Fall/Winter 2019

Headline Discoveries

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Articles in This Issue

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Headline Discoveries

CRISPR - Is There Anything It Can't Do?

You'd be hard pressed to pick up a science or medical journal these days without reading something about CRISPR.

Since the game-changing CRISPR-Cas9 methodology was first harnessed for genome editing seven years ago, endless possibilities have been explored by a range of industries.

Biochemists are working around the clock to test the boundaries and limitations of this innovative practice. Meanwhile, everyone from big pharma to agriculture, food science, medical, botany, energy, manufacturing, chemistry, and, of course, the military, is wringing their hands at the infinite potential of this innovative and evolving method.

Endless Possibilities

This sophisticated gene editing technique is light years beyond the heavy-handed DNA altering methods that were used to help produce insulin. Gene editing with CRISPR is said to be as simple as changing computer code with the right software. CRISPR systems are not only simpler, but faster and cheaper than preceding methods. Beyond the knowhow, all that's needed is the right lab equipment and a carefully selected sample of Clustered Regularly Interspaced Palindromic Repeats, or CRISPR for short. So, where can you find this magical protein elixir with the clumsy name? Bacteria.

Utilizing these repeated helix strands, scientists can precisely target, cut, and even replace snippets of genetic material and, essentially, alter the DNA of any organism on Earth – bacteria, viruses, mold, plants, coral, insects, reptiles, birds, fish, mammals, and yes, humans.

A New Era of Medical Advancement

The good news about CRISPR is that scientists are now more hopeful than ever that we can find a cure for cancer and other aggressive diseases. We are about to embark on a new era of detecting, treating, and even preventing diseases. Early progress has already been made with sickle cell anemia and cystic fibrosis. Cancer and HIV may be next. Truly, we may soon have the capability of eliminating strands of DNA that make someone predisposed to a hereditary illness.

This may be the most exciting potential use for CRISPR, but also one that raises flags and triggers arguments. There's a fine line between therapy (disease curing) and enhancement (self-improvement, similar to plastic surgery) and conditions (deafness, dwarfism) and diseases. There's also gene editing vs. gene selection, or germline modification. The former may be practiced on an embryo to reduce the risk of a hereditary illness, while the latter may be used to reduce the likelihood of being overweight or having brown eyes. Debating viable vs. non-viable gene editing and selection will likely become a future political hot button. Assuming for a moment that common sense will prevail and that the future of CRISPR will be in responsible and necessary practice, the medical applications are profound. We will soon have the power to reduce human suffering in unprecedented ways.

New doors will open into disease research, organ transplant, and drug discovery. New medications will be developed far more frequently as CRISPR opens up a new assortment of chemicals, compounds, and specially designed molecules. Mother Nature could soon become fair game as the science community may toy with the idea of saving dying species from extinction, rescuing dying coral reefs and other eco-systems. And as if that wasn't enough, scientists will also be able to explore new possibilities for advancements with biofuels and eco-friendly energy alternatives.

Applications for Every Industry

Meanwhile, farmers may be able to protect crops from insects, fungi, and even severe climate like droughts and floods. And speaking of insects, CRISPR has already been tested on mosquitos to see if there might be a whole new way to reduce the spread of malaria.

Of course, businesses of all sorts will be lining up to realize the potential benefits. Manufacturers will have new materials to work with that are lighter, sturdier, or cheaper to produce. The food industry will have a field day with heartier vegetables and new varieties of fruit. Botanists will have new ways of studying plants and zoologists new ways of studying animals.

It won't all happen at once and there will be bumps in the road as we figure out the limitations and challenges of this very new and powerful advancement. The potential for CRISPR applications may well be limitless. We may actually be on the precipice of making the world a better place to live.

OHAUS

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Fish Slime Swimming with Pathogen-Killing Bacteria

By Christina Phillis

Most fish are equipped with a slimy protective coating that helps them escape from potential predators, but also guards them from various germs. Scientists at Oregon State University in Corvallis are searching this fish slime for bacteria that can be used to create new antibiotics.

Novel drug options are needed because many pathogens are no longer responding to existing medicines. One significant example is a methicillin-resistant strain of *Staphylococcus aureus* (known as MRSA).

These bacteria used to be completely susceptible to penicillin and related antibiotics. But after adapting over years of exposure, *S. aureus* bacteria have become completely resistant to those antibiotics. As a result, MRSA infections are notoriously difficult to treat, and typically require intravenous therapy with multiple medications.

While researchers had not previously considered fish slime when searching the ocean for new drug sources, it may prove to be a promising area of study. "We know that niche environments often harbor a surprising array of different microorganisms," said Roger Linington, chemist, Simon Fraser University in Vancouver, Canada.

Slime Attack

After collecting swabs of slime from 17 species of juvenile fish, the team of researchers smeared the swabs on petri dishes filled with agar and other nutrients for the bacteria. As expected, the bacteria grew in different sizes and shapes, some as blue-green streaks, and others as orange splotches. They used these and other features to classify the bacteria and found a total of 47 different types.

About half were effective against MRSA, and five of the strains, collected from a pink surfperch, were very effective at killing MRSA.

Something Fishy

The bacteria from surfperch produce molecules called phenazines, which allow it to kill other bacteria. This makes phenazines a potential candidate for new and useful drugs for humans and a strain the team is eager to learn more about.

By studying 10 new specimens of this fish variety, they hope to find out how important this strain of bacteria is for the slime ecosystem of the surfperch. If the bacteria are present, they will test them to see if they also produce phenazines.

Sandra Loesgen, a chemist at Oregon State University and researcher on the team, believes there is still a lot to understand about how microbes affect the health of their hosts. "We need to have much more effort in that area to isolate the bacteria and understand their function," said Loesgen.

Over time, the team hopes to find more than just well-known bacteria and molecules. They want to find new and useful solutions that stick.

DISCUSSION QUESTIONS

Research the issues associated with antibiotic resistance. Why is this such an important problem to overcome?

Where can researchers find other naturally occurring bacteria to study for potential drug development?

VOCABULARY

ANTIBIOTIC RESISTANCE MICROBES PHENAZINES PATHOGENS

FOR ADDITIONAL READING

New methods that use nanoparticles to selectively deliver anti-cancer drugs hold the promise of fewer negative reactions to chemotherapy treatments.

Visit **fisheredu.com/nanoparticles** to read the full article.

Scientists Can Convert Ocean Waves into Energy

By Ralph Birch

When it comes to finding alternate sources of renewable energy, researchers are not shy about making waves.

While most people think of solar and wind power as the best ways to generate clean energy, these methods do have downfalls. The sun only shines during the day, and wind is inconsistent, making it difficult to capture energy with regularity.

But waves are always crashing to the shores from our planet's oceans, making wave-based energy a nearly constant resource.

How Does It Work?

Waves are created when wind blows across the water. On the surface, it looks like the water is bobbing up and down. Although the water may appear to travel from one place to another, it doesn't actually move very far. The water moves in a circular pattern — up to the top of the wave and back down to the other side.

This pattern of movement occurs in very deep water, where the gently bobbing waves, known as swells, are prevalent. But the action of waves changes as they get closer to the shore.

> "There is more than enough natural energy in the ocean."

As the water gets shallower, it's no longer able to travel in circles because the ground gets in the way. Water bumps up against the ocean floor, changing the circular motion from the deep into more of an oval. The water hits the ground, causing the top of the wave to lurch forward faster than the bottom and crash on the beach.

Underwater Energy Collection

Wave energy systems use the movement of the water to create electricity. Some devices are designed to harness the power of breaking waves, while others can generate power from swells or the pressure exerted by the waves on the ocean floor. But all of them have the same goal — to convert wave energy into clean, electrical energy.

Because of transmission limitations like the length of cables used to transmit the electrical power, wave energy works best for communities located closer to the coast. About 40 percent of the world's population lives within 60 miles of an ocean, which means a lot of coastal communities could be powered by wave energy.

The Coasts with the Most

Not all coastal areas are ideal for generating this type of power. The land beneath the ocean affects the size and shape of the waves. Additionally, wave energy converters are costly to make, so scientists want to place them in areas with plenty of wave action, but not where the converters could be damaged by a storm.

Australian scientists are using computer modeling to zero in on the best locations to place wave energy converters. Joao Morim Nascimento and Nick Cartwright, environmental engineers at Griffith University, used the models to find hotspots with the ideal traits for converter placement on the southeast coast of Australia. Each site they found is within three miles of the shore and no more than 72 feet deep.

"There is more than enough natural energy in the ocean," Cartwright said. "The challenge is to harness and convert enough of it into power."

Because of the promise shown by early wave energy research, the next step is to ensure that ocean wildlife and ecosystems won't be harmed by the process.

DISCUSSION QUESTIONS

Do you think there's a way to make wave energy more readily available to people who don't live near the coast?

What types of disturbances could wave energy converters cause on the ocean floor?

VOCABULARY

SWELLS COASTAL
CONVERTER ECOSYSTEM

FOR ADDITIONAL READING

A marine microbe could play a small part in solving a larger problem: plastic pollution in our oceans.

Visit **fisheredu.com/microbes** to read the full article.

New Atomic Particles May Be Escaping Detection

By Dora Fatula

Particle physicists at the Large Hadron Collider (LHC) think they may have missed something.

For decades, they've used the collider to force protons and electrons to collide at high speeds in a search for new particles and materials. But the LHC's two main detectors — the Compact Muon Solenoid (CMS) and A Toroidal LHC Apparatus (ATLAS) — were designed to detect rapidly decaying particles, leading them to suspect that some long-lived particles may have escaped detection.

A Bit of Background

At 16.7 miles in circumference, the Large Hadron Collider is the world's largest and most powerful particle accelerator. It sits between 164 and 574 feet beneath the ground outside of Geneva, Switzerland, and in 2012 it made international news when scientists used it to discover the Higgs boson — the final composite particle whose existence was predicted by the Standard Model of Particles and Forces.

"We haven't found any new physics with the assumptions we started with, so maybe we need to change the assumptions."

In basic terms, here's how it works: superconducting magnets and accelerating structures boost the energy of particles traveling in opposite directions through an ultrahigh vacuum. Once the particles are traveling at nearly the speed of light, they're made to collide. When they do, the particles break apart into new heavy particles that quickly decay into lighter particles that we're already familiar with.

But those new particles are only around for a tiny fraction of a second. The Higgs, for instance, decayed in a trillionth of a nanosecond. CMS and ATLAS were designed and configured to look specifically for those short-lived particles, but by being so focused they may have allowed longer-lived particles to go undetected. Even if they're just a few millimeters out of place, they could be seen as an anomaly or missed entirely.

Searching for New Possibilities

Physicists now want to know if their collisions really are creating those long-lived particles. And if so, they want to know how the new particles could advance our knowledge of physics. To find out, they're rethinking how they use the LHC.

One change could be to the way data is culled. CMS and ATLAS automatically delete data from collisions that don't seem interesting, but in doing so they could be deleting data from long-lived particles. So keeping more data could lead to a new discovery. Another change may be to add six more detectors, which could find particles so long-lived that they escape CMS and ATLAS entirely.

According to Juliette Alimena, a physicist at Ohio State University who works with CMS, finding these new particles could require a change in thinking. "We haven't found any new physics with the assumptions we started with," she said, "so maybe we need to change the assumptions."

DISCUSSION QUESTIONS

What is the difference between an accelerator and a collider?

Why was discovery of the Higgs boson so important?

When did the study of atomic particles begin?

VOCABULARY

COMPOSITE PARTICLE · HIGGS BOSON · PARTICLE PHYSICS

A Potential Link Between Autism and Gut Bacteria

By Moira Bell

In a recent study, researchers discovered preliminary evidence potentially linking gut bacteria with autism.

Disorders on the autism spectrum seem to be related to genetics, but other factors may be involved. Prior studies have shown differences in the microbiomes of people with and without autism, but cause and effect are not clear. When colonized by microbes from the feces of people with autism, mice developed autism-like behaviors.

Gut Reaction

To test their theory, microbiologists at the California Institute of Technology (Caltech) in Pasadena put fecal samples in the stomachs of germ-free mice, some from children with autism and some from children without the disorder. They then mated the pairs of mice colonized with the same microbiomes to expose offspring to the set of human microbes early on in their development.

Utilizing a set of behavioral tests typically used to gauge autism-like symptoms in mice, they evaluated the offspring. They recorded behaviors like how often a mouse vocalized and approached or interacted with another mouse.

The mice colonized with bacteria from children with autism were less social and displayed more repetitive behaviors than mice with microbiomes from children without autism. They also had lower levels of what are believed to be helpful bacteria, which break down amino acids in food. These amino acid byproducts can travel through the bloodstream and possibly into the brain.

Neural Connection

Levels of 27 metabolites in the gut also differed between the two groups. Mice that received microbes from people with autism had lower levels of taurine and 5-aminovaleric acid (5AV). The 5AV molecules bind to neurons and inhibit their activity. This result supports the hypothesis that an imbalance between excitatory and inhibitory signals in the brain may cause autism.

The study also found differences in the mouse brains, specifically with the way that DNA messages are processed before being translated into proteins.

Shakuntla Gondalia, a gut microbiome researcher at Swinburn University of Technology in Hawthorne, Australia, suggests replicating the study outside the U.S. because environment and diet affect the microbiome.

These results probably won't lead to specific microbiome-based treatments anytime soon, and the two metabolites highlighted might not be relevant for people with autism. Still, the findings so far suggest that searching for other metabolite differences in people with autism would be a promising step forward in the development of potential treatments for this disorder.

DISCUSSION QUESTIONS

Categorize environmental and physiological causes of autism. Do you notice any patterns?

Research further the relationship between gut microbiomes and the nervous system. List other conditions affected by this connection.

VOCABULARY

MICROBES MICROBIOMES METABOLITES

FOR ADDITIONAL READING

Two European studies show that consuming ultra-processed foods significantly increases the risk of cardiovascular disease and death.

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Tiny Fish Have Big Impact on Coral Reef Ecosystem

By Kylie Wolfe

Have you ever wondered what life is like underwater, in the depths of the ocean? Even the experts do. Because scientists don't entirely understand the success of coral reef ecosystems, they're conducting studies to learn more about this aquatic oasis.

Researchers at Simon Fraser University in Burnaby, Canada, took a closer look at the organisms that live in coral communities to see how they're helping each other thrive. The study found that cryptobenthic fish, critters about the size of your little finger, are critical to the survival of larger fish. Their work was recently published in *Science*.

Understanding Life Under Water

Coral can stretch for miles and the fish that live there survive on reef resources, even in low-productivity oceans. Researchers use the term internal nutrient cycling to explain this concept, shedding light on the unknown elements of the ecosystem's success.

A large part of that success lies with cryptobenthic reef fish, especially gobies, blennies, and cardinalfishes. They're considered the smallest marine vertebrate, weighing as little as 0.1 grams and often measuring less than a centimeter in length. Only 10 percent of cryptobenthic fish grow to five centimeters.

Redeye gobies, for example, are elusive and brightly colored. They swim swiftly when startled and dominate larval fish communities, just like other members of the species.

Great Barrier Reef blennies like to flee and hide but are critical to the success of the reef. Seemingly insignificant in size, they're actually very important and in constant supply.

"You'd just perhaps notice them as these little flashes of red, white, and yellow that kind of skedaddle to safety," says Simon Brandl, coral reef ecologist and the study's lead researcher.

Ultimately, cryptobenthic fish have to consider what's best for survival. They use coral for shelter and protection, and many of their larvae stay close to home. This isn't the case for many larger fish species that travel great distances in open water.

Their presence helps to keep the reef diverse and productive, serving their purpose effectively and efficiently.

Continued on ***page 12***

Studying Sea Creatures

Just like tropical rainforests, coral reefs are home to a variety of organisms. Cryptobenthic fish alone account for about 3,000 species, not including those yet to be discovered.

“I was blown away by how many there are and how diverse they are,” said Brandl.

To learn more, he and his team set up 85 nets around sections of coral in Belize, French Polynesia, and Australia. Doing so scared away everything except the cryptobenthic fish that naturally cling to the crevices of the coral. The researchers then released an anesthetic into the water, causing the fish to float. They counted up to 100 of them per square meter and, after studying their lifecycles, determined that roughly 60 percent of the creatures consumed in the reef belong to this group.

“Cryptobenthics do one thing particularly well: getting eaten,” said Brandl.

> Their presence helps to keep the reef diverse and productive, serving their purpose effectively and efficiently.

Some species of these fish can produce seven generations per year, providing a constant food source for reef dwellers. Most are actually eaten within the first few weeks of existence, and though their lifespan is short, a high level of reproduction keeps them in full supply.

Brandl and team also generated computer simulations of spawning, larval return, and adult replacement, helping to better understand their life cycle.

Prior to this study, these important little fish were overlooked. But understanding their contribution means better understanding the coral reef ecosystem.

Rising Tides and Temperatures

With knowledge comes the responsibility of protecting delicate environments. Many of these fish need coral to survive, but climate change is threatening their existence. As global temperatures rise, ocean temperatures rise, absorbing excess heat from the atmosphere. This change leads to coral bleaching events, where, quite simply, the color of the coral is lost. In some instances, the reef can recover, but the longer the event lasts, the less likely it is to bounce back.

Bleaching events are like warning signs, signaling a threat to global ecosystem health. Reefs will eventually reach a point of no return where this warming will begin to impact less-sensitive systems.

Scientists caution that climate change is happening faster than coral reefs can handle. The frequency of these events has increased four to five times what it was in 1980. And these numbers will only continue to increase with rising temperatures.

Coral reefs themselves are home to more than a quarter of all fish species. And without it to call their home, cryptobenthic fish could become threatened, impacting the reef’s overall food chain.

Survival Mode

Though they often go unnoticed, cryptobenthic fish greatly impact the coral reef ecosystem. They’re a source of food for larger fish, reproducing regularly and playing a vital role in the overall fitness of the reef. But with the threat of climate change, many of the fish communities may be in danger.

No longer missing a piece of the puzzle, scientists hope that the distinct lifestyle of cryptobenthic fish will at least help sustain and support a strong system of underwater life.

DISCUSSION QUESTIONS

What makes cryptobenthic fish unique?

How would the coral reef ecosystem be impacted without the presence of these fish?

How might coral bleaching serve as a warning sign for future climate change-related threats?

VOCABULARY

ECOSYSTEM CORAL REEF

CORAL BLEACHING CLIMATE CHANGE

Night Lights: Scientists Learn More About STEVE

By Kevin Ritchart

What's the deal with STEVE?

Thanks to the collection and analysis of satellite data, scientists are now closer than ever to explaining STEVE, a reddish-purple band of light that appears in the night sky. STEVE, short for Strong Thermal Emission Velocity Enhancement, stretches from east to west and is sometimes accompanied by a row of vertical green stripes.

STEVE has been observed in the skies of the northern U.S., throughout Canada, and as far away as New Zealand and the United Kingdom.

Citizen scientists have been capturing images of STEVE for years, according to Don Hampton, a space physicist at the University of Alaska-Fairbanks. But only recently have scientists really begun to gather reliable data about how STEVE forms.

Scientists also may be able to predict the effects of weather on satellite signals. Heated air particles form STEVE's purple ribbon, while electron showers from space create the green "picket fence" formation.

Interpreting Data

Yukitoshi Nishimura, a space physicist from Boston University, was part of a team that analyzed data from satellites that passed by STEVE in 2008 and again in 2016. The satellites observed particles and waves of energy surrounding the lights in the sky.

> Different chemicals in the air are responsible for the various colors that appear.

Nishimura and his team confirmed that a stream of electrically charged gas, known as plasma, is what creates the purple stripe. The plasma flows from east to west at approximately 3 miles per second, which creates friction that heats the particles in the air and results in some of them emitting a purple hue. Their findings were published earlier this year in *Geophysical Research Letters*.

Color Creation

Different chemicals in the air are responsible for the various colors that appear. Nishimura's team isn't exactly sure which plasma particles are the ones creating the purple stripe in the sky.

The vertical green lights are a little easier to explain. When electrons rain down from space, some of their energy is transferred to oxygen molecules in the sky. The excited oxygen molecules have a green glow.

This phenomenon is similar to other auroras that appear in the sky, like the famed northern lights. But it's unusual for electrons to bombard the atmosphere at the latitudes where STEVE forms, which is closer to the equator than most other auroras.

While a great deal has been discovered recently, more analysis may help researchers learn even more about STEVE in the years to come.

DISCUSSION QUESTIONS

Have you ever seen a light formation like STEVE in the night sky? Where was it, and what time of day/year did you see it?

What other factors do you think might contribute to the colors of the lights we can see in the sky?

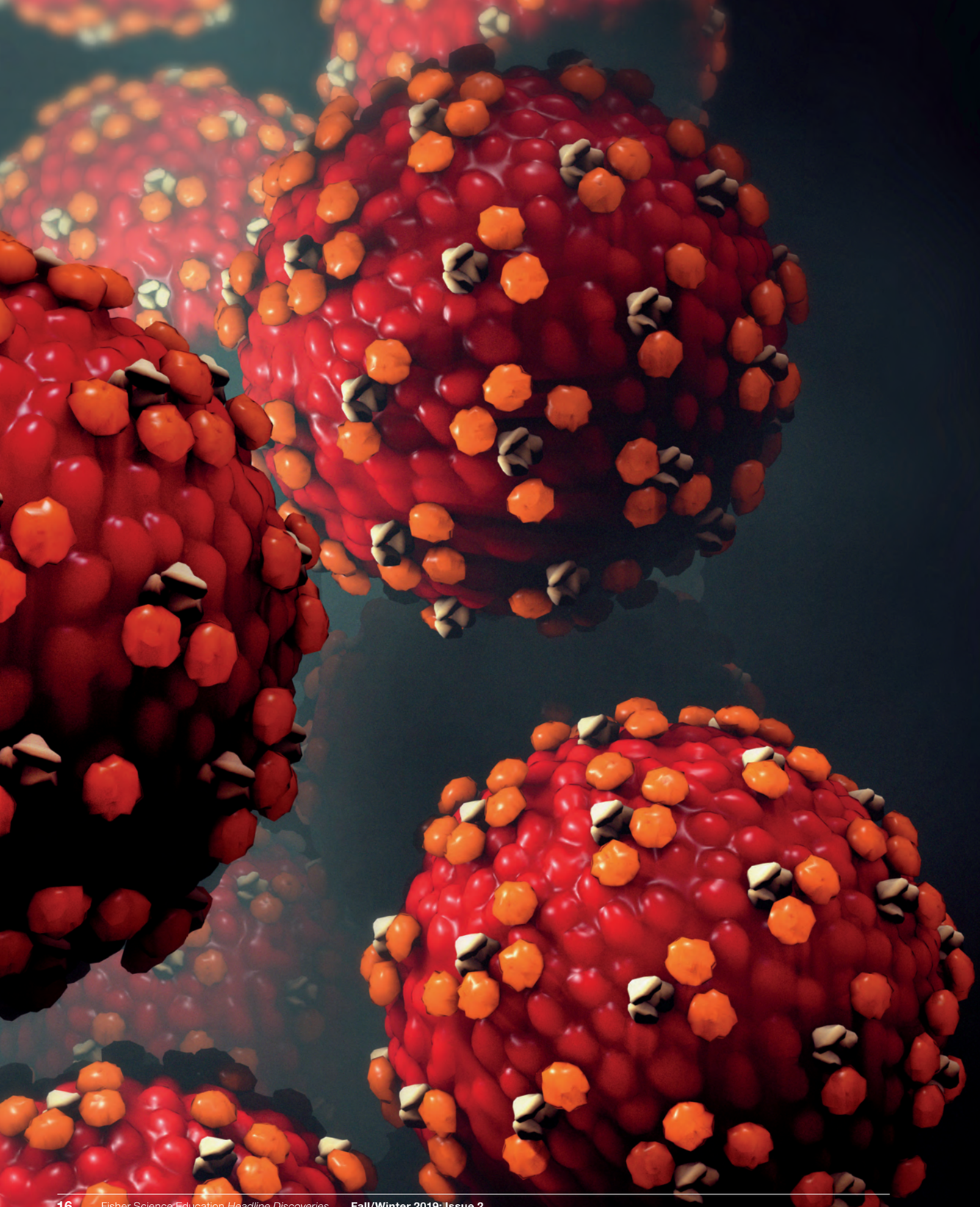
VOCABULARY

SATELLITE PLASMA
ELECTRONS AURORAS

FOR ADDITIONAL READING

Recent studies of images of Pluto raise the possibility of icy volcanic eruptions of ammonia and organic chemicals, important chemical precursors to life.

Visit **fisheredu.com/volcanoes** to read the full article.



The Effect of Measles on Immunity

By Iva Fedorka

Recent studies confirm that individuals infected with the measles virus also experience other immune system changes that can affect their overall health for significant and extended periods of time.

This understanding may help explain the true extent of health safety provided by measles vaccinations. By protecting one's immune system from a measles virus attack, greater protective effects against other pathogens are simultaneously produced.

The Measles Virus

Measles, or rubeola, is a highly contagious disease caused by an RNA virus. Passed via airborne/respiratory routes, it causes systemic illness in humans and other primates. Symptoms include fever, skin rash, and also coughs, upper respiratory inflammation (cold-like congestion and mucus), and conjunctivitis (eye irritation).

When someone with the measles coughs or sneezes, the virus can survive for as long as two hours. In its new host, it targets immune cells in the nasal and pharyngeal mucosa, the lung alveoli, and the tissue between the eyelid and cornea. The virus then multiplies inside the cells, and spreads to the bone marrow, thymus, spleen, tonsils, lymph nodes, and other areas of immune cell concentration. Eventually, new viral particles move to the respiratory tract to be passed on to others.

> "Wherever you introduce measles vaccination, you always reduce childhood mortality. Always."

Acute infections can last for several weeks, and symptoms appear between seven and ten days after exposure. People are the most contagious from days four through eight, when they have fevers, runny noses, and coughs, but may not yet have a rash.

Immune Suppression

Measles symptoms are uncomfortable, but it's important to note that the disease also causes a temporary loss of immune cells that can increase one's susceptibility to ear and other infections, pneumonia, and diarrhea.

"The virus has an enormously strong predilection to infect cells of the immune system," said Bert Rima. An infectious disease researcher at Queen's University Belfast in Northern Ireland, Rima and his colleagues reported on their findings of immune system invasion in preserved human tissue in 2018.

In 2013, virologist Rik de Swart of Erasmus University Medical Center in the Netherlands and his colleagues studied children in a Netherlands community of Orthodox Protestants. In the "Dutch Bible Belt," parents refuse to vaccinate their children, which leads to regular measles outbreaks. The last outbreak ended in 2000, so the next occurrence was expected.

The parents gave permission to collect blood samples from their healthy, unvaccinated children. The new outbreak started as soon as sampling began, and the group successfully collected "before" and "after" samples from 77 children.

"The virus preferentially infects cells in the immune system that carry the memory of previously experienced infections," de Swart says. These memory B and T white blood cells help the body react quickly when infectious threats recur. The study found a decrease in these memory cells, which creates an "immune amnesia," as reported in a 2018 issue of *Nature Communications*.

The Aftereffects

The immune system may need months to years to regain full function. Researchers, including de Swart and Michael Mina, an infectious disease epidemiologist and pathologist at Harvard University, looked at the health records of children in the U.K. from 1990 to 2014. As reported in *BMJ Open* in 2018, children who had had measles were more likely than non-infected children to be treated for another infection within the five years following their bout with the disease.

Mina and colleagues reviewed medical records in Denmark, England, Wales, and the U.S., and found similar results. During outbreaks, non-measles infections were more likely to be fatal to children who also contracted the measles. The connection was even greater when they examined records from several years afterward.

"Every little blip in the mortality data could be explained by the measles incidence data over the previous 30 months," Mina said.

Recovery

New research methods may help us better understand how the immune system eventually recovers.

And, although measles are uneventful infections for most children, it is still not a harmless childhood disease. Moreover, we have a vaccine.

"Wherever you introduce measles vaccination, you always reduce childhood mortality. Always," said de Swart.

"At the end of the day, we know how to prevent this potentially lethal disease," Mina said. "It's so simple."

DISCUSSION QUESTIONS

What defines an outbreak?

Why are some people opposed to vaccinations?

What other conditions are related to suppressed immune systems?

VOCABULARY

VACCINE MORTALITY INCIDENCE

FOR ADDITIONAL READING

A recent study reveals that antibiotic contamination in rivers around the globe has reached alarming levels.

Visit **fisheredu.com/antibiotics** to read the full article.

Students Build Geometry Skills by Building Tiny Houses

By Gina Wynn

Through an innovative applied-math curriculum, 18 students at a Columbia, MO, high school are building their geometry skills by building tiny houses for people in need.

Battle High School (BHS) is one of about 500 schools following the Geometry in Construction (GiC) curriculum that helps reinforce classroom concepts by bringing them to life in real-world situations — like constructing a house.

Other schools charge students with projects that include building chicken coops, barns, and backyard furniture, according to Scott Burke, a GiC teacher in Lakewood, CO, and one of the curriculum's co-designers.

Learning to Give Back

The GiC courses offer an alternative method of teaching math, economics, and problem-solving abilities. According to geometry teacher Brian Hancock, who co-teaches the BHS course with woodworking and construction leader Carl Dement, the construction process drives the order in which students learn.

> "In some ways, it is actually more challenging [than a traditional course]."

To progress on the house, students "have to troubleshoot and figure it out and use the math tools that we've given to them," said Hancock. But "the biggest thing about this class is the altruistic piece behind it," he added. "We're building this house to give to somebody who may not have a house."

When construction is finished, the class plans to donate the house to the nonprofit that donated the building materials, Central Missouri Community Action, which works to combat poverty in the region.

Common Core Concerns

Despite the benefits that GiC courses offer to students and members of their communities, some school district officials may hesitate to take them on out of concern about meeting Common Core Standards in math and English language arts.

The National Governors Association Center for Best Practices developed the career and college-ready standards in 2010 in partnership with the Council of Chief State School Officers.

Math is "such a high-stakes course," said Carol Fletcher, deputy director of the University of Texas at Austin STEM Center, which provides training on the curriculum for teachers. She notes, however, that GiC is designed to cover all of the same Common Core State Standards as traditional geometry.

"In some ways, it is actually more challenging [than a traditional course], because so much of it is applied," she said. "For kids who are used to just doing book math and being good at it, it pushes them out of their comfort zone."

Collecting Data

Unfortunately, gathering data that proves the value of the hands-on courses is challenging. While students in the GiC course outscored traditional geometry students in math at Loveland High School in Colorado from 2009 to 2012, the cause of the rise in scores is unclear. Students self-selected for the courses, so other factors could have come into play.

Burke, who is helping to expand the GiC program in other communities, hopes he'll be able to gather more definitive data.

DISCUSSION QUESTIONS

Why might students find it easier to learn geometry by applying geometric concepts to building a house?

How would you feel about taking a GiC course??

VOCABULARY

CURRICULUM ALTRUISM

COMMON CORE STANDARDS

FOR ADDITIONAL READING

When 700 bats moved into his attic, a Dublin teen built a bat detector to record their calls and learn more about them.

Visit **fisheredu.com/bats** to read the full article.

New Type of Wood Can Reduce Cooling Costs

By Ralph Birch

Researchers have found a way to separate wood into its components to make it more capable of dispersing heat.

When most materials are heated, they emit energy as photons of near-infrared (NIR) light. The NIR light is absorbed by molecules in the air nearby, trapping the heat.

In recent years, researchers have created plastic films and paints that can absorb heat and emit energy at longer, mid-infrared wavelengths that are not absorbed by the air. If these photons are emitted upward, they pass through the sky unimpeded and release their energy in deep space.

But to use the films and paints in buildings, they would have to be applied to rooftops or other surfaces to keep NIR photons from escaping.

Would Wood Work?

To see if these heat-trapping attributes could be incorporated into the structure of a building, researchers focused on wood. Liangbing Hu, a materials scientist at the University of Maryland-College Park, and his team considered wood's three primary components: cellulose, hemicellulose, and lignin.

Cellulose and hemicellulose both form long, straw-like structures, and the lignin holds them together. But, in addition to its binding properties, lignin is a strong emitter of infrared light. Therefore, the research team knew the lignin had to be removed.

> Though the energy savings will be significant, the new wood could be priced higher than the average customer wants to pay.

Researchers used a simple chemical procedure to separate wood into its components. They soaked basswood in a hydrogen peroxide solution, which broke the long lignin molecules into small fragments. The lignin fragments diffused out of the chemical solution and were washed away. The remaining cellulose and hemicellulose was fused together using an industrial vise called a hot press. The resulting product was eight times stronger than natural wood.

Cooling Effects

Along with the added strength, the absence of lignin made the new wood white. This allows it to reflect nearly all incoming light, absorb heat from its surroundings, and radiate energy as mid-infrared light. This cools the surfaces to which the wood is attached by as much as 10°C, according to a recent issue of *Science*.

The new wood doesn't radiate heat quite as well as some of the plastic films on the market, but it stays cool to the touch, which may make a big difference when it comes to cutting energy costs for cooling a home.

If the new wood were applied to the outside of buildings in warmer climates like the southwest U.S., the passive cooling effect could reduce air conditioning costs by up to 60 percent. It also could provide relief when used to build homes in developing countries where air conditioning is less common.

Further exploration of the material's potential is needed, since wood products may not suit all applications and climates.

DISCUSSION QUESTIONS

What other uses can you think of for this new type of wood?

Can you think of any drawbacks to manipulating wood in this way?

VOCABULARY

PHOTONS INFRARED CELLULOSE HEMICELLULOSE LIGNIN

FOR ADDITIONAL READING

A new type of bandage offers promising results, healing wounds faster with the power of electricity.

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Protein Helps Mosquitoes Detect Human Sweat

By Kevin Ritchart

Geneticists are closer to figuring out how mosquitoes detect our sweat. They have identified a scent-sniffing protein in mosquito antennae called IR8a that can sense the lactic acid coming off our skin.

A large part of the human scent comes from the lactic acid excreted through the skin and by the many microbes that live on our skin.

The *Aedes aegypti* mosquito is known to prefer human blood to the blood of other animals. Since the 1960s, researchers have suspected that lactic acid might be one of the key reasons why *Aedes aegypti* target humans.

We might not think of this mosquito as more than a minor annoyance, unless you consider that the *Aedes aegypti* is known to spread the viruses that cause Zika, dengue fever, and many more.

Sweat Equity

Geneticist Matthew DeGennaro and his team at Florida International University worked with *Aedes aegypti* that produce the proper form of IR8a as well as some that make an altered form of the protein that doesn't function properly.

Both sets of mosquitoes were offered a sweat-covered human arm or a sweat-stained shirt sleeve. The mosquitoes with the altered form of IR8a were only half as likely to land on the skin or fabric as those with the proper IR8a. DeGennaro and his team shared their findings earlier this year in *Current Biology*.

The system that mosquitoes use for scent detection is quite complex, according to DeGennaro. They rely on three families of odor-sniffing proteins, all of which have overlapping abilities to identify substances present in the air.

Finding a Target

The IR8a protein detects acids, among other compounds. As a mosquito searches for a target, it combines cues relating to airborne chemicals with information about heat, moisture, and visual clues about potential bite sites.

Additionally, mosquitoes are able to detect the carbon dioxide we exhale, providing yet another cue that they're closing in on their next meal.

The more we understand about these pests, the better we'll be able to defend against them and the diseases they spread in the future.

DISCUSSION QUESTIONS

What other environmental factors attract mosquitoes to us?

What are some things we can do to mask the scents coming off our skin?

VOCABULARY

ANTENNAE LACTIC ACID
ZIKA VIRUS DENGUE FEVER

FOR ADDITIONAL READING

Researchers genetically modified a fungus to produce spider toxin, and they're using it to fight against malaria mosquitoes.

Visit **fisheredu.com/spidertoxin** to read the full article.

Notre Dame: Rebuilding History with Science

By Mike Howie

The world looked on in sadness as Notre Dame Cathedral burned in April 2019. The Parisian landmark, which has stood in the city's center since medieval times, lost its iconic spire and much of its wooden roof. However, most of the structure and the artwork inside were saved from the blaze thanks to the tireless efforts of Paris fire brigades.

High-Tech Tools

As fire fighters worked through the night, they had technology on their side. They flew two DJI drones, a Mavic Pro and a Matrice 210, to monitor the fire and help them plan how to use available resources. While drones aren't typically allowed to fly in Paris, DJI cooperated with French authorities by temporarily removing the geofencing that prevents their drones from flying in restricted areas.

Fire fighters also enlisted the help of an 1,100-pound robot named Colossus to fight the fire within the cathedral when conditions became too dangerous for humans. The waterproof, fireproof machine used a motorized cannon that can spray more than 660 gallons of water per minute to lower temperatures inside the nave. Ultimately, the robot helped to save human lives as well as the structure, including the famous belfries.

Learning from Disaster

Now that the fire is out, the French government and other organizations are beginning to plan efforts to restore Notre Dame, and many see this as a learning opportunity. The Laboratory for the Restoration of Historical Monuments in Champs-sur-Marne, France, for example, is looking to science to help with the restoration, learn more about the cathedral, and better understand the behavior of certain materials. And the French National Centre for Scientific Research plans to analyze isotopes in the timber frame — samples of which wouldn't otherwise be available — to gain insights into medieval climate.

Laser-Accurate Restoration

While the restoration process will take years and possibly even decades to complete, workers will have detailed 3D models to use as a guide. In 2000, renowned architectural historian and Vassar Associate Professor of Art Andrew Tallon used laser technology and advanced imaging techniques to build a digital model of Notre Dame. Over five days, Tallon scanned the building 50 times and gathered more than one billion data points, which could now be invaluable in rebuilding the cathedral.

Tallon's scans are even accurate enough to help recreate the cathedral's fallen gargoyles and chimeras. Dutch company Concr3de — a specialist in stone 3D printing for construction — claims that it can use rubble and ashes from the broken statues to 3D print exact replicas. After grinding the limestone rubble and combining it with fire ashes and other materials, they could use Tallon's models as a guide for their printers.

DISCUSSION QUESTIONS

What made the Notre Dame fire so difficult to fight?

How could similar fires be prevented?

VOCABULARY

3D PRINTING ISOTOPE

GEOFENCING MEDIEVAL

FOR ADDITIONAL READING

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