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Supplier Index:

ADVANCED MICROSCOPY GROUP....19
ALDON....25
ALTAY SCIENTIFIC....16, 21
AMERICAN 3B SCIENTIFIC....9
AMERICAN EDUCATIONAL PRODUCTS....20
AQUA PHOENIX....2, 5
BEL-ART....19-20
CELESTRON....22
CORNING....10
CYBER-ANATOMY....23
DIVERSIFIED WOODCRAFTS....6
EDVOTEK....7
EISCO....17
ESTES INDUSTRIES....19
FISHER SCIENCE EDUCATION....13, 28
FISHERBRAND....8
JOHANNES LIEDER....22
K'NEX....5
KEN-A-VISION....21
KIMBLE CHASE....20
LAB-AIDS....12
LAMOTTE....24
LEARNING RESOURCES....5
MYSTAIR INC....2
NEO/SCI....8
OHAUS....27
REVOLUTIONARY SCIENCE....23
SIMULATION CURRICULUM CORPORATION....19
SPER SCIENTIFIC....24
SWIFT....14
THERMO SCIENTIFIC....10, 15
TROEMNER....12
UNITED SCIENTIFIC SUPPLIES....17

Inside This Issue:

STEM....3
ELEMENTARY....4
BIOTECHNOLOGY....6-7
LIFE SCIENCES....8-9
CHEMISTRY....11
PHYSICAL SCIENCE....16-17
ASTRONOMY AND EARTH SCIENCE....12-13, 18
TECHNOLOGY....22-23
ENVIRONMENTAL....24-25
SCIENCE HISTORY....26

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ABOUT OUR SUPERHERO:

Cosmic Ray uses telescopic vision to see the universe's most distant objects.

– Illustration by Michael Andrulonis

CAREER SPOTLIGHT: ASTROPHYSICIST

By Gwen Myslinski

Credit: NASA

NASA's Hubble *f nds hundreds of young galaxies in early universe*

Does life exist somewhere else beyond Earth? How did we come to exist? How does the universe work? There are lots of unanswered questions about the universe and the people who try to answer those questions are astrophysicists. They are the professionals whose specialty combines astronomy and physics to study the universe, galaxies, black holes, stars and other space entities. They are always on the hunt to answer the universe's continuously changing conditions and its origin.

EDUCATION AND TRAINING

Astrophysicists have a passion for the unknown, are great at problem-solving and have a strong liking for the sciences. These scientists ask lots of questions, develop theories and hypotheses, which are often based on incomplete information, and design experiments to try to find answers.

To become an astrophysicist, one would need a Ph.D. in astronomy or astrophysics from an accredited university. Here are some tips to becoming a sought-after astrophysicist:

- While obtaining a Ph.D, work under the guidance of someone recognized in the field, and collaborate with other project scientists
- Take a postdoctoral fellowship (like an internship) in a different country from where you grew up and were educated — this is the only time for 100 percent research, without any administrative duties or support
- After the postdoctoral fellowship, apply for senior fellowships and permanent positions

It's important to make a name (for yourself) early because there's a short list of open positions available.

JOB OUTLOOK

Many astrophysicists in this field aren't usually after fame, fortune or prestige; many are searching for answers and want to know that their lives had been worthwhile. According to the U.S. Bureau of Labor Statistics, the median salary is $105,000. Ray Norris, an astrophysicist at the CSIRO Australia Telescope National Facility, was doing research for his Ph.D. when he discovered a new piece of knowledge that no one else knew at the time. When he realized it, he found the feeling "intoxicating and addictive." He "spent the rest of [his] life trying to get regular fixes."

There are few employment opportunities available for astrophysicists, though according to U.S. Bureau of Labor Statistics between 2010 and 2020 the field is expected to increase by 14 percent and according to **http://careers.stateuniversity.com/pages/7753/Astrophysicist.html**, those in biotechnology and nanotechnology will have better job opportunities. Private firms are also expected to recruit a significant number of astrophysicists.

Learn more about our career spotlight at **www.fisheredu.com/STEM**.

CLASSROOM DISCUSSION

- Astrophysicists from NASA are working on a well-known, two-year mission that launched in August. What is it? (Hint: It's covered in *Headline Discoveries*.)
- How do most astrophysicists get the funding to do their research?

STEM ADVANTAGE: DIGITAL UNIVERSE

By Robert Marshall, Educator, Carnegie Science Center

Credit: Jim Judkis

In college, while earning my undergraduate astronomy degree, I experienced first hand the importance of STEM education. I am a presenter for the Buhl Planetarium at Carnegie Science Center and was educating the public every day, using a simulated night sky reflected off a gigantic dome. With a brand-new digital projection system, I had the capability to leave Earth and navigate the three-dimensional universe. Once the museum closed I was free to play.

My technological exploration had led to real scientific learning. I came to the understanding of how the universe was assembled: planets, stars, galaxies, cosmos. Furthermore, I familiarized myself with incomprehensible scale: astronomical units, light-years and giga parsecs. You cannot touch the Milky Way, but its billions of stars, all mapped using real astronomical data, were at my fingertips. This allowed me to be the creator of my own learning curve. I was inspired. I became excited and motivated for class. Among my classmates, I felt I had a distinct advantage because of Digital Universe. Even though everyone was being taught the same concepts during lecture, I was, on my own time, interacting with, and visualizing, these concepts in a digital laboratory. I was making unique connections between two parallel universes.

Today, most of the American education system recognizes the importance of STEM education. "How do we know it is working?" I recently asked a STEM education researcher. "Reach into your pocket," he replied. Dr. Brad McClain from the University of Denver was referring to the placement of my cellphone. In other words, the outcome might be quantitatively difficult to measure but we can see the results: technological creations integrated all around us — like Digital Universe. Today's smartphones are the result of the collaboration of science, technology, engineering and mathematics. And there are dozens of free applications that allow users to interact with the night sky by holding their phone up to label stars, planets, even satellites. I can only image that, one day, everyone will have a Digital Universe application, just like the one that changed my life, on their phone that can be carried around in their pocket.

CLASSROOM DISCUSSION

- Where is the closest planetarium to you? Does it have a digital system?
- What must a phone know in order to show its user the proper position of celestial objects? For instance, what about your location on Earth? Time?

WRITTEN IN THE STARS

By Ashley Peterson

Autumn is a great time for stargazing; the nights are clear, longer than summer's, and the temperatures dip just enough to increase atmospheric seeing. If you live in the Northern Hemisphere, several constellations should be visible during the fall months. Constellations are formations of bright stars that appear close to each other in the night sky. The shapes they form depend on your point of view, but civilizations and cultures throughout history have created their own patterns in the sky based on stories and people that were important to them.

CEPHEUS AND CASSIOPEIA

Looking North, the constellations Cepheus and Cassiopeia are named after the King and Queen of Ethiopia in Greek mythology and appear side by side in the night sky. The stars of Cassiopeia, during the fall, form a letter "M" that represents her crown. Cepheus is shaped like a house, and because its stars are of lesser apparent magnitude than Cassiopeia, it can be difficult to see. However, this region of the sky is of particular interest to astronomers as it is full of double stars, binary systems in which one star orbits another, and contains three red supergiants, all found in our Milky Way Galaxy.

ANDROMEDA AND CETUS

Andromeda is a "V" shaped constellation named after the princess of the mythical kingdom of Ethiopia. According to Greek mythology, Andromeda's mother, Queen Cassiopeia, bragged that she was prettier than the sea nymphs. The nymphs complained to Poseidon, the god of the sea, who in turn sent the sea monster, Cetus, to destroy her land. The queen and her husband, King Cepheus, were forced to sacrifice their daughter Andromeda to save the country. Today, Cetus is also commonly referred to as "the whale" because of its shape in the sky. Due to its size, there are only a few months of the year, in autumn, when the entire constellation is visible.

PERSEUS

Perseus is a Greek hero, most famous for slaying Medusa. According to myth, anyone who laid eyes on Medusa's face would turn to stone, but Perseus was able to defeat Medusa by hiding behind his shielding mirror. The legend says that on his way home, he came upon Cetus, and rescued Princess Andromeda using the head of Medusa to turn the monster to stone. Perseus appears as a backwards "K" in the night sky. With some imagination, stargazers can make out the image of a man with two arms stretching out, possibly holding a weapon or the head of Medusa.

A BRILLIANT STORY IS IN THE STARS

You may not be able to spot all of these constellations right away, but with a little patience and the right conditions, the autumn sky has a story to tell. Grab a pair of binoculars, a cup of hot cocoa and enjoy the view!

CLASSROOM DISCUSSION

- Why are most constellations seasonal, only visible during certain months of the year?
- Can you name another constellation and explain how/why it is was named?

TURNING BACK (AND FORTH) THE HANDS OF TIME

By Alida Cataldo

Twice a year, most of us have to turn our clocks back or forward one hour to start or end Daylight Saving Time (DST). Why do we do this?

During World War I, Germany saw DST as a way to save coal by reducing the need for artificial light. The U.S. followed suit in 1918 but didn't require the states to participate. DST was mandated during World War II to save resources; and, between February 9, 1942, and September 30, 1945, it was in effect year round.

After the war, DST again became optional and remains so today. States and territories that don't observe it are Arizona, Hawaii, Puerto Rico, the Virgin Islands, American Samoa, Guam and the Northern Marianas Islands. Even counties within a state can — and do — opt out.

DOES DAYLIGHT SAVING TIME REALLY SAVE ANYTHING?

Only 27 percent of Americans believe DST saves energy. But cases can be made for and against:

- In the U.S., DST was extended through the winter of the 1973-1974 energy crisis, resulting in a 1 percent decrease in electrical load
- The U.S. Department of Energy reported that, in 2008, DST reduced overall energy consumption by 0.02 percent ... a small percentage, but a large amount considering how much energy the U.S. consumes
- In Australia, energy consumption during DST was less in the evenings, but more in the mornings
- In Indiana, energy for lighting dropped but air conditioning usage increased

THE EFFECTS ON US

Our circadian body clocks are set by light and darkness. One study maintains that we "never adjust to gaining an 'extra' hour of sunlight." Another indicated that the risk of heart attack increases just after DST goes into effect, most likely because of "disturbed sleep and disruption of biological rhythms." But there are health benefits, as many of us spend more evenings in outside activities.

A 2010 survey by Rasmussen showed that 47 percent of us don't think DST is worth the hassle. Love it or hate it, it's here to stay ... unless, of course, Congress changes its mind again.

CLASSROOM DISCUSSION

- Do you think Daylight Saving Time is a good thing? Why or why not?
- Some places in the U.S. don't implement Daylight Saving Time; how could that affect business, industry and government?

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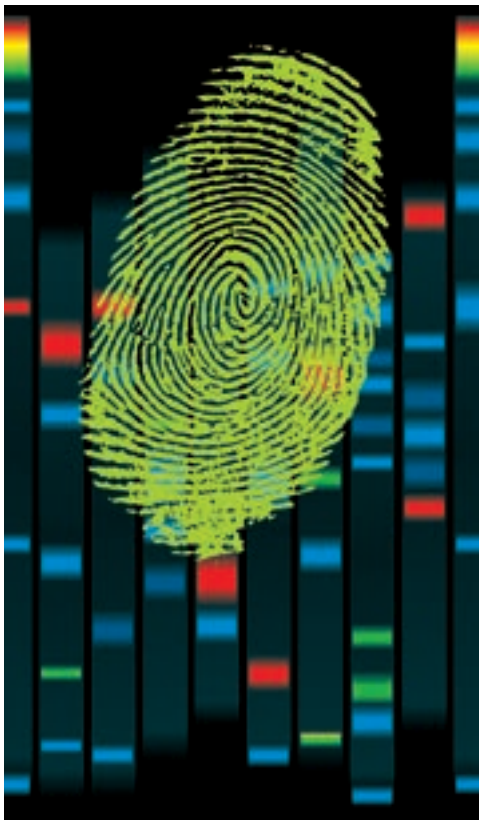
FORENSIC SCIENCE: THE TRUTH CAN SET THEM FREE

By Patti Dobranski



Imagine spending more than half of your life in prison for a crime you did not commit. Microscopic hair evidence presented in a 1978 murder case in Washington, D.C., made this a reality for Santae A. Tribble.

But after 28 years behind bars, Tribble, now 51, has been set free by recent DNA testing of that hair, which ultimately excluded him as the killer.

SCIENCE STEPS IN

Questions about the reliability of past DNA evidence inspired the National Academy of Sciences (NAS) to ask the White House and Congress to remove crime labs from both law enforcement and prosecutors' control. At the very least, the NAS would like to strengthen the presence of science and standards of the nation's forensic science system.

In response to this movement, the U.S. Department of Justice and the FBI are now reviewing thousands of criminal cases to see if any defendants were indeed wrongly accused or entitled to a new trial.

Why? Tribble's case is not so unusual.

UNRELIABLE PAST EVIDENCE

Since 1989, there are virtually tens of thousands of cases where prime suspects were identified and pursued — until DNA testing (prior to conviction) proved that they were wrongly accused, according to the Innocence Project, a New York-based organization founded in 1992 to assist prisoners who could be exonerated through DNA evidence.

Government officials have not yet decided when they would notify defense attorneys or the Innocence Project about new scientific findings or components of the new FBI review process.

CLASSROOM DISCUSSION

- Do you think the National Academy of Sciences should be in control of the nation's forensic science system with no input from the Justice Department or the FBI? Why or why not?
- Can you think of any other areas of government where scientific input can improve the system and/or the quality of life in the U.S.?

DANCER TO THE CORE

By Merry Morris

There is something almost magical about movements of a trained dancer. Whether lithe or powerful, the dancer portrays beauty and meaning through simple movement of the human body.

Dancing requires tremendous work and commitment. According to Heidi Ashton of the University of Leicester, "Becoming a dancer requires dedication and passion, years of tough, relentless training, and [it] involves fierce competition and harsh criticism."

But beyond the training and focus, research now shows that the aptitude for dancing goes deep — REAL DEEP — right down to the genes.

GENETIC SURPRISE

Psychology professor Richard P. Ebstein from the Hebrew University in the Psychology Department's Center for Human Genetics in the Social Sciences has published results showing that dancers differ from the rest of the general population on a very basic level. Certain aspects of their genetic codes, specifically those that code for the serotonin transporter and arginine vasopressin receptor 1a, inherently function at a different level than the rest of us.

These genes do not, as one might image, support longer or stronger legs or offer other athletic advantage. They function on another level entirely: in the spiritual and communicative spheres. Serotonin, one of our hormones — chemicals that regulate cells and organs — transmits electrical impulses across the synapses (or spaces) between nerve cells. Beyond purely physical effects, it is associated with spirituality, as well as the capacity for transcendence — the understanding of things beyond normal or objective experience. The other gene researched, arginine vasopressin receptor 1a, is sometimes referred to as the "fidelity" gene and promotes social communication and bonding.

SPIRITUAL TRAITS

Taking another approach to investigate dancers, Ebstein provided questionnaires to the 85 members of his study population to show where they placed on the Tellegen Absorption Scale and the Tridimensional Personality Questionnaire, which correlate spirituality and need for social contact and communication, respectively. When he compared athletes (for their comparable physical ability) and others who were neither dancers nor athletes, the dancers showed "a heightened sense of communication, often of a symbolic and ceremonial nature, and a strong spiritual personality trait," according to Ebstein.

Again, the research reflected innate qualities of dancers. As Heidi Ashton also wrote of dancers, "Dance is not what they do, it's who they are."

CLASSROOM DISCUSSION

- Human genetics is the study of inheritance as it applies to humans. How might human genetic research increase our knowledge of the human condition?
- Neurotransmitters, the chemicals that carry electrical impulses between nerve cells, play a critical part in how the human brain functions; research other neurotransmitters and report how they affect the brain and the rest of the body

AQUATIC DEAD ZONES

By Mary Rose Thomas-Glaser

Credit: R. Diaz, et al/World Resources Institute 2011

Around the world, nearly 500 coastal areas are slowly suffocating due to the lack of oxygen needed to support a diverse aquatic ecosystem. These oxygen-depleted, or hypoxic, "dead zones" result from an excess of nutrients such as nitrogen and phosphorus that causes an explosive growth of algae, phytoplankton and seaweed on the water's surface. These algal blooms prevent sunlight from penetrating the water surface and oxygen from being absorbed by aquatic plants and microorganisms. As the algae dies, oxygen in the water is rapidly consumed in the decomposition process. Without oxygen, shrimp, crabs, clams and other organisms that can't quickly leave the waters are asphyxiated.

CAUSES OF DEAD ZONES

Though a natural phenomenon, dead zones have been greatly exacerbated by human activities. The collective increase in farming, industrial activities and population contribute to excessive releases of nitrogen and phosphorus into the air, soil and water a process known as eutrophication. In the U.S. and developed countries, use of fertilizers and manure in agriculture can result in contaminated runoff that enters the waterways. In third-world countries, untreated sewage and industrial wastes are often disposed of directly into waterways. Additionally, atmospheric nitrogen from burning of fossil fuels is redeposited in precipitation. This nutrient-enriched runoff flows through creeks, streams and rivers until it reaches coastal waters where under ordinary conditions, the tides continuously mix and oxygenate the waters. However, during calm periods, when ocean currents diminish and mixing stops, colder, low-oxygen ocean waters can become trapped under lighter freshwater for extended periods. When this "stratification" occurs, a dead zone is created.

Dead zones typically occur in the spring to fall months and can last from weeks to months. The storms associated with hurricane season actually help to alleviate dead zones.

EFFECTS OF DEAD ZONES

One of the most acute impacts of dead zones is the immediate loss of aquatic life such as larva, shellfish and small fish at the bottom of the food chain. This loss ripples up the coastal food chain and can cause the death of marine animals and wading birds.

Some algal blooms, such as red or brown tides, contain toxic cyanobacteria that can poison fish, birds and other marine life and potentially humans. People have become seriously ill and even died from eating shellfish harvested from contaminated areas. Since shellfish are filter feeders, they absorb the microbes and toxins found in algal blooms.

CLASSROOM DISCUSSION

- What are the short- and long-term impacts of dead zones on aquatic biodiversity and ecosystems?
- What are sources of nitrogen pollution and how can they be reduced?

ADVANCING TOWARD SYNTHETIC LIFE: XNA

By Cory Bickel

DNA and RNA are the molecules that make up and carry out the instructions of the genetic code of every organism on Earth. But a new twist on these molecules has opened up possibilities of synthetic life forms with non-traditional genetic material. XNAs, or xeno-nucleic acids, are slightly altered forms of DNA. DNA has a backbone of sugar molecules strung together in long chains. By changing these sugar molecules from the usual form, six different XNAs were made with different sugar backbones. Attached to the sugar backbone in DNA and XNA are the bases A, T, C or G, and the order of these bases spells out the genetic code. Because these bases are unchanged in XNA, it has the same ability as DNA to store genetic information.

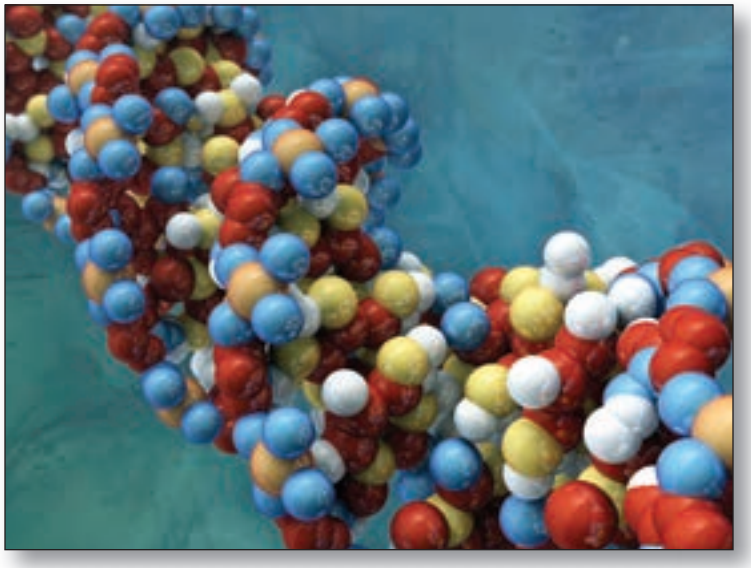
XNA CAN BE INHERITED

Scientists also created enzymes that could make a DNA copy of XNA with fairly high accuracy, as well as enzymes that were capable of reading a DNA sequence and making XNA. The ability of XNA to be copied in this way means that it can be considered inheritable, just like DNA.

XNA CAN EVOLVE

An experiment that mimicked Darwin's process of natural selection showed that XNAs are capable of evolving. After many rounds of amplification, mutation and selection of a pool of XNAs, sequences were found that had evolved to bind specific RNA or protein targets.

The abilities of XNAs to be inherited and evolve mean that they possess the same properties that make DNA a functional genetic material. Although there is a lot more work to be done, XNA could, in theory, be used to create completely synthetic life forms that could reproduce and adapt to new environments.



CLASSROOM DISCUSSION

- XNA show that non-traditional molecules could be capable of carrying genetic information and supporting life; what does this mean regarding the search for life on other planets?
- XNA is a potential source of new drugs and therapies because of its ability to bind molecules very specifically; why does its synthetic nature give it an advantage over DNA or RNA for these applications?

CLOTHES THAT CLEAN THEMSELVES!

By Alida Cataldo

Want to wear that filthy T-shirt again tomorrow? No problem! Just hang it in the sun, and it'll be stain- and odor-free in just a few hours!

Scientists in China have discovered that coating cotton fabric with titanium dioxide — along with silver iodide — causes sunlight to remove stains and kill the bacteria that causes odors.

Titanium dioxide (TiO_2) is a photocatalyst that triggers chemical reactions in light and is commonly used in sunscreens. Its bright white pigment is used as a dye in paints, soaps, tattoo inks, cosmetics and even food. It can also be found in the rubber, plastics, textiles and paper industries; and it's been used to create self-cleaning tile, glass and even fabrics before now. In fact for 40 years, many have known that titanium dioxide could remove fabric stains. But until now, it was effective only in ultraviolet light. This new discovery adds nitrogen ions and silver iodide nanoparticles to clean fabric in any natural light and boost cleaning power by about seven times.

But there's more work to be done before we're all wearing cotton that cleans itself. Studies have indicated that titanium dioxide powder irritates airways, so it's recommended that anyone working with it wear a respirator. Also, the World Health Organization is warning that there is "sufficient evidence that titanium dioxide is carcinogenic in experimental animals." Before this treated self-cleaning cotton is used for clothing, scientists need to do a bit more experimenting to ensure that it's safe.

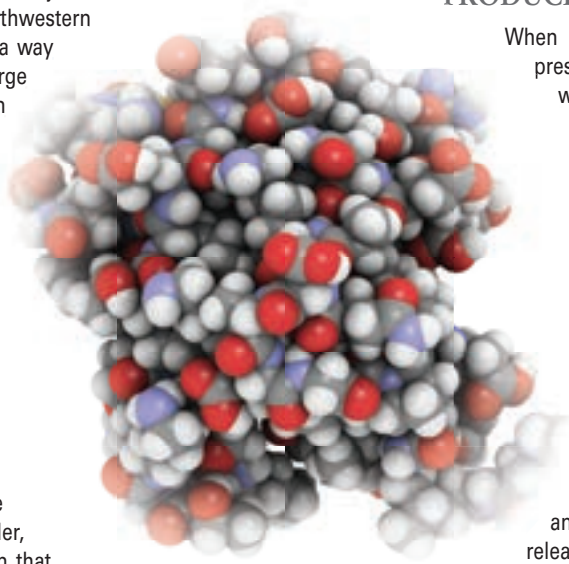
CLASSROOM DISCUSSION

- Do you think that self-cleaning clothes will be popular? Why or why not?
- What other materials, besides cotton, might be made self-cleaning?

RADICAL ENERGY

By Pam Sherwood

The quest for previously untapped energy may have just led to a ubiquitous source — plastics. Engineers at Northwestern University in Evanston, Illinois, have identified a way to get energy from plastics, which are made of large molecules known as polymers. In fact, when subjected to mechanical stresses, such as by bending or squeezing, polymers have been shown to undergo homolytic cleavage, which produces small amounts of chemical energy. Common examples of polymers under mechanical stress include vehicle tires and the soles of athletic shoes. Although this phenomenon has been recognized for decades, the energy produced by polymers under mechanical stress has not been utilized in any significant way.



Polymer, derived from the Greek words poly (many) and meros (parts), refers to a large molecule composed of a long chain of smaller, repeated structural units. Scientists have shown that when a polymer is bent or squeezed, the bonds between the atoms within the molecule can break apart. When this results in the two electrons of a covalent chemical bond being redistributed with one electron going to each of the two atoms previously involved in the bond, it is referred to as homolytic cleavage. The result of homolytic cleavage is the generation of two atoms with unpaired electrons, known as radicals, which are highly reactive species.

PRODUCING CLEAN ENERGY

When a polymer undergoes homolytic cleavage in the presence of water, the free radicals generated react with the water to form a substance called hydrogen peroxide (H_2O_2), which in turn can drive several types of chemical processes. Soft, spongy polymers perform best under these conditions. These spongy polymers can be considered solid-state chemical reagents that convert mechanical energy into chemical energy in a "clean," environmentally friendly fashion. In fact, this method of collecting energy from polymers can be as efficient as coal-burning power plants.

Unfortunately, this same free radical producing reaction can occur when polymeric materials that are implanted in the human body (such as catheters and breast implants) stretch or bend. In these cases the release of free radicals in the body may increase health risks because of their ability to cause cellular damage and health problems.

CLASSROOM DISCUSSION

- What other common materials are made of polymers?
- What other clean energy sources are available?

INVISIBLE SPACE BRIDGE

By Gwen Myslinski

Not even telescopic vision could show an invisible cosmic bridge made up of dark matter, because — you guessed it — it's invisible.

The night sky contains all kinds of wonderment, including two massive galaxy clusters: Abell 222 and Abell 223, located 2.7 billion light-years away. Both are constructed from thousands of galaxies and therefore emit an overabundance of light. But in between the two clusters there's no light or radiation, only dark matter — an invisible bridge. How do astronomers know it's there if no one can see it? Because of the effect the dark matter has on the clusters that are visible. The dark matter's gravitational force is so strong that scientists are able to detect mass, and have determined the "bridge" is actually made up of giant webs of invisible threads, also known as filaments.

FIL-A-WHAT?

Astronomers can't see the filaments. To prove filaments actually do exist between the two clusters, scientists looked for cosmic "lensing." In the universe, where there is a lot of mass there is a lot of gravity. Gravity can bend light. The filaments that make up the dark matter bridge, therefore, can bend starlight before it reaches an observer here on Earth. Many people have experienced this for themselves — by looking through a glass of water and seeing the room differently.

After studying the light, scientists were able to determine that the filaments had as much mass as a galaxy cluster even though it appears as if nothing is there!

Scientists don't know what makes up dark matter, but hope that by learning more about filaments they will understand how visible galaxies and galaxy clusters were originally formed.

Credit: NASA, ESA and D. Coe (JPL/Caltech and STScI)
Illustration by Michael Andrulonis

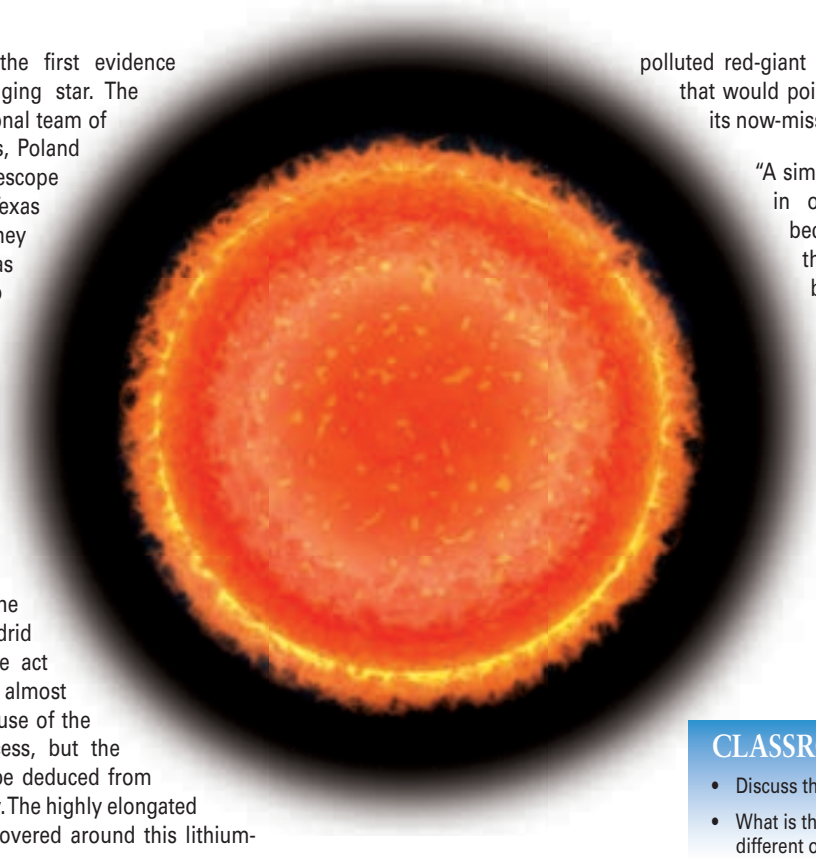
Dark Matter Map in Galaxy Cluster Abell 1689. Astronmers used the lensing technique to create the map.

CLASSROOM DISCUSSION

- What's another example of lensing?
- Where are the Abell clusters in the sky?

PLANET'S DESTRUCTION BY ITS STAR

By Brianne McCurley



Astronomers recently discovered the first evidence of a planet's destruction by its aging star. The discovery was made by an international team of astronomers from the United States, Poland and Spain at the Hobby Eberly telescope at the McDonald Observatory in Texas while studying the star BD+48 740. They believe the planet was destroyed as the star began expanding in size into a "red giant." A red giant is a type of star that is near the end of its life; a phase that lasts a few million years, which is relatively short compared to other stellar life stages. Within a red giant, the rising temperature in its core would cause the star to expand in size and destroy any nearby planets.

According to Eva Villaver of the Universidad Autonoma de Madrid in Spain, "Catching a planet in the act of being devoured by a star is an almost improbable feat to accomplish because of the comparative swiftness of the process, but the occurrence of such a collision can be deduced from the way it affects the stellar chemistry. The highly elongated orbit of the massive planet we discovered around this lithium-polluted red-giant star is exactly the kind of evidence that would point to the star's recent destruction of its now-missing planet."

"A similar fate may await the inner planets in our solar system, when the sun becomes a red giant and expands all the way out to Earth's orbit some five billion years from now," added Alex Wolszczan, and Evan Pugh, Professor of Astronomy and Astrophysics at Penn State University. Our own sun will transform into a red giant, some five billion years from now, a process that will force it to become larger and push it past the Earth's orbit, certainly destroying everything in its path.

CLASSROOM DISCUSSION

- Discuss the characteristics of a red giant
- What is the life cycle of a star? Are there different outcomes for different mass stars?

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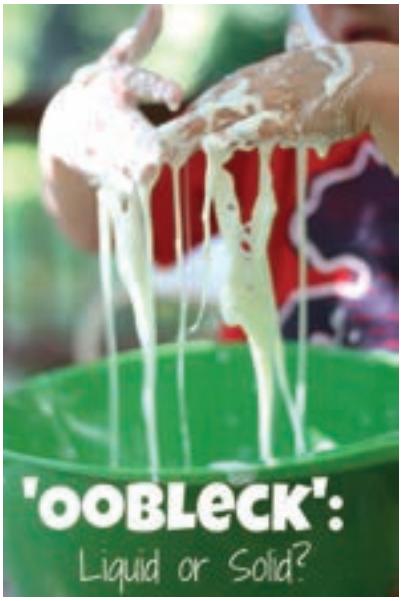
WHAT IN THE WORLD IS OOBLECK?

By Brian Marks



It's the gooey, messy, sticky, green substance that fell from the sky in Dr. Seuss' book *Bartholomew and the Oobleck*. In the story, the King of Didd is bored, so he asks his magicians to change the weather and Oobleck fell from the sky, covering the entire kingdom. Eventually, in the world of science, the word Oobleck became synonymous with a substance that pours like a liquid, but when force is added to the substance, like hitting or squeezing with your hands, it becomes solid.

NON-NEWTONIAN FLUID

Sir Isaac Newton's third law of motion states that for every action in nature there is an equal and opposite reaction. Applying this law, hitting or smacking Oobleck should result in a splash — similar to smacking water in a swimming pool. Amazingly, if you filled a swimming pool with the gooey stuff, you can run across the surface without getting wet. Oobleck does not splash; in fact, it momentarily becomes a solid substance.

Further, it's an example of a fluid that has changing viscosity (how thick or thin a substance is). Its thickness changes depending on the stress or force applied to it and is considered to be "Non-Newtonian."

Conversely, when a fluid's viscosity is constant, it is referred to as a "Newtonian" fluid.

Non-Newtonian or Oobleck-like fluids include ketchup and quicksand. Ketchup becomes less viscous when agitated and is easier to pour if you shake first. Also, quicksand gets more viscous when force is applied, so swim slowly to shore when trying to escape quicksand. If not, it will get thicker the more force you use to escape.

CORNSTARCH AND WATER

If you don't have quicksand nearby, mixing cornstarch and water is the classic experiment to simulate Oobleck goo. Typically, it's a mixture of 1 cup of water to ½ cup of cornstarch with food coloring added to make for some gooey, sticky fun! You can get hands-on experience with Oobleck's unusual physical properties by touching, pouring and mixing the cornstarch and water mixture. Luckily, it cleans up easily with water!

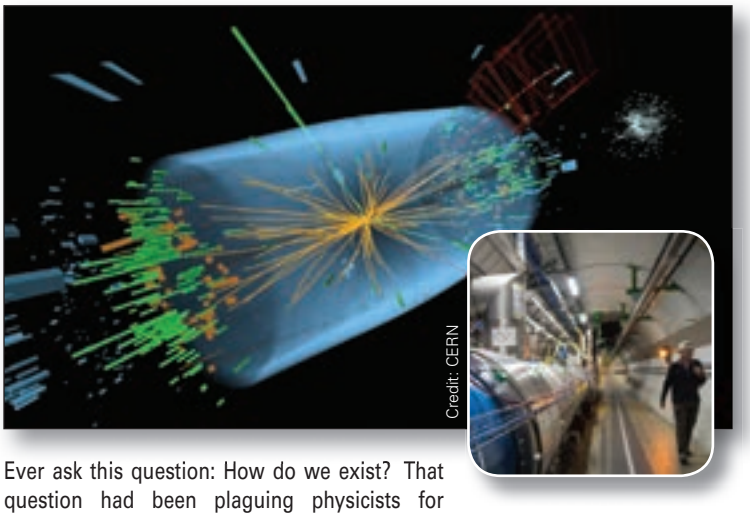
CLASSROOM DISCUSSION

- What other non-Newtonian substances can you think of? Is Silly Putty™ non-Newtonian? How about glass?
- What would happen if you put Oobleck in the freezer? What if you left it out in the sun?

A NEW BOSON DISCOVERED!

By Gwen Myslinski

Credit: CERN



Credit: CERN

Ever ask this question: How do we exist? That question had been plaguing physicists for decades, and this summer there might be an answer. The particle that would complete the standard model of physics with an explanation of why objects in our universe have mass may have been found according to a press release on July 4, 2012, at the European Organization for Nuclear Research (CERN).

Everything in the universe — plants, people, stars — has mass, made of atoms, which are all constructed of smaller sub-atomic particles: quarks, leptons, bosons, etc. Physicists have been able to use math to describe all these particles in the universe, as well as the forces that hold them together. This way of looking at things is called the standard model. All the particles have been identified, all that is, except one — Higgs boson.

Boson particles operate like messengers, carrying a force of some sort between particles. Higgs boson is a little different. Instead of force, it is constructed from the Higgs field that is responsible for giving all other particles mass. If the Higgs field didn't exist, physicists theorize nothing in the universe would have mass. Galaxies, stars, Earth, and certainly people, would not exist.

DISCOVERING THE 'GOD PARTICLE'

CERN, located in Geneva, Switzerland, is the world's largest center for scientific research, focusing on physics — specifically what the universe is made of and how it works. They have complex scientific instruments and use them to learn more about the laws of nature. One instrument is a large, underground tunnel called the Large Hadron Collider. This is what scientists used to discover the Higgs boson candidate.

The discovery wasn't an easy one. There were two teams searching for the Higgs, and to make the particle appear, each team had to smash two protons into each other near the speed of light. This created an explosion that lasted for a split second; the Higgs boson would appear and then fall apart into lighter-weight particles. Both teams independently shared similar findings, ensuring the results hinted at the discovery of a boson.

CLASSROOM DISCUSSION

- Now that Higgs boson has been potentially discovered, what else (dark matter, other particles, etc.) do you think will be discovered in the CERN underground Large Hadron Collider? How long do you think these discoveries will take?
- Once scientists have had a little time to explore and understand Higgs boson, do you think they will find many more unknowns? Any ideas as to what?

CURIOSITY EXPLORES MARS

By Joe Giacobello

Has there ever been life on Mars? To help answer this fascinating question, NASA recently sent a six-wheeled, mobile rover called Mars Science Laboratory (MSL), affectionately called *Curiosity*, to explore the Martian terrain. The $2.5 billion nuclear robotic explorer touched down on Mars August 6. Its mission: to search for evidence that Mars might once have hosted life, even if the organisms were only one-celled microbes.

CURIOSITY

Created by NASA, *Curiosity* is by far the largest science lab — the size of a small SUV — with the most advanced research instruments ever sent to Mars— or any other planet for that matter. During its scheduled 23-Earth-month mission, it will scoop material from the ground, drill samples from rocks and analyze them with greater range than any previous Mars rover.

A full suite of advanced instruments will analyze samples of material collected by *Curiosity's* long, probing arm, with the ability to identify a wide range of organic (carbon containing) compounds. An imaging device mounted on the arm will take extreme close-up photos of rocks, soil and, if present, ice, showing minute details smaller than the width of a human hair. Several mast cameras will image the rover's surroundings in high-res color.

THE SEARCH FOR LIFE

Curiosity will assess whether Mars has ever had or still has environmental conditions favorable to microbial life. Evidence suggests the planet was once much more habitable than it is today, but whether living organisms actually existed there is still a mystery. Landforms visible on Mars strongly suggest that liquid water did exist on the planet's surface in the past, demonstrating the planet's potential for habitability. But recent evidence suggests that any water on the Martian surface may have been too salty or acidic to support regular terrestrial life. Hopefully the MSL mission will help to answer the question as to whether our small neighboring planet has, or ever has had, the ability to develop and sustain life.

Curious about *Curiosity*? Learn more at **www.nasa.gov/mars**.

Artist's concept of Curiosity *using the Chemistry Camera.*

Credit: NASA/JPL – Caltech

Close-up from one of the cameras on Curiosity, *showing two grains of Martian sand on penny; one below Lincoln's ear, and one below the f rst nine in the year 1909.*

Credit: NASA/JPL – Caltech/MSS

CLASSROOM DISCUSSION

- Discuss the similarities and differences between Mars and Earth
- Do you believe that there could indeed be life somewhere else in the Solar System? What about on planets around other stars? Why?

ERUPTIVE DISORDER

By Terri Sota

New research on volcanic eruptions suggests that all that goes up does not necessarily come down. Explosions of halogen gases, most notably bromine and chlorine, are capable of reaching the stratosphere and damaging protective ozone. A GEOMAR study of 70,000 years of volcanic activity in Central America estimates that each of the 14 (examined) eruptions propelled 4,000 to 600,000 tons of bromine into the atmosphere and temporarily thinned the ozone layer.

Combining a mixture of existing atmospheric models, field work and geochemistry, researchers analyzed magma samples using high energy radiation to estimate the amount of gas before and after the eruptions. They calculated the difference between the two concentrations to arrive at the quantity of bromine and chlorine that was released.

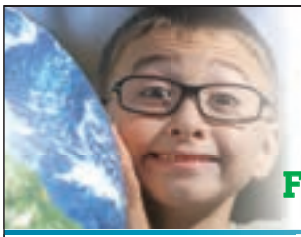
What is the chemistry between these gases and ozone? Both chlorine and bromine are members of the Periodic Table's Group VII — elements with seven electrons in their outer shells (eight is desirable for stability). At the first chance, these atoms will hijack electrons from passing ozone to enhance their stability. Just one chlorine atom has the power to destroy more than 100,000 ozone molecules. Thankfully, hydrogen chloride (the chlorine-containing compound prevalent in volcanic eruptions) dissolves readily in water and is usually deactivated by precipitation. Successful bans on chlorofluorocarbons (CFCs) have diminished human contributions and further reduced stratospheric chlorine levels.

For these reasons, scientists have nominated bromine as the halogen of the atmospheric research hour. While 100 times less abundant than chlorine in an eruption, bromine has 10X more ozone-depleting power. Other natural sources of the gas include ocean waters and brine wells, but it is the unpredictable, explosive delivery of the gas from volcanoes that warrants ongoing investigation. When Alaska's Kasatochi Volcano erupted in August 2008, high bromine concentrations were detected by Europe's first polar-orbiting satellite. One day after the eruption, instruments aboard the *MetOp*-A recorded 50 to 120 tons of reactive bromine in the atmosphere.

The authors of the study warn that tropical volcanoes have the ability to influence stratospheric chemistry all around the globe and deplete ozone over a widespread area. Continuing research will try to assess the damage done to the ozone in the past and predict the impact of volcanic gas activity in the future.

CLASSROOM DISCUSSION

- Discuss the behavioral differences of elements with varied numbers of outer shell electrons
- What are some of the other dangers posed by a volcanic eruption?



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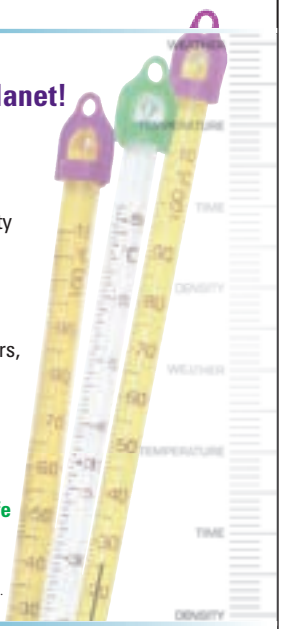

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MILKY WAY RECREATED

By Gwen Myslinski

People use computers every day — it's become a way of life. There are even supercomputers that are faster and more technologically advanced than the everyday computers that many are familiar with. What can these supercomputers do? Lots — even simulate an almost exact, extra-high resolution replica of the Milky Way galaxy. It may not sound like much, but it took researchers nine months to figure out the correct calculations — something that would take current, ordinary PCs 570 years to complete.

ERIS GALAXY

Astrophysicists from the University of Zurich, together with astronomers from the University of California at Santa Cruz, used supercomputers from Zurich's Swiss National Supercomputer Center and the NASA Advanced Supercomputer Division's Pleiades to create "Eris," the name of the simulated galaxy. "The Eris galaxy is a massive spiral galaxy with a central bar of bright stars and other structural properties consistent with galaxies like the Milky Way," according to a press release from UC Santa Cruz.

It has taken 20 years for astrophysicists to understand such a complex system like the formation of the Milky Way realistically, and creating Eris is proof that the base theories of astrophysics were correct. According to the University of Zurich, "All previous attempts to recreate the formation of spiral galaxies like the Milky Way faltered on one of two points: Either the simulated spiral galaxies displayed too many stars at the center or the overall stellar mass was several times too big."

Future generations can now use this simulation for additional predictions and future findings. If only there was a time machine to see what the future holds ...

Credit: University of Zurich

Left: simulated galaxy, the gas is red and the stars are blue; Right: a photo in false color of the galaxy M74, again the gas is red and the stars are blue. In both photos the spiral arms of the gas are apparent.

CLASSROOM DISCUSSION

- What else could this simulation predict?
- With technology advancing so quickly, what would you want to explore and with what technology (phones, computers, telescopes, etc.)?

GOOD VIBRATIONS

By Phil DeSimone

Energy is all around us; it is constantly being exerted to power devices such as your computer screen, your car and even your own body generates and consumes energy. Typically, powering an electrical device involves the simple process of plugging a cord into the wall. The act is almost magical, but this old-fashioned trick may soon be replaced. Imagine the possibility of capturing energy efficiently and reusing it without the need of any messy and tangled wires!

According to the U.S. Department of Energy, more than half of the energy generated in America will be wasted, mainly as heat. New technologies are emerging to capture this energy that may otherwise be wasted. One advancing technology in particular is piezoelectricity. Piezoelectric sensors react to sound, vibration and movement. The piezoelectric sensors generally contain crystals and ceramics that send an electrical charge after being compressed. The most common crystal used is quartz (SiO_2) due to its composition of positive and negative atoms. When quartz bends, the positive and negative atoms separate to create the electrical signal.

While you are walking, every step leaves energy behind. The idea is to capture this energy and convert it to electricity. This technology does not create a lot of power as of now, but it has the potential to change the future for small hand-held devices and is already being used for biomedical devices and sensors. Touch screen phones incorporate piezoelectric sensors, and for upcoming development there is potential to charge your phone based off the movements it endures in your pocket throughout the day. Piezoelectric technology has also been integrated under the floors at dance clubs. As people dance, the floor absorbs that energy and the sensors send out the signal working as a generator. The more dancing that is being done, the more power that can be generated to display lights and provide music.

As technology continues to advance, there are plenty of possibilities to create clean energy. Everyday activities such as exercising on a treadmill or traveling to work in a bumpy vehicle can be providing sustainable energy. Some humans are capable of producing an output of 2,000 watts during a short sprint. Let us not rely on the use of batteries and wires that connect energy, but use ourselves to power the world.

CLASSROOM DISCUSSION

- What are other activities that can be applied to produce energy by using piezoelectric sensors?
- Do you think that this technology will actually be a big part of the future? Why or why not?

BIGGER MEANS GREENER

By Brianne McCurley

Contrary to popular belief that going "green" means to occupy a smaller apartment or own a smaller automobile, the larger the wind turbine, the greener it is. The size of wind turbines is now reaching 420' — that's longer than a football field. Wind turbines have quadrupled in size over the past 30 years. A report published in the American Chemical Society's journal, *Environmental Science & Technology*, reviewed the energy it took to build, transport, maintain and dispose of large wind turbines. The study found that larger models become more sustainable over time because they produce larger amounts of energy than smaller turbines. Only the turbines are growing in size; the supports and motors remain the same, thus cutting down on production costs.

The lead author of the study, Marloes Caduff of the Zurich Institute of Environmental Engineering, said she was surprised at how much the carbon footprint declined over time. The study found that as manufacturing wind turbines doubled, the global warming potential per kilowatt-hour of electricity dropped 14 percent. Wind turbines will continue to grow in size as the industry grows and companies become more efficient with production.

The United States and China have some of the largest wind farms in the world. In the future, wind farms may decrease in size due to the higher-capacity models producing more energy. Fewer turbines and less acreage will be required to create the same amount of energy. An additional way that wind turbines are green is that the electricity they produce does not lead to any harmful emissions. Wind is a renewable resource — a clean and safe source of power.

DID YOU KNOW?

- Wind is caused by the uneven heating of the Earth's surface by the sun
- The United States' largest wind farm in Texas has 627 turbines that sit on 100,000 acres; it produces 781.5 megawatts, which delivers enough energy to power 265,000 homes
- In 200 B.C. the first recorded uses of wind power were to pump water and grind grain
- The early windmills in Europe were turned on a horizontal axis instead of a vertical one

CLASSROOM DISCUSSION

- Discuss the difference between renewable resources and non-renewable resources
- What other renewable resources are used for energy production?

EXTREME CLIMATE "FIXING"

By Ashley Peterson

The Earth is getting hotter. The average temperature of our planet has been rising rapidly in response to human activities, such as the burning of fossil fuels and deforestation, which add heat-trapping greenhouse gases to the atmosphere. If man continues to produce these gases at current or faster rates, the negative impacts on the planet will be great. While many scientists and environmentalists remain focused on ways to reduce the amount of greenhouse gases that are emitted into the atmosphere, others have begun exploring various "geoengineering" technologies.

Geoengineering is defined as "the deliberate large-scale intervention in the Earth's climate system, in order to moderate global warming." Below are just a few of the climate engineering ideas scientists have proposed to tackle global warming.

ARTIFICIAL VOLCANOES

When volcanoes erupt they emit giant, sulfur-rich clouds into the atmosphere. The particles that make up these clouds act like tiny mirrors that reflect the sun's light and heat into space. When Mount Pinatubo erupted in 1991 in the Philippines, the sulfur cloud cooled the Earth by 0.9 degrees Fahrenheit the following year. Some scientists have proposed that building artificial volcanoes to pump bits of sulfur-heavy material, similar to volcanic ash, into the atmosphere could produce a similar level of cooling.

CLOUD SHIPS

In theory these wind-powered devices take in ocean water and spray a fine mist of sea salt, which creates ocean clouds that are denser and whiter than regular clouds, thus reflecting more of the sun's heat back into space.

WHITE ROOFS

Perhaps one of the simplest geoengineering fixes is to make roofs more reflective by painting them white. Dark roofs reflect about 10 to 20 percent of sunlight, whereas light-colored, "cool roofs," send about 70 to 80 percent of the sun's rays back into space. What's more, reflective-roofed buildings don't get as hot on the inside, thus reducing the need for air conditioning.

The total effects of most geoengineering endeavors are not well understood, and most are met with some level of opposition. While these types of ideas could someday help address the effects of climate change, they will not serve as substitutes for emission controls or stop global warming in its tracks. Nevertheless, scientists recognize that new ideas and innovation will prove vital in addressing our planet's most pressing issue.

CLASSROOM DISCUSSION

- What is one thing that you can do to help address climate change and global warming on a small scale?
- Which of the ideas listed do you think could be the most effective plan for moderating global warming?

WHAT IF?

By April Bailey

Long before explorers sailed across the seas, automobiles took people across country and NASA scientists and engineers landed a man on the moon, somebody asked, "What if?"

Still asking are individuals involved in Archeoastronomy — an interesting and recently reinvented discipline.

Simply put, Archeoastronomy looks at how people in the past understood what they saw in the sky and how they applied this knowledge to their own lives. Different components that typically fall under the scientific disciplines of Archeology and Astronomy are considered, in addition to sizable use of elements from cultural anthropology, religions, mythology, cycles of nature, art and inscriptions, ethnographies and mathematics.

Studied are the remnants of ancient civilizations, looking in particular at structures that were built, their adornments and meaning, their placement in relationship to each other and to their immediate surroundings, plus how they were built or arranged according to the alignment of things in the sky at different points in the year.

Commonly, associations are made between the structures and calendars — used to indicate planting and harvesting times. Additionally, they are seen as places for visitation from gods or other deities who were worshipped and to whom offerings would be made.

Take, for example, the study of ancient pyramids in Egypt, Mexico and Italy — known to have geographical alignments nearly identical to each other, and to the stars that make up Orion's Belt. This fact has been discussed, and it has been suggested that this is possible evidence of cross-cultural contact between different civilizations at a time when travel was extremely difficult. Investigators speculate that the only reason the pyramids were laid out in such a precise manner was as a flight aid for those that could see the structures from above.

While the downfall of Archeoastronomy is that it can't give us concrete answers, the beauty of it is that it stimulates us to keep asking, "What if?"

CLASSROOM DISCUSSION

- Name three countries other than Egypt where ancient pyramids can be found
- Name two things the discipline of Archeoastronomy considers to learn about ancient civilizations

SALLY RIDE: SCIENTIFIC PIONEER (1951-2012)

By Patricia Rogler

Sally Ride was a famous astronaut and physicist who was a pioneer in many ways. She was the first American woman to fly in space, and at the age of 32, she was also the youngest American in space. She was the only person to sit on both panels investigating the *Challenger* shuttle accident in 1986 and the *Columbia* crash in 2003. She was the first director of NASA's Office of Exploration, and she helped develop the space shuttle's robotic arm, used for the deployment and retrieval of satellites.

EDUCATION

She received bachelor's degrees in physics and English in 1973, a master's degree in physics in 1975, and a Ph.D. in astrophysics in 1978, all from Stanford. As she was finishing her studies, she noticed an advertisement from NASA, encouraging men and women to apply for the space program. Of 8,000 applicants, she was one of the 35 chosen.

NASA AND BEYOND

During her time at NASA, she was part of the crew for the *Challenger* shuttle which launched on June 18, 1983. She was also part of a second shuttle mission in 1984. She was scheduled for a third mission, but NASA halted all missions following the *Challenger* shuttle accident which killed all crew members onboard. After the investigation, she became the director of NASA's office for long-range and strategic planning. In 1987 she retired from NASA, and in 1989 became a professor of physics and the director of the California Space Institute at the University of California, San Diego. In 2001 she started her own company, Sally Ride Science, which provides school programs and materials to inspire young people, especially girls, to pursue careers in science.

Sally Ride has been awarded many honors for her scientific contributions, including being inducted into the National Women's Hall of Fame and the Astronaut Hall of Fame. She has received the NASA Space Flight Medal and the NCAA's Theodore Roosevelt Award, among others. President Obama described her as "a national hero and a powerful role model" when she passed away in July 2012.

CLASSROOM DISCUSSION

- Have Sally Ride's accomplishments given you an interest in science? If so, in what scientific discipline are you most interested and why?
- Do you think NASA should continue its exploration of the moon, do you think they should concentrate on Mars now or do you think they should discontinue space exploration?

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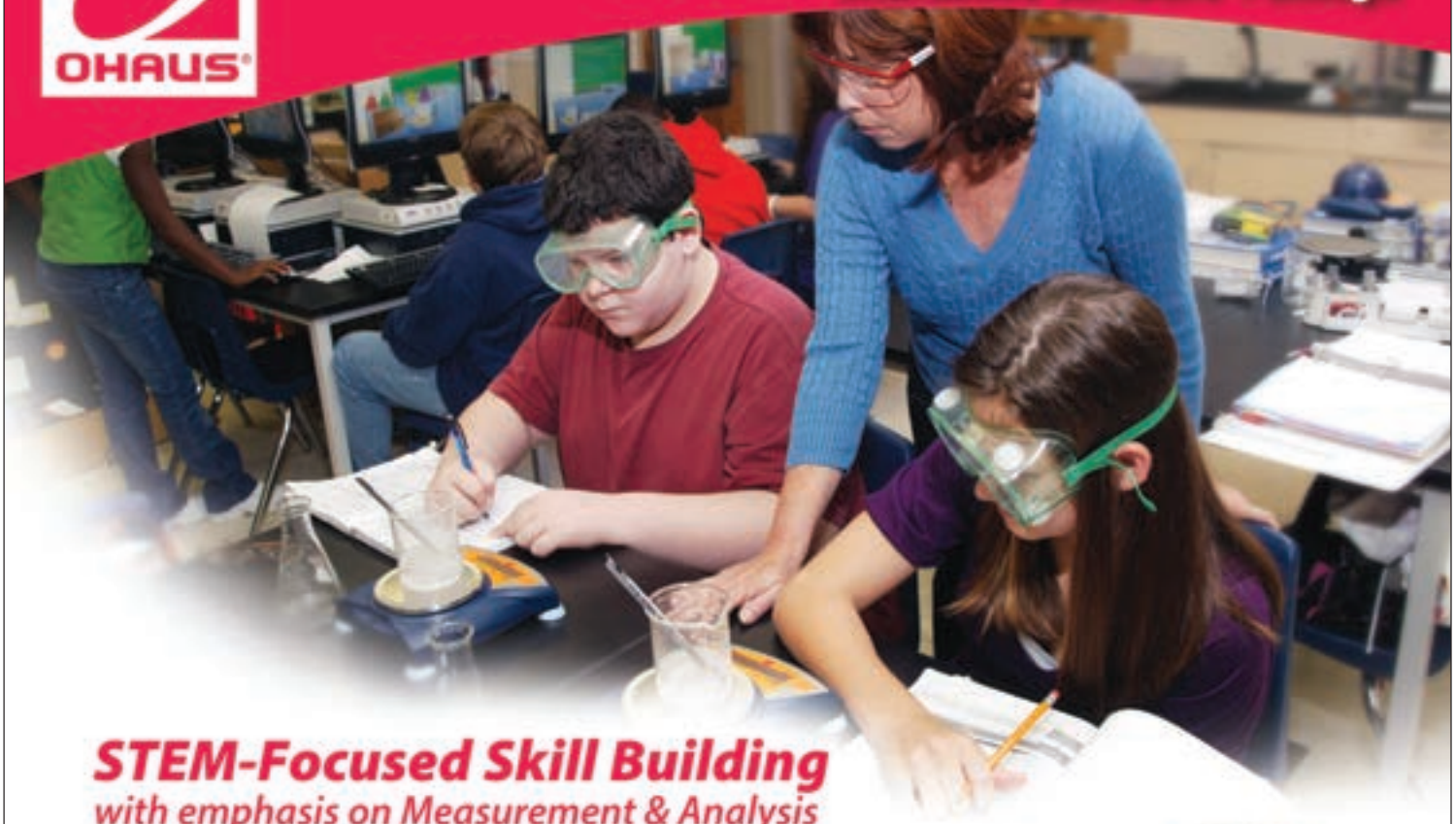

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