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

Holly Hereau
Thurston High School
Redford, MI
@hhereau

Wayne Wright
Thurston High School
Redford, MI
@wewright1234
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.
Why is the use of phenomena important to get to these performance expectations?

To explain the phenomena students will use:

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Cross Cutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obtaining, Evaluating, and Communicating Information</td>
<td>LS4.B: Natural Selection</td>
<td>Cause and Effect Patterns</td>
</tr>
<tr>
<td>Constructing Explanations and Designing Solutions</td>
<td>LS4.C: Adaptation</td>
<td></td>
</tr>
<tr>
<td>Analyzing and Interpreting Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engaging in Argument from Evidence</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Students as partners in knowledge building

“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?
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.

tinyurl.com/antibioticsHSB
Effective Anchoring Phenomena...

- Are immediately (or progressively) interesting to explore
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 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?

tinyurl.com/antibioticsHSB
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 races

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 $\text{2,049,442}$ illnesses, $\text{23,000}$ 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 $\text{250,000}$ illnesses, $\text{14,000}$ 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?
- 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?
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.

[Link: tinyurl.com/antibioticsHSB]
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

Students attempt to make sense of the Phenomenon

Students Identify Related Phenomena

Develop Questions & Next Steps
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

<table>
<thead>
<tr>
<th>Explore Anchoring Phenomena</th>
<th>Attempt to Make Sense</th>
<th>Identify Related Phenomena</th>
<th>Develop Questions and Next Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Sun and Ocean" /></td>
<td><img src="image2" alt="Circular Diagram" /></td>
<td><img src="image3" alt="Cloud and Glass" /></td>
<td><img src="image4" alt="Question Mark" /></td>
</tr>
<tr>
<td><em>What do we notice?</em></td>
<td><em>How can we explain this? Do our explanations agree?</em></td>
<td><em>Where else does something similar happen?</em></td>
<td><em>What can we do to figure out how to explain all this?</em></td>
</tr>
</tbody>
</table>

### Questions:

- **What question would students say they are trying to figure out right now?**
- **How does this element support **figuring out**?**
- **How does this element support **a classroom culture where all students have access**?**
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.

**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.

**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?**”
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.

**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?”
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.
What else is going on?

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?
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?
How do students put their ideas together?

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

Lesson Routine

L1
Anchoring phenomena

L2
Investigation

L3a
Investigation

L4
Investigation

Questions

How common is this sort of problem? How can you get MRSA?

Where are the bacteria around us?

How are we using our antibiotics? How do antibiotics work anyway?

Phenomena / Problems

and students' prior experiences

MRSA and other pan-resistant bacterial infections are becoming more common over time. People can get MRSA in hospitals.

What we figured out

A girl (Addie) had a bacterial infection (MRSA) that could not be killed with any type of antibiotic. We had lots of questions!

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.

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).
Student questions motivate each lesson

Students use practices to make sense of phenomena

### Storylines

#### Lesson Routine

**L1**
- Anchoring phenomena

**L2**
- Investigation

**L3a**
- Investigation

**L4**
- Investigation

#### Questions

- How common is this sort of problem? How can you get MRSA?
- Where are the bacteria around us?
- How are we using our antibiotics? How do antibiotics work anyway?

#### Phenomena / Problems

- A girl (Addie) had a bacterial infection (MRSA) that could not be killed with any type of antibiotic. We had lots of questions!
- MRSA and other pan-resistant bacterial infections are becoming more common over time. People can get MRSA in hospitals.
- 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.
- 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

Student questions motivate each lesson

Students use practices to make sense of phenomena

Questions arise from what students figured out so far

<table>
<thead>
<tr>
<th>Lesson Routine</th>
<th>Questions</th>
<th>Phenomena / Problems</th>
<th>What we figured out</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 Anchoring phenomena</td>
<td>A girl (Addie) had a bacterial infection (MRSA) that could not be killed with any type of antibiotic. We had lots of questions!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2 Investigation</td>
<td>How common is this sort of problem? How can you get MRSA?</td>
<td>MRSA and other pan-resistant bacterial infections are becoming more common over time. People can get MRSA in hospitals.</td>
<td></td>
</tr>
<tr>
<td>L3a Investigation</td>
<td>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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L4 Investigation</td>
<td>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).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 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**

<table>
<thead>
<tr>
<th>Lesson Routine</th>
<th>Questions</th>
<th>Phenomena / Problems</th>
<th>What we figured out</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 Anchoring phenomena</td>
<td></td>
<td>and students' prior experiences</td>
<td>A girl (Addie) had a bacterial infection (MRSA) that could not be killed with any type of antibiotic. We had lots of questions!</td>
</tr>
<tr>
<td>L2 Investigation</td>
<td>How common is this sort of problem? How can you get MRSA?</td>
<td></td>
<td>MRSA and other pan-resistant bacterial infections are becoming more common over time. People can get MRSA in hospitals.</td>
</tr>
<tr>
<td>L3a Investigation</td>
<td>Where are the bacteria around us?</td>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>L4 Investigation</td>
<td>How are we using our antibiotics? How do antibiotics work anyway?</td>
<td></td>
<td>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).</td>
</tr>
</tbody>
</table>
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

This research was funded by grants from the Gordon and Betty Moore Foundation and the Carnegie Corporation of NY to Northwestern University; and training grant #R305B140042 from the US Department of Education, Institute of Education Sciences to the Multidisciplinary Program in Education Sciences, Northwestern University. The opinions expressed herein are those of the authors and not necessarily those of these foundations and other agencies.