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Pemaquid Point Lighthouse located near Bristol, Maine. Shot by Paul Riewerts on 08/24/2010 using a Nikon D300 camera, 24mm focal length, F22 aperture, 1/2.5s shutter speed, ISO 200. Visit www.PaulRPhotography.com to see more of Paul’s work.

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**From the President**

*by Ardis Herrold, NESTA President 2010 – 2012*

**“Rth Science”**

I have a proposal for the membership: Can we rename what we teach?

Since our last issue, we have witnessed the effects of deadly tornadoes and massive floods. The last Space Shuttle has launched into space. Gas prices linger near record high levels. And yet, Earth Science is still not emphasized in the K-12 curricula in many parts of the country. The situation is really sadder still. Science itself is not emphasized.

In a time when our nation continues to push for excellence in education, the many initiatives such as Race to the Top, the Common Core Standards Initiative and No Child Left Behind do not directly address scientific literacy as an essential outcome for K-12 education. What are the essentials? The three R’s, of course! Never mind that only one of them begins with that letter. Reading, writing and mathematics are considered to be the three areas of competency most related to economic success.

Is the primary goal of our educational system to turn out a cadre of moneymakers? Does it matter at all, that in an increasingly technological world, our citizens should have at least a basic knowledge of science? What about learning to preserve that world and finding the best ways to exist within the many nuances of its systems? Would science literacy serve us well when making complex ethical decisions, or when voting? What about encouraging the study of science for the sake of random discovery?

The Space Shuttle is an iconic example of what science and technology can accomplish when allowed to flourish. Some may argue the Shuttle’s relevancy, but the Space Shuttle program was responsible for developing over one hundred direct technology spinoffs that led to the development of items such as the artificial heart, green lubricants and infrared firefighting equipment.

Back to my proposal: Why rename Earth Science? First, it has “R” appeal. If mathematics can be called “rithmetic”, then why can’t we drop two vowels to become members of the elite R group? Our R also stands for Relevant. (Notice how other sciences do not have such prominent R appeal.)

Shortly before its final launch, Space Shuttle Commander Chris Ferguson said, “The shuttle’s always going to be a reflection to what a great nation can do when it dares to be bold and commits to follow through. We’re not ending the journey today...we’re completing a chapter of a journey that will never end.” As teachers, we probably all feel a bit of this each time we say goodbye to another class at the end of the year. So, this fall, as you are beginning this next chapter with all of your new charges, keep it relevant and fun as you teach the lifetime gift of the very important four R’s.

FROM THE EXECUTIVE DIRECTOR

by Roberta Johnson

Dear NESTA Members,

Greetings from NESTA at the beginning of another school year! I hope you have had a great and restful summer, and are reinvigorated for the school year to come. Furthermore, I hope that the resources and programs we in NESTA offer will help support you in your teaching.

I hope you enjoy the photos at the left that my family took earlier on our summer vacation this year. We spent a week in Moab, Utah, including three days in Arches National Park. What a fabulous location for geology enthusiasts! In fact, while we were there, we were delighted to see three universities (two from Massachusetts and one from Santa Barbara) doing field courses with students – they were staying in the campground, too. Of course, I have loaded our summer’s geologic photos up on our NESTA website in our Image Galleries with the hope that these images may be useful to you, too. I hope you return the favor by loading up your geologic photos of interest to our website, to help your fellow teachers and NESTA members!

You can load up images on our website (http://www.nestanet.org/cms/content/resources/submit).

This issue of The Earth Scientist includes a listing of our events at the Fall 2011 NSTA Area Conferences in Hartford, New Orleans, and Seattle. In addition to our traditional and ever popular Share-a-Thons and Rock and Mineral Raffles, we are adding three workshops at each Conference! The workshops will focus on Earth System science, climate change, and geology, leveraging our new program, Windows to the Universe (http://www.windows2universe.org/)! At each conference, all of our events will be in the same room, and scheduled on Friday – providing you with a full day of Earth science professional development from NESTA. Our events are free with registration at the NSTA conference. I hope we get to see you at one or more of our events!

Many Earth and Space Science teachers – members and non-members of NESTA – consistently mention the value of our Share-a-Thons at the NSTA conferences. Some have told me that this event is the reason that they attend NSTA, since they can get so much information from trusted
sources, all in one place! If you will be able to attend the meetings and you have a classroom activity that you think is particularly valuable in terms of achieving learning objectives and that consistently works for students, please do consider participating as a presenter at one or more of our Share-a-Thons.

Presenting at a Share-a-Thon consists of describing your lesson, activity, or lab to colleagues as they circulate around the room. The presenter is provided with a table to set up the materials for their activity. As Share-a-Thon attendees visit the table, the presenter provides a brief synopsis of the activity and a handout with the necessary methods on how to run the activity in the classroom. Share-a-Thons are typically attended by approximately 150 - 200 teachers during each 1-hr session of the National NSTA conference and 50 – 100 teachers at Area conferences. Presenters need to bring copies of their activity as hand-outs for session attendees, as well as other presenters at the session.

If you are interested in presenting at one or more of our upcoming Share-a-thons, please apply online (https://www.nestanet.org/cms/content/conferences/nsta/shareathons/apply), and NESTA’s Share-a-Thon Coordinator, Michelle Harris, will be in touch with you soon. Share-a-thons provide a great opportunity to share your activities and simultaneously have a chance to meet an extended group of your colleagues in a professional meeting. Some school administrators are more likely to agree to allow you to attend the conference if you are a presenter, and therefore by presenting at a NESTA Share-a-Thon you may have a better chance to be allowed to attend one of the NSTA conferences. To help you document your involvement, all Share-a-Thon presenters receive a letter of appreciation from NESTA acknowledging their participation. For more information about NESTA Share-a-Thons, please visit our website Share-a-Thon page (http://www.nestanet.org/cms/content/conferences/nsta/shareathons).

Best Regards,

Dr. Roberta Johnson
Executive Director, NESTA

EDITOR’S CORNER

I truly enjoyed working on this issue of The Earth Scientist (TES). I had the chance to collaborate with the authors of the seven fine articles being shared within these pages. We are fortunate to be able to share with you the wide spectrum of Earth Science ideas and topics that are contained in this issue of TES.

If you would like to submit an article for potential publication in TES, note that guidelines for submission may be found within this issue of TES as well as on line at www.nestanet.org

The hard copy version of this Fall issue of the TES contains a pair of posters. Both intended for use in your classroom, the first poster announces the 14th Annual Earth Science Week sponsored by the American Geological Institute (AGI), with the theme “Our Ever-Changing Earth”. The second poster draws attention to the 2nd Annual National Fossil Day, sponsored by the National Park Service (NPS). It is hoped that both of these posters will generate discussion and enthusiasm in your classroom and among your students.

Tom Ervin
TES Editor
NESTA Workshops at the Fall 2011 NSTA Area Conferences

NESTA is pleased to announce our sessions at the NSTA Area Conference for fall 2011. NESTA will be offering workshops at all three Area Conferences, and we look forward to seeing you there! This year, in addition to our traditional and ever-popular Share-a-Thon and exciting Rock and Mineral Raffle, we will also be offering workshops on Earth System science, climate change, and geology leveraging our new program, Windows to the Universe (http://www.windows2universe.org/)! All of our events will be in the same room, scheduled for Friday at each conference – providing you with a full day of Earth science professional development from the National Earth Science Teachers Association. Our events are free with registration at the NSTA conference.

As the largest professional society focused on K-12 Earth and space science educators nationally, we invite you to join our organization. NESTA members also receive a 50% discount on Educator Membership in Windows to the Universe, which provides you additional benefits and services on the website available only to members.

Want to present at one or more of our Share-a-Thons? NESTA welcomes teachers and education specialists interested in sharing exemplary tested Earth and space science related classroom activities and resources at our Share-a-Thon. If you are interested in presenting, apply online (http://www.nestanet.org/cms/content/conferences/nsta/shareathons/apply).

NESTA sessions in Hartford
All events on Friday, October 28 in the Connecticut Convention Center, Ballroom C
9:30 - 10:30 am - Activities Across the Earth System
11:00 am - noon - Climate Change Classroom Toolkit
12:30 - 1:30 pm - Let’s Get Well Grounded
2:00 - 3:00 pm - Share-a-Thon
3:30 - 4:30 pm - Rock and Mineral Raffle

NESTA sessions in New Orleans
All events on Friday, November 11 in the Ernest N. Morial Convention Center, R09
8:00 - 9:00 am - Let’s Get Well Grounded
9:30 - 10:30 am - Climate Change Classroom Toolkit
11:00 am - noon - Activities Across the Earth System
2:00 - 3:00 pm - Share-a-Thon
3:30 - 4:30 pm - Rock and Mineral Raffle

NESTA sessions in Seattle
All events on Friday, December 9 in the Washington State Convention Center, Ballroom 6E
8:00 - 9:00 am - Let’s Get Well Grounded
9:30 - 10:30 am - Climate Change Classroom Toolkit
11:00 am - noon - Activities Across the Earth System
2:00 – 3:00 pm - Share-a-Thon
3:30 - 4:30 pm - Rock and Mineral Raffle

Join NESTA at http://www.nestanet.org/cms/content/join
Become an Educator Member of Windows to the Universe at http://www.windows2universe.org/new_membership_services.html

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To become a member of NESTA visit www.nestanet.org.

To get more information about NESTA or advertising in our publications, or to get copies of back issues, contact the NESTA Office at 720-328-5351 or marlene.dimarco@gmail.com

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Like young people studying Earth science in school today, the Earth itself is in a constant state of development. Changes can be fast, as in flash floods and volcanic eruptions, or slow, as in the movement of glaciers and tectonic plates. We see evidence of change in everything -- from drilled ice cores to ozone measurements to the fossil record. That’s why Earth Science Week 2011 focuses on the theme of “Our Ever-Changing Earth.”

During the 14th annual Earth Science Week (Oct. 9-15, 2011), millions of people in all 50 states and around the globe are conducting classroom activities, preparing competition projects, visiting museums and science centers, and learning about Earth science through the Earth Science Week program’s events, resources, and information. This year’s celebration highlights the important roles that paleontologists, geologists, and other earth scientists play in building understanding of the complex interactions among the earth systems -- atmosphere, hydrosphere, geosphere, and biosphere -- over time.

Each year, the American Geological Institute (AGI) reaches more than 45 million people through the Earth Science Week campaign promoting better understanding of the geosciences and stewardship of the planet.

Day by Day

The Earth sciences are so numerous and varied that it would be impossible to cover everything at once. That’s why participants emphasize different areas on different days:

- EarthCachers around the world will use GPS devices to take part in geocaching “treasure hunts” for geoscience learning opportunities on International EarthCache Day (www.earthcache.org), Sunday, Oct. 9. Since 2004, more than a million people have visited EarthCaches worldwide.

No Child Left Inside Day, on Tuesday, Oct. 11, invites young people to go outdoors and learn about Earth science firsthand. A free online guide (www.earthsciweek.org/ncli) recommends learning activities, resources, and tips.

The National Park Service and AGI are collaborating to conduct the second annual National Fossil Day. On Wednesday, Oct. 12, participate in activities taking place at parks and other locations across the country. Learn more at http://nature.nps.gov/geology/nationalfossilday/.

AGI again is working with the Association for Women Geoscientists to organize the third annual Women in the Geosciences Day, on Thursday, Oct. 13. Visit a classroom. Take your daughter, niece, or granddaughter to a geoscience workplace. Share the excitement of Earth science careers with young women.

On Friday, Oct. 14, the American Chemical Society and AGI invite you to explore links between Earth science and chemistry, particularly since this is the International Year of Chemistry (IYC). Visit IYC Worldwide (www.chemistry2011.org) or the IYC 2011 Chemistry Calendar (www.acs.org/iyc2011).

A Wealth of Resources

How can you participate? This year’s educator kit and website (www.earthsciweek.org) provide more than a hundred lessons, materials, and links on Earth science. The 2011 Earth Science Week Poster (enclosed in this issue of The Earth Scientist) features an activity designed to help young people think about changes in the planet’s air, water, land, and living things over time. These initiatives and resources are designed to teach everyone about “our ever-changing Earth” during Earth Science Week. To receive the $6.95 kit, including the Big Ideas DVD and dozens of other resources, order online (http://www.agiweb.org/pubs/pubdetail.html?item=609606) or call 703-379-2480.

In addition, Earth science enthusiasts and educators throughout the United States are using the Earth Science Organizations website (www.earthsciweek.org/gpn) to identify event collaborators where they live. An online map not only identifies potential partners but also provides contact information and driving directions.

And the SEED Earth Science Week Online Toolkit, created in partnership with Schlumberger Excellence in Educational Development, provides geoscience learning resources for speakers of Spanish and English, both inside and outside the United States. Check the Earth Science Week website for this new feature.

Proven Results

If you’ve never participated previously, you might wonder how others have found the experience. Earth Science Week’s value is confirmed annually through an independent, survey-based evaluation.

In response to a survey on the 2010 celebration, 86 percent of respondents recently said that program resources and activities were very or somewhat important to educating students and others about earth science. Comparing participation last year and plans for next year, 88 percent said they anticipated either increasing or maintaining level participation.
A large majority of participants (85 percent) said Earth Science Week offers opportunities for teaching and promoting Earth science that they wouldn’t have otherwise. Most respondents find Earth Science Week and related resources highly useful, with 74 percent rating the program’s overall usefulness as “excellent” or “good.” When respondents were asked to rate nearly 17 key items from the Earth Science Week 2010 Toolkit and the Earth Science Week Website, all were rated “very useful” or “useful” by between 95 percent and 68 percent.

Transform Education

It’s never been more important for students to master the core knowledge and skills of Earth science. Students and others can draw on a sound education in the geosciences to understand the headlines that daily sound alarms about issues ranging from energy and climate change to natural disasters.

How can you get involved? Visit the Earth Science Week website (www.earthsciweek.org) to find out about ways to participate, events and organizations in your community, the monthly electronic newsletter, and the Earth Science Week kit. The kit contains dozens of posters, brochures, flyers, CDs, DVDs, bookmarks, and classroom activities for all grade levels, designed by the American Geological Institute and our Earth Science Week partners. The website also offers a planning checklist, tips for fundraising, ideas for events, recommendations for working with the news media, educational activities linked to the national standards, ways to get official recognition, downloadable logos and images, and much more.

Students are eligible to enter AGI’s Earth Science Week national contests. The photography contest, open to all ages, focuses on the theme “A World of Change in My Community.” Students in kindergarten through grade five may enter the visual arts contest, “Picturing Our Ever-Changing Earth.” In addition, students in grades six through nine are eligible to enter the essay contest, which highlights interactions among natural processes: “How Change Shapes Our Planet.” For each contest, the first-place prize is $300 and a copy of AGI’s Faces of Earth 2-DVD set. Contest entry information also is available on the website (www.earthsciweek.org/contests).

For resources, materials, and activities designed to help you lead an exciting and educational Earth Science Week celebration, please visit our website (www.earthsciweek.org)!

About the Author

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National Fossil Day is a celebration to promote public awareness and stewardship of fossils, as well as to foster a greater appreciation of their scientific and educational values. National Fossil Day is celebrated annually on the Wednesday of Earth Science Week in October. National Fossil Day 2011 will be October 12. This article will provide a brief introduction to National Fossil Day, why it was established, what is its mission, and provide some ideas for how you can celebrate it in the classroom this year.

The inaugural National Fossil Day was held last year on October 13, 2010, but the driving force behind the celebration really gathered steam during early spring of 2009. On March 30th of that year, President Obama signed the Paleontological Resources Preservation Act into law as part of a large group of legislation for public lands nationwide. Amidst other provisions to support fossil resource management, research, and protection, the law called for establishment of a program to increase public awareness about the significance of paleontological resources. From this directive sprang the idea for a National Fossil Day. Last year the National Park Service (NPS) and the American Geological Institute (AGI) decided to hold National Fossil Day during AGI’s Earth Science Week to take advantage of the week’s emphasis of geosciences education. In 2010, More than 120 agencies, avocational groups, fossil sites, museums and universities, and professional organizations joined as National Fossil Day partners. This year there are more than 130 partners already signed up and the federal Bureau of Land Management is also taking a leadership role in planning. National Fossil Day partners participate in a number of ways. Many plan special events at their facilities, while others send representatives to speak at schools and museums. Visit the National Fossil Day website and click on “Events” for a frequently updated list of events organized by states. In 2010, more than 50 events were held in 30 states. A kick-off event was held on the National Mall in Washington, DC, and was attended by 1,200 local school children. President Obama also wrote a letter of support to National Fossil Day participants across the country. In 2011, we are hoping for National Fossil Day events in 40 states and in all 50 by 2012!

One of the goals of National Fossil Day is to tell stories about many types of fossils. Anything that was once living, or made by something that was once living can become a fossil. Animals. Plants. Even trackways and dung! Most people associate fossils with dinosaurs, but there are hundreds of thousands of other types of fossils. From trilobites to titanotheres (featured on the National Fossil Day logo in Figure 1), mosasaurs (featured on the 2011 National Fossil Day Artwork in Figure 2) dinosaur trackways, and giant palm fronds to giant ground sloths, the past is full of fantastic
creatures waiting to be discovered! However National Fossil Day is about more than just fossils. It also highlights the work of paleontologists discovering and describing fossils, and how different agencies, institutions and organizations take care of fossils. National Fossil Day also celebrates the stories told by fossils. How ancient organisms responded to changes in climate, life, and landscapes through time is particularly relevant for us today on a planet whose climate is changing.

There are many ways to engage your students through a variety of National Fossil Day activities in the classroom, including participating in the art and photography contest, completing the Junior Paleontologist program, or by attending a local event. In the classroom, National Fossil Day can be celebrated any day (or every day!). We encourage teachers to integrate fossils in their classes any time during the year. Parks have developed classroom activities using fossil themes for art, history, math, reading and writing, and science inquiry. Some activities tie into visits to a park, while others can be completed in a classroom. Visit the National Fossil Day website and click on “Activities” to find links to classroom activities from parks across the country. Got a great fossil activity that you want to share? Contact us, and we can post it on the website.

National Fossil Day is hosting an art and photography contest, open to anyone of any age. Submissions from classrooms are certainly welcome! The 2011 theme is “Fossils in my Backyard.” Different fossils are found in different parts of the country. As part of the art contest, we are asking participants to take some time to explore and research the different types of fossils found in your region, state, hometown, or even your backyard! Some states even have a designated “state fossil.” The submitted artwork or photograph should represent those local fossils. Submissions are due by mail on Wednesday, October 5, 2011. Visit the National Fossil Day website, click on “Art and Photography Contest” for more information, entry forms, and websites to find more information about local fossils. All participants will receive a certificate and, in addition to a small prize, the top four entries from each age group will be displayed on the National Fossil Day website. You can also view last year’s winners on our website.

The National Park Service Junior Paleontologist program is modeled after the well-known Junior Ranger program. Rather than focusing on the resources and stories of one particular park—as in
the Junior Ranger program—the Junior Paleontologist program takes an NPS-wide approach to paleontology and fossils. It includes 16 activities for Junior Paleontologists to explore the ways paleontologists work, learn about changes through Earth history, and help protect fossils in national parks. Examples in the booklet come from parks across the country, including many parks not established for fossil resources. Upon completion of the booklet, which does not require visiting a park, Junior Paleontologists earn a badge or certificate. Visit the Junior Paleontologist page on the National Fossil Day website for more information, to download PDFs of the booklet and certificate, or to check availability of classroom sets of booklets and badges.

These are activities that can easily be completed in the classroom, but perhaps the best tool for instructing your students on the importance of fossils is to take them out into the field. The webpage includes field guides that can be adapted for this purpose, or, our partnering organizations host wonderfully instructive and fun events to celebrate National Fossil Day. Students can join a ranger-led hike at a National Park Service area, participate in an “excavation” at a museum, or participate in a number of other activities. Each partner site that hosts an activity does so in its own capacity. Teachers interested in bringing his or her students out of the classroom for the day should check the “Events” page on our website for schedules and event plans in order to choose the best opportunity for their class. As mentioned above, we are hoping for events in 40 states in 2011. If you have a great idea for one at your school, let us know and we can post it.

Bringing National Fossil Day into the classroom can be a simple, but memorable exercise for all involved. We aim to inspire the next generation of paleontologists. For more information, visit the National Fossil Day website (http://nature.nps.gov/geology/nationalfossilday/index.cfm) or contact National Fossil Day coordinator Eva Lyon (national.fossil.day@gmail.com).

Are you looking for some quality mineral or fossil specimens for your classes? Or maybe for you?

Check out the assortment of minerals and fossil specimens available on our Online Store from Nature’s Own!
Classroom specimens and collections, jewelry, and household items available!

Visit our online store at www.windows2universe.org/store, and click on “Nature’s Own”
Windows to the Universe members get a 10% discount!
Abundant evidence is available from multiple different components of the Earth system that show that the Earth’s climate is undergoing dramatic changes on a very short time scale (geologically-speaking) (Solomon et al., 2007). Whether we look at the atmosphere, the ocean, flora, fauna, and even from space, indications are that the Earth is warming due to the dramatic increase of greenhouse gases in the Earth’s atmosphere.

From the educational perspective, there are numerous opportunities and challenges posed by the topic of climate change. Opportunities include the fact that climate change science is inherently interdisciplinary and involves complex coupled systems. As a result, teaching about climate change offers a chance to have students develop an understanding of the unifying processes of science. It provides them an opportunity to put the knowledge they have developed in other courses (for instance math, physics, chemistry, and biology, as well as economics, government, and ethics) into play in an interdisciplinary fashion. In addition, since this topic is in the news on almost a daily basis, the subject is highly relevant to students (and society in general) – both today, and for their future. Furthermore, the topic allows students to develop an understanding of the Nature of Science – how our understanding grows and changes as new results are obtained and new discoveries are made.

Educational challenges posed by climate change include the fact that this subject area has become increasingly politicized in the past several years. In some places, teachers have received hostile treatment for teaching about climate change, including threats from parents and requests from administrators to not include it in their courses. In a recent survey of K-12 Earth and space science educators by NESTA, a significant number of respondents from some states indicate that climate change is being treated somewhat like evolution, with a common community perspective in some regions for the country that “both sides” of the concept should be taught. Furthermore, given the depressing litany of observations and model results showing the consequences of increased greenhouse gases on life on the planet, students can easily be led to depressing conclusions about their future without sufficient focus on youth-empowerment as a component of climate change education. Not surprisingly, some teachers may choose to simply dodge the bullet, and focus on other elements of the curriculum, rather than having to suffer the consequences of teaching about this difficult topic.
The purpose of this article – the first is a series to appear here in *The Earth Scientist* - is to provide you information about a set of freely-available, exemplary, and tested climate change education resources available to you online. These resources have been developed over the past decade by the NCAR Online Education: Climate Discovery Program, in collaboration with Windows to the Universe (http://www.windows2universe.org) and NESTA. The original materials were developed through a series of workshops offered at the National Center for Atmospheric Research (NCAR) in Boulder Colorado from 2002 – 2005. These workshops were then modified to be available through online courses offered by NCAR Online Education, through workshops and short courses offered at NSTA and other conferences, and most recently through six Web Seminars offered by the Global Climate Change Educator Professional Development Network, in collaboration with Windows to the Universe, NESTA, and NSTA, with support from the NASA Global Climate Change Education Program. Our Web Seminars, which were offered in Fall 2009 and Spring 2010, are available on the NSTA Learning Center Archive at http://learningcenter.nsta.org/products/symposia_seminars/UCAR/webseminar.aspx. Resources on the Learning Center Archive include the presentation power point for each Web Seminar, which provide information on where you can find all of the relevant classroom activities and resources, as well as the record of the Web Seminar itself, including comments from participants.

**An Introduction to Earth’s Climate**

Our first Web Seminar provides an introduction to the Earth’s climate. It includes a discussion of the difference between weather and climate, examines the factors that control the Earth’s climate, and explores related concepts such as albedo and associated feedbacks.

Weather is the state of the atmosphere at a time and place described by precipitation, air pressure, winds, and temperature (see Figure 1). Climate is the average state of the atmosphere as described by precipitation, winds and temperature determined over a long period of time – normally 30 years. As those of us involved in gardening know, regional climates are influenced by the latitude and altitude of a location, as well as the proximity to geographic features such as mountains and oceans.

When we discuss global climate, we are referring to average climate over the entire Earth, taking into account global data over long periods of time. Of course, this means that climate in any specific region may vary significantly from the global average climate. Any one specific weather event – whether an intense snow storm, torrential rain, or heat wave – is not evidence of climate change. We can only identify climate change over long periods of time, when the average weather (or climate) is seen to change from that of a previous time. Indeed, the new “Climate Normals” released by the National Climatic Data Center (http://www.ncdc.noaa.gov/oa/ncdc.

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**Figure 1.** A NOAA weather forecast for Tuesday, November 7, 2006, showing high and low pressure regions, various types of weather fronts, and anticipated precipitation.

**Figure 2.** Differences in NCDC Climate Normals (1981-2010 versus 1971-2000) for maximum temperature (F).
html) on July 1, 2011 for the 1981 – 2010 interval (which replace the values previously available for the 1971-2000 interval) reflect the warming trend of recent years. Figure 2 shows the statewide differences between the new and previous climate normals for maximum temperature. Across the mainland United States, the maximum temperature has increased in each state from 0.1° to 0.9° F. Similarly, the statewide difference in minimum temperatures has increased within the same range in each state, with an even larger increase in minimum temperature on average across the country.

Global climate is determined by the balance of solar radiation incident on the Earth, and the amount of that radiation that is reflected, absorbed, and re-radiated from the Earth’s surface, atmosphere and clouds back to the surface atmosphere and space. Central to this balance is the concept of “albedo” – a measure of the reflectivity of a surface. Dark parts of the Earth’s surface have a low albedo and absorb the majority of the radiation incident upon them. Light parts of the Earth’s surface – like snow and ice – have a high albedo and reflect the majority of the radiation incident upon them (as any of us know, who have been skiing on a sunny day without sunscreen!).

Observations of the amount of ice locked in mountain glaciers and in the Arctic and Antarctic regions have shown that the ice has declined dramatically over the past two decades almost everywhere on the planet. As these highly reflective components of the Earth system decrease in area, the remaining surface has, on average, a lower albedo, resulting in an increased absorption of solar energy and increased warming in the Earth system. This is an example of a “positive feedback loop” – an increase in one parameter of a system resulting in changes in the system that further increase that parameter.

Another key component of the Earth’s energy balance is the absorption and re-emission of energy by atmospheric gases. Greenhouse gases are gases that absorb and re-emit energy at thermal infrared wavelengths in all directions in the atmosphere, resulting in atmospheric warming. Although some greenhouse warming is natural and makes our planet habitable, the dramatic increase in greenhouse gases over the past century – by over 20% in the last 50 years and 30% overall since 1750 – is causing a resultant increase in atmospheric warming due to this absorption and re-emission process. Figure 3 shows measurements from the Mauna Loa observatory in Hawaii from 1957 to May 2011 of the concentration of atmospheric carbon dioxide in a place expected to be relatively “clean”, and far removed from sources of local pollution (in the middle of the Pacific Ocean). These measurements, started by Charles Keeling of Scripps (Keeling, 1960), show that CO₂ has been steadily increasing in the atmosphere since measurements began, rising from approximately 315 ppm to approximately 395 ppm today. The measurements also show a clear signature of the seasonal growth and decay of land plants in the northern hemisphere, through which CO₂ is absorbed in the spring and released in the fall. Measurements from the South Pole over this time period show the same increase overall increase in CO₂ levels, although with less seasonal variation.

Aerosols also play an important role in the Earth’s energy balance. Aerosols are small particulates in the atmosphere that directly scatter incident solar radiation and absorb/re-emit terrestrial radiation. Aerosols are emitted by a variety of sources – volcanoes, dust, biomass burning, and sea salt
to name a few. Volcanoes can launch sulfate particles high into the stratosphere which are rapidly transported by stratospheric winds to encircle the planet, and can result in atmospheric cooling that last one or two years, as in the case of the Mount Pinatubo eruption in 1991 (see http://mls.jpl.nasa.gov/joe/chem_benefits_for_layperson.html which shows sulfur dioxide abundances measured on 21 September 1991, approximately 100 days after the Mt. Pinatubo eruption, by NASA's Upper Atmosphere Research Satellite Microwave Limb Sounder).

Classroom Activities

Our Introduction to Earth’s Climate Web Seminar, available on the NSTA Learning Center, provides a number of classroom activities you can use to bring this content to life for your students. The list below provides an overview, and links to several activities related to the topics discussed above.

- **Differences Between Climate and Weather** (NCAR Climate Discovery Teacher’s Guide, http://eo.ucar.edu/educators/ClimateDiscovery/LIA_lesson1_9.28.05.pdf), in which students collect and graph local weather data, learn the distinctions between weather and climate, and understand that daily weather measurements are highly variable compared to long-term climate data.

- **Looking into Surface Albedo** (Windows to the Universe website, http://www.windows2universe.org/teacher_resources/teach_icealbedo.html), in which students explore how the color of materials impact the reflectivity of a surface and use these results to understand ice-albedo feedback.

- **Changing Planet: Melting Glaciers** (Windows to the Universe website, http://www.windows2universe.org/teacher_resources/melting_glaciers.html), in which students examine photographs of alpine glaciers to understand how they have changed with time over the past century, assess possible reasons for glacier retreat over long and short periods, and learn about possible impacts of global glacial retreat.


Conclusion

Future articles in this series will include an overview of the Web Seminars provided on the NSTA Learning Center developed through this program along with overviews and links to related classroom activities. Topics of upcoming Web Seminars in this series include Clues to the Climates of the Past, Global Climate Change and the Earth System, Effects of Climate Change, and Predicting Future Climate and Considering Solutions.

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References


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Windows to the Universe is a project of the National Earth Science Teachers Association
Montana is known as the Big Sky Country, with miles of clear, inky night skies, and minimal light pollution; the perfect place to explore bodies beyond our home planet. But how do teachers who teach in geographically isolated communities get the professional development and hands-on experiences needed to integrate these dark skies into their curriculum? Participation in Montana’s T4T, part of the larger Galileoscope project from NESTA, is one step in the process.

The Montana T4T Galileoscope Project, made possible through the generous donation of $250,000 by Ric and Jean Edelman, that allowed the American Astronomical Society working through the National Optical Astronomy Observatory (NOAO) to distribute more than 15,000 Galileoscopes to teachers nationwide; targeted two audiences: teachers from the larger urban area schools, principally Billings, who typically have access to professional development programs but have marginal budgets to purchase equipment for their science classrooms, and teachers who teach in geographically isolated and often economically depressed communities.

The first set of workshops were held in an Earth Science classroom at one of the two all Freshman Academies in Billings. This venue was selected for several reasons. First, while Astronomy is addressed multiple times within Montana State Science Standard 4 (OPI, 2006) and the students have expected outcomes in grades 4, 8 and upon graduation, few teachers in the state have access to the equipment to meet even the minimal expectation voiced in Benchmark 4.7 for the fourth grade, identify technology and methods used for space exploration (e.g., star parties, space shuttles, telescopes). Second, at the time of the project, this author was actively teaching Earth science, a required, year-long course for many of the state’s ninth graders. One additional reason specific to the Billings district, Astronomy is addressed within the district’s curriculum document (Billings Public Schools, 2004) with multiple objectives and inclusion in the district wide summative assessment instrument, making access to equipment and new delivery methods of particular interest to teachers in this district.
The second set of workshops of the Montana T4T Grant was specific to teachers working in the more rural areas of the state. Thirty-eight teachers from Absarokee to Winifred were involved in several workshops, with attendance as low as one and as high as thirty. The workshop that had 30 teachers was a unique event, and not only because the author was able to get 56 boxes of Galileoscopes in his Eurovan, but because the teachers engaged in this part of the Montana T4T Grant, all work on the Crow and Northern Cheyenne Indian Reservations.

The teachers attending the workshops teach in a variety of schools including public, private and Tribal; and all of the public schools represented are also defined as “in need of improvement” by the Montana Office of Public Instruction (OPI) based on their mathematics and reading scores (OPI, 2010). The private (Catholic) and Tribal schools are not required to follow the same test taking procedures as the public schools and data on their performance on state testing and adequate yearly progress is not available so it is difficult to define their status under No Child Left Behind (NCLB).

While the public schools may by definition “need improvement” the teachers who participated in the T4T all have been identified by their administrators as “having a passion for science” and meet all, or most of, the nine attributes of teacher leaders identified by York-Barr, and Duke (2004). This group of teachers of science is also actively engaged in a Master degree program that has been designed to be culturally meaningful and to build a vibrant and committed learning community of teachers of science for American Indian students. One of the foundations of this program is to weave content and pedagogy with Native science and mathematics through historical and contemporary Tribal contexts that produce a fabric of learning unique to reservation schools. One way to build upon this foundation is to integrate meaningful professional development into the content of the teachers’ existing graduate courses. In the fall, this cohort will participate in an Astronomy course that gives the teachers the opportunity to locate celestial bodies though traditional and technological means and integrates the names of stars, planets and constellations in the Crow and Northern Cheyenne languages. (Northern Cheyenne Nation, 2006).

Last May, in preparation for their participation in this scheduled fall course, the teachers and their students built their Galileoscopes during one of their Physics content classes. From a whole day workshop, three hours were allocated for the teachers to be introduced to the project, build their scopes and to explore with them. One of the most common comments, “Hey, did I do this right? Is everything supposed to be upside down?” This was a perfect opportunity for the Physics instructor to revisit optics and lenses and emphasized the benefit of hands-on/minds-on exploration as a means of uncovering weakness in previous learning. So with their Galileoscopes in hand and armed with sound pedagogical skills, expert content knowledge, and an awareness of their student’s
culture as called for in the research (Nelson-Barber and Trumbull-Estin, 1995; Bowman, 2003; Gordon, Stephens, and Sparrow, 2005) these teachers are now better equipped to help their Native American students achieve at levels on par with and even above their white counterparts on state assessments.

Thanks to the generosity of Ric and Jean Edelman, the American Astronomical Society, the National Optical Astronomy Observatory, and NESTA more than sixty teachers in Montana were provided with the opportunity to build telescopes for use in their classrooms. Thirty of these teachers will also use these telescopes as they participate in a graduate level Astronomy course that will help them link their teaching to the cultural and linguistic heritage of the reservation communities where they teach.

References


Why should I open and read the NESTA ENews emails?
NESTA’s monthly ENews provides brief summaries of stories and projects that have a direct link to the Earth Sciences and or the teaching of Earth Sciences. Many of these short articles provide links to more information or complete websites that those interested can follow. The ENews also contains information regarding teacher opportunities for research, professional development, and even grants. The reader will also find a calendar with items that have time critical information or may be occurring later that month or the next month. The ENews will also be adding state related links each month. The goal is to provide links to two states’ Earth Science sites each month. For example, in the June 2011 issue we focused on Earth Science resources in Alabama and Colorado.
Abstract

Steven D’Hondt and Fumio Inagaki, co-chief scientists, led Expedition 329 of the JOIDES Resolution to the South Pacific Gyre last October. I was asked to be the Education Officer for the expedition. The overall objective of the expedition was to study microbial life in the deep ocean sediments where nutrients and sunlight are lacking. The study area was in extremely deep water and about as far from any of the continents as one can get. My role was to communicate the goings-on with students in classrooms.

It all started with an email on a Tuesday morning in October. We need an Education Officer for Expedition 329, on the JOIDES Resolution, would you consider it? Sure! I said. When does the JR sail? You need to be in Tahiti on Saturday. And the race to get everything in order began! Needless to say, I made it!

Expedition 329 of the JOIDES Resolution a day early since everything, including me, was ready. Of the 122 people on board, twenty-eight were scientists from the United States, Japan, China, Korea, France, United Kingdom, Germany, Switzerland, Denmark, Poland, and Norway. Most were meeting each other for the first time. We spent the next four days in transit while everyone became friends.

Those first days were hectic as everyone was unpacking and calibrating equipment so all would be ready when those eagerly anticipated words “Core on Deck!” would be heard. We reached our first site late at night and it didn’t take long for the drilling crew to go to work.

Expedition 329 was a different type of cruise than most because it was basically dedicated to microbiology, not geology. The science crew consisted mostly of microbiologists, some chemists, several petrologists, sedimentologists, physical properties specialists, and a paleomagnetist. The study area was the South Pacific Gyre (a giant circular oceanic surface current) because it is considered to be a desert out in the ocean. There is very little life throughout the entire water column. The objectives of the expedition were:

1) to determine the amount of biomass within the sediments,
2) determine if the microbes are using hydrogen as a source of energy since sunlight is not available,
3) to compare microbial habitat conditions from the margin of the gyre to its center, and
4) to investigate whether microbes can be sustained within the basalt for more than 13 million years.
One of the co-chief scientists, Steven D’Hondt, proposed this expedition in 2004 and conducted the survey cruise from December 2006 to January 2007. The survey cruise used seismic reflectivity and surface coring to collect data used to select the final sites. One of the underlying reasons for choosing the South Pacific Gyre was because this is one of the few places within the oceans that has not been drilled and studied. The other co-chief scientist was Fumio Inagaki was a microbiologist from Japan. A total of seven sites were cored. In general, the plan was to drill three separate holes at each site, one dedicated to biogeochemistry, one for microbiology, and one to determine the stratigraphy, although usually additional holes were drilled for a variety of reasons. The scientists had a two-fold agenda. They worked as a group to address the objectives of Expedition 329 and they also collected samples, as individuals, to conduct their own research to be completed and analyzed back at their home universities or research institutions. The results of some of the individual research projects may not be known for as many as five years due to the very slow growth rate of many of the microbes. There is a one-year moratorium for all expeditions; so participating scientists will certainly have the opportunity to publish.

The first site, designated U1365 in IODP (Integrated Ocean Drilling Program) nomenclature was in the deepest (5700 meters) water of the voyage. There were 71 meters of sediments covering the basement basalt. The sediment cores were quickly placed in a refrigerated room to satisfy the requirements of the microbiologists. Samples were taken, under cold working conditions, from the bottom of each core for culturing. A portion of the core was also sent to the chemists for squeezing to extract interstitial water for analysis. Once basalt was reached, rotary coring, rather than piston coring, was used to drill into the basalt to a depth of 53 meters. This not only gave the petrologists some work, but some of the microbiologists also needed samples of rock. They were interested in whether or not microbes could exist within fractures or mineral veins in basalt. Concerns over poor hole conditions (pillow lavas were encountered) lead to the decision to stop coring. It was feared that since the pillow lava was highly broken and fractured and therefore unconsolidated that pieces might fall from the sides of the bore hole and become wedged between the drill string and the hole walls. A bad thing.

After five days of drilling, we headed off to our next location. The next three sites were progressively closer to the East Pacific Rise, which meant the sediments got thinner and the basalt younger (approximately 6 million years). The easternmost site, U1368, was also the last one to be cored for basalt and was in 3750 meters of water. It was drilled to a depth of 115 meters beneath the seafloor, including 12 meters of sediments. This was the only site where hole conditions were good enough for logging. Logging is the process of lowering a set of instruments by wire down into a hole to gather physical data about the hole’s geology. A concern, always present when logging, is getting the tools stuck in the hole due to collapsed walls. Site U1368 also marked the halfway point in our eight-week expedition. An interesting associated fact is that this site U1368 was one of the furthest points that you can get from all of the continents. Talk about being isolated! With little planktonic life, the ocean was very clear and took on a brilliant blue color due to the refraction of sunlight. I, for one,
have never seen water appear to be so blue. Early in the expedition, we were visited by white-tipped sharks, Mahi Mahi, tuna, and several Minke whales but out in the center of the South Pacific Gyre, there were no such visits.

The work schedule for the scientists, as well as the ship’s crew, was twelve-hour shifts, seven days a week. At the end of each shift, there was a short cross-over meeting where separate discussions within the physical scientists group and the biological scientists group focused on sampling and analytical techniques and preliminary results. Much of the shift work involved measuring the concentration of chemicals found in the interstitial water of the sediments, counting microbes in the ocean water and within the sediments, and preparing samples that would be analyzed back on land. The many labs on the JOIDES Resolution, located on several decks, were always busy. At the end of each drilling site, a general scientific meeting was convened in the conference room, where scientists shared their results and entered into discussions and questions.

As the Education Officer, my role was to blog on a daily basis about what was happening on board so that students, teachers, and the general public could stay abreast of what ocean drilling is all about. In addition, I conducted many live video conferences with classrooms, camps, and after school community groups, mainly in the United States, but also in several foreign countries. As we toured the labs, the students got to ask the scientists about what they were doing for research, why they became scientists, and about ship life. On several occasions, we were touring the labs on the core deck when the now familiar “Core on Deck!” announcement was heard over the PA system. We quickly altered our tour route and headed outside giving the students the opportunity to watch a core being brought up and laid out for cutting and labeling. One of the exciting things about these live interactions was that students and teachers could request to visit specific places on the ship and I was usually able to accommodate them.

The second half of Expedition 329 transected the South Pacific Gyre in a southwestern direction from the center to the margin. The sediments got thicker and the basalt older as we now moved further from the ridge. There was no need to core basalt but small pieces were recovered in the piston corer at the sediment/basalt interface. At U1369, considerably further south, the sediment thickness was just 16 meters. As we made our way to U1371, the last drilling site of the expedition, we encountered the latitude of the Roaring 40s. The winds picked up noticeably and the rocking began. There isn’t much land at that southern latitude to interfere with the prevailing Northwesterlies so they are capable of creating havoc with the ocean surface. Fortunately, they were short lived, until the final transit to Auckland. A storm in the area rocked the ship day and night so it was difficult to walk around or even stand in one place. For several days, we had to put up with 18-foot swells. Items that were not tied down found their way to the floor. You know the sea is churning when your dinner plate slides across the table and you lurch to catch it!

After bucking headwinds, we finally made it to Auckland, New Zealand just about on schedule where another science crew was waiting for their turn to sail on the JOIDES Resolution and take their chances with the sea.

I want to thank Leslie Peart and Sharon Cooper for giving me the opportunity to participate in an actual research leg aboard the JOIDES Resolution. Leslie and Sharon work for the Deep Earth Academy, which is the education arm of the Integrated Ocean Drilling Program (IODP) and part of Ocean Leadership.
Abstract

Yellowstone National Park is one of the most geologically dynamic places on Earth; three of the earth’s largest known volcanic eruptions have shaped this landscape. Situated above an active magma chamber, over 10,000 geysers, hot springs, mud pots, fumaroles, and steam explosion craters in and around the caldera make Yellowstone the world’s largest hydrothermal system, greater than all other locations on Earth combined. Annually, 1000-3000 earthquakes are typically recorded on the Yellowstone Plateau. Uplift and subsidence of the Yellowstone Caldera occur regularly; such activity is inferred to be related to magma recharge, crystallization of magma, and/or movement of hydrothermal fluids at depth.

Straddled on the southeast edge of the Yellowstone Caldera, Yellowstone Lake is a product of those forces and has a 140-year research legacy that demonstrates strong linkages between its geologic past and the life that thrives within the lake today. Recent discoveries from an extensive multi-year geophysical campaign led to the discovery that the floor of Yellowstone Lake is hydrothermally very active. Recent studies at several of these active vents have employed powerful techniques in molecular genetics and have laid the ground work for a new, exciting characterization of the lake. The model of the “old” Yellowstone Lake, thought to be composed of nutrient-poor snowmelt with cold water life forms, is significantly modified by the new discoveries on the lake floor which show areas of hot and nutrient-rich waters, oases for diverse life, and has provided a snapshot of an altogether “new” lake. Science teachers are participating in species collection and identification activities that have added to the known biodiversity of both the “old” and “new” Yellowstone Lake, and are bringing cutting-edge research alive in their classrooms.

Yellowstone Lake: The Center of the Yellowstone Geosystem

The Yellowstone Caldera is the result of one of the largest volcanic explosions the world has known in recent geological history, a mere 640,000 years ago. That mega-eruption was followed by more recent eruptions, the last occurring just 70,000 years ago. The aftermath of this chaos is the 20-million-acre landscape we know today as the Greater Yellowstone Ecosystem. One low point in the caldera is Yellowstone Lake, which is a top attraction within the park. While the lake is beautiful and serene, its volcanic heritage is closer than you might think as you stand along the lakeshore and enjoy the view. In fact, this vista of the lake belies its great youth, for it only began emerging in its present configuration from under an estimated 1,000 m icecap around 15,000 years.
ago. This not only makes the lake young, as lakes go, but it also means that its biodiversity must have a youthful dimension as well.

At 2356 m above sea level and 342 km², Yellowstone Lake is the largest high elevation lake in North America and the centerpiece of the Yellowstone Geocosystem because it is here that lake, river, and terrestrial ecosystems merge and form the underlying resource for an enormous food web. The lake is home to a large population of Yellowstone cutthroat trout and these fish and other aquatic inhabitants are important food sources for grizzly bears, and 40 other known wildlife species.

Mapping Yellowstone Lake

Yellowstone Lake has been scientifically studied since the 1871 Hayden expedition. These early explorers were interested in finding the headwaters of the Yellowstone River and anxious to probe the mysteries of the lake. Henry Elliott, a member of the survey party, produced the first bathymetric map of Yellowstone Lake (submerged equivalent of a topographic map).

Five bathymetric maps of the lake have been made since the Hayden Survey, each created with improved technology, accuracy, and precision. Research on the lake system in the late 1990s determined that available maps were inadequate for more detailed study of the lake, especially with respect to whether a significant hydrothermal system, so common elsewhere within the caldera, also might be present on the lake floor. In 1999, the U.S. Geological Survey (USGS), working with the National Park Service (NPS), began a project to map the lake using high-resolution swath-sonar and high frequency seismic-reflection profiles. Using state-of-the-art differential GPS for navigation, these data sets were complimented with high-resolution aeromagnetic data and hundreds of dives to the lake floor with a submersible remotely operated vehicle (ROV). These datasets created a high-resolution three-dimensional map of the lake.

High-resolution multi-beam swath sonar was used to produce a detailed image of the bottom of the lake. Acoustic waves patterned in a fan shape were sent out of a transmitter mounted to the hull of the park service’s vessel the RV Cutthroat. The energy is bounced back to the collectors that interpret the return signal which is used to detail the underwater bathymetry.

Seismic-reflection profiling using a high frequency “chirp” sonar system transmitted computer-generated pulses of acoustic energy and was employed to
better understand the underlying sediments and structures in the upper 25 m of the lake floor. The sound from the chirp travels down through the water column and, depending on its frequency, penetrates to different depths, the layers of sediments and rocks on the lake floor along a narrow swath. Some of this sound reflects or echoes off the sediment and travels back up to the surface where it is recorded. The return time and intensity of the returning energy helped researchers to map the structure of the lake floor and underlying layers as the boat traveled along a pre-determined GPS course.

The modern geophysical surveys provide valuable new high-resolution data; however, that data is remote. In contrast, photographic documentation and physical sampling of fluids and solids at active hydrothermal vents on the floor of Yellowstone Lake was enabled through the use of a remotely operated vehicle. The ROV, developed and operated by Dave Lovalvo of Eastern Oceanics, is approximately 1.5 meters in length and is equipped to collect solids, fluids, microbial mats, and temperatures; the video camera mounted at the front of the ROV acts as the researchers’ eyes. The ROV allows researchers to investigate and safely sample from the boat never-before-known thermal features. Manned and unmanned submarines have been used to in the recent past explore deep ocean trenches and search for famous shipwrecks like the Titanic yet their use on inland freshwater bodies is rare.

An Active Earth Supports Unique Life

Earthquakes are a common occurrence in Yellowstone National Park and average 1,000 to 3,000 per year. Data are transmitted from Yellowstone to the University of Utah in real-time by satellite links from a network of 26 continuous recording Global Positioning System (GPS) stations that measure ground deformation and from 31 seismometers located in the Yellowstone area. Real time data and other pertinent information are available on the Yellowstone Seismic Network webpage www.uusatrg.utah.edu/. The Yellowstone Volcano Observatory (YVO), created through a partnership between the USGS, NPS, and the University of Utah, monitors earthquake and hydrothermal activity throughout the area (see www.volcanos.usgs.gov/yvo/).

An unusually strong swarm of earthquakes was identified in late December 2008 starting in the central basin of Yellowstone Lake and migrating northward at a rate of approximately 1 km/ day. In this vicinity 811 earthquakes occurred over approximately 10 days. The largest earthquake registered a magnitude 4.1 and more than ten were felt by employees in the area. This was the third-most energetic swarm recorded in the Park since 1985; and underscores the active nature of the park.

Over 650 hydrothermal vents were identified during the recent mapping of the lake floor, making the lake the third largest thermal basin in the Park. Fluids from some of these features were analyzed and found to be similar to vent fluids in thermal areas throughout the Park. These fluids contain dissolved gases: carbon dioxide, hydrogen sulfide, and other potentially toxic elements including mercury and arsenic. Vent fluids carry high levels of silica (SiO₂) having passed through thick layers of rhyolite below. In Bridge Bay, formations formed around 11,000 years ago—now called siliceous spires—were discovered; they are somewhat similar in origin to black smokers discovered on the ocean floor. Examination of samples from one spire showed that the monoliths were not only comprised of unstratified silica (expected to precipitate when hot silica-enriched fluids...
enter cold lake water) but also of filamentous bacteria and diatoms. The spire field contains about a dozen structures and represents a spectacular example of the interplay between geology, chemistry, and biology. This discovery led to additional research on communities at active vent sites in the lake.

**The Molecular All-Taxa Biodiversity Inventory**

Using the new bathometric and geologic maps, an interdisciplinary group of scientists from several universities began an initiative to conduct a Molecular-All-Taxa-Biodiversity Inventory (MATBI) of Yellowstone Lake. The objective was to identify the unknown living organisms in the lake and to examine the influence of hydrothermal features on life in the lake. The pilot study began in 2004 and researchers collected samples from the lake water and vent fluids. Molecular genetics methods were then used to identify organisms.

The pilot inventory roughly doubled our knowledge of the biodiversity within the lake from 263 species gathered from over 100 years of scientific study, to 493 collected during the 4 day pilot campaign. Only two species were found to be alike on both the original species inventory and the new MATBI inventory, which demonstrates the power of new genetic technologies. The former notion of the high-altitude lake as a cold, low-nutrient, simple system was challenged. Yellowstone Lake’s biodiversity is much richer and broader than concluded by any previous study. A large-scale MATBI was undertaken in 2008 and continues today. New species from the lake have been detected in all three domains of life: Bacteria, Archaea, and Eukarya.

One focus of the expanded MATBI survey is an in-depth characterization of eukaryotic lake species. For the first time, microscopic plants like algae, and animals like crustaceans and rotifers are being surveyed. Crustaceans are being studied in detail because of their importance on the aquatic food web. A recent discovery in the West Thumb of the lake defines a rare oasis of life on the lake floor. A colony of moss, worms, and various forms of crustaceans flourish in hot tub temperatures (32°C+ waters), 30 meters below the surface of the lake and well below any light detection ability of humans. Vent fluids super-saturated in carbon dioxide provide the carbon source for the moss, which presumably uses very low levels of light to photosynthesize.

**Ecosystem Linkages**

Microscopic organisms are extremely important to the lake ecosystem; they make up a significant portion of biomass and are at the base of food chains in Yellowstone Lake. Scientists theorize that planktonic bacteria and archaea form the base of the food pyramid which, in turn, are feeding a diverse array of almost-as-tiny bacteria-eating invertebrates and carnivorous algae. These predators then become food for rotifers, crustaceans (mostly copepods, cladocerans, and scuds) and insects which are the basis of diet for fish and birds in the lake.

Active hydrothermal vents on the lake floor attract a diverse biota. One vent in the West Thumb basin is referred to as the “Trout Jacuzzi” because of the frequency of cutthroat trout feeding on organisms dislodged by the strong vent currents. Scientists found that bioaccumulation of mercury—a common hydrothermal vent element—occurs when it is sequestered in increasing concentration as it is passes up the food chain from the vent waters to plankton to the trout. The mode of

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**Figure 4.** Siliceous spires rising up to 8 meters in height were mapped and collected in the Bridge Bay area of Yellowstone Lake. Spires were found to be composed of silica and silicified filamentous bacteria, archaea and diatoms.

**Figure 5.** Tiny crustaceans thrive in Yellowstone Lake waters and serve an intermediate role in a large and complex food chain. This is *Hesperodiaptomus shoshone*, a copepod discovered and named in Yellowstone in the 19th Century and still common in Yellowstone's many lakes.

**Figure 5.** Siliceous spires rising up to 8 meters in height were mapped and collected in the Bridge Bay area of Yellowstone Lake. Spires were found to be composed of silica and silicified filamentous bacteria, archaea and diatoms.

**Figure 5.** Tiny crustaceans thrive in Yellowstone Lake waters and serve an intermediate role in a large and complex food chain. This is *Hesperodiaptomus shoshone*, a copepod discovered and named in Yellowstone in the 19th Century and still common in Yellowstone's many lakes.
bioaccumulation hasn’t been studied in detail, but presumably involves the bacterial conversion of mercury to methyl mercury (a more toxic form), which is incorporated into bacterial cells and then transferred to small crustaceans or other organisms during feeding.

This linkage of chemistry, geology, and biology has implications at the higher end of the food chain as cutthroat trout are a critical food source for grizzly bears, ospreys, otters, and bald eagles. With help from the USGS Interagency Grizzly Bear Study Team, hair samples from grizzly bears that frequent Yellowstone Lake and its tributaries were tested. Investigations found that mercury levels were dramatically higher in bears that feed on cutthroat trout from Yellowstone Lake. Spawning trout are the only source of mercury in bear foods in Yellowstone, but the levels of mercury that bears accumulate are apparently not detrimental to their health.

From the Lake to the Classroom

In the summers of 2010 and 2011, teachers selected from across the nation participated in a week-long field class, *Yellowstone Lake Geology and Ecology*, offered through the Master’s in Science Education (MSSE) at Montana State University (MSU). Teachers took part in field geology sessions and collected lake organisms as part of the MATBI project. Teachers first taxonomically identified organisms using microscopes in a field lab and then returned to MSU to perform genetic analyses. Data collected by the teachers is included in the growing biodiversity inventory of Yellowstone Lake.

While the teachers left Yellowstone enthusiastic about what they learned regarding the lake, they were most complimentary about being a part of the “real work of research”. Yellowstone Lake is visited by a high percentage of the park’s 3 million annual visitors, but few leave the park with the unique understanding of the spectacular and complex biogeochemical linkages connecting the lake and the surrounding ecosystem. The *Yellowstone Lake Geology and Ecology* participants had come to learn about an American icon, and had indeed. For more information about the MATBI project, future course dates and additional resources for teachers, check out MSSE Yellowstone Lake Ecology on Facebook, or The Greater Yellowstone Science Learning Center (http://greateryellowstonescience.org/).
References


Resources

Three podcasts were created about the Lake project and can be found on YouTube:

Yellowstone Bioblitz http://www.youtube.com/watch?v=UG0NuO1v-VQY

Yellowstone Geology http://www.youtube.com/watch?v=aaN-vAUL0xw

Yellowstone Lake History http://www.youtube.com/watch?v=T6yZM8WlfAM

About the Author

Susan Kelly has been living and working in the Greater Yellowstone Ecosystem for 20 years. She works as an Education and Outreach Specialist at Montana State University on a variety of Yellowstone-centered projects, and has worked as a seasonal interpretive Park Ranger in both Yellowstone and Grand Teton National Parks. She received her undergraduate degree in environmental conservation from the University of Colorado-Boulder, and a master’s degree in earth sciences from Montana State University (MSU) in Bozeman. She enjoys working with teachers through the Master of Science in Science Education (MSSE) at MSU. She can be reached at susan.kelly@montana.edu.
Student Misconceptions: Where Did You Get That Idea?

By Virginia Malone

Abstract

Identifying the source of a student misconception may allow teachers to select and tailor student activities to dispel the misconception. Many misconceptions come from student misinterpretation of their own observations. Others come from incorrectly interpreting images and information from books or other media. Lack of direct observations or experiences are yet another source of misconceptions. Providing activities that look at misconceptions from more than one perspective may help students to better understand concepts.

Many students have misconceptions about the natural world and how it works. In order to dispel misconceptions it is sometimes helpful to consider the possible origins of misconceptions. Misconceptions seem to arise from incorrectly relating a new concept to a familiar experience, accepting answers without real understanding, incorrectly interpreting images from textbooks or other media, and lack of observations and experiences. The following are some of the common misconceptions of my students, the possible sources of these misconceptions, and some possible methods of changing students’ ideas about our world.

Misconception #1: The orbit of Earth is highly elliptical.

This misconception may be the result of illustrations in textbooks showing an elliptical orbit with the term “highly exaggerated.” Without some understanding of the term, highly exaggerated, and what it means in this illustration, students come away with a misconception. A common teaching activity that sadly reinforces the misconception is having students learn to draw ellipses, which are generally drawn highly elliptical and adds to the misconception. To dispel this misconception, an illustrator may show the orbit as circular, which is drawn to scale, leading the student to believe that Earth’s orbit is a perfect circle, yet another misconception. Dispelling the first myth without planting the second misconception requires an in-depth look at the orbit of Earth and the precise nature of the terms: highly exaggerated, drawn to scale, elliptical, and circular. While it is desirable to have students understand the basic mathematics involved in determining the shape of the orbit, this is generally beyond the ability of 8th grade students. Dispelling the orbit misconception requires looking at the orbit from multiple perspectives. For example, after a discussion of the terms and Earth’s orbit, students may be provided with multiple illustrations of Earth’s orbit, some exaggerated and some not, some with the term “drawn to scale” and others not, some indicated to scale, and not to scale. Two drawings should then be generated by the students, one of an ellipse with the
foci far apart and one with the foci close together. Each pair of students completes a table similar to the one below. Class answers are compiled and discussed.

<table>
<thead>
<tr>
<th>Illustration number</th>
<th>How is the illustration like the Earth’s orbit?</th>
<th>How does the illustration differ from the Earth’s orbit?</th>
<th>How could the illustration be improved or labeled to prevent misunderstanding?</th>
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**Misconception #2:**
**Earth is closest to the sun in the summer time.**

Often, students conclude that Earth must be closer to the Sun in the summer time since common experience with heat sources illustrates that the closer one is to the source the warmer one feels. Therefore this misconception makes very good sense since the sun is our heat source. Challenging students to explain the seasons in terms of the southern hemisphere, with its reversed seasons calls their naive concept into question. The 5 million miles between Earth’s apogee and perigee look like a huge difference to a student who considers 100 miles a very long way. While students might acquiesce to teacher explanations, they often retain the misconception that our distance from the sun plays the largest role in summer time temperatures. Since this misconception intuitively makes sense, it requires extensive time to dispel. Laboratory investigations, worksheets, direct teaching, and weekly graphs of the sun’s path across the sky are all important for a real understanding of the causes of the season. Viewing different models of Earth relative to the Sun helps to student to understand the causes of seasonal temperature variations. For a wide variety of perspectives see http://www.physicalgeography.net/fundamentals/6h.html

**Misconception #3:**
**Seasons are caused by changes in the tilt of the Earth.**

Asking students what causes the seasons will generally bring a pat answer, the tilt of Earth on its axis. However, asking students to explain how the tilt causes the seasons will often result in an explanation that indicates that the North Pole is sometimes pointed at the North Star and at other times pointed opposite the North Star and sometimes even perpendicular to the plane of the orbit. For this common misconception see figure 2.

**Student misconception that the tilt of Earth changes throughout the year**

Students have learned the correct answer, but have a misconception about the rather stable direction of Earth’s tilted axis. Students with this misconception can correctly answer some questions about the cause of seasons, but have an incorrect mental model of Earth’s axis as it orbits the sun. Showing the Earth in four positions always pointed toward the North Star rather than wobbling
Misconception #4:
The moon can only be seen at night.

Since many students rarely have time to make close observations of the sky, this misconception can persist. Even after a single observation students may disclaim the observation explaining it away with some sort of magical thinking or totally forgetting the observation. This misconception can be dispelled by taking students out several times during the year when the moon is visible during the school day.

Misconception #5:
The Earth is a perfect sphere.

Today many first graders can parrot the fact that the earth is a sphere and never even consider that it was once considered flat. Ask students to explain why people in the Southern Hemisphere do not fall off the Earth and the concept of roundness becomes a conundrum for students. Most students have only seen the Earth depicted as sphere, but have often not considered the impact of living on a sphere. The measurements that indicate it is not perfectly spherical are far beyond students in the early grades so it makes sense to teach them that the Earth is a sphere. Later they learn that it is not really a perfect sphere. The concept of scale eludes most students. If they are taught the actual shape of the Earth, the picture they will draw of Earth when reduced to the size of tennis ball will look very much like a squashed ball of clay. So, again, in dispelling one misconception we can easily introduce another. After teaching the actual shape and some of the simple proofs that it is not perfectly spherical, students receive pictures taken from space. In pairs they are to explain the shape of Earth as seen from space. After these observations they are asked to explain why the picture is different from the calculated shape.

Misconception #6:
The Earth is a lumpy sphere rather than smooth.

This misconception is often tied to the fact that students observe things like mountains, hills, canyons and gullies. Logically a globe should have raised mountain ranges and often does. Without a concept of scale, students may be able to parrot that the Earth is smooth, but do not really internalize how smooth it really is, since they relate back to globes that have raised mountain chains. Have students use a microscope to view a piece of paper. Is the paper as smooth as it feels? If we were as small as a bacterium, how would the fibers in the paper appear to us? If Earth were reduced to the size of a marble it would be much smoother than a marble. A discussion on different perspectives and scale usually eliminate this misconception.

Misconception #7:
The thicker a rock layer the longer it took to form.

Most students look at rock layers and assume that thicker layers take longer to form than thinner layers just as it takes longer to build a taller tower of blocks than a shorter one. Provide a pile of sand next to a sheet of paper. Have students record the time it takes to build up four or five millimeters of sand on the paper by blowing on the pile of sand. Pour a thick layer of a different colored...
sand on top of the layer the student made. Have students compare the time it took for their thin layer and your thick layer to form. Have them explain why the thicker layer took less time to form. Show some pictures of thick layers of mud after a flood or tsunami compared to thin layers of sediment that formed before. Be sure to include some thick layers that took longer to form than the thinner ones so students do not come away with the misconception that all thicker rock layers are deposited more quickly than thinner ones. They should come to appreciate that the thickness of rock layers is not a reliable indication of the time required to build up the layer.

Misconception #8:
The phases of the moon are caused by Earth’s shadow on the moon.

The cause of phases of the moon seems be counter intuitive to many students. If they understand that Earth casts a shadow, they easily assume that passing through the shadow causes the phases. They have much experience with shadows hiding parts of objects, thus constantly reinforcing this misconception. This particular misconception is common among adults who also seem to find it very difficult to mentally visualize how looking at a sphere from different vantage points would cause it to appear to have a different shape. Paint half of a small white foam ball black. Put a thin dowel through the bottom of a shoe box painted black on the inside. Punch a hole in one end of the box. Put the ball on dowel.

When the students turn the dowel and view the ball through the peephole the ball will appear to change shape. It is our perspective that causes the change in shape rather than a shadow. Care must be taken in the discussion to be sure students do not believe that the phases of the moon are caused by the moon’s rotation or that the moon is half black and half white.

I have presented a few of the many misconceptions my students have had, and some activities I have used to help them better understand some phenomena. All students have misconceptions. Identifying the sources of misconceptions may help teachers prevent the misconception in the first place. Providing multiple perspectives of a specific concept seems to help dispel misconceptions they do have. Some misconceptions are very difficult for an individual to shed as they become part of the person’s belief system and are accepted without the need for scientific evidence. Dispelling misconceptions involves instilling students with the idea that there is a need for scientific evidence. To find out where your students get particular misconceptions, you may simply ask, “Where did you get that idea?”

About the Author

Virginia Malone is a retired 8th and 9th grade Earth and Life Science Teacher from Northside Independent School District in San Antonio, TX. She has also excelled as a test developer and vice president of Harcourt Educational Measurement, and now works with Pearson in San Antonio, TX.

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Twenty Five Years Ago in TES

Twenty Five years ago, TES was in its third year of publication. In 1986, the cover of Volume 3, issue 3 featured a surface map of the planet Mars. Inside the issue featured an article, *The Geology of Mars*. Within the article were eight photos recently released from U.S. landers and orbiters: Viking I and II. There was an article documenting *Some Recent Climatic Fluctuations in Michigan*, hinting at Global Warming.

There was a ground breaking article which presented *The New Global Tectonics: A Revolution in the Earth Sciences*. Finally, on the last page, there was a notice which stated that articles for inclusion in the TES could be sent to the editor via Compuserve, promising that the editor would check the TES mailbox “twice monthly”. Albeit a shaky start, it is clear that NESTA was declaring that the internet highway had opened!

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For further information contact
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Treasurer
dimmick@esteacher.org
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