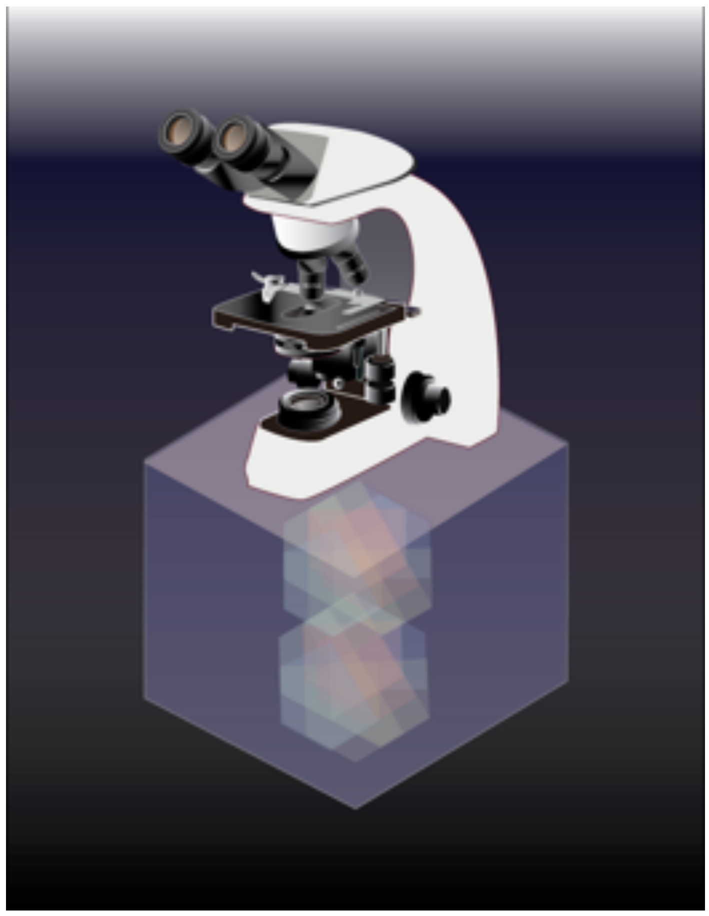
Teacher and Student Guides
The Mice of Riddle Place:
"The Incident of Izzy Ramirez"
Meadowlark Science and Education, LLC.



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Teacher and Student Guides

Table of Contents

Overview

"Chapters and Chapters at a glance" (Learning Zones: STEM, NGSS, CCSM)

The "Chapters and Chapters at a glance" views provide a clear look at the STEM subject matter, Next Generation Science Standards, and Common Core Standards for Math in the game. For the purposes of clarity, these have been mapped to **chapters** which are designated learning areas in the game space where specific STEM related content is found. The chapters are created for teachers who want a quick reference point, where if for example, they would like students to go to a specific content area in the game as part of their lesson plan. Teachers will know what content, standards, and objectives exist within each zone of learning. Students will be able to play the game "The Mice of Riddle Place®: The Incident of Izzy Ramirez" and find these chapters contain a brief introductory audio clip discussing what can be found in each level. The chapters are essentially in game levels that allow a student to play a portion of the game. In addition, to a description of the game chapters, the script for each chapter as experienced by a player of the game is provided in the Chapters section of this e-book.

Teacher Guides (Big Ideas: Science and Math)

The Science and Math teacher guides are designed to be streamlined and powerful guides for teachers to have a means to access core knowledge found both in the game and with the Next Generation Science Standards, and Common Core Standards for Math in a middle school level classroom. The teacher guides encourage the presentation of "big ideas" for students, therefore setting up engaging scenarios for students to grasp and discuss key pieces of content that are found in the science and math standards. A big idea centered approach is discussed in the science and math teacher guides, so students will understand the causes and effects regarding the phenomena of "particle filled air" as it triggers the conditions of asthma. The math guide uses big ideas to teach students the 'phenomena' that air is a quantity (e.g., that it has mass and volume and fills a living space) and can be expressed in an equation that describes how **air as a quantity** can be propelled through a space. From a STEM career perspective, students can know that this is how engineers design ventilation systems for schools, homes, and even hospitals.

Student Guides (5E's: Engage, Explore, Explain, Extend, and Evaluate)

We have supplied a number of STEM based worksheets for use with the game. The students guides are another side of the immersive and engaging approach to STEM learning that both the game, the teacher guides, and student guides try to setup for students in your classroom. The student guides borrow on the 5E instructional model (see below), based on constructivist approaches to education from Jean Piaget.[1]

An example cited here, from the WNET website [link here] presents a teaching scenario for learning, that is very similar to the vent problem found in the Math guide:

"Groups of students in a science class are discussing a problem in physics. Though the teacher knows the "answer" to the problem, she focuses on helping students restate their questions in useful ways. She prompts each student to reflect on and examine his or her current knowledge. When one of the students comes up with the relevant concept, the teacher seizes upon it, and indicates to the group that this might be a fruitful avenue for them to explore. They design and perform relevant experiments. Afterward, the students and teacher talk about what they have learned, and how their observations and experiments helped (or did not help) them to better understand the concept."

In the approach of using aspects of the 5E model, teachers are asked to look at the world together with their students through the "lens" of ideas. For example, this may be looking at the phenomena of dust or particle filled air, or understanding how air is a quantity that can be expressed in the language of mathematics.

1 NASA has a great resource page that outlines the 5E model: see link here : https://nasaeclips.arc.nasa.gov/teachertoolbox/the5e

Once this aspect of teaching with ideas is mastered, students will be off and running to try to see and comprehend the phenomena that exists in their environment and the key elements of disciplinary knowledge to be found in a given content subject matter.

Do you have a great idea for a lesson plan? Share it with us!

The teacher guides are meant to be open and flexible structures for use in your classroom. It was the main idea in designing them as open, that teachers would be free to tailor or customize them to fit their classrooms.

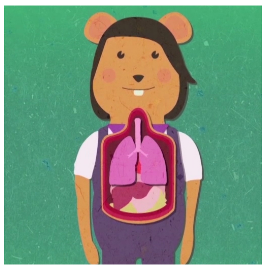
We would like to add to the library of great teaching examples to enhance the teacher and student guides. If you'd like to submit an idea we'd like to feature you as an innovative educator on our website: share your success, share your ideas, and how you use our innovative materials in the classroom. Please feel free to email them to us! Contributing teachers will have an opportunity be featured on the Meadowlark Science and Education, LLC ©.

Please contact us at: http://www.meadowlarkscience.com/

Chapters found in the game

Chapters:

1. Asthma Introduction: STEM core: Science, Technology, Engineering, Math



Players will interact with two lab technicians who are identified as interactive avatars by the floating exclamation mark situated above their heads (in the extended edition) or with M.A.R.V.I.N the robot mouse, (in the classroom edition) depending on the version of the game that was downloaded. The triggers in the apartment that have been the source of Izzy Ramirez's asthma will be first discussed with players here by the lab technicians in the lab. The lab is equipped with a Virtual Intelligence, to supply players (students) with the key features about the situation of "bad air" that is causing Izzy to have asthma attacks. The Monitor in the environment, will provide a brief introductory video on asthma that explains how "bad air" in the form of particles is causing inflammation in Izzy's lungs. Players will then navigate M.A.R.V.I.N the robot mouse in the bio-dome to discover the clues that will lead to understanding the fundamental environmental "triggers" behind Izzy's asthma.

In game: Want to make a recipe for "bad air"? In this clue finding game, you will try to unlock the answers for what ingredients are in the air causing Izzy Ramirez to suffer asthma attacks. You will enlist the help of M.A.R.V.I.N. the intelligent lab on wheels, in order to get this mouse robot to help find you the answers!

2. Clue Collection: STEM core: Science, Technology, Engineering, Math

In this chapter, players will explore Izzy Ramirez's apartment in search of answers as to what environmental "triggers" are triggering Izzy's asthma. There are four main clues here: 1. The water dripping from the ceiling causing mold on the ceiling tile 2. The flowering maple plant 3. Izzy's stuffed animal bunny full of dust and dust mites. 4. The tobacco smoke pouring from the vent.

In game: In Chapter 1, you learned how "bad air" in the form of particles is causing inflammation in Izzy's lungs and triggering her recent asthma attacks. Now, in addition to understanding that air is like a soupy mixture of different types of airborne particles, you have to find the four clues in Izzy's apartment that make up this bad air concoction in her apartment. Go forward Detective!

3. Microscope Investigation: STEM core: Science, Technology, Engineering, Math

One of the core "science" experiences is presented to players of the game here. Players will conduct a test of Izzy's sputum in order to test her Eosinophil count by viewing these cells under a microscope. Players will count the number of cells. In order to establish an average count a slide with a grid is utilized and this is called a hemocytometer. The increased presence of Eosinophils represents the presence of inflammation related to asthma.

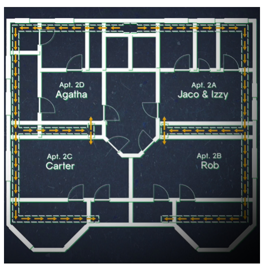
In game: Alright M.A.R.V.I.N.'s main brain, this is where you'll teach the robot mouse how to function like a true scientist and you will experience the life (as close as can be) of a real scientist in a lab who studies the effects of air on people's health. You have already been gathering clues as to what objects in Izzy's apartment could be causing her asthma, now you will look at a sample of Izzy's sputum closely under a microscope to learn about the cells that are involved in an asthma attack.

4. Trigger Elimination Screen:

In this chapter, players will go back to Izzy Ramirez's apartment in to remove the "triggers" that are triggering Izzy's asthma.

In game: In Chapter 2, you collected clues which are triggering Izzy Ramirez's recent asthma attacks. Now it's time to start removing some of the identified triggers to see how they affect Izzy's health.

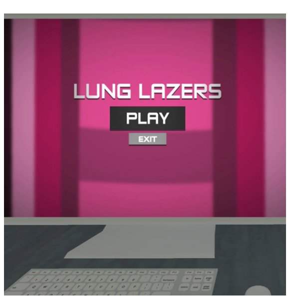
5. DuctWork Engineering: STEM core: Science, Technology, Engineering, Math



Players will experience a core “math and engineering” context based math problem here. Players will learn how the circular area of a vent is related to the amount of air that can be brought into a room in order to refresh the air in the room. Players will experience a linear equation that engineers use to calculate what kind of venting and duct system to match to the volume of a room.

In game: Air is a quantity that has volume and takes up space. Just think of what happens if you contain a volume of air in a balloon. Indoors, we use a vent to freshen the air of a room. It takes speed or a fancier word: velocity, to move the air inside a vent and out into a room. It’s time to explore the ductwork in Izzy’s apartment now that you’ve been gathering clues, analyzing data and using the microscope.

6. Mold Swab mini game: STEM core: Science, and Math



Here students engage in a mini game called “Lung Lazers.” The goal is to control the mucus that is entering Izzy’s lungs, by playing the role of a starship set out to battle the huge gobs of mucus. Lung Lazers offers players an opportunity to understand how mucus is created in the lung pathways because of the 2D cutaway schematic view of the lungs.

In game: One way the body defends the lungs against particles which are like alien invaders that it doesn’t want entering the body, is to create mucus in order to trap the particles. In order to help the lungs along, you must battle the particles with your ship inside Izzy’s lungs in the game Lung Lazers! Please don’t have any fun playing this game……just kidding!

7. Remediation: STEM core: Science, Technology, Engineering, Math

Here players learn the four kinds of remediation necessary to reducing the “triggers” that have been causing Izzy’s asthma. Players will replace each of the four triggers with: 1. The asthma friendly bunny. 2. A HEPA filter installed vacuum cleaner. 3. A HEPA air filter. 4. Clean hypoallergenic bedding.

In game: Previously, in Chapter 6, you tried to prevent Izzy’s immune system’s response to an invasion of particles in the awesome mini game “Lung Lazers.” However, there are also things we can do to help change the “bad air” quality in her apartment. In order to help reduce Izzy’s chances for more asthma attacks are you ready to figure out what you can do?

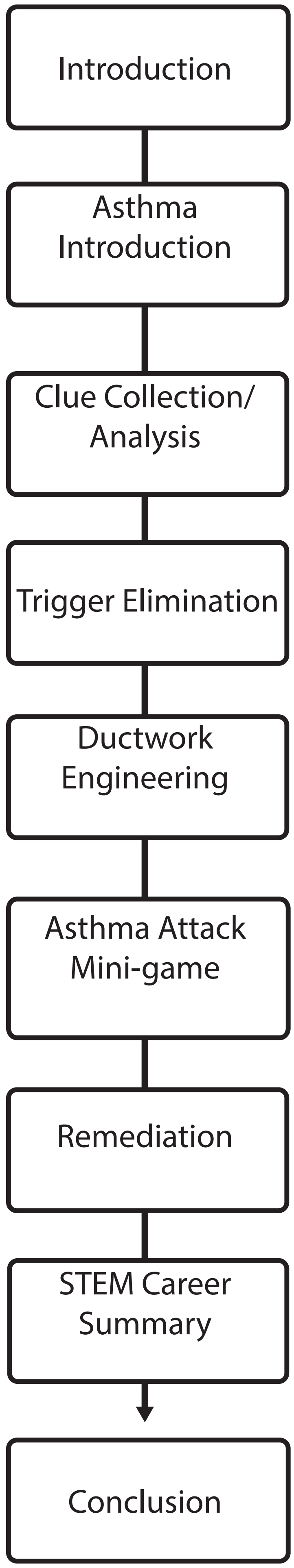
8. STEM Career survey: STEM core: Science, Technology, Engineering, Math

Here players will report their findings from playing the game “The Incident of Izzy Ramirez” to the lab technician Susan or M.A.R.V.I.N. the robot mouse. This is the concluding interaction of the game, with a discussion about the paths to careers and opportunities in the field of science, technology, engineering, and math.

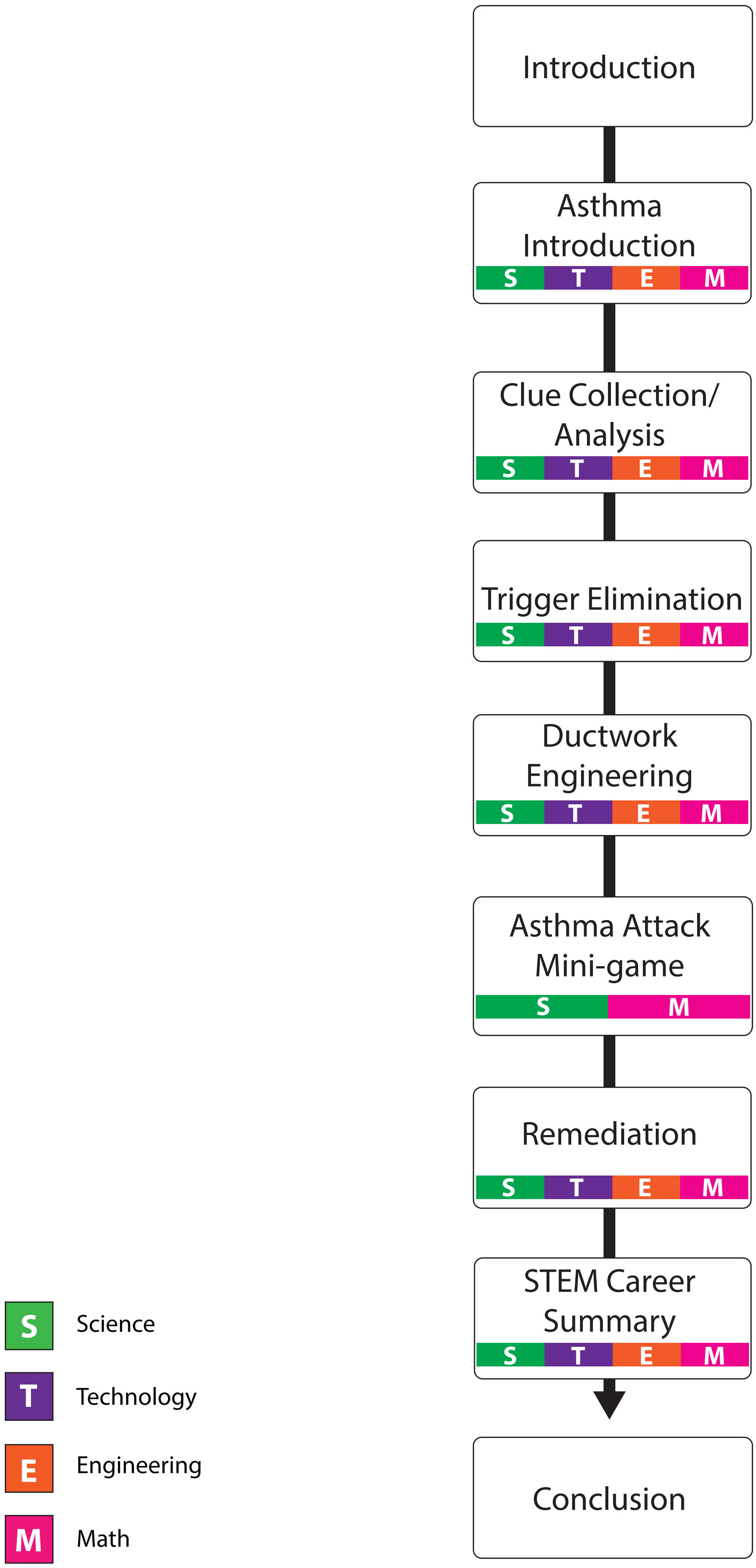
In game: You have come to the last chapter of “The Incident of Izzy Ramirez.” Before you go, take a minute to learn how today you actually did four important jobs: you were a scientist, an engineer, a mathematician, and also a high tech mouse. Drop in here to see what the future could hold.

"Chapters at a Glance"

"Game Chapters"



"STEM"


Introduction
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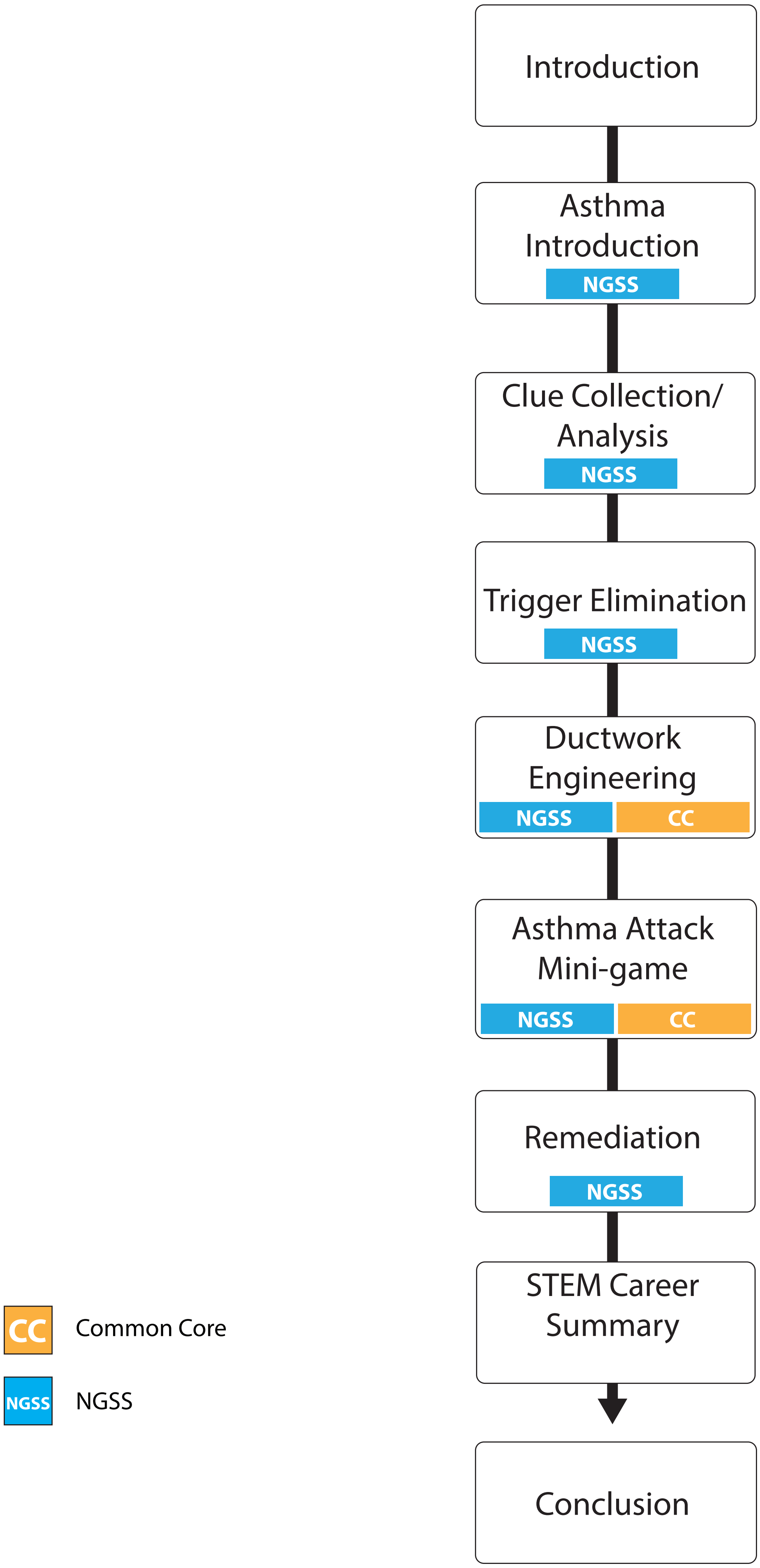
S T E M
Clue Collection/ Analysis
S T E M
Trigger Elimination
S T E M
Ductwork Engineering
S T E M
Asthma Attack Mini-game
S M
Remediation
S T E M
STEM Career Summary
S T E M
Conclusion
S Science
T Technology
E Engineering
M Math

“Standards”


Introduction
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Clue Collection/ Analysis
NGSS
Trigger Elimination
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Ductwork Engineering
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NGSS
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Conclusion
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Common Core
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NGSS

Next Generation Science Standards, "At a Glance"

NGSS.MS-ETS 1-3

Performance Expectations, Engineering Design: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

* **Science and Engineering Practices:** Developing and using models, analyzing interpreting data, engaging in argument from evidence

NGSS.ETS 1.A

Defining and Delimiting Engineering Problems: The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specifications of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS 1-4)

NGSS.ETS 1.B

Developing Possible Solutions: A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS 1-4)

* There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS 1-2), (MS-ETS 1-4)

NGSS. ETS 1.C

Optimizing the Design Solution: Although one design may not perform the best across all tests, identifying the charateristics of the design that performed the best in each test can provide useful information for the redesign process–that is, some of those characteristics may be incorporated into the new design. (MS-ETS 1-3)

* The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS 1-4)

Math Common Core Standards, “At a Glance”

CCSS.MATH.CONTENT.6RP.2

Understand the concept of a unit rate a/b associated with a ratio a:b with $b \neq 0$, and use rate language in a the context of a ratio relationship. For example, “This recipe has a ratio of 3 cups of flour to 4 cups of sugar, so there is 3/4 cup of flour for each cup of sugar.” “We paid $75 for 15 hamburgers, which is a rate of $5 per hamburger.”

CCSS.MATH.CONTENT.7G.B.4

Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.

CCSS.MATH.CONTENT.7G.B.6

Solve real-world mathematical problems involving area, volume, and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prism.

CCSS.MATH.CONTENT.8F.B.4

Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values.

CCSS.MATH.CONTENT.8F.5

Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualtitative features of a function that has been described verbally.

Science Guide

Science Guide

Next Generation Science Standards/Idea Based guide
for teacher use with:
The Mice of Riddle Place®
"The Incident of Izzy Ramirez"

Next Generation Science Standards: here

Preface to the teacher guide

The central premise of this science teacher guide for “The Mice of Riddle Place®: The Incident of Izzy Ramirez” game is to provide a teacher with a big-idea centered approach to relaying fascinating aspects of STEM (Science, Technology, Engineering, and Math) core content to students in a classroom. Big-ideas are the tools of the discipline (one phenomena in science is that “light” can travel in either the form of a particle or a wave). Big ideas capture regularities in a phenomenon; these regularities, of course, are identified (always tentatively) by scholars in the discipline.

The big-idea approach begins with identifying a regularity that helps explain objects or events for students and that, if understood, will, literally, open their eyes to an interesting aspect of the phenomenon. An example, presented in the science guide and game is the notion that: "air contains an enormous amount of particulate matter invisible to our everyday eyes.” In the case of the causes behind a human ailment or condition such as asthma these unseen particles can cause irritation in our lungs which are designed to filter particles (e.g, dust, pollen) that enter the air pathway. The lungs, also happen to be the main thoroughfare for oxygen molecules to enter the blood stream. The guide and game, are organized around big ideas--and the phenomena those ideas will help them understand--should connect well with science and math content standards for middle school students (i.e., Next Generation Science Standards and the Common Core Standards for Math).

Thus, students will have the opportunity to explore learning zones that have been built around STEM learning with science standards (Next Generation Science Standards) and Common Core standards for middle school level math.

The main idea here is that teachers have experience working with their own science curriculum and teaching it with students in their classroom everyday. What this innovative guide will hopefully lend to your teaching is a way to open up aspects of the discipline for science and math that compliment your use of the game and teaching. Simply described: it is a way to find new approaches to ideas held and found in the standards - maybe you try the strategy outlined here and discover that students grasp the ideas faster and this ‘lightens’ the cognitive load of teaching and learning in your classroom. Minimalism and elegance of the curriculum structure are the ultimate goals - no belaboring - just simple, powerful, direct presentation of the ideas and the math.

The approach here gives you some clear starting points for how to initiate an idea-based discussion with your students either before or after they have played the game. We have worked to make the science learning strategies very simple and clear - in this case we have provided you with the roots and an underlying idea structure over which you are free to design, build and add to the branches of your teaching and learning curriculum tree so to speak. We hope that it gives you a dynamic way to teach both with the game and the content, so that (you) the teacher enhance and engage students' thinking before and after they have played the game.

Summary of the science ideas in this guide (teacher background knowledge)

1. Big Idea 1: Today's houses are built to protect us from the effects of hot and cold weather. There is only one problem - modern houses are sometimes built so airtight that they often pose a challenge for the occupants living in the house because this air becomes contained within the walls and rooms of your house and can't circulate. In this way, a house can be a trap or container for the kinds of particle laden air that's constantly moving in our natural environment. Learning to see our friend Izzy's home in this way might give you an opportunity to understand how the home could be a leading cause for her asthma.

The main idea is that most modern houses are built to be airtight, so much so that they can trap mold, pollen, and other forms of dust particles inside.

2. Big Idea 2: Our everyday environment is full of microscopic particles that carry traces of human, animal, organic, and non-organic matter. If you could see your home like a scientist who studies the world on a cellular and molecular level, from the point of view of a chemist for example — then you would begin to understand how these particles might have an influence on our health because they are part of a complex mixture of air (oxygen) and thousands of other airborne particles we breathe on planet earth everyday of our life.

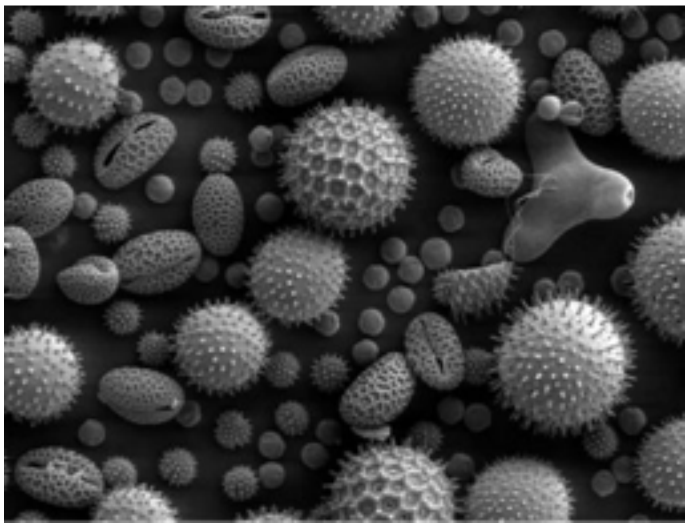
3. Big Idea 3: Asthma is a human ailment caused by the lung's reaction to specific kinds of particle-laden air that create a great deal of irritation to the special fibers in our lungs called cilia. When this irritation begins, the body's defense mechanism kicks in to stop these particles from causing further damage. From the video in the game, this idea is of main emphasis for students: "When the lungs become irritated, the immune system is activated and produces special inflammatory cells called Eosinophils.

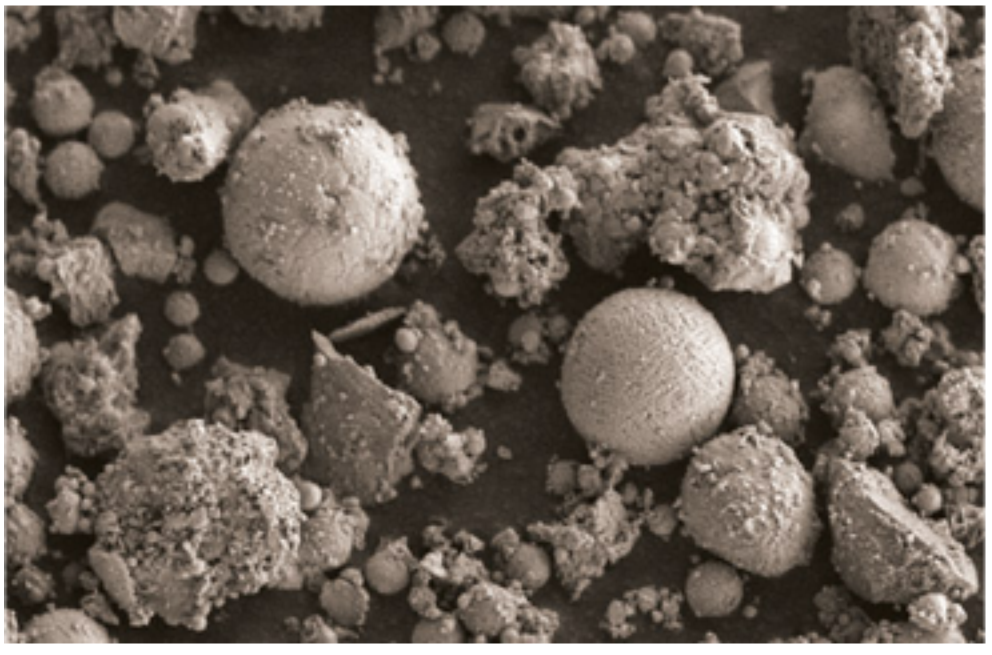
This combination of tightened lung muscles, extra mucus, and activating the body's immune system combine to create what is called an asthma attack.

Mini-Lab (courtesy of Brandy Thrasher): This teacher has designed an activity called "Sticky Traps." The big idea here is to trap airborne particles on pieces of clear tape. You can have students conduct this experiment by hanging tape in your classroom, outside, at home - after 24-48 hours have passed have your students collect their "Sticky Traps" and look at what they collected under microscopes.

Extension of the Mini-Lab (courtesy of Elizabeth Rugh) This teacher has suggested an extension of the mini-lab, where students can test the air quality of their homes both outside and inside. The students can then compare the "sticky traps" at different times of the day. Taking care to note the time and the percentage of dust that has been captured by the traps over the course of a day. Students will be bring these air quality tests into school and compare and discuss them in class with their peers.

Under the microscope: Discuss what dust and pollen look like under a microscope with your students! (You can printout the labeled microscope diagram for students to enhance their understanding of tools of the trade





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NGSS.MS-LS1-3

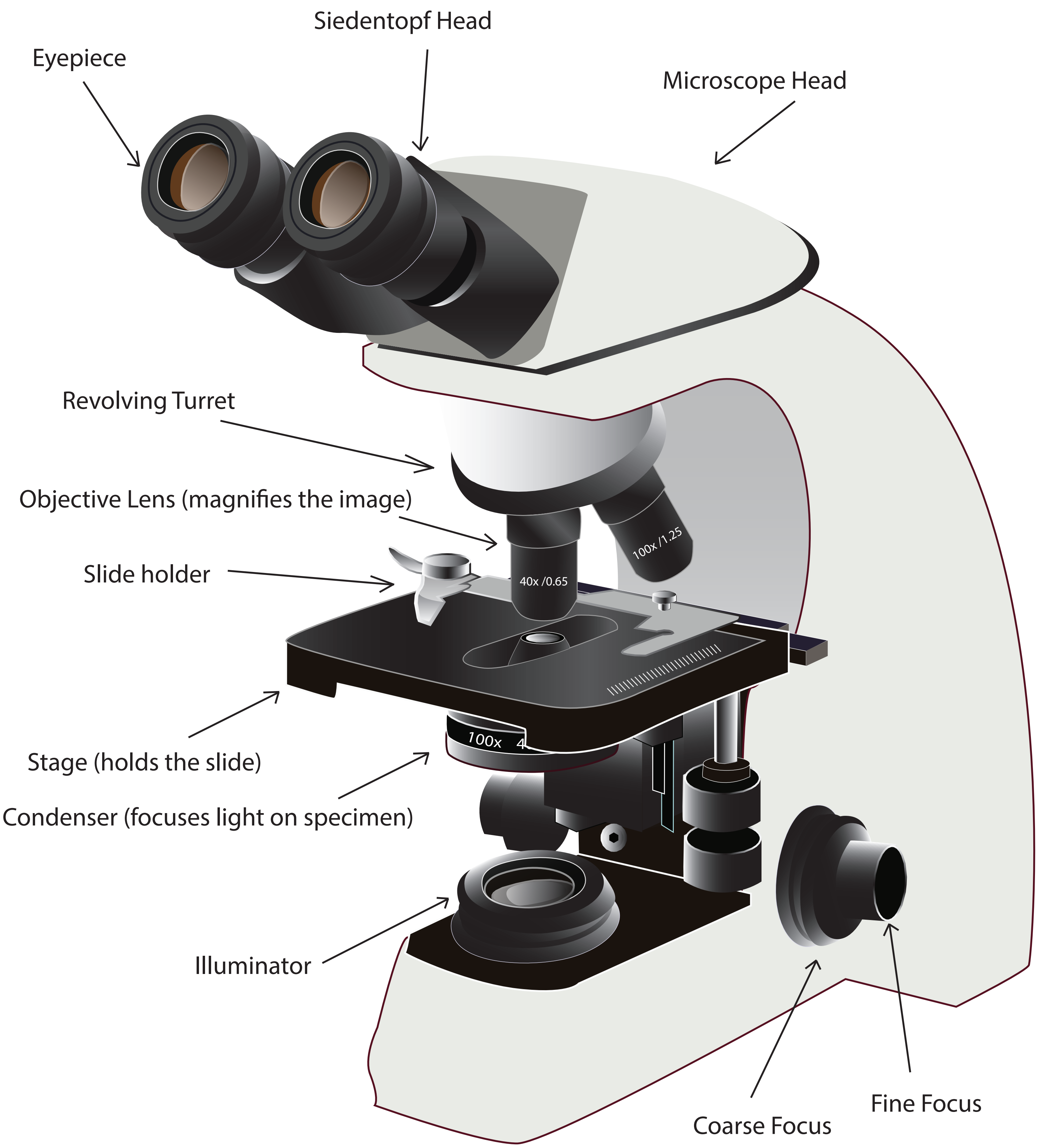
Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

Discplinary Core Ideas: NGSS. MS-LS1-A

All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular) (MS-LS1-1)

* Within cells, special structures are responsible for particular functions, and the cell membrane forms boundary that controls what enters and leaves the cell. (MS-LS1-2)
* 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)

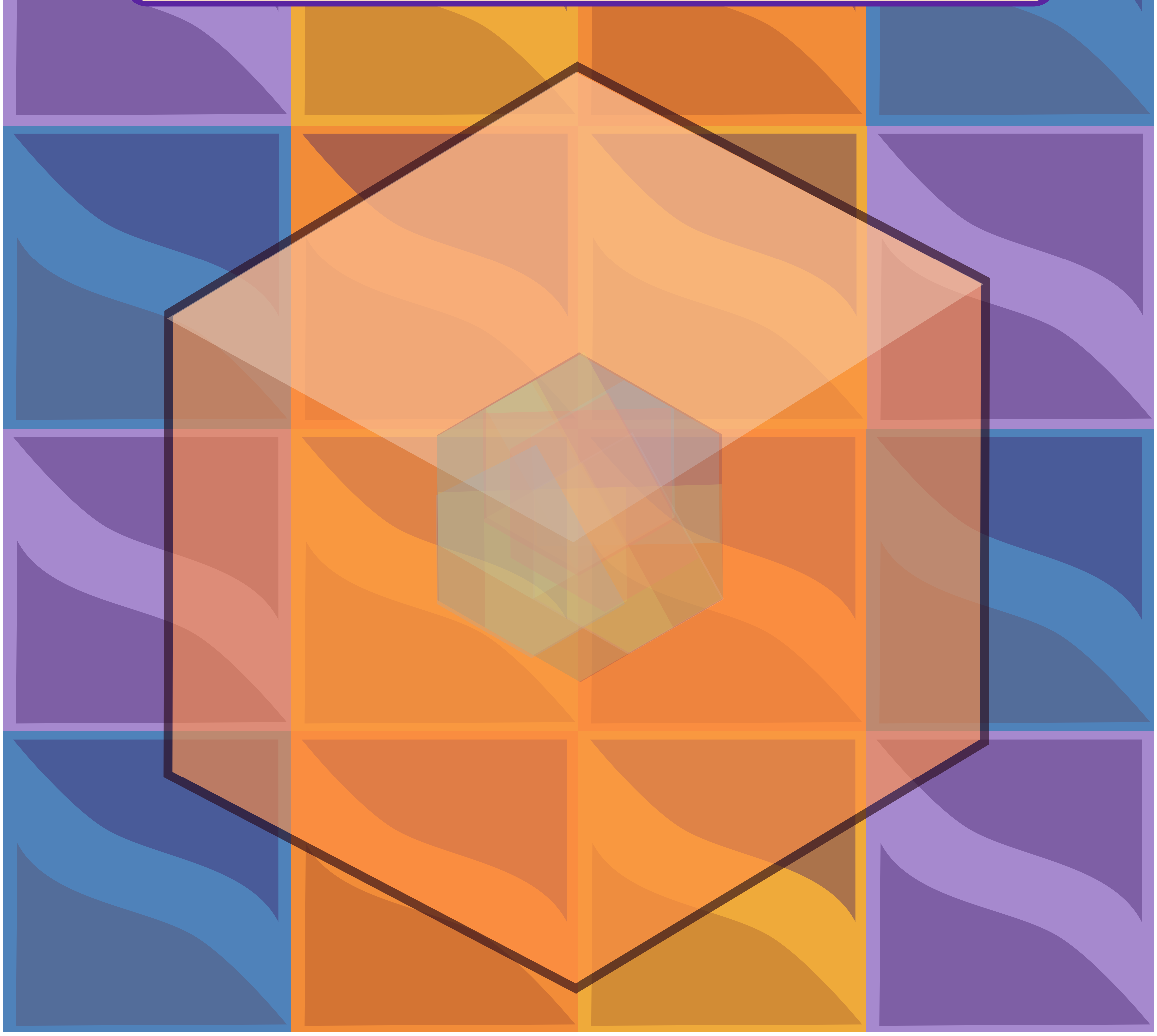
PRINTOUT FOR STUDENT AND TEACHER USE



Math Guide

Math Guide

Common Core Standards/Idea Based guide
for teacher use with
The Mice of Riddle Place®
"The Incident of Izzy Ramirez"



Preface to the teacher guide

The central premise of this math teacher guide for "The Mice of Riddle Place®: The Incident of Izzy Ramirez" game is to provide a teacher with a big-idea centered approach to relaying fascinating aspects of STEM (Science, Technology, Engineering, and Math) core content to students in a classroom. Big-ideas are the tools of the discipline (one phenomena in math, not well understood as it relates to negative number: it could be described as the idea that there is "life beyond zero"--the notion that a negative number also has directionality and magnitude). Big ideas capture regularities in a phenomenon; these regularities, of course, are identified (always tentatively) by scholars in the discipline.

The big-idea approach begins with identifying a regularity that helps explain objects or events for students and that, if understood, will, literally, open their eyes to an interesting aspect of the phenomenon. An example, presented here in the math guide and game is the notion that: "air is a quantity" as such, it can exert pressure on an object. Also when it comes to propelling this quantity through the opening of a vent, a vent shape is needed with the most efficient surface area possible. This is so the air can pass through the interior of the vent with minimal friction. A circle is the big kid on the block, when calculating the interior area of a triangle, square, and circle for a vent to move air through and comparing amongst them. **[see illustrations 1 - 3]** It's important to know this when one thinks about air cycling into and out of a room (with vents).

The fresh air that comes into the room pushes some of the stale air out of the room. Some new air molecules arrive and some leave and this is measured, like cubes of ice, as volume with mass. **[see illustrations 4 - 6]** In this way, students can understand that the interior size and opening of a vent and the amount of energy needed to push new air into the room are directly related to one another. This relationship, they can also understand, is straightforward (i.e., linear) and thus easily expressed in the language of math as an equation. The guide and game, are organized around big ideas--and the phenomena those ideas will help students understand--should connect well with science and math content standards for middle school students (i.e., Next Generation Science Standards and the Common Core Standards for Math).

Thus, students will have the opportunity to explore 'learning zones' that have been built around STEM learning with science standards (Next Generation Science Standards) and Common Core standards for middle school level Math.

Summary of the math ideas in this guide (teacher background knowledge)

1. Students should comprehend the geometric marvel about the area of a circle, based on Statement 1 of the Isoperimetric Theorem: "Among all planar shapes with the same perimeter the circle has the largest area."

2. Students can understand that the interior size and opening of a vent and the amount of energy needed to push new air into the room are directly related to one another. This relationship, they can also understand, is straightforward (i.e., linear) and thus easily expressed in the language of math as an equation.

3. The bigger the vent size, the faster the air change rate.

4. To optimize the situation: a circular shape wins the competition for interior surface area for a vent hands down, because when the length of a triangle's side, a square's side, or a circle's radius at a similar size are compared using the formula for area — the circle will always have the biggest area.

The main idea here is that teachers have experience working with their own curriculum and teaching students in their classroom everyday. What this innovative guide will hopefully lend to your teaching is a way to open up aspects of the discipline for science and math that compliment your use of the game and teaching. Simply described: it is a way to find new approaches to ideas held and found in the standards — maybe you try the strategy outlined here and discover that students grasp the ideas faster and this 'lightens' the cognitive load of teaching and learning in your classroom. Minimalism and elegance of the curriculum structure are the ultimate goals - no belaboring - just simple, powerful, direct presentation of the ideas and the math.

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Math Common Core Standards, "At a Glance"

CCSS.MATH.CONTENT.6RP.2

Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in a the context of a ratio relationship. For example, "This recipe has a ratio of 3 cups of flour to 4 cups of sugar, so there is 3/4 cup of flour for each cup of sugar." "We paid $75 for 15 hamburgers, which is a rate of $5 per hamburger."

CCSS.MATH.CONTENT.7G.B.4

Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.

CCSS.MATH.CONTENT.7G.B.6

Solve real-world mathematical problems involving area, volume, and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prism.

CCSS.MATH.CONTENT.8F.B.4

Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values.

CCSS.MATH.CONTENT.8F.5

Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualtitative features of a function that has been described verbally.

Big Idea 1:

Before introducing the equation and the math that goes with it, we'll introduce you to the big idea, the large goal of the equation:

A. Maximize the interior surface area of a given air vent shape (in this case a circle) / while minimizing friction when propelling a 'quantity' of air through a vent.

B. How do you propel a quantity from one place to another most efficiently?

C. For the physics part of the problem: what is the most efficient shape for propelling a quantity (in this case air) from one place to another? To maintain a minimum amount of friction, you want to maximize the area so you choose a form that happens to have both. The answer: a circle.

D. Although all things appear equal, the central variable in the equation is q. The variable q = velocity x area. The most efficient vent size to refresh the volume of a room uses the area of a circle to calculate the volumetric air flow rate. The formula for the area of a circle (remind students) is what? $A = \pi r^2$

E. When the perimeter is the same, a circle has the most surface area compared to a square, or equilateral triangle.

F. The equation presents a linear relationship between two variables (Table 1).

With a given vent, the velocity of the air duct varies.

With a given air duct, the area of the vent varies.

Note: You can think about incorporating the following piece on rockets as an extension activity. For example, this may be for use in a high school level classroom:

For example, when a rocket meant to propel a spacecraft into outer space is designed, the most important feature of the rocket potentially is the size, shape, and area of the nozzle (see De Laval nozzle), the basis upon which the design happens to utilize the cross-sectional area of a circle. link here 1 This is an interesting variation on the problem appearing in the game because it shows that at the point where area of the throat of the nozzle decreases, the gas's acceleration increases, and where the cross-sectional area is at its smallest point - the velocity for the rocket is sonic. At the nozzle's throat the cross-sectional area immediately increases allowing the gas to expand rapidly - thus having a super-sonic effect on the velocity. link here 2 In early rocket designs, the nozzle was originally cone shaped, but then this was eventually changed to a bell shaped nozzle - interesting side note! link here 3

Teacher guided presentation begins here:

The equation below is meant to calculate how much fresh air to bring into Izzy's the mouse's apartment in a 60 minute interval of time.

$n = (60 \times q) / V$

Table: The linear relationships expressed in the problem

situation	**dependent variable**	**independent variable**	**constant**	**linear equation**
In a given space	air change rate (n)	air flow volume rate (q)	volume of space (V)	$n = 60 * q/V$
With a given vent	air flow volume rate (q)	velocity (v)	area of the vent (A)	$q = v * A$
With a given vent of air duct	air flow volume rate (q)	area of the vent (A)	velocity (v)	$q = v * A$

Present the lesson

The problem: Find the way for Izzy's apartment to meet a desirable air change rate, over the course of an hour to cycle fresh air in her room from the air vents. The ideal goal is to cycle the air through the room between 10-18 times per hour.

Conceptually building the equation

Big Idea 2: We want students to understand the meaning of the equation (n=60*q/V) before it is revealed. This is of strategic learning importance for getting students to 'grasp' the math ideas that follow in the game.

We want students to understand:

What is the relationship between energy (velocity), time, and the interior surface area of a vent for 'propelling' or venting a fresh supply of air into the room?

To meet the above purposes, we start with the definition of what we are calculating: air change rate. We introduce the equation to students rather than just present the equation to them, so that they understand the meaning of the equation, and meet the above goals.

The math logic: Teacher guided presentation with students

Question 1: What is air change rate?

Answer 1: Air change rate means the speed that air can be added or removed from a space in one hour's time.

Question 2: How to find out how much air can be added or removed from a living space in an hour?

Answer 2: We divide how much air is flowing in the space per hour by the volume of space itself.

Thus, the equation is:

Air change rate per hour = (how much air is flowing in the space per hour)/(the volume of the space)

Question 3: How to find "how much air is flowing in the space per hour"?

Answer 3: We already found out how to calculate the air change rater per hour, but to measure how much air is flowing in the vent per hour is a challenge in several ways. First, we break down the number to measure a smaller unit of time first and then multiply to get the result. We can break down the measurement for how much air is flowing through the vent per minute, and then multiply it by 60 because there are 60 minutes in an hour.

Question 4: How to find the volume of the space?

Answer 4: The volume of the space is Length x Width x Height.

Question: It is easier to communicate this idea in math using letters to represent the equation than using words. We've agreed to use "n" to represent the air change rate per hour, use "q" for how much air is flowing per minute, and use "V" for the volume of the space. Thus, what does the equation look like now?

Answer 5: $n=(60\times q)/V$

The problem: Find the way for Izzy's apartment to meet the desired air change rate, which means you need to find the air change rate in the room to have the desired fresh air in the apartment.

We already talked about the equation for how to calculate the air change rate:

$n= 60 \times q/V$

n= air changes per hour/air change rate

q= Volumetric flow rate of air in cubic feet per minute (cfm) x the area of the vent

V is volume of space

Compute the value of q

Now we need to compute the value of q. From the definition of q: q= Volumetric flow rate of air in cubic feet per minute (cfm). In physics, we know what velocity means. Air velocity is usually presented in the unit of meter per second or feet per second. Therefore, to get q, we need to multiply the air velocity by the vent area. Also, we need to convert the units of velocity first, in order to get the same unit as q.

Volume of air flow = Velocity * vent area

q= v*A

q= Volumetric flow rate of air in cubic feet per minute

v = air velocity in feet per minute

A= vent area in square feet

With a given vent, calculate the air change rate for different air ducts:

Now let's do the calculation for different air ducts. Note: with the given vent, the area is given and fixed.

n= 60 **x** q/V

n= air changes per hour/air change rate

q= Volumetric flow rate of air in cubic feet per minute (cfm)

V is volume of space

q= v **x** A

q= Volumetric flow rate of air in cubic feet per minute

v = air velocity in feet per minute

A= vent area in square feet

To get **n**, you calculate **q** first. When the vent is fixed for a certain air duct: **q** and **v** are in a linear relationship. Plug in different values of **v** from table 3, to get **q**. By plugging in different values of **v** and **q**, students are able to see that when **v** increases, **q** increases. When **v** decreases, **q** decreases. Because when **A** is fixed, **v** and **q** are in a linear relationship.

After you get q each time, you plug in q in the formula n=60*q/V. When the space is given - V is fixed. Plug in different values of q, to get n. By plugging in different values of q and get n, students are able to see that when q increases, n increases. When q decreases, n decreases. When V is fixed, n and q are in a linear relationship.

Teacher note: Here students can draw graphs that express the linear relationship between the variables in the equation.

When you calculate various outcomes for the variable n, students will see that the max n still didn't meet the desired air change rate for Izzy's current apartment with the given vent. Then, ask students, what else can Izzy do?

*Use the max velocity of air duct and see what kind of vent will meet the desired air change rate.

Stick with the same air duct, change the area of the vent:

Start with a circle shaped vent, let's change the area of the vent. Changing the area of a circle will change the diameter of the circle. Do some more calculations here:

n= 60 **x** q/V

n= air changes per hour/air change rate

q= Volumetric flow rate of air in cubic feet per minute (cfm)

V is volume of space

q= v **x** A

q= Volumetric flow rate of air in cubic feet per minute

v = air velocity in feet per minute

A= vent area in square feet

A (circle) = area of a circle = pi **x** radius **x** radius

Radius = diameter/2

To get n, you calculate q first. When using the max velocity, v is fixed. With the fixed v, q and A are linear relationship. Plug in different values of A, to get q. By plugging in different values of A and get q, students are able to see that when A increases, q increases. When A decreases, q decreases. Because when v is fixed, A and q are linear relationship.

After you get q each time, you plug in q in the formula n=60 **x** q/V. When the space is given, the V is fixed. Plug in different values of q, to get n. By plugging in different values of q and get n, students are able to see that when q increases, n increases. When q decreases, n decreases. When V is fixed, n and q are linear relationship.

Stick with the same air duct, but change the shape of the vent:

Think about changing the shape of the vent. Start with a rectangle. Let's do some more calculations:

n= 60 **x** q/V

n= air changes per hour/air change rate

q= Volumetric flow rate of air in cubic feet per minute (cfm)

V is volume of space

q= v **x** A

q= Volumetric flow rate of air in cubic feet per minute

v = air velocity in feet per minute

A= vent area in square feet

A (rectangle)=length **x** width

To get n, you calculate q first. When use the max velocity, the v is fixed. With the fixed v, q and A are linear relationship. Plug in different values of A, to get q. By plugging in different values of A and get q, students are able to see that when A increases, q increases. When A decreases, q decreases. Because when v is fixed, A and q are linear relationship.

After you get q each time, you plug in q in the formula n=60*q/V. When the space is given, the V is fixed. Plug in different values of q, to get n. By plugging in different values of q and get n, students are able to see that when q increases, n increases. When q decreases, n decreases. When V is fixed, n and q are linear relationship.

Summary of the math project

1. Within a given room, students will conceptually understand that the air change rate is related to the velocity of air duct and the size of the vent.

2. The bigger the vent size, the faster the air change rate.

3. To maximize area, while minimizing friction regarding propelling a 'quantity of air' through a room: a circular shape is the best. When measurements are the same, a circle will always have the largest surface area compared to a square, rectangle, or triangle. [See Illustrations #1-3]

1. Students are tasked with creating a conduit for air
2. Assuming a piece of sheet metal with a perimeter of 16 inches
3. They can make a conduit into an equilateral triangle, square or circle
4. Students must pick the most efficient duct shape that allows the most area for air flow

Assuming the material has a 16 inch perimeter, construct conduits in the shape of:

1. Equilateral Triangle
2. Square
3. Circle

Which one has more surface area?

Calculate the circumference of the circle, and outer perimeter of the equilateral triangle, square:

Illustration #1

$p = 3s$	$p = 4s$	Circumference $= 2 \pi r$
$16 = 3s$	$16 = 4s$	$16 = 2 \pi r$
$16/3 = s$	$16/4 = s$	$16 / 2 \pi = r$
$5.33 = s$	$4 = s$	$2.54 = r$

Then area:

Illustration #2

$$A = \frac{\sqrt{3}}{4}s^2$$

$$s = 5.33$$

$$A = \frac{\sqrt{3}}{4}5.33^2$$

$$A = 12.3$$

$$A = s^2$$

$$s = 4$$

$$A = 4^2$$

$$A = 16$$

$$r = 2.54$$

$$A = \pi r^2$$

$$A = \pi 2.54^2$$

$$A = 20.3$$

Assuming 16 inches of material, the circle is a more efficient design for a duct due to the greatest amount of area to perimeter ratio.

Equilateral triangle < 1

Square =1

Circle >1

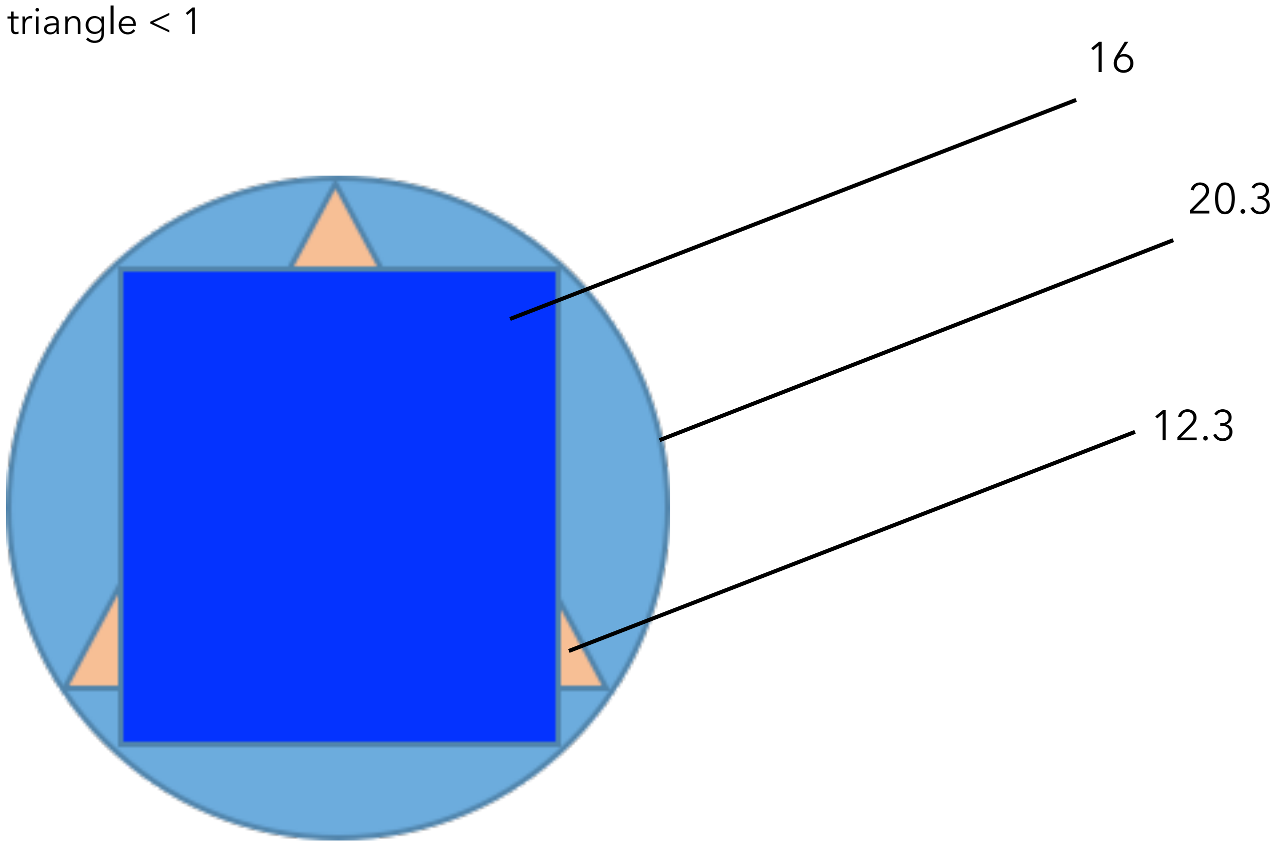
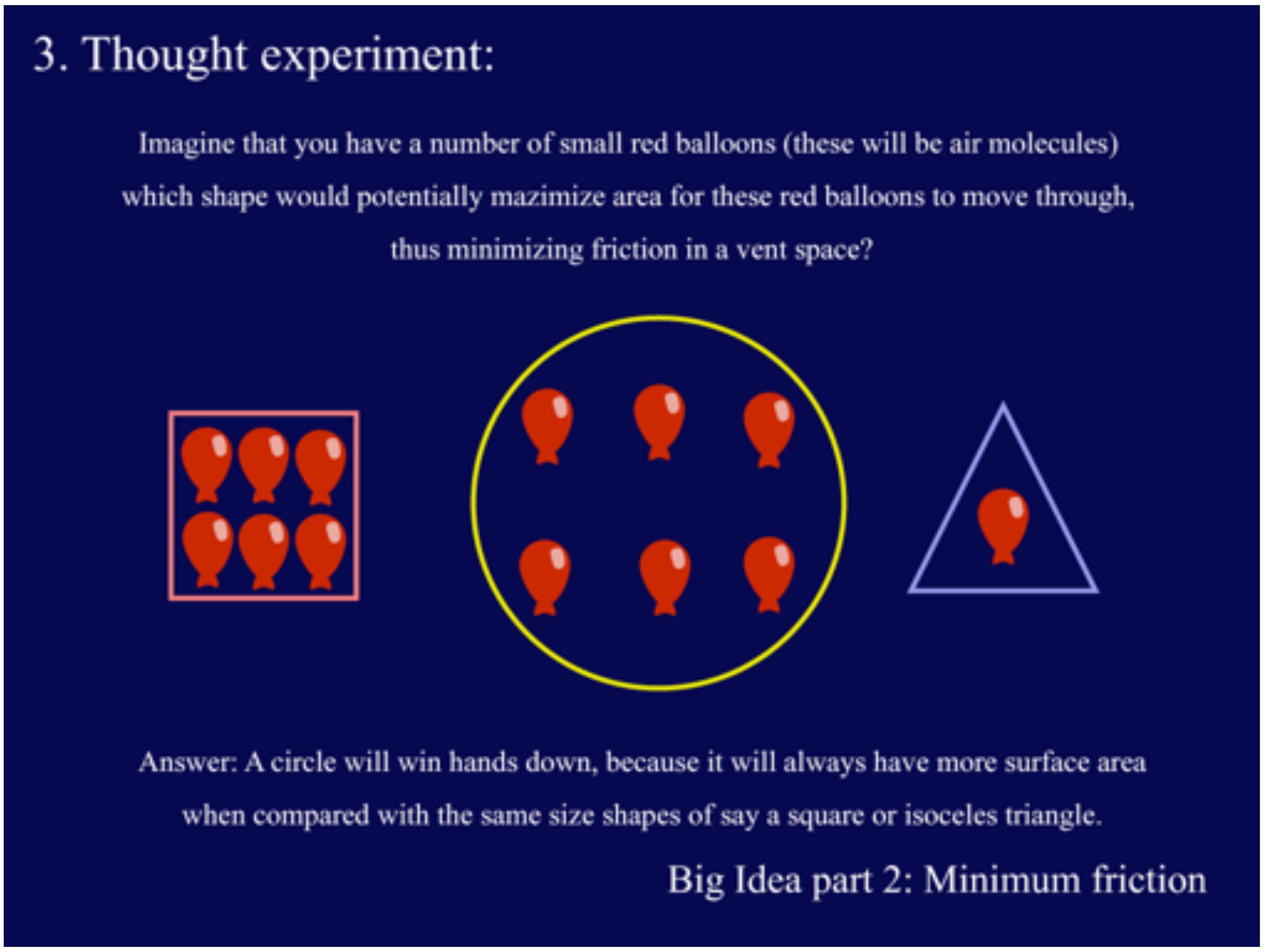
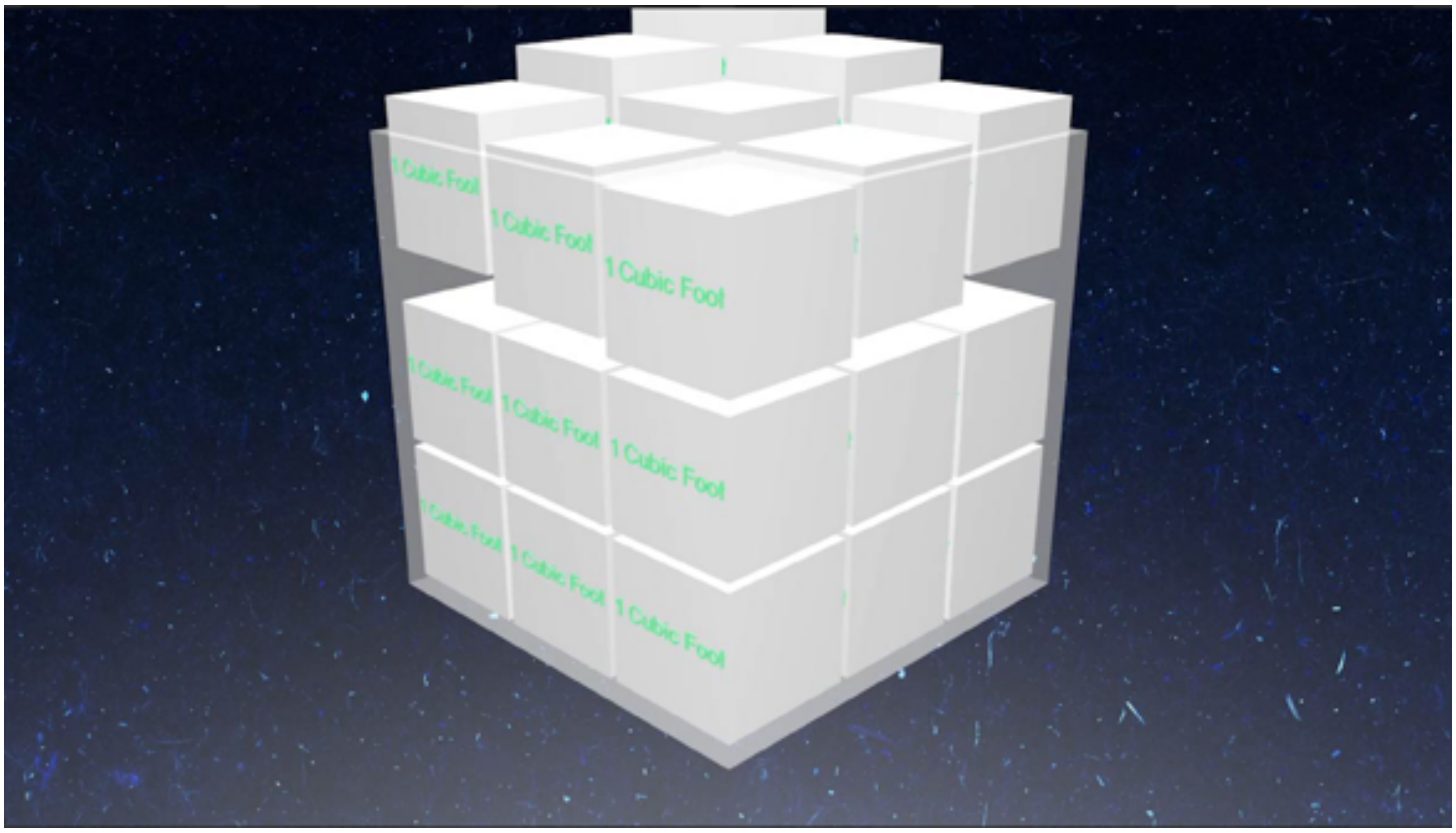
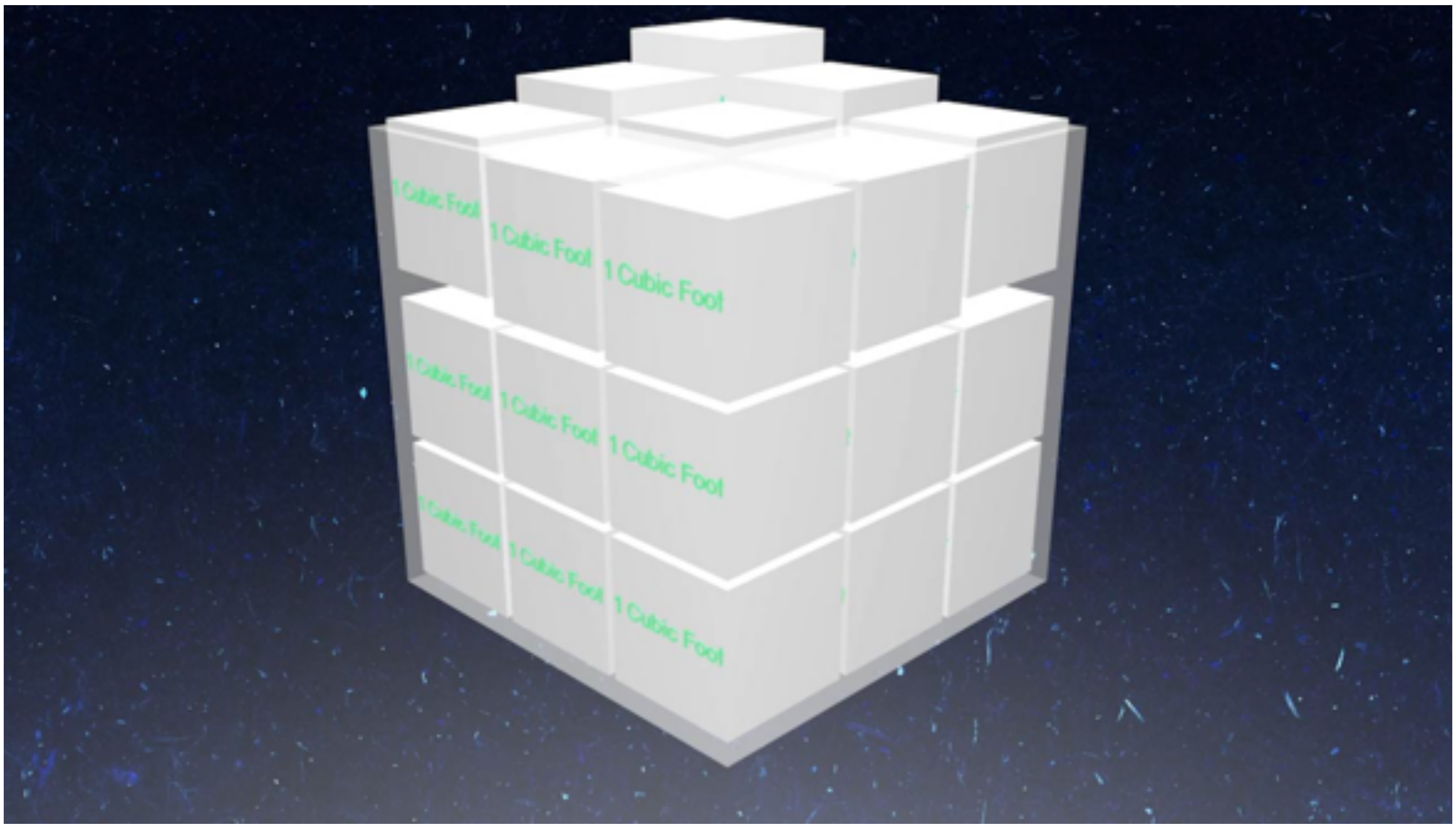


Illustration #3



Illustrations # 4-6

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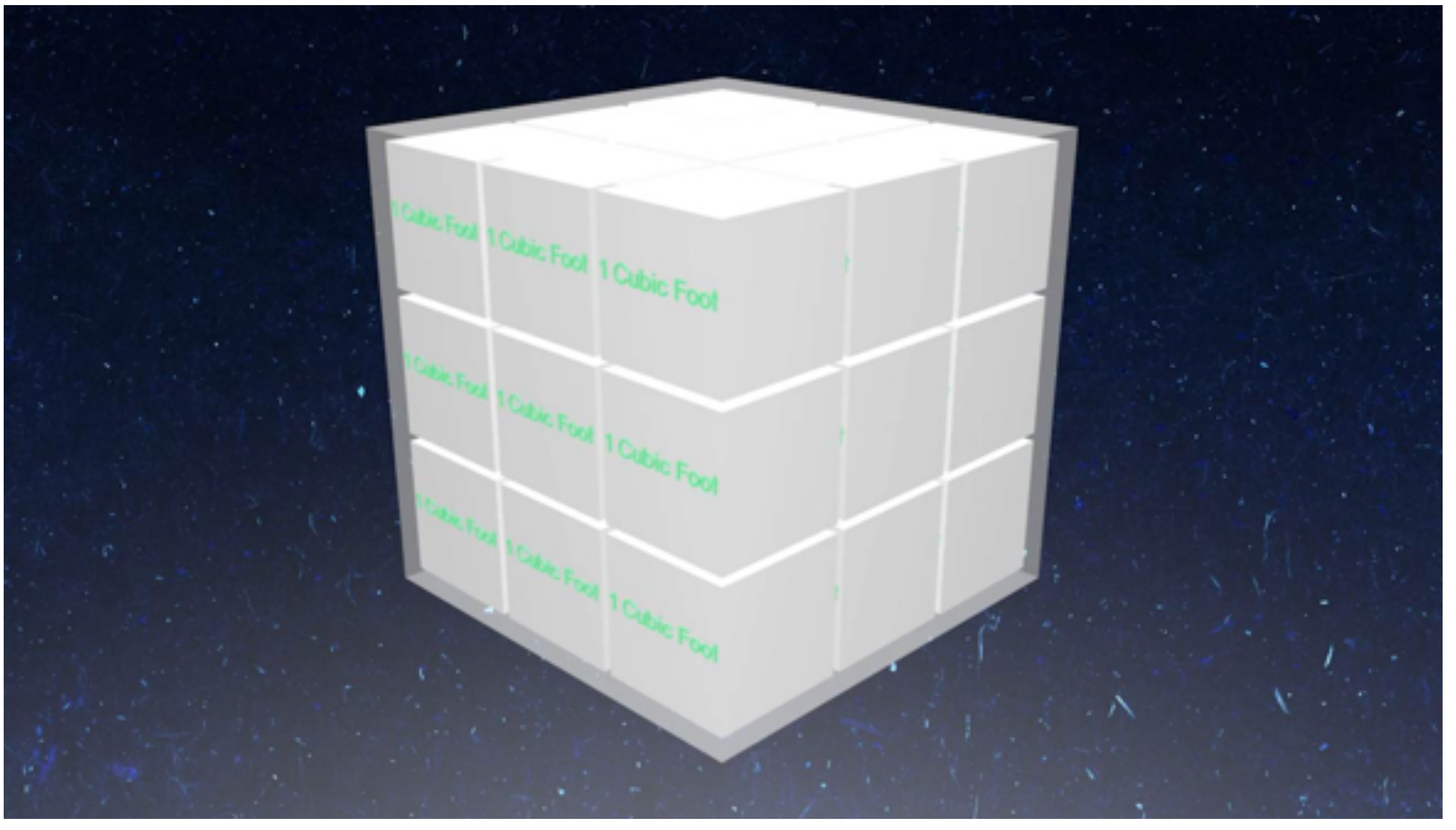
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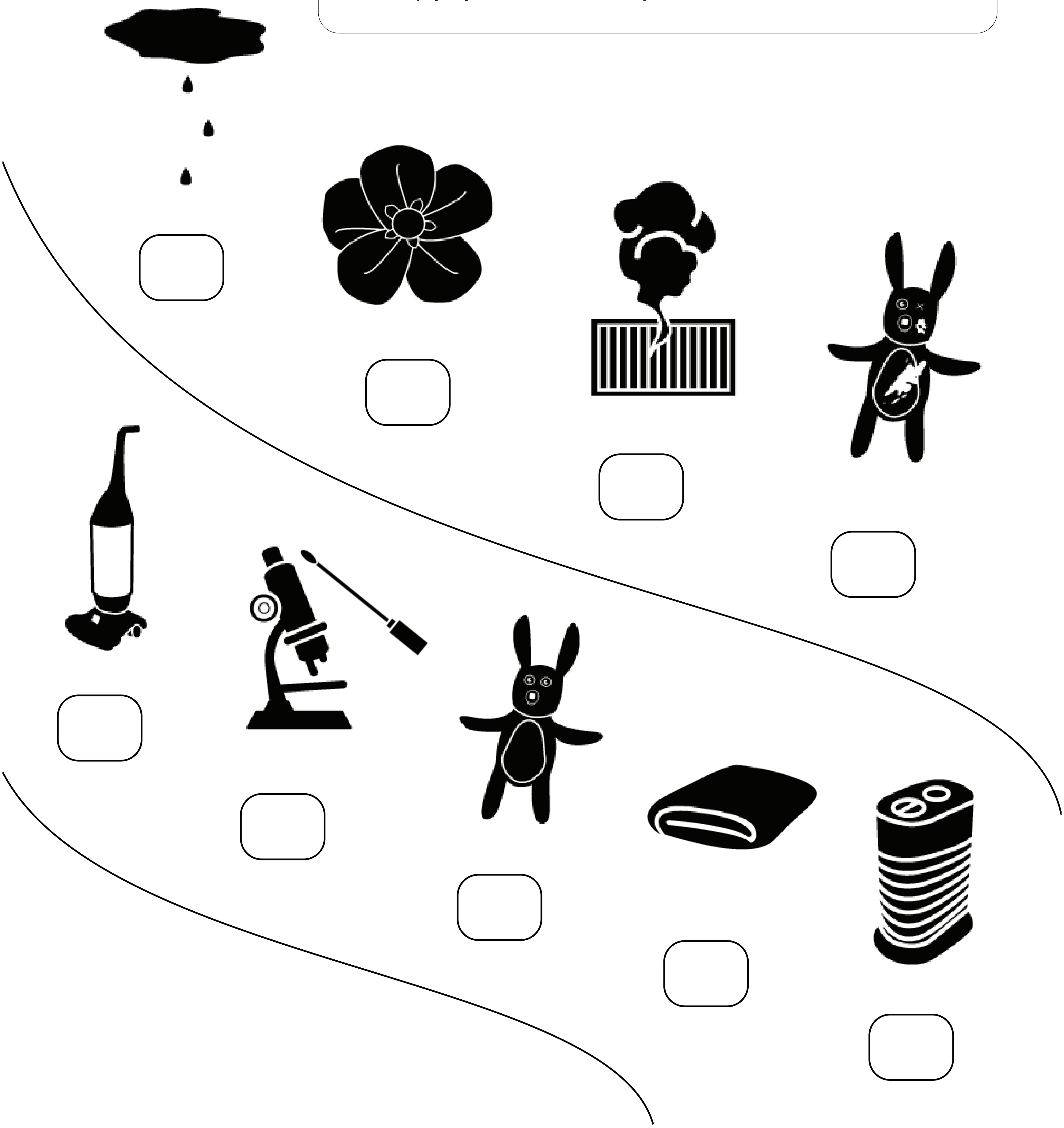
Student Guides

5e Explore

Mission 1 - “Clue Sleuth - Seek and Find”

Discover your “sleuth” IQ: Check the clue boxes when you discover a new clue in the game. Tally up all the clues you found, add together the numbers from your date of birth, multiply by 36, and divide by 3.

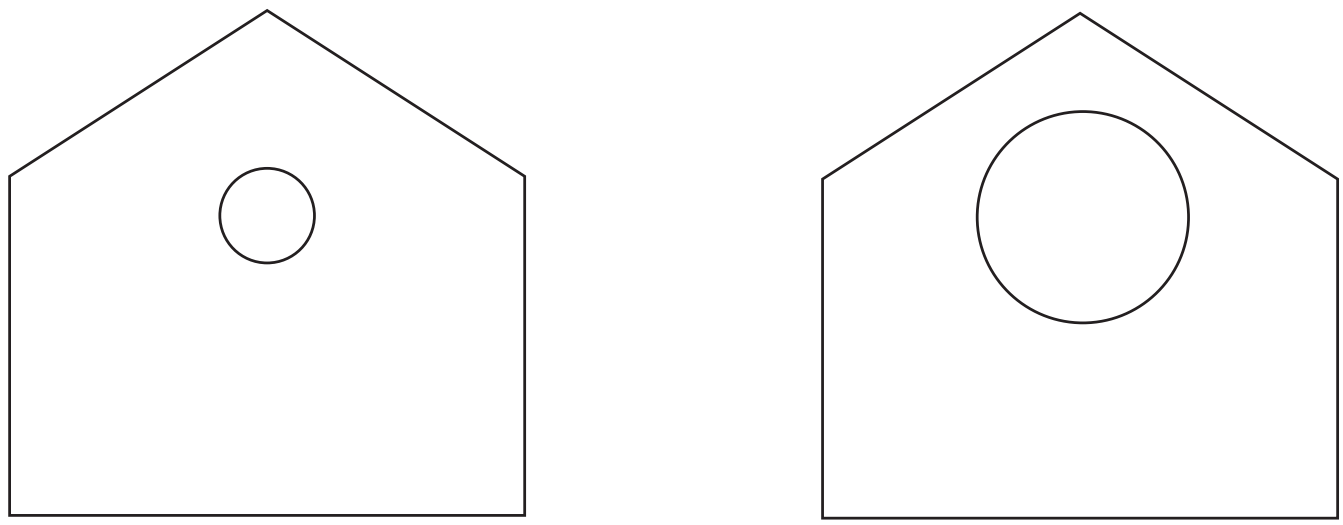


5e Engage

Mission 1 - “Vent - a - rama”

Here are two houses with same size rooms. Each house has an opening for air to refresh a room. How long does it take for the two different size openings to refresh the air in the house?

Hint: What variables might you need to have to answer how long it will take? List two. You can even try to invent your own equation to describe this fresh air change rate challenge. Work out your math idea experiment below :



Albert Einstein used to work his ideas out on paper and a blackboard way before sharing them with the math and science community. The correct answer at this stage isn’t important.
You are exploring mathematical relationships and their existence along with ideas.

Bonus: Are there any mathematical terms that can describe your ideas above?

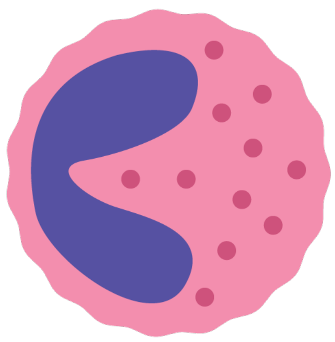
Assessing understanding

5e Engage

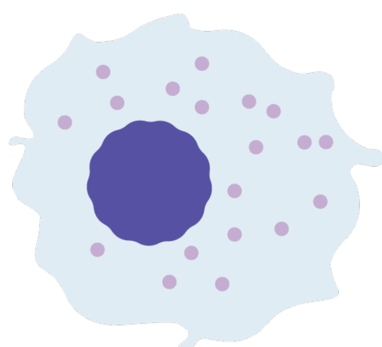
Mission 3 - “Match Case”

Match the cells! Here you have three cells: Eosinophil, Macrophages, Neutrophil

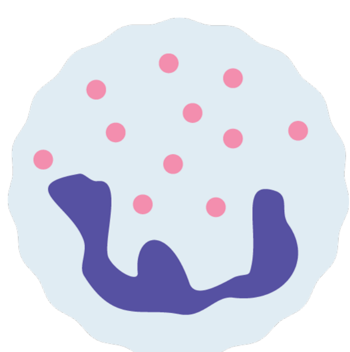
Draw a line to the correct image of the cell and the correct name of the cell



Neutrophil



Eosinophil



Macrophage