



Welcome to “Using Phenomena to Drive Student Learning in a Unit of Instruction”



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How does phenomena help us support a classroom culture of figuring out for all students?



Anchoring and Investigative Phenomena

We will show how we use an Anchoring Phenomenon to drive learning of a complex idea in a High School Unit

We will show how we use Investigative Phenomena to support a culture of “figuring out” - so all students participate in knowledge building while explaining the complex idea



Using the High School Storyline Example



We will familiarize ourselves with the Performance Expectations we are building toward in the high school Natural Selection example unit “Why don’t antibiotics work like they use to?”

We will examine the anchoring phenomenon in this unit

We will figure out the key characteristics that make the anchor and investigative phenomena effective

What do we want students to be able to explain?



The first part of this unit gets students to explain Natural Selection only:

HS-LS4-3: Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

HS-LS4-4: Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

NGSS PERFORMANCE EXPECTATIONS BUNDLE		
Natural Selection and Evolution		
HS-LS4-1	HS-LS4-2	HS-LS4-3
HS-LS4-4	HS-LS4-5	

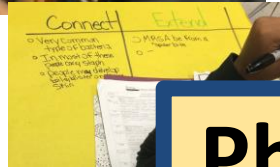
Why is the use of phenomena important to get to these performance expectations?



To explain the phenomena students will use:

Science and Engineering Practices	Disciplinary Core Ideas	Cross Cutting Concepts
Obtaining, Evaluating, and Communicating Information Constructing Explanations and Designing Solutions Analyzing and Interpreting Data Engaging in Argument from Evidence	LS4.B: Natural Selection LS4.C: Adaptation	Cause and Effect Patterns

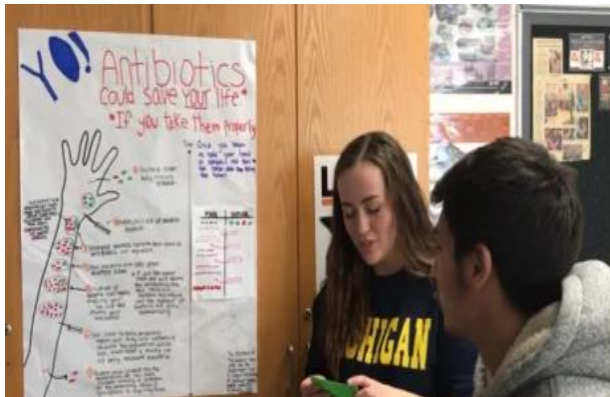
Students as partners in knowledge building



Phenomena

“We figure out the science ideas.”

“We figure out where we are going each step.”



“We put the pieces of the science ideas together over time.”

Thinking about the Natural Selection Storyline and how to employ phenomena



- How can we use an anchoring phenomenon to motivate developing a complex model like natural selection?
- Can we use student questions to motivate investigations that look at new phenomenon that will be helpful in developing our ideas about natural selection?
- Can students construct a model of natural selection step by step by building up from their explanations of their investigations of phenomenon?

High School Natural Selection Unit Target PEs



HS-LS4-1: Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

HS-LS4-2: Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

HS-LS4-3: Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

HS-LS4-4: Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

HS-LS4-5: Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.



What key elements are necessary to ensure the anchoring phenomenon can carry the unit?



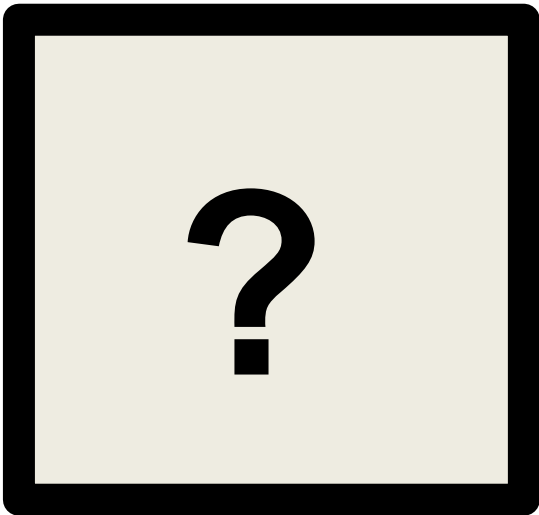
Elements of the Anchoring Phenomenon Routine

- Students Explore the Anchoring Phenomenon - *What do we notice?*
- Students attempt to make sense of the Phenomenon - *How can we explain this? Do our explanations agree?*
- Students Identify Related Phenomena - *Where else does something like this happen?*
- Develop Questions & Next Steps - *What do we need to figure out?*

Why don't antibiotics work like they used to?



The teacher introduces unit by asking a question:
Can you recall a time you were really sick? If so, what happened



The teacher introduces students to a case of a young girl who had a pan-resistant infection.



Effective Anchoring Phenomena...



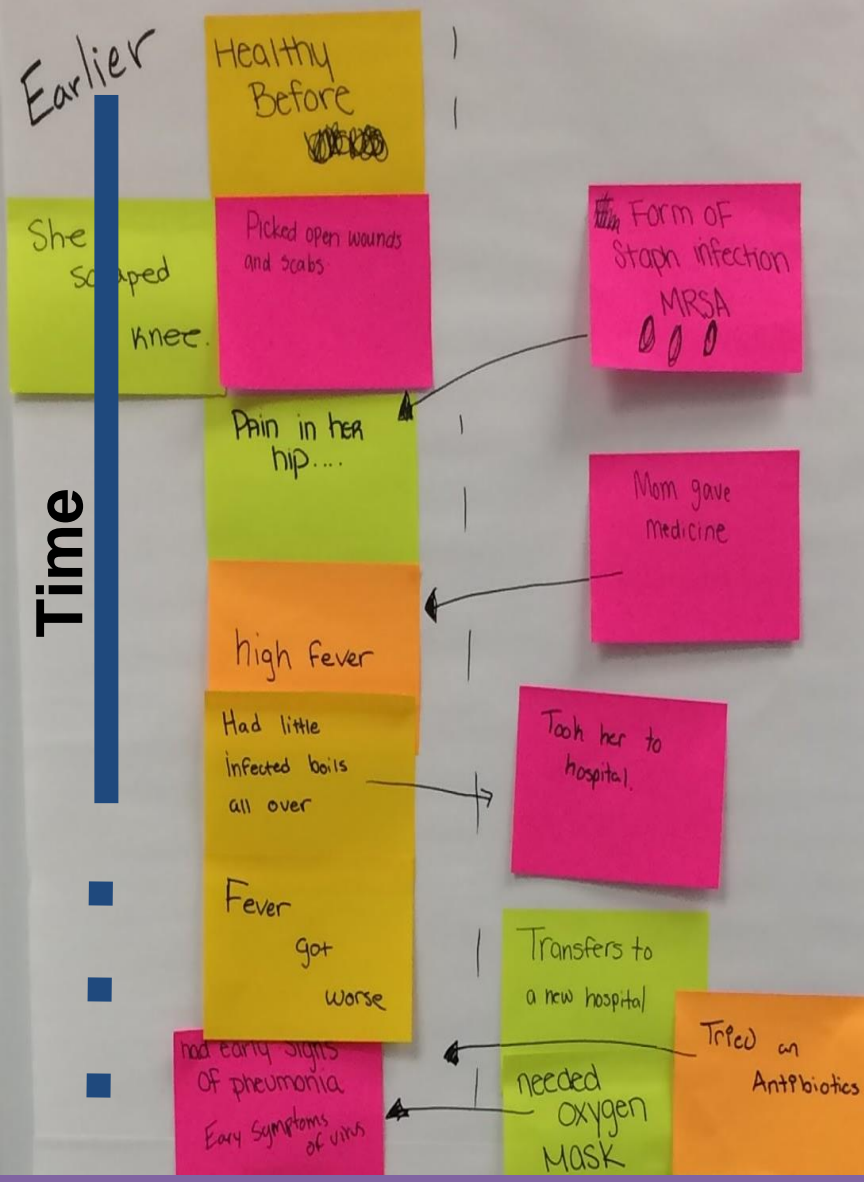
- Are immediately (or progressively) interesting to explore



6th hour *inside* Addie's Case *outside*

Earlier

Time

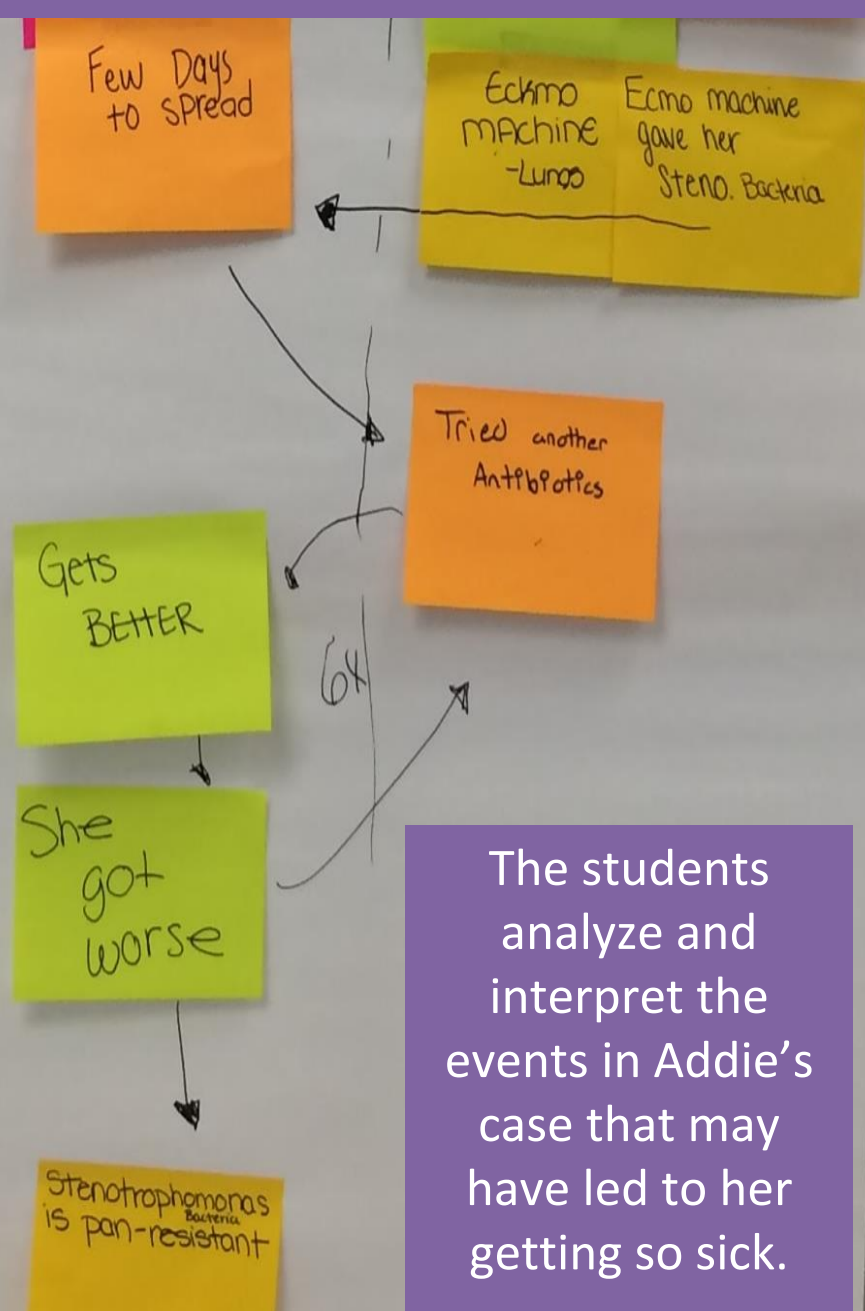


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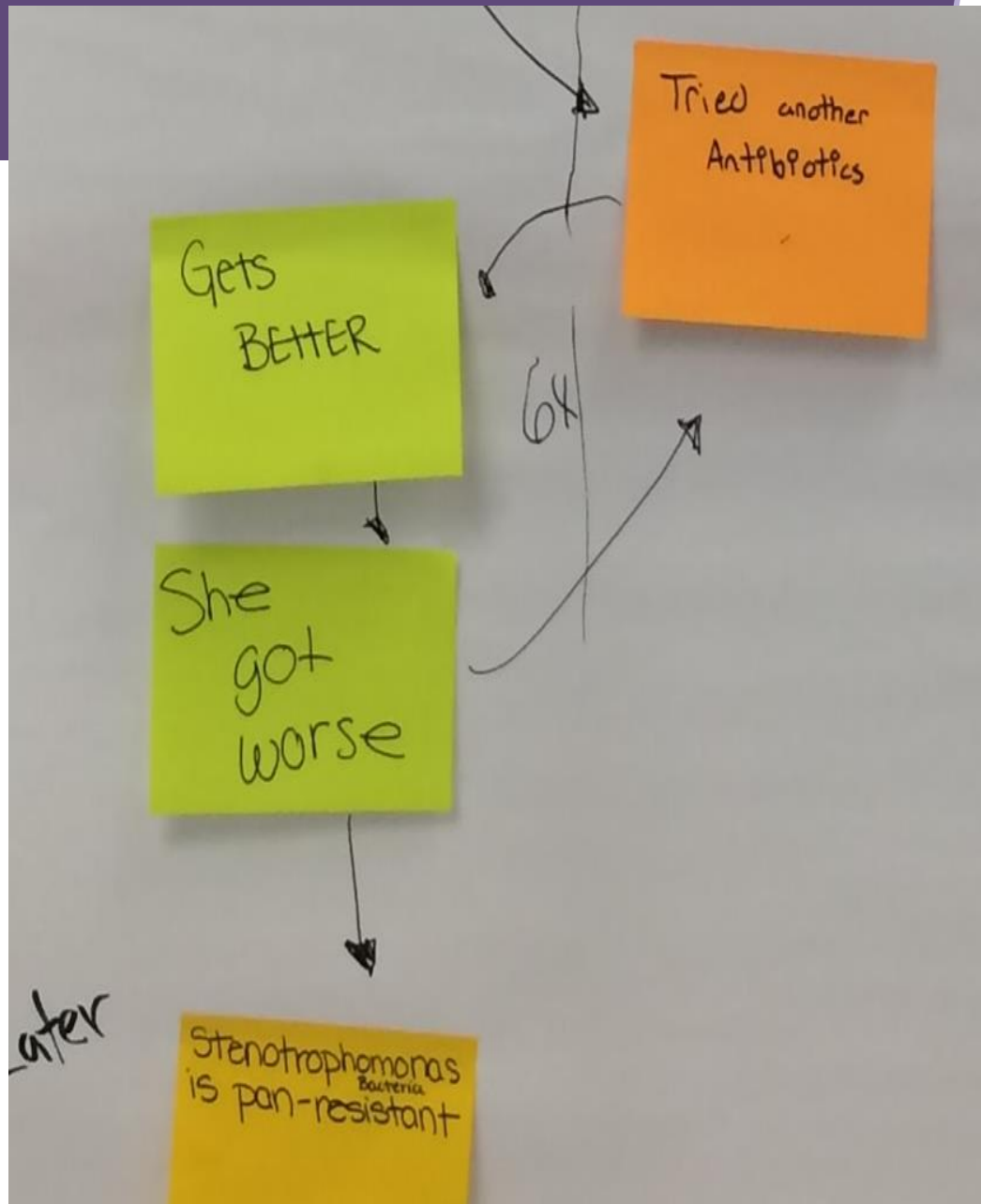
Time

Later

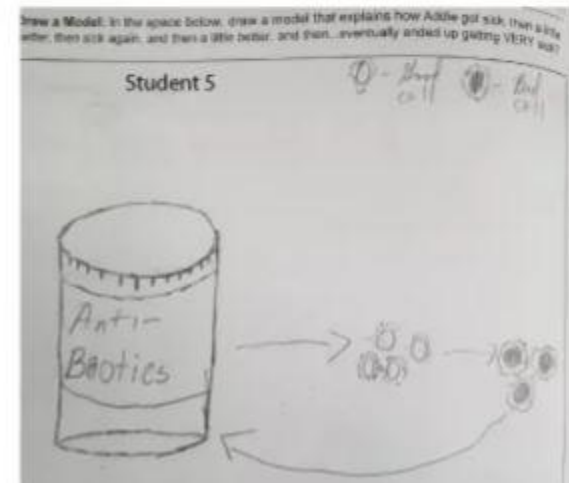
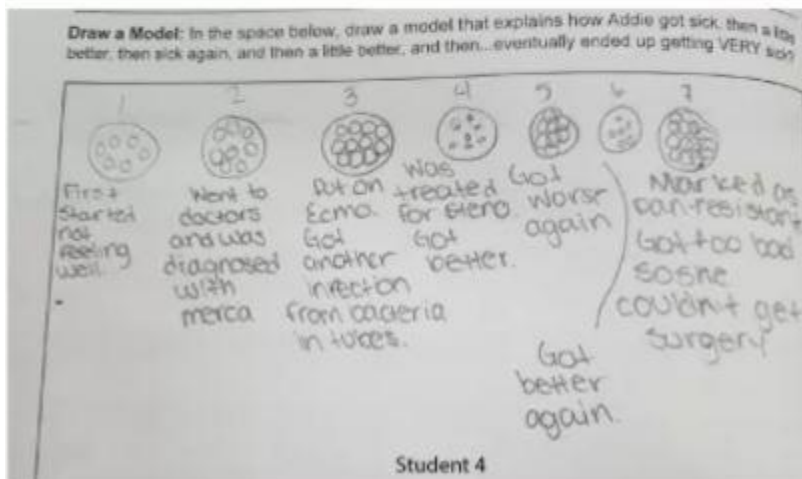
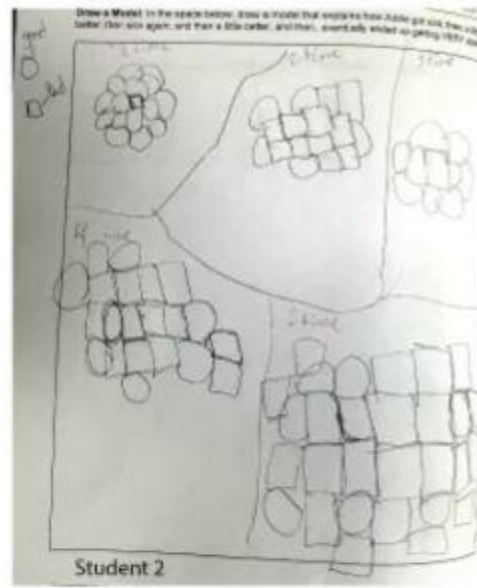


The students analyze and interpret the events in Addie's case that may have led to her getting so sick.

Students conclude that they are curious about how Addie got sick took antibiotics got better then got worse... took another antibiotic got better then worse... etc. until she was pan resistant.



Students attempt to explain the phenomenon.



What do our models have in common? How are they different?



In Common in Models

- Antibiotics, bacteria, WBC as components interacting w/ each other
- Showed Addie at different Stages.
- Antibiotics killed some bacteria but other bacteria became stronger and killed/attack antibiotics.
- ~~There~~ There was an inside/outside of Addie.
- Showed the sickness in cycles
- The surviving bacteria multiplied

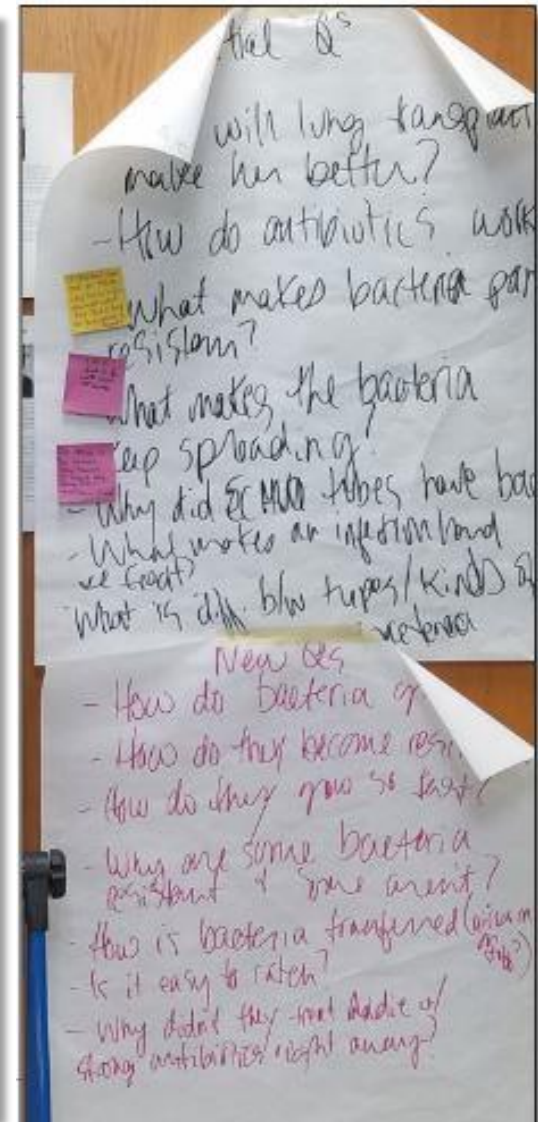
2nd Differences in Models

- Differing levels of interaction between Addie and bacteria
- Some ^{used} pictures and some used words to create model

Students' Initial Questions



- *Why does some MRSA live harmlessly?*
- *How do antibiotics work?*
- *What makes the bacteria keep spreading?*
- *Why did ECMO tubes have bacteria?*
- *What makes an infection hard to treat?*
- *How do bacteria grow?*
- *How do they become resistant?*
- *Why are some bacteria resistant and some aren't?*
- *Does being around antibiotics make it easier for bacteria to become resistant?*
- *Is it [MRSA] easy to catch?*
- *Why didn't they treat Addie w/ strong antibiotics right away?*



Effective Anchoring Phenomena...



- Are immediately (or progressively) interesting to explore
- Lead us to wonder
- Generate controversy (competing explanations)

Students explore some information about antibiotic resistance and uncover related phenomena



Who gets MRSA?

- Very Common Bacteria (Staph) - get it through Skin to Skin Contact
- Found on people's skin
- Gay men more likely to get this (STD?)
- Healthy people get this too!

Is there only one Variation/Strain of Staph?

- No, there are many types over time.
- Multiple strains - they are all related.
- New emerging strains

What is the History of Resistance to different Strains of Bacteria?

- there was just a few at the beginning and now there are many strains
- once the antibiotic was introduced sometime past then we started getting resistance?

How many cases like Addie were there in the past?

- keep good Hygiene
- People are overusing antibiotics, causing more cases

What do Community Resistance & Hospital Resistance mean?

- has more resistance in hospital, and happened first in hospital.
- Different materials grow/hold bacteria better than others.
 - Cloth holds it better than vinyl

NATIONAL SUMMARY DATA

Estimated minimum number of illnesses and deaths caused by antibiotic resistance*:

At least **2,049,442** illnesses,
 23,000 deaths

**bacteria and fungus included in this report.*



+

Estimated minimum number of illnesses and death due to *Clostridium difficile* (*C. difficile*), a unique bacterial infection that, although not significantly resistant to the drugs used to treat it, is directly related to antibiotic use and resistance:

At least **250,000** illnesses,
 14,000 deaths

WHERE DO INFECTIONS HAPPEN?

Antibiotic-resistant infections can happen anywhere. Data show that most happen in the general community; however, most deaths related to antibiotic resistance happen in healthcare settings, such as hospitals and nursing homes.

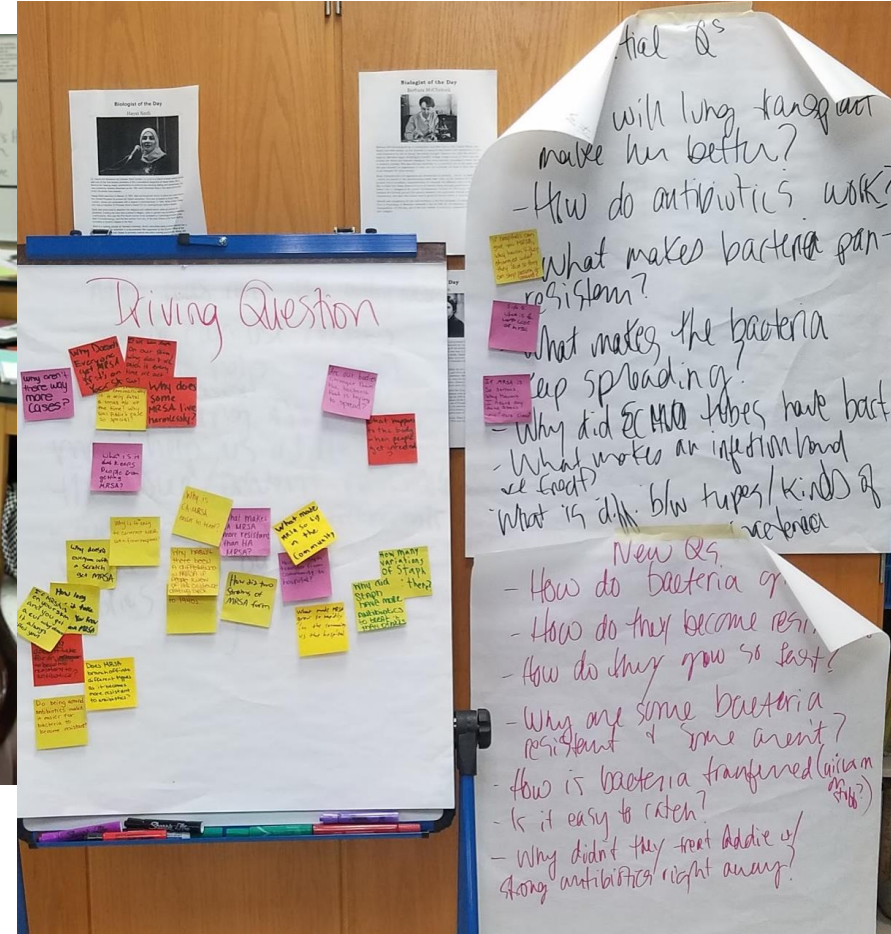


Effective Anchoring Phenomena...



- Are immediately (or progressively) interesting to explore
- Lead us to wonder
- Generate controversy (competing explanations)
- Connect to other experiences that students have had with related phenomena in the world.

Students generate questions



Here are some of the students' questions.

- *Why doesn't everyone get MRSA if it's on your skin?*
- *Why does some MRSA live harmlessly?*
- *Why is it easy to contract MRSA even from hospitals?*
- *Why is CA-MRSA easier to treat?*
- *How did two strains of MRSA form?*
- *How long does it take for a bacteria (sic) to become resistant to antibiotics?*
- *Does MRSA branch off into different types as it becomes more resistant to antibiotics?*
- *Does being around antibiotics make it easier for bacteria to become resistant?*
- *Why did staph have more antibiotics to treat it than others?*
- *How many variations of staph are there?*



Effective Anchoring Phenomena...



- Are immediately (or progressively) interesting to explore
- Lead us to wonder
- Generate controversy (competing explanations)
- Connect to other experiences that students have had with related phenomena in the world.
- **Generate questions**



Initial Question Board

- *Why does some MRSA live harmlessly?*
- *How do antibiotics work?*
- *What makes the bacteria keep spreading?*
- *Why did ECMO tubes have bacteria?*
- *What makes an infection hard to treat?*
- *How do bacteria grow?*
- *How do they become resistant?*
- *Why are some bacteria resistant?*
- *Does being around antibiotics make it easier for bacteria to become resistant?*
- *Why didn't they treat Addie w/ strong antibiotics right away?*

Driving Question Board

- *Why doesn't everyone get MRSA if it's on your skin?*
- *Why does some MRSA live harmlessly?*
- *Why is it easy to contract MRSA even from hospitals?*
- *Why is CA-MRSA easier to treat?*
- *How did two strains of MRSA form?*
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- *Does being around antibiotics make it easier for bacteria to become resistant?*
- *Why did staph have more antibiotics to treat it than others?*
- *How many variations of staph are there?*

Students brainstorm ways to investigate their questions



- Watch videos on bacteria - (to figure out) how it spreads / grows?
- Microscopes to look at them - See which environment have more bacteria
- See how many people go to a place, check bacteria — how often cleaned & how much bacteria
- Put antibiotics in Petri dish with bacteria and see what happens.
- Try using cleaner vs. not using cleaner
- Use different doses of antibiotics.
- Put (bacteria) in a dish and see how long they live.
- Change temp with bacteria - see what happens.



Effective Anchoring Phenomena...



- Are immediately (or progressively) interesting to explore
- Lead us to wonder
- Generate controversy (competing explanations)
- Connect to other experiences that students have had with related phenomena in the world.
- Generate questions and **ideas for investigations**

What have we accomplished so far?

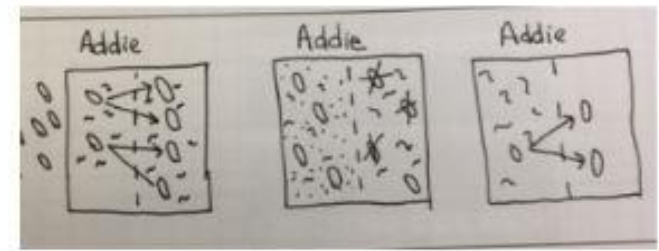


**Students Explore
the Anchoring
Phenomenon**



What do we notice?

**Students
attempt to make
sense of the
Phenomenon**



How can we explain this?
Do our explanations agree?

**Students Identify
Related
Phenomena**



Where else does
something similar happen?

**Develop
Questions &
Next Steps**



What can we do to figure
out how to explain all this?



Effective Anchoring Phenomena...



- Are immediately (or progressively) interesting to explore
- Lead us to wonder
- Generate controversy (competing explanations)
- Connect to other experiences that students have had with related phenomena in the world.
- Generate questions and ideas for investigations
- Becomes our goal to try explain (by some later point in the unit).

*In this role we refer to such a phenomena as an **anchoring phenomena** as it anchors the launch of the unit and is something we will revisit in future lessons.*





Let's Experience and Anchoring Phenomenon



Let's Experience and Anchoring Phenomenon



Anchoring Phenomenon Routine Tracker: Evolution Unit

	Explore Anchoring Phenomena	Attempt to Make Sense	Identify Related Phenomena	Develop Questions and Next Steps
	 <p>What do we notice?</p>	 <p>How can we explain this? Do our explanations agree?</p>	 <p>Where else does something similar happen?</p>	 <p>What can we do to figure out how to explain all this?</p>
<i>What question would students say they are trying to figure out right now?</i>				
<i>How does this element support figuring out?</i>				
<i>How does this element support a classroom culture where all students have access?</i>				



Anchoring and Investigative Phenomena

We will show how we use an Anchoring Phenomenon to drive learning of a complex idea in a High School Unit

We will show how we use Investigative Phenomena to support a culture of “figuring out” - so all students participate in knowledge building while explaining the complex idea

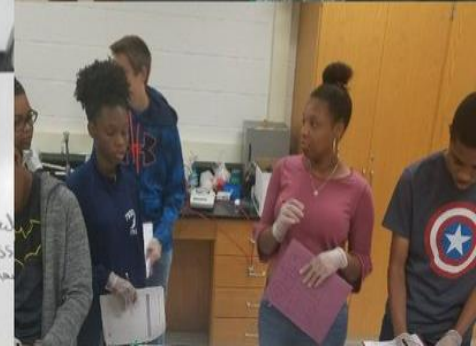
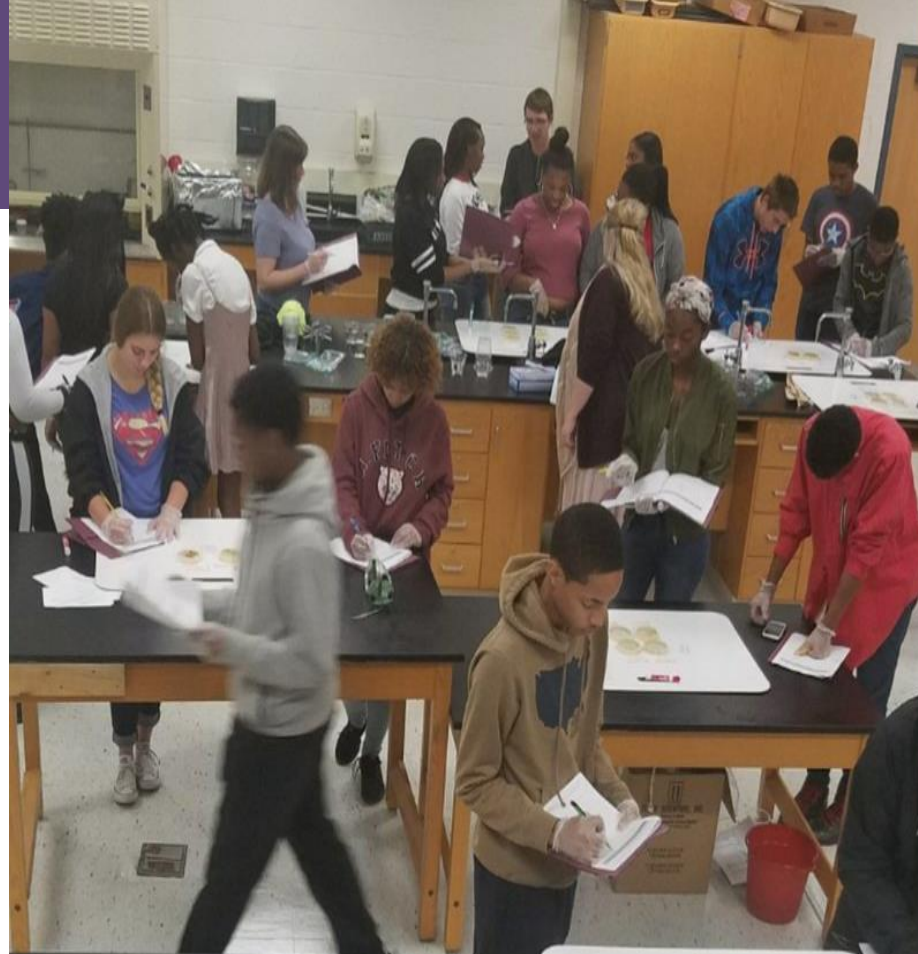


What did students decide to test first?



- Watch videos on bacteria - (to figure out) how it spreads / grows?
- Microscopes to look at them - See which environment have more bacteria
- See how many people go to a place, check bacteria — how often cleaned & how much bacteria
- Put antibiotics in Petri dish with bacteria and see what happens.
- Try using cleaner vs. not using cleaner
- Use different doses of antibiotics.
- Put (bacteria) in a dish and see how long they live.
- Change temp with bacteria - see what happens.

Where are bacteria in our environment?
How do they grow?





Effective Investigative Phenomena bridge both of these

We need to find out where bacteria are and what they need to grow because...

Teacher's Perspective:
Students need to build and use science ideas

NGSS PERFORMANCE EXPECTATIONS BUNDLE		
Natural Selection and Evolution		
HS-LS4-1	HS-LS4-2	HS-LS4-3
HS-LS4-4	HS-LS4-5	

Kids' Perspective: We're trying to see where in our school we can find bacteria and what cleaning supplies get rid of them.



HS-LS4-2: Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) **the potential for a species to increase in number**, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) **competition for limited resources**, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.



Because we're trying to answer our Driving Question **"How do bacteria grow and how do we get them on us or off of us?"**





Effective Investigative Phenomena bridge both of these

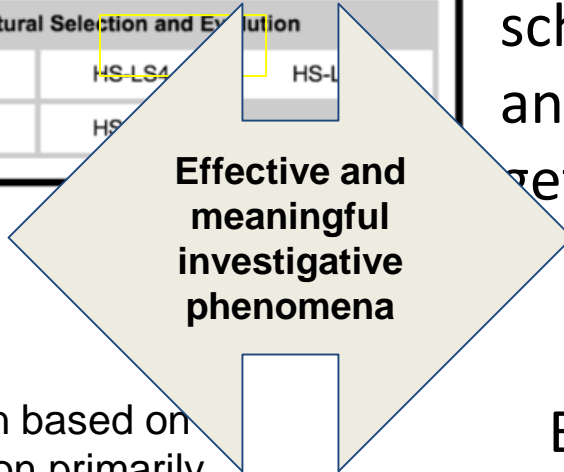
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NGSS PERFORMANCE EXPECTATIONS BUNDLE		
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HS-LS4-1	HS-LS4	HS-L
HS-LS4-4	HS	



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Because we're trying to answer our Driving Question **"How do bacteria grow and how do we get them on us or off of us?"**



Results of this investigation led to more questions....



Students decide they want to “zoom in” to understand if bacteria were growing larger or if they were growing in number on their petri dishes. They find out by watching this video and then created a mathematical model to show this.

Making Sense of Investigation 1:
 Use the time it takes a single bacteria to reproduce into two bacteria to do a quick calculation. How long would it take to end up with 8 bacteria, if you started with 1 bacteria in this environment?
 60 min

Creating a Mathematical Model Investigation 1:
 First complete the table showing the growth of the bacteria population over 400 minutes. Then construct a graph of # bacteria vs. time in hours.

Bacteria Growth

Time (min)	Time (hrs)	# of bacteria
0	0	1
20	1/3	2
40	2/3	4
60	1	8
80	1 1/3	16
100	1 2/3	32
120	2	64
140	2 1/3	128
160	2 2/3	256
180	3	512
200	3 1/3	1024
220	3 2/3	2048
240	4	4096
260	4 1/3	8192
280	4 2/3	16384
300	5	32768
320	5 1/3	65536
340	5 2/3	131072
360	6	262144
380	6 1/3	524288
400	6 2/3	1048576

of bacteria

Describe in words, the pattern of change of population growth in the table and graph.

The is small and slow for the first 5 hours or so. Then the rate of reproduction increases greatly as shown by the jump in the graph.

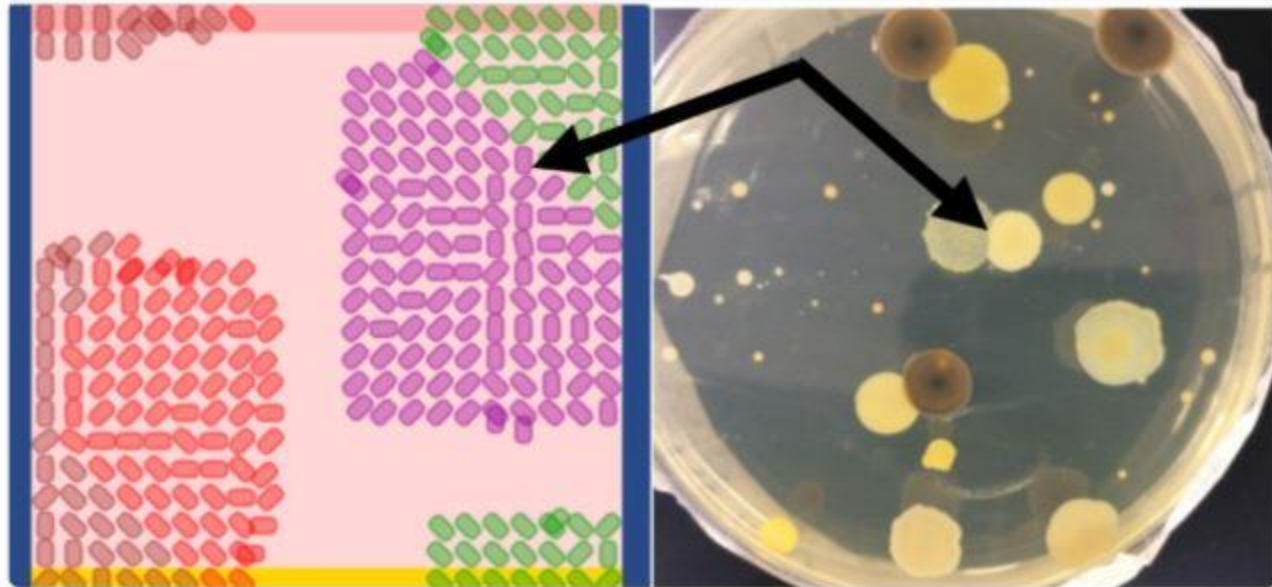
What else is going on?



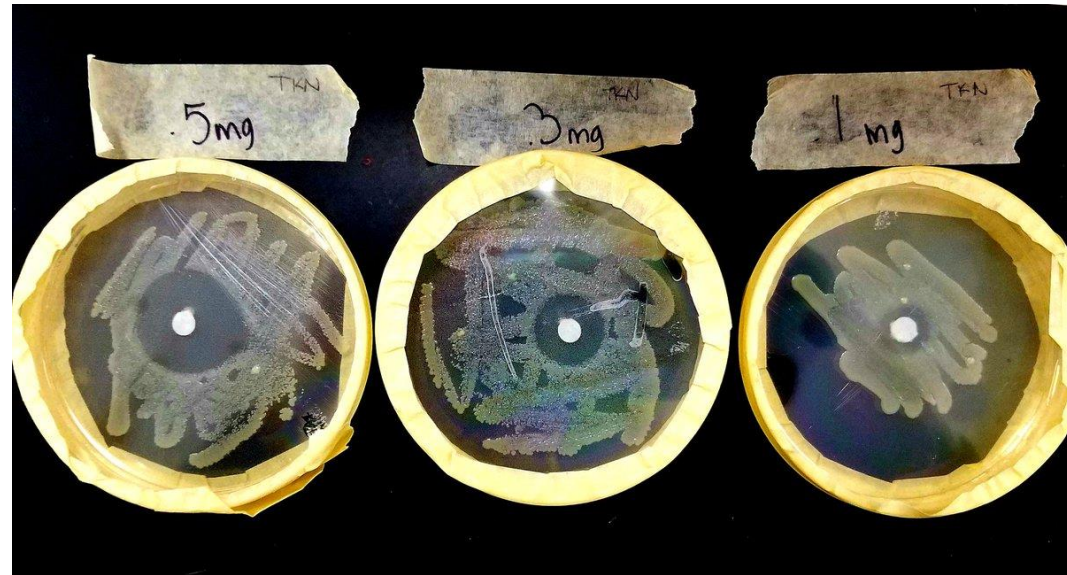
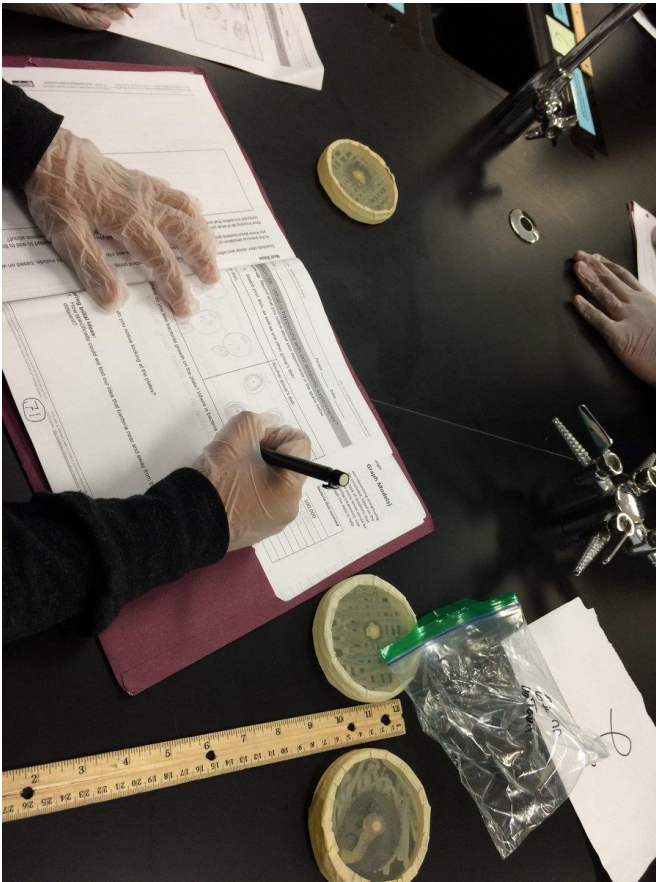
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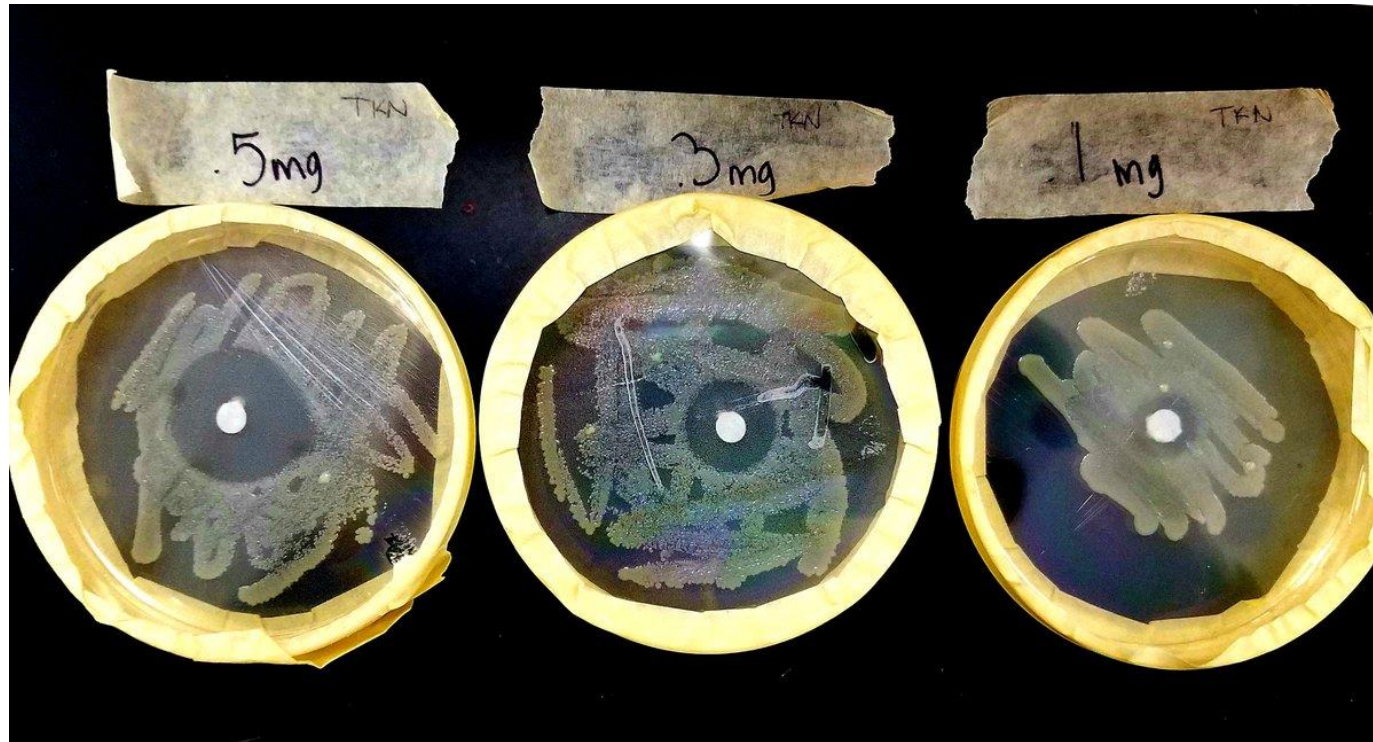
Last week SS were making connections between the computer simulation and their petri dishes. How might simulations lead to understanding?



How can we kill bacteria?



How Do We Push Students to Go Deeper and Revise Their Ideas?



Wait, why aren't they all dead?

Investigations Can Center On Multiple Phenomena



- Throughout the unit, students use multiple investigative phenomena. After the anchoring phenomenon, we use more phenomena to make progress on our questions...which often leads to more questions and more phenomena we need to explore

In this role we refer to such a phenomena as an *investigative phenomena* as it forms the basis for our investigations.



Effective Phenomena...



- Are immediately (or progressively) interesting to explore
- Lead us to wonder
- Generate controversy (competing explanations)
- Connect to other experiences that students have had with related phenomena in the world.
- Generate questions and ideas for investigations
- Advance our understanding of the key science ideas at our grade level as we work to explain it
- Become part of the puzzle we have figured out that is going to eventually help us explain other phenomena (e.g. the anchoring phenomenon).

How do students put their ideas together?



Lesson

What did we do?

What did we figure out?

What should be in our model?

- Addie Video
- ↓
- Models
- ↓
- Infographic
- ↓
- Question Board
- ↓
- Designing Experiment
- ↓
- Do the experiment
- ↓
- Articles on Antibiotics
- ↓
- Results from Experiment
- ↓
- Video of Bacteria reproducing
- ↓
- Math Model
- ↓
- Bacteria Growth
- Computer Simulation

Anti-Biotic graphs

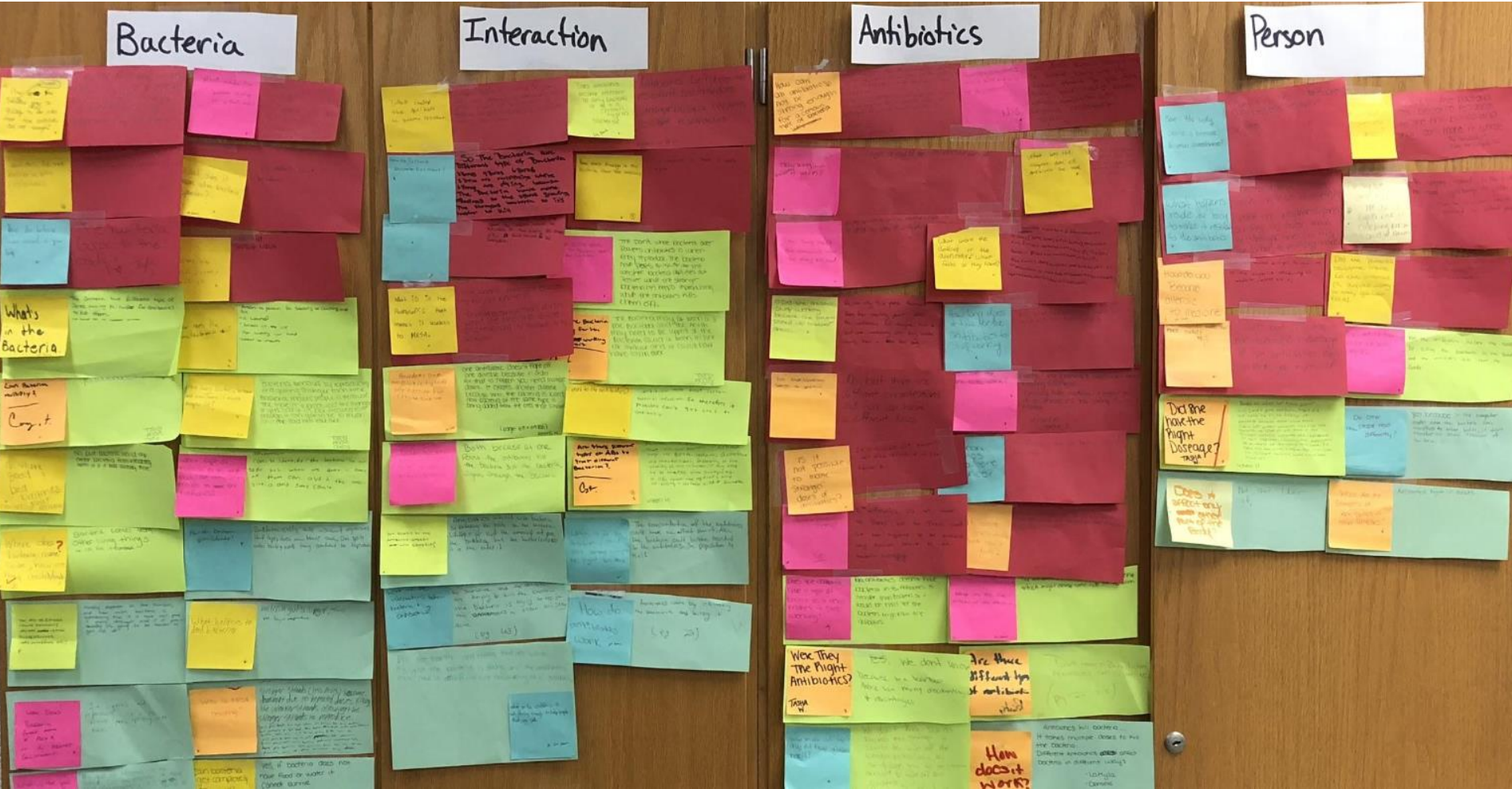
Set up of Antibiotic

- Watched the video
- Made a timeline to find out how she got sick.
- Made initial model to explain how antibiotics stopped working.
- We looked at an infographic to see how common cases like Addie happen
- We researched looking at articles to find out more about Antibiotic Resistance
- We ~~talked~~ ^{with a question of} what we thought was important to figure out in order to figure out Antibiotic Resistance
- We organized our questions.
- Talked about how to "catch" Bacteria.
- Touched Petri dish waited to see what happened.
- Designed experiment around 5 A's - where do we find Bacteria?
- Swabbed / Did experiment after feedback from other students. - How does bacteria transfer on me? - How do I kill Bacteria?
- Read Mission Critical Article... Recommendations for Antibiotics
- Read How Antibiotics Work
- Looked at the results from our investigation.
- Looked at the results from other investigations
- Wrote a CER on our findings.
- Watched a time lapse video of Bacteria reproducing
- Where did they get the # 5,000 Billion Billion Bacteria?
- Created a mathematical model to help explain the question above.
- Computer simulations
- Watched 4 different types of Bacteria reproduce
- Created a mathematical model to show how many doses work
- Created a mathematical model of Dose that includes Bacterial growth
- Set up Lab and made Predictions.

- Antibiotics stopped working ^{got worse} → Antibiotics
- Something changed with Bacteria ^{4x} → Antibiotics
- We have a lot of Ideas why the antibiotics stopped working. ^{Penicillin} → Antibiotics
- A lot of People get Antibiotic Resistance... Not all people Die.
- This is happening more often.
- We have a lot of Questions about how this is happening
- Bacteria Needs Food & Water to Survive.
- Bacteria grow. Time
- certain areas have better environments for Bacteria to grow.
- Different Antibiotics Affect Bacteria in different ways.
 - Beta Lactam - Bacteria explodes
 - Macrolides - stops proteins from being made
 - Quinolones - stops reproduction
- Bacteria was found more in frequently used places.
- Bacteria grow... But in order to see it we needed a certain environment.
- When Bacteria grow they split in two
 - Every 20 min they split in two
 - the growth was exponential
- Bacteria only produce the same type of Bacteria
- Variation in Starting Bacteria.
 - Bacteria Stop reproducing
 - Ran out of Space/Food
 - ran into other Bacteria/ competition.
 - Antibiotics
- Antibiotics Kill Bacteria
- It takes multiple Doses to kill all the Bacteria...
- In Between Doses Bacteria reproduce.
 - Clear to the same the more particles of Antibiotics.
 - Always spread the same distance.

- Bacteria getting worse... we don't agree what that looks like
- Antibiotics affecting Bacteria
- An Area / Environment
- Bacteria growing... Need to figure this out
- Resources for the bacteria to survive.
- Bacteria grow/spread... Need to figure this out...
- the environment
- Antibiotics stopping / Killing Bacteria
- Variation of Starting Bacteria
- Bacteria only produce the same type
- there are factors that stop Bacteria from reproducing
- Antibiotics killing Bacteria
- Have multiple Doses

How do students put their ideas together?



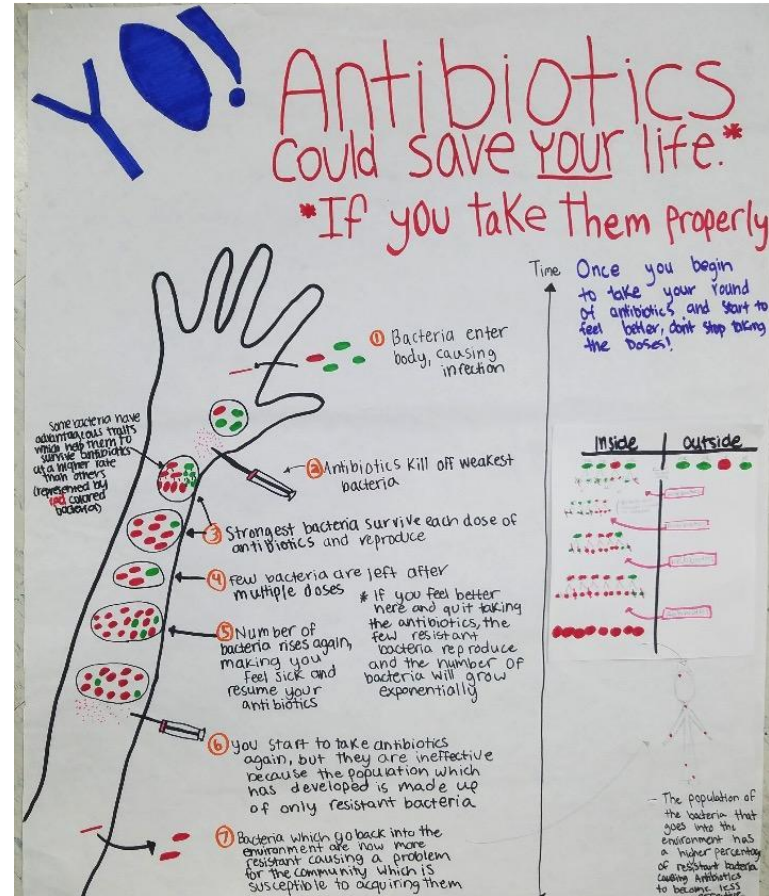
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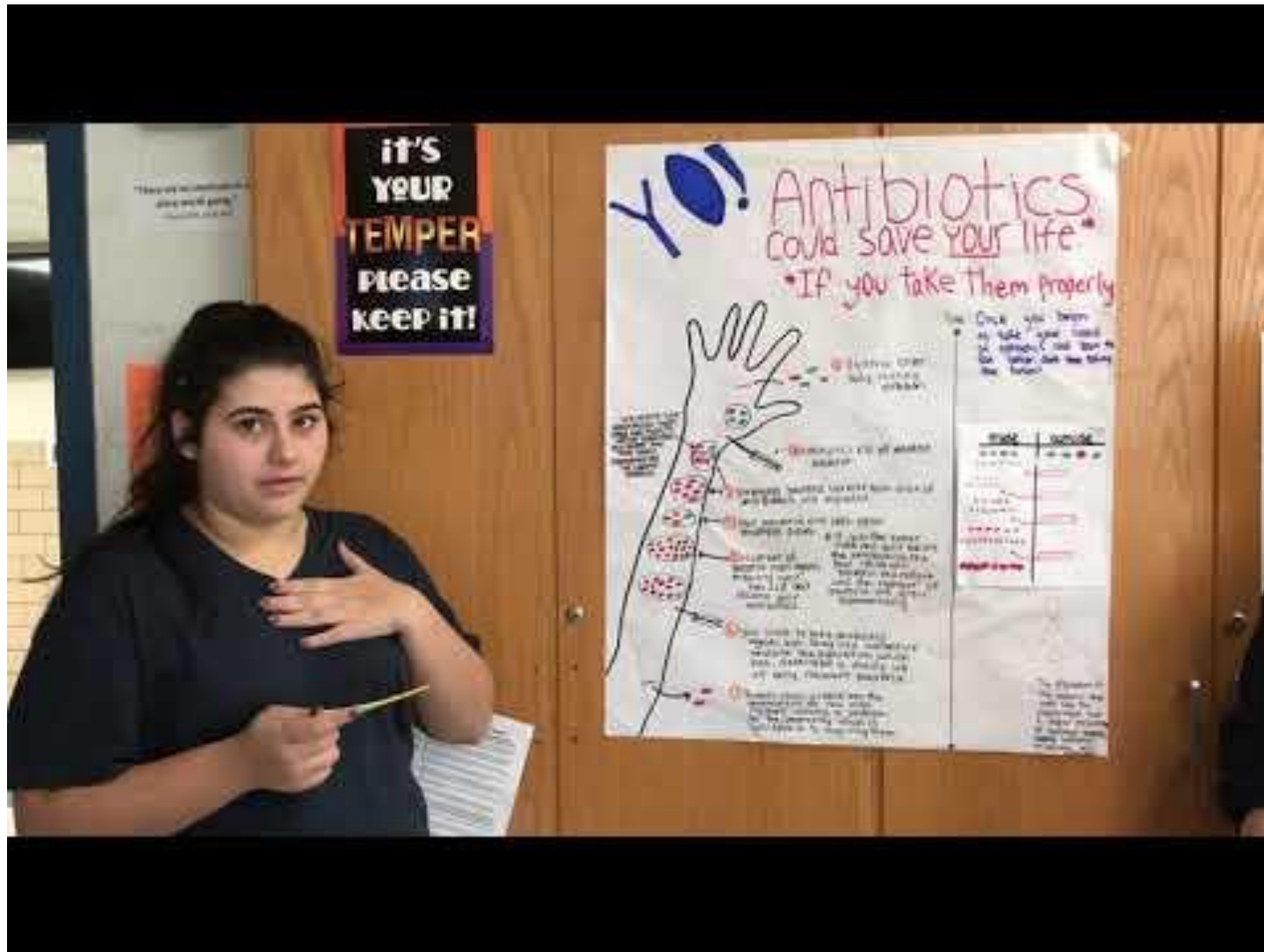
Holly Hereau
@hhereau

Following

Students create a PSA to explain why it's important to take antibiotics as they have been prescribed. Nervous but excited to exchange feedback with students from Kentucky!
[@ThurstonHS](#) [@BenchFly](#) #ngss
[#whydontantibioticsworkliketheyusedto](#)

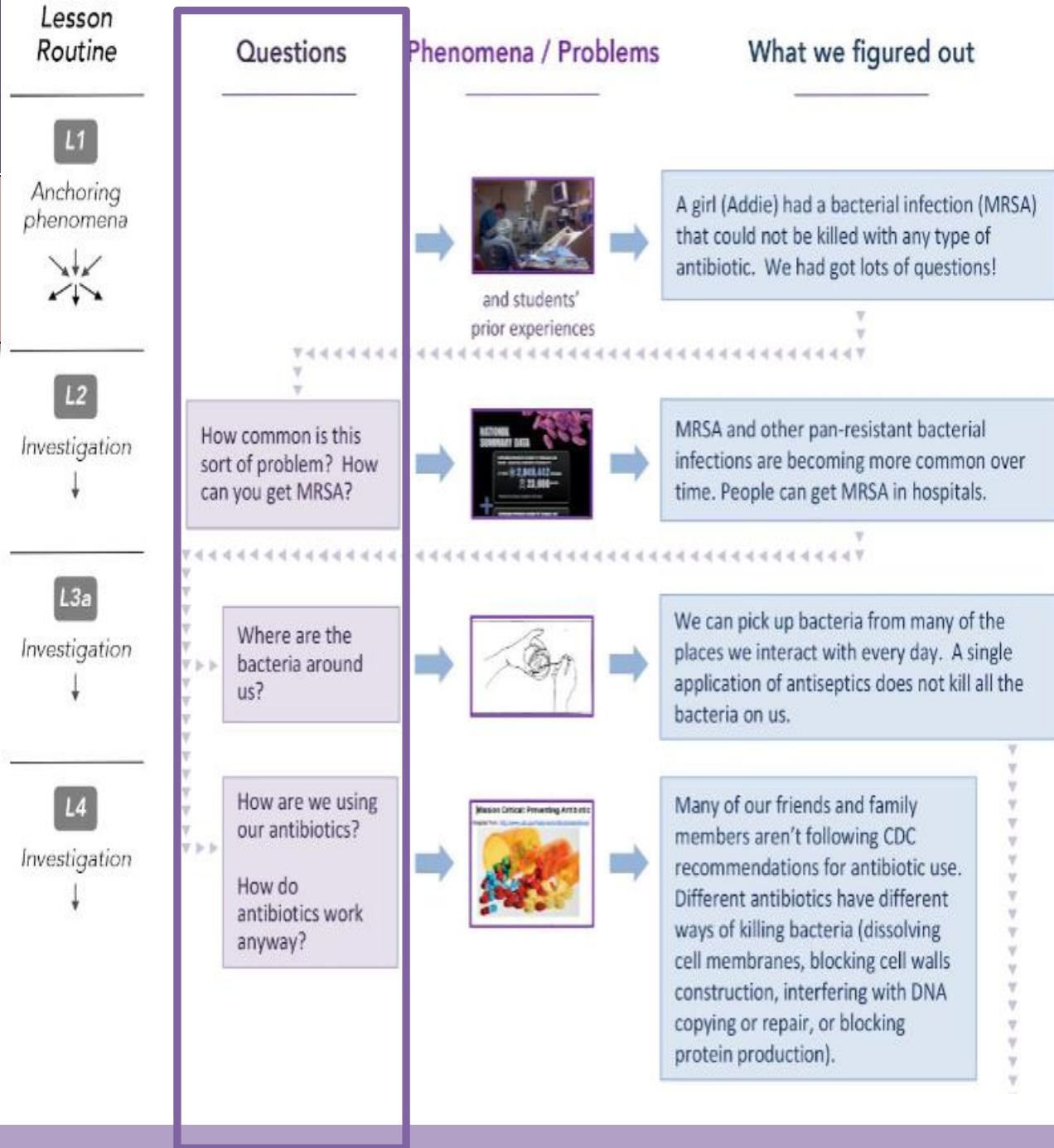


How do students put their ideas together?



Storylines

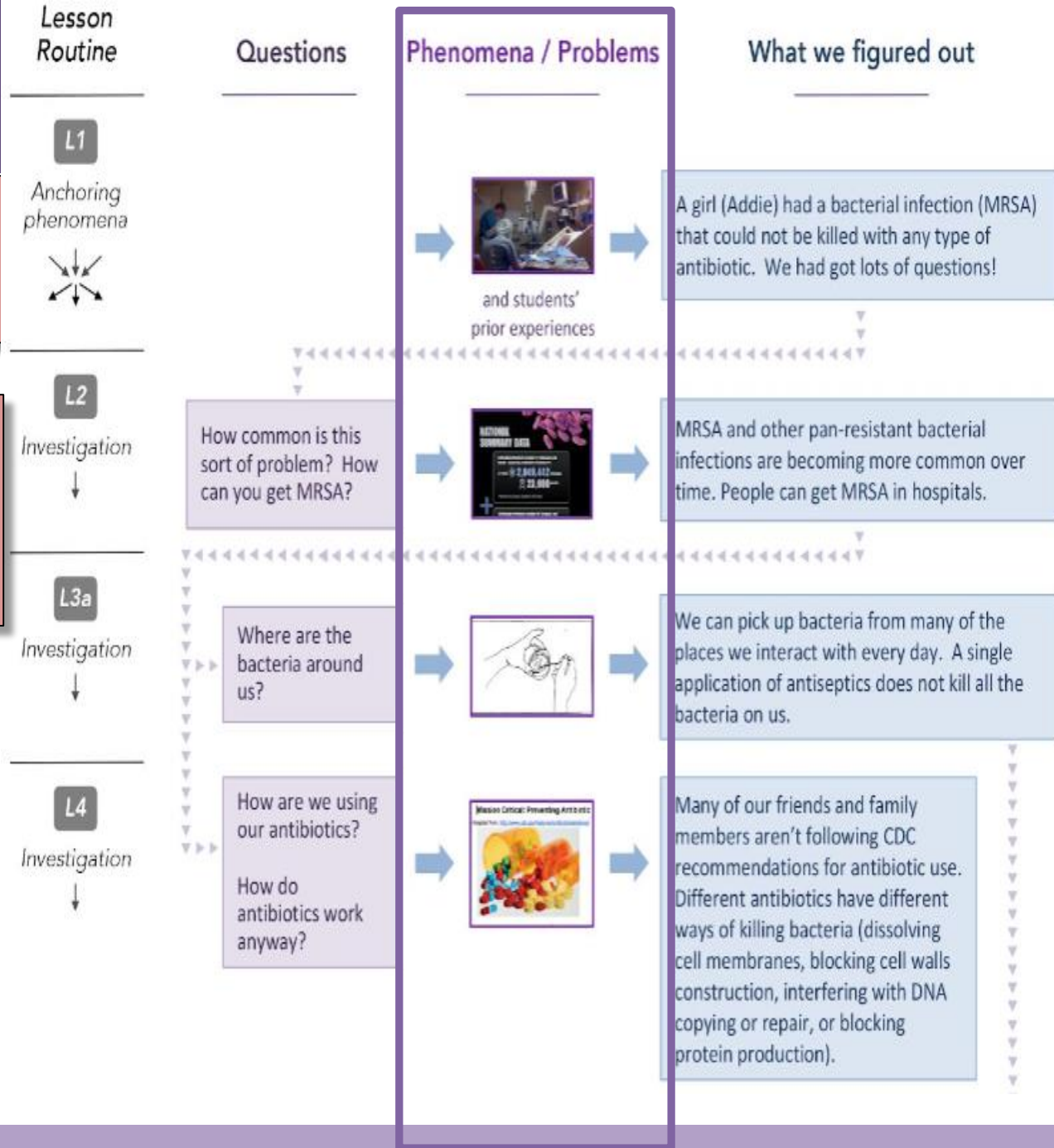
Student questions motivate each lesson



Storylines

Student questions motivate each lesson

Students use practices to make sense of phenomena

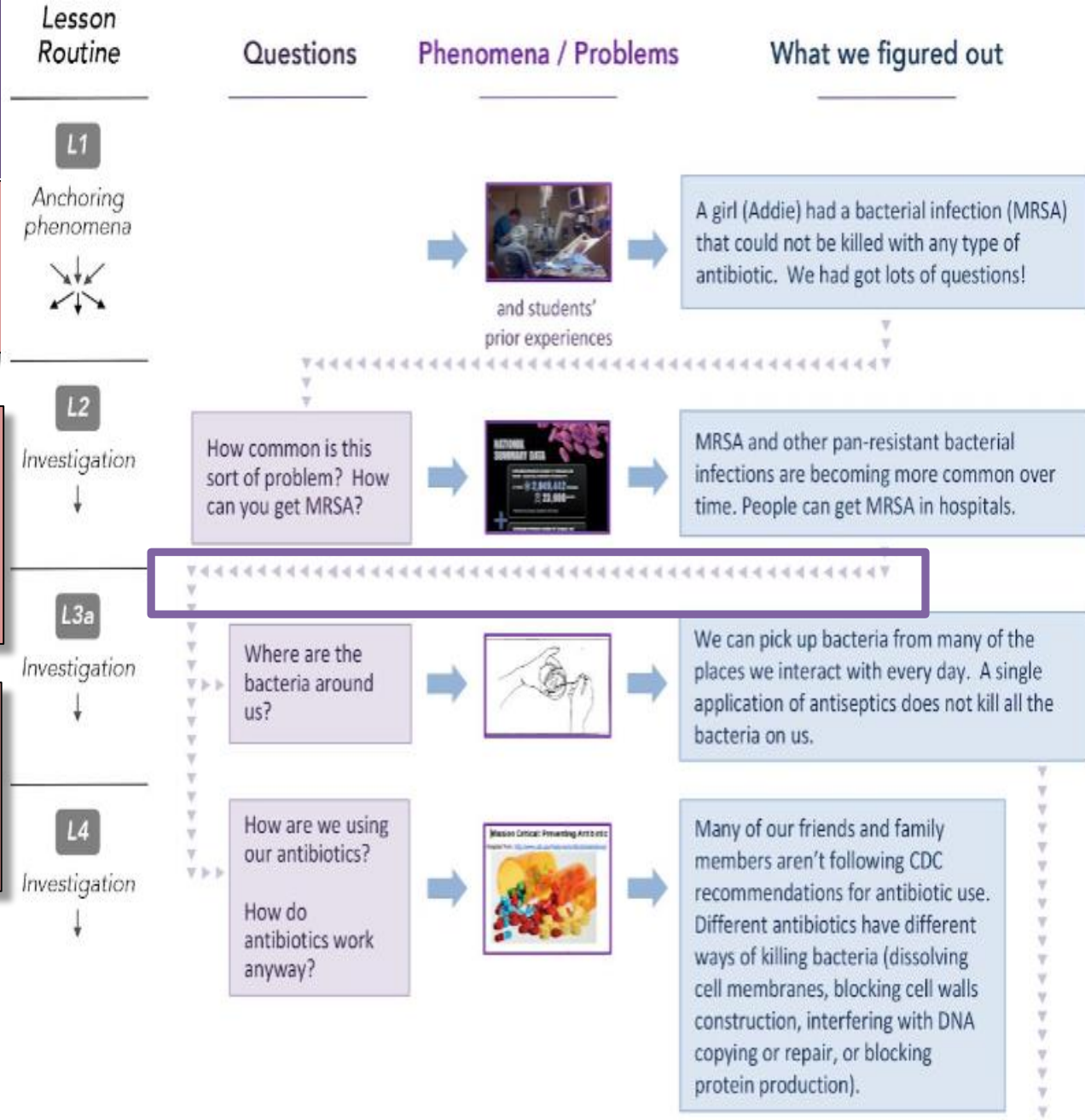


Storylines

Student questions motivate each lesson

Students use practices to make sense of phenomena

Questions arise from what students figured out so far



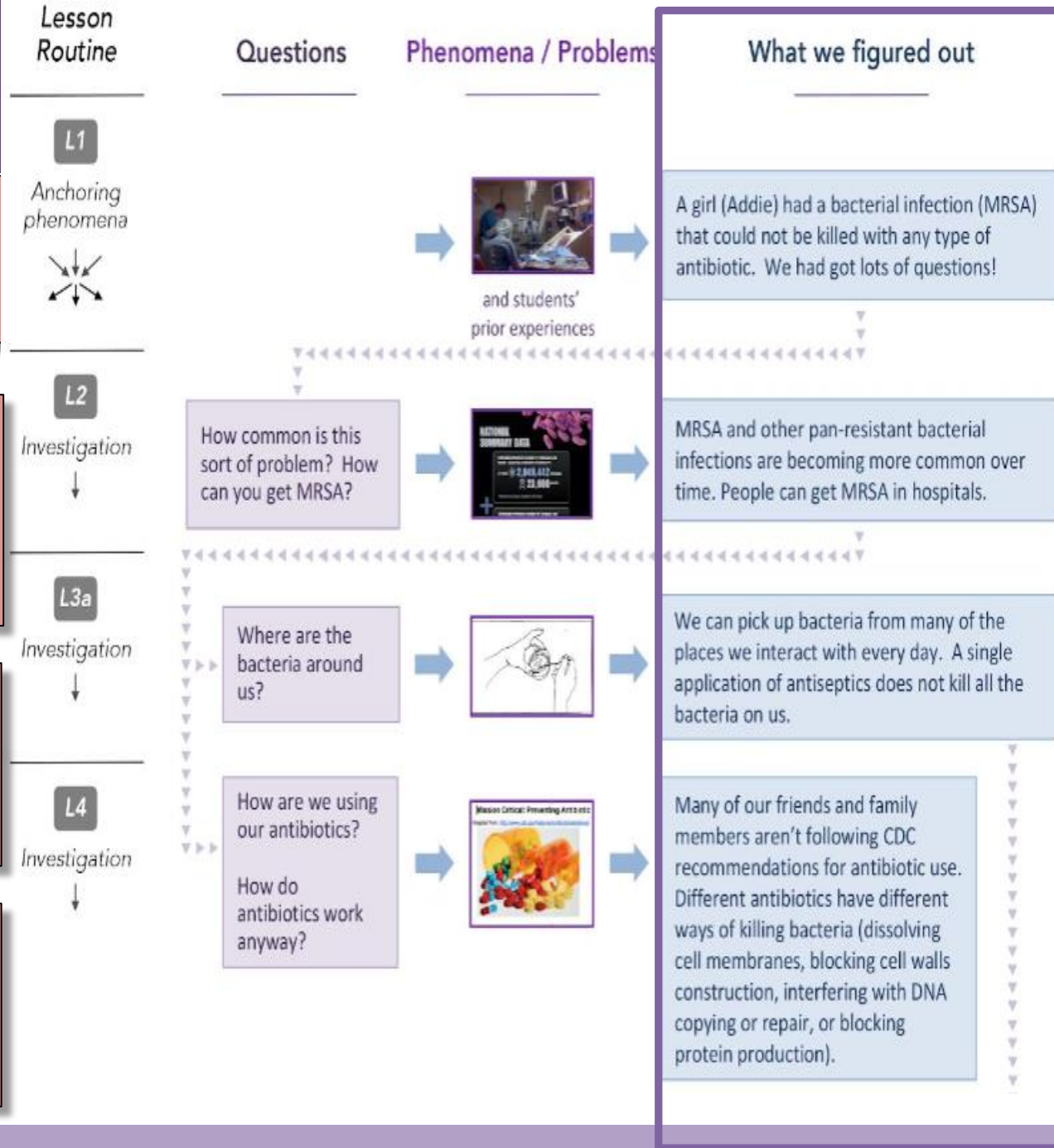
Storylines

Student questions motivate each lesson

Students use practices to make sense of phenomena

Questions arise from what students figured out so far

Students build ideas incrementally over time



Summary



- The teacher and unit design work together to support students in developing questions or identifying problems to solve about the phenomenon
- ***Students'*** questions and problems become the motivation for each investigation or design challenge
- Students put their ideas together across lessons to make sense of phenomena and solve the problem.



The examples we showed are open source materials developed by teams of teachers and are freely available, along with supporting teacher guides and lesson plans to try out. There are other K-12 examples available at this site too, and more are coming soon.



Systems

Questions?



Download this unit and other
open-source storylines:
[http://www.nextgenstorylines.
org](http://www.nextgenstorylines.org)

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