone 3 Below zone 2	**Continuous Blood Flow/Highest** Pa is greater in both systole and diastole than PA 0 mmHg so blood flow is continuous

Zone 1 Blood Flow Occurs Under Abnormal Conditions

- **Pulmonary systolic arterial pressure is too low** (severe blood loss) or
- **Alveolar pressure is too High**

- An upright person is breathing against a positive air pressure so that PA is at least 10mmHg greater than normal Systolic Pa is normal → no blood will flow



Zones 1, 2 & 3 of Pulmonary Blood Flow

Effect of Exercise on Blood Flow

Blood flow increases through all parts of the lung

Pulmonary vascular pressures rise enough to convert lung apices from zone 2 to 3 pattern of blood flow

Accommodation of Increased Blood Flow In Lungs

- **Heavy exercise → 4-7** times increase in Pulmonary blood flow
  - 3 ways to accommodate

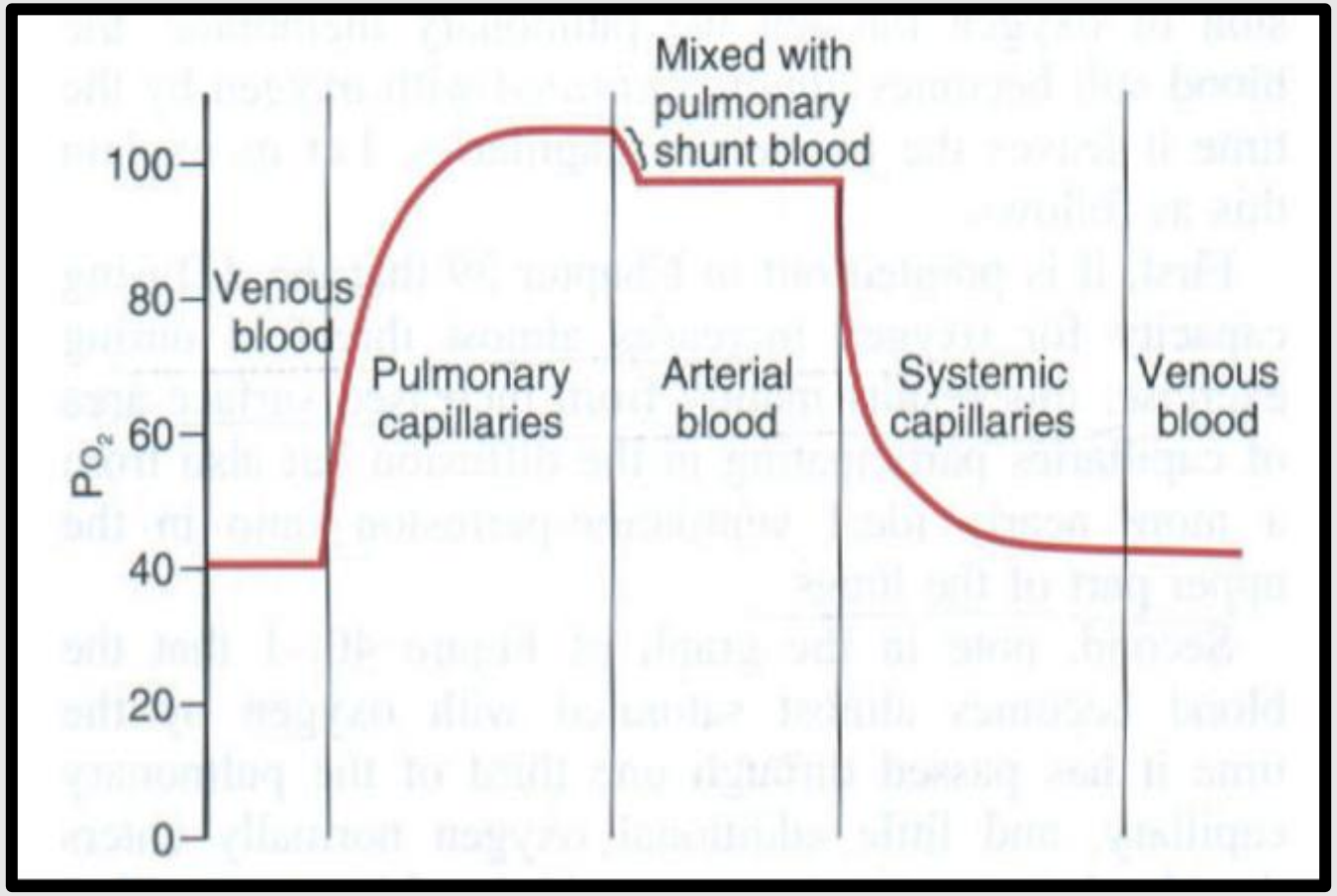
1. ↑ the number of open capillaries (3-fold)
2. Distending the capillaries (2-fold ↑ in rate of flow)
3. ↑ Pulmonary Arterial Pressure

The first 2 changes ↓ Pulmonary Vascular Resistance so much that Pa rises very little

NORMAL VALUES

- Alveolar P_{O2} = 100 mmHg
- Arterial P_{O2} = 100 mmHg
- Alveolar P_{CO2} = 40 mmHg
- Arterial P_{CO2} = 40 mmHg
- Venous P_{O2} = 40 mmHg
- Venous P_{CO2} = 46 mmHg

PO2 Levels In Different Regions



References

- Guyton & Hall Physiology
- BRS Physiology
- Ganong's Review of Medical Physiology
- Sherwood Physiology


Thank
you!