Stage 1
Identify Desired Results

Catchy Title: The Breathtaking Nature of the Urban Explosion, Part 4
Theme/Topic of Lesson: Breathing Patterns & Oxygen Concentration in Exhaled Air
Time Commitment: 90 minutes
Subject Area(s):
Educational Technology - Integrating technology into the classroom
Health - Environmental health
Health - Body systems and senses
Health - Chronic conditions
Mathematics - Applied mathematics
Science - Biological and life sciences
Grade Level(s): 9,10,11,12
Standards Alignment:
Class Challenge Question:

How do the patterns of breathing and levels of oxygen change with different activities?

Overview:

The disease of asthma is becoming epidemic in urban areas. The *Breathing Easy* Web Quest, in Part 3 of this series of 4 "The Breathtaking Nature..." lessons, introduces this respiratory disorder's history and treatment. The investigations in Part 4, will assist in completing the students' understanding of asthma by explaining the anatomy and physiology of the respiratory system. The absorption of oxygen and release of carbon dioxide are investigated using *Vernier* interface technology (http://www.vernier.com/index.html). Students will be introduced to the *Vernier LabPro* and *Logger Pro* software through setting up and completing the laboratory, instructions which are found on the website produced for this lesson, *Breathing Easy Laboratory* at: http://www.fastol.com/~renkwitz/breathing_easy_experimen.htm. The setting up of the lab and the operation of the *LabPro* interface and *Logger Pro* software should be investigated by the instructor prior to the student laboratory activity.

Stage 2
Determine Acceptable Evidence

Life Science (9-12)	**Maryland Content Standards** Students will use scientific skills and processes to explain the dynamic nature of living things, their	**Maryland State Indicators** **3.12.1** explain that most life functions involve chemical reactions regulated

	interactions, and the results from the interactions that occur over time.	by information stored within the cell and may be influenced by the cell's response to its **environment**. The student will be able to describe the unique characteristics of chemical compounds and macromolecules utilized by living systems (water, carbohydrates, lipids, proteins, nucleic acids, minerals, vitamins). (CLG 3.1.1.)
Life Science (9-12)	**Maryland Content Standards** Students will use scientific skills and processes to explain the dynamic nature of living things, their interactions, and the results from the interactions that occur over time.	**Maryland State Indicators 3.12.2** The student will be able to discuss factors involved in the regulation of chemical activity as part of a homeostatic mechanism (osmosis, temperature, pH, enzyme regulation). (CLG 3.1.2.) The student will describe the flow of matter and energy between living systems and the physical environment (water cycle, carbon cycle, nitrogen cycle, photosynthesis, cellular respiration, chemosynthesis). (CLG 3.1.3.) The student will explain the function of structures found in cellular and multicellular organisms (transportation of materials, waste disposal, movement, feedback, asexual and sexual reproduction, control of structures, capture and release of energy, protein synthesis). (CLG 3.2.1.) The student will conclude that cells exist within a narrow range of environmental conditions and changes to that environment, either naturally occurring or induced, may cause death of the cell or organism (pH, temperature, light, water, oxygen, carbon dioxide, radiation, toxins). (CLG 3.2.2.)
Life Science (9-12)	**Maryland Content Standards** Students will use scientific skills and	**Maryland State Indicators 3.12.12**

	processes to explain the dynamic nature of living things, their interactions, and the results from the interactions that occur over time.	analyze the **interdependence** of diverse living **organisms** and their interactions with the components of the **biosphere**. The student will analyze the interrelationships and interdependencies among different organisms and explain how these relationships contribute to the stability of the ecosystem (diversity, succession, niche). (CLG 3.5.2.) The student will investigate how natural and man-made changes in environmental conditions will affect individual organisms and the dynamics of populations (depletion of food, destruction of habitats, disease, natural disasters, pollution, population increase, urbanization). (CLG 3.5.3.) The student will illustrate how all organisms are part of and depend on two major global food webs (oceanic food web, terrestrial food web). (CLG 3.5.4.) The student will analyze the consequences and/or trade-offs between technological changes and their effect on the individual, society and the environment. They may select topics such as bioethics, genetic engineering, endangered species, and food supply. (CLG 3.6.1.)
Process of Communication (9-12)	**Maryland Content Standards** Students organize and consolidate their mathematical thinking in order to analyze and use information, and present ideas with words, symbols, visual displays, and technology.	**Maryland State Indicators** **1** **In order to communicate mathematically, students will be able to:** *-discuss, read, listen, and observe to obtain mathematical information from a variety of sources (SFS 3.2)* -use multiple representations to express mathematical concepts and solutions (MLO 5.10, SFS 2.4) -represent problem situations and express their solutions using concrete, pictorial,

		tabular, graphical, and algebraic methods (MLO 5.11, SFS 3.1) -*clarify meaning by asking questions, supporting solutions with evidence, and explaining mathematical ideas in oral and written forms (SFS 3.1)* -use mathematical language and symbolism appropriately (MLO 5.12, SFS 3.2) -*organize, interpret, and* describe situations mathematically by providing mathematical ideas and evidence in *oral and* written form (MLO 5.13, SFS 3.1, SFS 3.2) -*give and use feedback to revise mathematical thinking/presentations/solutions (SFS 3.1, SFS 3.3)* -present results in written, oral, and visual forms (MLO 5.14, SFS 3.1, SFS 3.2) -*describe the reasoning and processes used in order to reach the solution to a problem*
Knowledge of Statistics (9-12)	**Maryland Content Standards** Students will collect, organize, display, analyze, and interpret data to make decisions and predictions.	**Maryland State Indicators 4.12.3** a. make informed decisions and predictions based upon the results of **simulations** and data from research (CLG 3.2.1.) • *describe data, make predictions, and draw **inferences*** b. interpret data and/or make predictions by finding and using a **line of best fit** and by using a given curve of best fit (CLG 3.2.2.) • *determine the equation of a line that best fits a set of linear data*

Learning Objectives:

The Students will:

- use a computer to monitor the respiratory rate of an individual.
- evaluate the effect of holding of breath on the respiratory cycle.
- evaluate the effect of rebreathing of air on the respiratory cycle.

- use an O2 Gas Sensor to determine residual oxygen levels in exhaled air.
- evaluate how internal O2 and CO2 concentrations influence breathing patterns.

Assessment

Examples of sample results can be found on "Teacher Information Sheets 1 & 2."

Stage 3
Plan Learning Experiences

Resources

Other Technology	**Graphical Analysis 3 Cables** Available from Vernier Software & Technology - Order Code GA ($80)	
	http://www.vernier.com/index.html	
	Gas Pressure Sensor Tubing Works with the LabPro software. Available from Vernier Software & Technology Order Code PS	
	http://www.vernier.com/index.html	
	Respiration Monitor Belt Cables Works with the LabPro Software, Available from Vernier Software & Technology - Order Code RMB ($58)	
	http://www.vernier.com/index.html	
	Oxygen Gas Sensor Cables Works with the LabPro software - Available from Vernier Software & Technology - Order Code O2-BTA ($184)	
	http://www.vernier.com/index.html	
Software	**Logger Pro 3** software installed into computer for this lesson; available from Vernier Software & Technology - Order Code LP ($99)	
	http://www.vernier.com/index.html	

	LabPro This interface with cables is available from Vernier Software & Technology, Order Code LabPro ($220)
	http://www.vernier.com/index.html
Internet Sites	**Breathing Easy Laboratory** The site created for this lesson, which gives detailed procedures for the lesson's laboratory investigation.
	http://www.fastol.com/~renkwitz/breathing_easy_experimen.htm

Materials
as determined by instructor

- Computer with USB or serial port and Internet connected with *Logger Pro* 3 software installed
- Graphical Analysis 3 Cables

- LabPro interface with cables
- Gas Pressure Sensor cables
- Respiration Monitor Belt cables
- Oxygen Gas Sensor cables
- plastic produce bag 30 X 40 cm (12" X 16")
- small paper grocery bag
- OPTIONAL: Graphing Calculator
- OPTIONAL: CBL2 interface - Available from Vernier Software & Technology http://www.vernier.com/index.html Order Code CBL2 ($166)
- OPTIONAL: Graph Link - Available from Vernier Software & Technology http://www.vernier.com/index.html Order Code GLC-USB ($17)

Not Specified

- The Breathtaking_Nature_4_Teacher_Info_Sheet_1 (View)
- The_Breathtaking_Nature_4_Teacher_Info_Sheet_2 (View)

Vocabulary

- **respiratory system** - The organs that are involved in breathing. These include the nose, throat, larynx, trachea, bronchi, and lungs.
- **Luer-lock** - A locking device to secure sensors to interface.
- **alveoli** - A small cell containing air in the lungs, a sac-like dilation of the alveolar ducts in the lung (plural: alveoli)
- **pulmonary capillaries** - The small blood vessels that circulate blood through the lungs.

- **chemoreceptors** - Cells specialized to detect chemical substances and relay that information centrally in the nervous system. Chemoreceptors may monitor external stimuli, as in taste and olfaction, or internal stimuli, such as the concentrations of oxygen and carbon dioxide in the blood.
- **hyperventilation** - A state in which there is an increased amount of air entering the pulmonary alveoli (increased alveolar ventilation), resulting in reduction of carbon dioxide tension and eventually leading to alkalosis.

Procedures

The detailed and illustrated procedures for the laboratory investigation are found on the *Breathing Easy Laboratory* site, created for this lesson at: http://www.fastol.com/~renkwitz/breathing_easy_experimen.htm.

1. Prepare the computer for data collection by opening the Experiment 26 folder from the Biology with Computers folder of Logger Pro. Then open the experiment file that matches the probe you are using. There are two graphs displayed and two Meter windows. The top graph's vertical axis has pressure scaled from 96 to 110 kPa. The horizontal axis has time scaled from 0 to 180 seconds. The data rate is set to take five samples per second. The Meter window to the right displays live pressure readings from the sensor. The lower graph's vertical axis has respiration rate scaled from 0 to 20 breaths/minute. The horizontal axis has time scaled from 0 to 180 seconds. The Meter window to the right displays the calculated respiration rate when data is being collected.
2. If your Gas Pressure Sensor has a blue plastic valve on it, place the valve in the position shown in Figure 2.
3. Select one member of the group as the test subject. Wrap the Respiration Monitor Belt snugly around the test subject's chest. Press the Velcro strips together at the back. Position the belt on the test subject so that the belt's air bladder is resting over the base of the rib cage and in alignment with the elbows as shown in Figure 3.
4. Attach the Respiration Monitor Belt to the Gas Pressure Sensor. There are two rubber tubes connected to the bladder. One tube has a white Luer-lock connector at the end and the other tube has a bulb pump attached. Connect the Luer-lock connector to the stem on the Gas Pressure Sensor with a gentle half turn.
5. Have the test subject sit upright in a chair. Close the shut-off screw of the bulb pump by turning it clockwise as far as it will go. Pump air into the bladder by squeezing on the bulb pump. Fill the bladder as full as possible without being uncomfortable for the test subject.
6. The pressure reading displayed in the Meter window should increase about 6 kPa above the initial pressure reading (e.g., at sea level, the pressure would increase from about 100 to 106 kPa). At this pressure, the belt and bladder should press firmly against the test subject's diaphragm. Pressures will vary, depending upon how tightly the belt was initially wrapped around the test subject.
7. As the test subject breathes in and out normally, the displayed pressure alternately increases and decreases over a range of about 2 &endash; 3 kPa. If the range is less than 1 kPa, it may be necessary to pump more air into the bladder. Note: If you still do not have an adequate range, you may need to tighten the belt.

Part l: Holding of Breath
8. Instruct the test subject to breathe normally. Start collecting data by clicking . When data has been collected for 60 seconds, have the test subject hold his or her breath for 30 to 45 seconds. The test subject should breathe normally for the remainder of the data collection once breath has been released.
9. Examine the respiration rates recorded in the bottom graph by clicking the Examine button, . As you move the mouse pointer from point to point on the graph the data values are displayed in the examine window. Determine the respiration rate before and after the test subject's breath was held and record the values in Table 1.

Part ll: Rebreathing of Air
10. Prepare the computer for data collection by opening the Experiment 26B folder from the Biology with Computers folder of Logger Pro. Then open the experiment file that matches the probe you are using. The vertical axis has pressure scaled from 98 to 112 kPa. The horizontal axis has time scaled from 0 to 300 seconds. The data rate is set to take five samples per second. The Meter window to the right displays live pressure readings from the sensor.
11. Place a small paper bag into a plastic produce bag. Have the test subject cover his or her mouth with the bags, tight enough to create an air-tight seal. The test subject should breathe normally into the bags throughout the course of the data collection process.
12. Click to begin data collection. Again, the test subject should be sitting and facing away from the computer screen. Collect respiration data for the full 300 seconds while breathing into the sack. Important: Anyone prone to dizziness or nausea should not be tested in this section of the experiment. If the test subject experiences dizziness, nausea, or a headache during data collection, testing should be stopped immediately.
13. Once you have finished collecting data in Step 12, calculate the maximum height of the respiration waveforms for the intervals of 0 to 30 seconds, 120 to 150 seconds, and 240 to 270 seconds:
a. Move the mouse pointer to the beginning of the section you are examining. Hold down the mouse button. Drag the pointer to the end of the section and release the mouse button.
b. Click the Statistics button, to determine the statistics for the selected data.
c. Subtract the minimum pressure value from the maximum value (in kPa).
d. Record this value for each section as the wave amplitude in Table 2.

Day 1: Urban Explosion and its Consequences
Daily Challenge Question: How can a computer be used to show the respiration rate of an individual? How does internal oxygen and carbon dioxide influence breathing patterns?
90 minutes
Set-up Directions:

Student groups should be organized by the teacher into their cooperative groups of 2 or more, based on computer skills, and assigned a computer. Each Internet-ready computer should have the *Breathing Easy Laboratory* uploaded.
(http://www.fastol.com/~renkwitz/breathing_easy_experimen.htm)

Teacher Information: Breathing Easy Laboratory - Part 1

• When putting on the Respiration Monitor Belt, try to get as tight a fit as is comfortable.
• Always have the test subject sit in a position in which they are unable to see the computer screen. This will help ensure that they do not consciously alter their respiration rate.
• *Anyone prone to dizziness or nausea should not be tested in the section of the experiment involving the rebreathing of their own air.* If the person being tested experiences dizziness, nausea, or a headache during testing, stop data collection. *Students who are sensitive to hyperventilation or are nervous by nature should not be tested*.
• The calibration stored in the Experiment 26 experiment file from the Biology with Computers folder of LoggerPro works well for this experiment. This calibration is for the Respiration Sensor (kPa).

Teacher Information: Breathing Easy Laboratory – Part 2
• This exercise is meant as an investigative study. Results may vary from those printed here. Variations in results may be due to different body mass, age, fitness, and sex of the students.
• The best bag to use for this experiment is a bread bag. This is the same bag that comes with every loaf of bread you purchase from the super market. The advantages to this type of bag are that it is pliable, large, and easy to obtain.
• To secure the bag to the 02 Gas Sensor, cut a small hole the size of a half dollar and feed the sensor through the hole. Use tape to seal the bag to the sensor and prevent any air from escaping at that junction. Most any type of tape will work.
• Once the sensor is mounted on the ring stand with the test tube clamp, students can rotate the sensor enough so that it is pointing more in their direction. This may prove easier to use rather than having the sensor pointing straight down.
• Students may find it easier to hold their breath if they are facing away from the computer screen.
• *Students with asthma or other respiratory ailments should not participate as the subject in this experiment.*

Teacher Presentation & Motivation:

The following questions can be used to begin the experiment and to alert students to the purpose of the experiments.
1. How long do you think you can hold your breath?
2. When you hold your breath, what do you think happens to the oxygen concentration in your lungs? Explain.
3. When you hold your breath, what do you think happens to the carbon dioxide concentration in your lungs? Explain.
4. On average, people can hold their breath for a minute. What do you think prevents people from holding their breath for 2 or 3 minutes?

Activity 1 - Breathing Easy Laboratory

Student pairs or groups will follow laboratory procedures on the illustrated website and complete investigation.

Focus for Media Interaction
Focus for Media Interaction: The focus for media interaction is a specific task to complete and/or information to identify during or after viewing of video segments, Web sites or other multimedia elements.

Student pairs or groups will follow laboratory procedures on the illustrated website and complete investigation.

Viewing Activities
What will your students be responsible for while viewing this piece of multi-media or video?

Student pairs or groups will follow laboratory procedures on the illustrated website and complete investigation.

Post Viewing Activities
How will students utilize the information they gathered while viewing the multi-media or video?

1. Student groups will answer the questions on the *Breathing Easy Laboratory* site:

1. Did the oxygen concentration change as you expected? If not, explain how it was different.

2. Did the amount of time you held your breath change after hyperventilation (taking the 10 quick breaths)? If so, did the time increase or decrease? Explain.

3. After hyperventilation, was the resulting concentration of oxygen in your exhaled breath higher or lower than in the first attempt? How much did it change? What do you contribute this to?

4. On the first trial, what do you believe forced you to start breathing again?

5. On the second trial, what do you believe forced you to start breathing again?

6. Based on your answers to questions 4 and 5, does the concentration of oxygen or carbon dioxide have a greater influence on how long one can hold his breath?

2. Students will discuss the results of their investigations.

Wrap Up:

After students have completed the exercises and questions that attend the investigations, then the teacher should appoint a student leader to direct a discussion of results.

Enrichment Options

Community Connection

Invite a local physician to provide and explain actual respiratory patterns of asthma patients.

Parent-Home Connection

The lesson is available on the Internet and could be virtually worked through by both students and their parents at home. After completing the WebQuest and having their student explain the rate and oxygen investigations, family members can discuss what measures they feel they should take to improve respiratory efficiency.

Cross-Curricular Extensions

- **Health**
  Investigate the relationship of various chronic lung disorders to the respiratory rate and oxygen absorption. Examples: lung cancer, asbestosis, etc.
- **Mathematics**
  Graphing of respiratory data can be done under varying conditions; exercise, resting, etc. Then extrapolations and predictions from this standard data can be made by theoretically changing the conditions. The purpose of such extrapolations is to determine if the respiratory functions reflect random or nonrandom patterns.
- **Technology**
  Investigate how the *LabPro* interface transduces the *Vernier* sensor inputs into numerical data.

Stage 4
Teacher Reflection

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Program: EnviroHealth Connections
Author's School System: Dorchester County Public Schools
Author's School: Cambridge-South Dorchester High