Lung Power and Air Pollution
Grade 7, Science

Length of Lesson:
2 hours 20 minutes to 3 hours (depending on whether shortcut is selected)

National and/or Local Standards:
[NAAEE Guidelines for Excellence in Environmental Education](#)
Strand 1B: Designing Investigations
Strand 1C: Collecting Information
Strand 1F: Working with Models
Strand 2.4 Human/Environment Interactions

Georgia Performance Standards:
S7L4 Students will examine the dependence of organisms on one another and their environments.
c. Recognize that changes in environmental conditions can affect the survival of both individuals and entire species.

S7CS9 Students will investigate the features of the process of scientific inquiry.
a. Investigations are conducted for different reasons, which include exploring new phenomena, confirming previous results, testing how well a theory predicts, and comparing competing theories.
b. Scientific investigations usually involve collecting evidence, reasoning, devising hypotheses, and formulating explanations to make sense of collected evidence.

S7L2 Students will describe the structure and function of cells, tissues, organs, and organ systems.
e. Explain the purpose of the major organ systems in the human body (i.e., digestion, respiration, reproduction, circulation, excretion, movement, control, and coordination, and for protection from disease).

Complementary Standards:
S7CS4 Students will use tools and instruments for observing, measuring, and manipulating equipment and materials in scientific activities.

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b. Use appropriate tools for measuring objects and/or substances.
c. Learn and use on a regular basis standard safety practices for scientific investigations.

Focus: Lung Power and Air Pollution
In this lesson on the respiratory system and the impact of air pollution on the human body, seventh graders will determine the air quality for their area by analyzing data from monitoring stations; convert this data to an Air Quality Index value; investigate the impact of air pollution by measuring and comparing their own vital lung capacity on days with healthy and unhealthy air quality; and brainstorm strategies for protecting their respiratory systems from the harmful effects of air pollution. It is recommended that students complete "Every Breath You Take," the first lesson in this unit, before beginning these activities.

Materials:
For the teacher (recommended):
- Equipment to display Web resources to class, for Steps Three and Four (i.e. interactive whiteboard OR Internet-connected computer with scan converter and screen or TV OR individual Internet-connected computers for students)

For each student or group of students:
- One color copy of Air Quality Index Chart: (http://airnow.gov/index.cfm?action=static.aqi)

For Vital Lung Capacity Experiment (one per team):
- One 2 or 3 liter plastic bottle
- One large plastic dishpan
- One metric ruler
- One waterproof marking pen
- One calculator
- Masking tape (approx. 16")
- One graduated cylinder or beaker

Each student will need:
- One 30 – 60 cm (1 – 2 ft) length of aquarium or surgical tubing (not to be shared, for safety reasons)
- One copy of Lung Power and Pollution Lab Report (attached)

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- One clipboard
- Internet-connected computer for monitoring pollution data and graphing experiment results (optional)

Procedure:
Step One: Teacher Preparation
Decide how to divide the class into six teams. Assemble supplies needed for the investigations (see Materials List). Print student copies of the Air Quality Index (AQI) Chart (http://airnow.gov/index.cfm?action=static.aqi) in color, for use at Step Two; and the **Lung Power Lab Report** (attached below) for use at Step Three. Print a copy of Lung Capacity Experiment Directions (http://www.tryscience.com/experiments/experiments_lung_athome.html) for each team to use at Step Five. Find a suitable outside location where the lung capacity investigations can take place. Determine boundaries for students in that area, check for safety hazards, and identify or arrange for tables that can be used for the lab setup.

Plan for the investigations in Steps Five and Six to be done on a day when air quality is healthy and repeated on another day when air quality is unhealthy, to maximize differences between results. To help the teacher schedule the experiments, Web sites linked at this step provide information about current air quality and air quality typical for various times of year, in both rural and urban areas. (Urban areas, where ozone is often the major pollutant, experience worse air quality late on summer days, as ultraviolet light combines with vehicle emissions to form ozone. In such locations, it may be ideal to conduct one investigation in the morning and one in the afternoon. In areas where coal-fired power plants produce the main pollutants, there will be less of an effect on lung capacity on a windy day, when pollutants are blown to other areas, than on a calm one).

For metro Atlanta: The Clean Air Campaign offers air quality forecasts on the Web site (http://www.cleanaircampaign.org/Air-We-Breathe/Today-s-Air-Quality) and through Smog Alerts issued via e-mail. To receive the e-mail alerts, sign up here: (http://www.cleanaircampaign.org/About-Us/Subscriptions/Smog-Alerts). In addition, archived Ozone maps (http://airnow.gov/index.cfm?action=airnow.currentmaps) provide information about the seasons and times of day when ozone and

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particulate matter are most unhealthy, for each region of the U.S.

For Columbus and Augusta areas: The Clean Air Campaign offers Smog Alerts issued via e-mail. To receive these alerts, sign up here: (http://www.cleanaircampaign.org/About-Us/Subscriptions/Smog-Alerts).

For other parts of Georgia: The Georgia Ambient Monitoring Program (http://www.air.dnr.state.ga.us/amp/) provides hourly updates on levels of the six major pollutants at locations across the state. Call (404)362-4909 for an automated voice recording or visit the Web site and click on the nearest location to see current information. Note that AQI levels over 100 for any individual pollutant are considered unhealthy.

In the lesson Introduction (Step Two), it is highly recommended that the teacher show students each of the Web resources linked above, emphasizing data for your particular area. Arrange for equipment to do this. (For instance, an interactive whiteboard may be used to display Web pages OR an Internet-connected computer, scan converter, LCD projector, and screen or TV hookup. As an alternative, students may view the Web resources individually on Internet-connected computers, as a discussion is lead by the teacher. Because some of the Web resources are interactive, it is not recommended that Web pages be copied as transparencies for an overhead projector or for student handouts).

Shortcut Option: If time is short or Internet-connected computers not available to students, the Pollution Detectives and Data Conversion activities at Steps Three and Four may be omitted. To provide continuity for the rest of the lesson, however, the teacher must identify the *current Air Quality Index (AQI) level* and the *major pollutant of the day* (if any) by checking the Web sites listed above.

Step Two: Introduction, Duration - 20 minutes
Introduce the lesson by asking the class to define air pollution. (Air pollution is unwanted and potentially unhealthy matter in the air) Then ask students how it is possible to know whether air is polluted. (Responses may include sensing by sight or smell; proximity to apparent sources of pollution such as smokestacks, forest fires, and

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vehicles; or direct measurement of pollutants). Provide each student (or small group of students) with a color copy of the AQI Chart (http://airnow.gov/index.cfm?action=static.aqi). Have students identify the colors which reflect healthy or moderate air quality (green and yellow) as well as the colors which indicate unhealthy levels for sensitive groups (orange) and unhealthy for all people (red and purple). Ask the class to guess which types of air pollution the index measures. [The six major pollutants measured for the AQI are ozone, sulfur dioxide, carbon monoxide, nitrogen dioxide, particulate matter smaller than 10 ppm (dust), and particular matter smaller than 2.5 ppm (smoke and soot)]. Solicit opinions as to how the AQI is determined. [Monitoring stations collect data on the six major pollutants. A formula is used to combine the levels of pollutants, but the index always identifies the specific pollutant that has triggered an Alert, if air quality levels are unhealthy. If none of the six pollutants are present in unhealthy levels, the AQI reflects healthy air quality.]

Step Three: Pollution Detectives, *(Skip this step if Shortcut Option is selected),* Duration - 20 minutes
Tell students that monitoring stations across Georgia collect data on pollutants every day. Display the Trackstar Web site (http://trackstar.4teachers.org/trackstar/) for the class (enter #355673 in the "Find Track" box), paraphrasing the annotations for each frame, to show the kinds of air quality information which can be obtained for your area. Note the current Air Quality Index (AQI) level and the major pollutant of the day (if any). Distribute a copy of the Lab Report (included below) to each individual. Shortcut Option: If time is short or Internet-connected computers not available to students, the balance of Steps Three and Four may be omitted. To provide continuity for the rest of the lesson, students will need to remember the previously-noted AQI level and specific major pollutant.

Divide the class into six teams and assign each team one of the following pollutants: ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, large particulate matter (PM10.0), and fine particulate matter (PM2.5). Each team will determine the current level of an assigned pollutant by reviewing data from the Ambient Monitoring Program (http://www.air.dnr.state.ga.us/amp/) with an Internet-connected computer; click on "Today" next to the name of a pollutant to find out what the acceptable level is; click on a monitoring station, as selected

by the teacher, to display data; and conclude whether the pollutant is present at an unhealthy level by comparing the standard to the measured level. For ozone, use raw data instead of backward-looking 8-hour averages. Note that 24-hour time is used on charts. Students should observe whether the measured level is above or below the red line (standard) on the graph. All data and conclusions should be recorded on the attached Lab Report. [Variation: The teacher may pre-select multiple monitoring locations, and direct each member of the team to collect data for the team's pollutant from one of those stations (except for ozone). If enough Internet-connected computers are available, this would allow every child to be fully engaged in the assignment].

Step Four: Converting Air Pollution Data to Air Quality Index Values *(Skip this step if Shortcut Option is selected),* Duration - 0 to 20 minutes
Using a special online formula-calculator (http://cfpub.epa.gov/airnow/index.cfm?action=aqi.conc_aqi_calc), students should enter their team's pollution datum from the previous step and convert it to an Air Quality Index value. To accomplish this, students will use a pull-down menu to select a pollutant, enter the concentration level, and click 'Calculate' to convert to the Air Quality Index. Students should be sure to scroll down and read the corresponding health advisory. While everyone is still at the computers, the teacher will call for pollution concentration levels from each team and record this on the board or on a large chart. Then direct the students to repeat the AQI conversion process for the data provided by other teams. This information should be recorded on the table in the Lab Report. (If the teacher elected to have teams collect data from more than one monitoring station, this data should be converted too).

When all the data has been converted, review the results. Identify the overall air quality and major pollutant of the day (if any). *This is important to know for the next part of the lab.* Discuss factors which may affect pollution levels (proximity to an urban area, season, time of day, proximity to power plants, type of fuel power plant uses, etc.). In Georgia, most AQI alerts (unhealthy levels) in urban areas are related to vehicle emissions. Have students guess which two pollutants are most closely associated with vehicle emissions, and thus most

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likely to trigger AQI alerts in urban areas. (ozone and particulates). Since ozone is only formed in the presence of ultraviolet light, ask students what time of day and in which season ozone is most likely to trigger an AQI alert (afternoon and evening in summer). Optional: Segue into the next part of the lab by displaying or directing students to this animation (http://www.tryscience.com/experiments/experiments_begin.html?lung) of the Lung Capacity Experiment they are about to do. Click on "Try Offline" to review materials and procedures for the lung capacity experiment.

Step Five: Investigating Lung Capacity, Duration - 45 minutes
Students should stay in the previously-assigned six teams. Take students and materials *outside* for this investigation, so that the impact of air quality can affect results. Explain that each student will be conducting a hands-on investigation to determine his or her own lung capacity, using the water displacement method. Review any ground rules or safety considerations for working outside.

Ask students why vital lung capacity is important to their health? [Larger lung capacity allows more oxygen to be delivered to red blood cells and distributed throughout the body. Larger lung capacity also enables more carbon dioxide - the waste material of cells - to be removed from the body]. Then ask students how they think air pollution could affect lung capacity. [Depending on their own health and risk group, students may predict that vital lung capacities will decrease or stay the same when the air is polluted, and may predict that it would depend on the type or level of pollutant, accept all responses]. Ask whether every student would be affected the same way? [Because people with respiratory illnesses have damaged lung tissue, their vital lung capacity is already reduced].

Using information from the previous steps, identify the current AQI value (and major pollutant, if any) and confirm for students whether the investigation conducted today will reflect a healthy or unhealthy air pollution level. [If teacher selected shortcut option and skipped Steps Three and Four, or if this investigation is taking place on a day other than when Step Four was completed, refer to The Clean Air Campaign (http://www.cleanaircampaign.org/) or Ambient Monitoring Program Web site (http://www.air.dnr.state.ga.us/amp/) to quickly determine

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current air quality conditions]. Distribute supplies and Experiment Directions (http://www.tryscience.com/experiments/experiments_lung_athome.html) to each team and instruct team members to take turns, assist each other, and share equipment (other than tubing, which each individual receives and should mark with initials). Refer students to the Lab Report (distributed at Step Three) on which all data should be recorded. Note that each student should conduct three trials of the experiment average the results.

Step Six: Repetition of Lung Capacity Experiment at a Time or Day with Different Air Quality, Duration- 30 minutes
Repeat the investigation at Step Five on a different day or at a different time of the same day, when the Air Quality Index is significantly different. The two investigations (at Steps Five and Six) must compare vital lung capacity measured one time when air quality is good, and one time when air quality is unhealthy.

Step Seven: Graphing Data, Duration - 20 minutes
Students should graph the data from their lung capacity experiments. The Lab Report provides grid paper for this purpose. However, if access to Internet-connected computers for the class is easy, the teacher may prefer to have students enter data at the Create A Graph website (http://nces.ed.gov/nceskids/createagraph/) to easily produce full color graphs in an assortment of formats and styles.

Step Eight: Debriefing, Duration – 30 minutes
Ask each team to present their results. Review the Conclusions sections of the Lab Report, this way: Poll students to see if there was a difference in their average lung capacities, on the day when air quality was good compared to the day when air quality was unhealthy. If results are unexpected, consider why. (Not enough contrast in air quality from first experiment to the next, not enough time outside to make a difference, different pollutants present from one day to the next, etc.) Challenge the class to think of reasons for variations in lung capacity among students, other than pollution (Different size, age, respiratory system condition, and athleticism). Ask why a runner might be at risk for respiratory health effects of air pollution. (Athletic people have greater lung capacity and can therefore breathe in more polluted

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air. In addition, runners often exercise in afternoon or evening, along roadsides, causing greater exposure to pollutants).

Be sure to reserve time to discuss sources of air pollution in your area, brainstorm how air pollution could be reduced, and develop strategies for protecting lung health. The specifics of this discussion will vary according to your geographic location and the major pollutants in the area. For instance, in urban areas where ground level ozone may be the major pollutant, students could brainstorm ways to reduce vehicle emissions. In areas affected more by power plant emissions, students could brainstorm ways to limit emissions, conserve energy, or switch to sources of energy which produce less pollution. If convenient to display Web resources for the class, refer to the Scorecard Pollution Locator (http://www.scorecard.org/env-releases/cap/) for information on air pollution in your area. (Select Smog and Particulates or Hazardous Air from the left side menu; then type in your zip code and investigate the Map Locating Pollution Sources and the Air Quality Rankings for your community). Refer to the Clean Air Campaign Web site (http://www.cleanaircampaign.org/Air-We-Breathe) for ideas about reducing pollution and mitigating its health effects on the respiratory system.

Wrap up by reiterating the big ideas in this lesson:
- Vital lung capacity affects the ability to take in oxygen and distribute it to red blood cells.
- Vital lung capacity also affects the ability to eliminate waste (carbon dioxide) from the body.
- Lung capacity can be affected by changes in the environment, such as air pollution.
- Reduced lung capacity and impaired respiratory function can compromise the health of an individual and affect survival.
- Air quality is measured at monitoring stations located throughout the state.
- The Air Quality Index (AQI) is a color-coded rating of the six major air pollutants, based on data received from monitoring stations.
- People can protect their respiratory systems by avoiding exposure when air quality is "unhealthy," according to the AQI index.

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- Air pollution can be reduced by cutting power plant and vehicle emissions and changing behaviors.

Assessment:
- Students will demonstrate understanding of the respiratory system by building working spirometers and using them to measure their own vital lung capacity on days of varying air quality. Completed lab reports will be used to assess student participation and understanding of the primary learning outcomes of this lesson. A scoring rubric is attached.
- Scoring Rubric for "Lung Power and Air Pollution" Lab Report
- The Scoring Rubric can be used to evaluate all the activities in this lesson.

Follow-Up:
After you have taught this lesson plan, please tell the Clean Air Schools program about your efforts in a brief, 60-second online survey at CleanAirCampaign.org. The information you provide is invaluable in helping this non-profit education program direct its resources to improving these lesson plans and creating new materials for your students. Thanks!

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Lung Power & Pollution Lab Report

Name _____

Partners_____

Note: Work may be completed in teams but an individual lab report is required from each student.

***Directions and all Web sites needed for this lab report may be found at Trackstar Track #355673
Go to http://trackstar.4teachers.org/trackstar/ and enter # 355673 in the "Find Track" box.***

Pollution Detectives: (Internet-connected computer required: See Trackstar Track 355673, Frame 6) Use Ambient Monitoring Program Web site: http://www.air.dnr.state.ga.us/amp/. Select "Today" for the pollutant you want; then read about the standard (allowable level). Note: if standard is not displayed, go back and click on pollutant to view. Select location (or scroll down for Atlanta sites); and record highest concentration level of pollutant for day.

Date: _____ **Monitoring Location:** _____

Name of our teams' assigned pollutant: _____

Highest concentration level of pollutant for the day: _____ (indicate unit) **Time:** _____

How does current level relate to standard?(circle one)   **Below**   **At standard**   **Above**

Conversion of Data to Air Quality Index (AQI) Value (Internet-connected computer required: See **Trackstar Track 355673, Frame 7**) Use AQI Calculator Web site:
http://www.epa.gov/airnow/aqi/conc_aqi_calc.html Select name of pollutant (from pull-down menu); enter the concentration level; and click on "Calculate." Record the Air Quality Index value and info.
AQI Value: _____ (list index number)

AQI Category: _____   **AQI Color:** _____

Sensitive Groups at this AQI Level: _____

Health Effects at this AQI Level:
_____

Cautionary Statements at this AQI Level:
_____

Results of All Teams, for the Six Major Pollutants (class activity/ circle major pollutant, if any) While everyone is still at the computers, the teacher will call for pollution concentration levels from each team and record this on the board or on a large chart. Students should repeat the AQI conversion process for the data provided by other teams. This information should be recorded on the table below. (If the teacher elected to have teams collect data from more than one monitoring station, this data should be converted too).

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Pollutant > V Data	Ozone (Raw data)	SO$_2$ (Sulfur dioxide)	NO$_2$ (Nitrogendioxide)	CO (Carbon monoxide)	Particles <10ppm	Particles <2.5ppm
Concentration						
AQ Index #						
AQI Color						
AQI Category						

Determining Vital Lung Capacity, Part 1 (individual activities with team, outside)

Purpose of this Investigation:
To determine "vital lung capacity" using the water displacement method.

Background:
There are three ways to measure lung capacity. The first, vital lung capacity, is the largest amount of air that can be exhaled after taking a deep breath. The second, tidal volume, is the amount of air taken in during normal breathing. And the third, expiratory reserve is the amount of air that is left in the lungs after exhaling in normal breathing. In this investigation, we will measure vital lung capacity.

Directions:
Use the printed instructions provided by your teacher OR refer to **TrackstarTrack 355673, Frame 8**, OR visit this Web page: http://www.tryscience.com/experiments/experiments_lung_athome.html.
Mark your initials on your surgical tubing and save for repeated use.

Make a Prediction:
You can reasonably predict your vital lung capacity before starting the experiment, by using the formula below. However, lung capacity is affected by various physiological characteristics (anatomical build, youth, air quality, and the presence or absence of respiratory diseases). The smaller or younger a person is, the less lung capacity he or she will usually have. First, have one of your partners help you measure your height in centimeters. (Then help your partners do the same). Now make a prediction using this formula:

V = (0.041 x h) – (0.018 x a) – 2.69
where V is vital lung capacity in liters, h is your height in centimeters, and a is your age in years. Fill in your height and age on the blank lines. Then multiply (vertically) by the factors shown and write the products in the boxes. Subtract (horizontally) as indicated. Show your calculations:

_____cm (height)   _____ years (age)

X 0.041   X 0.018

V = [   ]   **minus**   [   ]us   **2.69** =   [   ]

*My Predicted Vital Lung Capacity is _____ liters. Predicted Vital Lung Capacity x 1000 = _____ml

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Record Air Quality Data:
Date of this investigation: _____
Record the Air Quality Index value for your location on this date: _____
What is the major pollutant (if any)? _____

Measure and Record Vital Lung Capacity:
Record your measurements to the nearest 100 ml on the chart. Calculate average of three trials.

MY VITAL LUNG CAPACITY	
Trials	**Vital Lung Capacity (ml)**
1	
2	
3	
Average	

Graph the Results: Graph data on the chart paper below OR go to the Create A Graph web site (**http://nces.ed.gov/nceskids/createagraph/default.aspx**); make a graph; and print it out.
Conclusions:
Compare your predicted vital lung capacity to your average vital lung capacity, and answer the following questions.

What was the amount of the difference between predicted and average actual lung capacity?
_____

Was the average value from the investigation greater or smaller than your prediction?
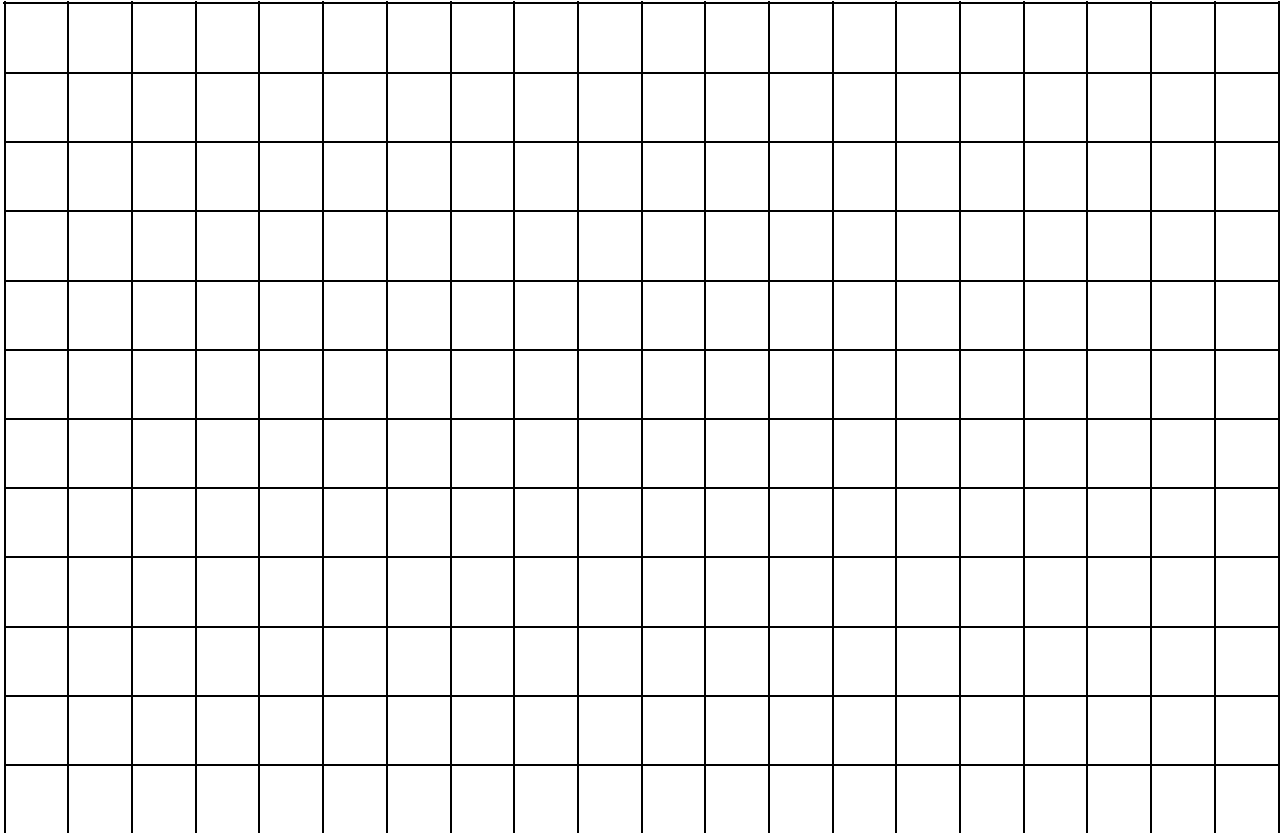_____

What might explain this difference?
_____

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Graph of Results for Investigation Part 1:
Create a bar graph with results of the three tests of your vital lung capacity. Show the average value as a line across the bars. Title the graph. Label the x and y axes. OR Go to the Create A Graph web site (http://nces.ed.gov/nceskids/createagraph/default.aspx); make a graph; and print it out.

Title of Graph: _____

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Determining Vital Lung Capacity, Part 2

Purpose of this Investigation:
To determine "vital lung capacity" using the water displacement method, **on a day with different air quality than that during Part 1** of this experiment. .

Follow the Directions:
Use the printed instructions provided by your teacher, or refer to Trackstar **Track #355673, Frame 8**, OR visit this Web page: http://www.tryscience.com/experiments/experiments_lung_athome.html.

Record Air Quality Data:
Date of this investigation: _____
Record the Air Quality Index value for your location on this date: _____
What is the major pollutant (if any)? _____

Make a Prediction:
You can predict your personal vital lung capacity before starting the experiment, by using the formula below. However, lung capacity is also affected by physiological characteristics (anatomical build, youth, air quality, and the presence of respiratory diseases). The smaller or younger a person is, the less lung capacity he or she will usually have. Have one of your partners help you measure your height in centimeters. (Then help your partners do the same). Now make a prediction using this formula:

V = (0.041 x h) – (0.018 x a) – 2.69
where V is vital lung capacity in liters, h is your height in centimeters, and a is your age in years. Fill in your height and age on the blank lines. Then multiply (vertically) by the factors shown and write the products in the boxes. Subtract (horizontally) as indicated. Show your calculations:

_____cm (height)   _____ years (age)
X 0.041   X 0.018

V = [ ]   **less**   [ ]   **less**   **2.69** =   [ ]

*My Predicted Vital Lung Capacity is _____ liters
*Predicted Vital Lung Capacity x 1000 = _____ml

Record Vital Lung Capacity
Record your measurements to the nearest 100 ml on the chart, using the length of tubing marked with your initials. Calculate the average of three trials.

MY VITAL LUNG CAPACITY	
Trials	**Vital Lung Capacity (ml)**
1	
2	
3	
Average	

Graph Results: Graph data on the chart paper below OR got to the Create A Graph web site (**http://nces.ed.gov/nceskids/createagraph/default.aspx**); make a graph; and print it out.

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Comparing Vital Lung Capacity on Days of Differing Air Quality

Conclusions:
Consider your results from the lung capacity investigation, parts 1 and 2.   Was your vital lung capacity larger or smaller on the day of lower (worse) air quality?
_____

What might be some reasons for the difference, if any?
_____
_____

Identify some probable sources of air pollution in your area.
_____
_____

List some strategies for protecting your lung health on days when the air quality is poor.
_____
_____

Brainstorm some ideas for improving air quality.
_____
_____

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Graph of Results for Vital Lung Capacity Investigation, Part 2: Create a bar graph with results of the three tests of your vital lung capacity. Show the average value as a line across the bars. Title the graph. Label the x and y axes. OR Go to the Create A Graph web site (http://nces.ed.gov/nceskids/createagraph/default.aspx); make a graph; and print it out.

Title of Graph: _____

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