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Waste Not:

Recycled Water is the Future

By Iva Fedorka

Many consider water a free, natural resource, but collecting, purifying, storing and distributing water costs billions of dollars annually. And because recycling efforts to increase supply and reduce costs are not regulated at the federal level, occasional contamination crises, like the high levels of lead found in drinking water in Flint, Michigan, never fail to raise concerns.

Although the water in oceans is abundant, its salt content makes it undrinkable. Eliminate the water trapped in glaciers and icecaps, and only about one percent of all the world's water is fresh. A very small portion of that fresh water is found in waterways, with the remainder trapped in soil or aquifers. Regional and local water shortages have become increasingly common, and access to water is also becoming an international issue, with adjoining countries competing for limited resources.

A Battery of Tests to Support Regulations

In the United States, the regulation of water and wastewater is federally mandated by the Environmental Protection Agency (EPA). As part of the Clean Water Act (CWA), the EPA oversees wastewater discharge and treatment, and the National Pollutant Discharge Elimination System (NPDES) issues permits that

establish specific discharge limits, requirements for monitoring and reporting, and other measures to ensure that pollutants do not harm the environment. Under the Safe Drinking Water Act (SDWA), the EPA sets drinking water quality standards and oversees the states, localities and water suppliers that implement them.

To fulfill regulatory requirements, approximately 100 substances are measured in ambient water, drinking water and wastewater. Some water testing is focused on nutrients and microorganisms such as bacteria, viruses, protozoa and parasites. Chemical contaminants may occur naturally or can be introduced by man; these include nitrogen, bleach, salts, pesticides and metal, and compounds found in pharmaceuticals and personal care products.

Other tests detect physical contaminants — like sediment or suspended organic materials from soil erosion — that affect the appearance or properties of water. And water can contain natural or introduced radiological contaminants, like cesium, plutonium and uranium.

Recycling Requires Rethinking

The costs for testing and treating water and wastewater can be reduced when either is conserved

or recycled. Since all water is continuously "re-used" through the hydrologic cycle of precipitation, condensation and evaporation, there may be shortcuts or reuse opportunities yet to be identified within that cycle. "Graywater" from sinks and showers does not constitute "wastewater" and can be used, untreated, for irrigation. "Blackwater" (actual sewage) can be treated to become "reclaimed water" that is suitable for irrigating parks, golf courses, cemeteries and other landscaping. This recycled water is also used for steam turbines or industrial machinery. Some communities have moved all the way to 100% recycling and retain and repurpose all of their wastewater.

A better understanding of exactly how wastewater is treated could increase public support for recycling. When a toilet is flushed, its contents are carried via sewer to a municipal wastewater plant where grates or screens are used to separate any large, solid material from the liquid. The liquids are then placed into a settling tank where smaller solids fall to the bottom and oils rise to the surface. Next, the wastewater moves to an aeration tank where the oxygen helps microbes digest the waste further. After a final settling step, the clarified water is treated with antimicrobial ultraviolet light or chlorine to kill any remaining microorganisms before the water is released.

"In essence, there is no wastewater, just wasted water," said Ben Grumbles, president of the U.S. Water Alliance and a member of the Water Science and Technology Board. To Grumbles' point, successful water recycling programs require a paradigm shift: "used" or "waste" water can become a valuable resource rather than something to dispose of. Studies have also shown that chemical levels and pathogens in existing water supplies and recycled water are essentially equivalent, and sometimes lower.

"The fact is, people already drink reused water," said Ken Herd, the Water Supply Program Director for the Southwest Florida district. But currently there are neither national standards for, nor great interest in, water reuse.

[DISCUSSION QUESTIONS]

Do you or your community recycle water? If so, how?

What other instances of water contamination have happened in the United States?

[VOCABULARY]

GRAYWATER

BLACKWATER

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Recording History in the Technosphere

By Rita Waimer

The surface of our Earth consists of layer after layer of sedimentary rock collectively known as strata. The oldest layers, including the ones where dinosaurs once roamed and are now buried, are on the bottom while the newest sit on top. These layers form slowly over time as debris and rocks pile up on sediment. The weight of all that debris, paired with heat from the Earth, turns sediment into hard rocks. Digging through the layers and examining what they're made of can tell you a lot about what happened back then, including what the weather was like, what animals were around, and where large bodies of water formed.

For most of the Earth's history these layers consisted of natural materials like mud, sand, stones, and even animal and plant remains. Now, however, humans are adding a new layer that consists of everything

we've made — tools, farms, buildings, roads, trash, gadgets and much, much more. This layer is known as the technosphere.

Massive and Growing

Until recently nobody had tried to estimate the mass of the technosphere, but now Jan Zalasiewicz, a geologist at the University of Leicester in England, has done just that. Using satellite images, maps and geological knowledge, he and his team found that there are approximately 30 trillion tons of man-made stuff scattered over 31 million square miles. To put that number in perspective, it's about 100,000 times more than the weight of all living humans.

Part of the reason there's so much material is because it comes from

all of human history, back to and even before the time of the ancient Romans. But it's also because not very much of the technosphere gets recycled, so it continually grows. Eventually all that junk will be buried and become rock like any other layer, leaving evidence of what the Anthropocene — the current period of humans dominating the climate and environment — was like.

The incredible diversity of the technosphere will give future geologists a lot to look at. While much of it may be black carbon from food in landfills and piles of rubble from former cities, there will also be techno-fossils that help date time periods. For example, the popular iPhone 7 would clearly mark 2016 in spots all around the world, while destruction from World War II would mark the middle of the 20th century.

Predicting Wildfires with Climate Change Models

By Ralph Birch

Scientists are turning up the heat in the quest to protect populated areas from wildfires.

An international team of researchers employed satellite technology to analyze 23 million wildfires from 2002 through 2013 and identified the locations of nearly 500 of the most extreme wildfires. By pinpointing the most fire-prone areas in eastern Australia and the Mediterranean, researchers are hoping government officials will move to strengthen their defenses and prevent potentially catastrophic consequences of future wildfire events.

Climate change modeling has revealed that the number of days conducive to extreme wildfires could increase up to 50 percent in the years to come.

Learning from the Past

University of Tasmania Professor of

Environmental Change Biology David Bowman led a team of researchers — including those from the University of Idaho and South Dakota State University — to identify 478 particularly devastating wildfires. Of those 478, 144 wildfires were found to have occurred in areas where humans have built in highly flammable forest landscapes in southern Australia and western North America.

"Extreme fire events are a global and natural phenomenon, particularly in forested areas that have pronounced dry seasons," Bowman said. "With the exception of land clearance, the research found that extremely intense fires are associated with anomalous weather — such as droughts, winds, or in desert regions, following particularly wet seasons."

Forecasting the Future

Future climate change modeling has identified the eastern coast

of Australia, including the city of Brisbane, as well as Mediterranean countries like Spain, Portugal, France, Greece and Turkey as prime territory for extreme wildfire events to occur.

"The projections suggest an increase in the days conducive to extreme wildfire events by 20 to 50 percent in these disaster-prone landscapes, with sharper increases in the subtropical Southern Hemisphere, and the European Mediterranean Basin," Bowman said.

Remembering Black Tuesday

The research conducted by Bowman and his team was published in *Nature Ecology and Evolution*. Their findings were revealed on the 50th anniversary of the devastating 1967 Hobart bushfires which claimed the lives of 62 Australians, injured 900 and left 7,000 homeless. February 7, 1967 is known as Black Tuesday for the damage left in the wake of 110



[DISCUSSION QUESTIONS]

In what ways have you contributed to the technosphere?

What could we do to reduce the size of the technosphere?

[VOCABULARY]

ANTHROPOCENE

STRATA

SEDIMENT



[DISCUSSION QUESTIONS]

What are some ways people can help protect wooded areas from fire?

Aside from the locations listed in the article, what other areas of the world do you think are susceptible to wildfires?

[VOCABULARY]

FLAMMABLE

CLIMATE CHANGE MODELING

SUBTROPICAL

ANOMALOUS

Tracking Nanoparticles Using DNA Barcodes

By Lacey Cirinelli

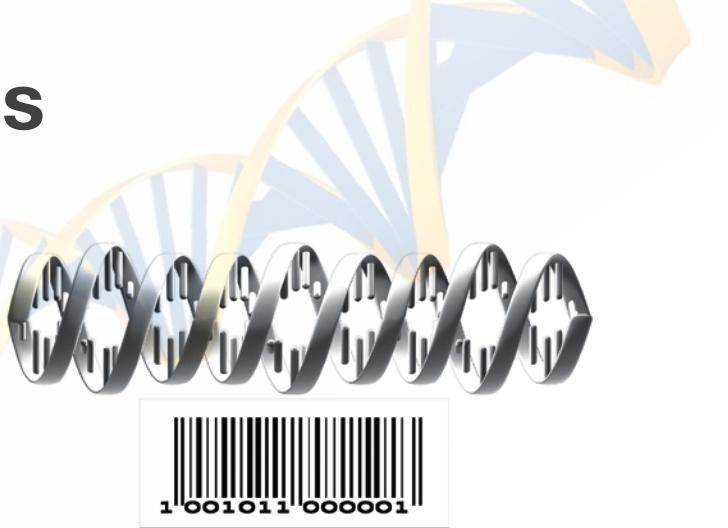
Imagine being able to deliver a necessary drug directly to sick cells in a patient's body. Gene therapy is an experimental technique that aims to do just that using genetic material as the "drug." It's difficult to control where genes are delivered, so researchers are turning to materials thinner than a human hair for help.

Gene therapy uses DNA or RNA to treat or prevent a disease by replacing a "sick" (mutated) gene with a "healthy" (therapeutic) copy. The gene is carried by a vector, or vehicle, which delivers the gene to the targeted cells. Ideally, a gene therapy vector targets only the necessary cells or organs (i.e. islet cells in the pancreas for diabetes) and can deliver and activate the genetic material without triggering an immune response. Unfortunately, researchers struggle to control which organs take up vectors carrying therapeutic genes, and testing potential vectors is time consuming.

Tiny Size, Big Potential

Over the past two decades, researchers have developed numerous synthetic particles in an effort to find better gene therapy vectors. One major focus has been nanoparticles, which have a diameter of 100nm or less and are smaller than red blood cells. Typically, new vectors are tested individually in cell culture and then in animals. However, researchers at the University of Florida, Massachusetts Institute of Technology, and Georgia Tech recently developed a more efficient way to simultaneously test multiple nanoparticles using DNA barcodes as localization markers.

In the new method, individual types of nanoparticles are labeled with pieces of DNA before being injected into mice. The DNA snippet acts as a barcode, allowing researchers to examine the animal's organs and determine which nanoparticles were



delivered to a single organ, which entered multiple organs, and which did not enter any organs. Using DNA in this way could allow researchers to test hundreds of different nanoparticles at one time while using as little as three animals per set of nanoparticles.

While the initial results are promising, more work must be done. Only non-toxic nanoparticles that are stable in aqueous solutions were tested, and large DNA strands and active therapeutic genes also still must be examined. However, DNA barcoded nanoparticles could quickly identify which nanoparticle vectors can

be delivered most effectively while providing a better understanding of how the body processes nanoparticle vectors during disease.

[DISCUSSION QUESTIONS]

Why might a vector that works in cell culture fail in animal studies?

Why is it undesirable for a therapeutic gene to be taken up by the wrong cells?

[VOCABULARY]

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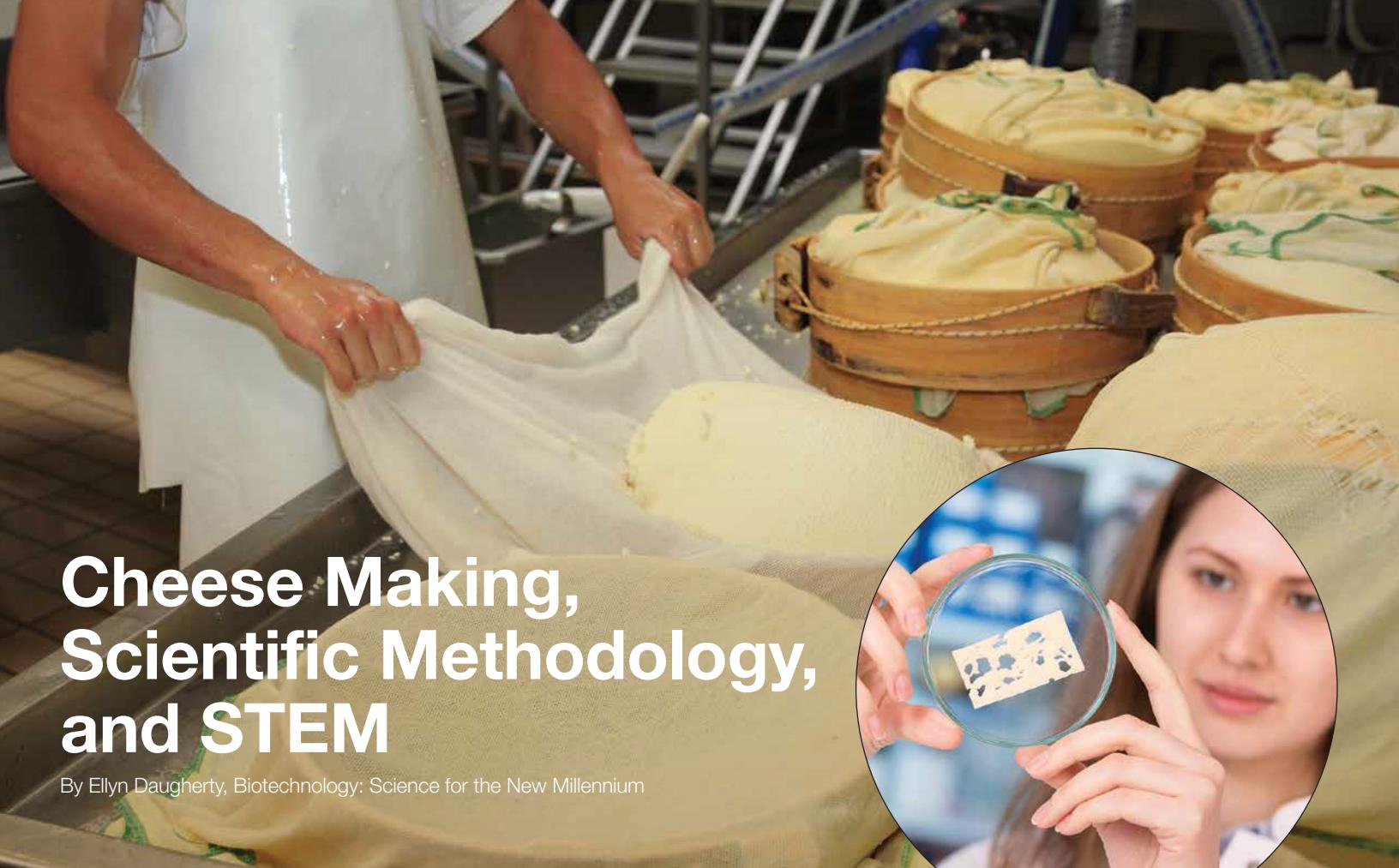
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Cheese Making, Scientific Methodology, and STEM

By Ellyn Daugherty, Biotechnology: Science for the New Millennium

One challenge facing science educators is giving students experiences that grow their interest in scientific research and applications. A cheese-making lab can emphasize scientific methodology and stimulate interest in science.

How Cheese is Made

For centuries, people made cheese by letting naturally occurring bacteria turn the milk "sour." Milk curdles, or sours, due to enzyme activity and pH changes. During curdling, the protein in milk (casein) becomes a solid and leaves a liquid (whey) behind. Milk bacteria produce enzymes that use milk sugar and proteins for energy. Some cheese is still made this way, but cheese makers usually want to make more cheese in a shorter time frame than this allows. One method to shorten the process is to add a starter culture of cheese curds (which include milk-curdling bacteria), to milk. The starter culture speeds curdling and the specific microbes help control flavor, odor, texture, and other qualities. Many modern cheeses are produced using this process.

Milk will also curdle within minutes when enzymes like rennin are added.

Rennin (also known as chymosin) is a protease or protein enzyme found in calf stomachs. Rennin chops milk protein into smaller pieces that then form loose curds, like cottage cheese. The curds can be pressed to remove the whey and then aged in a variety of ways to produce soft or hard cheeses.

Isolating rennin used to require killing calves and purifying the rennin from other stomach proteins. Therefore, rennin is not vegetarian (the animal is killed) and is expensive to isolate. However, around 1980, scientists realized they could make rennin more efficiently by using recombinant DNA technology. They transferred the cow rennin gene into fungus cells, which read the DNA code and produced the rennin enzyme. Recombinant rennin is basically the same as natural cow rennin, so it chops casein and curdles milk in the same way. Through the years, scientists have modified the genetic code slightly to make recombinant rennin work even better. Because it is easier and cheaper to manufacture rennin in fungi than to isolate it from calves, recombinant rennin is less expensive than cow rennin and is commonly used today to make the majority of cheeses.

Relating Cheese Making to STEM

Making cheese is a powerful vehicle for teaching scientific methodology that brings STEM concepts into the classroom. Many teachers use a cheese-making activity to illustrate enzyme activity because rennin dramatically demonstrates the catalytic nature of enzymes. It's also fun and easy to make cheese in a classroom lab, and the teacher can design a simple lab activity around it.

Many variables affect the rate and quality of cheese production. In a controlled experiment, the goal is to collect numerical data in order to test and measure the effect of a single variable at a time (i.e. the effect of curdling agent) and minimize the effects of other variables. To conduct a controlled experiment to test the effect of different agents on the rate of milk curdling, begin with a small amount of cheese-making background. Next, ask students to consider which of three curdling agents (bacterial starter, cow rennin, or recombinant rennin) and a control treatment (water) will curdle milk faster. The effect of different curdling agents on the rate (mass/time) of curdling can be measured while other variables (measurement, temperature, etc.) that might affect curdling are identified and minimized.

Making cheese is a good activity to introduce the concept of controlled experiments while giving students their first exposure to common laboratory measurements using pipets, micropipets, balances, and filtering units. It also introduces students to bioethical dilemmas such as the slaughter of animals to retrieve rennin. Finally, students are asked to consider the impact of biotechnological advances on the cheese industry. The cheese-making experiment provides opportunities for students to use scientific methods and apply science, engineering, and technology to solve problems, and it sets the stage for further development of and reflection on lab skills.

[CLASSROOM ACTIVITIES]

Temperature affects enzyme activity:
Design a controlled experiment that tests rennin activity at three temperatures between 20°C and 40°C.

Use the internet to find examples of commercially available cheeses made using cow or recombinant rennin.

[VOCABULARY]

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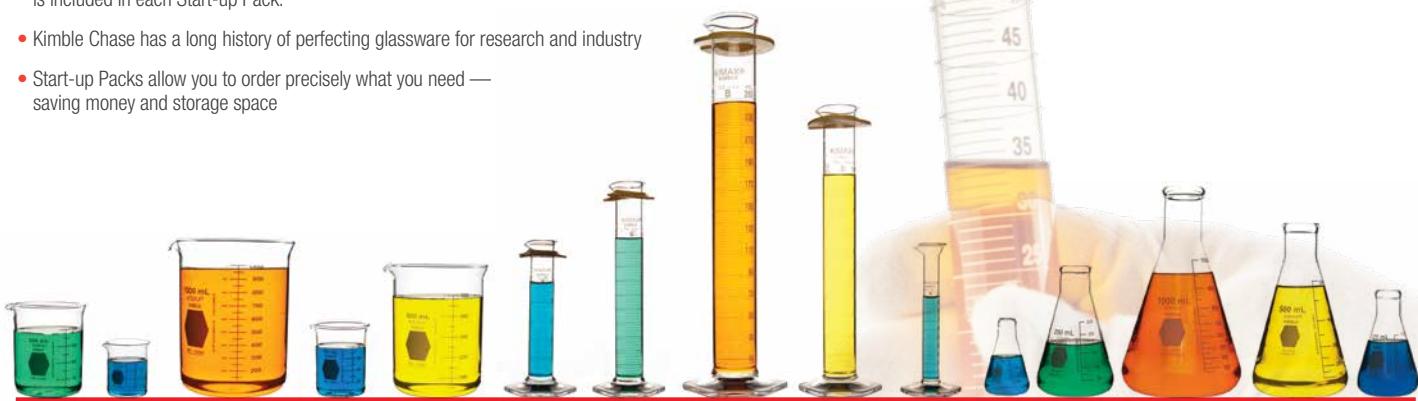
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To Tweet or Not to Tweet

By Sam Russell

Have you ever wondered why birds of the same species tweet identical songs? A recent study has connected the levels of dopamine, a neurotransmitter, to the song that a bird sings. A neurotransmitter is a chemical that is released at the end of a nerve cell to send messages to another nerve cell or neuron. Dopamine is an important neurotransmitter that is triggered by rewards and helps encourage a certain behavior or action to be performed. When people eat delicious foods or quench their thirst, there is a spike in dopamine signals.

A baby bird learning to sing is similar to a human baby learning to talk. Baby birds start learning how to sing by babbling. Usually a baby bird will learn from its father, listening and memorizing the song to perfection. How does a bird's dopamine level help contribute to learning the perfect song? A neuroscientist and his team recently studied this very question.

The Experiment

Jesse Goldberg is a neuroscientist at Cornell University in Ithaca, New York. His interest in connecting dopamine levels and the songs of zebra finches started with an experiment that placed the finches in special chambers that had microphones and speakers to record their songs. After the recordings were made, the songs were played back for the birds to hear.

Tiny recording wires were inserted into the birds' brains to measure the activity of dopamine-making cells. The song of each finch was played back either normally or with a slight change in pitch to detect if there was indeed a change in dopamine levels.

The Results

Goldberg and his group of researchers found that when the song of each zebra finch was played back



normally, the dopamine-making cells showed a small amount of activity. But when the song was played back at a change in pitch, there was a large drop in dopamine. The drop in dopamine levels indicated that the messages were not being transmitted or, in this case, that the song was not going to the brain.

Goldberg hypothesized that the dopamine system (in birds specifically, as well as other animals), is used to help indicate whether an action or signal is correct or not. The results Goldberg and his team found with dopamine spikes and declines based on the zebra finch song playback may help scientists understand how humans learn.

[DISCUSSION QUESTIONS]

Goldberg and his team did research specifically with zebra finches relating dopamine levels to the sound of their song. Would the learning process be different and would dopamine levels change if scientists studied a different animal that learns by sight instead of sound?

What are some other neurotransmitters and to what kinds of behaviors do these contribute?

[VOCABULARY]

HYPOTHESIS

NEUROTRANSMITTER

DOPAMINE

No More Choosing Sides in Gym Class

By Celeste Beley



Whether you are a top-notch athlete or someone who would prefer an art class over gym, most of us share the dread that comes when it's time to pick teams for that dodgeball or kickball tournament. Some teachers may have moved away from the "team captain" system, but being chosen for a new team can still create anxiety. An education professor at Brigham Young University is studying how students experience gym class — more specifically, how playing music and choosing teams can affect them.

Picking Sides

In *The Physical Educator*, David Barney, Associate Professor of Teacher Education, published a study after observing junior high boys pick teams. He observed that

publicly choosing teams does not influence the team's performance, but can have an emotional impact on each student.

Team-picking has been a standard practice for gym classes, but the negative effects continue. Most of the kids interviewed said that they didn't like the process, although most were willing to go with whatever the teacher planned. When asked two days later, few could recall which team won, but they still remembered the negative feelings they had when teams were chosen.

Barney has proposed that teams should be chosen privately and by the teacher. This enables students to work and play with classmates that may not be in their circle of friends. And since the teacher assigns the

teams, they don't feel ashamed or excluded and therefore perceive the process to be fairer.

Music and Sports

In a separate study published in the *International Journal of Physical Education*, Barney found that gym is 5.87 times more enjoyable when music is being played. Imagine being hit in the face by a dodgeball and then hearing Taylor Swift tell you to "Shake it Off." Would it make your recovery a little easier? Probably.

Besides the mental motivation, the music also provides physical motivation. "When the music is on, I just feel like dancing all the time," one student said in an interview. Other students felt that the music kept them motivated and inspired them to work harder. We know what music pumps us up, but the research found that contemporary songs, with approximately 120 to 160 beats per minute, are best for a gym class setting.

The ultimate goal of physical

education classes is to develop a commitment to personal physical health. Background music and teacher-determined teams are two methods that can help kids have positive experiences in their gym classes and lead to that lifelong commitment.

[DISCUSSION QUESTIONS]

Discuss your own experiences in physical fitness classes. Do you think teacher-chosen teams have better results than publicly chosen teams?

Does the type of music have an effect on your physical activity? Discuss various styles of music and how they affect your physical activity.

[ACTIVITY]

Create two separate playlists of songs for a physical fitness class using the parameters discussed in the article: one featuring songs of 120-160 beats per minute, and one featuring songs with less than 120 beats per minute. On separate days, play those songs for a gym class and then interview the participants to determine which playlist they felt motivated them more. Collect physical activity data from personal fitness trackers and compare.



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Whales Led Astray by the Sun

By David Ispphording



Imagine the joy of walking along the beach: the sand, the sound of the waves, and birds flying through the air. Now imagine a beached whale blocking your path. This alarming scenario happens frequently each year on coastal beaches all across the planet, and not just with whales, but dolphins and porpoises, as well. These cetaceans find themselves out of the water, individually or in groups, beached and stranded, because they were confused and lost their way. Confused by what, though?

Blame it on the Sun

The Sun belches enormous bubbles of charged particles into our solar system. These particles have been shown to significantly influence orbiting satellites and power grids

when they collide with the Earth's magnetosphere. Scientists wonder if these collisions also interfere with the navigation systems of cetaceans, which rely on magnetic fields, scrambling their operations and confusing the animals. The National Aeronautics and Space Administration (NASA), the Bureau of Ocean Energy Management (BOEM) and the International Fund for Animal Welfare (IFAW) have teamed up to help save these animals and investigate why these beachings happen.

Making Observations

The researchers have identified some common characteristics surrounding these beaching events. First, the geography of the sites is

often similar: gently sloping beaches with fine-grained sand. Also, some areas around the globe have a higher frequency of beaching than others, namely areas of Australia, New Zealand, and Massachusetts. Lastly, severe storms and extreme low tides during certain phases of the moon can also play a role.

Gathering Data

By joining forces, pooling resources and collaborating, the NASA, BOEM, and IFAW team will be able to draw upon a combined wealth of data. From these beaching reports, field recordings, and solar observations, they may be able to connect the dots regarding the cetaceans' wayward landings and behavior. If solar emissions can be further linked

to beaching, then scientists may be able to tell when a beaching event could occur due to the elevated solar and magnetic-field activity caused by the Sun's charged gas releases. If this is the case, then scientists would have a warning when the solar storms occurred and could possibly take steps to protect the animals from stranding themselves. Let's hope this will be the case and these beautiful creatures will stay safely in the water.

[DISCUSSION QUESTIONS]

What else could possibly cause a beaching?

When a beaching does occur, what steps should be taken to help the animals get back in the water?



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Locomotion	

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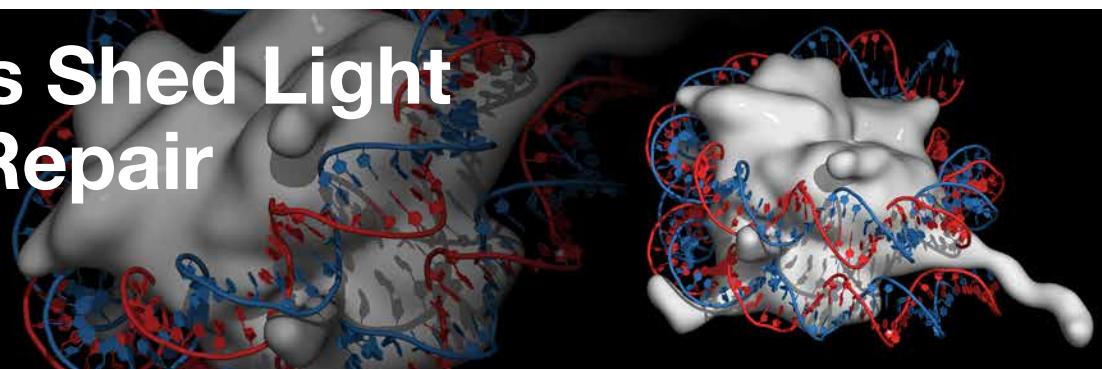
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Scientists Shed Light on DNA Repair

By Christina Phillis



Almost as easily as a glass gets knocked over and breaks, the DNA in cells within our bodies can be damaged when exposed to the right environmental factors. In response, molecular repair mechanisms find and fix mutations or other forms of damage. Now researchers from the University of North Carolina School of Medicine have demonstrated these functions in bacterial cells of two important excision repair proteins: Mfd and UvrD.

Nucleotide excision repair occurs in both human and bacterial cells when damaged sections of DNA, typically those exposed to ultraviolet light, are cut out in order to fix the strand. To better understand the molecular mechanisms behind excision repair, the team studied *Escherichia coli*

bacteria. They used a recently developed technique called eXcision Repair-sequencing (XR-seq), which allows researchers to track which pieces of DNA are snipped during the repair process. First used in 2015 to create a UV repair map of the human genome, this method was employed in 2016 to generate the damage and repair maps of cisplatin for the entire genome. (Cisplatin is an anticancer drug that kills cancer cells by damaging their DNA.)

The Fixers

To observe the method behind bacterial DNA repair, the researchers brought about mutations by exposing *E.coli* bacteria to ultraviolet rays. They then used XR-seq to confirm which sections of the genome were

being repaired.

During this process, they discovered that repairs were only happening in cells that contained the protein Mfd. In addition, they found that Mfd is what prompts other proteins to cut out damaged DNA for replacement, and reactivates molecular machinery that stops working due to damage. Another protein, UvrD, makes it possible for these proteins to clean up by unwinding the damaged DNA that has been cut out of the strand.

"The biochemical mechanisms of these proteins have been known for years from experiments involving purified protein and DNA, and that's very important, but in this new work we've clarified these proteins' roles in living cells," said co-senior author

Christopher P. Selby, PhD, research assistant professor of biochemistry and biophysics at UNC.

These findings will not only help scientists learn more about DNA repair in humans, but also could lead to the development of better antibacterial drugs.

[DISCUSSION QUESTIONS]

Why might these findings be helpful when developing antibacterial drugs?

What other advancements in medicine might come from better knowledge of DNA repair in humans?

[VOCABULARY]

MUTATION
PROTEINS

GENOME
EXCISION

Teen Violence Can Spread Like a Virus

By Kevin Ritchart

A recent study conducted by researchers from Ohio State University has found that teens with violent friends are nearly twice as likely to exhibit violent tendencies themselves.

Psychologist Brad Bushman and political scientist Robert Bond reached their conclusion after analyzing data from the National Longitudinal Study of Adolescent Health (or Add Health, as it's more commonly known). Three times in a span of several years, Add Health researchers met with more than 90,000 students in the United States in grades seven through 12.

Bushman and Bond's analysis, which was published in February's *American Journal for Public Health*, focused on students with friends and/or siblings who also had been interviewed as a means of finding a link between violence and certain social groups.

By the Numbers

Teens who had admitted to being involved in a serious fight at least once during their interviews also were asked about the frequency of their fighting, whether they had injured someone badly enough during a fight to require medical attention, and whether they'd ever pulled out a knife or a gun to use during a fight.

Teens with friends who had admitted being in a serious fight were 48 percent more likely to get into an altercation themselves. Meanwhile, teens with siblings who had revealed being in a serious fight were 38 percent more likely to engage in violent behavior.

Teens with friends who had hurt someone badly enough to need medical attention were almost twice as likely to hurt someone in the same manner themselves, and teens with friends who admitted to using a knife or gun in a fight were 40 percent more likely to mimic that behavior.

"People learn aggression and violence the same way they learn other behaviors — through direct experience and by observing others," Bushman said.

Diagnosing the Virus

As if the raw numbers aren't convincing enough, Bushman and Bond's research used a technique called network analysis to uncover how violence tends to spread through social groups. They found that violent incidents tend to cluster among small groups — and that it's not just a direct friend of a violent teen who is more likely to become violent themselves. Up to four people away from the original teen (a friend of a friend of a friend, as it were) also showed an increased propensity for violence.

Bushman and Bond have compared their findings regarding violence among teens to the spreading of a virus. While the results of this study

are indeed alarming, it's worthwhile to note that positive behaviors like sharing and cooperation have shown to be contagious as well.

"Like other contagious diseases, one can prevent and treat violence," Bushman said. "Prevention comes in the form of avoiding exposure to violence."

[DISCUSSION QUESTIONS]

What are some other behaviors —positive or negative — that can spread through social groups in the same way violence does?

Aside from teaching alternative, non-violent methods of conflict resolution, what are some other ways to curb the spread of violent behavior among teens?

[VOCABULARY]

AGGRESSION

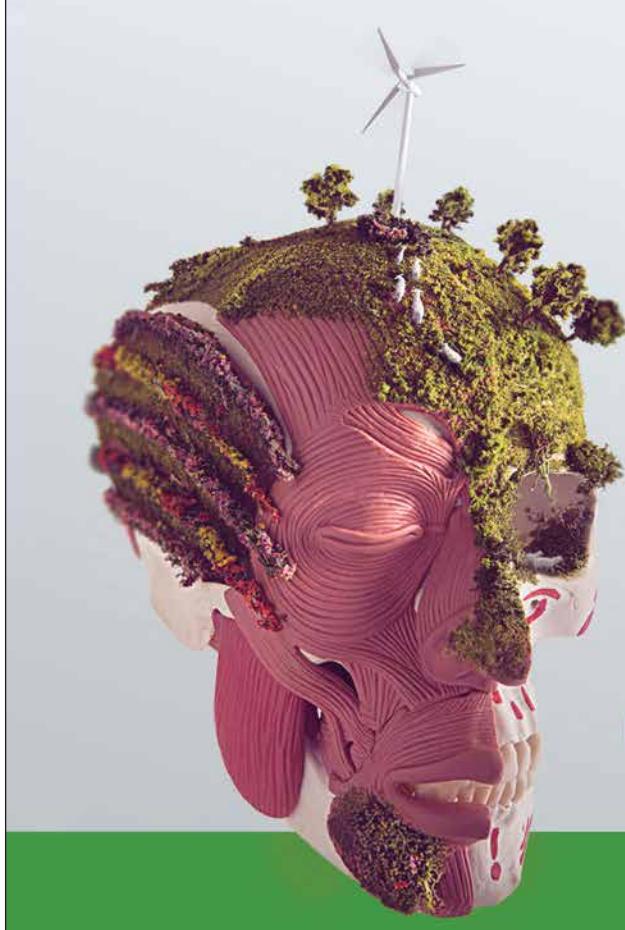
NETWORK ANALYSIS



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Green Plants Inspire Better Solar Cells

By Mike Howie

Solar energy is one of the most commonly talked about and frequently used alternatives to traditional energy sources like coal and oil. While it's not nearly as prevalent as the other two, solar energy use is becoming more and more popular, growing 20 percent per year over the past 15 years. Today, the photovoltaic cells that are used to collect solar energy are used on everything from the International Space Station to cheap handheld calculators.

Despite their growing popularity and the promise of clean, sustainable energy, our current solar cells are far from perfect: the most affordable ones are only 20 percent efficient. That poor performance is the result of fluctuations in the amount of energy being emitted by the sun. If the panel absorbs too much energy it can be damaged, so conventional panels

use voltage converters and feedback controllers to suppress fluctuations. This waste of energy is part of what prevents more people from using solar panels as a main source of energy.

Natural Inspiration

Green plants, on the other hand, are very good at absorbing the fluctuating energy from the sun and using it to photosynthesize their food. Nathan Gabor, a physicist at the University of California, Riverside, discovered why this is when he and his team used the photosynthetic success of green plants as a guiding fact in their quest to create better solar cells.

The team came up with a new quantum heat engine photocell that incorporates two photon-absorbing channels: one that absorbs high-

power wavelengths and one that absorbs low-power wavelengths. The cell switches between the two channels to accommodate varying levels of solar input, and by doing so provides a steady output without needing active feedback or adaptive control mechanisms.

In testing their new cell, Gabor and team found that green light doesn't help regulate the amount of energy being absorbed, so they tweaked their cell to reject it completely. Their discovery suggests that plants regulate solar energy in the same way, reflecting green light and therefore taking on a green coloration. In the end, the team not only created a better, more efficient solar cell, but they also made an interesting connection between quantum mechanical structure and the plants in your backyard.



[DISCUSSION QUESTIONS]

Where have you seen solar panels being used?

What else could affect how well solar panels work?

[VOCABULARY]

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Cat-Like Instincts!

By Justin Kovach

Your furry feline friend "Mr. Whiskers" may seem docile, but in reality he's a natural predator with superb instincts. Cats' instincts are actually a combination of hearing and an understanding of the cause and effect of some elements of physics, according to a recent study conducted by researchers at Kyoto University in Japan. The research team was led by Saho Takagi, and their study was published in the journal *Animal Cognition*.

The team previously discovered that cats use their excellent hearing to predict the presence of unseen objects. After learning this, the researchers wanted to find out if our nine-lived friends used a causal rule to determine if a container held an object based on the sound (or lack thereof) that it made when shaken. They further wanted to learn a cat's expectation towards the container: Would the cat expect something to fall out when the container was turned over?

Physical laws were tested using two experimental conditions.

One was congruent: shaking was accompanied by a sound and an object falling out of the container, or shaking with no sound and no object. The other was non-congruent: no shaking sound accompanied by an object falling out of the container or vice versa.

The cats looked at containers that were shaken and produced a noise for longer periods of time, which suggests that they used a physical law to predict the existence of an object based on the rattling sound. The cats also gazed much longer at things that didn't make sense, such as an object dropping despite having made no noise while being shaken. Basically, the cats realized when something should or should not happen based on the physical characteristics of the situation.

What does this all mean?

The researchers concluded that cats use sounds to predict the presence of objects in their environment, even when they can't see them. Because of this understanding, cats have



developed a natural hunting style. Using their understanding of basic physics, cats can stalk prey and predict where it will be even with poor visibility.

So remember, Mr. Whiskers may be lazily lying on your couch or lap, but he knows what's going on around him. If he decides to pounce, he'll know exactly where to jump without ever seeing the object that caught his attention. Which, as we all know, was probably something dangling from a string of yarn.

[DISCUSSION QUESTIONS]

What environmental factors do cats use to understand their surroundings?

Have you ever seen a cat react to something that came up from behind it, or something it could not see?

[VOCABULARY]

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Recorded-Breaking Snack Attack from Black Hole

By Justin Kovach

We have witnessed dozens of stars served up as the main course for the super hungry black holes of the universe, but we have never seen the buffet that researchers at the University of New Hampshire recently observed.

Generally, black holes feast on stars that are close to them for an average of a year. It's called a tidal disruption event (TDE) and we've been detecting them since the 1990s. Using data from three X-ray telescopes from NASA, Swift and the European Space Agency (ESA), researchers have been able to view evidence of a major TDE.

TDEs are caused by the intense

gravitational pull created by a black hole. Objects such as stars that get too close to a black hole can be destroyed, sometimes also flinging debris out at high speeds. Everything that isn't ejected falls into the black hole. The "consumed" material heats up to millions of degrees, causing it to generate multi-wavelength X-ray flares that can be viewed by satellites.

A Long Abbreviated Name

XJ1500+0154 is the abbreviated name of an X-ray source from a black hole in a small galaxy about 1.8 billion light years from Earth. Studying X-ray data from this supermassive black hole showed that radiation levels from the material surrounding the

black hole are extremely high. This occurs because the Eddington limit (or luminosity) has been exceeded. (The Eddington limit is the balance between the outward radiation pressure and the inward pull of a black hole's gravity.)

From studying this specific black hole, physicists have concluded that supermassive black holes can grow significantly from TDEs and surpass the Eddington limit. This has also helped scientists understand how supermassive black holes reach sizes greater than a billion times the size that our own sun was in the early days of the universe.

Scientific models predict that this

extremely ravenous black hole will soon run out of "food" and eventually disappear from our prying eyes — extinguishing its presence in our universe.

[DISCUSSION QUESTIONS]

What happens to time and space in a black hole?

What is the difference between a black hole and a worm hole?

Are black holes common in the Universe? Where is the closest black hole to earth?

[VOCABULARY]

GRAVITY
X-RAY

BLACK HOLE
RADIATION

Bridge of Stars

By Robert Marshall, Fisher Science Education

Credit: V. Belokurov / D. Erkal / A. Mellinger

Magellanic Clouds

The term satellite came long before mankind started building rockets to put machines in space. The word is derived from the Latin root *satelles*, meaning companion, and in the science of astronomy it's used to describe the moons of planets as well as smaller galaxies found in clusters. Similar to the way moons orbit their parent planets, satellite galaxies follow a gravitational path towards their host galaxies. The Large and Small Magellanic Clouds (named after explorer Ferdinand Magellan and abbreviated LMC and SMC) are two of dozens of dwarf galaxies that surround our Milky Way Galaxy. The Magellanic Clouds are visible to the naked eye, but only in the southern hemisphere.

RR Lyrae Stars

Astronomers still do not know exactly how or when the Milky Way and all of its satellite galaxies formed. To answer such an ambitious question, scientists must fully understand the mass and velocities of the LMC and SMC. Using the European Space Agency's (ESA) Gaia, a highly sensitive space-based telescope, a team of international astronomers observed prehistoric, variable-type stars. These RR Lyrae stars have a unique identifiable luminous pulse (like a beacon) that can be seen over time using a detector like that onboard Gaia.

Pieces of the Cosmic Pie

Researchers were hoping to use RR Lyrae stars to determine precise distances to help answer when the galaxy was formed, but were surprised to discover halos of previously undetected stars surrounding the satellite galaxies. This indicates that the clouds have greater masses than anticipated. Even more exciting, they discovered a stream of stars that bridge the 43,000 light-year gap between the clouds and their halos. Though this bridge was thought to exist based on the satellites' known interactions with each other, it had never been observed. This discovery is another step closer to answering the bigger questions of how and when the Milky Way formed.

The LMC & SMC, their stellar halos, and the RR Lyrae star bridge represented with pale white veils.

[DISCUSSION QUESTIONS]

Planets in our solar system orbit the sun and can be seen in both hemispheres from season to season. Why are the LMC and SMC, which orbit the Milky Way, only visible in the southern hemisphere?

[VOCABULARY]

SATELLITE

ASTRONOMY

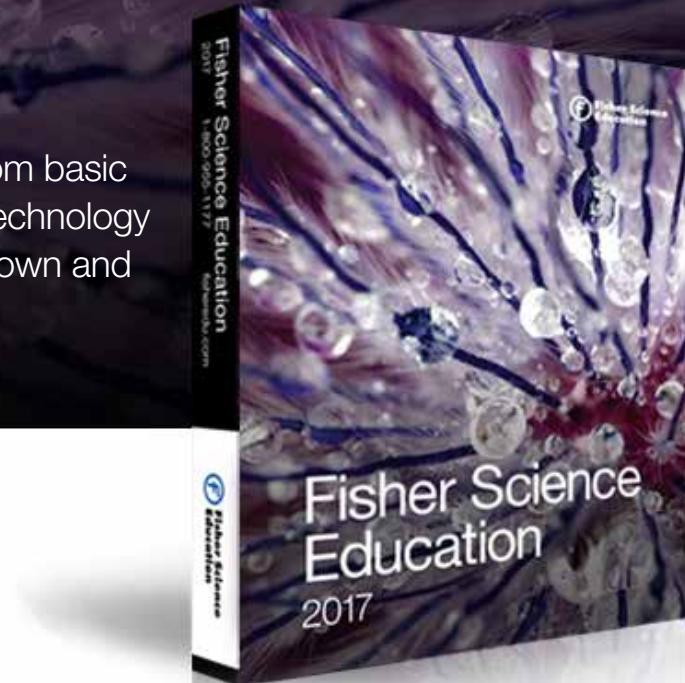
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Vitamins Give Batteries a Boost

By Moira Bell



It's no secret that vitamins are good for you, but according to new research, vitamins might be good for your cell phone battery as well. A team of chemists at the University of Toronto have created a battery that stores energy using flavin from vitamin B2 — the same vitamin needed for a healthy liver, skin, hair and eyes. Researchers believe that this material provides a more affordable and environmentally friendly option than what is currently used in batteries.

Inside a Battery

Batteries consist of three basic parts: a positive terminal, a negative terminal and an electrolyte solution. When a battery is connected to a device, electrons flow from the negatively charged electrode of the

battery, or the anode, out to the device, then into the cathode. Ions travel through the electrolyte solution to balance the charge. This process happens in reverse when the device is connected to a charger. The flavin acts as the cathode, the part of the battery that stores the electricity that is released when connected to a device.

Bio-Derived Batteries

Battery parts made from biologically derived materials are not new. The difference between this version and past iterations is that it's the first to utilize bio-derived polymers, or long-chain molecules, for one of the electrodes. This means that the battery energy can be stored in a vitamin-created plastic. The alternatives include metals such as

cobalt, which are more expensive, harder to process and cause more harm to the environment.

The chemists came across the right bio-derived material while testing various long-chain polymers. The specific type is referred to as a pendant group polymer, which is the group of molecules attached to a "backbone" chain of a long molecule.

Working with vitamin B2 that originates in genetically modified fungi, the team used a semi-synthetic process to prepare the polymer by linking two flavin units to a long-chain molecule backbone. The result allows for a high-capacity, high-voltage battery.

Currently, the team is working with a prototype that is the size of a hearing

aid battery. In the future, they hope this discovery will lead to powerful, thin, flexible and possibly even transparent metal-free batteries for use in devices like smartphones and tablets. Might this soon mean it'll take a text message a day to keep the doctor away?

[DISCUSSION QUESTIONS]

What are the benefits of using thinner, flexible batteries?

Besides smartphones and tablets, can you think of any other devices that would benefit from a thinner, more flexible battery?

[VOCABULARY]

ELECTRODE

POLYMER

ANODE

Space Algae Could Feed a Trip to Mars

By Mike Howie

It may seem unlikely, but there are a few terrestrial organisms that can survive in outer space. Lichens, bacteria and tardigrades have weathered the harsh conditions before, and now researchers have added two more species to the list: algae from the *Sphaerocystis* species and cyanobacteria from the *Nostoc* species.

As part of the Biology and Mars Experiment, which aims to help us understand the extent to which terrestrial life can survive in space for a possible trip to Mars, Dr. Thomas Leya and his team from the Fraunhofer Institute in Potsdam, Germany sent the two species to the International Space Station (ISS), where they were attached to the outside of the craft for 16 months. Through studying the algae and cyanobacteria in the lab,

the team had already learned that both are mostly unharmed by long-term desiccation stress, extreme temperatures and radiation. The native homes of each — Norway and Antarctica, respectively — are part of why the species do so well in the cold, and why they were selected for the experiment. The researchers did all the work they could in the lab, but the samples had to make a trip to the space station to experience the full, extreme conditions of near-Earth orbit.

A Long, Cold, Irradiated Orbit

Once attached to the space station, the specimens were exposed to a near vacuum, temperatures ranging from -4°F to 116°F, and constant ultraviolet radiation with only a

neutral-density filter, which reduced the effects of radiation, for protection. The researchers suspected that the organisms would survive the cold and UVA/UVB radiation, but they were particularly interested to see how the organisms reacted to UVC radiation, which is extremely harmful. Surprisingly, the algal strains were left unscathed by the radiation, and moreover survived well in the dryness of space.

The results of the experiment are another step forward for an eventual mission to Mars. Studying how and to what extent the algae's DNA was damaged will help us learn how to protect our own DNA against UV radiation and how to grow food on the Red Planet — both of which will be essential for an extended stay away from Earth.

Beyond aiding our ambitions for space travel, the findings could also help us learn how life on our pale-blue dot began. They support the panspermia theory, which suggests that early life forms may have made their way to Earth on meteorites.

[DISCUSSION QUESTIONS]

How else could the findings help improve our lives?

Would you want to live on Mars? Why or why not?

[VOCABULARY]

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by Thermo Fisher Scientific

Scientists Develop Forensic Method to Identify Humans Using Hair Proteins

By Amanda McCrea



Identifying a person is critical to crime scene investigators, law enforcement and even archeologists. Scientifically, the best way to identify someone is from a DNA sample. However, a new scientific technique may prove otherwise.

DNA vs. Proteins

DNA has been the optimal evidence for identifying humans because it is unique to every person and is inherited from one's parents. However, environmental conditions such as heat and light can damage DNA and make it useless as an

identification tool. DNA molecules also degrade over time, and DNA recovered at a crime scene could be from several people, making it difficult to identify a single person. Scientists at the Lawrence Livermore National Laboratory (LLNL) have developed the first biological technique for identifying a human using the proteins found in hair. Dr. Brad Hart, a chemist at the LLNL, explains that DNA is very fragile, but proteins are chemically more stable. Proteins are chains of molecules formed from amino acids as instructed by your DNA, so there is a connection between DNA and hair proteins.

Using Hair to Make Identifications

This new technique of using hair proteins was developed by Dr. Glendon Parker, a biochemist with the LLNL. He and his team of scientists examined both male and female hair samples from European Americans, African Americans, Kenyans and even skeletal remains from the 18th century. A total of 185 protein markers were found in the hair samples, each of which would be unique in every person.

This method is still in the development phase, but may be an

invaluable tool for law enforcement officers and forensic scientists when it is further refined. Dr. Hart believes this method will be a game-changer in the forensic field.

[DISCUSSION QUESTIONS]

Why is DNA not as dependable as proteins?

What is a protein marker and how can it be used to identify a person?

How will this new scientific technique impact forensic scientists? Do you think this technique will be accepted in court? Why or why not?

Magnets May Cull Deadly Germs from Blood

By April Fischione

When someone is admitted to the hospital for an outpatient procedure, they wouldn't expect to develop a life-threatening illness. However, sepsis is one such illness caused by the body's response to an infection. Sepsis develops when your immune system reacts to fight an infection, but the response instead causes inflammation throughout the body. An infection anywhere in the body can trigger sepsis. Each year, more than a million Americans are affected by this condition and 28% of the cases prove to be fatal. Treatment for sepsis must be started quickly, and cases can worsen dramatically by the time doctors identify the condition and determine the best treatment.

There's a Chance

Our immune systems use antibodies to attack and latch onto bacteria and viruses, and a chemical engineer at the Swiss Federal Laboratory for Materials Science and Technology invented a way to track those antibodies. If antibodies were attached to tiny particles of iron oxide, one could use a magnet to remove them along with bacteria that they contacted from the blood. This theory was tested using the bacteria *Staphylococcus aureus* (which can cause sepsis) and a blood-like liquid. After adding antibody-coated iron oxide particles to the contaminated liquid, 98% of the bacteria were

collected by the strength of a simple magnet.

The Future is Near

In the near future, doctors may be able to treat sepsis in a manner similar to the treatment of severe kidney disease. Patients with sepsis would be hooked up to a machine that would treat their infection by removing bacteria as they become coated with the iron-oxide antibody mixture. Sepsis is a life-threatening illness, and both time and lives may be saved with the assistance of magnets.

[DISCUSSION QUESTIONS]

How is severe kidney disease treated?

What is the difference between sepsis and septicemia (blood poisoning)?

[VOCABULARY]

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Fighting Pathogens: A New Test to Save Crops

By Rita Waimer

Every year, viruses kill millions of dollars of crops in Florida alone. Add to that the other tropical and subtropical regions of the world where these viruses spread and you see that they're an immense problem, especially in areas where vegetables are essential to people's livelihood.

Many of these viruses belong to the genus *Begomovirus*, which infects a wide range of dicotyledonous plants, including crops like tomatoes, beans, squash and cotton. Growers must treat plants infected with these viruses and manage the outbreak as quickly as possible to minimize losses, as an unchecked outbreak could substantially reduce plant yields. Even if a grower notices viral symptoms early, it takes time to run tests and then manage the outbreak.

Finding the Virus

A pathogen cannot be identified by its symptoms because many pathogens cause the same symptoms. They may give the grower an idea of what's wrong, but testing is the only way to be sure. For that, a sample from an infected plant must be sent to a lab.

Because viruses can't be cultured like a fungus or bacteria, the lab has to run a polymerase chain reaction. However, many labs don't run those tests because they're expensive and time consuming. Even if they do run the tests, answers aren't guaranteed: assays exist for only a fraction of the 1,600 known plant viruses. Many growers are left with inconclusive or inaccurate results and a field of dying crops — a hefty expense.

A Better Way

Thankfully, it looks like those slow, expensive and possibly ineffective tests are about to be replaced: Jane Polston revealed in the Virology Journal that recombinase polymerase amplification can identify the cause of a disease faster and cheaper than PCR tests. Working at the University of Florida Institute of Food and Agricultural Sciences, she and her colleagues modified the test to check for viruses transmitted by whiteflies in Florida. Their new test makes it easier for labs to identify viruses in plants and crops, giving growers a better chance to save their crops and avoid losses. The UF/IFAS Plant Diagnostic Center officially adopted the new test in the summer of 2016 to benefit Florida's growers,

and Polston and her team hope that other clinics will follow suit and use the test to better equip themselves to diagnose plant viruses.

[DISCUSSION QUESTIONS]

What other kinds of plants are susceptible to viruses?

What can growers do to prevent their crops from becoming infected by viruses?

[VOCABULARY]

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Newly Discovered Octopus Imperiled by Deep-Sea Mining Plans

By Steven Steinfeld



Courtesy of NOAA Office of Ocean Exploration and Research, Hohonu Moana 2016

A semi-transparent species of octopus — nicknamed Casper after the cartoon ghost — was discovered last spring near Hawaii, but scientists are now concerned for their survival. They lay eggs in areas where companies want to mine for valuable metals that are used in our electronic devices.

Marine ecologist Autun Purser explored the South Pacific's deep seafloor, where rocky nodules containing valuable manganese are common, in 2015. "The nodules grow like pearls," said Purser. "They usually

start growing over a shark's tooth or a bit of broken shell. Slowly [...] they form layers of rock." The layers often include scarce metals that are used in making cellphones and computers.

The metals' land deposits have been mined already, so the sea is the next frontier. But mining teams could disrupt the environment and endanger these rare octopuses. "We thought we should try to understand what animals are in the area before we start mining," said Purser.

Eggs on Nodules Containing Valuable Metals

His team's swimming robot covered the seafloor over 4 kilometers (or 2.5 miles) below the surface. The robot's camera took pictures of 29 octopuses from two different species. Some were curled around eggs that had been laid on dead sea sponges that were clinging to the nodules. This guarding or "brooding" behavior can continue for more than a year.

Daniel Jones, marine biologist at England's National Oceanography Centre, says Purser's work "is critical for enriching our understanding of this poorly-known deep-sea environment." Purser's team is also comparing plowed and unplowed sites. Early findings indicate that harvested nodules do not return, even after decades. Without the nodules, there would be no attached sponges and therefore no place for an octopus to lay eggs.

Future deep-sea metal mining may take place across the seafloor, destroying the ecosystem where these octopuses live. If companies must mine, Purser hopes it's in small patches and that many nodules are preserved. "It would be nice to say don't do any mining," he observes, "but we all use mobile phones."

[DISCUSSION QUESTIONS]

Why is it important to preserve rare species like these octopuses?

What steps should be taken before any seafloor mining begins?

[VOCABULARY]

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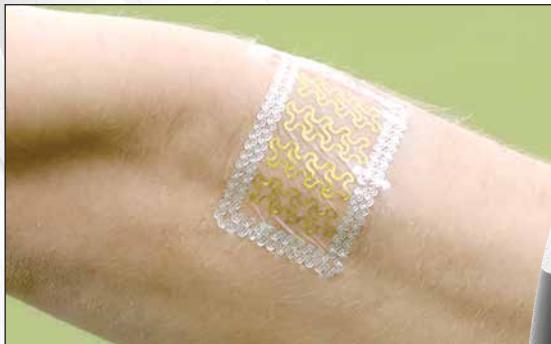
POLAR 3D

Thousands Flock to CES 2017 to Conduct Business and Shape Our Future

by Rose Meli



LG W7 OLED (organic light-emitting diode) flat panel: 65-inch; 18 pounds; protrudes 0.15 inches when attached to a wall



Rotex e-tattoo collects your body data and sends it to your phone.



Mayfield Robotics' Kuri Robot is a small but highly intelligent personal buddy.

The 50th annual Consumer Electronics Show (CES) was held from January 5th through the 8th at the Las Vegas Convention Center. Las Vegas has become the show's annual home since 1998, and this year a record breaking 175,000 attendees canvased 3.6 million net square feet to view products ranging from the practical to the out-and-out weird.

Who Will Hit the Jackpot with the Next "It Gadget"?

Every year government officials, investors, marketing executives, content creators, innovation architects, retailers and technology enthusiasts eagerly "shop" the floor, evaluating which new product has the practicality and "wow" power to be the thing that catapults us into our next technology-based personal breakthrough. Whether it is a VR (virtual reality) encounter or the prospect of experiencing 5G telecommunication for the first time (rolling out in 2020), CES is all about being the latest and greatest. This year's theme focused on connectivity and our new era of innovation. It's not just products on display, but also the experiences that the products enable. The possibilities are seemingly endless, making time spent at CES feel like a trip into our not-too-distant future.

Driverless Cars and Poker Faced Robots up the Ante

Smart technology and virtual-based products led the pack, ranging from concept cars that drive themselves to tattoos and rings that measure heart rate and body temperature. L'Oreal introduced hair brushes that measure the quality of hair care, and Carnival unveiled wearable medallions that can be used on cruises to unlock rooms and make purchases.

Robotics continued to be wildly popular. Robotic baristas seemed to battle over which was better: coffee, tea or cappuccino. Kuri, a product of Mayfield Robotics, is mobile, aware and full of personality. It can move through the home easily, even remembering the floor plan of your house. Its LED lights will even let you know what kind of mood it's in. The built-in camera can record and save video to let you know when the kids are home, or to take some extra-cute cat videos of their antics when you're not around.

The Skinny on Televisions and Projectors: A Winning Hand

From smartphones to laptops, another theme was the thinner the better. Skinny televisions stole the show by providing practicality to consumers who lack wall space and jaw-dropping visuals to technophiles. LG introduced the W7 OLED (organic

light-emitting diode) flat panel 65-inch model that weighs just 18 pounds and protrudes a mere 0.15 inches (as thick as a couple of coins stacked together) when attached to a wall. The OLED technology promises a 25 percent higher peak brightness and better color. The TV will hit the market in March 2017 and sell for approximately \$8,000.

Sony introduced an Xperia Projector prototype, which projects a screen onto any flat surface and uses IR sensors to turn that surface into a 10-point multitouch screen. It can also project an 80-inch image onto a nearby wall. This device is similar to an Android phone, but without cellular connectivity, and can browse the internet and play movies and games, allowing for a more enjoyable experience than a limiting cell phone screen. It's also child friendly, preventing little ones from spilling onto or dropping mobile devices.

Wild Cards

The following products may not become staples in our everyday lives, but may find a place in some niche markets: radiation-blocking underwear, baby diaper monitor, Bluetooth toaster, anti-pollution scarf, buzzing shorts (to eliminate the need to check your smartphone), levitating speakers, virtual reality shoes, and fridge cameras that notify you when food needs to be thrown away. From

the weird to the wonderful, CES 2017 had something for everyone.

Future Wheel Spin

CES 2018 will take place next January from the 9th to the 12th. With so many new concepts and products to ponder, it's mind-boggling to consider the prospect of outdoing the 2017 show. Technology industry experts are currently hard at work laying the foundation for what is sure to be another fascinating and rapidly advancing year for technology — first seen in Las Vegas and then by the world.

[DISCUSSION QUESTIONS]

What would be the primary job function of a person who held the fun job title of Content Creator or Innovation Architect? What type of skills would be needed to perform these job tasks?

Envision yourself as an Inventor of technology, and then name some new features and functions that you would add to your current SMART phone's capabilities.

[VOCABULARY]

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Biotechnology uses living systems to develop products, increase quality of life, and improve the health of our planet. It requires a highly trained workforce, and career opportunities in biotechnology are as diverse as they are rewarding. Some jobs fall into the areas of research and development, including lab technician, zoologist, food/plant scientist, microbiologist, biochemist, and biomedical engineer. Biotech careers can also exist outside the lab in fields like technical writing, sales, marketing, and manufacturing. Such a variety of jobs demands a wide-range of education and training, but all careers in biotechnology are built

on strong foundations in science and economics.

Biotechnology's interdisciplinary nature demands biotech professionals to be well-versed in multiple STEM (Science, Technology, Engineering and Math) areas including biology, chemistry, environmental science, physics, and engineering. Preparing students to become tomorrow's biotech super heroes is a tall order, and some employers may give priority to candidates with hands-on lab experience. That's why the Fisher Science Education team has partnered with Ellyn Daugherty, educator and author of *Biotechnology: Science for the New Millennium, 2017* (BS4NM) to provide the most current, flexible, and well-supported biotech curriculum available.

Biotechnology: Science for the New Millennium 2017 (BS4NM) uses a

lab manual and textbook to present complex subjects in small doses. Students of all levels can master the material, which helps to instill science literacy, research skills, and career awareness. Furthermore, the flexibility of BS4NM makes it ideal for high school and college settings. The curriculum can be used as an introductory course for careers in pharmaceuticals or environmental engineering, or as a capstone class to illustrate the application of general chemistry, biology, physics, or environmental science. It can also be tailored to a single semester's curriculum, or extended to cover four years' worth of high school or college activities, ensuring that each school can develop a biotech program to meet the future career needs of their students. Additionally, BS4NM provides extensive teacher support materials, including lesson plans and professional development opportunities to ensure that

instructors feel confident in the ever-changing world of biotech.

As the premier supplier of BS4NM materials, the Fisher Science Education brand provides one-stop-shopping and dedicated product support for educators using the *Biotechnology: Science for the New Millennium, 2017* curriculum. Visit fisheredu.com/BS4NM to learn more about how the BS4NM textbook, lab manual, teacher support resources, and materials lists can prepare your students for STEM careers.

[DISCUSSION QUESTIONS]

How do hands-on lab experiments prepare students for future careers?

What examples can you find of biotechnology products?

[VOCABULARY]

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Top 10 STEM Jobs of 2016

Jobs in STEM fields (Science, Technology, Engineering and Math) are expected to grow about 13% by 2022 — that's more than 9 million jobs in five years! These opportunities encompass a broad range of skill sets, industries, and talents.

10. Mathematician

Mathematicians conduct research to explore and develop theories or use established theories to solve real-world problems. Mathematicians can fill many roles, including financial analyst, system analyst, professor, or teacher.

Median Salary: \$103,720

Expected Job Openings: 700

9. Information Security Analyst

Information security analysts plan and implement security measures to protect computer networks and systems. Most work for computer companies, consulting firms or in the business and financial industries.

Median Salary: \$88,890

Expected Job Openings: 14,800

8. Financial Advisor

Financial advisors help clients create budgets, provide advice about investing or help with retirement planning. Some may actually invest on behalf of a client or sell insurance.

Median Salary: \$81,060

Expected Job Openings: 73,900

7. IT Manager

IT managers are responsible for implementing and maintaining an organization's technology infrastructure. This includes processing systems, data management, and communications tools.

Median Salary: \$127,640

Expected Job Openings: 53,700

6. Biomedical Engineer

Biomedical engineers design devices and equipment, including artificial organs, replacement body parts and machines for diagnosing medical issues.

Median Salary: \$86,950

Expected Job Openings: 5,100

5. Accountant

An accountant inspects or keeps financial records for an individual or business. They may prepare taxes and audits or provide bookkeeping services in all levels of business.

Median Salary: \$65,940

Expected Job Openings: 142,400

4. Web Developer

A web developer specializes in programming internet applications. This can include the design and overall look and feel or the code that supports the functionality.

Median Salary: \$63,490

Expected Job Openings: 39,500

3. Statistician

Statisticians collect and analyze data to solve real-world problems using statistical data. They are commonly working in business, engineering, or healthcare.

Median Salary: \$79,990

Expected Job Openings: 10,100

2. Software Developer

Software developers are the creative minds behind computer programs. They can develop the applications that allow users to run specific tasks on a computer or smartphone, or they can work on the systems that run those devices.

Median Salary: \$95,510

Expected Job Openings: 135,300

1. Computer Systems Analyst

Computer systems analysts study an organization's computer systems, procedures and design information systems to help the organization operate more efficiently.

Median Salary: \$82,710

Expected Job Openings: 118,600



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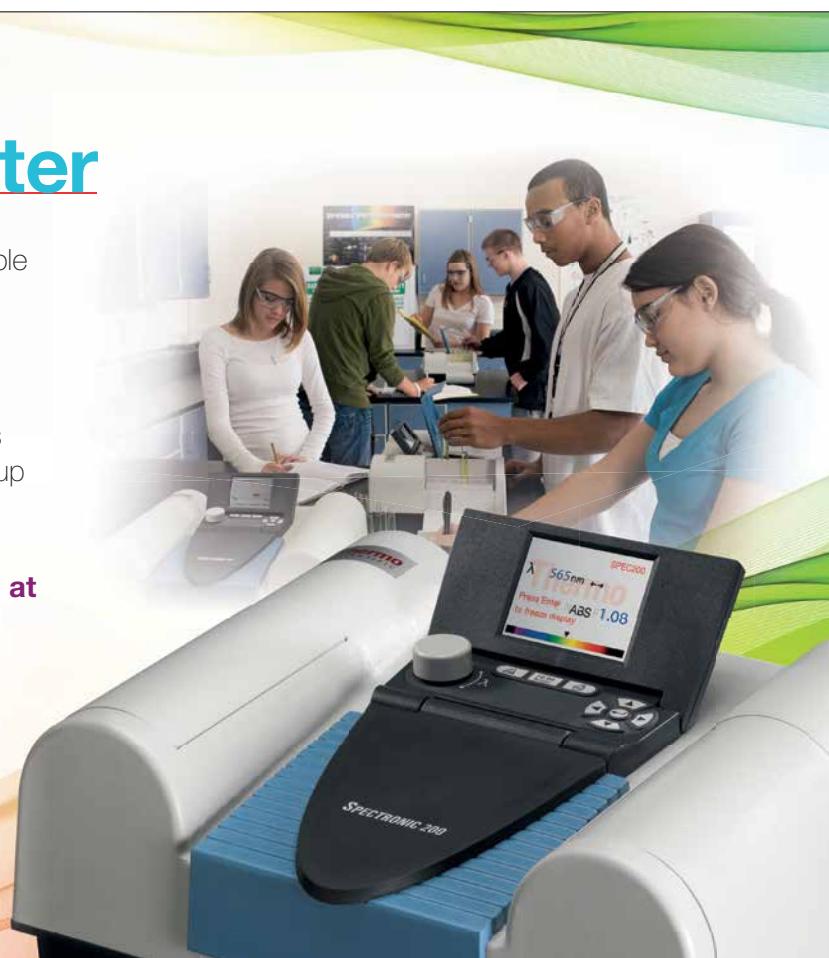
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