Science Newsletter

Volume 1, Issue 4
High School Edition

Earth and the Universe: *What does it look like?*

At the elementary level, students begin to look at the processes that shape the Earth, eventually moving into the Earth-sun-moon system. At the middle level, students begin to investigate *how* these changes occur. In the space sciences, students move beyond observations and into the concept of scale.

At the high school level students assimilate this learning through the use of models and observations to bring supporting evidence to explain these phenomena. In the space sciences, students look at the universe as a whole, analyzing evidence for origins of the universe and its components.

The Break Down

Earth and the Universe is composed of topics from the earth sciences and the space sciences. They can be described as follows:

A) Earth Sciences

- analysis and constraints of methods for determining the age of the earth and geologic features
- the scientific development of the Theory of Plate Tectonics—from Wegner's continental drift to our current model
- the short- and long-term impact of changes on the geology and biology of the planet.

B) Space Sciences

- role of gravity in the formation of the universe
- analysis of theories related to astronomical formation (nebular theory for solar systems; big bang for the universe)
- analysis, and constraints, of methods for determining the age of the solar system and universe
- stellar life cycles and their role in developing heavy elements
- the concept of *speed of light* and its role in "looking back in time"

Common Misconceptions

A) Earth Sciences

- Students have difficulty connecting mountain building and volcanoes with the Theory of Plate Tectonics. They believe that the earth today is as it always has been.

B) Space Sciences

- The most common student misconceptions concern stars: students believe that all stars are the same distance from the earth, they are evenly distributed throughout the universe, they are all the same, and their brightness depends only on its distance from the earth.

C) Gravity

- Students have difficulty grasping the concept of gravity. Part of the difficulty arises from the concept of "down" (Why don't people in the Southern Hemisphere 'fall off'?).
- Some students believe that there is a connection between air and gravity, that air "pushes" them onto the Earth. As such, students don't believe that gravity occurs in space or planets/moons without an atmosphere (thought to be due to Hollywood's portrayals).
- Students have difficulty with gravitational magnitude. Some believe that gravity increases with height; some believe that gravity decreases with height while others believe that gravity increases with height until the object leaves Earth's atmosphere. (*Making Sense of Secondary Science, p. 164*) It is suggested that "…teaching the concepts of spherical earth, space, and gravity in close connection to each other" will help clarify this misconception. (*Benchmarks for Science Literacy, p. 335*)

D) Models

- Students lack the distinction between the engineering model of experimentation (production of desirable outcome) and the scientific model of experimentation (understanding the relation between cause and effect).
- Students believe that all models are physical copies, not conceptual representations.
- Students don't understand that comparing its implications with actual observations tests a model. This very important concept is imperative to the understanding of scientific theories and how they become stronger with predicted observational data.

Resources

A) General

NSTA Learning Center (http://learningcenter.nsta.org)

The undiscovered resource for finding some free stuff! You have access to journal articles, science objects (interactive, simulation-based learning), e-chapters from selected books, and web seminars. To download free material you'll need to register (also free). After registering you will have your own "library" of downloads, a place to journal your learning, and a future feature will be a one-stop record of your NSTA conference participation. NSTA's Learning Center can hold your professional development documentation.

B) Earth Science

1. Who's on First? A Relative Dating Activity (http://www.ucmp.berkeley.edu/fosrec/BarBar.html)

This inquiry-based activity leads students through the concept of fossil correlation to relatively date rock layers. Instructions, teacher notes, and suggested evaluative questions are included.

2. Scientific American Frontiers (http://www.pbs.org/saf/1305/video/watchonline.htm)

Into the Deep is a two-part program with Dr. Robert Ballard. In Park 1, Dr. Ballard talks about his discovery of hydrothermal vents along the mid-ocean ridge, the life forms there, and how these vents change the chemistry of the ocean and land (SC-H-EU-S-2). Part 2, though not directly related to content, chronicles his career change from a geologist to an explorer; the process and reasoning he used to find the Titanic, Lusitania, and other sunken ships; and his vision for human's colonizing the world's oceans (what a great class discussion!)

3. This Dynamic Earth: The Story of Plate Tectonics (http://pubs.usgs.gov/gip/dynamic/dynamic.html)

This USGS publication provides information about the historical development of the theory, its evidence, and the effect of plate movement on the planet and its life. You can download a copy of the entire publication for printing.

C) Space Science

1. Scientific American Frontiers (http://www.pbs.org/saf/1405)

The Dark Side of the Universe discusses topics such as the Big Bang, dark matter and dark energy. Much of what is presented in this episode deals with the use of modeling and computer simulations to study evidence about the universe (SC-H-EU-U-6). This episode is divided into three segments and you can choose where you'd like to start via transcript lines. A teacher's guide and web resources are also available.

2. NOVA (http://www.pbs.org/wgbh/nova/blackhole)

Monster of the Milky Way discusses black holes that are found in the center of galaxies, including our own Milky Way. The power of this video is how it shows the process of science: predictions, discoveries, co-operation among scientists, and the independent findings of different teams coming to the same conclusions.

The show is divided into seven convenient chapters. Chapter 2 deals specifically with the concept of gravity. An activity you can do in class to teach or reinforce this concept is found in the Black Hole Educator's Guide (activity 3) at http://glast.sonoma.edu/teachers/blackholes/index.html . A large-scale demonstration model can be found from Gravity Probe-B (http://einstein.stanford.edu). Link to "gp-b classroom" and then "spacetime model instructions".

3. Dark Matter: Probing What You Can't See (http://universe.sonoma.edu/activites/dark_matter.html)

This activity takes students through a simulated process of "how do we know it's there if we can't see it". This is an excellent inquiry-based activity, complete with background information for teachers. You may wish to use this in conjunction with the *Frontiers* segment.

4. Bad Astronomy (http://www.badastronomy.com)

This website, hosted by astronomer Dr. Phil Plait, is a great source for news and correct information about common misconceptions (i.e. the Moon Landing Hoax). Phil also critiques movies for their science content—useful for teachers! I work with Phil through my work with NASA Education and Public Outreach at Sonoma State University, and I can say that he's very knowledgeable, personable, and writes in a way a layperson can understand—definitely not your stereotypical scientist.

5. The Origin of the Solar System (http://csep10.phys.utk.edu/astr161/lect/solarsys/nebular.html)

This is a series of lecture notes, complete with diagrams, that explain the Nebular Theory of our solar systems formation. The entire lecture series about the solar system is available.

D) Cool Stuff to add discussion to the class

1. SOHO Screensaver (http://sohowww.nascom.nasa.gov/freestuff)

A free downloadable screensaver that updates the newest **live** images of the sun every time your computer goes into screensaver mode. All images are from the SOHO (Solar and Heliospheric Observatory) satellite. This was a talking piece in my class during class change or after lunch, especially since there are a number of filters on the satellite. This confused students when the sun was blue or green until they understood what the filters were doing. You can also talk about sunspots and coronal mass ejections.

2. Earth Science Picture of the Day (http://epod.usra.edu)
3. Astronomy Picture of the Day (http://antwrp.gsfc.nasa.gov/apod/astropix.html)

Both of these sites are sponsored by NASA's Goddard Space Flight Center and have a description of each day's image, including an archive. This is a great resource if you're looking for pictures/images of specific objects.

What is 'critical' vocabulary for science?

In his book *Building Background Knowledge for Academic Achievement*, Dr. Robert Marzano provides estimates of the number of terms that can be taught at various grade levels. Marzano suggests that while students in 1st grade can only be taught one new word per week, this number rises to five words/week in 4th grade, to 20 words/week by 7th grade and peaks at 25 words/week in high school. These numbers are cumulative across all subjects and not just limited to science. In essence Marzano, who is a supporter of direct vocabulary instruction, has determined that 4 to 5 new terms per week are the maximum (for high school) that can be successfully introduced in any subject area. This requires teachers to identify terms that are truly 'essential' rather than those that are only 'supplemental' and to focus on the essential.

For example, consider this list of terms from a chapter on earth history from a general science text:

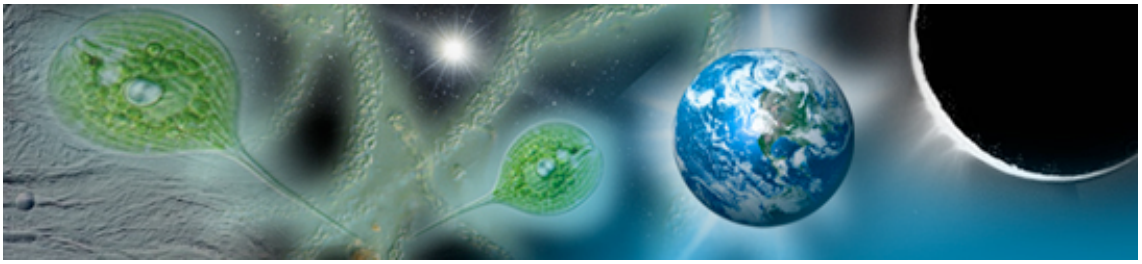
cast	Cenozoic era	fossil	geologic time	geologic time scale
Mesozoic era	Mold	Paleozoic era	petrification	Precambrian era

Marzano suggests that a viable option for schools to separate the essential terms from the supplemental ones is to identify only those that are essential for all students to learn regardless of their aspirations after high school. Using this criterion, not all of these 10 words can be truly considered essential. The list could potentially be reduced to as few as two terms: fossil and geologic time.

It is important to remember that students can often recall the definitions of new terms from working memory, yet be unable to apply the true meaning of those terms to new and unfamiliar situations. Narrowing the number of terms they are required to learn allows us to teach for understanding rather than for simple recall that never rises beyond DOK 1.

Finally, it is important to realize that there is no vocabulary list for the KCCT. Several districts/individuals have created lists, but the KDE and the Content Advisory Committees for Science do not have or use any such list.

Earth and the Universe—Education and Implications



According to the 2006 high school science KPR (Kentucky Performance Report), the worst performing sub-domain was earth/space sciences. Twenty-five percent of all open-response questions were scored either a blank or a zero, and only one percent scored a 4. It has been suggested that one reason for this trend is that earth/space science has been incorporated into an integrated course taught at 9th grade. While there is nothing wrong with this, students may not have fully grasped the importance of these sciences, especially if they're treated as stand-alone disciplines. Through an incorporation of the earth and space sciences with other science disciplines, students gain a higher understanding of the sciences.

One method by which this integration can be accomplished is through the interdisciplinary science of astrobiology—a cutting-edge discipline. It is described as:

> Astrobiology is devoted to the scientific study of life in the universe - its origin, evolution, distribution, and future. This multidisciplinary field brings together the physical and biological sciences to address some of the most fundamental questions of the natural world: How do living systems emerge? How do habitable worlds form and how do they evolve? Does life exist on worlds other than Earth? How could terrestrial life potentially survive and adapt beyond our home planet?
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> Scientists now realize that the origin and evolution of life itself cannot be fully understood unless viewed from a larger perspective than just our own Earth. Biologists are working with astronomers to describe the formation of life's chemical precursors, to discover new planets, and to determine their habitability; with chemists to understand the transition from molecular interaction to life itself; with geologists to search for evidence of water and key minerals on other planets; with paleontologists and evolutionary molecular biologists to look for and comprehend the earliest forms of life, as well as with climatologists, planetary scientists, and researchers from nearly every field of science.
>
> NASA Astrobiology Institute

I am aware of two curricula that are currently available for this discipline. One is *Astrobiology* developed by TERC (http://astrobio.terc.edu). This curriculum comes complete with student text and teacher materials. Each section has a "challenge" that, due to its openness, students of all levels can complete. The end of the course has a culminating activity for students to complete. The second is *Voyages Through Time* developed by the SETI Institute (http://www.voyagesthroughtime.org). All lessons are on CD-ROM and are based on the theme of evolution (universe, planetary systems, life, technology). Both of these are inquiry-based, integrated courses developed primarily for 8th /9th grade.

For further information and resources about this exciting discipline, check out the NASA Astrobiology Institute (http://nai.nasa.gov) or the Astrobiology homepage (http://astrobiology.arc.nasa.gov).

I am currently gathering information about how schools cover the earth and space science topics. If any one is interested in pursing a course in astrobiology, please contact me directly (rae.mcentyre@education.ky.gov)