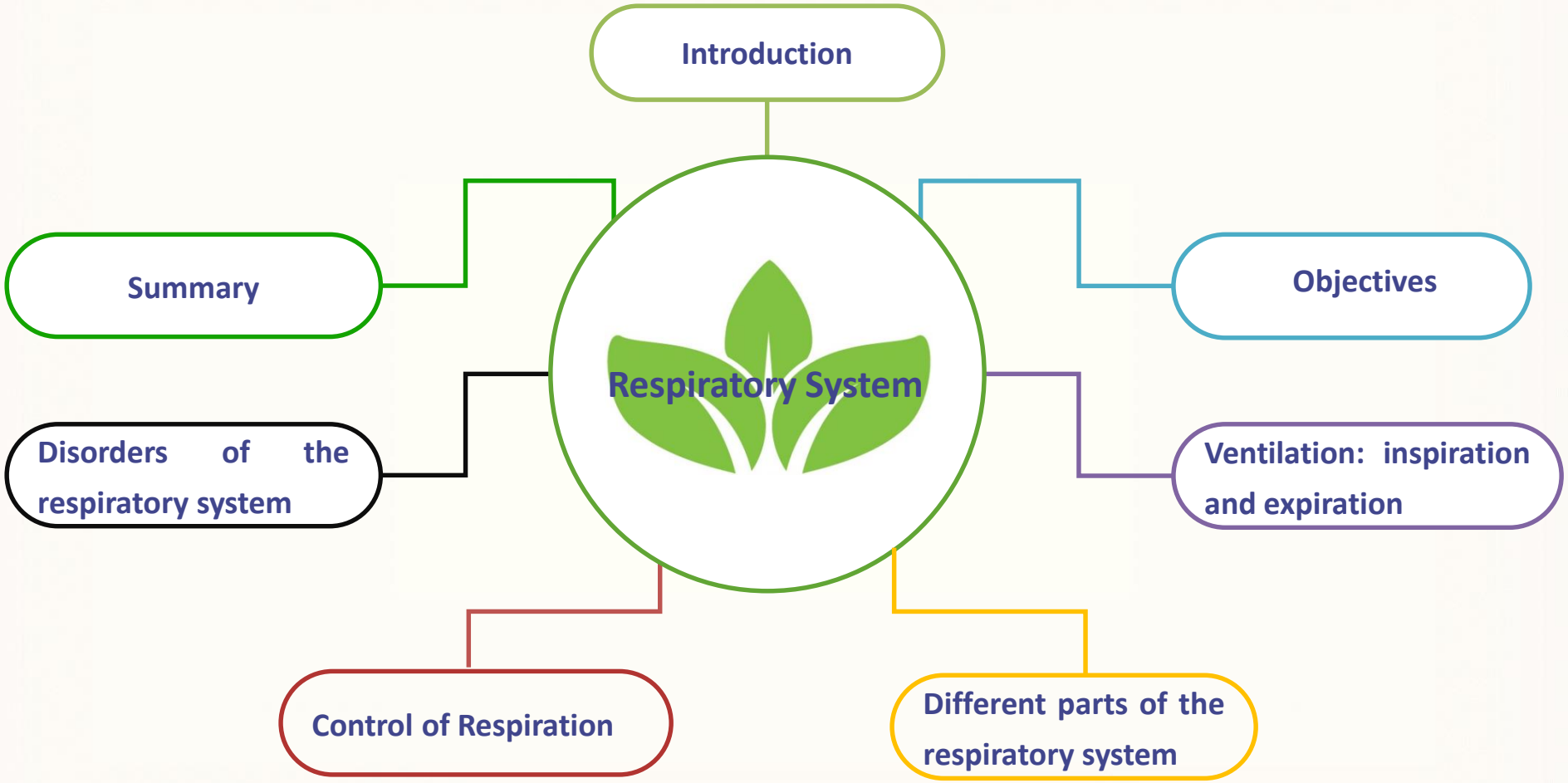
Mind Map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Different parts of the respiratory system

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Introduction

The respiratory system allows animals to move oxygen (needed for cellular respiration) into body tissues and remove carbon dioxide (waste product of cellular respiration) from cells.

- Oxygen (O_2) is used to produce ATP in the mitochondria, by breaking down of glucose (cellular respiration).
- Carbon dioxide (CO_2) is produced as a waste product.

Introduction

Basic functions

- Passageway for respiration
- Cleaning air of particulate matter
- Moistens and warms incoming air to body temperature.
- Produces Sounds- Resonating chambers for voice
- Receptors for smell
- Gas Exchange - Supplies body with oxygen
  - Disposes of carbon dioxide
- Regulates blood pH (Homeostasis).

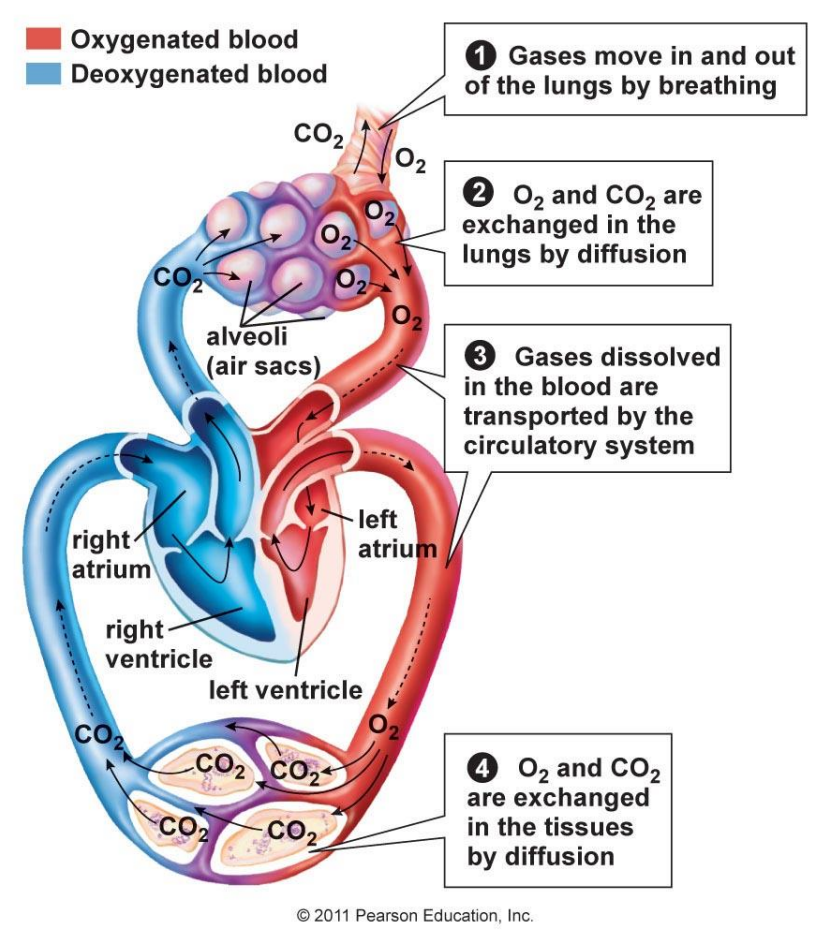
Objectives

- To review the main components and general organization of the respiratory system.
- To understand the ventilation process: inspiration and expiration.
- To understand the gas exchange processing between the blood and alveoli.
- To identify the regulation of the respiratory system.
- To know the main disorders of the respiratory system

Respiratory System

There are four respiration processes:

- Breathing (ventilation): air into (inspiration) and out of lungs (expiration)
- External respiration (Pulmonary): Exchanging air between the body (lungs) and the bloodstream).
- Internal respiration (tissue or cellular): Bringing oxygen to the cells and removing carbon dioxide from them (gas exchange between blood and tissues).
- Cellular respiration: oxygen use for breaking down nutrients to produce ATP, carbon dioxide as waste.



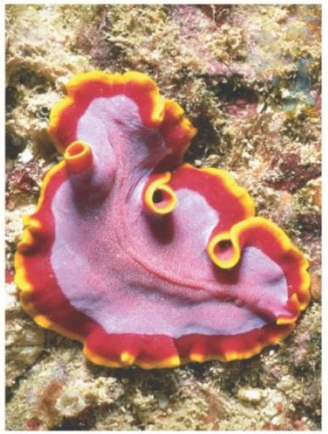
Respiratory System

Gas exchange in lower animals

- Some animals simply allow gases to diffuse through their skins.

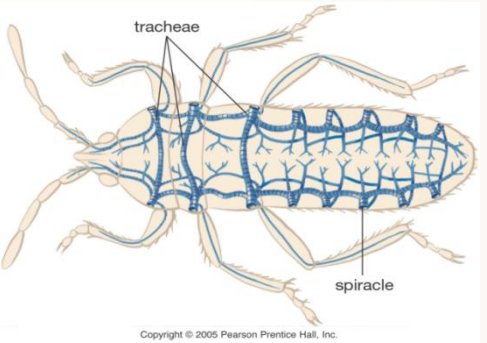
Structures specialized for gas exchange include:

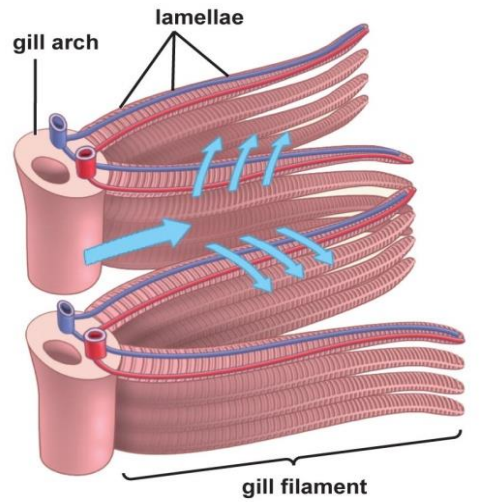
- gills (aquatic animals)
- spiracles (terrestrial insects)
- lungs (most terrestrial vertebrates)



(a) Flatworm

(b) Jellyfish





(b) Gill structure

Respiratory System

What happens when you breathe in?

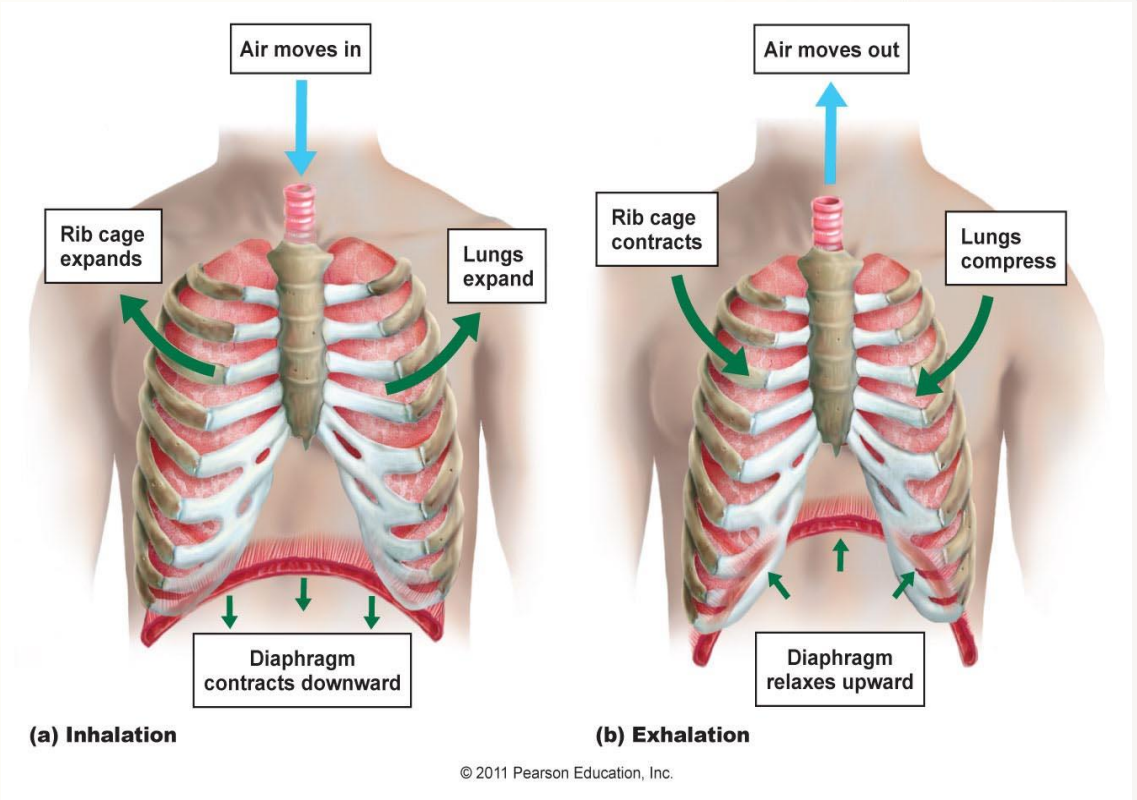
Breathing consists of two phases, inspiration and expiration.

Inspiration

The process of taking in air. We also call it inhalation. the process of blowing air in. The intercostal muscles contract elevating chest wall and expanding volume of chest, lowering pressure in lungs, pulling in air.

Expiration

The process of blowing out air. We also call it exhalation. The diaphragm and intercostal muscles relaxed allowing chest to lower resulting in increase of pressure in chest and expulsion of air.



Respiratory System

Inspiration

Occurs as alveolar pressure drops below atmospheric pressure.

For convenience atmospheric pressure = 0 mm Hg

A (-) value then indicates pressure below atmospheric P

A (+) value indicates pressure above atmospheric P

- At the start of inspiration (time = 0), atmospheric pressure = alveolar pressure.

⟹ No net movement of gases!

- At time 0 to 2 seconds: Expansion of thoracic cage and corresponding pleural membranes and lung tissue causes alveolar pressure to drop to -1 mm Hg.

⟹ Air enters the lungs down the partial pressure gradient

Respiratory System

Expiration

Occurs as alveolar pressure elevates above atmospheric pressure due to a shrinking thoracic cage.

- At time 2-4 seconds

Inspiratory muscles relax, elastic tissue of corresponding structures initiates a recoil back to resting state. This decreases volume and correspondingly increases alveolar pressure to 1 mm Hg. This is above atmospheric pressure

- At time 4 seconds

Atmospheric pressure once again equals alveolar pressure and there is no net movement.

Respiratory System

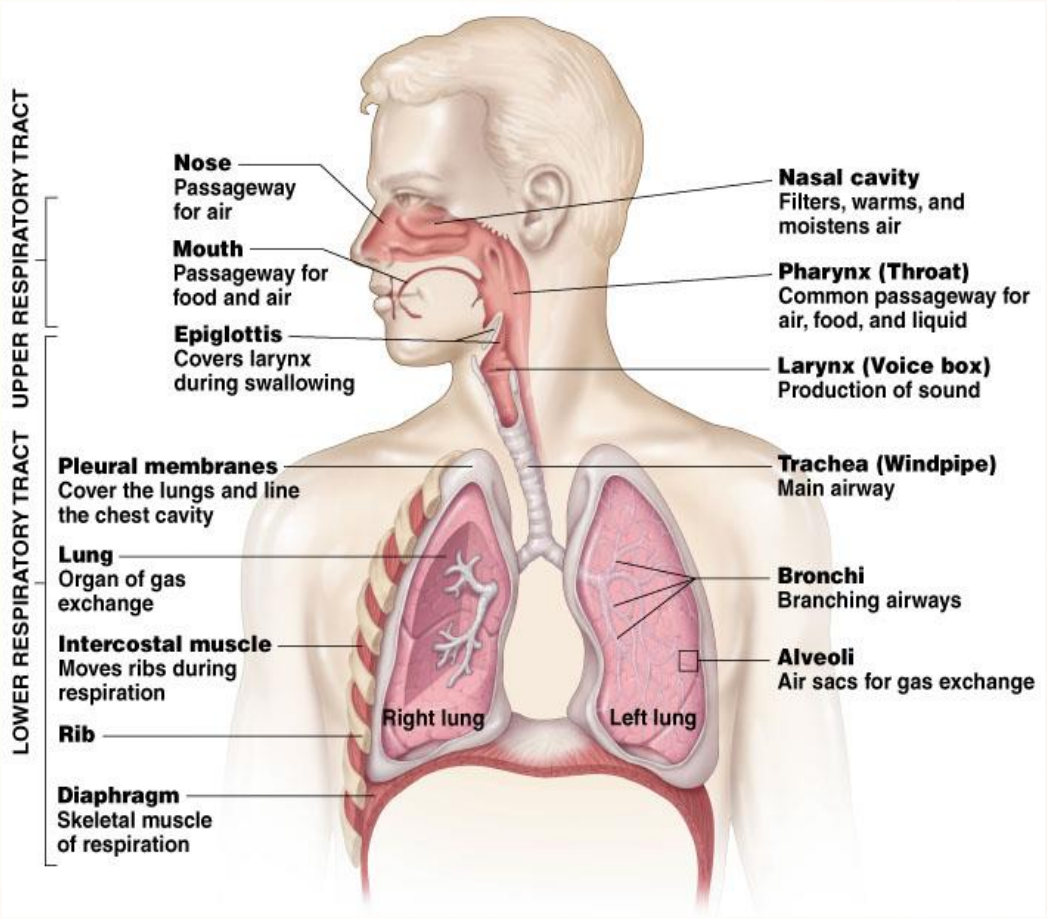
The respiratory system is divided into:

Upper tract

Nose, pharynx and associated structures

Lower tract

Larynx, trachea, bronchi, lungs



Respiratory System

Nose

- Contains the paranasal sinuses where air is warmed
- Contains cilia which is responsible for filtering out foreign bodies.

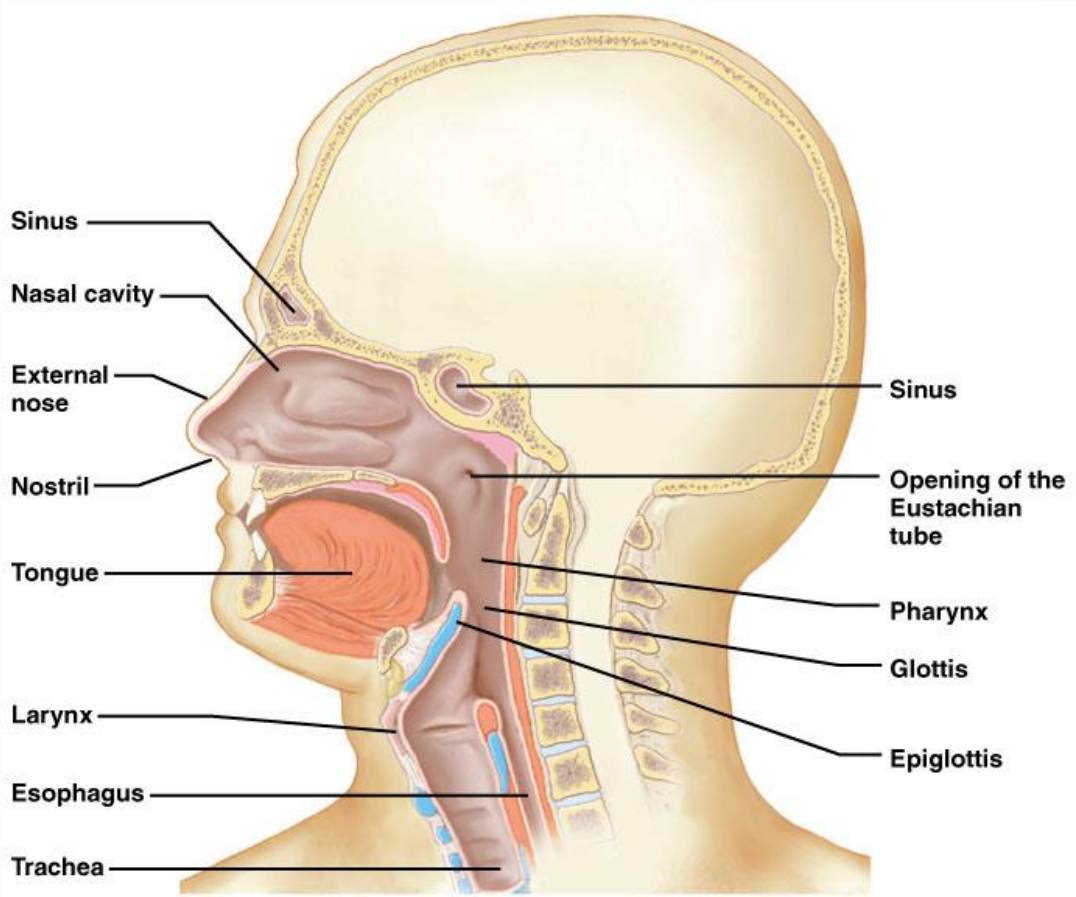
Pharynx

Is a passageway for both air and food. Most of the time, the pathway for air is open, except when we swallow.

Larynx

- Prevents food and drink from entering the trachea.
- Assists in sound production.

The voice box, where vocal chords are located.



Respiratory System

Trachea (Or windpipe)

Rings of cartilage that transports air to and from lungs.

Trachea is lined with fine hairs called cilia which filter air before it reaches the lungs

Bronchi

Two branches at the end of the trachea, each lead to a lung.

- Primary bronchi (main bronchi)
- Secondary (lobar) bronchi
- Tertiary (segmental) bronchi - branch into each lung segment.

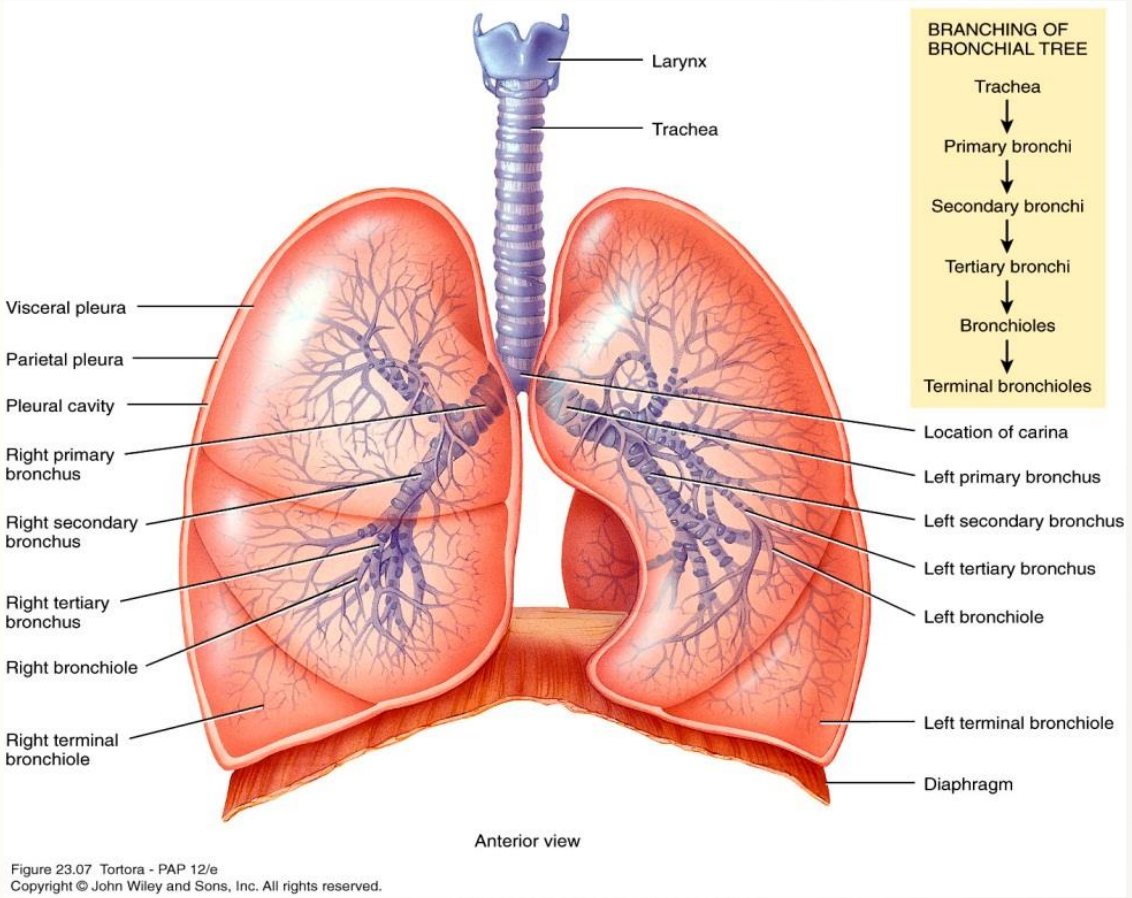


Figure 23.07 Tortora - PAP 12/e

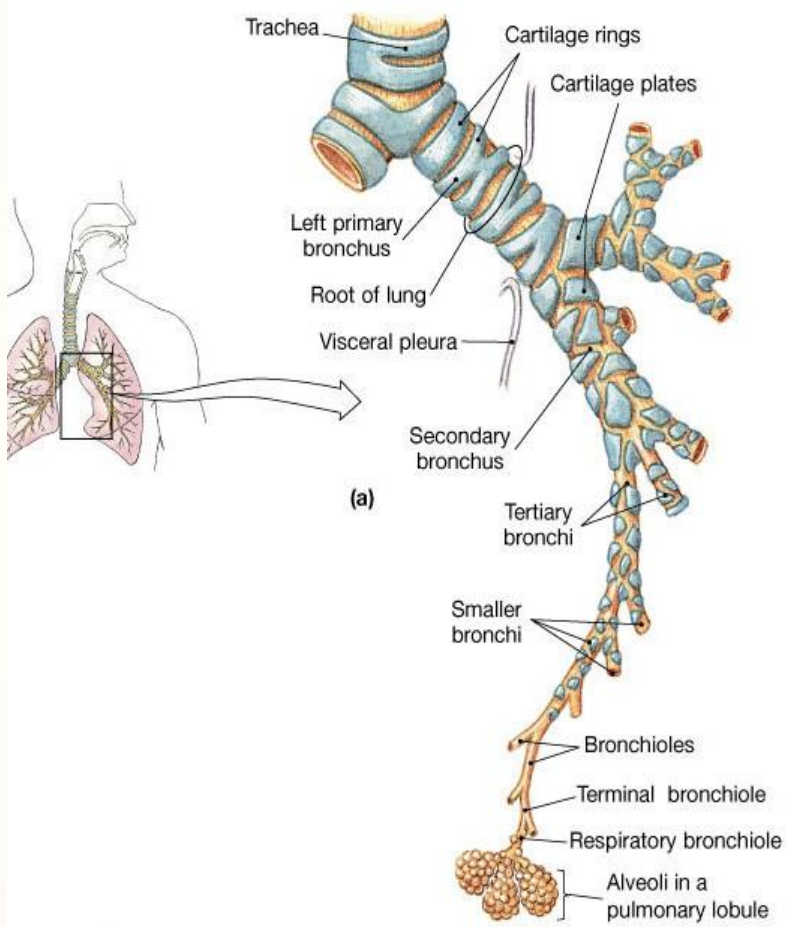
Respiratory System

Bronchioles

- A network of little bronchi, less than 1 mm in diameter, leading from the bronchi into the lung tissue and ultimately to air sacs.
- Terminal bronchioles: less than 0.5 mm in diameter, and lead to alveolar ducts.

Alveoli

Alveolar ducts lead to alveolar sacs and alveoli are the functional respiratory units in the lung where gases are exchanged.



Respiratory System

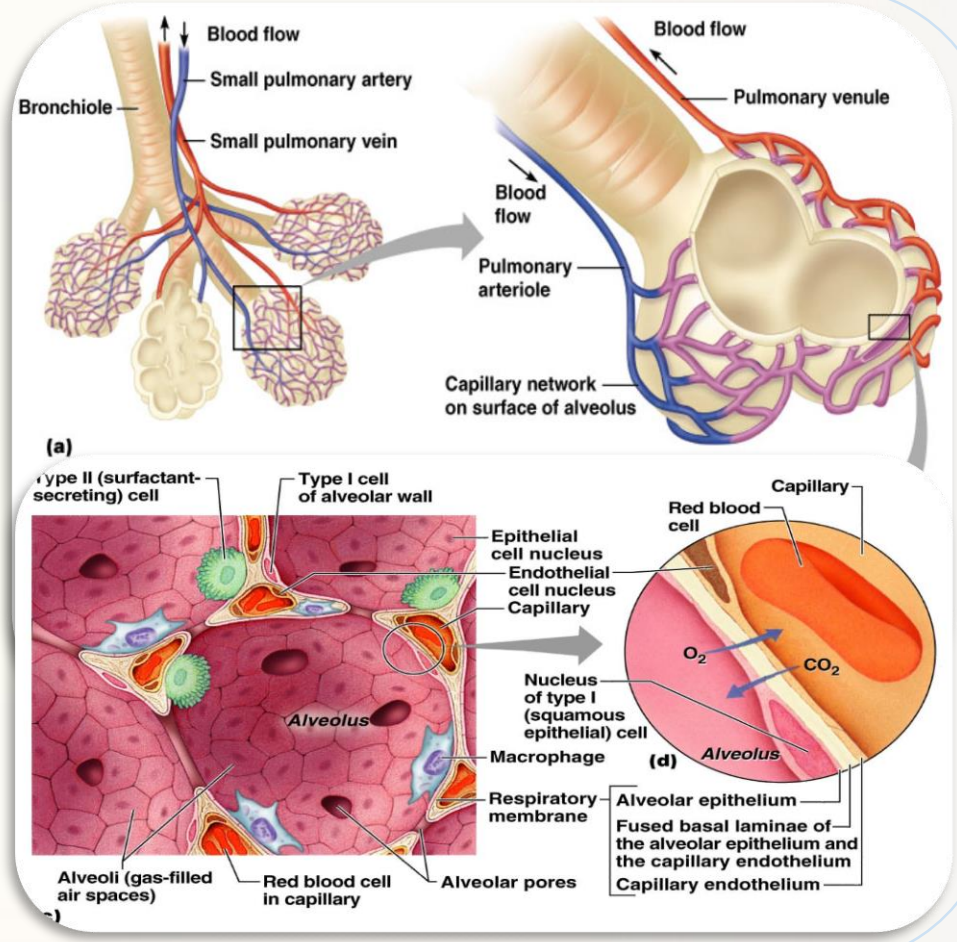
Gas Exchange Between the Blood and Alveoli

The respiratory surface is made up of the alveoli and capillary walls.

The alveoli are moist, thin-walled pockets which are the site of gas exchange.

Alveoli cell types

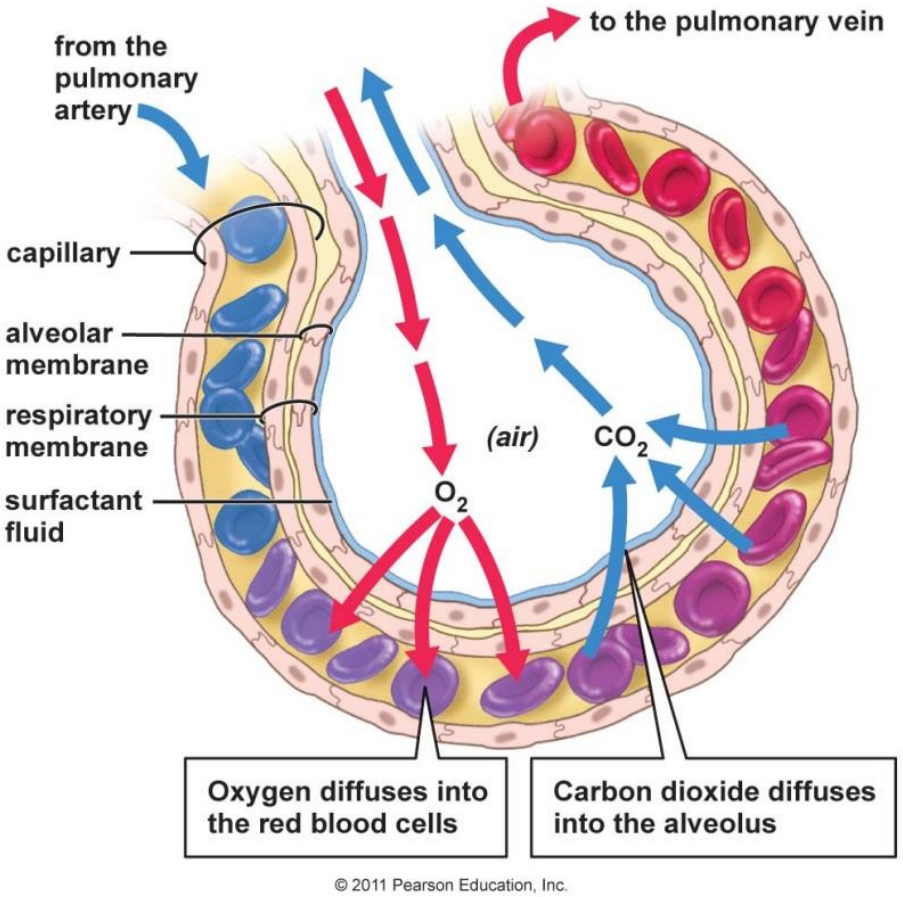
- Type I cells: site of gas exchange
- Type II cells: secrete a slightly oily surfactant that prevents the alveolar walls from collapsing and sticking together.
- Macrophages: for defense.



Respiratory System

In the alveolus

- The walls of the capillaries and the alveoli may share the same membrane.
- Air entering the lungs contains more oxygen and less carbon dioxide than the blood that flows in the pulmonary capillaries.
- Blood arriving in pulmonary arteries has low PO2 and high PCO2
- The concentration gradient causes O2 to enter blood and CO2 to leave blood.
- Rapid exchange allows blood and alveolar air to reach equilibrium.



Respiratory System

Hemoglobin binds to oxygen that diffuses into the blood stream.

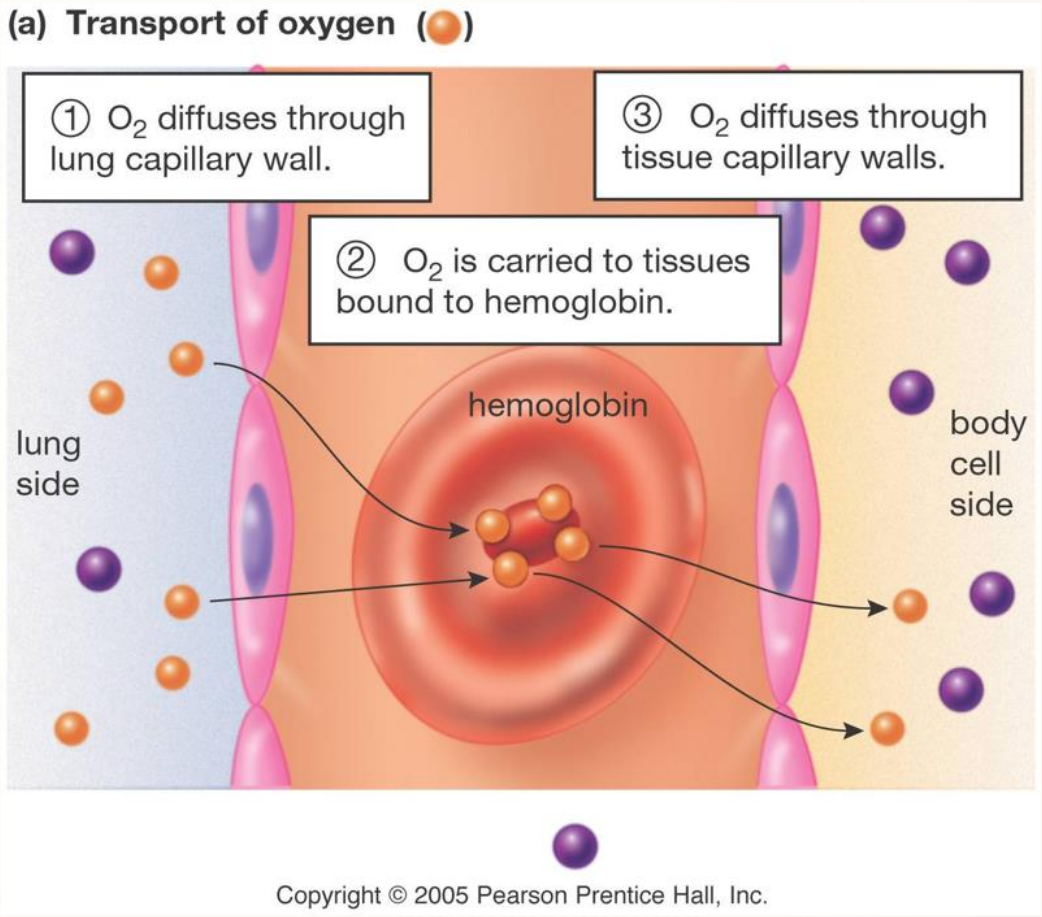
External respiration

$$\underset{\text{deoxyhemoglobin}}{Hb} + \underset{\text{oxygen}}{\downarrow O_2} \longrightarrow \underset{\text{oxyhemoglobin}}{HbO_2}$$

"Down" arrow indicates that oxygen is entering the body.

$$\underset{\text{hydrogen ion}}{H^+} + \underset{\text{bicarbonate ion}}{HCO_3^-} \longrightarrow H_2CO_3 \longrightarrow \underset{\text{water}}{H_2O} + \underset{\text{carbon dioxide}}{CO_2\uparrow}$$

"Up" arrow indicates carbon dioxide is leaving the body.



Respiratory System

Internal respiration

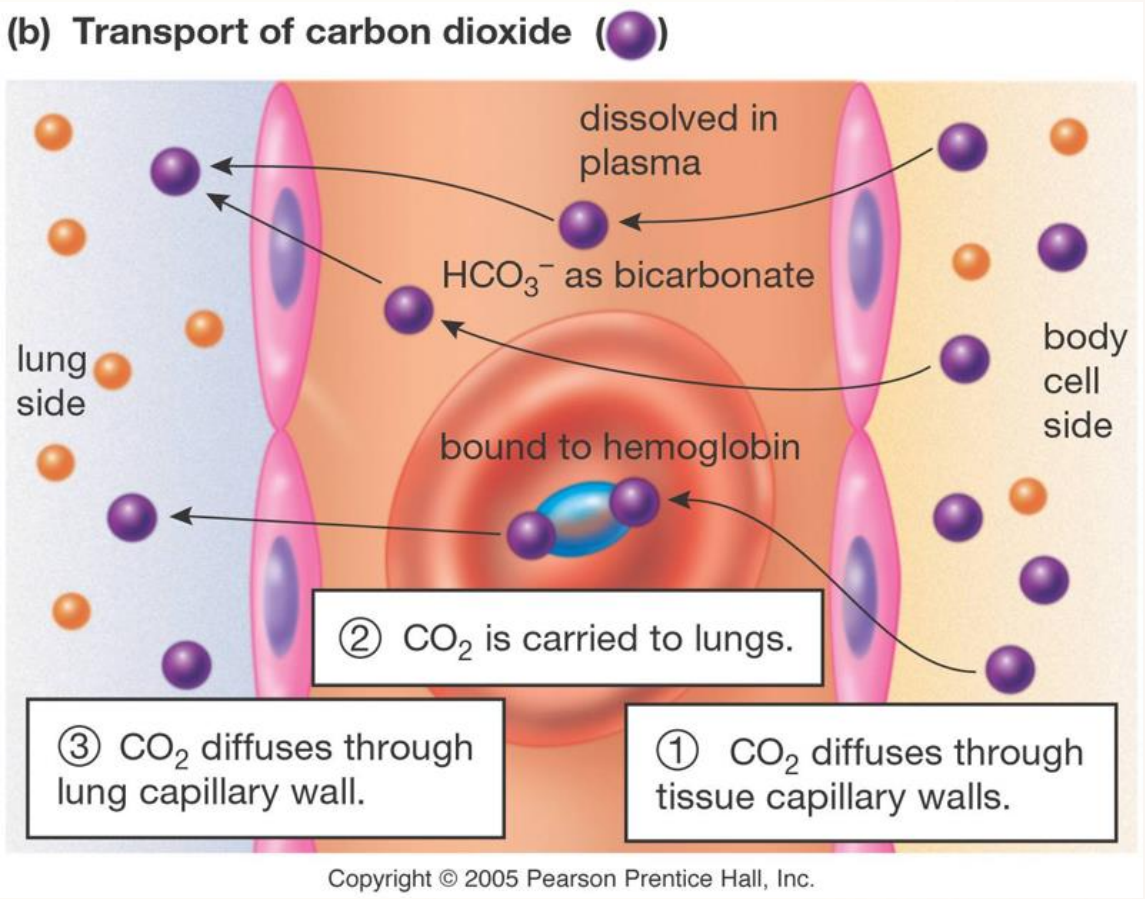
$$HbO_2 \longrightarrow Hb + O_2$$

oxyhemoglobin — deoxyhemoglobin — oxygen

Carbon dioxide can dissolve in plasma, and about 70% forms bicarbonate ions.

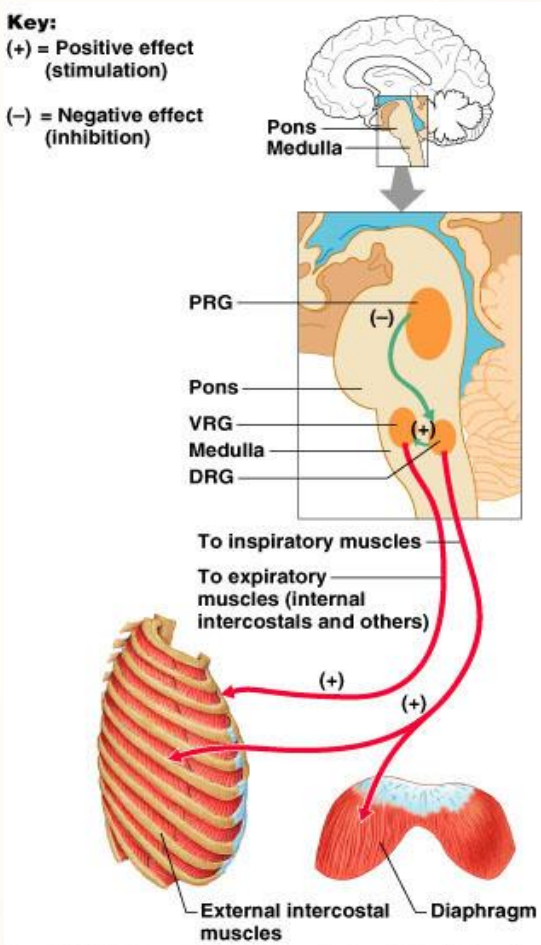
$$CO_2 + H_2O \overset{\text{carbonic anhydrase}}{\rightleftharpoons} H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

carbon dioxide — water — carbonic acid — hydrogen ion — bicarbonate ion



Control of Respiration

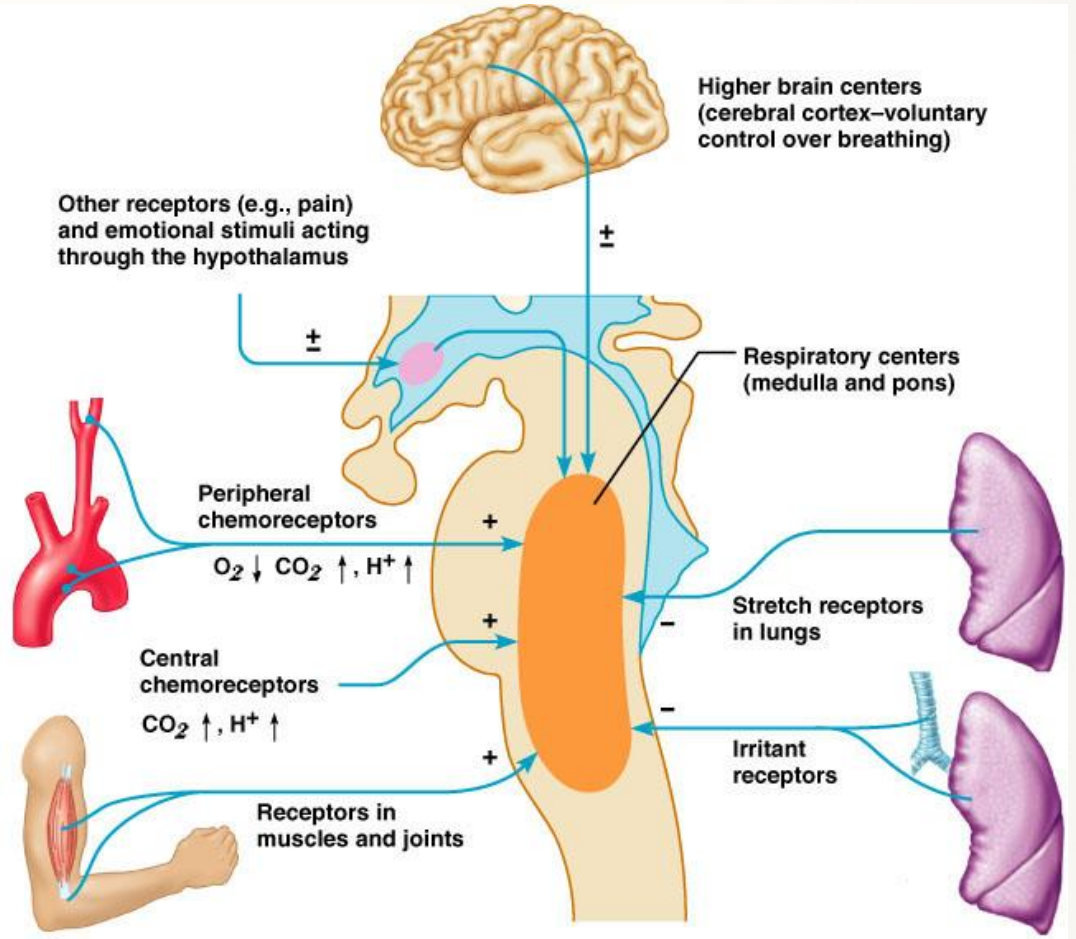
- The dorsal respiratory group (DRG), or inspiratory center:
  - Is located near the root of nerve IX
  - Appears to be the pacesetting respiratory center
  - Excites the inspiratory muscles and sets eupnea (12-15 breaths/minute in humans)
  - Becomes dormant during expiration
- The ventral respiratory group (VRG) is involved in forced inspiration and expiration.



Control of Respiration

Pons Respiratory Centers:

- Pons centers:
  - Influence and modify activity of the medullary centers
  - Smooth out inspiration and expiration transitions and vice versa.
- The pontine respiratory group (PRG) – continuously inhibits the inspiration center.
- Hypothalamic controls act through the limbic system to modify rate and depth of respiration. Example: breath holding that occurs in anger.



Control of Respiration

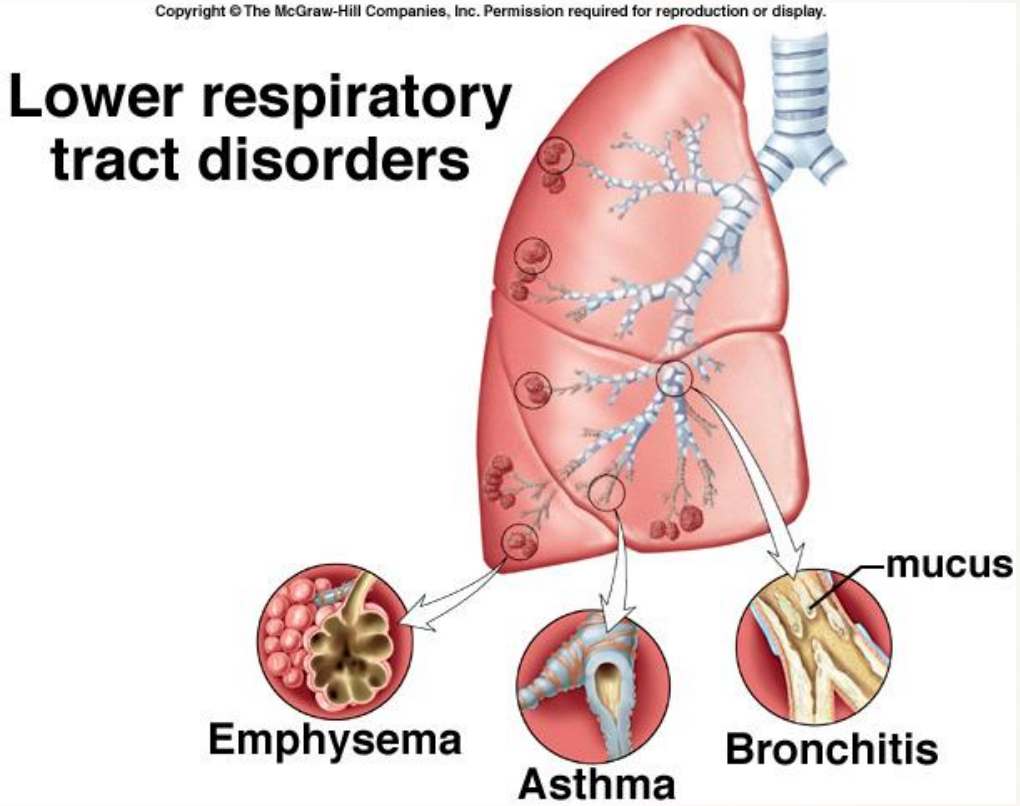
- Cortical input: voluntary adjustment of patterns (For talking or cessation of breathing while swimming).
- Chemoreceptor input: Central receptors in medulla are sensitive to the increase of H+ or PCO2
  - Changes in arterial pH can modify respiratory rate even if carbon dioxide and oxygen levels are normal
  - Increased ventilation in response to falling pH is mediated by peripheral chemoreceptors.
  - Changing PCO2 levels are monitored by chemoreceptors of the brain stem.
  - PCO2 levels rise (hypercapnia) resulting in increased depth and rate of breathing .
  - A rise in body temperature acts to increase respiratory rate

Exercise and Altitude

- When exercise increases oxygen demands, the frequency with which a given red blood cell travels form the lung to the heart must increase. Thus, the physiologic requirements of exercise demand the coupling of increased circulatory and respiratory activities to meet the gas exchange requirements.
- At high altitudes, the number of molecules/volume of oxygen is smaller than at sea level. The body does not get the amount of oxygen it is used to. The athlete's body compensates for this decrease in oxygen uptake with corresponding tachycardia. When the body is suddenly without its usual oxygen supply, hyperventilation can occur.

Disorders of Respiratory System

- **A**sthma: Condition in which breathing is impaired by constriction of bronchi and bronchioles, cough, and thick mucus secretions
- Emphysema: Permanent and irreversible destruction of alveolar walls
- Bronchitis: Inflammation of the mucous membranes of the bronchi.
- Infections (Bacterial, fungal, or viral): pneumonia, tuberculosis, botulism
- Lung cancer
- Cystic fibrosis: disease of the exocrine glands that causes secretion of abnormally thick mucus which leads to chronic obstruction.



Disorders of Respiratory System

- Inhaled smoke contains: CO2, which affects the CO2 diffusion gradient.
- carcinogenic chemicals that can trigger tumors.
- Toxic nicotine, which paralyzes cilia that normally clean the lungs.

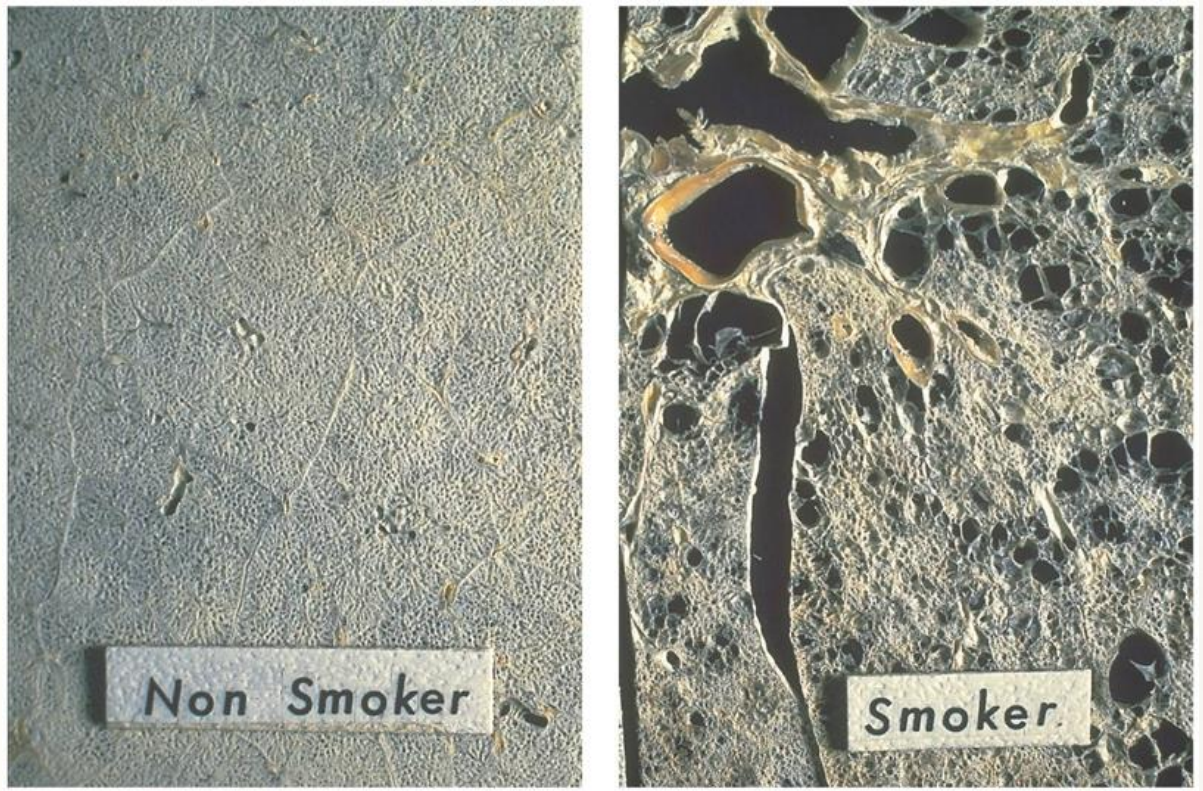
Disorders of Respiratory

Effects of smoking

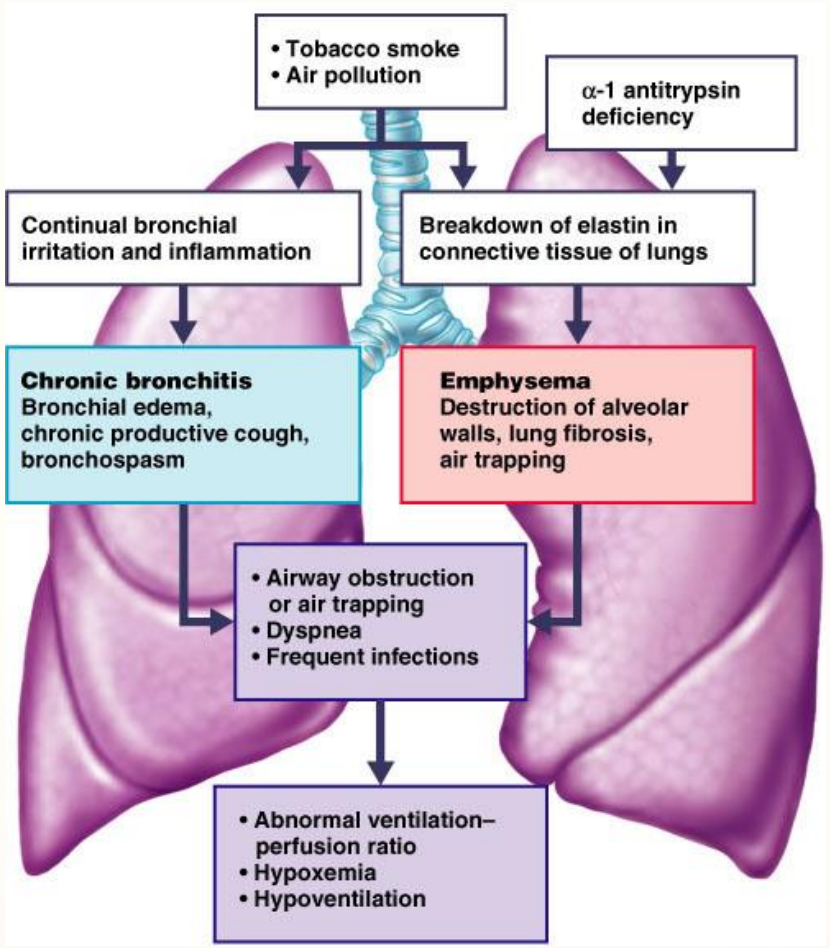
- Besides cancer, smoking can also lead to emphysema: Alveoli become dry, brittle, and eventually rupture.

Both active and passive smoking ("second-hand" smoke) can lead to lung problems.

- When people quit smoking, if the lungs are not damaged they can often clean themselves because the cilia are no longer paralyzed.

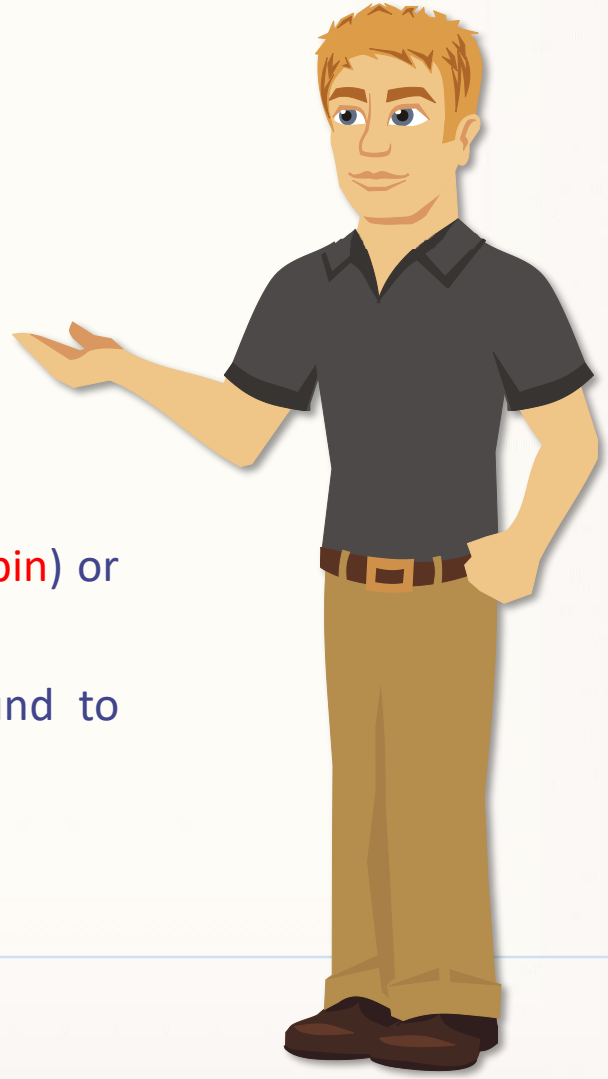


Disorders of Respiratory



Summary

- Respiratory system allows :
  - gas exchange between air and circulating blood
  - moving air to and from exchange surfaces
  - protection of respiratory surfaces
  - sound production
  - facilitating olfaction
- Oxygen transport: bound to hemoglobin in red blood cells (oxyhemoglobin) or dissolved in blood plasma (low %).
- Carbon dioxide transport: dissolved in blood plasma (low %) or bound to hemoglobin, or in the form of plasma bicarbonate (about 70%).



- Structures and functions of the lungs:
  - lobes and surfaces, the bronchi
  - the bronchioles, alveoli and alveolar ducts
  - blood supply to the lungs
- Respiratory physiology:
  - External (pulmonary) respiration: gases exchanged between air and blood.
  - Internal (tissue) respiration: gases exchanged between cells and blood.

- Pulmonary ventilation:
  - air movement
  - pressure changes
  - the mechanics of breathing
- Control of respiration:
  - local regulation (lung perfusion, alveolar ventilation)
  - respiratory centers of the brain (in medulla oblongata).
  - respiratory reflexes
  - voluntary control of respiration