Breathe Easy! A Lesson in Respiratory Function

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| **Major Section** | **Content** |
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| Lesson Overview | Overall Purpose* The purpose of this lesson is to help students gain knowledge of the respiratory system. Students will use a variety of active learning strategies to explore anatomical structures and to understand the process of breathing. Students will work in groups to analyze variation in respiratory functions caused by obstructive lung disorders.

Estimated Timeframe* This project will be conducted over a two-week period. It includes one lecture time of one hour to be conducted as an interactive REACT lesson after students have completed their lab assignments. Lab activities will be conducted during two lab periods (2 hours each).
* The instructor will provide feedback to students and will assess their progress. Students will submit a lab report. Groups will present their findings to the class. Students will integrate lab findings with lecture and research information.

Courses for Implementation* Anatomy & Physiology II
* Pathophysiology
* Intro to Respiratory Care
* Practical Nursing
* Medical Assistant

Key Terms* Respiratory tract
* Alveolar cells
* Pressure gradients
* Thoracic cage
* Boyle’s law
* Respiratory volumes and capacities
* FEV/FVC
* Blood pH
* Bronchial tree
* Restrictive and obstructive disorders
* Spirometry

Standards/Skills AddressedAcademic Concepts* Describe respiratory anatomy and lung function.
* Describe how the movement of the diaphragm drives the movement of air in and out of the lungs.
* Calculate and graph respiratory volumes and capacities.

Technical Concepts* Identify the histological structure of the respiratory tract.
* Diagnostic procedures using a spirometer

Employability Concepts* Group collaboration
* Written and oral communication
* Problem solving strategies
* Organizational skills

Industry Standards Addressed* N/A

Learner Outcomes/Student Learning Objectives* Relate the function of any portion of the respiratory tract to its gross and microscopic anatomy.
* Explain how pressure gradients account for flow of air in and out of the lungs, and how those gradients are produced.
* Measure respiratory volumes and capacities using a spirometer.
* Analyze spirometry values of obstructive lung disorders.
* Explore different career pathways in pulmonary care.
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| Equipment/Materials | Materials/Equipment/Texts* Histological slides of respiratory tract (Basic Medical Histology Slide Set, Item # 311998 Carolina Biological)
* Compound microscope
* Colored pencils
* Spirometer (Portable Dry Spirometer, Item # 692670 Carolina Biological)
* Disposable mouthpiece (Pack of 100, Item # 692671 Carolina Biological)
* Graph paper
* Bell jar model (Lung Function Model, Item # 692636 Carolina Biological)

Safety Precautions* Do not participate in the spirometry test if lung disorders have been diagnosed.
* Replace the disposable mouthpiece after each use.
* Bell jar model warning: CHOKING HAZARD – Children under 8 years can choke or suffocate on uninflated or broken balloons.

Cleanup Instructions* Keep spirometer clean and sanitized between uses.
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| Discussion | Industry/Real-world Scenario* Pulmonary medicine is a branch of internal medicine that deals with the diagnosis, treatment, and prevention of respiratory disorders. Some of these disorders fall under different categories such as restriction and obstruction of the lungs. Pulmonary clinics provide services to patients with respiratory disorders. Services include patient education, diagnosis, treatment, and patient care. Patient care is provided by teams of health care professionals who are committed to patient-centered care utilizing the latest advances in medical information and technology.
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| Instructional Strategies | Proposed Teaching Strategies* Students will work in groups and will assume different roles performed by professionals at a pulmonary clinic.
* Students will learn about different career paths in respiratory care.
* Students will practice time management in fulfilling lesson activities.

Bloom’s* Solve, illustrate, calculate, use, interpret, relate, apply, explain, interpret, measure, describe, compare, differentiate, demonstrate

REACT* **Relate**—You are working in a respiratory therapy clinic. Your task is to analyze three patients with obstructive and/or restrictive disorders. You must educate your patients regarding their respiratory disorders and explain the structural damage in their lungs and how their lung function tests will vary with their diseases. Conduct the following activities to learn respiratory concepts and techniques for diagnosis and assessment of respiratory patients.
	+ Students watch a four-minute video (<https://youtu.be/ka08HxOXDLM>) describing COPDs and services provided by the lung center.
* **Experience**—Students will work in pairs to describe the pathological changes that would be expected in the lungs of a COPD patient. Students will draw a diagram of the bronchial tree to indicate the structural changes in a patient with emphysema and chronic bronchitis.
* **Apply**—Use the diagram constructed in the “Experience” activity to indicate what structures students should focus on to diagnose COPD patients. Students will also analyze their diagrams to show how structural impairments impact gas exchange and cause air trapping in the lungs. Students will illustrate how COPD causes an increase in carbon dioxide in the blood. Students will generate a short list of priorities for care of patients.
* **Cooperate**—Students will form groups of four to organize as pulmonary clinic teams to manage the care of two COPD patients. Group members should identify their roles and write a brief description of the work they provide to the clinic. Each group will devise a plan to assess a pulmonary function test for each student in the group.
	+ Students will learn how to perform pulmonary function tests using a spirometer (<https://foundation.chestnet.org/patient-education-resources/spirometry-procedure/>). Students will record their forced vital capacity (FVC) and forced expiratory volume–one second (FEV1). The FVC represents the volume of air that the lungs can exhale following a deep breath, and the FEV1 is a measure of how much air can be exhaled in one second after a deep breath. Students will then calculate their FEV1/FVC ratio and will use these values to determine normal and abnormal values compared to a reference individual. (Normal is equal to or greater than 70%.) Predicted values are obtained by using the Spirometry Reference Value Calculator on the Centers for Disease Control and Prevention website [(https://www.cdc.gov/niosh/topics/spirometry/refcalculator.html](https://www.cdc.gov/niosh/topics/spirometry/refcalculator.html)). Each group will record individual FVC and FEV1 scores on a chart to show flow of air in the lungs (L) and time (seconds).
* **Transfer**—Each group will make a short presentation to educate their patients about the lung disease and how it impacts their lung function. Groups will share their findings with the class. Each group will use the bell jar model to demonstrate the breathing process and the data collected from their spirometry measurements and diagrams. In addition, students must also explain how the FVC and FEV values would be different if their patients had restrictive disorders. (Use the “Respiratory-Transfer Presentation Rubric” for assessment.)
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| Activities/Lesson Procedure | Activity PreparationInstructor* Mini-Lectures: Review respiratory functions, anatomy, respiratory mechanisms, pressure gradient and volume relationship, Boyle’s law of respiration, respiratory volumes and capacities, COPDs, gas exchange, and air trapping.
* Demonstrate how to navigate through the virtual dissection of the respiratory anatomical structures using the GALE 3D interactive human anatomy tool [(http://cyber.galegroup.com/cyber/IANAT/activities/361?u=durham\_tccl&p=IANAT](http://cyber.galegroup.com/cyber/IANAT/activities/361?u=durham_tccl&p=IANAT)).
* Infographic – Lungs: How Gas Exchange Works ([https://www.carolina.com/teacher-resources/Interactive/infographic-lungs-how- gas-exchange-works/tr39619.tr](https://www.carolina.com/teacher-resources/Interactive/infographic-lungs-how-gas-exchange-works/tr39619.tr))
* Describe the epithelium throughout the respiratory system and the function of the tissue type.
* Demonstrate how to use a spirometer (<https://www.carolina.com/teacher-resources/Video/dry-spirometer-product-feature-video/tr28286.tr>).
	+ Spirometry Reference Value Calculator (<https://www.cdc.gov/niosh/topics/spirometry/refcalculator.html>)
* Describe the parts of the bell jar model.
	+ The small balloon inside the bottle represents the lung.
	+ The jar represents the thoracic cage.
	+ The plastic balloon handle represents the diaphragm.

Student* Review how to properly use light microscope.
* Review lab safety procedures.
* Bring lab notebook.
* Manage time.
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|  | Activity Steps1. *(45 Minutes)* Perform virtual dissection of the respiratory tract. Identify all major organs and describe their function. Use the GALE 3D interactive human anatomy online tool (<http://cyber.galegroup.com/cyber/IANAT/activities/361?u=durham_tccl&p=IANAT>). Take the short online quiz at the end of the interactive lab.
2. *(45 Minutes)* Distinguish the trachea, bronchi, terminal bronchioles, bronchioles, alveolar ducts, alveolar sacs, and alveoli based on key structural features. Identify the different types of alveolar cells and their functions. Draw and label structures observed with the microscope. Use different colors for illustration.
3. *(45 Minutes)* Using the bell jar model, demonstrate how the process of breathing works and how the diaphragm contracts to allow air to inflate the lungs. Explain the relevancy of Boyle’s law to this process. (Boyle’s law states that *at constant temperature, for a fixed amount of gas, pressure and volume are inversely proportional.*)
4. *(45 Minutes)* Use the spirometer to measures vital capacity, forced expiratory volume, forced vital capacity, tidal volume, and expiratory reserve volume. Then calculate FEV1/FVC ratios, inspiratory reserve volume, and inspiratory capacity from the values obtained. Graph these values and measurements for subject.
5. Correlate variations of respiratory values to restrictive and obstructive diseases.
6. *(90 Minutes)* Perform the REACT activity. (See “Instructional Strategies.”)
7. *(30 Minutes)* Write a lab report. (See lab report templates at <http://templatelab.com/lab-report/>.)

Expected ResultsAt the end of the labs, students will be able to:* Identify respiratory structures at the gross anatomy and microscopic level.
* Collect data on respiratory values.
* Calculate respiratory values using formulas and measured values.

Extension Option* Research restrictive lung disorders and their impact on respiratory volumes and capacities.
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| Faculty Resources | BackgroundThe respiratory system is composed of a series of tubes ending in very thin-walled sacs (alveoli) within the lungs. The alveolar walls are made of flat, scaly cells that allow rapid diffusion of oxygen and carbon dioxide. Breathing or respiration is a repetitive cycle that brings air into the lungs (inspiration) and takes air out of the lungs (expiration). This process occurs through to the contraction and relaxation of the diaphragm, which changes the pressure gradient inside the lungs relative to atmospheric pressure. This process can be explained by Boyle’s law of respiration, which states that there is an inverse relationship between volume and pressure. As the diaphragm contracts, the thoracic cavity expands and its volume increases, leading to a drop in the pressure inside the lungs relative to atmospheric pressure. The negative pressure inside the lungs drives air through the respiratory tract and ultimately in the alveoli, where oxygen diffuses into the blood and carbon dioxide is expelled out of the lungs. The oxygenated blood is then transported to all the tissues in the body to allow them to produce more energy to continue their metabolic activities. In quiet breathing, the dimensions of the thoracic cavity increase by a few millimeters in each direction, allowing 500 mL of air to flow into the respiratory tract at a rate of about 12 breaths per minute. Spirometry is a common test used to assess lung function by measuring the amount of air in the lungs during respiration.A spirometry test can aid in diagnosis and assessment of restrictive and obstructive lung disorders. In degenerative lung diseases where the lungs are hardened by scar tissue, compliance is greatly reduced, thereby limiting the amount of air that enters the lungs. Spirometry can also be used to monitor the effectiveness of medical treatments for patients with lung diseases. The most important values that can be obtained from spirometry include forced vital capacity (FVC), forced expiratory volume (FEV), and forced expiratory volume in one second (FEV1). These values are compared to normal, predicted values of people who are similar in age, height, weight, gender, and ethnicity. Predicted pulmonary function test values can be used to assess chronic obstructive pulmonary diseases (COPD). In obstructive lung disease, the predicted FEV1/FVC ratio is typically less than 70 percent.Obstructive disorders are those that interfere with airflow by narrowing and obstructing the airway, making it harder to inhale or exhale. The rate and depth of breathing is adjusted to match the rate of ventilation of the lungs and the rate of carbon dioxide production in the body. When the body is unable to efficiently expel carbon dioxide from the lungs, it accumulates in the body and ultimately is converted to carbonic acid, which then dissociates to hydrogen ions. The excess amount of hydrogen ions will then lower the pH of the blood, leading to respiratory acidosis.Respiratory acidosis can develop from COPD. This group of disorders is characterized by long-term obstruction of airflow and reduction in lung ventilation. Major COPDs such as chronic bronchitis and emphysema lead to reduction in lung volumes and capacities. COPDs interfere with gas exchange, thus leading to low levels of oxygen and high levels of carbon dioxide and low blood pH. |
|  | Handouts and Supplemental Materials* Figures for lung volumes and capacities adapted from [https://opentextbc.ca/anatomyandphysiology/chapter/22-3-the-process-of-](https://opentextbc.ca/anatomyandphysiology/chapter/22-3-the-process-of-breathing/) [breathing/](https://opentextbc.ca/anatomyandphysiology/chapter/22-3-the-process-of-breathing/)

Lab Report Content* Title (description of the experiment)
* Date (date the experiment was conducted)
* Lab partners (group members)
* Purpose (summary of why the experiment was performed)
* Introduction (brief description of the topic)
* Materials (list of reagents and equipment used for the experiment)
* Procedure (description of methods)
* Data (write data and show graphs)
* Results (show calculations)
* Conclusion/Analysis (discuss findings)
* References (citations and resources)

Review and Assessment Question* Trace the path of a molecule of oxygen from the nose to the bloodstream.

Answer* Nose to pharynx to larynx to trachea to bronchi to interlobar bronchioles to terminal bronchioles to respiratory bronchioles to alveolar duct to alveolar sac to alveolus to type I alveolar cells to basement membrane to endothelial cell to blood to hemoglobin of red blood cells

Suggested Websites* All links embedded in lesson plan
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| Assessment | How will students demonstrate what they have learned?Assessment Tools or Processes:* Performance task checklists
* Lab participation
* Discussion participation
* Group presentation
* Laboratory reports
* Tracing activity (See “Review and Assessment Question.”)

How to use a dry portable spirometer1. Place a mouthpiece attached to the spirometer in your mouth. Be sure to make a tight seal with your lips so all of the air will go into the spirometer.
2. Pinch your nose to keep air from leaking out of your nose.
3. After breathing normally, slowly blow out into the mouthpiece until your lungs are empty.
4. Take a big, deep breath to fill up your lungs completely.
5. As soon as your lungs are full, blow out into the spirometer, as hard and as fast as you can.
	* Forced vital capacity (FVC) is the total amount of air you can exhale after taking the deepest breath possible.
	* Forced expiratory volume (FEV) is the amount of air you can forcefully exhale during the first, second, and third seconds of the FVC test.
	* Forced expiratory volume in one second (FEV1) is the amount of air you can forcefully exhale during the first second of the FVC test.
6. Record values for 1 to 6 seconds.
7. Repeat the procedure three times and average the numbers.
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**Respiratory-Transfer Presentation Rubric**

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| **Categories** | **Scales** | **Grades and Comments** |
| **Background** | 4 = Provides adequate introduction with relevant information to the topic of interest.3= Provides non-specific background information that does not tie in well to the topic.2 = Provides a very generic background.1 = Provides an inappropriate background and/or was very difficult to read and/or understand. |  |
| **Presentation** | 4 = Demonstrates a clear and concise flow of ideas; passionate interest in the topic, and engagement with the class. Visuals augment comprehension.3 = Demonstrates a clear flow of ideas, general interest in the topic, and engagement with the class. Limited visuals.2 = Focus is lost, or ideas are hard to follow; lack of enthusiasm or interest; limited engagement with the class. Visuals are disorganized.1 = Focus and ideas are absent; lack of enthusiasm or interest; no engagement with the class. No visuals. |  |
| **Discussion** | 4 = Results are thoroughly analyzed and conclusions drawn.3 = Results are somewhat analyzed and conclusions drawn.2 = Results are analyzed but no conclusions drawn.1 = Results only superficially reviewed and no analysis is presented. |  |