

Synthesizing Earth System Essential Principles: What Everyone Needs to Know

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A series of initiatives have been undertaken to define what constitutes literacy in Earth system science disciplines and in environmental education.

The process has yielded a multitude of “essential” principles.

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.

2

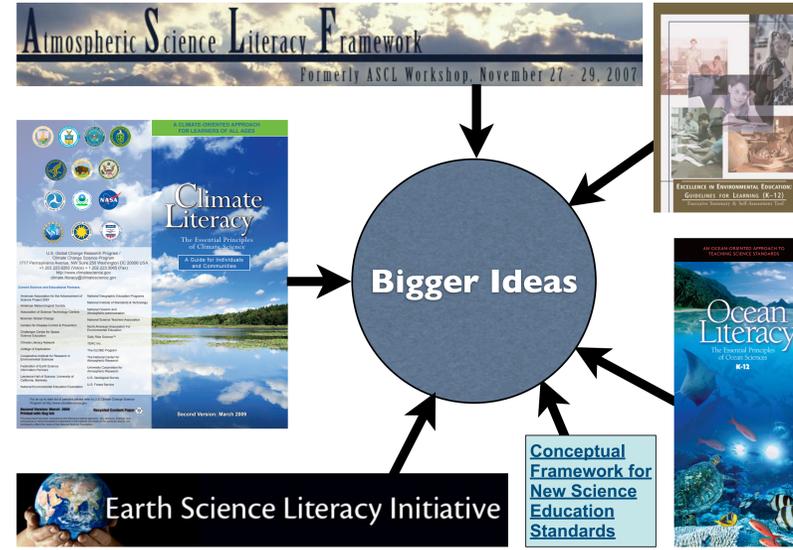
Where we are:

	Essential Principles	Fundamental Concepts
	7	44
	8	47
	7	33
	9	75
TOTAL	31	198

These totals do not include the NAAEE Guidelines or the Core Ideas from the NRC's Framework for Science Education: Preliminary Public Draft.

3

How can we synthesize?



4

“Big ideas” simply aren’t big enough.

5

The second of three key findings of the National Research Council’s Committee on How People Learn is:

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.

These charts use a framework of five BIGGER IDEAS and two overarching questions to provide a coherent framework for the ideas expressed in the various literacy documents.

Color-coding is used to show which big idea or overarching questions connect most directly to different principles. White coloration indicates connection to overarching questions.

6 Overarching Questions: <i>How do we know what we know? How does what we know inform our decision making?</i>					
Bigger Ideas <i>Real Earth System Science</i> http://virtualfieldwork.org/Big_Ideas.html	Earth & Space Science Core Ideas <i>A Framework for Science Education: Preliminary Public Draft</i>	Ocean Literacy Principles http://coexploration.org/oceanliteracy/documents/OceanLitChart.pdf	Climate Literacy Principles http://climateliteracynow.org	Atmospheric Science Literacy Principles http://eo.ucar.edu/asl/index.html	Earth Science Literacy Big Ideas http://www.earthscienceliteracy.org/
Earth is a system of systems.	Earth is a complex and dynamic 4.6-billion-year-old system of rock, water, air, and life.	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.	Earth’s surface continually changes from the cycling of water and rock driven by sunlight and gravity.	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.	Human activities are constrained by and, in turn, affect all other processes at Earth’s surface.	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.	Humans are a small part of a vast Universe; planet Earth is part of the Solar System, which is part of the Milky Way galaxy, which is one of hundreds of billions of galaxies in the Universe.	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.
To understand (deep) space and time, models and maps are necessary.		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.
		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 modeling.		Earth is 4.6 billion years old.
					Earth is the water planet.

These are in draft form and are expected to change slightly.

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These could be expanded and aligned as the above are. Focus was upon Earth system science (ESS). While these areas are clearly connected to ESS, the level of detail is beyond the scope of the other initiatives. The yellow to green shading of this arrow, coupled with the rainbows are intended to show that all of the big ideas are addressed within *The Guidelines*.

Excellence in Environmental Education: Guidelines for Learning (K–12)
<http://www.naaee.org/programs-and-initiatives/guidelines-for-excellence/>

Strand 1: Questioning, Analysis and Interpretation Skills
Strand 2: Knowledge of Environmental Processes and Systems
2.1—The Earth as a physical system
A) Processes that shape the Earth—Learners understand the major physical processes that shape the Earth. They can relate these processes, especially those that are large-scale and long-term, to characteristics of the Earth.
• Relate different types of climate to processes such as the transfer of heat energy, cloud formation, wind and ocean currents, atmospheric circulation patterns, and the cycling of water. Explain how positive feedback loops can affect climate.
• Use examples such as the El Niño effect or the Santa Ana winds to illustrate how changes in wind patterns or ocean temperatures can affect weather in different parts of the world.
• Explain distinctive landforms in terms of the physical processes (particularly those related to changes in the Earth’s crust or long-term processes such as erosion) that shaped them.
• Describe possible relationships between surface water and ground water. For example, create a model or a cross-sectional drawing that shows surface- and groundwater flows in a local drainage. Explain why surface and ground water are related in these ways.
B) Changes in matter—Learners apply their understanding of chemical reactions to round out their explanations of environmental characteristics and everyday phenomena.
• Explain everyday chemical reactions such as burning fossil fuels, photosynthesis, or the creation of smog in terms such as the release or consumption of energy, the products of these reactions, and how these products may be involved in further chemical reactions and/or affect biogeochemical cycles.
• Explain the chemical components of biological processes such as photosynthesis, respiration, nitrogen fixation, or decomposition, and how biological and physical processes fit in the overall process of biogeochemical cycling.
• Explain why elements cycle through the biosphere at different rates, describing influences on reaction rates. (Oxygen and nitrogen cycle quickly, for example, while phosphorus tends to be released from its immobile form more slowly, depending upon factors such as soil acidity.)
C) Energy—Learners apply their knowledge of energy and matter to understand phenomena in the world around them.
• Compare different means of generating electricity (such as coal-burning plants, nuclear reactors, wind, geothermal, and hydropower) in terms of the transformation of energy among forms, the relationship of matter and energy, and efficiency/production of heat energy.
• Explain differences in conductivity among materials and relate these ideas to real-world phenomena.
• Compare the efficiency of various types of motors or heating systems.
• Use the laws of thermodynamics to explain why natural systems need a certain amount of energy input to maintain their organization.
• Explain the dynamic relationship between greenhouse gases, solar energy absorption and radiation, and climate.
2.2—The living environment
2.3—Humans and their societies
2.4—Environment and society
Strand 3: Skills for Understanding and Addressing Environmental Issues
3.1—Skills for analyzing and investigating environmental issues
3.2—Decision-making and citizenship skills
Strand 4: Personal and Civic Responsibility

