

Headline Discoveries

October–December 2016 » Issue 4



Invisible Security

Combating Fraud a Matter of Connecting the Dots

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Combating Fraud a Matter of Connecting the Dots

By Kevin Ritchart

A staggering \$650 billion per year is lost to counterfeiting worldwide, according to the International Chamber of Commerce, but advancements in the realm of invisible ink could put a dent in that number in the years to come.

A team of Chinese scientists has developed a new form of invisible ink based on carbon nitride quantum dots. Information written with this ink is not visible under ambient or ultraviolet (UV) light, but it can be viewed under a fluorescence microplate reader. Anything written with this type of ink can be further encrypted or decrypted by quenching or recovering fluorescence with different types of reagents.

Quantum dots have optoelectronic properties that can be controlled by changing the size of the dots. The Chinese scientists used quantum dots made from graphitic carbon nitride in the development of this new type of invisible ink. Graphitic carbon nitride consists of ring systems of carbon and nitrogen atoms that are linked in two-dimensional molecular layers. The makeup of the dots is similar to graphite, which is one of the forms of pure carbon, but it also has the properties of a semiconductor.

The primary function of fluorescing security inks is to ensure products and documents – such as stock certificates, transport documents, currency notes and identity cards – are secure. Counterfeiting of these types of documents can cost a company money in lost profits or damage to its reputation. When it comes to fraud involving pharmaceuticals or machine parts, human lives could be endangered.

Let There Be Light

Counterfeiters have figured out how to imitate UV tags, but copying security ink that's not visible under UV light is much more difficult to do. Researchers also have had success in developing an inexpensive form of invisible ink that is based on water-soluble quantum dots, which are essentially nanoscopic "heaps" of semiconducting material. Anything written with this new type of ink is unable to be viewed in ambient or UV light because it's nearly transparent in the visible light range and emits fluorescence with a peak in the UV range. The ink is only visible under a microplate reader like those used in biological fluorescence tests.

Writing using the ink can be further encrypted or decrypted using oxalic acid, which makes the ink invisible even under the influence of the microplate reader. Sodium bicarbonate can be used to reverse the process, making the ink visible once again.

Any change to ink's color or composition also makes the act of counterfeiting more difficult. Without specific knowledge of every ingredient and the precise amounts used, counterfeiters would be unable to replicate ink. Both the chemical makeup and various proprietary encryption processes make it impossible for even the ink's creators to re-create or reverse-engineer the end product.

Primary Colors

Scientists at Northwestern University formulated the ink by mixing a simple sugar (cyclodextrin) and a competitive binding agent with an active ingredient (a molecule called heterorotaxane) whose

fluorescent color changes along the spectrum from red to yellow to green depending on how the components come together. An infinite number of color combinations can be easily defined. The sugar itself is colorless, but it encapsulates some of the other components of the ink selectively. This makes it difficult to predict and difficult for counterfeiters to replicate.

While the ink itself can change colors based on its own composition, the type of paper the ink is applied to can also impact where the ink falls on the color spectrum. For example, scientists found that an ink that appears orange on standard copy paper appears green when applied to newsprint.

Advancements in the field of invisible ink essentially allow individuals and organizations to create their own unique security codes by manually adjusting the parameters of an ink's key components. Without knowing the parameters of a particular security in "recipe," it would be virtually impossible for counterfeiters to break the code.



[CLASSROOM DISCUSSION]

What documents and products do you think would benefit from security inks?
What applications other than security could invisible inks have?

[VOCABULARY]

FLUORESCENCE

QUANTUM

UV LIGHT



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2016 Summer Olympics Are Greenest Ever

By April Fischione



The Olympic Games originated in ancient Greece over 3,000 years ago and were named after their initial location, Olympia. According to legend, Hercules, the son of Zeus and the first Olympic athlete, founded the Games to honor his father. The Olympic Games were on a hiatus from 393 A.D. until 1896 when Baron Pierre de Coubertin reinstated them and hosted 280 participants competing in 43 events in Athens, Greece. The Games have changed significantly since then, expanding to feature over 11,000 athletes competing in 28 events this summer in Rio de Janeiro, Brazil.

Be the Green Team, Not the Mean Team

Companies increasingly strive to make their products more ecofriendly and green, so it should come as no surprise that the hosting countries of the Olympic Games are doing the same.

The 2012 London Olympics, which had sustainability as their main focus, were believed to be the greenest of the Games at that time. In preparation London planted 2,000 native trees and 300,000 wetland plants. They also cleaned up contaminated soil. Food vendors used compostable packaging to reduce waste, and the country drew nearly 10 percent of its power for the Games from renewable sources.

Rio sought to mitigate, and create climate benefits for, two million tons of Games emissions. Brazil went through external audits to assure their

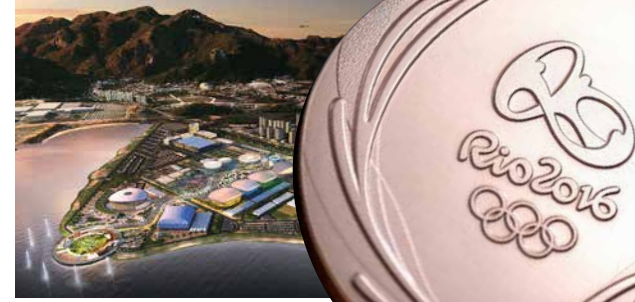
sustainability efforts, which included providing sustainably sourced meat and vegetarian options to athletes, reducing the volume of material and energy its workforce needed to put on the Olympics, and sorting through waste to recycle everything they could.

In Rio, Even the Gold Was Green

The winners' medals did not escape scrutiny, either. The gold medals were made from gold that was extracted without the use of mercury and produced according to sustainability criteria. The silver and bronze medals were made from 30 percent recycled materials, and the ribbons used to suspend the medals all came from recycled plastic bottles. The podiums, which were made from organic materials, were designed to be reused as furniture after the Games. Organizers even went so far as to eliminate the flower bouquets medalists are traditionally awarded,

instead presenting medalists with carved wooden statues of the Rio Olympics logo.

In the wake of widespread reports of contamination and unsanitary conditions in Rio de Janeiro over the last year, it was truly incredible to look at the before and after images of the city and see all of the progress they made to make their Olympic Games the greenest ever.



[CLASSROOM DISCUSSION]

What other steps can the next host city take to make the Games green?

Where are the next Winter and Summer Olympic Games to be held?

[VOCABULARY]

CONTAMINATION

SUSTAINABILITY



10 Fun Facts about Sharks

By Justin Kovach

Sharks make the news for all the wrong reasons, but there are many other points of interest about this majestic fish that deserve consideration. So let's sink our teeth into some fun facts about this celebrated deep-sea predator:

1. There are over 500 species of shark varying in size, shape, environment and diet. While some are small, others, like the whale shark, can grow up to 40 feet long.

2. Sharks live in every part of the ocean, and some can survive in fresh water. One of the most interesting in appearance is the Mitsukurina owstoni, or goblin shark, so called for its facial features. It is the oldest living species among lamniform sharks, dating back to about 125 million years ago.

3. The first sharks are believed to have evolved about 400-455 million years ago. But it may have been even longer ago because unlike other fish, sharks have a flexible cartilage skeleton that is rarely preserved the same way typical fish bones are.

4. All sharks have several rows of teeth, which they lose regularly, only to be replaced by new ones.

5. Sharks eat fish, crustaceans, mollusks, plankton, marine mammals and even other sharks. Their strong sense of smell allows them to detect blood in the water miles away.

6. Most sharks are cold-blooded. But some sharks, such as the great white shark, are warm-blooded, which enables them to grow and swim faster. But they need to eat up to 10 times more than their cold-blooded cousins.

7. Some etymologists believe the word shark derives from earlier German and Dutch words for a shifty character, while others suggest it comes from Xoc (pronounced "shoke"), which means "great fish" in the Mayan language of Yucatec.

8. The largest known species was the megalodon, which grew longer than 50 feet. But you're safe from that behemoth, as it went extinct around 2.6 million years ago.

9. The notion that sharks can't develop cancer is a myth. They do, as we've known since at least 1908.

10. Humans perceive sharks as a threat, yet the fishing industry kills up to 100 million sharks a year just for their dorsal fins. The slaughtered far outnumber the few shark attacks that are reported each year. So

even though they can be aggressive, remember that when you're swimming in the ocean, you're swimming in their home. It is best to be not only cautious but also appreciative of this diverse and ancient species that is an integral part of a vast and magnificent ecosystem.

[CLASSROOM DISCUSSION]

What other interesting facts about sharks do you know?

What conservation efforts are being made on sharks' behalf? Discuss their benefits or other measures that may be necessary to ensure their survival.

[VOCABULARY]

BUOYANCY

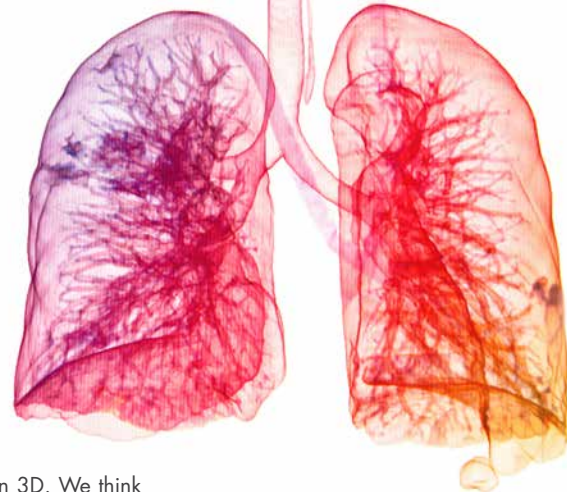
ETYMOLOGY

LAMNIFORM



3D Imaging Used to Diagnose Lung Disease

By Christina Phillis



Scientists from the University of Southampton have used a 3-D X-ray imaging technology, originally designed to look inside jet engines, to capture images of a particular kind of lung disease.

The Technology

Idiopathic Pulmonary Fibrosis (IPF) is normally diagnosed using a computerized tomography (CT) scan or by using a microscope to view a lung biopsy sample. Accurate diagnosis of IPF can be difficult using these techniques, which is why scientists were eager to try the Microfocus CT. With this new technology, scientists can view lung tissue samples with a similar level of detail as a microscope, but in 3D. The system rotates 360 degrees while taking thousands of 2-D images, which it then uses to build detailed 3-D versions.

Imaging the Spread of a Disease

Using this new technique, scientists were able to uncover new information on how IPF spreads throughout the lungs. IPF is a type of interstitial lung disease that causes inflammation and scarring of the lung tissue. Those diagnosed have difficulty breathing and a life expectancy of three to five years.

The scarring associated with IPF was always thought of as progressing in a wave from the outside to the inside of the lung. But the team of researchers discovered that the disease occurs in many individual areas of the lung at the same time. With this information, doctors can make sure they develop targeted therapies that focus on these areas. According to lead author of the study Mark Jones, accurate diagnosis is essential to starting the correct treatment.

"This technology advance is very exciting as for the first time it gives us the chance to view lung biopsy samples in 3D. We think that the new information gained from seeing the lung in 3D has the potential to transform how diseases such as IPF are diagnosed. It will also help to increase our understanding of how these scarring lung diseases develop, which we hope will ultimately mean better targeted treatments are developed for every patient," said Jones.

Cell-CT is another 3D imaging system being used to analyze lung tissue samples. According to initial studies it has the potential to make widespread use of lung cancer screening more feasible. These technologies and others are just a few of the ways that the healthcare industry is adopting equipment from other fields to advance the diagnosis and treatment of various diseases.

[CLASSROOM DISCUSSION]

Think of another tool or piece of equipment that has the potential to be used across disciplines.

How does knowing more about a disease early on lead to better treatment?

[VOCABULARY]

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Genetically Modified Mosquitoes Cut Rate of Viral Disease

By Lacey Cirinelli

It's no secret that mosquitos carry disease. Both Dengue fever and the Zika virus can be transmitted through *Aedes aegypti* mosquito bites. But now we're learning that *A. aegypti* mosquitos may actually reduce instances of viral disease thanks to genetic engineering.

While male mosquitos thrive on nectar, female mosquitos require protein from animal blood to produce eggs. If a female mosquito bites a human infected with a virus like Dengue or Zika, she becomes infected with the disease and can transmit it to the next human she bites. Dengue virus is considered the most important mosquito-spread disease because of its rapidly growing incidence.

Dengue fever, which has no cure or vaccine, is characterized by high fever, headache, skin rash and occasionally fatal bleeding. Zika virus, on the other hand, often presents without symptoms but is linked to

serious neurological disorders and birth defects. The most severe Zika-related birth defect is microcephaly, which causes infants to have abnormally small heads, often leading to seizures, developmental delays and death. Because of the potentially severe implications of mosquito-borne diseases, developing new ways to control mosquito populations has become a key research focus.

Mutant Mosquitos

Traditional attempts at limiting mosquito-borne disease try to reduce mosquito populations through the use of pesticides, trapping and the removal of still water. However, Oxitec, a biotech company in Abingdon, England, has created genetically modified (GM) *A. aegypti* mosquitos that have an impaired ability to reproduce. These GM mosquitos need the antibiotic tetracycline to develop beyond adolescence. GM males given tetracycline have the ability

to breed as usual, but the larvae produced die before they are mature enough to bite. After a few days, both mature mosquitos and offspring are dead, reducing the size of the next generation of mosquitos.

In 2015, Oxitec mosquitos were released into the CECAP/Eldorado area of Piracicaba, Brazil, which had the city's highest rates of Dengue fever in 2014 and 2015. After one year, CECAP/Eldorado's Dengue fever rate dropped by 91 percent, compared to the rest of the city's 52 percent drop. Similar trials conducted in the Cayman Islands, Malaysia and Panama reported 75 to 90 percent reductions in *A. aegypti* populations.

While this is only the first study to definitively link GM mosquitos to reduced rates of disease, it's giving researchers hope that mosquito-borne viruses may have finally met their match.



[CLASSROOM DISCUSSION]

How does reducing the mosquito population impact diseases like Dengue and Zika?

What negative side effects could result from GM mosquitos in the wild?

[VOCABULARY]

AEDES AEGYPTI MOSQUITOS

DENGUE FEVER

GENETIC ENGINEERING

GENETICALLY MODIFIED ORGANISMS (GMO)

MICROCEPHALY

ZIKA VIRUS



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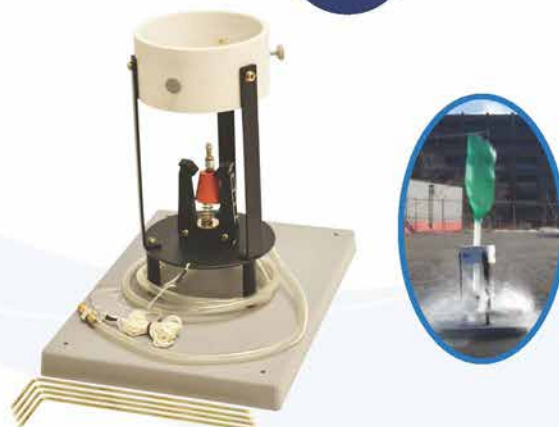
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Animal-Free Cosmetic Testing Now a Reality

By Celeste Beley

Testing cosmetic products has always been controversial among animal-rights advocates, mostly because of tests that have been conducted on animals or cosmetics that use animal components. While some countries, like China, actually require all cosmetic products to be tested on animals, others, including all of the European Union nations, have banned animal testing altogether. In the United States, animal testing is legal but not required.

Now a laboratory in the United Kingdom has developed a method it claims is cruelty-free and more scientific than traditional testing. Their goal is to work with the industry and governments around the world to help advance “non-animal” cosmetics testing.

An Alternative to Cruelty

XCellR8, located in Cheshire, UK, started with a desire to offer completely cruelty-free testing to the cosmetics industry. Its researchers use cells from human skin donated by cosmetic surgery patients. The cells are isolated from the donated samples and then grown in the lab.

The laboratory-grown skin is nearly identical to real skin on the body, including a skin barrier that allows full cosmetic formulations to be applied to the surface. The lab then incubates the skin models with samples or ingredients to evaluate how much damage they cause over time. Cosmetic ingredients can be absorbed into the bloodstream through the skin and then passed to other organs, so testing on actual human skin may more accurately determine the risks or benefits of using products or ingredients.

There are other human cell alternatives to traditional animal testing, but those methods still use animal components such as bovine or horse serum. “In many cases the culture of human cells still requires the use of animal components such as blood-derived components or liver extract, which mean that ultimately animals still have to be sacrificed for that work,” said XCellR8 co-founder Carol Barker-Treasure, Ph.D. “One of the unique things about XCellR8 is that we’ve eradicated all of those components and so we have a truly animal-free testing laboratory,” she added.

In addition to offering ethical advancements, XCellR8 believes its animal-free tests are better at predicting safe human product use compared to traditional animal-based tests.



[DISCUSSION QUESTIONS]

What are the benefits and drawbacks to using human cells to test cosmetic products?

Discuss the pros and cons of animal testing of any kind. Which stance would you take, and why?

[VOCABULARY]

BOVINE SERUM

HORSE SERUM

ERADICATE

ETHICAL



Mysterious Virus is Killing Largemouth Bass

By Clayton Summerstone

A new virus has been discovered, and it’s being connected to a widespread die-off of largemouth bass in Wisconsin.

Pine Lake in Wisconsin’s Forest County is the epicenter of the virus’ damage. The U.S. Fish and Wildlife Service’s La Crosse Fish Health Center isolated the virus, following the May 2015 surge of fish deaths in the northeastern Wisconsin lake.

While it is still unclear if the virus that was discovered is indeed the primary cause of the fish deaths, there’s been no documentation at Pine Lake of large fish kills involving a single species like largemouth bass. That certainly makes things even more puzzling as to what the root source of the virus actually is.

In short, the pathogen was definitely new to the science world, and despite not being linked directly to fish deaths, the virus is related to other viruses

associated with disease in other fish species.

What’s Next-Generation Sequencing All About?

Identification of the virus was made possible by “next-generation sequencing” technologies that allow biologists to sequence millions of molecules of genetic material in a sample. The biologists then employ very powerful computers to analyze results before determining their results.

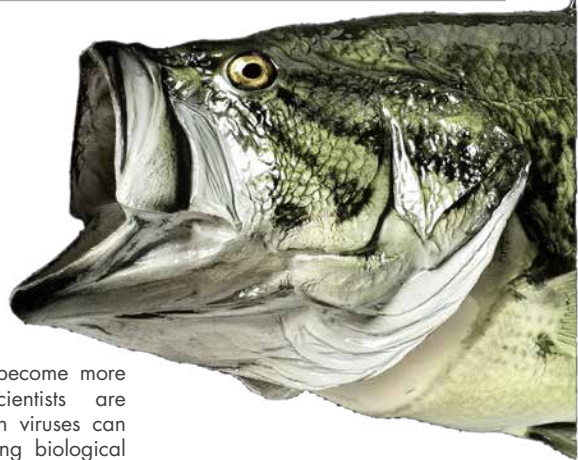
There are extremely complex genomic research questions that require a wealth of information beyond standard DNA sequencing technologies to answer. But now next-generation sequencing is bridging that gap and proving to be a reliable tool for helping to solve these mysteries.

As these technologies become more widely available, scientists are confident that more fish viruses can be identified by studying biological systems in a unique way.

This should come as welcome news to the fishing industry, because if this particular virus can be directly linked to the death of these fish, it will have serious financial implications.

Currently, anglers spend roughly \$2.1 billion annually in the state, according to the Department of Natural Resources (DNR), and Wisconsin’s aquaculture has an estimated \$21 million annual impact on the economy. Just the commercial fishery for the Great Lakes alone has an annual value of \$23 million.

Investigations like this one remind us of the crucial role that science plays



in helping us to manage our resources and evaluate the economic benefits of potential measures. Without the backing of efficient and progressive science practices, states like Wisconsin would struggle to respond effectively to problems like these.

[DISCUSSION QUESTIONS]

What are some other viruses that have impacted lake water inhabitants?

What other potential factors involved could be causing the fish to die?

[VOCABULARY]

VIRUS

PATHOGEN



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Cultured Meat Could Help Save the Environment

By Mike Howie

Scientists are becoming high-tech farmers of the future by growing meat in their labs. But this isn't some meat substitute, and it's not genetically modified. Rather, it's tissue-engineered food that's already been made.

Cultured Meat

In 2013, Mark Post of Maastricht University grew a hamburger patty in a petri dish. It cost \$300,000 for him to do it, and the taste was reportedly lacking, but it was a start. He did it by taking stem cells from a cow, removing the fat cells, and putting the muscle cells in a bioreactor full of nutrients. In time, each muscle cell turned into a trillion new muscle cells, which were placed on a support structure to connect into muscle fibers. The look and feel of the meat was reportedly spot on, so all that's left is to improve the taste and lower the price, which is already in the works.

Post and his team are working on fat tissue now, which is what gives meat its flavor. As for the price, they're already on track to reduce it to \$11 per burger — a price not unheard of in upscale restaurants — or \$36 per pound. This price will further decrease as the product moves into mass production. If all goes well, lab-grown meat will eventually enter supermarkets as a slightly pricier alternative to traditional meat, then in the following years it will become

more common, to the point that it would be identical to traditional meat in both flavor and price.

Beef is just the beginning of all this. Already, a team led by Amit Gefen of Tel Aviv University in Israel is working on a lab-grown chicken. Because chicken accounts for one-third of all the meat eaten in the world, their success would mark an important progression. From there the process can move on to different cuts of meat, and even more animals.

Environmental and Health Benefits

Growing meat in labs instead of on farms will drastically cut down on pollution and resource consumption. According to the Food and Agriculture Organization (FAO), animal protein production in the U.S. requires 28 calories of feed for every calorie of meat produced. On top of that, one pound of beef can require more than 1,500 gallons of water to produce. And then there's the land consumption — 26 percent of the Earth's ice-free surface is used for grazing livestock. Finally, 15 to 18 percent of all global greenhouse gases come from livestock. All of this added together has a hefty impact on our resources and environment.

But, as projected today, mass producing cultured meat doesn't have nearly as big of an environmental impact. It will use far less gas and water and

put out far fewer emissions than raising animals, and will use less energy than everything but raising poultry.

It might even be a bit healthier to eat. There wouldn't be large groups of animals in one relatively small space spreading diseases to one another, meaning outbreaks like swine flu and avian flu would be far less likely. Similarly, the meat wouldn't be exposed to as much dirt and bacteria, which are what lead to food poisoning from things like *E.coli* and Salmonella. Eventually the production process will be entirely sterile, meaning antibiotics would no longer be necessary.

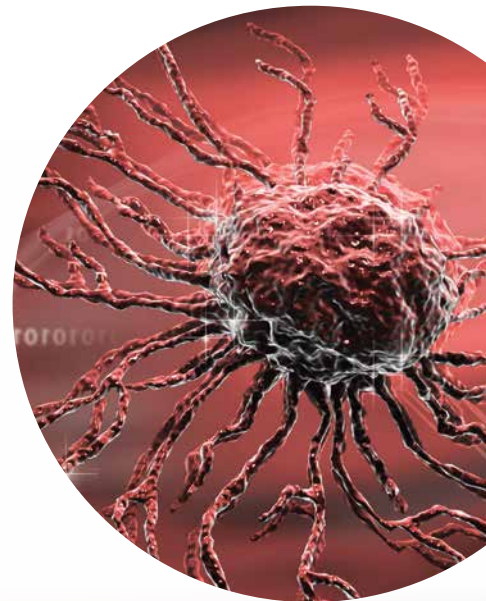
And it's not just that there would be less risk of illness and disease with cultured meat — it could actually be more nutritious. Natural meat contains saturated fatty acids, which are known to contribute to cardiovascular disease and type-2 diabetes. But with cultured meats, scientists can make and add whatever fats they want, such as omega-3 fatty acids, which are a much healthier option. They could even fortify the meat by adding vitamins to it.



Not So Fast

The science has a lot of promise to it, and the benefits are something many people will agree on. But this is something that's going to take a while to become a common part of our culinary lives. These are just the early days of cultured meat, and it will take time to refine the process and begin production on any kind of large scale.

One day, however, you'll be able to eat a steak that really earns a cruelty-free label.



[CLASSROOM DISCUSSION]

Would you eat tissue-engineered food? Why or why not?

Would you be willing to pay more for healthier food that benefits the environment? Why or why not?

[VOCABULARY]

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Fighting Pathogens: A Few Good Bacteria

By Hamilton Waldron

Most people understand that there are good fats, cholesterol and sugars, but the whole concept of probiotics is a bit more complex. Probably because we tend to regard bacteria as a bad thing.

But there are actually several kinds of beneficial bacteria in our bodies, one of which may be a type of bacteria located in the human nasal cavity that was recently discovered by researchers in Germany.

The bacterium, which produces a new antibiotic compound currently referred to as Lugdunin, could eventually help establish a whole new class of antibiotic medicines to fight drug-resistant bacterial infections.

Lugdunin actually lives in an area of the nose that is home to more than

50 different kinds of bacteria. It also happens to be the first known example of a new class of peptide antibiotics, which are compounds consisting of two or more amino acids chained by a unique bond that helps join them together.

The bacterium that produces Lugdunin is known as *Staphylococcus lugdunensis*. Researchers have found that in experiments with mice, it is able to effectively treat a skin infection caused by the bacteria *Staphylococcus aureus*.

In addition to those lab findings, the researchers have also studied 187 hospital patients' nasal swabs, and found that of those with *S. lugdunensis* bacteria in noses, only 5.9 percent also were at risk of possible infection.

New Discoveries in Picking for Peptides

To bring it all into perspective, it's still necessary to take a moment and understand how early all this research is. The team of researchers involved will need many years of work before the possibility of any new medicine emerging from all their extensive testing. But even these initial developments help to validate the way we use peptide antibiotics.

Various peptides are recommended for burning fat, building muscle, and improving athletic performance. Sometimes referred to as "small proteins," their usage has skyrocketed with professional athletes in recent years. This is because they possess therapeutic capabilities that help

maximize a body's ability to fight off and recover from any sort of breakdown.

When there are so many deadly pathogens and superbugs around that put our bodies at risk, it's nice to know that the basis for a possible game-changer in antibiotics could be right under our noses — or even in them.

[DISCUSSION QUESTIONS]

Do you know of any foods containing probiotics that you enjoy eating? What are some other kinds of good bacteria that our bodies need?

[VOCABULARY]

PATHOGENS

PEPTIDES



Fidgeting Is Fine, Walking Is Better

By Clayton Summerstone



Research continues to prove that sitting for long periods of time reduces blood flow to the legs, which can have serious ramifications for cardiovascular health. However, researchers have now discovered that fidgeting while seated actually helps safeguard the arteries from harm.

The science here is simple, really. The friction of the flowing blood on the artery wall is the action that is beneficial to vascular health. This particular study observed 11 healthy young men and women before and after three hours of sitting. The participants were instructed to fidget one leg intermittently — tapping one foot for one minute, followed by four minutes of rest — while keeping the other leg stationary.

The study's researchers determined that blood flow in the fidgeting leg increased, while the stationary leg showed a decline in blood flow.

Take it a "Step" Further

While it's nice to know that fidgeting can actually benefit health, there are plenty of things we can do throughout the day to improve our blood circulation.

For instance, it's no secret that working at a standing desk can be a good way to avoid the reduced blood flow to the legs that results from sitting. But nothing beats a good walk. Whether that's walking to refill your water bottle, or taking a brisk stroll on your lunch break, the more we can break free from our stationary routines, the better.

Because it's not just physical health that benefits from greater mobility. Mental acuity improves, too, as will your overall performance at your studies or work the more active you become throughout the day.

Here are some exercises you can do right at your desk:

- Get out of your chair every once in a while to try some leg squats. Do five sets for 30 seconds.
- Wall push-ups: Find a flat wall, and push off the surface. Do five sets for 30 seconds.
- Calf raises are simple and easy. All you need to do is stand up and rest your hands on the end of your desk. Then just raise your heels until you're balancing your body weight on the balls of your feet. Hold that pose, and then lower yourself back to a normal stance. Repeat as many times as you'd like.

We are all busy throughout the day, and we have all wished there were more hours in a day. But until that day comes (it won't), every fidgety movement we make, and every small step we take, will ultimately contribute to better blood flow and improved health.

[DISCUSSION QUESTIONS]

What are some other exercises that you can do at your desk?
What are the pros and cons of using a standing desk?

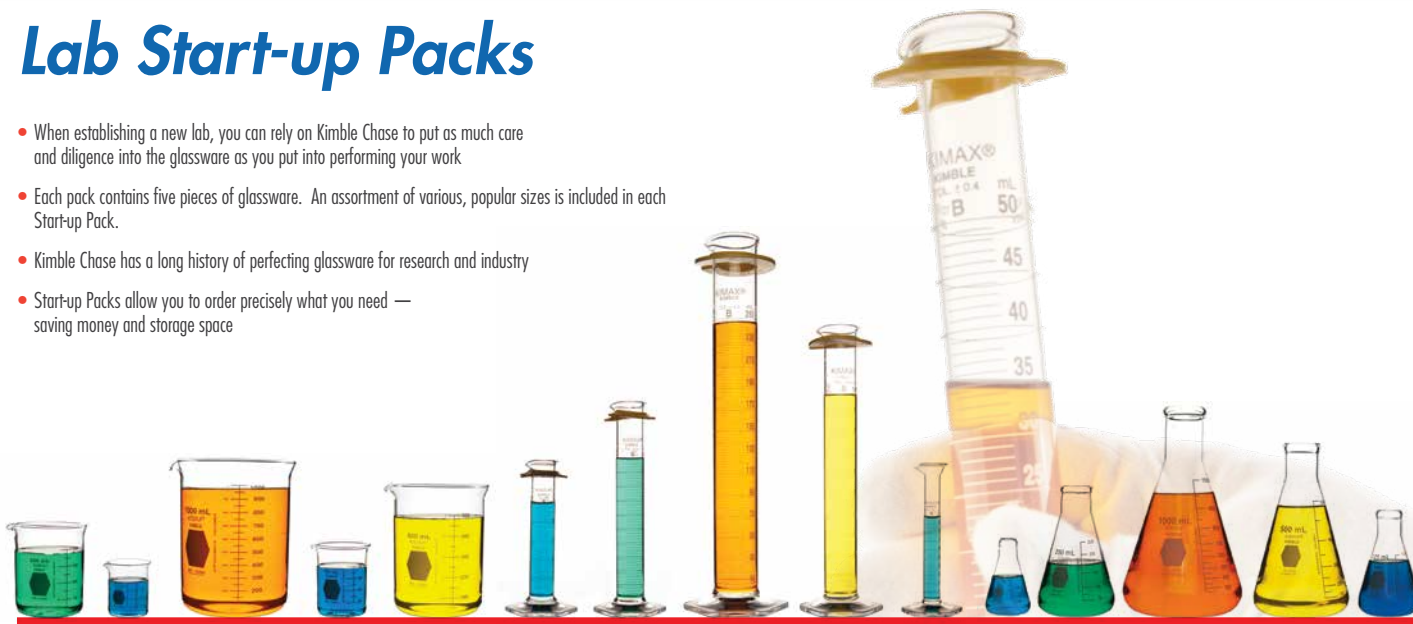
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Weighing in on the Gravity Tunnel

By Ralph Birch

It would take about 42 minutes to fall through the Earth. Actually, it's more like 38 minutes. But wait, assuming you could drill a hole from one side of the planet straight through to the other, would it even be possible to fall through the Earth at all?

Physics teachers have been posing this question to students for years, but coming up with the "right" answer to this theoretical problem has been the subject of debate for some time. The so-called gravity tunnel problem does make some incorrect assumptions that have a significant impact on the outcome of this fantasy fall.

First, it's unrealistic to assume for the sake of mathematical calculation that the Earth is the same density all the way through. It is widely accepted that the outer layers of the planet are less dense and that the composition of

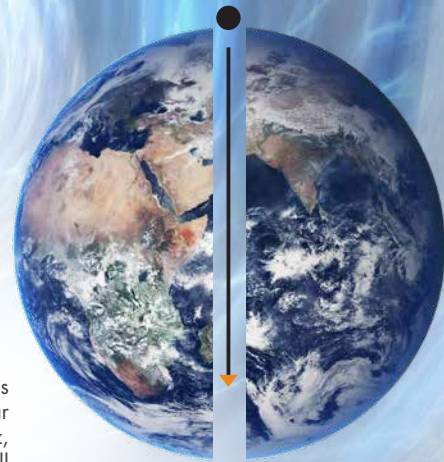
the planet becomes denser the closer you get to the center.

Even if you assume that the Earth, like a bowling or billiard ball, is the same density throughout, it is necessary to calculate the changes in the force of gravity as an object — in this case a person — falls through the tunnel. The strength of the gravitational force pulling toward the center of the Earth is going to vary depending on the distance of an object from that center point. The farther away an object is, the weaker the force of gravity. But as an object gets closer to the center, the pull of gravity strengthens. (In physics, this is known as the shell theorem, originally posited by Isaac Newton.) Additionally, the calculation would have to take into account the friction and wind resistance within the tunnel that would serve to slow down the falling object.

Because of the inconsistencies associated with this particular calculation, Alexander Klotz, a graduate student at McGill University in Montreal, Canada, began searching for ways to more realistically represent the mass distribution of the Earth. Klotz used seismic data to more accurately depict the density changes from the surface to the center and back out to the surface on the other side. His new way of thinking is what shaved four minutes off the time of the fall.

While physics professors around the world will still present the gravity tunnel problem to their students, they'll be able to add Klotz's recent findings to their lectures.

"With the right idea it's still possible to make, not a monumental discovery, but an incremental one," Klotz said.



DISCUSSION QUESTIONS

Can you think of any other calculations like the gravity tunnel problem that might be challenging for physicists to figure out?

Name some everyday activities that are affected by friction and wind resistance.

VOCABULARY

GRAVITY

SEISMIC

DENSITY



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Your Brain Can Predict How Objects Move

By Moira Bell

Imagine a glass full of water that's too close to the edge of a table or a stack of toys in your room with one action figure dangling precariously. You would immediately feel the need to reposition these objects before one fell to the ground, right? According to a recently published study, this is no accident. Scientists have found areas of the brain that become active when people predict how objects move in the world based on physical laws.

To find out exactly where these physics simulations are occurring in the brain, scientists asked 12 people to watch a series of videos featuring an unsteady block tower. Some participants had to answer questions based on visual information alone, such as how many blocks were blue and how many blocks were yellow. Meanwhile, other participants were asked to predict which way the blocks would fall if the tower collapsed.

Several areas of the brain were active, according to scans, when participants had to predict the occurrence of physical events. These same areas of the brain also lit up on the scan when people passively watched a video of rolling and colliding objects.

Physics on the Brain

Found in the premotor cortex and the supplementary motor area of the brain, the areas that were active during these experiments are thought to be involved in planning actions, such as reaching to grab a pen. The results of this study suggest that physics intuition and action planning are closely linked in the brain. "We believe this might be because infants learn physics models of the world as they hone their motor skills, handling objects to learn how they behave," said Jason Fischer, a cognitive scientist at Johns Hopkins University and co-author of the study. For example,

babies first learn that objects have to be touching to have any physical effects on each other. Next they learn that an object has to be on top of another to be supported by it. Then they learn about an object's center of mass and other important properties.

Humans are not the only animals that rely on their brains to quickly calculate physics equations. And, according to Fischer, it may be even more important to animals than it is to us, as they need to know what surfaces they can jump onto that can support them.

Hopefully this makes you feel a little bit better about taking Physics. Or maybe you'll just feel slightly more inclined to challenge your cat to a game of Jenga.



[DISCUSSION QUESTIONS]

What are some other examples of how your body knows what to do without you thinking about it?

What do the results of this study teach us about the brain?

[VOCABULARY]

CORTEX

MOTOR

INTUITION



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Researchers Watch the Brain Do Math

By Lacey Cirinelli



Have you ever wondered how your brain works as you solve a problem? Researchers at Carnegie Mellon University (CMU) in Pittsburgh recently got one step closer to understanding how the brain processes complex problems. The lab of John R. Anderson, Ph.D., the R.K. Mellon University Professor of Psychology and Computer Science at CMU, imaged

80 participants' brains as they solved math problems using a technique called functional magnetic resonance imaging, or fMRI — a neuroimaging technique that measures blood flow in the brain during specific tasks. The more active an area of the brain is, the more oxygen and nutrients it requires. Because blood supplies oxygen and nutrients to the brain, increased blood flow to a brain region indicates increased activity in that area and helps researchers pinpoint what areas of the brain are involved in the task.

After practicing problem-solving strategies, participants completed math problems during an fMRI. Following each problem, participants were given feedback about their response. Once all of the data was collected, researchers analyzed it using a combined HSMM-MVPA approach. MVPA, or multi-voxel pattern analysis, is a statistical method commonly used to identify momentary patterns of activity. HSMM, or hidden semi-Markov

model, is a statistical method that helps explain how patterns in an unseen process, like thinking, play out over time. The combination of HSMM and MVPA allowed researchers to determine which phase of cognition subjects were in as well as how long they spent in each phase. Although both techniques have previously been used to analyze neuroimaging data separately, they had never been used together.

The analysis revealed four distinct phases of cognition: encoding, planning, solving, and responding. The time spent in each phase varied depending on the difficulty of the problem being solved. For instance, more complex problems that required more mental effort showed a longer solving stage.

From the Lab to the Classroom

CMU, widely recognized for its pioneering work in both artificial intelligence and cognitive psychology,

has been a leader in cognitive research for decades. Dr. Anderson's lab in particular pairs cognitive research with computer engineering to create cognitive tutors — software that models a student's learning to provide personalized hints, feedback and prompts. Now that researchers are able to examine how the brain processes complex math tasks, they hope to use the phases of cognition to improve available cognitive tutors.

[DISCUSSION QUESTIONS]

Why would knowing the length of each cognitive phase as opposed to total time spent solving the problem be important?

How could a cognitive tutor help students learn in schools?

[VOCABULARY]

COGNITION

COGNITIVE TUTOR

FUNCTIONAL MAGNETIC RESONANCE IMAGING (fMRI)



Jupiter: Galileo to Juno

By Robert Marshall

The first recorded telescopic observations by Galileo over 400 years ago depicted a “wandering star,” today known as a planet, which disobeyed the laws of nature. With an oval-like outline it was clearly not perfectly spherical as all heavenly bodies were believed to be, and more importantly its newly discovered moons, or natural satellites, appeared, over the course of several nights, to orbit Jupiter itself, not the Earth.

These were among the first clues that the Solar System might be centered on the Sun, which amounted to a very outrageous viewpoint during the 17th century. But even today, in the 21st century, Jupiter still harbors secrets waiting to be revealed.

What Scientists Know

Just as Earth has clouds that can be seen from space, so does Jupiter —

but that’s where the similarities end. Made entirely of hydrogen and helium gases, Jupiter is simply a gigantic ball of atmosphere consisting of clouds, belts and zones. These features form stripe-like bands where both the red and white colors alternate as well as their rotating directions. But these are swirling clouds of mystery.

Jupiter’s Great Red Spot, which by itself spans twice the size of Earth, is identified as a storm whose activity can be traced for hundreds of years through observation. Yet what drives it is still unknown.

Juno Jets to Jupiter

As the largest planet in the solar system, Jupiter has the greatest gravitational field (second to the Sun), making any spacecraft approach tedious. This past summer, on July 4, almost five years after its August 5, 2011 launch, Juno

initiated a 35-minute engine burn at more than three million miles away to begin its orbit and insertion of the King Planet. On August 27, 2016, during Juno’s nearest approach of a mere 2,600 miles above the cloud tops, it passed by Jupiter closer than any other previous spacecraft.

During this and the next 30 orbits, before an eventual planned crash into the atmosphere, Juno will not only undergo extreme gravitational forces but will pass through debris fields that rival the rings of Saturn and radiation levels more than six million times stronger than those found naturally here on Earth.

If Juno can survive long enough it will map gravitational and magnetic fields as well as help determine if Jupiter has an interior core. Such data will play a pivotal role in helping us answer deeper questions about the formation and evolution of our Solar System.



[DISCUSSION QUESTIONS]

How might an event like Comet Shoemaker-Levy 9’s crash into Jupiter in 1994 make us think about adding another constraint to the Drake Equation?

[VOCABULARY]

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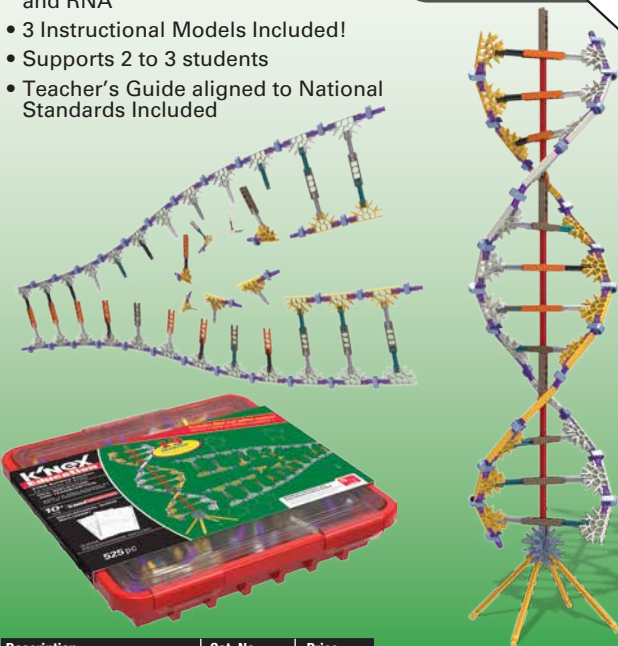
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Safety, Morality and the Myth of the Self-Driving Car

By Kevin Ritchart



Technological advancements are bringing society ever closer to a vehicle that drives itself, which begs the question: just because we can make a self-driving car, should we?

The Myth of the Self-Driving Car

Advocates of autonomous vehicles point out potential benefits like increased traffic efficiency, reduced pollution and fewer traffic accidents, most of which result from human error. But the idea that a driver can trust their vehicle to take them from point A to point B without incident sounds like science fiction to many.

Especially after the occupant of a 2015 Tesla Model S was killed this May when the car, which was operating in Autopilot mode, failed to avoid an 18-wheeler that turned in

front of it. The vehicle's sensors were unable to distinguish between the truck's white side and the sky above it.

The vision systems employed by these early self-driving cars utilize low-resolution cameras to identify objects outside the car. But the technology is far from perfect, according to Carnegie Mellon University professor Ragunathan Rajkumar, who says you need at least two sensors to get high reliability.

Despite warnings that the Autopilot feature merely assists drivers and is still being tested, the occupant of the Tesla that crashed in May failed to see the truck or respond by steering away or applying the brakes manually. The National Highway Traffic Safety Administration (NHTSA) is investigating the crash, and has yet to issue a report.

The Moral Dilemma

These technologies raise another dilemma: when a car's self-driving program must choose between protecting its passengers or the public, whose lives does it deem more valuable?

In a 2015 survey, participants opposed the idea of an automated vehicle saving the life of just one pedestrian at the expense of its passenger. But nearly three-quarters of respondents said it was more morally acceptable for a driverless car to sacrifice the life of one passenger to save 10 pedestrians.

When asked to rank their own safety and that of their family versus pedestrian safety, however, respondents' support for pedestrians dropped precipitously.

The Road Ahead

Until self-driving cars are more than a novelty, the successes and failures of these vehicles will continue to be debated in the court of public opinion. But make no mistake, the automotive industry is gearing up for an increasingly automated future.

[DISCUSSION QUESTIONS]

Would you feel safe riding in an autonomous car? Why or why not? What do you expect from future modes of transportation?

[VOCABULARY]

AUTONOMOUS

AUTOPILOT

NOVELTY



Around the World in a Solar-Powered Plane

By Justin Kovach



Bertrand Piccard, the son of the celebrated undersea explorer Jacques Piccard, had already set a milestone after becoming the first human to circle the earth in a hot-air balloon. Now Piccard, along with fellow aviator Andre Borschberg, has established a new record by becoming one of the first humans to transverse the globe in a solar-powered airplane.

Have Sun, Will Travel

When Piccard took the plane, dubbed Solar Impulse 2, in for its final landing on July 26, 2016, he completed a 16-month, 24,500-mile flight around the world. The plane had amassed almost 500 hours of flight time since setting out on its journey from Abu Dhabi on March 9, 2015.

At 208 feet, which is more than two-thirds the length of a football field, the wingspan of Solar Impulse 2 is longer than that of a Boeing 747. Yet despite this expanse, the plane only weighs as much as an average family car. Solar Impulse 2 is a propeller-driven aircraft with four engines that are powered by 17,000 solar cells built into the wings. Excess energy collected during the flight was stored in onboard batteries.

Several factors contributed to the success of this record-breaking flight. Foremost, perhaps, was the mental stamina of the pilots. Cruising at speeds of only 56 miles per hour at altitudes of 29,500 feet, the pilots had to stay awake and alert for hours on end. The innovative design and construction of the aircraft itself

cannot be underestimated, either. And weather played a role as well, occasionally hindering smooth flying and causing the plane to be grounded for months at a time in some countries.

Setting a Solar-Powered Precedent for the Future

Solar Impulse 2 made history in both aviation and energy by becoming the first fuel-free flight around the planet. And its accomplishment may change the design of passenger planes and the nature of commuting in the future. At the press conference following the flight's historic completion, Piccard said, "I'm sure that within the next 10 years we'll see electric airplanes carrying 50 passengers on short- to medium-haul flights."

Whatever the future of air travel holds it will owe in part to the high-flying accomplishments of Solar Impulse 2 and its adventurous crew.

[DISCUSSION QUESTIONS]

In what other areas of your daily life do you feel solar energy could be harnessed and used?

Describe other clean energies besides solar. Which do you think will be more widely used, and why?

[VOCABULARY]

CLEAN ENERGY

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Testosterone and the Teenage Brain

By Kevin Ritchart

Scientists are beginning to understand the role testosterone plays in the maturity and decision-making of the adolescent brain.

When an adult brain processes an emotion, multiple areas of the brain are activated, beginning with the limbic system. A small area located deep within the brain, the limbic system is the spot where emotional reactions originate. In the adult brain, the prefrontal cortex, which can be found in the front of the brain right behind the forehead, also plays a key role in keeping emotional reactions in check.

The brain of a teenager can't simply be categorized as a larger version of a child's brain or a smaller version of an adult's. As children grow, their brains develop, and different areas of the brain form connections or disconnect from one another.

The amygdala is the area of the limbic system that controls emotions like fear. Adolescents tend to activate

the amygdala more often when faced with emotional situations, according to neuroscientist Anna Tyborowska of Radboud University in the Netherlands.

Tyborowska was part of a team of scientists who recruited a group of 14-year-old boys and girls for a brain study. Test subjects were placed inside a functional magnetic resonance imaging (fMRI) machine so the scientists could measure blood flow in the brain while the subjects performed certain tasks.

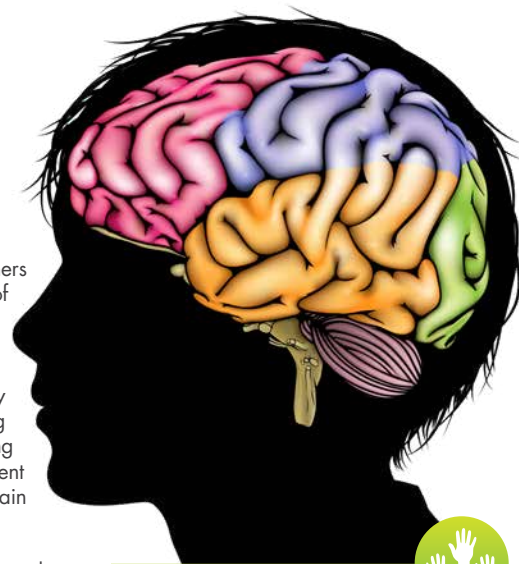
The teens were given a joystick and asked to push the lever away from them when they saw an angry face and pull it toward them when they saw a happy face. Then researchers switched the responses, asking the subjects to pull the joystick toward them when they saw an angry face and push it away when presented with a happy one.

"Approaching something threatening is an unnatural response that requires self-control," Tyborowska said.

As part of the study, researchers also measured levels of testosterone, a hormone that rises in both males and females during puberty. Testosterone is partly responsible for reorganizing the brain and controlling the development of different structures within the brain throughout adolescence.

When placed in situations where emotional control is required, teens with less testosterone rely on their limbic systems. This makes their brain activity more akin to that of a younger child. Conversely, teens with higher levels of testosterone take a more adult approach when it comes to their emotions, relying more on the prefrontal cortex.

Though every child — and every brain — is unique, scientists are learning more about the involvement of testosterone in adolescent emotional maturity with each new study they perform.



[DISCUSSION QUESTIONS]

Aside from fear and anger, what are some other extreme emotional responses that could trigger the amygdala?

What do you think scientists would find if they performed a similar study on kids younger than 14? Older than 14?

[VOCABULARY]

LIMBIC SYSTEM

PREFRONTAL CORTEX

AMYGDALA

TESTOSTERONE



Chemistry Can Reveal Your Emotions at the Movies

By Danielle Ferrante

A recent study has established a link between a movie scene's emotional content and the chemicals people exhale as they watch it, giving the phrase "suspense is in the air" new meaning.

The Experiment

Jonathan Williams is an atmospheric chemist at the Max Planck Institute for Chemistry in Mainz, Germany. His interest in measuring the levels of gases in the air started with his experiment at a soccer stadium in Mainz. Williams wanted to see if the fans' breath would affect the levels of greenhouse gases in the air. The answer was no, because his findings yielded results on a very small scale — but he did notice that carbon dioxide levels increased when the fans cheered excitedly. This prompted Williams to investigate further in a more controlled environment: a movie theater.

More than 9,500 people viewed 108

screenings of 16 movies from different genres, scenes from each of which were assigned a label based on the average rating of 10 volunteers. The labels consisted of three parts: a general term such as "comedy" or "romantic;" a second set that was more specific and referred directly to the scene's content such as "laughter" or "injury;" and an emotional assessment scheme that used two separate five-point scales, one ranging from happy to sad and the other from excited to calm. Each scene was assigned a label only when two thirds of the volunteers agreed.

During the movie the doors were closed to allow for a controlled circulation of air, which was measured for volatile organic compounds (VOCs) by instruments located outside of the room. The instruments captured those compounds then accelerated them with an electric field to determine what molecules they were made up of as well as how much of each molecule they contained.

The Results

Williams and his team found that certain scenes, primarily those that had people laughing or on the edge of their seats, produced the highest amounts of carbon dioxide and isoprene. Isoprene is the most abundant hydrocarbon measurable in the breath of humans. They attributed this spike to certain physical reactions such as increased pulse and breathing or tense muscle movements.

All living organisms, no matter how small, emit chemicals into the environment, and understanding how these chemicals interact can provide huge insights into the world around us. Going forward, Williams believes exhaled air measurements could allow scientists to investigate human metabolism in greater detail and even allow marketers to quickly measure how a group of people feel about their products.



[DISCUSSION QUESTIONS]

Can you think of any other factors that might have contributed to the increased carbon dioxide levels during the movie besides the scene they were watching?

Williams mentioned that the moviegoer's pulses and breathing rates increased, resulting in the spike of isoprene levels. What other physical reactions could scientists look at to measure this increase?

[VOCABULARY]

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Warming Oceans Bleach Coral Reefs

By Rita Waimer

Coral reefs color seabeds in shallow, warm seas all over the world, but what many people may forget is that they are actually living organisms. Beyond that, they are diverse habitats that are home to all types of marine life. And just like all of the fish that call them home, coral reefs can die.

A piece of coral is mostly made up of tiny animals called polyps that survive by feeding on small creatures that pass close by. Their color, however, comes from single-celled algae called Zooxanthellae that photosynthesize food, some of which is passed to the host coral.

exist in a delicate balance that can be affected by a number of things, one of which is fluctuations in water temperature. That's exactly what has led to the bleaching of coral in the Maldives this year, as well as the bleaching of the Great Barrier Reef and reefs in Western Australia.

This year's record high temperatures warmed waters in the Indian Ocean around the Maldives, and that increase in water temperature put stress on the coral. In turn, the coral expelled the colorful algae, leaving nothing but nearly transparent tissue over a stony skeleton.

Agency studied the bleaching event in partnership with the International Union for Conservation of Nature (IUCN) and found that more than 60 percent of coral reefs in the island chain were affected, with up to 90 percent of reefs affected in some areas. This bleaching event started in 2014 with a strong El Niño in the Pacific Ocean and has since become the longest bleaching event in recorded history. In October of 2015 the U.S. National Oceanic and Atmospheric Association declared it a global bleaching event. Coral Reef Watch coordinator Mark Eakin said that it could last well into 2016, which has proven to be true.

will quickly erode, wiping out habitats for ecologically and economically important marine life, and leaving the coast of the Maldives more vulnerable to storms.

The Effects of Climate Change on Coral

Together, the polyps and algae co-

A Global Event

The Maldives Marine Research Center and the Environmental Protection

[DISCUSSION QUESTIONS]

How widely could the bleaching phenomenon spread if the trend of rising temperatures continues?

How could the loss of coral reefs affect the people who live in the Maldives?

[VOCABULARY]

- CORAL
- POLYP
- ZOOXANTHELLAE
- BLEACH



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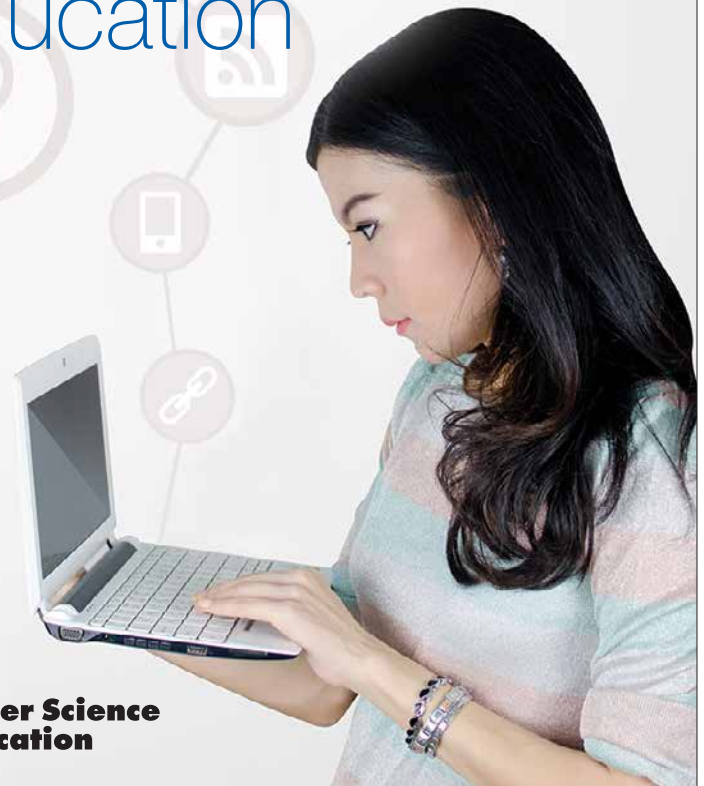


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Fisher Science Education



No Turning Back for Diseased Oak Trees

By Christina Phillis

Just as easily as you can catch a cold, plants can catch and pass on diseases to each other. One such disease, known as “sudden oak death,” is killing oak trees across Northern California.

The plant pathogen causing the devastation is called *Phytophthora ramorum*. It is a water mold that penetrates trees through their bark, killing them within one to five years. It annihilates the vascular system of trees by attacking its cambium, the layer between the wood and bark. Because many species of trees can carry the mold without showing any symptoms, it's very easy for the disease to spread and not be caught or contained.

The first signs of the disease occurred in 1995. *P. ramorum* is believed to have entered the United States with imported ornamental plants. A new study, published by researchers at the University of California-Davis, estimates that the last chance to stop it was in 2002. The team used a disease model that is similar to those used to track human pathogens. Even if a full-scale effort was employed today, the

model predicts that forests along the west coast would be consumed and billions of trees would be put at risk.

Stopping the Spread

The best method to try to beat the disease would involve cutting down oak trees and other carriers that border the infected areas in an effort to prevent it from progressing any farther. Wildlife officials in Oregon saw some success with similar methods, but the disease ended up spreading anyway because their efforts came too late.

The greatest obstacle to containing this disease is a lack of funds. If the California Department of Forestry and Fire Protection were to spend its full 2015-16 budget of \$90 million, about 9,000 square miles of oak forest would still be lost. Using the same amount of resources 10 years ago would have resulted in a loss of about 5,000 square miles.

Dealing with the Aftermath

California's oak trees serve as “keystone species,” meaning they support ecological communities of other plants and animals. There are 300 different species in California that live in habitats made up mostly of oak trees. The effects of this disease will substantially alter the state's biological diversity.

At this point, the state of California must focus on living with and managing the disease. Moving forward, this will involve restoring affected areas, removing infected trees and deploying beneficial wildfires.

[DISCUSSION QUESTIONS]

Describe the potential effects of “sudden oak death” on surrounding plants and animals.

Besides widespread pathogens, what other large-scale events have the potential to alter ecosystems?

[VOCABULARY]

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S05262	Fisher Scientific RT Basic 220mm Top/U.S. Plug	5L	55 lb.	230 x 230 x 65mm	6w	\$274.40



The Science of Snow

By Mike Howie and Lisa Jancarik

All snow begins with a single snow crystal. This crystal forms when water vapor freezes, and as it falls it takes on a unique hexagonal shape. Eventually the crystal will collide with other snow crystals, growing larger and larger until it becomes a fluffy snowflake.

Looking at snowflakes under a microscope reveals that no two are the same, but that they do share some similar characteristics. In the 1930s, Japanese physicist Ukichiro Nakaya studied these shapes — finding stars, plates, prisms and columns — and how temperature and humidity affect their formation. He found that star-shaped crystals form at the lowest temperatures, and that branching occurs with high humidity.

Snow easily traps air, making it an excellent insulator for humans and animals alike. Animals hibernating in cold climates burrow into snow caves, trapping their body heat to stay warm all winter long. And humans pack snow into blocks to make igloos, which similarly trap heat and can be up to 70° Fahrenheit (21° Celsius) warmer than the outside air when they house a fire.

How Snow Forms

Snow is most common in the high-altitude and high-latitude areas of the world, so the closer you are to the poles or the top of a mountain the more likely you are to find snow. When temperatures reach or dip below freezing with minimal moisture in the air, snow crystals begin to form in the atmosphere and grow into snowflakes. If temperatures are warm enough on the ground, around 41° Fahrenheit (5° Celsius), the snow will land and begin to accumulate, but if it's any warmer it will simply melt. It can never be too cold to snow, but heavy snowfalls are more common when the air on the ground is relatively warm.

Large lakes also bring large amounts of snow to an area with what has become known as the lake effect: When cold, dry air passes over a warm body of water it cools the air on the surface, picking up moisture that becomes clouds. When those clouds get large enough and move over land they produce snow, blanketing the area around the lake. This is very common along the Great Lakes in the United States.

But not all snow is natural. Ski resorts commonly use snow machines to make their own snow and extend the ski season. These machines shoot droplets of water into the outside air, which quickly freeze and fall as snow. While the machines can produce snow when there is no natural precipitation, they still need low temperatures and humidity levels to work.

Beyond just being natural or man-made, snow has many natural variations. And because it can sit on the ground for so long it exists in layers. Inevitably, some of those layers are weaker than others, and a shift in weather or any additional load on a weak layer — like a skier or fresh snowfall — can make it collapse and trigger an avalanche.

Snow and Climate

Snow reflects 80 to 90 percent of sunlight, which cools the Earth and regulates the exchange of heat between the surface of the planet and the atmosphere. It serves as a protective layer for soil and the organisms that live in it, insulating against the extremes of air temperature and locking in moisture.

Climate change, however, is melting this protection away. By impacting the amount of snowfall and the timing of the snow season, climate change is reducing the amount of snow that will cover the Earth in coming years. Europe and Asia will experience this most dramatically, but it will affect the entire world. In the United States, snowfall has been on the decline since at least 1930. The only outlier here is the Great Lakes, which have seen slightly more snowfall than previous years.

The loss of this snow is already beginning to affect the water supply in some areas. In April of 2015, California Governor Jerry Brown announced statewide water restrictions in reaction to a shrinking Sierra Nevada snowpack. Snowmelt provides as much as 75 percent of water in some areas of the U.S., and at one point it was scarce enough to leave the South Platte River in Colorado and Nebraska dry.



[CLASSROOM DISCUSSION]

How much snow does your area get every year? Does it get more or less snow than it did in the past?

What different kinds of snow have you seen, and what makes them different?

[VOCABULARY]

AVALANCHE

INSULATE

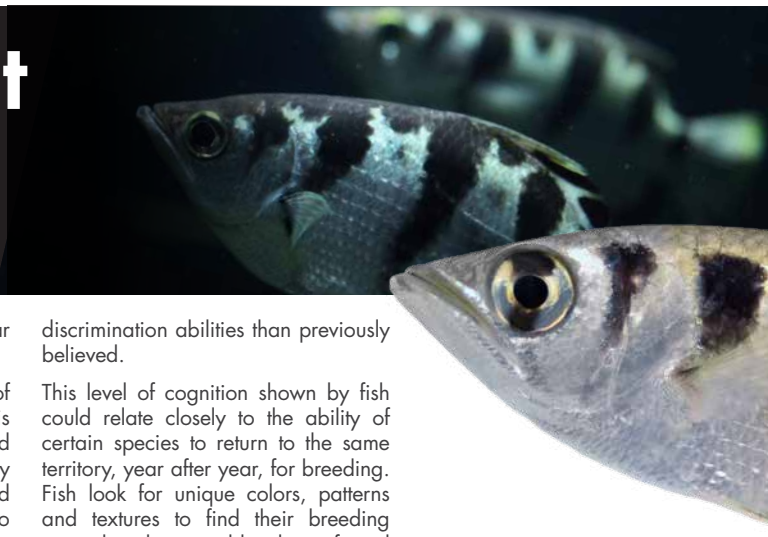
LAKE EFFECT

WATER VAPOR



Facing Facts About Fish Brains

By Ralph Birch



There's something fishy going on in Australia.

A recent study conducted by scientists from the University of Oxford and Australia's University of Queensland has concluded that a species of tropical fish possesses the ability to recognize faces. Despite the lack of a neocortex, which is the part of the brain that controls visual recognition, the archerfish has demonstrated the ability to accurately distinguish between faces more than three-quarters of the time.

The archerfish, which is native to Australia and southeast Asia, was selected for this research based on its ability to spit a jet of water. This technique is typically utilized as a defense mechanism against insects looking to prey on the archerfish, but scientists used the spitting as a way for the fish to choose between faces.

Researchers presented the archerfish with two different images and offered

food as a reward when a particular face was selected.

"This can give us a huge amount of information about what the fish is able to see and how they do it," said Dr. Cait Newport of the University of Oxford, who has also performed similar experiments with Picasso triggerfish.

In subsequent tests, the archerfish viewed a series of learned faces and was able to distinguish between those images and up to 44 new faces with an 81 percent success rate. The fish were able to identify the faces even when features like head shape and color were removed from the images.

The Australian study found that complicated brain makeup is not necessary to recognize human faces, though the identification of subtle features is a key component. Newport and her colleagues now believe that fish have significantly greater visual

discrimination abilities than previously believed.

This level of cognition shown by fish could relate closely to the ability of certain species to return to the same territory, year after year, for breeding. Fish look for unique colors, patterns and textures to find their breeding grounds — but mass bleaching of coral reefs could make this more difficult.

Bleaching of reefs occurs when water is too warm, which forces coral to expel living algae. The algae calcify and turn white and eventually die, which is a threat to locations like the Great Barrier Reef and the marine life native to that region.

"We don't know if they're still going to be able to find their territories, their homes," Newport observed. "We don't know how that will affect how they detect predators or potential prey."

Read more about the bleaching of coral on page 22.

[CLASSROOM DISCUSSION]

Discuss some other ways enhanced vision and brain function can impact a fish in its natural habitat.

What other animals with so-called "simple" brains may be smarter than we think?

[VOCABULARY]

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A student interested in microbiology should take biology and chemistry courses in high school. In college, a bachelor's degree in microbiology or biochemistry is the best path into this field. Statistics and other math courses will be helpful for understanding and analyzing data. Furthermore, experience in a lab with a professor is highly recommended. In most cases, a doctorate in microbiology is a necessary precursor to independent research.

According to the Bureau of Labor Statistics, the demand for microbiologists will increase by 13 percent from 2010 to 2020. Students interested in microbiology can look forward to a median salary of \$65,920. Microbiologists can find work in the public sector, the private sector for health, energy and other companies, or colleges and universities.



Pokemon Go: More than Just a Game

By Mike Howie

When people think of video games, they probably imagine sitting in front of a TV, controller in hand, moving nothing but thumbs and fingers for hours on end. Or perhaps lounging about with a smartphone, swiping and tapping toward a new high score. But the viral hit "Pokemon Go" is changing the way we think about video games.

When the mobile game launched in early July it was an instant hit. For kids it was another way to play a game and enjoy a world that's been around for a lifetime, while for some older players it was a dose of nostalgia, transporting them to the 90s when Pokemon originally gripped the world with cartoons, card games, video games, and a burning desire to catch 'em all.

Real World, Virtual Monsters

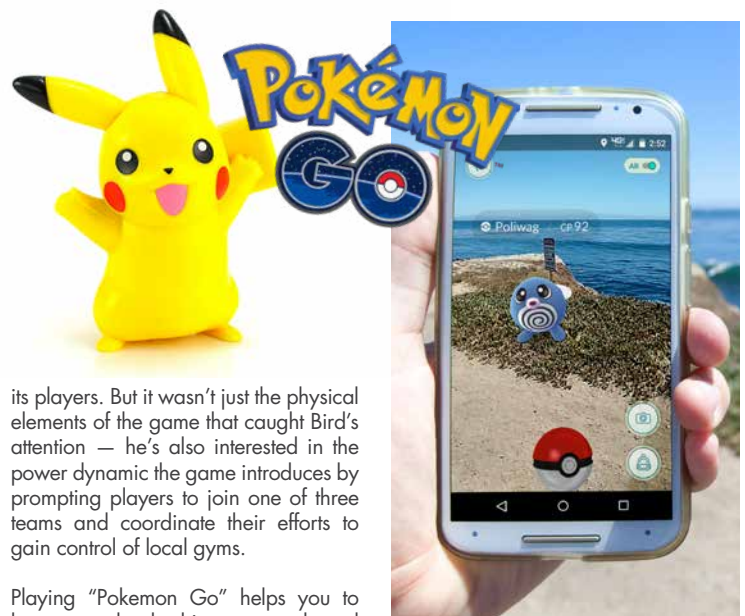
What sets "Pokemon Go" apart is how much it makes you physically move, and that's what inspired instructor Steven Bird at the University of Idaho

to include it in the curriculum for his physical education class, "Pop Culture Games."

The game uses the GPS in your mobile device to transport you to a virtual, Pokemon-filled version of the real world. A mall may become a Pokéon gym, where you can train your Pokemon in battle and win control of the gym for your team. A gas station may become a Pokéstop, where you can stock up on pokeballs, potions and lures. And everything in between is the tall grass, where you can search far and wide for wild Pokemon to catch.

Be the Very Best, Like No One Ever Was

Moving between the different in-game locations requires you to move about in the real world, and Bird — along with a number of players who noted their sore legs on Twitter — quickly noticed how much exercise the game can get out of



its players. But it wasn't just the physical elements of the game that caught Bird's attention — he's also interested in the power dynamic the game introduces by prompting players to join one of three teams and coordinate their efforts to gain control of local gyms.

Playing "Pokemon Go" helps you to hone your leadership, teamwork and ethics skills by forcing you to work with other players, leading many to adopt a collaborative mindset: you teach me and I'll teach you.

The world of video games is evolving, and it's becoming more educational than you might think.

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[CLASSROOM DISCUSSION]

What other games, besides sports, prompt players to be up and active? What other fun ways are there to incorporate physical activity into a daily routine?

[VOCABULARY]

ETHICS

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Everyone, it seems, is talking about adding 3D printing to their curriculum and classrooms. But whether you already have some experience or are a first-time 3D printer, you'll need the right tools to make the best decisions, and the right approach: Administrators and teachers must work together to integrate the technology into current course offerings to make sure that 3D printing functions as a learning tool — not just the latest toy.



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S24020	\$899.00

Choosing the Right Printer

There are many different providers of 3D printing equipment, but as an educator you should look for one with a strong background and presence in education. These companies provide support and information through educator- and school-specific offerings that make integrating the printer into the classroom easy on students and staff. Choosing a printer that has established curriculum will further ease your efforts and combine engineering, core science, math, art and other subjects with hands-on learning.

Overall, you should consider several factors when choosing a 3D printer, including quality of output, reliability, ease of use, and range of materials. You should also look for a brand that provides great software and network compatibility. Finally, you should consider a company that offers a technology platform that supports continued growth, helping your students collaborate and share their work.

Ready to get started?

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The Benefits of 3D Printing in the Classroom

3D printing offers several ways for students to gain hands-on experience and marketable skills before leaving high school. As a teaching tool, it can allow for interactive learning and be used across many grades, subjects and skill levels. Instructors from kindergarten through college, in topics from science, engineering and math to art, history and geography, can use 3D printing to make an impact in the classroom and beyond. 3D printing is likely to play a major role in the future of how things are made, and introducing it as a learning tool today can better prepare students for the world of tomorrow.

The Next Step

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