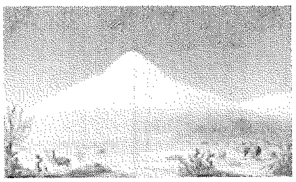
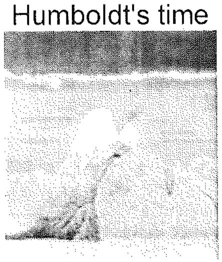
Meeting 13 • 18 February 2014
Week 7: Rocks & soil, weather & water

Version:
2/18/14

pictures of the week



Mt. Chimborazo, illustration from Humboldt's time



Humboldt's iconic engraving of Mt. Chimborazo

thought-bite of the week:

"...often during astronomic observations I almost dropped my instruments when I realized my face and hands were covered with these hairy bees. Our guides assured us that these bees only attacked when you annoyed them by picking them up by their legs. I did not try."

(Humboldt, "Personal Narrative", from *Jaguars and Electric Eels*, ed. & trans. Wilson, p. 17)

mini-text of the week (start):

"...the general phenomena of plant distribution..."

Humboldt, "Personal Narrative", from *Jaguars and Electric Eels*, ed. & trans. Wilson, pp. 14-16 (read more)

Topics for today (key to symbols)

• (10') This week's thought-bite and mini-text: expensive instruments, extreme conditions, and great insights about geography, climate, and species distribution. An example of debate among climate scientists that is very appropriate to the Stegner/Powell reading you have started: Justin Gillis, "Science Linking Drought to Global Warming", NYT What data do YOU collect first-hand, how do you do it, how precise is it, and how much do you trust it? Think bathroom, car, shopping, smartphone Groups discuss meaning and distinction of: factual, objective, impartial, truthful (not to mention: authoritative, definitive). How does this apply to your book reports, especially how you judge what's in those books?
• (10') An example of a very different course / project that relates to sustainabilty (and distant lands), and also illustrates how valuable are having many different kinds of knowledge / skills, and also teamwork and individual initiative. Small groups discuss and report out: What skills and behaviors are needed for "SpeakEasy"? How does that apply to our course? "Getting it" - the need and the difficulty
• (20') Species descriptions, group projects, and book review activity: What about AvH's life and work might spark interest in: 1) AP students of various subjects; 2) middle-/high-school boys, especially non-privileged/minority learns (and especially ones that have unduly high self-images); 3) elementary school girls; 4) special-needs learners; 5) school teachers and administrators; 6) communities that could be linked to H? Why the dimension of doing the activities with an eye to writing for a specific audience / helping other learners? 1) understand good learning; 2) evaluate your own educational experience; c)

practice for later parenthood and citizenship; d) what satisfaction do we get out of writing papers that only the student and - maybe* - the instructor will ready (*if you're lucky / unlucky)?

Hallmarks / gauges of strong species descriptions / group projects: 1) Is it about you or about sustainable environmentalism and AvH? 2) Will your audience learn ABOUT or learn TO, or both? 3) Could a teacher use youractivity a) as is; b) by adding something to it? 4) Does it contribute balance to a larger effort (or is it just another take on the penguin / squid)? 5) Could you confidently present it publicly? Example: PSU Student Research Symposium

Example of a hypothetical project: "Humboldt and Electricity"

Projects that might have attractice "degrees of difficulty": 1) culture contact / clash; 2) human rights; 3) youngest learners / disadvantaged learners; 4) disliked subject areas (STEM!); 5) undersupported subject areas (art); 6) integrative approaches (multiple subject areas / levels of learners).

- (10') Large-scale educational issues combined with our course activities: How standards are used to develop curriculum (curricula?) and learning activities. Example of major sources of lesson plans; curriculum mapping for STEM+Hawaiian language at the Lyon Arboretum; the PSU/Oregon "STEM+German" grant project; article (H0152) "School Gardens Blooming Teach Lessons On Nutrition, Environment, Science, Teamwork".

- (05') Small groups (usual classroom groups or project groups) kick these ideas around while they (the ideas, if not the groups) are still fresh

- (10') If time (or you can do on your own): Check your progress (other than by your current grades and the midterm) – and explore the related issues of standards, assessment and grading by exploring this self-evaluation guide for the middle of the term; this applies to your recent writing assignment, to your performance in the course, and to your larger roles as citizen and (possibly) parent.

- On the horizon:

Soon: A last quantification activity: precise measurement of altitude / distance (demo, then do in groups). Thought questions: Are all angles and degrees created equal? Why use a barometer to measure altitude when the theodolites and trig tables are there?

Looking further ahead (projects, etc.): presentation (continuation) about educational standards and their parts in the course: 1) Improving your learnign by helping others to learn - This is preparation for assignments about species description and group projects.

looking ahead: presentation of project ideas (just the ideas, not finished projects) in week ••

Later: what it's like to read Darwin; Humboldt-named species; forming teams and scoping out projects (ideas for group projects); the iconic graphic of Chimborazo; apps Humboldt would have liked; what shall we do with (to??) the people who haven't revealed their interests and strengths and don't get "on board" when they're needed?

The New York Times http://nyti.ms/1bWHkF8

SCIENCE

Science Linking Drought to Global Warming Remains Matter of Dispute

By JUSTIN GILLIS FEB. 16, 2014

In delivering aid to drought-stricken California last week, President Obama and his aides cited the state as an example of what could be in store for much of the rest of the country as human-caused climate change intensifies.

But in doing so, they were pushing at the boundaries of scientific knowledge about the relationship between climate change and drought. While a trend of increasing drought that may be linked to global warming has been documented in some regions, including parts of the Mediterranean and in the Southwestern United States, there is no scientific consensus yet that it is a worldwide phenomenon. Nor is there definitive evidence that it is causing California's problems.

In fact, the most recent computer projections suggest that as the world warms, California should get wetter, not drier, in the winter, when the state gets the bulk of its precipitation. That has prompted some of the leading experts to suggest that climate change most likely had little role in causing the drought.

"I'm pretty sure the severity of this thing is due to natural variability," said Richard Seager, a climate scientist who studies water issues at the Lamont-Doherty Earth Observatory of Columbia University.

To be sure, 2013 was the driest year in 119 years of record keeping in California. But extreme droughts have happened in the state before, and the experts say this one bears a notable resemblance to some of those, including a crippling drought in 1976 and 1977.

Over all, drought seems to be decreasing in the central United States and certain other parts of the world, though that is entirely consistent with the longstanding prediction that wet areas of the world will get wetter in a warming climate, even as the dry ones get drier.

What may be different about this drought is that, whatever the cause, the effects appear to have been made worse by climatic warming. And in making that case last week, scientists said, the administration was on solid ground.

California has been warming along with most regions of the United States, and temperatures in recent months have been markedly higher than during the 1976-77 drought. In fact, for some of the state's most important agricultural regions, summer lasted practically into January, with high temperatures of 10 or 15 degrees above normal on some days.

The consequence, scientists say, has been that any moisture the state does get evaporates more rapidly, intensifying the effects of the drought on agriculture in particular. "We are going through a pattern we've seen before, but we're doing it in a warmer environment," said Michael Anderson, the California state climatologist.

The White House science adviser, John P. Holdren, said in a briefing last week: "Scientifically, no single episode of extreme weather, no storm, no flood, no drought can be said to have been caused by global climate change. But the global climate has now been so extensively impacted by the human-caused buildup of greenhouse gases that weather practically everywhere is being influenced by climate change."

The drought eased a bit with heavy rains in Northern California this month, but many major reservoirs have only half the water expected for this time of year. "I think the situation is still pretty severe," said Prof. Alex Hall, who studies climate at the University of California, Los Angeles.

California gets much of its water from snow in the winter along the western slopes of the Sierra Nevada. That means 38 million people and a $45 billion agricultural economy are critically dependent on about five heavy storms a year.

If a ridge of high atmospheric pressure develops off the California coast, it can easily push moisture-bearing winds to the north, so that the water falls closer to Seattle than Sacramento. Just such a ridge has been parked off California for

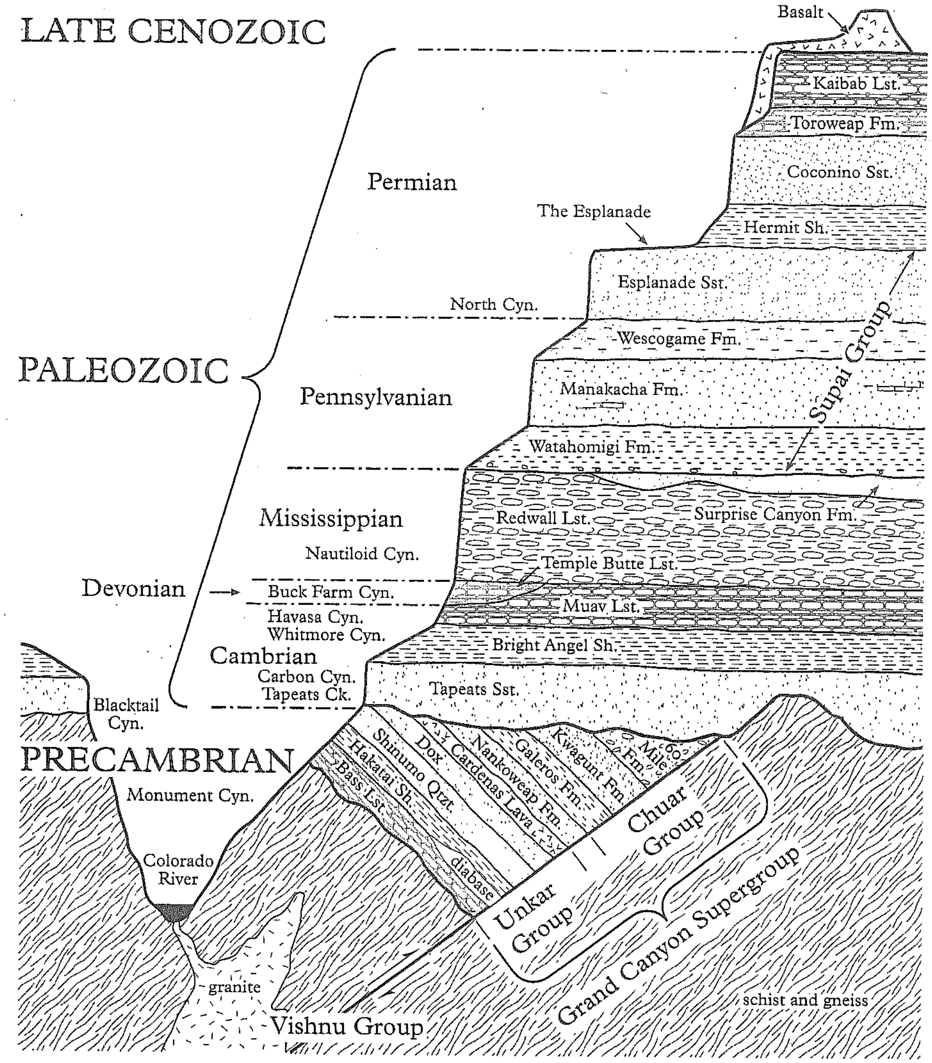
Overview of Grand Canyon geology as of 2005
Douglas Palmer

The essential ingredient in the formation of the Canyon was the process of vertical uplift of the Colorado Plateau over a period of nearly six million years to form a vast uplifted tableland over a large portion of the states of Arizona, Colorado, New Mexico and Utah. The uplift rejuvenated and re-empowered the ancient river to dramatic effect. The altitude of the Canyon and its flanking cliffs ranges from 2793 m down to 518 m above sea level. The maximum depth of the Canyon at any one location is about 1829 m (6000 ft) from rim to floor, but is more typically around 1.5 km deep, and its width varies between 0.5 and 30 km.

The water that flows through the Canyon is derived from four rivers, the Green, Colorado, San Juan and Little Colorado, and together they drain a huge area of many hundreds of square kilometres. Continuing erosion by both the permanent and seasonal rivers produces many impressive waterfalls and rapids (over 100 are named) along the Canyon. Although the Canyon is neither the deepest nor longest gorge in the world, it nevertheless has achieved icon status in global terms.

Protection of the Grand Canyon has quite a long history, dating back to 1893 when it was declared a forest reserve, but protection was very limited as mining, lumbering and hunting were permitted. The Canyon's remaining wildlife was protected in 1906 when it upgraded to a game reserve. Redesignation as a national monument followed in 1908 and eventually led on February 26th, 1919 to an Act of Congress that declared the Grand Canyon as a National Park. Finally in the US context, in 1975 the National Park was enlarged to nearly half a million hectares (4930 sq km or 1900 sq miles) with the incorporation of some adjacent national recreation areas, while 34,000 ha were removed into the Havasupai Indian Reservation. From the international perspective the Canyon was inscribed on the World Heritage List in 1979.

From the scientific investigation of the Canyon's strata we now know that it took the Colorado River a 'mere' 3–5 million years to cut its way down through what geologists call layer-cake strata of the Canyon's rocks. Layer upon layer of horizontal strata are laid out one upon the other. The youngest and most recent layers at the top of the pile form the plateau landscape surface. But these 'recent' surface rocks are now known to be some 270 million years old. Peering into the



A diagrammatic vertical section through Earth Time as represented by the succession of strata in the Grand Canyon (redrawn from Beus, S. S. and Morales, M., 2003).

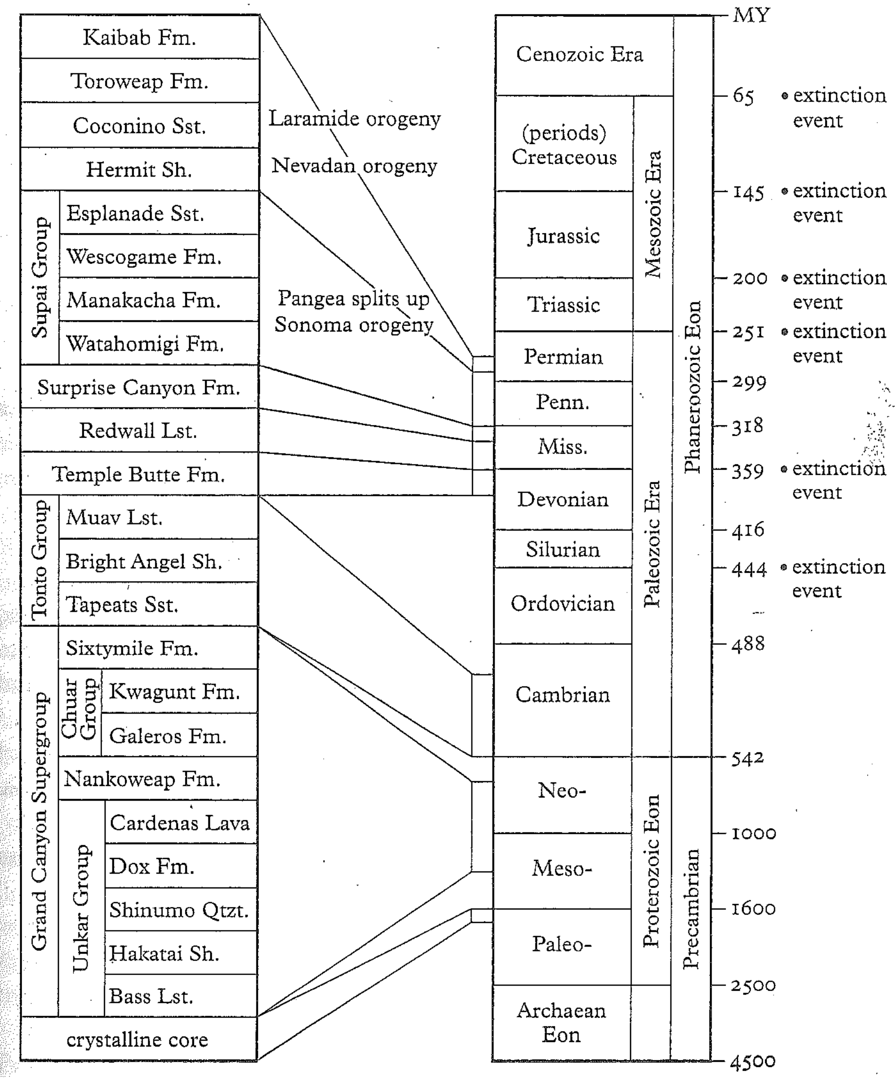
Mind the gap – the small matter of the Permo-Triassic extinction...

Neither Murchison nor any other mid-nineteenth-century geologists spotted any sign that the end of Permian times was marked by the biggest extinction event in the history of life. Perhaps as few as 10 per cent of species survived beyond the end of the Permian, so there really was a huge turnover in life forms. It is not as if Murchison and his contemporaries were not concerned about the changes in fossils from one group of strata to the next; they were. It was because it was the presence of such changes that they were using to justify distinct 'systems' of strata.

Part of the problem was that although the concept of catastrophic revolutions in the history of life was not new, such 'revolutions' had generally been dismissed as a reality by the 1830s. Catastrophism was associated with the outmoded ideas of the Diluvialists and the very idea of 'revolution' was too closely associated with the all too real and recent horrors of French Revolution for comfort. Since the dénouement of the Flood as a significant event in the history of life, gradualism, as propounded by Lyell, was the generally accepted historical process underpinning Earth processes and the rock record. Extinction of species and even whole groups of organisms such as the trilobites, graptolites or ammonites was accepted, but their loss was not connected to any specific large-scale catastrophic events.

Indeed, the most innovative idea about the history of life, the Darwin/Wallace theory of evolution, required slow, gradual progression and change rather than any dramatic collapses and subsequent 'explosions' of renewed life. Detailed records and descriptions of fossils and their distribution in time and space was only just beginning in the mid-nineteenth century. Nobody was in a position to review the overall state of the record yet, but it was not long before such overviews were possible.

Curiously, it was Darwin's attack, in *The Origin of Species*, on the imperfection of the fossil record that in 1860 prompted one of the first and most informative of the early overviews of the record by John Phillips. In 1860 Phillips was President of the Geological Society and had been invited to give the prestigious Rede



The succession of Grand Canyon strata (left) matched with the complete sequence of Earth Time to show the number and duration of the gaps in the Canyon record.

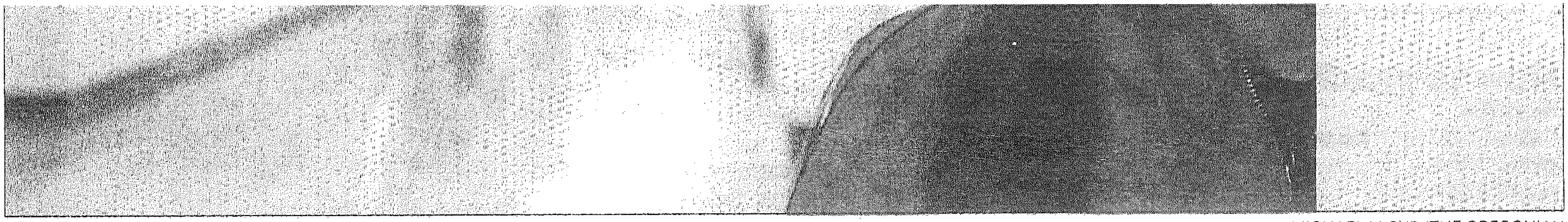
Empty desks | Steps to success

Oregonian A1
Feb 16 2014

Clackamas High School cracks the attendance code

MICHAEL LLOYD/THE OREGONIAN

Heather Dabud, a Clackamas High junior, is back on track to graduate on time with her class. When she got mired in a pattern of skipping classes and failing them, the school responded with relentless prodding to do better.



MICHAEL LLOYD/THE OREGONIAN

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BETSY HAMMOND/THE OREGONIAN

Clackamas High junior Paxton Donato has made a habit of showing up for every class every day, and his grades are now strong. Clackamas has one of the lowest absentee rates of any large or medium-size Oregon high school.

Go to oregonlive.com/education to find:

- A searchable database with absentee statistics on every public school in Oregon
- Interactive maps where you can zoom in to find statistics by school and area
- An interactive chart that shows the relationship between absenteeism and economic status
- Videos on absenteeism's disastrous effect on education and on Clackamas High School and its successful approach to enforcing attendance
- Photo galleries and online-only stories
- An invitation to share your experiences with absenteeism, whether as a parent, educator or community member

By Betsy Hammond
betsyhammond@oregonian.com

Ray Byzewski, dean of students at Clackamas High School, gets straight to the point with Jonathan, a junior at the big suburban school:

"You have 42 missed class periods. I need to know what is going on."

The teen, who enrolled at Clackamas High a few weeks into the school year, did not see this coming. He routinely skipped class at his previous school, and no one called him on it like this.

He verbally dodges and weaves, claiming the records are wrong, that he's been in class, that there was a family emergency, that he's thinking of trying for a GED.

Byzewski, however, has done his homework and buys none of it. He offers help but says firmly: "While you are here at Clackamas High, you will go to class."

And like that, the dark-haired junior finds himself on a path familiar to many Clackamas students, one with firm guardrails on each side. School officials will make it impossible to go unnoticed and as difficult as possible to skip class.

There's a reason Clackamas High School has the fourth-lowest chronic absenteeism rate among Oregon's 100 largest high schools and a top-10 graduation rate for low-income students.

Byzewski and other adults have formed a web designed to catch every student who misses 16 classes, the equivalent of four days of school. They check on red-flagged students every day, telling them how much they care about their success.

They hand out candy and high-fives to students who show. But students who keep skipping may find a parent

*See **Absent**, A15*

Oregon's absenteeism epidemic

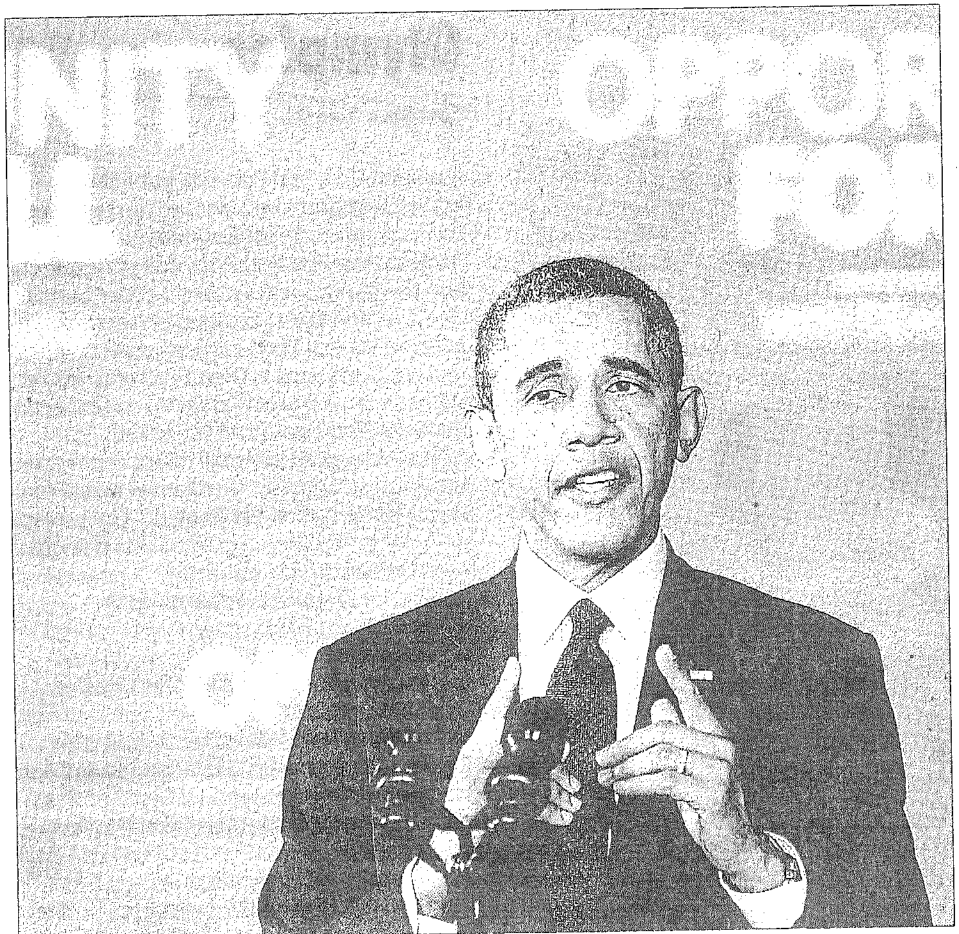
Last Sunday: Rampant absenteeism puts thousands of students at risk of failure.

Wednesday: Missing too much first grade sets students back for years.

Friday: Despite a sparkling new school, Vernonia students skip at sky-high rates.

Saturday: Middle and high school absences put diplomas in jeopardy.

Today: Vigilance at Clackamas High School helps keep kids in class.



MANUEL BALCE CENETA/ASSOCIATED PRESS

President Barack Obama has focused on improving early-childhood education and access to college, but not enough is being done to improve high school education, psychology professor Laurence Steinberg says.

Oregonian Feb 16 2014 O2

OUR HIGH SCHOOLS ARE A DISASTER

Boredom is a part of the curriculum

By Laurence Steinberg

PHILADELPHIA –

Every once in a while, education policy squeezes its way onto President Barack Obama's public agenda, as it did in during last month's State of the Union address. Lately, two issues have grabbed his (and just about everyone else's) attention: early-childhood education and access to college. But while these scholastic bookends are important, there is an awful lot of room for improvement between them. American high schools, in particular, are a disaster.

In international assessments, our elementary school students generally score toward the top of the distribution, and our middle school students usually place somewhat above the average. But our high school students score well below the international average, and they fare especially badly in math and science compared with our country's chief economic rivals.

What's holding back our teenagers?

One clue comes from a little-known 2003 study based on Organization for Economic Cooperation and Development (OECD) data that compares the world's 15-year-olds on two measures of student engagement: participation and "belongingness." The measure of participation was based on how often students attended school, arrived on time and showed up for class. The measure of belongingness was based on how much students felt they fit in to the student body, were liked by their schoolmates and felt that they had friends in school. We might think of the first measure as an index of academic engagement and the second as a measure of social engagement.

On the measure of academic engagement, the U.S. scored only at the international average, and far lower than our chief economic rivals: China, Korea, Japan and Germany. In these countries, students show up for school and attend their classes more reliably than almost anywhere else in the world. But on the measure of social engagement, the United States topped China, Korea and Japan.

In America, high school is for socializing. It's a convenient gathering place, where the really important activities are interrupted by all those annoying classes. For all but the very best American students – the ones in AP classes bound for the nation's most selective colleges and universities – high school is tedious and unchallenging. Studies that have tracked American adolescents' moods over the course of the day find that levels of boredom are highest during their time in school.

One might be tempted to write these findings off as mere confirmation of the well-known fact that adolescents find everything boring. In fact, a huge proportion of the world's high school students say that school is boring. But American high schools are even more boring than schools in nearly every other country, according to OECD surveys. And surveys of exchange students who have studied in America, as well as surveys of American adolescents who have studied abroad, confirm this. More than half of American high school students who have studied in another country agree that our schools are easier. Objectively, they are probably correct: American high school students spend far less time on schoolwork than their counterparts in the rest of the world.

Trends in achievement within the U.S. reveal just how bad our high schools are relative to our schools for younger students. The National Assessment of Educational Progress, administered by the U.S. Department of Education, routinely tests three age groups: 9-year-olds, 13-year-olds and 17-year-olds. Over the past 40 years, reading scores rose by 6 percent among 9-year-olds and 3 percent among 13-year-olds. Math scores rose by 11 percent among

9-year-olds and 7 percent among 13-year-olds.

By contrast, high school students haven't made any progress at all. Reading and math scores have remained flat among 17-year-olds, as have their scores on subject area tests in science, writing, geography and history. And by absolute, rather than relative, standards, American high school students' achievement is scandalous.

In other words, over the past 40 years, despite endless debates about curricula, testing, teacher training, teachers' salaries and performance standards, and despite billions of dollars invested in school reform, there has been no improvement – none – in the academic proficiency of American high school students.

It's not just No Child Left Behind or Race to the Top that has failed our adolescents – it's every single thing we have tried. The list of unsuccessful experiments is long and dispiriting. Charter high schools don't perform any better than standard public high schools, at least with respect to student achievement. Once one accounts for differences in the family backgrounds of students who attend public and private high schools, there is no advantage to going to private school, either. Vouchers make no difference in student outcomes. No wonder school administrators and teachers from Atlanta to Chicago to my hometown of Philadelphia have been caught fudging data on student performance. It's the only education strategy that consistently gets results.

We need to rethink high school in America. It is true that providing high-quality preschool to all children is an important component of comprehensive education reform. But we can't just do this, cross our fingers and hope for the best. Early intervention is an investment, not an inoculation.

In recent years experts in early-child development have called for programs designed to strengthen children's "non-cognitive" skills, pointing to research that demonstrates that later scholastic success hinges not only on conventional academic abilities but on capacities like self-control. Research on the determinants of success in adolescence and beyond has come to a similar conclusion: If we want our teenagers to thrive, we need to help them develop the non-cognitive traits it takes to complete a college degree – traits like determination, self-control and grit. This means classes that really challenge students to work hard – something that fewer than one in six high school students report experiencing, according to Diploma to Nowhere, a 2008 report published by Strong American Schools. Unfortunately, our high schools demand so little of students that these essential capacities aren't nurtured. As a consequence, many high school graduates, even those who have acquired the necessary academic skills to pursue college coursework, lack the wherewithal to persevere in college. Making college more affordable will not fix this problem, though we should do that too.

The good news is that advances in neuroscience are revealing adolescence to be a second period of heightened brain plasticity, not unlike the first few years of life. Even better, brain regions that are important for the development of essential non-cognitive skills are among the most malleable. And one of the most important contributors to their maturation is pushing individuals beyond their intellectual comfort zones.

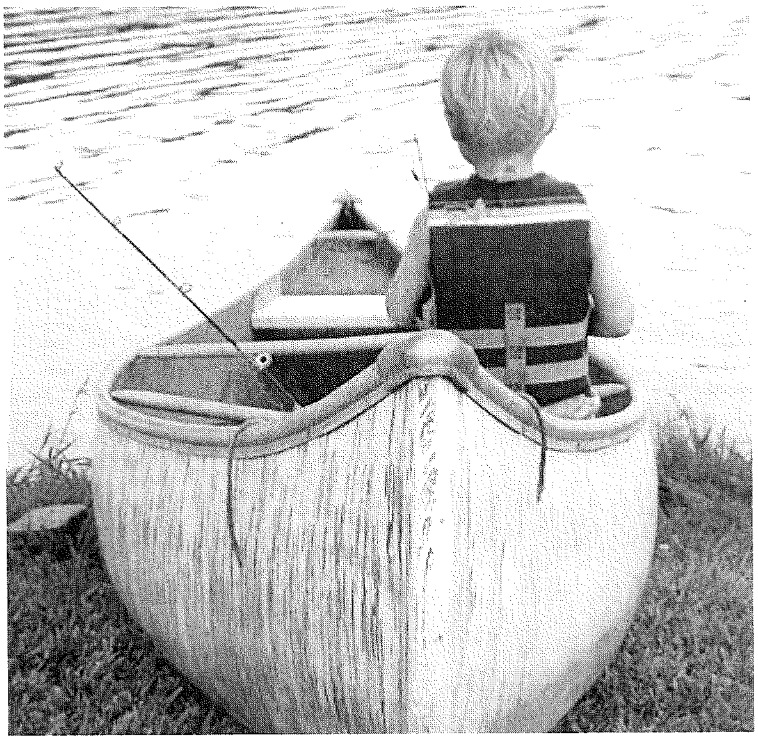
It's time for us to stop squandering this opportunity. Our kids will never rise to the challenge if the challenge doesn't come.

Laurence Steinberg is a psychology professor at Temple University and author of the forthcoming "Age of Opportunity: Revelations from the New Science of Adolescence."

eGFI
Dream Up the Future

Lesson: Can-Do Canoe

Posted on November 13th, 2011 by Mary Lord



(*Lesson from IEEE's* TryEngineering.org)

In this activity, teams of students in grades 3 -12 explore the engineering design process by building model canoes from everyday materials and testing their design in a basin. The canoes must be able to float for three minutes and, for older students, support a load. Students then evaluate the effectiveness of their canoes and those of other teams, and present their findings to the class.

Grade Level: 3 -12 [ages 8-18]

Time: Two or three 45-minute sessions

Learning Objectives

After completing this activity, students should have a better understanding of:

Engineering materials
Engineering design
Planning, construction, and testing
Teamwork

Learning Outcomes

As a result of this activity, students should develop an understanding of:

engineering and design
problem solving
teamwork
Standards

National Science Education Standards

As a result of activities, all students should develop:

Content Standard A: Science as Inquiry

Abilities necessary to do scientific inquiry
Understanding about scientific inquiry

Content Standard E: Science and Technology

Abilities of technological design [K-12]
Understandings about science and technology [5-12]

Content Standard F: Science in Personal and Social Perspectives

Science and technology in local challenges [K-4]
Risks and benefits; Science and technology in society [5-8]
Personal and community health; science and technology in local, national, and global challenges [9-12]

Content Standard G: History and Nature of Science

Science as a human endeavor [K-8]
History of science [5-8]
Nature of scientific knowledge; historical perspectives [9-12]

International Technology Education Association

The Nature of Technology

Standard 1. Students will develop an understanding of the characteristics and scope of technology.

Technology and Society

Standard 4. Students will develop an understanding of the cultural, social, economic, and political effects of technology
Standard 6. Students will develop an understanding of the role of society in the development and use of technology
Standard 7. Students will develop an understanding of the influence of technology on history

Design

Standard 8. Students will develop an understanding of the attributes of design
Standard 9. Students will develop an understanding of engineering design
Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

Standard 13. Students will develop abilities to assess the impact of products and systems

The Designed World

Standard 17. Students will develop an understanding of, and be able to select and use, information and communications technologies.

Summary

Canoes have been hand-built for centuries. This lesson explores how engineering has changed their manufacturing over time, including the development of durable, lighter materials. Working in teams of "engineers, " students design and build their own canoe models out of everyday items. Like real engineers, they have design constraints, such as limited mateirals. They test their models on water, where they must stay afloat for 3 minutes carrying a load. Then students evaluate their results, and present their findings to the class.

Materials

For each group:

Popsicle sticks, wooden spoons, small balsa wood pieces, bendable wire (florist's or craft wire), string, paper clips, rubber bands, toothpicks, aluminum foil, plastic wrap, wooden dowels or other materials, glue.

Student worksheet
Teacher worksheet
Water, large basin or sink, measuring cup or other pouring device

Procedure

1. Show students the resource sheets (pages 5 & 6 of the .pdf) either to read in class or assign as homework.
2. Divide the class into groups of two or three students, providing a set of materials to each team.
3. Explain students must develop their own working canoe from everyday items, and it must be able to stay afloat without falling apart for 3 minutes. (Note: For older or advanced students, consider adding coins or other weight to the design challenge.)
4. The canoe must be at least 8 inches in length.
5. Students brainstorm ideas to develop a plan for their canoe. They agree on the materials they will need, and write or draw their plan and present it to the class.
6. Students can request additional quantities of materials (up to two sets of materials per team) and trade unlimited quantities with other teams to assemble their ideal parts list.
7. Students execute their plans. They may need to rethink their designs, request materials, trade with other teams, or start over.
8. Next, teams test their canoes to see if any can float for three minutes.
9. Teams complete an evaluation worksheet and present their findings to the class.

Extensions

For older students, develop a canoe that can hold a heavy load, such as coins.
Explore local concrete canoe competitions.
Write a paragraph or essay on how engineering and materials have changed ship design over the years.

A .pdf of this lesson can be found at *TryEngineering.org*.

Filed under: Class Activities, Grades 6-8, Grades 6-8, Grades 9-12, Grades 9-12, Grades K-5, Grades K-5, Lesson Plans

Tags: boat, canoe, Class Activities, Design, Lesson Plan, Lesson Plans, Native American

« Mass. Starts Early College STEM Program | Contest: eCYBERMISSION »

Lyon Arboretum
School outreach

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HCPS III

Preschool Plants Field Trip (PreK)
Field trip activities support Hawai'i Preschool Content Standards, approved by the School Readiness Task Force.

Plants and Me Field Trip (K)
Kindergarten HCPS III benchmarks targeted for this field trip:
Science K.1.1 Scientific Inquiry Use the senses to make observations
Science K.1.2 Scientific Inquiry Ask questions about the world around them
Science K.4.1 Science, Technology, and Society Identify differences between living and non-living things
Science K.6.1 Nature of Matter Classify objects by their attributes (e.g., physical properties, materials of which they are made)
Social Studies K.8.1 Limited Resources and Choice Explain people's basic needs and how they fulfill them
Physical Education K-2.2.2 Safety and Play Etiquette Identify basic rules for safe participation in physical activities

AN OCEAN OF DIFFERENCE

pp 4-7 of 16

In the complex recipe of Earth's climate and weather, no ingredient is more important than the Sun. Without its intense energy, life on our planet would be impossible. At an average distance of 93 million miles (150 million kilometers), only 1/2 billionth of the Sun's energy reaches Earth. Yet even that fraction of the Sun's power is massive—totaling some 1.8 x 10^{14} kilowatts, or more than 300,000 times the electrical generating capacity of the United States![1]

Not all of that solar radiation reaches the surface of Earth. Some energy is scattered by the atmosphere on its way to the surface or is reflected back by the clouds,[2] leaving about 45 percent to complete the journey. This solar radiation is absorbed (as heat) in differing amounts by the various surfaces on Earth. Land areas heat up quickly during the day and cool rapidly at night, radiating much of their energy back to space. Luckily, atmospheric gases such as carbon dioxide and water vapor retain certain types of radiation that warm the atmosphere. Scientists have termed this phenomenon the *greenhouse effect*.

As compared with the continents, the world's oceans absorb much more of the incoming solar radiation and reflect much less back to space. That is because water has a higher *heat capacity* (holds more heat per unit volume) than land or air. Not surprisingly, the oceans' higher heat capacity directly affects the climate of our planet. The insulating effect of water gives coastal areas a more moderate range of temperatures than inland areas have at the same latitude.

The energy from the Sun (in the form of heat) fuels the circulation of Earth's atmosphere. Regions near the equator receive more heat than those near the poles. Warmer, lighter air rises at the equator while cooler, denser air sinks at the poles. This sets up a pole-to-equator movement of air at the surface and an equator-to-pole movement of air aloft, although actual atmospheric circulation is somewhat more complex. Because of Earth's rotation, atmospheric winds appear to be deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.

Ocean Currents—Going with the Flow

The circulation of the world's oceans generally mirrors the movements of the atmosphere. Surface currents driven by atmospheric winds move warm equatorial waters to the poles and cold polar waters toward the equator—setting up nearly circular patterns of movement known as *gyres*. Before steam-powered ships were introduced in the nineteenth century, sailors used these winds and currents to cross vast stretches of ocean. Many of the routes they took, such as those between Europe and America, were physically longer than the trade routes used today. Rather than setting out directly west from Europe, sailors moved parallel to the west coasts of Europe and North Africa until they reached the "trade winds" that carried them westward across the Atlantic to the Caribbean.

Today scientists recognize that ocean currents are more than natural highways of commerce. These massive movements of ocean water play a pivotal role in determining the climate of Earth, although their behavior is not entirely understood. And, of the myriad currents flowing through the open ocean and along the edges of continents, the Gulf Stream may have the greatest influence on climate.

This swift-moving current transports more than 100 times the outflow of all the world's rivers as it moves northeastward from Cuba to Newfoundland. Caribbean heat continues eastward (in the form of the North Atlantic Drift), greatly moderating the coastal European climate. Much of Britain, the southern parts of which lie north of the U.S.–Canadian border, experiences winters as mild as those of northern Florida, Georgia, and South Carolina, which are fifteen to twenty degrees in latitude further south![3]

The counterpart to the Gulf Stream in the Pacific is the Kuroshio (or Japan) Current, which moves from the Philippines northward past Taiwan and Japan. Overall, the climatic effects of the Kuroshio Current are less extensive than those of the Gulf Stream. Towering mountain ranges along the west coast of North America confine the effects of the current's waters to relatively small areas.

Other, similar currents affect climate on the rest of the planet. The relatively cold California, Peru, Benguela, and Canary Currents flow around the west coasts of the Americas, Africa, and Europe, creating cool, moist surface air with frequent fog and overcast skies.

El Niño—An Ocean Child

Not all ocean waters have a moderating effect on weather and climate. A massive ocean-atmosphere interaction in the tropical Pacific known as El Niño has brought about climatic devastation worldwide. The term *El Niño* (Spanish for "the Christ Child") was coined more than a century ago by Peruvian and Ecuadorian fishermen who noted that in some years a warm ocean current appeared during the Christmas season and lasted for several months.

The fishermen noticed because when the warm waters were present, fish were less abundant, threatening their livelihood. Even worse, they encountered heavy rains and flooding.

Scientists now understand that these fishermen were observing part of El Niño. The strongest El Niño event of this century occurred from 1982 to 1983 and has been blamed for $8 billion in damage worldwide. Climatic effects of this El Niño included drought and brush fires in Australia, Indonesia, southern India, and parts of Africa and Brazil. In contrast, heavy rains fell along the equator, in Southern California, and the southeastern United States, while winter temperatures soared far above normal in the interior of Canada.

While scientists do not entirely understand the causes of El Niño, they believe that it is linked to dramatic atmospheric changes that typically occur over the North Pacific every 2 to 7 years. In normal years, prevailing winds blowing from the east help to push Earth's warmest ocean water into the western Pacific. For reasons that aren't clear, occasionally the prevailing winds weaken and the warm water begins to move eastward across the Pacific toward South America—starting El Niño.

El Niño's effects extend far beyond the South American coast. Storm systems that would normally have been kept farther west by the prevailing winds move into the central equatorial Pacific, bringing heavy rain to typically dry islands. These heavy storm systems further disrupt the normal flow of the *jet streams* across the Northern Hemisphere.

In any El Niño year the polar jet stream shifts northward over western North America, resulting in mild winters over western Canada and the north central United States. At the same time the subtropical jet stream is more vigorous than normal, bringing heavy rainfall to the southern United States.

Tomorrow's Forecast. . .

Every day scientists gather vast amounts of data about the world's oceans from Earth-orbiting satellites, ocean-traversing research vessels, and drifting buoys. Advanced computer models process this raw data, helping scientists to forecast not only the probability of common weather systems but also the dramatic effects of El Niño. These efforts have been so successful that individuals, corporations, and governments alike have come to depend on weather and climate forecasts to make critical choices. Whether it's a decision to plant more or less of a crop, to import or export a product, or to invest in a developing technology, the ocean is an important factor.

Yet there is still much to be learned about the complex interactions between the ocean and atmosphere in determining our planet's weather. The ocean and atmosphere are so intertwined that it is often unclear which is driving the other at any given time. However, whatever the process, the ocean will always play an important role in tomorrow's weather.

GLOSSARY OF KEY TERMS

Weather
The immediate atmospheric conditions: temperature, humidity, precipitation

Climate
The long-term weather conditions in a specific geographic area

Greenhouse effect
The process by which Earth's surface is warmed by comparatively short-wavelength solar radiation and its atmosphere is warmed by relatively long-wavelength radiation reflected from its surface

Heat capacity
The amount of energy required to raise the temperature of a substance by a given amount

Gyres
Circular or spiral forms of water movement in an open ocean basin

Jet streams
Belts of strong winds in the upper atmosphere that separate warm and cold regions at Earth's surface

LESSON PLAN
Step 1

OCEAN CURRENTS—GOING WITH THE FLOW

Objectives

- Locate the continents and oceans of Earth.
- Identify the basic circulation patterns of the oceans.
- Evaluate the relation between ocean currents and trade routes of the past.

Materials

- Copies of Worksheet 1, page 7.
- Pencils or pens.
- World maps or globes (you might also use the atlas section of your social studies book).
- National Geographic ocean map of currents and speeds (if available).

Subjects

- Science, geography, social studies

Procedure

1. Using the Introduction as a guide, tell your students that the oceans play a major role in determining the climate of our planet. Be sure to mention the oceans' ability to store vast amounts of solar energy (in the form of heat) and capacity to distribute that energy around the planet through currents and accompanying atmospheric winds.

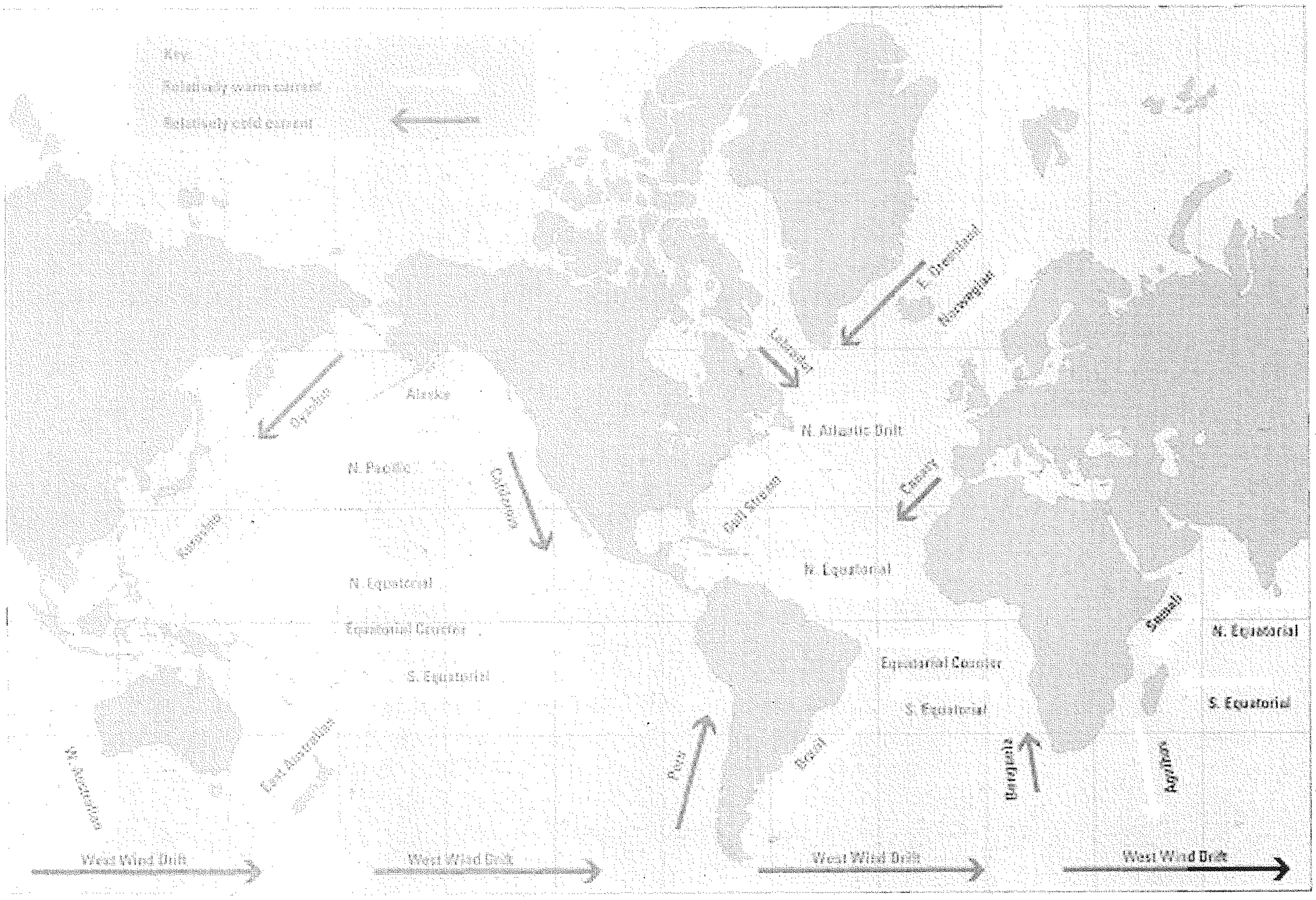
2. Give each student a copy of Worksheet 1. (*Make sure each student has access to a map or globe with the continents and oceans clearly labeled.*) Ask your students to label the continents and oceans on both worksheet maps. You may wish to have students venture answers before consulting map sources, especially if your school lies within a coastal area or if you have recently completed a geography unit.

3. Direct your students to the map of ocean currents on Worksheet 1. Tell them that the map shows the relative temperatures of the currents—some are warmer than the waters surrounding them, others are cooler. Ask students to evaluate what relation exists between the temperature of the currents and their direction of flow. (*Students should conclude that warmer currents flow from the equator to higher latitudes, while colder currents flow from the polar regions toward the equator.*) This evaluation may be difficult for some students. You may wish to take a representative warm and cold current and ask students to identify whether the water in each flows toward or away from the equator. Apply the same questions to other currents to establish an understanding of the general pattern of current flow.

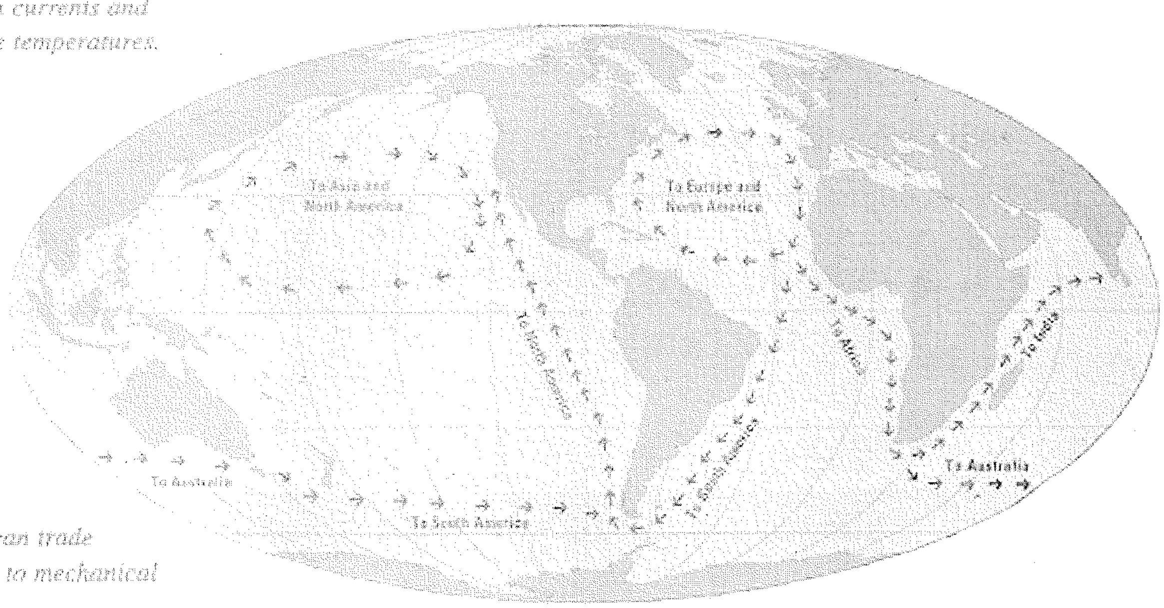
4. Tell your students that today scientists understand how ocean currents affect global climate. Remind them that the oceans are tremendous reservoirs of solar energy (in the form of heat) and that ocean currents move this energy around the globe. For an example, you may wish to describe the effects of the Gulf Stream on the climate of coastal Europe and North America (*this information can be found in the Introduction*).

5. To conclude the activity, direct your students to the map of ocean trade and travel routes on Worksheet 1. Tell your students that well before there was much scientific understanding of ocean currents sailors used currents to navigate. Ask students to consider how ocean-going vessels may have been powered before the advent of steam engines or any other mechanical power. They will probably say that vessels were mostly powered by the winds. Next, direct students to examine closely the trade and travel routes shown on Worksheet 1. Ask them to compare these routes to the flow of ocean currents on the top part of the worksheet. (*Students should conclude that trade and travel routes largely followed the flow of atmospheric winds and ocean currents.*)

WORKSHEET 1
Ocean Currents



Major ocean currents and their relative temperatures.



Selected ocean trade routes prior to mechanical propulsion.