How can we Mitigate an Epidemic?

Unit 1: Nature of Science

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Table of Contents

Learning Objectives: Point out which learning objectives are emphasized in each section or question.

Background Student Information: Alerts teacher to additional information or knowledge that will enhance student understanding of the activity.

Background Teacher Information: Alerts teacher to additional information or knowledge that will help guide students through the information.

Argumentation and Collaboration: Students should discuss these questions as a group, brainstorm possible answers, give reasons for each, and compare and decide best answers as a group.

Epistemic Callout: Suggested ways to help promote students' epistemic practices when learning about and conducting scientific investigations of complex systems through modeling and argumentation.

Color Key for Speaker Notes

Extension: Suggestions for ways to explore specific topics within the activity in greater depth.

Activity Tip: Suggestion(s) for structuring the activity in the classroom

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Day 1

Goals

A) Develop criteria for good scientific models
B) Utilize sound scientific practices
C) Constructively critique peers to develop scientific consensus

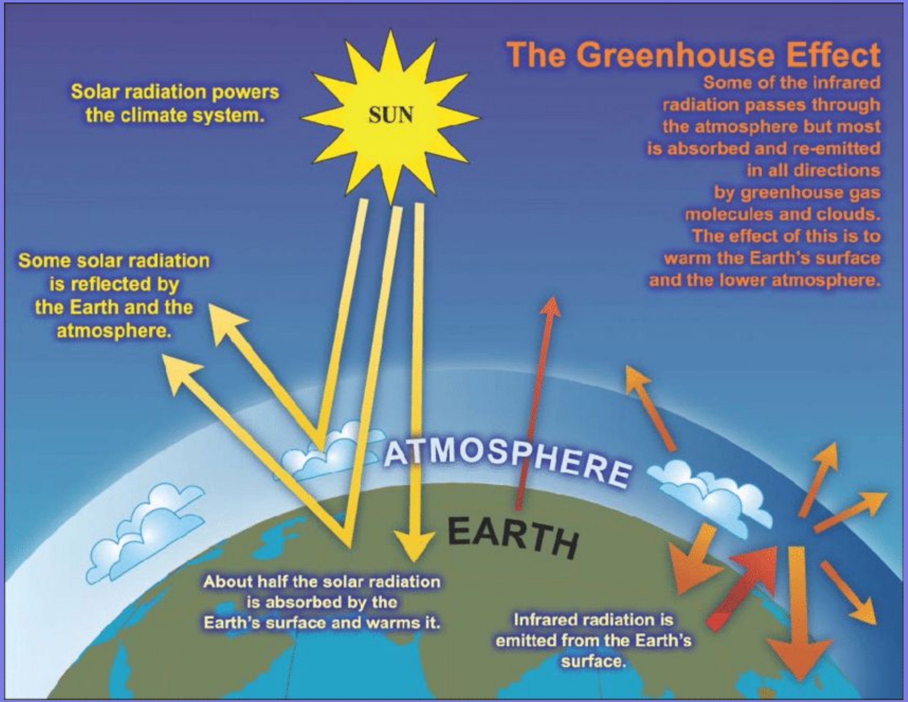
Do Now Day 1

1. What is a scientific model?
2. How do scientists evaluate scientific models?

Write your thoughts about each of these questions in our "Student Slideshow" (Slides 1&2).

In this first unit, we will explore how scientists think about the world. We'll start by engaging in an important scientific practice: modeling.

Models are representations that explain how the world is. Here are some examples of scientific models.



Model of the greenhouse effect

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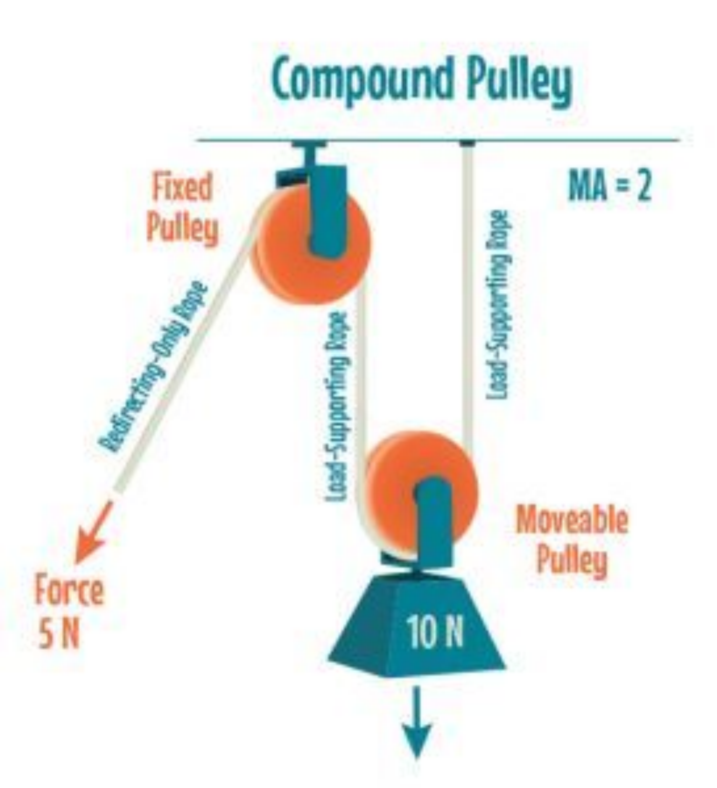

Model of a compound pulley

In this first unit, we will explore how scientists think about the world. We'll start by engaging in an important scientific practice: modeling.

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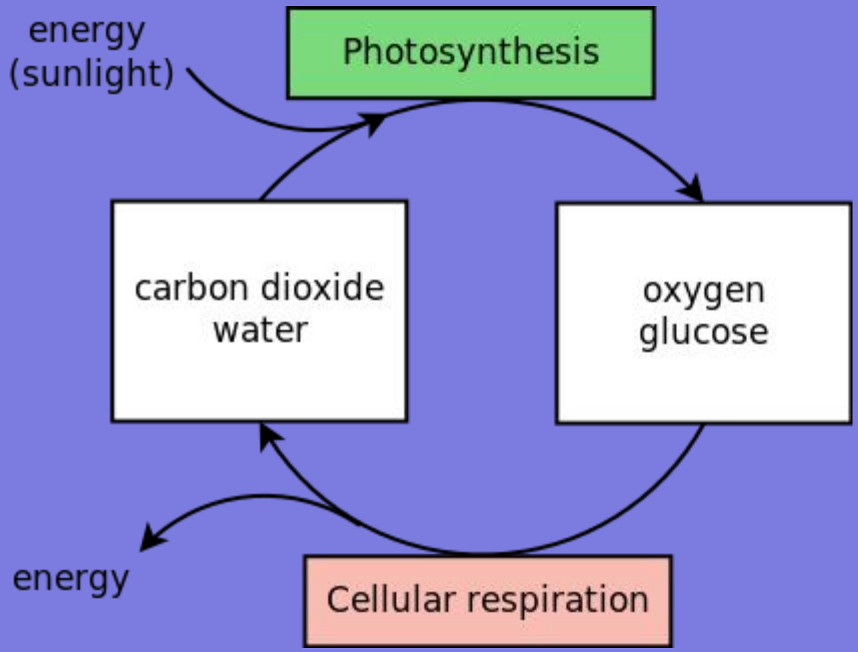

Model of photosynthesis

Now you will make models in groups.

Your model should try to explain how these cars work.

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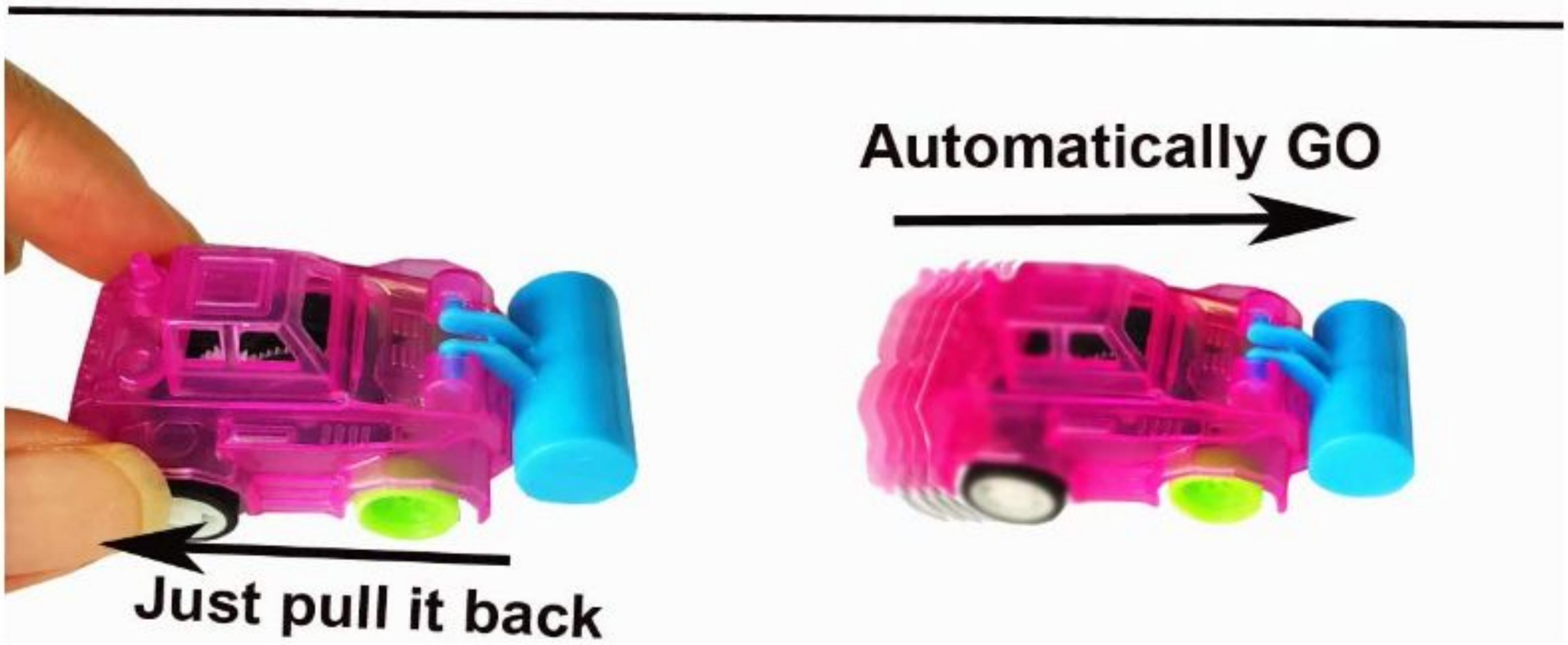

1. Your group has a toy car at the lab table.
2. Rules:
    a. You may not open/break the car at any time, even to "check your guess."
    b. You may not intentionally "break" the cars (throw them hard on the ground, etc).
3. Your goals:
    a. Gather evidence to determine how this car works
    b. Draw a <u>model</u> that represents what you conclude about the likely internal mechanism.
    c. Include a written explanation that explains your model and what evidence you have to support your model.

Record and be ready to present:

1. The important evidence you gathered.
2. Your model (draw it)
3. Your written explanation: How does your model explain your evidence?

Gather evidence, and create your models!

-- Compare your evidence, model, and written explanation with one other group.

-- Discuss what questions you have, and what other evidence you could gather to try to answer these questions.

-- Return to your own group. Gather any additional evidence. Revise your models and written explanations.

Discuss your evidence and models

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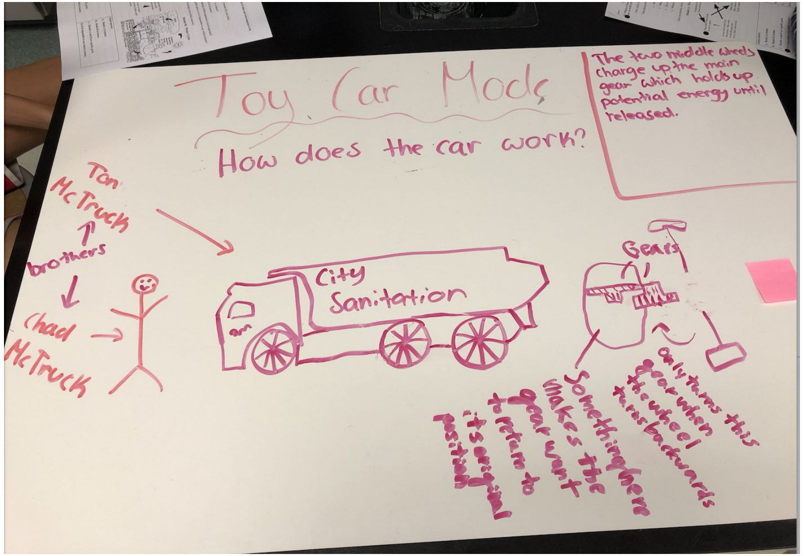
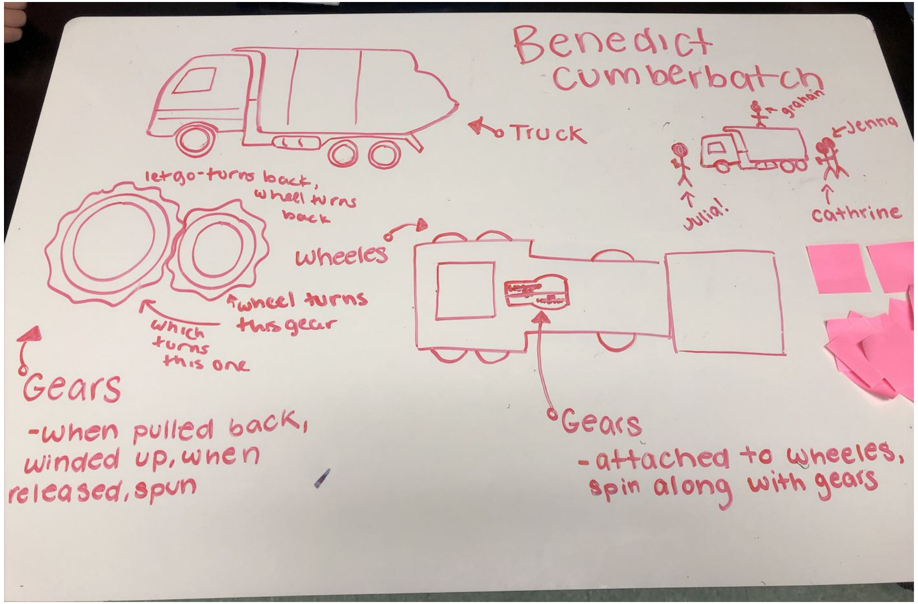
Examples of student models





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Some of the evidence that students may develop:

Car could push 5 markers but not scissors or eraser.

Car travels only straight.

Car moved forward with more force than pulled back

Car moved various speeds on different surfaces

If you wind the car on a rougher surface, it goes farther.

If you wind the car up longer, it goes farther.

Gallery Walk

Walk around and review each model.

As you walk around, think about what makes models good, or not as good.

In other words, what are the characteristics or criteria of good models?

If you dyads, as you review the models, develop at list of at least 4 characteristics that good models have (or you can think of these as 4 criteria that good models should meet).

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A note about including one core criterion for evidence: Fit with all the evidence (or as much of the evidence as possible).

An example

Here is a model.

<<< Show a model in which the spinning of the wheels triggers an internal key to wind up, always exactly the same point.>>>

This model fits three critical pieces of evidence that we gathered.

First, when you move the car backwards, it causes the car to move forward. This is because the key is set, and then unwinds, allowing the car to move through a spring.

Second, car moves different speeds on different surfaces. This is because it takes more energy to move on rougher surfaces, and the spring has the same amount of evidence each time.

Third, the car moves in a straight line. This is because there is no turning mechanism in the car.

How good is this model?

Reflection on Day's Activities

What are similarities and differences between what we have done today and what scientists do in their work?

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Day 2

Goals

a) To introduce students to the epidemic simulation and the PBL
b) To prime students to understand that carrying out a scientific investigation involves iterative sensemaking

Do Now Day 2

1. Based on your rankings of the evidence from best to worst in last night's homework, and on your reasons for your ranking:
   a. What are the characteristics of good scientific methods? Write at least three characteristics of good scientific methods.

Write your thoughts about each of these questions in our "Student Slideshow" (Slide 6).

Revise Class Criteria of Good Models

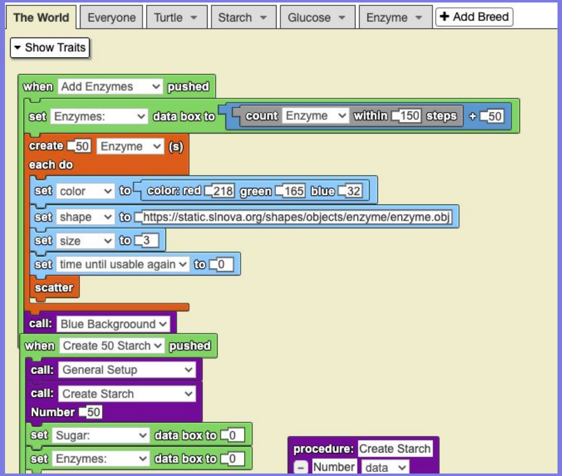
What were your criteria of good models?

What do you consider the most important criteria and why?

Your Research and Modeling Tool: BioGraph

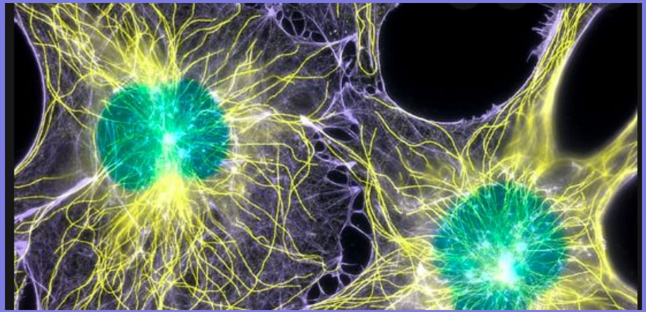
BioGraph models are a type of **Agent-based Model**

Agents have behaviors, often described by **simple rules**, and interactions with other agents, which in turn influence their behaviors. By **modeling agents individually**, the full effects of the diversity that exists among agents in their attributes and behaviours can be observed as it gives rise to the **behavior of the system as a whole**.



Your Research and Modeling Tool: BioGraph

BioGraph tools can be used to model **complex systems**



These are systems composed of **many components** which may interact with each other. These systems have distinct properties that arise from these relationships, such as **nonlinearity**, **emergence**, **adaptation**, and **feedback loops**, among others

A Problem to Solve

Your turn to think like a scientist

The World Health Organization (WHO) is the United Nations agency that connects nations, partners and people to promote health, keep the world safe and serve the vulnerable – so everyone, everywhere can attain the highest level of health. Among other things, the WHO coordinates the world's response to health emergencies through science-based policies and programs.

Recently the WHO was alerted to a very serious disease outbreak that happened in two different towns. Patients originally present with a fever, chills, exhaustion, and muscle aches. You and your colleagues are a team of scientists in one of the towns that is charged with investigating information about the disease outbreak.

You have access to a simulation that specifies important data about the disease in terms of transmission rates, death rates, and mitigation strategies (or how to prevent transmission). You must work with the model and your team to understand the best ways to contain the spread so that more people will not get sick in the town and also to advise the WHO on how to educate the public.

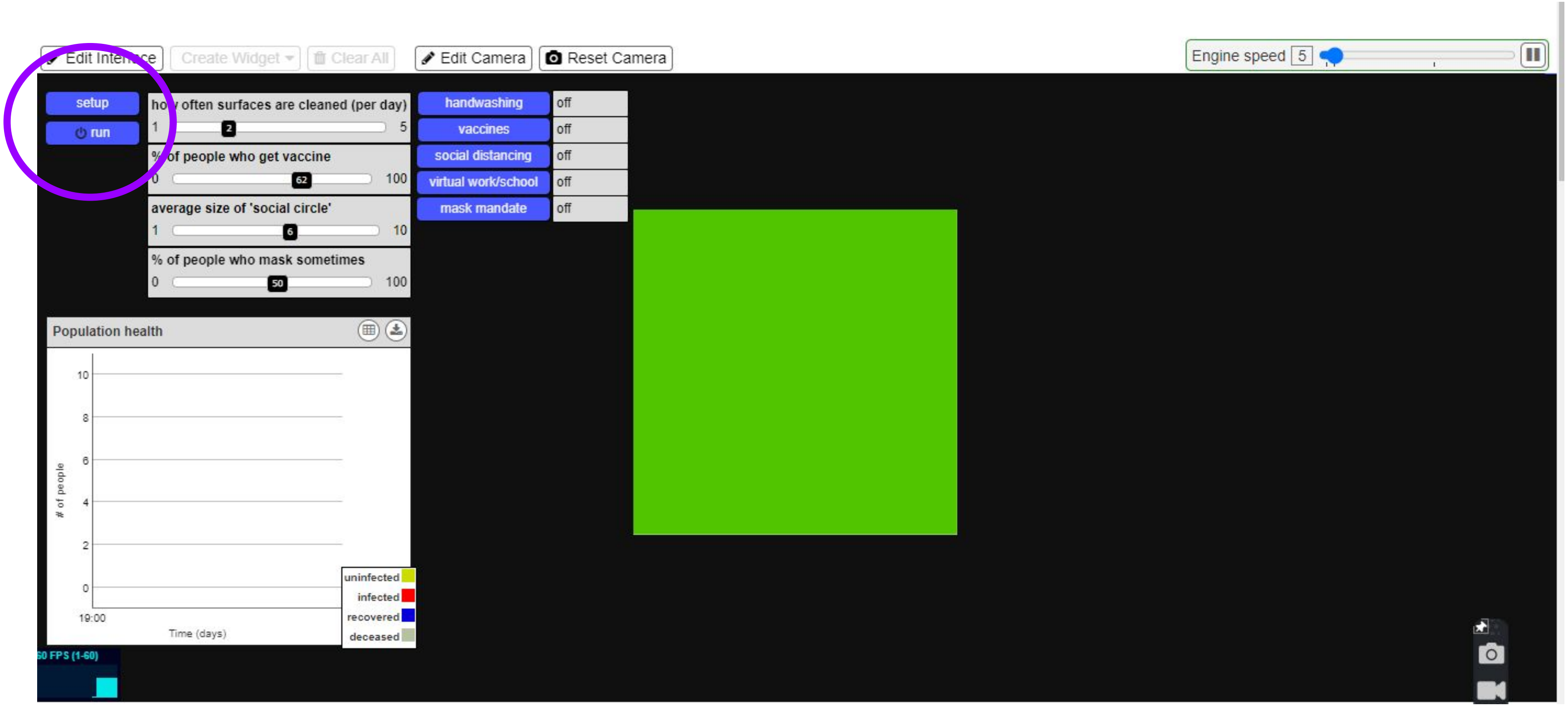
Throughout the next few days, you will learn about essential scientific practices that will allow you to make accurate scientific conclusions. The WHO requests that you submit for public evaluation, the methods that you have used to investigate the disease outbreak with the model, and the recommendations on the strategies that people should use to prevent spread based on your investigation. You and the other teams of scientists will convene to share research with the WHO in a week. Thank you for this important service.

Your Research Question

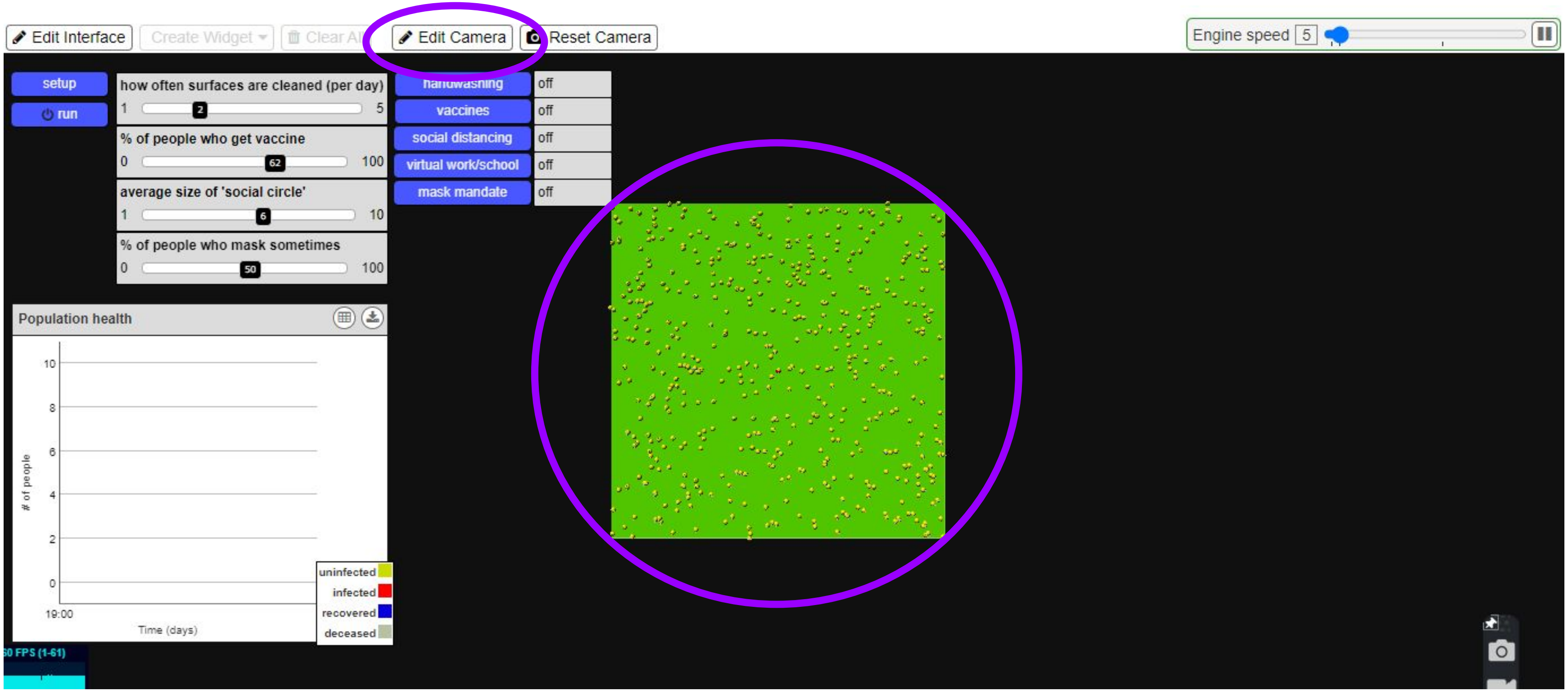
What are your best recommendations of mitigation strategies for the public to stop the spread of this disease and how did you arrive at your conclusions?

The Simulation

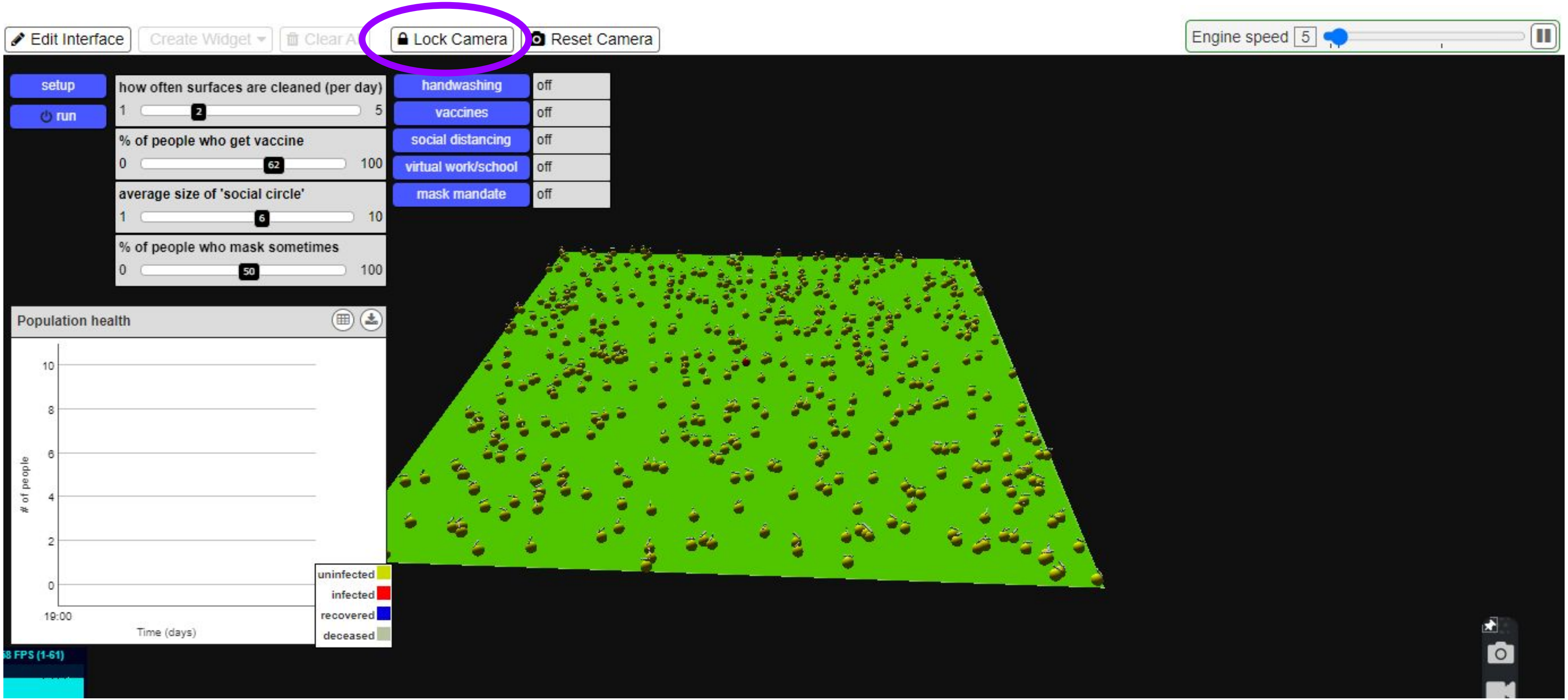
Click setup to start an experiment



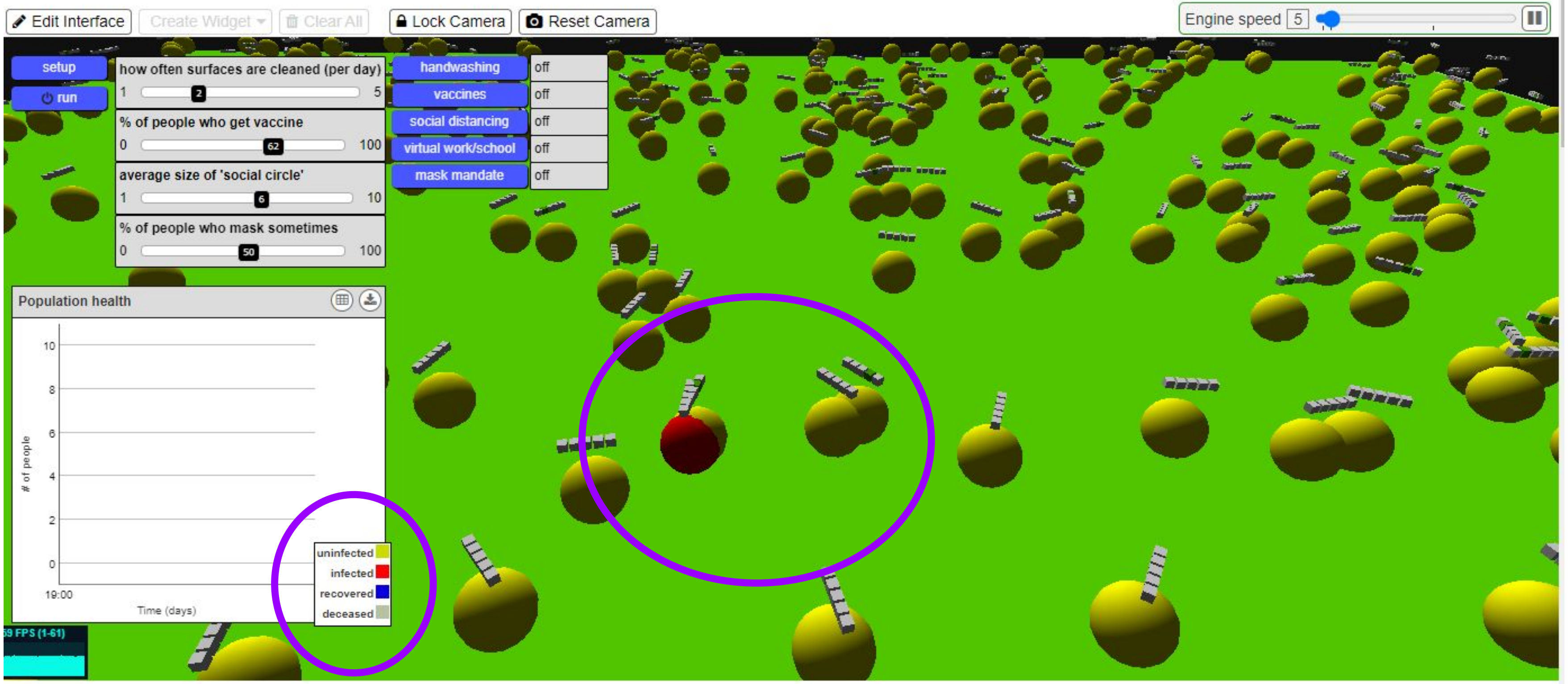
Edit camera to zoom in on the green ‘spaceland’



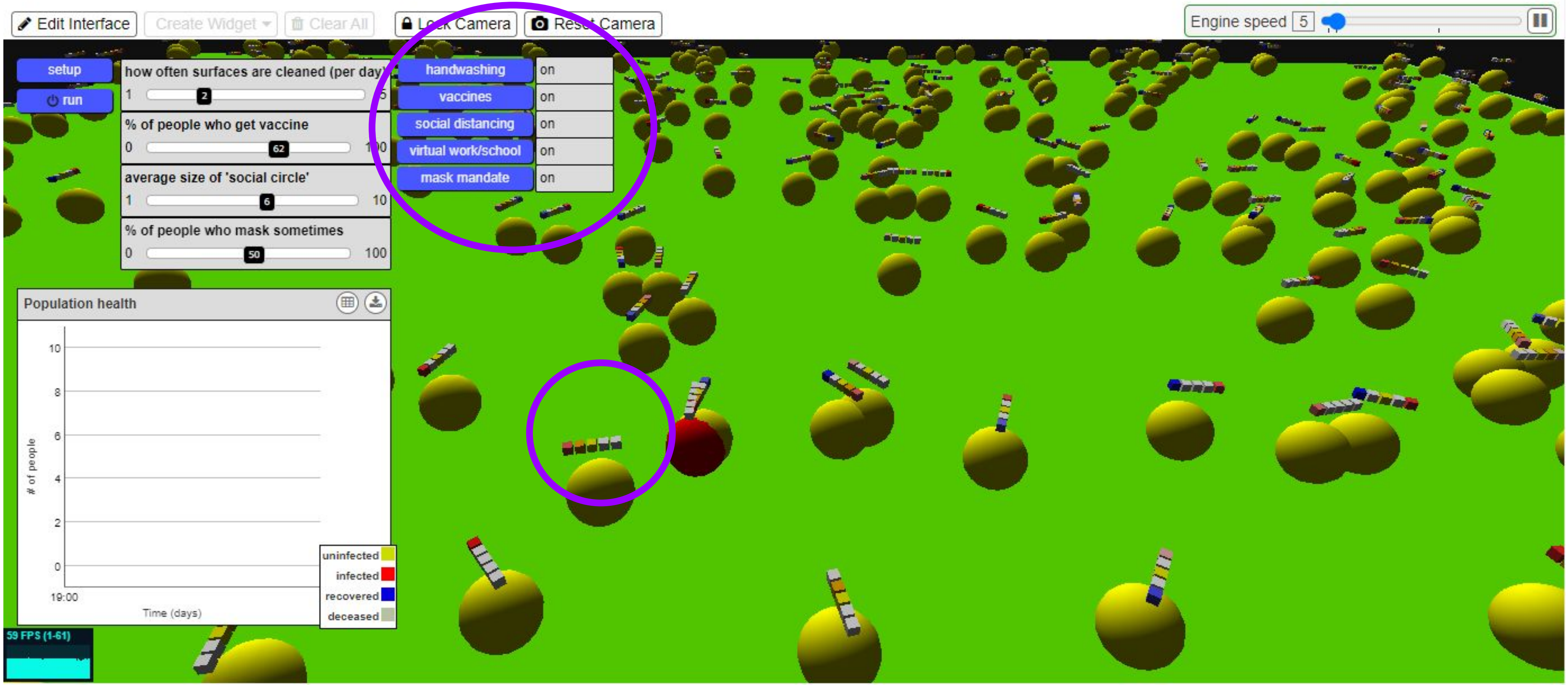
Lock camera to freeze the view



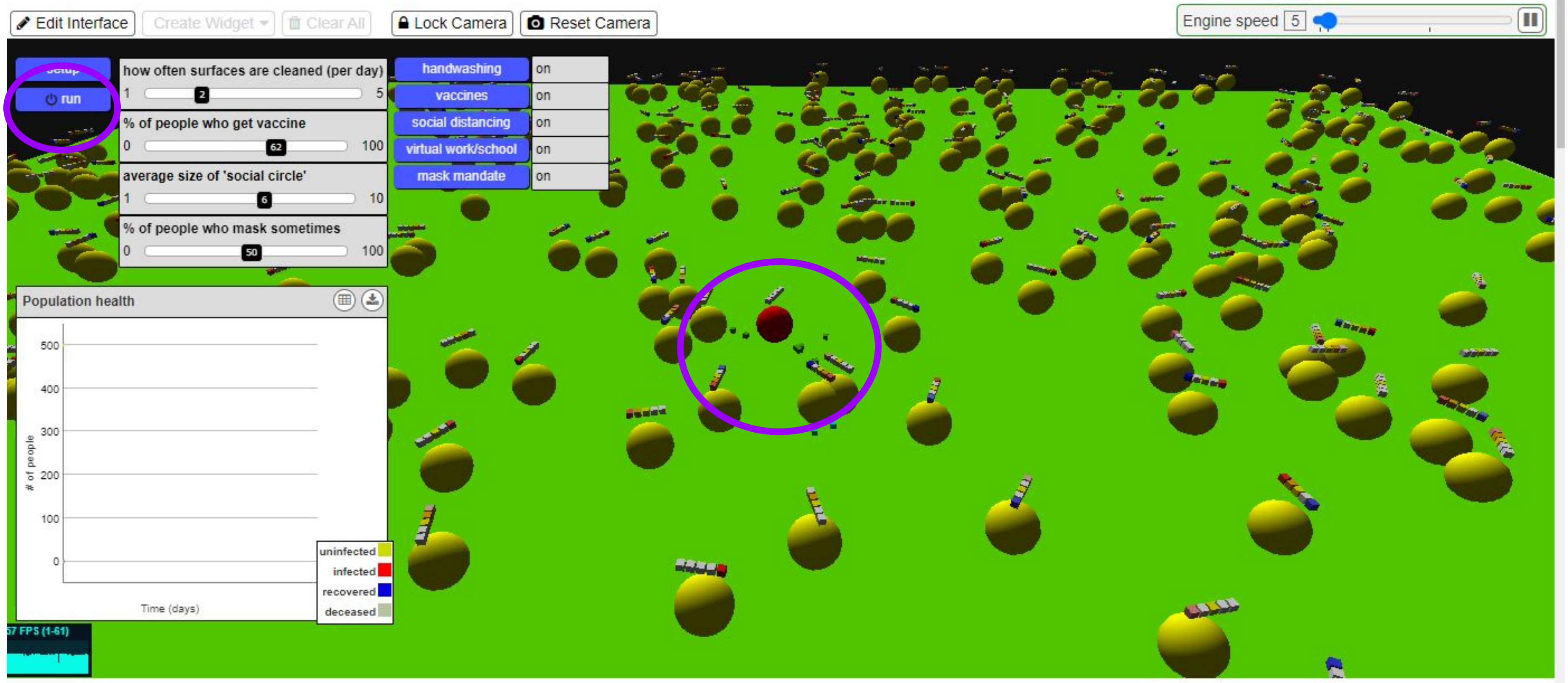
Spheres represent individual people (or agents) in the town



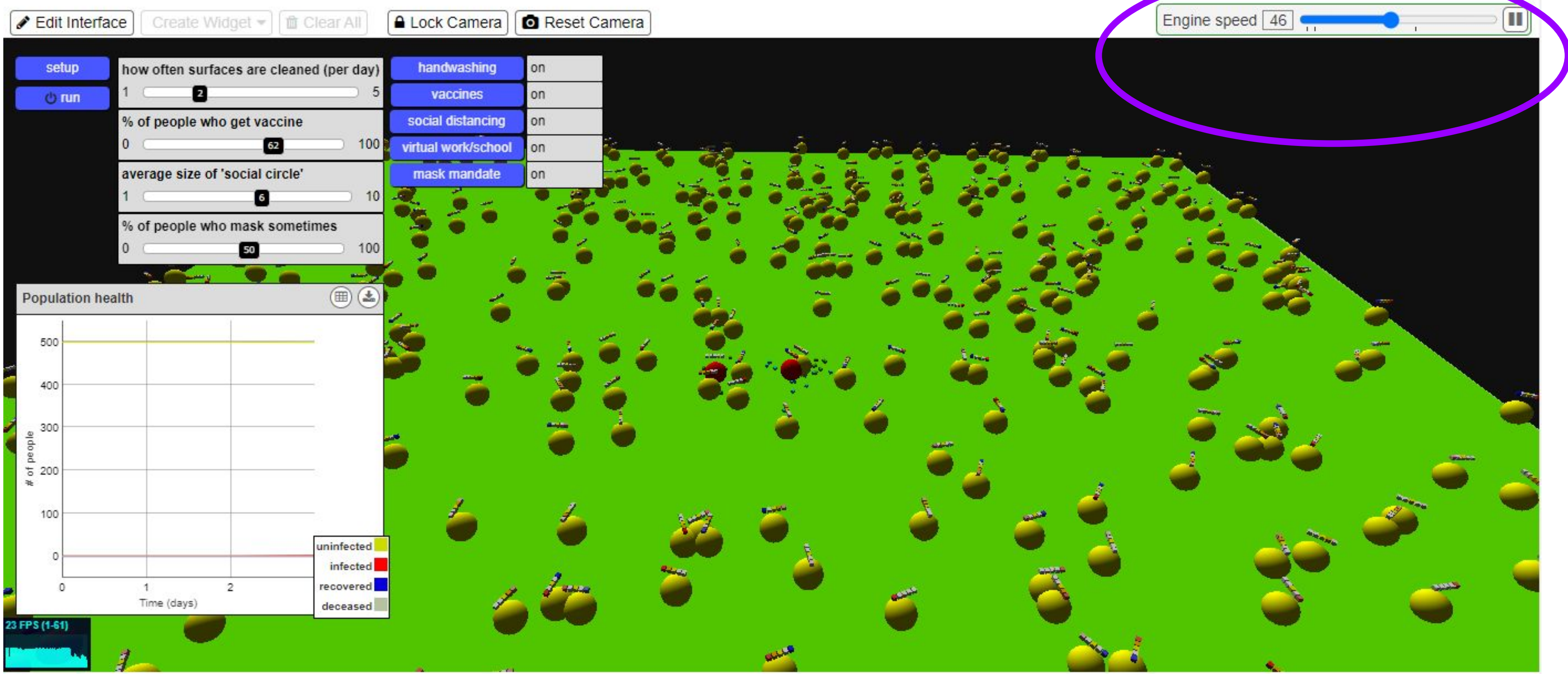
Possible mitigation factors to enable in the model



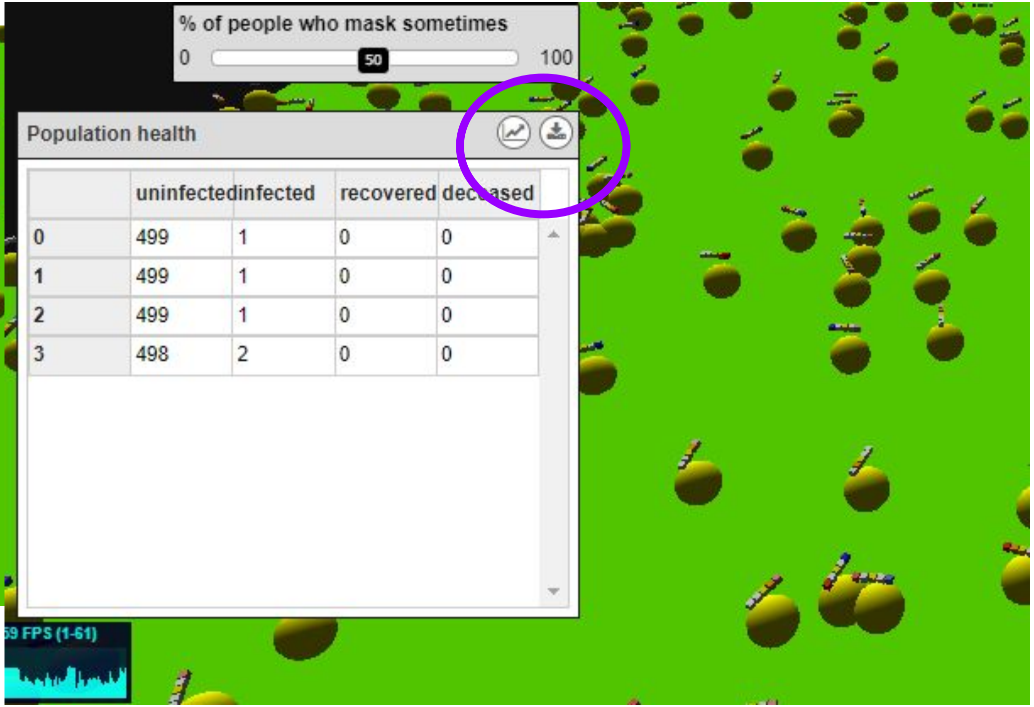
Click run to observe movement and air particles of infected individuals



Adjust engine speed to increase speed of data collection



Notice the three types of data representations available in the model



What should you be doing with your group?

1. Use the following features on the simulation:
   a. Setup, run, edit camera, various mitigation strategies (for ex., handwashing, vaccines), engine speed, table view
2. Play with different mitigation strategies
   a. Choose to enable one mitigation strategy, run the simulation, observe the trend and make an observation (do this multiple times)
   b. Fill the table on your group's slide in the Student Slideshow (Slide 8)

Research Question Refresher

What are your best recommendations of mitigation strategies for the public to stop the spread of this disease and how did you arrive at your conclusions?

Reflection on Day's Activities

Assumptions made by the scientists and simulation!

- How do scientists' beliefs or assumptions of the world shape the explanations or the models they come up with?
- Do the tools scientists use have in-built assumptions as well?
- Should these assumptions be made explicit? [Why/ Why not?]

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Day 3

Goals

Biology Content Learning Objectives

1) Characteristics of controlled experiments
2) Components of a scientific hypothesis
3) Effect of antibiotics on bacterial growth

Epistemic Learning Objectives

1) Systematic planning and carrying out investigations
2) Make sure the model fits the evidence

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Day 4

Goals

1) Have student create their experimental designs. Students explore their model and test their hypothesis
2) Students explicitly mention the criteria for methods
3) Students have a first draft of their methods

Do Now Day 4

1. Based on your review of Alexander Fleming's journey to identify penicillin: :
   a. What are the characteristics of good scientific methods that we need to add to our class list?

Review our initial ideas on "Student Slideshow" (Slide #6).

Essential Question:

What are your best recommendations of mitigation Strategies for the public to stop the spread of this disease and how did you arrive at your conclusions?

What should you be doing with your group?

1. Make a **prediction** to answer the question: What mitigation strategy(ies) would you recommend to your town? Justify your recommendations.
2. Develop a **procedure** to address the question in step #1
3. Record the steps of the procedure on your group's slide
4. Explain why you are taking these steps in the "Rationale" column (consider the requirements for good scientific methods outlined on Student Slideshow Slide 6)
5. Carry out your procedure, taking careful notes and data along the way.
6. Be prepared to share your work so far with classmates!

Group 1

Group Prediction

Step	**Rationale**

Group 1 Data Presentation

Prompts for Group who don't know where to begin

- Is it better to test lots of different mitigation strategies at once, or one at a time? Why?
  - *If necessary, the teacher can give students an example of why one at a time is a good idea by giving them nonsensical directions - i.e set 3 settings randomly, then another 3 settings randomly, then asking what we learned about one of those settings. Students should have difficulty answering and lead them to the conclusion this is not a reliable practice.*
- What mitigation strategy did you predict would have the most influence?
- What is a way that you can test that mitigation strategy and see if you were right?
- Do you think it's better to set the slider number for that mitigation strategy randomly, or at set variables?
- Try running that mitigation strategy at 0%, and then at 100%. Are there different results? Should we test it at different settings besides those two? Which ones?
- Run the simulation at the same settings a few times. Do you get the same results every time? *(Predicted answer is no)*. Why do you think that is? Is that realistic to real-life, or not? What does that mean for the methods of our experiment - is running it once going to give you definitive results?
- When will you stop this trial *(what number of ticks, or when what condition is reached)*? Will it be at the same time every time?

Prompts for Group who finish early

- Teacher should read over the group's copy of steps/rationale - most groups could probably add more justification or be more specific in their steps.
- Look at your steps - would someone in another group, given this simulation, be able to follow **EXACTLY** what you did step by step? Poke holes in this if necessary.
  - *If multiple groups **in the same town** are finished, you can ask them to try to follow each other's procedure and see if they have questions for each other to be more specific in their documentation.*
- Have you collected enough data to be "done"? Are you 100% confident in all of your conclusions? Is there room to collect more data to confirm your results?
- What was the best mitigation strategy? Combination of strategies? Do you think your town will follow these mitigation strategies - what might happen in the real world that might get in the way? Jot down some notes on that in your journal.
- How could your group manipulate your data so it easy for others to understand? Could we transform the raw data and represent it using graphs, figures, or other models? A group could work on this.

Experimental Design Critique

Reflection on Day's Activities

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Day 5

Goals

1) Develop scientific arguments
2) Understand the components of a scientific argument

What should you be doing with your groups? Comparing results

- Yesterday you conducted experiments to investigate how to mitigate the spread of the disease.
- Today, you'll engage in the scientific practice of comparing your results with each other, figuring out what is similar and different, and understanding why they are similar or different. (This is a regular practice in science.)
- In this activity, two groups will work together. Compare and contrast what simulations you ran yesterday, and what your findings were.
- Be ready to report on these prompts. Fill out the slide in the Student Slideshow (Slide 15)
  - What do you agree on?
  - What do you disagree on?
  - For each area of disagreement, why do you disagree? (Check your methods carefully. Could your disagreements arise because of different methods?)

What should you be doing with your groups? Analyzing Scientific Methods

- Assess the other groups methodology using the criteria on Slide #6
  - Copy and paste the table that outlines the groups steps onto the appropriate slide.
  - Determine which (if any) of the criteria for good scientific methods is being addressed.

Example 1: Why do these groups have different results.

- Show a result from one town.
- Experiment 1--1 trial. REsults I
- Experiment 2--5 trials. Results II.
- [Need actual simulation results to create this slide. Ideally, pick something that the two towns are pretty similar on, so that we stay focused on methodology.]

Example 2: These groups want to find out HOW effective vaccines are. Why do they REACH different conclusions?

Vax yes, everything else no.
5 times.
Average deaths in 100 days: 24.

Conclusion: The vaccines do not work; 24 people still die!

Vax yes, everything else no.
5 times.
Average deaths in 100 days: 25.

Vax no, everything else no.
5 times.
Average deaths in 100 days: 90.

Conclusion: The vaccines are quite effective. Fewer people die with.

Example 2: These groups want to find out HOW EFFECTIVE MASKS ARE. Why do they REACH different conclusions?

Vax yes, masks yes. 5 times. Average deaths in 100 days: 15.	Vax no, masks no, everything else no. 5 times. Average deaths in 100 days: 98.

Conclusion: Masks are very effective. They reduce deaths from 98 to 15.

Mask yes, everything else no. 5 times. Average deaths in 100 days: 88.	Max no, everything else no. 5 times. Average deaths in 100 days: 96.

Conclusion: Masks are not very effective; they only reduce deaths by a little.

Example 3: Why do these groups have different results.

- Show a result from one town.
- Experiment 1. No comparison group.
- Experiment 2. Properly controlled comparison.
- [Need actual simulation results to create this slide. Ideally, pick something that the two towns are pretty similar on, so that we stay focused on methodology.]

The process of sharing your findings with peers is considered <u>scientific argumentation</u>. To convince other scientists of your findings it is important to develop a strong argument.

WOULD YOU EVALUATE THE STRENGTH OF THIS ARGUMENT?

Claim: Sanitizing surfaces does not reduce spread of the disease.

Evidence: We conducted an experiment in Florida.

Reasoning: The experiment shows that sanitizing surfaces made no difference, so sanitizing doesn’t work.

How about this argument?

Claim: Sanitizing surfaces does not reduce spread of the disease.

Evidence: We conducted an experiment in Florida. Group 1: Six schools with a total of 4302 students and staff agreed to carefully sanitize their surfaces every day. Group 2: Six schools (with 4418 students and staff) agreed not to do it. The schools were very similar in community size, income, and other variables. Over 4 weeks, there was no difference in the number of people with the disease. There were zero people who got the disease in each groups.

Reasoning: because there was no difference between the groups of schools, we conclude that sanitizing surfaces does not prevent disease spread.

How about this argument?

Claim: Sanitizing surfaces doe [illegible] e disease.

Evidence: We conducted an expe [illegible] chools with a total of 4302 students and staf [illegible] itize their surfaces every day. Six (with [illegible] students and staff) agreed not to do it. The schools were very similar in community size, income, and other variables. Over 4 weeks, there was no difference in the number of people with the disease. There were zero people in each condition.

Reasoning: because there was no difference between the conditions, we conclude that sanitizing surfaces does not prevent disease spread.

Because the evidence and reasoning are explained in more detail, we can identify a problem if there is one.

How about this argument?

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Reasoning: because there was no difference s, we conclude that sanitizing surfaces does not d.

Because the evidence and reasoning are explained in more detail, we can identify a problem if there is one.

And the problem teaches us something about how to develop better evidence. So the “problem” is very important, because it helps us advance our methods and ideas.

Reflection on Day's Activities

Advancing ideas in science

- What are the practices we have engaged in the last several days? What have we done so far to try to find out which factors mitigate?

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Day 6

Goals

1. Students connect their feedback to the team's epistemic reasoning practices
2. Students revise their methods based on the feedback collected in lesson 4 and 5
3. Students collect new data based on these new methods and rewrite conclusions accordingly
4. Students share their data publicly and "conference" to determine takeaways and preliminary CLASS conclusions.

Essential Question:

What are your best recommendations of mitigation Strategies for the public to stop the spread of this disease and how did you arrive at your conclusions?

Last Class: Scientific Argumentation

What should you be doing with your group?

- Go back to your methodology slide in the Student Slideshow and make any adjustments to improve the validity of your results.
  - Do not delete the original procedure, but make changes in red and use the strikethrough formatting option.
- Carry out your updated procedure--record your findings on your Group’s Data slide (do not delete original data).
- Create a digital poster to present your findings as a scientific argument.

Lab Team 1 Research Poster

Names:

Introduction

Background

Background text here, including essential question and why question is important.

Prediction

Prediction text here, including rationale for prediction.

Research

Procedural Steps

Included detailed and numbered steps.

Results

Include results here, using **both** written explanations and data represented in visual ways

Conclusion

Analysis

What did you learn from your data/experiments? Was your prediction supported or negated by the data?

Recommendations

- Write your recommendations here
- Write your recommendations here
- Write your recommendations here
- Write your recommendations here

Discussion

This is how scientists conclude their papers by summarizing key takeaways.

Conference time!

1. Half group tours the other groups and listens to (Brief) Presentation
2. other half stays behind to present your findings
3. Switch when timer runs out

In your Lab groups:

1. Discuss what you saw at the conference - what are the key similarities and differences you noticed?
2. Come up with a conclusion statement that answers these key questions:
   a. After reviewing the class data, our lab can conclude that ____________ *(relating to mitigation strategies).*
   b. We are _____ % confident in our conclusions, because _________.
   c. Therefore, we think the town should do the following: _____________.
3. Record your conclusion on the Student Slideshow.

Reflection on Day's Activities