Human Anatomy and Physiology

The Respiratory System

Basic functions of the respiratory system:

as a **Gas exchange – supply oxygen to aerobic tissues in the body and remove carbon dioxide waste product.**

-Pulmonary ventilation - the physics of getting air in- to and out- of the lungs (ventilation).

-External respiration - gas exchange between the lungs and blood (oxygen loading and CO_2 unloading).

-Transport of respiratory gases - movement of blood (thus gases) from the lungs to the cell and tissues.

-Internal respiration – gas exchange between the capillaries and the tissues (oxygen unloading and CO_2 loading)

Human Anatomy and Physiology

The Respiratory System

Functional anatomy of the respiratory system:

Conducting Zone

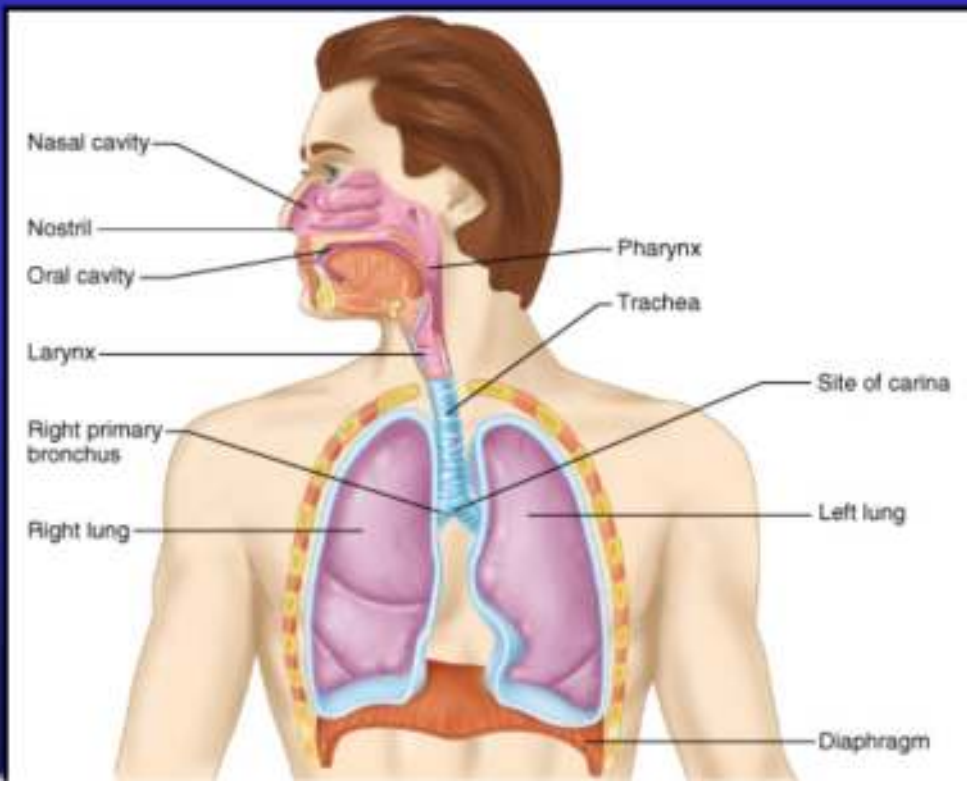
Rigid conduits for air to reach site of gas exchange

- -nose
- -nasal cavity
- -pharynx
- -larynx
- -trachea
- -bronchi

-Respiratory Zone

site of gas exchange

- -respiratory bronchioles
- -alveolar ducts

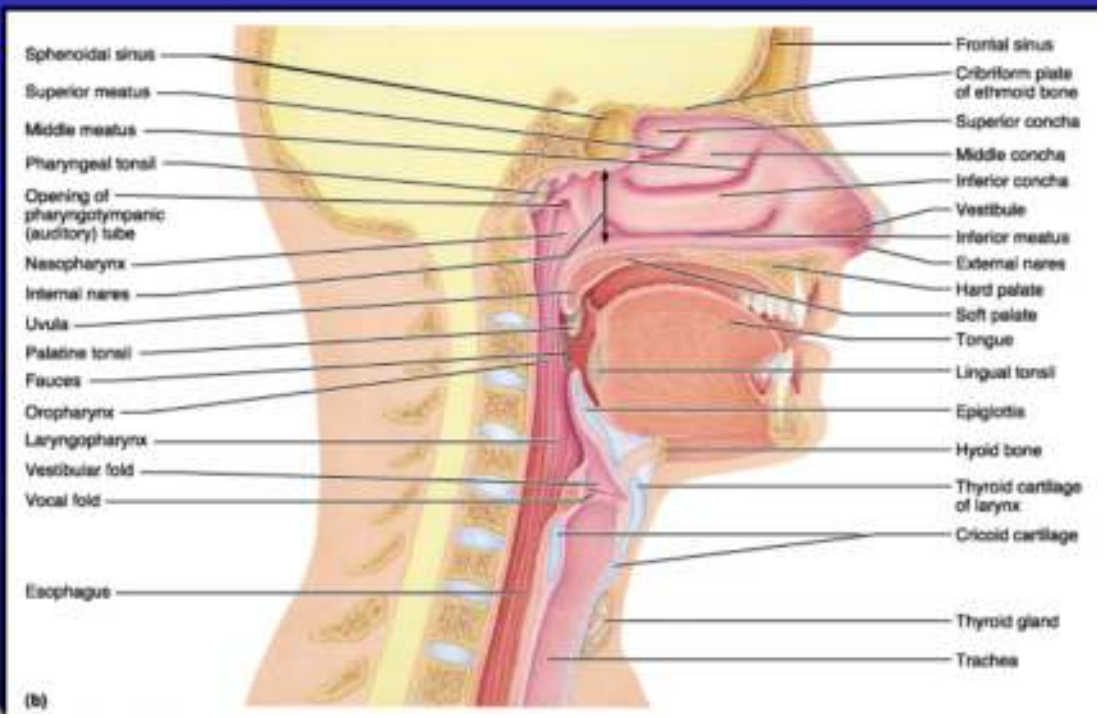


Human Anatomy and Physiology
The conducting zone

Conducting Zone:

Nose
- -airway
- -moistens and warms air
- -filters inspired air
- -resonating chamber for speech
- -olfaction

-paranasal sinuses
- -frontal, sphenoid, ethmoid and maxillary bones
- -warm and moisten air



Human Anatomy and Physiology
The conducting zone

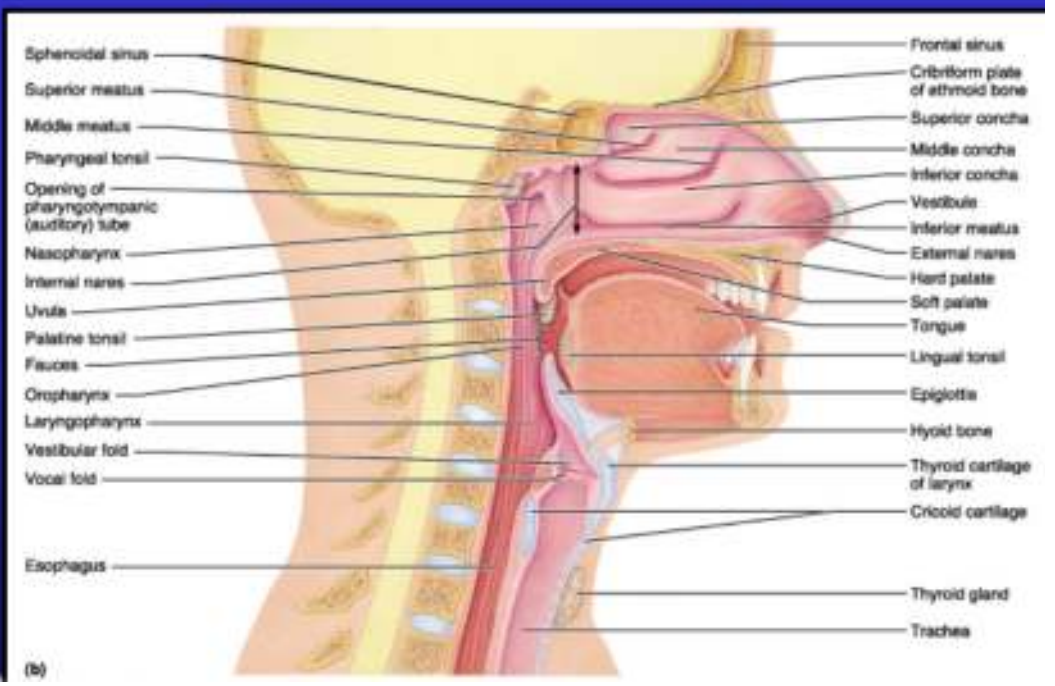
Conducting Zone:

Pharynx

-connects the nasal cavity and mouth to the larynx and esophagus

-common pathway for food and air (throat)

-nasopharynx
-oropharynx
-laryngopharynx

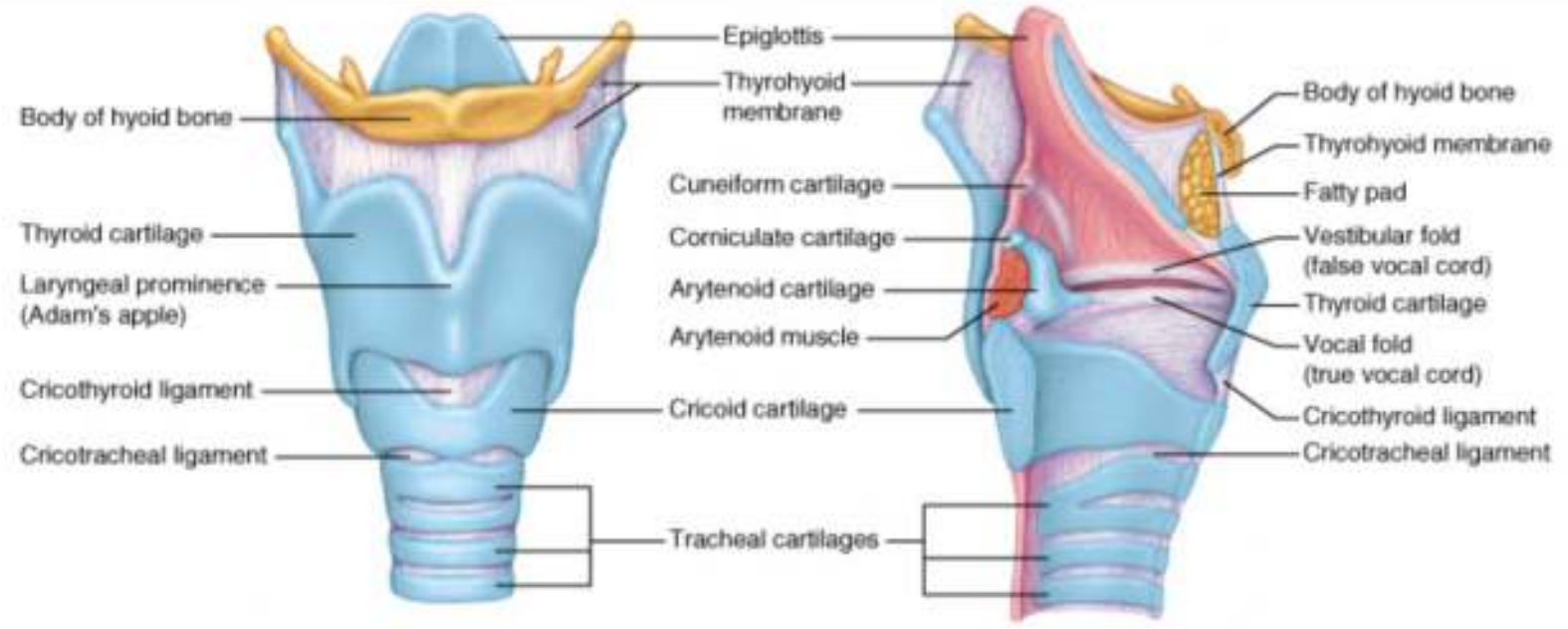


Human Anatomy and Physiology

The conducting zone

Conducting Zone:

Laryngopharynx – common passage way for food and air
Larynx – voice box



Human Anatomy and Physiology
The conducting zone

Conducting Zone:

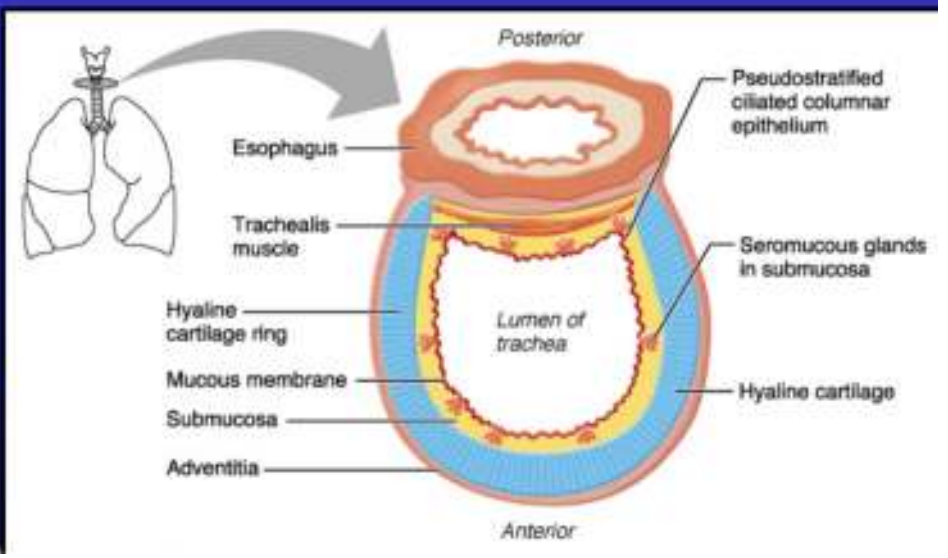
Trachea

-windpipe
-larynx at division forming two primary bronchi at midthorax

-mucosa – pseudostratified epithelium (goblet cells)

-submucosa – connective tissue seromucous glands – mucous

-advantitia – CT hyaline cartilage



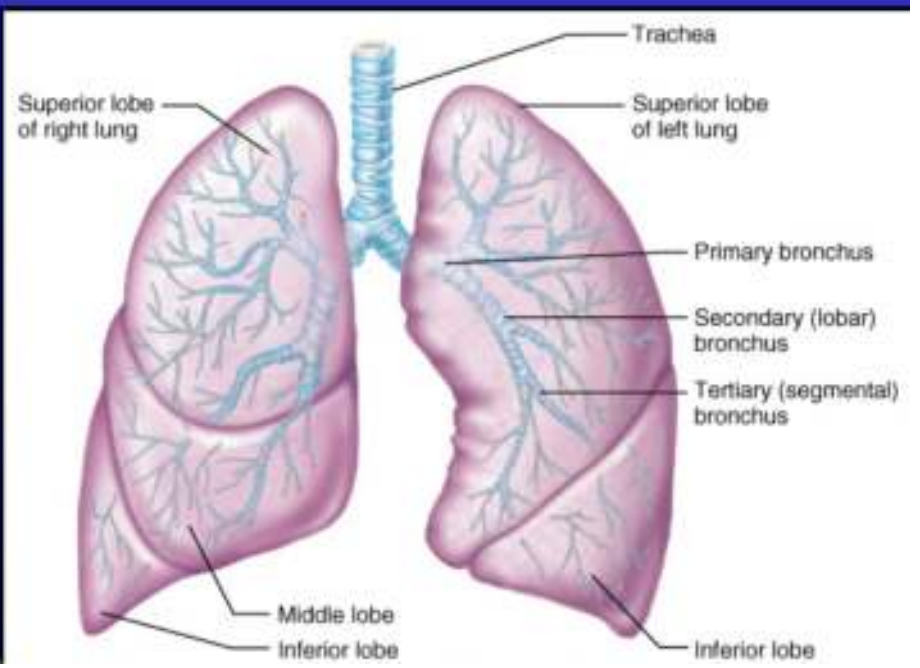
Human Anatomy and Physiology

The conducting zone

Conducting Zone:

Bronchi
Bronchial tree

-left and right primary bronchi
-formed by divisions of the trachea
-secondary bronchi (lobar)
-inside the lungs
-3 on the right
-2 on the left
-tertiary bronchi (segmental)
-fourth-order
-fifth-order
-23 orders of branching air ways
-bronchioles (under 1 mm in diameter



Human Anatomy and Physiology

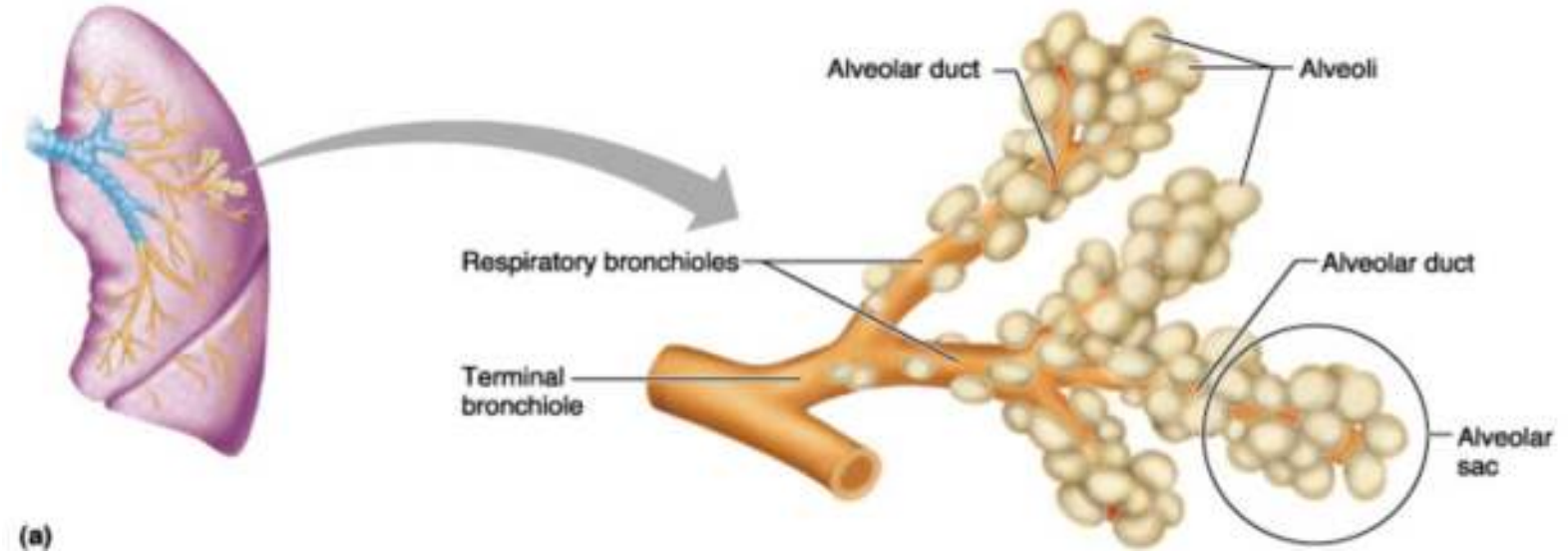
The conducting zone

Conducting Zone:

Bronchioles

-bronchioles (under 1 mm in diameter)

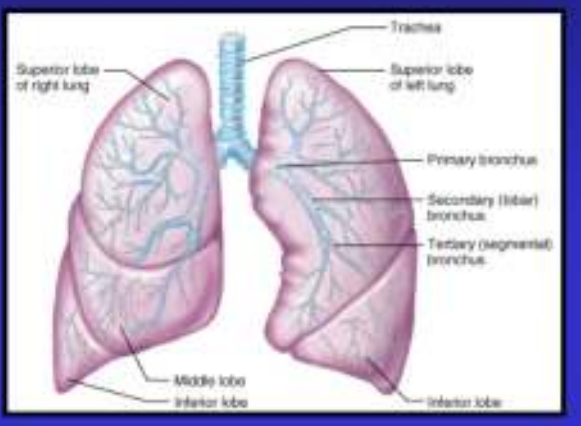
-terminal bronchioiles (less than 0.5 mm)



Human Anatomy and Physiology

The conducting zone

Conducting Zone:

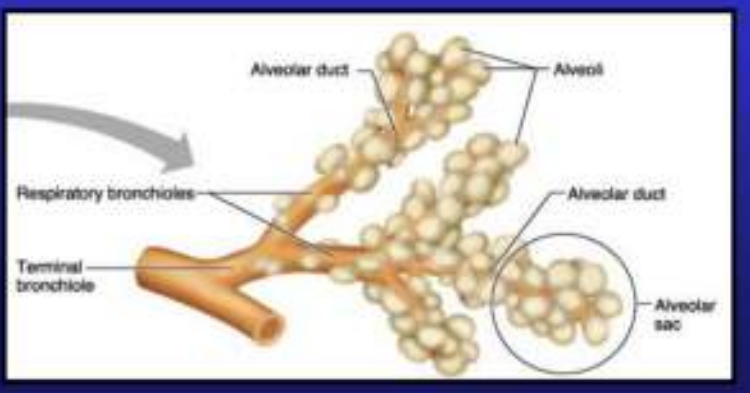


Cartilage:

-rings
-irregular plates
-no cartilage in bronchioles
-replaced by elastic fibers

Epithelium:

-pseudostratified (ciliated)
-columnar (ciliated)
-cuboidal in terminal bronchioles (no cilia)



Smooth Muscle:

-increases as tubes get smaller

Human Anatomy and Physiology

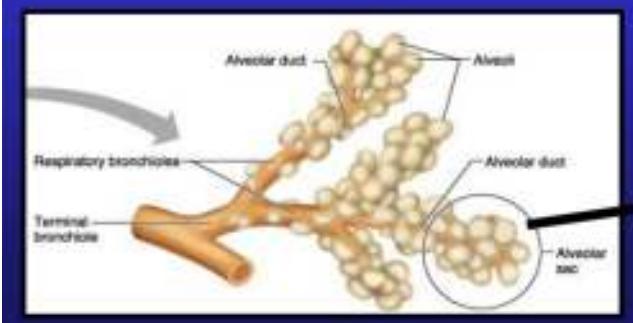
The respiratory zone

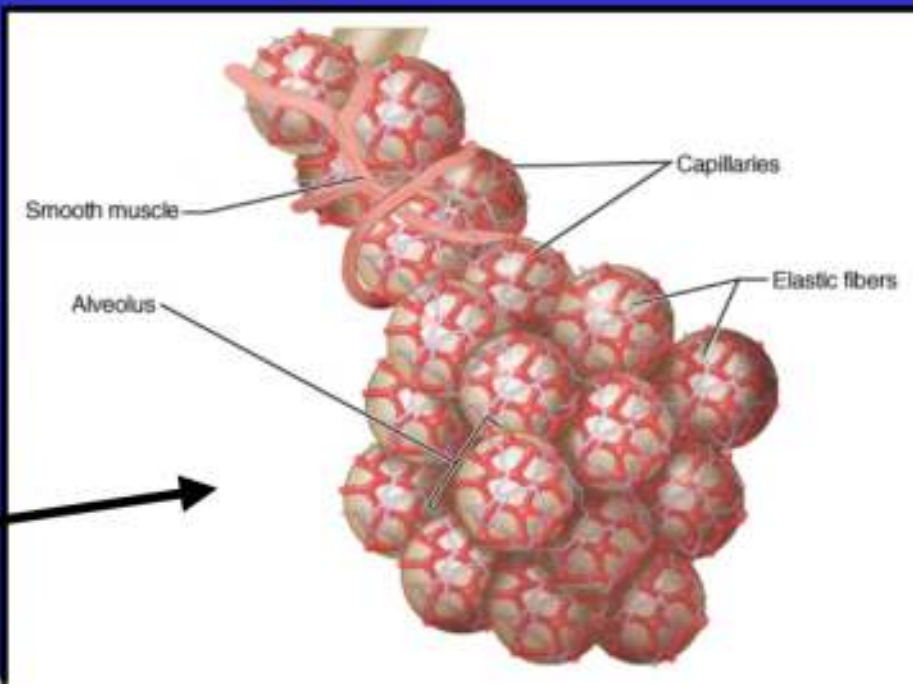
Respiratory Zone:

- Respiratory bronchioiles
- Alveoli (300 million)
- Alveolar ducts
- Alveolar sacs

Gas Exchange:

- respiratory membrane

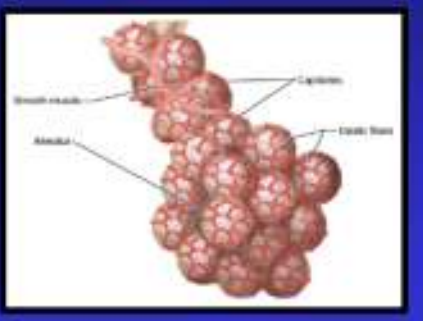




Human Anatomy and Physiology
The respiratory zone

Respiratory Zone:

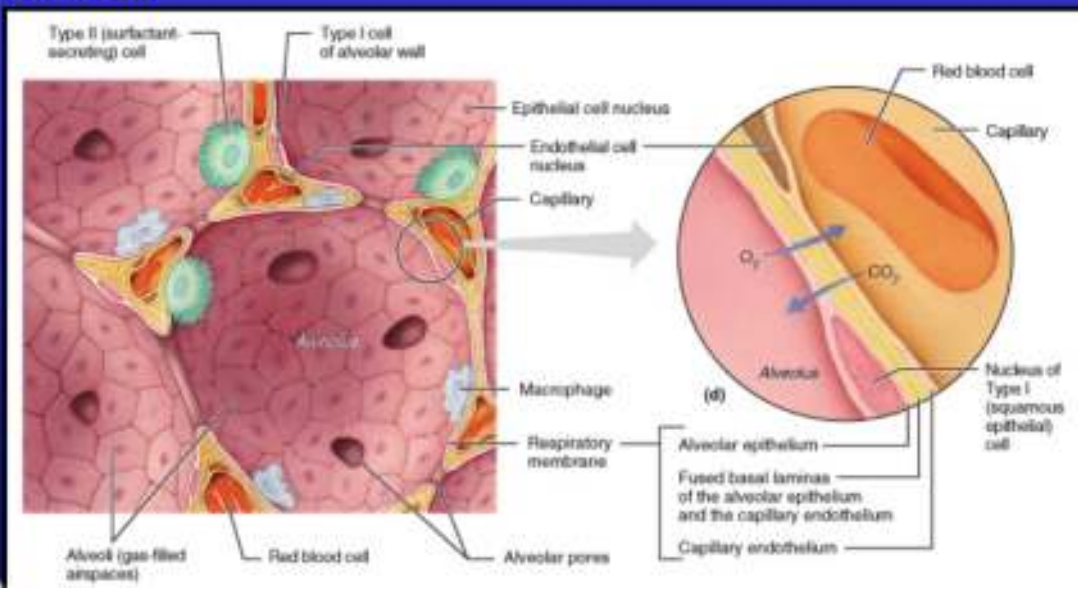
Respiratory membrane (air-blood barrier) or (Alveolar-capillary membrane) is composed of:
-simple squamous epithelial cells (Type I cells)
-cobweb of pulmonary capillaries



Primary function is gas exchange

-Type II cells (cuboidal) surfactant

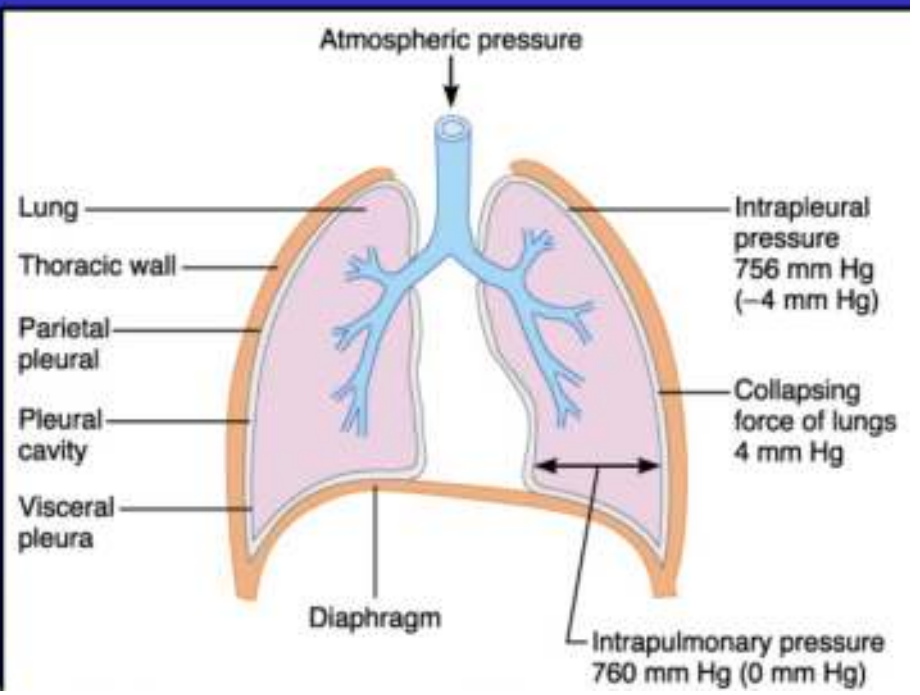
-elastic fibers
-alveolar pores allow for pressure equalization between alveoli
-alveolar macrophages (dust cells)



Human Anatomy and Physiology
Lungs and Pleural Coverings

Pleural Coverings:

-double layered serosa
-parietal pleura lines the thoracic wall
-pulmonary or visceral pleura which covers the lung surface
-pleural cavity is the space between the two layers
-pleural fluid fills the cavity



Human Anatomy and Physiology

Blood Supply and Innervation of the Lungs

Blood supply:

-Pulmonary circulation
-Bronchial circulation

Pulmonary arteries from the right side of the heart supply blood to the lungs.
-pulmonary arteries branch profusely along with the bronchi
-pulmonary capillary networks surrounding alveoli

-pulmonary veins form post alveoli to carry oxygenated blood back to the heart

Bronchial arteries come from the aorta and enter the lung at the hilus
-the bronchial arteries run along the branching bronchi and supply lung tissue except the alveoli
-bronchial veins drain the bronchi but most moves into the pulmonary circulation

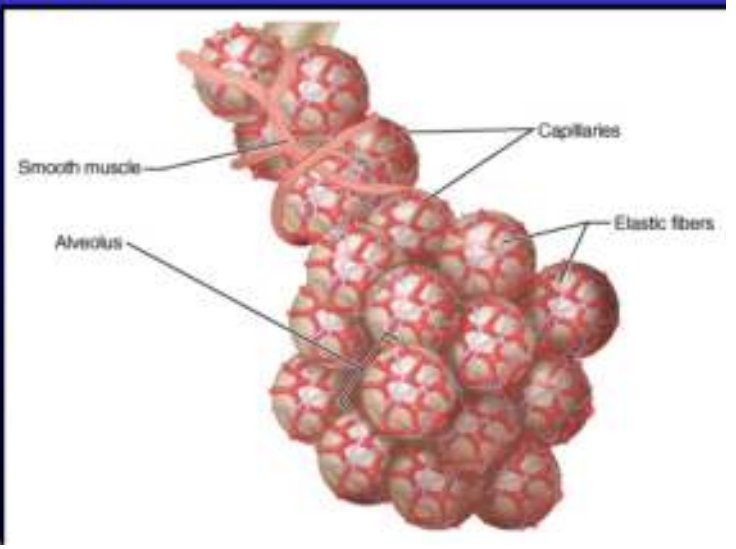
Human Anatomy and Physiology
Blood Supply and Innervation of the Lungs

Innervation:

-parasympathetic motor fibers (some sympathetic fibers)
-visceral sensory fibers

Enter the lung through the pulmonary plexus on the lung root

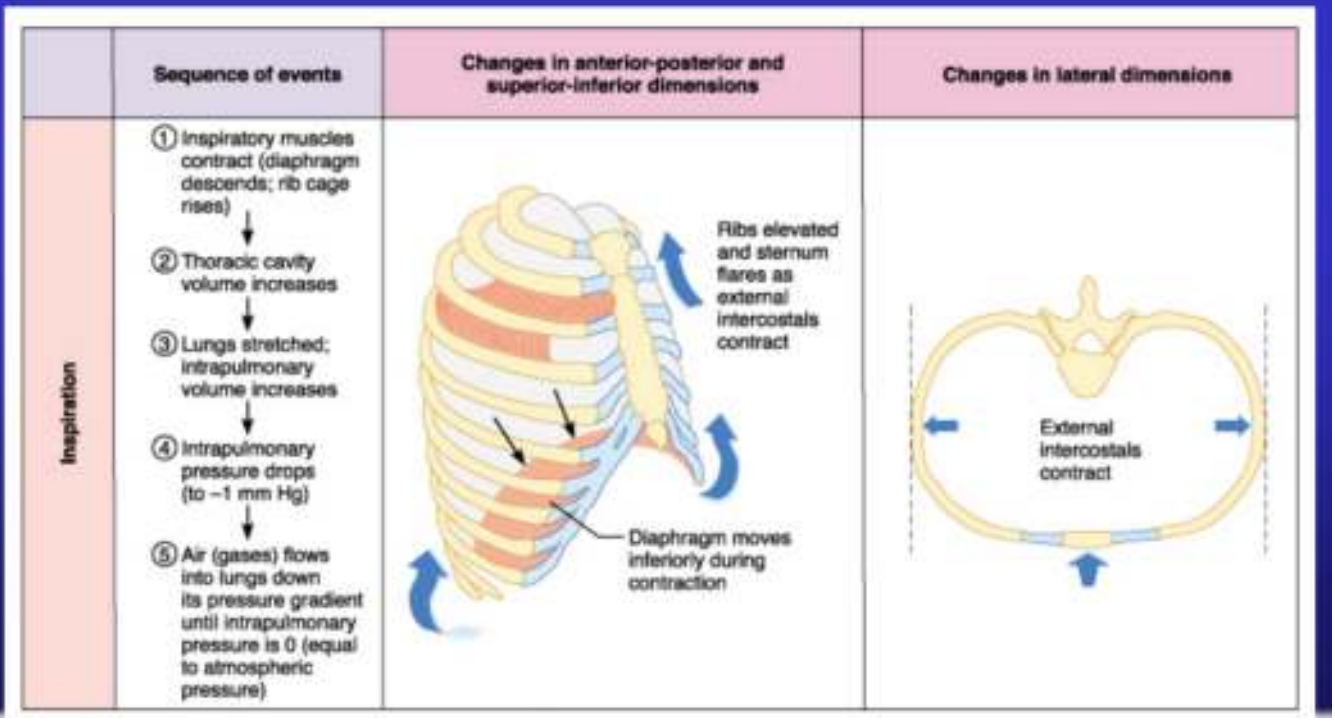
parasympathetic fibers – constrict the air tubes
sympathetic fibers – dilate air tubes



Human Anatomy and Physiology
Respiratory Mechanics

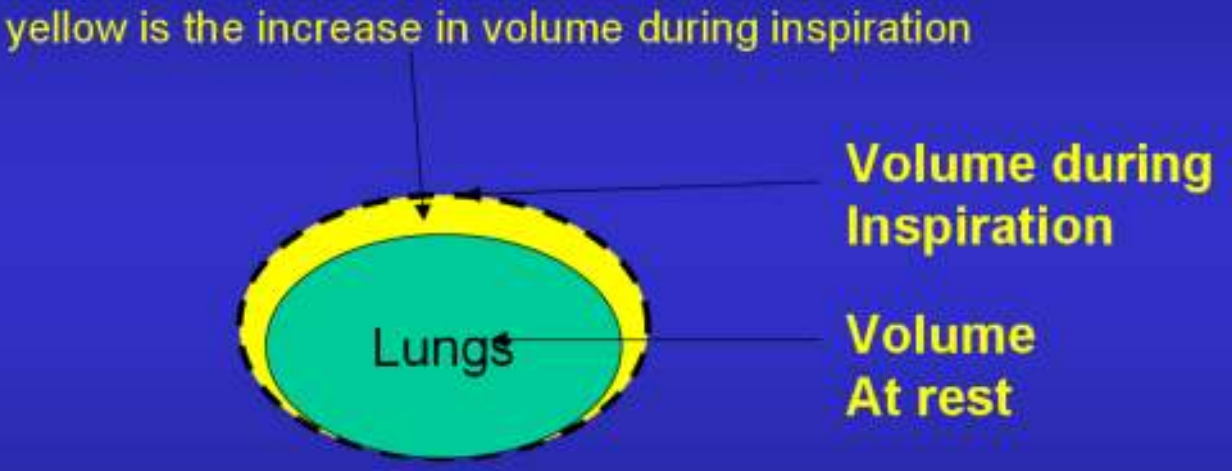
Breathing:

Simply pressure changes driven by diaphragm and external intercostal muscle contractions



Human Anatomy and Physiology
Respiratory Mechanics

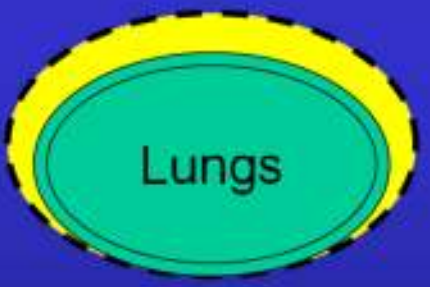
Breathing:



Human Anatomy and Physiology
Respiratory Mechanics

Breathing:

Increased volume causes a drop in pressure if the system is closed.
Where is the system closed to the outside?

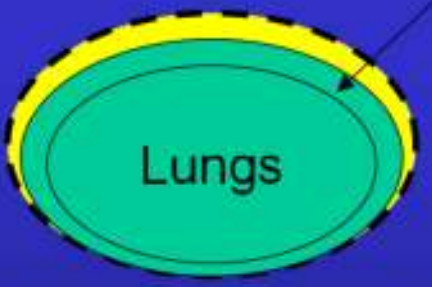


Boyle's law – $P_1V_1 = P_2V_2$

Human Anatomy and Physiology
Respiratory Mechanics

Breathing:

Increased volume causes a drop in pressure if the system is closed.
Where is the system closed to the outside? ***The pleural cavity!***

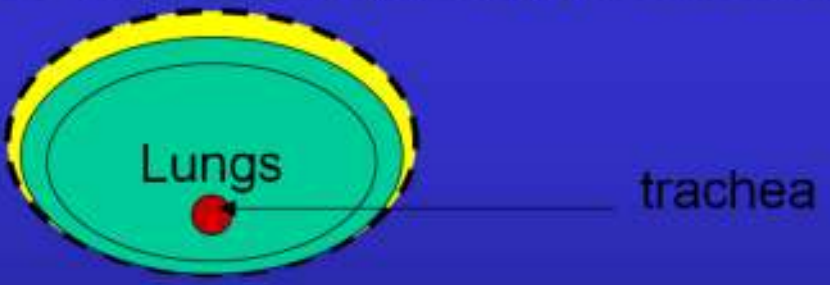


The decrease in intrapleural cavity pressure is translated to the lungs via the inner visceral pleural membrane because it is attached to the outer surface of the lung
Thus, an increase in volume causes a decrease in intrapleural pressure because it is a closed system.

Human Anatomy and Physiology
Respiratory Mechanics

Breathing:

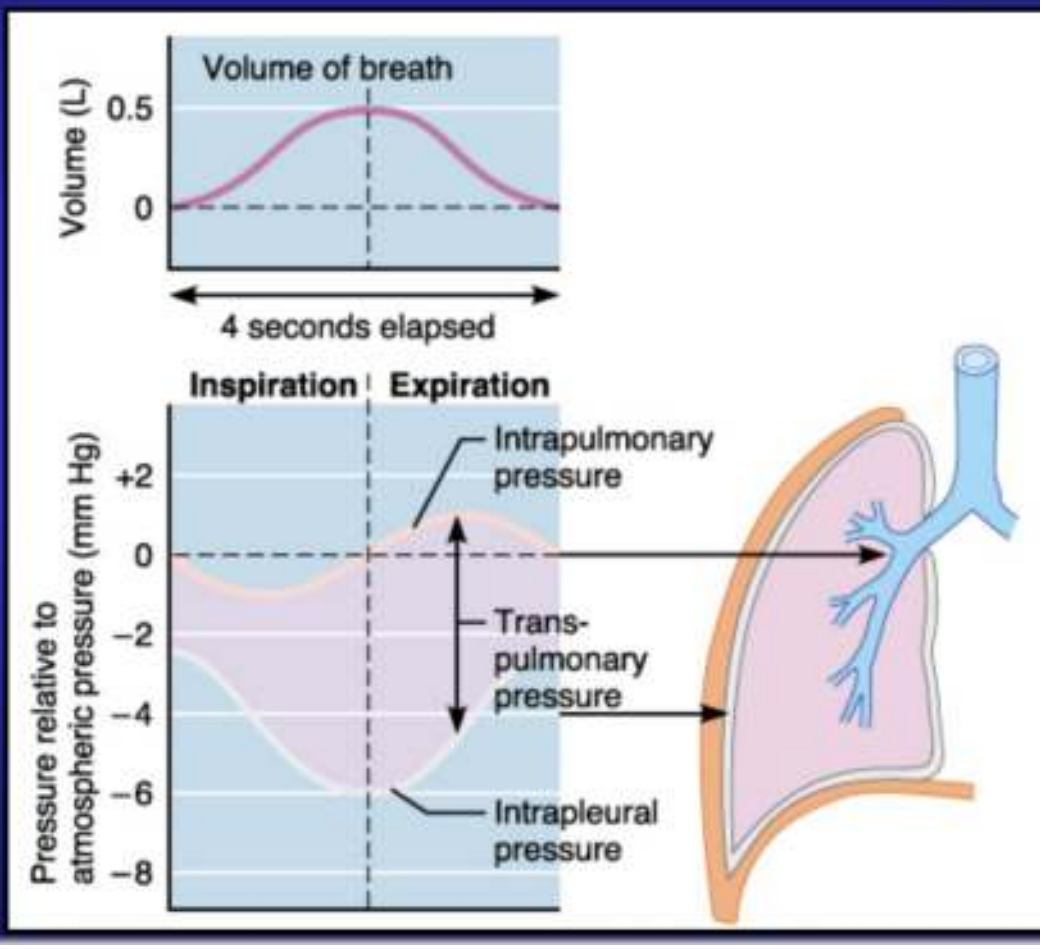
The lungs are an open system via the trachea and as such as intrapleural pressure drops lung volume increases and lung pressure also decreases. However, because the lungs are open to the outside, air rushes into the lungs to equalize the pressure. Thus, the drop in pulmonary pressure is transient.



Pulmonary pressure returns to zero as air moves into the lungs to take up the volume change (drop in pressure).

Human Anatomy and Physiology

Respiratory Mechanics



Human Anatomy and Physiology
Respiratory Mechanics

Breathing:

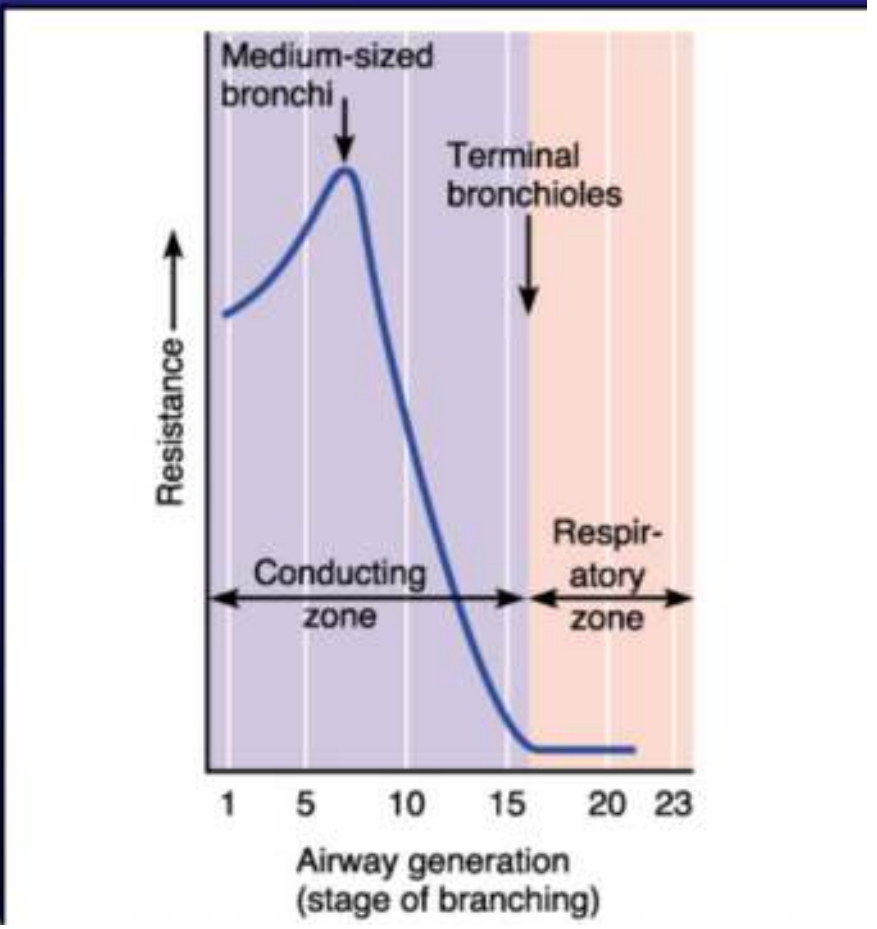
Airway Resistance-

-friction or drag along the respiratory passageway

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

-maximum resistance in medium size bronchi then drops as cross sectional area increases

-bronchiole smooth muscle very sensitive to parasym stimulation



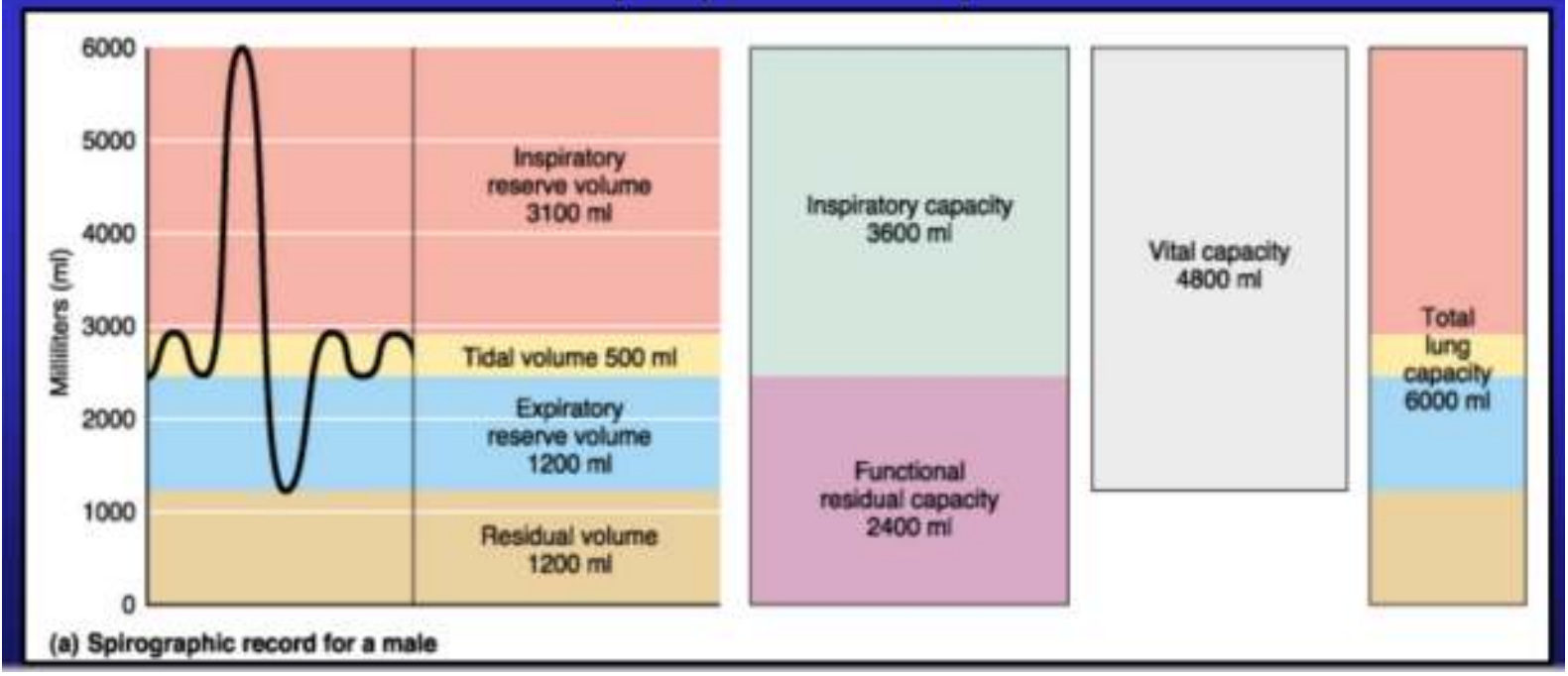
Human Anatomy and Physiology

Respiratory Mechanics

Lung volumes

dead space – -volume of air filling the conducting zone and never contributes to gas exchange (anatomical dead space 150 ml).

-if some of the alveoli collapse or are obstructed (alveolar dead space). Total dead space = AnaDS + AlvDS



Human Anatomy and Physiology
Respiratory Mechanics

Breathing:

-

	Measurement	Adult male average value	Adult female average value	Description
Respiratory volumes	Tidal volume (TV)	500 ml	500 ml	Amount of air inhaled or exhaled with each breath under resting conditions
	Inspiratory reserve volume (IRV)	3100 ml	1900 ml	Amount of air that can be forcefully inhaled after a normal tidal volume inhalation
	Expiratory reserve volume (ERV)	1200 ml	700 ml	Amount of air that can be forcefully exhaled after a normal tidal volume exhalation
	Residual volume (RV)	1200 ml	1100 ml	Amount of air remaining in the lungs after a forced exhalation
Respiratory capacities	Total lung capacity (TLC)	6000 ml	4200 ml	Maximum amount of air contained in lungs after a maximum inspiratory effort: TLC = TV + IRV + ERV + RV
	Vital capacity (VC)	4800 ml	3100 ml	Maximum amount of air that can be expired after a maximum inspiratory effort: VC = TV + IRV + ERV (should be 80% TLC)
	Inspiratory capacity (IC)	3600 ml	2400 ml	Maximum amount of air that can be inspired after a normal expiration: IC = TV + IRV
	Functional residual capacity (FRC)	2400 ml	1800 ml	Volume of air remaining in the lungs after a normal tidal volume expiration: FRC = ERV + RV

(b) Summary of respiratory volumes and capacities for males and females

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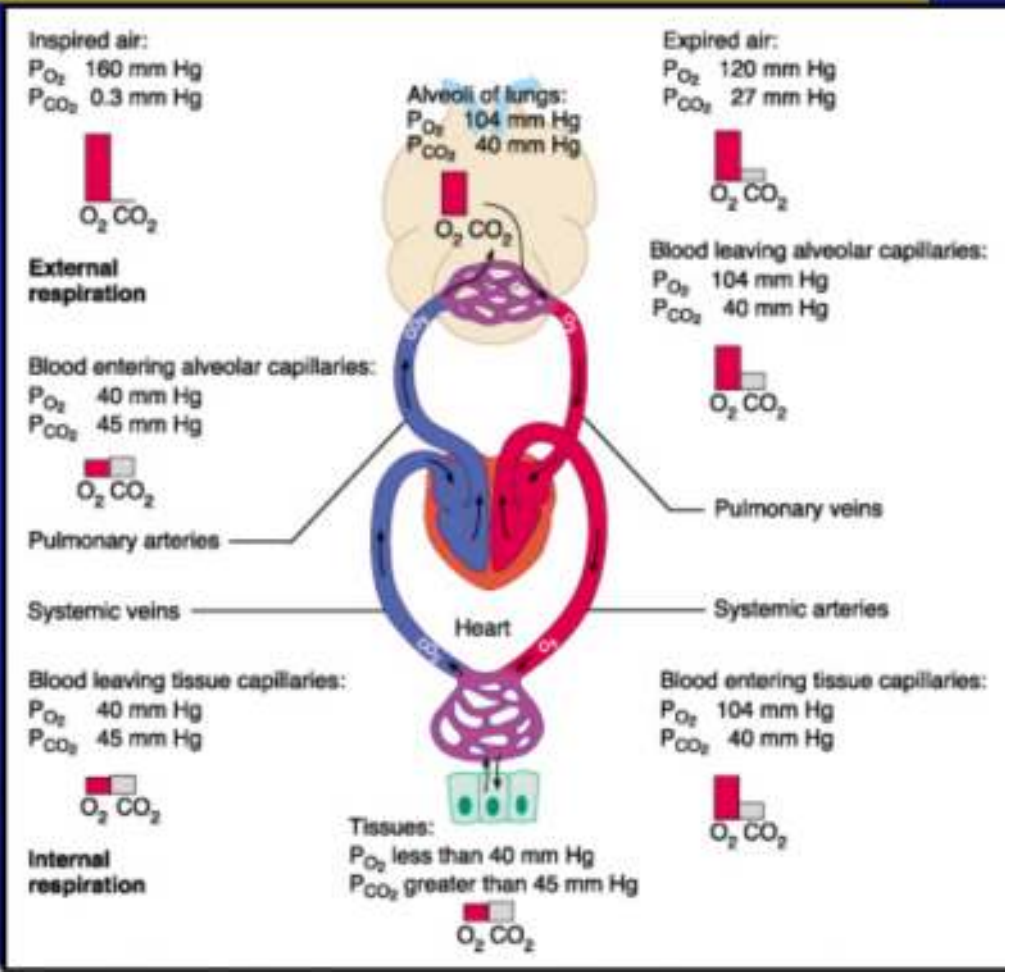
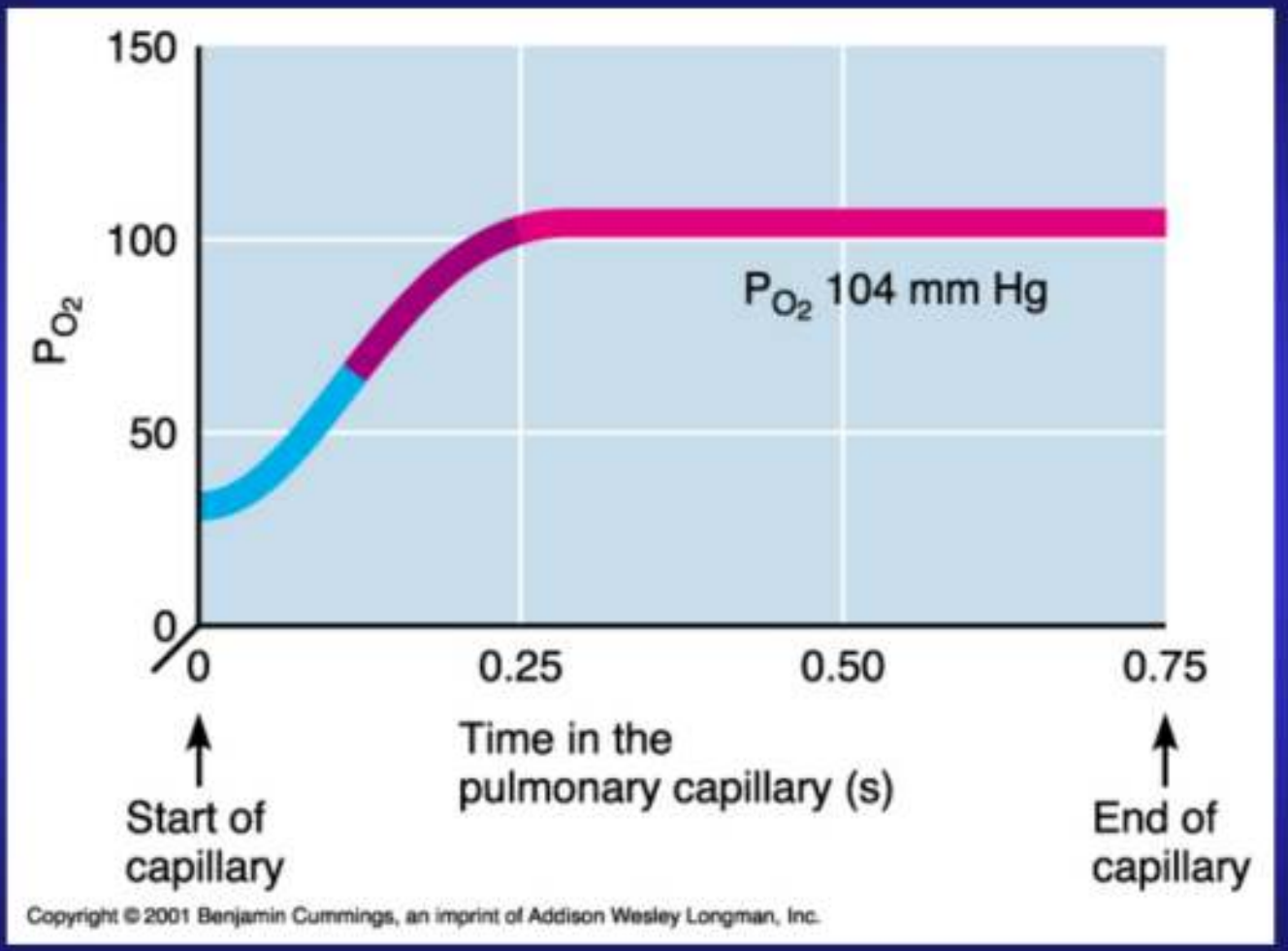
Human Anatomy and Physiology

Gas Exchange

Gas exchange:

-





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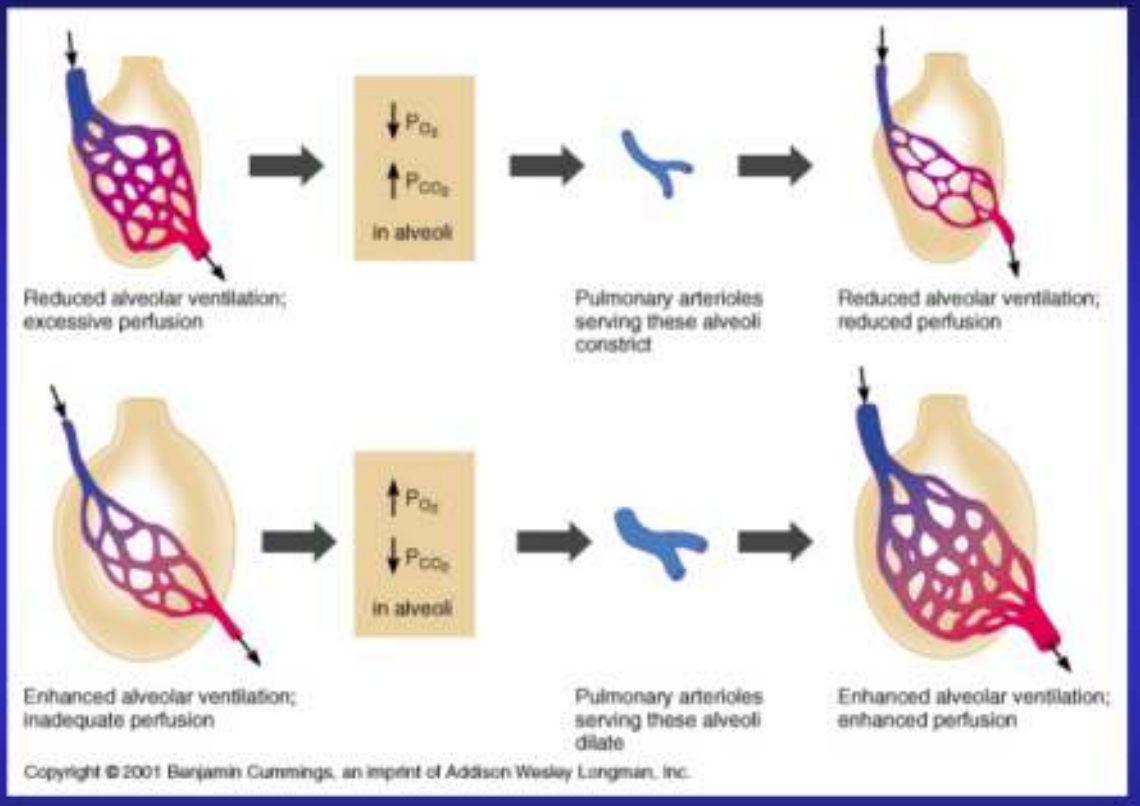

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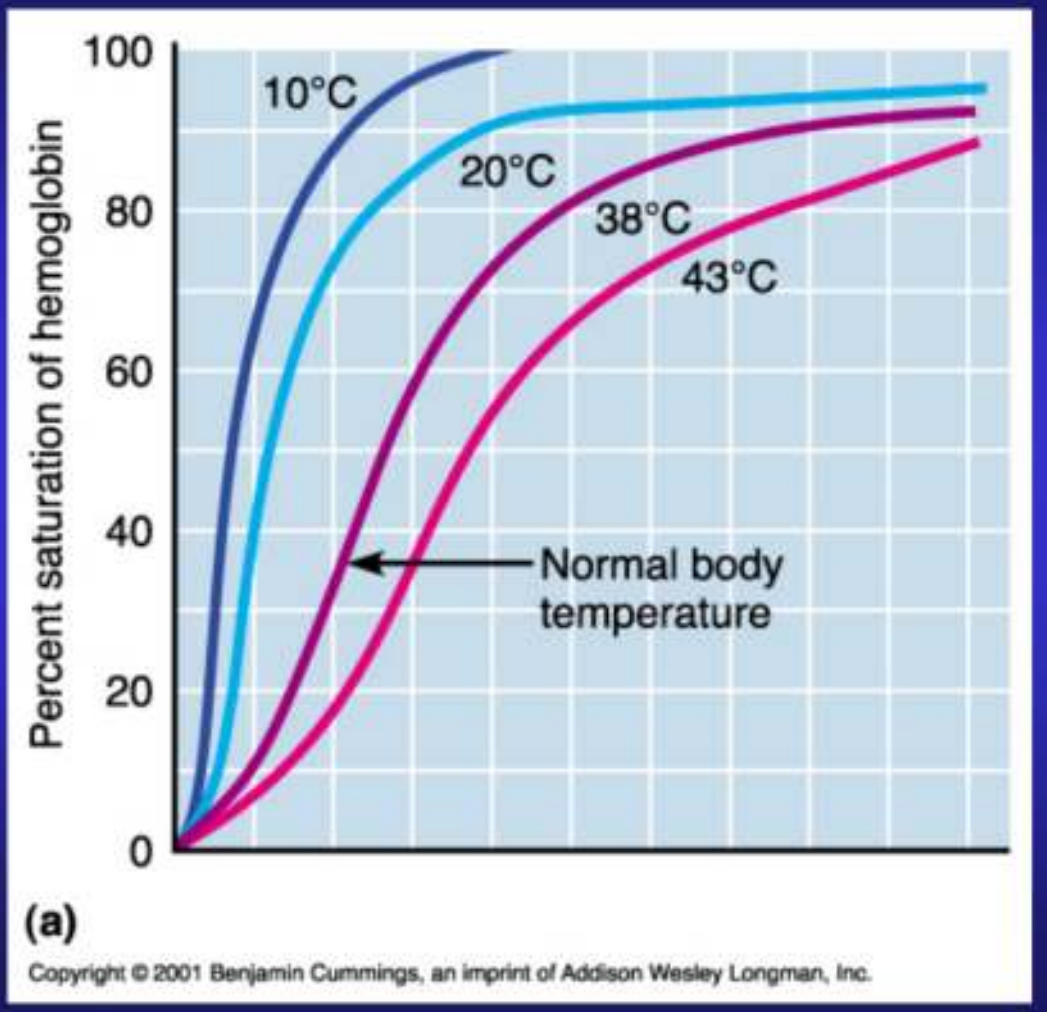

(a)

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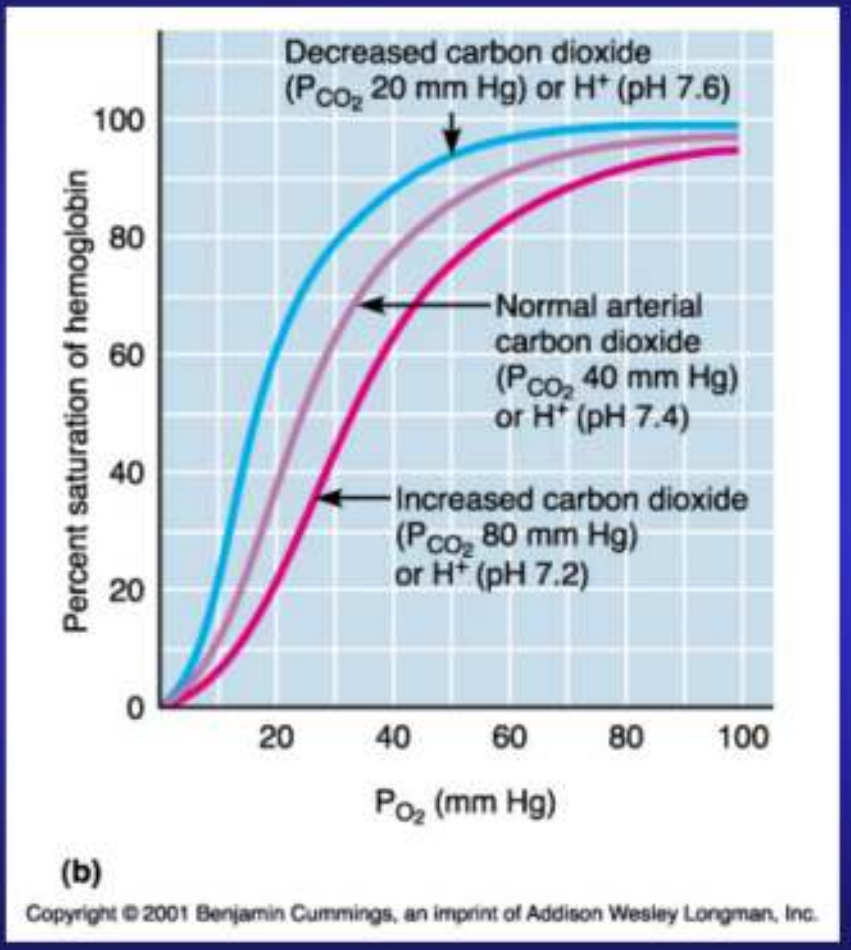

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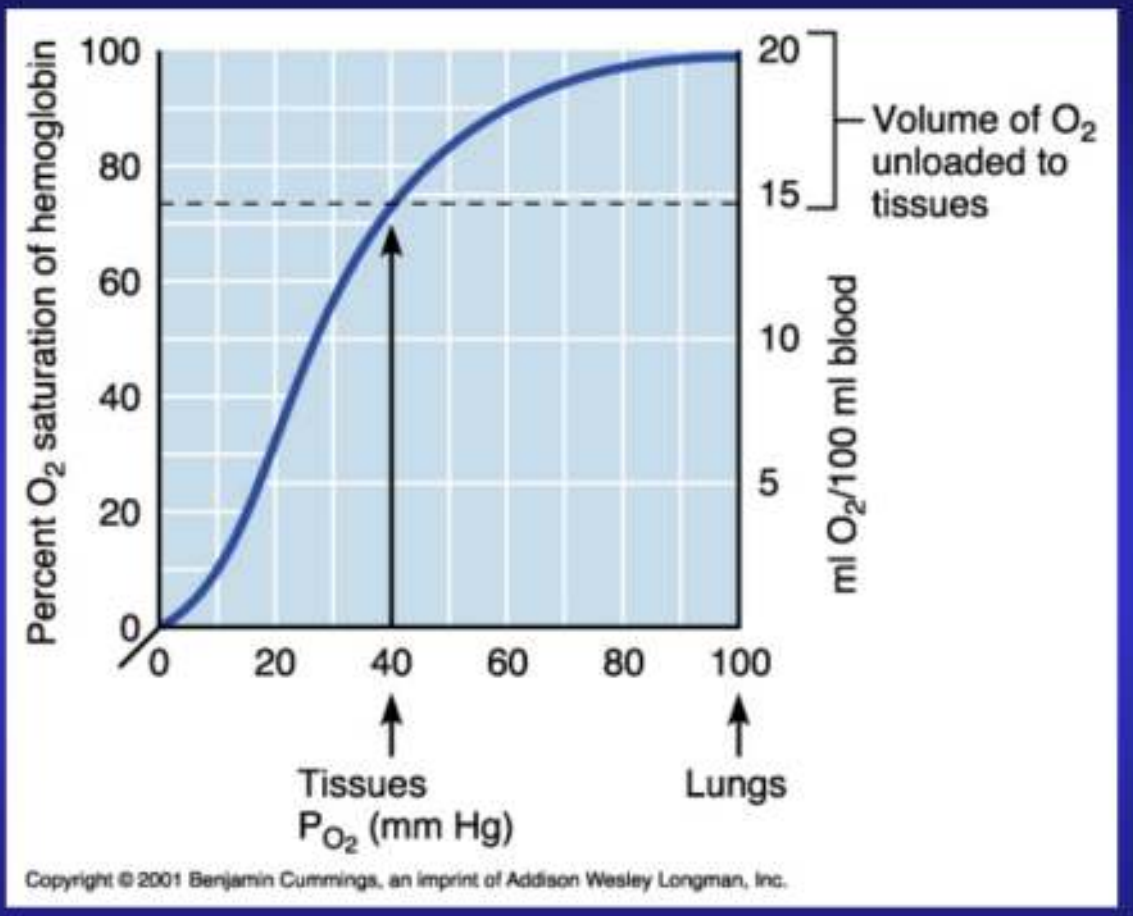

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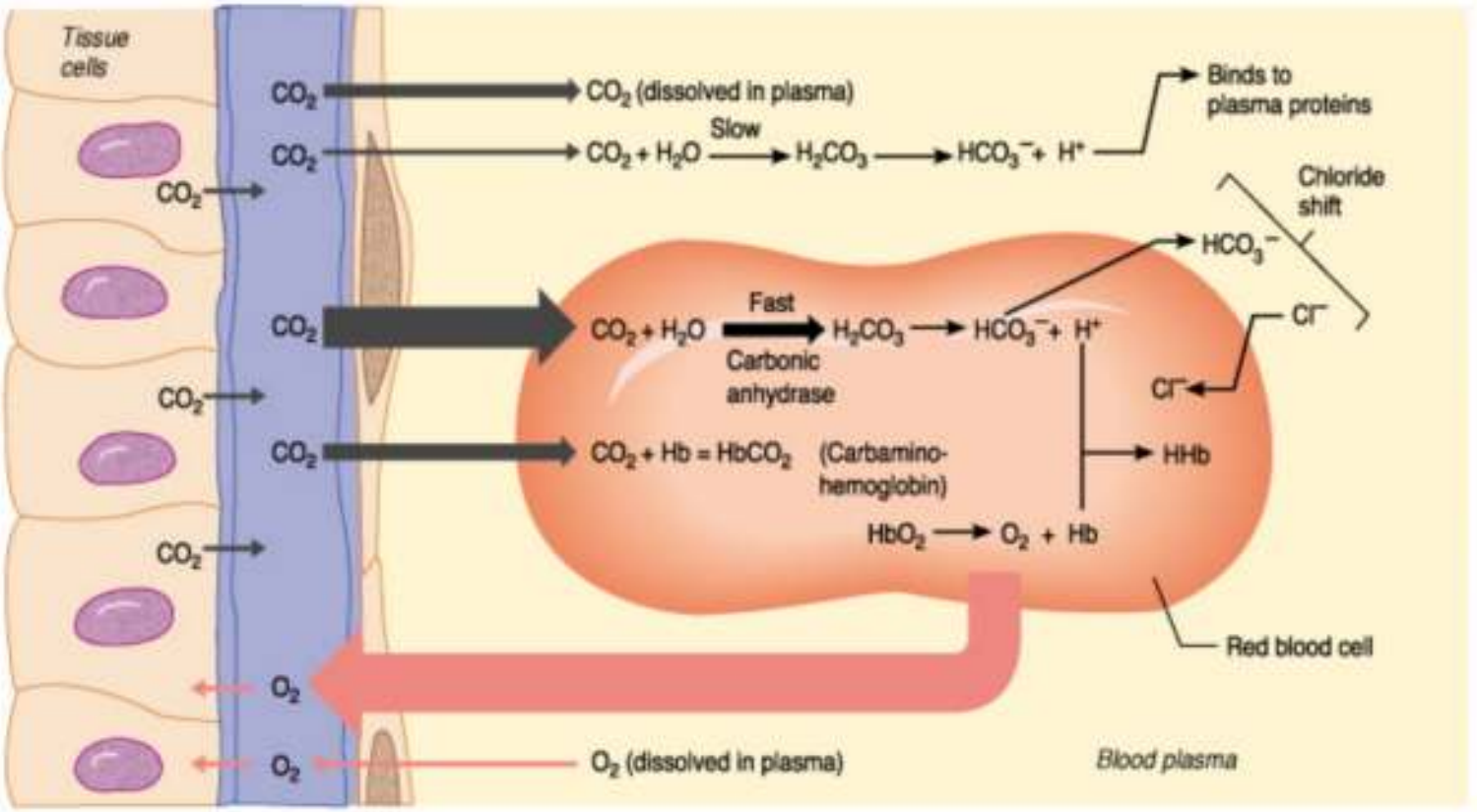

(a) Oxygen release and carbon dioxide pickup at the tissues

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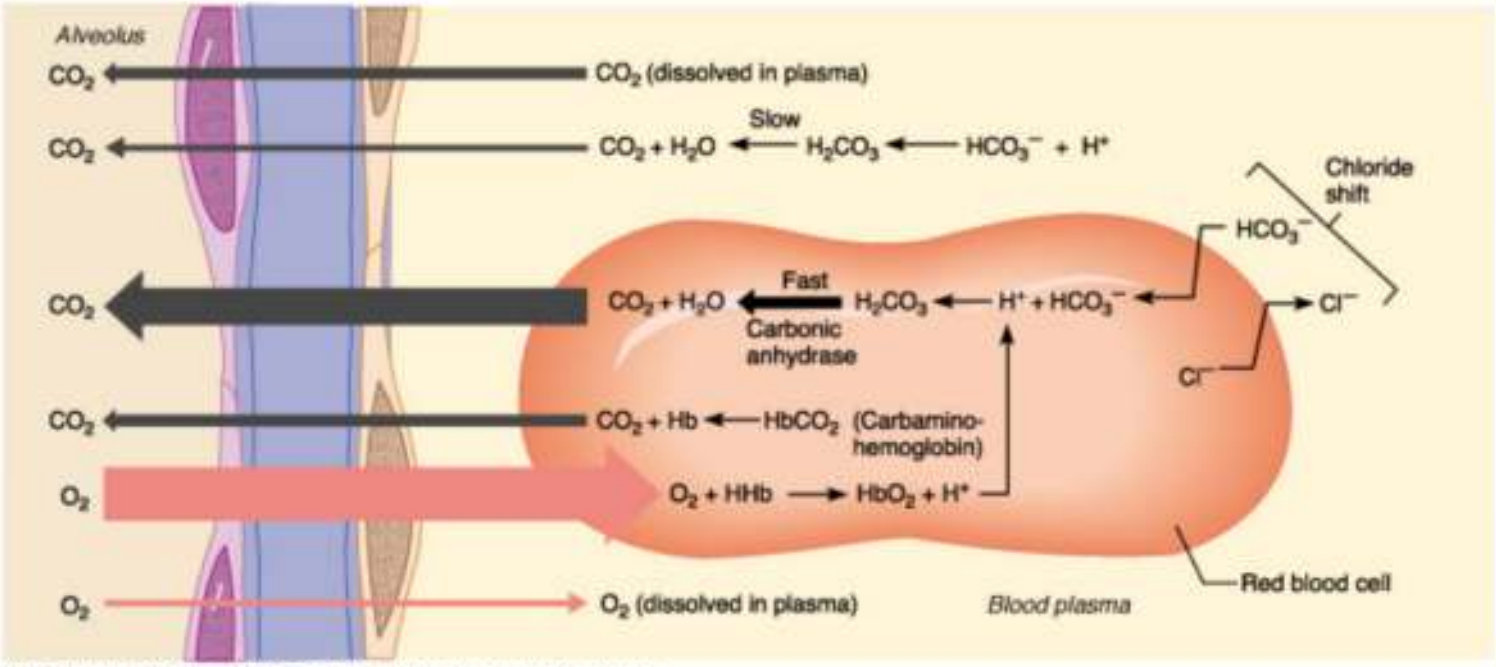

(b) Oxygen pickup and carbon dioxide release in the lungs

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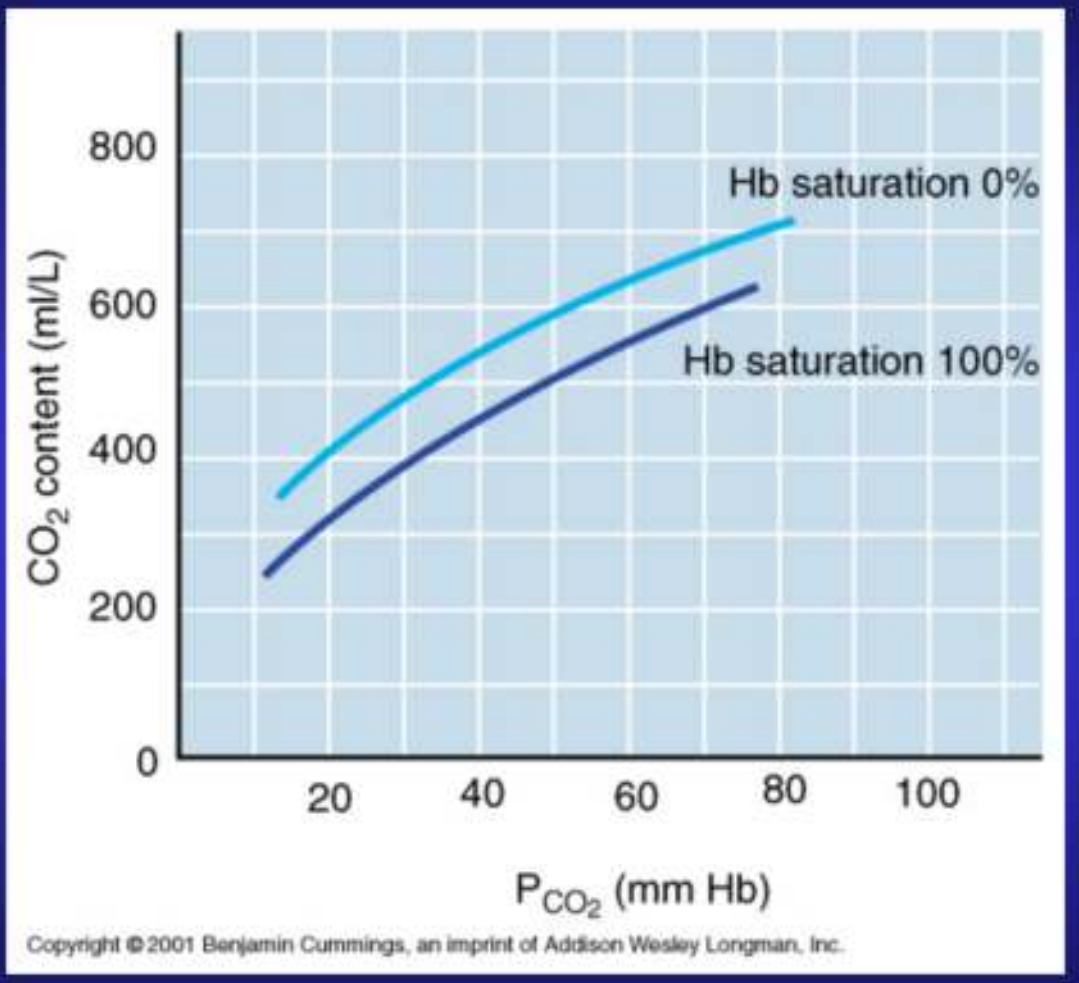

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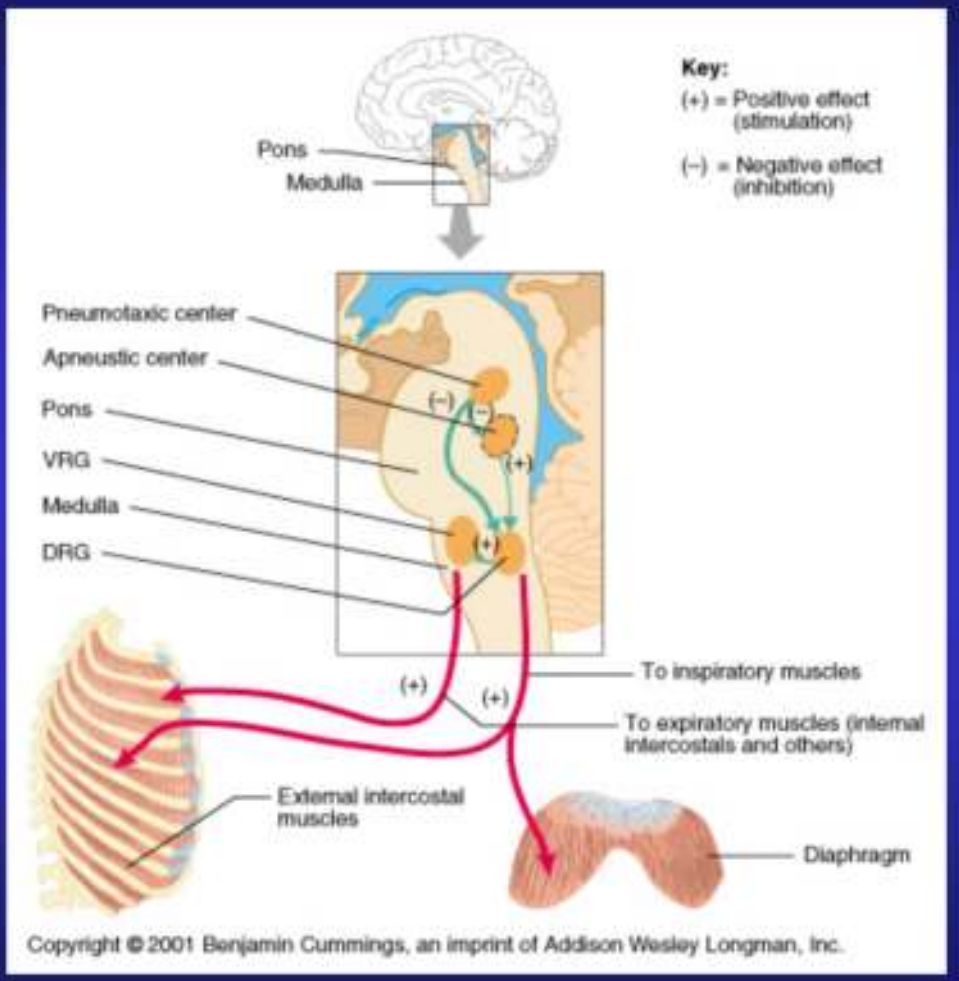

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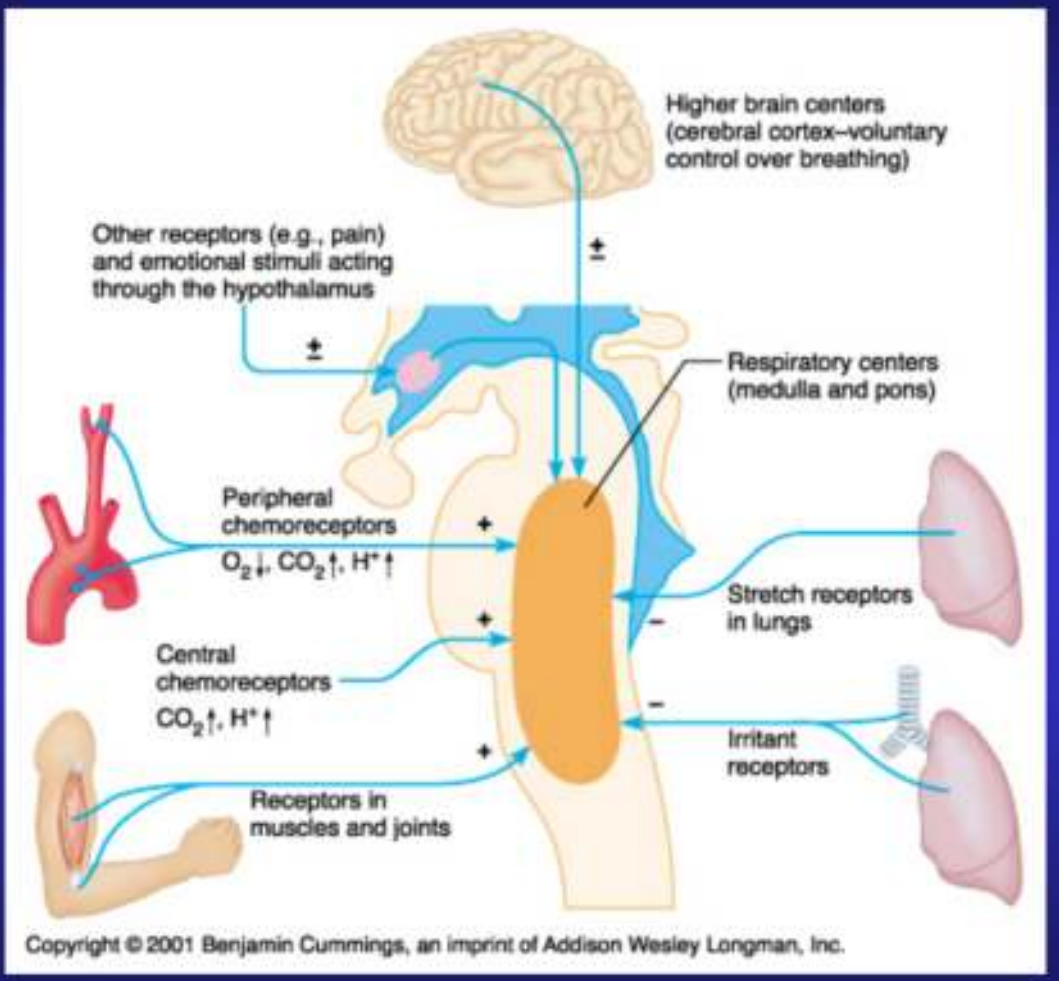

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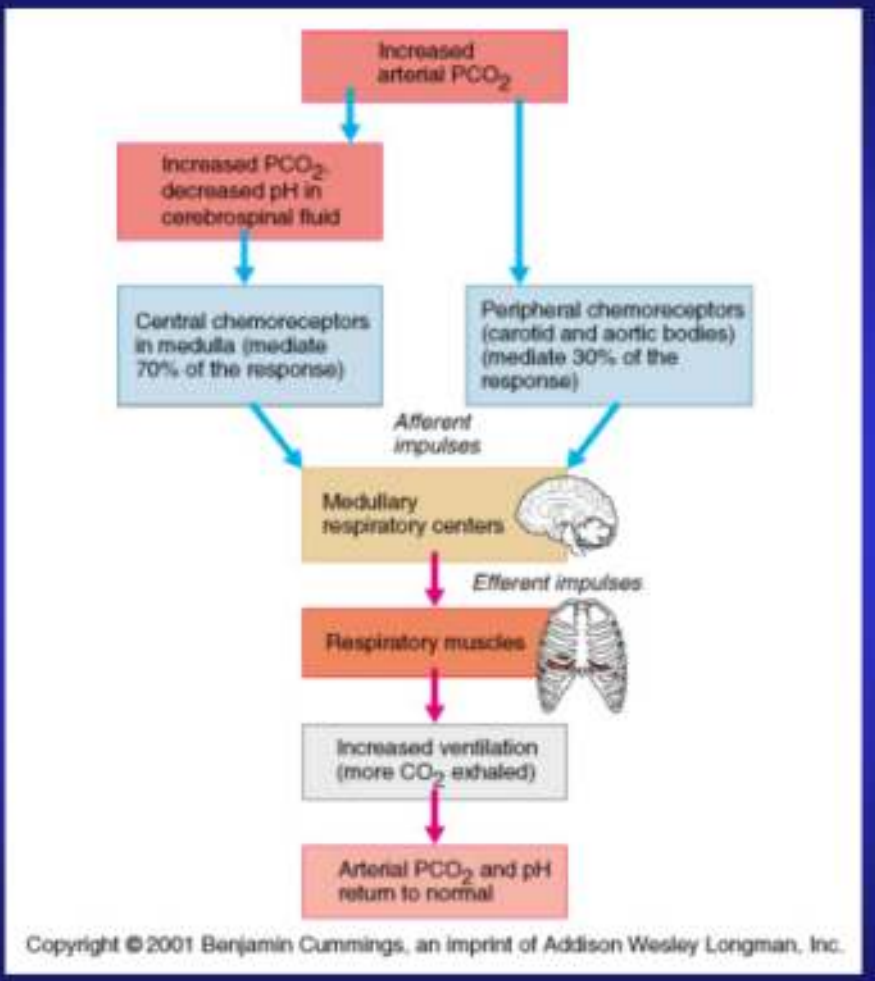

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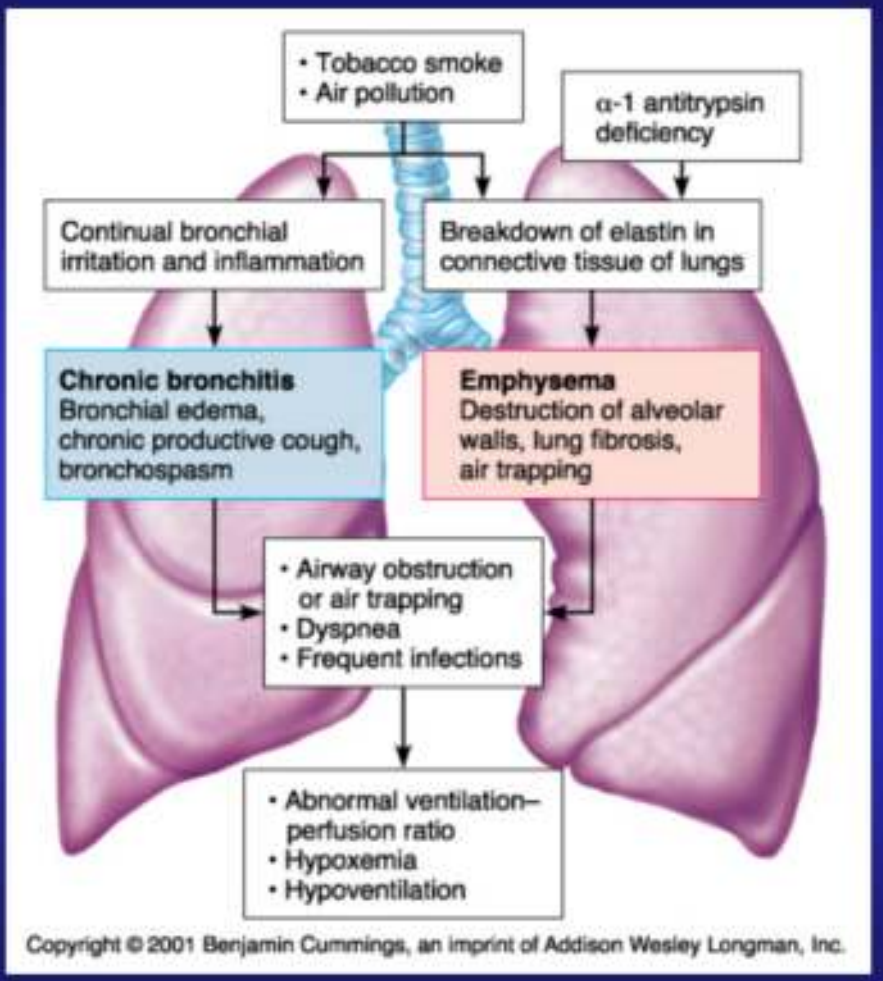

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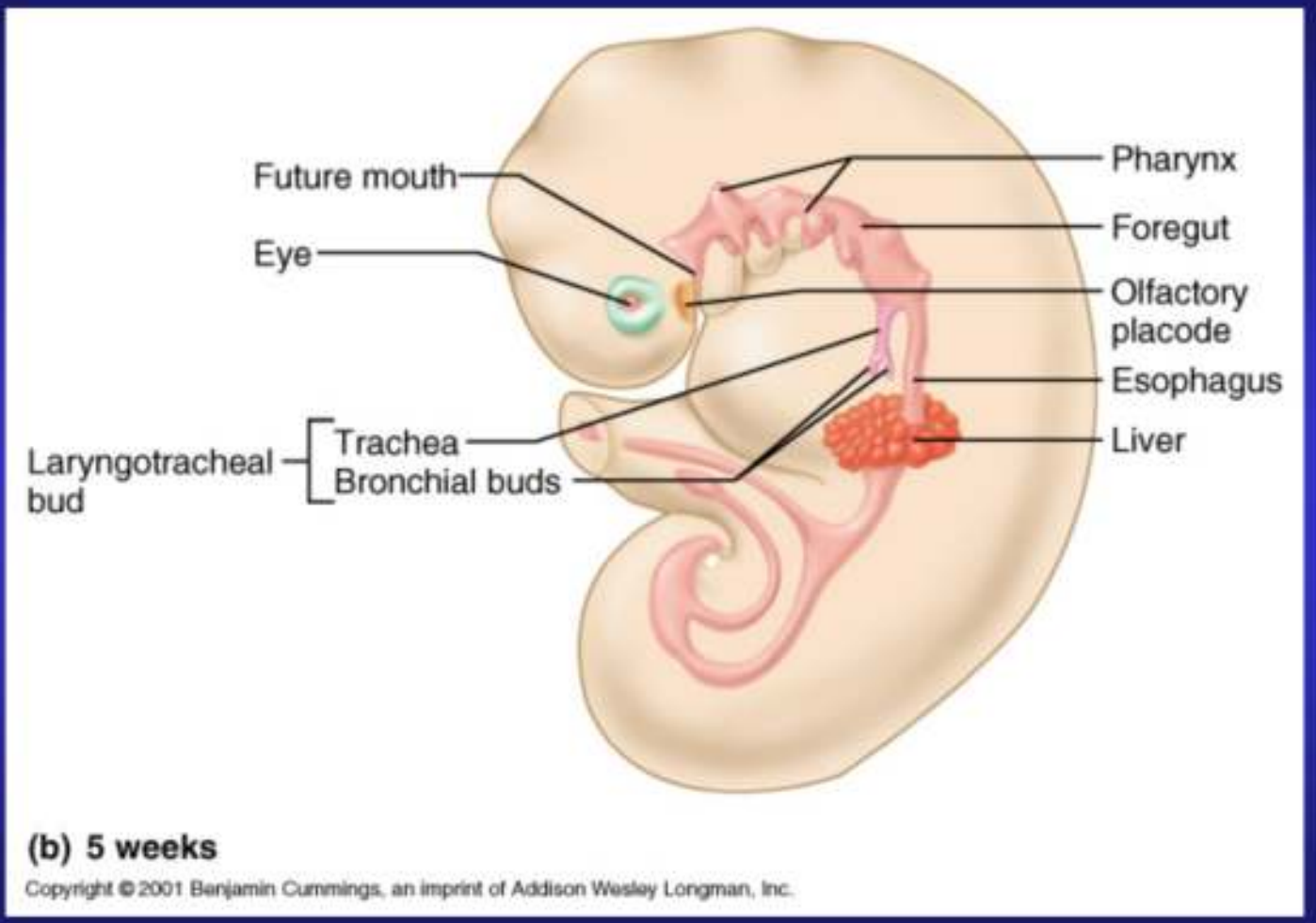

(b) 5 weeks

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