RESPIRATION

Biology 12 Human Systems

Purpose of Respiration

- To ensure that the cells of the body are supplied with oxygen which is needed for aerobic cellular respiration
- To remove the gas CO_2 which a byproduct of aerobic cellular respiration
- Note the respiratory system is assisted by the circulatory system which transports the gases between the blood and the tissue

Key Terms and Definitions

Breathing

- the ventilation of air in and out of the lungs
- caused by the contraction and relaxation of the **diaphragm** and **intercostals muscles**

External Respiration

- occurs in the **lungs** and involves the **pulmonary circulation**
- the exchange of gases between the aveoli and the blood of the pulmonary capillaries
- the mechanism behind this exchange is diffusion
- O_2 diffuses from the aveoli into the blood of the pulmonary capillaries
- CO_2 diffuses from the blood of the pulmonary capillaries into the aveoli

Key Terms and Definitions

Internal Respiration

- Occurs **throughout the body** and involves the **systemic circulation**
- The exchange of gases between the tissue and the blood of the systemic capillaries
- The mechanism behind this exchange is diffusion
- O_2 diffuses from the blood of the systemic capillaries into the tissue
- CO_2 diffuses from the tissue into the blood of the systemic capillaries

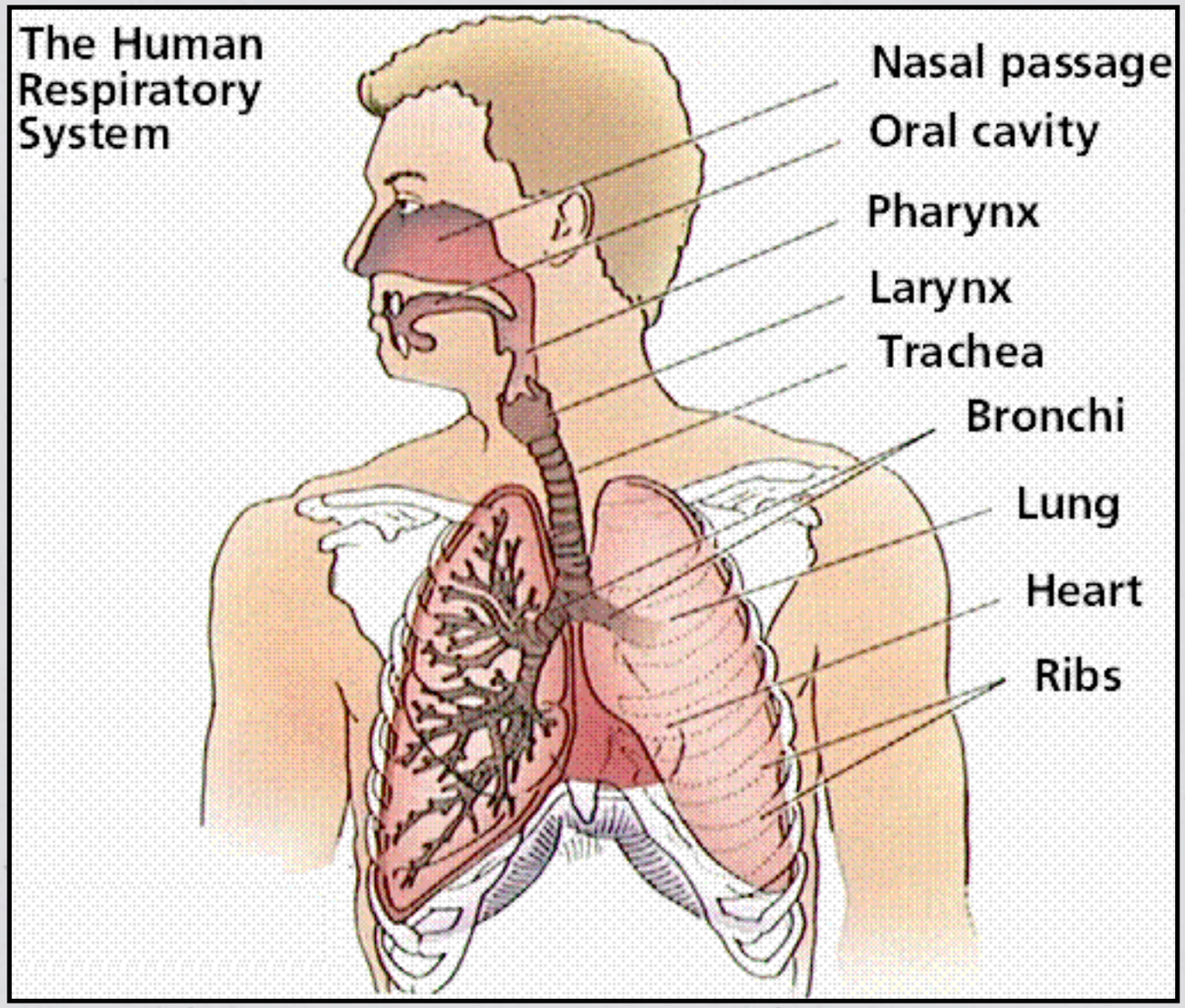
Aerobic Cellular Respiration

- The use of O_2 gas by the cells to release energy from molecules such as glucose
- The gas CO_2 and water are byproducts of this process

Glucose + O_2 CO_2 + H_2O + energy

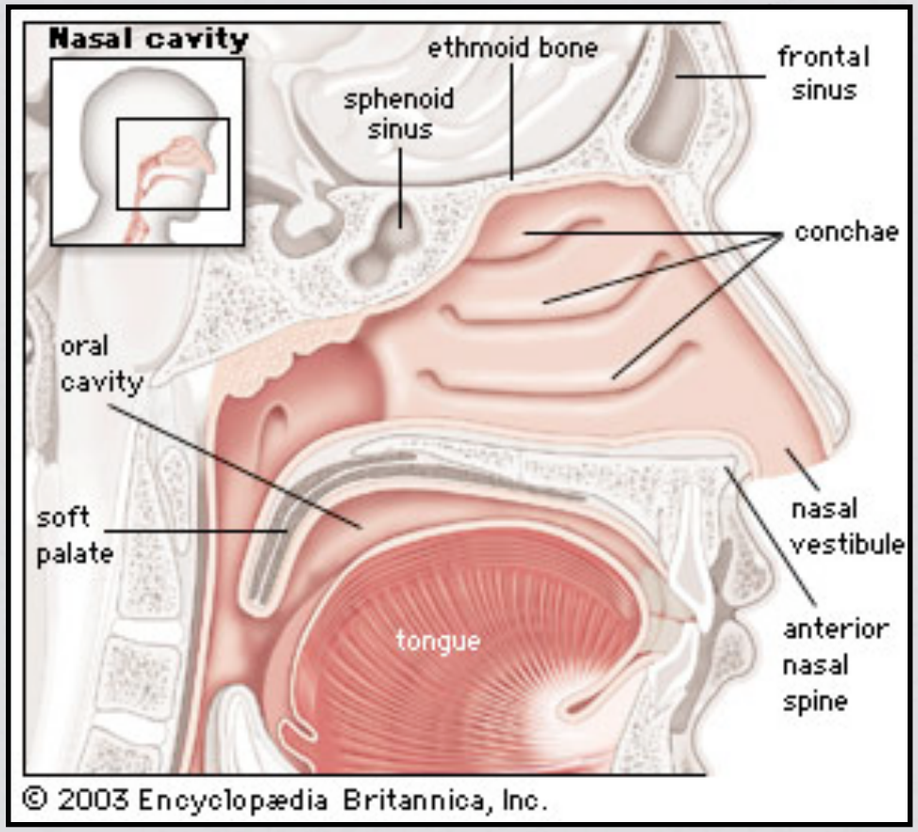
The Respiration Pathway

- The respiratory pathway extends from the nostrils of the nose to the aveoli of the lungs
- This pathway allows air that is high in O_2 to enter the lungs and allows air that is high in CO_2 to exit the lungs



Nostrils and Nasal Cavities

- Air enters through the nostrils and then goes into the two nasal cavities
- Within the nasal cavities, air is **warmed, moistened** and **filtered** due to the presence of **cilia** and **mucous**



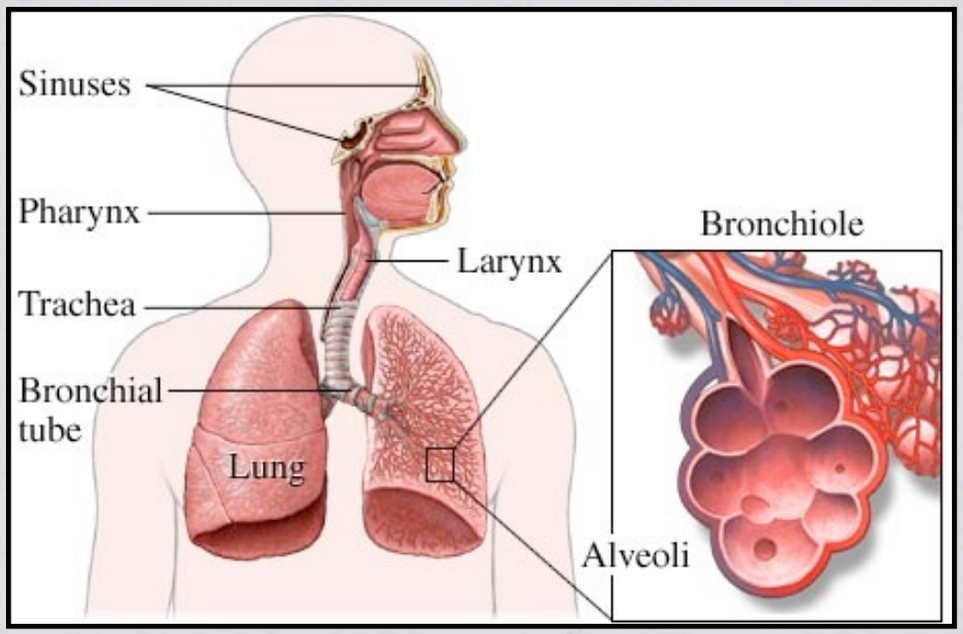
Pharynx and Larynx

<u>Pharynx</u>

- From the nasal cavities the air enters the pharynx which is a chamber at the back of the nasal cavities (connects the oral and nasal cavities)

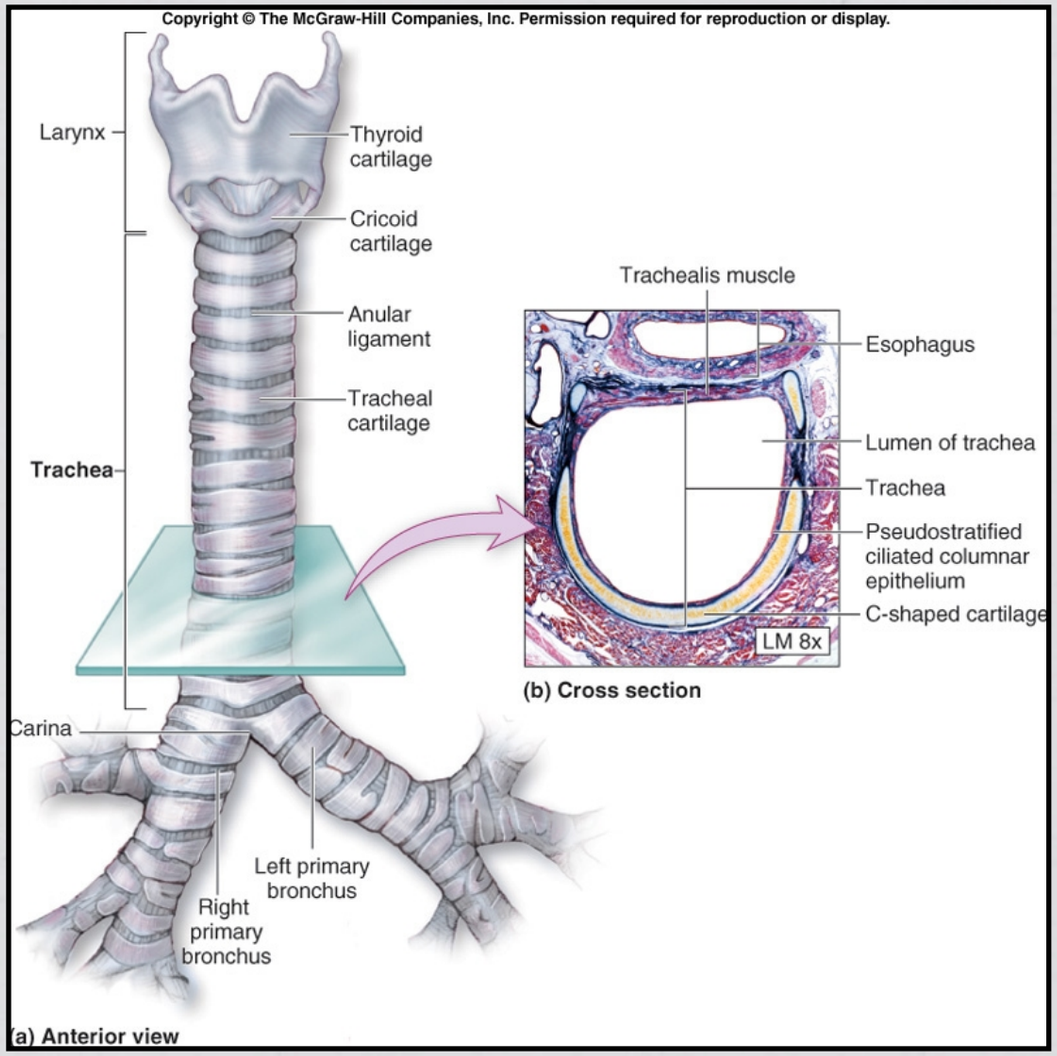
<u>Larynx</u>

- From the pharynx, the enters passes through an opening called the **glottis** into the larynx
- A flap of tissue called the **epiglottis** prevents food from passing through the glottis and entering the trachea
- The larynx contains the **vocal chords** which vibrate and produce sound when air passes through them



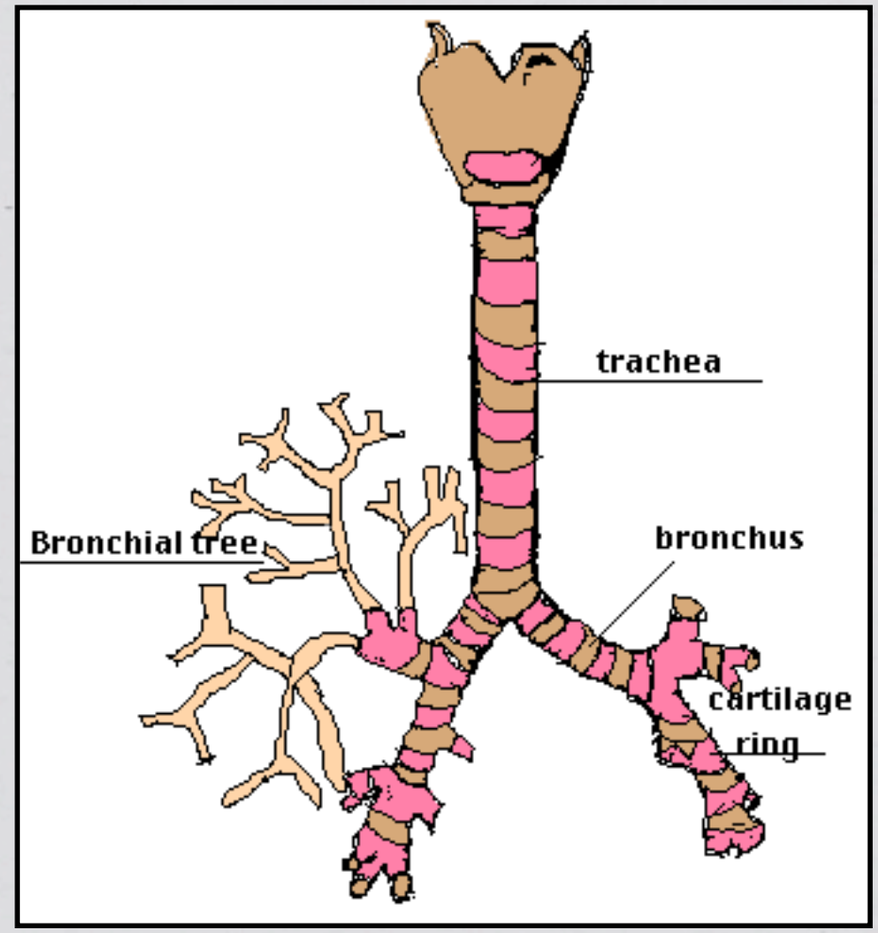
Trachea

- From the larynx, air enters a tube called the **trachea**
- The epithelial cells of the trachea have **cilia** and produce **mucous**
- The mucous traps particles in the air and the cilia beat upward to remove these particles from the trachea
- The trachea also has rings of **cartilage** in its walls to hold it open and allow air to move through it freely



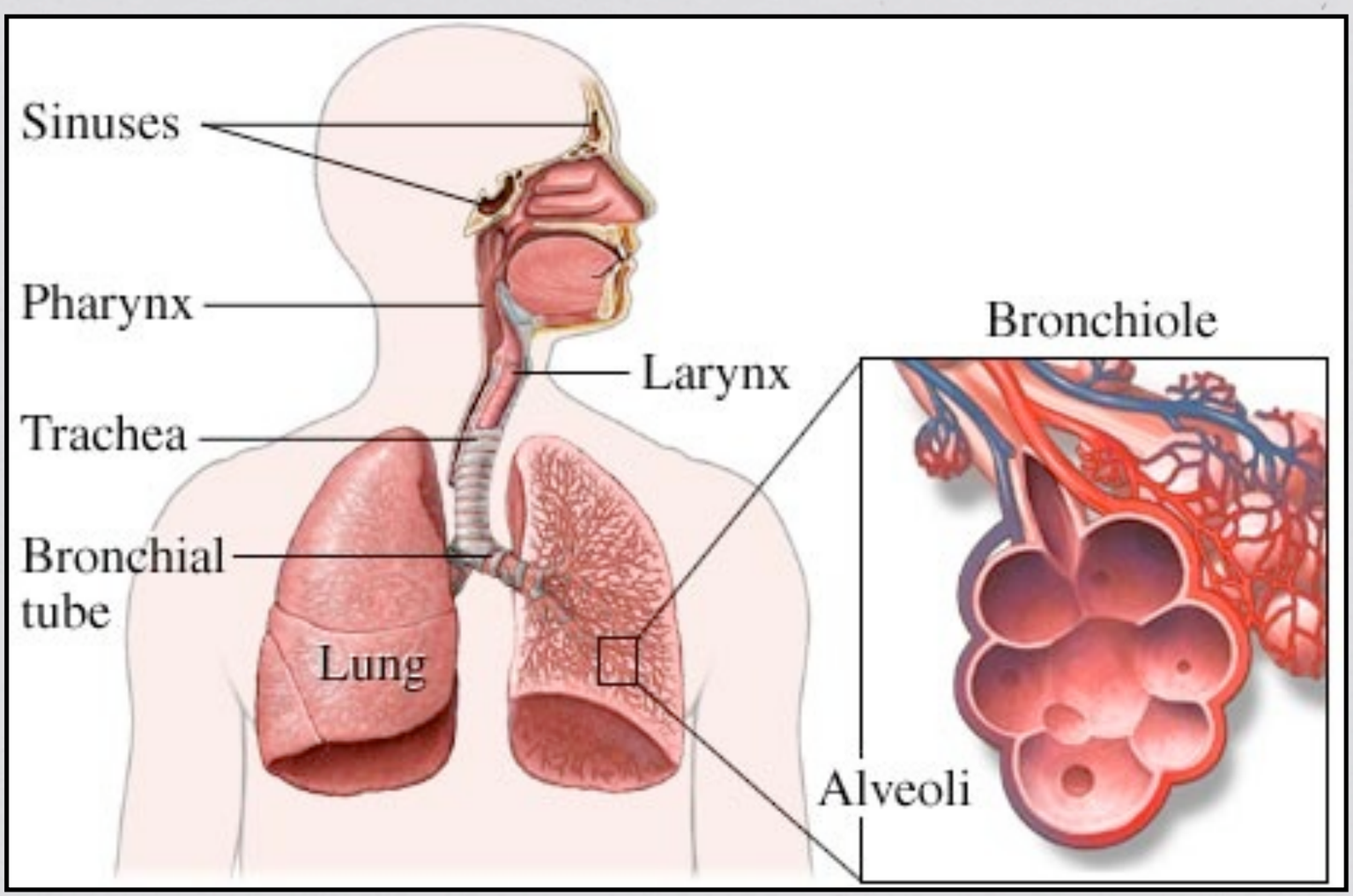
Bronchi

- Within the thoracic cavity, the trachea branches into two **bronchi**
- One bronchi goes to each lung
- Like the trachea, the bronchi have cilia, mucous and rings of cartilage



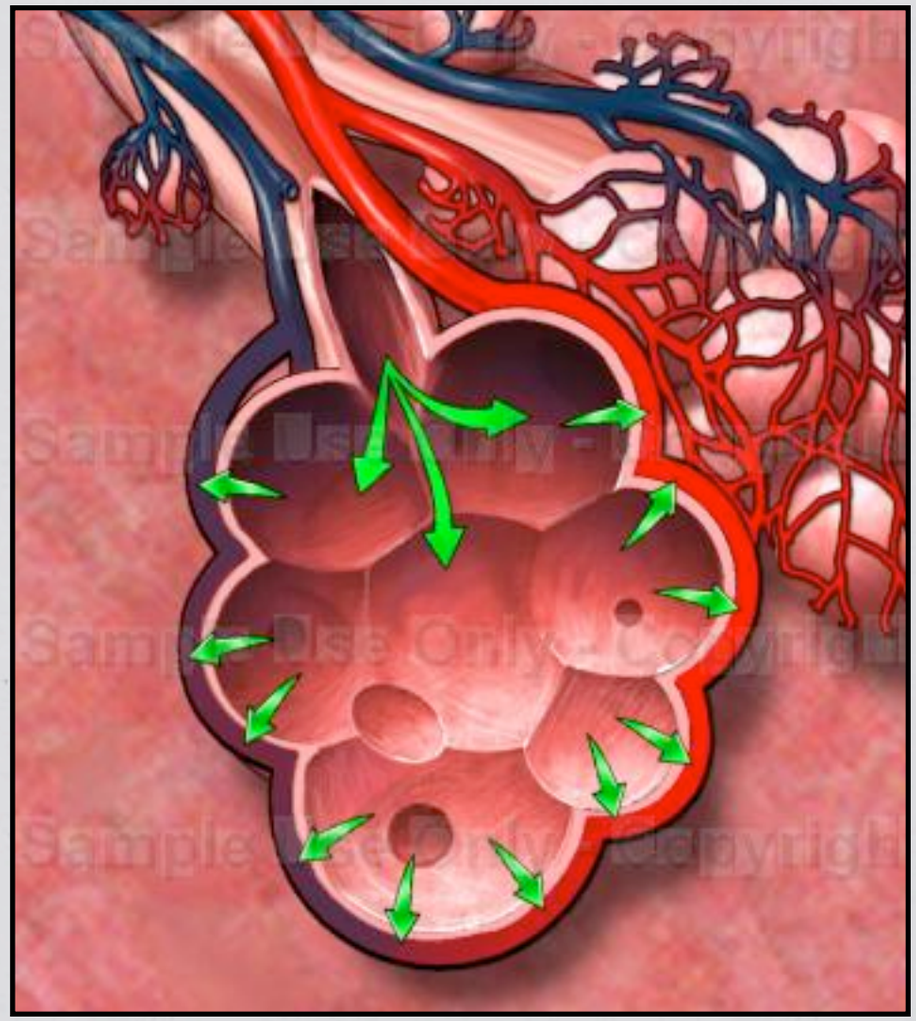
Bronchioles

- Once in the lungs, the bronchi branch into a large number of **bronchioles**, which carry air to and from all areas of the lungs
- As the bronchioles branch, their walls become very thin and they lack the cartilage seen in the bronchi and trachea



Alveoli

- The bronchioles end in clusters of air sacs called **alveoli**
- The alveoli are the site of gas exchange (**external respiration**)
- The alveoli have a number of structural features to facilitate external respiration:
  - Very **thin walls** to allow for easy diffusion
  - **Many alveoli** in each lung to maximize **surface area** for gas exchange
  - Surrounded by **pulmonary capillaries** which carry blood
  - Lined with **surfactant**, a protein that lowers surface tension and prevents the aveoli from closing



Pleural Membranes

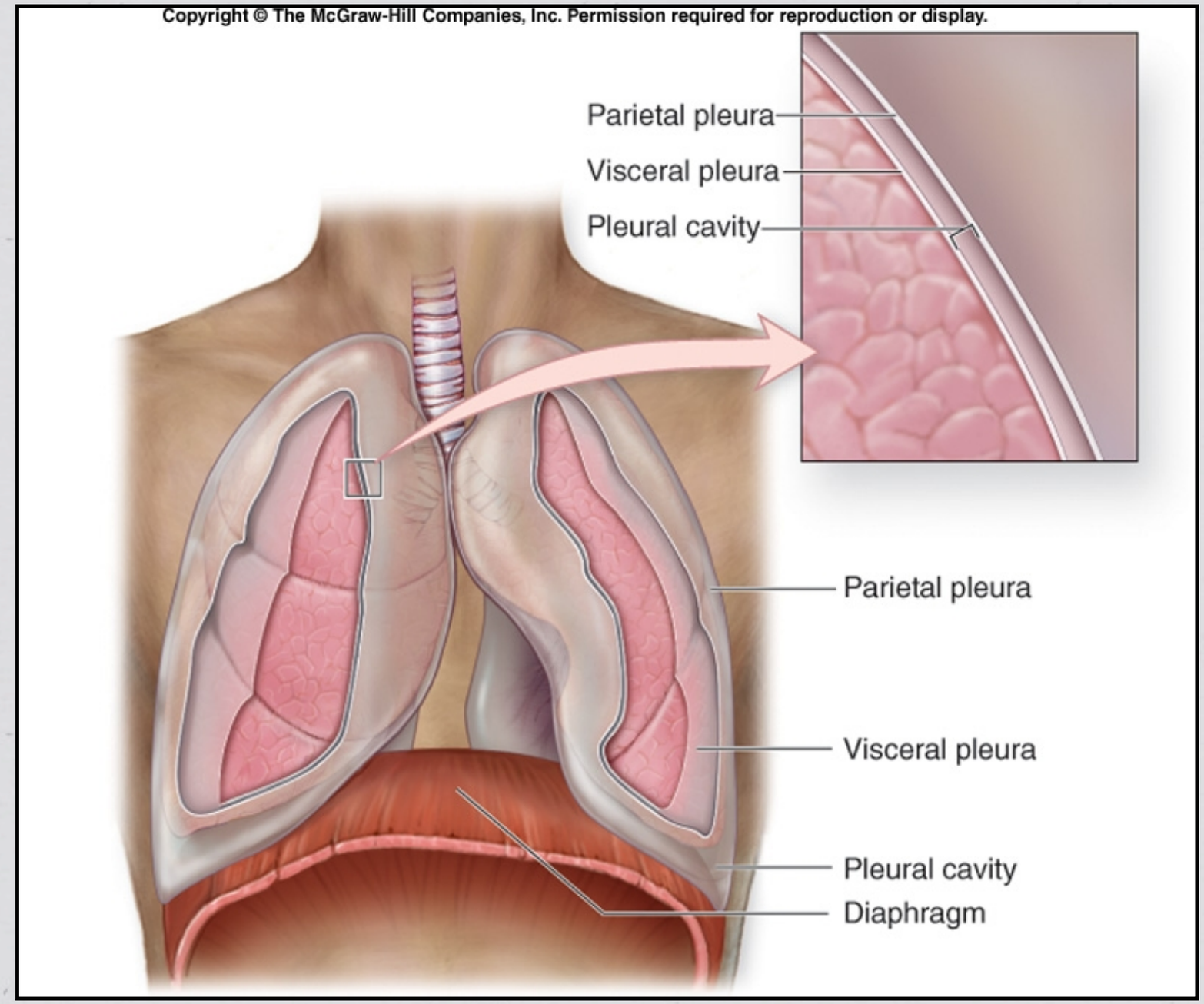
Location

- There are two pleural membranes surrounding the lungs
- One is fused to the surface of the lungs, the other is attached to the rib cage and the diaphragm
- There is a space inbetween the two membranes called the **intrapleural** space which contains a thin film of fluid
- The pressure between the membranes is lower than atmospheric pressure

Functions

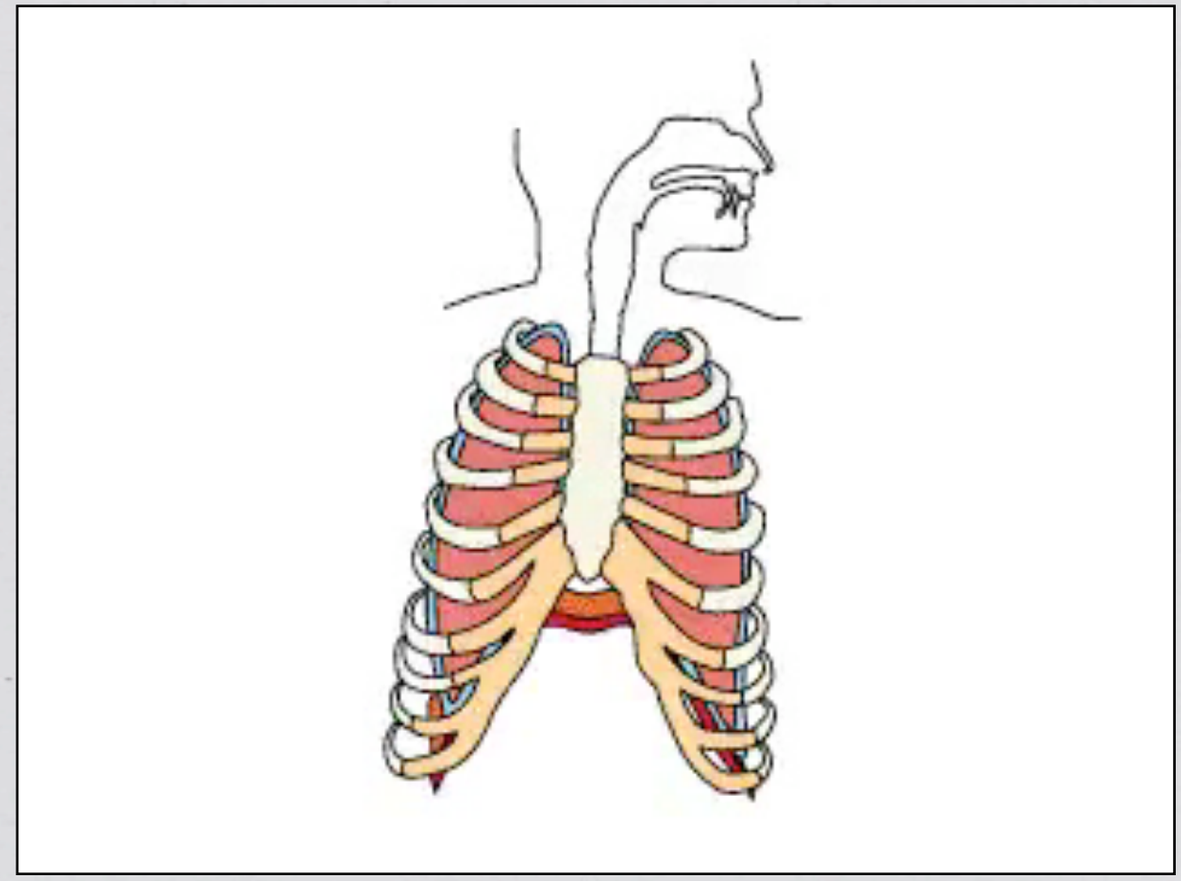
- The thin film of fluid between the membranes provides **lubrication** and thus reduces friction between the lungs and other surfaces during breathing
- Since the pressure is lower than atmospheric pressure, expansion of the lungs during breathing is easier

Pleural Membranes



Breathing: Inhalation & Exhalation

- Breathing is the ventilation of air in and out of the lungs
- Breathing involves the following muscles:
  - **Diaphragm** which is found at the base of the lungs
  - **Intercostals** which are between the ribs



Breathing: Inhalation & Exhalation

- Breathing is controlled by neurons found in the **respiratory centre** of the **medulla oblongata**
- These neurons are sensitive to the amount of **CO_2** and **H^+ ions** in the blood

- Other receptors found in the **carotid artery** and the **aorta** are sensitive to the level of **O_2** in the blood as well as the amount of **CO_2** and **H^+ ions** in the blood
- These receptors are called the **carotid bodies** and the **aortic bodies**
- The level of O_2 in the blood is NOT as important as the amount of **CO_2** and **H^+ ions** in the blood in terms of controlling breathing

Inhalation

- Inhalation is the **active** phase of breathing since it involves the **contraction** of muscles
- When CO_2 and H^+ ion levels in the blood reach a certain level, the neurons in the respiratory centre of the medulla oblongata and those in the carotid and aortic bodies are **stimulated**

Inhalation

- The respiratory centre then sends **nerve impulses** to:
  - The **diaphragm** causing it to **contract** and move **downwards**
  - The **intercostals muscles** causing them to **contract** and move the ribcage **outwards**

- These events cause an increase in the **size** of the **lungs** and a **decrease** in **pressure**
- Thus causing air to flow **into** the **lungs**

Exhalation

- Exhalation is considered a **passive** phase of breathing since it involves the **relaxation** of muscles
- When neurons and receptors are no longer stimulated, impulses are no longer sent to the diaphragm and intercostals muscles
    - The **diaphragm relaxes**, moving upwards
    - The **intercostals muscles** relax, allowing the ribcage to move **in** and **down**

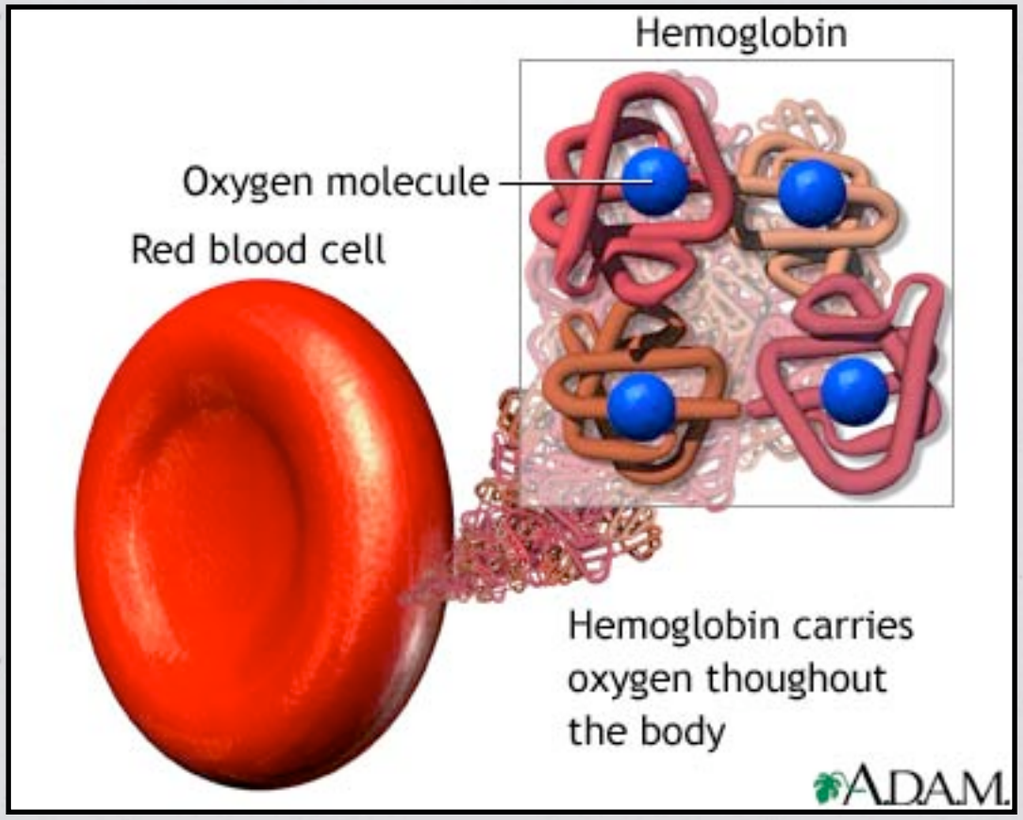
Gas Exchange During Internal & External Respiration

Molecules Involved

- Hemoglobin **Hb**
- Oxyhemoglobin **HbO_2**
- Carbaminohemoglobin **$HbCO_2$**
- Reduced Hemoglobin **HHb**

- Oxygen **O_2**
- Carbon Dioxide **CO_2**
- Carbonic Acid **H_2CO_3**

- Hydrogen Ions **H^+**
- Bicarbonate Ions **HCO_3^-**



What Happens During External Respiration?

- Oxygen bonds with hemoglobin forming oxyhemoglobin
- Bicarbonate ions react with hydrogen ions to form carbon dioxide and water (and exhaled)
- Reduced hemoglobin releases the hydrogen ions it is carrying forming hemoglobin
- Other forms of carbon dioxide (carbaminohemoglobin and carbon dioxide dissolved in the plasma) are converted to carbon dioxide gas (and exhaled)

In other words…

- Oxygen bonds with hemoglobin forming oxyhemoglobin
- Hemoglobin bonds with oxygen according to the following reaction:

$$Hb + O_2 \rightarrow HbO_2$$

- Bicarbonate ions react with the Hydrogen ions that are released from reduced hemoglobin and are converted to water and carbon dioxide, according to the reaction below
- The enzyme **Carbonic Anhydrase** catalyzes this reaction
- The water and carbon dioxide are then exhaled.

$$HCO_3^- + H^+ \rightarrow H_2CO_3 \rightarrow CO_2 \text{ (exhaled)} + H_2O \text{ (exhaled)}$$

- Hemoglobin carrying Hydrogen ions is called <u>reduced hemoglobin</u>.
- Hemoglobin releases the Hydrogen ions it is carrying according to the following reaction:

$$HHb \rightarrow Hb + H^+$$

- Hemoglobin carrying Carbon Dioxide is called <u>carbaminohemoglobin</u>.
- Hemoglobin releases the Carbon Dioxide it is carrying according to the following reaction:

$$HbCO_2 \rightarrow Hb + CO_2 \text{ (exhaled)}$$

Summarize…

I. $HHb \rightarrow Hb + H^+$

$HCO_3^- + H^+ \rightarrow H_2CO_3 \rightarrow CO_2$ (exhaled) + H_2O (exhaled)

2. $Hb + O_2 \rightarrow HbO_2$

3. $HbCO_2 \rightarrow Hb + CO_2$ (exhaled)

What Happens During Internal Respiration?

- Oxyhemoglobin releases the oxygen it is carrying forming hemoglobin. The oxygen diffuses into the tissue cells from the blood
- Carbon dioxide dissolves in the plasma
- Carbon dioxide and water diffuse into the blood from the tissue cells and are converted to hydrogen ions and bicarbonate ion.
- Carbon dioxide bonds to hemoglobin forming carbaminohemoglobin
- Hemoglobin bonds with hydrogen ions

- Oxyhemoglobin releases the oxygen it is carrying forming hemoglobin. The oxygen diffuses into the tissue cells from the blood.

$$HbO_2 \rightarrow Hb + O_2$$

- Carbon Dioxide is carried in the blood in several ways:
  - About 9% of CO_2 is carried in the blood as dissolved CO_2,
  - Another 25% of CO_2 is carried bound to hemoglobin and called carbaminohemoglobin
  - The remaining 65% is carried as Bicarbonate ion (HCO_3^{-}).
  - The bicarbonate ion is produced in two stages according to the reaction which is catalyzed by **carbonic anhydrase**

$$H_2O + CO_2 \rightarrow H_2CO_3 \rightarrow HCO_3^- + H^+$$

- Carbon dioxide bonds to hemoglobin forming carbaminohemoglobin
- Hemoglobin bonds with hydrogen ions

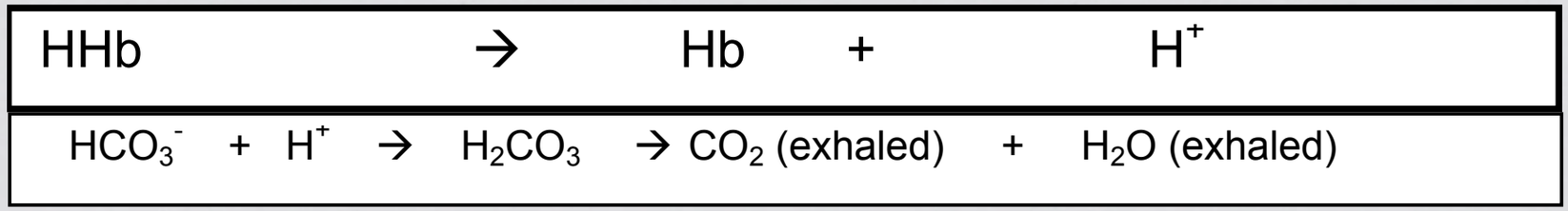
$$Hb + H^+ \rightarrow HHb$$

$$Hb + CO_2 \rightarrow HbCO_2$$

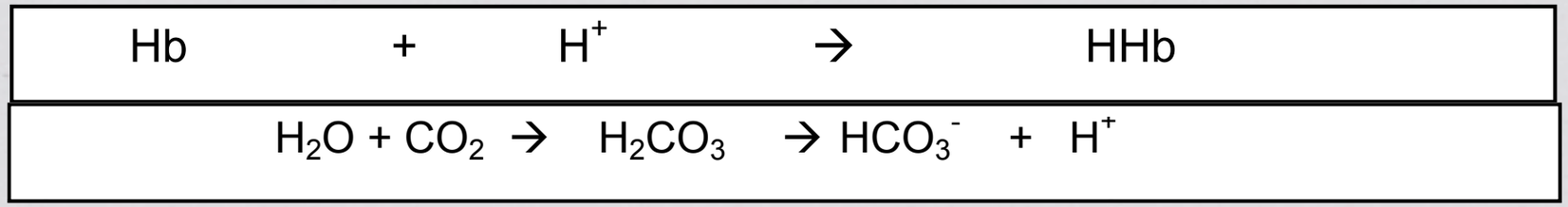
- The red blood cells contain an enzyme called **Carbonic Anhydrase** that catalyzes the reaction of carbonic acid to bicarbonate and hydrogen ion
- As more carbon dioxide is taken up by the blood the blood becomes increasingly acid.
- As the acidity increases, the hemoglobin gives up its oxygen more readily.
- The hemoglobin then binds with the excess H^+ ions and carries them to the lungs
- Therefore as CO_2 enters the blood, more oxygen is given off and taken in by the tissues.

SEE THE SIMILARITIES?

External Respiration



Internal Respiration



SEE THE SIMILARITIES?

External Respiration

$$Hb + O_2 \rightarrow HbO_2$$

Internal Respiration

$$HbO_2 \rightarrow Hb + O_2$$

External Respiration

$$HbCO_2 \rightarrow Hb + CO_2 \text{ (exhaled)}$$

Internal Respiration

$$Hb + CO_2 \rightarrow HbCO_2$$