





Using Phenomena to Drive Student Learning in a Unit of Instruction for High School Students



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Figuring out Phenomena

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

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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

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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

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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	

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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	LS4.B: Natural Selection	Cause and Effect
Constructing Explanations and Designing Solutions	LS4.C: Adaptation	Patterns
Analyzing and Interpreting Data		
Engaging in Argument from Evidence		

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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.”

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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?

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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?



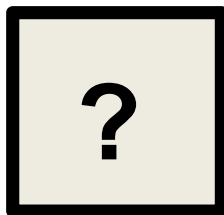
Elements of the Anchoring Phenomenon Routine

- 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

Addie's Case

with hour *inside* *outside*

Earlier

Healthy Before

She scraped knee

Nicked then washed the knee

Pain in her hip...

High Fever

Had time between tests as over

Fever got worse

Had some signs of pneumonia. Even symptoms of it.

Form of Staph infection MRSA

Went for medicine

Took her to hospital

Transfers to a real hospital

needed oxygen mask

Tried on Antibiotics

Continued

Few days to spread

Echo machine gave her Steno bacteria

Tried another Antibiotics

Gets BETTER

She got worse

Stenotrophomonas Bacterium is pan-resistant

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

Continued on the top

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.

tinyurl.com/antibioticsHSB

students attempt to explain the phenomenon.

tinyurl.com/antibioticsHSB

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 was an inside/outside of Addie.
- Showed the sickness in cycles
- The surviving bacteria multiplied

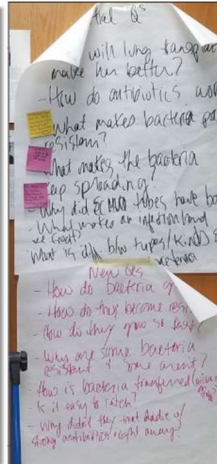
2nd Differences in Models

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

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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?



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Effective Anchoring Phenomena...

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

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Students explore some information about antibiotic resistance and uncover related phenomena

Who gets MRSA?

- Very Contagious Bacteria (Staph) - get it through Skin to Skin Contact
- Found on Dead's Skin
- Easy to catch - often 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?

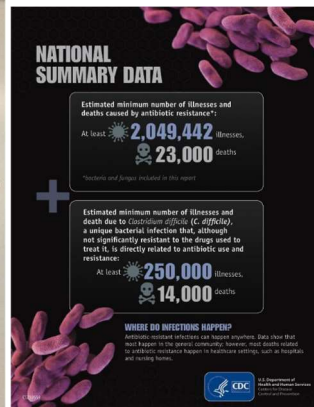
- There was just a few at the beginning and now there are many strains
- One the antibiotic was introduced sometime past then we started getting resistance?

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 wood



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Effective Anchoring Phenomena...

- Are immediately (or progressively) interesting to explore
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- Connect to other experiences that students have had with related phenomena in the world.

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Students generate questions



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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?*



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Effective Anchoring Phenomena...

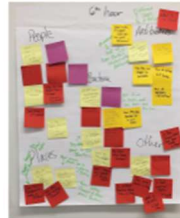
- Are immediately (or progressively) interesting to explore
- Lead us to wonder
- Generate controversy (competing explanations)
- Connect to other experiences that students have had with related phenomena in the world.
- **Generate questions**

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Initial Question Board	Driving Question Board
<ul style="list-style-type: none"> • <i>Why does some MRSA live harmlessly?</i> • <i>How do antibiotics work?</i> • <i>What makes the bacteria keep spreading?</i> • <i>Why did ECMO tubes have bacteria?</i> • <i>What makes an infection hard to treat?</i> • <i>How do bacteria grow?</i> • <i>How do they become resistant?</i> • <i>Why are some bacteria resistant?</i> • <i>Does being around antibiotics make it easier for bacteria to become resistant?</i> • <i>Why didn't they treat Addie w/ strong antibiotics right away?</i> 	<ul style="list-style-type: none"> ▪ <i>Why doesn't everyone get MRSA if it's on your skin?</i> ▪ <i>Why does some MRSA live harmlessly?</i> ▪ <i>Why is it easy to contract MRSA even from hospitals?</i> ▪ <i>Why is CA-MRSA easier to treat?</i> ▪ <i>How did two strains of MRSA form?</i> ▪ <i>How long does it take for a bacteria (sic) to become resistant to antibiotics?</i> ▪ <i>Does MRSA branch off into different types as it becomes more resistant to antibiotics?</i> ▪ <i>Does being around antibiotics make it easier for bacteria to become resistant?</i> ▪ <i>Why did staph have more antibiotics to treat it than others?</i> ▪ <i>How many variations of staph are there?</i>

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?

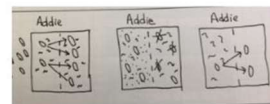
Students attempt to make sense of the Phenomenon



Students Identify Related Phenomena

Where else does something similar happen?

Develop Questions & Next Steps



How can we explain this?
Do our explanations agree?



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.*

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		
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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

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

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

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?"

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.

Effective and meaningful investigative phenomena

NGSS PERFORMANCE EXPECTATIONS BUNDLE

Natural Selection and Evolution		
HS-LS4-1	HS-LS4-2	HS-LS4-3
HS-LS4-4	HS-LS4-5	HS-LS4-6

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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.

Time (min)	Area (mm ²)	Substrate
0	0	
10	1.5	2
20	2.5	4
30	4.5	10
40	7.5	20
50	12.5	40
60	20	80
70	35	160
80	60	320
90	100	640
100	175	1280
110	300	2560
120	500	5120
130	850	10240
140	1400	20480
150	2400	40960
160	4000	81920
170	6750	163840
180	11500	327680
190	19500	655360
200	33000	1310720
210	56000	2621440
220	95000	5242880
230	160000	10485760
240	270000	20971520
250	460000	41943040
260	780000	83886080
270	1350000	167772160
280	2300000	335544320
290	3900000	671088640
300	6700000	1342177280
310	11500000	2684354560
320	19500000	5368709120
330	33000000	10737418240
340	56000000	21474836480
350	95000000	42949672960
360	160000000	85899345920
370	270000000	171798691840
380	460000000	343597383680
390	780000000	687194767360
400	1350000000	1374389534720

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.

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What else is going on?

Oct 23

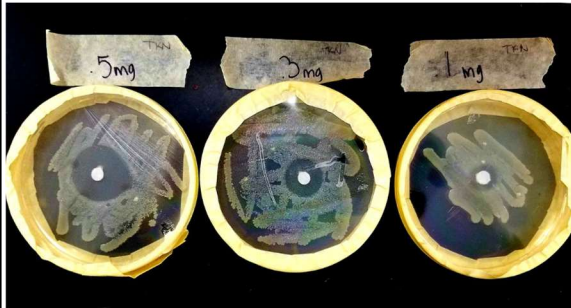
Last week SS were making connections between the computer simulation and their petri dishes. How might simulations lead to understanding?

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How can we kill bacteria?

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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

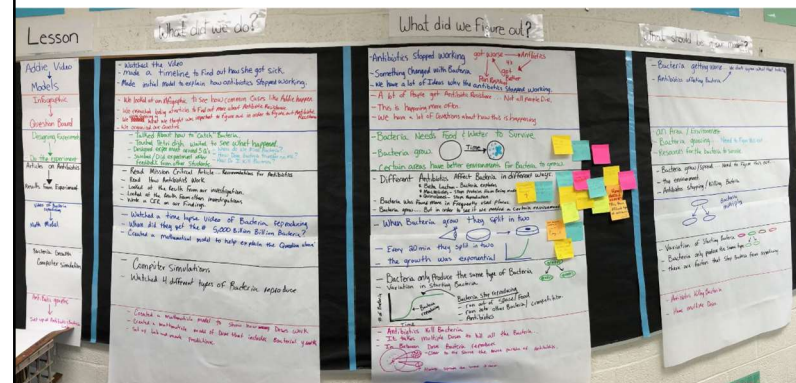
*In this role we refer to such a phenomena as an **investigative phenomena** as it forms the basis for our investigations.*

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?



How do students put their ideas together?

Molly Hureau @mollyhureau 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

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How do students put their ideas together?

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Storylines

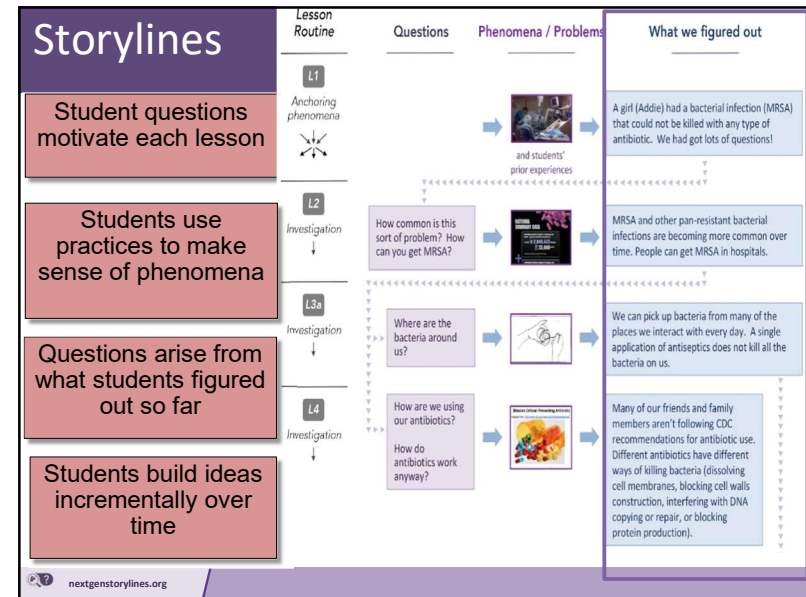
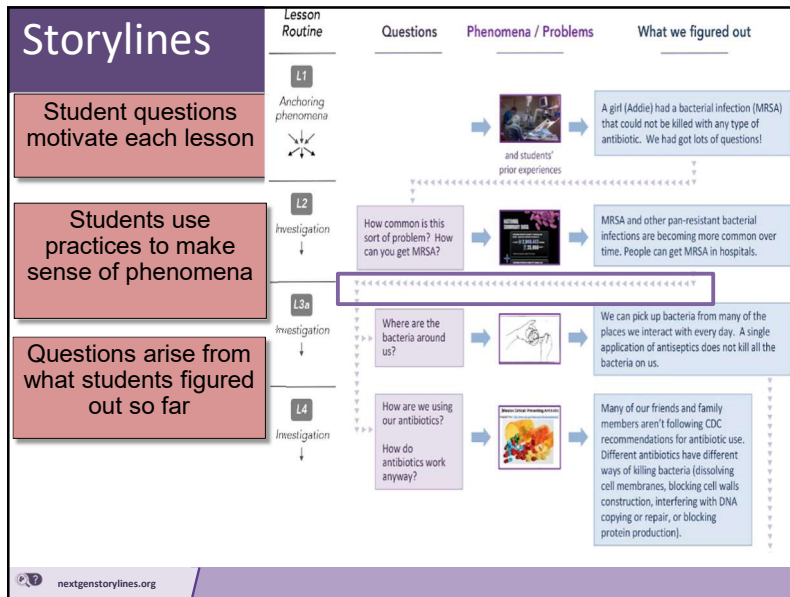
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Lesson Routine	Questions	Phenomena / Problems	What we figured out
L1 Anchoring phenomena 		 and students' prior experiences	A girl (Addie) had a bacterial infection (MRSA) that could not be killed with any type of antibiotic. We had got lots of questions!
L2 Investigation ↓	How common is this sort of problem? How can you get MRSA?		MRSA and other pan-resistant bacterial infections are becoming more common over time. People can get MRSA in hospitals.
L3a Investigation ↓	Where are the bacteria around us?		We can pick up bacteria from many of the places we interact with every day. A single application of antiseptics does not kill all the bacteria on us.
L4 Investigation ↓	How are we using our antibiotics? How do antibiotics work anyway?		Many of our friends and family members aren't following CDC recommendations for antibiotic use. Different antibiotics have different ways of killing bacteria (dissolving cell membranes, blocking cell walls construction, interfering with DNA copying or repair, or blocking protein production).

Storylines

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Lesson Routine	Questions	Phenomena / Problems	What we figured out
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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.

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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.

Questions?



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

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