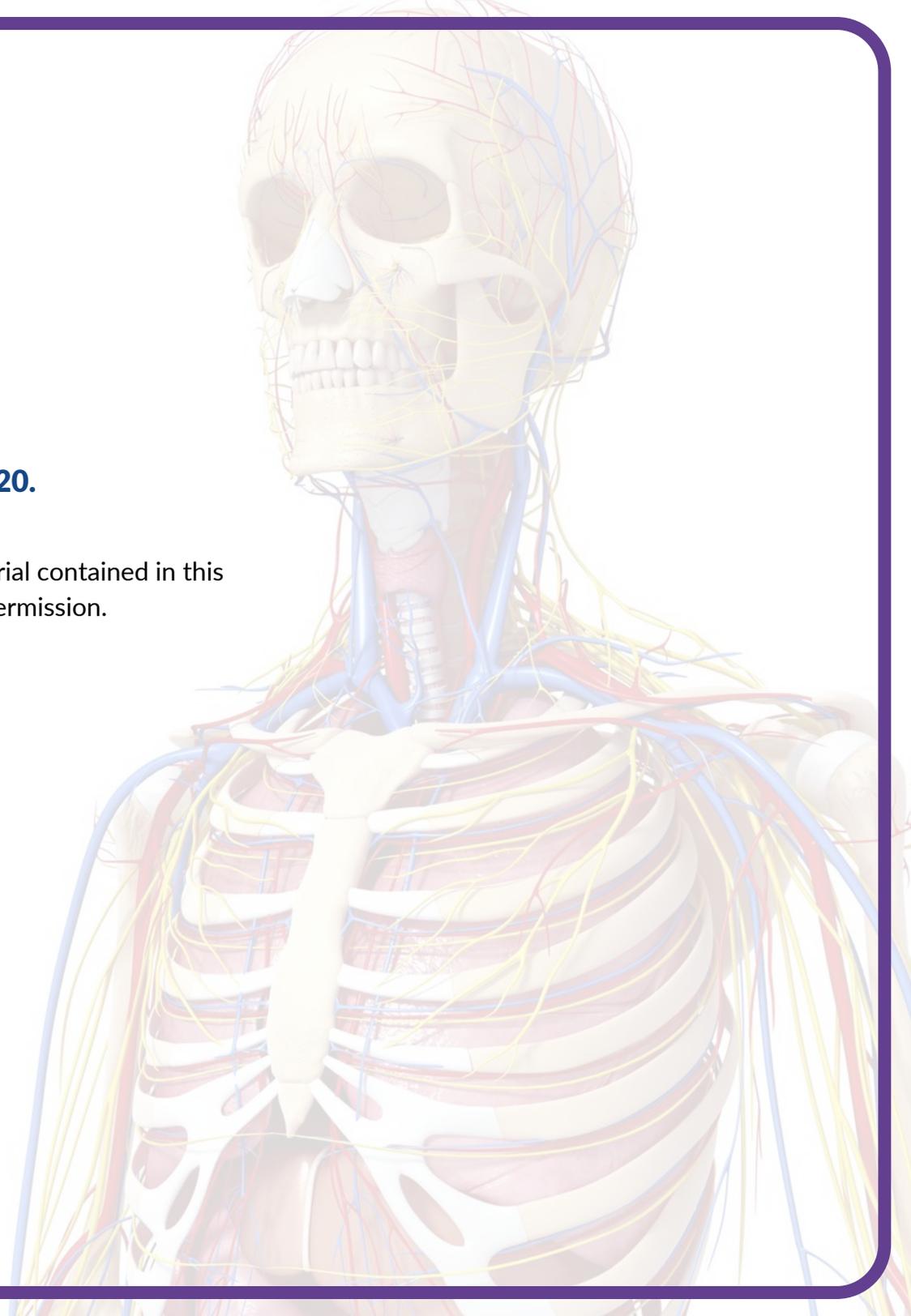


# Respiratory System Workbook

*(accompanies 3D4Medical and 3DAnatomica apps)*

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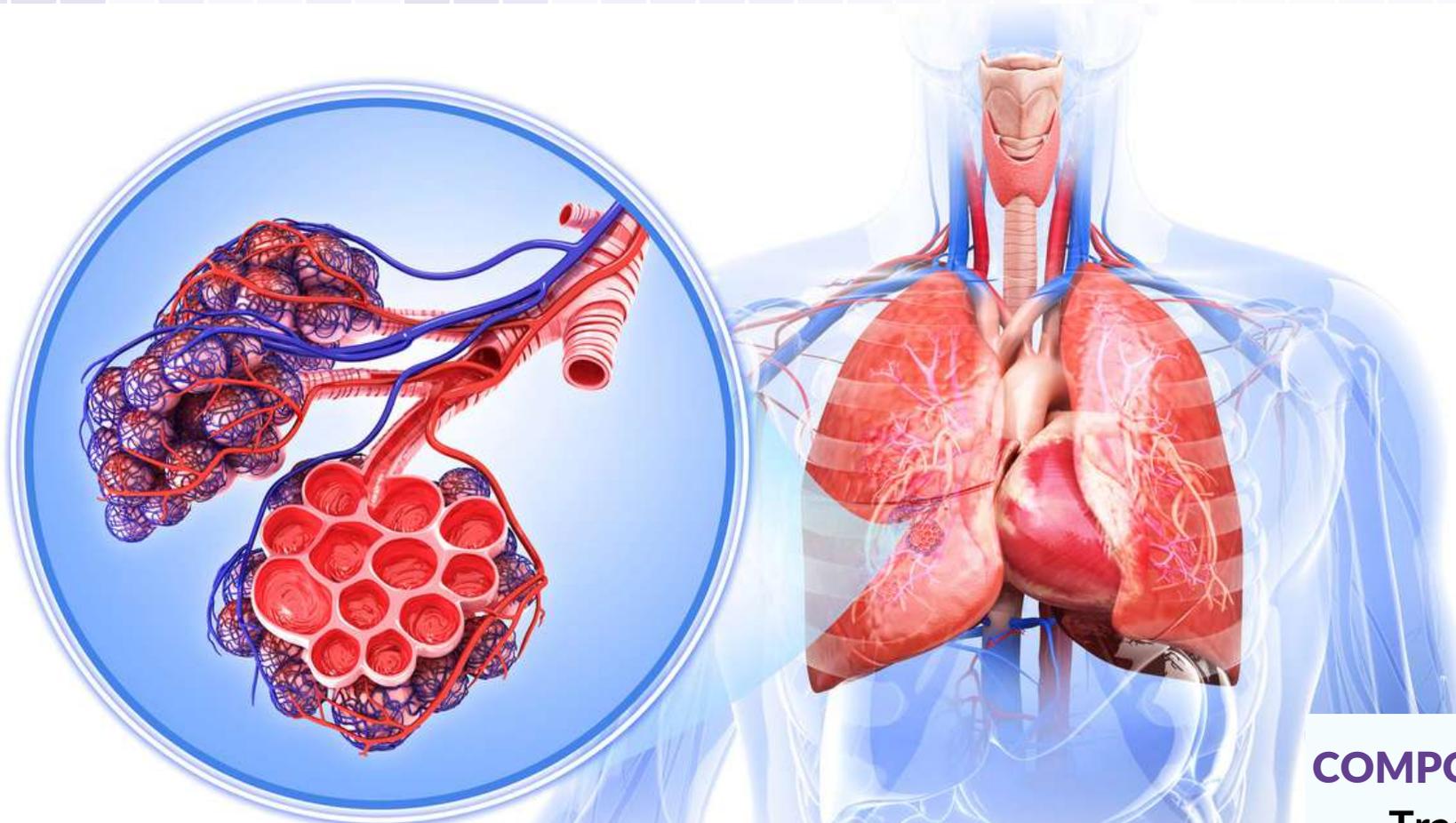
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# Learning Objectives

- Describe the function of the respiratory system and its major organs.
- Describe the relationships between the different components of the respiratory system.
- Explain how the respiratory and circulatory systems are interdependent.
- Explain how the respiratory system maintains homeostasis in the body

# Respiratory System Overview



The main function of the respiratory system is **pulmonary respiration** - gas exchange within/between the body and the external environment. Secondary functions include voice production, body temperature regulation, acid-base regulation, and olfaction (sense of smell).

## COMPONENTS

- Trachea
- Bronchi
- Bronchioles
- Alveoli
- Lungs
- Diaphragm

### LARYNX:

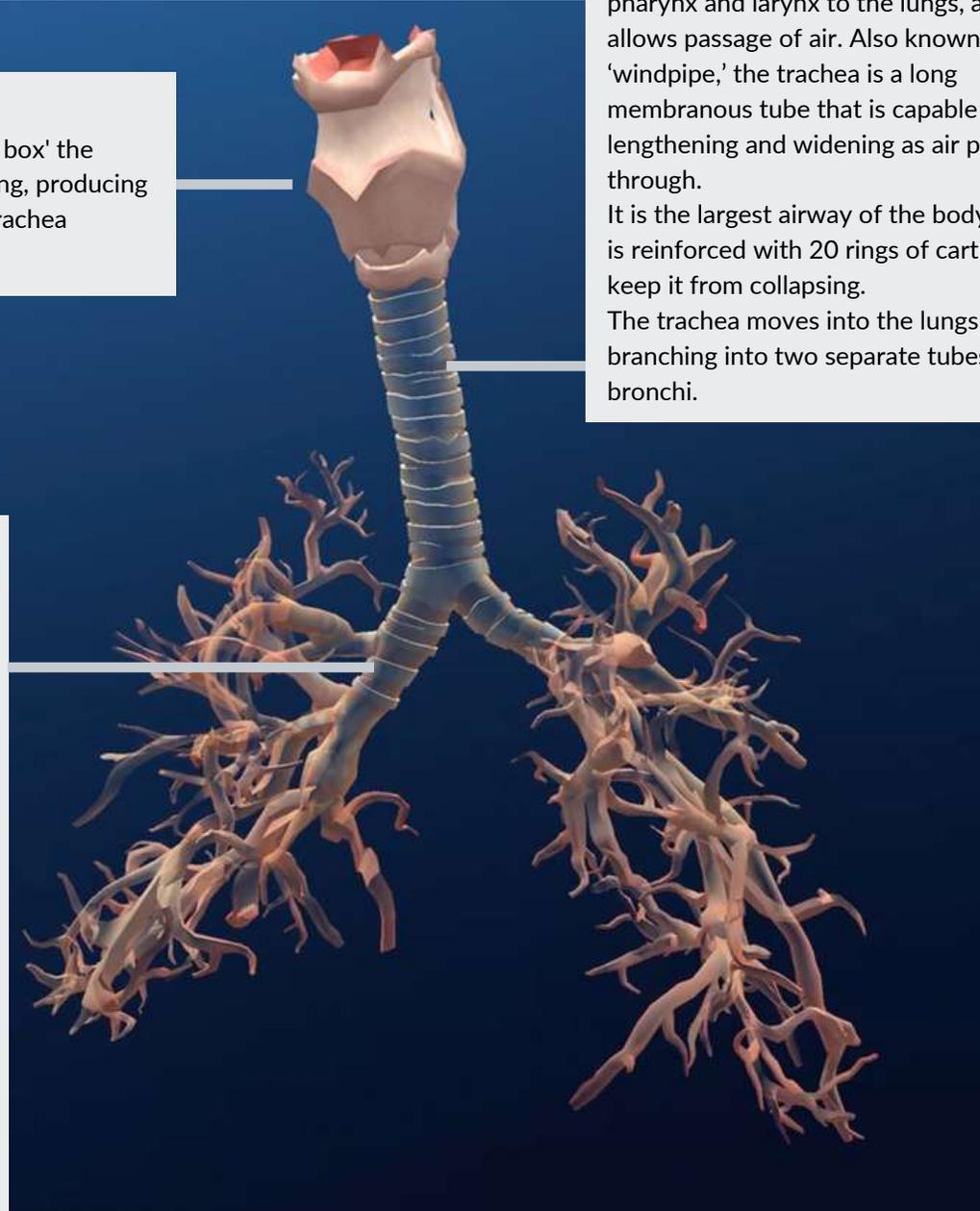
Commonly called the 'voice box' the larynx is involved in breathing, producing sound, and protecting the trachea against food aspiration.

### BRONCHI:

Extensions of the trachea that carry air from the trachea into the lungs. There are two main bronchi that directly originate from the trachea; these main bronchi continue to branch into smaller and smaller bronchi. Each main bronchus supplies air to a single lung. While they are similar in structure to the trachea with cartilage and a mucous membrane, bronchi are also supported with a layer of smooth muscle fibres between the membrane and cartilage.

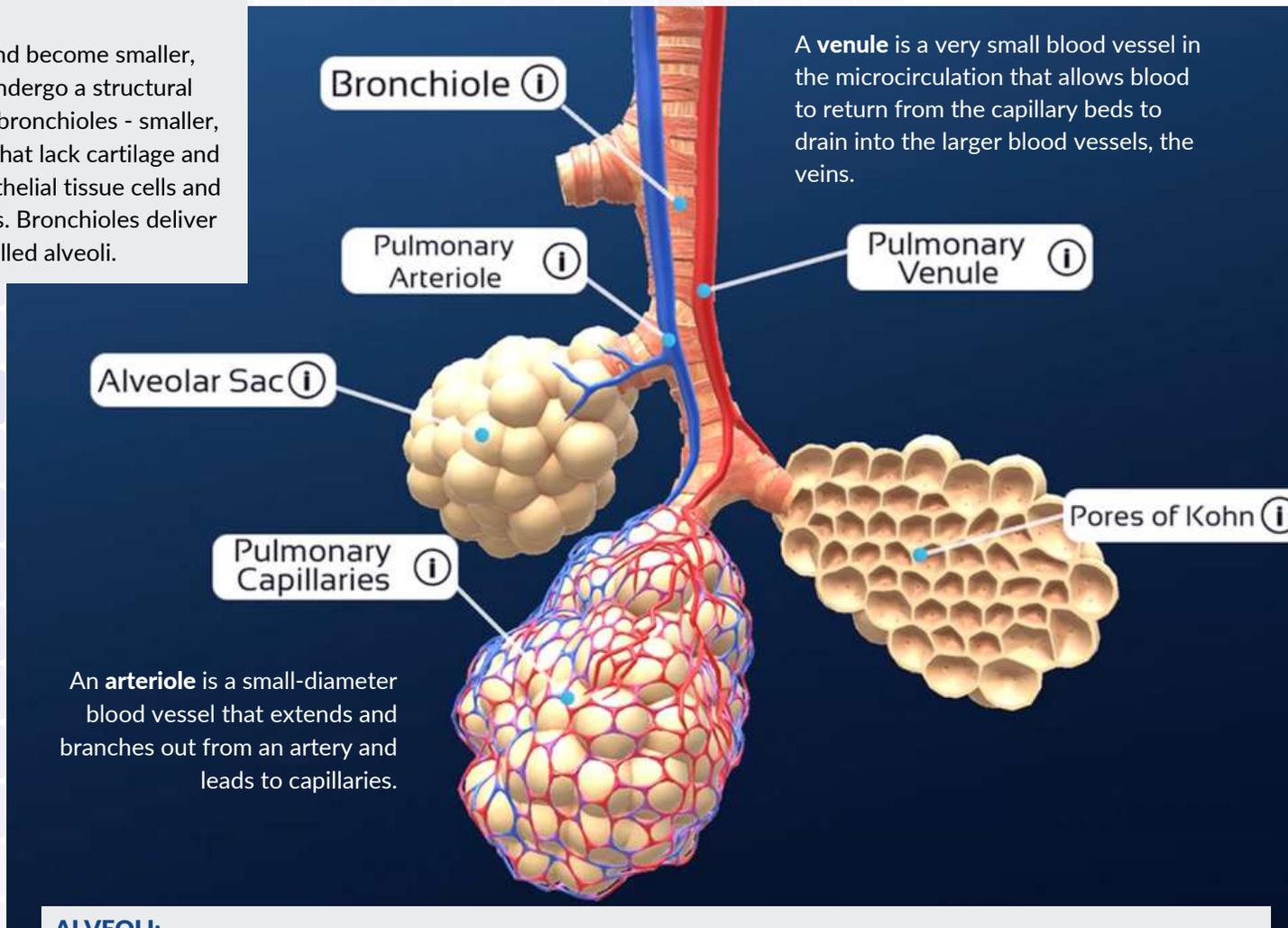
### TRACHEA:

A cartilaginous tube that connects the pharynx and larynx to the lungs, and allows passage of air. Also known as the 'windpipe,' the trachea is a long membranous tube that is capable of lengthening and widening as air passes through. It is the largest airway of the body, and it is reinforced with 20 rings of cartilage to keep it from collapsing. The trachea moves into the lungs by branching into two separate tubes called bronchi.



### BRONCHIOLE:

As they branch off and become smaller, bronchi eventually undergo a structural change and become bronchioles - smaller, thin-walled airways that lack cartilage and are composed of epithelial tissue cells and smooth muscle fibres. Bronchioles deliver air to little air sacs called alveoli.



A **venule** is a very small blood vessel in the microcirculation that allows blood to return from the capillary beds to drain into the larger blood vessels, the veins.

An **arteriole** is a small-diameter blood vessel that extends and branches out from an artery and leads to capillaries.

### ALVEOLI:

Terminal air sacs that are located at the end of the respiratory tree (alveolus/alveolar sac singular). Upon inhalation, the alveoli fill with air; upon exhalation, air leaves the alveoli. They are just one cell thick and lined with a fluid called a surfactant to maintain shape and surface tension, the wall of each alveolus is the site of gas exchange via diffusion. The primary function of an alveolus is to exchange oxygen and carbon dioxide to and from the bloodstream. The anatomy of an alveolus consists of an epithelial layer lining the alveolar membrane. Alveoli are further surrounded by blood vessels known as capillaries to allow oxygen and carbon dioxide to move freely between the respiratory and circulatory systems. The endothelial cells of the capillary often fuse with the epithelial cells of the alveoli to allow for rapid diffusion. Adjacent alveoli can pass air, lining fluid, and cells to each other through microscopic holes in alveolar walls called the pores of Kohn.

## LUNGS:

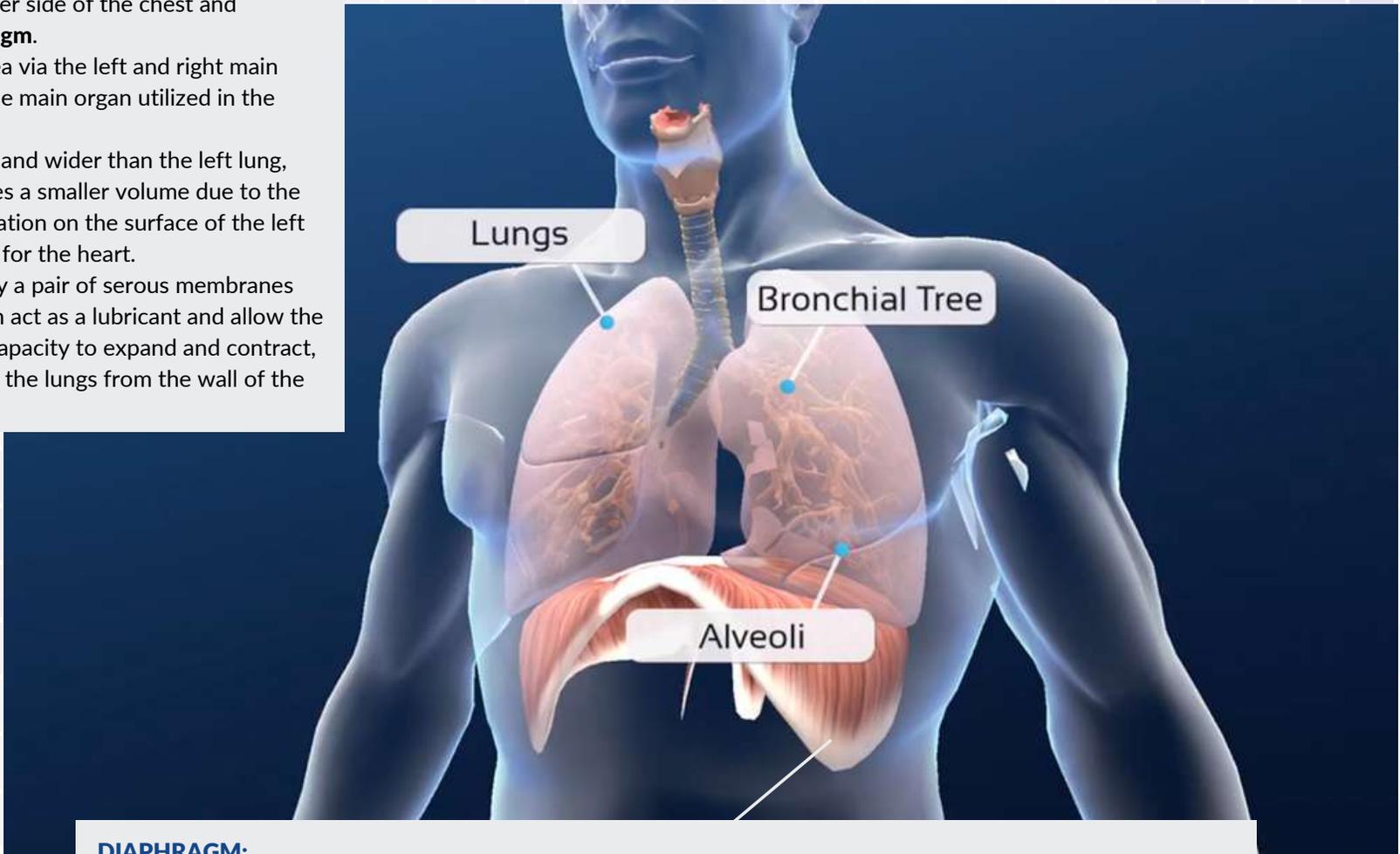
A pair of spongy respiratory organs that expand and fill with air on an inhale, and deflate and empty of air on an exhale.

They are located on either side of the chest and bordered by the **diaphragm**.

Connected to the trachea via the left and right main **bronchi**, the lungs are the main organ utilized in the respiratory system.

The right lung is shorter and wider than the left lung, and the left lung occupies a smaller volume due to the cardiac notch, an indentation on the surface of the left lung which allows space for the heart.

The lungs are covered by a pair of serous membranes known as **pleurae**, which act as a lubricant and allow the lungs to optimize their capacity to expand and contract, in addition to separating the lungs from the wall of the thoracic cavity.



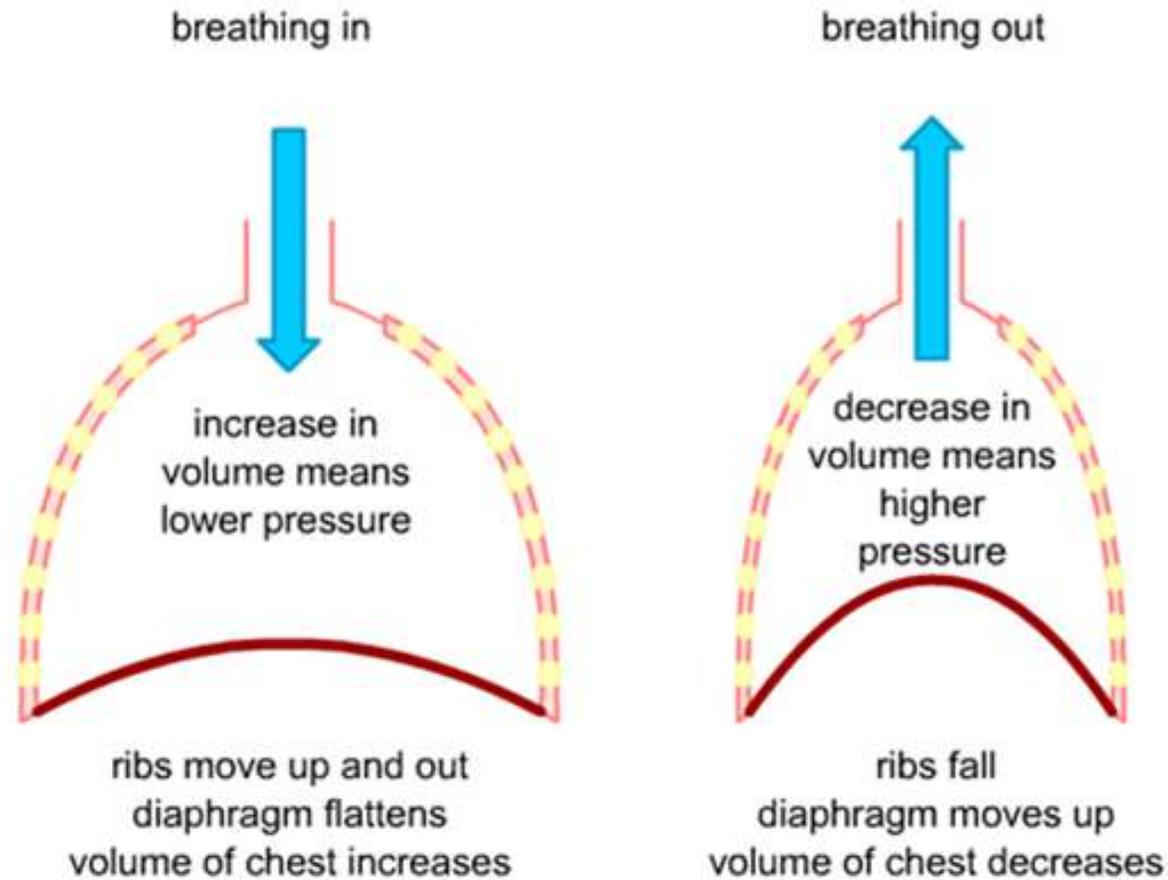
## DIAPHRAGM:

Located below the lungs, the diaphragm is the major muscle of respiration and separates the abdomen from the chest. During inhalation, the diaphragm contracts and flattens which creates negative pressure, similar to a vacuum, and pulls air into the lungs. During exhalation, the diaphragm relaxes and pushes air out of the lungs.

The diaphragm has three large openings to allow important structures to pass through:

The **esophageal opening** for the esophagus and the vagus nerve, both of which are important for the digestive system; the **aortic opening** for the aorta and the **thoracic duct** for the circulatory and lymphatic systems, respectively; and the caval opening for the inferior vena cava in the circulatory system.

# Most mammals breath using negative pressure breathing



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- Gasses move from **high** pressure areas to low pressure areas

## Trachea

- As air travels down the **trachea**, it moves into each lung, through the divided branches of the **bronchial tube**

## Bronchial tube

- Within the lungs, it branches further into **bronchioles**

## Bronchioles

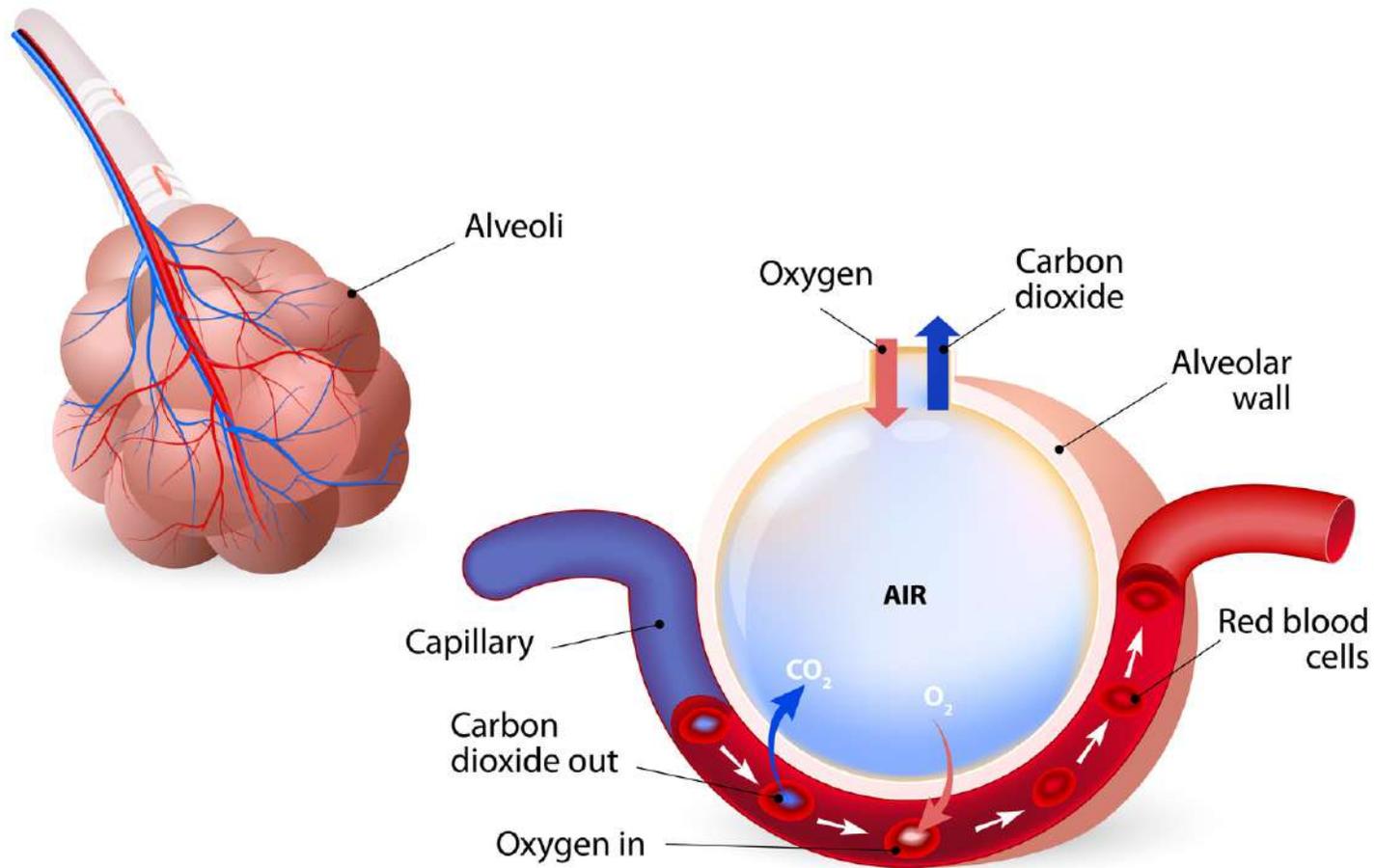
- Tiny, **thin** walled sacs are on the end of the bronchioles called **alveoli**

## Alveoli

- Site of **oxygen exchange**

Picture the branches of trees, but with thousands of little balloons on them instead of leaves!

# Gas Exchange in the Lungs



## CAPILLARIES:

Tiny blood vessels that connect veins and arteries throughout the body, and are just one cell wall thick. This means that various substances like gases, nutrients, waste products, hormones etc. can pass across the cell wall of capillaries; it is through the capillaries that oxygen, nutrients, and other substances are exchanged between the blood and tissues. They cover alveoli to allow oxygen and carbon dioxide to move freely between the respiratory and circulatory systems. The majority of blood vessels found in the body are capillaries. The anatomy of a capillary consists of a thin layer of endothelial cells (tunica intima) and is surrounded by a protein matrix called the basal lamina.

## How Does the Respiratory System Help Maintain Homeostasis?

**Homeostasis** is maintained by the respiratory system in two ways: **gas exchange** and **regulation of blood pH**.

Gas exchange is performed by the lungs by eliminating carbon dioxide, a waste product given off by cellular respiration. As carbon dioxide exits the body, oxygen needed for cellular respiration enters the body through the lungs. Adenosine triphosphate (ATP), produced by cellular respiration, provides the energy for the body to perform many functions, including nerve conduction and muscle contraction. Lack of oxygen affects brain function, sense of judgment, and a host of other problems.

### Gas Exchange

Gas exchange in the lungs and in the alveoli is between the alveolar air and the blood in the pulmonary capillaries. This exchange is a result of increased concentration of CO<sub>2</sub>, and a decrease of oxygen. This process of exchange is done through diffusion.

### External Respiration

External respiration is the exchange of gas between the air in the alveoli and the blood within the pulmonary capillaries. A normal rate of respiration is 12-25 breaths per minute. In external respiration, gases diffuse in either direction across the walls of the alveoli. Oxygen diffuses from the air into the blood and carbon dioxide diffuses out of the blood into the air. Most of the carbon dioxide is carried to the lungs in plasma as bicarbonate ions (HCO<sub>3</sub><sup>-</sup>). When blood enters the pulmonary capillaries, the bicarbonate ions and hydrogen ions are converted to carbonic acid (H<sub>2</sub>CO<sub>3</sub>) and then back into carbon dioxide (CO<sub>2</sub>) and water. This chemical reaction also uses up hydrogen ions. The removal of these ions gives the blood a more neutral pH, allowing hemoglobin to bind up more oxygen. De-oxygenated blood "blue blood" coming from the pulmonary arteries, generally has an oxygen partial pressure (pp) of 40 mmHg and CO<sub>2</sub> pp of 45 mmHg. Oxygenated blood leaving the lungs via the pulmonary veins has an O<sub>2</sub> pp of 100 mmHg and CO<sub>2</sub> pp of 40 mmHg.

### Internal Respiration

Internal respiration is the exchanging of gases at the cellular level.

# Respiratory Homeostasis

Chemoreceptors

Blood pH

$P_aO_2$

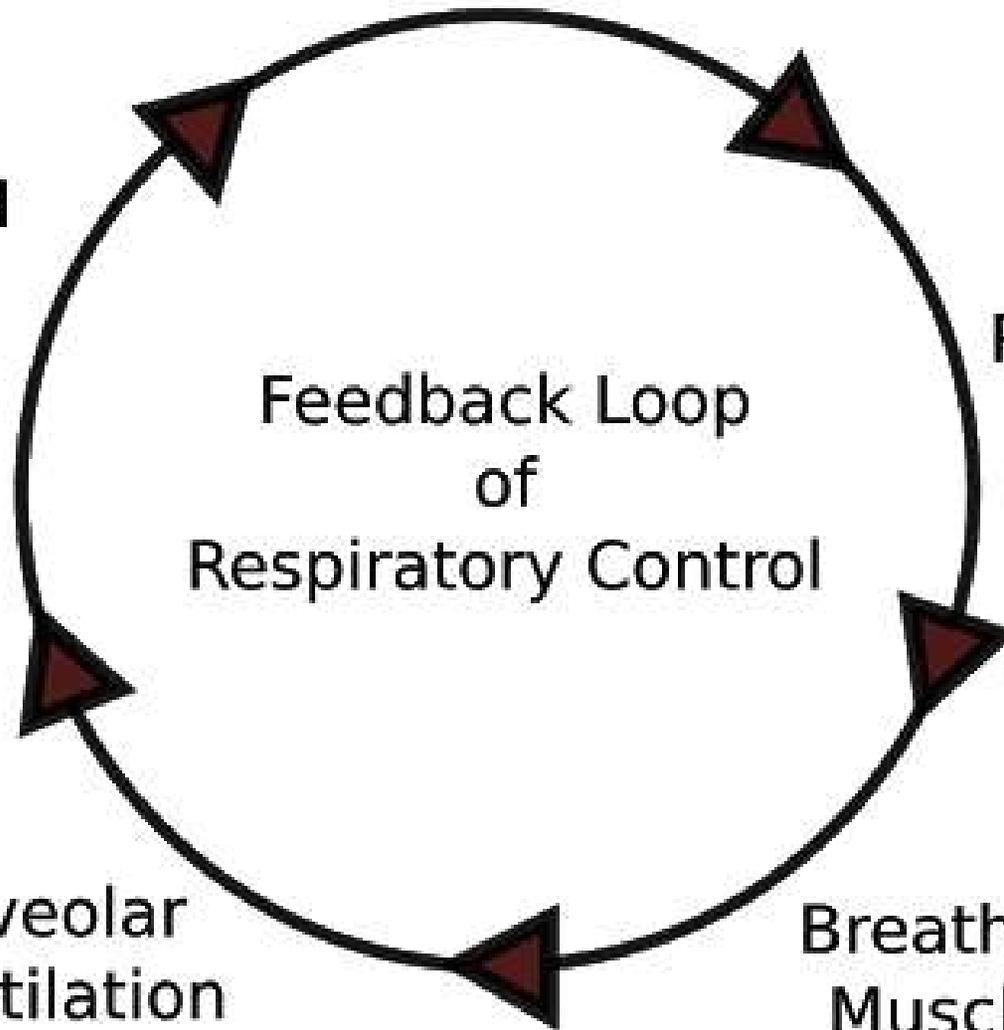
$P_aCO_2$

Brainstem  
Respiratory  
Centers

Feedback Loop  
of  
Respiratory Control

Alveolar  
Ventilation  
Rate

Breathing  
Muscles

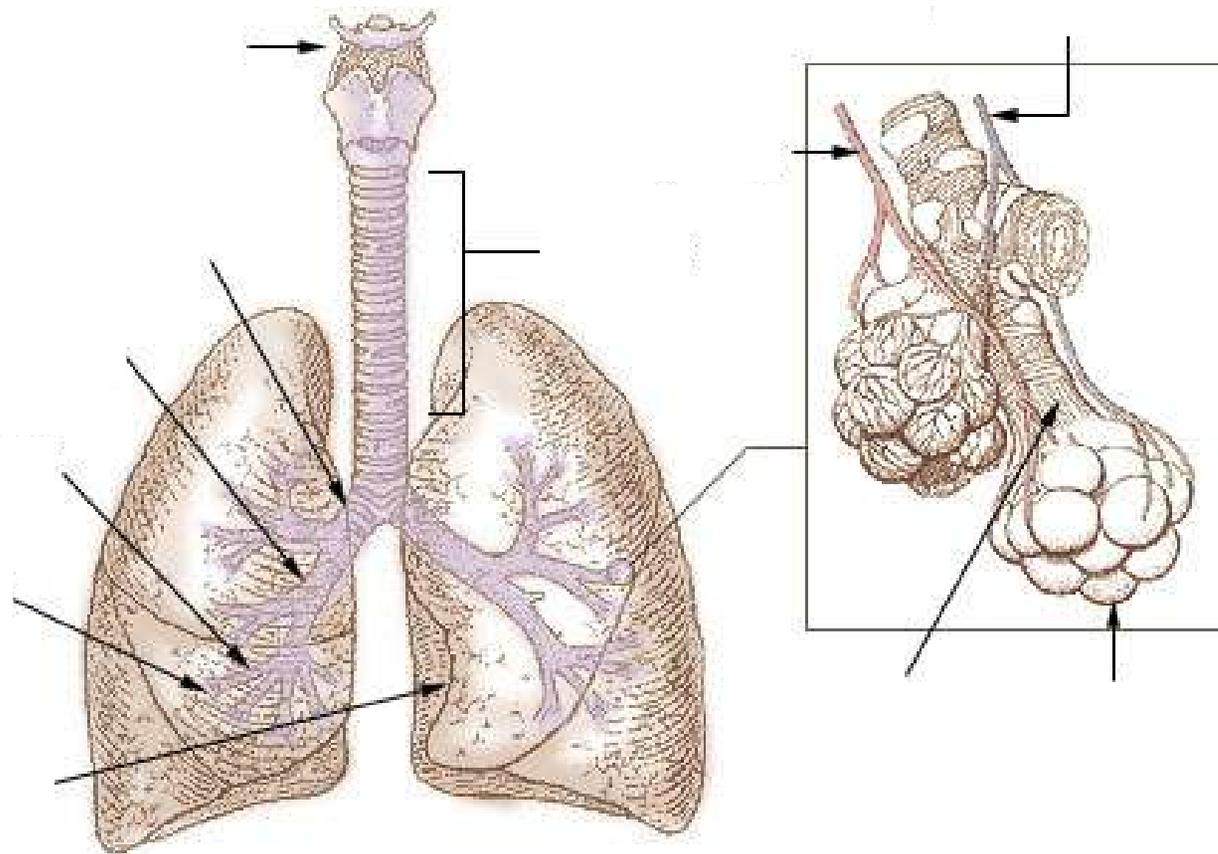


# Review Break

- What is one way the respiratory system maintains homeostasis within the body?
- What is one way the respiratory system interacts with other body systems?
- What are the main structures air moves through within the respiratory system?

# QUIZ!

Label the respiratory system diagram below.



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