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Meet the STEM-Credibles!
SEE BACK COVER
DO TIRED PEOPLE CRAVE JUNK FOOD?
WHERE'S THE LAB-GROWN BEEF?
CORAL FIGHTS BACK AGAINST WARMING SEAS
RARE CORPSE FLOWER BLOOMS
How are you celebrating
Special Report: Headline Discoveries now published four times a year
Headline Discoveries
April-June 2016 » Issue 2
MEGACITIES
Striving for Sustainability
Zika Virus Outbreak
What Makes Fireflies Light Up?
HEADLINE DISCOVERIES
Jan/Feb 2011; Issue 1
HEADLINE
Discoveries
Fall 2023
Celebrating 20 Years of
Headline Discoveries
Jellyfish May Learn Without Brains
Vinyl Revival Meets Science
New: Discovery Roundup
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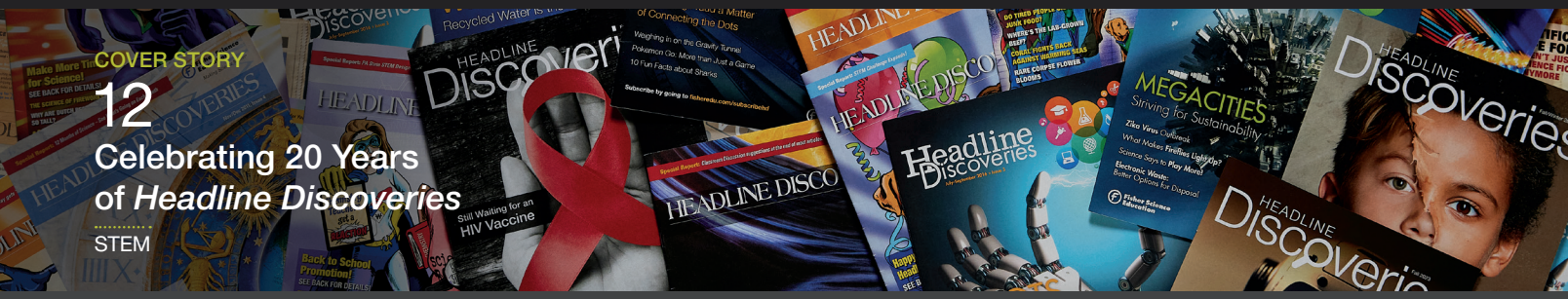
HEADLINE Discoveries

Spring 2024



COVER STORY

Supplier Index

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Celebrate the 2023 Thermo Fisher Scientific Junior Innovators Challenge Award Winners

By Kylie Wolfe

Last fall, 30 students participated in the Thermo Fisher Scientific Junior Innovators Challenge (Thermo Fisher JIC) Finals Week in Washington, D.C., which brought together sixth, seventh, and eighth graders from across the United States for a week of STEM activities and team projects. Finalists competed for over $100,000 in awards, including a $25,000 grand prize.

The Thermo Fisher JIC, a program of Society for Science, is the nation's premier middle school science, technology, engineering, and mathematics (STEM) competition and reaches 65,000 students annually through affiliated science and engineering fairs.

Meet the 2023 Top Award Winners

Finalists competed for the following cash awards. Each award had a different focus, including mastering STEM subjects, improving the community, demonstrating leadership skills, and more.

Thermo Fisher Scientific ASCEND (Aspiring Scientists Cultivating Exciting New Discoveries) Award—$25,000

Shanya Gill, a sixth grade student from San Jose, California, was inspired to build a faster, more accurate fire detector after a restaurant near her house burned down. What she created could decrease emergency response times, fulfilling her goal of making buildings safer while preventing disasters.

Broadcom Coding with Commitment™ Award—$10,000

Keshvee Sekhda, an eighth grade student from Sugar Hill, Georgia, co-developed a mobile app that uses photos and health scan images to help identify breast, lung, and skin cancer.

DoD STEM Talent Award—$10,000

Maya Gandhi, an eighth grade student from Anaheim, California, constructed microbial fuel cells using four different materials to determine which would boost electricity production.

Lemelson Award for Invention—$10,000

Adyant Bhavsar, a seventh grade student from San Jose, California, built a triboelectric nanogenerator to increase the reliability of sensors that monitor for natural disasters.

Robert Wood Johnson Foundation Award for Health Advancement—$10,000

Elizabeth Louise Olvera, a seventh grade student from Goleta, California, studied the absorbency of six natural fiber-based fabrics that could be used to make more affordable and reusable menstrual pads.

Meet the 2023 STEM Award Winners

Finalists could also be awarded first or second place in STEM subject areas. First place winners received $3,500 and second place winners received $2,500 to attend a STEM summer camp.

Science Award

First Place: Veronica Howard, an eighth grade student from Redwood City, California, tested organic and conventional produce to see if pesticides were more abundant on one or the other.

Second Place: Elizabeth Shen, an eighth grade student from Portland, Oregon, found a low-cost way to determine water's rate of diffusion and modify its speed.

Technology Award

First Place: Advait Badrish, a seventh grade student from Redmond, Washington, built an app that can be used to analyze heart sounds to check for abnormalities.

Second Place: Chloe Svetlana Fierro, a sixth grade student from El Paso, Texas, analyzed the thermal performance of cork against common insulation materials.

Engineering Award

First Place: Krishna Bhatt, an eighth grade student from San Jose, California, designed a wearable device that helps users maintain their balance to prevent falls.

Second Place: Claire Xu, an eighth grade student from San Jose, California, and her teammate Venice Parnell used food scraps to create vegan leathers and tested each for durability and water resistance.

Mathematics Award

First Place: Tate D. Plohr, an eighth grade student from Los Alamos, New Mexico, used computer modeling to study solar flares and the factors that affect their stability.

Second Place: Amritha Praveen, an eighth grade student from Buffalo Grove, Illinois, measured the body's response to music to provide effective music therapy recommendations.

Visit societyforscience.org/jic/2023-finalists/ to learn more about each student and their project.

Become a Junior Innovator in 2024

Do you find these projects inspiring and want to get involved this year?

Middle school students who place in the top 10 percent at a Society for Science-affiliated science or engineering fair are eligible to apply for the Thermo Fisher JIC. Applications are reviewed by a panel of judges who select the top 300 Junior Innovators and, ultimately, the 30 finalists who will take part in the Finals Week competition.

Visit societyforscience.org/jic/ to find your local fair and learn how to apply in 2024.

FACTS ABOUT THE 2023 THERMO FISHER JIC FINALISTS

- More than half of this year's finalists identify as female
- The top project category was engineering
- The states with the most finalists were California, Texas, and Georgia
- Over half of the finalists attend public schools

Lucid Dreamers Reach Out from the World of Sleep

By Mark Miller

Have you ever realized that you were having a dream while it was happening? If so, you may be a lucid dreamer. According to the article "'Lucid' dreamers could solve mysteries about sleeping minds" in *Science News Explores*, scientists are working with people with this ability to conduct research about the nature of our dreams.

Responding in Real Time

Lucid dreaming isn't daydreaming. In fact, most lucid dreams occur during rapid eye movement or REM sleep, which is experienced about 60 to 90 minutes after falling asleep.

Once in this state, lucid dreamers can do more than just become aware that they are dreaming; they can achieve some control over their dreams, perform tasks, and even communicate with waking researchers in real time.

According to the article, neuroscientists Karen Konkoly and Martin Dresler and sleep neurologist Isabelle Arnulf asked lucid dreamers to answer yes-or-no questions or solve rudimentary math problems while they were dreaming. They posed questions 158 times and didn't receive many responses, but six participants provided 29 correct responses—including the correct answer to: What is eight minus six?

The subjects communicated by moving their eyes from left to right or smiling or frowning. Electrodes attached to their bodies detected these movements.

Dream Job

Finding lucid dreamers for these studies is a challenge. Surveys reveal that only about half of adults say they've ever had a lucid dream and only 23 percent have lucid dreams every month, according to the Sleep Foundation. And the studies require more than just experiencing lucid dreams.

"It's a lot harder than just passively lucid dreaming in your bed," says participant Christopher Mazurek. "You realize, 'OK, I have to stabilize the dream. I have to remember what the task is. I have to do the task without the dream falling apart.'"

Scientists are exploring ways to enlarge the available pool. One method is to play sound cues that subjects associate with being self-aware and then play the cues again during sleep. Another is to recruit subjects with narcolepsy, a condition that makes it difficult to stay awake. "They're just champions at lucid dreams," says Arnulf, whose team performed a study where 18 out of 21 narcoleptic subjects experienced lucid dreaming while sleeping in the lab.

Sleep Solutions

Scientists are trying to answer a range of questions by tapping into the slumbering mind: Do dreams help us solve problems? How do we differentiate what we imagine from what we perceive? How do we experience emotions in dreams? And perhaps the biggest question of all: Why do we dream? If you're a lucid dreamer, maybe you can help.

DISCUSSION QUESTIONS

Have you ever had a lucid dream? Describe the experience.

What is REM sleep?

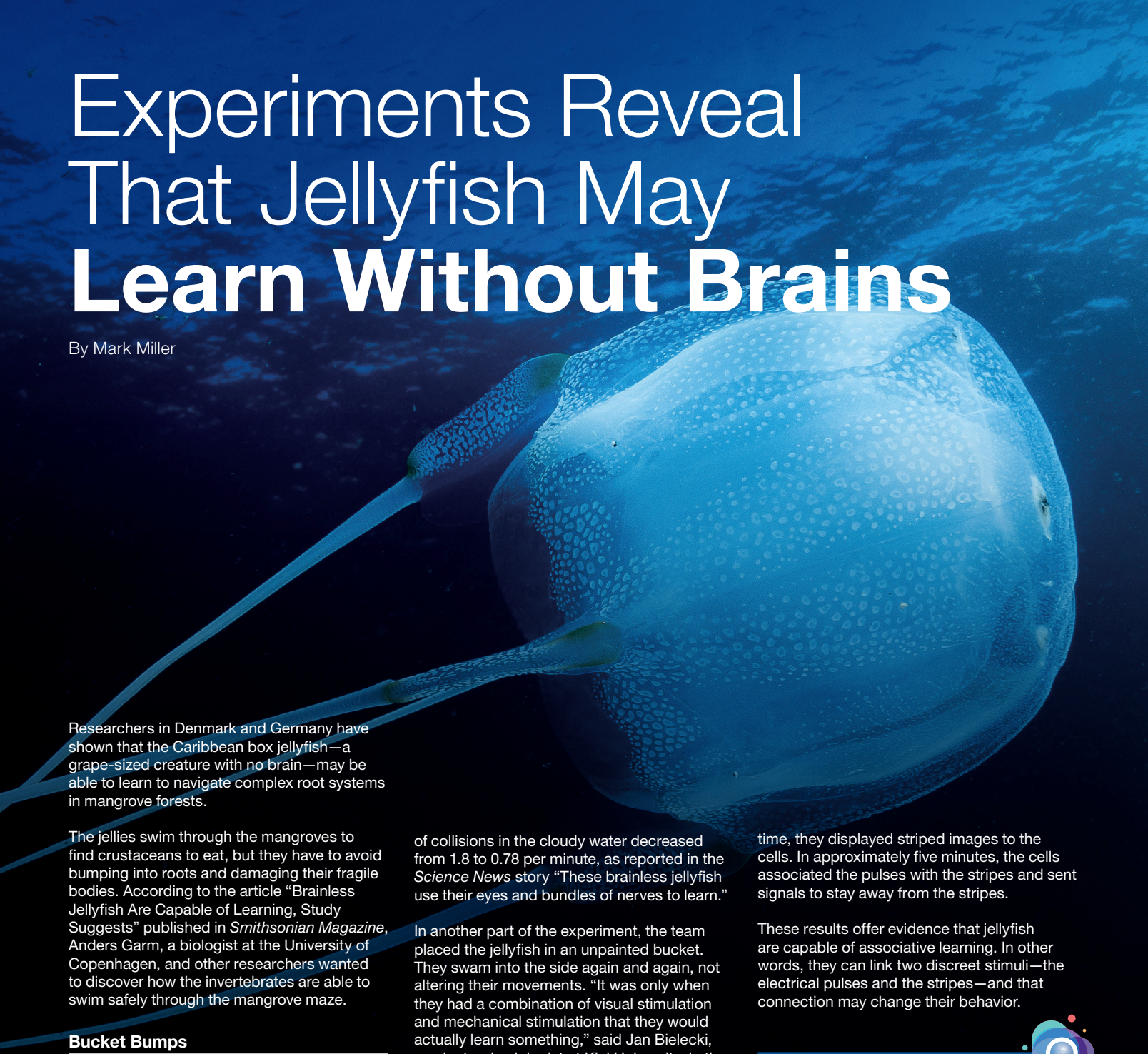
What happens to our brains while we're asleep?

VOCABULARY

LUCID RAPID EYE MOVEMENT NEUROSCIENTIST NEUROLOGIST

Experiments Reveal That Jellyfish May **Learn Without Brains**

By Mark Miller



Researchers in Denmark and Germany have shown that the Caribbean box jellyfish—a grape-sized creature with no brain—may be able to learn to navigate complex root systems in mangrove forests.

The jellies swim through the mangroves to find crustaceans to eat, but they have to avoid bumping into roots and damaging their fragile bodies. According to the article "Brainless Jellyfish Are Capable of Learning, Study Suggests" published in *Smithsonian Magazine*, Anders Garm, a biologist at the University of Copenhagen, and other researchers wanted to discover how the invertebrates are able to swim safely through the mangrove maze.

Bucket Bumps

The team set up an experiment using buckets of water painted on the inside to simulate the jellyfish habitat. One was painted with clearly contrasted black and white stripes to replicate the mangrove roots in clear water. Another displayed gray and white stripes to mimic how the roots might look in cloudy conditions.

They placed the jellyfish in the buckets and recorded their activity. As anticipated, the jellyfish—likely relying on their 24 eyes—had no difficulty staying clear of the painted roots in the clear water. In the cloudy water, however, they did bump into the sides—at first. But in under eight minutes, the average number of collisions in the cloudy water decreased from 1.8 to 0.78 per minute, as reported in the *Science News* story "These brainless jellyfish use their eyes and bundles of nerves to learn."

In another part of the experiment, the team placed the jellyfish in an unpainted bucket. They swam into the side again and again, not altering their movements. "It was only when they had a combination of visual stimulation and mechanical stimulation that they would actually learn something," said Jan Bielecki, an electrophysiologist at Kiel University, in the journal *Nature*.

Look in the Eyes

The combination of feeling and seeing seemed to hold the key to the jellyfishes' cognitive capabilities, but scientists thought that the eyes alone were where the learning might be occurring.

To find out, they performed an isolated test of the four vision centers or rhopalia (each containing six eyes) of a jellyfish. They applied an electrical pulse to these sensory cells to imitate contact with an obstacle. At the same time, they displayed striped images to the cells. In approximately five minutes, the cells associated the pulses with the stripes and sent signals to stay away from the stripes.

These results offer evidence that jellyfish are capable of associative learning. In other words, they can link two discreet stimuli—the electrical pulses and the stripes—and that connection may change their behavior.

DISCUSSION QUESTIONS

Approximately how long have jellyfish existed?

How would you define an experiment?

Can you think of other examples of animals demonstrating associative learning abilities?

VOCABULARY

MANGROVE CRUSTACEAN INVERTEBRATE STIMULI COGNITIVE

Exploring the Periodic Table:
Rare Earth Elements

By Iva Fedorka

Rare earth elements (REE) are a group of 17 soft and silver-white metals that are valued for their luminescent and magnetic qualities. In the periodic table, they make up the group called the lanthanoids and include other elements in Group 3.

Despite their name, REEs are not really scarce. Cerium, atomic number 58, is actually more plentiful than copper. However, REEs are not found in concentrated forms like other metals.

Physical and Chemical Characteristics

REEs tarnish slowly in air, ignite spontaneously at 400°C (752°F), and often form oxides with other elements. Their biological function is minimal.

The electron structure of REEs makes them unique—their electrons in 4f orbits give them powerful magnetic properties and the ability to emit light at specific wavelengths.

- High-powered lasers are made using yttrium and neodymium
- Internet signals are boosted by erbium
- Colors on television, computer, and telephone screens come from various REEs
- Headphone sounds, hard drive data storage, magnetic resonance imaging (MRI), and wind turbines depend on magnets containing neodymium
- Electric vehicle batteries are more heat-resistant when dysprosium is added
- Crude oil is transformed using cerium as a catalyst
- Nuclear reactor control relies on the neutron-absorbing ability of gadolinium
- The conductivity of photovoltaic solar cells is enhanced by tellurium alloys

Supply and Availability

To obtain a significant quantity of REEs, a large amount of raw material is needed. The mine sites are often open pits that disrupt ecosystems and produce waste ponds full of toxic acids, heavy metals, and radioactive material. Although REEs have been found on every continent, more than 90 percent of the global supply currently comes from China.

Non-traditional sources of REEs, like mine tailings, geothermal brines, and coal byproducts, may help diversify their supply chain. But methods haven't been developed to process them economically, which creates both a challenge and an opportunity for discovering new ways to process, reclaim, and recycle these precious materials.

An Alternate Method

Researchers at Lawrence Livermore National Laboratory (LLNL) are using bioengineered bacteria to recover REEs from raw materials. Using bio-adsorption of leachates from metal-mine tailings and rare earth deposits, the team showed better efficiency and selectivity for REEs versus other non-rare earth metals.

"To alleviate supply vulnerability and diversify the global REE supply chain, we've developed a new extraction methodology using engineered bacteria that allowed us to tap into low-grade feedstocks," said Yongqin Jiao, lead author of a paper appearing in *Environmental Science & Technology*.

The microorganisms provide a large surface area and cell surface functional groups with metal coordination functionality. The cells can also tolerate multiple adsorption-desorption cycles without needing frequent regeneration.

"Our results demonstrate the technical and economic feasibility of coupling bioengineering with biosorption for REE extraction," Jiao said.

REEs are essential for clean energy industries, a high-tech economy, and even national security, so the search for cost-effective and environmentally friendly methods of producing these elements continues.

DISCUSSION QUESTIONS

How are copper, silver, gold, and other metals purified from ores?

Are there any active REE mining sites in the United States?

What is the national laboratory system?

VOCABULARY

CATALYST ELECTRON

ELEMENT EXTRACT

How AI Helped Decipher an Ancient Roman Scroll

By Gina Wynn

In 79 A.D., a massive volcanic eruption covered the Roman city of Herculaneum in over 65 feet of ash, hiding nearly 2,000 valuable scrolls for centuries. When they were discovered in the late 1700s in a buried luxury villa, the charred documents were thought to be unreadable. Thanks to technology and a collaborative scientific contest, however, a 21-year-old student has been able to identify the first whole word.

Modern Interprets Ancient

To speed up the process of finding a way to read the ancient texts, Brent Seales and his team at the University of Kentucky in Lexington set up the Vesuvius Challenge—a competition designed to tap into the creativity and expertise of researchers worldwide. Seales and his colleagues posted X-ray computed tomography (CT) scans of the scrolls and their codes on the Challenge website scrollprize.org and offered prize money to teams or individuals who met certain criteria for decoding letters and passages.

So far, Challenge participants are contributing to a mood of "unbridled optimism" for Seales and his colleagues, according to the *Nature* article "AI reads text from ancient Herculaneum scroll for the first time". A computer science major at the University of Nebraska-Lincoln, Luke Farritor, has successfully deciphered the first whole word in the scrolls—purple, written in Greek. He was able to view the letters through a machine-learning algorithm he created, an application of advanced artificial intelligence (AI).

Great Minds Think Alike

Shortly after Farritor, Freie University Berlin graduate student Youssef Nader independently discovered the same word. Both received part of the $50,000 "First Letters" prize. The first person or team to decipher four continuous passages of at least 140 characters will win $700,000.

Competitors use a technique called "virtual unwrapping," developed by Seales, to help decode the scrolls, according to the CNN article "AI reads text from famously inscrutable ancient scroll for the first time." This process virtually flattens the pages using the curved layers in the CT scans as guides. Advanced AI trained to look for ink on the pages is then applied.

Crackle and Pop

Because the ink on the scrolls is mostly made of charcoal and water—like the carbonized, plant-based papyrus to which it was applied—it doesn't show up on the CT scans. So instead of analyzing the ink properties, Farritor decided to focus on the minute differences in the papyrus surface texture under the ink, *Nature* reported. Another Vesuvius Challenge competitor first drew attention to the differing texture or "crackle." Farritor's algorithm highlighted the crackle that ended up revealing the hidden letters.

Peeking into the Past

Farritor's breakthrough is scientifically and culturally important because similar algorithms might be able to help unlock knowledge in other unreadable ancient texts, including the remaining 600 scrolls recovered from the villa library. Unfortunately, attempts to physically unroll a large portion of the excavated scrolls left them in crumbled pieces and fragments.

Farritor's and Nader's ability to decipher parts of the scrolls while leaving them intact not only sheds light on ancient history, but it also shows how technology and teamwork can uncover secrets lost for centuries. Seales and his team's dedication to understanding these forgotten manuscripts is opening a new door to the past, making history come alive in new ways.

DISCUSSION QUESTIONS

How else can AI be used?

Have you ever used it?

What risks are involved with using AI?

VOCABULARY

CARBONIZED DECIPHER PAPYRUS

Is Bacteria the Future of **Sustainable Fashion?**

By Lynne Lescott

Would you wear a shirt, socks, and shoes made from bacteria? It may sound gross, but it could become the future of fashion and help reduce waste that contributes to climate change.

Fast Fashion

Traditional clothing production often harms the environment. During mass production, toxic chemicals are used to treat and dye the fibers that become wearable textiles. The chemicals and fiber waste created during the process can enter water supplies near the factory. Footwear and clothing manufacturers also produce emissions and contribute an estimated 8.6 percent of all global greenhouse gas emissions. That's more than the European Union combined, and the amount has rapidly increased during the past 25 years.

What's the biggest factor in this? People. Recent studies show that clothing production doubled worldwide between 2000 and 2014 to keep up with consumer demand for trendy fashion items. As fashion preferences change quickly, consumers throw away off-trend clothing more often. Discarded clothing and footwear are usually incinerated or dumped in landfills, where they emit greenhouse gases and leach toxic substances into the soil over hundreds of years—that's how long it can take for them to decompose.

That's why fast fashion is a phenomenon that both climate activists and a growing number of clothing manufacturers are trying to end. As experts experiment with new, sustainable processes, bacterial-based clothing production is emerging as one promising solution.

A Potential Fast Fashion Fix

How did bacteria become a sustainable fashion superhero in the first place? It began 200 years ago with the identification of an organic compound called plant cellulose (PC). PC is found in all green plants and its fibers form a strong, biodegradable matrix that strengthens cell walls. People have actually used PC to make textiles and paper products for thousands of years.

About 150 years ago, a scientist discovered that cellulose is also produced by bacteria. Bacterial cellulose (BC) has the same biodegradable properties as PC, yet it's stronger, more stable, moldable, and has a higher purity. BC can be grown using bacterial cultures.

In a recent collaboration between a well-known fashion brand and a biomaterials company, mango waste was used to nourish and grow BC. Before this partnership the waste would have decayed in a landfill, expelling methane gas. The team used the BC grown from cultures to create sheets of BC fibers. The BC sheets were processed without toxic chemicals and dyed using natural substances before being woven and formed into biodegradeable jackets.

At both ends of the cycle and at each step between, the team focused on creating a sustainable process that could be scaled to produce biodegradeable fashionwear. And BC is the key to the plan.

A Sustainable Fashion Trend

Similar collaborations between scientists and the fashion industry may spur new ways to combine BC's superhero qualities with sustainable production practices. And that's a fashion trend worth rooting for.

DISCUSSION QUESTIONS

What other types of waste could be used to grow bacteria?

What other products could bacterial cellulose be used to make? Make a list.

VOCABULARY

BIODEGRADEABLE CELLULOSE BACTERIA BIOMATERIALS

Vinyl Revival:
The Science of Spinning and the Allure of Record Sound

By Gina Wynn

For the first time since 1987, vinyl records outsold CDs, according to a recent Recording Industry Association of America report. Some say this resurging popularity of vinyl is being driven by nostalgia and others credit the comeback to its unique sound.

Older music enthusiasts may be more influenced by nostalgia. People who grew up in the 1970s may remember joyfully playing tunes on portable turntables, spending hours scrutinizing album cover art, and memorizing every lyric printed on record sleeves to help them sing along to their favorite songs.

Groovy Sound

As for the unforgettable sound of vinyl, some prefer it over the studio-sampled tones of digital recordings. Often described as "warm," the rhythmic crackling sounds you hear when a record plays actually come from deficiencies in turntables, according to Stanley Lipshitz of the Audio Research Group at the University of Waterloo in Canada as reported in the *Popular Science* article "Are Records Really Better?" by Corey Binns.

Lipshitz said that sound waves coming out of the speakers, along with the needle's passage over the hills and valleys of the grooves carved into records, cause them to vibrate as they revolve. Some consider these added vibrations musical imperfections, but many find them appealing.

Manufacturing Hits

Although vibration causes mixed feelings among listeners, it's an unintended byproduct of record manufacturing, an intricate process that requires attention to detail. Before manufacturing can begin, however, the songs or "tracks" designated for the record must go through a process called mastering. This is when specially trained sound engineers check the sequencing and quality of each track and optimize them for vinyl.

The mastered files are then turned into grooves on a lacquer plate through a technique called lathe cutting. Electroplating follows, meaning the grooves are filled in, raised, and turned into stampers, much like an ink stamper.

Next, polyvinyl chloride (PVC) pellets are heated and compressed hydraulically between two stampers to add the essential grooves to both sides of the record. The grooves replicate the shape of the sound waves produced by the musicians. The newly grooved records are then cooled, trimmed, shaped, and checked for quality. Once approved, they undergo a final curing process to prevent warping.

Musical Merry-Go-Round

To hear the music on a vinyl record, you place it on a turntable, which has a spinning base and a needle called a stylus at the end of a thin arm. The stylus vibrates and travels over the grooves of the record as it spins, and the vibrations are turned into an electrical signal by a cartridge at the end of the arm. This signal is then sent to the record player's amplifier, allowing us to hear the music.

Arguments can be made about whether your favorite songs sound better this way or whether CDs, cassette tapes, or digital formats provide better audio experiences. Most people can agree that the sound of each format is different, but not necessarily better. Fortunately, we can choose whichever is the most pleasurable and convenient when we need a musical boost.

DISCUSSION QUESTIONS

How do you prefer to listen to music? Why?

Have you ever listened to a vinyl record? What do you think of the sound?

VOCABULARY

AMPLIFIER BYPRODUCT MASTER NOSTALGIA TRACK

Celebrating 20 Years of *Headline Discoveries*

By Christina P. Hooton

Just like any subject you learn about in school, science is best taught and understood with real-world examples. According to futureeducators.org, using authentic scenarios can help make learning more meaningful for students and spark excitement in the classroom. This makes it easier for teachers to engage students with abstract scientific topics.

That was the original inspiration behind *Headline Discoveries*. Now embarking on its next decade of educational science news, this publication has been helping teachers and inspiring students in science for 20 years. Learn how it originated and has evolved over its impressive run.

Inspiring Teachers and Students

Headline Discoveries launched in 2004 to provide science educators with a classroom teaching aid. Jill Jones, then category manager of the Fisher Science Education brand, who helped launch the publication, used her experience developing programs at the Carnegie Science Center in Pittsburgh, Pennsylvania, to better understand the challenges of elementary school teachers trying to teach and be well-versed in multiple subject areas.

"We realized there is a lot of content in the news that has great nuggets of information that teachers can learn from and, most importantly, share with their students," said Jones, now vice president of sales for academic and government segments at Thermo Fisher Scientific. "*Headline Discoveries* was designed to give teachers real-world current science content and get students excited about what they're learning and how it impacts the world."

The publication first launched as a newspaper, the environmentally conscious choice at the time, with four issues per year. It featured many of the same topics you see today, including biology, chemistry, physical science, and more. Originally, its audience was elementary school students and teachers, but the publication has since evolved to include articles for high-school and college students as well.

"The articles have also changed over the years, going from short snippets to longer pieces, including editorials," said Celeste Beley, market development manager for the Fisher Science Education brand at Thermo Fisher. "Vocabulary words and discussion questions were added to give teachers the option to turn the articles into content literacy tools."

The publication was only available in print until 2012 when the *Headline Discoveries* web page first launched. It straddled both the print and digital worlds until the end of 2020 when it transitioned to being entirely online. This move reflects the commitment of the Fisher Science Education brand, as part of Thermo Fisher Scientific, to achieve net-zero emissions by 2050.

Honoring Teachers as Superheroes

Headline Discoveries has existed in various forms and designs over the years, too, even featuring different science superheroes on its covers. The STEMcredibles had superpowers inspired by different disciplines of science.

"At the time, teachers were feeling underappreciated and underpaid. With these characters, we created a persona that honored teachers as superheroes," said Jones.

When the Fisher Science Education team visited trade shows, they brought their banner exclaiming "Science Teachers Are Superheroes Every Day," and teachers lined up to have their photos taken with the sign, sometimes in their own superhero gear, said Jones.

The campaign won the team a coveted Markie award, an honor granted by Oracle for customer experience innovation and excellence in advertising, marketing, sales, service, and e-commerce.

Over the years, the *Headline Discoveries* design evolved and matured with its growing audience, including college students.

Tackling Tough Topics and Tough Times

During the pandemic, *Headline Discoveries* remained a steady resource and online tool for educators who were being tasked with teaching remotely. As the Black Lives Matter movement took shape around the same time, the Fisher Science Education team did not shy away from the conversation. They published a cover article discussing how racism is a product of culture not science.

Presenting unbiased scientific facts has always been a driving force behind the publication and always will be.

Looking Toward the Future

As the world around us changes, we will continue to highlight topics that really matter to you. Articles that delve into the science behind climate change will undoubtedly continue to fill our pages. New applications of artificial intelligence in the science and education world will certainly be present, too. We can't predict what's to come next, but one thing we can say for sure is we're excited for the next 20 years of bringing real-world science into your classrooms.

DISCUSSION QUESTIONS

What makes learning about science using real-world examples so effective?

Imagine that you are a science teacher. Brainstorm ways to make learning more engaging for students in your grade.

VOCABULARY

APPLICATION

LITERACY


HEADLINE DISCOVERIES
Mar/Apr 2012; Issue 2
Sep/Oct 2013; Issue 3
Special Report: How Science Classrooms Will Change
Fisher Science Education
Making Science Matter
HEADLINE DISCOVERIES
Mar/Apr 2014; Issue 2
How are you celebrating
Day & DNA Day?
Special Report: Glowing Sheep Fight AIDS
HEADLINE DISCOVER
Meet the STEM-Credibles!
SEE BACK COVER
DO TIRED PEOPLE CRAVE JUNK FOOD?
WHERE'S THE LAB-GROWN BEEF?
CORAL FIGHTS BACK AGAINST WARMING SEAS
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HEADLINE DISCOVERIES
Jan/Feb 2011; Issue 1
Headline Discoveries
April–June 2016 » Issue 2
MEGACITIES
Striving for Sustainability
Zika Virus Outbreak
What Makes Fireflies Light Up?
Science Says to Play More!
Electronic Waste:
Better Options for Disposal
Fisher Science Education
HEADLINE Discoveries
Fall/Winter 202
Headline Discoveries
July–September 2016 » Issue 3
ROBOTS in the Lab
Automation Through the Ages
Happy 100th, National Parks!
Addicted to Cell Phones
Why Does It Taste Like That?
HEADLINE Discoveries
Fall 2023
How AI Can Hurt or Help in the Cla
fisher science education

Genetic Super Crops

May Help Us Fight Climate Change

By Christina P. Hooton

Climate change has the potential to affect many aspects of our lives, including the food we eat. When disastrous floods, droughts, and diseases ravage farmlands, crops suffer. To prevent massive disruption to our food supply, scientists are trying to make plants stronger and amp up their climate change-fighting powers.

Resilient Rice

One significant development is the use of genetically modified rice in India. This special type of rice contains a genetic material called Sub1A, which allows the plants to survive underwater for up to two weeks, making them resistant to severe flooding. One farmer who adopted this genetically modified rice reported that they were able to save half of their crops after devastating floods.

Carbon Capturing Machines

Scientists are actively trying to boost this capability by optimizing photosynthesis, the process by which plants convert sunlight into energy.

Roughly **30 percent** of the carbon dioxide released by humans each year is absorbed by plants.

Plants have a natural safety valve that protects them from sun damage, venting sunlight as heat instead of absorbing it when the rays are too strong. In this mode, plants capture less carbon. To help leaves respond to the changing sun faster, scientists at the University of Illinois Urbana-Champaign increased the levels of three proteins that control these safety valves in tobacco plants. These altered genes made the plants grow 14 to 20 percent larger, allowing them to store more carbon in their tissues.

And that's not the only tweak scientists are looking to make. A team of University of Essex researchers extracted genes from different types of pond scum to enhance tobacco plants. They pulled genes from cyanobacteria to improve the conversion of CO_2 into sugars and borrowed genes from red algae to increase the amount of light captured. The tobacco plants ended up growing 27 percent larger and were better at handling water conditions.

Robust Roots

Carbon capture begins above ground for plants, but what's happening below the soil is just as important. When plants die, microbes in the soil consume the captured carbon and spew it and other greenhouse gases into the air. Deeper and denser roots can help retain carbon for longer periods.

Wolfgang Busch, a plant biologist at the Salk Institute in San Diego, California, has been collecting root photos and videos to find genes that can help plants grow deeper and bigger root systems. His team has identified 50 genes that can make this happen, including one that makes *A. thaliana* plants grow roots twice as deep.

Genetic modifications like these are exciting advancements that offer promise in a changing climate for farmers and society as a whole.

DISCUSSION QUESTIONS

What are some of the benefits and risks of producing and eating genetically modified food?

Brainstorm other ways farmers and scientists can make crops more resilient in the face of climate change.

VOCABULARY

GENETIC PHOTOSYNTHESIS
CARBON GREENHOUSE GASES

Discovery Roundup: **The Brain**

By Kylie Wolfe

Marathons and Myelin

When athletes run marathons, their bodies push through pain and pull energy from every part of the body, all to endure and succeed. A new study posted at bioRxiv.org suggests that runners may even be expending brain energy, using myelin—the tissue that insulates neurons—as another source of fuel.

Brain scans showed that runners have less myelin following a long-distance race than before one. But after two weeks, their supply of myelin recovers to about pre-race levels. This supports the concept of myelin plasticity, the idea that this protective layer can shift in size and quantity to meet the body's needs.

Feeling Faint

Fainting isn't always caused by an underlying medical issue. Sometimes the sight of blood or experiencing an extreme emotion can cause a person to faint. And there's no other meaning behind it—except that researchers can now offer a scientific explanation.

A study published in *Nature* revealed that a pathway connecting the heart's ventricles to an area of the brainstem helps the body and mind coordinate heart rate, blood pressure, and breathing. When that pathway was stimulated in mice, their heart rates dropped quickly, and they fainted. These findings increase our understanding of fainting and the potential for better treatments.

Eavesdropping Electrodes

When you listen to music, your brain decodes all of the lyrics, rhythms, and harmonies, and that interpretation results in distinct neural signals. A study published in *PLOS Biology* used electrode implants to record this type of brain activity in 29 people. Then, using a computer model, the team recreated sounds that were similar to a song participants had listened to.

Through this experiment, researchers were also able to determine what areas of the brain reacted to certain aspects of the music. These findings, and the ability to translate the brain's electrical signals into sound, could someday help improve communication devices for people with disabilities.

Astronaut Anatomy

Space travel is a dream come true for astronauts, but it also takes a toll on the human body. A recent study in *Scientific Reports* found that a trip to space causes the brain's ventricles to expand and collect additional fluid in response to lower gravity. And once the mission is complete, these structures don't recover quickly.

Researchers took MRI scans of 30 astronauts before and after their space missions and found that longer missions result in more swelling. Astronauts who had been to space within the last three years didn't experience much swelling because their ventricles hadn't returned to their original sizes yet, but those who hadn't been to space in three or more years came back with ventricles 10 to 25 percent larger. This suggests that astronauts may need to space out their space travel to help ensure their health and safety.

DISCUSSION QUESTIONS

What is myelin plasticity?

Why is it helpful for scientists to be able to decode brain activity?

How does blood pressure affect a person's heart rate and chance of fainting?

In what other ways might space travel affect the human body?

VOCABULARY

MYELIN ELECTRODE

BRAINSTEM VENTRICLES

The Other Space Race:

Moons of the Solar System

By Tom Wright

When you gaze into the night sky and look at the moon, do you ever wonder how that view would change if you were on a different planet? Mercury, for example, doesn't have any moons. Venus has such dense cloud cover that you wouldn't be able to see the sky. Even if you could see the sky, Venus doesn't have moons. But if you were on Mars, you would see two, Phobos and Deimos.

And what about the outer planets? Neptune has 14 moons and Uranus has 27. Until 2018, Jupiter was leading the charge at 95, but over the past few years Saturn passed Jupiter and is now credited with a whopping 146 moons. Just think, there's always a full moon and a new moon in the Saturnian sky.

Capturing the Moon

The latest batch of Saturn's moons was discovered using a technique called "shift and stack" in which multiple pictures of the moons are taken and layered on top of each other. This gives an enhanced image and allows objects that are barely detectable in a single picture to be amplified and enhanced, helping astronomers see smaller and smaller moons. This process takes over two years to complete because pictures must be taken over time to eliminate any objects that are simply passing by Saturn and not orbiting it.

This technique has been previously used on Neptune and Uranus, but a study from 2019 through 2021 was the first time it was used on Saturn. A team led by Dr. Edward Ashton initiated the project at the University of British Columbia and used the Canada-France-Hawaii Telescope (CFHT) mounted on top of Mauna Kea in Hawaii. Through the shift and stack process, this team was able to identify 63 moons—some as small as 1.5 miles in diameter.

Competing for the Lead

Saturn is the first planet to have more than 100 discovered moons. It should be noted that a similar study has not been performed on Jupiter yet, but it's only a matter of time before it's examined with the same techniques.

Will Jupiter jump back into the lead? Will Saturn retain its crown as the planet with the most moons? We won't know the answer to this question for years to come, but for the time being, Saturn is the reigning king of the solar system.

DISCUSSION QUESTIONS

How big does an object have to be to be considered a moon?

Why did researchers use the shift and stack method to study Saturn before Jupiter?

Can you think of other uses for the shift and stack method?

VOCABULARY

MOON

PLANET

TELESCOPE

Can Robots Tutor Birds?

By Iva Fedorka

Young birds, like other animals, learn best by imitating adults. To further understand the benefits of first-hand observation in birds, researchers used robots to study and train them.

The study involved recording high-speed videos of singing adult zebra finch males to analyze their head, beak, and throat movements. Using 3D scanning, 3D printing, and color-realistic painting, the researchers created a device called the RoboFinch that could mimic the movements and behavior of real finches. The findings of this study were published in *Methods in Ecology and Evolution* in April 2023.

The Experiment

Researchers divided young zebra finches into four groups, all of which heard song recordings through a nearby speaker. One group only heard the recording, while another group was accompanied by non-singing live female birds. The remaining two groups were exposed to the robot birds, with one group having the robot's movements synchronized with the singing and the other group seeing unsynchronized behavior.

The birds exposed to the robots showed a higher interest in them and the speaker, regardless of whether they actually learned the songs. Ralph Simon, a bioacoustics researcher at the Nuremberg Zoo in Germany and a member of the RoboFinch team, stated that the young birds immediately became interested in the robots and approached them within a few minutes of hearing the singing.

The chicks in the group with the synchronized robot sang less during the playback, indicating that they were listening to the recording. The birds paired with the non-singing females also sang less while hearing the songs.

During the first week of the study, the finch chicks exposed to the robot with synchronized beak movements spent 27 percent of their time near the robot, while those exposed to out-of-sync movements spent only 5 percent of their time nearby. The finches that only heard the recording, with or without female birds, spent less than 5 percent of their time near the speaker.

Can Robots Help?

The potential real-world applications of this research are significant.

These robots could help orphaned or endangered wild birds learn how to sing, as some young birds may not learn their species' characteristic calls without role models. The decline of bird species worldwide, as reported by *BirdLife International* in 2018, and the loss of nearly 3 billion North American birds since 1970, according to a 2019 study in *Science*, highlight the importance of finding innovative solutions to address this issue.

The paper includes information about open-source software and assembly instructions, with the hope that other researchers will use these tools to study various aspects of birdsong learning, such as audio-visual cues, multisensory cues during song development, signal detection, recognition, learning, and memory.

DISCUSSION QUESTIONS

What other animal behaviors could be studied using robots?

Are robots being used to study human behaviors?

VOCABULARY

ROLE MODEL MULTISENSORY

SPECIES SYNCHRONIZED

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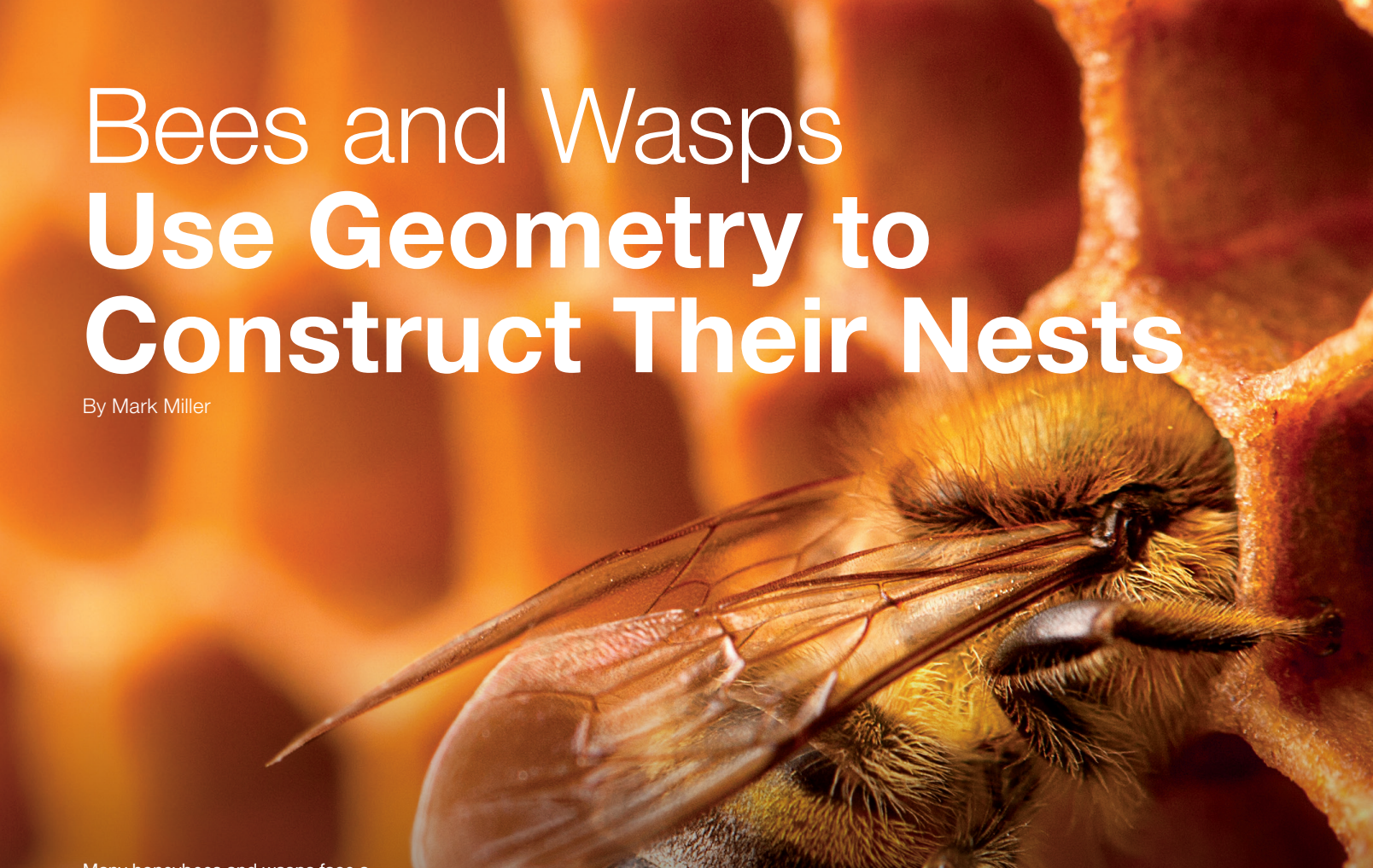
Bees and Wasps Use Geometry to Construct Their Nests

By Mark Miller



Many honeybees and wasps face a construction challenge. To build their nests, bees use wax and wasps use paper pulp to form hexagons, which provide a stable, space- and material-efficient design. But as their homes expand, they need to make hexagons of different sizes, and the differing, six-sided shapes don't connect efficiently. Recently, scientists discovered that the insects are using geometry to solve the problem.

Room to Grow

The kinds of bees and wasps that face this problem are social insects. This means that they cooperate in raising offspring that aren't their own, live in populations where generations coexist, and limit reproduction to only certain members of their colonies, according to the article "Common Social Bees and Wasps of Pennsylvania: Behavior, Lifecycle, and Management," published by Penn State Extension. During the growth of their nests, reproductive bees and wasps require spaces larger than those of existing worker cells—leading to a development dilemma.

"Think of someone tiling your bathroom floor," said Michael L. Smith, PhD, a biologist at Auburn University, in the *Science News Explores* article "Bees and wasps devised the same clever math trick to build nests." If you have to connect smaller hexagons with larger ones, there will eventually be "some kind of an issue when you try to [merge] them together." For these insects, merging the different sizes could waste resources that they work hard to obtain. Bees must consume honey to produce wax and wasps need to gather pieces of wood and water to manufacture building materials.

Odd-Sided Solution

Smith and a team of researchers determined that geometry holds the architectural answer. The scientists used automated image technology to analyze 115 nests and measured the length of the cell walls and the number of neighboring cells. The analysis also included cells that were not perfect hexagons—something scientists had previously ignored but turned out to be the key to joining the different-sized cells.

The bees and wasps used five-sided pentagons and seven-sided heptagons to link the differing hexagons. When a pentagon is connected to a heptagon, the same number of outer sides results as when pairing two hexagons—ten.

Model Approach

Nils Napp, PhD, a computer scientist at Cornell University, used a mathematical model to demonstrate that simply adding larger hexagons to smaller ones would create wasteful gaps or the need to build unusable spaces. Based on the model, incorporating pentagons and heptagons would be an optimal response. "What the bees and wasps are doing is close to the best possible geometric solution," he said in *Science News Explores*.

DISCUSSION QUESTIONS

What are some of the advantages of using hexagons to build something?

What is a mathematical model and how can it be used?

Using a hand-made or computer drawing, show how hexagons of different sizes can be linked together without wasting space.

VOCABULARY

GEOMETRY CELL

INSECT COLONY

Hydrogels Make Headway: Pulling Water Out of Thin Air

By Kelley Northam

Clean water is as essential as it is precious to our health, hygiene, and habitat. However, over two billion people live in areas with inadequate water supplies. And, with climate change contributing, half of the global population could face water scarcity issues as early as 2025.

Two of the easiest ways to combat the water crisis are turning off the faucet while brushing your teeth and only running the dishwasher when it's full. After all, you can't pull water out of thin air.

Or can you?

Massachusetts Institute of Technology (MIT) mechanical engineer Carlos Díaz-Marín and his team have shown that you can actually get water out of thin air with the help of hydrogels.

A Salty Solution

Hydrogels can absorb and house water and are made of meshed polymers—smaller units chemically bonded together to form larger molecules. While hydrogels are not new, Díaz-Marín and his team expanded hydrogel research by publishing their findings on hygroscopic hydrogel absorbency in the journal *Advanced Materials*.

The team began their experiment by creating a hydrogel tube made from polyacrylamide, a polymer comprised of long, threadlike materials. Then, they sliced the tubes into thin disks and submerged them in containers of water, each with different lithium chloride salt concentrations. Lithium chloride was chosen because it can absorb more than ten times its mass in moisture.

While similar tests had only soaked hydrogels for a few days, researchers soaked these hydrogels for 30 days and found that the hydrogels absorbed and retained 24 grams of salt per gram of polymer—four times more than past studies. This salt uptick also allowed the hydrogels to pull more water from the air than previous experiments.

The researchers continued the experiment by using the salty hydrogels to absorb moisture from the air at various levels of humidity. They discovered that the hydrogels performed this task without leaking at 30, 50, and 70 percent relative humidity. This is particularly significant given that 30 percent relative humidity is lower than typical nighttime desert humidity levels.

A Pool of Possibilities

These results point to new hydrogel applications and innovative ways to combat the water crisis. Díaz-Marín and his team are now developing a hydrogel-powered device capable of harvesting vapors to generate drinking water, even in deserts and drought-prone areas. This device could extract two to five liters of water per day, supplying an average person's daily water intake.

While we can all do our part by consciously conserving water, researchers like Díaz-Marín are finding new ways to conserve and create water to help turn the tide and save lives worldwide.

DISCUSSION QUESTIONS

What form was the water in before the hydrogel absorbed it?

What form was the water in after the hydrogel absorbed it?

What are some ways that you can conserve water?

VOCABULARY

POLYMER MOLECULE

HYDROGEL HUMIDITY

Mighty Melanin:
How a Synthetic Version Could Repair Skin

By Kelley Northam

While many of us enjoy soaking up some sunshine, many of us have also experienced sunshine's painful aftermath—sunburn. Sunburn can take the fun out of a beach trip and cause long-term damage, such as premature aging and skin cancer. In fact, the risk of developing malignant melanoma, one of the deadliest forms of skin cancer, doubles if you experience five or more sunburns.

Although naturally occurring melanin, the pigment that gives color to our skin, eyes, and hair, defends against some sun damage, medical professionals have been searching for new therapies to mitigate the harmful health effects of exposure.

A Burning Question

Researchers at Northwestern University, Kurt Lu, MD, and Nathan Gianneschi, PhD, have discovered one way to do just that, taking inspiration from the body's first line of defense against ultraviolet (UV) light—melanin.

Finding Sunburn's Silver Lining

Lu and Gianneschi have been studying melanin for nearly ten years and recently published an article in the journal *npj Regenerative Medicine* about how synthetic melanin can promote skin tissue repair.

They began their experiment by creating a topical cream containing synthetic melanin, similar to the body's natural melanin. Then, they used a chemical to blister human skin tissue samples. This reaction inflamed and separated the upper layers of skin, releasing free radicals, which are the unstable molecules responsible for damaging cells and causing skin aging and cancer. A few hours later, they applied the cream to the blistered tissue samples.

Within the first few days, the cream triggered an immune response that helped the skin's own free radical-fighting enzymes recover. The cream also stopped the creation of inflammatory proteins, starting a chain of healing responses, including preserving the healthy skin layers underneath the wound. In the control samples without the cream, the blistering continued.

While Lu and Gianneschi continue to determine the best formulation of the synthetic melanin cream, their results strongly point to synthetic melanin preventing and healing skin damage.

New Applications on the Horizon

In addition to sun and environmental skin damage, synthetic melanin cream shows promise as a soothing, therapeutic treatment for burn patients and cancer patients undergoing radiation therapy.

Lu and Gianneschi are also participating in research programs funded by the U.S. Department of Defense and the National Institutes of Health to study melanin's potential as fabric dye that could absorb poisonous toxins like nerve gas to better protect those in the military.

This ongoing research to uncover the applications of synthetic melanin could someday help everyone safely enjoy more days in the sun.

DISCUSSION QUESTIONS

What type of light does the sun produce?

Why would scientists test both an experimental group of samples with the cream and a control group of samples without the cream?

VOCABULARY

MELANIN MELANOMA CANCER

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