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

Module Contents

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 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.
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).
WHST.6-8.1	Write arguments focused on discipline-specific content.
SL.8.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.
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: 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: 45-60 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 and how to help someone who is having an asthma attack

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, Claim Evidence Reasoning summary
- ❒ 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, graph paper

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, vacuum cleaner hose

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: Asthma Attacks: Cause & Effect
- ❒ 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: American Lung Association, Air Pollution & Exercise.

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: American Lung Association.

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

Activity 1 (Engage): Introducing Tatiana & Calvin

ACTIVITY DETAILS

Time: 30-45 minutes

Objectives

- ✓ 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

Materials

- ✓ Projector & speakers (for video)
- ✓ Anchor chart paper and markers
- ✓ Local asthma data posters

Handouts

- ✓ Patient Record (teacher and student versions)
- ✓ KWL Chart

Teacher Tip

- ✓ If students who have asthma volunteer to play the roles of Tatiana and Calvin, it may make it easier for them to answer questions, but remind them that they are playing a role and should not share their personal health information.

Activity summary: Students are introduced to the anchor phenomenon for the unit: two young people who occasionally have difficulty breathing. They also share background knowledge and develop questions to explore. Finally, they examine local youth asthma statistics to understand the risk asthma poses to their communities.

Standards Connection

SEP: Asking Questions & Defining Problems
CCC: Cause & Effect

Before the activity: One option for the role play portion of this activity is to have 1 or 2 students play Tatiana and Calvin. You will need to identify students who can play these roles in advance and prepare them by giving them the Teacher Guide Patient Records, and explaining to them how to answer students' questions. See the Teacher Tip in the sidebar for additional suggestions about the students.

A second option, if you do not have students who can play Tatiana or Calvin (or you prefer not to do the role play), is to do the warmup and Step 1 of the activity, then show the first part of the video "Between Life & Breath" as an introduction to the patient: https://www.youtube.com/watch?v=OCosTBwG4Pg. Stop the video at 4:30 (before it begins to talk about asthma) and have students chart the symptoms that they see in the video. Then jump ahead to Step 4 of the activity and continue as normal.

A note about role-playing

Students will be excited about taking part in the role play if you are excited and invested in it. Think about ways you can make it more authentic for students. For example, wear scrubs to work (if allowed) and put up signs in the classroom indicating that they are in a medical facility.

Warmup: What questions do doctors ask their patients?

- Possible answers: how are you feeling? What hurts? When does it hurt? etc.
- The purpose of this warmup is to prepare students for the Q&A coming up in step 3 of the activity.

1. **Frame the activity:** Tell students that today they are starting a new investigation where they will act as doctors to help one or two young people who have a common medical problem. In a moment, you will introduce them to the "patients", and the students will have the opportunity to ask them questions about their medical issue. Throughout the investigation, they will use medical thinking to study their patients' problem.

2. **Introduce Tatiana & Calvin:** Pass out the blank "Patient Record" sheet to students and tell them that their first job is to learn what symptoms their patients have. Bring your "patients" up to the front and have them share their names (they should also bring their completed copies of their patient records for reference if they need them). If you have two student volunteers, divide the class into two groups and have each group work with one patient.

3. **Chart symptoms:** Have students fill in the top line of information on their charts. Then have students take turns asking Tatiana/Calvin questions to learn more about what's bothering them. Encourage students to take on the role of doctors as they talk to their patients. Have them think about good follow up questions that a doctor would ask. If they ask Tatiana or Calvin a question they don't know the answer to, have them write down the question on their charts.
    - Symptoms students should uncover: coughing, difficulty breathing, difficulty exercising, wheezing, high heart rate, on some days it's worse than others
    - Students *may* also uncover: they live in a city, near a road that has lots of trucks, they like to play outside, and their symptoms are worse during the summer. If students don't uncover these now, they will have a chance later in the module.

    After students have completed their medical interviews, thank Tatiana and Calvin and have them return to their seats. Have students share what they learned as a whole class, and record the symptoms and information on anchor chart. If there are unanswered questions (unknown answers), write them down as well.

4. **Preliminary diagnosis & KWL Chart.** Ask students to consider what their diagnosis might be. They will likely say that they think Tatiana and Calvin have asthma (if not, you can ask prompting questions to lead them this way). Have them add this preliminary diagnosis to the bottom of their Patient Record sheets. Also ask them what they think might be causing their asthma attacks. Depending on what students know about asthma, they may or may not have ideas about what brings on an asthma attack. Have them add any ideas they have to their preliminary diagnosis.

TEACHER NOTES

Extension

✓ If time permits, and you have stethoscopes for Activity 2, you can have students take Tatiana and Calvin's heart rate (in anticipation of the next activity)

Teacher Tip

✓ Students with asthma (or who have a close friend or relative with asthma) will likely be engaged with the phenomenon quickly, but others may not be. Use the KWL chart and the local asthma data to help these students to develop curiosity about additional aspects of the phenomenon such as how your lungs work and why certain communities are affected more than others to get them engaged in the module.

TEACHER NOTES

Modifications

- ✓ Have students make their own KWL charts in their notebooks.

Differentiation

- ✓ Create KWL charts with sentence starters or with a few responses already written.

Virginia Asthma Rates

- ✓ Asthma rates in Virginia are below the national average. If you live in Virginia, it may be worthwhile to also share the rates in DC as a way to highlight the problem

Pass out the student KWL charts. On a class KWL chart, write Asthma & Breathing at the top, and have students do the same on their charts. Give students a few minutes to write things on their own charts about what they know and want to know about asthma and breathing. If they are not sure what to write about asthma, remind them that they know some things about breathing, and what might cause someone to have of difficulty breathing. If they don't have things they want to know, push them on whether they know what causes an asthma attack or how your lungs work. Have students share what they know and want to know, and add them to the class chart. Next, have students write things that they would like to learn about Tatiana and Calvin or about asthma and breathing.

Make sure not to provide additional information about asthma to students at this stage of the module. As students develop questions, their curiosity will grow. In the activities ahead, they will develop their own explanations about asthma and their diagnosis.

Sample KWL Chart

Asthma & Breathing		
Know	Want to Know	Learned
Asthma has to do with your lungs People with asthma use an inhaler People with asthma cough a lot People with asthma sometimes can't breathe	Where do you get asthma from? Is asthma contagious? What does an inhaler do? Why is it hard for Tatiana and Calvin to breathe?	

5. **Local asthma data:** Ask students if they think asthma is a problem for kids or other people in their neighborhood (be mindful not to ask students for personal health information, but leave the door open for them to make a personal connection). Tell them that as medical professionals, it is their job to investigate whether conditions like asthma are problems in their communities.

Choose one or more sets of local asthma statistics from the posters below that you think will be most relevant to students. Share them with either by projecting them where all students can see, or putting them up on signs around the room.

Have students read the poster(s) and talk with a partner about how they feel about the statistics. Then have partners share out what they talked about with the class. Use this as an opportunity to point out that asthma is a problem not just for individual patients like Tatiana and Calvin, but also for whole communities. Have students add any additional information from the statistics to their KWL charts in the "Learned" column, and any new questions they have to the "Want to Know" column. Push students to think about why asthma might be worse in some places compared to others.

Tell students that they will come back to this KWL chart throughout the investigation as they learn additional information about asthma.

6. **Formative assessment**: Collect students' KWL charts, or circulate around the room and mark down who has completed their chart. Have students share a question that they are particularly interested in learning the answer to during their investigation.

Air Quality Champion

Dr. Janet Phoenix is an Assistant Research Professor at George Washington University. She also works closely with families in DC to help children with asthma. Read the interview at the end of the module to learn more about Janet and her amazing work.

TEACHER NOTES

Teacher Background Knowledge

- ✓ For an excellent (and disturbing) report on the relationship among poverty, race, location, and asthma in Baltimore, read this article from the Capital News Service: https://cnsmaryland.org/2017/12/04/baltimores-asthma-hot-spot-is-poor-african-american-neighborhood-with-lots-of-empty-houses/

Recommended

- ✓ Have students read the interview with this module's Air Quality Champion to help them understand the people who keep us safe from air pollution and the kinds of work that they do.

STUDENT HANDOUT

Patient Record

Today's Date	**Doctor's Name**
Patient Name	
Age	**Height**
Heart symptoms	
Respiratory symptoms	
Digestive symptoms	
Additional information (ex. other aches and pains, home/neighborhood information, exposure to chemicals or other hazards, etc.)	
Medications taken	
Preliminary Diagnosis	

TEACHER GUIDE

Patient Record

Today's Date	**Doctor's Name**
Patient Name Tatiana Eliza	
Age	**Height**

Heart symptoms

- Heart races sometimes, especially when running

Respiratory symptoms

- Gets very hard to breathe sometimes
- Coughing
- Can't talk when it's hard to breathe

Digestive symptoms

- none

Additional information (ex. other aches and pains, home/neighborhood information, exposure to chemicals or other hazards, etc.)

- Tightness in chest
- Lives in the city near a road that has a lot of trucks
- Symptoms are worse in the summer

Medications taken

- none

Preliminary Diagnosis

- Asthma attack

TEACHER GUIDE

Patient Record

Today's Date	**Doctor's Name**
Patient Name Calvin Robertson	
Age	**Height**

Heart symptoms

- High heart rate when he has a hard time breathing

Respiratory symptoms

- Gets very hard to breathe sometimes
- Coughing
- Wheezing

Digestive symptoms

- none

Additional information (ex. other aches and pains, home/neighborhood information, exposure to chemicals or other hazards, etc.)

- Lives in the city near a big highway
- Likes to play outside
- Symptoms are worse in the summer

Medications taken

- Uses an inhaler

Preliminary Diagnosis

- Asthma attack

STUDENT HANDOUT

Name _____

Know	Want to Know	Learned

CLASSROOM POSTER

Washington, D.C. Asthma Statistics

- 31% of teenagers in D.C. have asthma compared to 21% nationally

- Students of color in DC are far more likely to have asthma than white students

Black = 32.1%
American Indian = 33.6%
Hispanic = 28.8%
White = 20.5%

Source: DC Health Matters: https://www.dchealthmatters.org/indicators?keywords=asthma

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Virginia Asthma Statistics

- 6% of Virginia students visited an ER or urgent care because of asthma in 2013.

- 6.9% of children under 17 in Virginia had asthma in 2016, which is below the national average of 7.5%

Source: Virginia Department of Health: https://www.vdh.virginia.gov/asthma/asthma-infographic/; https://www.vdh.virginia.gov/content/uploads/sites/94/2018/11/Asthma-Burden-Report_Final_102320181.pdf

CLASSROOM POSTER

Baltimore, MD Asthma Statistics

- 28% of high school students in Baltimore City reported having been diagnosed with asthma in their lifetime, compared to 20% of students nationwide in 2007.
- 20% of Baltimore City children under 18 have asthma, which is more than twice the national average (9.4%)
- Baltimore's pediatric asthma hospitalization rate is the highest in Maryland and one of the highest in the nation.

Source: Baltimore City Health Department
https://health.baltimorecity.gov/node/454#:~:text=%20Baltimore%20City%20children%20under%2018,%E2%80%8Bthe%20highest%20in%20the%20nation.

Maryland Asthma Statistics

- Lifetime asthma prevalence in Maryland children showed an increase of approximately 54.7% from 2001 to 2010.
- The child lifetime asthma prevalence is significantly higher in Maryland vs. the United States (16.4% vs. 12.6%).

Source: Maryland Department of Health and Mental Hygiene
https://phpa.health.maryland.gov/mch/Documents/Asthma%20in%20Maryland%202012.pdf

CLASSROOM POSTER

National Asthma Statistics

- Asthma accounts for the greatest loss of productivity either through missed work days or school absenteeism.

- Nationally, it is estimated that 10 million work days and almost 14 million school days are missed each year due to asthma.

- About 6 million children (1 in 12) ages 0-17 have asthma.

Sources: Baltimore City Health Department: https://health.baltimorecity.gov/news/blog-post/2015-05-14-let%E2%80%99s-talk-about-how-b%E2%80%99more-asthma-aware#:~:text=Asthma%20accounts%20for%20the%20greatest,each%20year%20due%20to%20asthma.
US Centers for Disease Control & Prevention: https://www.cdc.gov/vitalsigns/childhood-asthma/index.html#:~:text=1%20in%2012.,to%20about%205%25%20in%202013.

Activity 2 (Explore): Breathing & Exercise

Activity summary: In this activity, students investigate the connection between the respiratory system and circulatory system by doing a set of experiments involving measuring heart rate and breathing.

Standards Connection

DCI: LS 1.A: Structure & Function
SEP: Planning & Carrying Out Investigations
CCC: Cause & Effect

Warmup: When have you gotten out of breath before?

- Students may say things like: when they exercise, when they climb a lot of stairs, when they're tired, etc.
- This warmup is designed to help students begin to make a connection with the experience of having an asthma attack

1. **Frame the activity:** Tell students that you are going to look back at some of the questions they created during our last activity. Use the KWL chart to bring up questions such as:
   - Why is it hard for Tatiana and Calvin to exercise?
   - Why do you get out of breath?
   - What happens to your body when you exercise?

   While it is impractical to have students design this whole experiment from scratch, they likely have ideas about how they could use experiments to answer these questions. Use the strategies below to help them refine these ideas:
   - Ask students how they could possibly test how your body reacts to exercise. If they suggest doing exercises, ask what kind of exercise they could do in a classroom. Write down these answers on the board to save for Test 2 & Test 4.
   - Ask what kinds of measurements they could take to see how your body reacts to exercise and asthma. They will likely include heart rate, and possibly breathing in some way.
   - Ask how they could simulate what it's like to have asthma. They may not suggest using a straw to limit air intake, but they may have some equally interesting suggestions.

   While students respond to your prompts, use follow up questioning to help guide their thinking (ex. what data can you collect about breathing?). You will likely be able to help them come up with ideas that match or are similar to the tests you have planned.

ACTIVITY DETAILS

Time: 60 minutes

Objectives

- ✓ Students will make a connection between breathing and heart rate, especially as related to exercise
- ✓ Students will recognize that shortness of breath can make it hard to exercise

Materials

- ✓ Thin straws (diameter approx. ¼ inch) – cut in half
- ✓ Timer (one per group or one for whole class)
- ✓ Stethoscope (optional) and cleaning wipes/alcohol

Handouts

- ✓ Experimental procedure and data collection sheet
- ✓ Claim-Evidence-Reasoning Summary

TEACHER NOTES

Differentiation & Accessibility

- ✓ Choose partners carefully so that students with needs (physical and/or cognitive) can support one another

Safety tips

- ✓ Wipe down stethoscopes with alcohol wipes after using
- ✓ Monitor students for any signs of difficulty breathing, especially during Test 4, to ensure their safety.

Modifications

- ✓ If you only have one timer, use a class timer on the projector or use a watch, and have all groups start and stop at the same time for both the breathing and the 30 seconds afterwards.
- ✓ If student computers are available, have students record their data in a Google spreadsheet to more easily share later on.

After students have had a chance to share their experiment ideas, tell them that they are going to do a set of experiments today like the ones they suggested. The experiments will help to answer some of these questions they had about Tatiana and Calvin by measuring their heart rate and their breathing. These are two ways to see how our body reacts to something like exercise.

2. **Introduce the experiment.** Start by sharing the main details of the experiments with students: they will be working in pairs to conduct four different tests using two different variables: resting or exercising and breathing normally or breathing through a straw (to simulate having asthma). Because there are two different variables they are testing, there are four different combinations. You may want to show them this chart or make one of your own to show the different tests.

	Resting	Exercising
Breathing normally	**Resting Breathing normally**	**Exercising Breathing normally**
Breathing through straw	**Resting Breathing through straw**	**Exercising Breathing through straw**

One student in each pair will be the participant, and the other will be the data collector. For each test, the participant will do the test while the data collector counts breaths, and measures heart rate afterwards. Assign student partners, and hand out the experiment procedure and data collection sheets.

NOTE: Breathing through a straw and exercising can be physically challenging for students. Students who have respiratory issues such as asthma should be the data collector for this experiment.

Students should not have a problem counting their breaths, but they may need practice measuring heart rate. If you have stethoscopes to use, this will make it easier. If not, have partners wrap their whole hand lightly around their partners' wrist. They should be able to feel a heartbeat. It may be helpful to do a practice round of data collection with students before starting the experiment.

3. **Test 1 (resting, no straw).** Hand out any additional materials such as stopwatches. Then review steps 1-3 of the procedure with students. When all students are ready to start, begin testing. Monitor students and support as necessary.

4. **Test 2 (exercise, no straw).** For this test, you will need to decide as a class what the "exercise" will be. Use suggestions from the framing part of the activity as a starting point. The exercise can be jumping jacks, jogging in place or any moderately strenuous exercise. Consider the capability of students in the class and any disabilities when choosing. Remind students that they will need to count breaths while doing the exercise so it shouldn't be overly complicated. Review steps 4-5 with students, then monitor and support as necessary.

5. **Pool data & review**. Have the class pool their data for Tests 1 & 2 either by writing it on the board, or by using a spreadsheet that is projected. Calculate averages for breathing and heart beats for each test and have students record the class data on the "Summary of Class Data" page of their data sheet. Have students answer the first two questions at the bottom of the sheet (When was heart rate fastest? When did they take the most breaths?) and review together as a group. If possible (based on the data), help students make a connection back to the opening questions: ex. when you exercise, your body takes more breaths and your heart beats faster.

6. **Test 3 (resting, with straw)**. Hand out straws to Partner As. Ask students what they might be trying to understand by using the straws (i.e., understanding what happens to your body when you don't get as much air). Review steps 6-7 with students, then monitor and support as necessary while they conduct the test. Be sure to remind students that they should only breathe through the straw (not their nose)

7. **Test 4 (exercising, with straw).** Review steps 8-9 with students, then monitor and support as necessary while they conduct the test. This test may be strenuous for students, so tell them that they can slow down their exercise if necessary, and they can stop if they don't feel well. Student safety is a priority.

8. **Pool data & review.** Have the class pool their data for Tests 3 & 4 the same way they did with Tests 1 & 2. Calculate averages and have students write them on their data sheets. Then have them answer the rest of the questions below with their partners. Students will likely see that they have higher heart rates and take more breaths when they exercise vs. not exercising, and they have higher heart rates and take more breaths when breathing through a straw vs. not. The highest heart rates and breathing will likely be while exercising and breathing through a straw. After students

TEACHER NOTES

Modification

✓ Before having students pool data with the whole class, have each pair get together with another pair to compare their data. Is it similar or different? Have them think about why it might be similar or different.

Graphing

✓ This experiment does not require a lot of complex data analysis that requires graphing, but it is a good opportunity for students to practice graphing their own data. If you would like, have students create bar graphs of their data (or the class data) from their four experiments to help with the analysis.

TEACHER NOTES

Extension

- ✓ If time permits, have students discuss other variables they could test to build further understanding what makes asthma worse (does temperature matter? Does being inside or outside matter? etc.) Even if students don't have time to do the tests, it will help build their scientific investigation skills.

Modification

- ✓ If the Claim-Evidence-Reasoning (CER) structure is new to students, this would be a good time to go over the structure and write this CER together as a class. You can also provide one or two of the pieces and have students write the other parts.

have answered the questions, lead a short discussion to summarize the results.

9. **Class discussion.** Return to the questions you considered at the beginning of class (ex. Why do Tatiana and Calvin have a hard time running or exercising?) Lead students through a group discussion to strengthen their understanding of the answers to these questions. Some key takeaways are:
    - **Your breathing rate goes up when you exercise because your body needs more air (oxygen).** Students may or may not know that they need the oxygen to get energy from the food they eat, but you can mention that the human body uses this oxygen to get energy for everything it does.
    - **Your heart rate increases when you get less air and when you exercise.** Students may know that your heart helps to deliver air (oxygen) to your body by pumping your blood which is carrying the oxygen, so when you have less air, you need to deliver it faster. If not, they will learn more about the connection between oxygen and how your body gets it in the next activity.

10. **Return to the KWL chart:** Have students take out the KWL charts they created in Activity 1 and display the class KWL chart you made. Have students identify anything new they've learned that helps them to understand the phenomenon. For example: your heart rate and your breathing rate are connected. Add any new learning to your chart while they add it to theirs.

11. **Formative assessment**. Hand out the Claim Evidence Reasoning (CER) summary sheet for students. Have them use the CER structure to write an answer to one of the questions using their data. You may want to choose which question they will answer (you can also choose another one). A possible CER response to the question: "Why is it hard for Tatiana and Calvin to exercise?" could be:
    - Claim: It is hard for Tatiana and Calvin to exercise because when you exercise your body needs more air and they can't get enough air because they can't breathe well (like the small straw).
    - Evidence: Our breathing rates were higher in Test 2 & 4 when we were exercising. It was hardest to exercise in Test 4 when we had to use the straw.
    - Reasoning: Your body needs air to exercise, and if you can't get enough air because you have trouble breathing, then it makes it hard to exercise.

Name _____

STUDENT HANDOUT

Experiment Procedure: Exercise & Breathing

Materials:

- Small straw (one for each person participating)
- Timer
- Stethoscope (optional) with cleaning wipes
- Data sheet

Procedure:

1. Decide which partner in your group will be participating in the experiment (A) and which partner will be collecting the data (B). Partner A will be performing the tests, while Partner B collects information from Partner A. Write your names on your data sheet.

<u>Test 1: Resting. No Straw</u>

2. Find the place on your data sheet that says "Test 1." You will write down your data for the first part of the experiment here.

3. For this test, Partner A will breathe normally. While they are breathing, both partners should count the number of breaths they take in 30 seconds. Partner B will use the timer to keep track of the time. **As soon as 30 seconds is finished**, record the number of breaths and start counting heartbeats for Partner A using a stethoscope or holding your partner's wrist. Begin the test when you are ready.

<u>Test 2: Exercising, No Straw</u>

4. Find the place on your data sheet that says "Test 2." You will write down all your data for this part of the experiment here.

5. This test is the same as Test 1, except this time Partner A will exercise using the method chosen by the class. Like the other tests, count breaths for 30 seconds during the test, and count heartbeats for 30 seconds after the test. Record your data as soon as you are finished.

Test 3: Resting, With Straw

6. Find the place on your data sheet that says "Test 3." You will write down all your data for this part of the experiment here.

7. This test is the same as Test 1, except this time Partner A will breathe through a straw. Partner A should make sure to only breathe through the straw and not their nose. Like the last test, count breaths for 30 seconds during the test, and count heartbeats for 30 seconds after the test. Record your data as soon as you are finished.

Test 4: Exercising, With Straw

8. Find the place on your data sheet that says "Test 4." You will write down all your data for this part of the experiment here.

9. This test is the same as Test 3, except this time Partner A will exercise. Like the other tests, count breaths for 30 seconds during the test, and count heartbeats for 30 seconds after the test. Record your data as soon as you are finished.

STUDENT HANDOUT

Data Sheet: Exercise & Breathing

Partner A Name: _____

Partner B Name: _____

No Straw

	Breaths in 30 seconds	Heart beats in 30 seconds
Resting	Test 1	Test 1
Exercising	Test 2	Test 2

With Straw

	Breaths in 30 seconds	Heart beats in 30 seconds
Resting	Test 3	Test 3
Exercising	Test 4	Test 4

Summary of Class Data

No Straw – Class Averages

	Breaths in 30 seconds	Heart beats in 30 seconds
Resting	Test 1	Test 1
Exercising	Test 2	Test 2

With Straw – Class Averages

	Breaths in 30 seconds	Heart beats in 30 seconds
Resting	Test 3	Test 3
Exercising	Test 4	Test 4

Compare your data for tests 1 with test 2 (resting vs. exercise). When was Partner As heart rate the fastest? _____

When did Partner A take the most breaths? _____

Compare your data for test 3 with test 4 (resting vs. exercise). When was Partner As heart rate the fastest? _____

When did Partner A take the most breaths? _____

Compare your data for test 1 with test 3 (straw vs. no straw). When was Partner As heart rate the fastest? _____

When did Partner A take the most breaths? _____

Compare your data for test 2 with test 4 (straw vs. no straw). When was Partner As heart rate the fastest? _____

When did Partner A take the most breaths? _____

Name_____

STUDENT HANDOUT

Claim-Evidence-Reasoning

Use the data from your experiments today to write a Claim-Evidence-Reasoning argument to answer one of the questions below:

- Why is it hard for Tatiana and Calvin to exercise?
- Why do people get out of breath?
- What happens to your body when you exercise?

Your claim should answer the question. Your evidence should come from your experiment data, and your reasoning should be based on what you know about how the human body works.

Claim:

Evidence:

Reasoning:

Activity 3 (Explain): The Respiratory & Circulatory Systems

ACTIVITY DETAILS

Time: 45 minutes

Objectives

- ✓ 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

Materials

- ✓ Computer & Projector
- ✓ Student computers (recommended)
- ✓ Headphones for students (for video) or speakers
- ✓ Red & blue (or purple) colored pencils or markers (optional)
- ✓ Vacuum cleaner hose (optional)

Handouts

- ✓ Respiratory and Circulatory Systems (diagram and graphic organizer) w/ teacher guide

Activity summary: In this activity, students use an online simulation to build background knowledge of how the respiratory and circulatory systems interact. They then use this information to compare and contrast the two systems using a Venn diagram.

Standards Connection

DCI: LS 1.A: Structure & Function
CCC: Systems & System Models

Warmup: Why do we need to breathe?

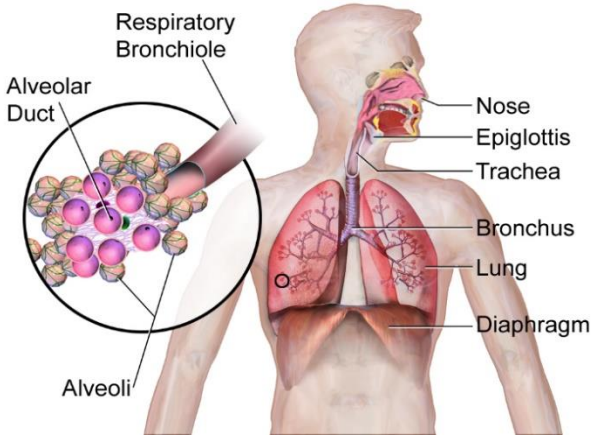
- This seemingly simply question can have answers that range from the basic ("to get air") to the complex ("to bring in oxygen that our cells need to get energy from food and remove carbon dioxide that our cells need to get rid of). The goal of this warmup is to activate students' background knowledge and get a survey of what they already know before the activity.

1. **Frame the activity:** Tell students that understanding what is happening to Tatiana and Calvin means we need to understand what's happening when air goes into their bodies. In this activity, they will build that understanding by learning more about human body systems.

2. **Charting background knowledge.** Use the warmup to hold a short discussion with students about what they already know about the respiratory system. Add these details to the class KWL chart they made in Activity 1 (and their individual charts if they have them). Students may already know things like "lungs are in the respiratory system" and "you breath oxygen and breathe out carbon dioxide." Limit the chart to what students already know. Be sure to use questions to determine students' understanding of the idea that the respiratory system is made of individual organs such as the lungs and trachea, and why it is called a "system" (because it is made of parts (organs) that work together).

3. **Organs of the respiratory system.** Hand out the Respiratory and Circulatory Systems sheet to students. Display the diagram of the respiratory system (below) where all students can see it, and go over the organs. If students already know some organs, start with the ones they know. Have students label their own diagrams as you go. NOTE: Some parts of the system have been left labeled because they are less critical for students to

memorize. Use the organ/organ system language when describing the parts to help students internalize the "organs make up an organ system" concept.



Source: https://upload.wikimedia.org/wikipedia/commons/e/e7/Respiratory_System_%28Illustration%29.png

4. **Lung attack simulation.** Have students take out their KWL charts from Activity 1, and tell them that they are going to use a simulation to learn more about how humans breathe. As they watch the simulation, they should add things they learned to the "Learned" section of their KWL chart (if they run out of room they can start on the back or get another KWL chart). Pass out student computers (if available) and have them complete the "Normal Breathing" section of the Lung Attack simulation found here: http://web1.pima.gov/deq/lungattack/lungplay.htm. If student computers are not available, you can run the simulation together using a projector.

   After students have completed the simulation, have them turn to a partner to compare what they learned and add anything they are missing to their charts. Then have the whole class share out what they learned, and add this information to the class KWL chart. One critical point to highlight is the fact that the respiratory system is the only way for humans to get oxygen into our bodies that our cells need to function. Key takeaways:
   - Oxygen is the gas in the air our body needs
   - Our whole bodies need oxygen
   - We get oxygen into our bodies through our lungs
   - Alveoli are the part of our lungs where oxygen gets into our blood and carbon dioxide comes out
   - Hemoglobin carries oxygen around our bodies

TEACHER NOTES

Teacher Tip

- ✓ Students should be able to use appropriate scientific terminology when talking about the respiratory system, but don't get bogged down in having students memorize a list of individual organs. This module focuses on the big concepts of human health and air pollution and should not feel like an anatomy lesson.
- ✓ A vacuum cleaner hose is a great way to show students what the trachea is like. It is flexible and rigid at the same time to allow air to flow even when you move your body around, yet it doesn't collapse when pressed on because of rings of cartilage that give it structure.

Differentiation

- ✓ Provide pre-filled copies of the respiratory system diagram to students (but still discuss the parts with them)

TEACHER NOTES

Connection to Activity 2

- ✓ Ask students what they were feeling when they were measuring heart rate in Activity 2 (the pressure from heart beats on their chest or through their blood vessels)

Organs of the circulatory system?

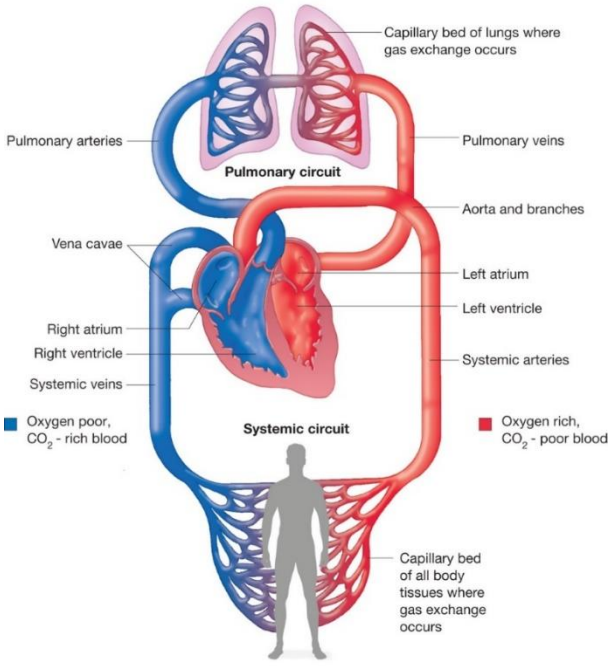
- ✓ Blood vessels such as arteries, veins, and capillaries are sometimes considered organs of the circulatory system, mainly because like other organs they are made of different kinds of tissues and serve a distinct function. However, since they are so different from other human organs, they are frequently not identified specifically this way. If students ask, you can ask them what they think, and then provide this information to support their understanding.

Differentiation

- ✓ Have students complete the Venn diagram with a partner instead of on their own.

5. **How the circulatory system works:** Ask students what happens to oxygen once it gets into our blood. They should remember from Lung Attack that it gets delivered throughout our bodies. Direct students' attention to the circulatory system diagram on the right side of their handouts. Tell students that to understand more about how this works, they're going to watch a video called "Exploring the Heart." Have students go to the video here (or show it using the projector): https://www.youtube.com/watch?v=-s5iCoCaofc, and have them follow along on their diagrams as they trace the path of a red blood cell.

   After the video, have students add arrows to their diagrams showing the flow of blood through the circulatory system. If colored pencils or markers are available, have students color in the key to the diagram (red is oxygen-rich/CO_2-poor blood, blue or purple is oxygen-poor, CO_2-rich blood) and color in the blood vessels in their diagram. You may want to do this together or display a color version of the diagram to help students draw the arrows and color the diagram correctly. Also be sure to ask students what the primary organ of the circulatory system is (the heart) to reinforce the organ/organ system idea.

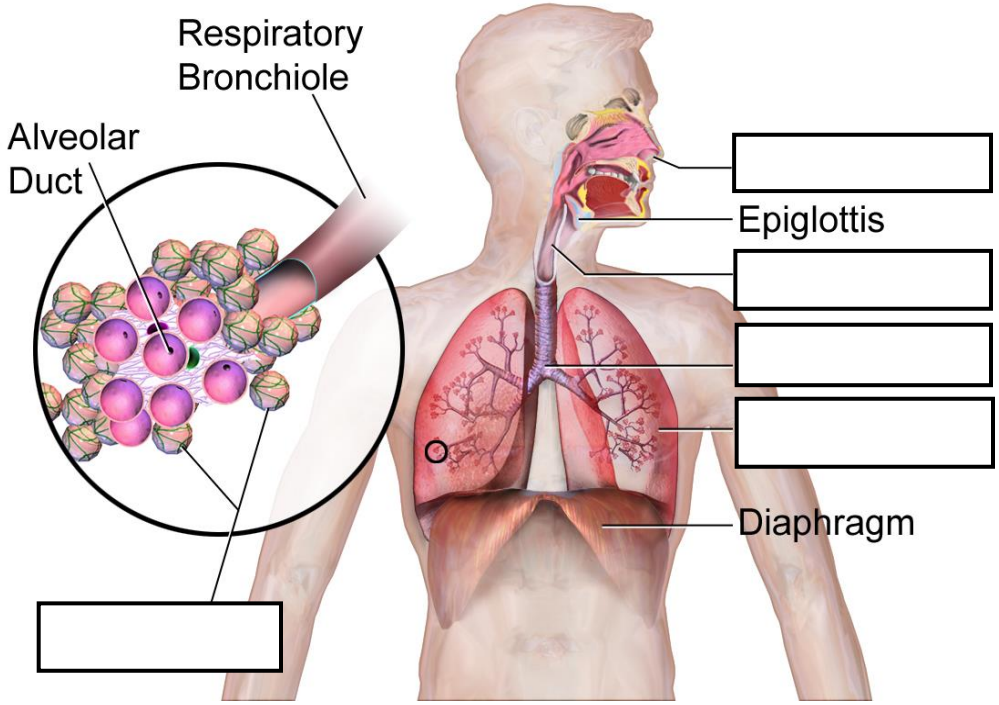


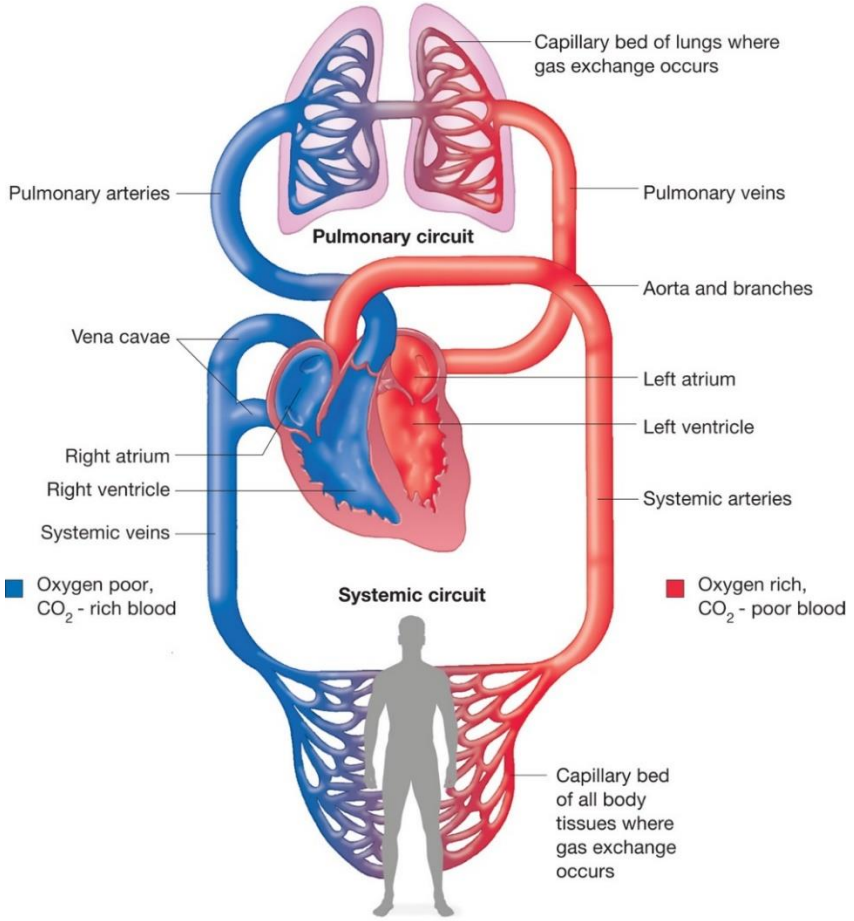
6. **Formative Assessment**: Have students complete the Venn diagram showing similarities and differences between the respiratory system and the circulatory system. You may want to give them a few hints to get them started. Check to see if students have the key points identified in the teacher guide. The "other important information" section can include other facts they've learned.

Name _____

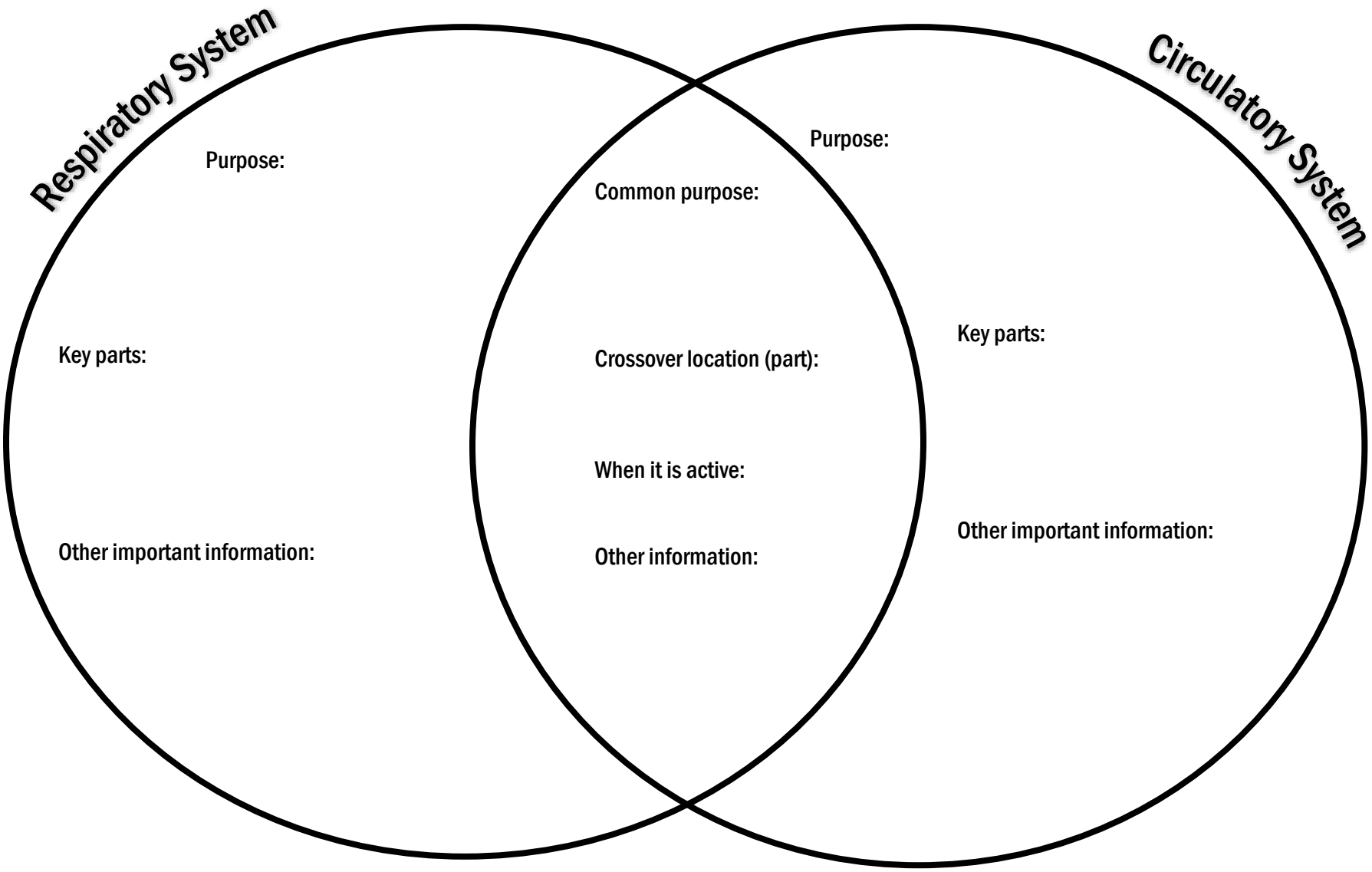
STUDENT HANDOUT

Respiratory & Circulatory Systems



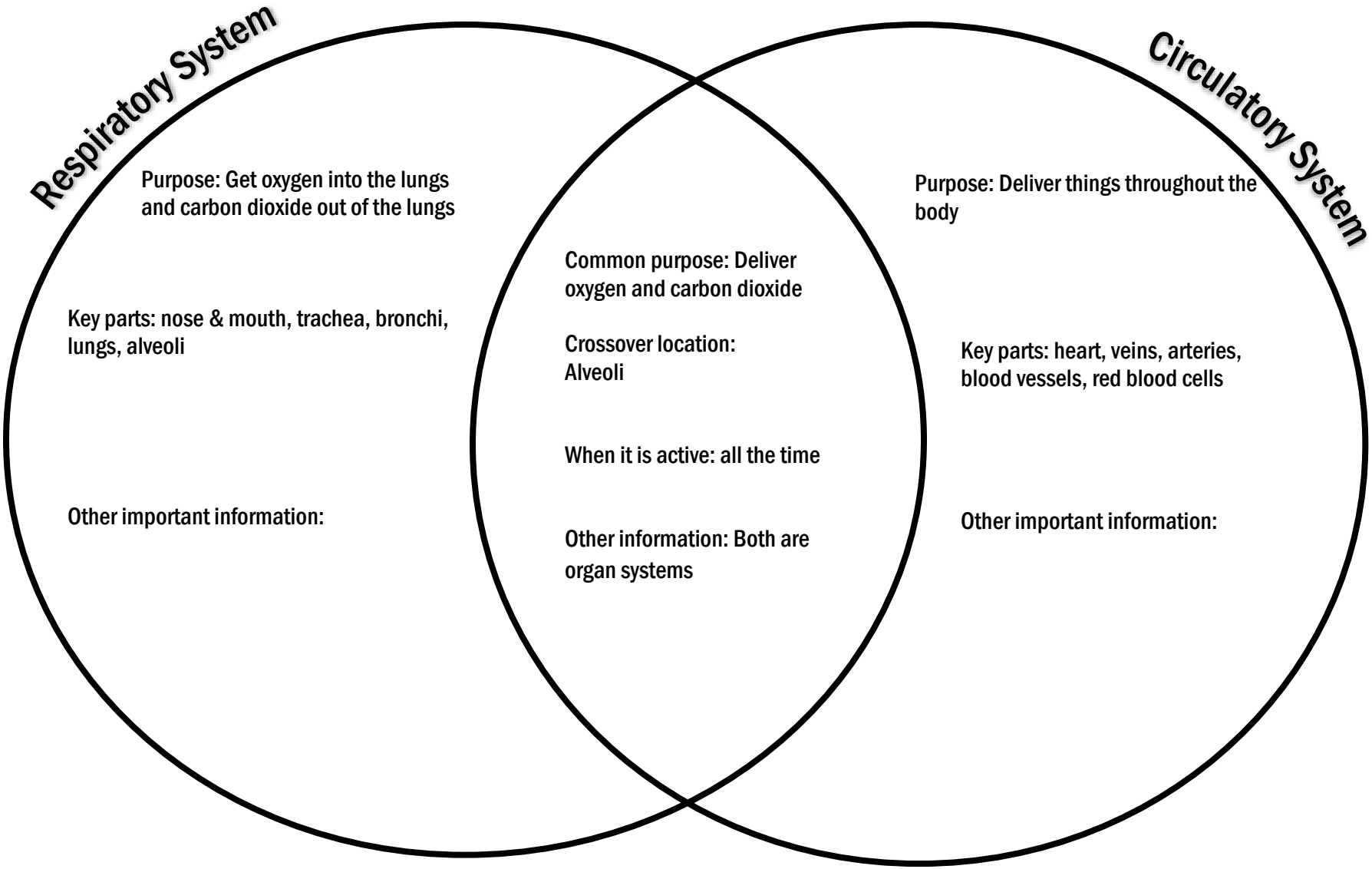


Compare & Contrast



TEACHER GUIDE

Compare & Contrast



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

Activity summary: In this activity, students use what they have learned so far in the module to create a model showing how the respiratory and circulatory systems interact.

ACTIVITY DETAILS

Time: 45 minutes

Objectives

- ✓ 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 to the different parts of our bodies

Materials

- ✓ Computer & projector
- ✓ Speakers (optional for video)
- ✓ Paper for student models
- ✓ Respiratory/Circulatory System Model (sample)

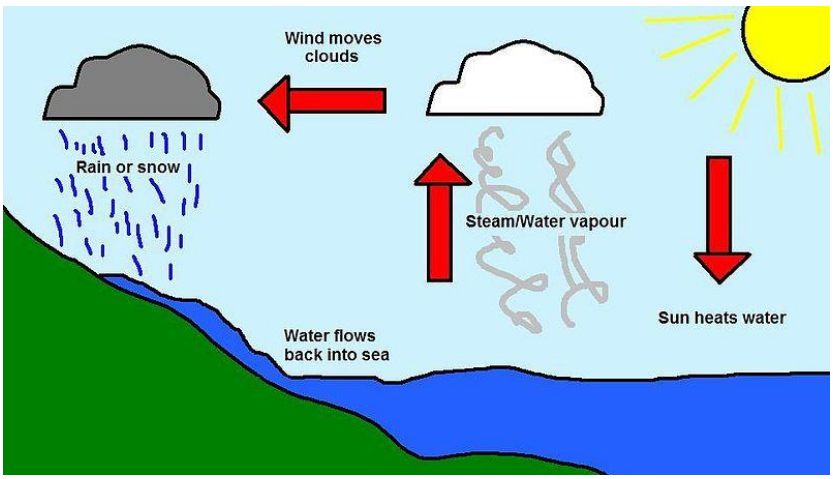
Handouts

- ✓ None

Standards Connection

DCI: LS 1.A: Structure & Function
SEP: Developing & Using Models
CCC: Systems & System Models

Warmup: Show students a simple scientific model like the water cycle model below:



Have students write down the answers to these three questions.

- What kinds of things do you see in this model?
- In what way does this model look realistic?
- In what way does this model not look realistic?

Go over the first question, and write students responses on the board. Make sure students mention the arrows, words, and objects. Afterwards, tell students that you will come back to these in a few minutes. Then go over questions two and three.

- The purpose of this warmup is for students to recognize that scientific models often include things like words, arrows, and simplified drawings of real-world things. Scientific models are often not physical, and they are used to explain phenomena like rain and clouds. They often do not look realistic, and can be very abstract.

1. **Frame the activity:** Tell students that when scientists are studying very complicated systems, like the human body, they use models to make the system easier to understand. We're going to create models today based upon everything we've learned so far. We'll use our models to help understand how oxygen gets to our bodies through the respiratory and circulatory systems. Hopefully this will help us to figure out what's happening with Tatiana and Calvin.

2. **Identify the respiratory system parts of the model:** On the board/chart paper, write: "Respiratory System" Ask students what they think needs to be in their models. They should use their notes from the previous activity and ideas from their warmup to help. Add their responses to the list.
    - Nose, lungs, bronchi, trachea, alveoli, air/oxygen, carbon dioxide

3. **Modeling the respiratory system**: Have students (on their own or in small groups), create a simple model of the respiratory system. Remind them that models don't need to look like the actual real-world objects. For example, they can draw a box and write "lungs" on it. They can use the two lists on the board to help them (parts of models and respiratory system). As students work, circulate and support as needed. You can use the sample Respiratory-Circulatory System Model at the end of the activity as a guide, but make sure students are all making their own models. Modeling is a valuable part of the sensemaking process, so student models will be similar, but will likely look different.

    When students have gotten their models to a point where they make sense, have them partner with another student (or another group) to share and explain their models. This provides the benefit of giving students a chance to practice explaining their models, and also to get ideas from their classmates. You may also want to show one model to the class and have students give "warm and cool" feedback to help highlight strong points and improve weak points in the model. This is a great way to help students improve their modeling and peer feedback skills. Afterwards, give students time to revise their models if they want.

4. **Identify the circulatory system parts of the model:** Write "circulatory system" on the board and add student responses. Make sure they include:
    - Heart, arteries, veins, blood, blood vessels

    They may also choose to include things like red blood cells or capillaries, but they should avoid getting into too many details like valves.

TEACHER NOTES

Mini-lesson

- ✓ If students have not created scientific models before, it is worth taking time to discuss the difference between a scientific model and a traditional model. See this website for more info on how to teach modeling to students: https://edu.rsc.org/feature/how-to-teach-scientific-models/3010560.article

Differentiation

- ✓ Instead of having students make their own models from scratch, put components of the model on small slips of paper (words, arrows, boxes), and have students create the model using the parts and glue/tape it onto a sheet of paper or into their notebooks
- ✓ Create a handout with boxes for body, respiratory system, and circulatory system, and have students fill in the rest of the model

TEACHER NOTES

NGSS connection

- ✓ The concept that the human body is a system of interacting subsystems is a key component of this module's focus Disciplinary Core Idea, and the focus Crosscutting Concept (Systems & System Models). While students may not have completely internalized the concept at this point in the module, having students discuss it and make connections to it whenever possible is a good way to reinforce the idea.

Teacher Tip

- ✓ Before the discussion about the human body as a system of interacting systems, you may want to review what a system is with students. Keep the definition simple so as not to add confusion: ex. a system is a thing made of parts that work together.

5. **Modeling the circulatory system:** Have students use their list to add the circulatory system to their models. Support them in particular in creating two different pathways from the heart to the lungs and back and from the heart to the rest of the body and back. Also remind them that some things they wanted to put in their model should go in a few different places (ex. oxygen and carbon dioxide). See the sample model at the end of the activity for ideas to help students.

   If students get stuck trying to draw a realistic model, remind them that their goal is to show how oxygen gets to all the parts of their bodies, not to draw the human body.

   Again, once they are done, have students share their revised models to get feedback, and give them time to make revisions afterwards.

6. **Model discussion.** Lead a discussion with students about how their models show how the human circulatory and respiratory systems are connected. Key points:
   - oxygen gets into our bodies through the respiratory system (nose/mouse, trachea, lungs, alveoli)
   - alveoli allow oxyen to get into our bloodstream.
   - The blood, pumped by the heart, delivers the oxygen to our cells.

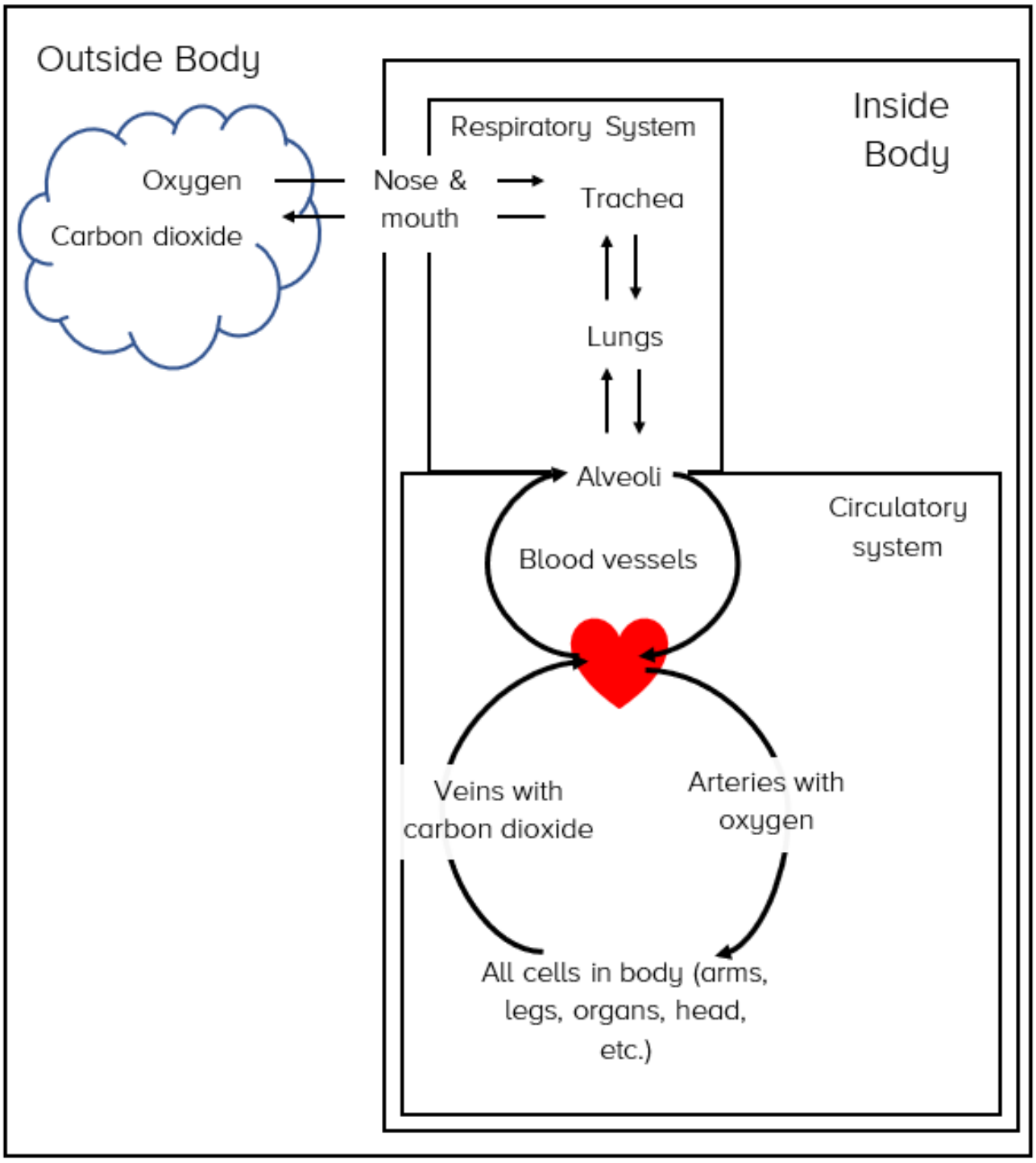
   Write the sentence, "The human body is a system of interacting systems" in a place where students can see it such as on the board or a piece of chart paper. Make sure students know what the word "system" means (see sidebar) and what the word "interacting" means, and then have them turn to a partner to decide if they agree or disagree with this statement, and what evidence they have to support their decision. After they have had time to talk, bring the class back together to talk. Students should be able to formulate the idea that the statement is true because the circulatory syste m and the respiratory system interact, and so do lots of other systems in the human body (even if they don't know the names of other systems).

TEACHER NOTES

7. **Formative Assessment (Return to the Phenomenon):** Ask students how they can use their models to help understand Tatiana & Calvin's problem. What do you think might be causing Tatiana & Calvin's breathing problem? Why is it worse when they exercise?
    - Possible explanations: Something in the air is keeping them from getting enough oxygen to their bodies through her lungs, something is wrong with their lungs/respiratory system.
    - It is less important at this point that students have "correct" answers than that they are using their models to help make logical hypotheses.

TEACHER GUIDE

Sample Respiratory-Circulatory System Model



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

Activity summary: In this activity, students examine ozone damage to leaves as a way to understand what happens to human lungs from exposure to ozone.

Standards Connection

DCI: LS 2.A: Interdependent Relationships in Ecosystems
SEP: Constructing Explanations
CCC: Cause & Effect

Warmup: We know that Tatiana and Calvin have trouble breathing sometimes. It is worse when they exercise, and it's also worse when they're outside a lot. Why do you think this is?

- Guide student discussion around the idea that environmental factors (like pollen, dust, air pollution, etc.) can affect our respiratory system.

1. **Frame the activity:** Tell students that when scientists identify an "effect" like an asthma attack, they are often curious about what is causing it. Remind students about Activity 1 when they discussed what might be causing Tatiana and Calvin's asthma attacks, and what might be causing asthma rates to be higher in some places. If they think that something in the air is causing it to be harder for Tatiana and Calvin to breathe, then they need to learn more about how things in the air affect living things. They can't cut open Tatiana's lungs, so instead they're going to look at plants to see how gases in the air affect them. Hand out the Leaf Investigation Lab sheets to students.

2. **Introduce ozone-damaged leaves**: Show students what ozone-damaged plant leaves look like. You can do this by taking them outside, bringing leaves inside, or showing them pictures like this tulip poplar leaf:

   Have students make observations of what they see and write them on the observation (right) side of their sheets.

Source: Michał Długosz, Wikimedia Commons

3. **Ozone damage discussion:** Ask students if they think the leaves are heathy. Why or why not? (you may want to show them healthy leaves for comparison). Ask students if they think the spots are a cause of something or an effect (they should say effect). Have them write "effect" on their papers next to where it says "observations." Then ask them what

ACTIVITY DETAILS

Time: 45-60 minutes

Objectives

- ✓ Students will understand that gases in the air (ozone in particular) can damage the delicate parts of living things

Materials

- ✓ Ozone damaged-leaves (pictures or actual leaves)
- ✓ Microscopes (optional)
- ✓ Leaf underside wet mount slides (optional)
- ✓ Projector & speakers

Handouts

- ✓ Leaf investigation lab sheet

Teacher Tip

- ✓ If you plan to use microscope slides o leaf undersides, make sure to prep the slides in advance and check to make sure you can see the stomata. Use this video on how to prep the slides: https://www.youtube.com/watch?v=5uv4lIWDECs

TEACHER NOTES

Teacher Tip

✓ Learn how to identify ozone-damaged leaves here: http://www.sicktree.com/pubs/ozone/r8-pr25/ozoneh2.htm#:~:text=Normally%2C%20the%20ozone%2Dinjured%20leaf,also%20drop%20their%20leaves%20early.

Teacher Tip

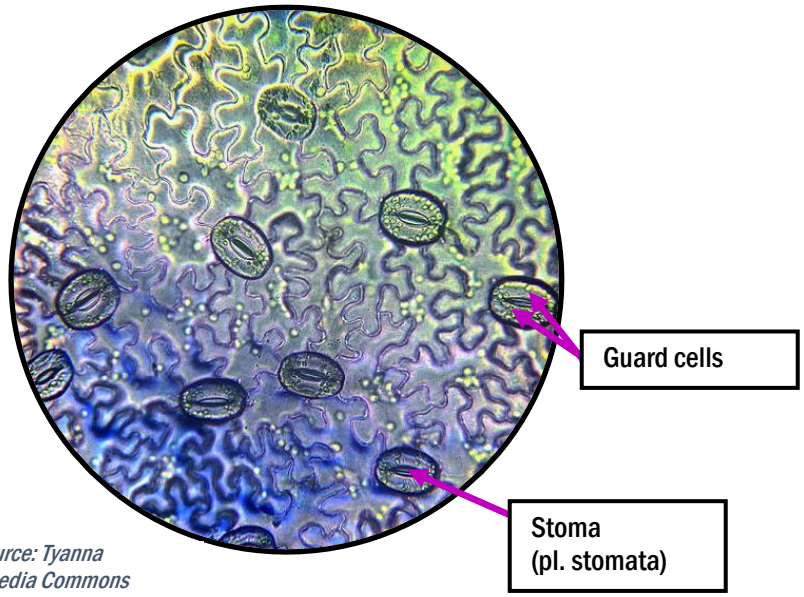
✓ This part of the activity is another good place to reinforce students' understanding of cells, and where they fit into the hierarchy of cells-tissues-organs-organ systems. You can also make a connection to red blood cells, which students learned about in Activity 3.

Teacher Tip

✓ Don't get bogged down in teaching students about stomata. The goal here is to help them understand that ozone can damage the inside of living things

they think might be causing this effect. Have them write the potential causes on the "cause" side of their sheets. These don't need to be correct (they should be hypotheses such as acid rain, insects, diseases, etc.). Ask students if they think gases in the air can cause damage like this.

4. **Take a closer look:** Tell students that you are going to look more closely at the cells on the underside of the leaves. If microscopes are available, have students look at peelings from under the leaves. If not, show them photographs of the undersides of the leaves through a microscope like the one shown on the next page.



Source: Tyanna Wikimedia Commons

Have students write their observations in the space on their lab sheets. Make sure students see and describe the stomata (little "mouths" on the leaf undersides).

5. **Stomata discussion:** Ask students a variety of questions to help them build understanding of stomata. Students may want to take notes on their lab sheets. Possible questions & answers:
   - What do stomata look like? (they look like lips, little mouths, donuts, etc.) *NOTE: the stomata are the pores (the holes) in the middle. The "guard cells" are the sides.*
   - What structure is a stoma made of? (it is a hole with two curved cells on the sides).
   - What do you think the function of a stoma and guard cells is? (to let things in and out of the leaves, and to keep things from getting in or out when they close)
   - What do you think can get in and out of the *undersides* of leaves? (gases like oxygen, carbon dioxide)
   - What gas do plants need to grow? (Carbon dioxide)

6. **Return to cause & effect:** Go back to students' original hypotheses about what might be causing the damage to these leaves. See if they have a better sense of what the correct cause is and why other causes are unlikely (ex. insect damage looks like little bites taken out of leaves). After discussion, tell students that damage like this is caused by something getting *inside* the leaves. In this case the leaves have ozone damage. Ask if any students have heard of ozone before.

7. **Ozone and plants reading:** Have students read the paragraph about ozone on their handout and answer the questions below the text. Answers:
    - Ozone is a gas
    - Ozone near the surface is harmful to living things
    - Ozone high up in the atmosphere is good for living things
    - Ozone prevents plant leaves from performing photosynthesis well

8. **Ozone gardens (optional):** Show students the video *Plants & Ozone Pollution* (link: https://youtu.be/77cCc16dTVo) starting at :52.

9. **Connecting the dots: Trees, lungs, and ozone damage.** Show students the picture below and ask them what they see. They will likely say this is a tree, but it's actually an upside-down casting of human lungs.

Source: Centre for Research Collections University of Edinburgh
Wikimedia Commons

Take a moment to point out to students where the trachea, bronchi, and alveoli are in the casting. Ask them where in the picture oxygen goes from the lungs to the circulatory system (at the very tips of the bronchioles, where the alveoli are). Then have them

TEACHER NOTES

Multimedia

- ✓ In the fluorescence photograph found here, the plant leaves on the right were grown with elevated ozone levels, and the leaves on the right were grown under normal conditions: https://earthobservatory.nasa.gov/ContentFeature/OzoneWeBreathe/Images/flourescence.jpg

  Read more about the research here: https://earthobservatory.nasa.gov/features/OzoneWeBreathe/ozone_we_breathe3.php

Clarification

- ✓ There are many similarities and differences between plant leaves and human lungs, especially the fact that they are where the organism has maximum surface area for gas exchange. Use the analogy to foster student understanding, but don't push it too far because it will get unnecessarily complex and may lead to student misconceptions.

TEACHER NOTES

Extension

- ✓ If time permits, have students make a Venn diagram showing how trees and human lungs are alike and different in terms of how they take in and release gases they need to survive.

Differentiation

- ✓ Discuss the formative assessment question before having students write out their answers.

think about a tree. Where does the carbon dioxide and the oxygen come in and out of trees? It is in the leaves, which are at the very tips of tree branches. Ask students when it comes to breathing, how are human lungs like trees? Focus the discussion to reach key points:

- Both trees and human lungs take in and releases gases they need to survive.
- Both trees and human lungs transfer gases at the tips of long "branches".

Next, ask students how human lungs are different from trees when it comes to breathing. Focus the discussion to reach these key points:

- Trees take in and release gases directly from their leaves. Humans need to breathe the gases into their lungs first from outside their bodies.
- Humans have alveoli where the gases are transferred in and out. Trees have stomata where gases are transferred in and out.

Finally, remind students where the ozone damage is in trees. Then have them consider where ozone damage might be in a human. Give them time to discuss with a partner before moving to the formative assessment.

10. **Return to the KWL chart:** Have students take out the KWL charts they created in Activity 1 and display the class KWL chart you made. Have students identify anything new they've learned that helps them to understand the phenomenon. For example:
    - Ozone is a gas in the atmosphere
    - Ozone can damage delicate parts of living things like the insides of plant leaves

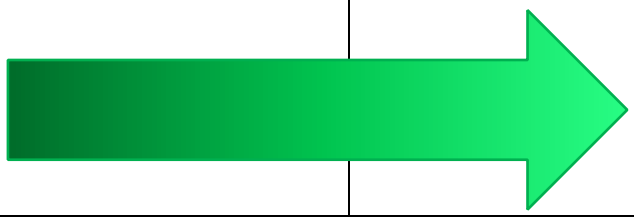
11. **Formative Assessment:** Have students write a hypothesis based on what we learned today about why they think Tatiana and Calvin have a hard time breathing when they go outside. Their hypothesis should include something about how gases (like ozone) can affect the insides of living things. Key points:
    - Tatiana and Calvin may have irritated or damaged lungs because of ozone. Ozone is a gas that is a kind of air pollution. Ozone can get into living things and damage them. If it got into Tatiana and Calvin's lungs, it may be hurting them.

Name _____

STUDENT HANDOUT

Leaf Investigation Lab

Cause	Observations
what do you think caused the leaf to look like that?	what does the leaf look like?



Observations of leaf undersides through a microscope. What do you see?

Ozone & Living Things

Ozone is a gas made of oxygen that is found in Earth's atmosphere. When it is formed high in the atmosphere, ozone is helpful for living things because it can block harmful radiation from the sun. However, when ozone is formed close to Earth's surface, it can damage the delicate parts of living things. This kind of ozone is formed from air pollution that comes from cars, trucks, and power plants. Ozone enters trees and other plants through their stomata and can damage the leaves so that they cannot perform photosynthesis well. Ozone can also be harmful to humans if they breathe it in, especially if the person who breathes it already has problems with their respiratory system.

1. What is ozone? _____
2. What kind of ozone is harmful to living things? _____
3. What kind of ozone is helpful to living things? _____
4. What effect does ozone have on the inside of plant leaves?

_____

_____

Summary

Write a hypothesis based on what we learned today about why Tatiana and Calvin have a hard time breathing when they go outside. Your hypothesis should include what you know about ozone and how it can affect the insides of living things.

Activity 6 (Explain): Air Pollution & Humans

Activity summary: Students use the Lung Attack simulation to deepen their understanding of how air pollution affects human lungs. Then they use this information to add to/revise their models of the circulatory and respiratory systems.

Standards Connection

DCI: LS 1.A: Structure & Function
SEP: Developing & Using Models
CCC: Systems & System Models; Cause & Effect

Warmup: What were Tatiana and Calvin's symptoms that we talked about at the beginning of this investigation?

- Use this as an opportunity to remind students of the phenomenon they are investigating so they can connect it to the simulation they are doing in this activity.

1. **Frame the activity:** During our last activity, we saw how ozone can harm plants. At the end of the last activity, we came up with some hypotheses about how ozone could be affecting Tatiana and Calvin. Today we're going to look more carefully at how ozone and other pollutants affect human lungs to see if it supports our hypotheses.

- **Lung Attack Part 2 (ozone & particulate matter):** Have students take out their KWL charts from Activity 1 (if they need more space they can use another chart). Either using students computers, or together as a class, have students continue the Lung Attack simulation: http://web1.pima.gov/deq/lungattack/lungplay.htm) with Ozone, PM10, and PM2.5. As they work through the simulation, have them add new details from what they learn to their KWL chart. Key takeaways:
    - Ozone attacks the cells in your bronchi
    - Ozone can trigger asthma attacks
    - Big particulate matter (PM10) is dirt, dust, mold, spores, pollen, etc.
    - PM 10 can block airways and make you cough
    - Small particulate matter (PM2.5) is made of heavy metals and other toxins
    - PM 2.5 can make you cough or make it hard to breathe. They can also cause cancer.

ACTIVITY DETAILS

Time: 30-45 minutes

Objectives

- ✓ Students will deepen their understanding of how air pollution affects human lungs
- ✓ Students will determine how air pollution (ozone and particulate matter) fit into their models of the circulatory/respiratory systems

Materials

- ✓ Student computers
- ✓ Computer & projector

Handouts

- ✓ Models (from Activity 4)
- ✓ KWL chart (from Activity 1)
- ✓ Asthma Attacks: Cause & Effect

Teacher Tip

- ✓ This module focuses on ozone as a cause of asthma attacks, but particulate matter (PM) is mentioned here because it is another pollutant that can have similar effects. PM is addressed much more

TEACHER NOTES

Modifications

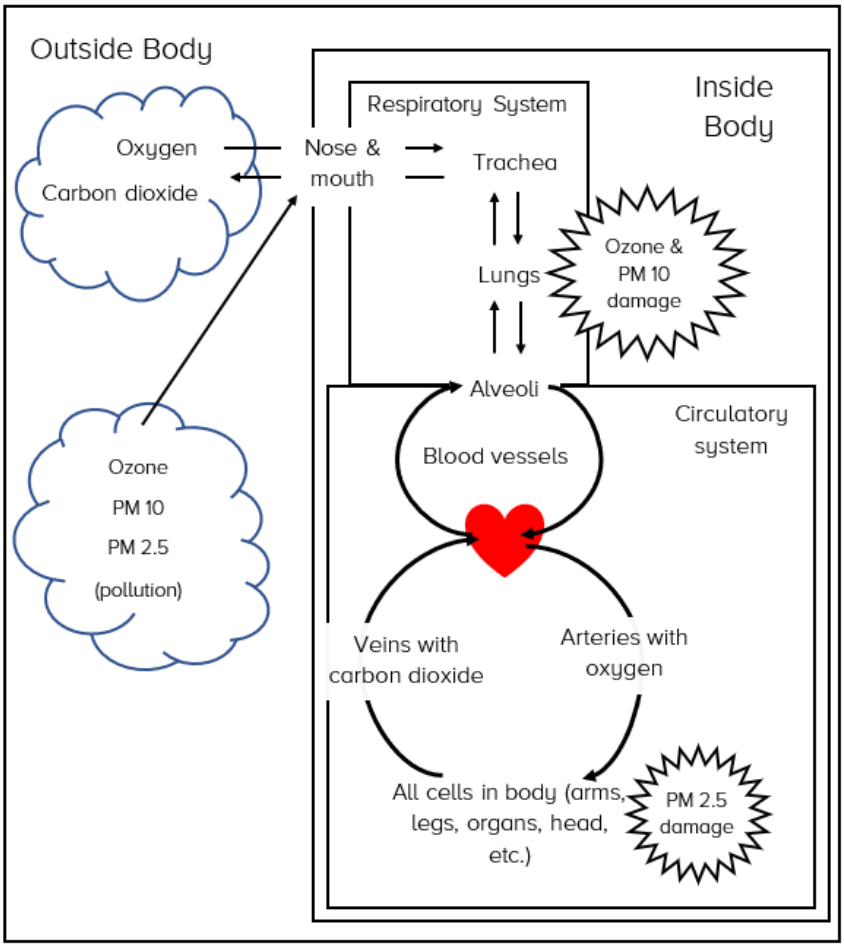
- ✓ Provide students with slips of paper with the new parts to add to their model (as in Activity 4)
- ✓ If students don't have their models from Activity 4, have some generic models that they can start from for this Activity

Differentiation

- ✓ Create a list of questions for students to answer while doing the Lung Attack simulation

After students have finished, you may want to have students share what they learned and add it to the class KWL chart. This is also a good time to clarify misconceptions and make sure all students understand the key takeaways.

- **Modeling air pollution and humans.** Have students take out their models of how the lungs and respiratory system work. Have them add ozone, PM10, and PM2.5 to their models. Their revised models might look something like this:



- **Return to the original phenomenon.** Remind students that they are acting as medical professionals for this investigation, and it is time to make their final diagnosis and explanation for Tatiana and Calvin. Have students take out their original Patient Record Sheets from Activity 1, the KWL charts they have been filling out, and their CER from Activity 2. Have students think about what might be causing Tatiana and Calvin's asthma attacks based on all the evidence they have so far, including the sources of respiratory problems that they have learned about in this module. In groups, have them develop a list of follow up questions that they want to ask Tatiana and Calvin to help with their diagnosis. See potential questions below.

  Have students ask their questions, and either answer them yourself, or have your original student actors answer. Key questions & answers:
  - Q: Is the air near you polluted? A: They don't really know the answer to this, but they do live near a busy road that has lots of trucks.
  - Q: Is there a lot of dust in the air near where you live? A: Yes
  - Q: Do you go outside a lot? A: Yes, they love to play outside
  - Q: Is it harder to breathe when there is traffic? A: Yes

- **Formative assessment**: Once students have asked enough questions to get to the heart of the phenomenon, pass out the Asthma Attacks: Cause & Effect sheet and have them write a complete "cause" to the "effect" of Tatiana &/or Calvin's symptoms, including why it is hard for them to exercise. Their explanation must address what is causing the asthma attacks and what that cause does to their bodies. Students should be encouraged to use their notes to answer the prompts.
  - Sample explanation (part 1): Tatiana and Calvin have asthma. Air pollution from the busy road near where they live causes them to have asthma attacks. The air pollution (ozone & PM) irritates their lungs (respiratory system) which makes it hard for them to breathe.
  - Sample explanation (part 2): Tatiana and Calvin have difficulty exercising because people need oxygen to operate. We get oxygen into our bodies through our respiratory systems, and to our cells through our circulatory systems. Since Tatiana and Calvin have problems with their respiratory systems, they have a hard time getting enough oxygen to their bodies, which makes it hard to exercise.

Name_____

TEACHER NOTES

Modification

✓ Before having students come up with their set of questions to ask Tatiana and Calvin, have them summarize their learning in their small groups using their KWL charts.

Clarification

✓ There are many different things that can cause an asthma attack including acid reflux, respiratory infections, stress, and even dry air. In this module, the focus is on air pollution – specifically ozone and particulate matter– as a cause. Make sure students realize that not all asthma attacks are caused by air pollution.

Asthma Attacks: Cause & Effect

Based on the evidence you have gathered, write an explanation for what is causing Tatiana and Calvin to have asthma attacks. Your answer should identify what you think is causing the attacks and what specific parts and systems of their bodies are affected by the cause.

Tatiana and Calvin both have difficulty exercising. Explain how asthma might could make it hard for them to run or do other exercises for a long time. Your answer should identify what body systems are involved in supplying your body with the things it needs to operate.

Activity 7 (Elaborate): Asthma & the AQI

Activity summary: In this activity, students learn how the EPA summarizes air quality using the Air Quality Index (AQI) and what behaviors are recommended when air quality is bad. They also learn what an asthma inhaler does (optional).

ACTIVITY DETAILS

Time: 45-60 minutes

Objectives

- ✓ Students will learn how to determine if air quality on a given day is good or bad
- ✓ Students will learn about how asthma inhalers help people to breathe (optional) and how to help someone who is having an asthma attack

Materials

- ✓ Student smartphones (if permitted)
- ✓ Computer & projector
- ✓ Student computers (optional)
- ✓ Markers/colored pencils (optional)

Handouts

- ✓ Understanding the AQI

Standards Connection

DCI: LS 2.A: Interdependent Relationships in Ecosystems

Warmup: What do you think you can do to protect your respiratory system from pollution?

- Stay inside if the pollution is bad, play in places that have less pollution

1. **Frame the activity:** Now that we know Tatiana and Calvin have trouble breathing because of asthma and air pollution, what recommendations can we make to them? As medical professionals, we need to find ways to help them stay safe and let them stay active.

2. **Looking up the Air Quality Index (AQI).** Show students the Clean Air Partners website for current and forecasted AQI (either on the projector, or their own computers): https://www.cleanairpartners.net/current-and-forecasted-air-quality

   Click on current to show the current air quality. Ask students what they can tell from the website about the current air quality where they live. The information should be very easy for students to find and understand.

3. **Looking up the AQI forecast.** Click on "forecasts" and ask students what they can tell from the website about the forecast for the air quality for the next two days.
   - Air quality is likely to be good (green) unless it is ozone season (late spring to early fall) or there are local events that cause PM2.5 to be high. AQI in the United States rarely gets into the red zone, although localized air quality can be bad, especially due to particular events.

TEACHER NOTES

Modifications

- ✓ Instead of having student group create fictional scenes, have them create short presentations about their AQI level. They can then give each other feedback on their presentations using a peer feedback rubric like this one: https://www.teacherspayteachers.com/Product/Presentation-Partner-Peer-Review-Rubric-4409187

Teacher Tip

- ✓ Be sure to follow your school's technology policy with regard to student devices, and remind students to talk to their parents about installing any software on their phones. This is also a good way for students to teach their parents how to monitor air quality.

Differentiation

- ✓ Create student scenes in advance, and have groups add details before presenting OR have all students read the scenes individually and decide what the AQI level is.

4. **Understanding the AQI scale.** Give students the "Understanding the AQI" handout and project it. If the student copies are in black & white, they can color in the AQI levels (optional). Note that the color names are written on the chart. Tell students that the United States Environmental Protection Agency (EPA) uses the AQI scale to let people know how safe the air is to breathe. Briefly review with students what the colors mean, and what steps should be taken for each color level.

5. **Stay safe scenarios.** Divide the class into 5 groups and tell students that they are going to be creating and presenting short scenes (30-60 seconds) showing what people should do to be safe when the AQI is at different levels. Each group will present their scene, and the class will have to guess what the AQI level is for the scene. You may want to provide an example of a scene (ex. holding soccer practice indoors if AQI is orange).

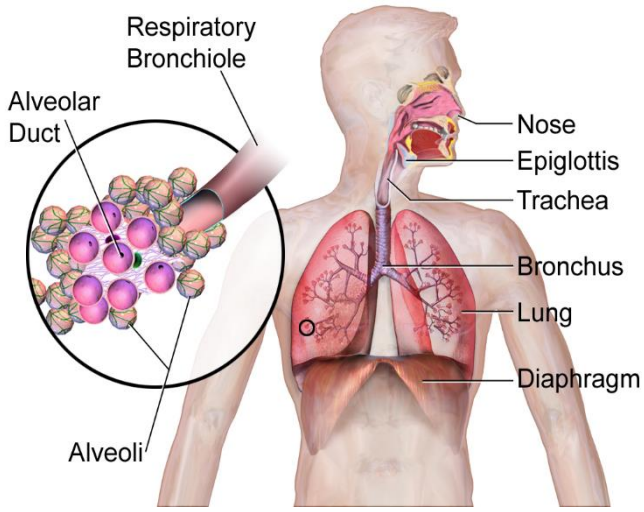
   In secret, assign each group one of the AQI levels. Circulate around the class to help students brainstorm their scenes. Once each group has a scene, and they have had a chance to practice, give each group time to present their scene, and have the other students use their AQI charts to try to guess what the AQI level is in the scene.

6. **Finding the AQI.** Share other ways that students can look up the AQI, for example using apps on their phones such as Clean Air Partners Air Quality app, and the Air Visual app. If students are allowed to use their smartphones at school, show them how they can add these apps to their phones.

7. **Understanding asthma inhalers (optional).** Show students a picture of an inhaler like the one below (or an actual inhaler if you have one), and ask them if they know what it is (at least one student will likely recognize it).

Ask students if they know what the inhaler is for. They will likely respond that it helps you to breathe. Tell students that sometimes air pollution can cause people to have asthma attacks even if they follow the AQI guidelines.

Tell students that inhalers are a way to quickly deliver medicine into your lungs. The medicine in most inhalers is called a "bronchodilator". Take a moment to break down this word for students by using the picture of the lungs from earlier in the unit so they can see where the bronchi and bronchioles are. Also explain to them what the word "dilate" means (expand) and ask them if they've ever had their eyes dilated at the eye doctor. See if they can figure out what a bronchodilator does (it opens up the air passages in your lungs).



Source: https://upload.wikimedia.org/wikipedia/commons/e/e7/Respiratory_System_%28Illustration%29.png

Tell students that the best possible thing they can do for someone who is having an asthma attack is to get their inhaler. They can also help by having the person sit upright and talk to them calmly. If they are having severe trouble breathing, call 911.

8. **Formative assessment**: Tell students to imagine that the EPA is predicting that tomorrow will be an orange AQI day. Have them make a list of 3 recommendations for Tatiana and Calvin to make sure they are safe from air pollution.
    - Possible responses: play a board game indoors instead of playing outside, taking their asthma inhaler to school, carpooling to school instead of walking, play basketball in the school gym instead of outside, etc.

TEACHER NOTES

Follow up to phenomenon video

✓ If you showed students the video "Between Life and Breath" for the phenomenon, the end of this activity is a good time to show it again with the ending. If you haven't used the video before you can also show it now to give students an idea of how to reach to a person having an asthma attack and the importance of having an inhaler nearby. The video can be found at: https://www.youtube.com/watch?v=OCosTBwG4Pg

Next steps

✓ This is the last activity in the module before the final assessment. You may want to have students review their KWL charts and add any details, or review their models before the end of module assessment.

Mini-Poster

UNDERSTANDING THE AQI*

Air Quality Action Guide

AQI Value	Level of Health Concern	Colors	Action Steps to Protect Your Health and Our Environment
0 – 50	Good	Green	Enjoy outdoor activities.
51 – 100	Moderate	Yellow	Air quality may pose a moderate risk, especially for those who are unusually sensitive to air pollution.
101 – 150	Unhealthy for Sensitive Groups	Orange	Children and active adults, people with respiratory disease, such as asthma and emphysema, and heart ailments should limit prolonged outdoor physical activity.
151 – 200	Unhealthy	Red	Sensitive groups in particular should avoid outdoor physical activities. Everyone else, especially children, should limit prolonged outdoor exertion.
201 – 300	Very Unhealthy	Purple	Everyone is strongly urged to follow all of the action steps listed previously AND avoid outdoor physical activities.

*Air Quality Index

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

Activity summary: For this final activity, students demonstrate what they have learned in the module about air pollution and human health by completing an assessment.

Standards Connection

DCI: LS 1.A: Structure & Function
DCI: LS 2.A: Interdependent Relationships in Ecosystems
SEP: Developing & Using Models; Constructing Explanations
CCC: Systems & System Models; Cause & Effect

Warmup: Choose a warmup based upon something from this module you want to review with students before the assessment.

1. **Frame the activity:** During this investigation, you have acted as medical professionals to diagnose your patients – Tatiana and Calvin – and get to the root cause of their problem. You have figured out what is causing their asthma to give them problems, and you have learned how the respiratory and circulatory systems work together to provide your body with oxygen. Today you are going to share what you've learned to show what you know.

2. **Summative assessment.** Provide the assessment to students and support as necessary.

3. **Grading & feedback.** Use the scoring guide provided to grade the assessment and provide feedback to students.

ACTIVITY DETAILS

Time: 30 minutes

Objectives

- ✓ Students will demonstrate what they have learned in the module about modeling the respiratory and circulatory systems, and the effect of air pollution on humans.

Handouts

- ✓ Our Lungs, Our Air, Our Health assessment

Differentiation

- ✓ Instead of having students write the constructed response answers completely, provide sentence starters or make the responses fill-in-the-blank with key concepts left blank for students to fill in.

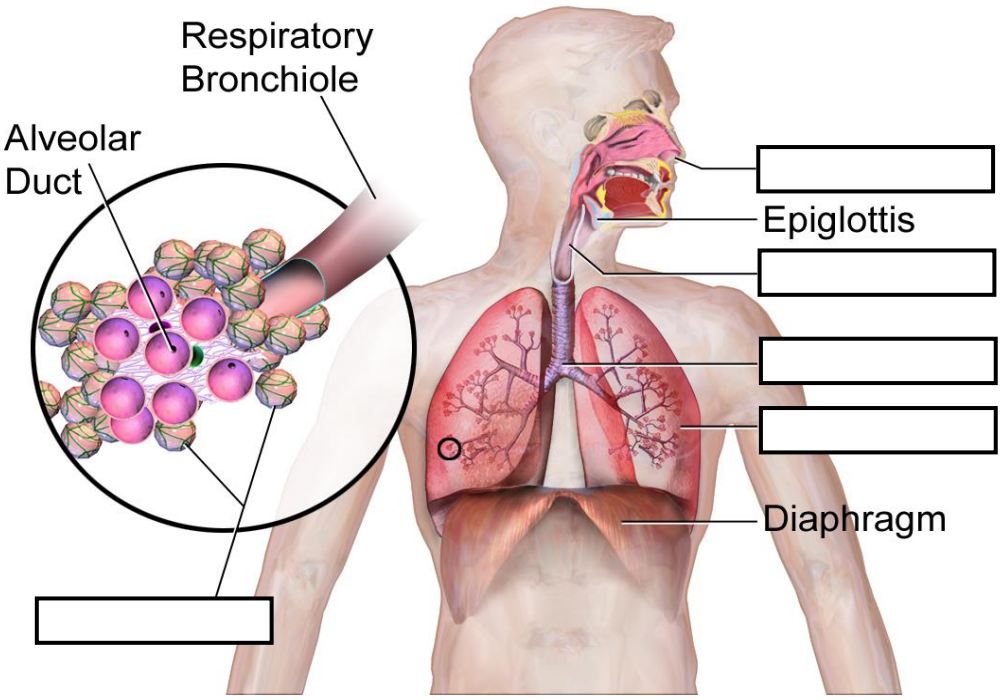
- ✓ For an added challenge, remove some of the parts of the model and have students add them in as part of the assessment.

Name_____

Our Lungs, Our Air, Our Health Module Assessment

Part 1: Organs of the Respiratory System

Directions: Use the word bank on the right to label the missing parts of the respiratory system in the diagram:



Word Bank

Lung

Trachea

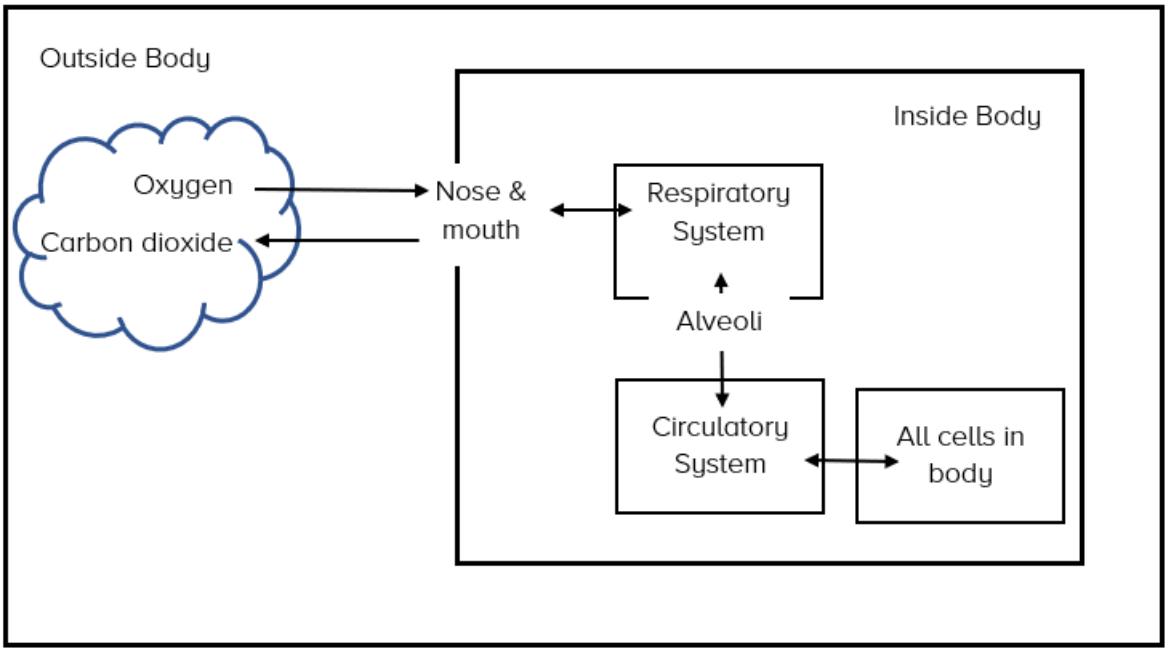
Alveoli

Nose

Bronchi

Part 2: The respiratory and circulatory systems

Directions: The simplified model below shows the human respiratory and circulatory systems. Use the model to answer the questions below.



Use the model to explain the path of oxygen from the environment outside the body to the cells in your body. Make sure to include parts of the circulatory and respiratory systems in your answer.

Explain why the arrows in the model go in two directions inside the body.

Part 3: The Human Body: A System of Systems

The human body is called a system of interacting systems. Explain what this means in your own words. In your answer…

- Briefly explain what a system is
- Use at least one example from what you have done or learned in this unit to support your answer.

SCORING GUIDE

Part 4: Air pollution

Add ozone to the model showing how it gets into the human body and what parts of humans it affects.

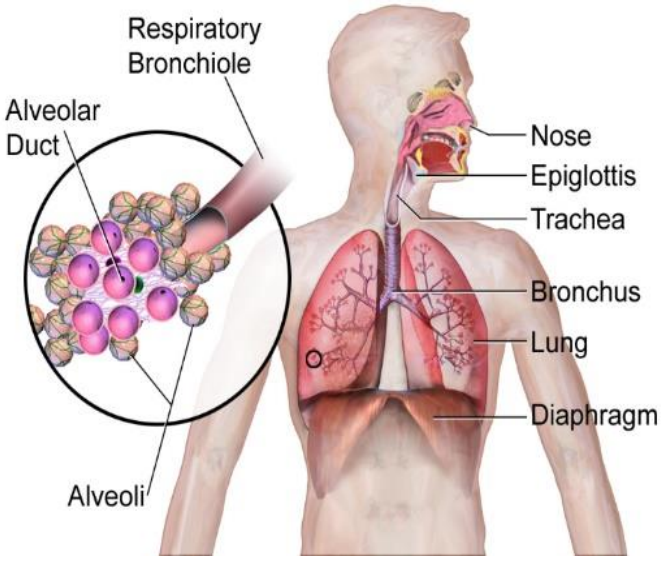
Add particulate matter 2.5 (PM 2.5) to the model showing how it gets into the human body and what parts of humans it affects.

Air pollution can make asthma worse when humans breathe it in. Air pollution is a cause, and an asthma attack is the effect. Explain how air pollution can cause an asthma attack. You can use the diagram on the first page and the model on the second page to help with your answer.

Our Lungs, Our Air, Our Health Module Assessment
Teacher Scoring Guide

		Points possible
Part 1	**Organs of the Respiratory System**	**5**
Part 2	**Modeling the Respiratory & Circulatory Systems**	**15**
Part 3	**The Human Body: A System of Systems**	**5**
Part 3	**Air pollution**	**10**
	Total Points	**30**

Part 1: Parts of the Respiratory System (5 points): One point for each correct answer



Source: https://upload.wikimedia.org/wikipedia/commons/e/e7/Respiratory_System_%28Illustration%29.png

Part 2: The Respiratory & Circulatory Systems (10 points)

Sample response:

- Oxygen enters the body through your nose and mouth when you breathe in. It travels down your trachea and into your lungs. When it reaches your alveoli, it goes out of the alveoli into your blood vessels. The heart pumps blood around the circulatory system. This caries the oxygen to all the cells of your body.
- The arrows go in two directions inside the body because oxygen is going to your cells from outside your body, and carbon dioxide is going from your cells to the environment in the opposite direction.

Points	Description
10	Student thoroughly and accurately describes the path of oxygen from the environment to parts of the body, including accurate scientific terminology for parts of the respiratory and circulatory systems. Student accurately explain why the arrows in the body go in two directions in the model.
8	Student describes the path of oxygen from the environment to parts of the body, but does not use accurate scientific terminology or includes a minor error in the pathway **OR** Student does not accurately explain why the arrows in the body go in two directions in the model
6	Student's description of the path of oxygen to parts of the body is partially correct but includes significant errors. Student does not accurately explain why the arrows in the body go in two directions in the model.
3	Student's description of the path of oxygen is incorrect and their answer does not explain why the arrows in the body go in two directions in the model.

Part 3: The Human Body: A System of Systems

- Sample response: The human body is called a system of interacting systems because a person is a system: it has a bunch of parts that work together, and those things have a bunch of parts that work together. For example, we have a circulatory system and a respiratory system that work together. They also have parts that work together. They are interacting because they depend on each other. The respiratory system gets oxygen from the air and gives it to the circulatory system to deliver. When we did our experiment with breathing and heart rate, when my partner exercised, his heart rate and his breathing both went up because the systems are connected.

Points	Description
5	Student's explanation is accurate and provides a meaningful example from the module to support it. They either explicitly or through their explanation, define what a system is.
4	Student's explanation is mostly accurate and provides an example from the module to support it. They may or may not define what a system is.
3	Student's explanation is on topic, but does not make it clear how the human body is system of systems. The example from the module is connected to systems but does not show how the body is a system of systems. They may or may not define what a system is.
3	Student's explanation is incorrect and shows significant misunderstanding of the concept. They may or may not have an example from the module and may or may not define what a system is.

Part 3: Air Pollution

Sample response:

- Model shows ozone entering the body through the nose and mouth, and affecting the lungs.
- Model shows PM 25. Entering the body through the nose and mouth, and affecting the lungs and "all cells of the body".
- Air pollution can cause an asthma attack because when ozone gets into your lungs, it irritates your bronchi and bronchioles in your lungs. When this happens, your lungs make mucus to stop the irritation. The mucus can make it hard for you to breathe. It also makes you cough. These can cause an asthma attack to happen.

Points	Description
10	Student accurately shows how pollution gets into the body and what parts of the body are affected by ozone and PM 2.5. Student thoroughly and accurately describes how air pollution can cause an asthma attack using appropriate scientific terminology.
8	Student has minor errors in either in the parts of the body that are affected by ozone and PM 2.5 OR in how air pollution can cause an asthma attack.
6	Student's response shows some understanding of how air pollution affects the body, but the response has significant errors in the parts of the body that are affected by ozone and PM 2.5 and in how air pollution can cause an asthma attack.
3	Student's response about how air pollution affects the body is mostly incorrect but shows some understanding.

Doing Our Part

- Plant an ozone garden at your school to identify whether ozone reaches harmful levels in your community. Specific species of plants are particularly sensitive to ozone and can indicate whether your community has an ozone problem. Learn more here: https://www.earthsciweek.org/classroom-activities/plant-ozone-monitoring-garden

- Look up the AQI using a computer or install an air quality app on your phone or your parents' phone. Use the AQI so you know when and how to avoid air pollution, especially on bad days.

- Be prepared for bad air quality situations, especially if you have asthma. For example, take your inhaler with you when the AQI is bad, and think about how you can get home from school if the air quality is bad. If you know someone with asthma, remember what you can do if they have an asthma attack and need your help.

- Avoid places where you know the air quality is likely to be bad, such as near roadways with lots of traffic (especially big trucks) or near power, cement, and chemical plants that are in your neighborhood. When walking to school, choose a route that stays away from busy streets.

- If you sometimes have difficulty breathing, talk to your parent(s) or doctor so they can make sure you get the help you need.

About this section

This section in included in every module either as a list or as part of an activity. It describes actions students can take to mitigate the effects of air pollution in their lives, and to help prevent air pollution from getting into the atmosphere. Many of these suggestions are the same from module to module, but there are variations depending on the focus of the module.

While the actions from this section are not explicitly built into the curriculum, they can be used in various ways to motivate students and provide them opportunities to take action to make a difference in their community.

Air Quality Champion in our Community

Name: Dr. Janet Phoenix
Title: Assistant Research Professor
Organization: George Washington University

How does your work relate to air quality?
I manage an asthma home visiting program. We provide education and tools for families to use to improve the health of their children with asthma. We provide vacuum cleaners to reduce allergic dust particles in the home, pest management for roaches and mice and dust mite covers for the bed. Many of the families we serve live in areas of the city where air quality is poor, because of close proximity to roadways. I also teach graduate students at George Washington University about how poverty and poor environmental conditions can contribute to poor health outcomes.

What motivates you to come to work every day?
It motivates me to know that the work we do helps families keep their children healthy. I also like training the future health care workforce.

How did your education lead you to the position that you have today?
I majored in Anthropology in college, and I studied how culture, beliefs and health intersect. That was a great foundation for medical school at Howard University. After medical school I studied at the Bloomberg School of Public Health at Johns Hopkins University.

What is your workspace like?
My office at George Washington University is in the middle of a densely populated urban center: Washington, D.C. When I am not conducting research, I am out in the city working with families of children with asthma. I also collaborate with organizations and agencies in the city that deal with asthma. Some of these agencies are responsible for improving housing conditions that make asthma worse like leaks and mold. I also work with agencies to write laws and enforce environmental regulations in order to keep people safer.

What accomplishment are you most proud of?
I am proud of forming a coalition called the Healthy Housing Collaborative. This group is working to improve housing conditions related to health for DC residents.

Is there something important that you want to share that we haven't asked?
I underestimated the role of good public policy (laws and regulations) when I began my career. Without these laws and regulations, it is difficult to keep communities safe from pollution sources that make the air hazardous to breathe. Elected officials don't always know how to keep the air clean. They depend upon citizens and experts to help them write and support environmental laws. It is important for you to understand the laws in your community, so you can make improvements and create new laws that are needed.

Glossary

AQI (Air Quality Index) – a scale for reporting daily air quality. The AQI tells you how clean or polluted the air is in a given location, and what the associated health risks are. The AQI focuses on health effects you may experience within a few hours or days after breathing polluted air.

artery – a muscular tube that is a part of the circulatory system, which carries blood (mainly oxygen-rich) from the heart to all parts of the body.

alveoli (singular alveolus) - tiny sacs in the lungs of mammals (including humans) that allow gases to transfer between the lungs and capillaries. This allows gases to enter and leave the bloodstream.

bronchi (singular bronchus) - passages or airways in the respiratory system that conduct air into the lungs

bronchodilator - a medication that relaxes and opens the airways, or bronchi, in the lungs.

capillary – a fine, branching blood vessel that connects the arteries to the veins in the circulatory system

cardiovascular system – another name for the circulatory system which references the heart (cardio-) and blood vessels (-vascular)

hemoglobin - a protein in human red blood cells that carries oxygen to the body's organs and tissues and transports carbon dioxide from organs and tissues back to the lungs.

ozone (O_3) - a natural and a man-made gas made of three oxygen atoms that occurs in the Earth's upper atmosphere (the stratosphere) and lower atmosphere (the troposphere). Depending on where it is in the atmosphere, ozone affects life on Earth in either good or bad ways.

particulate matter (abbreviation: PM) **-** a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Larger particles are called PM 10, smaller particles are called PM 2.5, based on their diameter in micrometers.

stomata (singular stoma) – a pore, found in the epidermis of leaves, stems, and other organs, that controls the rate of gas exchange into and out of plants.

trachea - (in human anatomy): a large membranous tube reinforced by rings of cartilage, extending from the larynx to the bronchial tubes and conveying air to and from the lungs. Also known as the windpipe

vein – a tube that is part of the circulatory system of the body, which carries blood (mainly oxygen-poor) toward the heart.