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Signs That Spring Has Sprung

By Christina P. Hooton

As winter's gray days and snow begin to give way to warmer temperatures and sunlight, spring has a way of slowly but surely announcing its presence in nature. From blossoming trees to busy bees, here are some signs of spring's arrival.

Bountiful Blossoms and Buds

Flowers of all shapes, sizes, and colors start popping up in spring. Some flowers, such as pearly white snowdrops and violet-hued crocuses, can start appearing early in the season when snow is still on the ground, while others, like plump peonies and star-shaped clematis, make their debut as late as May or June.

Although these flowers only last for a short period, they play an essential role in plant reproduction. Flowers attract pollinators like bees and other insects, which carry pollen that fertilizes the plant and helps it produce seeds. Animals or the wind then spread the seeds, so the plant continues to grow.

Spring flowers also like to show off on the branches of trees and bushes, like redbuds, magnolias, forsythia, and rhododendrons. Animals rely on blossoming trees for food and shelter. Some flowers eventually turn into fruit that falls to the ground for a variety of hungry animals and insects.

Busy Bees, Birds, and Babies

The beginning of spring is marked by a flurry of activity from animals and insects. Butterflies, like monarchs, return from their migration or emerge from hibernation and, along with bees and other insects, complete the critical task of pollinating flowers.

Many birds, such as swallows and nightingales, fly north after spending time as far away as South America, while others become more active after staying warm in their nests all winter. You'll hear them singing in the early morning, and it's no surprise as spring is an exciting time for them. This is when they find a mate, lay their eggs, and welcome chicks into the world.

Birds are not the only ones in baby mode. The mild weather and readily available food and resources during spring make it an ideal time for most animals to have babies, from rabbits and bears to toads and skunks.

Longer, Warmer Days

In the Northern Hemisphere, days start getting longer after the winter solstice in January and continue this way until the summer solstice in June. The light gained is much more noticeable in the springtime, though, because of daylight saving time, when we turn our clocks ahead by one hour.

The first official day of spring happens on the March, or vernal, equinox every year. This is when the Sun moves from south to north across the Earth's equator. On this day, there is nearly an equal amount of daylight and darkness. After this point, countries in the Northern Hemisphere tilt closer to the sun, and temperatures start getting warmer.

With its added daylight and burst of activity, spring is a great time to observe and discover the wonders of nature all around us.



DISCUSSION QUESTIONS

Track the progress of spring right in your backyard. Take note of the flowers and plants growing, animals and insects becoming more active, and daylight increasing.

Why do certain birds and insects fly south for the winter and return to northern habitats in the spring?

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Consider an Allied Health Career in Biomanufacturing

By Gina Wynn



The Commonwealth of Massachusetts alone is planning to add at least 20,000 life sciences jobs by the end of 2024—a 23 percent increase from 2020

If you are passionate about science but don't have the time or financial resources to commit to years of university study, a career in biomanufacturing may be right for you. With the amount of science knowledge you can obtain at a community college, you can embark on a career in a growing market sector that offers competitive pay, job security, and an opportunity to contribute to society.

What Is Biomanufacturing?

Biomanufacturing technology uses nature-based tools and materials—microorganisms, enzymes, and the fermentation process—to develop new products or improve upon existing ones. Biomanufacturing methods are used to produce biofuels, biopharmaceuticals, chemicals, human tissues, industrial enzymes, replacement organs, and vaccines, among other products. Because biomanufacturing works using natural processes, it typically requires less energy than the traditional synthetic processes that are often used to produce everyday items like plastics, soaps, textiles, and preservatives in food.

Appreciation for the value of biotechnology has been on the rise since the COVID-19 pandemic sparked a race for vaccine development. Advancements in cell and gene therapy—like the development of new treatments for genetic vision loss and some cancers—have also ignited interest in the possible biotechnological breakthroughs of the future.

A Booming Bioeconomy

Despite the economic uncertainty left in the wake of the pandemic, the biomanufacturing sector of the life sciences industry is thriving.

Companies are struggling to hire enough biotechnicians to adequately staff their production facilities. The Commonwealth of Massachusetts alone is planning to add at least 20,000 life sciences jobs by the end of 2024—a 23 percent increase from 2020—according to a 2021 report from Massachusetts Biotechnology Education Foundation (MassBioEd).

Companies like Ginkgo Bioworks in Boston expect to hire dozens of people over the next few years to run fermentation tanks, operate cell-growing machinery, and sequence DNA, according to the *Chemical & Engineering News* article “Help wanted in biomanufacturing” by Matt Blois.

In California, Maryland, North Carolina, and other states, private companies, industry groups, and educational institutions are funding short-term 10- to 12-week training programs to help swiftly prepare new talent to join the biomanufacturing workforce. And many companies formalize on-the-job learning in apprenticeship programs.

Long-Term Earning Potential

Depending on where you live, the amount of training you receive, and your experience, the average entry-level biopharma manufacturing salary ranges from \$45,000 to \$60,000 per year, according to the North Carolina Biotechnology Center article “Top 5 Reasons to Pivot Into a Biomanufacturing Career” by Mindy Hamlin. She also reported that the average North Carolina biopharma manufacturing salary is \$97,575, which is more than twice the state's average private-sector salary.

Benefits to the Planet

A biomanufacturing career not only offers competitive pay and an opportunity to be part of an expanding industry, it may also provide lifelong fulfillment. Biotechnology production methods can help the environment by reducing energy use, and products created through biotechnology are easier to dispose of and safer to recycle, according to the Advanced Technology Services article “Biomanufacturing: How Biology is Driving Manufacturing into the Future.” Advancements in biomanufacturing are also enabling medical innovations and treatments that could positively impact public health on a global scale.

To learn more about how you can benefit from a career in biomanufacturing, speak with a school or career counselor, visit community college websites, and browse internet resources that highlight programs being offered nationwide.

DISCUSSION QUESTIONS

Name some products you might find in your home that are created using biotechnology.

Why might products created using biotechnology be better for the environment?

VOCABULARY

APPRENTICESHIP BIOTECHNOLOGY

ENZYME FERMENTATION

SYNTHETIC

The Study of **Inflammation** and How It Relates to Chronic Diseases

Content
provided by:



In recent years, inflammation has become a focus of intense research in many medical and scientific fields. Roni Nowarski, assistant professor of neurology and immunology at Brigham and Women's Hospital in Boston, Massachusetts, explains that inflammation is "important across a range of seemingly distinct pathologies because immune cells are everywhere, even resident in organs, where they play an important role in monitoring and maintaining health."

The idea that inflammation—constant, low-level, immune-system activation—could be at the root of chronic diseases such as cancer, arthritis, asthma, diabetes, and even depression is a bold claim. Until relatively recently, this claim was met with skepticism in labs and lecture halls. Can unconnected illnesses of different organs and body parts really share a biological link? Researchers in molecular biology have been compiling evidence that many chronic conditions are triggered by the immune system's inflammatory response.

Gökhan S. Hotamisligil, Simmons professor of genetics and metabolism at the Harvard T.H. Chan School of Public Health, has constructed his research for the past 25 years on the premise that a person who has one chronic metabolic disease is more likely to develop others. "This is exactly the same cluster that emerges during aging," he says.

Debates Over Causality

Back in 1993, Hotamisligil teamed up with Bruce Spiegelman, Korsmeyer professor of cell biology and medicine, to identify the link between obesity and inflammation. The research duo discovered that fat cells produce an inflammatory signal that interferes with

the body's ability to regulate blood sugar. In addition to leading to obesity, this increases the risk of developing Type 2 diabetes.

Epidemiological studies have helped highlight the importance of lifestyle choices in controlling inflammation. In 2018, Samia Mora, a cardiovascular specialist and associate professor at Harvard Medical School, published a study of the Mediterranean diet and its positive impact on reducing inflammation and the chances of developing chronic diseases.

Critics argue that inflammation is a symptom in these diseases, rather than a root cause. But Hotamisligil disagrees. "Chronic inflammation is uniformly damaging and is absolutely causal to the process, because if you interfere with it, you can reverse the pathology," he argues. This ability to ward off diseases simply by reversing inflammation is a biological response dating back to the time of a common ancestor and retained across diverse species of animals. Hotamisligil points to experimental evidence: "If you can make *Drosophila* [fruit fly] diabetic, and then block the inflammatory response systems, you can cure diabetes in *Drosophila*, the same way you can reverse it in the mouse, in primates, and in humans, provided that you do it with the right tools."

Necessary Lab Tools

Among the most important pieces of lab equipment needed for this type of research is a high-speed centrifuge. The Frontier™ 5000 Series Micro from OHAUS is an excellent choice as it can accommodate



multiple rotor options and is available with or without refrigeration.

Designed for ease of operation, Frontier Micro centrifuges feature a uniquely designed splash-proof front panel with touchwheel control. An intuitive interface and easy-to-read, backlit LCD display allows for responsive operation—even when wearing gloves. Available biocontainment rotors enable research involving hazardous samples. The compact design saves valuable bench space in the lab.

Dependable benchtop micro centrifuges from OHAUS are ideal for high-speed molecular biology lab applications, such as DNA/RNA preparation, ultrafiltration, and more.

Sources

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Multiple authors. "Inflammation and Cancer," National Library of Medicine, National Center for Biotechnology Information, September 2019. [ncbi.nlm.nih.gov/pubmed/31704802](https://pubmed.ncbi.nlm.nih.gov/31704802/)



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One Telescope at a Time

By Tom Wright

Just when you thought the James Webb Space Telescope (JWST) was the greatest thing in space, NASA unveiled plans for a new telescope designed to locate and identify habitable planets in our galaxy.

That's right, astronomers are looking for planets where life already exists or could exist in the future.

In early January, members of the American Astronomical Society lined up to listen to Mark Clampin, director of the astrophysics division of NASA, discuss plans for the Habitable Worlds Observatory (HWO). This telescope

is still a long way from completion, but the ramifications of it are far reaching and delve into science fiction—making it possible to look for aliens and find planets for humans to potentially colonize.

Exploring Aliens and Other Worlds

The team working on this project identified over 5,000 astronomical objects called exoplanets, or planets that orbit around stars other than our own. Though the properties needed for life are often debated, most agree that there are at least four requirements. The planet must be:

- Rocky and not gaseous like Jupiter or Saturn
- Near a stable star that provides somewhat consistent light
- Cool enough to support liquid water
- Warm enough that the water isn't all frozen

The ability to host liquid water is mostly dependent on temperature, but there are a variety of other factors that must be met. Ultimately, water is the catalyst for life as we know it.

Of the 5,000 exoplanets identified, approximately 300 have the characteristics needed for life. Of those 300, only 25 are nearby (less than 100 light-years away). And these are the best candidates for colonization.

Launching the Habitable Worlds Observatory

The HWO is expected to launch in the 2040s—as early as seventeen years from now. Unlike the JWST, the HWO will be robotically serviceable. The JWST cannot be upgraded, serviced, or even refueled, but the HWO should have the capacity for all three, including upgrades to instrumentation as technology advances, giving it a much longer lifespan.

The HWO will be smaller than the JWST and can be housed in the nose cone of a conventional rocket. Unlike the JWST, it will not have to be unfolded when it is deployed. This lowers its chance of being damaged during deployment and will create tighter tolerances for the telescope's mirrors, allowing it to see into the ultraviolet spectrum and get a better glimpse of near-Earth exoplanets.

The HWO is still in its early stages and there are many hurdles to overcome. But once photos of the identified near-Earth exoplanets are available, astronomers might be able to answer this age-old question: Are we alone in the universe?

DISCUSSION QUESTIONS

Think about the requirements needed for life on Earth or another planet. What else do you consider a necessity to sustain life?

How will the Habitable Worlds Observatory improve our understanding of the universe?

VOCABULARY

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Paving the Way

The Secret to Ancient Roman Concrete

By Gina Wynn

If you've been to or even read about Europe, you're probably aware of the ancient Roman amphitheaters, temples, and other structures that have become popular tourist destinations. It's easy to view them as just typical historical sites, but the fact that the structures are still standing after over 2,000 years is quite remarkable.

A group of Massachusetts Institute of Technology (MIT) researchers led by chemist Admir Masic set out to learn what makes the structures so resilient. They discovered an ingredient in the concrete building material that may have given it a self-healing capability.

After investigating samples from a 2,000-year-old city wall at a site near Rome in Privernum, they concluded that calcium oxide, also called quicklime, has been boosting the longevity of the concrete. The results of their study were published in *Science Advances*.

Long-Lasting Lumps

In the lab, the group focused on tiny calcium deposits in the concrete. Although some scientists believed they were the result of poor mixing techniques, Masic and his team thought they could have been caused by quicklime in the dry concrete mixture.

Mixing quicklime with water initiates an exothermic chemical reaction. The heat produced would have stopped the lime from fully dissolving, creating lime lumps or "clasts" in the hardened concrete. When the researchers recreated the process using quicklime, the resulting material matched their samples from Privernum, lumps and all.

When the group filled the cracks in the concrete with water, the quicklime lumps dissolved and recrystallized, repairing fractures as wide as 0.6 millimeters. This self-healing characteristic may be behind the longevity of the structures that have been standing strong for nearly two millennia.

Learning from History

The Romans likely made the transformative quicklime by heating limestone to produce the white calcium oxide powder. Then they combined it with other ingredients to create their indispensable material.

"The new results show that at the basis of ancient Roman concrete's self-healing and longevity could be the way Romans mixed their raw ingredients, specifically how they used lime, the key component of the mix besides volcanic ash," said Masic, according to the *Reuters* article "Scientists chip away at how ancient Roman concrete stood test of time" by Will Dunham.

Although the Romans didn't invent concrete, they used it regularly in construction by 200 B.C.E. The material they called *opus caementicium* is more durable and practical than the concrete in use today. Modern concrete structures can begin to deteriorate within decades of being built.

A New Foundation

The MIT findings may lay the foundation for developing new types of self-healing concrete that can withstand the elements and time and reduce the need for costly repairs. And since cement production accounts for eight percent of the world's CO₂ emissions, reducing the amount of concrete we use on sealing cracks and rebuilding walls would also be good for the planet.

DISCUSSION QUESTIONS

Name some modern structures that are made from concrete.

How can reducing the amount of concrete we use help the environment?

VOCABULARY

CONCRETE DETERIORATE DISSOLVE

EXOTHERMIC LONGEVITY



Saying Goodbye to the Monarch Butterfly?

By Mark Miller

The black and orange markings of the monarch butterfly's wings make it one of nature's truly beautiful sights. But it's an amazing insect for other reasons, too. As part of its migration to Mexico from the northern United States and southern Canada, the delicate butterflies can cover distances of nearly 3,000 miles.

Now, according to a story published by the World Wildlife Fund (WWF), these extraordinary creatures may be disappearing. They have been classified as "Endangered" by the International Union for Conservation of Nature (IUCN).

The Red List

The IUCN classifies species at risk of becoming extinct on its Red List, a comprehensive source about animals, fungi, and plant species, including information about population, range, habitat, and other criteria.

Based on WWF monitoring, the population of eastern migratory monarch butterflies has decreased over 80 percent. Reasons for this decline, according to the WWF, include the use of herbicides in the U.S. When monarch butterflies travel north in the spring, they lay their eggs only on milkweed plants, which become the food source for the beginning of their lives as caterpillars. Herbicides are causing a loss of milkweed and threatening the monarchs' reproduction and survival. Another reason may be climate variations in North America that affect milkweed.

According to information from the Center for Biological Diversity, the monarchs' decline, along with that of other insects, may negatively impact humans. The falling populations can influence food resources that rely on the activities of pollinators such as bees and butterflies.

"Cataloging the migratory monarch butterfly of North America to the IUCN Red List could be an opportunity for the species"

A Living Symbol

Monarchs spend their winters in Mexico. They gather by the millions in the oyamel trees of the Monarch Butterfly Biosphere Reserve there. The WWF reports that they've become important symbols to local people, who believe the butterflies are the souls of ancestors that have passed away. Relatedly, the monarch's arrival in early November coincides with Mexico's Day of the Dead—a celebration of lost loved ones whose spirits are thought to return each year to visit their living families.

Back from the Brink

Like the souls of past ancestors, the monarch populations may also make a remarkable comeback. The WWF's monarch butterfly expert, Eduardo Rendon-Salinas, seems to think so. "Cataloging the migratory monarch butterfly of North America to the IUCN Red List could be an opportunity for the species," he says. "The governments of Canada, the U.S., and Mexico have the scientific basis to collaborate with conservation organizations, the private sector, and civil society in all the initiatives that seek to restore, conserve, and sustainably manage the ecosystems for the reproduction, migration, and overwintering of this emblematic species."

DISCUSSION QUESTIONS

- What is animal migration?
- What is the life cycle of butterflies?
- What effects can herbicides have on plant life?

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Gene Sequencing

A Brief History

By Iva Fedorka

Gene sequencing isn't new, and it's undergone many changes during the past 50 years. After the structure of DNA was determined in the 1950s, many attempts were made to determine its sequence, or the order of its nitrogenous bases.

Robert Holley, an American biochemist, sequenced the first tRNA in 1965, for which he was awarded the Nobel Prize in 1986. By 1972, DNA was sequenced using enzymes to break RNA into smaller sections, isolate these oligonucleotides, and separate them using electrophoresis and chromatography.

The First Generation

In the 1970s, Fredrick Sanger and his collaborators at the Medical Research Council Laboratory of Molecular Biology in Cambridge, United Kingdom, were working on an alternative DNA sequencing method. The "chain termination method," developed in 1977, uses radiolabeled and partially digested oligonucleotides to analyze pieces of the molecule. Later known as the Sanger method, it was widely used throughout the 2000s and earned Sanger a Nobel Prize in 1980.

Although other sequencing methods were also developed around the same time, they were all technically complex, time consuming, and tedious. The four DNA bases (A, C, G, and T) had to be identified by examining an autoradiogram and recording the data manually. The electrophoresis alone took about 12 hours to complete, and an equal amount of time was spent on radiography processing. Many more hours were required to read and record the sequences.

The Second Generation

The key to the next phase was automating and miniaturizing the assays to be able to perform multiple reactions at once. In 1987, scientists at Applied Biosystems* automated the Sanger sequencing process. DNA fragments were labeled with fluorescent dyes and data was collected and analyzed on a computer.

Additional sequencing techniques were developed from 1996 through 2005. Some

of these used the luminescence generated by pyrophosphate synthesis during sequencing, measured the hydrogen ions released during synthesis, or incorporated fluorescent dyes to detect successful synthesis.

The Third Generation

Single molecule real-time (SMRT) sequencing technologies (Pacific Biosciences, 2010) are considered by many to be the third generation of DNA sequencing. This type of sequencing uses zero-mode waveguides (ZMW), or "nanoholes," that contain a single DNA polymerase enzyme to incorporate a single nucleotide. Each nucleotide is labeled with a different fluorescent dye; signals emitted in the process are detected and recorded.

What's Next?

Many novel and personalized medical treatments are now based on genetic sequencing. As the technology continues to evolve, costs will likely decrease further, making earlier disease detection and treatment more accessible to all.

The Human Genome Project (HGP) completely mapped the first human reference genome in 2003. Using the Sanger method, it took 13 years and several billion dollars to complete. Using 2022 sequencing techniques, the project would have taken less than two weeks and cost around \$600.

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DISCUSSION QUESTIONS

What are Nobel Prizes and to whom are they awarded?

What are the DNA bases and what function do they serve in the structure of DNA?

VOCABULARY

ENZYME ELECTROPHORESIS

CHROMATOGRAPHY

The Environmental Contributions of the Civilian Conservation Corps

By Iva Fedorka



CCC Camp Photos

Above: William Koban
Photos supplied by Celeste Beley

On April 5, 1933, newly elected President Franklin D. Roosevelt signed an executive order that allocated \$10 million for emergency conservation work, launching the Civilian Conservation Corps (CCC). By midyear, 250,000 men had signed up.

The Need for Employment

In the United States, stock market prices fell precipitously on October 24, 1929. Despite government efforts to counteract the effects of this economic event, it triggered a ten-year period known as the Great Depression. By 1933, 24.9 percent of the national work force of 12,830,000 people were unemployed.

The CCC initially provided jobs for six months to unmarried and unemployed men between the ages of 18 and 25. The men worked in CCC camps, which were located on U.S. Army bases, in national parks, and in state parks and forests. The Army provided shelter, clothing, food, medical supplies, and equipment to the camps, while foresters, carpenters, and other government employees directed the work.

From 1933 to 1942, close to three million workers and their families received support from this national work relief program. The CCC itself had another 250,000 salaried employees, including teachers who taught 57,000 of the enrollees to read and write.

One Man's Story

William Koban (1923–2006), the grandfather of Thermo Fisher Scientific colleague Celeste Beley, joined the CCC around 1940. Koban was assigned to Haineyville Camp S-82-PA in Clinton County, Pennsylvania, approximately 215 miles from his home in Aliquippa, PA.

The work at Haineyville Camp was supervised by what is now the Pennsylvania Department of Conservation and Natural Resources. Koban worked in reforestation, planting trees, fighting fires, and building fire towers and fire trails.

Like other enrollees, Koban was given a uniform, fed regularly, and paid one dollar a day. Most of his earnings were sent to his family, a condition of enrollment. Since his brother John had also joined the CCC around the same time, their wages were critical for their parents and four other siblings, especially since their father only worked 26 weeks during 1939.

Koban recalled his CCC experience and fellow enrollees fondly, often telling stories about their activities, antics, and comradery. When the U.S. entered World War II, Koban joined the Army and served from 1943 to 1945. During that time, he was captured by the Germans and was held for 19 months in Stalag 2B, a prisoner of war (POW) camp. He

also received the Purple Heart.

Accomplishments

CCC members planted 3 billion trees to revitalize U.S. national forests and reduce the risk of dust storms. They established and landscaped 711 state parks and built lodges and hiking trails in national parks, historic battlefields, and other monument areas.

The value of the work performed nationwide by the CCC totals an estimated \$8 billion. Although the CCC ended in 1942 with the onset of U.S. involvement in World War II, its contributions to and support of our environment and natural resources are still evident today.

DISCUSSION QUESTIONS

What is reforestation and why is it important?

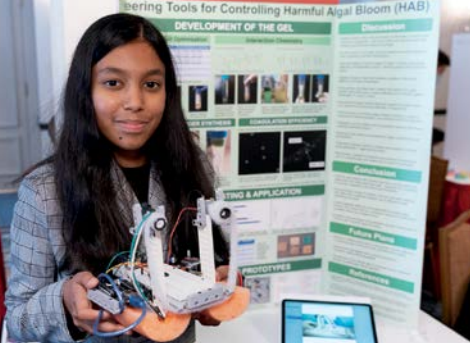
What organizations currently perform similar functions to the CCC?

What is a Purple Heart?

VOCABULARY

CIVILIAN CONSERVATION

CORPS



+ You Could Compete in the Next Thermo Fisher Scientific Junior Innovators Challenge



By Kylie Wolfe

Today's students are tomorrow's STEM leaders. That's why, through programs like the Thermo Fisher Scientific Junior Innovators Challenge, we're committed to providing opportunities that excite students about careers in STEM. Want to learn more? Keep reading.

What Is the Junior Innovators Challenge?

Thermo Fisher Scientific and Society for Science have partnered to bring you the Junior Innovators Challenge (JIC), the nation's premier middle school science, technology, engineering, and math (STEM) competition.

Those selected will travel to the national competition to showcase their projects, compete in teams, visit historical sites and organizations, and more. Over \$100,000 in awards are available, including a top prize of \$25,000.

How Can I Get Involved?

When you participate in a Society for Science-affiliated science fair, you've already taken the first step. Those who place in the top 10 percent at their local, state, or regional affiliated

fair become nominees, and those nominees are invited to apply for the Thermo Fisher JIC. If you were nominated, visit thermofisherjic.smapply.org to access this year's application page.

If your school or local fair is not affiliated with Society for Science and you're interested in participating, visit findafair.societyforscience.org to find a fair nearby. Most fairs take place between January and April.

And if you weren't nominated this year or didn't have the opportunity to participate in an affiliated fair, ask your teacher how you can get involved. Start brainstorming your science project now because we'd love to see you next year.

Who Can Enter?

Sixth, seventh, and eighth grade students are eligible for this competition, but they must first compete at their local affiliated science fair, become a nominee, and send in an application. All applications are reviewed by Society for Science. In September, the top 300 Junior Innovators and 30 finalists are announced. Students who place in the top 30 will be notified by Society for Science and are invited to attend the national competition.

Where Is the Competition?

The 2023 Thermo Fisher JIC will take place in Washington, D.C., in the fall. More details to come.

Why Should I Apply?

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- All **Finalists** receive \$500, an all-expense-paid trip to Washington, D.C., for themselves and a parent/guardian, and the opportunity to win more awards, including a \$25,000 grand prize.

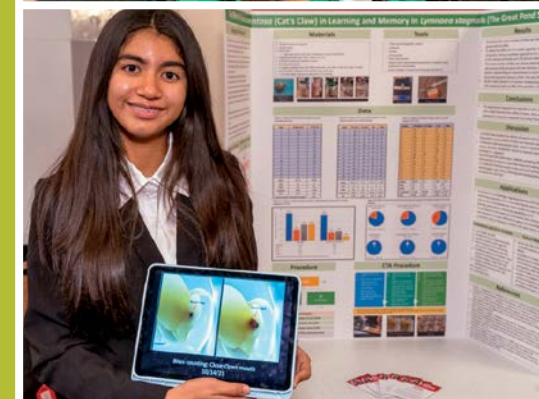
Visit societyforscience.org/jic to learn more.

Calling All Teachers

Is Your School's Science Fair Affiliated with Society for Science?

This year's science fairs are well underway and if yours is affiliated with Society for Science, we ask that you encourage eligible students to submit their applications for a chance to compete at the national level.

But if your school's science fair is not yet affiliated, you can take that step in August. Visit societyforscience.org/jic to learn more about affiliating your fair.



+ Meet Jason Wu

Senior Manager, Finance at Thermo Fisher Scientific
Former Participant in a Society for Science-Hosted Fair

Q: Let's start with an easy one—what do you love about science?

A: "Through science, you can learn so much about what goes on in the world. Like, why do blue whales, the biggest animals in the world, eat tiny little creatures like krill? It's those little facts that I always found interesting. Even now, I have a five-and-a-half-year-old who's always very curious about the world, always asking questions. And I feel like science is a great way to provide answers."

Q: Can you tell me a little bit about your science fair experience?

A: "I won the school science fair and then the state science fair and then had the opportunity to attend an international fair. It was a great experience because I could talk to my fellow contestants about their projects, how they set up their experiments, and the questions they were trying to answer."

Q: What was your project about?

A: "I decided to test the fish from my local supermarket, like getting pieces of salmon, pieces of cod, tuna, to really see the amount of mercury that's in some food products. Back then, I didn't have connections to a lab to test that out, so I cold called a couple of different labs in the region and one of them was nice enough to invite me in to use their mass spectrometry equipment."

Q: Did you gain new skills?

A: "Definitely learning to interact with different people and asking questions. I also learned how to observe and record results, analyze the data, write up conclusions, and be a good presenter. I feel like those skills are truly valuable for college, for your career, really anything in life."

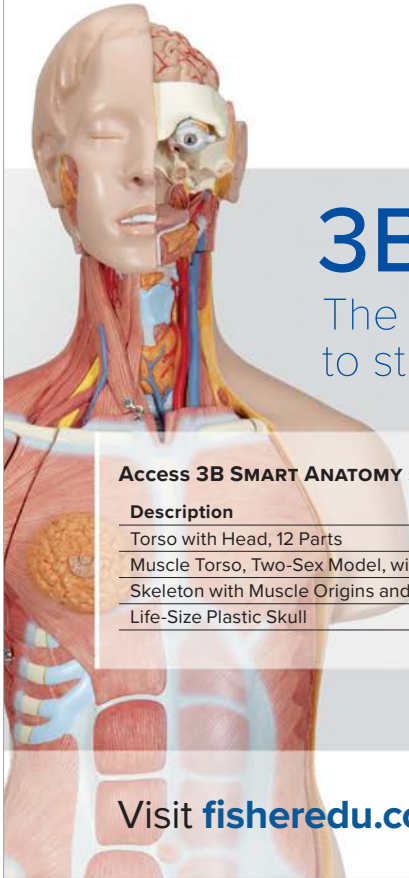
Q: Do you have any advice for this year's science fair participants?

A: "Keep moving forward, keep pushing your project, keep thinking of ways to attack it from different angles. Pretend to be a judge and think critically about your project to see how you can improve and make it better. You'll be surprised at what you might come up with—and if you do well, you might bring home some great prizes."

Q: How did your science fair experience impact your life?

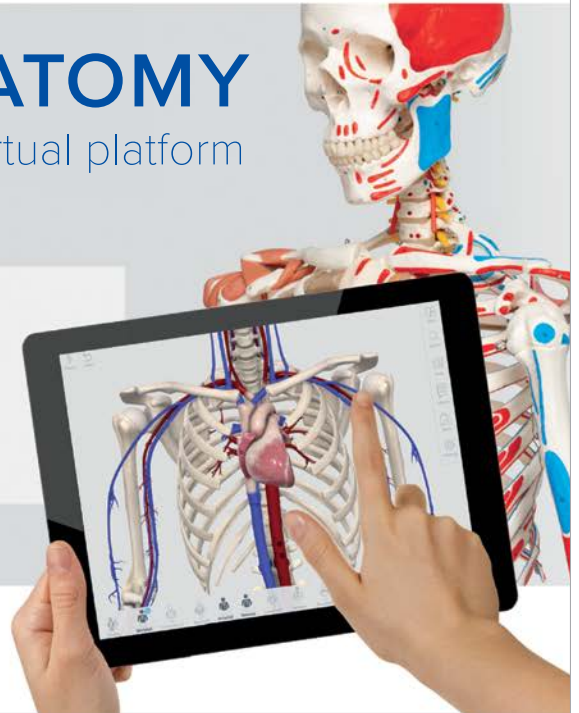
A: "I'm going to be thinking about [science fairs] as my daughter gets older because I want her to build the skills that come with being a scientist. Being able to observe and ask questions. It was a wonderful experience for me. And I'll look out for [competitions like this] in the future for her, too."





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How Snot Bubbles Help Echidnas Survive the Heat

By Gina Wynn

Snot is unpleasant. It makes us think of runny nosed toddlers and cold sufferers in need of a tissue. But for the Australian echidna, snot is a life saver.

In temperatures of 95° Fahrenheit or higher, short-beaked echidnas (*Tachyglossus aculeatus*) shouldn't be able to survive. However, new research has shown that they are able to keep cool enough to withstand the extreme temperatures of the deserts and tropical rainforests in Australia and New Guinea by blowing snot bubbles.

When the bubbles pop, they keep the spiny mammals' nasal passages moist, according to Christine Elizabeth Cooper and Philip Carew Withers of Curtin University and the University of Western Australia in Perth, Australia, who conducted the research. As the mucus evaporates in the echidna's beak, it draws heat away from the critter's blood flowing through its sinus cavity to help cool the animal. The details of the study were published in *Biology Letters*.

Watched in the Wild

Using infrared thermography, Cooper and Withers videotaped echidnas in Western Australian nature reserves once a month for a year. The videos revealed bright orange

and yellow areas of the creatures' bodies where they were the warmest. The tips of the echidnas' platypus-like noses appeared as dark purple splotches, however, indicating that they were comfortably cool.

The echidnas' spines were also purple, illustrating their insulating properties. In addition, the insides of their legs and bellies seemed to be poorly insulated, according to the report, enabling the hedgehog-like animals to shed more heat. All these avenues for heat evaporation could help regulate echidna body temperatures, which likely contributes to their higher-than-expected tolerance to hot weather.

Spiky Survivors

The research helps explain why echidnas continue to thrive in land habitats across the Australian continent, which is not the case for all its mammals. Echidnas also possess other traits not common to most mammals. They are monotremes, which means that they lay leathery eggs for reproduction instead of giving birth to live young.

Echidnas went down their own evolutionary path between 250 and 160 million years ago

when the ancient Pangaea supercontinent was splitting apart. The species in Australia, New Guinea, and Tasmania—considered to be primitive types of mammals—were then geographically isolated from their more-advanced mammal competitors on other land masses, enabling them to evolve differently.

Beating the Heat

“By learning how echidnas regulate heat, we may be able to gain a better understanding of how thermal regulation might have evolved in mammals,” said Cooper, as reported in the *Science News* article “These adorable Australian spike-balls beat the heat with snot bubbles” by Elise Cutts. It may also give us ideas for protecting other animal species living in warm climates as global temperatures continue to rise.

DISCUSSION QUESTIONS

Give examples of how other animals—including humans—regulate heat.

Name some other animals native to Australia. What are their unique characteristics?

VOCABULARY

EVAPORATE INFRARED INSULATE

REGULATE THERMOGRAPHY



Nature's Patterns

They're All Around Us

By Kimberly Perry

Have you ever looked at the center of a sunflower and been mesmerized by its intricate patterns? Or skipped a rock on a smooth-as-glass lake and watched the ripples flow out in a series of concentric circles? If so, you're witnessing patterns in nature. It's likely that you've even heard of some of these concepts in your math classes.

Understanding Patterns

For centuries, philosophers have wondered about the delicate patterns that appear in nature. Leonardo Bonacci, a 13th-century mathematician, sought to study these natural occurrences. His research led to what's known as the Fibonacci sequence, a set of increasing numbers that add together to equal the next number in the series. This results in a never-ending sequence: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, and so on. The number of petals on a flower and branches on a tree are just two examples of this.

Bonacci's work also led to a mathematical relationship known as the golden ratio. The value of this ratio is approximately 1.618 and is determined by dividing each number in the Fibonacci sequence by the number that comes before it. This pattern is found in the spiral patterns of snail shells.

Take a Closer Look at Sunflowers

From a distance, sunflowers seem simple, but they're a primary example of the Fibonacci

sequence. If you take the time to count a sunflower's seeds, you'll find evidence of the Fibonacci sequence. But plants don't always showcase these sequences perfectly. A study was published in *Royal Society Open Science* stating that of the sunflowers examined, one in five lacked this common pattern.

Find Fractals in Ferns

Ferns represent yet another mathematical mystery—fractals, or patterns that repeat indefinitely but at different scales. Michael Barnsley, a mathematician based in the United Kingdom, developed a formula that can be used to build a graphic representation of a fern that's mathematically accurate. Other examples of fractals in nature include pinecones and succulents.

Spot Spirals in Shells

Spirals, or curved patterns that begin at a central point and move outward, are commonly found in nature, too. They're most notably seen in shells. The golden spiral, which is based on the previously described golden ratio, can be observed via the arrangement of some flower petals. And once again, this naturally occurring pattern is rooted in mathematics.

Observe in the Outdoors

Although there are many examples of patterns in nature, there are some that simply don't follow the rules. That's because nature isn't always predictable, at least not mathematically—but that's where science steps in.

Flora and fauna will always strike a balance between the amount of energy they have available and the patterns they're destined to create to achieve the best outcome. Sometimes this results in a perfect pattern and sometimes it results in one of nature's unpredictable surprises.

DISCUSSION QUESTIONS

Take a short walk outside. What patterns do you see in nature?

List a few other ways that math and science work together to help us understand the world.

VOCABULARY

PATTERN FIBONACCI SEQUENCE

FRACTAL SPIRAL



Smartphones

Could Be Jeopardizing Your Study Space

By Kylie Wolfe

As you read this article, take note of what's nearby. Your computer, a notebook or pen, and most likely, your phone. Even though you tell yourself to buckle down and finish your homework or study for a test, you'll likely still reach for one of these items. But having your phone close by could be more of a distraction than a help—and science can explain why.

Establishing the Hypothesis

A study published in 2017 in the *Journal of the Association for Consumer Research* gained attention because it highlighted the effects of smartphones on the brain. The study's authors, Adrian Ward and his colleagues at the University of Texas at Austin, claimed that having a phone nearby could reduce one's cognitive capacity.

Participants were asked to solve math problems while remembering a series of letters. As these tests occurred, participants' phones were either on the desk, in their pocket, or in another room. When their phones were out of reach, participants performed better than when the phones were within reach.

Ward and team concluded that the presence of a phone can trap valuable cognitive resources. You may not be consciously aware of your phone or actively using it, but it's still impacting your mental capacity. That's because your brain is using up resources to help you not think about the phone or its contents.

Refreshing the Research

Over the last decade, many scientists have studied this "brain drain" hypothesis and published their findings. Another researcher, Doug Parry, a lecturer at Stellenbosch University, decided to combine these results to see how much of a problem society was facing.

After reviewing 27 studies from 25 publications, Parry found that having a phone nearby primarily affects working memory. Other studies had also explored sustained attention, inhibitory control, cognitive flexibility, and fluid intelligence, but Parry concluded that the results were not statistically significant in those areas.

This analysis was released in October 2022 and further emphasized the distracting role phones can play in everyday life. Parry explained that our awareness of the online world can occupy our minds even when we're not online.

Asking More Questions

As technology advances, phones will gain new features and become a larger part of our existence. Scientists will continue to study how phones impact cognition, too, but they suspect two factors are at play: one's overall attachment to the device and the fear of missing out.

We depend on our phones for the weather, to connect with others, and to make our lives easier. It's clear that phones aren't going anywhere, but maybe keeping them out of our study zones and workspaces could give our brains the ability to focus and thrive.

DISCUSSION QUESTIONS

When you have your phone nearby, how does it affect your concentration? Test it out.

How do you minimize distractions when you study?

VOCABULARY

COGNITIVE CAPACITY

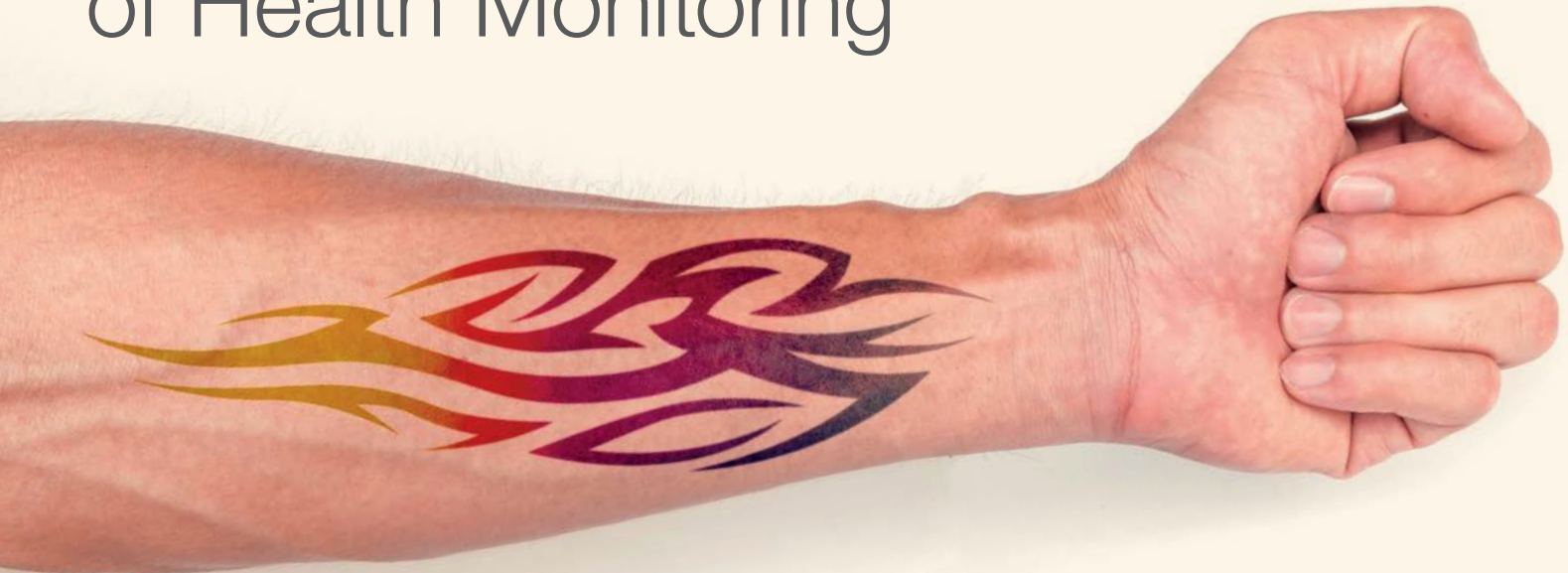
WORKING MEMORY

MENTAL CAPACITY



Color-Changing Tattoos

May Be the Future of Health Monitoring



By Dani Lewis

Imagine a world where you could design a personalized health tracking device that stays with you...*forever*.

A special kind of tattoo has been developed to help patients monitor fluctuating levels of glucose, albumin, or pH in their bodies. This color-changing tattoo requires a shallow injection into the dermis, located between the epidermis and hypodermis layers of the skin. The research was completed by Ali Yetisen and his team at The Technical University of Munich. Yetisen's team chose these three biomarkers because they serve as indicators for a range of health problems, according to their research paper "Dermal Tattoo Biosensors for Colorimetric Metabolite Detection" in *Angewandte Chemie International Edition*.

A Collision of Art and Science

"A functional cosmetic technology was developed by combining tattoo artistry and colorimetric biosensors," Yetisen and his team explained in their research. Each dye they created responds to a specific variable in the blood and changes color accordingly.

One of the dyes reacts to pH and gradually changes from yellow to blue, depending on the blood's acidity level. Another dye acts as a glucose sensor and shifts from light green to dark green, which could help people manage their diabetes. The third dye reads levels of

albumin and morphs between shades of blue, providing potential aid for people at risk of liver or kidney failure.

Color Changing, Life Saving

These chameleon-like tattoos have already been able to identify changes to key health markers in animals, which creates a promising future for monitoring chronic health conditions in humans.

The researchers also tested whether an app, accessed on a smartphone, would be capable of analyzing tattoo colors to gauge blood pH, glucose, or albumin levels. The app requires the user to take a photo of their tattoo with their phone's camera before it would be able to analyze the tattoo's color. Specific calibrations play a part in the app's ability to evaluate the shade, brightness, and saturation of the tattoo.

"If it works as well on a real human body as it does in the test system with pieces of pig skin, it could allow people to integrate blood biomarker levels with other digital health data that they already collect with their smartphones," said Eva Amsen in the *Forbes* article "Are Color-Changing Tattoos The Future Of Health Monitoring?"

Current Implications and Future Applications

One challenge that researchers are determined to overcome is making the ink color changes reversible. The pH-sensing ink stands alone as the only dye able to return to its original color. The dyes developed to detect glucose and

albumin are only able to change one time and cannot return to their original color, even if the respective biomarkers revert to their original levels. This issue will need to be addressed before the technology can be broadly introduced and expanded to wider functions.

"The applications of the sensors can be extended to the detection of electrolytes, proteins, pathogenic microorganisms, gases, and dehydration status," Yetisen's team told *News Medical Life Science* in "New color-changing tattoos can monitor glucose levels and other metabolites in real-time" by Lois Zoppi.

These metamorphic tattoos have yet to be tested on humans, so you'll have to wait a little longer to monitor your health with a personally designed, life-long wearable.

DISCUSSION QUESTIONS

What other health conditions or diseases could be monitored with color-changing tattoos?

What questions would you ask Yetisen and his team about the challenges of color-changing ink on human skin?

VOCABULARY

ALBUMIN BIOMARKER

GLUCOSE INTRADERMAL

METAMORPHIC pH



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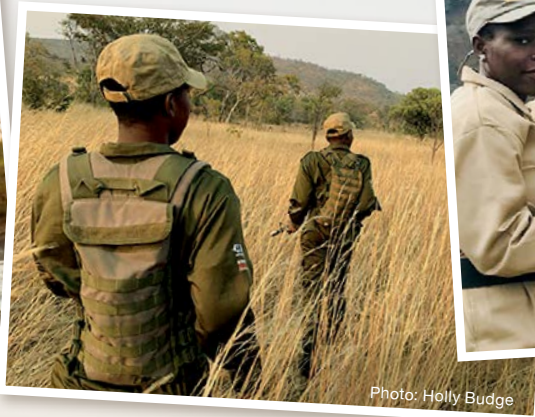
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Female Wildlife Rangers

Empowered to Protect the Planet

By Dani Lewis



Right now, over a million animal species are threatened with extinction—that's almost half of all species on Earth.

But just like mama bears protect their cubs in danger, women are banding together to protect endangered animals. There is a growing number of all-female wildlife ranger teams who dedicate their lives to protecting biodiversity, according to the *National Geographic* article "Female Wildlife Rangers." These women work tirelessly to achieve two main goals: defend endangered animals from poachers and empower communities with knowledge of conservation.

The Brave Ones

Becoming a wildlife ranger demands exceptional strength for difficult and potentially dangerous missions. Traditionally, women have not been viewed as suitable rangers in many communities. "In Africa, being a ranger was a job meant only for a man and not a woman, as we women were seen and taken as the weakest people. Our job was only to be home, give birth to children, cook, wash, go to the fields, and do all house chores," said Vimbai Kumire, an Akashinga sergeant and single mom of two, according to the *Daughters for Earth* article "Meet the Akashinga" by Lindsey Jean Schueman.

Despite these traditional viewpoints, brave women choose to devote their time to protecting endangered animals as wildlife rangers. They endure rigorous training to prepare for treacherous tasks. From meeting poachers head on to carrying out sting operations, they are equipped to do what it takes to protect animals.

Community-Led Success

The Black Mambas were organized as the first fully female anti-poaching unit in the world. Their organization is passionate about wildlife conservation in Greater Kruger National Park, an area where rhino poaching is more devastating than anywhere else. These women walk over 12 miles a day and collectively patrol almost 50,000 acres across South Africa. The Black Mambas have recorded that poaching has been reduced by 63 percent in the area where they operate.

Many other female ranger units like the Akashinga—an all-women anti-poaching unit in Zimbabwe—have found success through educating their local communities about the importance of conservation. This approach is encouraged by the International Anti-Poaching Foundation, as stated on its website: "If a community understands the economic benefits of preserving animals, then it will eliminate poaching without an armed struggle."

Women wildlife rangers prove their job is most effective when compassion for community works in conjunction with vigilant defense.

The Future Is Female

The growing support of female wildlife rangers impacts the lives of rangers themselves and their surrounding community members. With these jobs, women rangers can support their families, access healthcare, and continue their education.

"Usually, men are the first preference to be employed by companies. But now I have the respect of my community, and I will be

able to build my children's future," Sithabile Munenge, community scout for the National Park Rescue in Zimbabwe, explained in the *National Geographic* article.

Female wildlife rangers make a difference in our world—both in the lives of people and animals.

You can celebrate the success of these women by participating in Female Ranger Week events organized each June by How Many Elephants.

DISCUSSION QUESTIONS

How can communities support women wildlife rangers on a local and global level?

What other professions were traditionally seen as only suitable for men? How is this perspective changing across the world?

VOCABULARY

EXTINCTION BIODIVERSITY

CONSERVATION POACHING

TREACHEROUS

3D Printing Helps One Student Reach His Guitar Goals

By Mark Miller

Nehemiah Culver, a student at McKinley Senior High School in Canton, Ohio, has always dreamt of playing guitar. "When I'm playing, it feels like I'm actually on my own stage performing for thousands," he said in a report from News 5 Cleveland WEWS. But there was an obstacle standing between the freshman and his dream. Culver was born with cerebral palsy. The disorder affects his motor skills and makes it virtually impossible for him to use a guitar pick.

Up for a Challenge

Despite his physical setback, Culver enrolled in McKinley's guitar ensemble led by music instructor George Dean, according to an article in the *Canton Repository*. Dean helped by outfitting his own right-handed guitar for the left-handed Culver, but saw he needed to go further.

He asked Chad Weaver, who teaches career and technical education pre-engineering, if he and his students could use 3D printing to develop an assistive device that would enable Culver to manipulate a pick. 3D or three-dimensional printing involves designing an object in a computerized system or scanning a physical object to create a digital file. Based on the file, the printer builds up layers of thin liquid or powdered plastic until the object is completed. Weaver and his group were ready. Each year, they take on 3D printing projects and have produced prosthetic legs, welding tools, and other devices.

Collaborative Keys

Weaver designed a prototype and teamed up with his students to make adaptations. Dean pitched in, too, but the collaboration was just beginning.

Weaver requested his daughter, who studies music therapy at Cleveland State University, to assist with the project. "I reached out to her and also to Nehemiah's physical therapist during the development phase," said Weaver in the article. "They were both able to provide good feedback from the therapy side."

Trials to Triumph

Through trial and error, the team arrived at a solution. It consists of a sleeve that fits over Culver's lower forearm and wrist. Over the



sleeve is a Velcro wrist band. The 3D printed device is attached to this band and has a special slot that securely holds the pick. By moving his wrist and forearm, Culver can position the pick to strike the desired strings.

According to the *Canton Repository* report, Culver is now playing with accuracy and able to interact with music in new ways. In fact, he demonstrated his progress by using the device to perform at McKinley's holiday concert.

"When there is a will, there has to be a way," said Weaver. "Nehemiah had the will to play, Mr. Dean had the will to help him do so, and I was determined to find a way."

Photos Courtesy of Canton City Schools

DISCUSSION QUESTIONS

- How do disorders such as cerebral palsy affect motor skills?
- Name three famous left-handed guitarists.
- What common objects or devices have been developed using 3D printing?

VOCABULARY

- CEREBRAL PALSY PROSTHETIC
- MUSIC THERAPY TRIAL AND ERROR





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Sun-Powered System Turns Pollution into Fuel

By Mark Miller

New research shows that the plastics we use and the carbon dioxide (CO₂) we produce can be reborn as fuels and useful products. A *ScienceDaily* article reports that University of Cambridge researchers have developed a system that harnesses sunlight to simultaneously transform plastic into glycolic acid, a chemical compound used in cosmetics, and CO₂ into syngas, synthetic gas that's a key component of liquid fuels.

Dynamic Duo

The system is a chemical reactor with two separate compartments: one for plastics and another for greenhouse gases, according to a report published in the journal *Anthropocene*. The compartments are separated by a membrane with an electrode on either side. A negative electrode is used for CO₂ conversions and a positive electrode for plastics. Perovskite—an alternative to silicon for absorbing sunlight to create electricity—coats the negative electrode to fuel the two-way system.

Catalytic Advantages

Catalysts are used to facilitate the reactions and the system can be adjusted to produce different products by changing catalysts. The team at Cambridge considers this adjustability an important advantage. "What's so special about this system is the versatility and tuneability—we're making fairly simple carbon-based molecules right now, but in future, we could be able to tune the system to make far more complex products, just by changing the catalyst," explained Subhjit Bhattacharjee, PhD, a co-first author of the research published by the Cambridge team.

Another advantage is that the system was able to produce its results at a higher rate than conventional photocatalytic conversions. "Generally, CO₂

"With our system, basically you just shine a light at it, and it starts converting harmful products into something useful and sustainable."

conversion requires a lot of energy, but with our system, basically you just shine a light at it, and it starts converting harmful products into something useful and sustainable," said Motiar Rahaman, PhD, also a co-first author.

Fueling Solar Recycling

It's the first time these transformations have been combined into a single process using a solar-powered reactor, and it may mark a significant advancement in how pollutants can be reused.

"Developing a circular economy, where we make useful things from waste instead of throwing it into landfill, is vital if we're going to meaningfully address the climate crisis and protect the natural world," said Professor Erwin Reisner, PhD, senior author of the research.

The Cambridge team is planning to produce more complex molecules as they further develop the reactor, and they say similar techniques could be used to create entire solar-powered recycling plants.

DISCUSSION QUESTIONS

- How do chemical reactors work?
- What chemical reactions are caused by sunlight?
- Discuss the idea of a circular economy. Can you provide any examples?

VOCABULARY

- CARBON DIOXIDE CATALYST
- ELECTRODE MOLECULE
- PHOTOCATALYTIC



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