Respiratory system

Premedical - Biology

Questions

- What is the composition of atmosphere?
- Which gas is the most abundant in the atmosphere?

Composition of atmosphere

Nitrogen (N_2)	840 ppmv **(78.084%)**
Oxygen (O_2)	209,460 ppmv **(20.946%)**
Carbon dioxide (CO_2)	387 ppmv (0.0387%)
Argon (Ar), Neon (Ne), Helium (He), Methane (CH_4), Krypton (Kr), Hydrogen (H_2)	

ppmv: parts per million by volume

The gases we exhale is **increased (roughly 4% to 5%) in carbon dioxide and decreased of 5% to 10% of oxygen** than was inhaled.

Questions

- What is the function of Respiratory system?
- Which cells (epithelia) are responsible for a cleaning (filtration) function of respiratory system?

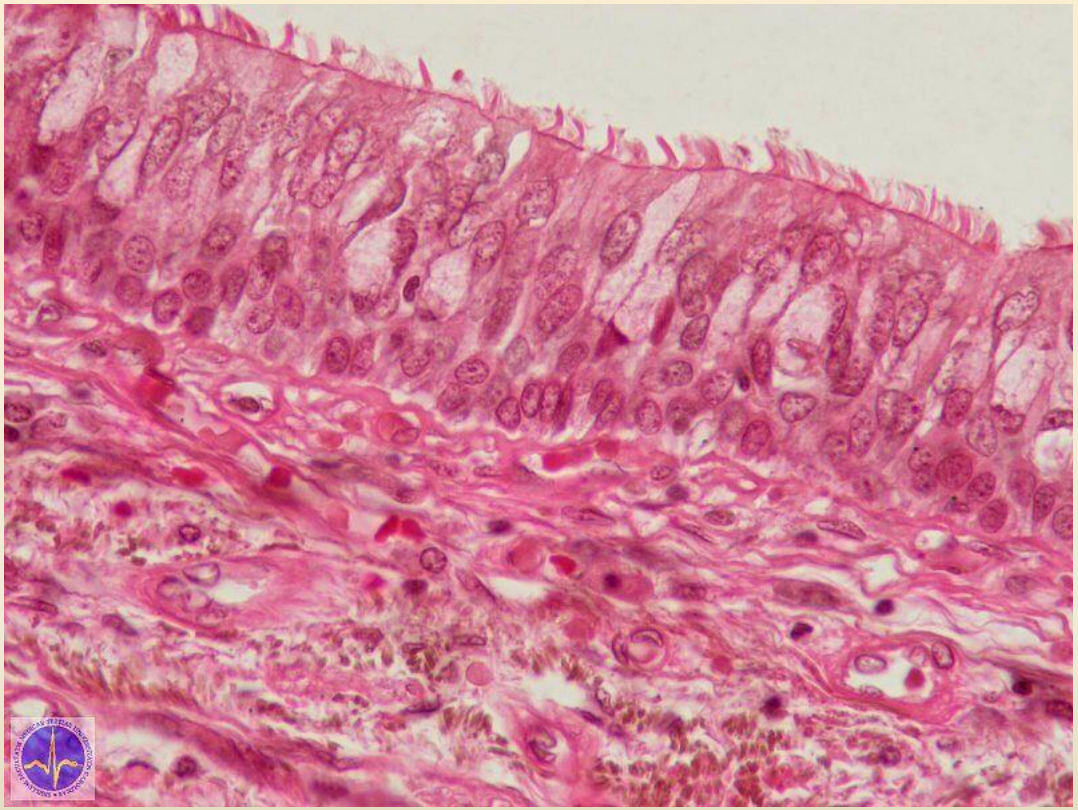
Functions

- Provides **an extensive area** for gas exchange between air & circulating blood
- Produce **sounds** involved in speaking, singing
- Assists in **regulation of blood volume, blood pressure** and the control of body pH
- Respiratory system and other tissues defend from invasion by pathogenic micro-organisms:

  Most foreign particles and pathogens have been removed due to **filtering, warming and moistening** in the respiratory system.

Respiratory epithelia

Pseudostratified e. or stratified ciliated columnar cells - trachea, bronchi, bronchioli

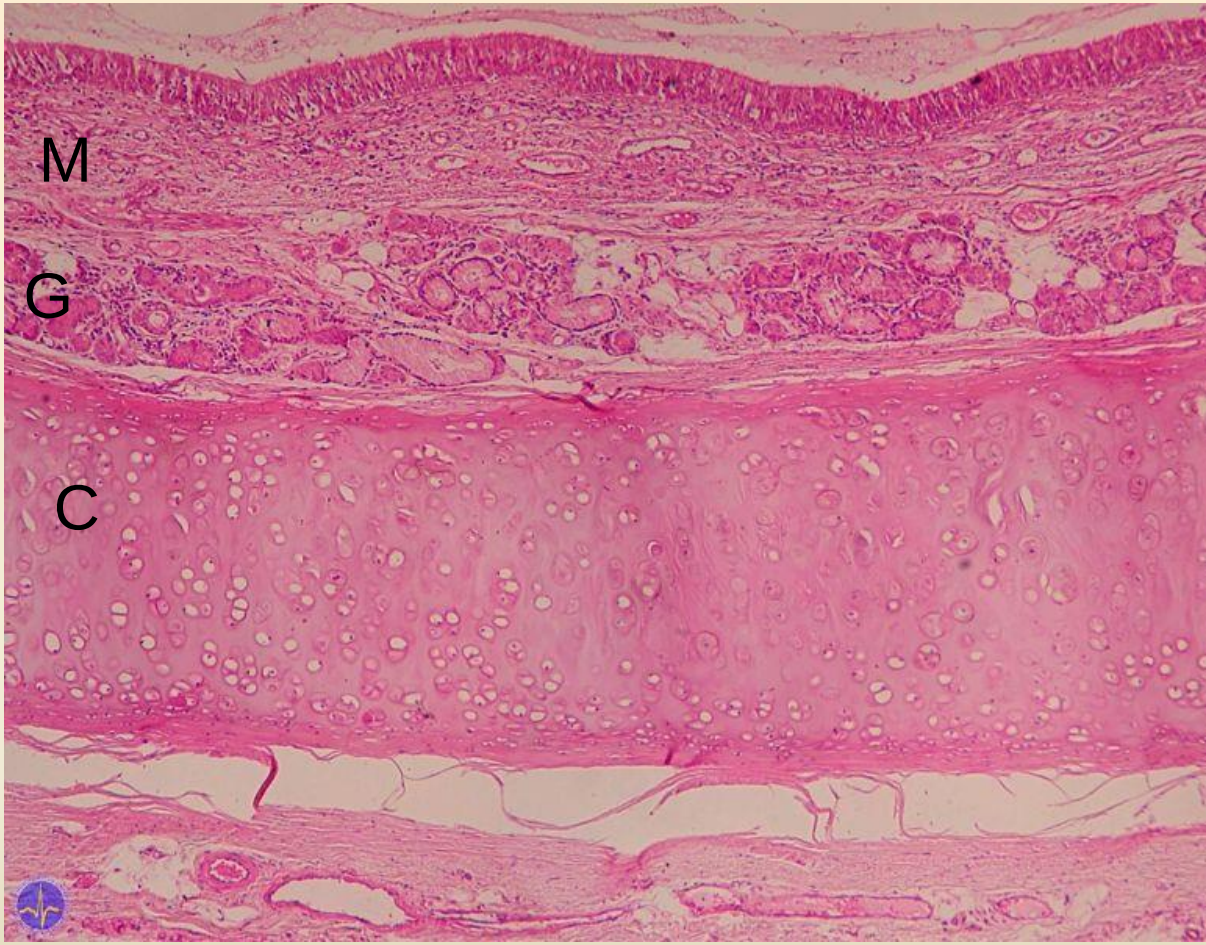


Submucosa contains **seromucous glands**. Clear, **mucous-secreting goblet cells** can be seen interspersed in the epithelium.

Questions

- What is the composition of the wall of the respiratory system (trachea)?

Wall of respiratory system



- **M = tracheal mucosa**
- in the submucosa m**ucous and seromucous glands (G)** are
- **C = hyaline cartilage (and elastic)**

Questions

- What is the composition of the mucus, what is it?

Mucus

It is a viscous colloid fluid containing **mucin, epithelial cells, leukocytes, antiseptic enzymes** (such as lysosyme), **immunoglobulins, inorganic salts, proteins** such as lactoferrin.

A major function of this mucus is to protect against infectious agents such as fungi, bacteria and viruses.

The average human body produces about **a liter of mucus per day**.

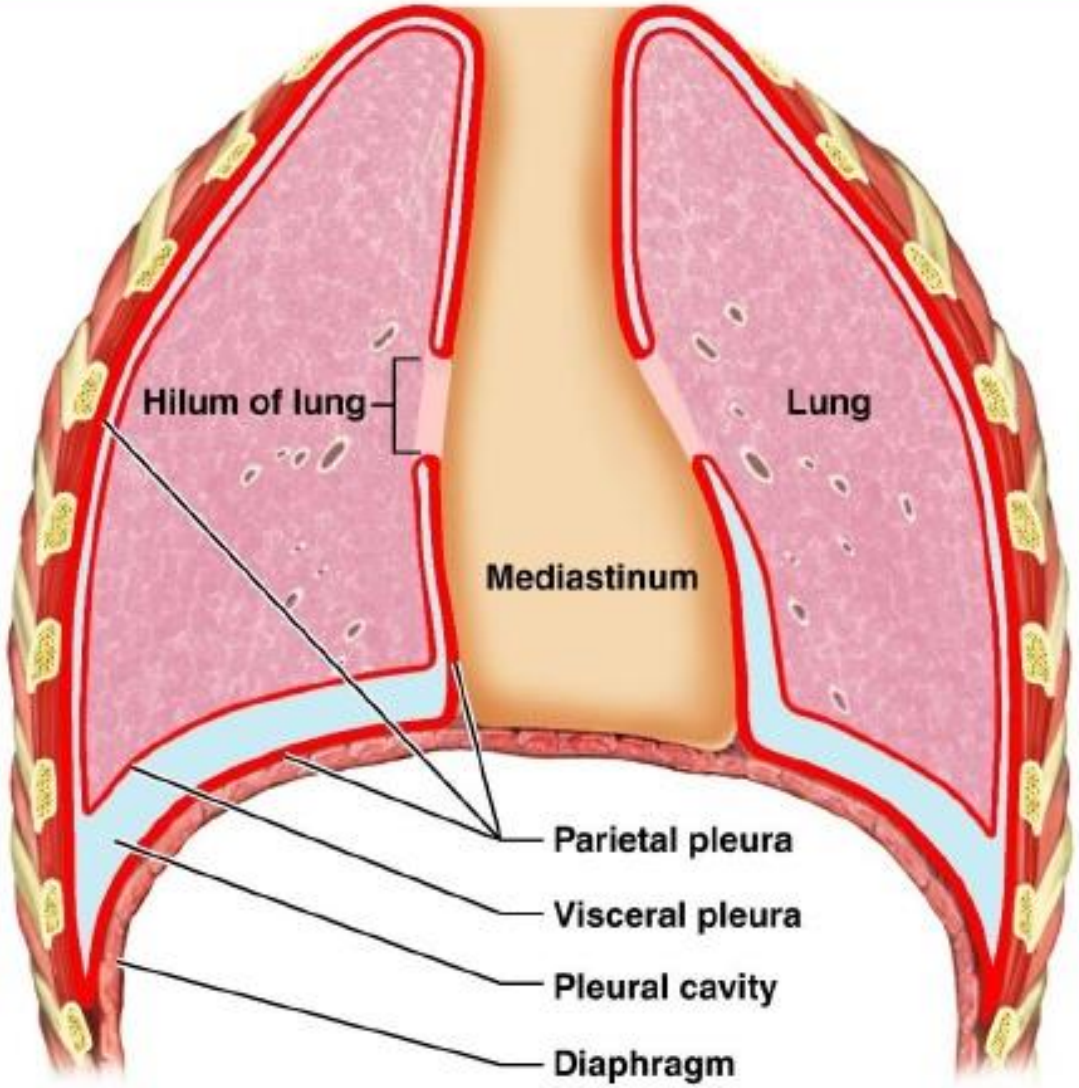
Questions

- **What the pleura is?**

Pleura

- **The serous membrane enveloping the lungs and lining the walls of the pulmonary cavities.**
- The **pleural cavity** is the body cavity that surrounds the lungs.
- The thin space between the two pleural layers normally contains a small amount **of pleural fluid**.
- It is a two-layered**: parietal and visceral** with cavity.
- The **parietal pleura** is outer layer and is attached to the chest wall.
- The **visceral pleura** is inner layer and covers the lungs and adjoining structures, blood vessels, bronchi and nerves.

Diagram of the Pleurae and Pleural Cavities



Lung‘s volume is maintained by the elastic force of the rib cage

Figure 21.11

Questions

- **What are the parts of the respiratory system??**

Conducting part / Breathing part

Upper respiratory system

Nose – external and nostrils

Nasal cavity - receptors for smell, *rhinitis,* moistens and warm the air

Paranasal sinuses, *sinusitis*

Pharynx – nasopharynx, oropharynx, laryngopharynx

Pharyngeal tonsils, Palatine tonsils

Epiglottis is **elastic cartilage** covered with a mucus membrane

Lower respiratory system

Larynx – vocal cords with ligaments, cartilage (hyalin, elastic) + Adam‘s apple

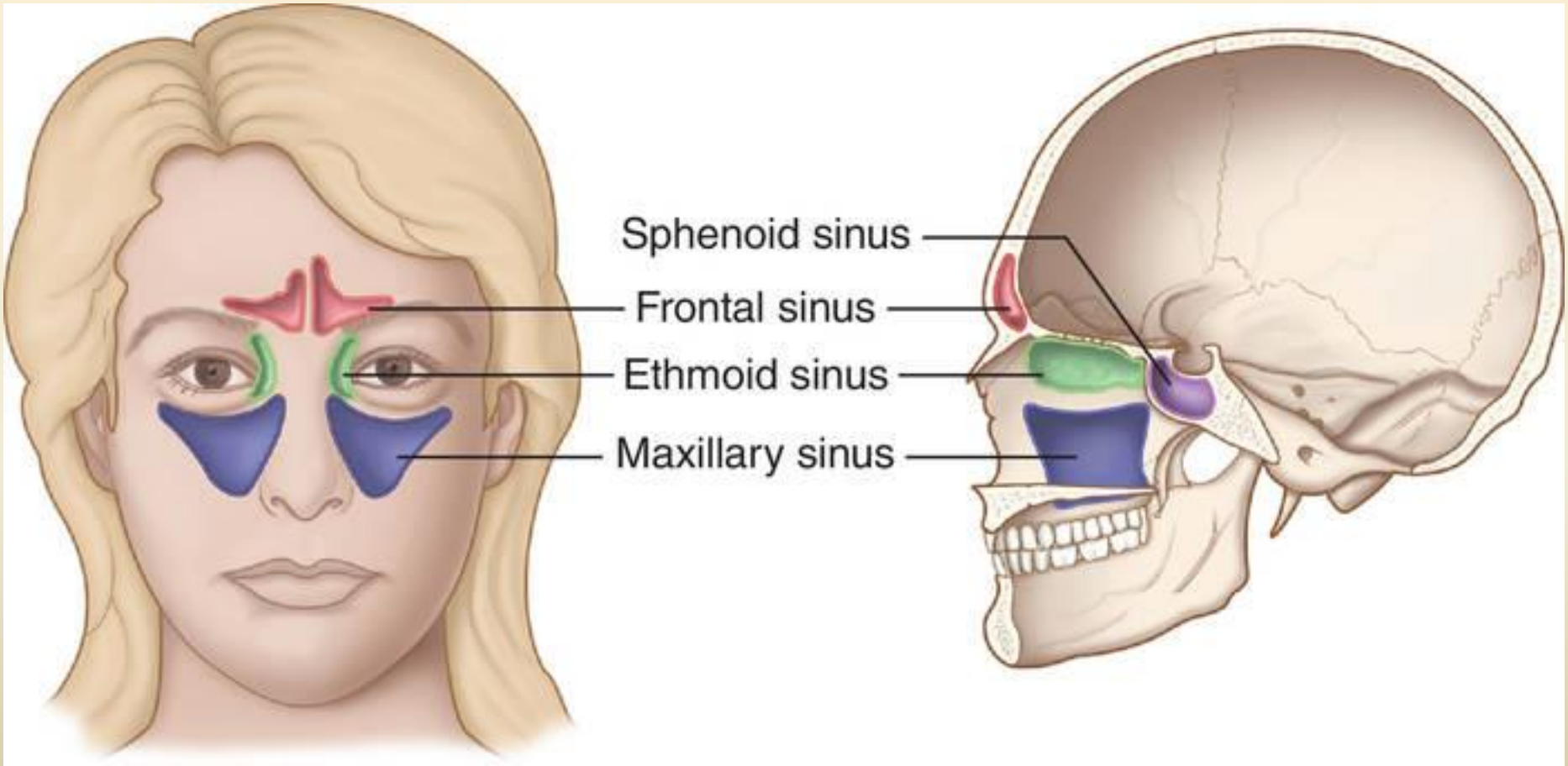
Trachea - cartilages

Bronchi - cartilages

Respiratory bronchiole – without cartilages, **Alveoli** } **Lungs**

PARANASAL SINUS

An air cavity in a facial bone, either the frontal, maxillary, sphenoid, or ethmoid bones; most paranasal sinuses occur in pairs. The paranasal sinuses are lined with ciliated epithelium that secretes mucus.



Upper Respiratory Tract

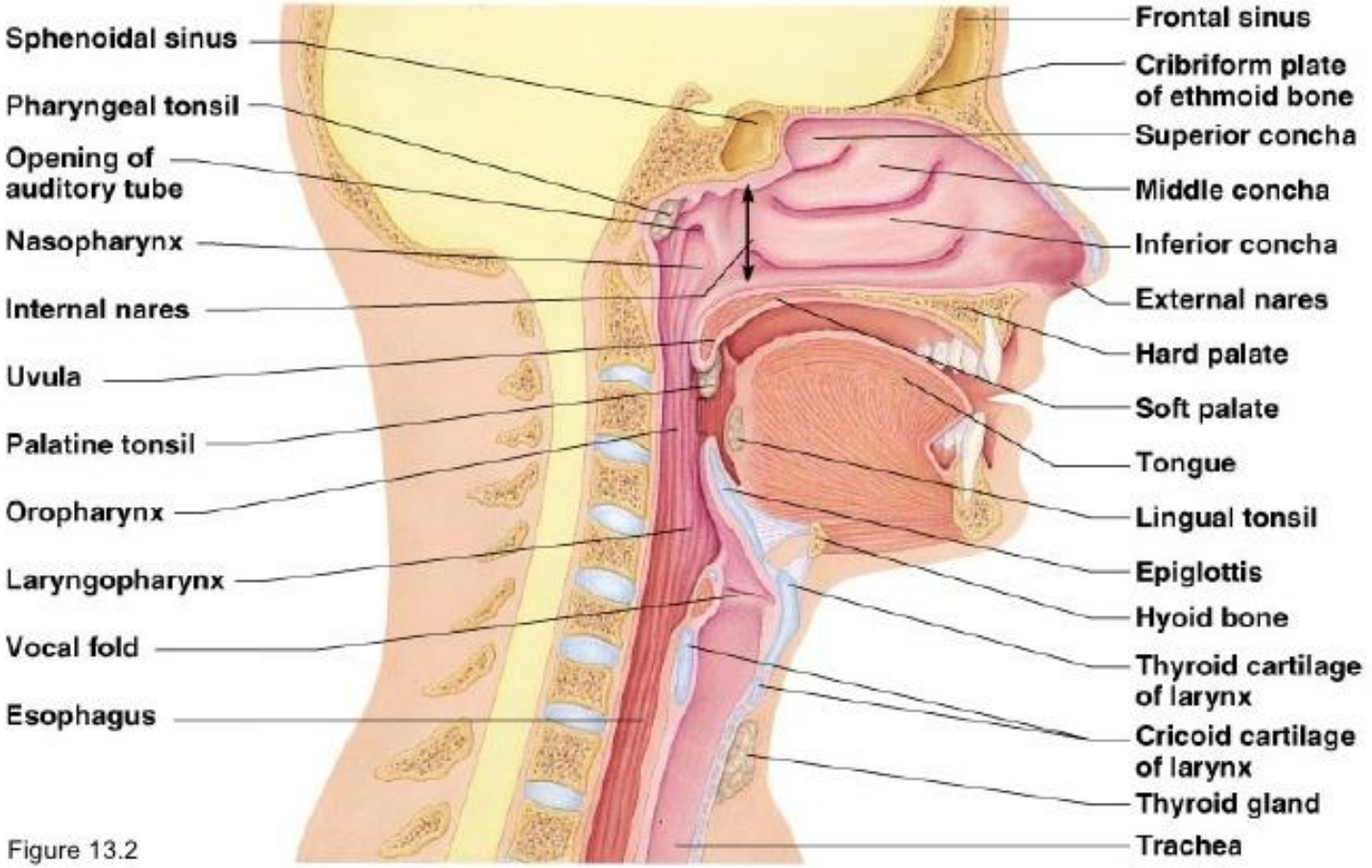


Figure 13.2

Slide 13.3b

Upper respiratory system

Lower respiratory system

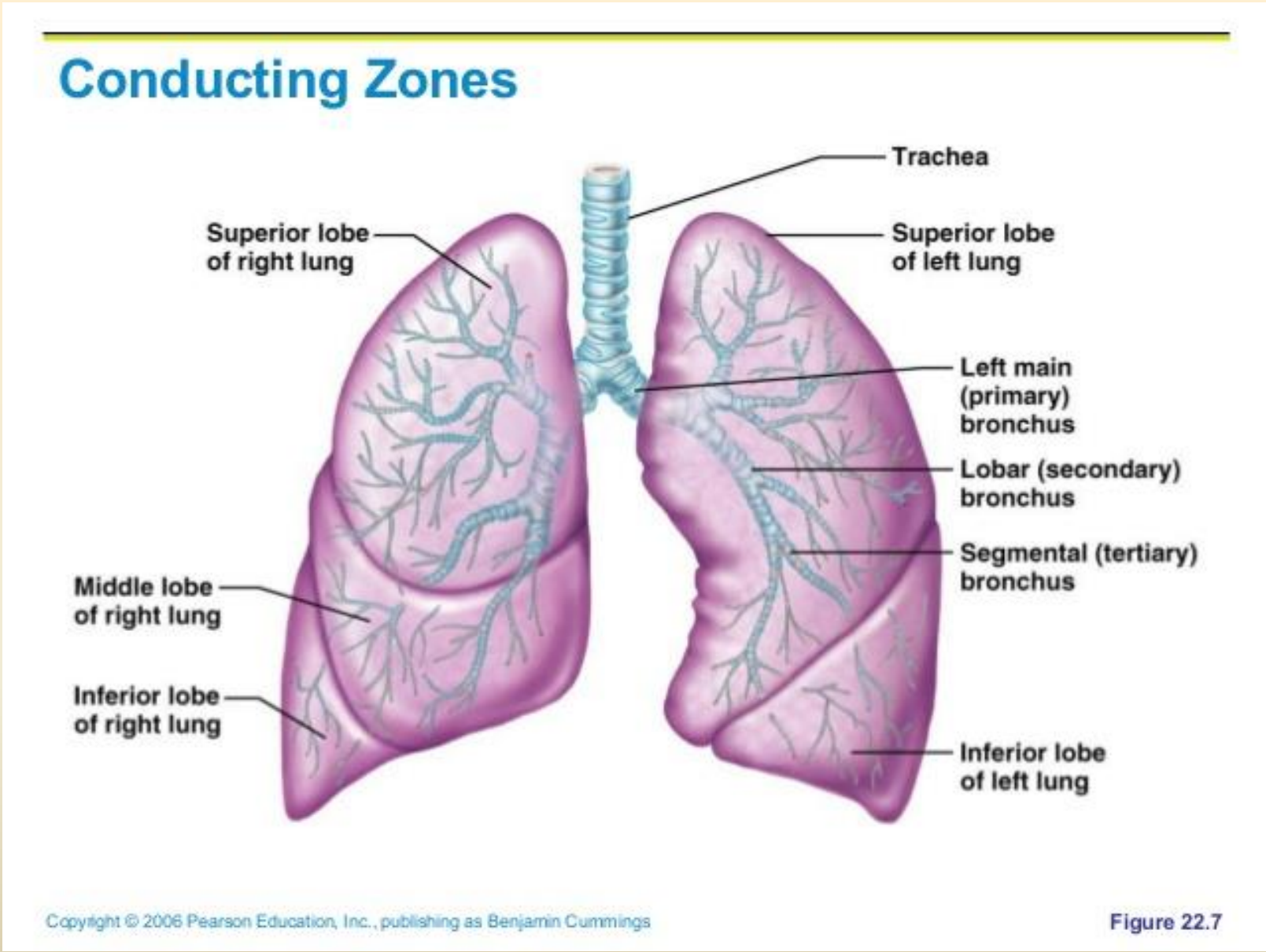
Trachea divides in bifurcation into two **main (primary)** bronchi.

Primary bronchi divide into **lobar bronchi** (secondary bronchi), they branch into **tercial segmental bronchi**.

Terminal bronchioles branch into 2 or more **respiratory bronchioles** and they branch again into **alveolar ducts (2-11).**

At the blind-ending alveolar ducts occur **alveolar sacs and alveoli** lined by pneumocytes

- Cartilage tissue disappears, amount of smooth muscle cells and elastic fibers decreases
- In bronchioles their wall **lacks cartilage and glands**



Lower respiratory system

Questions

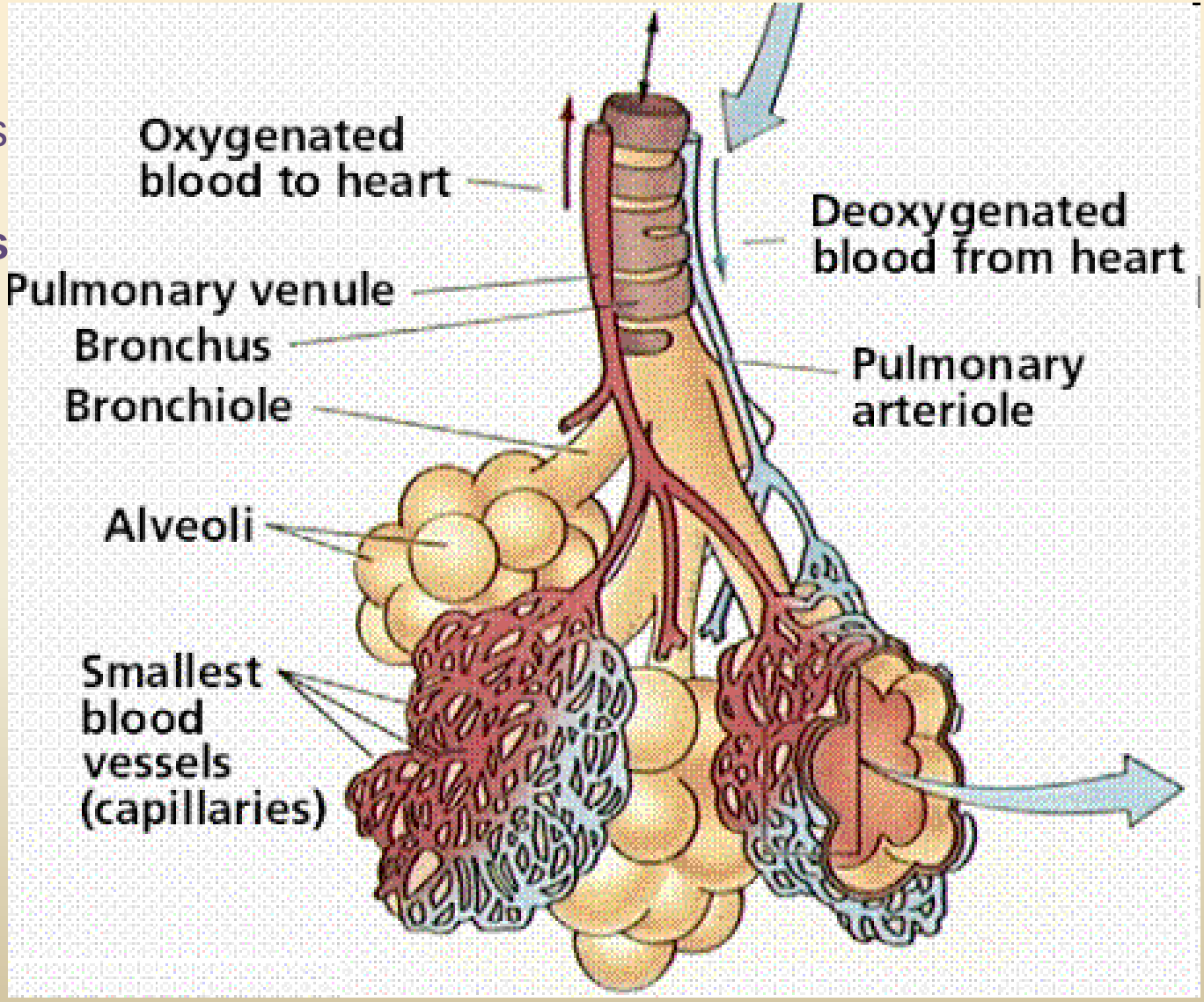
- **What is the blood circulation in the lung?**

Gas exchange – Air-blood barrier:

The Functional circulatory system is represented by **pulmonary arteries and veins**.

Nutrition for lung: bronchial artery.

The oxygen molecules diffuse from alveoli to the blood and carbon dioxide in the opposite direction.

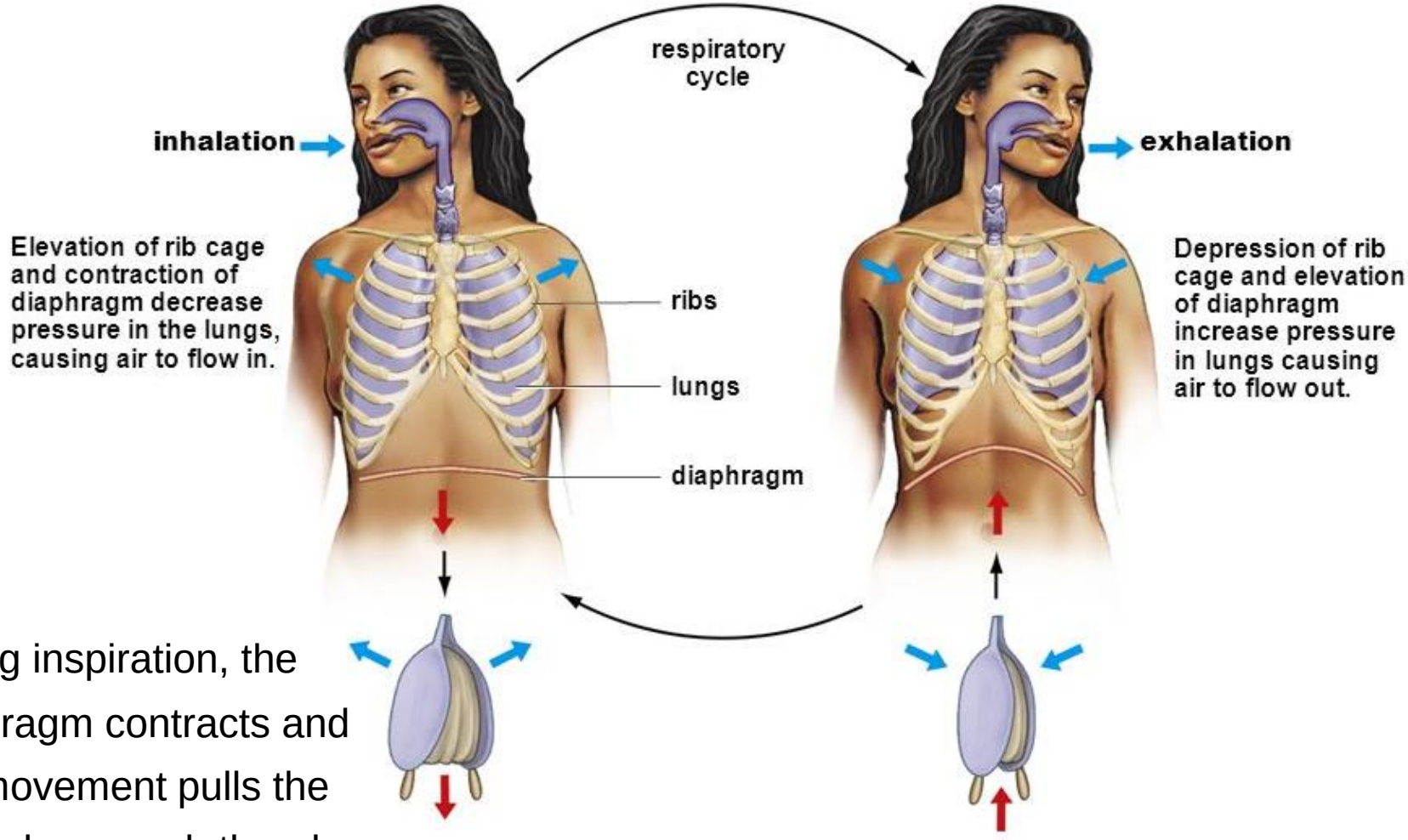


Questions

- What does the respiratory cycle look like?
- Which muscle is the most important for it?

Respiratory Cycle

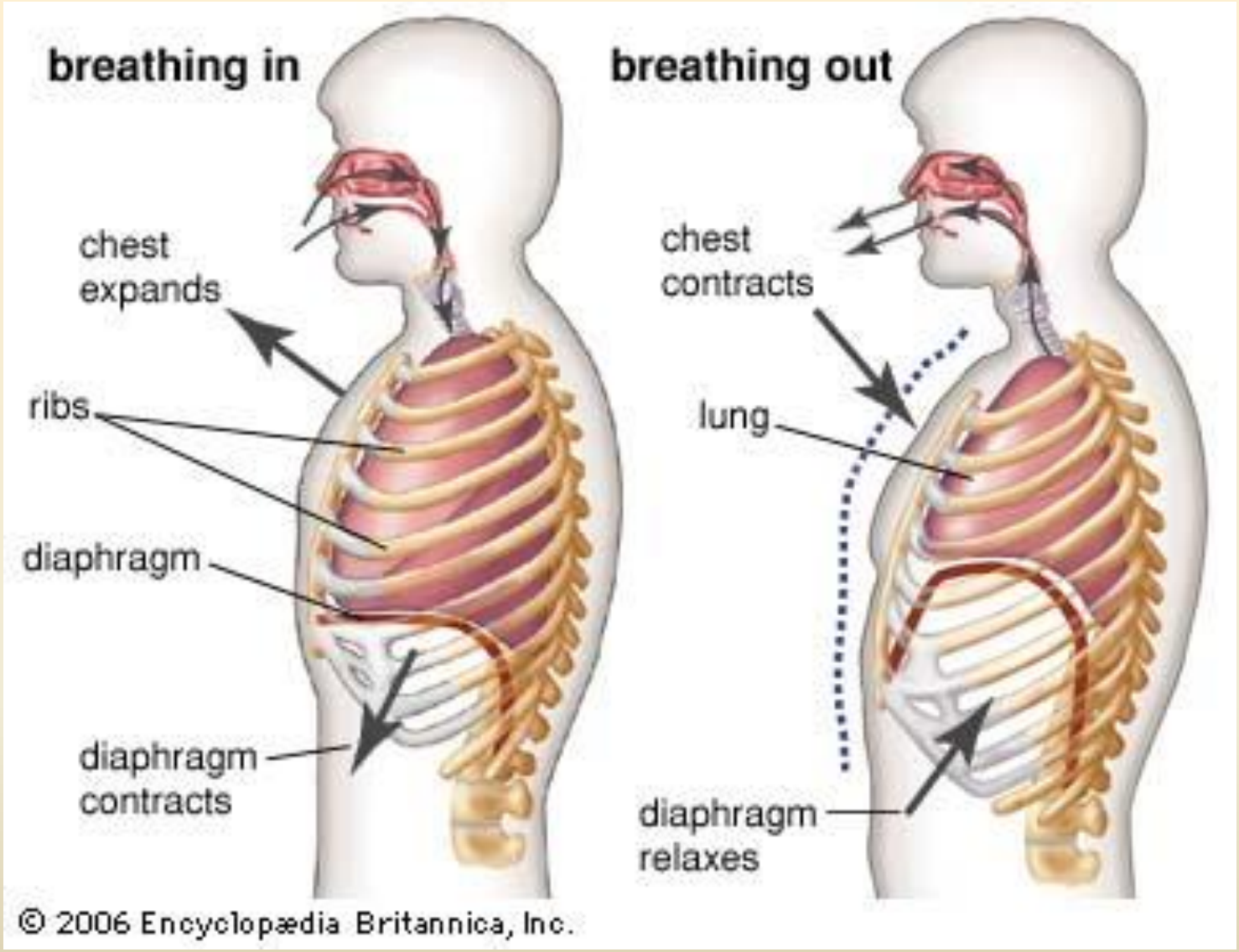
Gas is always moving to an area with lower pressure.



During inspiration, the diaphragm contracts and this movement pulls the lungs downward, thereby increasing their volume.

Figure 29.10

Respiratory Cycle



If the need for increased alveolar ventilation arises, as is the case of physical exercise, the activity of the diaphragm is supplemented by intercostal muscles .

Questions

- What is happening if the wind is knocked out of us?

Getting the wind knocked out of you

Is a commonly used idiom that mainly refers

to a kind of **diaphragm spasm**

that occurs when sudden force is applied to the abdomen.

It results in a temporary paralysis of the diaphragm that makes it difficult to breathe for a short period of time.

It can also occur from a strong blow to the back.

Questions

- What is happening during internal and external respiration?
  - How tick is a respiratory membrane?
  - What is a driving force for internal and external respiration?
  - What is happening during internal and external respiration in details?

Internal Respiration

the exchange of oxygen and carbon dioxide between the blood, lymph and body cells

External Respiration

carbon dioxide leaves the blood corpuscles they are "re-filled" with oxygen, because the concentration of oxygen is higher in the freshly inhaled air in the alveolus than in the incoming blood

Respiratory membrane

Respiratory membrane = alveolar-capillary membrane
layers:

1) Fluid surfactant in the alveoli

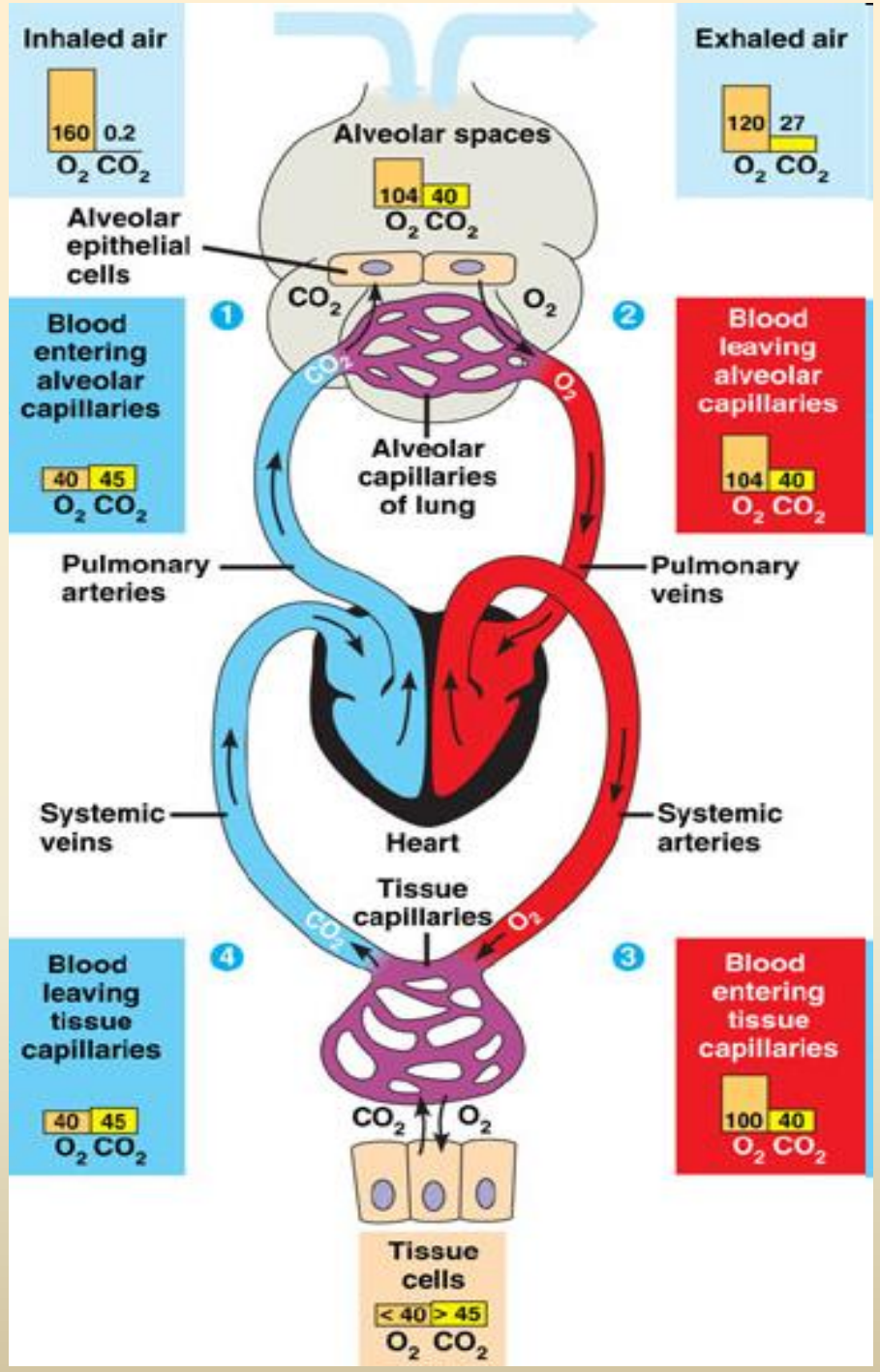
2) Pnemocytes

3) Basal membrane of epithel

4)Interstitium

4) Basal membrane

5) Endothelial cell



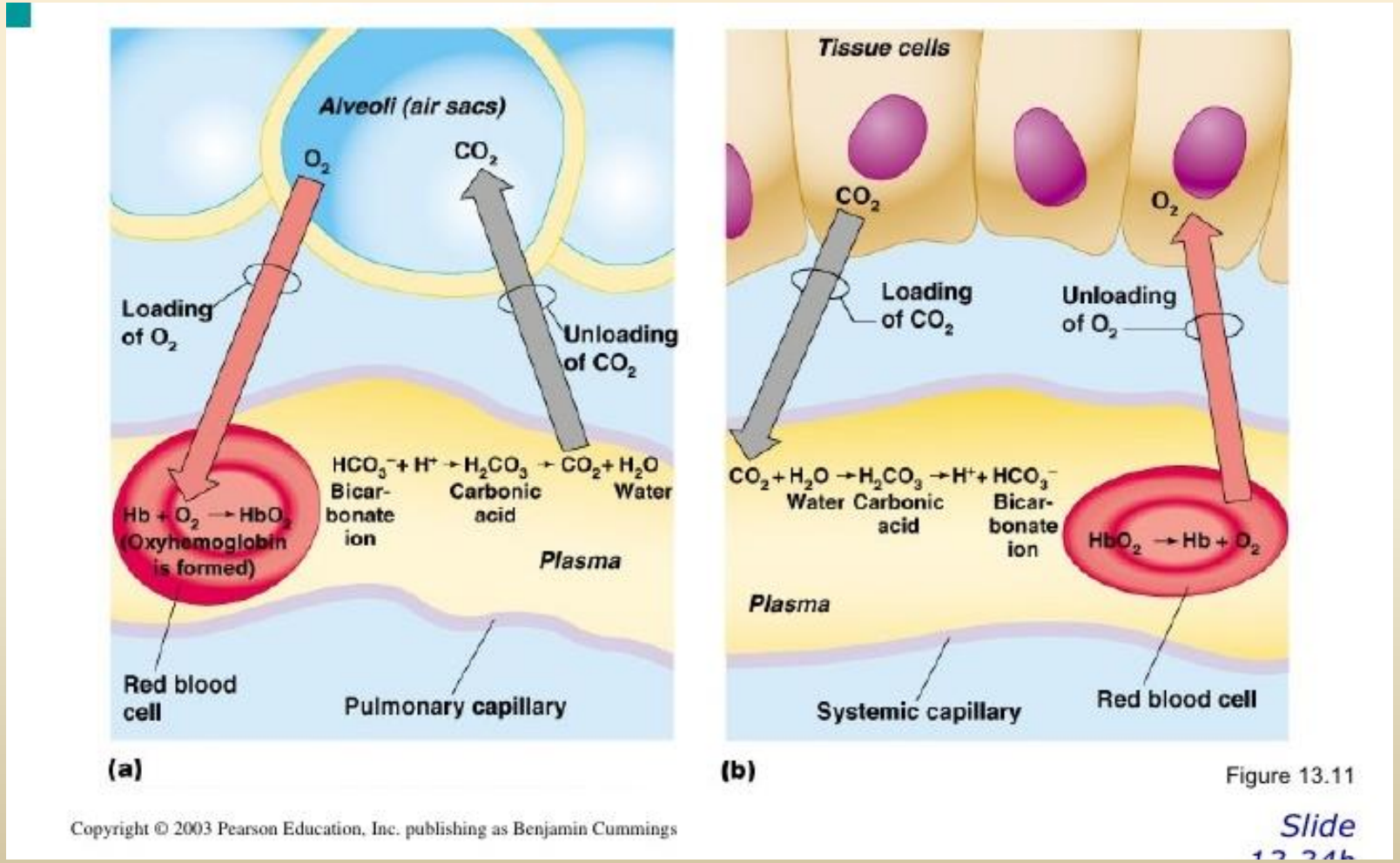
Partial pressure of oxygen and carbon dioxide is a driving force of internal and external respiration

The exchange of gases in systematic and pulmonary capillaries:

- O_2 diffuses from the alveoli into the blood and from the blood to cells

- CO_2 diffuses from the blood into alveoli and from the tissue to blood

in a compliance with **concentration gradient (partial pressure)**



Questions

- In what form does oxygen and carbon dioxide (gases) occur in the blood??

Blood gases

The blood gases can be generally transported in two ways:

1) Dissolved in blood - the solubility coefficient of **CO_2** is **22 times higher** than of **O_2**

2) Chemically bound to **hemoglobin and plasma proteins molecule**

Oxygen

- dissolved in blood – 1,5%
- Chemically bound to hemoglobin: One moll of **hemoglobin binds 4 moles of oxygen** molecules. It‘s 1**.35 ml of O_2 per 1g of Hb.**

Affinity to hemoglobin depend on

- Decreased pH decreases the affinity for oxygen
- Increased temperature decreases the affinity
- A presence of 2,3-bisphosphoglycerate (2,3-BPG)

Questions

- What is the pH and how is the body able to keep the pH in a balance??
- What is a acidosis and alkalosis and how is a body able to compensate these situation?

Acid-base homeostasis

Is the proper balance between acids and bases, in other words it is a ability to maintain the pH level in the physiological range. The pH is the negative logarithm of the hydrogen ion concentration.

$$\mathrm{pH} = \mathrm{p}K + \log \frac{[\mathrm{HA}]}{[\mathrm{A}^-]}$$

Bicarbonate buffering system

$$\mathrm{CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow HCO_3^- + H^+}$$

Biphosfphoric buffering system

Hemoglobin buffering system

pH of the normal range (pH – 7.4 ±0.04)

An excess of acid is called **acidosis** (pH less than 7.35) and an excess of bases is called **alkalosis** (pH greater than 7.45). The process that causes the imbalance is classified based on the etiology of the disturbance (respiratory or metabolic) and the direction of change in pH (acidosis or alkalosis).

process	pH	carbon dioxide	compensation
metabolic acidosis	down	down	respiratory
respiratory acidosis	down	up	renal
metabolic alkalosis	up	up	respiratory
respiratory alkalosis	up	down	renal

- While **exercising**,

the level of carbon dioxide in the blood increases due to **increased cellular respiration** by the muscles, which activates carotid and aortic bodies and the respiration center, which ultimately cause a **higher rate of respiration**. **An increased ventilation** leads to drop in pCO_2 and that leads to **increased pH.**

- During **rest**, the level of carbon dioxide is lower, so breathing rate is lower. This ensures an appropriate amount of oxygen is delivered to the muscles and other organs.
- **Decreased ventilation** (hypoventilation) leads to accumulation of $CO_2 \rightarrow$ Hypercapnia - increased pCO_2 and that leads to **acidification (decreased pH)**

Questions

- What is the regulation of breathing frequency?

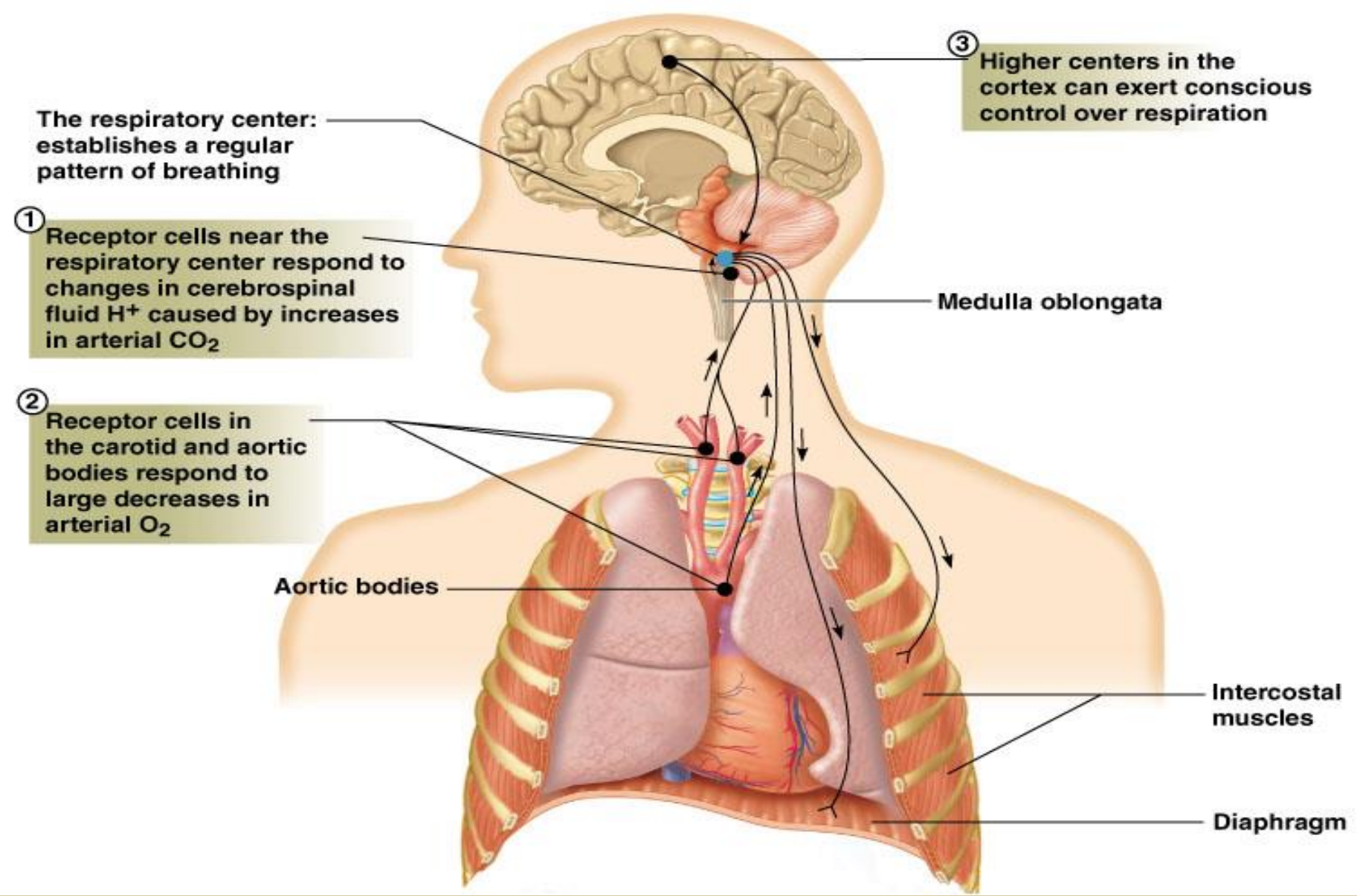
Regulation of Breathing

- **Peripheral and central chemoreceptors**

  Carotid and aortic bodies and bodies in medulla oblongata **are sensitive to carbon dioxide, pH, and oxygen levels**

- **Centre in the cortex** is responsible for conscious control; an ability to modify the rate of breathing is limited
- Mechanoreceptors (wall‘s) and receptors in muscles

Regulation of Breathing



Questions

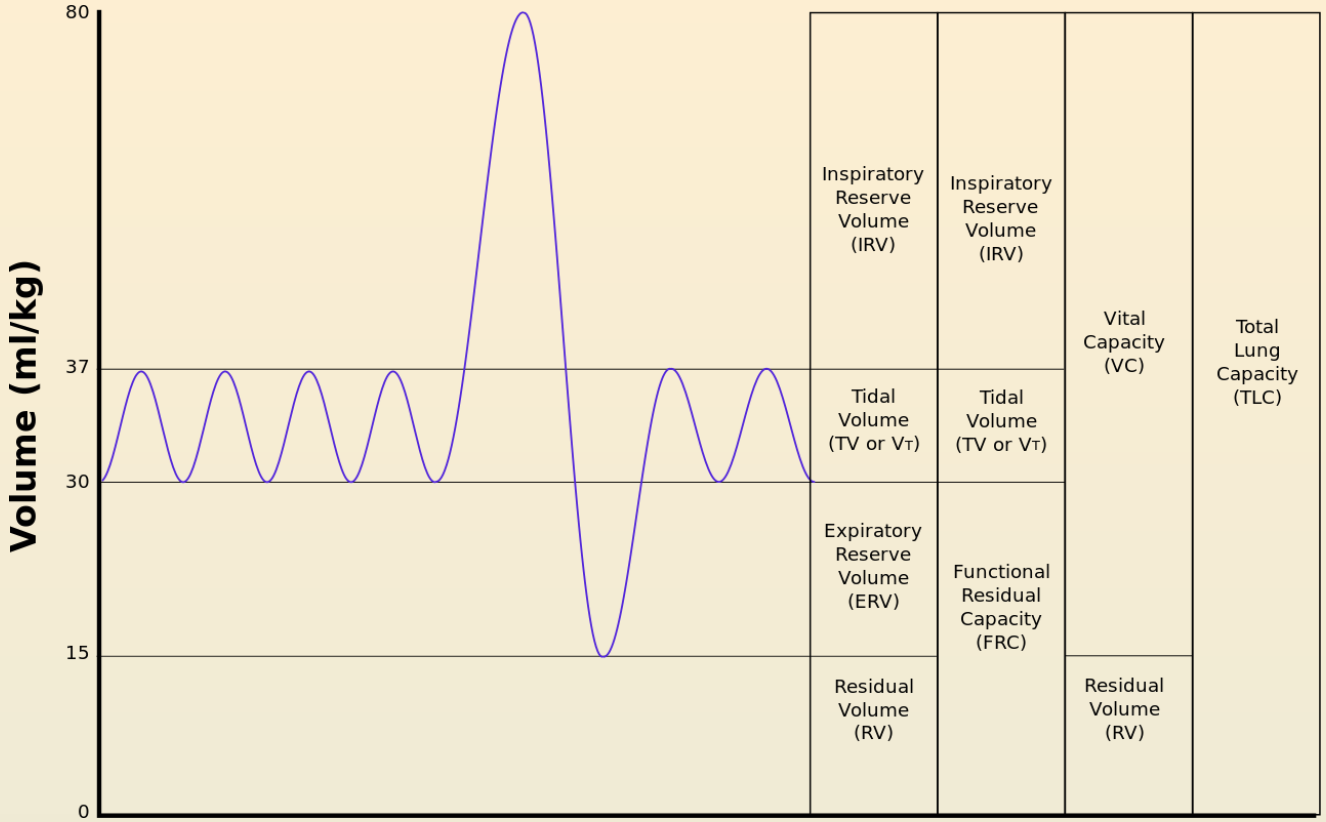
- What are the most important lung volumes and capacities??

Lung volumes and **lung capacities**

refer about the volumes of air associated with different phases of the respiratory cycle. Lung volumes are directly measured by spirometers.The volumes depend on human‘s physiology and life style:

Larger volumes	**Smaller volumes**
taller people	shorter people
non-smokers	smokers
athletes	non-athletes
people living at high altitudes	people living at low altitudes

Lung volumes and **lung capacities**



Vital capacity – VC The maximum volume that can be inhaled and exhaled

Expiratory reserve volume – ERV The maximum volume of air that can be exhaled "in addition" during maximal forced expiration.

Inspiratory Reserve volume–IRV The maximum volume that can be inhaled to inhale "in addition" during the maximal forced inspiration

Total lung capacity–TLC The entire volume of the lung, circa about 5800 ml

Thank you for your attention

Campbell, Neil A., Reece, Jane B., Cain Michael L., Jackson, Robert B., Minorsky, Peter V.**, Biology**, Benjamin-Cummings Publishing Company, 1996 –2010.