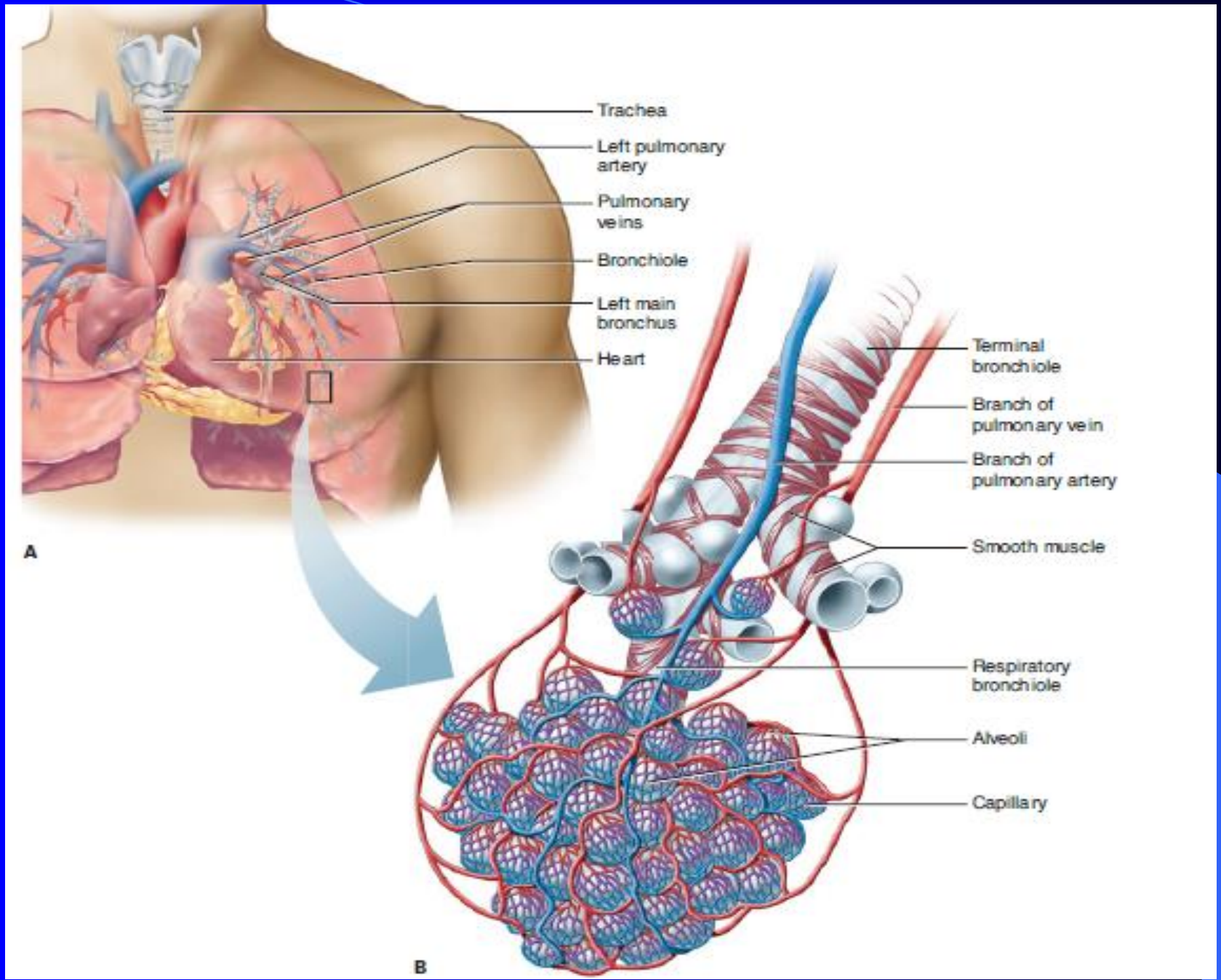
Respiratory Physiology


Trachea
Left pulmonary artery
Pulmonary veins
Bronchiole
Left main bronchus
Heart
A
Terminal bronchiole
Branch of pulmonary vein
Branch of pulmonary artery
Smooth muscle
Respiratory bronchiole
Alveoli
Capillary
B

	Name of branches	Number of tubes in branch
Conducting zone	Trachea	1
	Bronchi	2
		4
		8
	Bronchioles	16
		32
	Terminal bronchioles	6×10^4
Respiratory zone	Respiratory bronchioles	5×10^5
	Alveolar ducts	
	Alveolar sacs	8×10^6



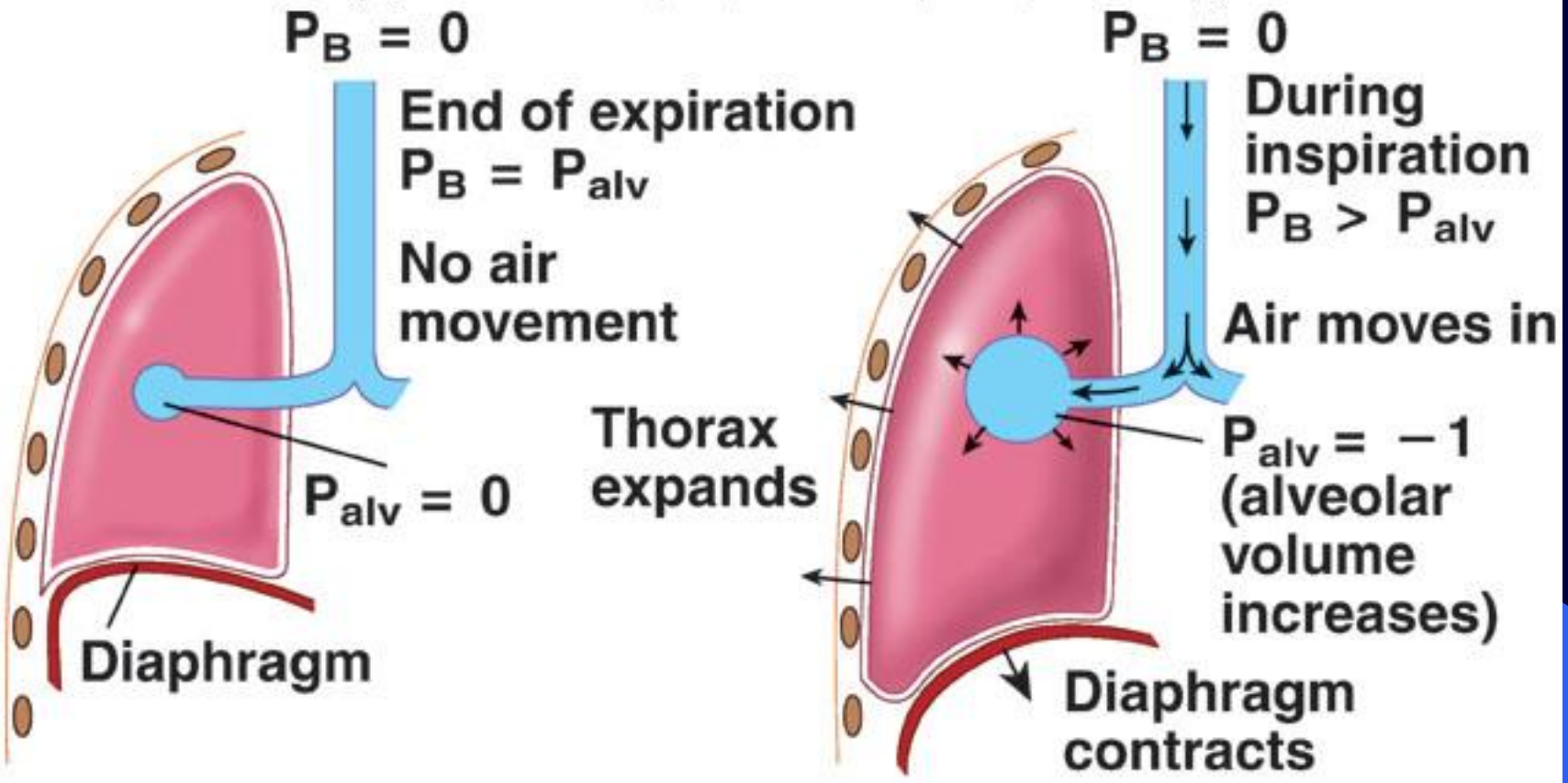
Overall function

- Gas exchange
- **Voice production**
- **Regulation of blood pH**
- **Protection**

Inspiration/Inhalation

- Diaphragm & Intercostal muscles
- Increases volume in thoracic cavity as muscles contract
- Volume of lungs increases
- Intrapulmonary pressure decreases (758 mm Hg)

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1. Barometric air pressure (P_B) is equal to alveolar pressure (P_{alv}) and there is no air movement.

2. Increased thoracic volume results in increased alveolar volume and decreased alveolar pressure. Barometric air pressure is greater than alveolar pressure, and air moves into the lungs.

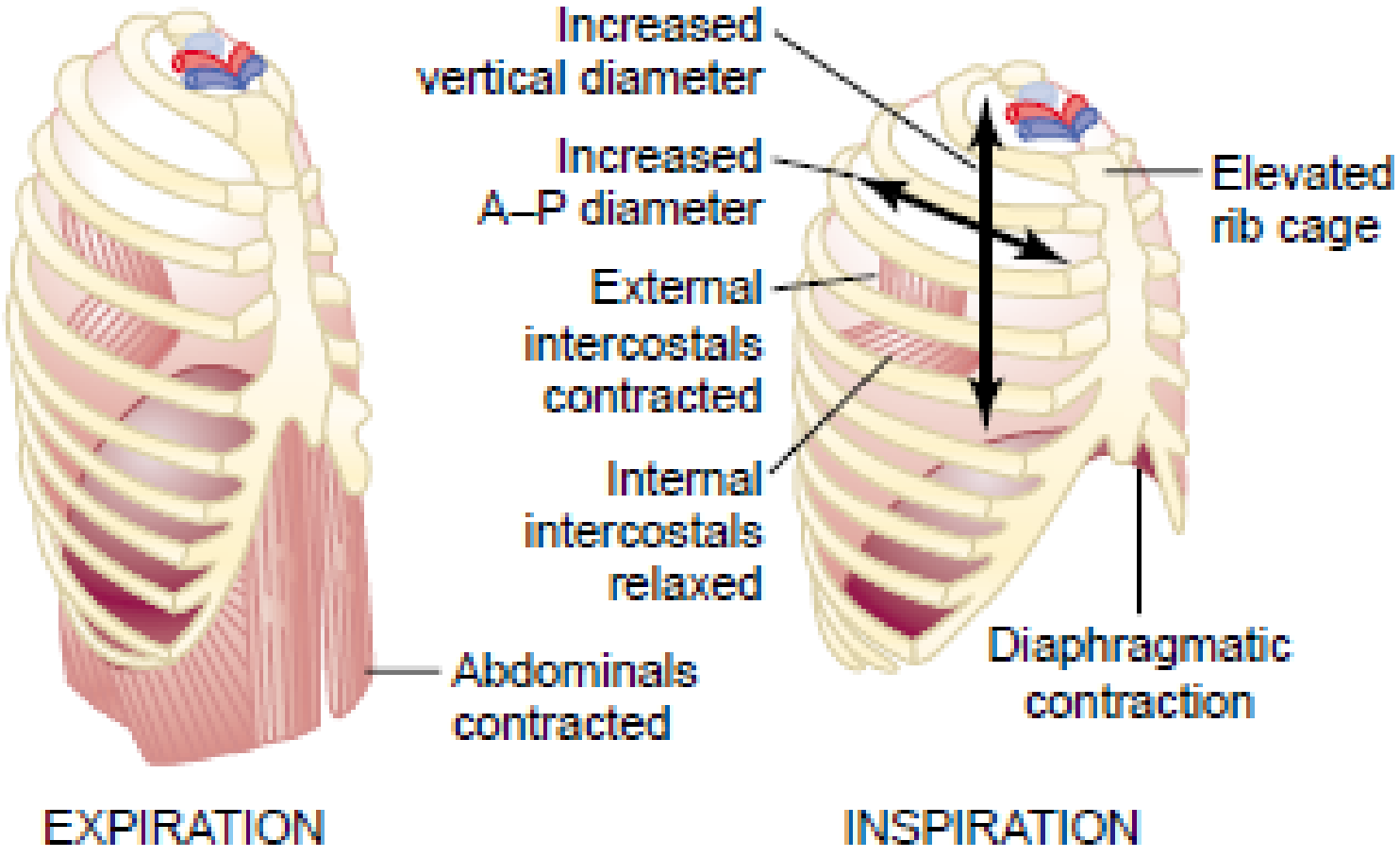


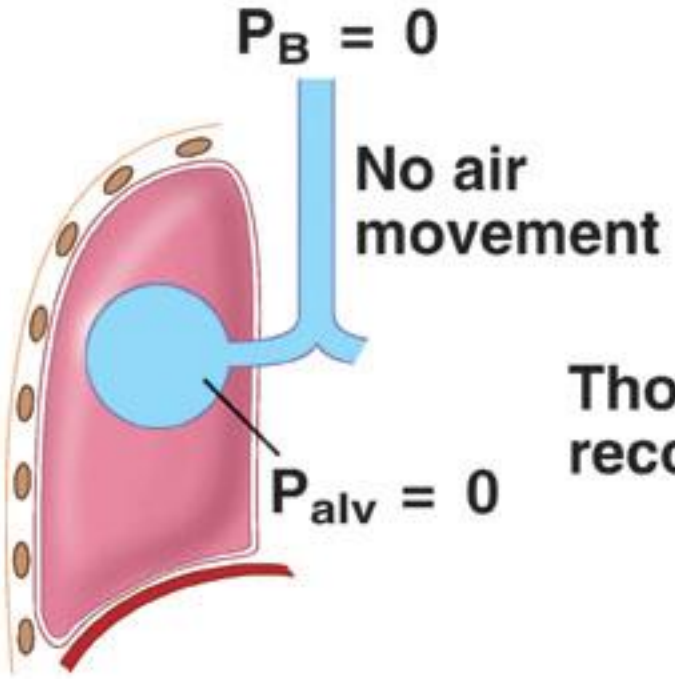
Figure 37–1

Contraction and expansion of the thoracic cage during expiration and inspiration, demonstrating diaphragmatic contraction, function of the intercostal muscles, and elevation and depression of the rib cage.

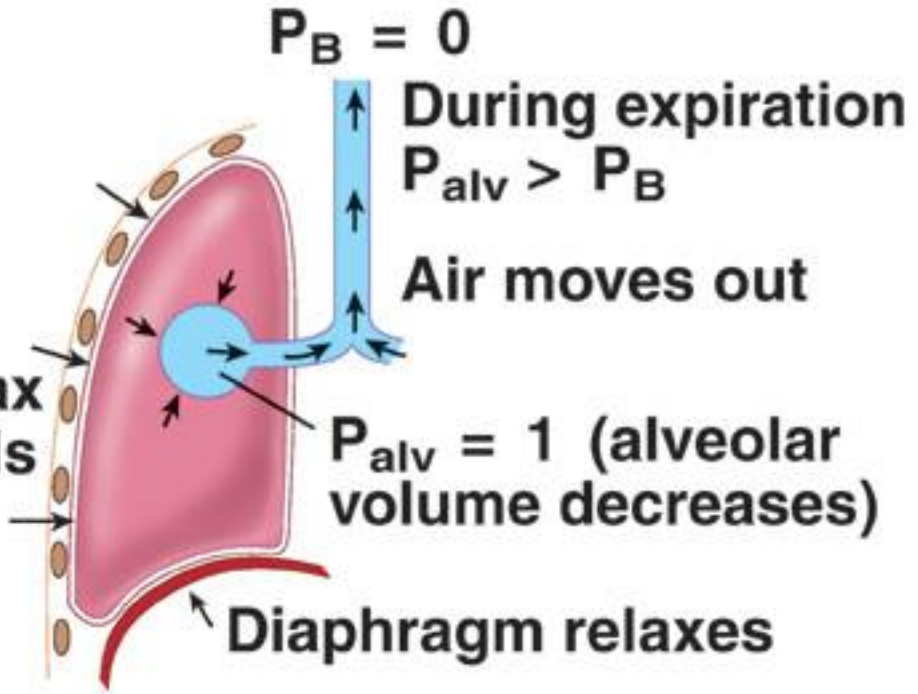
Expiration/Exhalation

- Muscles relax
- Volume of thoracic cavity decreases
- Volume of lungs decreases
- Intrapulmonary pressure increases (763 mm Hg)
- Forced expiration is active

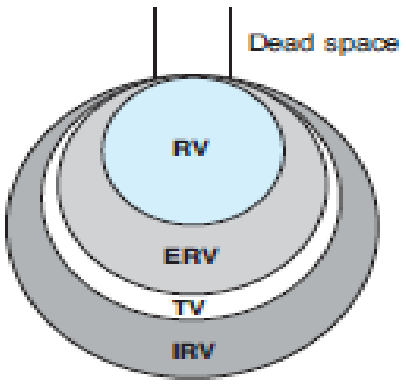
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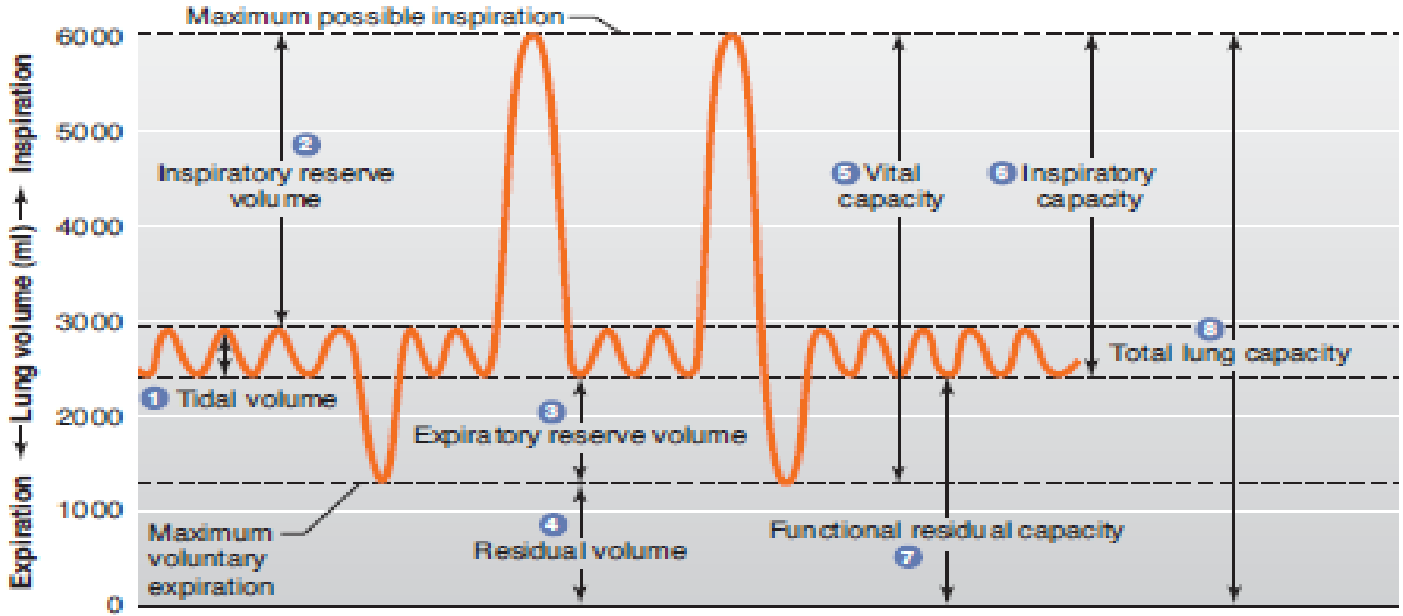


3. End of inspiration.



4. Decreased thoracic volume results in decreased alveolar volume and increased alveolar pressure. Alveolar pressure is greater than barometric air pressure, and air moves out of the lungs.





Respiratory Volumes and Capacities for an Average Young Adult Male		
Measurement	**Typical Value**	**Definition**
Respiratory Volumes		
1 Tidal volume (TV)	500 ml	Amount of air inhaled or exhaled in one breath during relaxed, quiet breathing
2 Inspiratory reserve volume (IRV)	3000 ml	Amount of air in excess of tidal inspiration that can be inhaled with maximum effort
3 Expiratory reserve volume (ERV)	1200 ml	Amount of air in excess of tidal expiration that can be exhaled with maximum effort
4 Residual volume (RV)	1200 ml	Amount of air remaining in the lungs after maximum expiration; keeps alveoli inflated between breaths and mixes with fresh air on next inspiration
Respiratory Capacities		
5 Vital capacity (VC)	4700 ml	Amount of air that can be exhaled with maximum effort after maximum inspiration (ERV + TV + IRV); used to assess strength of thoracic muscles as well as pulmonary function
6 Inspiratory capacity (IC)	3500 ml	Maximum amount of air that can be inhaled after a normal tidal expiration (TV + IRV)
7 Functional residual capacity (FRC)	2400 ml	Amount of air remaining in the lungs after a normal tidal expiration (RV + ERV)
8 Total lung capacity (TLC)	5900 ml	Maximum amount of air the lungs can contain (RV + VC)

FIGURE 35–7 **Lung volumes and capacity measurements. Top left:** A cartoon figure representing lung space divided into lung volumes. Dead space refers to areas where gas exchange does not occur; all other spaces are defined in the accompanying table. **Top right:** Spirometer recordings are shown with marked lung volumes and capacities. Table at bottom defines individual measurements and values from the top graphs. Note that residual volume, total lung capacity, and function residual capacity cannot be measure with a spirometer. (Right figure reproduced with permission from Widmaier EP, Raff H, Strang KT: *Vander's Human Physiology: The Mechanisms of Body Function*, 11th ed. McGraw-Hill, 2008.)

Abbreviations and Symbols Used in Pulmonary Function Studies

$$VC = IRV + V_T + ERV$$

$$VC = IC + ERV$$

$$TLC = VC + RV$$

$$TLC = IC + FRC$$

$$FRC = ERV + RV$$

$$RV = FRC - ERV$$

Lung Volumes & Capacities

- Tidal Volume (500 mls)
- Respiratory Rate (12 breaths/minute)
- Minute Respiratory Volume (6000 mls/min)

Table 37–1

Abbreviations and Symbols for Pulmonary Function

V_T	tidal volume	P_B	atmospheric pressure
FRC	functional residual capacity	Palv	alveolar pressure
ERV	expiratory reserve volume	Ppl	pleural pressure
RV	residual volume	P_{O_2}	partial pressure of oxygen
IC	inspiratory capacity	P_{CO_2}	partial pressure of carbon dioxide
IRV	inspiratory reserve volume	P_{N_2}	partial pressure of nitrogen
TLC	total lung capacity	P_{aO_2}	partial pressure of oxygen in arterial blood
VC	vital capacity	P_{aCO_2}	partial pressure of carbon dioxide in arterial blood
Raw	resistance of the airways to flow of air into the lung	P_{AO_2}	partial pressure of oxygen in alveolar gas
C	compliance	P_{ACO_2}	partial pressure of carbon dioxide in alveolar gas
V_D	volume of dead space gas	P_{AH_2O}	partial pressure of water in alveolar gas
V_A	volume of alveolar gas	R	respiratory exchange ratio
$\dot{V}_I$	inspired volume of ventilation per minute	$\dot{Q}$	cardiac output
$\dot{V}_E$	expired volume of ventilation per minute		
$\dot{V}_S$	shunt flow		
$\dot{V}_A$	alveolar ventilation per minute	Ca_{O_2}	concentration of oxygen in arterial blood
$\dot{V}_{O_2}$	rate of oxygen uptake per minute	$C\bar{v}_{O_2}$	concentration of oxygen in mixed venous blood
$\dot{V}_{CO_2}$	amount of carbon dioxide eliminated per minute	S_{O_2}	percentage saturation of hemoglobin with oxygen
$\dot{V}_{CO}$	rate of carbon monoxide uptake per minute	Sa_{O_2}	percentage saturation of hemoglobin with oxygen in arterial blood
$D_{L_{O_2}}$	diffusing capacity of the lungs for oxygen		
$D_{L_{CO}}$	diffusing capacity of the lungs for carbon monoxide		

Lung Volumes & Capacities

- Inspiratory Reserve Volume (3000, 2100 mls)
- Inspiratory Capacity (TV + IRV)

Lung Volumes & Capacities

- Expiratory Reserve Volume (1200, 800 mls)
- Residual Volume (1200 mls)
- Functional Residual Capacity (ERV + RV)
  - Air left in lungs after exhaling the tidal volume quietly

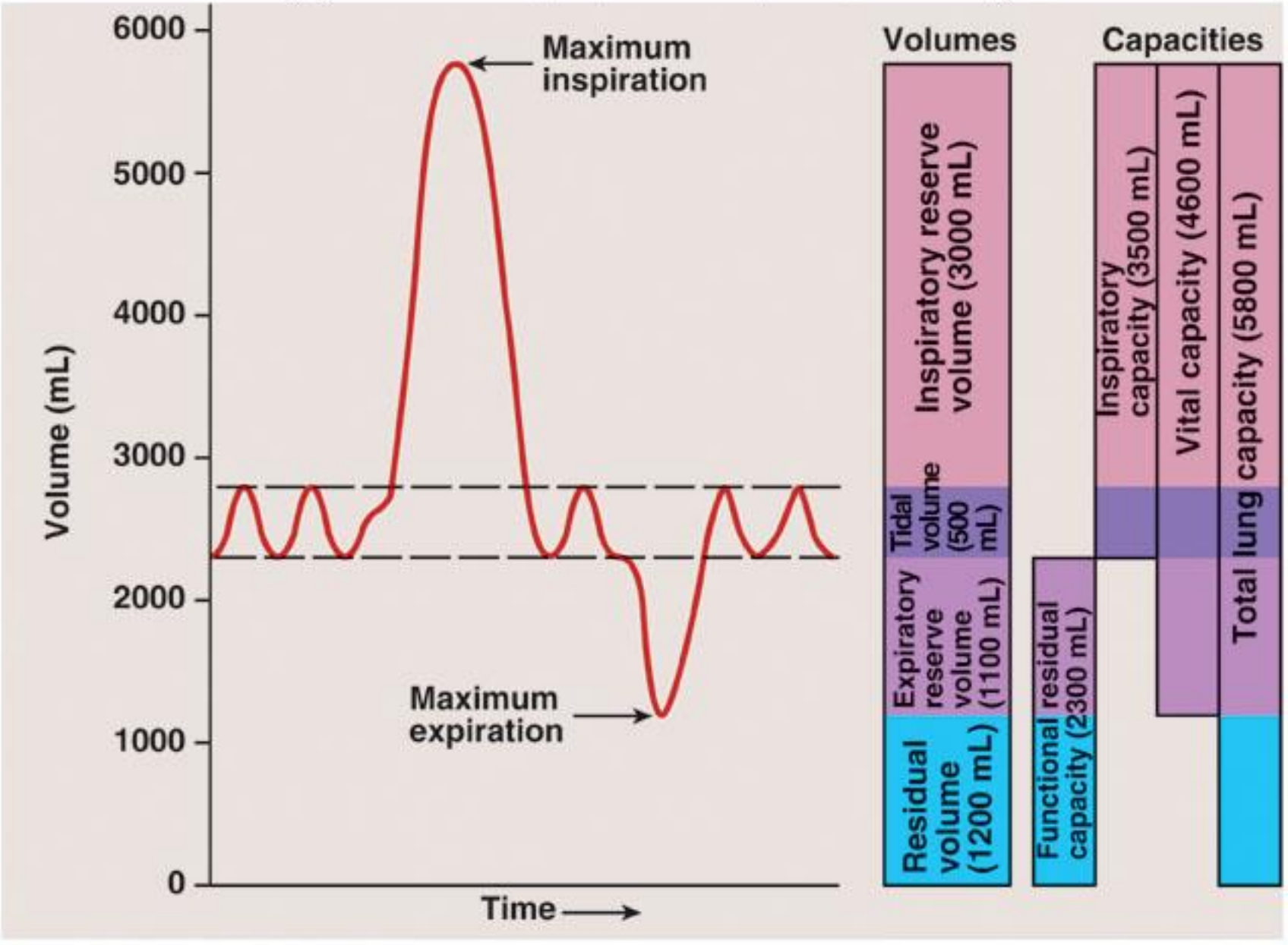
Lung Volumes & Capacities

- Vital Capacity
- IRV + TV + ERV = 4700, 3400 mls
- Maximum amount of air that can be moved in and out of lungs

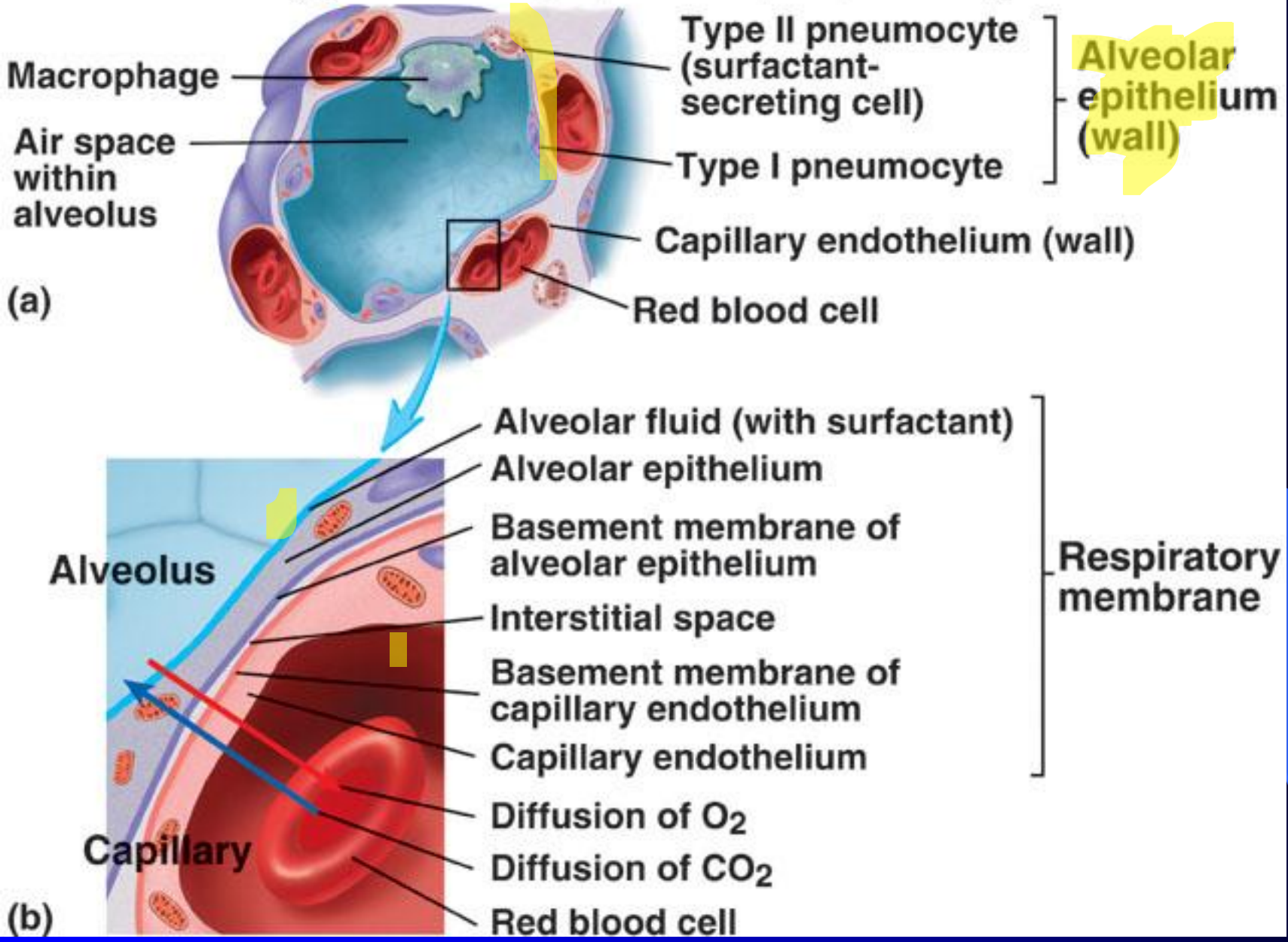
Lung Volumes & Capacities

- Total Lung Capacity (5900, 4400)
- Dead air volume (150 mls) – air not in the alveoli

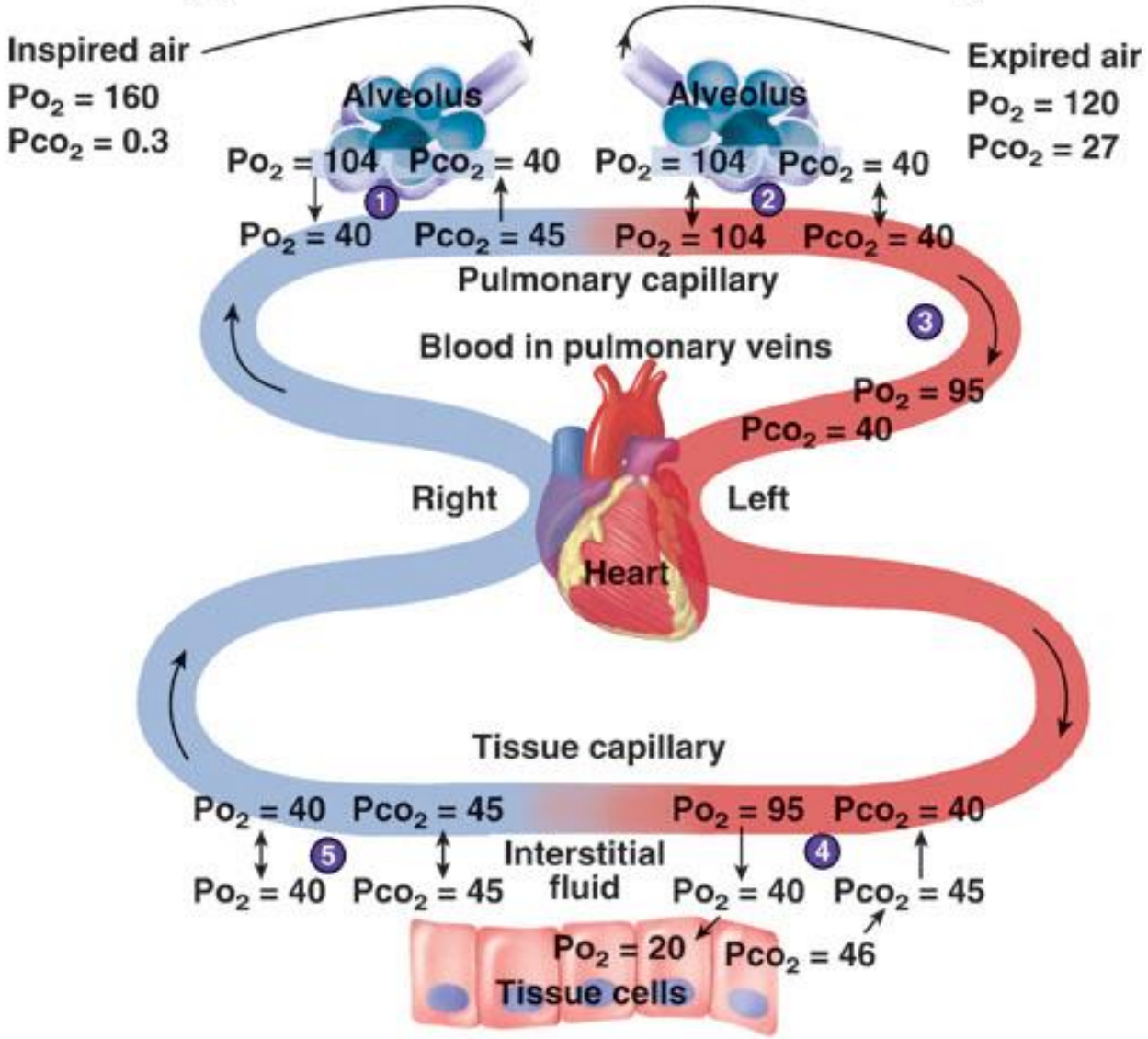
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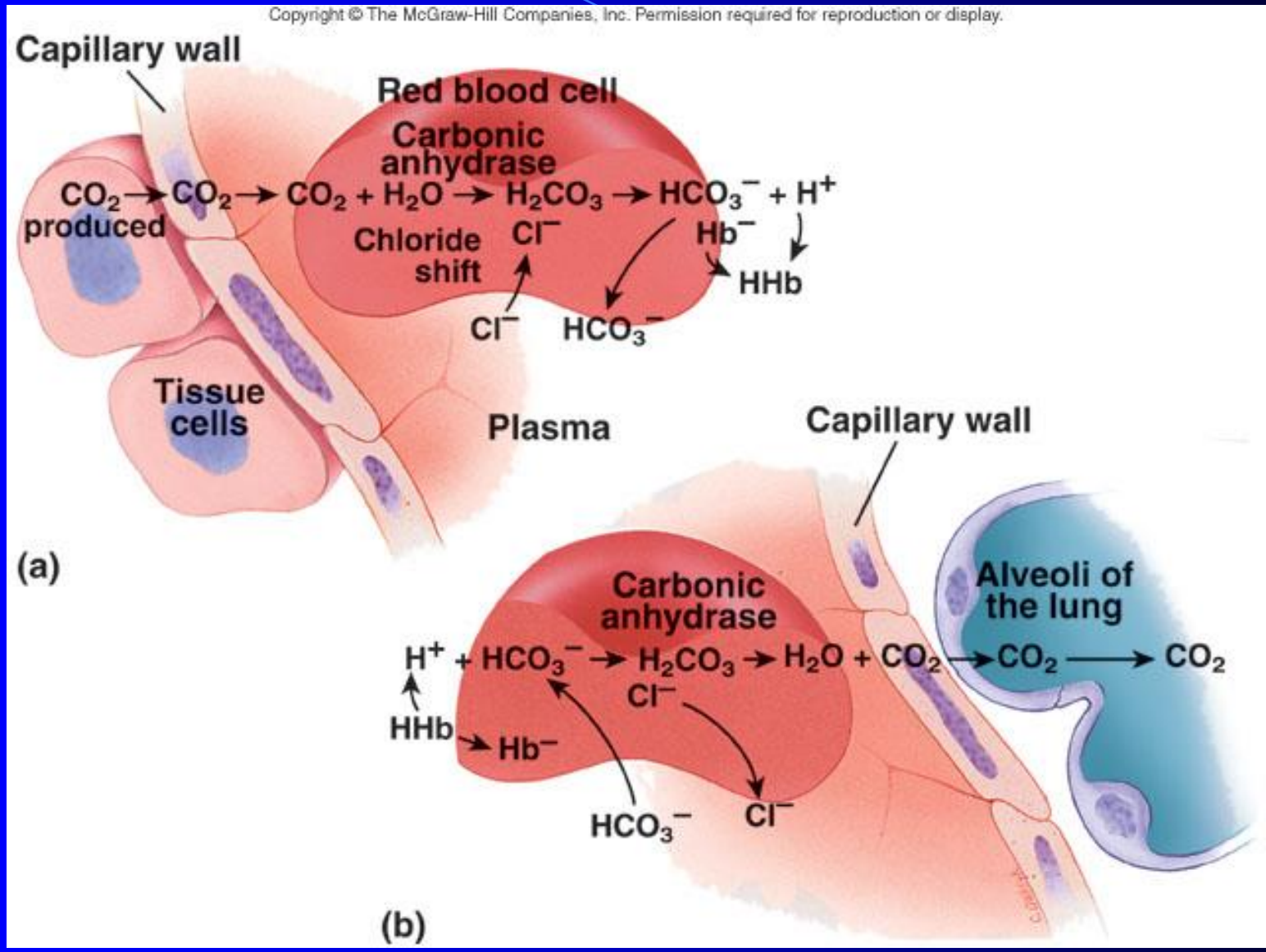
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Gas Transport

- CO2 transport
- 7% in plasma
- 23% in carbamino compounds (bound to globin part of Hb)
- 70% as Bicarbonate

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Controls of Respiration

- Medullary Rhythmicity Area
  - Medullary Inspiratory Neurons are main control of breathing
    - Pons neurons influence inspiration, with Pneumotaxic area limiting inspiration and Apneustic area prolonging inspiration.
    - Lung stretch receptors limit inspiration from being too deep

Controls of Respiration

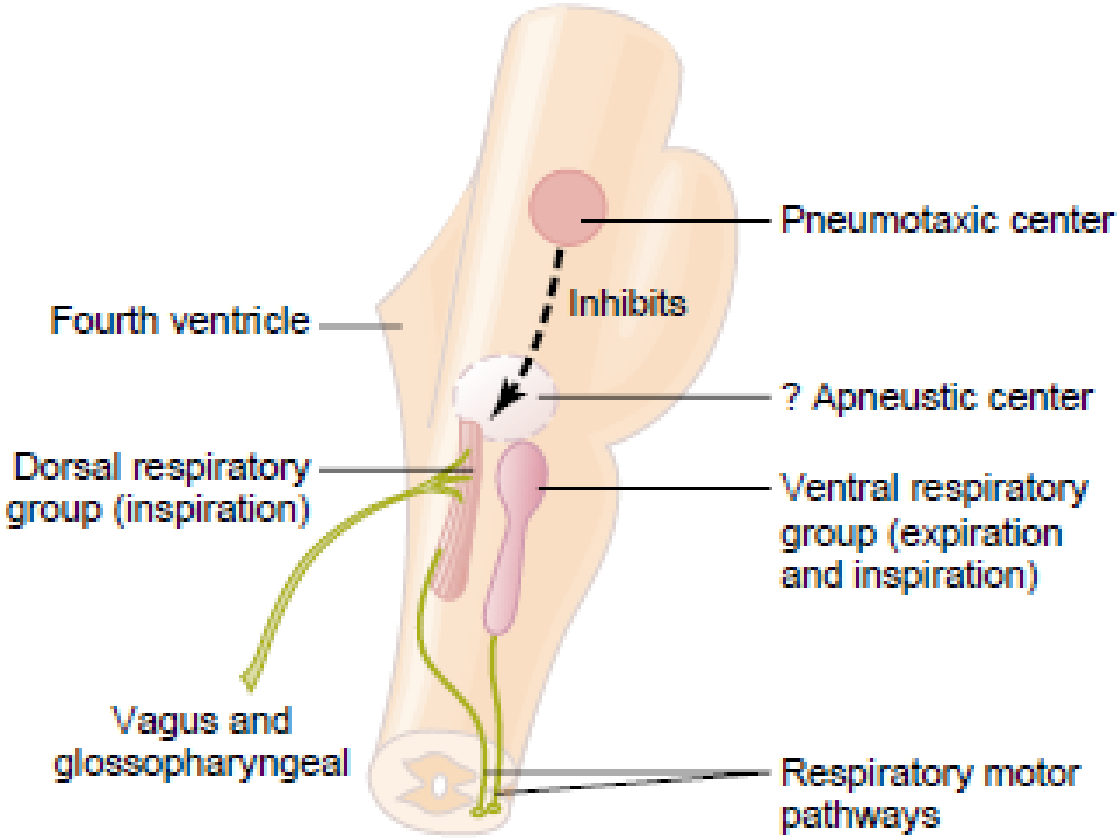


Figure 41–1

Organization of the respiratory center.

Controls

- Medullary Rhythmicity Area
  - Medullary Expiratory Neurons
    - Only active with exercise and forced expiration

Respiration describes the physical process of air moving in and out of the lung ???

- True
- False

Which of the following lung volumes or capacities includes the residual volume ??

- Tidal volume
- Vital capacity
- Inspiratory capacity
- Functional residual capacity