

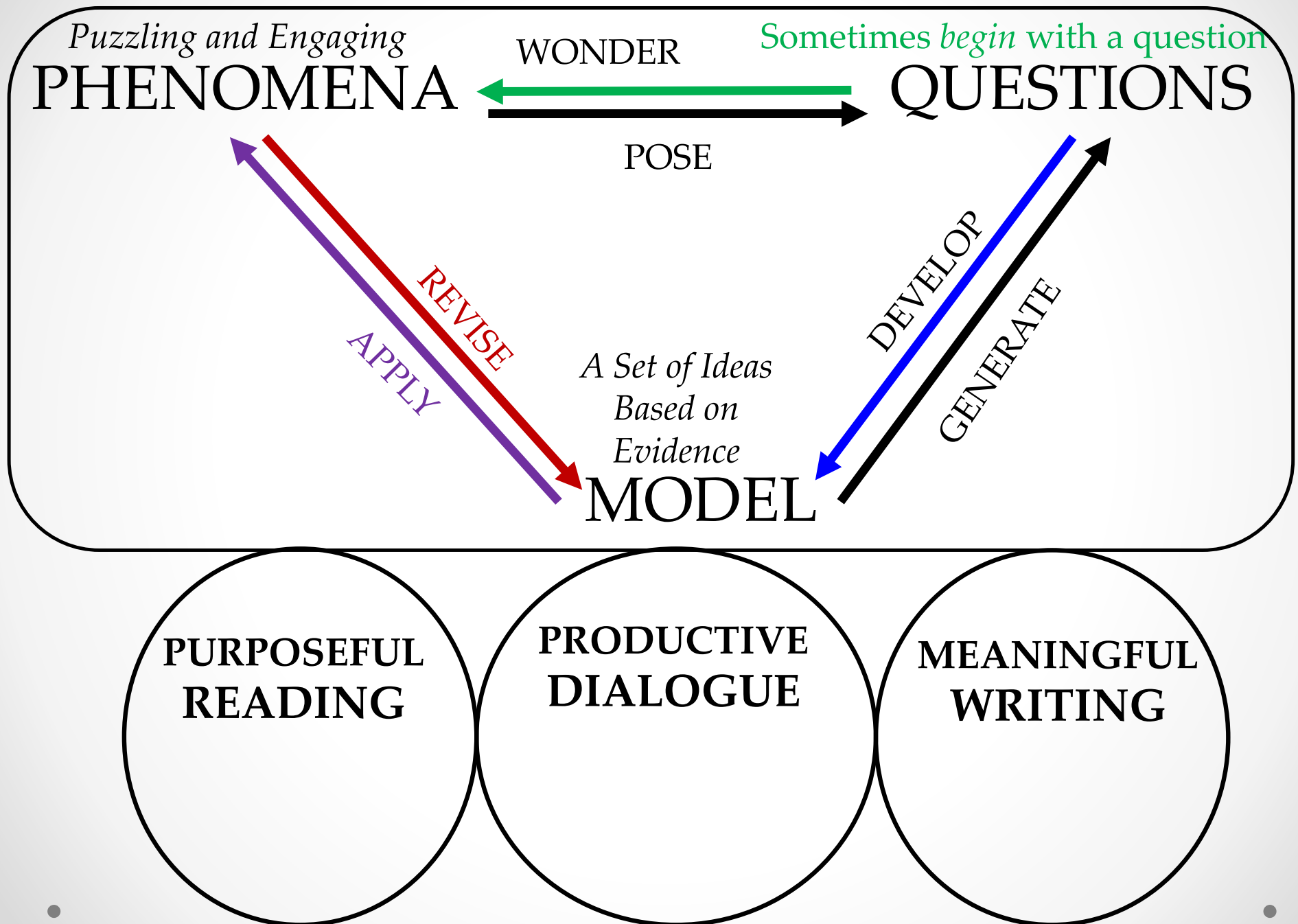
Phenomena-Questions-Models

Using phenomena, questions, and models to inform science instruction

Cindy Passmore and Arthur Beauchamp
March, 2017



Sense-making and Literacy Framework[©]



Scientist in the Crib

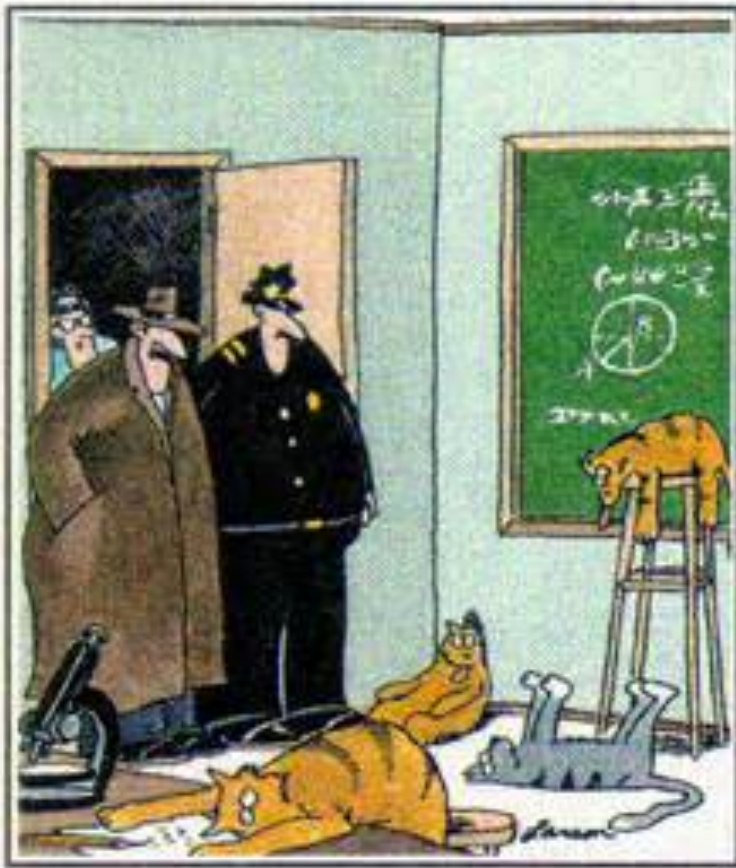
- The authors of “The Scientist in the Crib” advance a hypothesis that a baby is really like a scientist (and a scientist like a baby), forming ideas about the world, doing little experiments to test them, and refining or discarding ideas in light of experimental results. Indeed, the authors believe that children are driven by a need to explain, to understand, and this drive manifests itself during every stage of a child’s development.

Alison Gopnik, Andrew N. Meltzoff and Patricia K. Kuhl

Curiosity

Curiosity is the very basis of education and if you tell me that curiosity killed the cat, I say only the cat died nobly.

Arnold Edinborough



"Notice all the computations, theoretical scribbings, and lab equipment, Norm. ...
Yes, curiosity killed these cats."

Science is simply the word we use to describe a method of organizing our *curiosity*.

Tim Minchin

Phenomena

- Because there is a natural tendency to explain and/or seek explanation, phenomena can act as a starting point for NGSS learning sequences.
- In science education at all levels we can and should be taking advantage of this.
- However, science is often taught as if everything were known.

Phenomena



Phenomena

West shore of Lake Tahoe





Feb. 27, 2017
6:48 am
39° F
No wind
Rained 2 days ago



Phenomena



Phenomena



Conditions:

1. Bottle on its side.
2. Bottle on road.
3. 6:12 am.
4. Cloud cover.
5. 60°F, no wind.
6. Night was calm.

Phenomena

Bottle on side on playground

6:42 am

Clear sky

58°F, no wind

Night was calm



Phenomena



Phenomena



March 22, 2017

What makes a good phenomenon for the classroom?

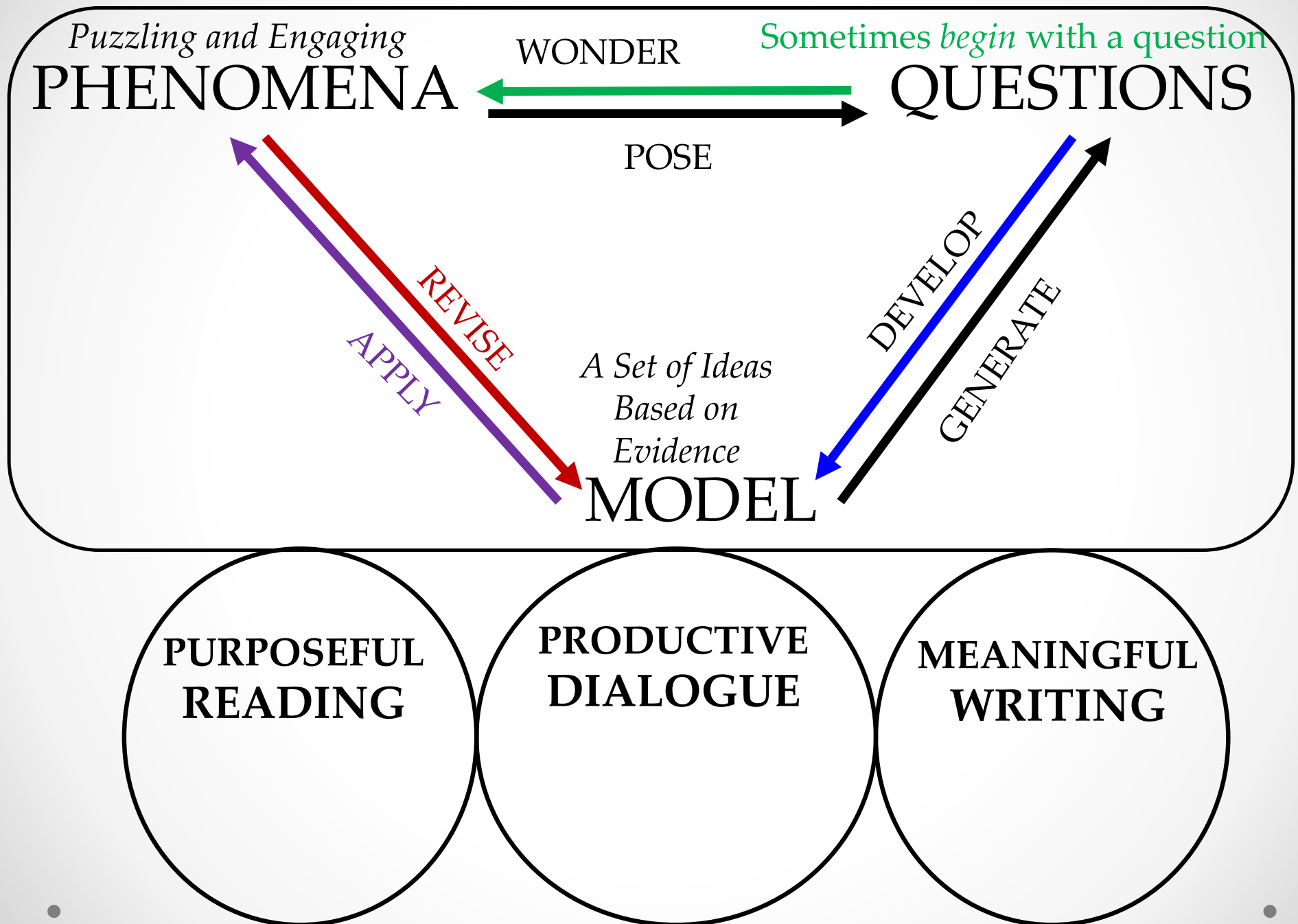
- **Easily observable and likely to spark wonder**
this does not mean it has to be phenomenal!
- **Would have available Data with Patterns:**
 - From Pictures/Video
 - From Text
 - From Scientists
 - From Student Investigations:
 - Observations
 - Measurements
 - Experiments
- **Connected to the DCI you are working on**

Phenomena can act as a useful starting place for instruction, act as a springboard for curiosity, and ground instructional sequences

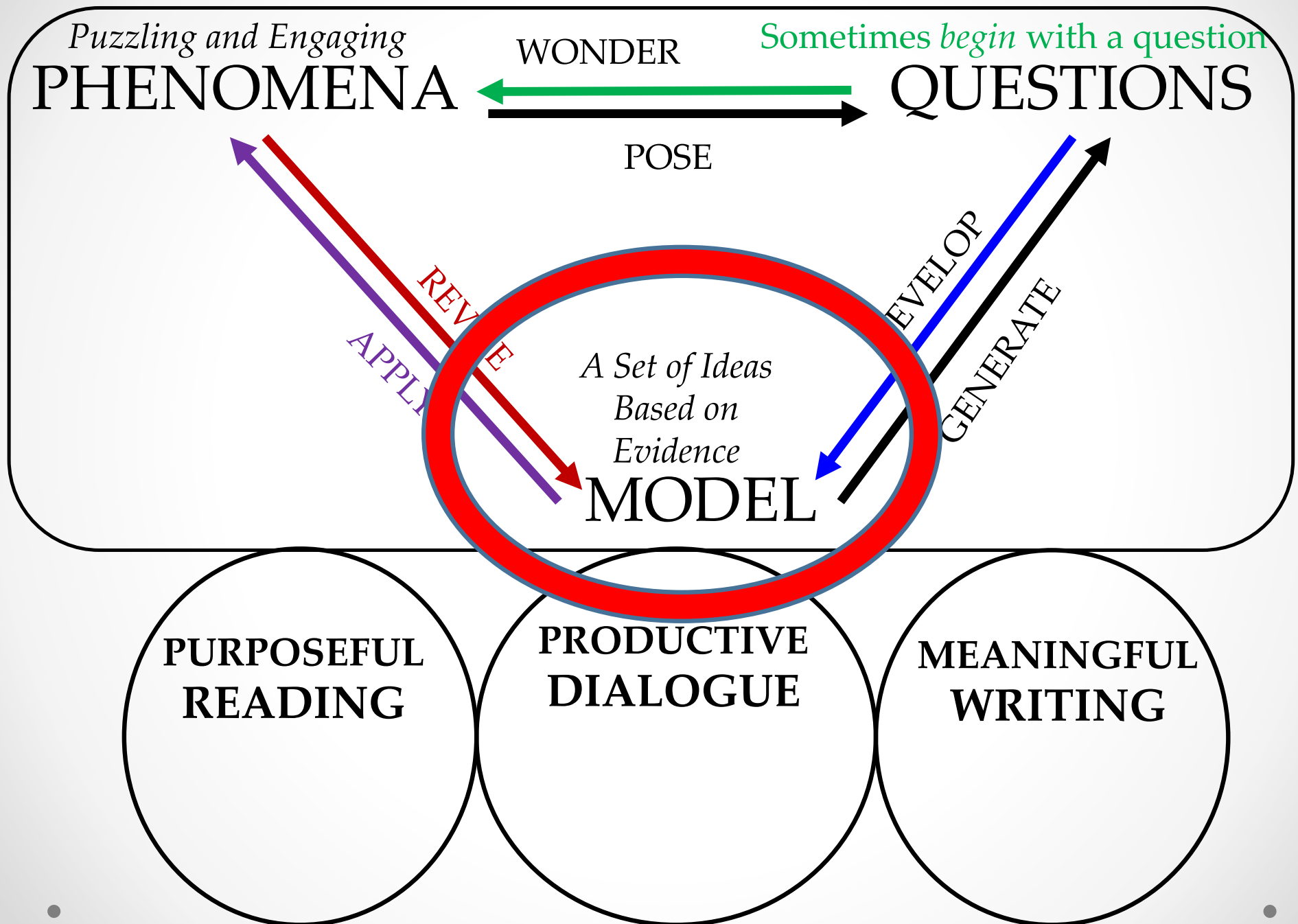
BUT, they can only do this if we harness the wonder in specific ways by asking questions.



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Questions

- Phenomena are often messy and complex.
- Questions and our existing models help us refine our wondering and focus on particular aspects of the phenomenon we are interested in exploring.



About the sunset: we might wonder...

- Why is it happening at this specific time today?
- In this location?
- Why is it colored?
- Why isn't it always colored?
- Etc.

Questioning

- Two techniques:
 - Question Formulation Technique
 - 5 Whys

Questioning

- The Right Question Institute

<http://rightquestion.org/education/>

Phenomena → Questions



5 Whys –

an iterative interrogative technique for exploring the cause and effect relationships underlying problems or phenomena.

By repeating the question "Why?" each question forms the basis of the next question.

1. Why did this phenomenon occur?

Because ice splits rocks.

2. Why does ice split rocks?



Water gets into small cracks in the rock. The water freezes repeatedly. Ice splits rocks because water expands when it freezes.

3. Why does water expand when it freezes?

Because in a liquid state water molecules can move around one another easily and get closer together. As water freezes the molecules move apart.



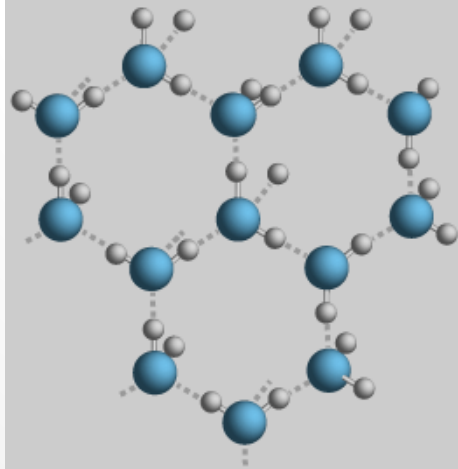
4. Why do the water molecules move apart?

Because water molecules are sort of a “V” shape and above 0°C they can move around each other and arrange tightly. When they reach 0°C they arrange into a configuration that takes up more space.



5. Why does this configuration take up more space?

Because hydrogen bonds form between H and O atoms and hold the molecules in an organized hexagonal lattice. This arrangement means that each H and O in the entire mass of ice must be oriented to their neighboring H and O in an identical repeating pattern held in place by the strength of the hydrogen bonds. And that pattern “spreads out” some to get into this arrangement (called an open crystalline structure).



Try out 5 Whys

- There are at least two underlying models we could be aiming for with the sunset phenomenon. Pick one and try out the 5 Whys technique.
 - Model ideas about light and color beginning with the question of: “Why is the sunset red tonight?”
 - Model ideas about time and location: “Why did the sunset at this particular moment (say 5:52 pm) and in this particular place on the horizon.”

A few reactions to 5 whys

- The utility of the why format to focus on mechanisms
- The challenge of the format may push us to jump over important ideas or go off in different directions
 - This is very productive for teacher brainstorming, but needs careful management in the classroom if used with kids

Return to the reasoning triangle

- So now we've noticed some interesting things in the world:

PHENOMENON

- And we wondered about specific aspects of that thing:

QUESTIONS

- So now we need to figure out what is going on.



If we ask mechanistic questions like:

- WHY does something happen or,
- What CAUSES the phenomenon

Then we are motivated to figure out some ideas about what we are wondering about.

WE NEED A MODEL!

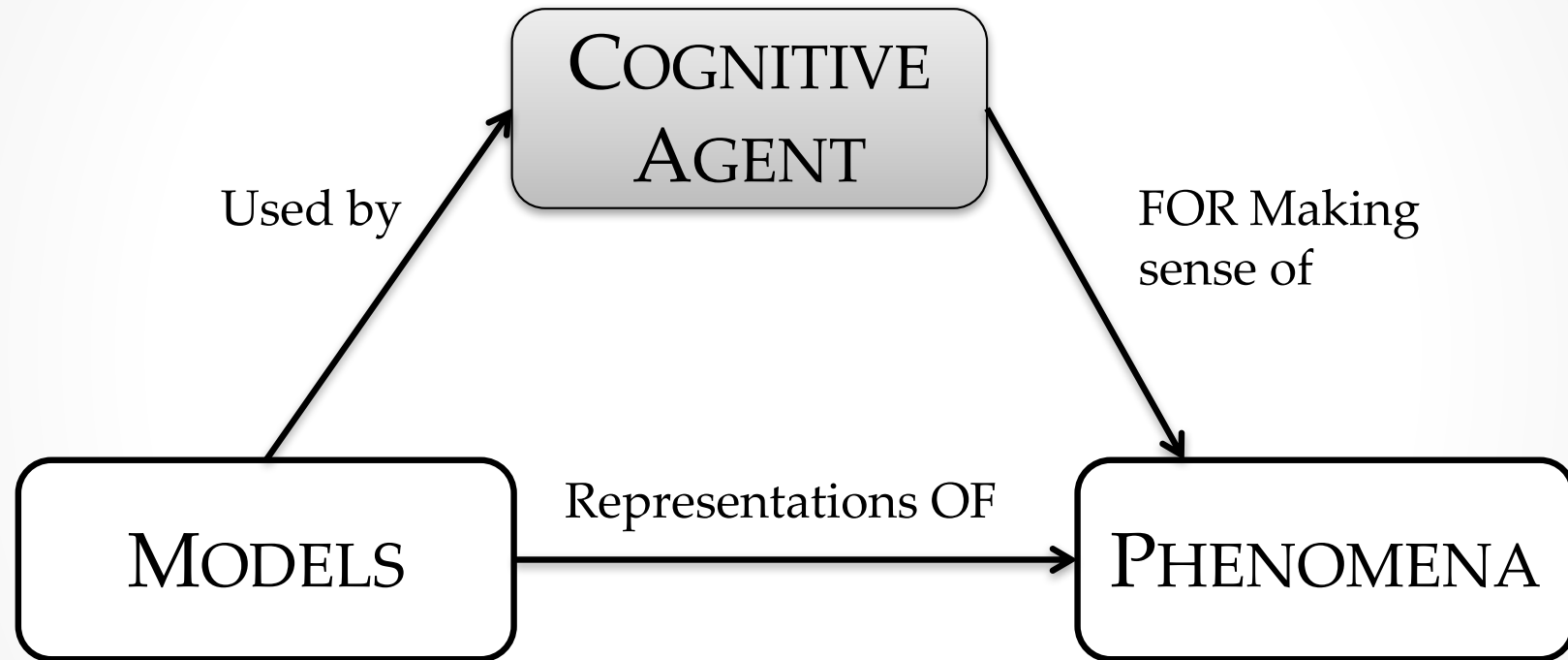
But this begs the question...

What is a Model?

Few terms are used in popular and scientific discourse more promiscuously than “model.”

- Goodman 1976, p.171, as cited in Odenbaugh 2009

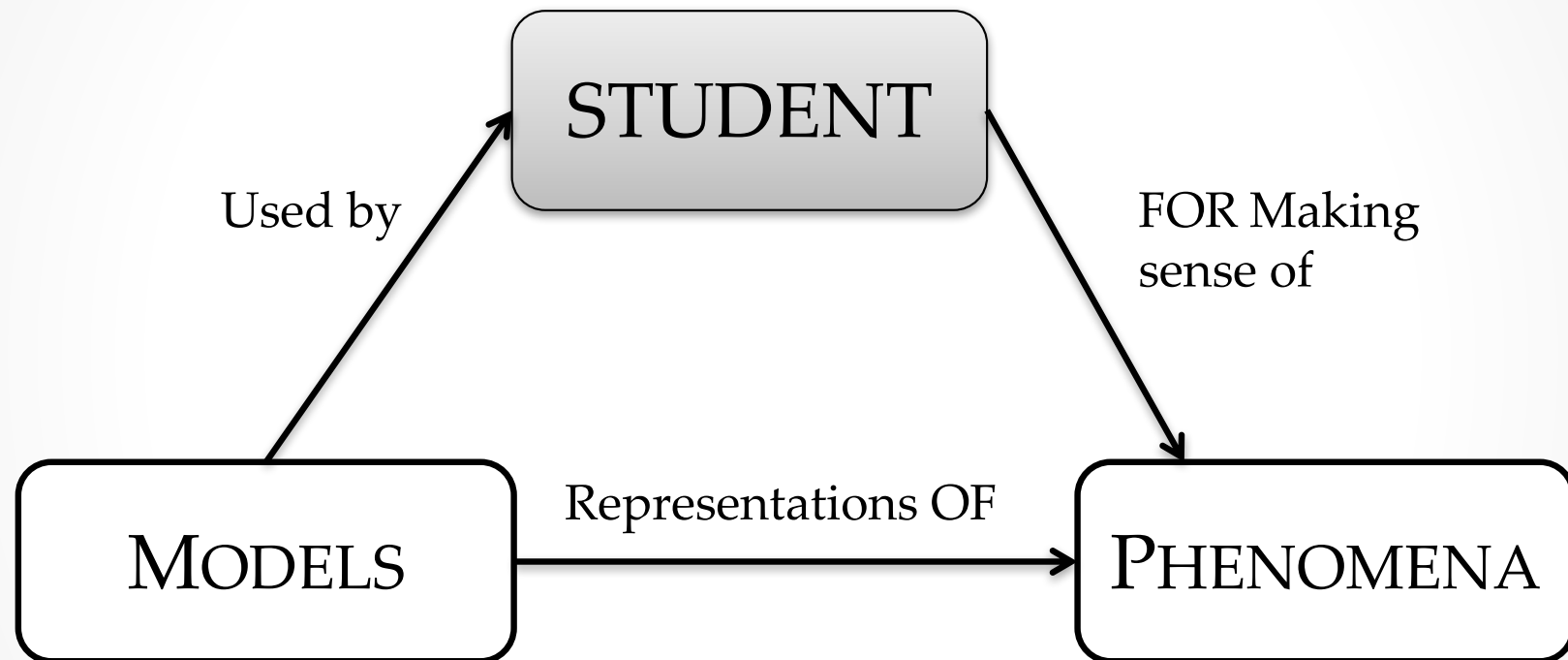
A Shift



Shift from Dyadic to Triadic (Knuuttila, 2005)

The OF/FOR Distinction

More Shift



Shift from Dyadic to Triadic (Knuuttila, 2005)

The OF/FOR Distinction

A shift in the instructional paradigm

Students are active (constructivist). *Use* models to help construct explanations of phenomena that make sense

Used by

STUDENT

FOR Making sense of

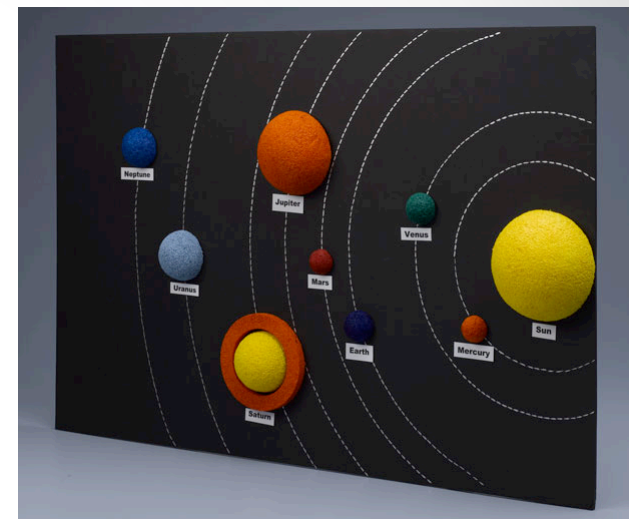
MODELS

Representations OF

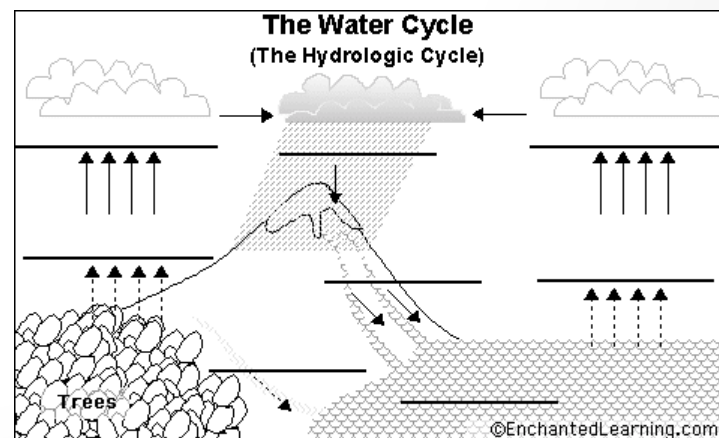
PHENOMENON

Students are passive (transmissionist). *Have* models “in their heads” that represent their understanding of target knowledge

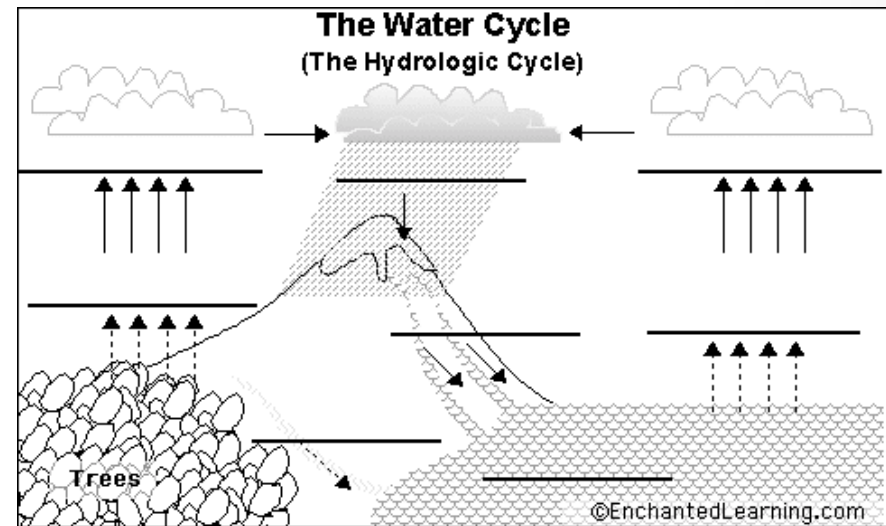
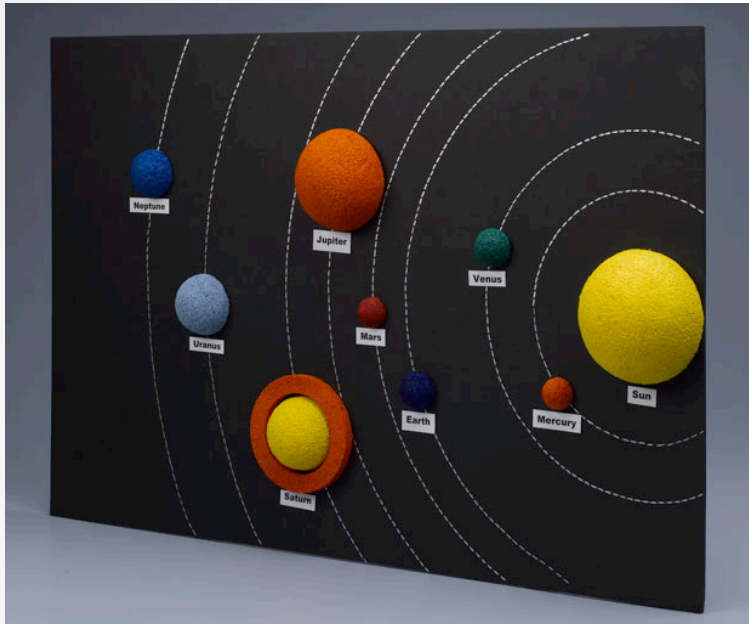
How 'MODELS FOR' helps us think about these?



$$\Delta E_{\text{thermal}} + \Delta E_{\text{bond}} = +Q$$



Try out '**MODELS FOR**' on these two
(hint: think about the PHENOMENA and QUESTIONS)



THINK...

How might the way we've been talking about models so far be different from how you've thought of models in the past?

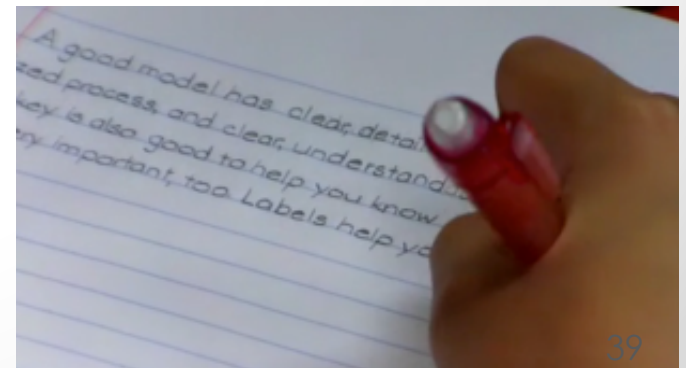
PAIR...

- With an elbow partner, share your thinking.

Why models?
Modeling as an
anchor practice

The Framework Says

“Models serve the purpose of being a tool for thinking with, making predictions and making sense of experience.” And further “scientists use models...to represent their current understanding of a system under study, to aid in the development of questions and explanations, and to communicate ideas to others.” (NRC, 2011,



DEVELOPING EXPLANATIONS

Models are revised and applied to “answer” or explain, predict, and solve

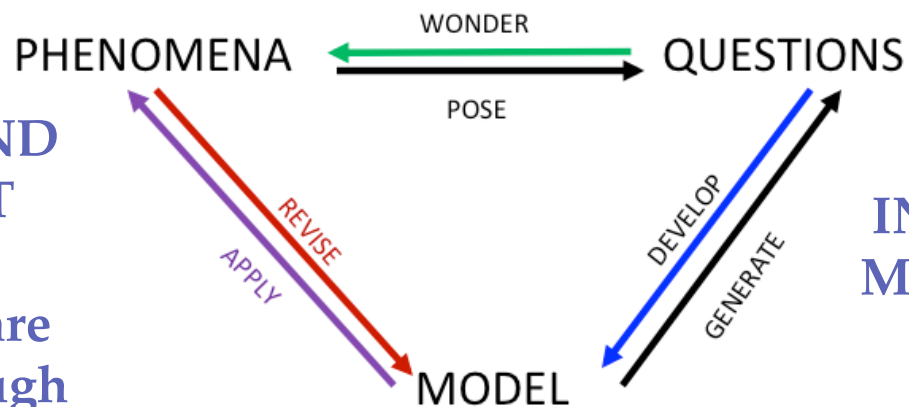
QUESTIONING
Models help identify questions and predict answers

ANALYZE AND INTERPRET DATA

And models are the filter through which data are interpreted

ARGUMENTATION

Argumentation is involved in both developing and evaluating models



INVESTIGATIONS
Models help point to empirical investigations

MATH AND COMP REASONING

We use mathematics to formulate some models and mathematical reasoning to evaluate models

COMMUNICATING & EVALUATING
Models hold and organize relevant information and become the focus of communicating ideas

Models and theories are the purpose and the outcomes of scientific practices. They are the tools for engineering design and problem solving. As such, modeling guides the other practices.

Why does all this really
matter?

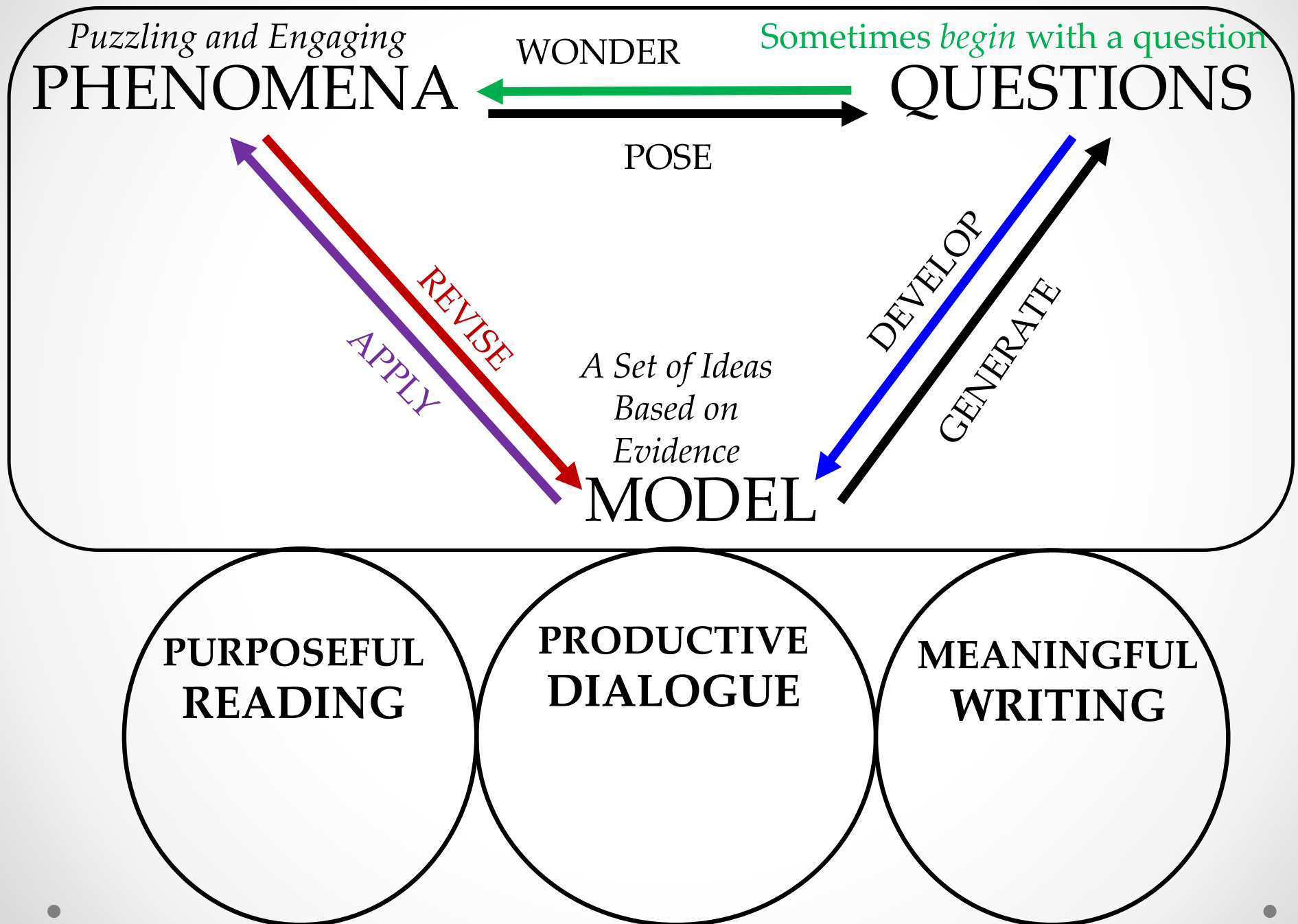
...



It is more important to pave the way for the child to *want to know* than to put him on a diet of facts he is not ready to assimilate.

-Rachel Carson

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Thank You

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Practices-resource.com