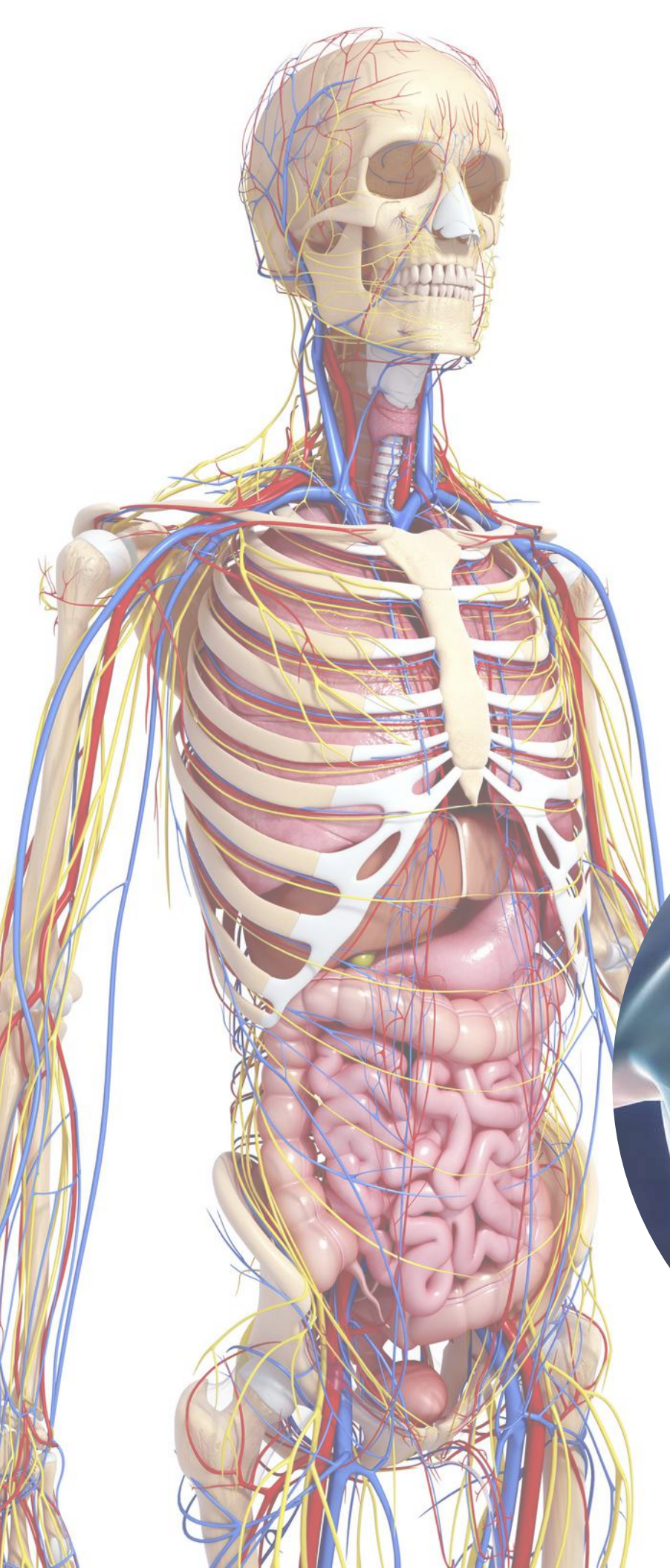
Respiratory System Lesson Plan

Grade 12



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The following unit plan was created in accordance with the Canadian Council on Animal Care's recommendations to replace procedures involving the use of animals in teaching, testing and research with suitable non-animal methods.

The Three Rs principle of Replacement states, if you can meet your scientific or educational goals without the use of animals, it is your ethical obligation to use non-animal methods. Grade 12 anatomy content is often taught using fetal pigs - here we offer an effective and humane alternative.

This is in alignment with the public's concern for animal welfare and a cultural respect for animals passed down from the Aboriginal perspectives of the First Peoples.

Elisabeth Ormandy created this unit plan and series of lesson plans for your use in teaching life science content to Grades 12 based on the BC Science Curriculum.

These Humane Science Education materials were developed to provide equivalent or greater standards in education for Canadian youth without the use of animals.

Curriculum Alignment

This lesson plan can be used to create classes for Grades 12 based on the BC Science Curriculum. Specific **Big Ideas** covered in this lesson plan include:

Grade 12 - Organ systems have complex interrelationships to maintain homeostasis.
ORGAN SYSTEMS:

- Structure and function
- Structural and functional interdependence
- Maintenance of homeostasis

We have recommended specific virtual anatomy tools to use to get the most out of the lesson plan. You'll find links to those on pages 5 & 6.

Lesson Plan Overview

Subject: Science

Unit Overview: Anatomy and Physiology

Unit Duration: ~90 minutes

Grade: 12

Big Idea: Organ systems have complex interrelationships to maintain homeostasis

Curricular Competencies

- *Analyze cause-and-effect relationships*
- *Construct, analyze, and interpret graphs, models, and/or diagrams*
- *Consider the changes in knowledge over time as tools and technologies have developed*

Content

- By the end of this lesson, students are expected to demonstrate understanding of the following:
  - *Human respiratory system:*
    - *Structure and function*
    - *Structural and functional interdependence*
    - *Maintenance of homeostasis*

Recommended Education Tools

Hardware & Workbooks:

This inventory is for a regular in-person class - use x1 iPad/tablet per student for responsible physical distancing. If teaching online, teachers can screen share their iPad/tablet or desktop.

- 6 (or more) iPads or other tablets
- 6 (or more) 3D Anatomica workbooks

Recommended Software:

- 3D Anatomica: https://3danatomica.com
- 3D4Medical Complete Anatomy: https://3d4medical.com

Lesson Plan Overview

Topic: Organ systems have complex interrelationships to maintain homeostasis. Homeostasis is maintained through physiological processes.

Content: The human respiratory system: organs, structure and function

Goals	Students will be able to: • 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
Objectives	After this lesson students will state the structure and function of each organ/tissue in the respiratory system and explain how the respiratory system is functionally interdependent with other body systems.
Materials	• 3DAnatomica • 3D4Medical Complete Anatomy • Respiratory System Workbook
Introduction	Using the 3DAnatomica and/or 3D4Medical app(s), the teacher will introduce the topic of respiratory organ structure and function.
Development	Questions to support inquiry-based learning: • What is the advantage of having specialized tissues in the respiratory system? • How does the respiratory system help the body maintain internal balance during exercise? • What are the impacts of external stimulants (e.g. alcohol, caffeine) on the respiratory system? • What lifestyle decisions would you make to improve your respiratory health? • How does the respiratory system respond to infection by a pathogen (e.g. coronavirus)?
Practice	Students will work independently or in pairs to navigate 3DAnatomica and/or 3D4Medical to learn about the structure and function of the respiratory organs.

Lesson Plan Approach

If teaching regular in-person classes:

- Split students into **6 groups**.
- Give each group a **Respiratory System workbook** to refer to, and one (or more) iPad(s) or tablet(s) with the **3D Anatomica app**, and **3D4Medical Complete Anatomy app** loaded and ready to use.
- Your **introduction** should include discussion of the function of the respiratory system, identifying its major components, and the vocabulary you would like students to learn (~ 15 mins). **Define homeostasis**. Have the students follow along using the 3D4Medical Complete Anatomy app.
- Have students **label "Major Structures"** diagram using 3D4 Medical
- **Discuss sequence** of organs and structures that air moves through within the respiratory system. Have students use the 3D Anatomica and 3D4Medical Complete Anatomy app to explore the flow of air in their groups, filling their 3D Anatomica workbook and/or handouts provided. This can be student or teacher led (40-45 mins).
- Explore the "**Structures in Detail**" pages using the 3D4 Medical App. The students can cut away at the structures in the app to locate structures that need to be labeled.
- Ask students to brainstorm **ways the respiratory system interacts with other systems,** and go over the specific examples provided.
- Discuss different ways the respiratory system helps maintain homeostasis using examples provided, then ask students to provide their own examples using what they've learned.
- **Close the class with a 20-minute recap** of what the students have learned, discuss how the parts of the respiratory system work together, and check for understanding. Begin a **conversation on ethics** of animals in science using the questions provided.

If teaching a physically-distanced class:

- Use x1 iPad for each student and proceed as per the directions above.

If teaching online:

- Lead the students through the respiratory system by screen sharing your own iPad/tablet or desktop with the 3D4Medical Complete Anatomy app installed, filling out the tables, and labeling the models as you go.
- Proceed as per the directions above.

Detailed Lesson Content & Teaching Notes

Introduction to the Lesson

Include a First Nations land acknowledgement and ask students to reflect on what respect for animals means to them. Provide an introduction to the human-relevant apps and models that will be used in class. Provide an overview of how to access AiSPI's Respiratory System workbooks if teaching remotely.

Introduction to the Topic

This class will explore the respiratory system at large.
We recommend covering the function of the respiratory system, identifying the major components of the system, and discussing the vocabulary you would like the students to learn early in the lesson.

THE RESPIRATORY SYSTEM AT-A-GLANCE

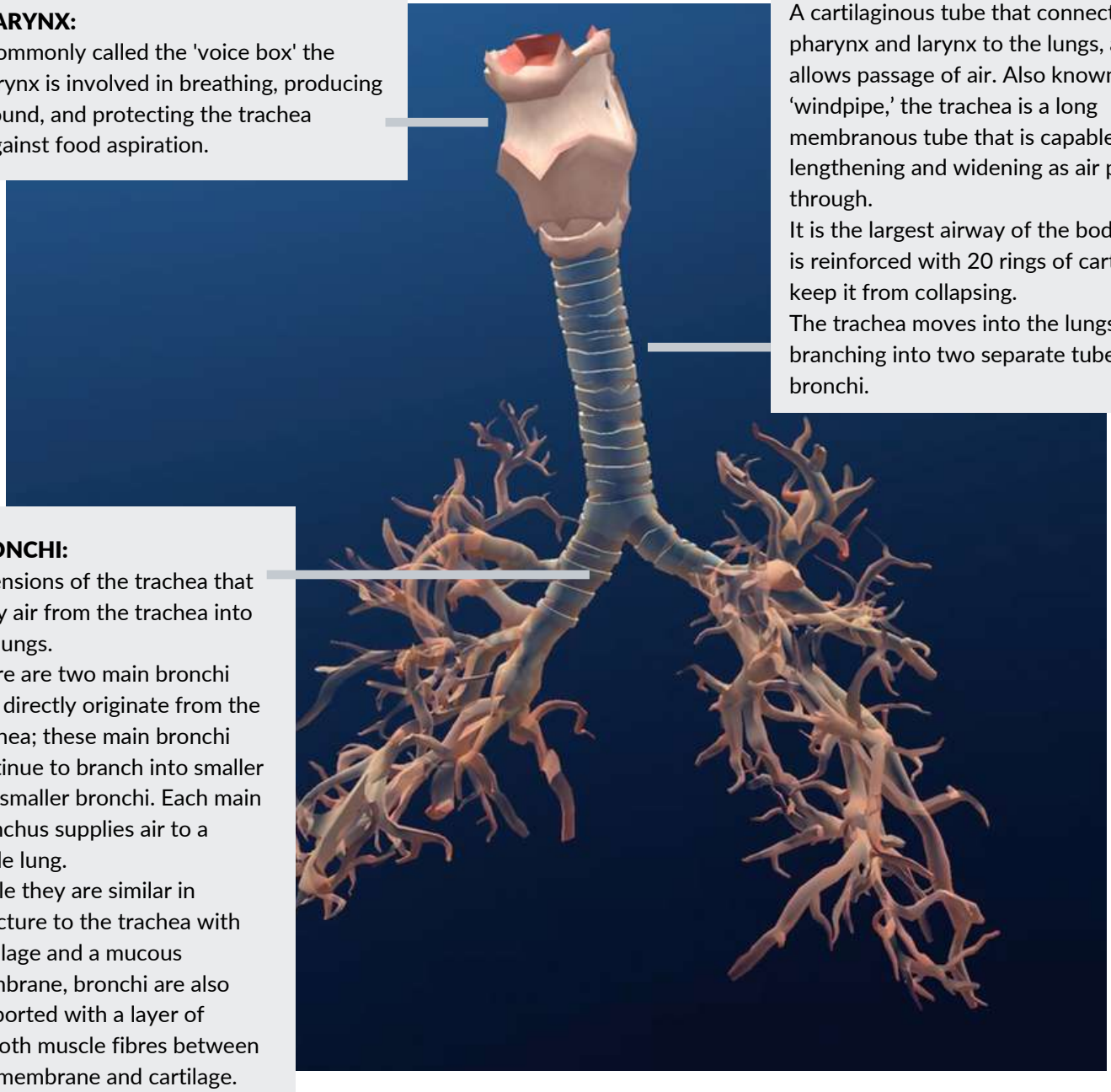
FUNCTION	The main function of the respiratory system is pulmonary respiration - gas exchange within/between the body and the external environment. Secondary functions include voice production, body temperature regulation, acid-base regulation, and olfaction (sense of smell).
COMPONENTS	Trachea, bronchi, bronchioles, alveoli, lungs, diaphragm.
IMPORTANT VOCABULARY	Nasal cavity, mouth, pharynx, larynx, trachea, windpipe, bronchi, bronchus, bronchioles, alveoli, alveolus, lungs, diaphragm, capillaries, pores of Kohn, pleurae, pulmonary respiration, upper respiratory tract, lower respiratory tract.

Components in Detail

Explore the major structures of the respiratory system with the class.

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

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.



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.

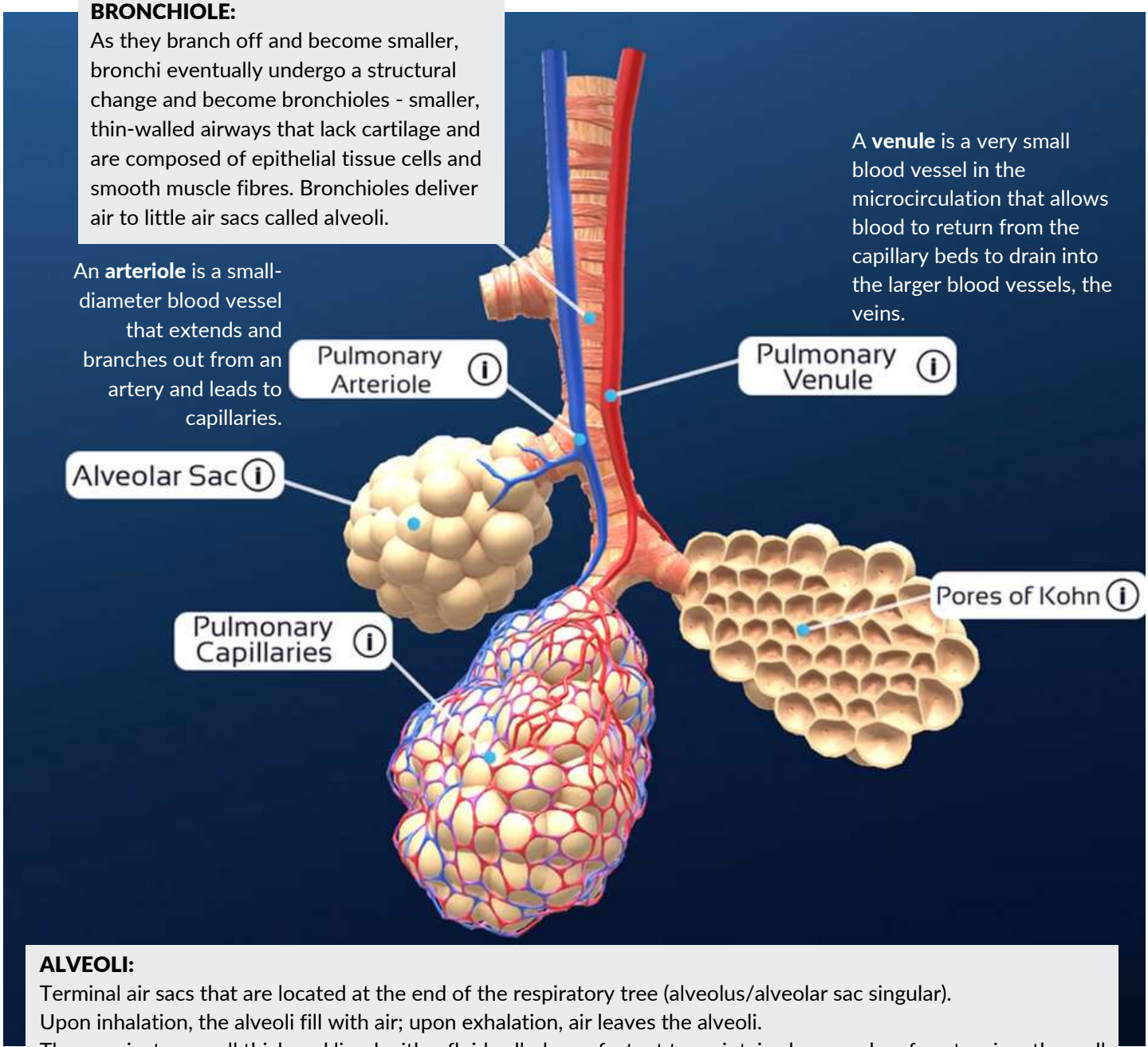
Components in Detail

Explore the major structures of the respiratory system with the class.

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.

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

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.

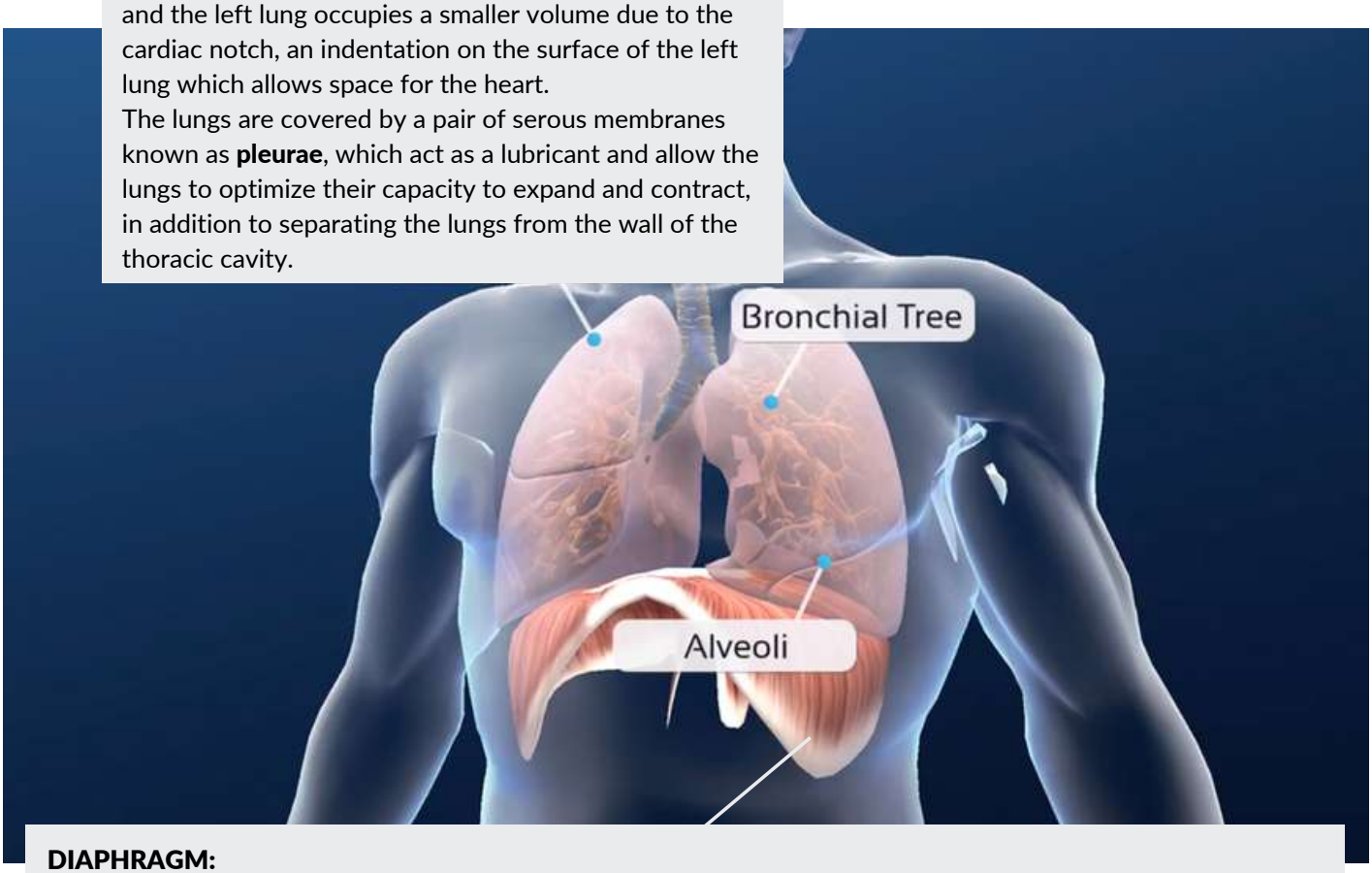


ALVEOLI:
Terminal air sacs that are located at the end of the respiratory tree (alveolus/alveolar sac singular).
Upon inhalation, the alveoli fill with air; upon exhalation, air leaves the alveoli.
They are just one cell thick and lined with a fluid called a surfactant to maintain shape and surface tension, 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.

Components in Detail

Explore the major structures of the respiratory system with the class.

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.



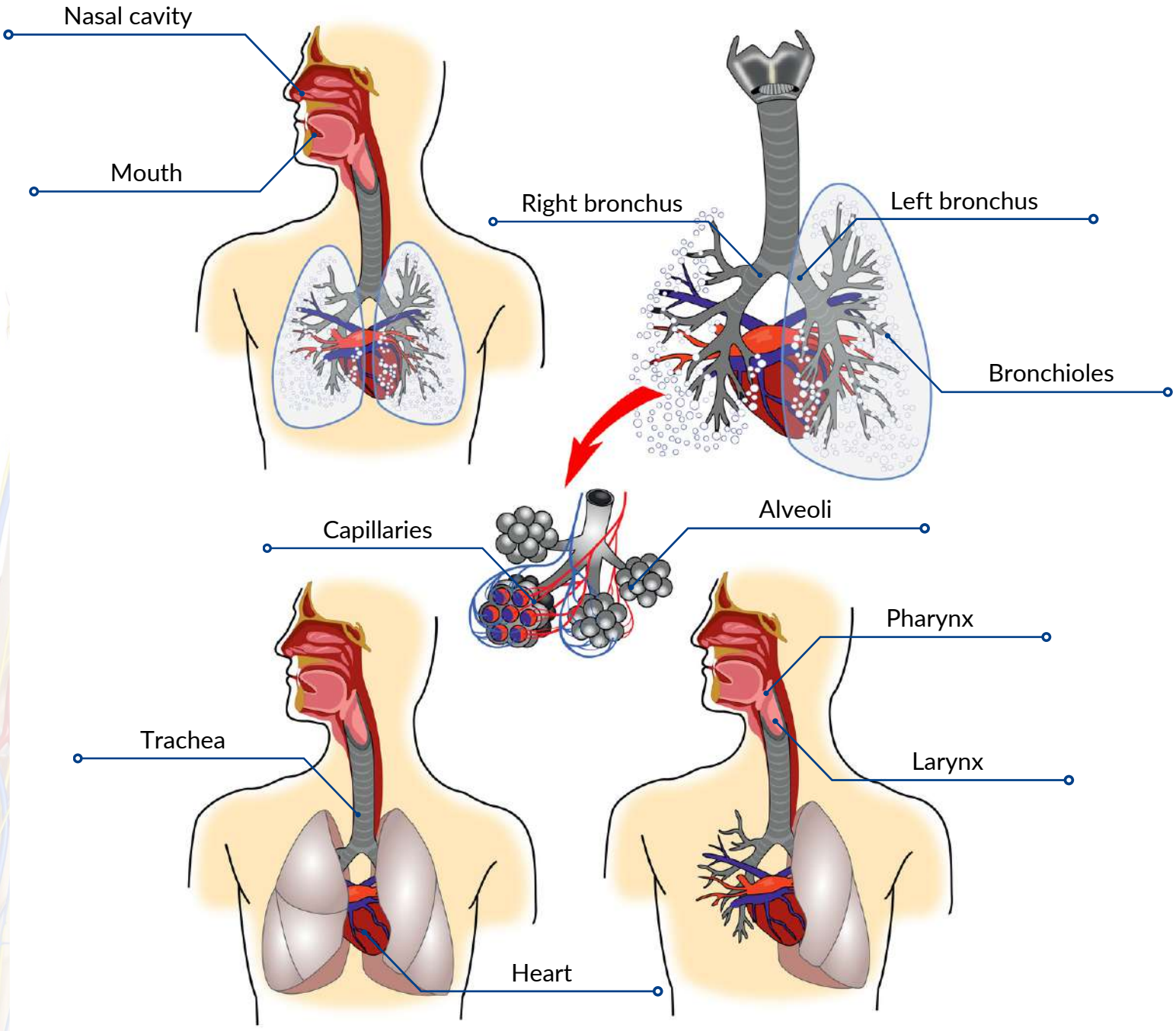
DIAPHRAGM:
Located below the lungs, the diaphragm is the major muscle of respiration and separates the abdomen from the chest. During inhalation, the diaphragm contracts and flattens which creates negative pressure, similar to a vacuum, and pulls air into the lungs. During exhalation, the diaphragm relaxes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

Discuss the passage of air through the respiratory system at large; the **3D4Medical Complete Anatomy** app is useful here for identifying and exploring the system in detail.

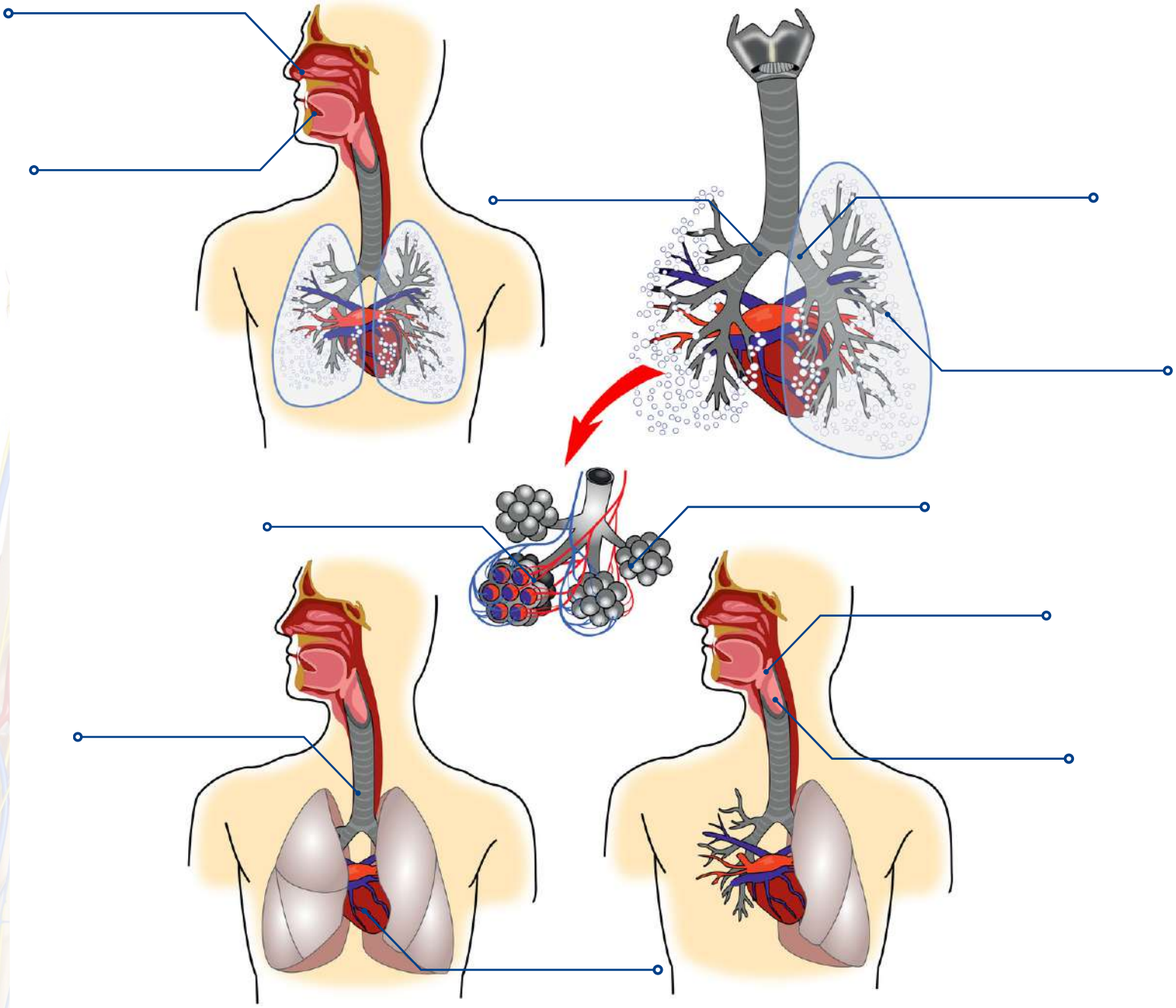
The respiratory system can be divided into two tracts:
the upper respiratory tract and the lower respiratory tract.

Upper respiratory tract	The journey through the human respiratory system begins with air entering the body through the **nasal cavity** and/or the **mouth**. • The nasal cavity and the mouth meet at a passageway in the throat called the **pharynx**. • The pharynx splits into two passageways - one for food and one for air. • At the top of the airway is the **larynx**, also known as the 'voice box.' • The airway continues as the **trachea,** also known as the 'windpipe.'
Lower respiratory tract	The trachea divides into left and right airways called **bronchi**, which extend into the left and right lungs, respectively. • As they move into the **lungs**, the bronchi in turn branch into smaller and smaller bronchi until they undergo a structural change, at which point they become small airways called **bronchioles**. • Each bronchiole eventually terminates at one of the few hundred million tiny air sacs known as **alveoli**. **Gaseous exchange** takes place in the alveoli: oxygen from the inhaled air diffuses through the alveolar walls into the blood in the surrounding **capillaries**, and carbon dioxide moves from the blood into the air inside the alveoli. • This exchange of gases therefore oxygenates blood, which is then later circulated throughout the body. • Carbon dioxide is then removed from the body as a waste product through exhalation from the lungs.

Respiratory System Anatomy (Teacher Copy)



Respiratory System Anatomy (Student Activity)



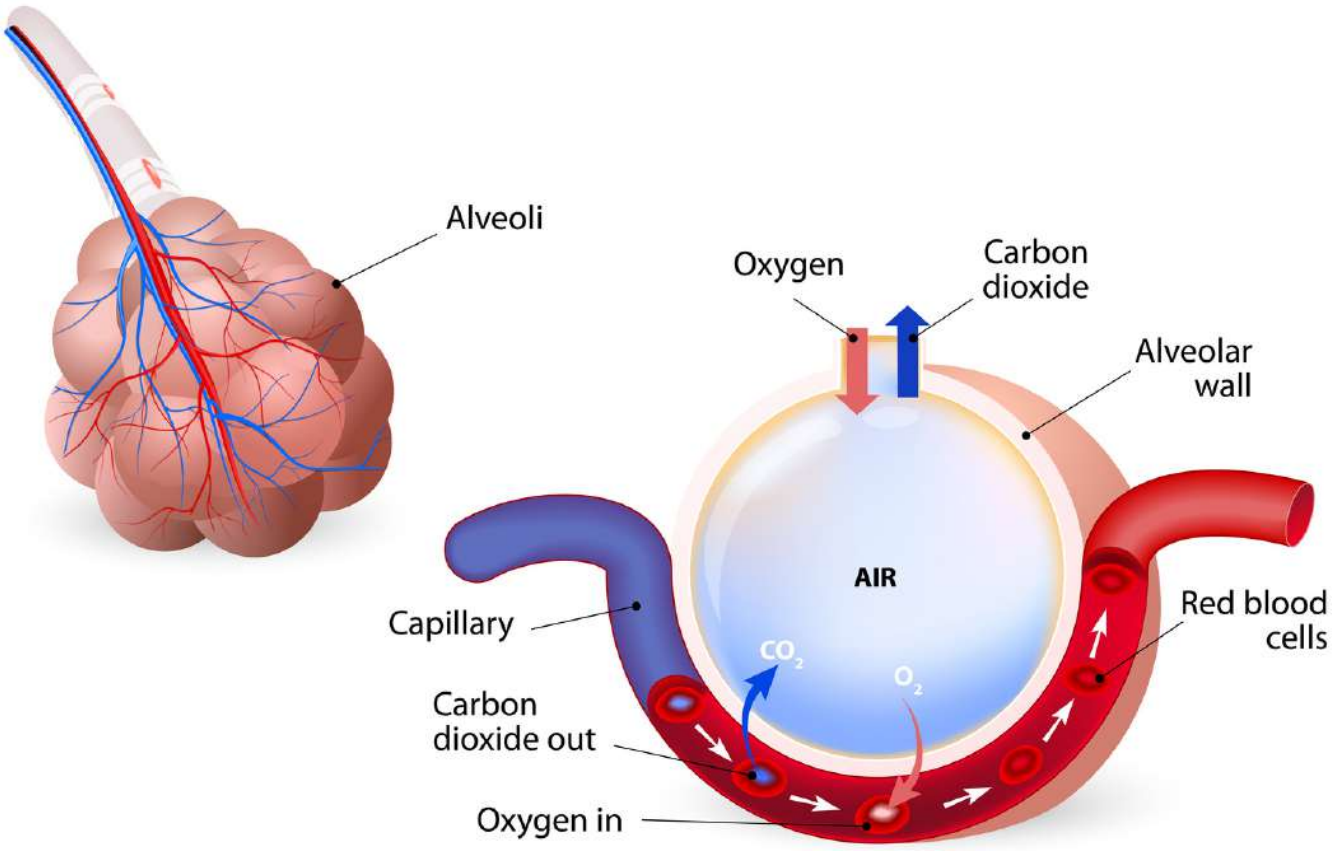
How Do the Respiratory & Circulatory Systems Work Together?

Ask students how they think the two organ systems work together – specific questions can include:

1. How does oxygen get into the bloodstream?

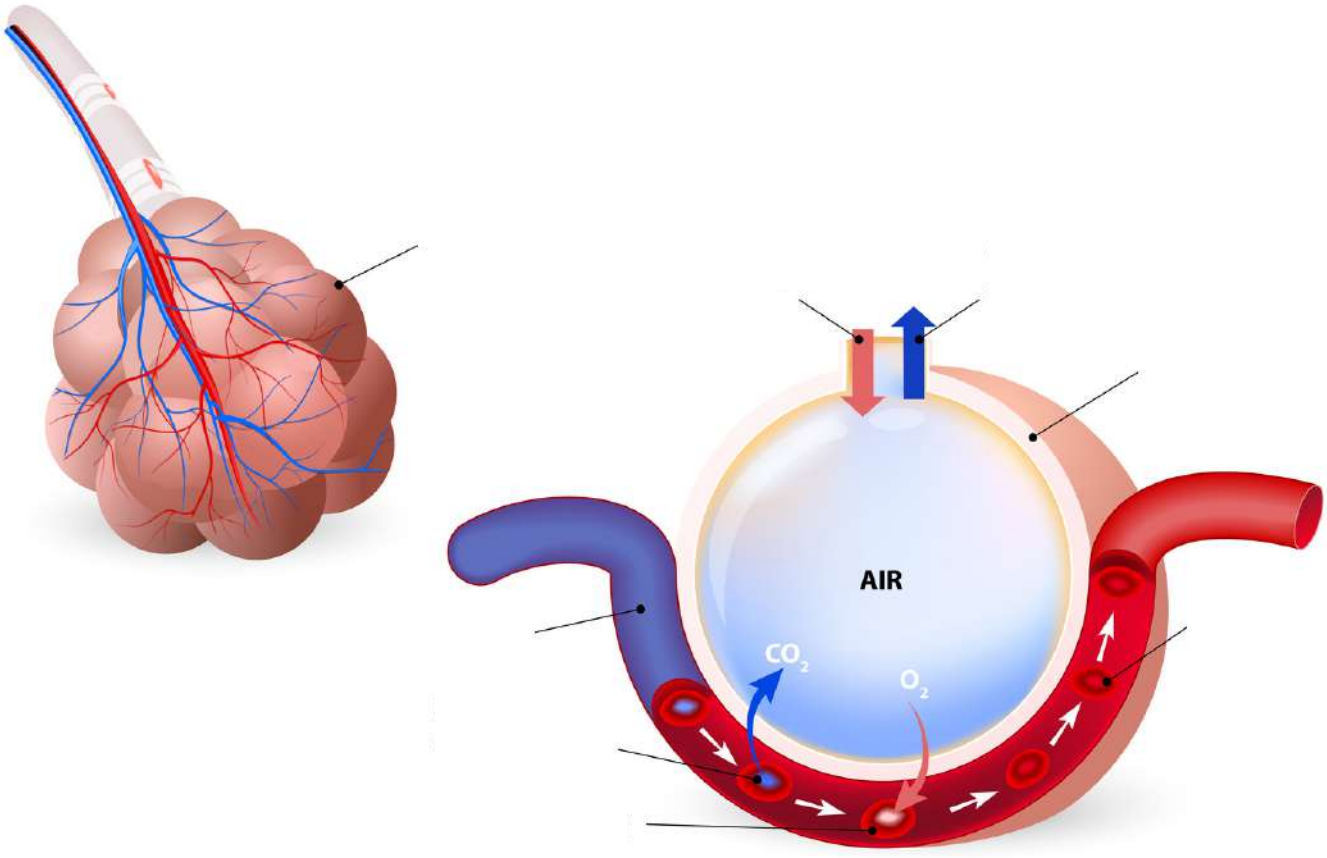
2. How do the respiratory and circulatory systems interact with each other?

Gas exchange in the alveoli of the lungs – the respiratory and circulatory systems are linked via the capillary network that surrounds the alveoli.



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.

Gas Exchange (student activity)



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 CO2, and a decrease of oxygen. This process of exchange is done through diffusion.

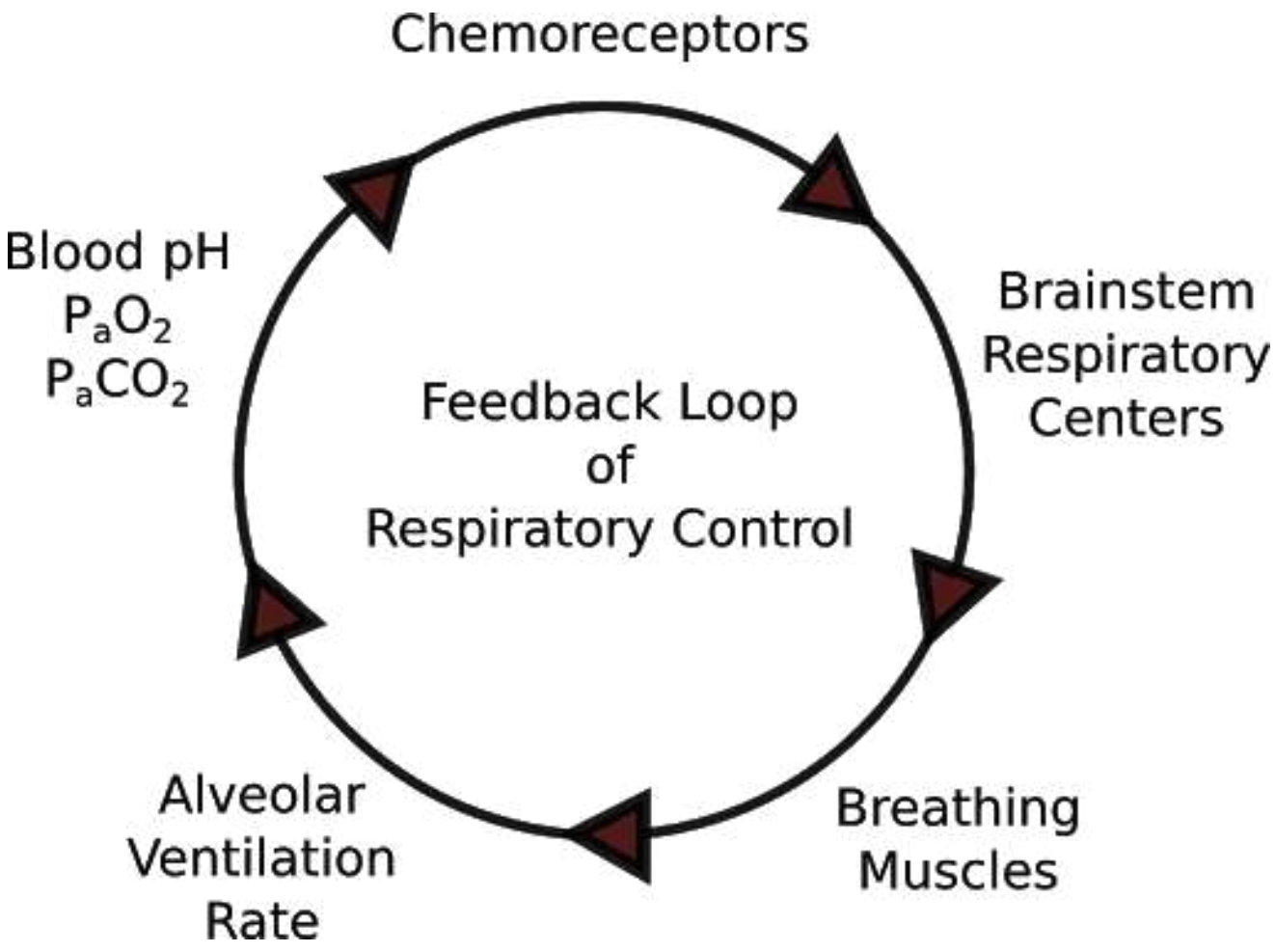
External Respiration

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 (HCO3-). When blood enters the pulmonary capillaries, the bicarbonate ions and hydrogen ions are converted to carbonic acid (H2CO3) and then back into carbon dioxide (CO2) 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 CO2 pp of 45 mmHg. Oxygenated blood leaving the lungs via the pulmonary veins has an O2 pp of 100 mmHg and CO2 pp of 40 mmHg.

Internal Respiration

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

Respiratory Homeostasis



Student Activity

- Ask students to bring their attention to their breathing without changing anything yet.
- Ask them to record how many breaths they take in 30 seconds.
- Now ask them to hold their breath for 15 seconds or longer.
- Ask them to record the following:

1. How many breaths they take in the 30 seconds after they start breathing again
2. How it felt to go without breathing

They should have recorded a slightly faster breathing rate after holding their breath - this is because when holding the breath the blood in the body becomes oxygen-deficient. The respiratory system, thanks to being triggered by various receptors responds by increasing the breathing rate to get the oxygen levels in the blood back to an optimal level.

Common Respiratory Diseases

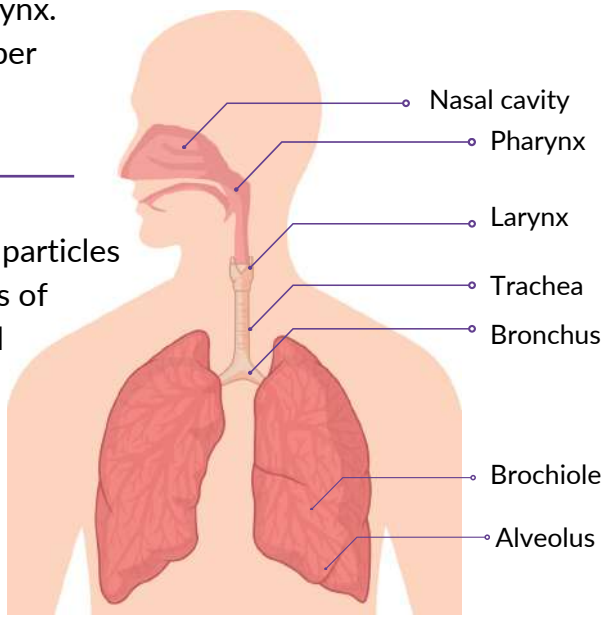
Rhinitis and laryngitis:
Large particles are deposited into the nose, pharynx and larynx. More soluble gases (e.g. sulfur dioxide) are absorbed by upper respiratory tract mucous membranes causing swelling and overproduction of mucus.

Tracheitis, bronchitis, bronchiolitis:
Large particles are deposited and cleared by the cilia. Small particles and fine fibres are deposited in bronchioles and bifurcations of alveolar ducts. Less soluble gases penetrate to deeper small airways.

Asthma and chronic obstructive pulmonary disease
Allergens and irritants are deposited in large airways by turbulent flow, causing inflammatory changes.

Cancer
Carcinogens (asbestos, polycyclic aromatic hydrocarbons) come into contact with bronchial epithelial cells causing gene mutations.

Interstitial disease
Small particles and fibres are deposited in terminal bronchioles, alveolar ducts and alveoli. Penetration in to the interstitium results in fibrosis and formation of granulomas.



Respiratory diseases affect respiratory homeostasis by reducing the amount of air that can flow through respiratory passages. As a result breathing becomes laboured - breath rate increases to compensate for the reduced amount of oxygen taken in with each breath. In many cases drugs can be given to help reduce inflammation and restore natural air flow (for example, when people with asthma are given medical inhalers). However, in the worst cases there is chronic inflammation so patients are given pure oxygen to breathe.

Closing Check-In and Discussion

During the check closing in:

Recap with the students the path air moves through within the respiratory system. Go over ways the respiratory system interacts with other body systems, as well as how it helps maintain homeostasis. Ask the following questions:

- **How might virtual dissections and models compare with using real specimens?**
- **Were you able to successfully learn the structure and function of individual parts of the respiratory system?**

Closing - Discussion on Ethics

The knowledge to create these accurate virtual models of the respiratory system had to initially come from real humans and or animals. However, now that we have such a plentiful resources for accurate models of these structures, as well as the ability to perform dissections virtually, do you think we need to continue using animals? Why or why not?

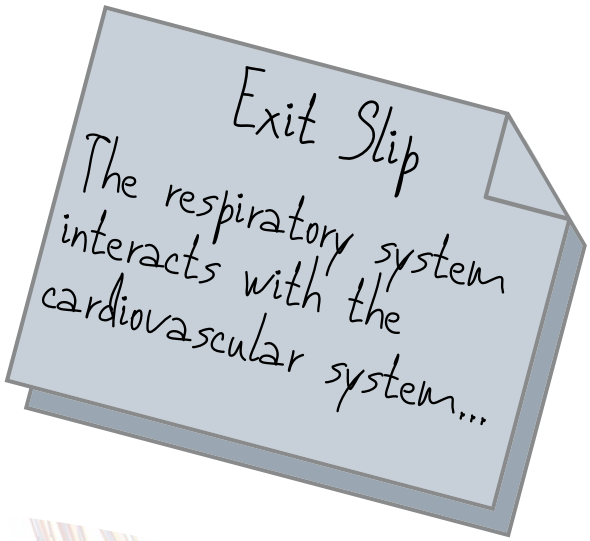
Think

Ask the students to think about where they stand on the subject of animal dissections and the use of animals in science. They don't need to answer right away, rather, this is to get them to start forming their own ethical opinions.

Formative Assessment

The formative assessment can be in the form of an exit slip. This involves asking each student at the end of the class to answer 2-3 questions on a sheet of paper and hand it in, with their names on it, to ensure understanding of the main concepts covered. Examples of questions to include:

- **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?**



Thank you for choosing these materials to support your science adventures!

These Humane Science Education materials were developed by **Elisabeth Ormandy** for the Canadian Society for Humane Science (2015-2022) working to achieve better science without animals. By choosing these unit plans, you have joined a growing family of Humane Science Educators!

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