LITERACY AND THE NEXT GENERATION SCIENCE STANDARDS

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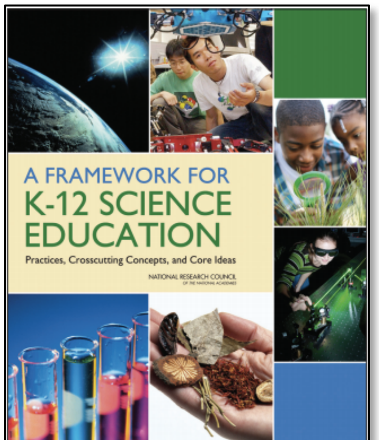
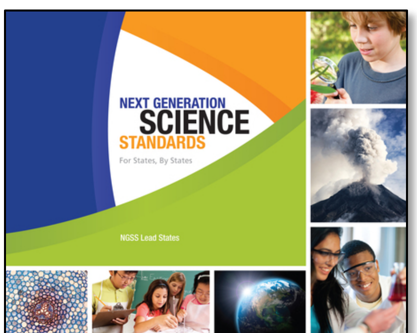
Shifts in NGSS for K-12 science





1. Organized around disciplinary core ideas (explanatory ideas)
2. Central role of scientific practices
3. Coherence: building and applying ideas across time

Science and Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Developing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Ideas built with practices are explanatory ideas

Learning *about* the science idea

- ***Learning that matter is made of particles called molecules.***

Vs.

NGSS: Figuring out how /why it works

- ***Developing a model that explains phenomena (compression, expansion, phase change)***
  - *Being able to explain why this makes sense*
  - *Being able to explain how we know this (evidence)*
  - *Being able say what the model can explain*

What kinds of literacy practices are part of science and engineering practice?

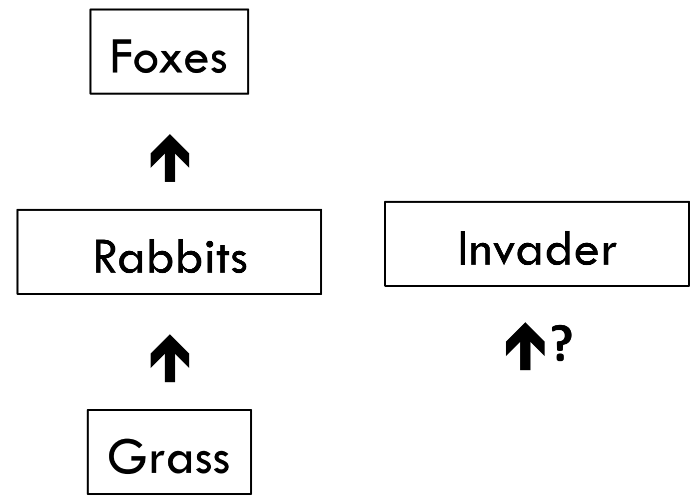
- Problem: reading and writing in science classrooms *traditionally* means
  - Reading definitions, explanations
  - Summarizing what you have read
  - Communicating what you read
  - Occasionally using what you read to make sense of something new
- But how can literacy practices be part of NGSS practices -- making sense of phenomena?

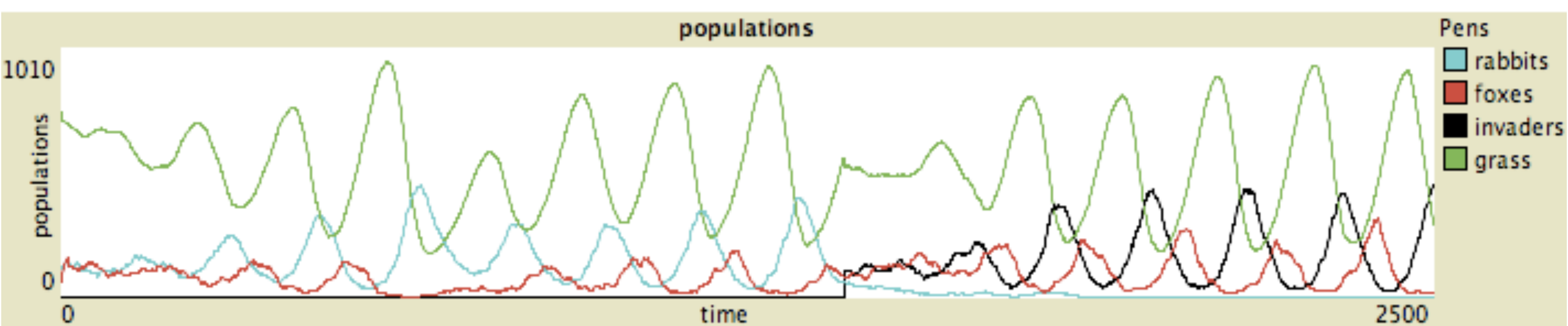
Defining Scientific Practices

Develop, evaluate, use and revise scientific knowledge

- *Cognitive work*:
  - *Steps* to gather data, build explanation
  - *Criteria* to guide and evaluate
- *Social interaction*: How to interact with others to do the scientific work
- *Discourse*: How to use language to build and refine scientific knowledge

Example 1: Scientific discourse in the classroom (6^{th} grade biology, IQWST)





A System of Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Developing explanations and designing solutions
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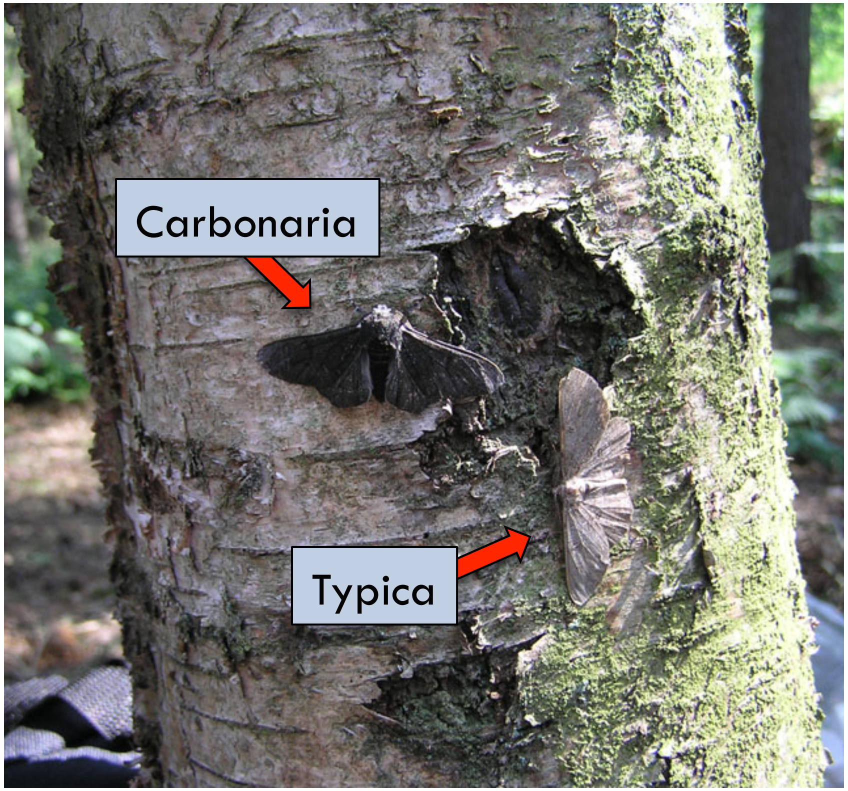
Example 2: Why do organisms look the way they do? (8th grade biology, IQWST)

- How do instructions affect traits?
  - Are there patterns in how traits are passed on?
  - How can organisms look the same on the outside but not carry the same information on the inside?
  - What happens if the alleles don't agree? (model building)
  - What happens if there are more than 2 variations?
- Does variation matter?
  - Does variation of a trait within a population affect the survival of individuals in that population? (Peppered Moths)
  - Does variation of a trait within another population affect individual survival as it did with peppered moths? (Finches)
  - Can we make a general model of population change?

The peppered moth investigation

"Beginning in the 1950s, scientists began to study the peppered moths. Their goal was to figure out why the *carbonaria* form of the moth had become more frequent than the *typica* peppered moth during the late 1800s. Before that time it had been very rare.

…The next sections contain four collections of studies. The studies look at different types of interactions between the moths and the abiotic and biotic factors in their ecosystem. These studies provide clues that can help figure out *why the populations of peppered moths have changed over time*."



Research Studies Jigsaw

1. **Pollution** – Does pollution have anything to do with the proportions of the *carbonaria* and *typica* peppered moths?
2. **Predation** – Do birds prey on one variation of the peppered moth more easily than the other?
3. **Pollution reduction** – How did the proportions of carbonaria and typica moths change in the last 50 years?
4. **Inheritance** – Is the color of the moth inherited or is it something that happens to the moth due to its environment?

- What do the results tell us about the research question?
- Regroup with one member per RQ: How can we put these studies together to construct an evidence-based explanation?

Example: Pollution Study #2

Motivation

The scientists studying the peppered moths wanted to investigate whether the pollution affected the plants and other organisms where the moths lived. If other organisms and plants were affected by the pollution, they wanted to see if that was connected to the increase in the *carbonaria* moths. Because sulfur dioxide is given off into the air when coal is burned, scientists tested the amount of it in the air in many different areas. They also examined the organisms in the area and the frequency of *carbonaria* versus *typica* moths in these same locations. They looked for a pattern between these three variables: amount of pollution, growth of organisms, and relative proportions of *carbonaria* versus *typica*.

They collected data to answer two questions.

Research questions

- Does the amount of pollution affect the lichen and trees?
- Is the type of lichen on trees related to the types of moths found there?

The results of the experiments to answer these two questions are reported in the following graphs.

Results: *How does the amount of pollution affect the other organisms in the ecosystem?*

- Scientists found a high correlation between the amount of air pollution (sulfur dioxide) and the growth of lichen on trees.

Results

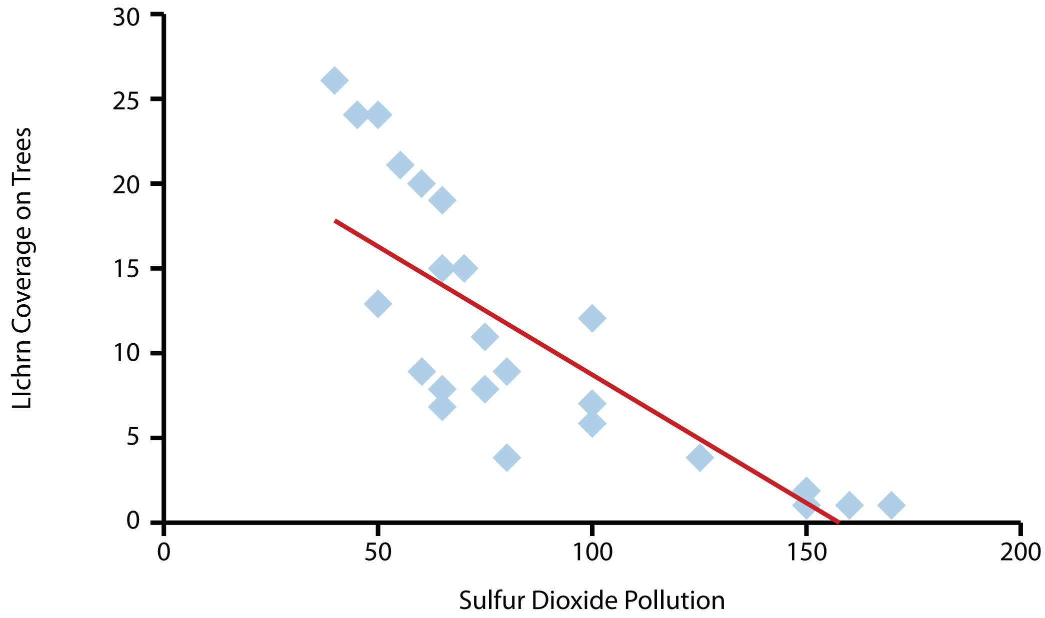


Fig. 2: The effect of sulfur dioxide pollution on the lichen coverage on trees. Each blue point shows a different site in England with varying degrees of pollution. The red line is the best-fit line through the center of the data points.

Results: *Is the type of lichen coverage on trees related to what types of moths are found there?*

Scientists found a high negative correlation between the amount of lichen coverage on trees and the proportion of peppered moths that were the *carbonaria* rather than the *typica* variation.

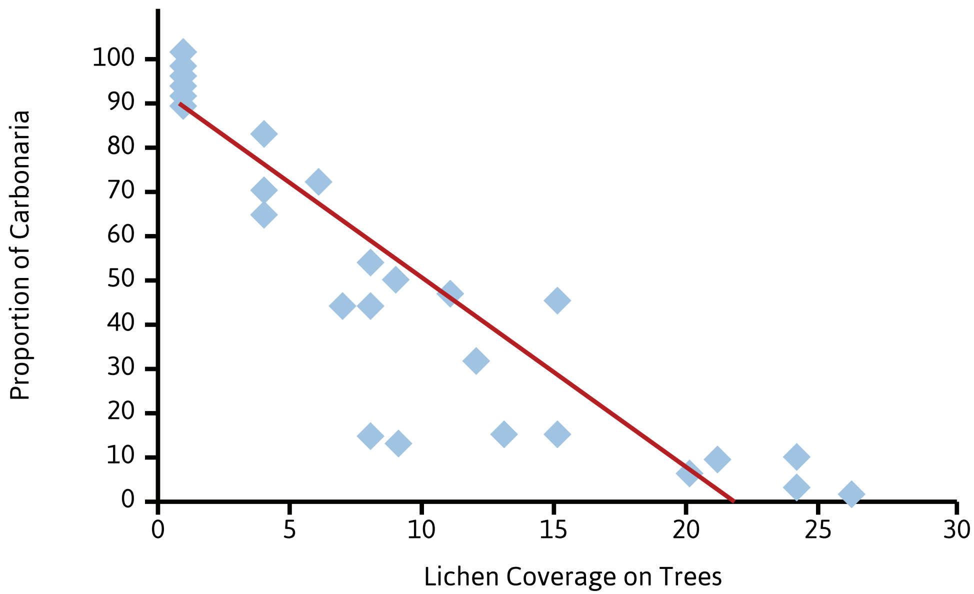


Fig. 3: The relationship between the lichen coverage on trees and the frequency of carbonaria peppered moths. Each blue point shows a different site in England with varying degrees of lichen coverage. The red line is the best-fit line through the center of the data points.

Results

Student explanation (1)

Moths in forests look the way they do because **pollution affects the amount of lichen growth on trees**, which **affects the moths' ability to hide from predators.** This leads to **one type of moth being eaten more than the other.**

Our evidence is that scientists have gathered information about the growth and predation patterns of typical and carbonaria moths in different amounts of environmental pollution. First, **lichens do not grow well in polluted areas** (graph 3). As the industrial revolution began, **more and more coal being burned polluted the air**. As more air is polluted, we see a **decrease in lichen** growth. This results in the **typical moth being eaten more often** (graph 1).

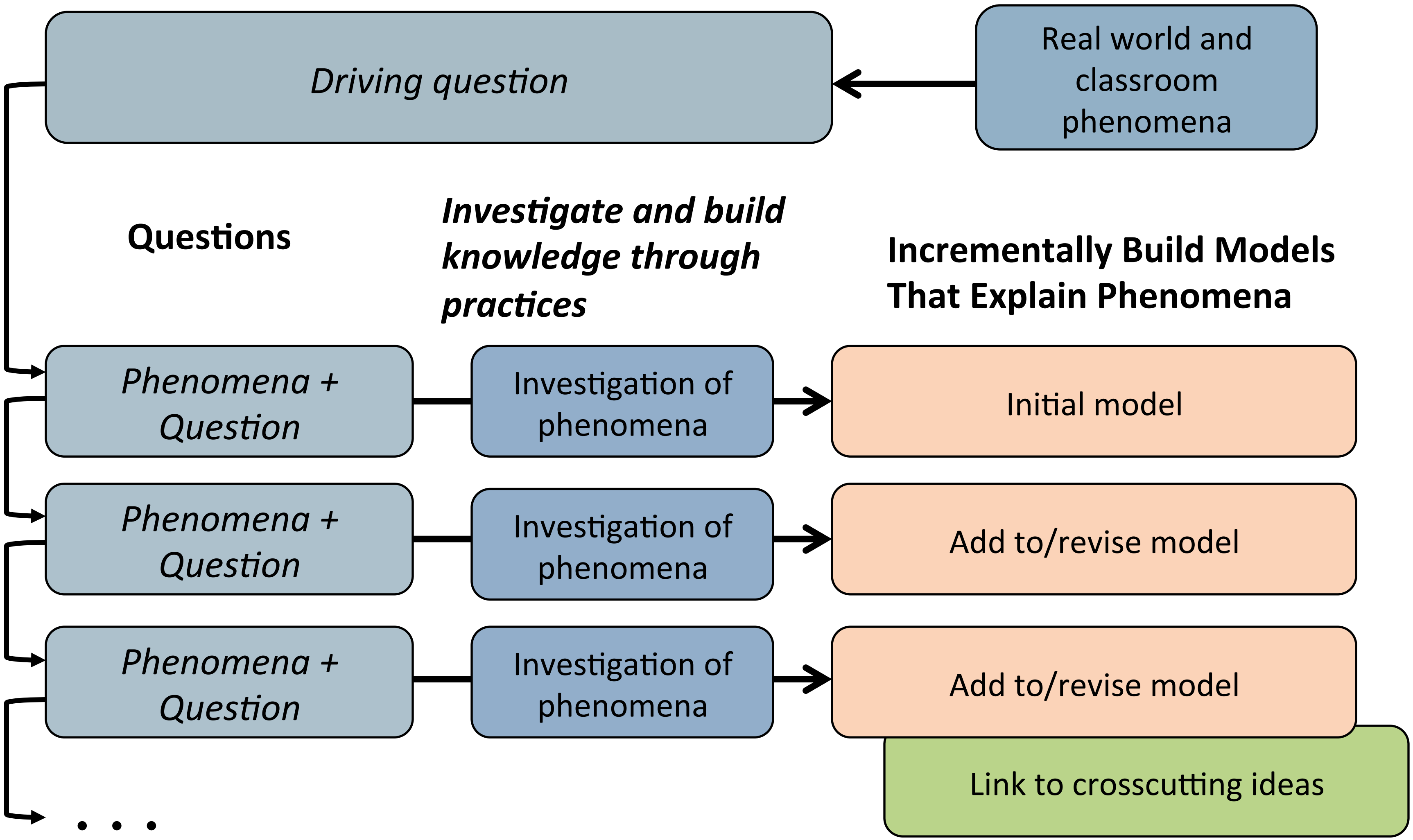
Student explanation (2)

This is because **predators can easily spot typical moths, which are colored to blend in with the lichens on trees.** The **less common carbonaria moth was brown and blended favorably with the lichen-less brown branches,** so **it was eaten in less polluted areas** (graph 1).

Student explanation (3)

Because of this, the **gene pool changed so that the majority of the moths were carbonarias** (graph 5). As people began **adopting cleaner fuels and environmental protection laws were put into effect in the 1950s**, the gene pool began to change again, **the typical moth now being the most populous** (graphs 5, 6). This is because **lichens began to grow again due to the cleaner air.** Also, we know that **the color of the moths is inherited** because scientists conducted an experiment to test this. They mated carbonarias with typical and with their own kinds and the results (table 4) showed that it is in fact inherited.

Coherence in storyline: Develop ideas to explain phenomena



Explanation in NGSS

Learning *about* the science idea

- ***Explain natural selection***

Vs.

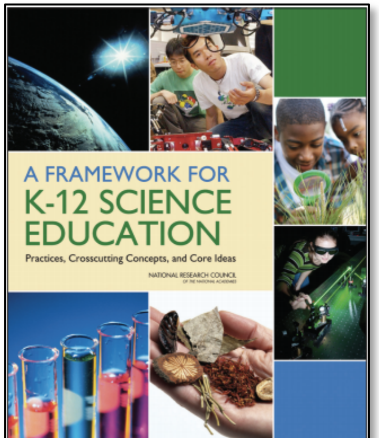
NGSS: Figuring out how /why it works

- ***Developing a model that explains why some populations changed over time***
  - *Construct a step by step account of how and why this happened*
  - *Explain how we know this (evidence)*
  - *Explain what these cases have in common*

Literacy and science practices

- Incremental putting together of an explanatory idea
- Defense and revision of the idea through argumentation
- Literacy practices to build, communicate, certique, refine explanations and models
  - *NOT* just reading answers
  - Classroom discourse to communicate idea, critique, reach consensus
  - Written argumentation
  - Use and develop scientific representations

Conclusions



1. **Explanatory ideas:** ***figuring out*** not just ***learning about***
2. **Scientific practices** build explanatory ideas
3. **Coherence: Storyline** where investigations are motivated by questions from phenomena, not order of topics in textbook

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