As we settle in, consider what’s most important in Earth science.

• If you asked your former students, “What’s the most important thing you learned in my class?” what would they say?

• How does that compare with what you hope they would say?

• Take a minute and think about it.

• Then talk to your neighbor about it.
What if We Only Taught Five Things? Focusing Earth Science Instruction on Bigger Ideas

Don Duggan-Haas, PRI & its Museum of the Earth
Sarah R. Miller, Deposit High School
Joseph Henderson, Roth Middle School & University of Rochester
“Let your affairs be as two or three, and not a hundred or a thousand.”

Henry David Thoreau
ReaL Earth System Science is a project of the Paleontological Research Institution (PRI) that is funded by NSF (DRK-12 0733303). The project helps teachers teach Regional and Local Earth system science using an inquiry-based approach, as a way to understand the global environment.

This is undertaken through several components:

- A series of 7 regional Teacher Friendly Guides (TFGs) to the geology of the United States. teacherfriendlyguide.org
- Teacher professional development programs
- The creation of Virtual Fieldwork Experiences (VFEs) virtualfieldwork.org
Plan for the hour:
Plan for the hour:

• Why teach just five (or so) things?
Plan for the hour:

- Why teach just five (or so) things?
- What five things?
Plan for the hour:

- Why teach just five (or so) things?
- What five things?
- How can we do that?
Why?

- The most important reason is that the overwhelming majority of Earth science course alumni don’t really understand much of the science we taught them for any length of time after the course is over.

- That demands a change in approach.

- ...but we can go into a little more detail than just that.
The Committee on How People Learn...

Key Finding #2 (of 3):
The Committee on How People Learn...

Key Finding #2 (of 3):

- To develop competence in an area of inquiry, students must:
The Committee on How People Learn...

Key Finding #2 (of 3):

- To develop competence in an area of inquiry, students must:
  - have a deep foundation of factual knowledge,
The Committee on How People Learn...

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  - understand facts and ideas in the context of a conceptual framework, and
Key Finding #2 (of 3):

- To develop competence in an area of inquiry, students must:
  
  - have a deep foundation of factual knowledge,
  
  - understand facts and ideas in the context of a conceptual framework, and
  
  - organize knowledge in ways that facilitate retrieval and application.
The ES Core Curriculum Guide has 22 Key Ideas.
The ES Core Curriculum Guide has 22 Key Ideas.

- Are some of these ideas more important than others?
The ES Core Curriculum Guide has 22 Key Ideas.

- Are some of these ideas more important than others?
- You can’t tell...
And there’s this to be aware of...

Earth Science Literacy Initiative

A series of efforts to define literacy in Earth systems science.

Atmospheric Science Literacy Framework

Formerly ASCL Workshop, November 27 - 29, 2007
<table>
<thead>
<tr>
<th>Where we are:</th>
<th>Essential Principles</th>
<th>Fundamental Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean Literacy</td>
<td>7</td>
<td>44</td>
</tr>
<tr>
<td>Climate Literacy</td>
<td>8</td>
<td>47</td>
</tr>
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<td>Atmospheric Science Literacy Framework</td>
<td>7</td>
<td>33</td>
</tr>
<tr>
<td>Earth Science Literacy Initiative</td>
<td>9</td>
<td>75</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>31</strong></td>
<td><strong>198</strong></td>
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</table>
So, we have around 200 fundamental concepts...

...to teach in 180 days of instruction.
Good luck with that!
Good luck with that! 😊
In fact...

There are no examples of creating thick descriptions of what everyone should understand about any topic that has led to wide swaths of the population understanding the target content, in spite of countless attempts to do just that throughout human history.
Big ideas, as commonly described, aren’t big enough.
What if we taught just a few things?
What if we taught just a few things?

- TIMSS found that American curricula in math and science are “an inch deep and a mile wide.”
What if we taught just a few things?

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- The typical US curriculum in MS & HS science or math addresses more than thirty major concepts in a single year.
What if we taught just a few things?

- TIMSS found that American curricula in math and science are “an inch deep and a mile wide.”
- The typical US curriculum in MS & HS science or math addresses more than thirty major concepts in a single year.
- In Japan, about seven...
What makes an idea *Really* big?
What makes an idea *Really* big?

- The idea cuts across the Earth science curriculum.
What makes an idea *Really* big?

- The idea cuts across the Earth science curriculum.
- Understanding of the idea is attainable by students and the understanding holds promise for retention.
What makes an idea *Really* big?

- The idea cuts across the Earth science curriculum.
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What makes an idea *Really* big?

- The idea cuts across the Earth science curriculum.
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- The idea is essential to understanding a variety of topics.
- The idea requires uncoverage; has a bottomless quality.
What makes an idea Really big?

- The idea cuts across the Earth science curriculum.
- Understanding of the idea is attainable by students and the understanding holds promise for retention.
- The idea is essential to understanding a variety of topics.
- The idea requires uncoverage; has a bottomless quality.

Furthermore, the entire Earth Science curriculum is represented by this (small) set of ideas.
What do you think?

• If all understanding of Earth science was lost except for a few paragraphs, what should those few paragraphs say?

• What key ideas do you want students to hold onto as a result of taking your class?

• Work in groups to brainstorm ideas using the criteria on the worksheet.
What do you harp on with the kids?

- Can we figure out how to productively harp on big ideas?
- Can what you already harp on being targeted toward big ideas?
• What’s most important?
• As we talk about this, we’ll distribute some materials you shouldn’t peek at quite yet.
• Then we’ll share our ideas.
Earth Science Bigger Ideas & Overarching Questions

Overarching Questions:

How do we know what we know?
How does what we know inform our decision-making?

Earth is a system of systems.

Physical and chemical principles are unchanging and drive both gradual and rapid changes in the Earth system.

To understand (deep) space and time, models and maps are necessary.
**Earth Science Bigger Ideas & Overarching Questions**

**Overarching Questions:**

- How do we know what we know?
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Wednesday, November 4, 2009
# Earth Science Bigger Ideas & Overarching Questions

**Overarching Questions:**

- How do we know what we know?
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| Earth is a system of systems. | The flow of energy drives the cycling of matter. | Life, including human life, influences and is influenced by the environment. | Physical and chemical principles are unchanging and drive both gradual and rapid changes in the Earth system. |

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| Overarching Questions: | How do we know what we know? | How does what we know inform our decision-making? |

Does each idea cut across the entire Earth science curriculum?
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Is understanding of the idea attainable by students and does the understanding hold promise for retention?
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Is each idea essential to understanding a variety of topics?
### Overarching Questions:

**How do we know what we know?**

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| Earth is a system of systems. | The flow of energy drives the cycling of matter. | Life, including human life, influences and is influenced by the environment. | Physical and chemical principles are unchanging and drive both gradual and rapid changes in the Earth system. | To understand (deep) space and time, models and maps are necessary. |

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**Does each idea require uncoverage/have a bottomless quality?**
| Earth is a system of systems. | The flow of energy drives the cycling of matter. | Life, including human life, influences and is influenced by the environment. | Physical and chemical principles are unchanging and drive both gradual and rapid changes in the Earth system. | To understand (deep) space and time, models and maps are necessary. |

Is the entire Earth science curriculum represented by this (small) set of ideas?

Wednesday, November 4, 2009
Connecting Ideas

The Flow of Energy Drives the Cycling of Matter.

1. Human activity has changed atmospheric chemistry, changing how

To Understand (Deep) Time and the Scale of Space, Models and Maps are Necessary.

2. Resulting in climate change

The Earth is a System of Systems.

A small set of basic rules operating over very long time periods yields

Complex organisms dissipate energy effectively thus driving evolution

Physical and chemical principles are unchanging and drive both gradual and rapid changes in the Earth system.

Life, including human life, influences and is influenced by the environment.

Models facilitate prediction, but uncertainty cannot be eliminated because...

Delays in feedback mask how...

Wednesday, November 4, 2009
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Models facilitate prediction, but uncertainty cannot be eliminated because...

A small set of basic rules operating over very long time periods yields...

Delays in feedback mask how...

Complex organisms dissipate energy effectively thus driving evolution.

over long time periods
So what?
So what?

- What does this mean for how we teach?
- What do you think?
- These typically aren’t units you would or should teach.
- How will you revisit these ideas again and again?
- What would be evidence that someone understands these ideas?
Know that it’s really hard.
Know that it’s really hard.

• ...like many things about teaching well.
Good questions matter.
Good questions matter.

- What would the world be like without convection? (In what units could you productively visit this question?)
Good questions matter.

• What would the world be like without convection? (In what units could you productively visit this question?)

• Why does the Earth (or our area) look the way it does?
Good questions matter.

• What would the world be like without convection? (In what units could you productively visit this question?)

• Why does the Earth (or our area) look the way it does?

• How does the model help us to understand what’s going on? Where does the model fall short? (About whatever model you’re looking at...)
Good questions matter.

- What would the world be like without convection? (In what units could you productively visit this question?)
- Why does the Earth (or our area) look the way it does?
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• How does the model help us to understand what’s going on? Where does the model fall short? (About whatever model you’re looking at…)

• How do we know what we know?
Essential Questions

• See Sarah’s matrix.

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Infuse the ideas across the curriculum.
Infuse the ideas across the curriculum.

• See Joe’s Lab questions.
Infuse the ideas across the curriculum.

- See Joe’s Lab questions.
- And Joe’s poster.
1. Summarize the main concepts of this laboratory experience.
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2. Connect this lab with one of the Big Ideas in Science. The list is in the back of the classroom if you don’t have your copy available.
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3. Connect this lab to at least one aspect of your life. How would this knowledge be useful to you either now or in the future?
Joe’s Lab Questions

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3. Connect this lab to at least one aspect of your life. How would this knowledge be useful to you either now or in the future?

4. How does this lab utilize science as a “way of knowing”?

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Back to what you harp on...

- What strategies work for you?
Wrapping up...

- There’s more about these ideas here:

- Follow the link for Big Ideas.
Bonus material...
### Overarching Questions:
How do we know what we know? How does what we know inform our decision-making?

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<td>The Earth System is composed of and part of a multitude of systems, which cycle and interact resulting in dynamic equilibrium (though the system evolves). The Earth is also nested in larger systems including the solar system and the universe. However there is an inherent unpredictability in systems, which are composed of an (effectively) infinite number of interacting parts that follow simple rules. Each system is qualitatively different from, but not necessarily greater than the sum of its parts.</td>
<td>The Earth is an open system – it is the constant flow of solar radiation that powers most surface Earth processes and drives the cycling of most matter at or near the Earth’s surface. Earth’s internal heat is a driving force below the surface. Energy flows and cycles through the Earth system. Matter cycles within it. Convection drives weather and climate, ocean currents, the rock cycle and plate tectonics.</td>
<td>Photosynthetic bacteria reformulated the atmosphere making Earth habitable. Humans have changed the lay of the land, altered the distribution of flora and fauna and are changing atmospheric chemistry in ways that alter the climate. Earth system processes affect where and how humans live. For example, many people live in the shadow of volcanoes because of the fertile farmland found there, however they must keep a constant vigil to maintain their safety. The human impact on the environment is growing as population increases and the use of technology expands.</td>
<td>Earth processes (erosion, evolution or plate tectonics, for example) operating today are the same as those operating since they arose in Earth history and they are obedient to the laws of chemistry and physics. While the processes constantly changing the Earth are essentially fixed, their rates are not. Tipping points are reached that can result in rapid changes cascading through Earth systems.</td>
<td>The use of models is fundamental to all of the Earth Sciences. Maps and models aid in the understanding of aspects of the Earth system for which direct observation is not possible. Models assist in the comprehension of time and space at both immense and sub-microscopic scales. When compared to the size and age of the universe, humanity is a speck in space and a blip in time.</td>
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<td><strong>The Earth System is a Complex System.</strong></td>
<td>How can recognizing and understanding feedback and patterns help you figure out what’s going on in the Earth System?</td>
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<td><strong>The Flow of Energy Drives the Cycling of Matter</strong></td>
<td>Why does the Earth look the way it does?</td>
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<td><strong>Humans and the Environment Impact Each Other.</strong></td>
<td>How do I fit in with all of Earth’s parts?</td>
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<tr>
<td><strong>Evolution and Uniformity Define the Earth System.</strong></td>
<td>How has the Earth changed over time? (What does the evolution of life have to do with that?) How does the past help us predict the future?</td>
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<tr>
<td><strong>To Understand (Deep) Time and the Scale of Space, Models and Maps are Necessary.</strong></td>
<td>What makes a good model?</td>
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<td><strong>Nature of science</strong></td>
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<td>The Earth System is a Complex System.</td>
<td>How can maps and models be used to understand interactions on earth?</td>
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<td>How can we predict if something will float or sink?</td>
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<td><strong>How does the interaction of air, water and earth shape the surface?</strong></td>
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<td>What connections are there between the changing surface of the earth and the evolution of life?</td>
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<td>The Flow of Energy Drives the Cycling of Matter</td>
<td>Are the continents really moving?</td>
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<td>Humans and the Environment Impact Each Other.</td>
<td>How does the movement of the Earth’s crust affect me?</td>
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<td>How do we know how old the Earth is?</td>
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<td>How can an earthquake be modeled?</td>
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<td>How does the weather affect me?</td>
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<td>Why do we have the weather we have?</td>
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<td>The Earth System is a Complex System.</td>
<td>What patterns can be found in the sky?</td>
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<tr>
<td>The Flow of Energy Drives the Cycling of Matter</td>
<td>Why do we have seasons?</td>
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<tr>
<td>Humans and the Environment Impact Each Other.</td>
<td>What does the life cycle of a star have to do with me?</td>
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<tr>
<td>Evolution and Uniformity Define the Earth System.</td>
<td>Why do we think the Universe is old?</td>
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<tr>
<td>To Understand (Deep) Time and the Scale of Space, Models and Maps are Necessary.</td>
<td>How big is space?</td>
</tr>
<tr>
<td>Nature of science</td>
<td>How do we know what we know?</td>
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