

The US Next Generation Science Standards and their Implications for the Teaching of Science

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June 2, 2015

2012 PISA Results

Mean score	Comparison country/ economy
580	Shanghai-China
555	Hong Kong-China
551	Singapore
547	Japan
545	Finland
541	Estonia
538	Korea
528	Viet Nam
526	Poland
525	Canada
525	Liechtenstein
524	Germany
523	Chinese Taipei
522	Netherlands
522	Ireland
521	Australia
521	Macao-China
516	New Zealand
515	Switzerland
514	Slovenia
514	United Kingdom
508	Czech Republic
506	Austria
505	Belgium
502	Latvia
499	France
498	Denmark
497	United States
497	Portugal



Main Points

1. Why new standards?
2. What are the new standards?
3. What are the implications for the teaching of science?

NATIONAL

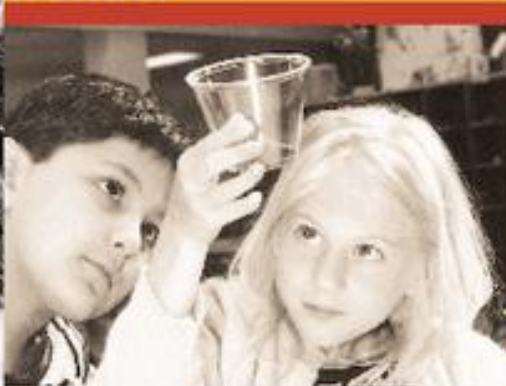
SCIENCE EDUCATION

STANDARDS

understand



wonder



assess



interact



encourage

explore

NATIONAL RESEARCH COUNCIL

The Trouble with Inquiry?

When engaging in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations.

“...nothing could be more stultifying, and, perhaps more important, nothing is further from the procedure of the scientist than a rigorous tabular progression through the supposed ‘steps’ of the scientific method

– *General Education in a Free Society, 1945*



Presidents Science Advisory Committee, ca. 1958

and the abstract. It would seem to me better to begin with a rabbit sitting under a raspberry bush or something of that sort, and perhaps end with an excursus into the nature and philosophy of science. I wonder if the fellows who teach biology in our country really believe the crap about "scientific method" with which they uniformly start their textbooks.

I hope to hell to get my present book ("The Prevalence of People") off to Scribners by June 15th. I am spending most of the summer at the Hopkins Marine Station -- I believe Prosser is their visitor for the first half of the summer, me for the second -- and I hope to spend most of my time there writing up last summer's work in the Pacific. It might also be a good chance to collect ideas about the aspects of marine biology that should go in a text. The decks should thus be fairly clear by next fall. When I was in New York the other day, I warned Scribners that I might be ratting on them for long enough to write a textbook, which they took with good grace. So I seem to be clear there too. I

I do hope we can manage at least to explore the possibilities of this project of Joe's.

With all the best,

Sincerely,

Marston Bates

Marston Bates

Sincerely,

Marston Bates

of this biology of Joe's

Phenomena

Do it

Ideas

Crazy Ideas in Science

- Day and Night is caused by a Spinning Earth
- The Continents have moved
- We have evolved from other animals
- The Earth is 5 billion years old
- Diseases are caused by tiny living organisms
- We live at the bottom of a sea of air
- You look like your parents because every cell carries a chemically coded message of how to reproduce yourself

History of Science as a History of Error

- Ptolemy's geocentric universe,
- Lamarkianism
- The ether,
- The Denial of Wegner/s Theory
- Cold fusion
- Phlogiston
- Spontaneous generation,

Higher Order Thinking

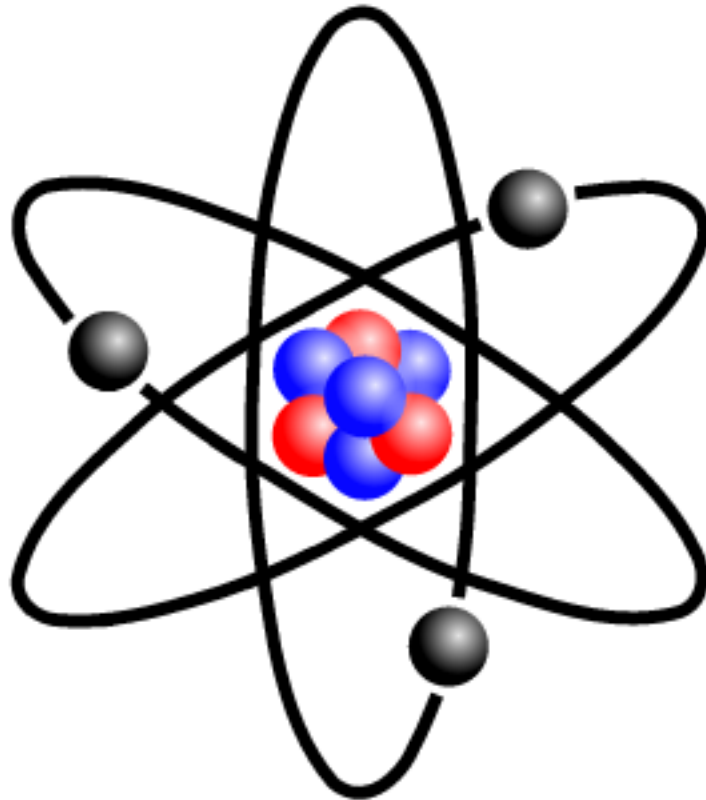
Recall of Information

Producing an Explanation

CONSTRUCTION

WHERE IS THE CRITIQUE & EVALUATION?

Critique: Identify 3 Flaws with this Model



Catching the Knowledge Wave?

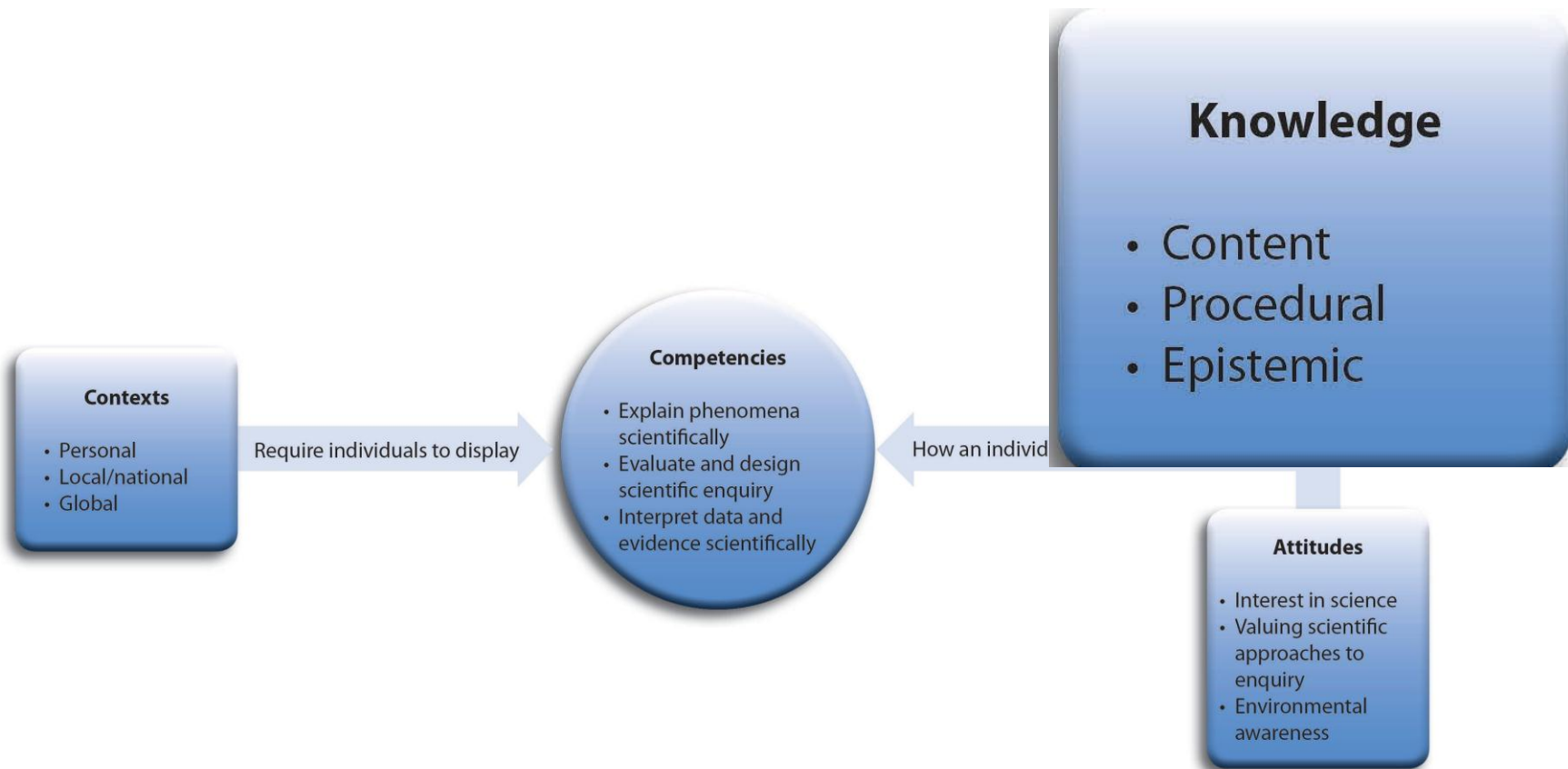
The Knowledge Society and the future of education

Jane Gilbert

In a world where there is an oversupply of information, the ability to make sense of information is now the scarce resource.

Given this, we should be presenting knowledge to students not as something monolithic, fixed and finished, but as something organic, something that is always developing, and always in process.

PISA 2015 Scientific Literacy Framework



Elaboration of the Definition

A scientifically literate person, therefore, is willing to engage in reasoned discourse about science and technology which requires the competencies to:

- **Explain phenomena scientifically:**
- **Evaluate and design scientific enquiry:**
- **Interpret data and evidence scientifically:**

COMMON CORE STATE STANDARDS FOR

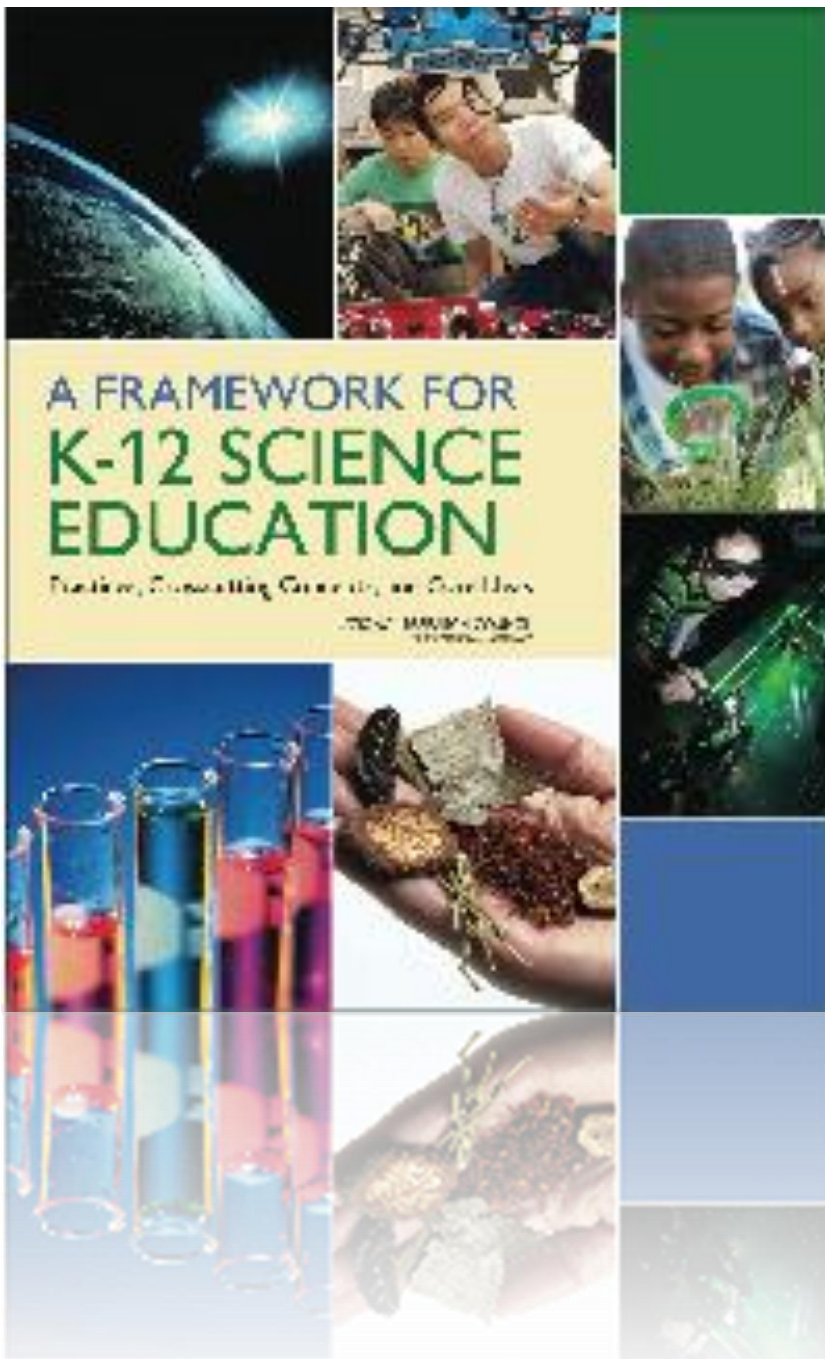
Mathematics



COMMON CORE STATE STANDARDS FOR

English Language Arts
&
Literacy in History/Social Studies,
Science, and Technical Subjects



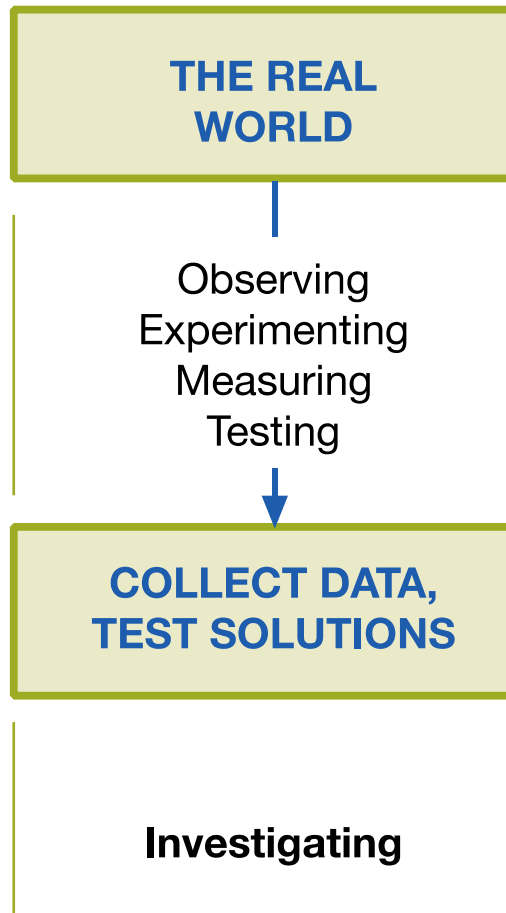


A FRAMEWORK FOR
**K-12 SCIENCE
EDUCATION**

Practices, Crosscutting Concepts, and Core Ideas

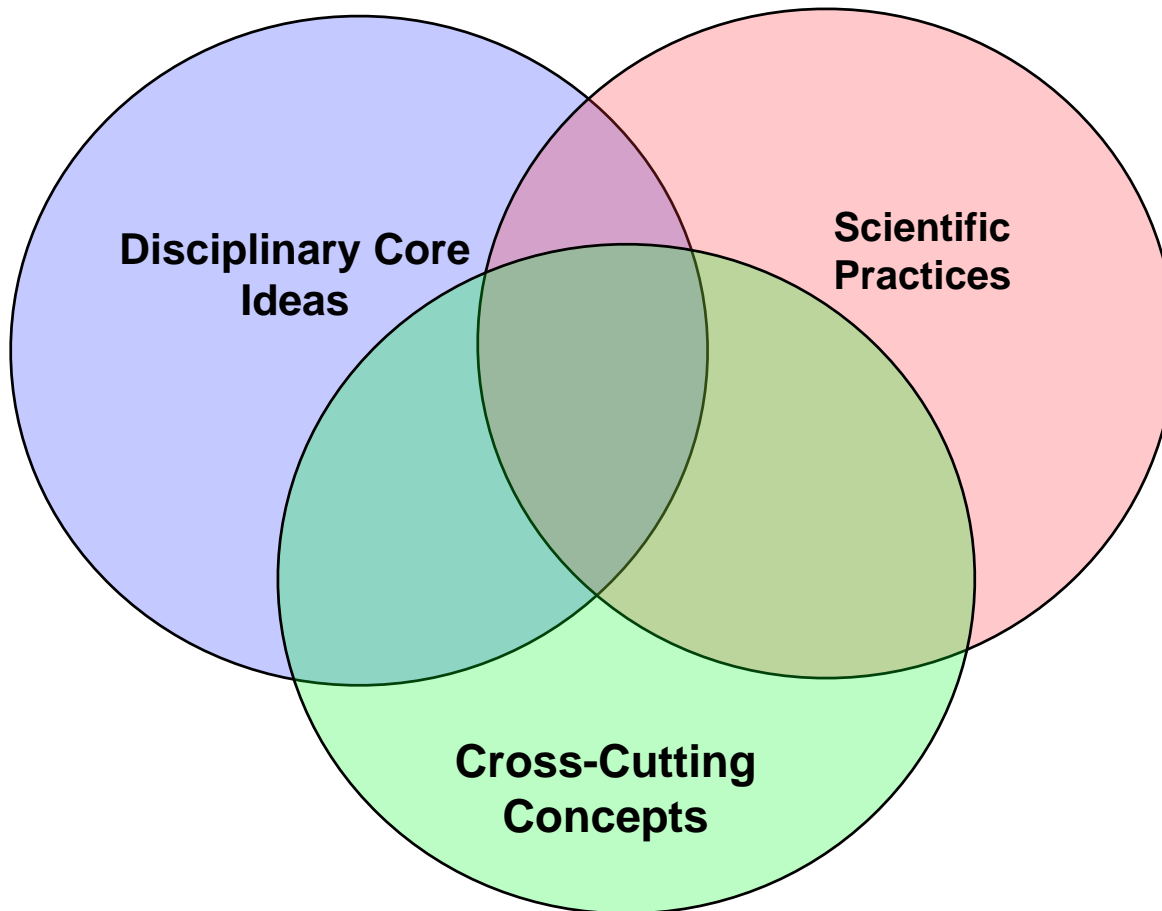
NATIONAL RESEARCH
COUNCIL ON SCIENCE AND EDUCATION

A Model for Scientific Practices?





The Components



Science as a Set of 8 Practices

1. Asking Questions & Defining Problems
2. Developing and Using Models
3. Planning and Carrying out Investigations
4. Analyzing and Interpreting Data
5. Using Mathematical and Computational Thinking
6. Constructing Explanations & Designing Solutions
7. Engaging in Argument from Evidence
8. Obtaining, Evaluating and Communicating Information

Cross-Cutting Concepts

1. Patterns
2. Cause and effect: Mechanism and explanation
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter: Flows, cycles, and conservation
6. Structure and function
7. Stability and change



NEXT GENERATION
SCIENCE
STANDARDS



Outcomes are *Performance* Expectations

Students who demonstrate understanding can

- Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
- Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

Students who demonstrate understanding can:

- 4-PS4-2.** **Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.** *[Assessment Boundary: Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works.]*
- 4-LS1-1.** **Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.** *[Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin.] [Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.]*
- 4-LS1-2.** **Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.** *[Clarification Statement: Emphasis is on systems of information transfer.] [Assessment Boundary: Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.]*

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.

- Develop a model to describe phenomena. (4-PS4-2)
- Use a model to test interactions concerning the functioning of a natural system. (4-LS1-2)

Engaging in Argument from Evidence

Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).

- Construct an argument with evidence, data, and/or a model. (4-LS1-1)

Disciplinary Core Ideas

PS4.B: Electromagnetic Radiation

- An object can be seen when light reflected from its surface enters the eyes. (4-PS4-2)

LS1.A: Structure and Function

- Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (4-LS1-1)

LS1.D: Information Processing

- Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions. (4-LS1-2)

Crosscutting Concepts

Cause and Effect

- Cause and effect relationships are routinely identified. (4-PS4-2)

Systems and System Models

- A system can be described in terms of its components and their interactions. (4-LS1-1), (4-LS1-2)

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-levels:

1.PS4.B (4-PS4-2); **1.LS1.A** (4-LS1-1); **1.LS1.D** (4-LS1-1); **3.LS3.B** (4-LS1-1); **MS.PS4.B** (4-PS4-2); **MS.LS1.A** (4-LS1-1),(4-LS1-2); **MS.LS1.D** (4-PS4-2),(4-LS1-2)

Common Core State Standards Connections:

ELA/Literacy -

W.4.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (4-LS1-1)

SL.4.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes. (4-PS4-2),(4-LS1-2)

Mathematics -

MP.4 Model with mathematics. (4-PS4-2)

4.G.A.1 Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. (4-PS4-2)

4.G.A.3 Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded across the line into matching parts. Identify line-symmetric figures and draw lines of symmetry. (4-LS1-1)

1. Asking Questions



Questions engage

- Why is the sky blue?
- What is the smallest piece of matter?
- What is the furthest star?

2. Developing and Using Models

1. Name 5 models you commonly use in teaching?
2. How do these models differ?

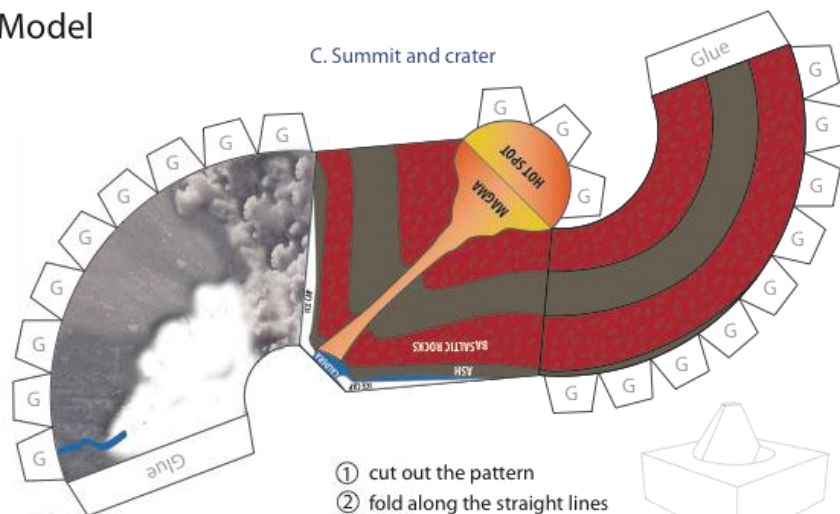
2. Developing and Using Models

Eyjafjallajökull * Volcano Model

(not to scale)

* pronounced Aya-feeyalla-yurkul

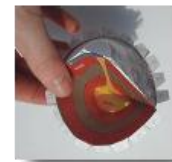
Making the base and ash plume



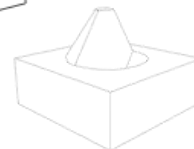
- 1 cut out the pattern
- 2 fold along the straight lines
- 3 glue tabs as indicated

Fold along centre and glue halves together

Folding the summit & crater



Summit & crater assembled

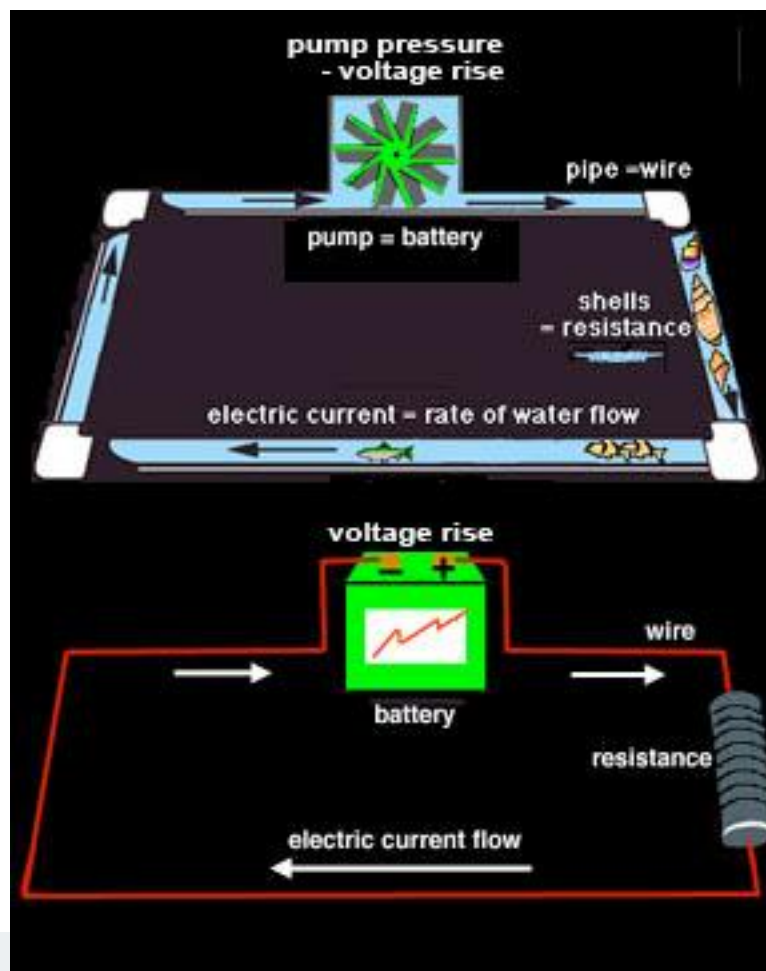


The finished model

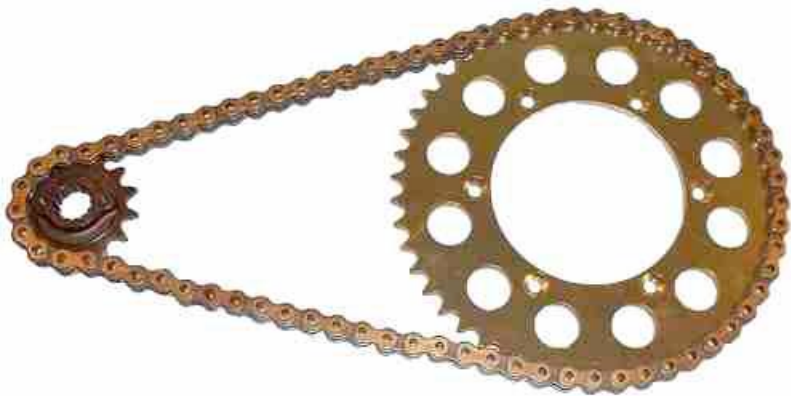


A. Ash plume

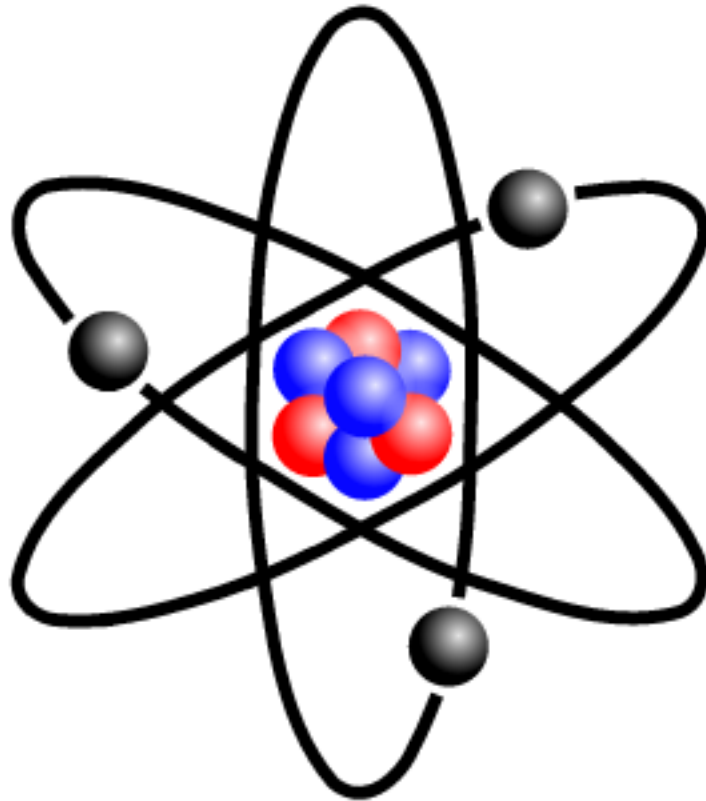
Water Model of an Electric Circuit



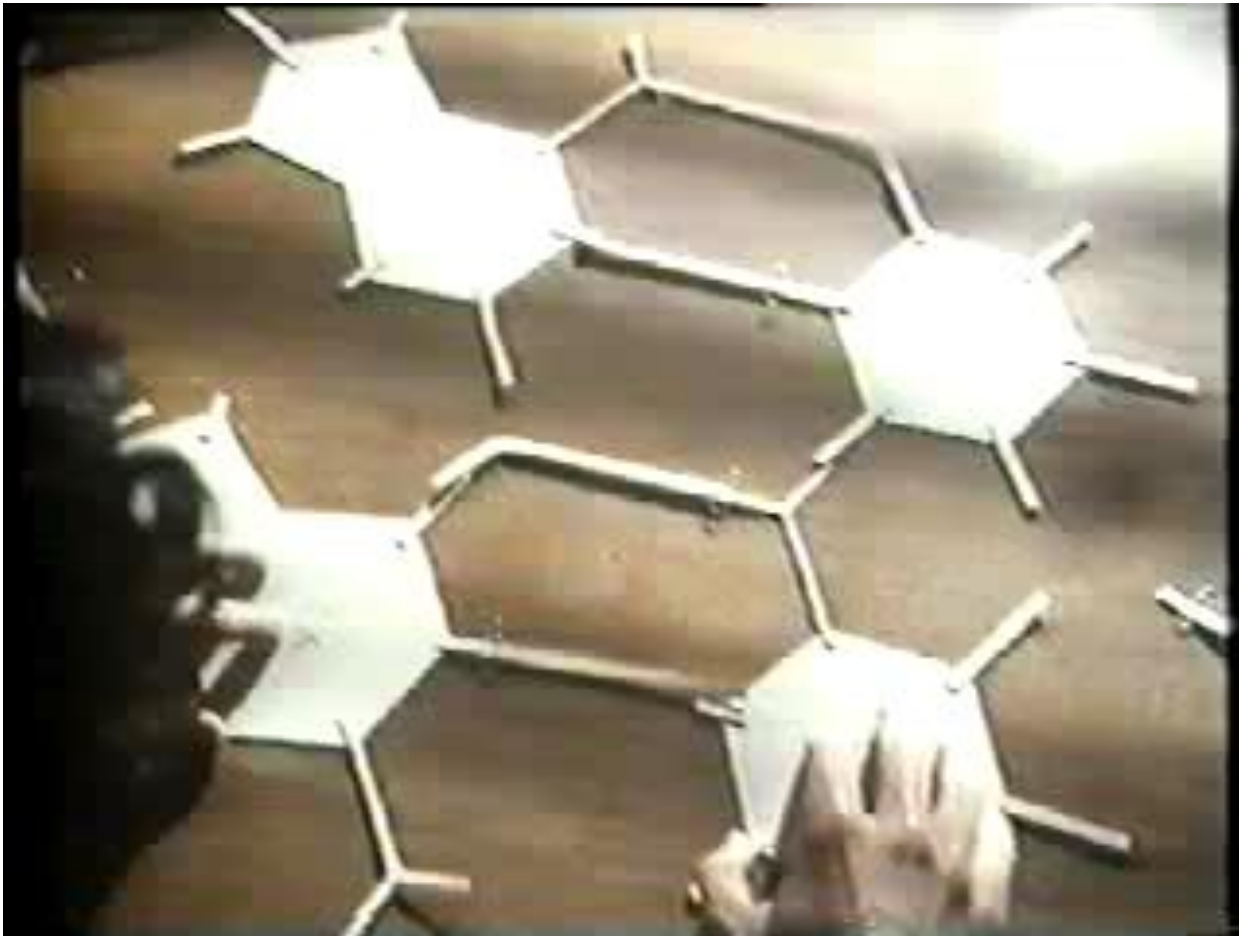
Bicycle Model of An Electric Circuit



Bohr Model of the Atom



Model Based Thinking



3. Planning and Carrying Out Investigations

How does the speed at which sugar dissolves depend on temperature?

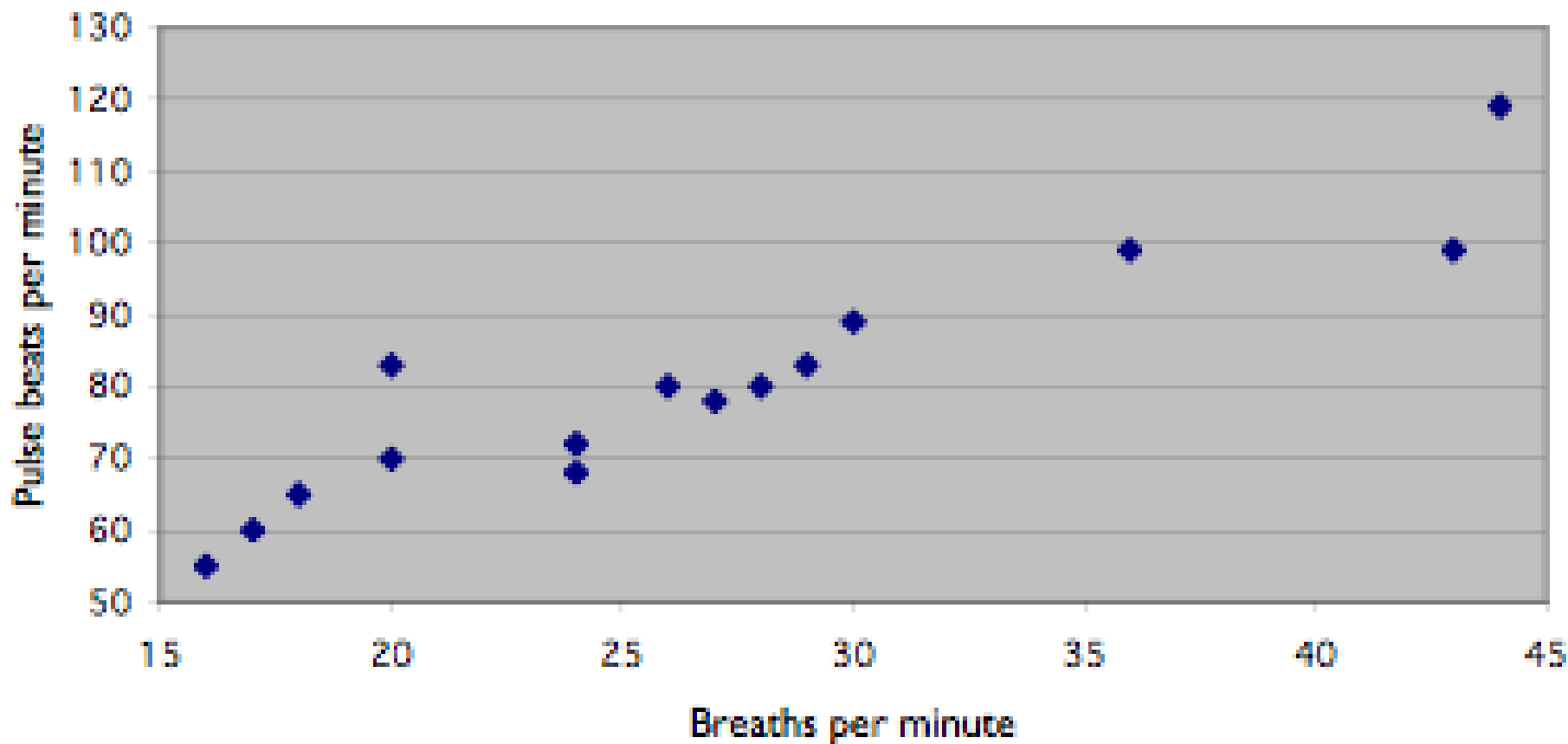
Possible Answers

Kirsty: We are looking to see how different temperatures affect how long it takes for the sugar to dissolve.

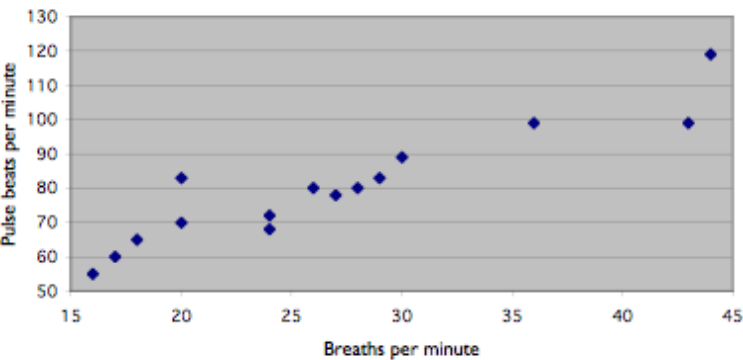
Alex: We are trying to find the best temperature for dissolving sugar in water.

Louise: We have to put the same amount of sugar in water with different temperatures and see what happens.

4. Analyzing and Interpreting Data



4. Analyzing and Interpreting Data



- (a) One pupil had the most breaths and she also had the highest pulse rate.
- (b) All the people with a high breath rate had a high pulse rate.
- (c) The higher your breathing rate, the greater the pulse rate.
- (d) On the whole, those people with a higher breath rate had a higher pulse rate.

5. Using Mathematics & Computational Thinking

$$\nabla \times \mathbf{B} = \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

1. Who is the tallest
2. Who is the smallest
3. What is the average?

WHALES

have hair

live birth

breathe air

FISH

lay eggs

have scales

breathe water

live in water

have fins

can swim

5. Constructing Explanations

Why do objects fall at the same rate in the absence of air?

- Twice the mass takes twice as long to speed up
- If the mass is double, the pull of gravity will double
- Gravity pulls on all objects
- Think of two objects, one twice as massive as the other
- Force is double but so is the mass

The Significance of Argument?

Construction
[Recall and Explanation]

v

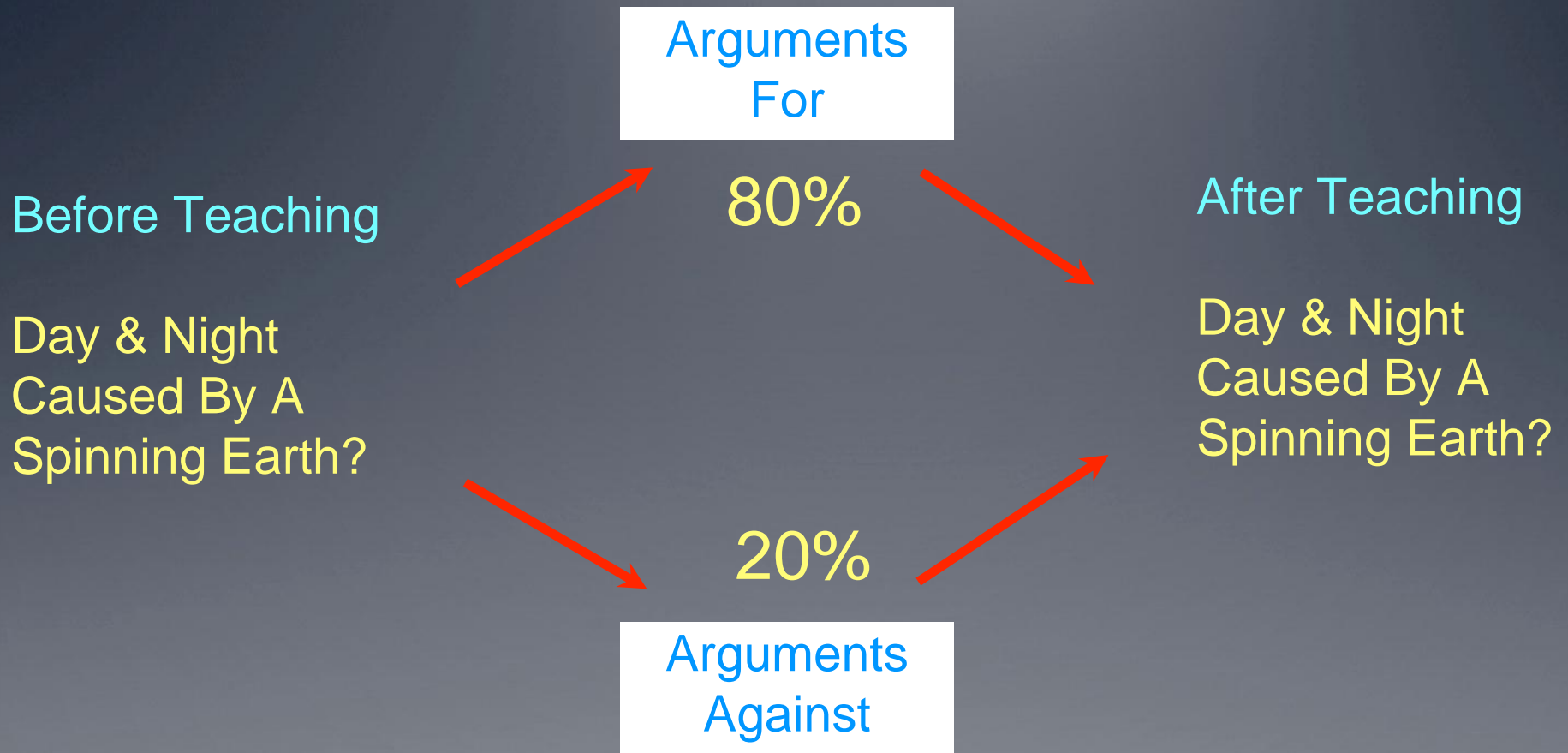
Critique
[Juxtaposition & Evaluation]

How do we know?

That Day and Night are caused by a Spinning Earth

Arguments Against:

1. The Sun moves
2. If you jumped up you would not land in the same spot
3. If the Earth was spinning at that rate, the speed at the equator is over a 1000 mph and you should be flung off



How Likely? Ratio of 4:1

Something in the Air?



Maria, Ted and Alexis are wondering where the water on the outside of the glass of water with ice comes from.

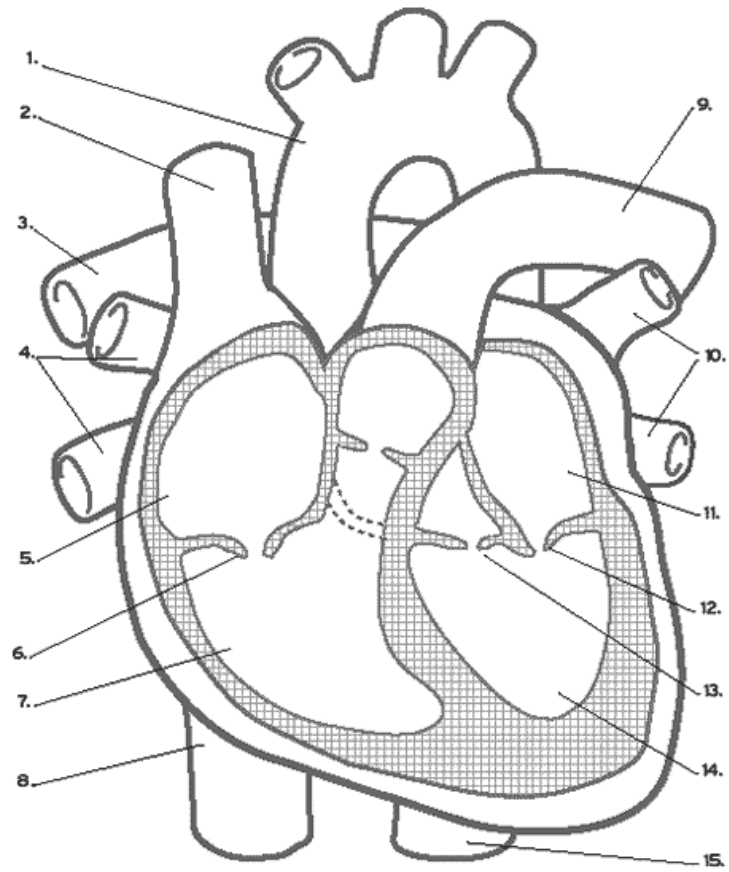
Maria: The water came through holes in the glass.

Ted: The water came over the top of the glass.

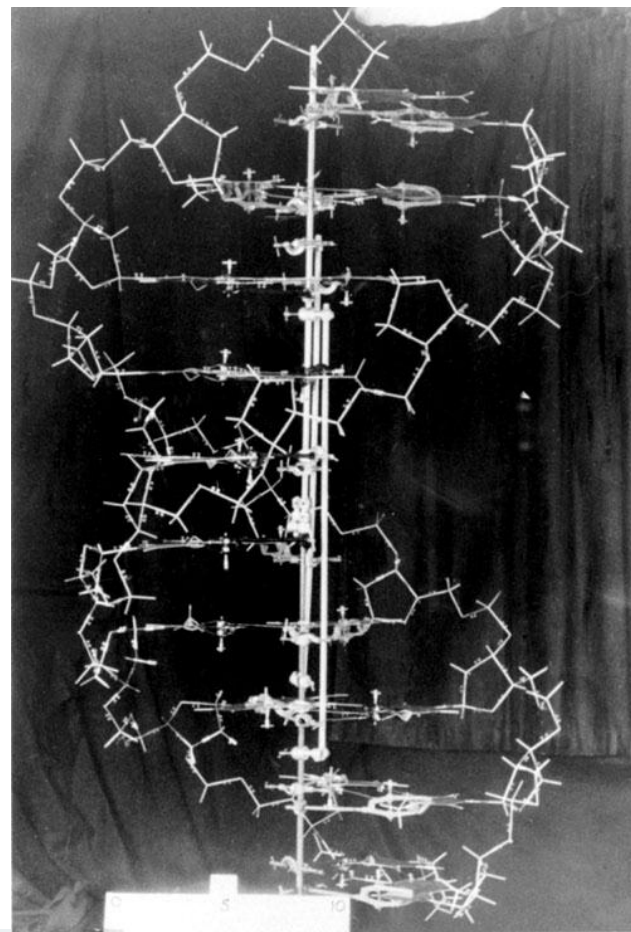
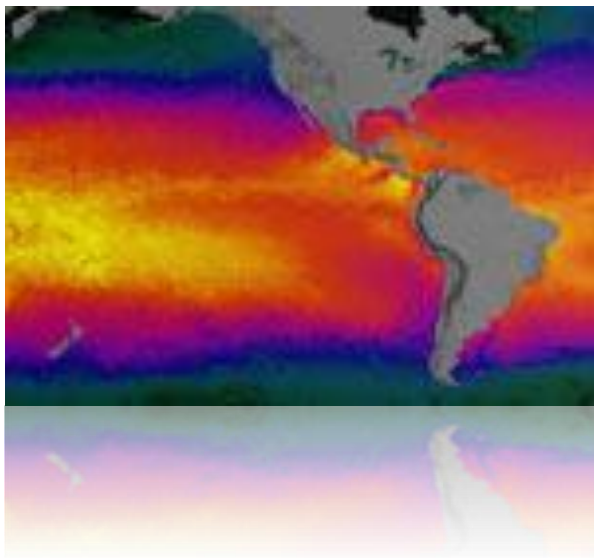
Alexis: The water came from the air.

8. Obtaining, Evaluating and Communicating Information

Diagrams



Symbols & Models

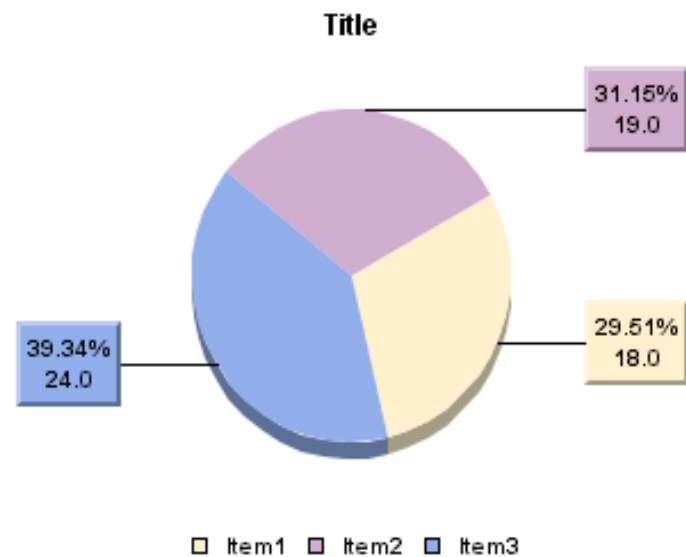
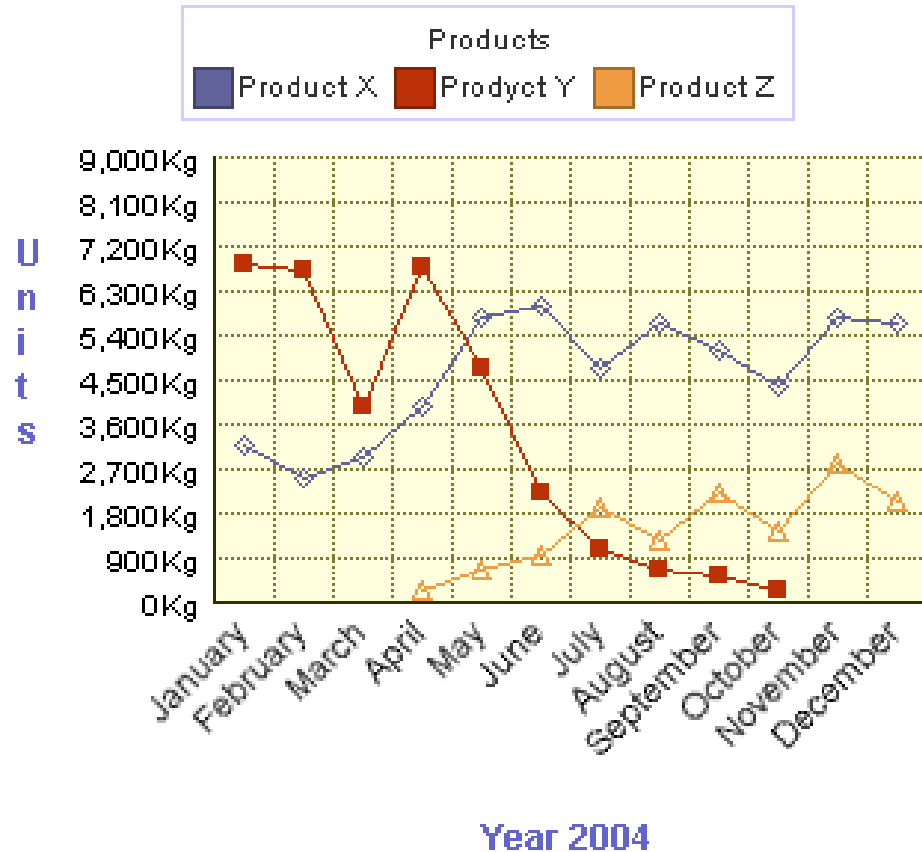


Original DNA demonstration model (scale gives distance in Angstroms)

Cold Spring Harbor Laboratory Archives

Charts and Graphs

Unit Production



Scientific Vizualizations



Mathematics

$$\nabla \cdot \mathbf{E} = 0$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

Requirements

Grade 6-8

Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

Grade 9-10

Analyze the author's purpose in providing an explanation, describing a procedure or discussing an experiment in a text defining the question the author seeks to address.

Views of Reading

Simple View of Reading

- * Decoding Words on paper
- * Knowing the Vocabulary

Complex View of Reading

- ▣ Perspective Taking
- ▣ Complex Reasoning
- ▣ Academic Language
- ▣ Background Knowledge

Not Learning to Read BUT Reading to Learn

READING TO LEARN IN SCIENCE

http://serpmedia.org/rtl_pending/

Summary

- Why NGSS?
 - ▣ Need to teach more than content
 - ▣ Develop an understanding of scientific practice
- What is NGSS?
 - ▣ Disciplinary Core Ideas
 - ▣ 8 Scientific Practices
 - ▣ 7 Cross-Cutting Concepts
- Defined in Terms of a set of Performance Expectations

Thank you

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