The Hole Truth on Vaping

Toxic Chemical Exposure Disruption to Systematic Homeostasis

(2 weeks; 50 minute class periods)

Authors

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SUBJECT/GRADE LEVEL

Subject Area(s): Science, Health

Grade Level(s): Middle School/High School

Materials

- Digital access for research or pre-printed research provided by the teacher
- Lab material per group
    - coffee filter, timer, tap water, food dye (any color), spray bottle (adjust as needed), hole punch or dissecting needle, dot sticker (or dot bandaid), 2x graduated cylinder 50 mL, funnel, ruler
- Claim-Evidence-Justification:
    - Poster or butcher paper, markers
    - Alternative option: Chromebook for either Google slide or Jamboard

STANDARDS

Next Generation Science Standards

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.

MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms

HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis

HS-PS1-6 Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

HS-PS1-11 Plan and conduct an investigation to compare the properties and behaviors of acids and bases.

Mathematics Standards | Common Core State Standards

6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation (MS-LS1-3)

HS-IF.C.7 Graph functions are expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. (HS-LS1-4)

English Language Arts Standards | Common Core State

CCSS.ELA-LITERACY.SL.11-12.1A: Come to discussions prepared, having read and researched the material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.
RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts =. (MS-LS1-3)
RI.6.8 Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. (MS-LS1-3)
WHST.6-8.1 Write arguments focused on discipline content (MS-LS1-3)
WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS1-3)
WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research (HS-LS1-1), (HS-LS1-6)

LESSON OBJECTIVE(S)

Students will be able to

1. Use the inquiry lab to identify the structure and function of a healthy lung vs a lung with emphysema.
2. Construct a model of emphysema and how it affects homeostasis between two or more systems. Provide one limitation (constraint) and improvement (criteria) of the inquiry lab model.

CAREER CONNECTION(S)

Mentor Background: Dr. Fudge Dylan, Research Chemist, Aberdeen Proving Ground, Maryland
Dr. Dylan Fudge is a research chemist working at DEVCOM Chemical Biological Center (CBC) with a focus on molecular toxicology with the threat agent sciences division. Dylan's current research aims to benefit the modern-day warfighter faced with biological and chemical threats by utilizing and advancing organ-on-a-chip (OOC) technology.

STEM Careers: Chemical biologist, Prototype engineer, Biophysicist, Toxicologist, Lab technician. Biologist, Resarch

ENGAGEMENT

Student handout

Brief Description: This activity engages students' prior knowledge with images and videos. It can be given to students before or after they have learned about the body systems: nervous system (brain), circulatory system, immune system, and pulmonary system.

Procedures:
Post the following two images (A and B) on the board for students to see and ask them to answer Engagement Question 1. Tell students there are no right or wrong answers and to think about their own experiences.

A 

B 

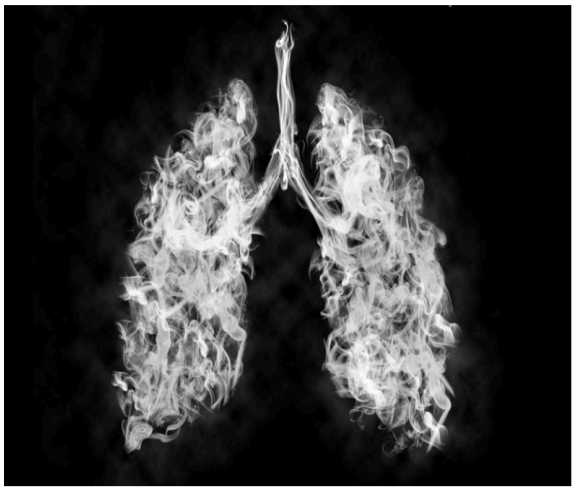
Video 1: [The truth about the MOST AIR POLLUTED COUNTRY IN THE WORLD]

Video 2: [American Lung Association's 2022 State of the Air report ranks Greater LA No. 1 in ozone pollution - ABC7 Los Angeles]

Give students about one minute to *think* and fill out the chart. Have students *pair share* with an elbow partner. Ask for students to volunteer answers for any of the boxes on the table. If students struggle to answer, use some of the guiding questions below:

1. Have you ever noticed that when looking downtown, the city looks hazy? Less colorful? Have you wondered why?
2. What is smog? What causes smog? Are there any health-related issues with smog?
3. How do you think that might affect your body? How it might affect your lungs?

After the initial discussion with students, have students take a look at images C and D:



The type of device used for vaping may indicate higher or lower risk factors, with vape pen users generally using fewer cigarettes, says Jessica Barrington-Trimis. (Illustration/Pascal Kiszon, iStock)

C



Exposing human airway cells to e-cigarette vapour containing nicotine in culture resulted in a decreased ability to move mucus or phlegm across the surface.

Nicotine in e-cigarettes may hamper mucus clearance from the human airways, increasing the risk of infection and injury, according to a study.

D

Ask students: How do you think the previous pictures are related to these pictures? Give students a few minutes to write down their ideas. Remind students that there are no right or wrong answers and they can draw (model) their answers if that helps. If students are struggling, ask: What do you think smoking does to your lungs? How is this related to vaping? Is vaping better than smoking? What do you think?

Discuss answers with students. After discussion, have students research similarities and differences between pollution and vaping and if there is a direct correlation between respiratory diseases in the population and smog/ air pollution. Students graph/ chart the data found and analyze the data to come up with an evidence-based statement.

Modifications:

- Provide sentence stems for ELL students. Have students discuss with elbow partners before sharing with the class.
- Put students in groups of 4's. Have students write their ideas on post-its and place them on butcher paper with the images. Have students re-arrange the post-its by stacking similar ideas.

EXPLORATION

Brief Description: An hands-on inquiry where students will simulate the inhalation of toxic particulates that accumulate in the lungs and measure the resulting negative consequence.

Procedures:

Time frame: one 50-minute class period.

Materials: coffee filter, timer, tap water, food dye (any color), spray bottle (adjust as needed), hole punch or dissecting needle, dot sticker (or dot bandaid), 2x graduated cylinder 50 mL, funnel, ruler

Appendix B: Picture examples of lab

Steps	Teaching moments
Control group: 1. In the first graduated cylinder, measure 50 mL of water. 2. In the empty second graduated cylinder, place a funnel on top. Place the coffee filter in the funnel. 3. Set a timer for 10 seconds. 4. Pour the 50 mL of water into the funnel and start the timer. At the end of the timer, remove the funnel and empty the remaining water. 5. Record the volume of the water collected in the 50 mL graduated cylinder.	The teacher can go through the experiment step by step with students and have them identify the control and experimental groups. Opportunities for formative assessment: Go through each step with the students and ask students what they think each step represents. Notes are given below to guide the discussion. The **control group** represents a healthy individual. ***Independent variable:** amounts of spray This can represent how many months/years of inhalation, living in a polluted area, or inhaling

Experimental group:

1. Add water to the spray bottle. Add 1-2 drops of food dye.
2. Open filter paper from the control group and spray the dye water over the filter paper.
3. Use the hole punch to puncture the filter paper on any dye droplets bigger than 2mm.
4. Let the filter paper dry in an oven (or use a hair dryer or overnight if no oven is available) and add a sticker dot to cover each hole punch.
5. Measure 50 mL of water in a graduated cylinder. On a second graduated cylinder, place the funnel and the filter with the dot stickers
6. Pour the water into the funnel, collecting it into the second graduated cylinder. Stop after 10 seconds.
7. Record the volume collected.
8. Repeat steps 2-7 another 3 times.

VOC. This is a good time to also discuss secondhand smoke and how it affects individuals differently. Depending on the time, the teacher can also discuss genetics.

Dependent variable: volume of water collected (mL)
The water represents oxygen. The filter represents the lungs. The graduated cylinder that collects the water represents the capillary in which the oxygen will get distributed to the rest of the body for cellular respiration.

Experimental group:
Step 2: test the spray bottle first and adjust the nozzle as necessary before giving it to students. Be sure to tell students NOT TO ADJUST nozzle.
Step 3: Smoke and toxic chemicals lead to cell death leaving holes in the alveoli.
Step 4: the dot sticker represents the immune system coming in and creating scar tissue. If available, use a dot bandaid to show the lungs are injured and the body is repairing it.
Step 8: Each spray represents the accumulation of toxic chemicals either from continued use of vaping, secondhand smoke, or the duration of living in a polluted environment.

*Adjust the independent variable (# of sprays) depending on the spray bottle).

Emphysema cannot be reversed.

Virtual options: there is no simulation currently for this lab. However, the materials can be easily adjusted so students can conduct the experiment at home.

Spray bottle: the student can dip fingertips in a bowl of water and flick it onto the filter.
Filter: instead of a filter, a paper towel can be used
Hole punch: student can use a pencil to poke a hole
Dot sticker/bandaid: tape
Graduated cylinder: the student can use a long cup and ruler to measure volume

Other modifications
Instead of using a hole punch and dot stickers, the inquiry lab can be modified using a ruler to measure the diameter of the dye. After each spray, the dye should be bigger in diameter. Students measure the surface area to demonstrate that the surface area in which oxygen is able to diffuse to the blood capillary decreases as the holes between alveoli increases the total volume.

Another option is to use an electronic balance with different particle sizes to represent different toxic chemicals. The mass of the filter paper can be taken to show the accumulation of toxic chemicals and scar tissues in a healthy vs unhealthy lung.

For higher-level students with a chemistry background, the use of dye concentration and spectrophotometer can be used. Set up a petri dish with clear water to represent healthy lungs. Spray the dye water and measure the absorbance. The teacher can set up a "known concentration" of food dye to represent when the lungs have reached COPD. The students will measure how many sprays (months) it takes before the start of chronic obstructive pulmonary disease (COPD) occurs.

Another chemistry modification includes the use of different concentrations of dyes. Have students dilute the dyes using $M_1V_1 = M_2V_2$ The different concentrations represent addiction. As a person continues to smoke, the body gets acclimated to the nicotine and needs more "dye" to get the same effects. Have students research why inhalation leads to addiction (teacher note: inhalation goes straight to blood and affects more quickly than chewing tobacco)

EXPLANATION

Brief Description: Introduce students to the symptoms of emphysema and COPD and the impact it has on family carers. Students will then create a Claim-Evidence-Justify presentation by analyzing the data from the explore inquiry lab and research scientific connections of the systematic consequences within the human body systems and to homeostasis.

Procedures:

Time frame: depending on students' independent research skills, this can take up to 3-4 class periods. If time is limited, the teacher can provide readings for students to choose from.

Write on the board: "How do inhaling toxic chemicals result in COPD and cause a disruption in other body systems?" Tell students they will create and present CEJ slide.

Claim: answers the question
Evidence: Graph of data and analysis
Justification: explain the negative consequence of toxic chemical exposure to the lungs and how it disrupts homeostasis in at least ONE other system.
Must have one relevant picture and citation.

Students are given time to research emphysema (and COPD) and how it disrupts homeostasis. Students must mention at least one other body system in the justification. The teacher should scaffold students' research with key ideas and review other body systems. Some ideas are listed below:

- Immune system: irritant causes the immune system to ramp up mucus production causing wheezing and coughing. Damage to cilia leads to lung infection. The immune system is also responsible for creating scar tissue.

- Circulatory/nervous: increased levels of carbon monoxide in the blood and less oxygen diffusing to the blood. The increase in CO_2 triggers chemoreceptors in the brain to increase breathing rate.
- Renal: increased breathing causes more production of concentrated urine to get rid of CO_2.
- Nervous/circulatory: Increase in CO_2 disrupts the acid-base equilibrium in the blood. Students research the buffer system in the blood and discuss how an increase in CO_2 disrupts homeostasis.

ELABORATION

Brief Description: Students will expand on their research based on interest.

Procedures:
Time frame: 1-2 class periods

Before beginning the independent research by students, the teacher should briefly explain emphysema and COPD symptoms. Emphasis should be placed on irreversible damage to the lungs and the slow death in which others would have to care for the patient long term. Patient stories are a good way to go; options include the following videos on Leonard Nimroy or the teen who had a double lung transplant after vaping can be shown.

Allow students to have freedom on what they what to research. Some ideas include:

- Vape flavors and how inhaling these aerosols results in health consequences
- Vaping vs cigarette: which is worse?
- How good are filters in air purifiers? How do air purifiers work?
- Sick building syndrome
- Other volatile organic compounds (VOC) and how we are exposed to them in everyday life
- Air purifying plants
- Acid-base equilibrium: ocean acidification
- Addiction and personalized medicine
- Linking inhalers (albuterol) effectiveness to work quickly for those with an asthma attack and linking to addiction to cigarettes and vapes
- Secondhand smoke
- California wildfires and air pollution
- Climate change and increase in air pollution

Have students report their research in on the Gist Summary handout. Have students with like ideas share what they discover and create a poster "advertisement". Post the poster and do a gallery walk so students can see other groups' research.

EVALUATION

Brief Description: Students will reflect on their learning by creating a model. Students will list the

criteria and constraints on an improved model.

Procedures:

Time frame: 1 class period

Have students create their own model first. Then, put students in groups of 3-4 with butcher paper/poster paper. The students will come to a consensus on how to model the inhalation of toxic chemicals and the damage to the body system. Students will also discuss the limitations of the inquiry lab in demonstrating emphysema. Use the posters in a gallery walk.

Alternative assignments: students can work independently or together on a Google Slide/Draw or Jamboard.

Some ideas of limitation: scar tissue formation prevents the elasticity of alveoli from inflating and deflating which cannot be seen in the model. The lungs have multiple alveoli sacs; the holes created between alveoli decrease surface area.

REFERENCES

- Emphysema - Harvard Health
- Pathophysiology of Emphysema and Implications - PMC (nih.gov)
- https://www.gettyimages.ca/photos/smog (pics A and B)

Appendix A: Student Handout

ENGAGEMENT

1. Observe images A and B and fill in the table below:

I notice….	It reminds me of…
I wonder….	

2. Observe image C and D. How do you think the previous images (A and B) are related to these images? Jot down your thoughts below:

3. Write down some information from your research. Be sure to write down the sites you used:

4. Write down your evidence-based statement:

EXPLORATION

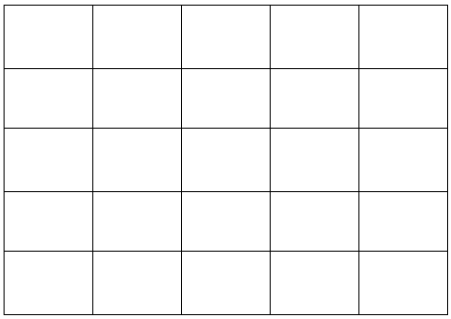
1. State the following:

Independent Variable	
Dependent Variable	

2. Data:

# of sprays	0	1	2	3	4
Water collected (mL)					

3. Analysis: Graph your results below



4. Post-Lab Questions:
   a. What did each part of the lab represent? The first one has been completed for you.

Lab equipment	What did it represent?
Filter paper	Lungs
Water	
Dye in water	
Hole punch	
Dot sticker/Bandaid	
Spray bottle	
Graduated Cylinder with Funnel	

ELABORATION

Gist Summary

1. Topic:

2. Five key phrases/words (in your own words) that explain what your research is about:

1.	
2.	
3.	
4.	
5.	

3. 20 Words Gist Summary: use the key phrases/words from question 2 to write a summary, *in your own words in exactly 20 words. Plagiarism of any type will result in no credit and disciplinary implications.*

4. Reflection *(1 paragraph): at least a paragraph response to the article you read. Your reaction should include why you like or dislike the article, what interested you, how impacts society, etc…*

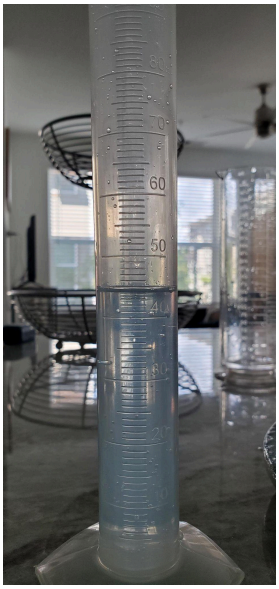
5. Provide the work citation in MLA format below. Use this website to help with the format. http://www.easybib.com/

EVALUATION

Model:
Limitation to model (constraints):
Improvement to model (criteria):

Appendix B: Pictures of lab set up

Control Group:  dropping water (oxygen) on filter (lungs)	

 Experimental Group: Step 3 and 4 (Bandaids (scar tissue) trial 1)	 Experimental Group: Step 3 and 4: trial 2 (repeating the process) More scar tissue
 Experimental Group: Step 3 and 4: Trial 3 (repeating the process for a third time) (more “scar tissue”)	 Water measurement for trial 1 (45 mL)
Water measurement for trial 2 (44 mL)	Water measurement for the third Trial was 44 mL also.