Modeling…It's All the Vogue!

Be a Modeling Teacher

(In the sense of NGSS, of Course)

Is this a model?

Why or why not? Write your first response on any scrap of paper.
(Don’t worry: This “quiz” doesn’t count.)

Or Is This a Model?

Get Ready to Catch!

One handed!

Your dominant hand!

How many fingers of your dominant hand were on water when you caught the globe?

Start with Your Preconceptions
Read the article

- Develop 3 single words terms for what a model is
- Think of concrete examples for the first three bullets on the second page.
- Look at the second bullet, top sidebar page 2. In what sense are "All models wrong?"
- Think of one modeling exercise you already do in your current classroom. Be prepared to share later in our day together.

Three definitions of models from *The Frameworks*

Models are representations developed to understand, communicate

Models explain and predict

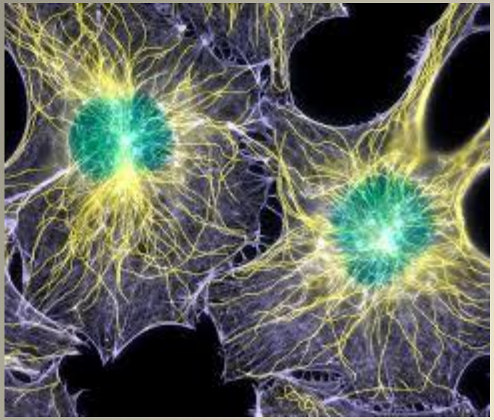
Models are created, refined and manipulated

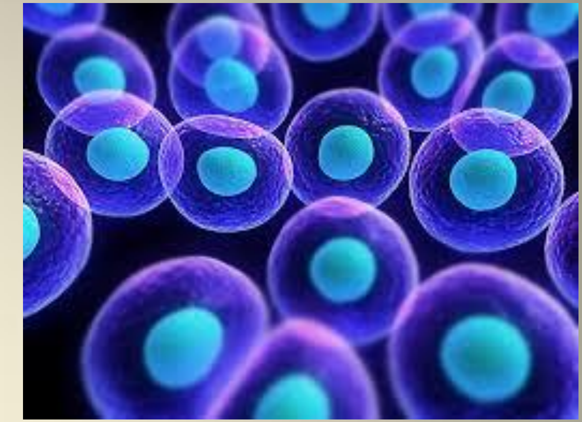
Models Explain

- More detail
- Different terms

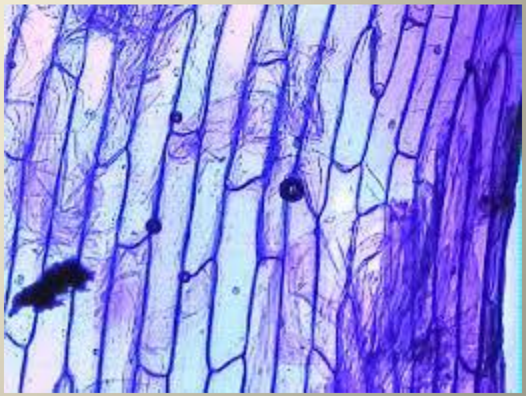
Models Predict

- Mathematical
- Representational



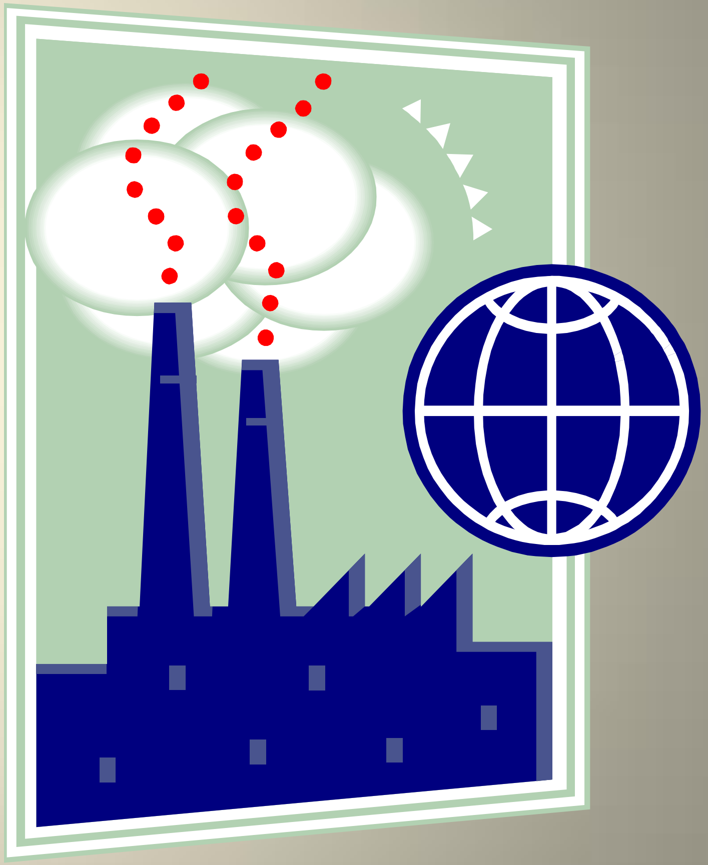


Does a jello "model" of a cell increase or reduce our understanding of cell structure and function?



Does a mathematical model of the extent of Earth's surface covered by water enable us to predict things like climate?

Hold that thought!



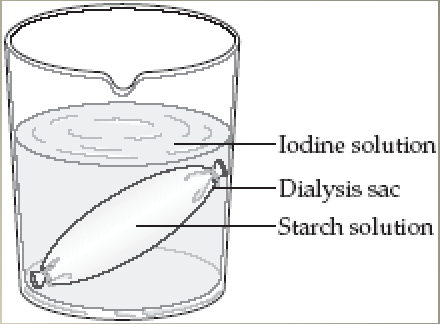
Back to the first question:

How might you model a cell?

Let’s model a cell again three ways.

For each procedure ask: Is this a model? Does it explain or predict? Why or why not?

Then go back to that first answer you gave. Would you change it?

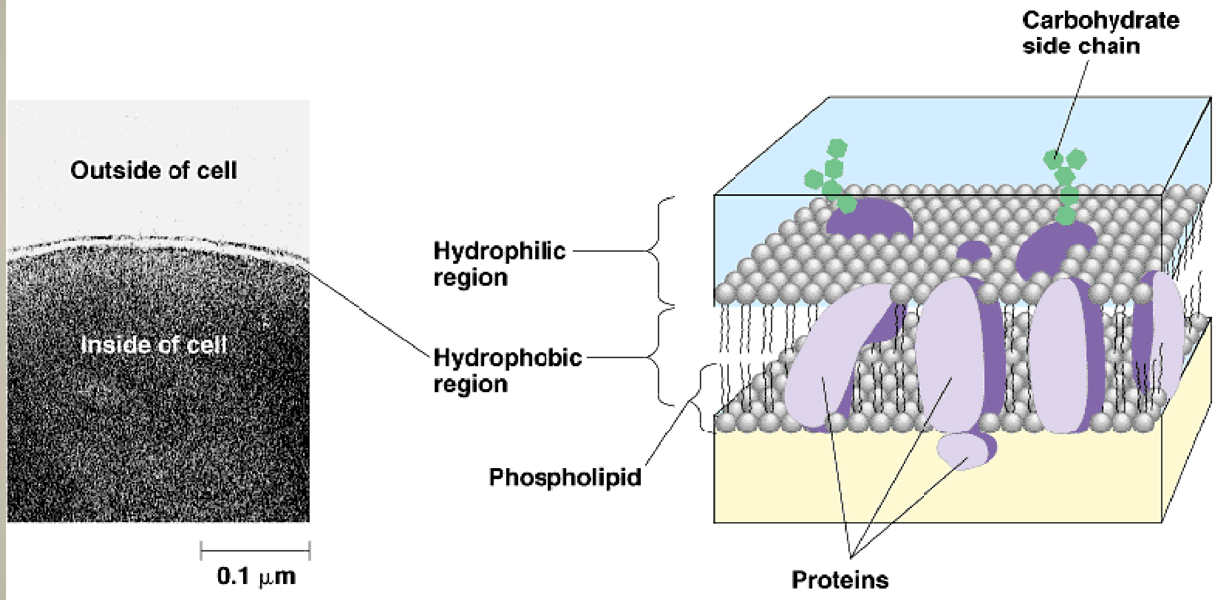


Activity #1:

Wet a piece of dialysis tubing. Tie it on the bottom. Make some “starch solution” by dissolving a peanut. Put it in your “model cell” and tie the top.

Now submerge your “model” in some iodine solution.

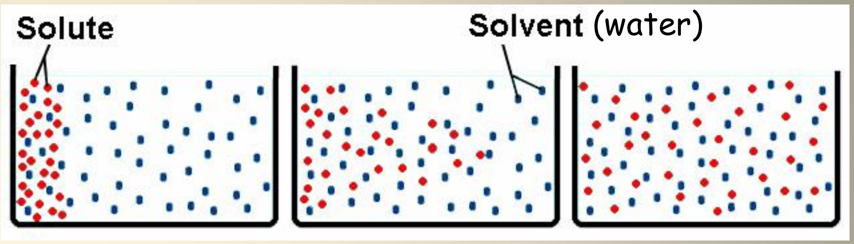
Dialysis tubing has the approximate pore size of a cell membrane.
What does this tell you about that structure? (Size)

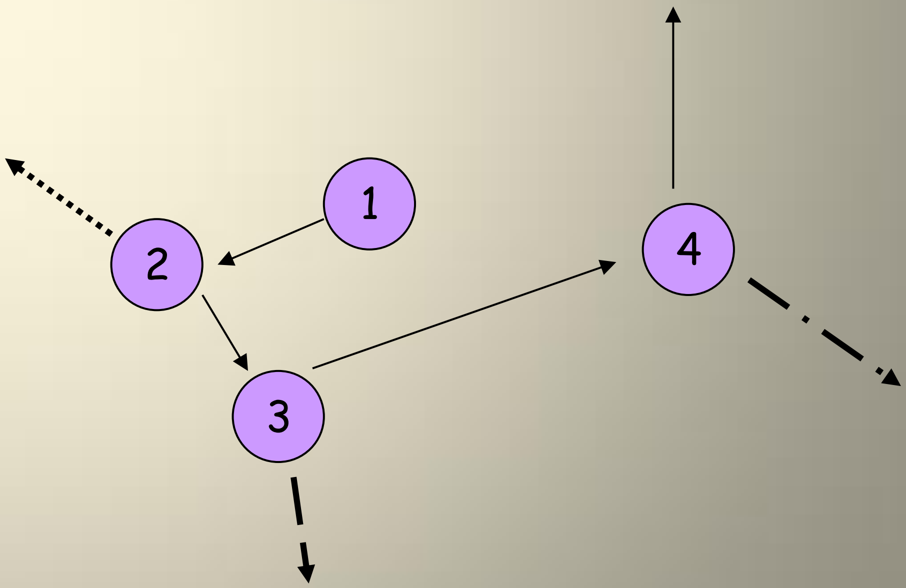

Carbohydrate side chain
Outside of cell
Hydrophilic region
Inside of cell
Hydrophobic region
Phospholipid
0.1 µm
Proteins

Diffusion

(Keep this thought—we'll talk about particles in the afternoon!)

- Solute molecules moving from an area of high concentration to an area of low concentration
  - Random motion drives diffusion
  - Movement is based on kinetic energy (speed), charge, and mass of molecules
  - Equilibrium is reached when there is an even distribution of solute molecules





Second Activity

Take a tiny bit of potato (or yeast) and immerse it in peroxide.

Observe!

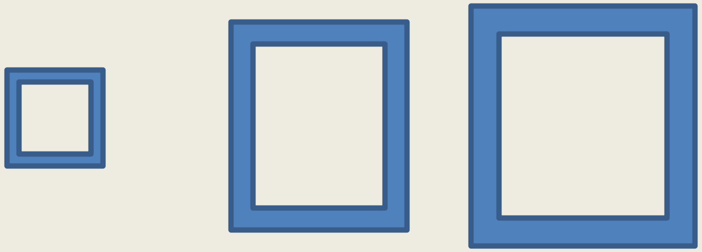
- How could the reaction be quantified?
- Is the reaction pH dependent?
- Is the reaction temperature dependent? (Keep this question in mind)
- What does the fact that it works in both potatoes and yeast tell us?
- Is this a model?

Another "oldie but goodie" experiment in modeling (which can be a bit messy)

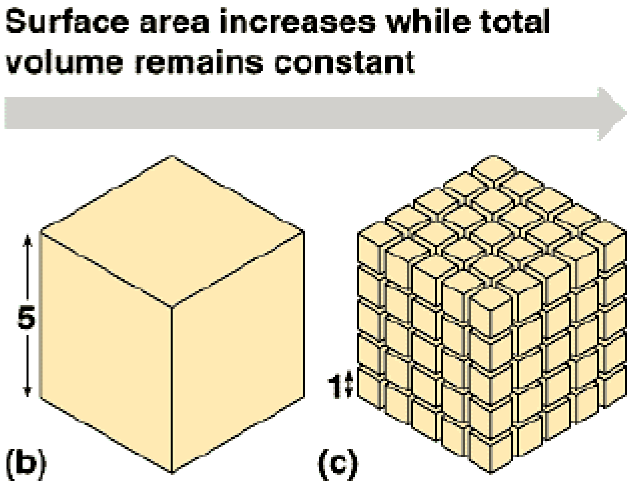
Cut 3 sizes of potato cubes.

Soak them each in iodine.

Calculate the surface area and volume of each cube, and the percent of the volume that "turned black" (was fed by the iodine.)



Why are most cells microscopic?



	(a)	(b)	(c)
Total surface area (height × width × number of sides × number of boxes)	6	150	750
Total volume (height × width × length × number of boxes)	1	125	125
Surface-area-to-volume ratio (area ÷ volume)	6	1.2	6

Why does an African elephant have bigger ears than an Indian elephant? Why does a Stegasaurus have a frill?

MODELS PREDICT

What properties of the cell have we modeled?

- Why do we model them one at a time?
- Look back at the article again:
  - Why are all models (especially in life science) always wrong in some way?
    - Use the dialysis tubing example; think of at least two ways in which it is wrong
  - In your group, generate other true modeling experiences for cells, appropriate for various grade levels
  - Find a performance expectation in NGSS that might be used (and watch assessment boundaries)

From the Frameworks:

Modeling=
Presenting information
(using labeled diagrams and text to present and explicate a model that describes and elucidates the process in question).

Why is a jello cell not a model but a potato bit probably so?

Performance Expectation

MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function. [Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.] [Assessment Boundary: Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.]

Performance Expectation

HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.] [Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.]

HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms

2.3 The Architecture of the *NGSS*

2.3.1 Essential Elements of the Foundation Boxes

In the picture below you can see the practices, disciplinary core ideas, and crosscutting concepts for the performance expectation you unpacked in the previous section. (The sections of text that refer to different performance expectations have been masked so we can continue focusing on this one.)

The three columns in the graphic are called the foundation boxes. This should appear familiar: you saw the same format in the interactive where you deconstructed a standard.

The foundation boxes provide a thorough unpack of each performance expectation by providing more detailed information about what each phrase means.

For example, in the performance expectation it states that students are to "develop a model to describe…" But describe what? Look at the blue column of the foundation box. This represents science and engineering practices. The foundation box tells us that the model should be used to describe, test, and predict more abstract phenomena. The phenomenon in this case is the flow of matter and energy in an ecosystem.

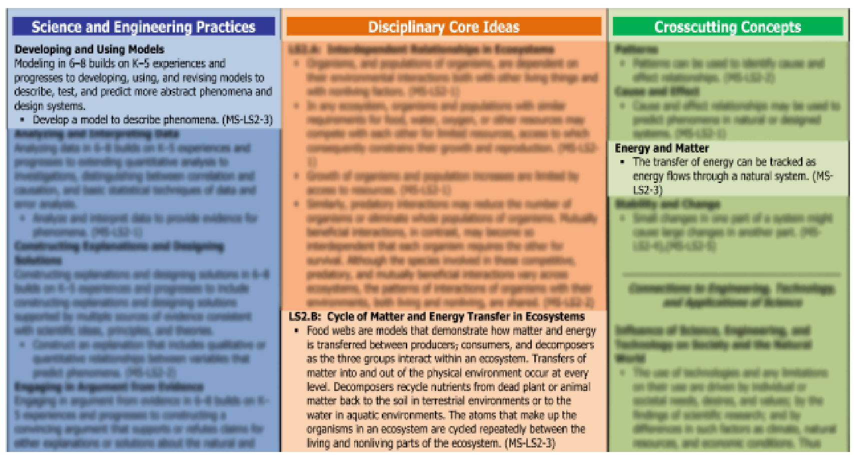


FIGURE 71 A foundation box highlighting the supporting information for performance expectation MS-LS2-3. Adapted from the *Next Generation Science Standards* ©2013 Achieve, Inc. on behalf of the 26 *NGSS* Lead States.

It may take an entire unit to prepare students to accomplish all of the pieces of a performance expectation. How will you figure out how to design daily lessons? The answer is in the color coded phrases on the previous page. Each of those phrases represents a segment of what students are expected to know and be able to do. The expanded explanations for each one are shown in the table below. It is important to remember that the specific combination of practice, core idea, and crosscutting concept in the performance expectation is for assessment. In planning instruction, we have far more freedom to mix and match. In fact, students will need to engage in multiple practices to develop an understanding of a core idea. Instruction will also provide multiple opportunities to make connections to crosscutting concepts. We can combine different practices with the given DCI to create a new **lesson-level learning performance** that will guide instruction for enabling students to meet the *NGSS* performance expectation.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe phenomena. (MS-LS2-3)	**LS2.B: Cycle of Matter and Energy Transfer in Ecosystems** • Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3) --- ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-LS2-3)

FIGURE 78 The foundations boxes for performance expectation MS-LS2-3. Adapted from the *Next Generation Science Standards.*

NGSS is very concerned with progressions. No more "Deal a Meal."

Kindergarten

- Pushes and pulls
- Movements can be measured

Second Grade

- Forces
- Measuring in standard units

Fourth Grade

- Opposing forces/balance/movement
- Representing measurements (arrows)

Consider how the unpacking process would work using an *NGSS* performance expectation.

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. (*NGSS* Lead States 2013)

First, identify the key concepts and skills.

The science and engineering practice is...

Check Your Thinking

The disciplinary core idea is...

Check Your Thinking

The crosscutting concept is...

Check Your Thinking

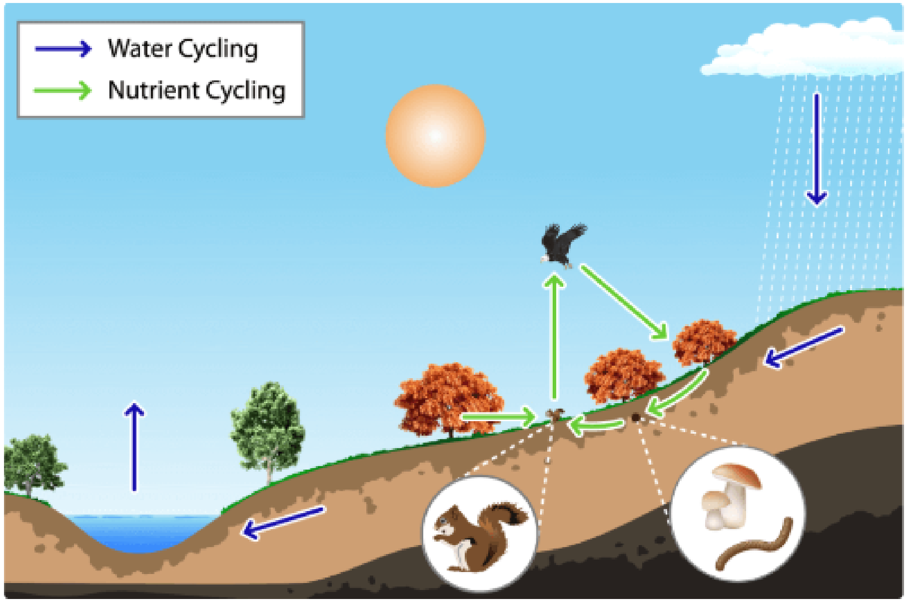


FIGURE 69 Here is an example model for the movement of matter between living (ex. squirrel, plants, eagle, mushroom) and nonliving (ex. soil, air, lake) parts of the ecosystem, allowing organisms to live, grow, and reproduce.

2.3.2 Using Performance Expectations

The *NGSS* already outline the required performances at the end of a grade level or grade band, but teachers may need to develop mini-performances for use on a day-to-day basis. Keep in mind that a single lesson will not meet an entire performance expectation; a series of lessons is needed for students to master the knowledge required for each performance expectation.

Let's look at an example, MS-LS2-3. Remember, each performance expectation is developed by combining a science or engineering practice (blue), disciplinary core idea (orange), and crosscutting concept (green).

Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

Take Notice!

FIGURE 77 By eating this grasshopper, the bearded dragon is transferring matter and energy from one organism to another.

Blowin' in the Wind

In Part II of our Modeling Adventure, we will explore the value of empty air…and how to build models about concepts across content areas from data and core ideas.

Buying a bus ticket for the kid

Performance Expectation

K-ESS3-1. Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live.

2-LS2-2. Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.*

Another variation

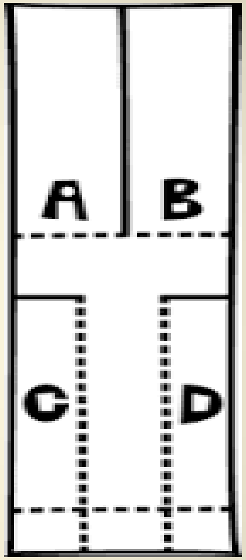
Cut and drop.

What is the design?

Identify the homologous parts?

Play with it a bit. Do some variations (as suggested by the paper directions.)

Compare size of paper clip, height of drop, and then if you want feather it out.



Performance Expectation:

1-LS1-1. Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.* [Clarification Statement: Examples of human problems that can be solved by mimicking plant or animal solutions could include designing clothing or equipment to protect bicyclists by mimicking turtle shells, acorn shells, and animal scales; stabilizing structures by mimicking animal tails and roots on plants; keeping out intruders by mimicking thorns on branches and animal quills; and, detecting intruders by mimicking eyes and ears.]

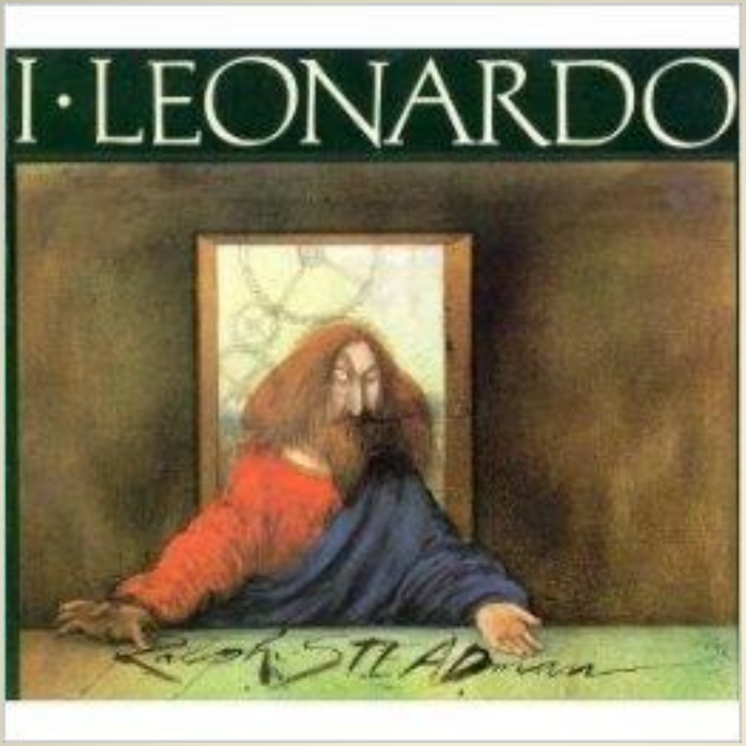
Is it STEM? Brainstorm all the Math, Science, Engineering and Technology links you might make.

Move into physical science:

Quick Probe: Can a helicopter glide like an airplane?

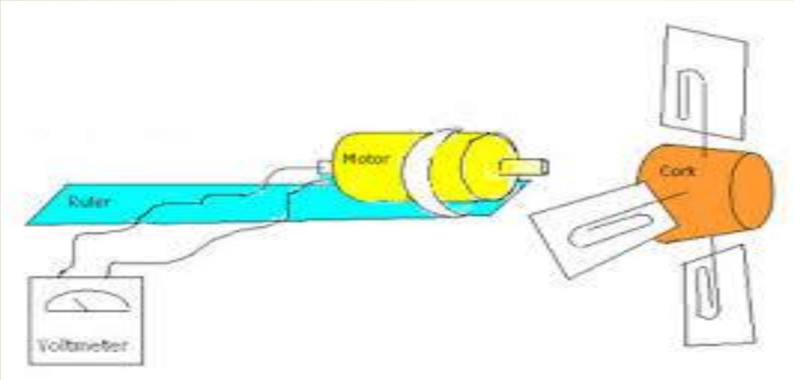
An airplane by its nature wants to fly. … A helicopter does not want to fly. It is maintained in the air by a variety of forces and controls working in opposition to each other, and if there is any disturbance in this delicate balance, the helicopter stops flying, immediately and disastrously. There is no such thing as a gliding helicopter.”

When the rotor blades start to spin, the air flowing over them produces lift, and this can cause the helicopter to rise into the air. So, the engine is used to turn the blades, and the turning blades produce the required lift. Very simple!



Many concepts and core ideas: One child. Another Lit Link to a STEM Book.

Engineering Challenge…a simple yet quantitative extension



Modeling over Time

(In which you get to be the model!)

1. Look in your package for two fossils. They are Devonian brachiopods, closely related. But one has “fins” and the other relatively dome-like.
   - Think of an environmental factor which might give one the advantage over the other
   - Think about modern situations where having this understanding might help biologists explain or predict.

Modeling Through Time

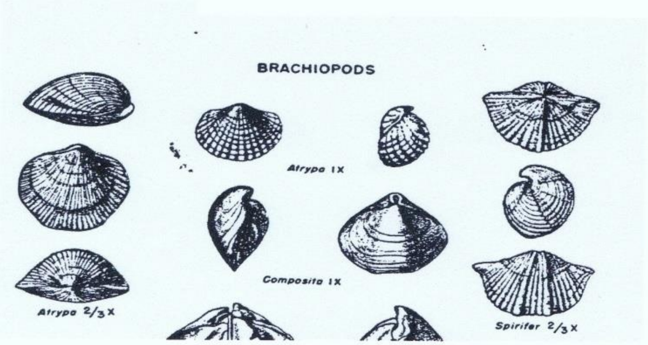
This time we'll begin with a middle school activity and then ask your group to scale it up and down in a developmentally appropriate way.

We'll start with two Devonian fossils:

They are both Brachiopods.

Look at Atrypa and Spirifer.

Describe their shape as carefully as you can. (The exact size doesn't matter as these were matched as closely as I could on a beach walk. Think of center of gravity, surface to volume ratio.)



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While the time periods in which they lived are about the same, there are certain strata in which one or the other predominates.

Think about their environment. (For purposes of comparison, their niche is approximately like a mussel.) How might the environment have differed over time for these animals?
____
____

What aspect of shape might be an advantage in different environments?________________
____
____

Develop a testable hypothesis that would explain which brachiopod had an advantage in which environment:____
____

How would you develop a model that could be tested?_______________________________
____
____
____

A quick simulation:

At a table, create two “environments” with bits of cloth.

- Spread a collection of “organisms” across one environment
- Have one participant *quickly* pick up five organisms. Record color.
- Respread and ask two other participants to quickly pick up five.
    - (Don’t overthink this!)
- Now repeat the experiment for another environment

I’ve given you a couple predators. Does the model that you are developing for prey apply to predators?

Now a model based on a true story! The story of Panama

Each group must find a place on the pavement outside.

Identify an Artist to draw North and South America at least 20 feet from the Arctic to the tip of Chile! (Hardest part of the day for most people.) Do not draw in the Isthmus of Panama right away. I put a little “cheat sheet” in your bag.

Distribute the role cards to various members of your group. The card will tell you whether you should start –North or South.

Now Panama! You can migrate.

BUT the principles of competition within Darwin’s model tells us that no two species with the same niche will exist in the same habitat for very long. So when you “meet” the organism with the same niche as you decide who dies off!

Please be back in 15 minutes with a report.

Performance Expectation

MS-LS4-2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. [Clarification Statement: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.]

MS-LS4-3. Analyze

Performance Expectations

MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.]

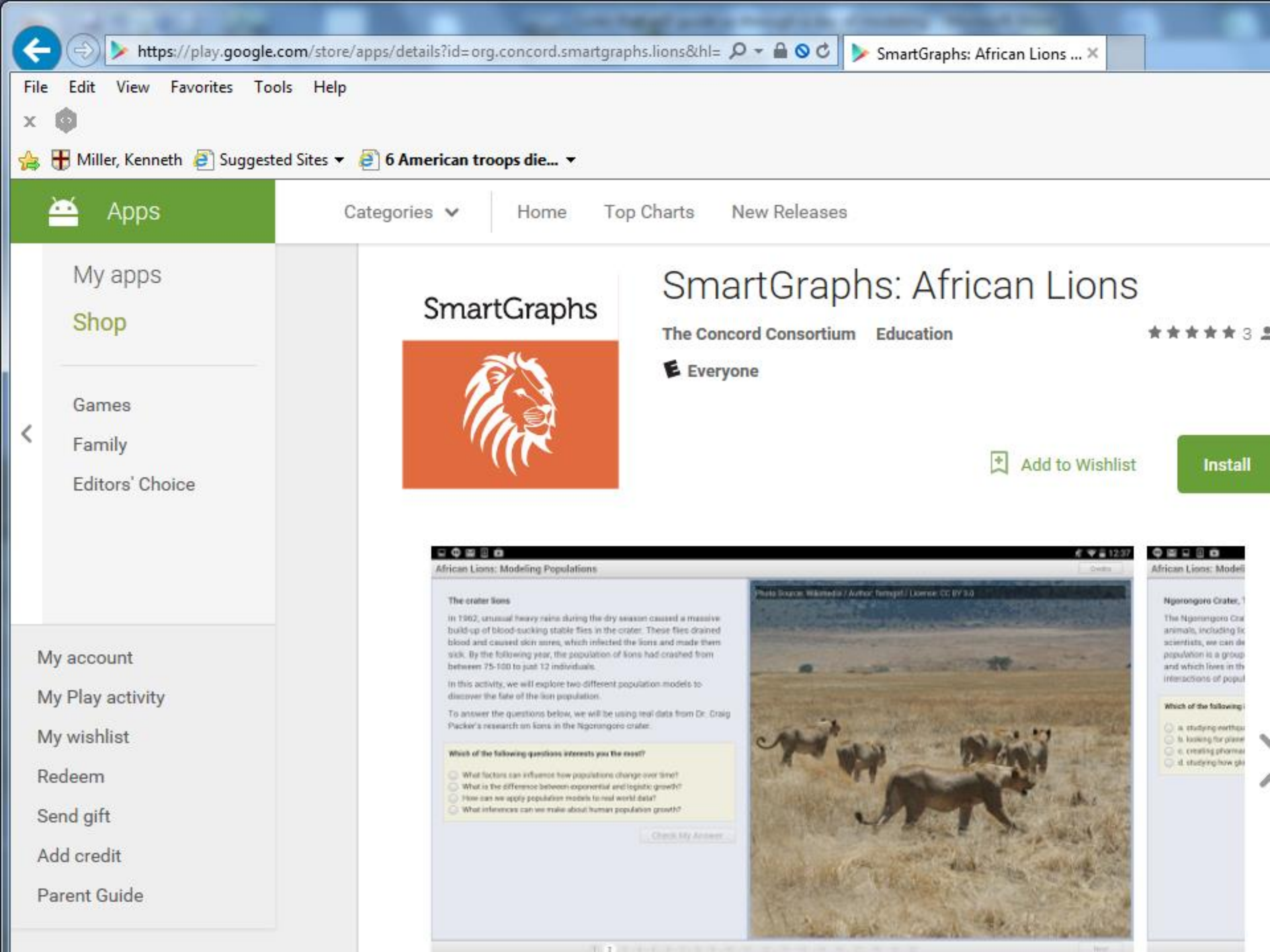
Performance Expectation

HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. [Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.] [Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.]

Always end (or begin!) with real world questions:

- Why do exotic species like kudzu or Florida iguanas take over so quickly?

- What will be the effect of climate change on migration and biodiversity?


https://play.google.com/store/apps/details?id=org.concord.smartgraphs.lions&hl=
SmartGraphs: African Lions ...
File
Edit
View
Favorites
Tools
Help
Miller, Kenneth
Suggested Sites
6 American troops die...
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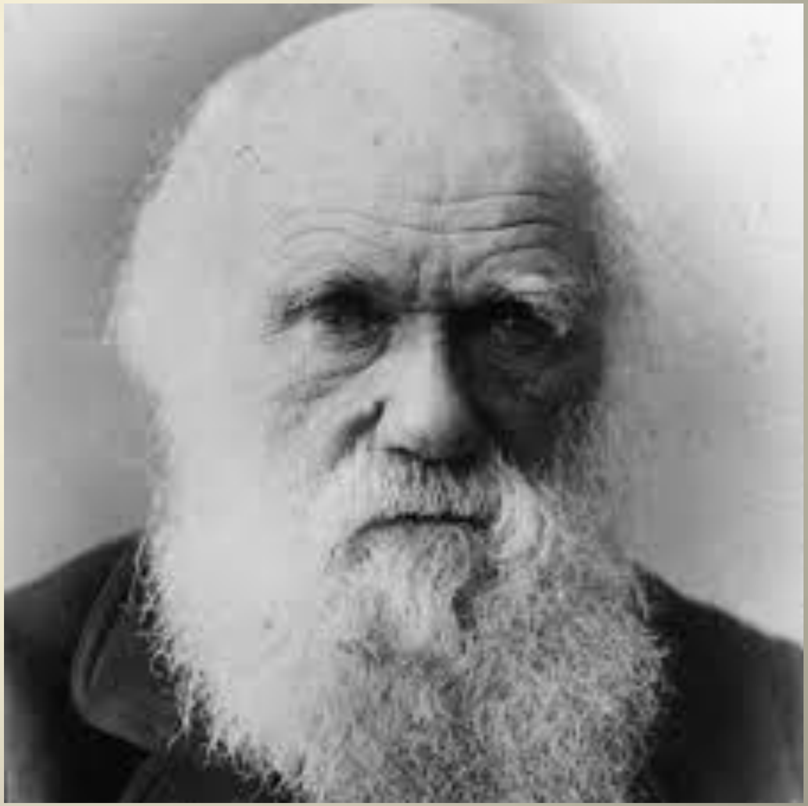
Top Charts
New Releases
My apps
Shop
Games
Family
Editors' Choice
My account
My Play activity
My wishlist
Redeem
Send gift
Add credit
Parent Guide
SmartGraphs
SmartGraphs: African Lions
The Concord Consortium
Education
Everyone
Add to Wishlist
Install
African Lions: Modeling Populations
The crater lions
In 1962, unusual heavy rains during the dry season caused a massive build-up of blood-sucking stable flies in the crater. These flies drained blood and caused skin sores, which infected the lions and made them sick. By the following year, the population of lions had crashed from between 75-100 to just 12 individuals.
In this activity, we will explore two different population models to discover the fate of the lion population.
To answer the questions below, we will be using real data from Dr. Craig Packer's research on lions in the Ngorongoro crater.
Which of the following questions interests you the most?
What factors can influence how populations change over time?
What is the difference between exponential and logistic growth?
How can we apply population models to real world data?
What inferences can we make about human population growth?

The Modelers…and a caution!

Mostly wrong…but a good model

Mostly right…but being revised



Part III: The Solution to Models of Particles

In which we explore seemingly separate phenomena and then establish the crosscutting concepts to build a model that can be used to both understand and predict.

Compare two particles

- Take the two sand samples. Put them in a bottle of water.
- How can you compare them?
- What properties can you model?

Dump the sandy water outside, please

- Take two “bead” samples.
- Compare them in water, again.
- What can you say about these particles compared to sand particles?

Use what you have learned

Compose an explanation of what you see based on your examination of particles!

A Preschool Activity?

This is a very simple preschool activity.

Can each member of your group describe it in terms that are developmentally appropriate?

(Define 3 sets of terms that might be used, at 3 levels, to describe what you are seeing.)

What measurement technique should be used at each level?

Repeat with warm water and describe the difference using the same language.

Another variation

Again, a simple activity.

Try the activity in cool and warm water.

Can you generalize from the two simple experiences?

Is there any similarity between phenomenon #1 and phenomenon #2?

- Gathering
- Reasoning
- Communicating

5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen. [Clarification Statement: Examples of evidence could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.]

MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures. [Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.] [Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete depiction of all individual atoms in a complex molecule or extended structure.]

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields. [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

Think Back to the Peroxide/Potato Activity

Are there similarities?
What can you conclude?

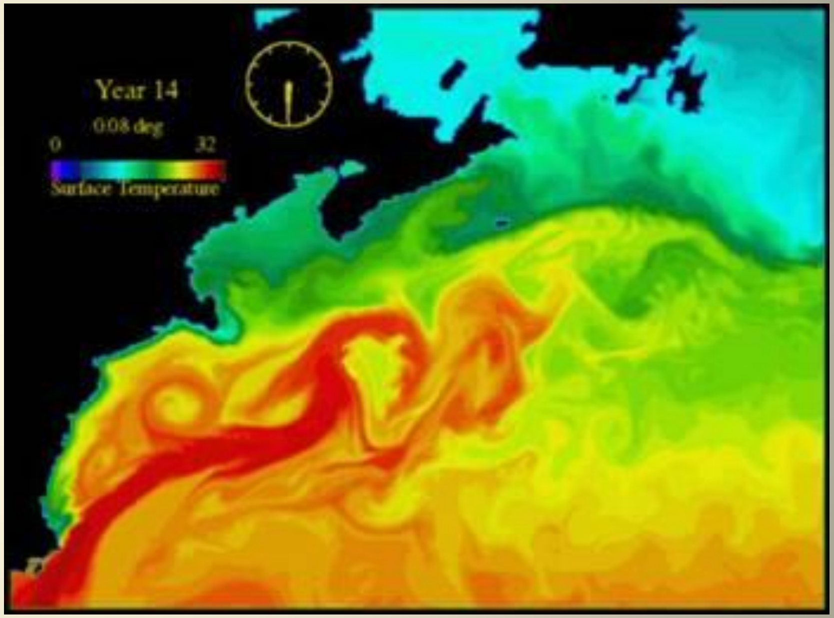
Variation! Break time…

Try the M&M activity but make the water acidic.

Cross Cut!

You developed a model for solutions.

Is there something in the phenomenon we just looked at that could be predicted or explained by the same model?



Ask Children to Model their Own Ideas

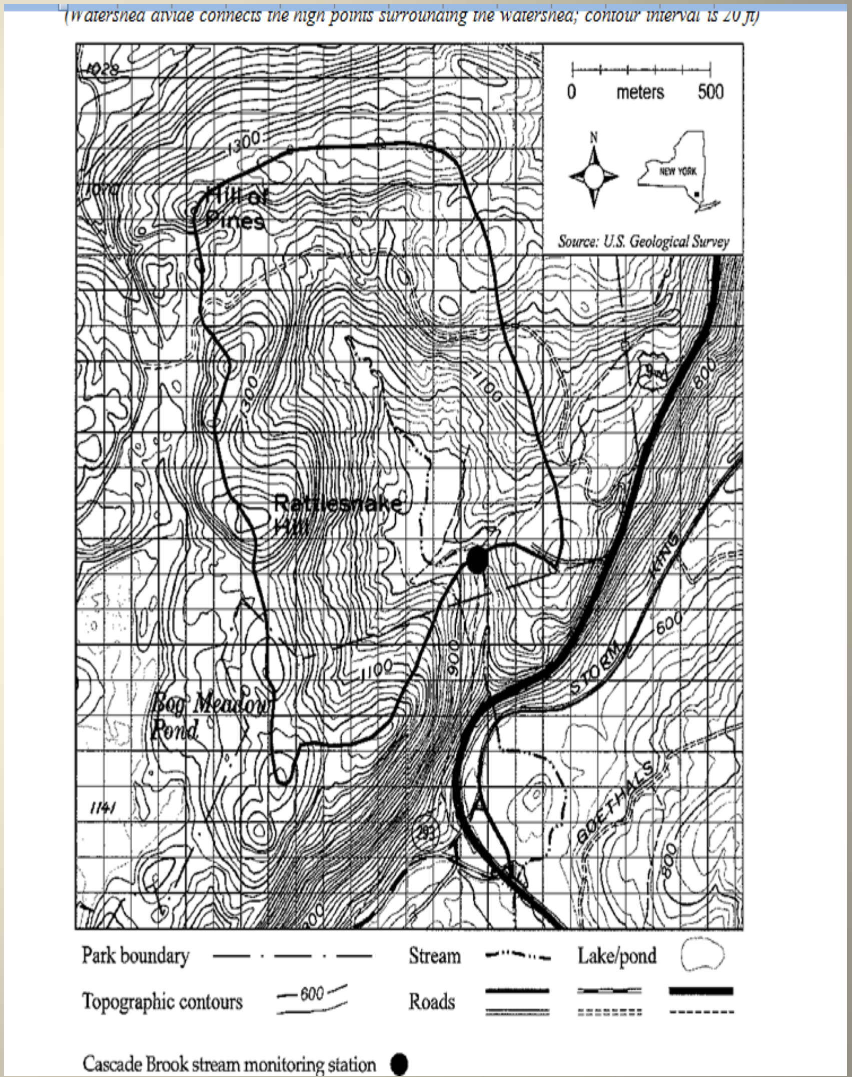
Erosion and Water Flow

- Physical modeling
- NGSS Model a watershed
  - Represent a physical model
  - Use your representation to calculate the amount of water that will pass the monitoring station

Why does it always get muddy on the playground?

Age appropriate modeling and measurement

The NGSS Website has outstanding activities on modeling with real-world connections.



Physical Science Modeling Is the Easiest of All

Let’s take a side trip to Concord Consortium:

A Final Model—this one for upper level physical science

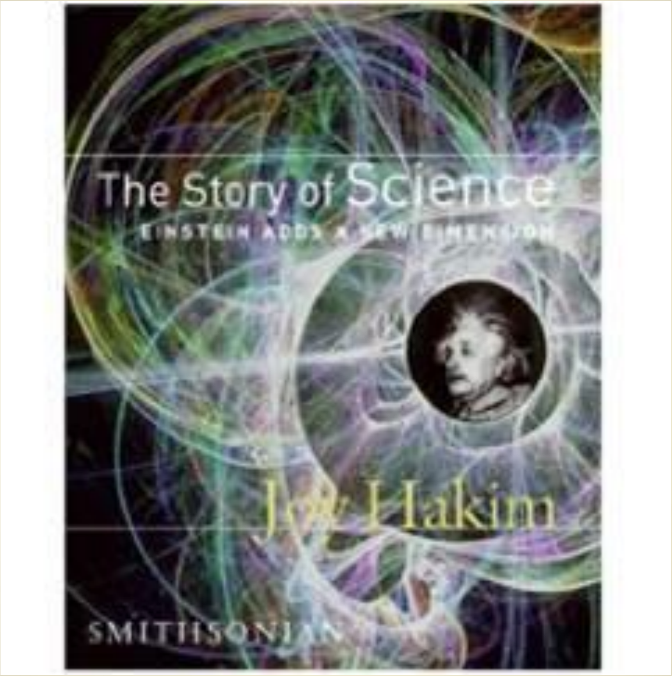
(I need another artist to draw a grid of 36 meter squares)

36 volunteer "atoms" each get a note card. If you are a "heavy" atom there will be a red dot on your card. Stand in a box and hold your hands out.

I'm the "bullet." I am going to walk through the grid. If I touch you and you are "red" spin and shout "bang". If you touch another "red" that atom also spins and shouts "bang."

I will redistribute cards 3 times and we'll repeat the simulation each time.

Integrate with a Great STEM Book to make such a model meaningful



OK, OK…why did we do something so silly?

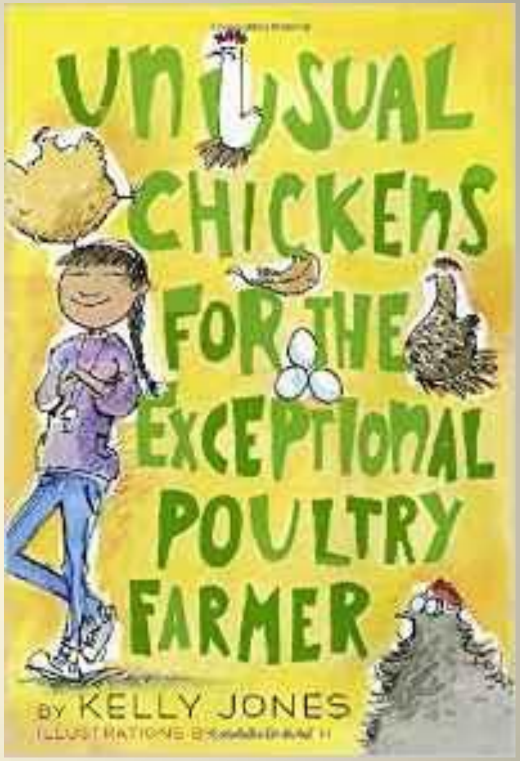
(Because it is May and your entire class has classroom fever!)

Because the concentration of heavy atoms determines whether a substance can sustain a nuclear reaction.

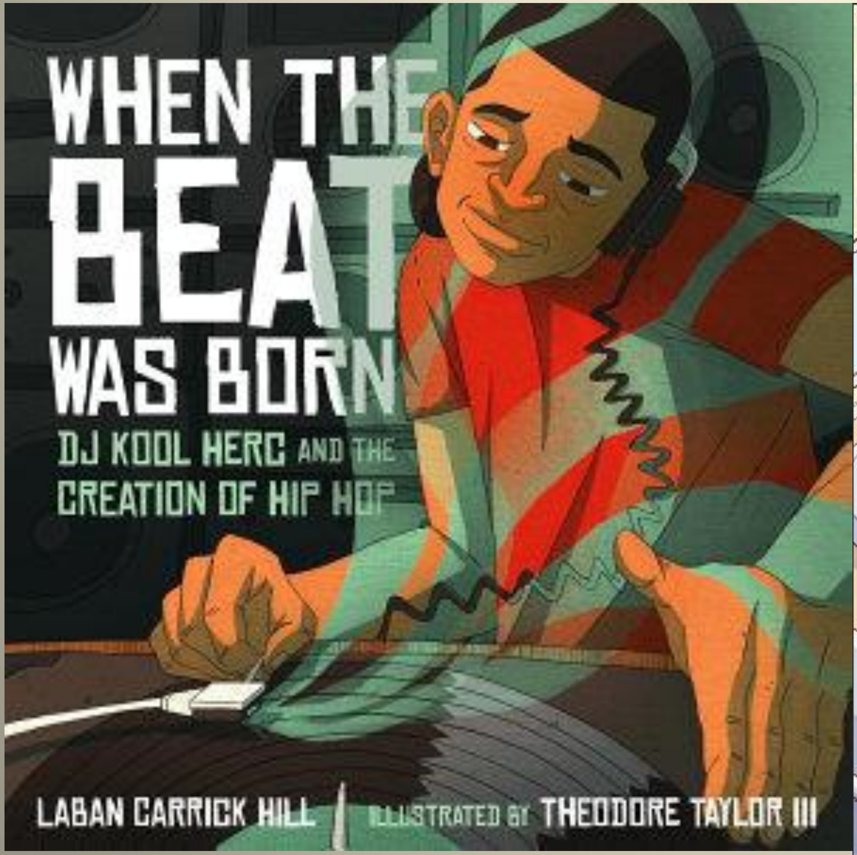
Because the number of centrifuges in Iran matters.

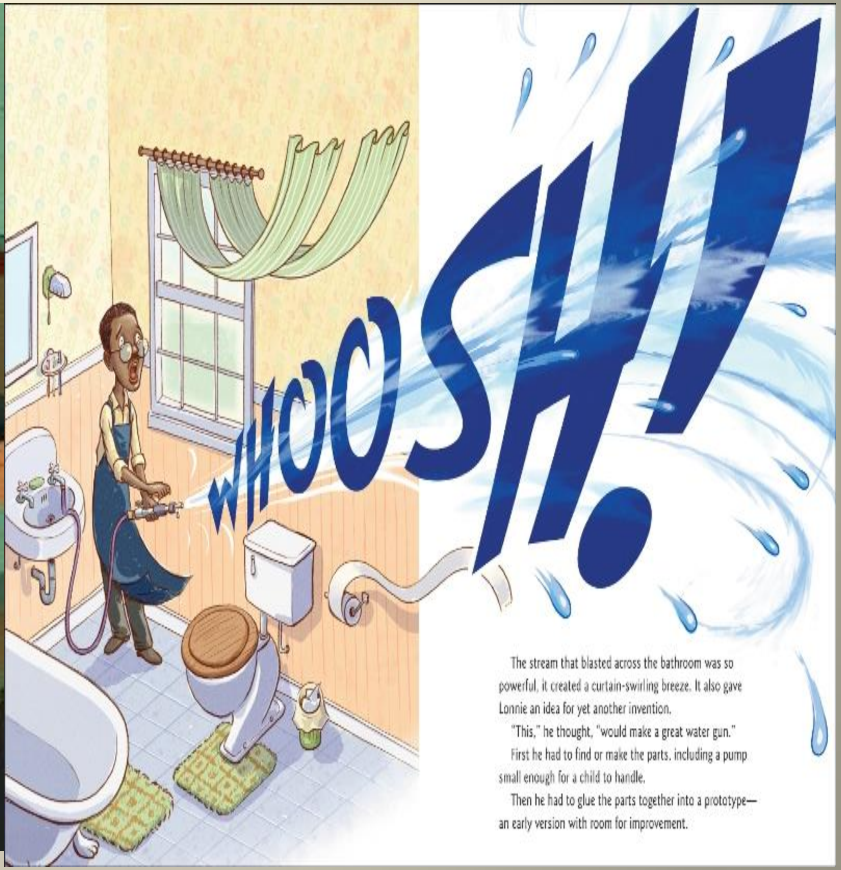
Because it ‘s a MODEL.

We Motivate Students by Connecting Their Questions to the Skills they Need to Answer Them

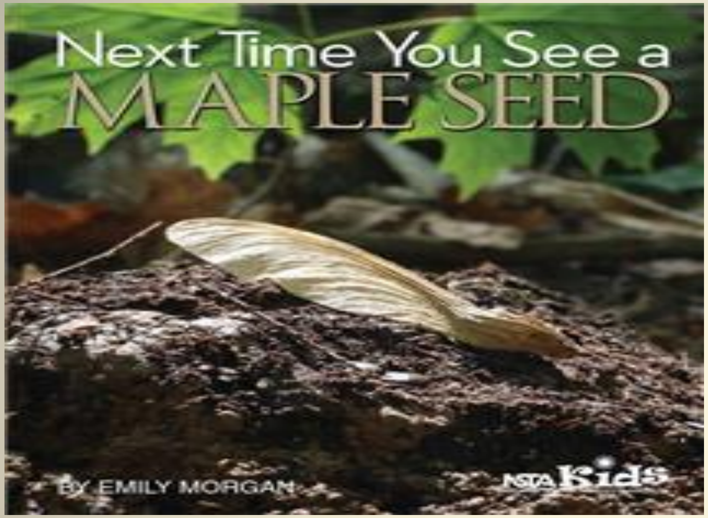


Connect with books about *their* phenomena to encourage modeling





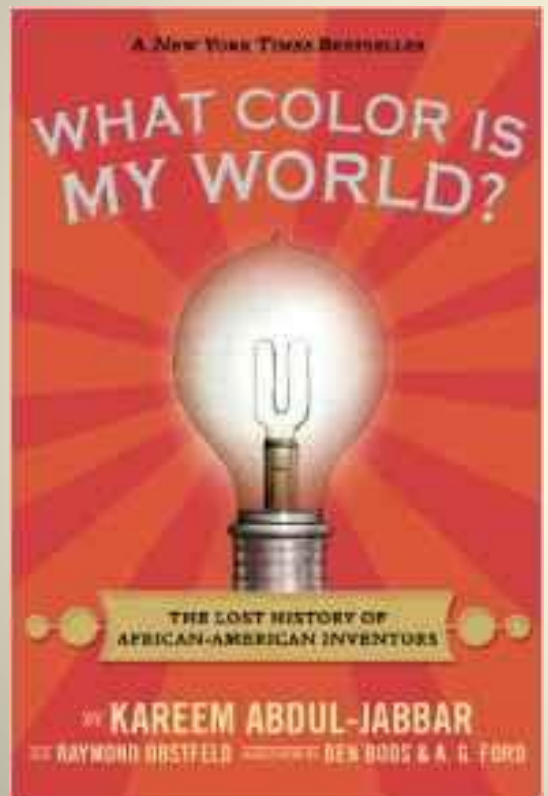
Books Can Teach Us to Communicate

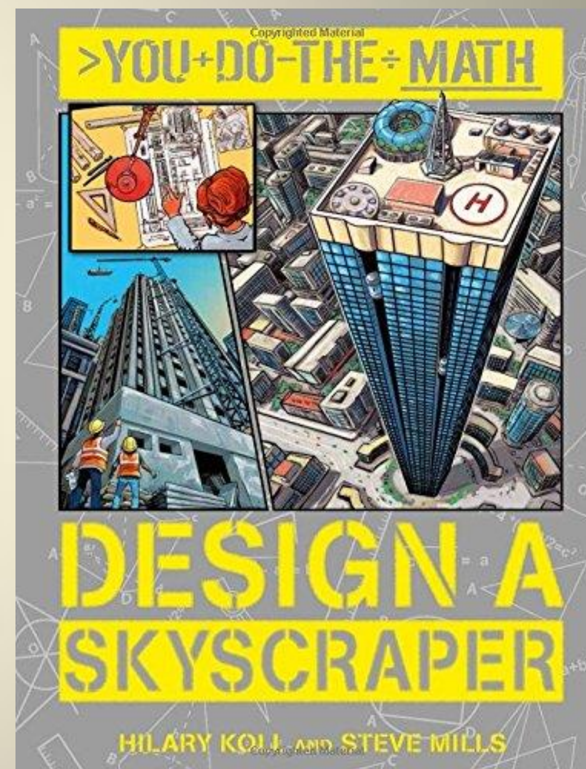


The association of language arts mainly with fiction and poetry is an <u>accident of recent intellectual history</u> that is not inherent in the nature of things….The substantive topics in literature, history, the arts, and the sciences that literate Americans take for granted are deeply interesting and highly engaging to children.

E.D. Hirsch, Jr., *The Knowledge Deficit*
New York: Houghton Mifflin, 2006, pp. 78-79

We inspire inventors by showing them that models can be used to predict and invent.





Another thought break:

Stephen Gilbert's book on models is a bit "pre-NGSS" but he has important things to say, not only about the practice but about the way we think about models both within and outside of scientific practice.

STOM's Got Talent

Your turn…

What is your favorite modeling experience?

In your group, each describe one.

Then vote: Pick one that you would like to elaborate on and make more three-dimensional. (Any grade level you'd like.)

Be prepared to discuss in ___ minutes.