

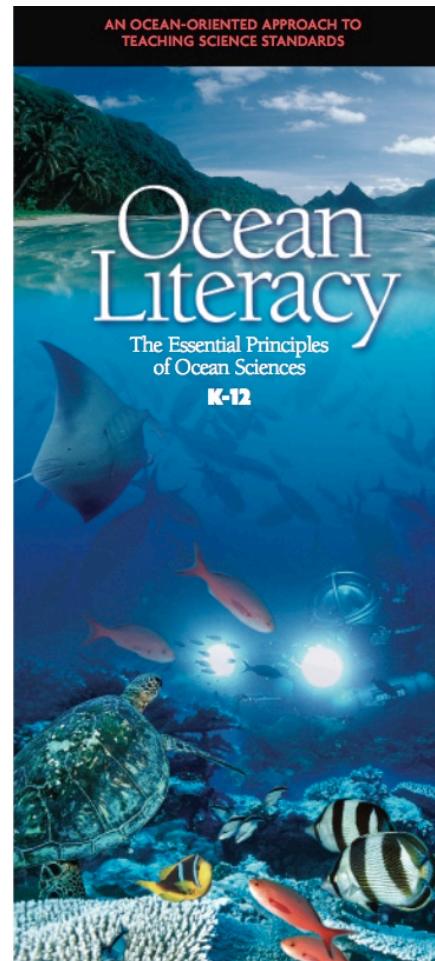
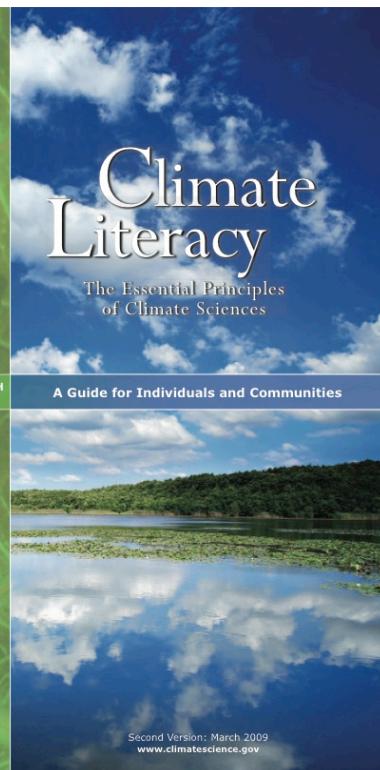
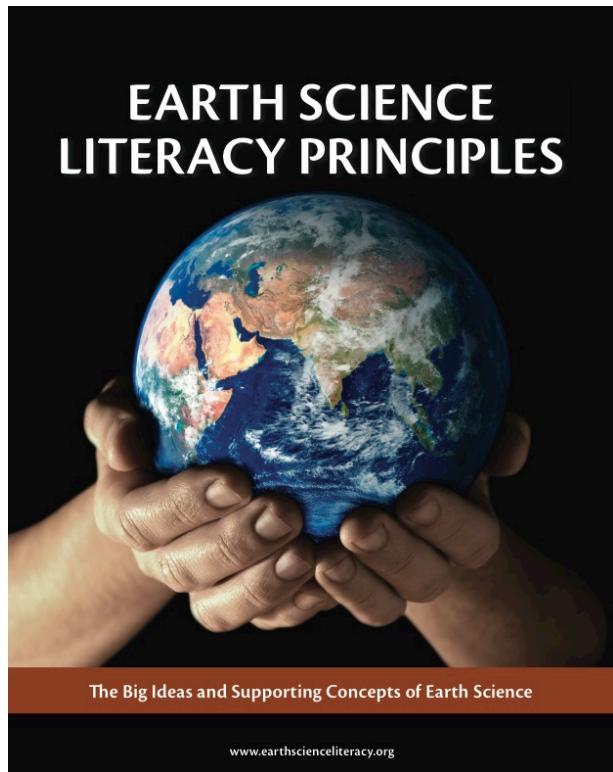


FOREST FOR THE TREES: EARTH SYSTEMS SCIENCE LITERACY INITIATIVES AND THE NEED FOR A SMALLER INTEGRATED SET OF PRINCIPLES

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Recent literacy efforts in Earth systems of Earth science, climate, oceanography, and atmospheric science.



Atmospheric Science Literacy - Essential Principles

1. Earth has a thin atmosphere that sustains life.
2. Energy from the Sun drives atmospheric processes.
3. Atmospheric circulations transport matter and energy.
4. Earth's atmosphere changes over time and space, giving rise to weather and climate.
5. Earth's atmosphere continuously interacts with the other components of the Earth System.
6. We seek to understand the past, present, and future behavior of Earth's atmosphere through scientific observation and reasoning.
7. Earth's atmosphere and humans are inextricably linked.

Climate Literacy - Essential Principles

- G.P. Humans can take actions to reduce climate change and its impact.
1. The sun is the primary source of energy for Earth's climate system.
 2. Climate is regulated by complex interactions among components of the Earth system.
 3. Life on Earth depends on, is shaped by, and affects climate.
 4. Climate varies over space and time through both natural and man-made processes.
 5. Our understanding of the climate system is improved through observations, theoretical studies, and modeling.
 6. Human activities are impacting the climate system.
 7. Climate change will have consequences for the Earth system and human lives.

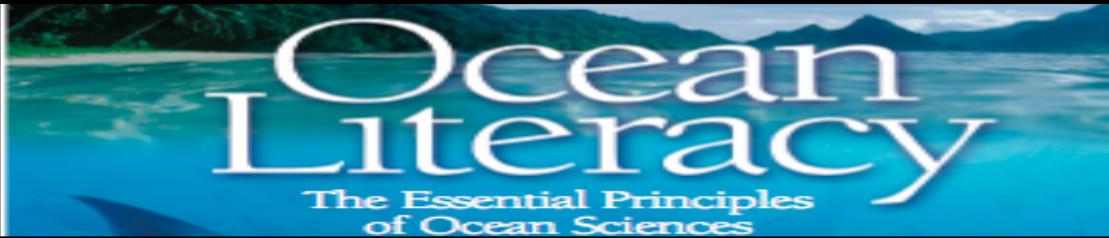
Earth Science Literacy - Big Ideas

1. Earth scientists use repeatable observations and testable ideas to understand and explain our planet.
2. Earth is 4.6 billion years old.
3. Earth is a complex system of interacting rock, water, air, and life.
4. Earth is continuously changing.
5. Earth is the water planet.
6. Life evolves on a dynamic Earth and continuously modifies Earth.
7. Humans depend on Earth for resources.
8. Natural hazards pose risks to humans.
9. Humans significantly alter the Earth.

Ocean Literacy - Essential Principles

1. The Earth has one big ocean with many features.
2. The ocean and life in the ocean shape the features of the Earth.
3. The ocean is a major influence on weather and climate.
4. The ocean makes Earth habitable.
5. The ocean supports a great diversity of life and ecosystems.
6. The ocean and humans are inextricably interconnected.
7. The ocean is largely unexplored.

Where we are:

	Essential Principles	Fundamental Concepts
	7	44
	8	46
	7	33
	9	75
TOTAL	31	198

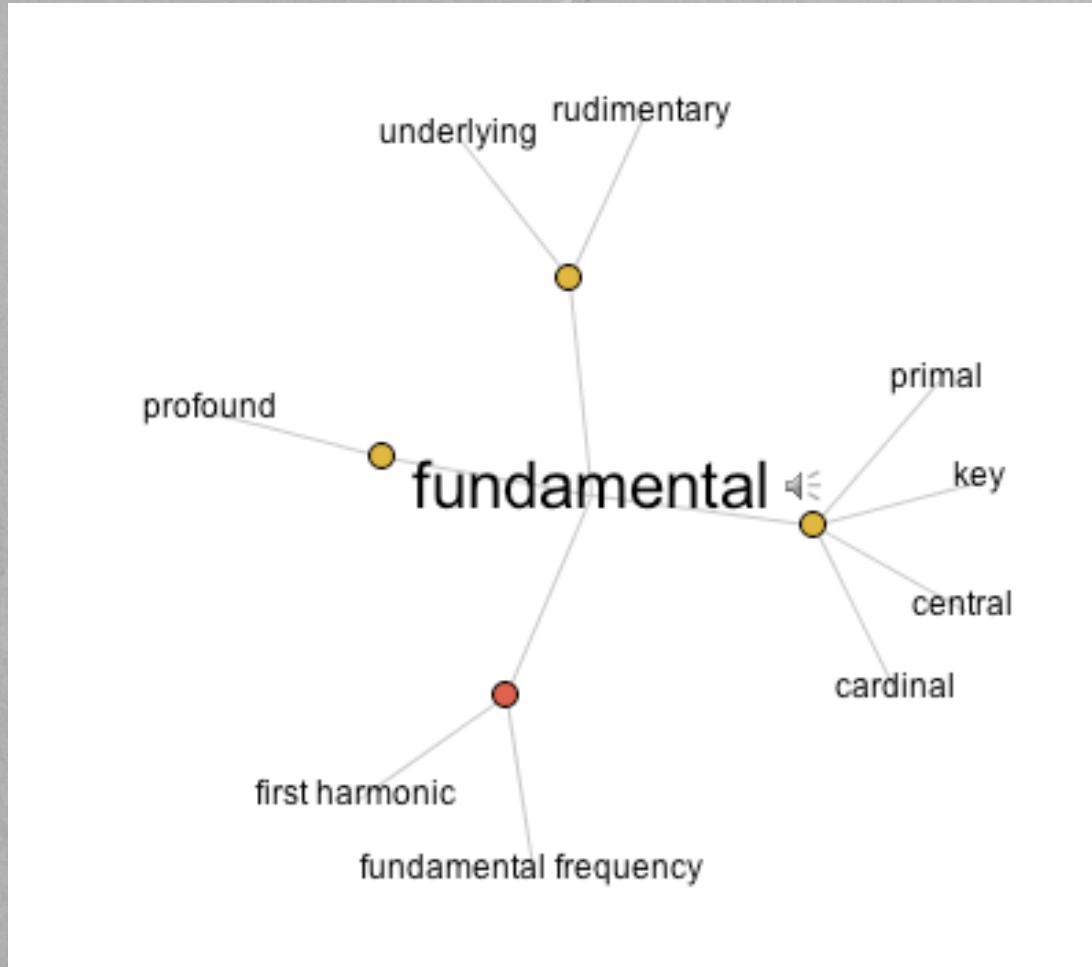
These initiatives:

- Intend to provide educators and citizens, alike, the Essential Principles and fundamental concepts that are deemed necessary for attaining scientific literacy relevant to Earth systems.
- Represent a consensus view of the most important Earth system science concepts.
- However...

We need to attend to the realities of school

- These principles target commencement level expectations.
- The majority of high school Earth science teachers in this country are in just four states.
- Physics, chemistry & biology dominate high school science (and have for 100 years).
- If Earth systems science is taught, astronomy is usually included in the same one year course.

So, we have around 200 fundamental concepts...



...to teach in 180 days of instruction.

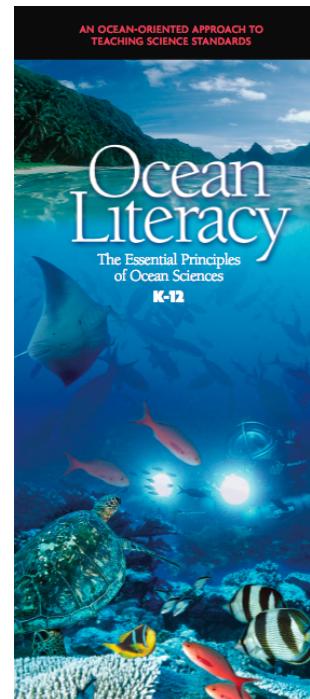
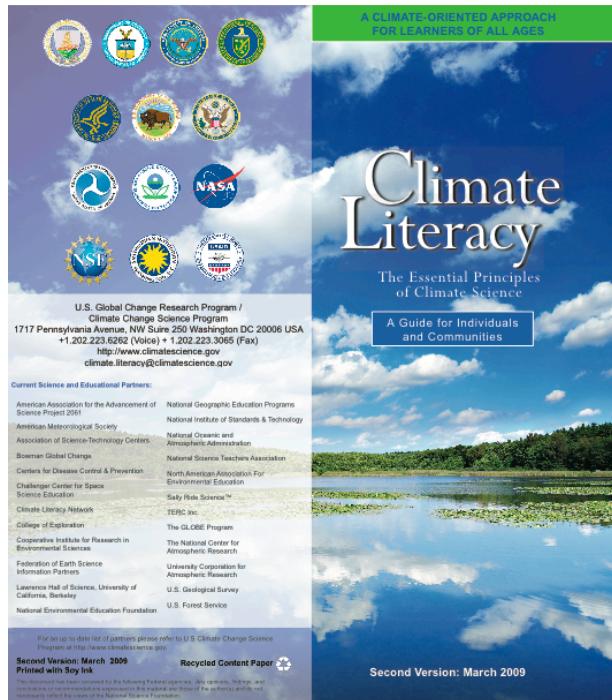
Good
luck with
that!



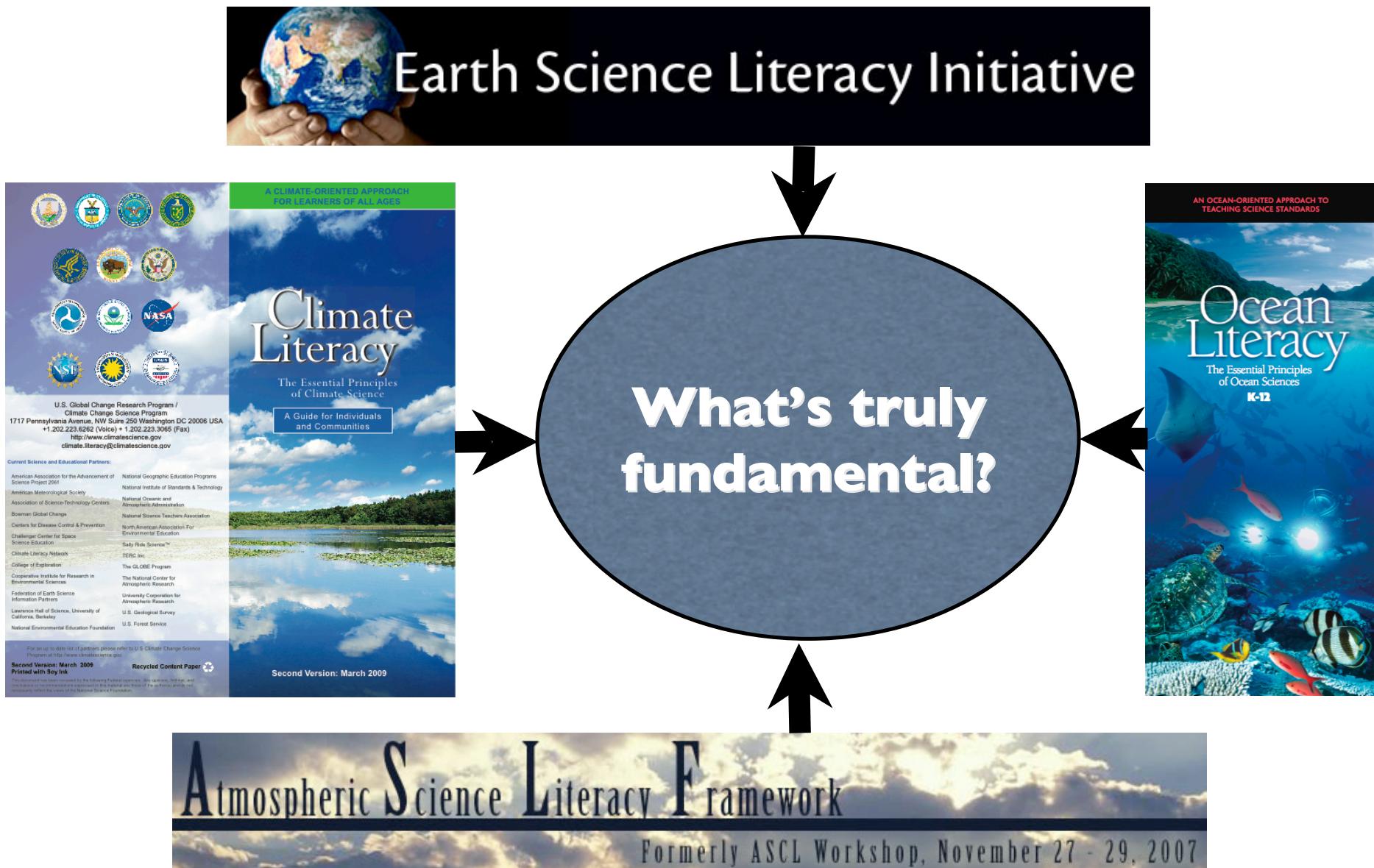
There are *no* examples of creating a thick description of what everyone should understand about *any* topic that has led to wide swaths of the population understanding the target content, in spite of countless attempts to do just that throughout human history.

**“Big ideas”
aren’t big
enough.**

How can we synthesize?



How can we synthesize?



What if we taught only a few profound ideas, but taught them deeply?

- Deep understanding of profound ideas requires knowledge of all (or most) of the literacy principles.
- *And* connects them to a coherent framework, thus increasing the likelihood of true understanding and retention.

If you asked your students to state the most vitally important ideas from your class...

- What would they say?
- How does that compare to what you hope they would say?

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.

Earth Science Bigger Ideas & Overarching Questions

Overarching Questions:

How do we know what we know?

How does what we know inform our decision-making?

The 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 rapid and gradual changes in the Earth system.	To understand (deep) space and time, models and maps are necessary.
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Does each idea cut across the entire Earth science curriculum?

Earth Science Bigger Ideas & Overarching Questions

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

Overarching Questions:

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

Bigger Ideas	<u>Ocean</u>	<u>Climate</u>	<u>Atmosphere</u>	<u>Earth Science</u>
Earth is a system of systems.	The ocean is a major influence on weather and climate.	Climate is regulated by complex interactions among components of the Earth system.	Earth's atmosphere continuously interacts with the other components of the Earth System.	Earth is a complex system of interacting rock, water, air, and life.
The flow of energy drives the cycling of matter.	The ocean supports a great diversity of life and ecosystems.	Life on Earth depends on, has been shaped by, and affects climate.	Energy from the Sun drives atmospheric processes.	Humans significantly alter the Earth.
Life, including human life, influences and is influenced by the environment.	The ocean makes Earth habitable.	The Sun is the primary source of energy for Earth's climate system.	Atmospheric circulations transport matter and energy.	Humans depend on Earth for resources.
Physical and chemical principles are unchanging and drive both gradual and rapid changes in the Earth system.	The ocean and humans are inextricably interconnected.	Climate change will have consequences for the Earth system and human lives.	Earth's atmosphere and humans are inextricably linked.	Natural hazards pose risks to humans.
	The ocean and life in the ocean shape the features of the Earth.	Human activities are impacting the climate system.	Earth has a thin atmosphere that sustains life.	Earth scientists use repeatable observations and testable ideas to understand and explain our planet.
	The Earth has one big ocean with many features.	Humans can take actions to reduce climate change and its impacts.	Earth's atmosphere changes over time and space, giving rise to weather and climate.	Life evolves on a dynamic Earth and continuously modifies Earth.
To understand (deep) space and time, models and maps are necessary.	The ocean is largely unexplored.	Climate varies over space and time through both natural and man-made processes.	We seek to understand the past, present, and future behavior of Earth's atmosphere through scientific observation and reasoning.	Earth is continually changing.
		Our understanding of the climate system is improved through observation, theoretical studies and		Earth is 4.6 billion years old.
				Earth is the water planet.

Atmospheric Science Literacy - Essential Principles

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3. Atmospheric circulations transport matter and energy.
4. Earth's atmosphere changes over time and space, giving rise to weather and climate.
5. Earth's atmosphere continuously interacts with the other components of the Earth System.
6. We seek to understand the past, present, and future behavior of Earth's atmosphere.

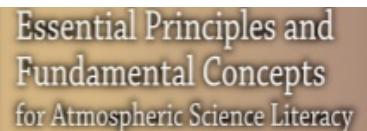
7. Our second approach to creating a smaller, integrated list was based on a content analysis of the four published sets of essential principles.

Earth Science
For most of the Essential Principles a concept in one list aligned well with a concept in at least one other list.

1. Earth is a complex system.
 2. Earth is 4.6 billion years old.
 3. Earth is a complex system of interacting rock, water, air, and life.
 4. Earth is continuously changing.
 5. Earth is the water planet.
 6. Life evolves on a dynamic Earth and continuously modifies Earth.
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 8. Natural hazards pose risks to humans.
 9. Humans significantly alter the Earth.
-
- ## Climate Literacy - Essential Principles
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1. The sun is the primary source of energy for Earth's climate system.
 2. Climate is regulated by complex interactions among components of the Earth system.
 3. Life on Earth depends on, is shaped by, and affects climate.
- Climate varies over space and time through both natural and human-influenced processes.

Earth systems

Exploration of Earth Systems occur through observations, scientific reasoning, and modeling



(#6)

We seek to understand the past, present, and future behavior of Earth's atmosphere through scientific *observation and reasoning*.



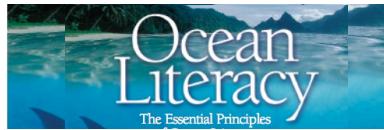
(#5)

Our understanding of the climate system is improved through *observations, theoretical studies, and modeling*.



(#1)

Earth scientists use repeatable *observations and testable ideas* to understand and explain our planet.



(#7)

The ocean *is largely unexplored*.

Earth systems

Earth is 4.6 billion years old

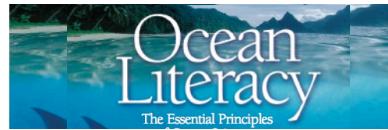
Essential Principles and
Fundamental Concepts
for Atmospheric Science Literacy



EARTH SCIENCE
LITERACY PRINCIPLES

(#2)

Earth is 4.6 billion years old



Integrated list of eleven overarching Essential Principles

1. Exploration of Earth Systems occur through observations, scientific reasoning, and modeling
2. Earth Systems involve complex interactions between rock, water, air, and life
3. The sun is the primary source of energy for Earth's climate system
4. Matter and energy are transported and transformed by Earth system processes (e.g., tectonic plate motions, denudation, and atmospheric and oceanic circulations)
5. Earth systems are continuously changing.
6. Humans are inextricably interconnected to the geosphere, hydrosphere, and atmosphere
7. Natural disasters and climate change threaten human civilization
8. Humans have become a significant agent of change to the geosphere, hydrosphere, and atmosphere
9. The biosphere depends on and affects the hydrosphere, the atmosphere, and the geosphere
10. Earth has a multifaceted ocean that covers most of Earth's surface.
11. Earth is 4.6 billion years old

Five overarching categories

1. Exploration of Earth Systems occur through observations, scientific reasoning, and modeling

Nature of science
 2. Earth Systems involve complex interactions between rock, water, air, and life
 3. The sun is the primary source of energy for Earth's climate system
 4. Matter and energy are transported and transformed by Earth system processes (e.g., tectonic plate motions, denudation, and atmospheric and oceanic circulations)
 5. Earth systems are continuously changing.

 6. Humans are inextricably interconnected to the geosphere, hydrosphere, and atmosphere
 7. Natural disasters and climate change threaten human civilization
 8. Humans have become a significant agent of change to the geosphere, hydrosphere, and atmosphere

 9. The biosphere depends on and affects the hydrosphere, the atmosphere, and the geosphere

Life
 10. Earth has a multifaceted ocean that covers most of Earth's surface.
 11. Earth is 4.6 billion years old
- Magnitude of time and space**

Five overarching categories

Nature of science

Matter & energy fluxes

Humanity & nature

Life

Magnitude of time and space

Bigger Ideas & Overarching Questions

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

The Earth is a system of systems.

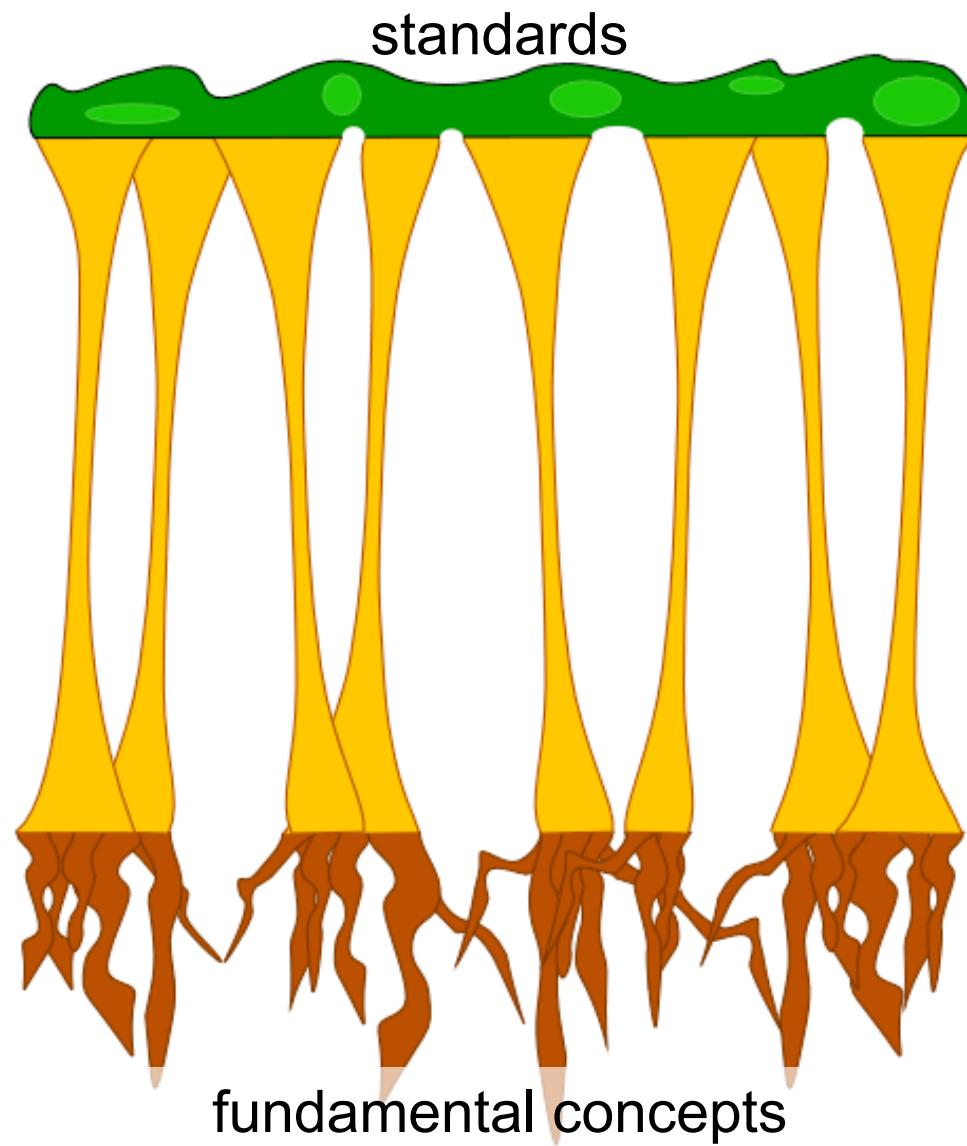
The flow of energy drives the cycling of matter.

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

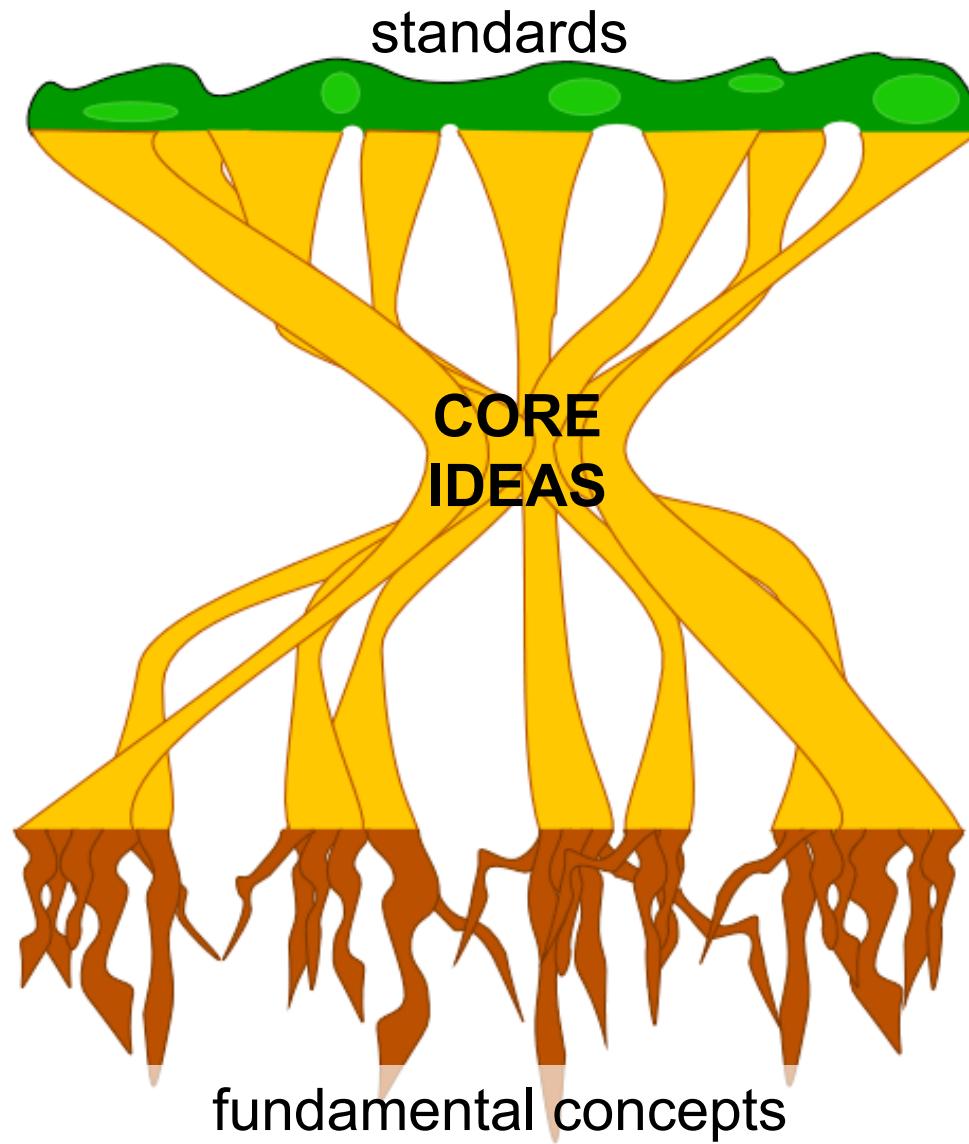
Life, including human life, influences and is influenced by the environment.

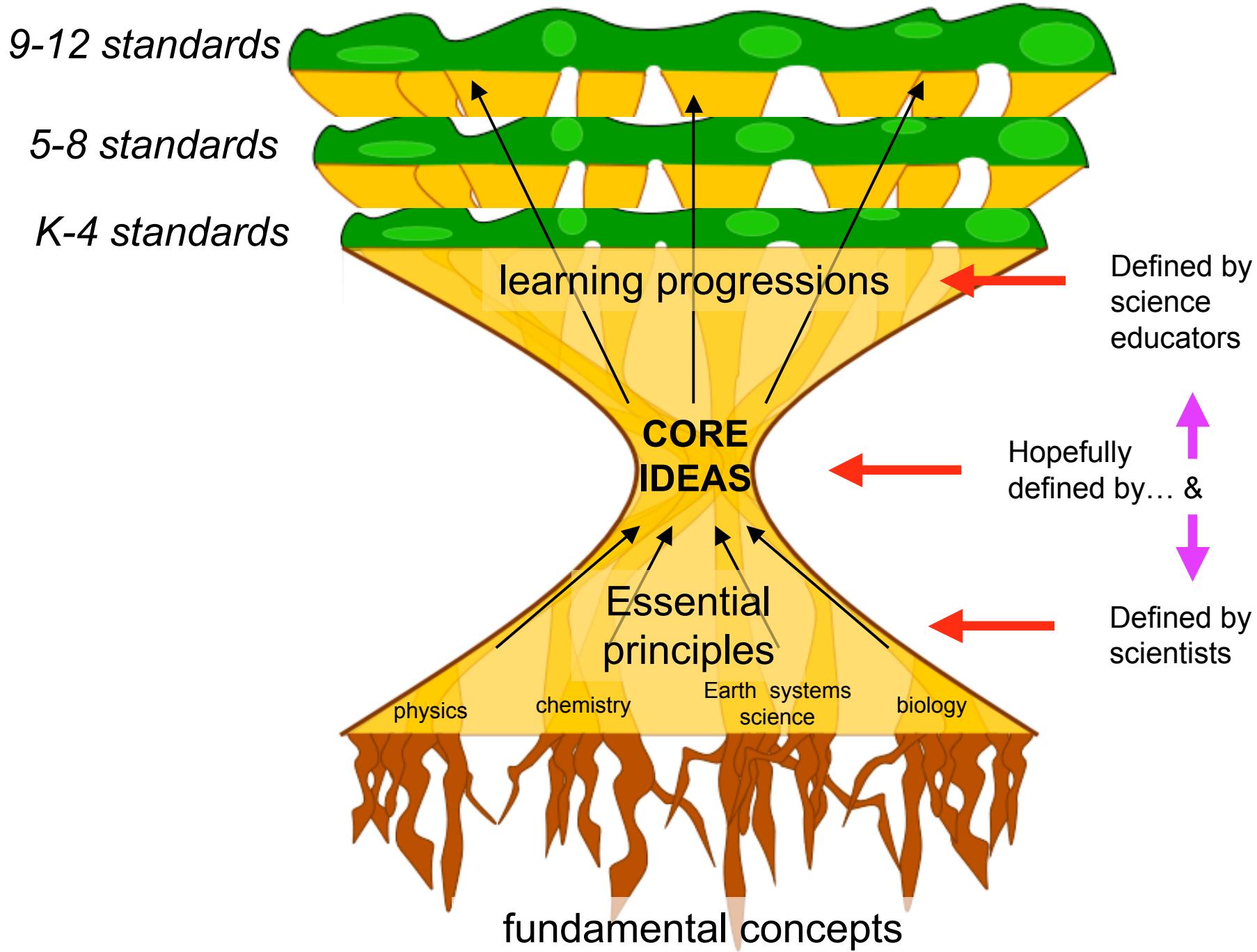
To understand (deep) space and time, models and maps are necessary.

Seeing the forest for the trees



Seeing the forest for the trees



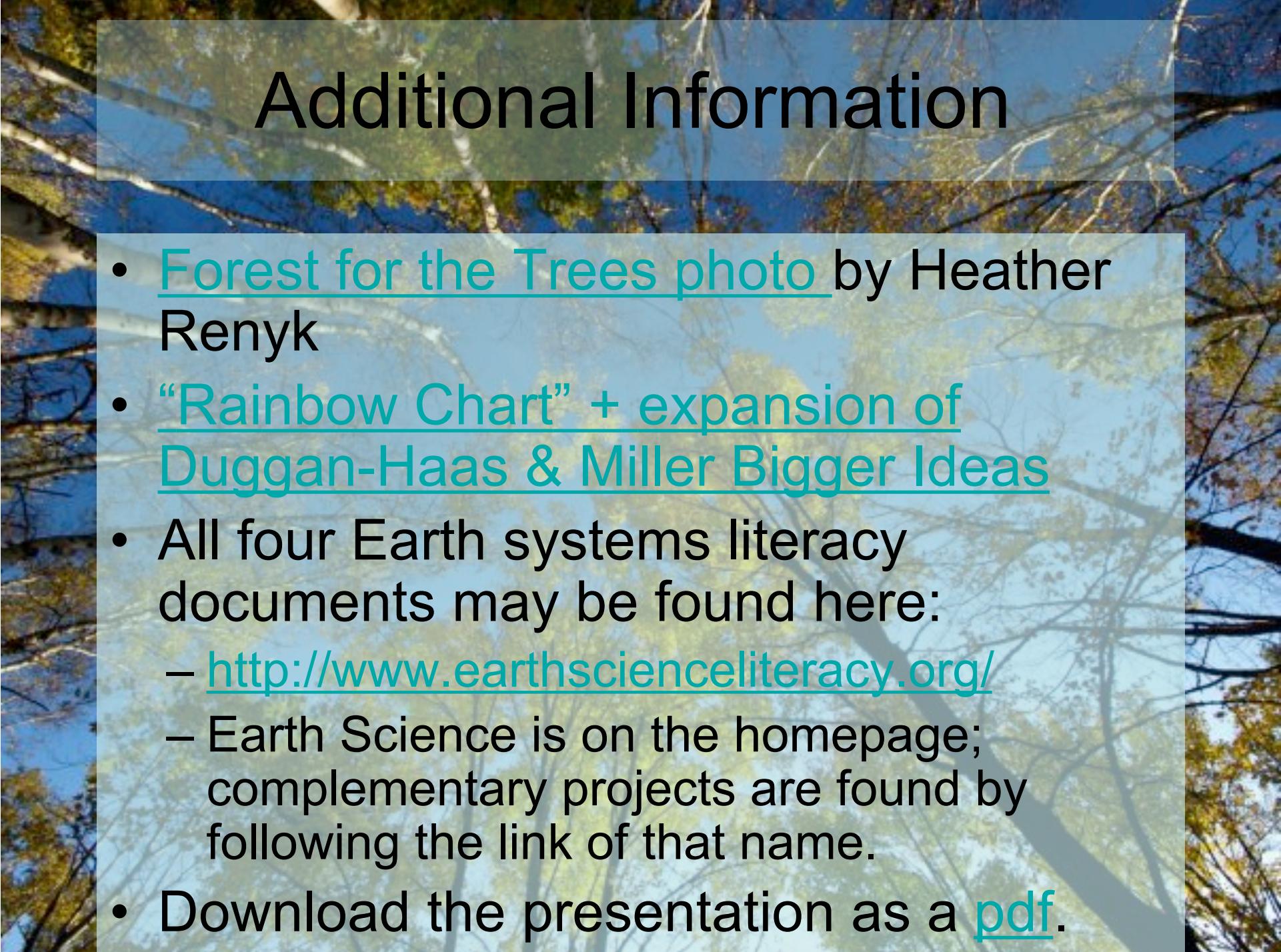




Questions?

**JUST
ONE:**

**CREATE
&
USE
A
SMALL,
MEMORABLE
&
COHERENT
SET OF
IDEAS.**



Additional Information

- Forest for the Trees photo by Heather Renyk
- “Rainbow Chart” + expansion of Duggan-Haas & Miller Bigger Ideas
- All four Earth systems literacy documents may be found here:
 - <http://www.earthscienceliteracy.org/>
 - Earth Science is on the homepage; complementary projects are found by following the link of that name.
- Download the presentation as a pdf.