MODULE 1

Our Lungs, Our Air, Our Health

The Effects of Ozone Pollution on Human Body Systems

Module Overview

The air we breathe provides us with the oxygen we need to survive, but it can also introduce dangerous and harmful chemicals into our lungs and our bodies. In this module, students will take on the role of medical professionals to investigate the phenomenon of an asthma attack. They will begin by studying the structure and function of the human respiratory system, and how it connects to the circulatory system. They will use this understanding to develop a model of how our bodies get and transfer oxygen to our cells. Then they will investigate the effects of ground-level ozone and its role in exacerbating the effects of asthma. They will also have the opportunity to connect this understanding with a common treatment for asthma. Finally, students will demonstrate what they know by using their models to show how air pollution affects the human body.

Anchor phenomenon:

Two students who are having difficulty breathing.

Pacing

- 7 activities + summative assessment
- Approximately 7 class periods + summative assessment

When to Teach This Module

Finding the right place within a science scope and sequence to investigate air pollution with students can be tricky. Below you will find some information about the module that can help you decide where this it might fit into your own plans for student leaning:

- Connection to Human Health: This module focuses on how individuals are affected physiologically by air pollution, in particular from ozone. It ties in very well with student investigations of human body systems, and would work well either integrated into, or at the end of a unit on cell biology. Activities in the unit will have additional relevance for students if they already have some background knowledge of cells, tissues, organs, and organ systems (especially the circulatory system) including the structure and function of different parts of living systems.

- Connection to Earth Science: Because this module looks at how air pollution affects humans, it would work well as an addition to a unit on the atmosphere, or a unit on human impacts to the environment. In both cases, the unit can provide a personal connection for students to see that air pollution is not just a hazard to the environment, it is potentially harmful to human health as well.

Standards Overview

Middle School NGSS standards alignment:

Performance Expectations:

Focus PE: MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. [Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.] [Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.]

Background PE: MS-LS2-3. Develop a model to describe the cycling of matter ~~and flow of energy~~ among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.]

Science & Engineering Practices

Focus SEP: Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and/or use a model to predict and/or describe phenomena.
- Develop a model to describe unobservable mechanisms.

Background SEP: Planning and carrying out investigations

Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.

- Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.
- Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

Background SEP: Constructing explanations

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Construct an explanation using models or representations.
- Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.

Disciplinary Core Ideas

Focus DCI: LS1.A: Structure and Function

In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.

Background DCI: LS2.A: Interdependent Relationships in Ecosystems

Organisms, and populations of organisms, are dependent on their environmental interactions ~~both with other living things~~ and with nonliving factors.

Crosscutting Concepts

Focus CCC: Systems and System Models – A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.
- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

Background CCC: Cause and Effect: Mechanism and Explanation – Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

NGSS 5th Grade Standards alignment

Performance Expectations:

5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. [Clarification Statement: Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system.] [Assessment Boundary: Assessment is limited to the interactions of two systems at a time.]

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. [Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.] [Assessment Boundary: Assessment does not include molecular explanations.]

Science & Engineering Practices

Focus SEP: Developing and Using Models

Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.

- Develop and/or use models to describe and/or predict phenomena.

Background SEP: Planning and carrying out investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.

- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.

Background SEP: Constructing explanations

Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.

- Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
- Identify the evidence that supports particular points in an explanation.

Disciplinary Core Ideas

Focus DCI: LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. (5-LS2-1)

Crosscutting Concepts

Focus CCC: Systems and System Models – A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.
- A system can be described in terms of its components and their interactions.

Background CCC: Cause and Effect: Mechanism and Explanation – Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

- Cause and effect relationships are routinely identified, tested, and used to explain change.

Virginia Standards of Learning (SOLs) alignment

Science & Engineering Practices	
6.1 (e)	Developing and using models. The student will… • use, develop, and revise models to predict and explain phenomena • evaluate limitations of models
6.1 (b)	Planning and carrying out investigations. The student will… • independently and collaboratively plan and conduct observational and experimental investigations; identify variables, constants, and controls where appropriate, and include the safe use of chemicals and equipment • take metric measurements using appropriate tools
6.2 (d)	Constructing and critiquing conclusions and explanations. The student will… • construct explanations that includes qualitative or quantitative relationships between variables • construct scientific explanations based on valid and reliable evidence obtained from sources (including the students' own investigations)
Content Standards	
6th Grade 6.9(c)	6.9 The student will investigate and understand that humans impact the environment and individuals can influence public policy decisions related to energy and the environment. Key ideas include c) major health and safety issues are associated with air and water quality
Life Science LS.2(c)	The student will investigate and understand that all living things are composed of one or more cells that support life processes, as described by the cell theory. Key ideas include c) similarities and differences between plant and animal cells determine how they support life processes

Common Core State Standards alignment

Literacy Standards	
RST.6-8.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
RST.6-8.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
WHST.6-8.1	Write arguments focused on discipline-specific content.
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
Math Standards	
MP.3	Construct viable arguments and critique the reasoning of others.
6.RP.A.3	Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.
6.SP.B.5	Summarize numerical data sets in relation to their context

5E Module Flow

Activity 1 (Engage): Introducing Tatiana & Calvin
Timing: 30-45 minutes
Purpose: Introducing the anchor phenomenon

- ✓ Students will ask questions to build understanding of the phenomenon
- ✓ Students will be able to describe the symptoms related to the phenomenon (asthma)
- ✓ Students will make connections to local asthma health statistics

Activity 2 (Explore): Breathing & Exercise
Timing: 45-60 minutes
Purpose: Making connections between the respiratory and circulatory systems

- ✓ Students will recognize a connection between breathing and heart rate, especially as related to exercise

Activity 3 (Explain): The Respiratory & Circulatory Systems
Timing: 45 minutes
Purpose: Building understanding of how the respiratory system works

- ✓ Students will know the main parts of the human respiratory system and what they are for
- ✓ Students will know the main parts of the human circulatory system and what they are for
- ✓ Students will know critical facts about the human respiratory system, ex. that oxygen is the gas in the air we need, and carbon dioxide is the gas we need to get rid of

Activity 4 (Explain): Modeling the Respiratory & Circulatory Systems
Timing: 45 minutes
Purpose: Creating a model of the respiratory and circulatory systems

- ✓ Students will create a model to show how the respiratory and circulatory systems connect to each other
- ✓ Students will use their models to explain how oxygen gets from the environment to all the cells of our bodies

Activity 5 (Explore): Seeing Ozone's Effects on Living Things
Timing: 30-45 minutes
Purpose: Understanding how pollution hurts living things

- ✓ Students will make connection between gases in the air (particularly ozone) and damage to delicate parts of living things

Activity 6 (Explain): Air Pollution & Humans
Timing: 30-45 minutes
Purpose: Adding pollution to models of the respiratory and circulatory systems

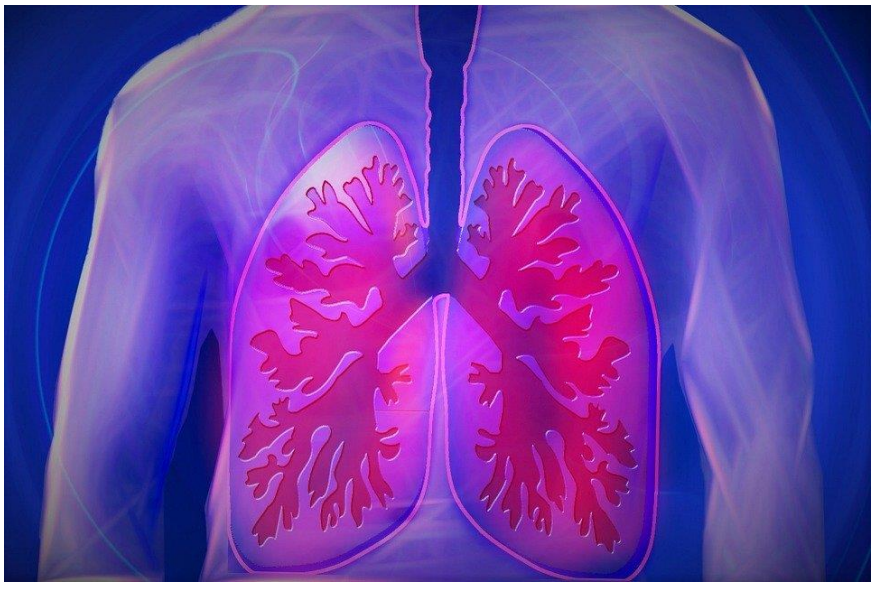
- ✓ Students will learn additional details about how pollution affects the human body
- ✓ Students will add pollution to their models of the respiratory/circulatory systems

Activity 7 (Elaborate): Asthma & the AQI
Timing: 30-45 minutes
Purpose: Learning how to live safely with asthma

- ✓ Students will learn how to determine if the air quality on a given day is bad
- ✓ Students will learn about how a treatment for asthma (inhaler) works

Activity 8 (Evaluate): Modeling Air Pollution & Human Health
Timing: 30-45 minutes
Purpose: Evaluating student understanding

- ✓ Students will use a model to describe the path that oxygen takes to get to cells.
- ✓ Students will label critical parts of the model.
- ✓ Students will explain the cause & effect relationship between asthma and air pollution using the model



Module Materials

Activity 1 (Engage): Introducing Tatiana & Calvin

- ❒ Handouts: Patient Record (teacher & student versions), KWL chart
- ❒ Materials needed: Projector & speakers, anchor chart paper and markers

Activity 2 (Explore): Breathing & Exercise

- ❒ Handouts: Experiment procedure & data collection sheet
- ❒ Materials needed: thin straws ~¼" diameter (one per pair of students), timer (one per group or one for the whole class)
- ❒ Optional materials: stethoscopes (one per pair of students) and cleaning wipes

Activity 3 (Explain): The Respiratory & Circulatory Systems

- ❒ Handouts: Respiratory system diagram (labeled & unlabeled)
- ❒ Materials needed: Computer & projector
- ❒ Optional materials: student computers (recommended), headphones (or speakers) for video, red & blue or purple colored pencils/markers

Activity 4 (Explain): Modeling the Respiratory & Circulatory Systems

- ❒ Handouts: N/A
- ❒ Materials needed: student notebooks/paper
- ❒ Optional materials: speaker (for video)

Activity 5 (Explore): Seeing Ozone's Effects on Living Things

- ❒ Handouts: Leaf Investigation lab sheet
- ❒ Materials needed: projector
- ❒ Optional materials: microscopes, ozone-damaged leaves, leaf-mount slide materials (slide, cover slip, dropper, scotch tape), computers

Activity 6 (Explain): Air Pollution & Humans

- ❒ Handouts: N/A
- ❒ Materials needed: KWL chart (from Activity 1), student models (from Activity 4), projector

Activity 7 (Elaborate): Asthma & the AQI

- ❒ Handouts: Understanding the AQI handout
- ❒ Materials needed: N/A
- ❒ Optional materials: students smartphones (if permitted), projector

Activity 8 (Evaluate): Modeling Air Pollution & Human Health

- ❒ Handouts: Summative assessment, scoring guide
- ❒ Materials needed: N/A

Teacher Background Information

Air Pollution & Exercise
American Lung Association, April 2000

WHO IS VULNERABLE

Millions of Americans live in areas where the air carries not only life-giving oxygen, but also noxious pollutants that reach unhealthful levels, such as ozone, carbon monoxide, fine particles, sulfur dioxide, nitrogen dioxide, or lead.

Exercise makes us more vulnerable to health damage from these pollutants. We breathe more air during exercise or strenuous work. We draw air more deeply into the lungs. And when we exercise heavily, we breathe mostly through the mouth, by-passing the body's first line of defense against pollution, the nose.

HOW AIR POLLUTION AFFECTS YOUR BODY

Our lungs are among the body's primary points of contact with the outside world. We may drink two liters of liquid each day. We breathe in an estimated 15,000 liters of air, approximately 6 to 10 liters every minute, drawing life-giving oxygen across 600 to 900 square feet of surface area in tiny sacs inside the lung.

Oxygen is necessary for our muscles to function. In fact, the purpose of exercise training is to improve the body's ability to deliver oxygen. As a result, when we exercise, we may increase our intake of air by as much as ten times our level at rest.

An endurance athlete can process as much as twenty times the normal intake. Mouth breathing during exercise by-passes the nasal passages, the body's natural air filter. These facts mean that when we exercise in polluted air, we increase our contact with the pollutants, and increase our vulnerability to health damage.

The interaction between air pollution and exercise is so strong that health scientists typically use exercising volunteers in their research.

MINIMIZE YOUR RISK: MANAGE YOUR EXERCISE

The news isn't all bad. You can minimize your exposure to air pollution by being aware of pollution and by following some simple guidelines: If you live in an area susceptible to air pollution, here's what you should do:

- Do train early in the day or in the evening.
- Do avoid midday or afternoon exercise, and avoid strenuous outdoor work, if possible, when ozone smog or other pollution levels are high.
- Do avoid congested streets and rush hour traffic; pollution levels can be high up to 50 feet from the roadway.
- Do make sure teachers, coaches and recreation officials know about air pollution and act accordingly.
- Most important, do be aware of the quality of the air you breathe!

Don't do the following:

- Don't take air pollution lightly, it can hurt all of us!
- Don't engage in strenuous outdoor activity when local officials issue health warnings.

Source: http://www.lungusa.org/site/pp.asp?c=dvLUK9O0E&b=36292

Children & Ozone Air Pollution Fact Sheet
American Lung Association, September 2000

While exposure to ozone air pollution causes adverse health effects in most people, children are especially susceptible to these effects. Children spend significantly more time outdoors, especially in the summertime when ozone levels are the highest.

National statistics show that children spend an average of 50 percent more time outdoors than do adults.

A recent study conducted by the American Lung Association shows that as many as 27.1 million children age 13 and under, and over 1.9 million children with asthma are potentially exposed to unhealthful levels of ozone based on the new 0.08 ppm, eight-hour ozone level standard.

Minority children are disproportionately represented in areas with high ozone levels. Approximately 61.3% of black children, 69.2% of Hispanic children and 67.7% of Asian-American children live in areas that exceed the 0.08 ppm ozone standard, while only 50.8% of white children live in such areas.

Children spend more time engaged in vigorous activity (i.e., exercise). Such activity results in breathing in more air, and therefore more pollution being taken deep into the lungs. A California study found that children spend three times as much time engaged in sports and vigorous activities as adults do.

Children have a higher breathing rate than adults relative to their body weight and lung surface area. This results in a greater dose of pollution delivered to their lungs. Most biological air pollution damage is related to the dose of pollution inhaled in relation to the body weight and surface area of the target organ.

Even when children experience significant drops in lung function, they do not seem to suffer or report some of the acute symptoms, such as coughing, wheezing or shortness of breath, associated with ozone exposure in adults. Thus, children are not likely to receive or may not understand the biological warnings to reduce their ozone exposure by stopping their exercise or moving indoors.

Children have narrower airways than do adults. Thus, irritation or inflammation caused by air pollution that would produce only a slight response in an adult can result in a potentially significant obstruction of the airways in a young child.

During exercise, children, like adults, breathe with both their nose and mouth rather than just their noses. When the nose is by-passed during the breathing process, the filtering effects of the nose are lost, therefore allowing more air pollution to be inhaled.

Air pollution, including ozone, can result in more frequent respiratory infections in children due to impairment of the lung's ability to defend itself. Scientists are concerned that children who experience more frequent lower respiratory infections may be at greater risk of lower-than-normal lung function later in life.

When ozone levels are high, children should avoid calisthenics, soccer, running and other strenuous outdoor exercise. They should be encouraged to participate in less strenuous activities such as recreational swimming, swinging or indoor activities such as floor hockey and gymnastics instead.

Source: http://www.lungusa.org/site/pp.asp?c=dvLUK9O0E&b=44567

Additional resources

Asthma:

- General asthma information (source: Mayo Clinic): https://www.mayoclinic.org/diseases-conditions/asthma/symptoms-causes/syc-20369653

Respiratory System:

- Structure and function (source: BBC) https://www.bbc.co.uk/bitesize/guides/z3xq6fr/revision/1

Circulatory System:

- How oxygen is delivered from the lungs to cells in the body (source: CK-12) https://www.ck12.org/c/life-science/breathing/lecture/Gaseous-Exchange/

Air Pollution & Human Health:

- PM2.5 and the Respiratory System: https://www.youtube.com/watch?v=QcS3ovdsgNI