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Fall 2022



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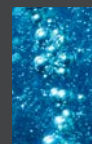
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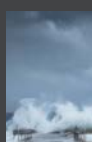
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James Webb Space Telescope

Captures Farthest Reaches of Space

By Tom Wright

The James Webb Space Telescope (JWST) made a splash across the internet in July as the National Aeronautics and Space Administration (NASA) released its first images. Every social media outlet was awash with pictures of distant galaxies and nebulae clusters. With the evolution of special effects in science fiction movies and television, it's easy to miss the significance of these images. The importance becomes a little clearer when you realize that you're seeing actual images rather than an artistic interpretation of deep space.

Upholding a Legacy

James Webb, for whom the telescope was named, was the administrator of NASA from 1961 to 1968, the era known as the golden age of space exploration. It was the era of the Mercury, Gemini, and Apollo programs, the last of which succeeded in preparing and landing the first humans on the moon.

JWST was first conceptualized in 1996 and, after a series of design changes and revisions, completed in 2016. It went through testing for the next five years and finally launched on December 25, 2021.

Viewing Space in Stunning Detail

The resolution of the JWST dwarfs the Hubble telescope in terms of detail and definition and is described as 100 times more powerful. But what truly makes the JWST so special is its ability to detect near-infrared and mid-infrared wavelengths. On the electromagnetic spectrum, infrared light is beyond the visible range. It passes through areas of dense gas and dust with little to no diffraction, meaning it can be detected accurately at longer distances. The JWST detects this infrared light effectively as different shades of gray, which are then converted to color. It's so precise that it can detect over 65,000 shades of gray.

One of the downsides of this accuracy is that heat released from the telescope itself can distort the images coming in. To account for this, the JWST must operate at a very low temperature, an astonishing 6.4 kelvins, or -273 degrees Celsius.

Spurring New Discoveries

This level of detection allows the JWST to look farther back in time than the Hubble telescope. Some of the tiny dots of light in the recently released images represent what galaxies looked like 13 billion years ago. The telescope can also measure the elemental composition of those galaxies, and scientists are already reporting new discoveries based on these images.

NASA Administrator Bill Nelson said, "These images, including the deepest infrared view of our universe that has ever been taken, show us how Webb will help to uncover the answers to questions we don't even yet know to ask; questions that will help us better understand our universe and humanity's place within it."

Photos courtesy of NASA.

DISCUSSION QUESTIONS

Why do scientists want to know more about distant galaxies? How will this knowledge help us understand our own galaxy better?

Think of other applications for the JWST besides looking at old galaxies. What else can scientists accomplish with such a powerful telescope?

VOCABULARY

GALAXY NEBULA

INFRARED WAVELENGTH

ELECTROMAGNETIC SPECTRUM



James Webb Space Telescope Mirror Seen in Full Bloom



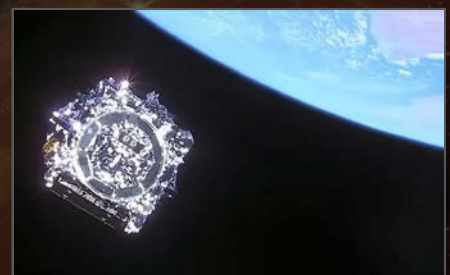
Webb Telescope Emerges from Chamber A After Cryogenic Testing



Gold-coated Engineering Design Unit (EDU) Primary Mirror Segment



James Webb Space Telescope Launch, December 25, 2021



Humanity's Last Glimpse of the James Webb Space Telescope



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ISEF Winners Create New Assistive Devices

By Iva Fedorka

The Regeneron International Science and Engineering Fair (ISEF) started in 1950 and is one of several competitions sponsored by the Society for Science. Close to 1,800 high school students from more than 70 countries, regions, and territories competed in ISEF in 2022, the first in-person fair held since the start of the COVID-19 pandemic.

This year's ISEF winners received nearly \$8 million in prizes for their independent research in categories like Animal Sciences, Biochemistry, Biomedical Engineering, Chemistry, Earth and Environmental Sciences, Mathematics, and more.

Navigation for the Visually Impaired

A second prize winner in the Robotics and Intelligent Machines category, Seoyoung Jun of Thomas Jefferson High School for Science and Technology in Virginia, titled her project *Mind Beacon: A Portable Spatial Recognition Device for the Visually Impaired Using a 3D Depth Sensor and Custom Tactile Display*. Her portable invention produces a beam of infrared light that bounces back to the device from walls, furniture, and other solid surfaces. The returned light activates a set of positional pins that can give the user an idea of the location of potential obstacles in the surrounding space.

Blind Companion

Fifteen-year-old Joud Eldeeb, a winner in the Embedded Systems category, attends Haitham Samy Hamad in Damanhur, Egypt. She built a shoe with vibrating sensors that sends alerts to visually impaired users about upcoming obstacles. The device uses an

Close to 1,800 high school students from more than 70 countries, regions, and territories competed in ISEF in 2022

ultrasonic sensor to detect stationary objects and a PIR sensor to detect moving objects. It also connects to a mobile device via Bluetooth. Users are alerted when an object is directly ahead of them, up to 100 cm (39 in.) away. The mobile device serves as an intermediary, but it can be used by itself.

Talk with the Hand

Sisters Shanttale, 18, and Charlotte Aquino Lopez, 16, were winners in the Engineering Technology: Statics and Dynamics category for developing a way to help the hearing impaired. These siblings attend the San Juan Math, Science and Technology Center in San Juan, Puerto Rico, and focused on bridging the gap between American Sign Language (ASL) speakers and non-speakers. They placed five flex sensors on the fingers of a glove-shaped device to gather and relay motion data about the glove's changing shape. A circuit board was used to translate the signals to produce a letter on an LCD screen and provide feedback to the user about the correct formation of the ASL letter or word. The screen also allows non-ASL speakers to see what is being said.

AI for ASL

Nand Vinchhi, a 17-year-old systems software coder from the National Public School,

Koramangala in Bangalore, India, wanted to create a project that doesn't require a device. The idea originated in a brainstorming session when Vinchhi decided to use artificial intelligence (AI) technology to translate ASL. First, he focused on the fingertips and other body parts important to signing. He used machine learning to identify those key points in video recordings, determined an algorithm, and analyzed results. The program can translate signs in real time with 90.4 percent accuracy and only a 0.3 second delay.

Visit societyforscience.org/isef to review abstracts and learn more about these and other science projects.

DISCUSSION QUESTIONS

Are similar devices already available to assist those with physical or sensory limitations?

What other conditions might benefit from a new device or technology?

VOCABULARY

ALGORITHM

ARTIFICIAL INTELLIGENCE

SENSOR

HACKATHON



Hands On? Hold On!

Safe Science Labs in a Post-Pandemic Classroom

Content provided by:



It has been nearly three years since the novel coronavirus, SARS-CoV-2, that causes COVID-19 first emerged and was declared a pandemic by the World Health Organization (WHO).¹ The virus promptly accelerated innovation, challenged scientists and healthcare professionals, closed schools, and made us consider how we can help prevent something like this from happening again.

The World Adapts

Scientists around the globe raced to create prophylactics and treatments to combat this often-deadly virus. They developed multiple effective vaccines against COVID-19, produced multitudes of masks to help reduce transmission, created antibody treatments, and began considering how to sanitize everything around us to stop the spread.² Many schools closed and reopened with hybrid learning models and by suspending hands-on laboratories, an important way to teach and learn about science.

A Teacher's Perspective

Mary Courtney, a chemistry teacher at East High School in Rochester, New York, explained these challenges and offered tips and tricks to keep students safe and engaged while working in labs.

“Students have been much more interested in wearing gloves since the pandemic. Lab equipment is shared by multiple classes throughout a day, and there is no time to clean all equipment. Having a ready supply of disposable gloves in a post-pandemic world is an easy way to assure that students feel comfortable with hygiene in the lab.”

She also had advice for teachers about keeping protective eyewear clean and safe for classes with a lot of students.

“In many schools, there is a class set of safety goggles that everyone uses. This has always struck me as somewhat unsanitary given the inevitability of someone having lice, pink eye, or another bacteria or virus at some point during the school year. Goggles can be sanitized in a UV cabinet, and it seems that good practice would be to assign each student their own personal goggles at the beginning of the year and have a storage system that keeps those organized. They can be sanitized in the UV cabinet at the



Students are **concerned about their own health and safety** during a lab, and when given the right tools to protect themselves and others, are more engaged and collaborative in the classroom.

end of class or end of the day, but each student would only wear their own goggles. This even increases students' willingness to wear them.”

Courtney also found that students are concerned about their own health and safety during a lab and are more engaged and collaborative in the classroom when given the right tools to protect themselves and others.

“Whenever possible, using disposable labware is a good practice. Students seem much more receptive to using tools such as pipets and stirring implements when they know they are the only ones to handle them and then dispose of them. I have noticed that my students over the past 15 years have been consistently particular about who and what has touched items that they will be using. Anything that can be done to help students feel comfortable with the touching of lab materials can be seen as a way to increase student participation and cooperation in the lab.”

Schools continue to navigate a post-pandemic world and the health and safety of educators, students, and families comes first. Schools need to have the right protective gear available to allow educators to teach and students to learn science through experiments in the classroom.

Educators rely on a variety of equipment to keep themselves and their students safe. Find aprons, gloves, lab coats, safety goggles and eyeglasses, and UV-sanitizing eyewear cabinets available from Eisco Scientific through the Fisher Science Education channel.

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Dragonflies: Masters of Flight

By Iva Fedorka



Dragonflies, with their long and brightly colored bodies, are one of the oldest insect species and some of the earliest flight innovators. A Cornell University group led by Jane Wang, professor of mechanical engineering and physics, is exploring how dragonflies can right themselves when falling upside down.

The team's paper was published in *Science* on May 12, 2022, by coauthors James Melfi, Ph.D. '15 and Anthony Leonardo of Howard Hughes Medical Institute (HHMI) in Ashburn, Virginia. Their findings reveal a series of mechanisms that begin with the dragonfly's five eyes and end with muscle control and wing angles.

Insect Flight

Wang has used mathematical modeling during the past 20 years to better understand insect flight mechanics. While visiting scientists at the HHMI Janelia Research Campus, she became interested in Leonardo's 3D dragonfly tracking work.

"When we looked at their flight behavior, we were simultaneously in awe and frustrated," she told *ScienceDaily*. "The trajectories are complex and unpredictable. Dragonflies constantly make maneuvers without following any obvious direction. It's mysterious."

The Investigation

In Wang and Melfi's experiment, the dragonflies were dropped upside down from a magnetic tether and carefully released without leg contact. This test method is similar to French physiologist Étienne-Jules Marey's 1880s falling cat experiments, where cats were dropped from an upside-down position to study how they usually land on their feet.

Markers were placed on the insects to help capture their movements using high-speed video (4,000 frames/second). With 3D tracking software, scientists analyzed the dragonflies' motions while also considering the variable aerodynamics of wing and air interactions, the way the dragonfly body responds to wing flapping, and gravity itself.

The group was able to create a computational model that simulated dragonfly aerobatics. Wang suspected that the insects assess their body position using their visual systems — two large compound eyes and three ocelli, or simple eyes. To test her theory, she obscured the insects' eyes and found that they had more difficulty righting themselves in flight without vision.

The team learned that visual cues trigger reflexes that send signals to the dragonfly's four wings, which are independently controlled. The observed rolling motion

comes primarily from wing pitch asymmetry. In just three or four wing strokes, roughly 200 milliseconds, a dragonfly can rotate 180 degrees to resume a right-side-up orientation.

"It took us a very long time to understand the mechanism by which a small amount of pitch asymmetry can lead to the observed rotation. The key asymmetry is hidden among many other changes," Wang said.

This combination of kinematic analysis, physical modeling, and 3D flight simulation offers a noninvasive way to study the connections between observed animal behaviors and their internal controls. Engineers can also use these insights to help improve performance in small flying machines and robots.

DISCUSSION QUESTIONS

What other animals can right themselves when flying or falling?

How does motion tracking work?

VOCABULARY

AEROBATIC

AERODYNAMICS

KINEMATICS



New Facility to Recreate the World's Worst Weather

By Mark Miller

Scientists are planning a first-of-its-kind facility to simulate the conditions of the planet's most devastating storms and hurricanes. Funded by a \$12.8 million grant from the National Science Foundation and led by researchers from Florida International University (FIU), *Science News* reports that the project will recreate winds of 290 kilometers per hour and storm surges towering six meters high.

Gathering Storms

Driving the project are the effects of climate change. Hurricanes are getting larger, rainier, stronger, and slower, according to *Science News*. Scientists believe that Atlantic Ocean storm seasons will continue to deliver a higher number of storms and more rapidly intensifying hurricanes have been present in recent seasons.

Research from the new facility will help coastal communities around the world engineer buildings, bridges, roads, and water and energy systems that can withstand this increasingly powerful weather.

Team Effort

The FIU team is working with wind and structural engineers, coastal and ocean engineers, computational modelers, and resilience experts from around the United States to bring the facility to life.

“We have challenged nature. Welcome to payback.”

They will also build on existing capabilities. FIU, for example, currently operates the Wall of Wind, a simulator housed in a hangar that generates category five hurricane winds. At Oregon State University, water wave tanks can simulate the gigantic power of tsunamis and storm surges.

One of the aims of the project is to combine these types of simulations into a single entity that can recreate the effects of extreme wind and water together.

Methods and Time

To create a comprehensive picture of nature's power, the team will combine three proven methods for studying the impact of severe storms: learning from field observations made after a storm, mimicking the behavior of storms by building experimental facilities, and constructing computer simulations to visualize the effects of storms over geographic areas.

Along with meeting a host of other challenges, it will take time to integrate these methodologies. The design phase for the facility is projected to be four years.

At the same time, nature's clock is ticking. With the accelerating intensity of storms, communities across the globe could be at greater risk with each passing season.

It's a reality not lost on director of extreme events research at FIU, Richard Olson, PhD. “I don't think anybody wants to be explaining 20 years from now why we didn't do this,” he said in the *Science News* report. “We have challenged nature. Welcome to payback.”

DISCUSSION QUESTIONS

Why are hurricanes so devastating? Use specific attributes to explain.

How are hurricane categories determined? Provide details about each category.

Identify three types of weather simulations.

VOCABULARY

HURRICANE

TSUNAMI

METER

METHODOLOGY



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Dog Breed Doesn't Dictate Personality

By Christina Hooton



Does your dog love strangers, or does it cower in fear at the slightest noise? Does it love to play fetch, or does it prefer to stand guard? We often attribute these personality traits to a dog's breed, but according to a new study from scientists at UMass Chan Medical School and the Broad Institute, breed may not be as strong an indicator of a dog's personality as we once thought. Experts agree that a dog's behavior results from many factors, including genes, development, socialization, and environment.

An Ancient Bond

Ancient wolves evolved into the modern dogs we call our best friends today. It all started when these prehistoric canines began relying on ancient humans for food and shelter. Humans learned they could rely on these proven predators for help with hunting and protection. Over time, the wolf evolved to be less fearful of humans and more docile. Certain species began to specialize in tasks like herding, retrieving, and providing protection.

It wasn't until much later that humans began breeding dogs for looks instead of specific jobs. In the 1880s, the American Kennel Club was formed and developed strict guidelines that defined the physical traits and personality of a dog's breed. These guidelines are still viewed as truths today.

Shedding New Light on Breed

To determine if breed truly impacts behavior, UMass and Broad Institute scientists surveyed over 18,000 dog owners, asking them over 100 questions about their dogs' sizes, lifestyles, and more. The proportion of purebreds versus mixed-breed dogs was half and half, a ratio representative of the real world. Saliva and blood samples were collected to DNA sequence 2,155 of the dogs in the survey and better understand their genetics.

"The genetics allowed us to piece apart the puzzle — especially for mixed-breed dogs that have multiple backgrounds — of where the DNA differs the most between dogs that differ in their traits," said Kathleen Morrill, a dog geneticist at the University of Massachusetts Chan Medical School, in a *Scientific American* article.

Study authors identified 11 genetic regions strongly tied to a dog's behavior. These behavioral regions were not found to be specific to any one of the 78 breeds studied. They concluded that only nine percent of the behavioral variation among different types of dogs could be explained by breed. Some traits seemed more closely related to breed, but these were service functions such as hunting or herding, behaviors that have been reinforced for thousands of years.

Breeding Understanding

Certain dog breeds get a bad rap. For example, pit bulls, thought to be much more aggressive, are less likely to be adopted from a shelter. Some breeds are outlawed or regulated by some U.S. jurisdictions. Knowing that a dog's behavior is not necessarily predetermined by breed may help to change some of these negative preconceptions and give certain breeds a new opportunity to find loving homes.

DISCUSSION QUESTIONS

Have you noticed certain behaviors with certain breeds of dogs? Are your observations consistent with the findings of this study?

How much of a dog's personality do you think depends on its owner and environment? How much do you think depends on genetics?

VOCABULARY

BREED

CANINE

SEQUENCE

PRECONCEPTION

Is There Plastic in Our Blood?

By Mark Miller



According to a report in *Smithsonian Magazine*, there very well could be.

A study from the Vrije Universiteit Amsterdam discovered microplastics — tiny plastic particles — in the blood of about 77 percent of its participants. “Our study is the first indication that we have polymer particles in our blood — it’s a breakthrough result,” said ecotoxicologist and one of the study’s coauthors, Dick Vethaak, PhD, in the report.

Cause for Concern

It’s not too surprising that plastic has found its way into our bodies. It’s in the foods we eat and the water we drink. An article about the study in *Science News Explores* states that we may also inhale microscopic plastic floating in the air.

But eating and inhaling plastic doesn’t mean it has technically become part of our bodies. That only happens if it enters our bloodstream, according to *Science News Explores*. And that’s what makes the discovery troubling. If microplastics are circulating in our blood, who knows where they might go or what harm they might do?

“It is certainly reasonable to be concerned,” Vethaak said in *Smithsonian Magazine*. “The particles are there and are transported throughout the body.”

Getting Small

To find the microplastics, Vethaak and the research team used chemicals to process blood samples collected from 22 adults. They filtered out the larger cells and performed further filtration on the liquid (plasma). The additional filtration eliminated any particles larger than 700 nanometers, 100 times smaller than the width of a human hair.

From there, they searched for molecules that make up plastics called polymers. Measurable amounts of four types were found in 17 of the samples: polyethylene, polyethylene terephthalate or PET, polystyrene, and polymethyl methacrylate or PMMA.

Polyethylene terephthalate was the most commonly found — in about half of the participants — and polymethyl methacrylate the least — uncovered in only one of the samples.

Possible Health Impacts

We now know that some human bloodstreams contain microplastics, but not much has been determined about what the effects might be.

Environmental health specialist at Memorial University in Newfoundland, Canada, Atanu Sarkar, PhD, said in the *Science News Explores* article that “microplastic can cause inflammation,” and that “these toxic chemicals can affect our hormonal and reproductive system.” Microplastics can also harm animals and ecosystems, the article said.

For Vethaak and his fellow ecotoxicologists, the plan is to expand their research by searching for additional types of polymers and increasing the sample size.

DISCUSSION QUESTIONS

- What are polymers?
- What functions does our blood perform?
- What do ecotoxicologists do?

VOCABULARY

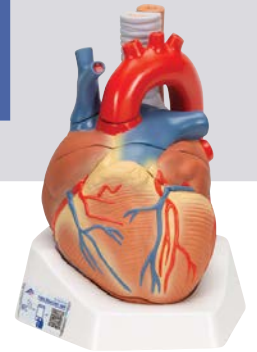
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*Blocks sold separately.



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Career Exploration

Funeral Service Professionals

By Kevin Drobish

Funeral service professionals provide care and support for the deceased as well as surviving family members and friends. This is accomplished by carefully crafting a memorable, personalized event that celebrates a person's life while acknowledging their death.

Key responsibilities include:

- Working with families to coordinate services and provide grief resources
- Scheduling and performing burials, cremations, and other forms of disposition
- Consulting with clergy, medical examiners/coroners, and cemetery staff
- Submitting legal paperwork with county, state, and federal officials
- Transporting, embalming, dressing, and cosmetizing the deceased
- Selling funeral products, prearranged services, and collecting payment
- Attending required continuing education programs to maintain professional licenses

Work Environment

Funeral service professionals perform duties in a variety of environments, including funeral homes, crematories, cemeteries, healthcare facilities, government offices, places of worship, event centers, private homes, and morgues.

Funeral service professionals can be required to be on call 24 hours a day depending on the size and business model of the funeral home. These buildings can range from small, family-owned firms to large corporate entities.

Core Skills

Attention to detail, event planning skills, empathy, and emotional intelligence are key skills in this field. It's also important to be able to lift heavy objects and stand for long periods of time, speak publicly, and have a working knowledge of human anatomy, chemistry, and pathology. In this line of work, a sincere desire to help others in a time of need and serve the community goes a long way.

Academic Requirements

Depending on your state of licensure, academic requirements can range from a high school diploma to a bachelor's degree. Most states require an associates degree from an accredited mortuary program, and a few accept a diploma/certificate.

Some states have split licensure that require different levels of education depending on what type of license is desired: embalming or funeral directing.

Licensure and Continuing Education

Most states require licensing and continuing education credits to maintain licensure once it's attained. When they have completed their educational programs, funeral service professionals must take a national board exam to graduate.

The next step is to complete an internship/apprenticeship which has varying lengths and requirements.

Job Outlooks and Salaries

According to the U.S. Bureau of Labor Statistics, the funeral service job market is expected to grow 4 percent from 2020 to 2030. This rate of growth is much slower than the average for most occupations.

Over the next decade, it's projected that an average of 4,000 openings will be available each year. The median annual wage for morticians, undertakers, and funeral arrangers was \$48,950 in May 2021. The median annual wage for funeral home managers/supervisors was \$74,000 in May 2021.

How Can I Prepare Myself?

To prepare for a career in funeral service, take high school courses in psychology, anatomy, pathology, and other sciences, as well as business management courses.

You can also research mortuary science educational programs and attend open house events. Then, contact a local funeral home and arrange to shadow with the director or directly seek employment.

To learn more about funeral service careers, visit:

- National Funeral Directors Association
- tradeCollege.org
- niche.com
- U.S. News and World Report
- Pittsburgh Institute of Mortuary Science

DISCUSSION QUESTIONS

What subjects should you study to be successful in this field?

What skills are most important in the funeral service industry?

VOCABULARY

LICENSE

MORTUARY SCIENCE





First Plants Grown in Lunar Soil May Lead to **Farming in Space**

By Mark Miller

Researchers at the University of Florida Institute of Food and Agricultural Sciences are the first to successfully grow plants in lunar soil brought back by the Apollo space missions. The lab-grown garden — part of research supporting the ambitious Artemis program at the National Aeronautics and Space Administration (NASA) — marks an important step toward growing plants and food on the moon and possibly worlds beyond.

Tough Growing

Dirt from the moon is a challenging environment for plant growth. According to an article in *Science News*, lunar soil, known as regolith, is a fine powder full of metallic iron, which, unlike oxidized iron, isn't beneficial to plants. It also contains tiny shards of glass as a result of the moon's surface being continually struck by micrometeorites. What it doesn't contain much of is nitrogen, phosphorus, or other nutrients.

The research team chose thale cress or *Arabidopsis thaliana* to grow in this unwelcoming world. It's a relative of mustard greens and other cruciferous vegetables like broccoli and cauliflower. A small, hardy plant that grows easily, thale cress is also the model organism used in multiple studies of plant biology, which means scientists have a good understanding of its genetic makeup.

The team combined thale cress seeds and water with gram-sized samples of soil from the Apollo 11, 12, and 17 missions. These were placed in terrarium boxes under LED lights in a cleanroom. They also planted control samples in terrestrial volcanic material and added a nutrient to all of the samples daily.

"After two days, they started to sprout!" said Anna-Lisa Paul, PhD, a professor of horticultural sciences at the University of Florida and part of the research team, in a report from NASA. "Everything sprouted. I can't tell you how astonished we were! Every plant — whether in a lunar sample or in a control — looked the same up until about day six."

Better Plots and Plants

As Paul's reaction indicates, both sample sets did not grow equally well. After about a week, the growth of the lunar samples slowed. They had stunted roots and leaves and an unhealthy, purplish pigmentation.

To better understand what had happened, the team conducted genetic analysis by studying the ribonucleic acid (RNA) from the plants grown in the moon soil. RNA transforms information from deoxyribonucleic acid (DNA) into proteins that carry out many of a living organism's biological processes. Examination of the RNA sequence of the plants' cells revealed that the thale cress was reacting as it typically does when the environment contains too much salt or heavy metals.

The plants had the most trouble growing in the soil samples from Apollo 11, perhaps because these were drawn from the moon's Sea of Tranquility, according to an NBC News story. This region, according to the story, is an older surface of the moon and has experienced greater cosmic radiation and solar wind.

"Everything sprouted.
I can't tell you how
astonished we were!"

A correlation between the age of the lunar soil and the performance of the plants may help future moon gardeners know where — or where not — to collect their planting soil. It may also help to select plants better suited to moon dirt. "Maybe spinach plants, which are very salt-tolerant, would have no trouble growing in lunar regolith," wondered Paul in *Science News*.

One Small Step

Although the lunar samples didn't produce growth as well as the volcanic soil, the research is a dramatic initial success that significantly advances the role of plant life in space exploration and habitation.

Plants can be used as model organisms to help study gravity, radiation, and other biological phenomena in space, according to a paper the University of Florida team published in *Nature*. It points out that plants help us understand how biological organisms adapt away from Earth and could provide food

and oxygen to support long-term habitation of space and even extraterrestrial surfaces. Using moon regolith could prove much more practical than transporting enough water to support hydroponic agriculture.

Returning to Space

The work done at the University of Florida is picking up where NASA left off. Over the course of their missions, Apollo crews returned to Earth with 842 pounds of moon rocks and soil. The plantings are making good use of these materials. "Here we are, 50 years later, completing experiments that were started back in the Apollo labs," said Robert Ferl, PhD, another member of the University of Florida team, in the NASA report.

The research plays a central role in the success of the Artemis program, which aims to return astronauts to the moon and establish a long-term presence there. Ultimately, its lunar missions will serve as a leaping-off point for human exploration of Mars.

"This research is critical to NASA's long-term human exploration goals as we'll need to use resources found on the moon and Mars to develop food sources for future astronauts living and operating in deep space," stated NASA Administrator Bill Nelson in the report.

DISCUSSION QUESTIONS

What are the key nutrients needed for healthy plant growth?

What makes up the composition of the moon's surface? What minerals and elements are present there?

Is there water on the moon?

Beyond providing food and oxygen, can you think of other functions plants might offer to support space exploration?

VOCABULARY

REGOLITH MICROMETEORITE

CRUCIFERAE RNA

ARTEMIS

Electrifying Orange Peel Oils Produces Pleasing Smells

By Mark Miller



Research by Holger Zorn, PhD, and a team at Justus Liebig University Giessen and BASF may lead to a better way to produce flavor and fragrance compounds from the oils found in orange peels. The team combined ethanol and electricity to derive pleasant-smelling compounds, some of which may not have been previously identified.

Essential Oil

Peeling an orange is like digging into its essence. You plunge your thumb beneath the skin. As you pull it back, a mist that smells of pure orange is released. Part of the oil in this mist is a compound called limonene that occurs naturally in lemons, oranges, and other fruits. When collected from discarded peels, it's used as a flavor and fragrance additive in beverages, perfumes, cosmetics, and other products.

Sustainable Oxidation

Limonene is often used in its original form, but it also serves as a starting point for creating other scents through a process called oxidation. Oxidation happens when a molecule, atom, or ion loses one or more

of its electrons in a chemical reaction. Sometimes this involves an element or compound combining with oxygen, but not always. Common examples are the formation of rust (iron oxide) or the flesh of an apple turning brown when exposed to air.

Traditionally, a type of synthetic oxidation transforms limonene into compounds. This technique relies on environmentally harmful substances such as strong chemicals and heavy metals. Zorn and team found another way. They mixed limonene with ethanol and then applied an electric current. This electrifying process resulted in an amber liquid that produced 17 different fruity-, herbal-, and citrusy-smelling compounds.

This relatively simple process marks a different, more sustainable direction for deriving compounds. The next step is conducting safety evaluations before the compounds can be introduced in commercial products.

Not Just Another Nice Smell

While the research done by Zorn and team derived compounds that make products

smell and taste better, the orange peels we often throw away provide a variety of other benefits. According to *The Times of India*, they contain high levels of polyphenols that can fight diabetes and obesity. They can cut through grease and condition wood in homemade, natural cleaners. You can use them to make pots for growing seeds, start a fire, or ward off mosquitoes. In research and the real world, there's more to orange peels than meets the nose.

DISCUSSION QUESTIONS

- How do we smell things?
- What forms of oxidation don't directly involve oxygen?
- What other uses can you think of for orange peels?

VOCABULARY

<u>COMPOUND</u>	<u>LIMONENE</u>
<u>ION</u>	<u>ETHANOL</u>
<u>POLYPHENOL</u>	

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New Technologies Lead to Alternative Ways to Deliver Medicine

By Kylie Wolfe

Would you rather take a pill or get a shot? New technologies could make needles less necessary in the world of medicine, helping some patients keep up with treatments they'd otherwise fear or dread.

Scientists at the Massachusetts Institute of Technology (MIT) designed a robotic pill to administer drugs without the use of a traditional needle and syringe. This pain-free alternative injects medicine internally, through the stomach wall, instead of through the skin. The team published its work in 2019 in *Science* and released updates in the March 2022 issue of *Matter*.

How It Works

MIT's robot is the size of a pea. Even though it's small, the weight of the device lets it sink to the bottom of the stomach once swallowed. The pill isn't a perfect sphere, but instead has a steeply domed shell like a leopard tortoise. This helps it roll right-side up, just like the reptile it's modeled after.

"No matter how I drop it, it always lands the same way," Robert Langer, a chemical engineer at MIT and member of the research team, told *Science News Explores*.

The pill is spring-loaded with a microneedle. The needle is held in place by sugar glass that gradually dissolves in the stomach. By adjusting the thickness of the sugar, scientists can change how long it takes to dissolve. This helps ensure that the needle is released, and the medicine administered, at the right time.

Real-Life Applications

Researchers from MIT have successfully used this robotic pill to give insulin to mini pigs. Typically, insulin cannot be taken orally because it breaks down in the stomach before reaching the bloodstream. This new approach keeps the treatment contained until it's injected into the stomach wall.



This teeny tiny pill has also delivered mRNA-based medicines, showing promise for future applications, like Pfizer's COVID-19 vaccine.

Patches Over Pills

A team in France designed an alternative to shots, too — medicine patches that are used inside the mouth. Placing these patches inside a person's cheek helps medicines enter the bloodstream quickly.

They also tested this technology as a vehicle for insulin — and the patches did just what they set out to, lowering the blood sugar of both mini pigs and cows. This information was reported in *ACS Applied Bio Materials* in February 2022.

Challenges and Limitations

Though pills and patches are more patient-friendly, they come with their own set of challenges. Some speculate that the robotic

pill may be too expensive for regular use and that the patch may not be able to deliver enough insulin.

Regardless, scientists say both technologies will expand treatment access to hesitant, needle-fearing patients. And that's a relief for many.

DISCUSSION QUESTIONS

Why is this research important in the world of medicine?

What other medical conditions, like diabetes, would benefit from having patches and pills as treatment alternatives?

VOCABULARY

INSULIN

MICRONEEDLE

ROBOT



The Amazon River: A Bridgeless Wonder

By Christina Hooton

The Amazon River in South America is one of the longest rivers in the world, measuring over 4,300 miles. It spans three countries — Brazil, Peru, and Columbia — is home to hundreds of species of fish and other marine life and serves as a source of water and food to more than 30 million people. Despite all its attributes, it lacks one thing — bridges.

This makes the Amazon River somewhat of an anomaly compared with the other great rivers of the world. For example, the Nile River in Africa, also the closest in length, has nine bridges, while the Danube in Europe, only a third of the size, has 133. The Yangtze River in China, the third largest in the world, has more than 100 bridges. Here are a few reasons the Amazon River is different.

Undeveloped Lands

From its headwaters in the Andes Mountains to its delta on the Atlantic Ocean, the Amazon River stretches through many sparsely

populated areas. Dense rainforest surrounds most of it, and there are very few major roads for bridges to connect to. In the cities and towns that do border the river, ferries and boats are used to transport goods and people, so they simply don't need bridges.

"There is no sufficiently pressing need for a bridge across the Amazon," said Walter Kaufmann, PhD, chair of structural engineering, Swiss Federal Institute of Technology Zurich, in a *Live Science* article.

Challenging Terrain

Building a bridge across the Amazon River would present a number of challenges for engineers. For one thing, its width and depth fluctuate from season to season. From June to November, known as dry season, its width ranges from two to six miles on average. But during wet season, from December through April, the river grows as wide as 30 miles and can be 50 feet higher than normal.

The river's soft soils and marshes present another obstacle. They would require long access viaducts and deep foundations, according to Kaufmann, solutions that would require a significant financial investment.

Future Plans

Although there would be many difficulties to overcome when building a bridge across the Amazon, there is much political interest

surrounding the idea. Jair Bolsonaro, the current President of Brazil, declared his desire to build a bridge that crosses the Amazon as part of his Rio Branco Project.

Provisional plans were developed for a bridge in the Upper Amazon. However, some wonder if the economic need for a bridge truly outweighs the financial burden and difficulties of building one. There is also the issue of conservation. This project could provide greater access to half of the country's remaining Amazon rainforest, something conservationists are keen to prevent.

Although its fate seems as unpredictable as the water it holds, this natural treasure remains relatively unspoiled — for now.

DISCUSSION QUESTIONS

Several obstacles stand in the way of building bridges across the Amazon. What other challenges can you think of?

In what ways would bridges change the Amazon River and its surrounding ecosystems and communities?

VOCABULARY

HEADWATERS

DELTA

VIADUCT

CONSERVATION



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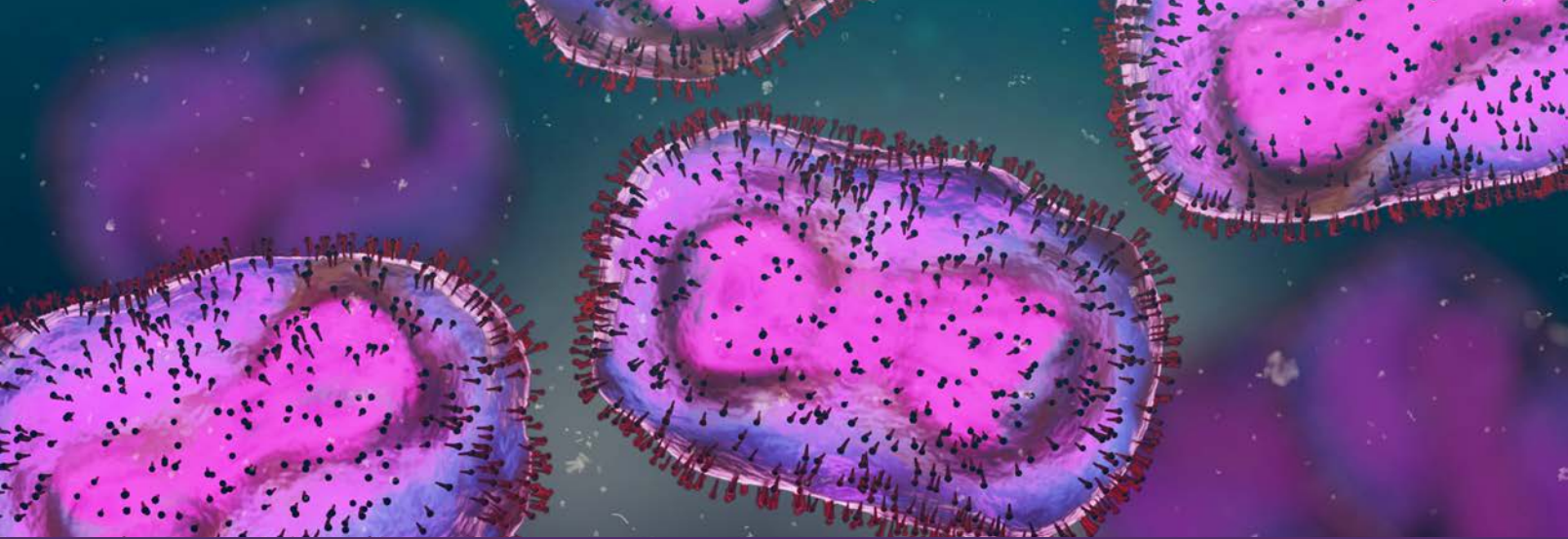
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Monkeypox Outbreak Sparks New Research

By Kylie Wolfe

A virus thought to be largely eradicated has resurfaced around the world. Scientists are studying its path to learn more about its transmission and help society limit its spread.

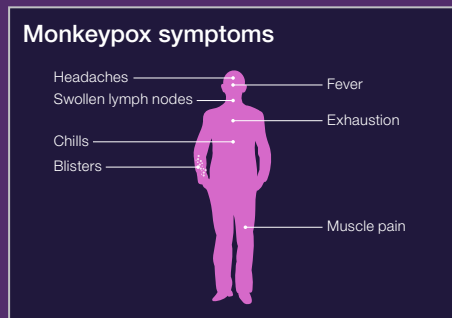
Monkeypox, a rare form of smallpox, is typically found in West and Central Africa. The disease is characterized by flu-like symptoms, including fever, headaches, lymph node swelling, and blisters. As of June 2022,

Congo Basin strain and the West African strain. The former has a 10 percent mortality rate and the latter a 1 percent mortality rate. The current outbreak seems to include only the West African strain.

Monkeypox spreads via skin-to-skin contact or respiratory droplets. Fortunately, it's not as transmissible as other viruses and can be contained by isolating infected patients. Also, the drugs and vaccines used to treat and prevent smallpox can do the same for this virus. Most people infected with it recover within a few weeks. Scientists are optimistic because it appears that monkeypox is not becoming more transmissible.

"We get concerned when we see a virus doing things that we don't normally see it doing," Anne Rimoin, an epidemiologist at the University of California, Los Angeles, told *Science*. "We now have to really reevaluate what we know about monkeypox — which has all been gleaned, essentially, from low-resource settings in Africa — in very, very different kinds of populations."

Even though the risks are low, it's important to be aware of the signs and how it can spread. As scientists do their part to learn more about this virus and its characteristics, you can do the same — for your own health and those around you.



the World Health Organization reported 3,413 cases across Africa, the Americas, the Mediterranean, Europe, and the Western Pacific region.

Looking Back

The monkeypox virus, from the *Orthopoxvirus* genus, was first discovered in monkeys in 1958. The first case in humans was confirmed in 1970. But despite its namesake, the virus most likely originates in rodents and other small mammals.

There are two prominent strains of monkeypox, the Central African or

Genetic Findings

Because monkeypox is a DNA virus, it's double stranded and more stable than a single-stranded RNA virus like SARS-CoV-2. This causes it to mutate slowly and means the existing cases are genetically similar. SARS-CoV-2, on the other hand, mutated and created new variants quickly throughout the pandemic.

Researchers have already sequenced samples of the monkeypox virus, which is much larger than that of SARS-CoV-2. This helped them identify that the current outbreak originated in Portugal.

Current Concerns

While there have been occasional outbreaks of monkeypox in recent decades, they tend to fizzle out naturally. This outbreak is different because of its widespread global impact.

DISCUSSION QUESTIONS

- What's the difference between a DNA virus and an RNA virus?
- Why are scientists concerned about this outbreak of monkeypox?
- How can you help prevent the spread of this virus?

VOCABULARY

- MONKEYPOX
- OUTBREAK
- TRANSMISSION



Rising Bubbles Help Collect Trash

By Iva Fedorka



The creek behind Dakota Perry's house often contains plastic bags, bottles, cups, and other waste. She presented her idea for cleaning up the creek at the 2022 Regeneron International Science and Engineering Fair (ISEF) held in Atlanta, Georgia. Perry is a sophomore at W.P. Davidson High School in Mobile, Alabama.

Perry was one of more than 1,100 high school finalists who attended the 2022 ISEF. Another 500 students competed virtually. Regeneron ISEF, sponsored by the Society for Science, awarded nearly \$8 million in prizes at this year's science fair.

How the Bubble Barrier Works

Perry was inspired by the Great Bubble Barrier in Amsterdam. The Dutch system uses a curtain of bubbles rising from the water bottom to gather and move floating trash to the side of the waterway.

Perry's curtain of bubbles would span the creek diagonally to stop the trash from escaping and move it back toward the shore. She made her system greener by incorporating hydropower and a solar-powered battery-operated conveyor belt to collect and transport the debris to a dumpster.

Tweaking the System

First, Perry focused on fine-tuning the bubble curtain, using her father's garage as her workshop.

"That was the most important part to figure out," Perry explained to *Science News Explores*. "For the bubble system to actually work and actually collect the trash, I have to know how much pressure the air compressor is supposed to push out."

Then, Perry measured the flow of the creek water after a rainstorm, when more trash typically washed downstream, to test whether the bubbles would be affected by heavier currents. The creek water moved at about 1.3 meters per second.

To mimic the water flow conditions in her test environment (her backyard pool), she rented a water pump from a hardware store. Then she drilled rows of small holes (1.5 millimeters in diameter) into a plastic pipe that she connected to an air compressor. Perry adjusted the air pressure, gradually increasing it until the bubbles rose consistently as a vertical curtain.

Trash Testing

To test the curtain's ability to collect plastic bottles and other trash, Perry added empty, water-filled, and rock-weighted bottles to the

pool water. All of them were stopped by the curtain and then moved along the bubble barrier to its end.

Although she was sure the technique would work, she didn't expect it to work so well. The current created by the bubbles also pulled leaves and other pool debris to the surface, implying that trash from the creek bottom would also move upwards.

What's Next?

Perry plans to add a water wheel to the system to power the air compressor, connecting them by pulley systems. The concept has had real-world success and doesn't interrupt traffic flow or harm wildlife.

DISCUSSION QUESTIONS

Where else could this method be used to remove trash from water?

Which system parameters would need to be adjusted to accommodate other waterways?

VOCABULARY

CURRENT

DEBRIS

DOWNSTREAM





New Hydrogen Generation Method Holds Promise

By Iva Fedorka

Washington State University (WSU) researchers used a small amount of electricity and an ethanol and water mixture to produce hydrogen, an innovation that may allow remote production of the gas.

Like electric vehicles (EVs), hydrogen fuel-cell powered cars don't emit carbon dioxide but must be refilled at fueling stations. Since the automotive industry is one of the largest polluters, reduced emissions through clean fuel technologies would affect atmospheric and overall pollution worldwide.

The Challenge

Hydrogen gas must be transported under pressure to maintain fueling stations for this alternative and clean automotive fuel. However, transporting and storing hydrogen gas in fuel tanks is a significant economic and safety issue, so hydrogen gas infrastructure is limited in the United States.

The Problem with EVs

Many consumers are opting for hydrogen fuel cell vehicles to minimize the pollution from EVs.

EVs require electricity, and, since nearly 80 percent of the global power supply comes from coal, oil, or other fossil fuels that produce greenhouse gas emissions, EVs have considerable carbon footprints.

Another limitation of EVs is their batteries. Mining for lithium and other battery materials harms the environment when miners

pollute natural water sources and destroy mountainsides. Lithium batteries are also difficult to recycle and contribute to electronic waste.

New Technology

The Caustic Aqueous Phase Electrochemical Reforming or CAPER procedure was developed by WSU scientists. Starting with an anode and a cathode, they applied a small electrical current to a mixture of ethanol, water, and a catalyst. The result was pure compressed hydrogen and liquid carbon dioxide.

"The presence of the ethanol in water changes the chemistry," graduate student Wei-Jyun Wang, a co-lead author on the paper, told *ScienceDaily*. "We can actually do our reaction at a much lower electrical voltage than is typically needed for pure water electrolysis."

CAPER consumes less than half the electricity needed for water electrolysis, another method to produce hydrogen. And, instead of compressing the hydrogen afterward, they found it took less energy to compress the liquid ethanol mixture at the outset and produced already compressed and ready-to-use hydrogen gas.

"This is a new way of thinking about how to produce hydrogen gas," said Su Ha, professor in the Gene and Linda Voiland School of Chemical Engineering and Bioengineering, a corresponding author on the paper published in *Applied Catalysis A*. "If there are enough

resources, I think it has a really good chance of making a big impact on the hydrogen economy in the near future."

"We're already using ethanol-containing gasoline at every gas station," said Ha. "You can imagine that an ethanol water mixture can be easily delivered to a local gas station using our existing infrastructure, and then using our technology, you can produce hydrogen that is ready to pump into a hydrogen fuel cell car. We don't need to worry about hydrogen storage or transportation at all."

The researchers are working to scale up the technology and operate it in a continuous manner. They also are working to make use of the carbon dioxide captured in the liquid.

DISCUSSION QUESTIONS

- How does a hydrogen fuel cell work?
- What other processes use hydrogen as a fuel?

VOCABULARY

- | | |
|----------------|------------------------|
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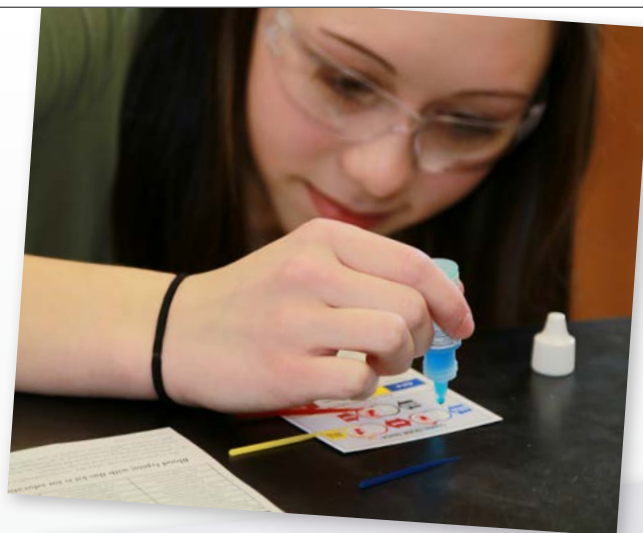
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Muography Moves Beyond the Pyramids

By Gina Wynn

When scientists discovered the presence of a hidden chamber inside Egypt's Great Pyramid of Giza in 2017 using muography, it drew attention to the scientific value of the technology that is now helping researchers study the interiors of volcanoes, see inside shipping containers, and more.

An Out-of-This-World Technique

Muography is used to determine the density of a structure or landmass by measuring how many subatomic particles called muons are absorbed as they pass through it. Muons form when particles in space — called cosmic rays — collide with atoms in the Earth's atmosphere. They continuously rain down on the Earth's surface at different angles at nearly the speed of light, penetrating (or bouncing off) rock and whatever else is in their path.

Muons even pierce through your thumbnails about once every minute, according to the *Science News Explores* article "Muons reveal the inner worlds of pyramids, volcanoes and more," by Emily Conover.

Particle Power

The successful use of muography in the Giza study that led to the discovery of the hidden space demonstrated that this type of particle physics could be useful in archaeology and in other disciplines as well. The details of the research were published in the November 2, 2017, *Nature* article "Discovery of a big void in Khufu's Pyramid by observation of cosmic-ray muons."

Muography can produce images of the insides of large objects without altering them, like the way X-ray or ultrasound machines in hospitals work on people. Unlike these other technologies, however, muography can span long distances and penetrate gigantic masses.

In the images, dark spots represent when muons bounced off large, dense objects, and bright spots indicate a gap that many muons were able to pass through. Color can also be used in the images: shades of red represent denser material and shades of blue mark less dense areas.

Muons are also plentiful and easy to detect with simple, compact devices that work with plastic strips and light sensors or photographic film. Common types of detectors include scintillation, nuclear emulsion, and gas. These devices can be placed in and around the structure being studied to gather data that helps map its internal density.

An Erupting Science

For some, muography offers an opportunity to better understand volcanoes and the danger they pose to communities. By creating a map of the channels inside a volcano and its other physical attributes, scientists may be able to learn how likely it is to erupt, potentially saving lives. If Mount Vesuvius that destroyed Pompeii, Italy, in A.D. 79 erupted again today, it would put 600,000 people living in the surrounding area in harm's way.

As part of the Muon Radiography of Vesuvius experiment (MURAVES), a research team has set up muon detectors a little less than a mile from the volcano's crater. After mapping muon and rock densities near its top, they found differences in density between the northwestern and southeastern sides. Their preliminary findings were published in the February 24, article "The MURAVES experiment: study of the Vesuvius Great Cone with Muon Radiography 2022," at arXiv.org.

The team surmised that the volcano walls have been thickened by new layers of material from

repeated eruptions. Knowing the strong and weak areas of Vesuvius's structure can help them predict where walls could collapse or landslides could occur. Thus, the people in the most dangerous areas could be evacuated at the first sign of an eruption.

Controlling Commerce

Muography may have everyday applications as well. Through an EU-funded project called SilentBorder (silentborder.eu), particle physicists are using muon detectors to prevent the smuggling of radioactive materials. They can perform non-intrusive inspections of cargo containers by measuring how muons scatter when they hit materials made of heavy elements like uranium.

Now that European customs officers have realized the value of muography, it's only a matter of time before other industries begin to harness the technology. The technique has come a long way since physicists first discovered muons in 1936 and wondered why they existed. Who would have thought that tiny particles from space would possess an unparalleled ability to uncover secrets of the past, expose concealed realms of the modern world, and maybe even predict natural disasters of the future?

DISCUSSION QUESTIONS

Have you ever had an X-ray? In what ways are X-rays similar to muography?

Name some other invisible particles that exist in our universe. Where do you find them?

VOCABULARY

[PARTICLE PHYSICS](#) [SUBATOMIC](#)

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How Sophisticated Is Chimpanzee Speech?

By Iva Fedorka



The ways that animals communicate with each other may be simple compared to human language.

Researchers at the Max Planck Institutes for Evolutionary Anthropology (MPI-EVA) and for Cognitive and Brain Sciences (MPI-CBS) in Leipzig, Germany, and the CNRS Institute for Cognitive Sciences in Bron, Lyon, France, recorded the vocalizations of chimpanzees in Tai, Ivory Coast for clues to language development in humans.

They made 4,826 recordings (980 hours) of 46 wild adult chimpanzees in three different communities, all of whom were habituated to human observation.

Let's Talk

Evolutionary science has not yet explained the origins of human language, which uniquely and flexibly combines sounds into words and words into a limitless number of sentences. And although the sequences produced by other animals seem relatively limited, most studies to-date haven't examined the full flexibility and structure of vocal sequences in other animals.

Humans use language by combining sounds to form words and then using the words to produce structured sentences. To understand the origin of language, researchers have typically compared the vocal production in primates and other animals to that in humans.

The complexity of human language does not lie in the number of sounds we make (below 50 in most languages), but in the way we combine those sounds to express ourselves. Non-human primates use nearly as many different calls to communicate but had not been observed to routinely combine them into vocal sequences.

Chimpanzees were found to communicate with each other using 38 different calls, up to ten call types, and hundreds of varying sequences. The combination of specific calls seemed to predictably recur in certain positions in the sequence.

Observations

"Observing animals in their natural social and ecological environment reveals a previously undiscovered complexity in the ways they communicate," first author Cédric Girard-Buttoz told *ScienceDaily*. "Syntax is a hallmark of human language and in order to elucidate the origin of this human ability it is crucial to understand how non-human primate vocalizations are structured," adds Emiliano Zaccarella, another lead author of the study.

"Our findings highlight a vocal communication system in chimpanzees that is much more complex and structured than previously thought," says co-author Tatiana Bortolato who recorded the vocalizations in the forest. "This is the first study in a larger project. By studying the rich complexity of the vocal sequences of wild chimpanzees, a socially complex species like humans, we expect to bring fresh insight into understanding where we come from and how our unique language evolved," Catherine Crockford, senior author on the study, points out.

Findings

Chimpanzees produced 390 unique vocal sequences. These included two single units voiced as a "bigram" sequence, and some of which were then embedded in three-unit "trigram" sequences (trigrams). Bigrams showed positional and transitional regularities within trigrams and certain bigrams occurred at the beginning or end of a trigram or with other specific units.

- The single-unit calls of chimpanzees seem specific in a range of contexts, including alarm, hunting, feeding, and greeting
- Chimpanzees use single units within numerous vocal sequences in loud calls (pant hoot) and in sequences voiced during feeding, nesting, fusion, greeting, and travel
- The acoustic structure of calls within a vocal sequence is the same as when they are single calls

These characteristics give chimpanzees a suitable vocal system for further study.

Conclusions

The authors postulate that a language system that communicates flexible meanings requires at least:

- Flexibility – most sounds or calls in the vocal repertoire can be combined with most of the others
- Ordering – Single units within sequences follow specific rules or patterns
- Recombination – independent short sequences are combined into longer sequences

Although there is no evidence that non-human species demonstrate all three characteristics, the authors believe that previous studies may not have looked for them in the same way. Researchers have heretofore rarely evaluated the entire vocal repertoire of non-singing species, so drawing definitive conclusions about animal vocal sequences may be premature.

The meaning of the study was not assessed nor has a quantitative examination of vocal sequence patterning been conducted. The authors intend to further investigate the meaning of these complex and structured vocal sequences and whether chimpanzees regularly increase the range of topics they "talk" about.

DISCUSSION QUESTIONS

Do you think that all animals have a way to communicate with others of their species? If so, what evidence is there?

What are the current theories about plant communication?

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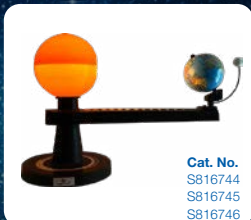


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