Science Standards, Curricula, and Assessment: What, When, and How

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Overview

In this session we will

- Discuss issues related to the what, when, and how of science curricula and instruction
- Become familiar with a new conception of science teaching and learning
  - Core concepts
  - Learning progressions
  - Four strands of science proficiency
- Provide ideas for formative assessments
- Gain access to resources that support this new conception of teaching and learning

Ohio's Science Content Standards

- 311 pages
  - Standard, Benchmark by grade level bands, grade level indicators
  - Professional commentary
- 6 content areas
  - Earth and Space Sciences
  - Life Sciences
  - Physical Sciences
  - Science and Technology
  - Scientific Inquiry
  - Scientific Ways of Knowing

High Dream vs. Reality of Science Instruction

- Science argument is rare in classrooms but central to science; teaching focuses on recall rather than model-based reasoning
- Classroom norms (teacher, textbooks provide answers) in tension with building scientific models from evidence
- Curricula and standards "mile wide, inch deep" (TIMSS)
- Layout of standards is based on grade level, rather than science concept relationships
- Modules/kits are common but remain discrete and disconnected

What and When to Teach?

- Districts/states determine what topics should be taught and when
  - Are all science topics equal in their importance?
  - When should specific topics be taught and in what sequence?

How to Teach?

Even if the science topics are being taught in the order prescribed by the district curriculum plan, students can still lack conceptual understanding and scientific habits of mind.

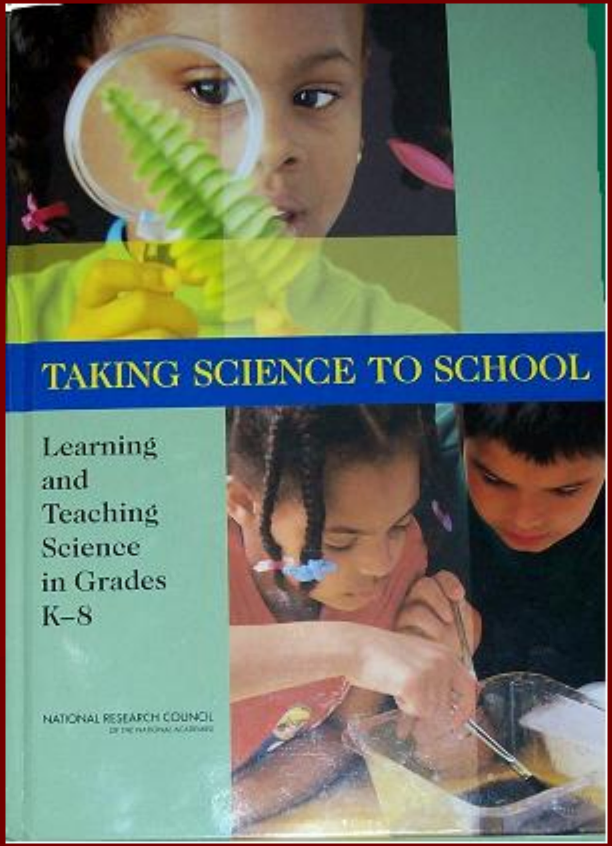
Why? What is still missing?

What, When, and How to Teach

Consider

- Decreasing the number of topics presented, focusing rather on a few **core concepts** in science (the What)
- Developing a research based, **learning progression** (the When)
- Facilitating **science proficiency** so students acquire scientific habits of mind as well as process skills (the How)

Taking Science to School: Learning and Teaching Science in Grades K-8



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Background on the Study

- 30-Month NRC Consensus Study -- five meetings beginning in November, 2004
- Related NRC Studies:
  - *How People Learn*, *Adding it Up*, *Starting Out Right*
- Sponsors: NSF, NICHD, Merck Institute for Science Education

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Committee Charge

- What do we know about how children learn science?
- What does this mean about how we should teach science?
- What further research is needed?

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Key Findings

- Students in grades K-8 can do more in science than is currently asked of them
- Science standards and curricula contain too many topics given equal emphasis
- Science classrooms typically provide few opportunities for students to engage in meaningful science
- Good science teaching requires more than expert knowledge of science content

The Four Strands of Scientific Proficiency

Students who understand science:

- Know, use, and interpret scientific explanations of the natural world
- Generate and evaluate scientific evidence and explanations
- Understand the nature and development of scientific knowledge
- Participate productively in scientific practices and discourse

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The Four Strands of Scientific Proficiency

- The four strands are interwoven in learning. Advances in one strand support advances in the others.
- The strands emphasize the idea of "knowledge in use" – that is students' knowledge is not static and proficiency involves deploying knowledge and skills across all four strands.
- Students are more likely to advance in their understanding of science when classrooms provide learning opportunities that attend to all four strands.

Photo adapted from http://www. columbianrope.com/ GoldlineNylon.htm

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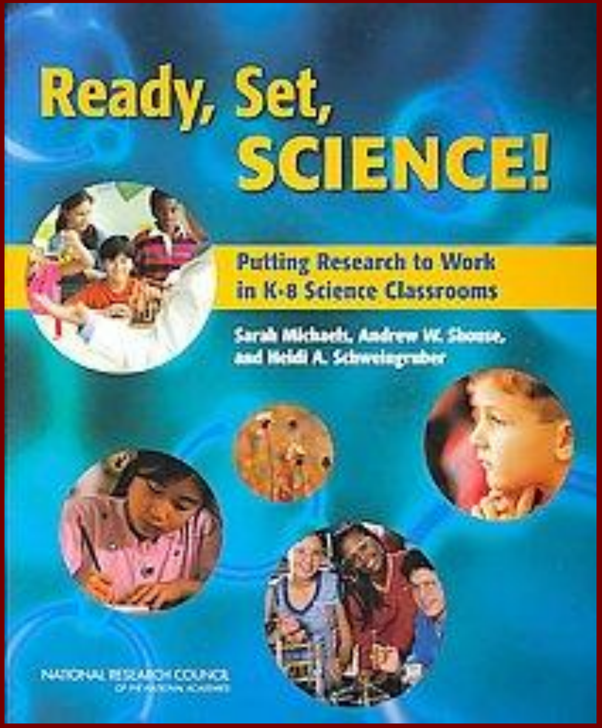
Ready, Set, Science!

- User friendly accounting of the findings from *Taking Science to School*
  - 8 Concise chapters
  - Questions for discussion

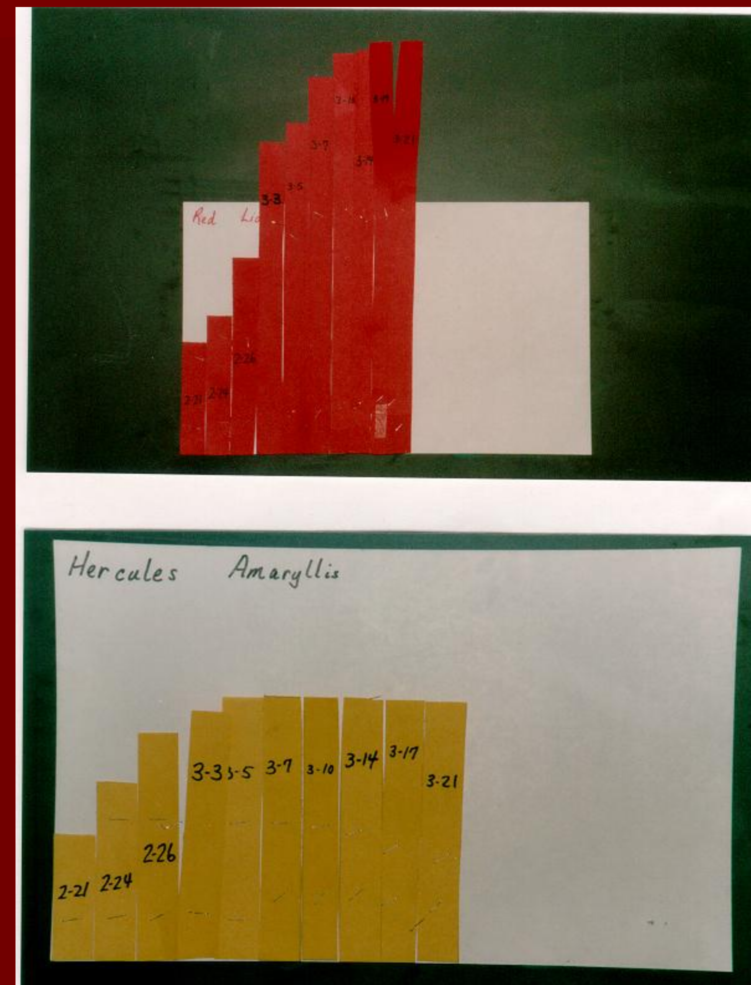


Ready, Set, Science!

Contains case studies that

- illustrate core concepts, learning progressions, and science proficiency
- encompass the what and when in a holistic way, rather than compartmentalizing science content separate from process skills
- Convey how teachers facilitate science proficiency in their students

Growth: First Grade



These case studies are elaborated in *Ready, Set, Science! p. 115.*

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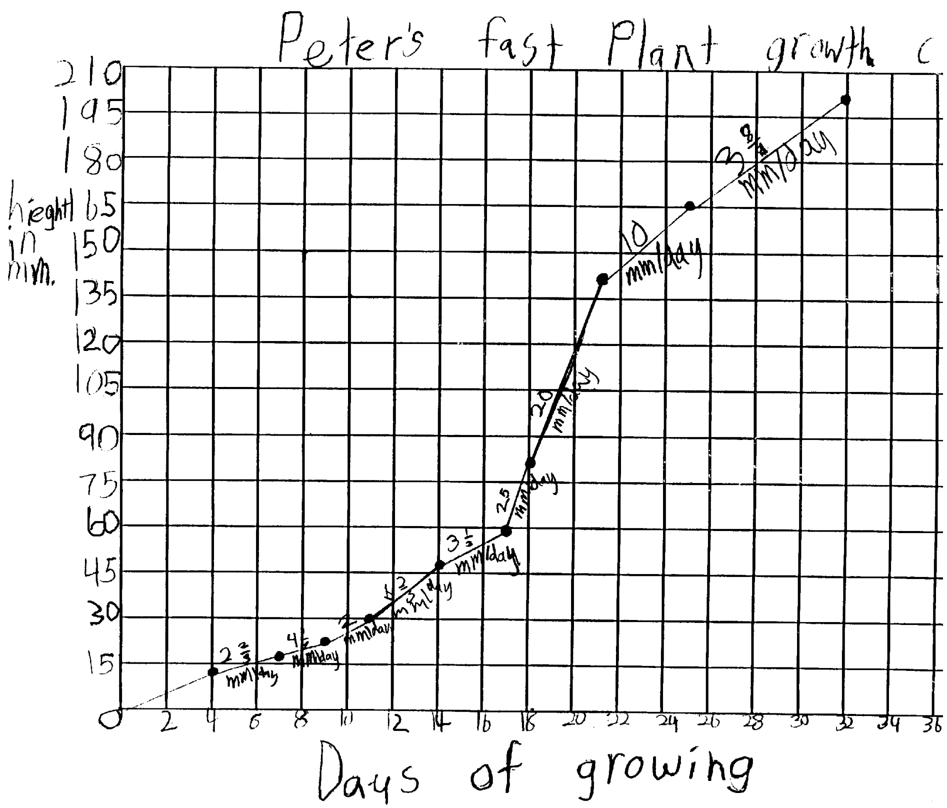
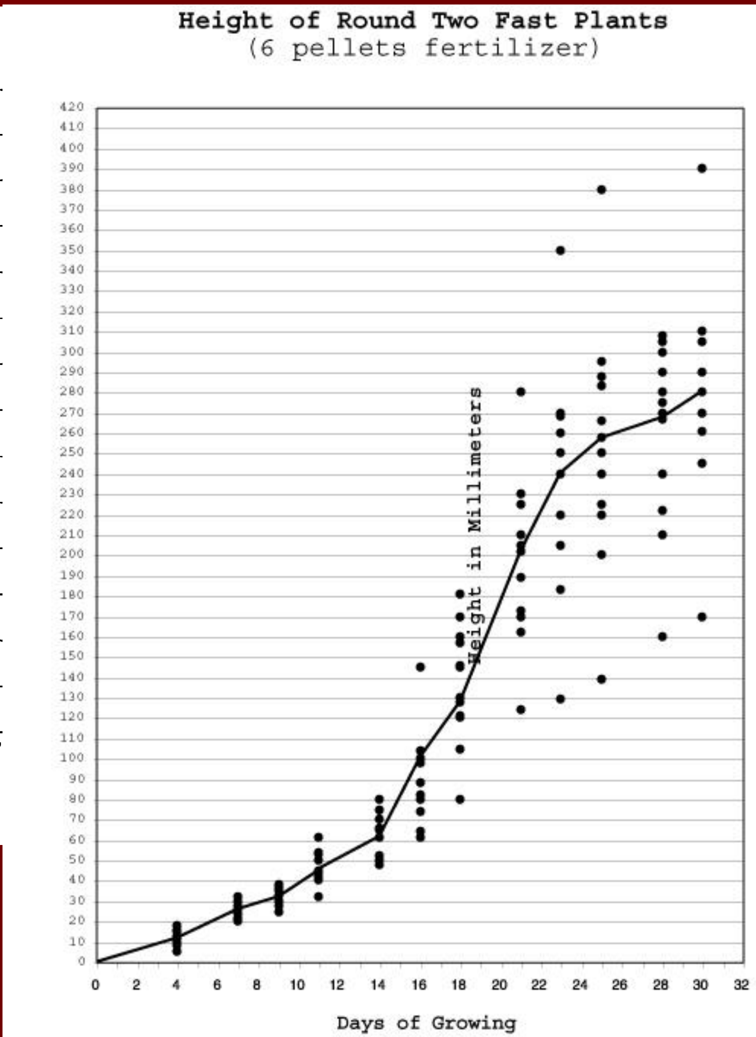
Growth: Third Grade





Ready, Set, Science! p. 116

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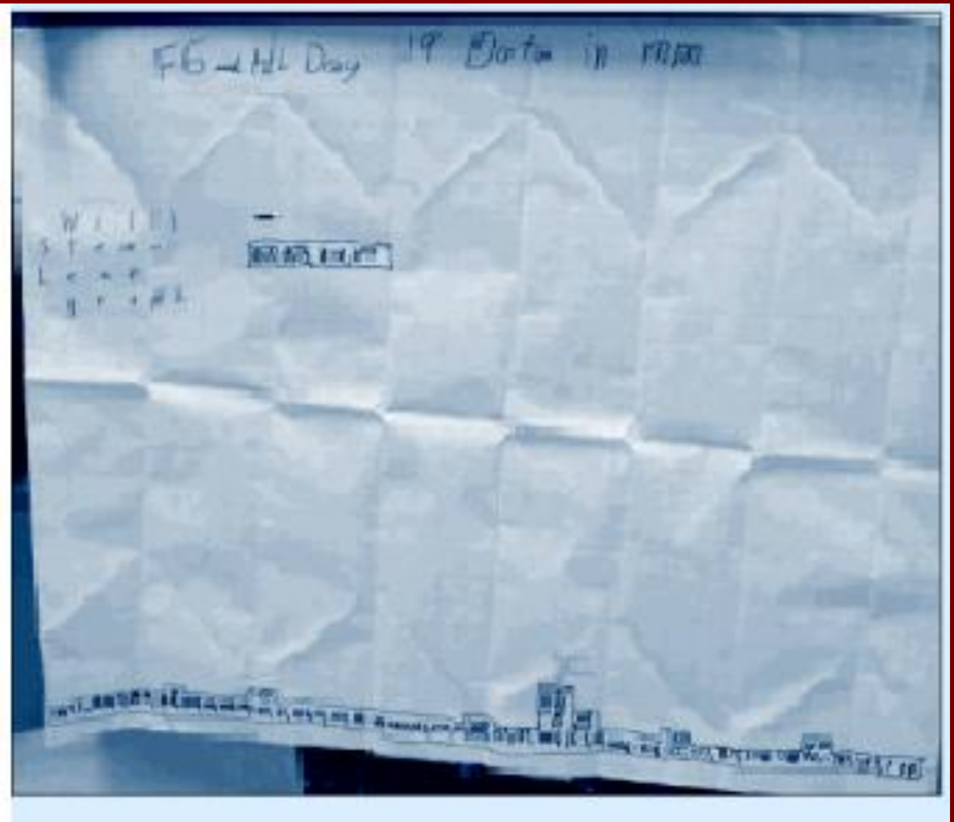
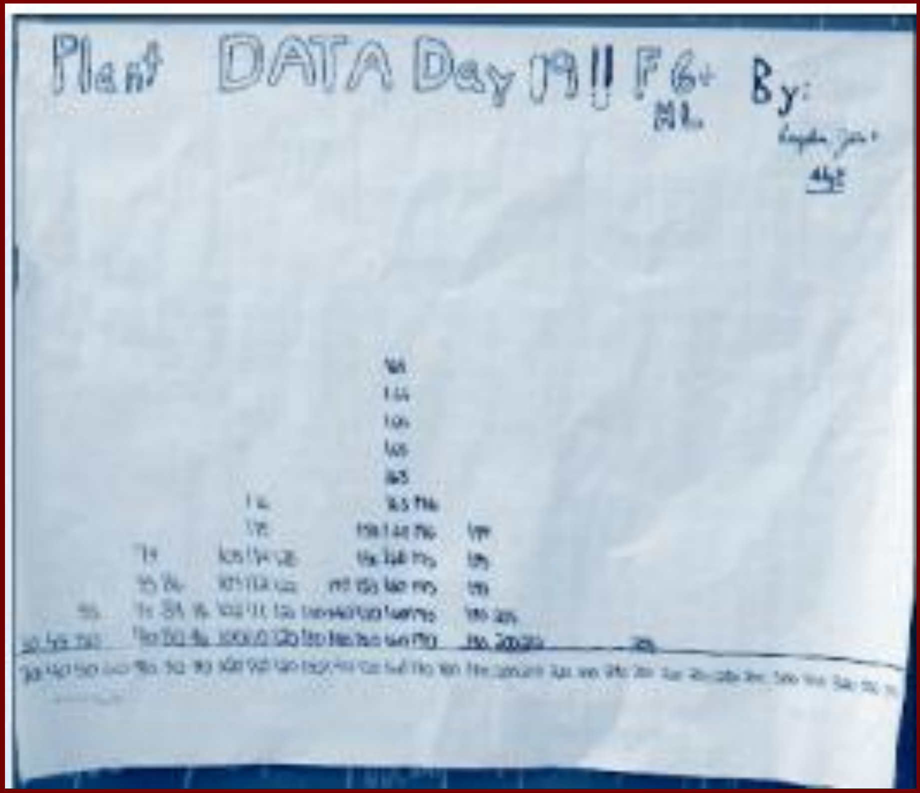
Growth: Fifth Grade



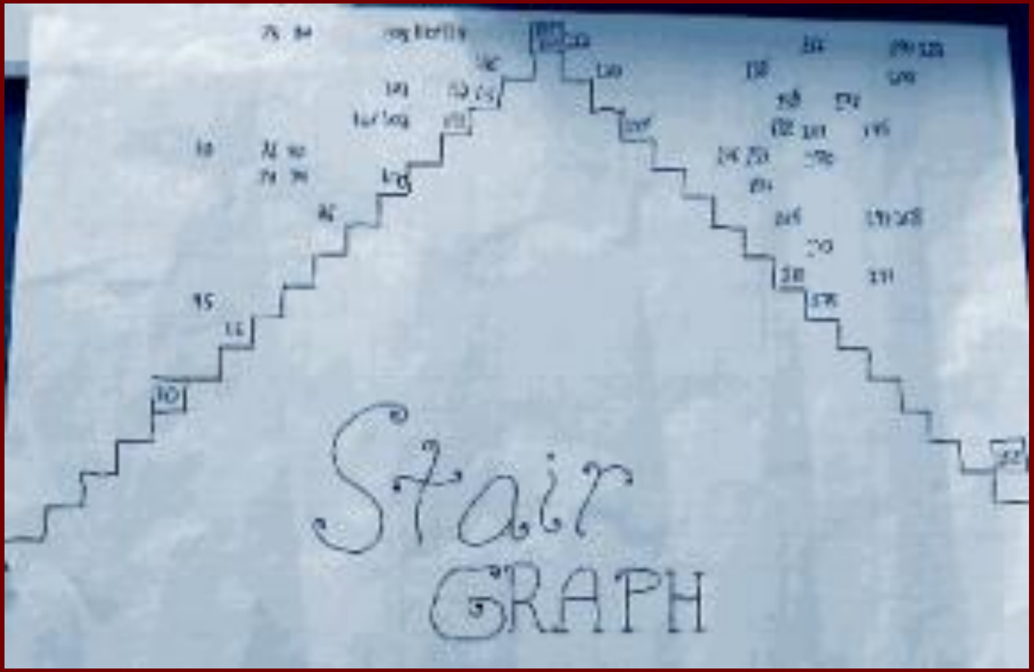
Stem and leaf plot, p. 121



“Bins” of ten, p. 122

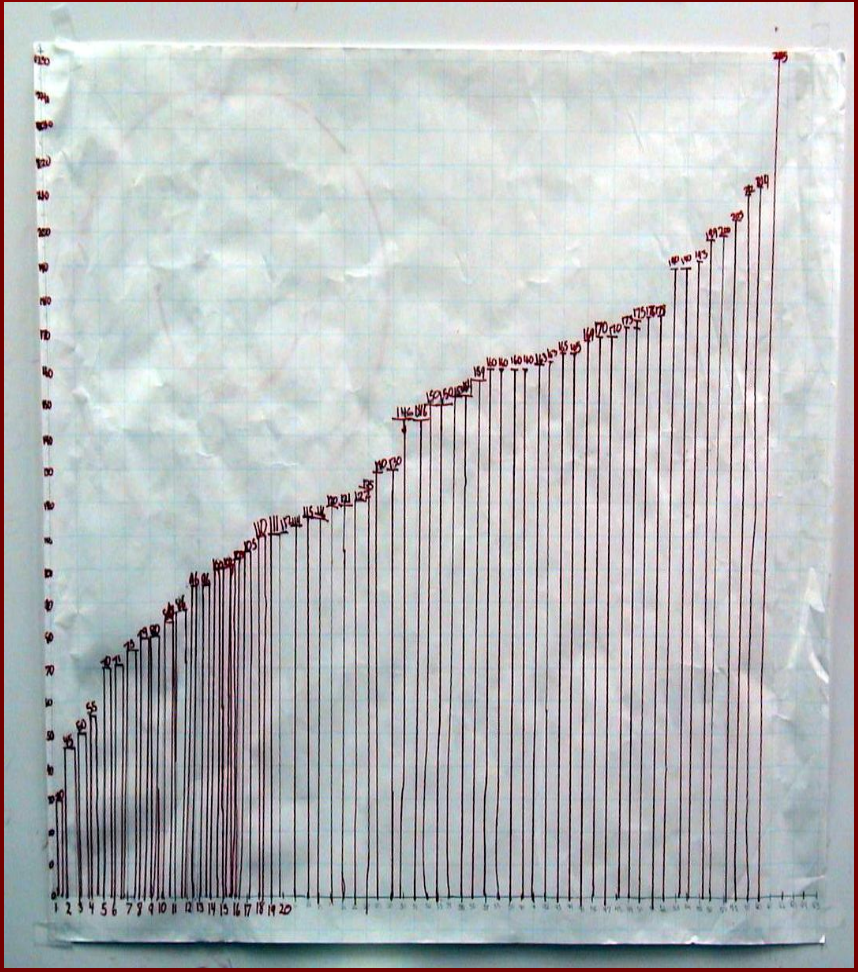
Growth: Fifth Grade

Used a 2D coordinate grid, p. 124



Median measure is at apex, p. 124

Growth: Fifth Grade



Though axes are unlabeled, the Y axis is height, and the X axis is plant specimen number, *p. 120*

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Measuring Proficiency

Rubistar

- Free service
- Provides generic rubrics in 10 different discipline areas that can be quickly customized and saved
- Categories could be made to parallel the 4 strands

Proficiency	4	3	2	1
Know, use and interpret scientific explanations of the natural world	Uses all relevant established science facts and theories to accurately interpret observations of current science activity.	Uses most relevant established science facts and theories to accurately interpret observations of current science activity.	Uses few relevant established science facts and theories OR inaccurately interprets observations of current science activity.	Uses few relevant established science facts and theories AND inaccurately interprets observations of current science activity.
Generate and evaluate scientific evidence and explanations	Competently produces and evaluates appropriate kinds of evidence for the given problem.	Competently produces and evaluates evidence, though omits a very germane type of evidence for the given problem.	Produces and evaluates some evidence for the given problem, though not entirely competently OR omits a very germane type of evidence.	Produces but does not evaluate evidence for the given problem OR produces and evaluates inappropriate evidence OR produces and incompetently evaluates evidence.

Proficiency	4	3	2	1
Understand the nature and development of scientific knowledge	Provides logical rationale for methodological choices and reasoning used to arrive at conclusions.	Provides rationale for methodological choices and reasoning used to arrive at conclusions, though not entirely logically valid.	Provides rationale for methodological choices OR reasoning used to arrive at conclusions, though not entirely logically valid.	Provides illogical or no rationale for methodological choices OR reasoning used to arrive at conclusions.
Participate productively in scientific practices and discourse	Demonstrates understanding of one's own and others' thought processes, by listening attentively and consistently responding appropriately.	Demonstrates understanding of one's own and others' thought processes, by listening attentively and sometimes responding appropriately.	Sometimes demonstrates understanding of one's own and others' thought processes. Does not consistently listen attentively and sometimes responds inappropriately.	Fails to demonstrate understanding of one's own and others' thought processes. Does not consistently listen attentively OR responds inappropriately OR does not respond at all.

Authentic Assessment of Student Growth

E-Portfolios

- *An Overview of E-Portfolios* by George Lorenzo and John Ittleson, 2005
  - Contains sections on student, teacher, and institutional portfolios

- *e-Portfolios: A Portal Site*
  - Contains FAQ's including the concept of, meaningful use of, and benefits of e-portfolios

Resources for the What

- What are the core concepts?
  - AAAS Benchmarks
  - National Science Education Standards
  - *Taking Science to School* acknowledges there is not a finite list although *Benchmarks* might come close

Resources for the When

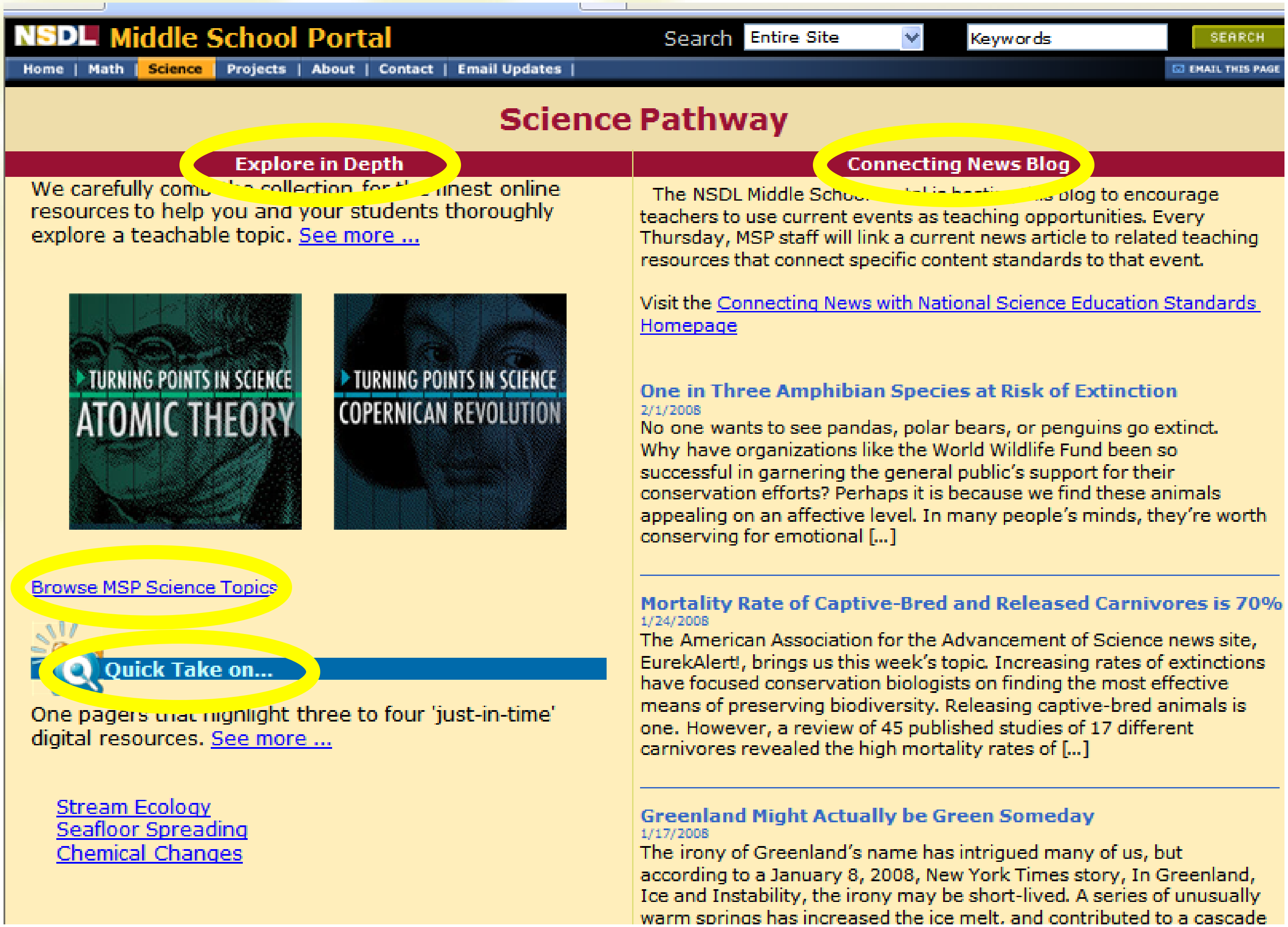
- AAAS Atlas for Science Literacy
- NSDL Science Literacy Maps
  - References for constructing a **learning progression**

Resources for the How

- *Taking Science to School: Learning and Teaching Science in Grades K-8*
- *Ready, Set, Science*
- NSDL Middle School Portal
  - funded through NSF - developed specifically for grades 5-8 mathematics and science middle school teachers

NSDL Middle School Portal

Science Pathway



NSDL Middle School Portal

Search Entire Site Keywords SEARCH

Home | Math | Science | Projects | About | Contact | Email Updates |

EMAIL THIS PAGE

Science Pathway

Explore in Depth

We carefully comb ... collection for t... finest online resources to help you and your students thoroughly explore a teachable topic. See more ...

TURNING POINTS IN SCIENCE ATOMIC THEORY

TURNING POINTS IN SCIENCE COPERNICAN REVOLUTION

Browse MSP Science Topics

Quick Take on...

One pagers ... highlight three to four 'just-in-time' digital resources. See more ...

- Stream Ecology
- Seafloor Spreading
- Chemical Changes

Connecting News Blog

The NSDL Middle Scho... ...blog to encourage teachers to use current events as teaching opportunities. Every Thursday, MSP staff will link a current news article to related teaching resources that connect specific content standards to that event.

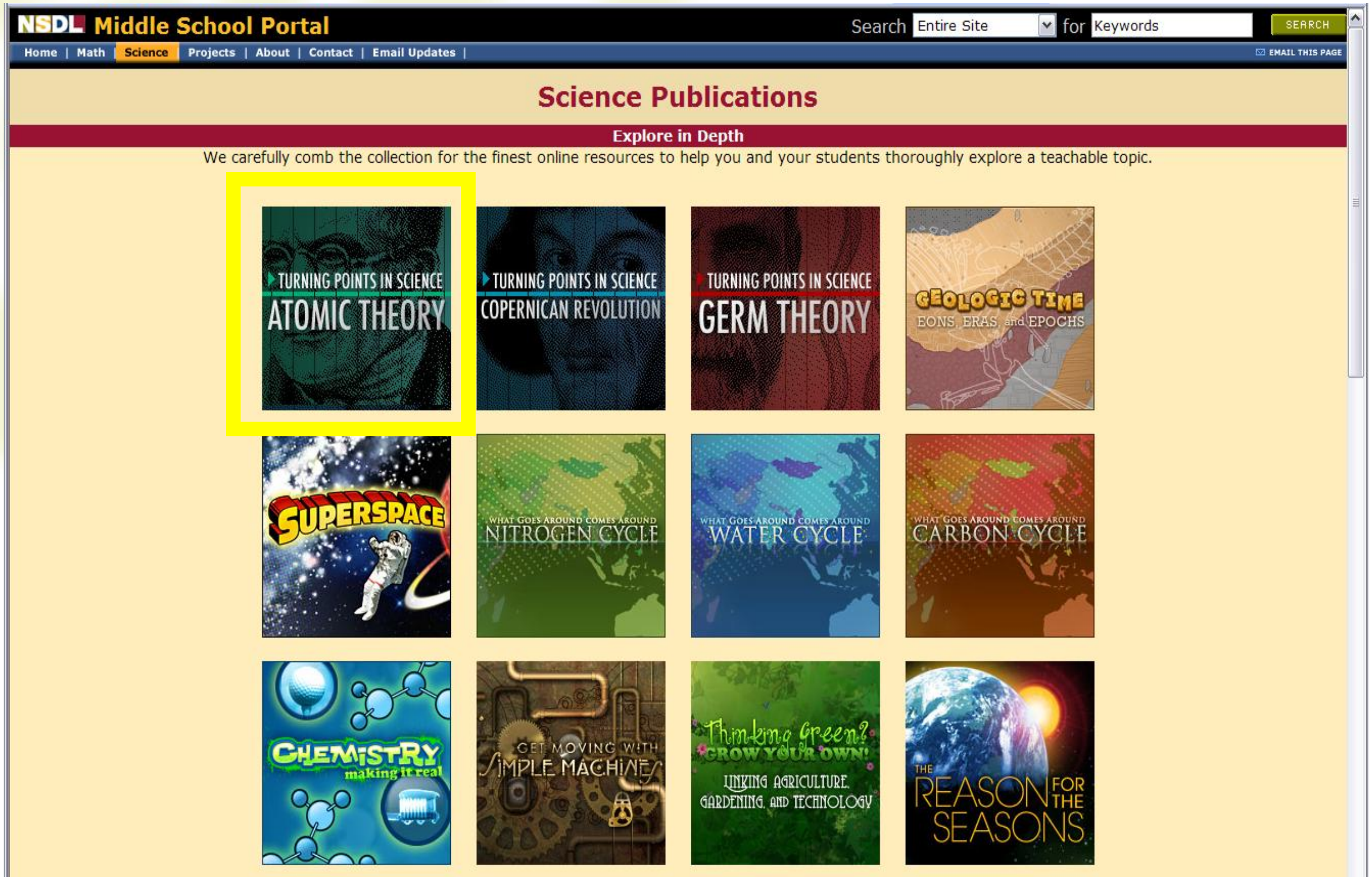
Visit the Connecting News with National Science Education Standards Homepage

One in Three Amphibian Species at Risk of Extinction
2/1/2008
No one wants to see pandas, polar bears, or penguins go extinct. Why have organizations like the World Wildlife Fund been so successful in garnering the general public's support for their conservation efforts? Perhaps it is because we find these animals appealing on an affective level. In many people's minds, they're worth conserving for emotional [...]

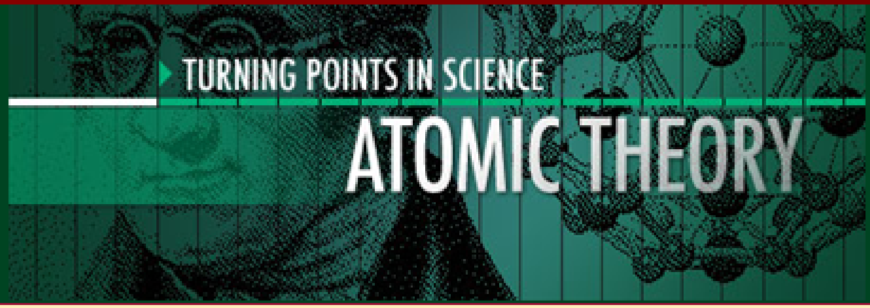
Mortality Rate of Captive-Bred and Released Carnivores is 70%
1/24/2008
The American Association for the Advancement of Science news site, EurekAlert!, brings us this week's topic. Increasing rates of extinctions have focused conservation biologists on finding the most effective means of preserving biodiversity. Releasing captive-bred animals is one. However, a review of 45 published studies of 17 different carnivores revealed the high mortality rates of [...]

Greenland Might Actually be Green Someday
1/17/2008
The irony of Greenland's name has intrigued many of us, but according to a January 8, 2008, New York Times story, In Greenland, Ice and Instability, the irony may be short-lived. A series of unusually warm springs has increased the ice melt, and contributed to a cascade

Science Publications: Explore in Depth



Atomic Theory



Introduction

This is the third publication in our series called *Turning Points in Science*, which highlights the history and nature of science. The first publication covered the topic of germ theory and the second the Copernican revolution. The third in the series, *Atomic Theory*, highlights human thinking and theorizing regarding the structure and nature of matter.

Several themes that appeared in the first two publications are seen in *Atomic Theory* as well. First, Copernican revolution conveyed two important reasons for a study of historical events in science: (1) Because it underscores and makes more real the nature of science — that science progresses when the findings of one person become the stepping stone for another to advance human understanding, and (2) because these turning points impacted society and culture in irreversible ways.

Second, the methods of science vary with the discipline. The methods in physical science are probably the closest to conceptions of science methods students may hold. In physical science, fairly certain conclusions can be drawn from well-controlled laboratory investigations because confounding variables are largely eliminated. Thus, the hypothetical-deductive model of science is often played out as predicted.

Third, like the previous two publications in the series, this publication aims to facilitate student mastery of the Science as Inquiry and History and Nature of Science content standards; this time in the context of elucidation of atomic theory. Thus, some of the Physical Science content standards are touched upon too.

Finally, as in the previous publications, avoiding the temptation of verification exercises remains a priority. Rather, allow students to make *their own* "discoveries," to interpret their observations, to make logical

Atomic Theory

Background Information for Teachers

Teachers have little time to get acquainted with the context and background of much of the content they are required to teach. We hope these resources save you time while providing you with helpful information that fills this information gap. Resources in this section will acquaint you with important figures in the field, the nature of their work, and the impacts of their work on world views of the nature and structure of matter.

The Particle Adventure: What Is Fundamental?
http://particleadventure.org/frameless/startstandard.html

Digital Libraries OSU

Although this tutorial is designed for high school students, it can serve as an excellent review for middle school teachers. It covers the history of particle physics, discussing, for example, Rutherford's experiment and findings as well how physicists study small particles and how we know what we know about atoms and the structure of matter. Parts of the tutorial are appropriate for sharing directly with middle school students. MSP full record

The History of Atomic Theory
http://www.lancs.ac.uk/ug/cooked1/index.htm

Digital Libraries OSU

This text is presented as a tutorial and overview starting with the ancient Greek ideas of the atom and continuing through the Bohr model. Some middle school students with high reading levels may be able to benefit directly from this resource. MSP full record

The Greek Concept of *Atomos*: The Indivisible Atom
http://dbhs.wvusd.k12.ca.us/webdocs/AtomicStructure/Greeks.html

Digital Libraries OSU

This well-organized page concisely presents the five points of atomism first articulated by Democritus, marking the earliest known theory of atomic structure. Links to other atomists are included. MSP full record

John Dalton
http://scienceworld.wolfram.com/biography/Dalton.html

Digital Libraries OSU

This short biography is accompanied by an image of Dalton and includes the three tenets of his atomic theory. The link to Berzelius illustrates how atomic theory was useful in identifying ions and ionic compounds
MSP full record

Atomic Theory

TURNING POINTS IN SCIENCE
ATOMIC THEORY

Lesson and Activities

With your knowledge of the history of atomic theory, you are ready to assist students in gaining accurate conceptions of the structure of matter and appreciation for how we know what we know about the atom. The lessons and activities in this section are designed to allow student insight into past and present perceptions of the structure of matter.

Early Atomic Understanding
http://particleadventure.org/other/history/earlyt.html

A brief timeline covers the major ancient Greeks and their beliefs about the nature of matter. Students can be asked: Who seemed to have the most imaginative ideas? The most probable? On what were these ideas based? How did their methods of science compare to current methods of science? Why? MSP full record

Guess What?
http://www.reachoutmichigan.org/funexperiments/agesubject/lessons/guesswhat.html

This hands-on activity for upper elementary and middle school students simulates how scientists make inferences regarding the structure of matter not directly observed. MSP full record

Strange Matter
http://www.strangematterexhibit.com/structure.html

This interactive page zooms from the outside of a beverage can down to the level of aluminum atoms. As the image zooms, a schematic reference scale shows the level of magnification the image represents. MSP full record

TE Activity: Gumdrop Atoms
http://www.teachengineering.org/view_activity.php?

Atomic Theory

Science Publications

National Science Education Standards Alignments

Concepts of this publication align with the following content standards of the *National Science Education Standards*.

History and Nature of Science: Content Standard G

Science as a Human Endeavor

- Women and men of various social and ethnic backgrounds — and with diverse interests, talents, qualities, and motivations — engage in the activities of science, engineering, and related fields such as the health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others.
- Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill, and creativity — as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.

Nature of Science

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations.
- In areas where active research is being pursued and in which there is not a great deal of experimental or observational evidence and understanding, it is normal for scientists to differ with one another about the interpretation of the evidence or theory being considered. Different scientists might publish conflicting experimental results or might draw different conclusions from the same data. Ideally, scientists acknowledge such conflict and work towards finding evidence that will resolve their disagreement.
- It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations,

Turning Points in Science: Atomic Theory

Introduction

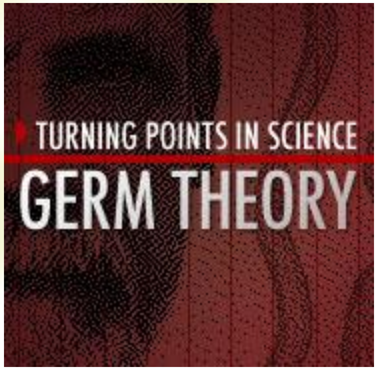
Background Information for Teachers

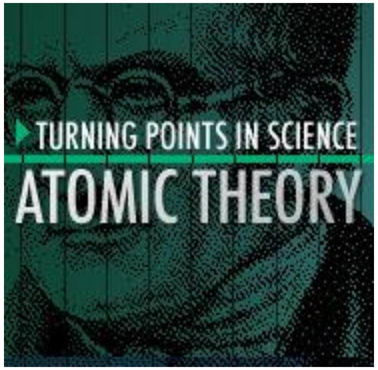
Lessons and Activities

National Science Education Standards

Science Publications: Series

Turning Points in Science highlights the history and nature of science





What Goes Around Comes Around ties the fundamental cycles of nature to real-world issues

To Think About

- What
  - core concepts
- When
  - as part of a learning progression
- How
  - facilitating science proficiency by attending to the four strands of science proficiency

FYI

- Links to this presentation and handout are available at http://expertvoices.nsdl.org/middle-school-math-science/2008/04/02/middle-school-portal-at-nmsa-essentials-conference/
- Expect e-mail take-homes from NMSA
- Mary LeFever – lefever.10@osu.edu