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Spring 2022



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spaces

Curbing Your Sweet Tooth

By Iva Fedorka

According to a study published in the journal *Circulation* in 2021, reducing the sugar content of packaged foods by one-fifth and in beverages by 40 percent could prevent 2,480,000 strokes, heart attacks, and cardiac arrests; 490,000 cardiovascular deaths; and 750,000 cases of diabetes in the United States over the lifetime of living adults (ages 35 to 79).

About the Study

Researchers from Massachusetts General Hospital (MGH), the Tufts University Friedman School of Nutrition Science & Policy, T.H. Chan School of Public Health at Harvard, and the New York City Department of Health and Mental Hygiene (NYC DOH) collaborated to create a simulation model to explore the effects of these changes.

The model was designed to quantify the health, economic, and equity impacts of a sugar-reduction policy proposed by the U.S. National Salt and Sugar Reduction Initiative (NSSRI). In 2018, this partnership of over 100 local, state, and national health organizations released targets for reducing sugar in 15 categories of packaged foods and beverages.

Voluntary Compliance or Policy

In February 2021, the policy for voluntary product reformulations by manufacturers was finalized. The study participants hope that the model will help create more awareness of and lay the groundwork for the production of foods and beverages that contain significantly less sugar.

Of course, an official national policy would require legislation that specified ways to monitor and report on the progress of food and beverage companies. Nevertheless, reducing sugar in commercially prepared foods and drinks is expected to have more health impact than a tax on sugar, sugar content labeling, or even barring sugary drinks in schools.

Potential Outcomes and Benefits

If the NSSRI policy remains in effect for 10 years, the model projects savings of \$4.28 billion in total net healthcare costs and \$118.04 billion over the adult population's lifetime. Add in the costs of lost productivity from sugar-related diseases, the savings rise to \$160.88 billion.

Achieving the NSSRI targets could increase quality-of-life years (QALYs) by 6.67 million and save \$160.88 billion in societal net costs. Projections predict cost-effectiveness in six years, highly cost-effectiveness in seven years, and cost-savings starting at nine years. In fact, the use of more conservative figures may be underestimating the potential financial benefits.

Conclusions

The regular consumption of high-sugar foods and beverages is linked to weight gain, obesity, Type 2 diabetes, heart disease, and other cardiovascular risk. Almost a third of U.S. adults are obese, half are diabetic or prediabetic, and almost half have some type of cardiovascular disease.

The United Kingdom, Norway, and Singapore have led the sugar-reformulation efforts to date. Product changes in the U.S. have successfully reduced trans fats, sodium, and other harmful ingredients from foods, but no specific sugar-reduction efforts have been made.

Implementing and achieving the NSSRI sugar reformation targets could produce substantial health gains, equity gains, and cost-savings in less than a decade.

DISCUSSION QUESTIONS

How does too much dietary sugar affect the incidence of cardiac disease?

Have you checked the sugar content for the foods and drinks you enjoy?

VOCABULARY

[CARDIAC](#)

[QUALITY OF LIFE](#)

[CARDIOVASCULAR](#)

Complex Development Patterns Found in Simple Biofilms

By Mark Miller

Research from the University of California San Diego reveals that simple bacterial communities called biofilms may be more advanced than first believed. *ScienceDaily* reports that Gürol Süel, a biological sciences professor at UC San Diego, and researchers from Stanford University and the Universitat Pompeu Fabra in Spain, have found that biofilms can be organized in complex patterns.

Biofilms are found throughout the world, from kitchen counters and boat hulls to the surface of your teeth. These basic clusters of bacteria produce a substance that helps them adhere to living and non-living surfaces. They were long thought unable to develop in complex, regulated patterns like the multicellular structures found in plants and animals.

“From a biological perspective our results suggest that the concept of cell patterning during development is far more ancient than previously thought,” said Süel. “Apparently, the ability of cells to segment themselves in space and time did not just emerge with plants and vertebrates but may go back over a billion years.”

According to a report in *ScienceAlert*, the research showed that biofilms grown in labs can demonstrate patterns of concentric rings or waves, much like those in tree rings or developing embryos. In multicellular organisms, this type of patterning is known as segmentation and is part of tissue and complex body form development.

The rod-shaped bacterium *Bacillus subtilis* — typically found in soil, humans, and biofilms — was used in the research. The team deprived the bacterium of nitrogen to help create a stressful growth environment. As the biofilm consumed nutrients and grew, a “wave” of nutrient depletion moved across the cells to create an elaborate pattern of repeating segments.

Because biofilms are so pervasive, implications of the research could be far reaching. Their commonplace nature creates investigative and developmental opportunities in fields as diverse as medicine, the food industry, and beyond.

The discovery is certainly important for developmental biology. According to *ScienceDaily*, Süel sees bacteria as a new way to study developmental patterns. “Having a bacterial system allows us to provide some answers that are difficult to obtain in vertebrate and plant systems because bacteria offer more experimentally accessible systems that could provide new insights for the field of development.”

DISCUSSION QUESTIONS

Discuss the general topic of developmental biology. What is it, and can you provide an example of how an organism develops?

What are the differences between multicell and single-cell organisms?

VOCABULARY

CELL

BACTERIA

NITROGEN



Supporting Advances in Personalized Medication

Content provided by:



Advances in pharmacogenomics and personalized medicine have led to a major focus on laboratory research.

Though personalized medicine has been around in one form or another for many years, recent scientific advances have cast a light on its current and future efficacy. We may share anatomy and organic functionality, but our genetic codes, hereditary makeup, and the environments in which we live can all impact how our bodies respond to treatment. In short, one size does not fit all.

Diseases can occur in different genetic variants. Just as we all have different reactions or non-reactions to allergens, so do we respond differently to medical treatments. After many years of trying to treat diseases with one-size-fits-all treatments that were thought suitable for any given disease, we now definitely know that individual characteristics can affect our response to drug treatments. And so, we've opened up the study and practice of a revolutionary approach to precision medicine that can be customized on a personal level.

From Allergies to Cancer and Everything in Between

Some of the earliest practices of personalized medicine appeared in the treatments of allergies and asthma. Allergen immunotherapy (AIT) treatments date back more than 100 years and were perhaps the first medical practices to take a truly customized approach to treatment. As far back as 1911, allergists recognized that diagnosing patients to treat their specific symptoms could be a much more

effective way of alleviating the respiratory symptoms of a range of allergies, including hay fever and rhinitis.

For many years, allergists have prescribed named patient products (NPPs) that are specifically prepared for a patient based on the results of allergy testing. This practice has come a long way in the century since it was introduced. Today, AIT takes into account molecular diagnostics for achieving the highest possible precision.¹

The concept of personalized medication now goes far beyond allergy treatment. Precision medication methods identify phenotypes of patients with less-common responses to treatment or unique healthcare needs.²

Sophisticated diagnostic tools inform clinicians of non-genomic and genomic determinants, which, when combined with patient symptoms, clinical history, and lifestyles, can allow for more precise and personalized diagnosis and prognostication. This has been especially critical in treating cancer patients and those suffering from a host of genetic and non-genetic hereditary diseases.

Active research in precision medicine is now converging with artificial intelligence to create extraordinary therapeutic and diagnostic possibilities. These advances have spawned a new discipline known as pharmacogenomics, which seeks to identify the variant genes that affect an individual patient's response to drugs. Pharmacogenomic analysis can identify disease susceptibility genes representing potential new drug targets. All of this will lead to novel approaches in drug discovery, an

individualized application of drug therapy, and new insights into disease prevention.³

The synergy between personalized medicine and AI, and their impact on the healthcare system, aligns with the ultimate goal of prevention and early detection of diseases affecting the individual, which could ultimately decrease the disease burden for the public at large and, by extension, the cost of preventable healthcare for all.²

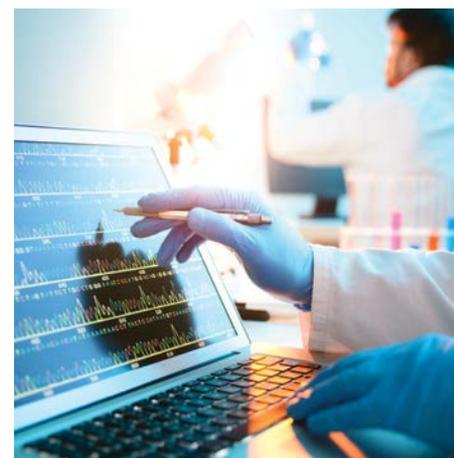
OHAUS Plays a Small but Important Role

For scientists to continue researching and testing in the growing and evolving field of pharmacogenomics, they need the right laboratory equipment. This is where OHAUS enters the picture.

Scientists rely on a range of precision laboratory instruments to help analyze samples. Among them are products OHAUS specializes in offering, such as centrifuges, vortex mixers, and hotplate/stirrers.

References

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2. "Precision Medicine, AI, and the Future of Personalized Healthcare," Johnson, Kevin, et al, Vanderbilt University Medical Center
3. "Pharmacogenomics: The Promise of Personalized Medicine," Mancinelli, Laviero, et al, University of California San Francisco Department of Biopharmaceutical Sciences, 3/7/2000





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Ingeniously Practical

Cool Science: Reusable Ice Cubes

By Christina P. Hooton

It doesn't get any cooler than this: Researchers at the University of California, Davis, are developing reusable ice cubes. Made from a hydrogel similar to Jell-O, these gel cubes can be reused roughly 10 to 12 times and are compostable. If proven effective, they could become an eco-friendly alternative to ice packs and lead to other food innovations.

Ice, Ice Baby

True to their name, hydrogel ice cubes contain gelatin, but they are mostly composed of water — 90 percent to be exact. Unlike regular ice cubes, which melt when exposed to heat, gel ice cubes trap the water in their structure, so they can be thawed and refrozen many times without losing their shape. Moreover, when an ice cube melts, the liquid is released and can carry bacteria to other foods, causing cross-contamination. Hence, gel ice cubes present a potentially cleaner alternative.

When compared with the cooling power of regular ice cubes, gel cubes come close. Researchers tested their effectiveness by packing foam-insulated containers with food samples and either gel or ice cubes. After almost an hour, ice-cooled samples reached 38°F, while gel-cooled samples reached 40°F.

Strength was another factor put to the test. When researchers increased the gelatin content, the cubes became stronger. However, higher gelatin percentages showed lower cooling efficiency. Gel cubes containing 10 percent gelatin had the best balance of cooling power and strength.

Skating on Thin Ice

With all their promise, gel ice cubes still present some challenges. They are more expensive than regular ice cubes, but reusability can help justify the price. The research team is already working to enhance stability by improving the connections between proteins in the gel's sponge structure.

Additionally, the gelatin might attract microbes. Although the cubes don't melt, they could still come in contact with other food and absorb bacteria. The gel cubes can be cleaned using bleach, but the gel might absorb the bleach and release it onto food, introducing safety concerns.

Another issue is that the gelatin itself is an animal product vegetarians would likely avoid.

Although there are some hurdles to overcome before gel ice cubes become mainstream,

the food industry could use this technology for other applications, such as freezing food. When food is frozen, its cells are destroyed by large ice crystals, causing changes to the taste and texture. The polymers in hydrogels could help control the size of these ice crystals, better preserving the quality of the food.

Gel ice cubes may be on ice for now, but the potential of hydrogel technology for food preservation is just starting to heat up.

DISCUSSION QUESTIONS

If proven viable, how could gel ice cubes benefit the environment?

What applications besides food preservation might benefit from gel ice cubes?

VOCABULARY

HYDROGEL GELATIN

CROSS-CONTAMINATION



How Climate Change Is Expanding the Troposphere

By Kylie Wolfe

Climate change is all around us. Maybe you've noticed warmer temperatures, excessive droughts, or changing weather patterns. There are plenty of examples in nature, but some aren't as easy to spot.

Scientists at the University of Toronto found yet another sign of global warming. The troposphere, the layer of the atmosphere closest to Earth's surface, has expanded by 165 to 200 feet per decade over the last forty years. These findings were published in *Science Advances* on November 5, 2021.

Layers of the Atmosphere

The Earth's atmosphere has five distinct layers: troposphere, stratosphere, mesosphere, thermosphere, and exosphere. Each layer has the same composition of gases, but their molecules get farther apart when they're farther away from Earth. In its entirety, the atmosphere extends from Earth's surface to 6,200 miles in the sky. It acts as a shield, making the planet livable by keeping it warm, giving us access to oxygen, and preventing excess evaporation.

The layer known as the troposphere holds water vapor and moisture, and it provides the right conditions for cloud formation. It varies in height depending on one's location; it can be

up to 12.4 miles thick above tropical zones and only 4.3 miles near the northern and southern poles.

It's typical for the troposphere's upper boundary, known as the tropopause, to rise and fall from season to season. Warmer air temperatures cause it to expand and cooler air temperatures to contract. But what's been occurring over the last few decades is an accumulation of greenhouse gases.

Some amount of greenhouse gases, such as carbon dioxide, methane, and nitrous oxide, in the atmosphere is natural. Unfortunately, these gases trap heat and, with more of them present due to human activities like driving cars and producing goods, increase warming. That jump in temperature is what's causing the lower atmosphere to expand.

The Toronto-based research team collected their data using weather balloons. As they ascended, the balloons took numerous measurements to help the scientists reach their conclusion.

A Word of Caution

"We see signs of global warming around us, in retreating glaciers and rising sea levels," Jane Liu, contributing researcher from the

University of Toronto, told *Science News for Students*. "Now, we see it in the height of the troposphere."

Even though the troposphere is home to practically all weather, researchers find it unlikely that the changes they see will affect the severity or frequency of the weather we experience. But they caution that it's yet another example of how climate change is changing our world.

DISCUSSION QUESTIONS

What signs of climate change are you familiar with? Make a list.

Draw a diagram of Earth and its atmosphere to explain why the troposphere is expanding. Use terms like "greenhouse gases," "rising temperatures," and "air molecules" to get started.

VOCABULARY

ATMOSPHERE

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Snail Slime and Gold Could Make Powerful Sunscreen

By Christina P. Hooton

Imagine reading the ingredients label on your bottle of sunscreen and seeing snail slime or gold. That may one day be a reality thanks to Italian researchers who tested the light-reflecting and absorbing power of gold nanoparticles combined with snail slime. Together, they may create a powerful, eco-friendly substance that is more effective than current sunscreens on the market.

A Slimy Substance

Scientists started their experiment by harvesting slime from the brown garden snail using an ozone-filled chamber that encourages slime production. They then mixed that slime with gold atoms dissolved in water. As a reduction agent, the snail slime gives electrons to gold, changing it from Au^{3+} to Au^0 , the metal form of gold. This form of gold doesn't dissolve in water. Its individual atoms form nanoparticles.

Reflecting Light

Traditional sunscreens work by reflecting sunlight with ingredients like zinc or titanium. Alone, gold reflects more light than these ingredients. When combined with snail slime, its sun-protecting power is boosted. That's because snail slime absorbs light while gold

reflects it. Slime-coated gold won when the team compared its light-reflecting ability with plain gold nanoparticles. This proves the mixture could result in a higher SPF sunscreen.

Better for Skin and the Planet

Gold nanoparticles are traditionally made using chemicals that release pollutants. Snail slime presents a greener way to do this.

Additionally, snail slime is good for skin. It can hydrate and lighten age spots. Combined with gold nanoparticles, it can help remove oxygen radicals from the skin. Oxygen radicals are produced by the body normally, but too many can be harmful. They can also make sunscreen less effective. Antioxidants are added to sunscreen to fight radicals. The gold nanoparticles being studied by Italian researchers can also serve this purpose.

Challenges Remain

Not all gold nanoparticles are created equal, though. The shape and size of a nanoparticle can give it different traits and control which chemicals it reacts with. This doesn't work for commercial products, which need to perform consistently. Snail slime may be disrupting the nanoparticles' perfect harmony. It contains

a variety of molecules, including peptides, carbohydrates, and proteins, that could be causing different reactions.

Scientists could solve these issues using a centrifuge, which separates different-sized particles, or by changing the thickness of the mixture by adding sugar.

No matter how it shakes out, snail slime and gold sunscreen is oozing with potential.

DISCUSSION QUESTIONS

Think of other personal care products derived from naturally occurring elements. What benefits do they provide?

Brainstorm other potential uses of gold nanoparticles and snail slime. Can their properties benefit other industries?

VOCABULARY

NANOPARTICLES TITANIUM

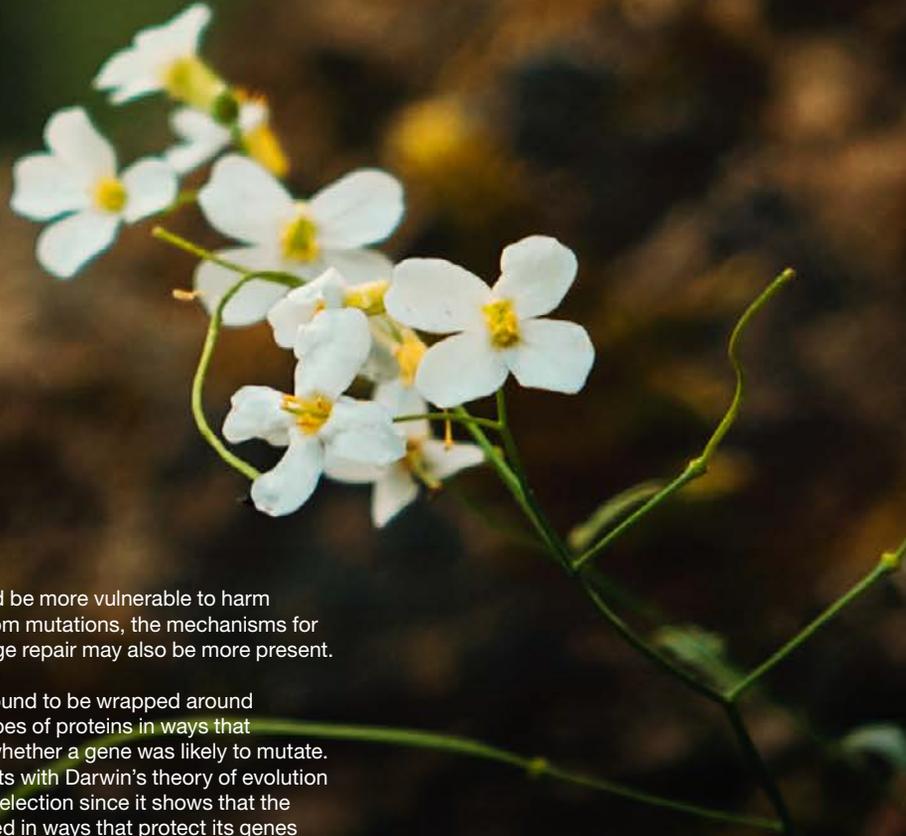
ATOMS ANTIOXIDANT

ZINC CENTRIFUGE



Evolution Is Not Random

By Iva Fedorka



New research from the University of California, Davis, and the Max Planck Institute for Developmental Biology in Germany found that DNA mutation is not random, as previously believed.

Their results, published in 2022 in the journal *Nature*, challenge current thinking about evolution. Since early in the twentieth century, it was believed that mutations (and their effects) occur randomly. The researchers were looking for confirmation of that belief but found something unexpected instead.

Starting with the Genome

Three years were spent sequencing the DNA of thale cress (*Arabidopsis thaliana*), a flowering weed with the relatively small genome (roughly 135 million base pairs*). The specimens at the Max Planck Institute were grown in the lab to provide a controlled space for any defective plants that would be unable to survive in nature.

More than one million mutations were uncovered while processing hundreds of plants; these appeared in nonrandom patterns. Instead, patches of the genome had lower mutation rates. These sections also included more essential genes, like those related to cell growth and gene expression.

Protection from Mutations

These important regions in the genome appear to be protected from mutation. Since these

areas would be more vulnerable to harm resulting from mutations, the mechanisms for DNA damage repair may also be more present.

DNA was found to be wrapped around different types of proteins in ways that predicted whether a gene was likely to mutate. This conflicts with Darwin's theory of evolution by natural selection since it shows that the plant evolved in ways that protect its genes from mutation and therefore improve its survival.

Mutations occurred less often in functionally constrained regions of the genome: frequency is halved inside genes and reduced by more than 60 percent in essential genes. The observed mutation frequencies also accurately predict patterns of genetic polymorphisms.

Implications for the Future

Plant breeders rely on genetic variation to develop better crops and could benefit by understanding which regions of the genome tend to mutate more than others. Scientists could also better predict or develop new treatments for cancer and other diseases that result from mutations.

These discoveries produce a more complete picture of the patterns of natural variation and may lead to new theoretical and practical research on the evolutionary role of mutation.

*By comparison, the human genome has approximately 3 billion base pairs.

DISCUSSION QUESTIONS

Who was Charles Darwin and what were his contributions to science?
Is cancer always caused by DNA mutations?

VOCABULARY

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MUTATION

GENOME



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CORNING

A New Type of Plastic May Mean Less Litter in Our Oceans

By Mark Miller

Plastic makes up 80 percent of the litter in the world's oceans. One of the reasons for this is that it takes so long to degrade — hundreds of years by some estimates. But a new variation on an old type of plastic that allows seawater to break it down in just weeks may hold hope for cleaner oceans.

While much of the plastic we use today is made from fossil fuels, a biodegradable plastic that originated in the 1930s made from corn and potato starch is showing new promise. Called polylactide (PLA), it proved to break down faster than conventional plastic — but only in compost, not in water, soil, or seawater.

PLA is a polymer. A polymer is a molecule formed by linking building blocks called monomers together to form a long chain. As reported in *Science News for Students*, Timo Rheinberger, a PhD student at the University of Twente in the Netherlands, is using genetic science to weaken the links in PLA's monomer chain to help it break down faster in seawater.

Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) are the genetic molecules that operate all living things. DNA contains the

instructions that RNA uses to help make enzymes, proteins, and other substances in cells. DNA contains the instructions and lasts longer. An RNA molecule breaks down after it has carried out its instructions.

Rheinberger and his colleagues took advantage of this behavior. They used parts of RNA molecules to weaken the links of PLA monomer chains. RNA contains chemical groups called hydroxyls that attract water. When these hydroxyl-containing portions of RNA are introduced into PLA's monomer chain, seawater attacks them and the chemical reaction speeds up the breakdown of the links in the chain.

With 15 percent of PLA's monomer links weakened, Rheinberger's study showed that the links broke down completely in two weeks. With only three percent weakened, it took about two years. The variation suggests that weakening PLA's monomer links can be used to control how quickly — or slowly — they degrade.

Rheinberger believes that more testing is needed. "You need a lot of material to start

those studies," he said, and his team has made only small amounts of modified PLA.

Someday, this modified PLA could find its way into everyday items like cups and plates. It could also be used in 3-D printers, in sutures, and in other industrial and biomedical applications. Hopefully, should it eventually find its way into our oceans, it will disappear much faster than conventional plastic does now.

DISCUSSION QUESTIONS

Talk about the effects of plastics pollution in oceans. How big is the problem, which areas are most affected, and what are some of the potential consequences?

Discuss polymerization. What is the nature of the chemical reaction of molecules when they combine?

VOCABULARY

POLYMER

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MONOMER





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The Healthcare Industry Is Hiring

Exploring Allied Health Roles That Go Beyond Patient Care

By Gina Wynn

There are many factors to consider when choosing a career. If industry growth, job security, opportunities for advancement, and earning potential are important to you, consider a future in healthcare. Even if you can't bear the site of blood and needles, there are plenty of healthcare roles that may suit your strengths and interests.

Personal and public health has been top of mind for most of us since the COVID-19 pandemic began. The critical need for healthcare workers has become apparent as hospital staff have been overwhelmed by record numbers of patients, and teams at COVID-19 testing centers and labs have been struggling to keep up with demand.

Even before the pandemic, reports had predicted the shortage of healthcare workers mostly due to an aging population that will continue to require more specialized healthcare services. Between 2000 and 2030, the number of Americans age 65 and over is expected to double, according to the Centers for Disease Control and Prevention. In addition, many physicians are getting older and nearing retirement, contributing to a growing need for more doctors.

Opportunities Within Allied Health Professions

This shortage also extends to allied health professionals — healthcare workers who aren't doctors and nurses — who are essential for keeping different parts of the healthcare system operating smoothly. Examples include cytotechnologists, radiologists, phlebotomists, diagnostic medical sonographers, respiratory therapists, dental hygienists, industrial hygienists, dietitians, speech language pathologists, healthcare administrators, and many other roles.

Employment in healthcare occupations is projected to grow 16 percent from 2020 to 2030 according to the Bureau of Labor Statistics, with the addition of about 2.6 million new jobs. This growth is much faster than the average for all occupations combined. In fact, healthcare is expected to add more jobs than any of the other occupational groups.

Demand for Your Skills and Job Security

These statistics suggest that if you choose to pursue a career in healthcare, your skills will most likely be in demand for the foreseeable

future and you should be able to find a job relatively easily once you complete the academic requirements for your field. You may also have more job security and opportunities for advancement.

In addition, for many healthcare roles, you will be able to live and work in almost any region of the United States. If you prefer or agree to work in a rural area where the deficit of healthcare workers is even more pronounced, you may also qualify for a college loan repayment/forgiveness program. This may prove to be an important benefit if you need help paying for school. You can view a list of Health Professional Shortage Areas at [data.HHS.gov](https://data.hhs.gov).

Employment in healthcare occupations is projected to grow 16 percent from 2020 to 2030, according to the Bureau of Labor Statistics, with the addition of about 2.6 million new jobs.

Education and Earning Potential

As for education, some healthcare careers require as little as 12 to 24 months of school at the community college level or as many as 8 to 13 years of specialized education after high school. Oftentimes, once you become established in a healthcare field, your employer may encourage you to further your education by reimbursing your tuition expenses and giving you time off to attend classes.

Generally, your earning potential in healthcare will increase with the amount of education and experience you gain in your specialty area (except for when demand for a skill exceeds the supply of workers, as it has for traveling nurses during the pandemic). A physician who goes to medical school for 13 years will earn more than a medical assistant with a high school diploma and a certificate from a one-year community college program. As reported on [explorehealthcareers.org](https://www.explorehealthcareers.org), on average, you can expect to make \$15 to \$50 per hour for an entry-level healthcare position.

Careers Beyond Patient Care

If you are interested in healthcare, but don't necessarily want to interact with patients, there are options for you as well. With an associate or bachelor's degree, you can work as a medical laboratory technician who uses scientific equipment to analyze patient specimens. If you are good with computers and data, health information management is an option. With a bachelor's degree plus another year of specialized training, you can become a blood bank technology specialist who tests and analyzes blood samples.

If you already have a bachelor's degree, consider pursuing a Master of Public Health degree, which would enable you to explore many different healthcare-related roles. To name a few, you could become a tropical disease specialist who studies serious diseases like malaria and works on the cutting edge of medicine. You could also become a management policy advisor who works on behalf of nonprofits or non-governmental organizations (NGOs) to shape healthcare policy. If you prefer to work in an office, you could also become a manager or director of a nonprofit or NGO that advocates for global or community health initiatives.

Contributing to the Greater Good

To learn more about your options in healthcare, talk to a career counselor at your high school, a local community college, or an accredited university. You can also find program-specific information on community college and university websites.

By pursuing a career in healthcare, you would not only enjoy professional stability and the opportunity for growth in your field, you would also engage in fulfilling work that impacts society and makes a meaningful difference in people's lives.

DISCUSSION QUESTIONS

Name some healthcare roles that don't involve working with patients. Why are these jobs important?

If you had to choose any career in the healthcare industry, what would you choose and why?

VOCABULARY

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Oceans Take the Heat, Set Record Temperatures

By Christina P. Hooton

The atmosphere is not the only thing getting warmer because of climate change. Ocean temperatures have reached record-breaking levels in the last three years, with 2021 being the hottest documented. Scientists reported these findings in *Advances in Atmospheric Sciences*, citing continued greenhouse gas emissions as the cause. Some of the excess heat building up in the atmosphere due to these emissions is absorbed into the oceans. From an increase in storm systems to dwindling marine habitats, rising ocean temperatures have far-reaching implications.

Casting a Wide Net

For the study, scientists collected and analyzed data from floating sensors positioned throughout the world's oceans, from the Antarctic circle to the tropics and beyond. Two international organizations manage these datasets: the Chinese Academy of Sciences and the National Oceanic and Atmospheric Administration within the United States Department of Commerce.

Tracking a Hot Streak

The data showed that the amount of heat in oceans last year increased by roughly 14 zettajoules, the equivalent of 20 times the entire world's annual energy consumption.

In addition, the previous five years had seen the five hottest ocean levels ever recorded. The 2018 level was a little lower than the 2017 record-breaker, but 2019, 2020, and 2021 each set their own new record-breaking levels. This is despite an ongoing La Niña event, a period of cool waters in the Pacific.

This pattern of warming has happened every decade since 1958, the rate of which has been increasing since the 1980s.

"The ocean heat content is relentlessly increasing, globally, and this is a primary indicator of human-induced climate change," said study co-author Kevin Trenberth in a statement to *Scientific American*.

Assessing the Damage

Warmer ocean temperatures can cause stronger, more extreme weather events such as heavy rain, thunderstorms, and tropical cyclones. This can have a deadly and destructive impact, especially on coastal towns.

Marine heatwaves and prolonged periods of warmer temperatures have also become more prevalent. This can displace the habitats of sea creatures by thousands of miles.

Additionally, as water heats up, it expands, which translates into rising sea levels. Melting glaciers exacerbate this problem. Another less desirable characteristic of warmer water is that it absorbs less carbon dioxide. With less carbon dioxide being captured by water, the atmosphere will heat up faster.

The documentation of rising ocean temperatures and their repercussions show just how interconnected climate change is, presenting both a challenge and an opportunity for humankind.

DISCUSSION QUESTIONS

Describe why the rate of ocean warming continues to increase.

Research the different animals and plants affected by warming oceans. How will their disruption alter ocean ecosystems?

VOCABULARY

GREENHOUSE GAS

MARINE

JOULE

ECOSYSTEM



Locusts Are Helping Scientists Understand Smell

By Kylie Wolfe



When you walk down a city street, you might smell pizza or coffee or bread as you pass a local shop. You might also smell exhaust from a car or trash from a nearby dumpster. These scents are distinct, and your brain doesn't hesitate to recognize the difference.

Researchers at the McKelvey School of Engineering at Washington University in St. Louis wanted to learn more about this odor-identifying process. The team observed the neural responses of locusts to better understand how the activation of certain cells translates to behavior. Their findings were published in *Proceedings of the National Academy of Sciences*.

Brain and Behavior

The research team began by training locusts to associate a smell with the promise of food. The locusts were given either hexanol or isoamyl acetate to smell, followed by grass to eat. Just like Pavlov's dogs, a famous example of classical conditioning, the locusts quickly learned to make the connection between

the odor and a snack and would open the appendages near their mouths known as palps.

When researchers assessed which neurons were active in the presence of an odor, they noticed different responses. Even though the patterns were inconsistent, the locusts exhibited the same behavior each time: opening their palps.

"The neural responses were highly variable," Barani Raman, professor of biomedical engineering at Washington University, told *Science Daily*. "That seemed to be at odds with what the locusts were doing, behaviorally."

Neural Response

Locusts sense the presence of an odor via olfactory receptor neurons in their antennae. These signals are transmitted and drive a response from other neurons. Even though the cellular responses varied, researchers saw the same physical action. To better understand, they defined two neural states: ON and OFF.

The ON neurons were active when an odor was present. The OFF neurons were active when an odor was not present. No matter

the experimental conditions, the ON neurons would activate in the presence of an odor and the locusts' palps would open. Therefore, if enough ON neurons were active and OFF neurons inactive, scientists could predict the locusts' behavior.

A Simple Conclusion

The Washington University research team has learned much about the brains and behaviors of locusts over years of study. One of their goals is to engineer a bomb-sniffing version of the species. For now, they're gaining a better understanding of the mechanisms these insects use to detect odors.

"We were surprised to find that this simple approach is all that was needed to robustly recognize an odorant," said Raman.

DISCUSSION QUESTIONS

What's the difference between ON and OFF neurons in this example?

What do these findings tell scientists about the relationship between the brain and behavior?

VOCABULARY

NEURON

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Conservationists Use Rewilding to Help Restore Ecosystems

By Kylie Wolfe

Animals of all shapes and sizes keep ecosystems in check, but human actions sometimes disrupt nature's balance. Teams across the globe are looking to restore various ecosystems by removing non-native species and reintroducing native species, animals that once called the areas home. Doing so could strengthen their habitats, creating healthier forests, curbing climate change, and helping society manage freshwater resources.

Restoring Balance

In the southeastern forests of Australia, an organization called Aussie Ark removed non-native foxes and feral cats that had been preying on local mammals. They reintroduced the Tasmanian devil, a carnivorous marsupial that helps protect native species by driving out non-native ones.

"The basic idea of rewilding is to give space for nature to do its job," Henrique Pereira, researcher at the German Center for Integrative Biodiversity Research, told *Science News for Students*. "The idea is to step back from trying to control nature." Now, the Tasmanian devils can do their own extermination work.

Fighting Climate Change

In Siberia, Russia, a different team is trying to restore an ecosystem that dates back thousands of years. The area used to be home to grazing animals and grasses, and the reintroduction of fur goats and camels is making that true once again.

This effort has been underway for 25 years and in that time, scientists have seen positive changes. New grasses are storing more carbon in their roots and the animals are keeping the soil frozen. Trampled ground stays 25 degrees Fahrenheit colder than untrampled ground. Keeping the soil frozen longer prevents

greenhouse gases like methane from escaping. This means recreating sustainable ecosystems could help scientists fight climate change.

Managing Water

In the state of Washington, biologists with the Tulalip Tribes Natural Resources Beaver Reintroduction Project are using beavers to improve salmon habitats and manage freshwater. These semi-aquatic rodents are nature's dam builders. When beaver-constructed dams begin to cause flooding, the team captures and relocates them to other areas.

In their new homes, they create cool pools of water where young salmon populations thrive. The beavers' efforts in rivers and streams also help form wetlands that keep wildfires from spreading and store water during dry spells.

Conservation for Generations

Conservationists leading these projects want to help society understand the importance of rewilding and the role animals play in various ecosystems. Their efforts represent only a subset of those taking place around the globe. Each example demonstrates how science can help reverse human actions that have negatively affected the planet. As more initiatives take place, conservationists hope to restore nature's balance — so it can be enjoyed for generations to come.

DISCUSSION QUESTIONS

What's the difference between native and non-native species and how do they affect each other?

Research other examples of rewilding. What did you find?

How can you be an advocate for conservation?

VOCABULARY

BIODIVERSITY ECOSYSTEM

CONSERVATION REWILDING

Mucus: The Body's Natural Barrier

By Mike Howie

Snot, boogers, nose gold — there are plenty of names for mucus, but why is it there? Whether congested with a cold or experiencing a runny nose on a cold day, you may have thought to yourself at some point, “Hmm, what does this stuff actually do?”

The short answer is that it's a kind of shield. Mucus protects sensitive parts of your body that are exposed to air but not protected by skin, like your eyes, throat, lungs, and digestive tract. Not only does mucus keep those areas moist, but it also catches unwanted substances like dirt, bacteria, and viruses that could make you sick or cause an infection.

A Sticky Barrier

When you inhale, you may be breathing in more than just air, particularly if you're in a dusty or dirty environment. You could also be breathing in pollen, for example, which might cause an allergic reaction. Or perhaps you could breathe in germs that could make you sick. Without mucus, those irritants would have an unimpeded path into your body.

Mucus is mostly made of water, along with salt and proteins called mucins that are covered in sugar molecules. The mucins have a negative electrical charge that attracts other molecules.

That makes mucus kind of like flypaper for tiny intruders. In the nose, it catches pollen, germs, and other microscopic particulates before they have a chance to get too far into your body. But then, of course, it has to go somewhere.

Within your nose, there are microscopic hairlike structures called cilia that move mucus toward either the throat or the front of the nose. Mucus that goes toward the throat is eventually swallowed, sometimes without you even noticing, and is broken down in the stomach. And any mucus that goes toward the front of the nose can easily be blown into a tissue and thrown away.

The mucus deeper inside the body, particularly the phlegm in your lungs, operates similarly. Think of when you've had a cold or flu that makes you cough. Sometimes a bit of phlegm will come up to remove irritants from the lungs. Basically, mucus provides a method for your body to destroy or remove harmful contaminants.

The Wide World of Goo

Mucus extends far beyond humans — many animals produce it, too. Even the family dog can come down with a runny nose or a phlegmy cough.

But there are also creatures that use mucus as more than just a protective barrier. For example, snails secrete a mucus that helps them get around, both pushing off and gliding on top of it. Some sea creatures, like hagfish and jellyfish, use it as a weapon to defend against predators. And biologists suspect that dolphins use mucus to make the clicking noise they use to find and hunt their prey.

Can mucus be funny? Sure, sometimes. Can it be gross, embarrassing, and annoying? Absolutely. But it's also a critical part of the body that helps us stay safe and healthy. In that respect, mucus is pretty cool.

DISCUSSION QUESTIONS

Mucus can often take on different colors. What can those colors tell us about the state of our bodies?

What other animals create mucus? How do they use it?

VOCABULARY

CILIA PHLEGM

MUCUS POLLEN





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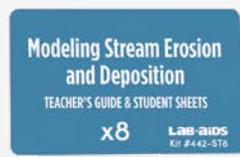
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Unexpected Particle Decay

Could Suggest New Fundamental Force

By Mike Howie

In March of 2021, a team of researchers colliding particles in the Large Hadron Collider at CERN under the border between France and Switzerland witnessed an event that could change physics as we know it.

The researchers were studying particles known as bottom or beauty quarks, one of the fundamental building blocks of matter according to the Standard Model of particle physics. They should decay into muons and electrons at the same rate after collision. Instead, something strange happened: the particles decayed into about 85 muons for every 100 electrons.

This suggests that there could be a fundamental force in physics that has yet to be identified.

The Standard Model

The Standard Model of particle physics is our best understanding of just about everything in the universe. It posits that all matter — stars, planets, people, even the paper or device you're reading this on — is made of two fundamental particles governed by four fundamental forces.

The two fundamental particles are quarks and leptons, both of which are divided into three pairs of particles. Quarks have the up quark and down quark, charm quark and strange quark, and the top quark and bottom (or beauty) quark. Leptons have the electron and

electron neutrino, muon and muon neutrino, and tau and tau neutrino.

The four forces are known as the strong force, the weak force, the electromagnetic force, and the gravitational force. Gravity is the weakest of these forces, and while it's identified by the Standard Model, it's not accounted for. So far, physicists have been unable to make it fit comfortably within the model.

While the Standard Model is indeed remarkable, it's not perfect. There are still facets of the universe that it fails to explain, like what dark matter really is and what happened to antimatter after the big bang.

However, the mysterious force witnessed at CERN could be one small step toward a more complete understanding of what makes the universe tick.

Measured Excitement

The researchers involved in the study hesitate to say that they've made a discovery. There's about a one in 1,000 chance that their results could be a statistical fluke, which is far from the one in 3.5 million chance that's the conventional threshold in physics for a discovery. But they're still celebrating.

"That's a small enough number to get us usually hyper-skeptical physicists at least cautiously excited," said Dr. Mitesh Patel of Imperial College London in England.

"I wouldn't say effusive but as excited as us physicists get."

According to CERN, there's about a 0.1 percent probability that the findings are compatible with what the Standard Model predicts. That means that if the findings are accurate — if particles really do behave in the way they appeared to in the experiment — then there must be some as yet unknown particle or force involved.

However, the findings are consistent with some other experiments conducted over the past decade, and there are related studies underway that could help verify the results.

The detector is scheduled for an upgrade in 2022, and then Dr. Patel and his team will be back to work, potentially uncovering the mysteries of the universe.

DISCUSSION QUESTIONS

What is it that makes gravity so hard to include in the Standard Model? Why can it safely be left out?

How can researchers witness events as microscopic and short lived as particle collisions?

VOCABULARY

LEPTON

NEUTRINO

MUON

QUARK



Finally, a Millipede That Lives Up to Its Name

By Gina Wynn



If you've ever worked in a garden, raked leaves, or cleaned out your garage or basement, you may have come across a small trainlike creature gliding along or curled up in a tiny ball. The abundance of legs probably helped you identify the critter as a millipede. Meaning "thousand feet" in Latin, the name has been a misnomer, until now.

With 80 to 400 appendages being the norm for common millipedes and 750 having been counted on rare species, "thousand feet" or "thousand-legger" has not been an accurate description of these animals. That is, until the recent discovery of a 1,306-legged millipede species in Western Australia. The Australian and Virginia Tech scientists who unearthed and identified the true millipedes published the details of their study in the December 16 issue of *Scientific Reports*.

She's Got Legs

The new millipede species named *Eumillipes persephone* set a world record as the animal with the greatest number of legs on Earth, according to the study. Eight representatives of the leggy species — male, female, and juvenile — were lured into traps by researchers searching for subterranean animals in up

to 197-foot-deep drill holes for mineral exploration. The traps, set at different levels, contained delicious, wet, decomposing leaf litter that the millipedes could not resist.

Cruising the Underworld

Aptly named *E. persephone* after Persephone, queen of the underworld, the record-holding arthropods feel at home in the cool, damp, dark environment. They tunnel through soil searching for decaying food with their hard-shelled, non-pigmented, cream-colored bodies that are approximately 3.5 to 4 inches long — about the size of a school ID.

Long and threadlike, the creatures are only around .037 inches wide. With no eyes, cone-shaped heads, and a beak for feeding, they use enormous antennae to navigate the depths of their world. Efficient scavengers, their 330 sliding trunk segments work with powerful jointed legs and feet to move in up to eight directions at once.

Early Explorers

Although best known for their means of locomotion, millipede species deserve recognition for their longevity. They are

thought to have been among the first animals on Earth to inhabit land more than 400 million years ago during the Silurian period. Today, there are around 10,000 species that live on every continent except Antarctica.

Compared to their ancient relatives, millipede characteristics have changed very little over time. Perhaps that explains why scientists are so astounded by their discovery of *E. persephone* and thrilled that one millipede species will finally live up to its name.

DISCUSSION QUESTIONS

How is *Eumillipes persephone* different from a millipede that you might find in your neighborhood?

How do the characteristics of *Eumillipes persephone* suit its habitat?

VOCABULARY

APPENDAGE

SUBTERRANEAN

ARTHROPOD

LOCOMOTION

MISNOMER

PIGMENT



Hedgehogs Reveal Nature's Ability to Develop Drug-Resistant Bacteria

By Mark Miller

Methicillin-resistant *Staphylococcus aureus* (MRSA) is an antibiotic-resistant bacteria that causes infections responsible for thousands of deaths each year. Scientists and medical professionals have long attributed such infections' drug resistance to their ability to adapt to and "outsmart" antibiotic treatments that were first mass produced in the 1940s.

Their thinking, in other words, is that these drug-resistant strains only came about after humans introduced antibiotics. But the recent discovery of MRSA in hedgehogs may be changing that thinking.

According to a report in *Science News*, Sophie Rasmussen, a researcher at the University of Oxford, examined a group of hedgehogs and found that 61 percent of the animals carried MRSA.

This discovery led to further investigation and the finding that MRSA was present in hedgehogs in the United Kingdom, Scandinavia, and the Czech Republic. Researchers then analyzed the genomes, or genetic instruction manuals, of the MRSA strains and determined that their lineages

appeared between 130 and 200 years ago — meaning that long before antibiotics, hedgehogs had evolved a natural way to resist the bacteria. But how?

Part of the answer was found in *Trichophyton erinacei*, a fungus that causes "hedgehog ringworm" in humans. A study from the 1960s revealed that this fungus found on hedgehog skin was able to kill some *S. aureus*, and researchers identified two penicillin-like antibiotics produced by the fungi.

The fungi "live in a bad neighborhood," said Gerry Wright, a biochemist involved in the research. He went on to explain that they compete with other microbes such as *S. aureus* to colonize the host hedgehogs. "They have to work out this arrangement where they can protect themselves."

Wright believes that antibiotic resistance comes about gradually as it is influenced by natural selection. In fact, it's reported that his work shows that resistance has ancient origins in places that have not been influenced by humans.

In this way, the hedgehogs may show a different path forward for antibiotic-resistance research. There has been a lot of work done in the soil microbial community as well as with human microbiomes. Animal microbiomes may now provide another source to help scientists create effective treatments for drug-resistant bacteria infections like MRSA.

DISCUSSION QUESTIONS

How do bacteria like MRSA come to resist antibiotics?

How do fungi live on animals?

VOCABULARY

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How Well Can Fish Tell Direction?

By Iva Fedorka



Can a fish drive a car? Some scientists designed an experiment to find out if fish could navigate a vehicle!

Animal Driving Studies

Conducted by researchers at Ben-Gurion University of the Negev in Beer-Sheva (Israel), the study was based on the concept of domain transfer: one species is placed into another one's environment and expected to perform a specific and somewhat familiar task. The study was led by neuroscientist Ronen Segev and co-author Ohad Ben-Shahar, a computer scientist and neuroscience researcher.

Kelly Lambert and her colleagues at the University of Richmond (Virginia) have already taught rats to operate vehicles made from plastic containers, using cereal treats as rewards. But the fish behavior takes animal driving experiments even further.

Driving Lessons

First, they created a Fish Operated Vehicle (FOV) that consisted of a shallow tank of water placed on a motorized wheeled platform. The FOV also had a camera that tracked the fish's location and movement and sent a streaming video signal to a PC.

Six goldfish (*Carassius auratus*) were evaluated to see whether they could use the FOV to change their position in the space. When they actively moved toward one of the tank walls, the FOV would move in that direction.

The Destination

Once it was shown that the fish could move the vehicle, they were then given a visual target (a pink board) where a food reward was waiting. The fish improved their "driving" with practice and were not fooled by decoys, dead-ends, and other distractions.

By the end of the trial, several had figured out the fastest and most direct route to the target and reached it from various locations in the space. This confirmed that the fish had not just memorized the routes but actively planned each journey.

Conclusions

Most animals must be able to successfully move around to forage for food, find shelter or a mate, and otherwise survive. Specific navigation skills, like space representation, differ by species, brain structure, ecological system, and other general and universal conditions.

The fish in the study were able to transfer their space representation and navigation skills to a new and different environment, which may indicate that they possess these universal species-independent abilities.

We are likely to hear more about animal driving experiments as researchers expand and diversify to more species and new tasks. Is an interspecies race in the future?

DISCUSSION QUESTIONS

Which animal would you suggest for the next driving study? Why?

Design a vehicle and driving controls that could be used by that animal.

VOCABULARY

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