

# HEADLINE DISCOVERIES

Oct-Dec 2015; Issue 4



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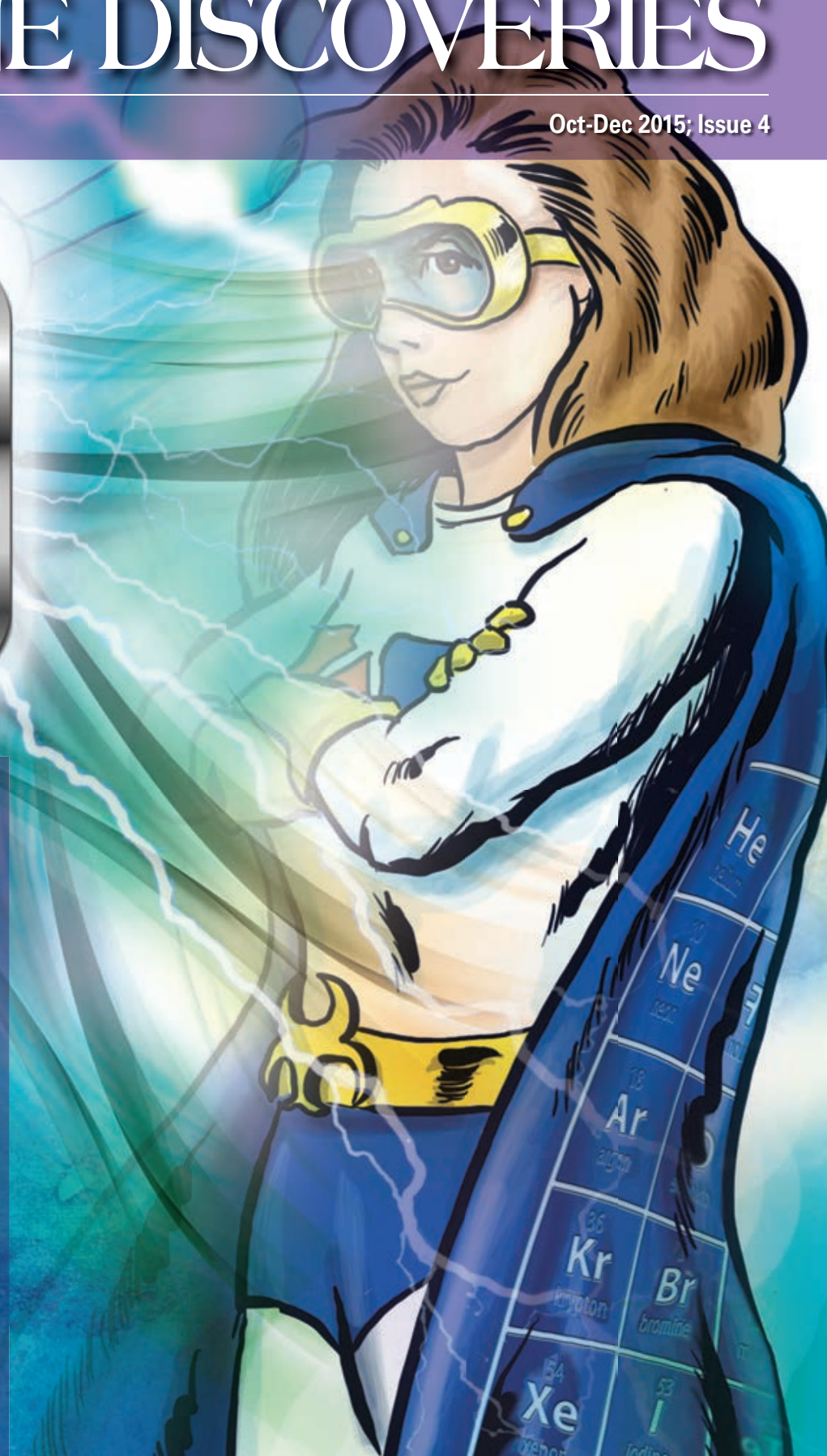
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# ELEVEN YEARS ON MARS

By Robert Marshall, Fisher Science Education

In the very first issue of *Headline Discoveries*, released in the spring of 2004, we wrote about the exciting news of the Spirit and Opportunity Mars rovers, landing just months before in January of that year. In an extended article, within the same issue, we expanded on the rovers' missions, spacecraft features, as well as conditions on the rusty red planet. Remarkably, as of the writing of this article, Opportunity continues to generate power from its solar panels and traverse the Martian terrain even 11.5 years later!

## SINCE OUR FIRST ISSUE

Opportunity has successfully traversed more than a marathon (26 miles) despite several driving scares and, maybe even more remarkable, a mission originally designed to only last 92 Earth days. Spirit, Opportunity's sister robot, landed near Gusev Crater on the opposite side of Mars just a few weeks prior. Also designed to last 90 Mars days, Spirit returned exceptional geological data before its last communication with driving engineers in March of 2010.

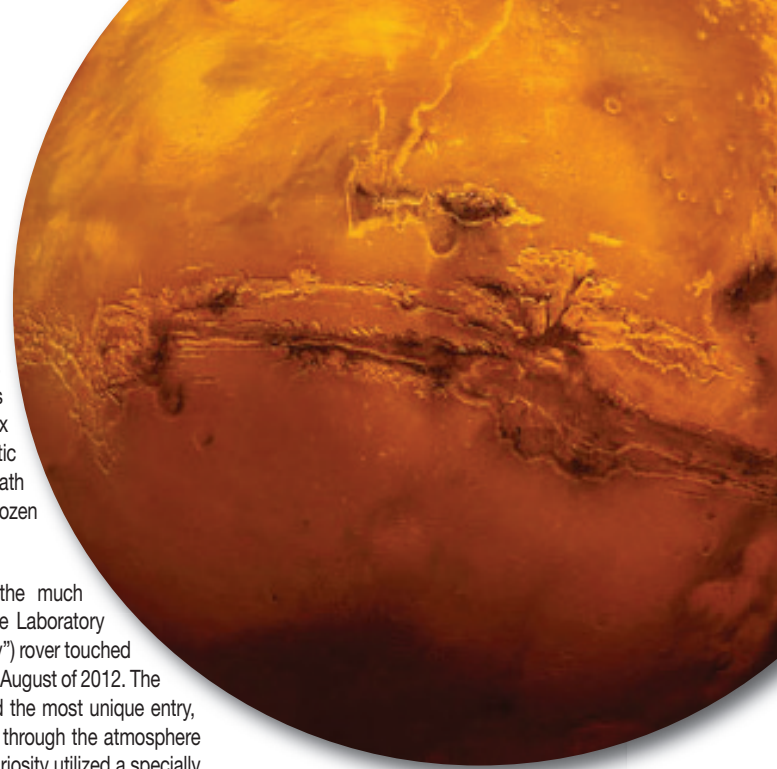
In 2005, NASA sent an orbiter, similar to the 2001 Mars Odyssey satellite, called the Mars Reconnaissance Orbiter (MRO). Together, the two spacecrafts have worked for a combined effort of 23 years to map the entire surface for geological data as well as allow scientists to choose best possible future landing sites. Furthermore, Odyssey and MRO form a communication network increasing bandwidth for surface spacecraft to send back high resolution images faster than direct communication with Earth's deep space network.

Two years later, in 2007, engineers launched a lander reminiscent of the 1975 Viking missions. Unlike Spirit and Opportunity, NASA's Phoenix lander has no wheels as it sits on the polar ice cap. Phoenix was designed with a robotic scooping arm so it could dig beneath the Martian surface revealing frozen carbon dioxide ice.

The world held its breath as the much anticipated one-ton Mars Science Laboratory (affectionately known as "Curiosity") rover touched down at the base of Gale Crater in August of 2012. The nuclear powered robot by far had the most unique entry, decent and landing (EDL). To get through the atmosphere and land on the surface safely, Curiosity utilized a specially designed trajectory adjustment system, the largest supersonic parachute ever designed, eight descent rockets and the infamous sky crane. The largest rover ever sent to the surface of another planet is currently still roving, even making its own driving decisions as cameras survey the terrain and software maps the three-dimensional surface.

## MARS EXPLORATION PROGRAM

As you can imagine, a lot of exploration and research leading to new discoveries has taken place concerning Mars since our first *Headline Discoveries* issue. We have NASA's Mars program to thank. Similar to the Space Race, the Mars program is currently the only existing initiative mankind has to continuously revisit a planet



(not the Moon) every few years. Initial instruments on board such spacecrafts were designed to try and find direct evidence of microbotic life, even if fossilized.

Focus has since shifted towards exploring habitability to try and answer questions, such as "Could Mars have ever harbored liquid water?". The twin rovers are examples of this because of their geological tools that have helped scientists identify river rock. But new generation robots, such as Curiosity, are starting to be constructed with a more biological purpose: human exploration. Engineers, working with scientists, are designing robots to sniff the air and measure radiation levels as we ourselves, as a species, begin to solve the challenge of a human mission to Mars. If we are to survive not only the journey but live on the surface for months or even years, what are all the dangers we must be aware of and understand? What missions and discoveries will be reported within the next 11 years? Stay tuned as we continue to report on Mars updates and space exploration.

## EXTENSION QUESTIONS

- Besides being classified as landers, how else is the Phoenix lander similar to the Viking missions? How are they different?
- Go online and watch the NASA video "Seven Minutes of Terror." How do the EDL engineers differ from careers of those who help drive the rover each day?



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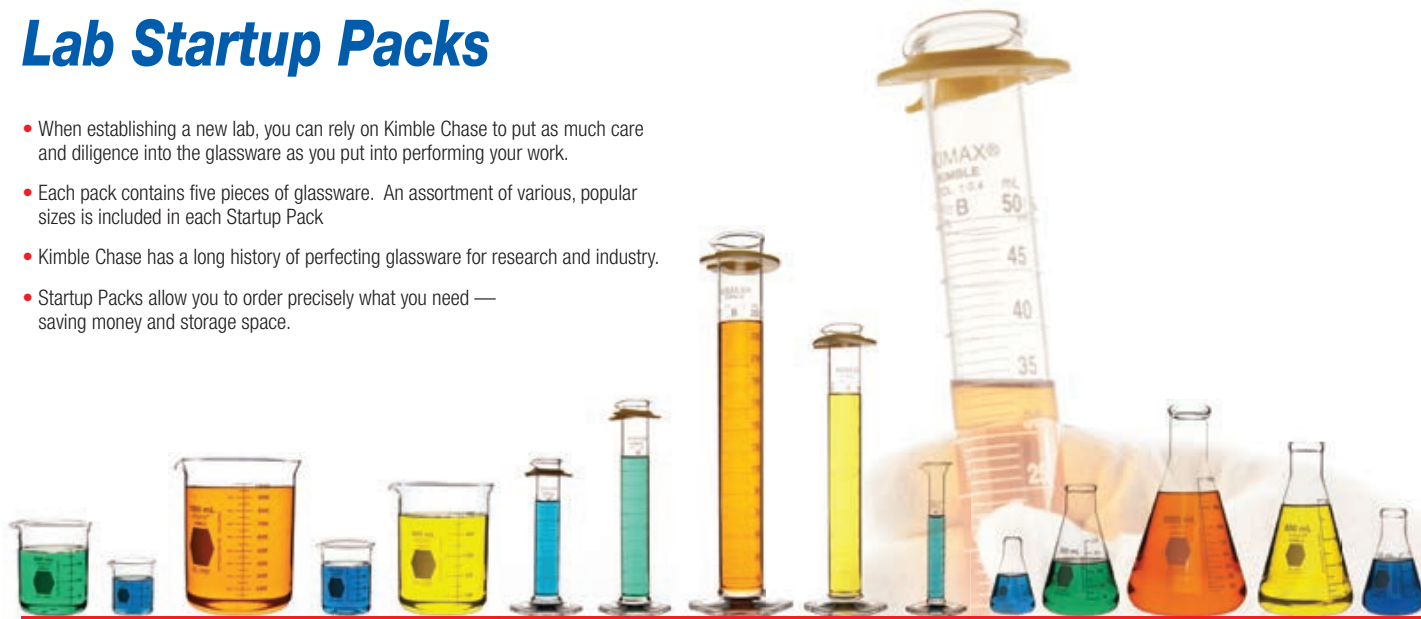
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# BRINGING BACK BABY (TORTOISES)

By Merry Morris

Pity the plight of the poor Galapagos tortoises. The past several hundred years have been tough. Their population, once estimated up to 250,000, has dropped precipitously. Whalers and pirates in the 1600s, 1700s and later, found these ancient creatures a meaty and easy-to-maintain food source for their voyages — tortoises could survive for long periods on a ship without food and water.

Many years later, researchers noted no new tortoise babies were surviving to replenish the diminishing tortoise population. Though these reptiles have long lives, without new offspring to replenish the population, their total numbers plummeted, making them one of the oldest and most endangered species. Not all the damage came from humans, though.

## SOMETHING HAD TO BE DONE... ABOUT THOSE RATS!

In some cases, rats are part of a balanced ecosystem, but on the Galapagos Islands these invaders were a scourge to the vigorous turtle population.

Rats are not native to the Galapagos Archipelago, but were carried to the isolated islands by whalers and privateers. A pirate's life, contrary to the swashbuckling movies, was not pleasant — disease, rotten food, limited hygiene opportunities and rats. One of the least

favorite assignments was going on rat patrol, ridding the ship of as many rats as possible (a Spanish galleon recounted killing literally thousands of rats as it sailed back to Europe from the Caribbean).

The Galapagos Islands provided a fine haven for escaping rats. Rats found the habitat quite pleasant, and the food sources plentiful. With few enemies and ample food, including tasty turtle eggs, the rat's numbers exploded.

Conservationists recognized the critical nature of the declining numbers of tortoises and began efforts to reduce the rat damage. For fifty years, their diligent efforts included snatching the buried tortoise eggs before the rats could devour them and raising hatchlings in the lab until they were older and less vulnerable to the rats.

Despite these efforts, they realized the rats had to go. In 2012, on the island of Pinzón, the war on rats began. Conservationists spread poisoned bait over the surface of the island's volcano and awaited the results.

## THE BABIES ARE BACK

Last December, success was apparent with the sighting of 10 newly hatched saddleback tortoises on Pinzón. These hatchlings had survived on their own without the benefit of human protection! For conservationists, who

believe no new turtles had survived on their own in the past 150 years, it must have been an amazing sight. Considering these reptiles can live more than a hundred years, the 10 survivors may promise higher populations for years in the future.



## CLASSROOM DISCUSSION

- Review how tortoises lay their eggs — how many, how long is incubation, what is the survival rate?
- Investigate the history and geography of the Galapagos Archipelago
- Were rats the only problem for tortoises on the islands? Consider what other invasive species had done in the Galapagos.

## VOCABULARY

- Archipelago
- Conservationist
- Population replenishment



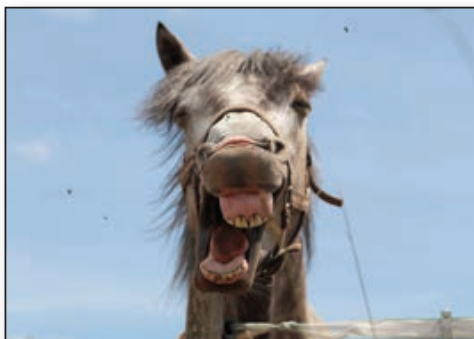
# HORSE FACIAL EXPRESSIONS MIRROR HUMANS

By Julianne Glaser

Body language and facial expression in particular are a nonverbal language that's universally understood. Around the globe, a smile conveys unequivocal happiness while a scowl shows contempt. Humans, in fact, can convey more than 27 emotions through facial expressions alone. Interestingly, new research has revealed that humans are not the only species to utilize facial movements to display emotion.

## STUDYING EQUINE EXPRESSION

Psychologists at the University of Sussex in the U.K. recently reported in PLOS One that horses also use the muscles underlying their facial features, particularly the eyes, nostrils and lips, to reveal their emotions to other



horses in a variety of social situations. In this extensive study, researchers analyzed videos of natural horse behavior and expressions to identify specific facial movements and the corresponding musculature. To capture this data, researchers created a coding system called EquiFACS (Equine Facial Action Coding System), which they used to describe and classify each individual facial expression.

Using EquiFACS, Jennifer Wathan, a researcher at the University of Sussex and one of the study's authors, and her colleagues discovered that horses can create 17 recognizable facial movements, such as "ears forward," "upper lip raiser" and "nostril lift." Comparatively, cats make 21 movements, dogs make 16 and chimpanzees make 13. This research demonstrates that horse expressions are far more complex than previously presumed and surprisingly similar to those of humans, despite anatomical differences in facial structure.

"Horses are undoubtedly emotional animals," according to Wathan, "but what they feel and how that is expressed is a question that we have yet to pin down." Results from this study have supplanted the previous theory that species distantly related to humans have far more simplistic facial expressions. For example, horses tend to raise their inner brow in negative emotional situations to express sadness or fear, in a manner very similar to humans and dogs.

Wathan believes this research could have positive implications in veterinary settings and in horse training programs and plans additional studies to identify the specific socio-emotional information horses communicate through their complex facial expressions.



## CLASSROOM DISCUSSION

- What additional implications does this research have for how we understand and relate to horses and other species?
- What other animals use complex facial expressions and body language? Are there similarities in their nonverbal communication?

## VOCABULARY

- Equine
- Veterinary
- Socio-emotional



# LIGHTING THE WAY THROUGH BRAIN SURGERY

By Merry Morris

Medulloblastoma. Anaplastic astrocytoma. Mixed glioma. Brain tumor. Regardless of the name, the diagnosis is terrifying to receive and a surgical challenge to treat.

As anyone who has seen a classroom dissection can tell you, structures that look well defined in textbook diagrams can be hard to discern in an actual organism. No dotted lines show you where to cut.

Brain surgeons face a similar, but much more daunting task. They must completely remove the tumor and only the tumor, without being able to see it clearly. While MRI scans are a tremendous tool for surgeons, images don't necessarily correspond to the surgical view. To distinguish healthy tissue from cancerous, surgeons must often rely on sight and touch.

Surgical removal of tumors is not always perfect. Iatrogenic injuries, those resulting from medical treatment, can result when vital tissues are damaged inadvertently. Short-term memory loss, motor difficulties, vision problems and other conditions can occur without medical errors. In some procedures, just getting to the tumor can be devastating to the patient.

## STAYING WITHIN THE LINES?

There will never be a "dotted line" for surgeons to follow to remove cancerous tissues, but an innovative

product — Tumor Paint — developed by Dr. Jim Olson, a pediatric oncologist, and his colleagues at Fred Hutchinson Medical Center in Seattle, aims to improve surgeons' chances of success. When injected into a patient's vein, Tumor Paint travels to the brain, passes through the blood-brain barrier and binds to and enters into malignant cells.

Viewed under near-infrared light, the "painted" cells literally glow, in theory allowing surgeons to see malignant tumor borders for more precise removal with less damage to nonmalignant tissue. The molecule responsible for this high-resolution tumor visualization is a combination of a protein chlorotoxin (from the deathstalker scorpion!) and a fluorescent dye, chosen for its emission in the near-IR range. Initial applications of the process revealed glowing tumor cells, just as predicted. After encouraging results in dogs, researchers won approval to continue Tumor Paint testing on human subjects.

Obtaining all approvals for Tumor Paint and getting it into widespread use is a complicated and lengthy process. Studies must verify that the paint can reach various tumor types, surgeons have improved surgical results and patients experience better outcomes. Researchers have passed commercial development of Tumor Paint to Blaze Bioscience, which has taken the compound through preclinical and into Phase One trials.



## CLASSROOM DISCUSSION

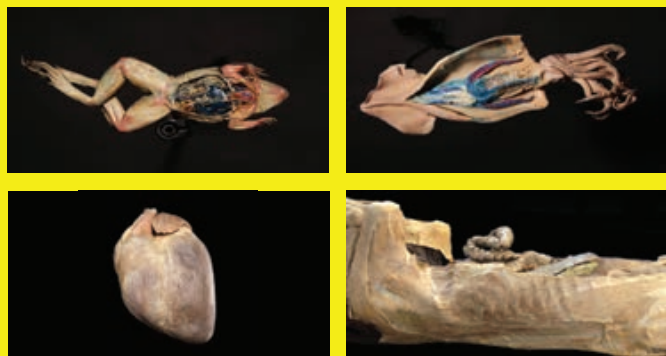
- Review the structures of the human brain. Which functions are associated with those structures?
- Investigate fluorescence. What happens on the molecular level when a material fluoresces?
- What is the blood-brain barrier? How does it protect the brain? How does it interfere with drug treatments?

## VOCABULARY

- Cancer
- Near-infrared wavelengths
- Fluorescence

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# “SMART” GEL IMMEDIATELY BEGINS HEALING PROCESS

By Merry Morris

Imagine this scenario: You're hiking through the primeval forest with your favorite hiking companion – your dog. You two have enjoyed many similar excursions through all kinds of terrain without incident, but today, neither of you are so lucky. A freak rockslide leaves the animal severely cut and bleeding profusely. You know the blood flow is dangerously fast and must be stopped before your canine friend bleeds out. You have to do something quickly.

If you had with you a syringe of Vetigel™, manufactured by Suneris, you could take command of the situation immediately simply by applying a bead of gel along the cut. To your great relief, the blood flow would stop almost instantly. This scenario is not something out of science fiction, but rather an example of biotechnology to the rescue.

## BLEEDING IS FAST, VETIGEL IS FASTER

The human face of the remarkable new hemostatic (blood-clotting) product is that of a young scientist-entrepreneur, Joe Landolino. As an undergraduate at New York University, this remarkable young innovator had an interest—polymers mimicking the structure of

their surroundings. Now head of a company to bring the product to market, he has created such a gel with important properties for stopping bleeding, especially in life-threatening situations. The gel binds quickly to the wound and initiates the clotting process. As long as the wound can be covered by the gel, the clotting and healing process can begin.

Not only is the Vetigel fast, it is faster than other means of staunching blood flow, doesn't require pressure on the wound and, being stable at room temperature, can be carried in a syringe into the woods or into battle – wherever it might be needed.

Vetigel is a “smart” polymer, and its biotechnology is pretty neat. To create this “smart” gel, polymers are extracted from plant cell walls. These polymers can reassemble into the pattern of new surroundings. When placed in an open wound, the polymers work with the body and reassemble, following the local pattern of the cells' natural matrix, extra cellular material or “ECM”, matching that of the specific location of the wound. Hence, the company's name, Suneris, from the Latin phrase *sui generis* or “of its own kind.”



While limited now to veterinary use, the approval process is underway for use on humans. When it is fully available, we can imagine an incredible thing – an injured soldier pulling out a syringe of Vetigel and applying it to his own wound, even before help can arrive.

## CLASSROOM DISCUSSION

- Investigate hemostasis: What are its stages, what promotes and what impedes the process? How long does it take the body to clot by itself?
- What are the characteristics of a “smart” biotechnology?
- What must be proven before a product can be used on humans?

## VOCABULARY

- Hemostasis
- Entrepreneur
- Polymer

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# 15 THINGS YOU DIDN'T KNOW ABOUT... SWEAT

Your DNA and fingerprints are uniquely yours, but what else about you is also individual? How about your sweat! Here are some facts about sweat that maybe you didn't know.

1. Sweat is composed of about 99 percent water and evaporates on the skin's surface to cool the body and keep it from overheating.
2. Sweat secretions include dermcidin, an antibiotic peptide that appears to regulate bacteria growth on the skin and may fight infection.
3. Men sweat up to twice as much as women, and both sexes sweat less with age.
4. A "sweat reflex" can be triggered by a single touch.
5. People with the skin condition atopic dermatitis can experience an immediate and serious allergic reaction to a fungal protein found in sweat called MGL\_1304.
6. If you're sweating red and you're not a hippo (who sweat red on the regular), you might have a rare condition called hematohidrosis. Blood vessels rupture and run into sweat glands, causing them to actually sweat blood.
7. Chromhidrosis causes humans to sweat orange, blue or other colors. While the rare condition can sometimes

be traced to ingesting certain drugs, the cause is not known in otherwise healthy people.

8. Healthy-person sweat often smells different from that of a sick person because the body emits volatile organic compounds based on metabolic condition, which can change when disease or infection is present.
9. Emotions can trigger changes in the composition of your sweat. An Austrian study collected sweat from participants during a scary movie and then during a neutral movie. Volunteers who sniffed the collected sweat pads were able to distinguish the difference.
10. In a different experiment, female participants determined the sweat of non-meat-eating men was more attractive than meat eaters.
11. An individual's sweat "fingerprint" includes a blend of 373 volatile compounds and remains consistent even while other components may fluctuate.
12. There are two types of sweat glands, apocrine and eccrine, and are universal to humans. Eccrine glands are present over most of our bodies, where apocrine glands are found only in our armpits and genital region.
13. Apocrine perspiration is responsible for most of the odor produced by our bodies because it's high in water



and waste products and promotes the growth of smelly bacteria. Our bodies only produce a very limited amount of apocrine sweat.

14. Eccrine sweat is produced in much larger quantities and spreads the apocrine over a larger surface area – taking the smell of the apocrine sweat along with it.

15. Human feet have 250,000 sweat glands and emit a half pint of liquid every day. The average human has more than 2.6 million glands throughout their body.

## FUN FACT:

Did you know that the lining of your outer ear has modified apocrine glands called ceruminous glands? These modified sweat glands produce ear wax. Ear wax is thought to prevent foreign material from entering your ears, including insects.

## VOCABULARY

- Dermcidin
- Apocrine
- Hematohidrosis
- Eccrine
- Chromhidrosis

# ALS ICE BUCKET CHALLENGE LEADS TO BREAKTHROUGHS

By Celeste Beley

How many of you spent last summer dumping a bucket of ice water over your head all in the name of charity? While most participants did donate to the cause, as well as take the frigid challenge, skeptics had a whole different take on the event as they wondered how ice water could actually make a difference. A year later and their questions are answered: money donated to the ALS Foundation has allowed researchers to work faster and more diligently so that a treatment may be as close as two to three years away.

Estimates state that the ALS Foundation received about 115 million dollars in donations in 2014, most of which went to medical research and treatment. Jonathan Ling, a researcher at Johns Hopkins University, explained that the funding went to an experiment focused on faults in TDP-43 (a protein that decodes DNA when it's functioning correctly), and specifically examining neurons in the brains of ALS patients. In mouse stem cell experiments, after restoration of TPD-43, damaged and dying cells were shown to come "back to life," and "looked completely normal," wrote Ling.

"With any luck this could lead to possibly a cure or really just slowing down this terrible disease," said Ling. Ling personally addressed the critics who doubted the

Ice Bucket Challenge as a stunt, stating "All of our donations have been amazingly helpful and we have been working tirelessly to find a cure. With the amount of money that the ice bucket challenge raised, I feel that there's a lot of hope and optimism now for real, meaningful therapies."

The ALS Association is equally thankful and hopeful that continued discoveries will be fueled by participating in the Ice Bucket Challenge. In addition to research, the ALS Association uses a portion of the donations for direct support of patients in need, in rural and underserved areas in particular. This support can include home health care, wheelchairs, special vehicles and breathing apparatuses.

## DISCUSSION QUESTIONS

- Did you take the ALS Ice Bucket Challenge? Why or why not? Do you think it could help find a cure?

## VOCABULARY

- Amyotrophic lateral sclerosis (ALS)
- Neuron
- Protein



# MAGNETS AND CENTS

By Celeste Beley

With as plentiful as magnets are in our everyday lives – from the electronics and motors to our refrigerators covered in them – it's hard to imagine that there are only a few metals that are naturally magnetic.

As we become more gadget obsessed, our need for magnetic materials increases. And now researchers have made magnets out of two non-magnetic metals: copper and manganese. This discovery could be useful in microscopic electronics and sensors.

## NATURALLY MAGNETIC

Almost all materials display some type of magnetic property when placed in a magnetic field. The electrons will point in the direction of the field, but in the case of a ferromagnet, the compass needles remain aligned even after the magnetic field is turned off.

Products that use magnets like speakers, motors, and electronics all contain iron, cobalt, nickel, or their alloys. But because there are so few naturally magnetic elements available, their application is restricted, hence the research into synthetic magnets.

## CREATING A MAGNET

To create the magnet using copper and manganese, researchers deposited a thin layer of buckyballs, a soccer ball shaped molecule made completely of carbon atoms that can pull electrons out of an adjacent metal, followed by a thin layer of copper or manganese, onto a non-

magnetic chip. The final piece was just 20 nanometers wide, but it retained its magnetic alignment even after it was taken out of the magnetic field. Although weak, the discovery was significant and was published in *Nature*.

Researchers then turned to how the materials were generating magnetism. The taller stacks contained greater magnetism, telling the researchers that the origination of the magnetism was in between the layers. To confirm their findings, they used a technique called Muon spin rotation to measure local magnetic field strength.

Muons, subatomic particles that have a compass-like spin at the interface where the metal and buckyballs meet, experienced the strongest rotations. This indicated that the electrons at the interface were the cause of the magnetism.

## FUTURE STATE

Lead author in the study, Oscar Cespedes, thinks they can still improve the overall magnetism. The copper, manganese and buckyball structure is 30 times weaker than iron, but as he points out "copper is pretty much as far from magnetic as you can get." Researchers believe that many other material combinations will exhibit this effect and they will continue to seek the right combination of molecule and metal to maximize their effects.



## DISCUSSION QUESTIONS

- How will the development of synthetic magnets aid the electronics industry? What other applications could benefit?
- What materials do you think could exhibit similar or stronger properties? Why?

## VOCABULARY

- Ferromagnet
- Buckyball
- Muon Spin Rotation

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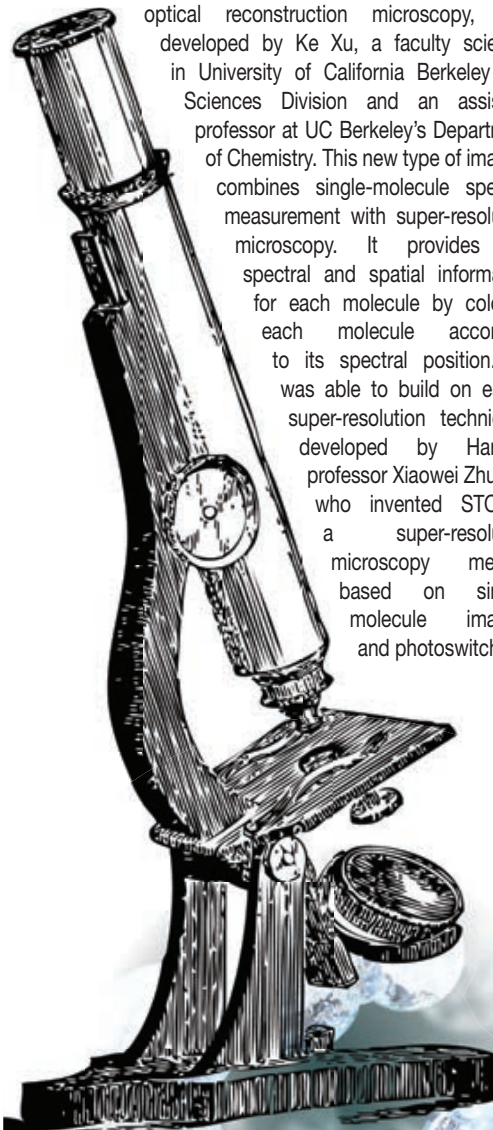


# FIRST TRUE-COLOR SUPER-RESOLUTION MICROSCOPY TECHNIQUE DEVELOPED

By Brianne McCurley

To say there have been many advancements in the field of microscopy since the development of the first compound microscope by Zaccharias Jansen in the late 16th century is an understatement. Jansen and his father, Dutch spectacle makers, built the first microscope by using three draw tubes with lenses inserted into the ends of the flanking tubes. They discovered a much larger image than expected; much larger than simple magnifying glass provided. The very first compound microscopes only magnified images between 6x – 9x. Microscopes of today can magnify images to the nanometer.

The SR-STORM, or spectrally resolved stochastic optical reconstruction microscopy, was developed by Ke Xu, a faculty scientist in University of California Berkeley Life Sciences Division and an assistant professor at UC Berkeley's Department of Chemistry. This new type of imaging combines single-molecule spectral measurement with super-resolution microscopy. It provides full spectral and spatial information for each molecule by coloring each molecule according to its spectral position. Xu was able to build on earlier super-resolution techniques developed by Harvard professor Xiaowei Zhuang, who invented STORM, a super-resolution microscopy method based on single-molecule imaging and photoswitching.



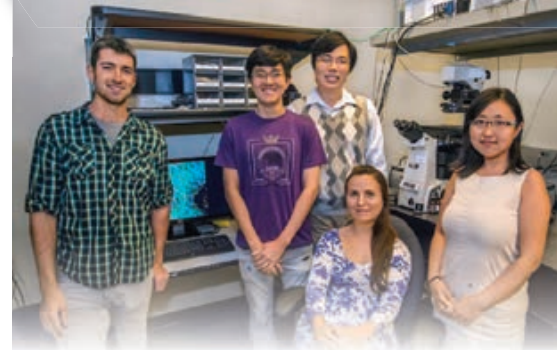
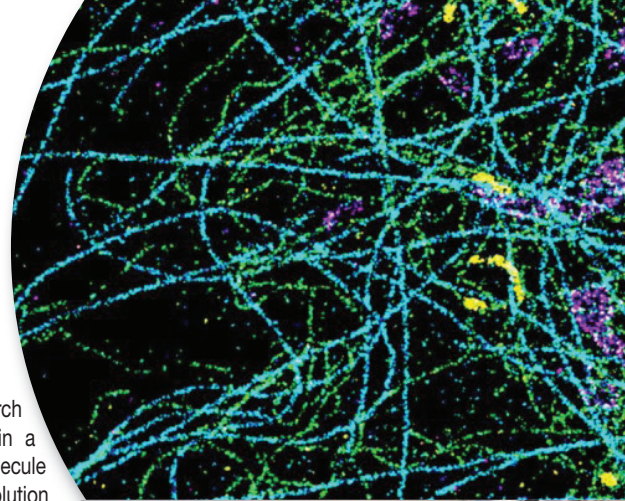
According to Science Daily, the SR-STORM research was reported in the journal Nature Methods in a paper titled, "Ultra-high-throughput single-molecule spectroscopy and spectrally resolved super-resolution microscopy," with co-authors Zhengyang Zhang, Samuel Kenny, Margaret Hauser and Wan Li, all of UC Berkeley.

According to Xu, "We measure both the position and spectrum of each individual molecule, plotting its super-resolved spatial position in two dimensions and coloring each molecule according to its spectral position, so in that sense, it's true-color super-resolution microscopy, which is the first of its kind. This is a new type of imaging, combining single-molecule spectral measurement with super-resolution microscopy."

## METHODOLOGY: THE PROCESS USED BY THE RESEARCHERS

1. They constructed a dual-objective system with two microscope lenses facing each other.
2. Xu and colleagues viewed the front and back of the sample at the same time and achieved unprecedented optical resolution (of approximately 10 nanometers) of a cell.
3. Next, they dyed the sample with 14 different dyes in a narrow emission window, excited and photoswitched the molecules with one laser. (While the spectra of the 14 dyes are heavily overlapping since they're close in emission, they found that the spectra of the individual molecules were surprisingly different and thus readily identifiable).
4. Then, they used four dyes to label four different subcellular structures, such as mitochondria and microtubules, and were able to easily distinguish molecules of different dyes based on their spectral mean alone, and each subcellular structure was a distinct color.

Researchers looked at the interactions between four biological components inside a cell in 3D and at very high resolution (about 10 nanometers). Xu stated that "the applications are mostly in fundamental research and cell biology at this point, but hopefully it will lead to medical applications."



Ke Xu (centre) and colleagues have pioneered a new super-resolution methodology to image single molecules with unprecedented spectral and spatial resolution (Roy Kaltschmidt/Berkeley Lab)

The SR-STORM allows one to view the cytoskeleton of a cell. "Using microscopy techniques, like SR-STORM, which include staining, researchers have been able to demonstrate the myriad forms which the cytoskeleton can take, and much has been learned about the architecture of the cytoskeleton." These advances may someday help researchers and doctors understand more about diseases, such as Alzheimer's, which is believed caused by the degradation of the cytoskeleton inside neurons.

## CLASSROOM DISCUSSION POINTS:

*Define these three types of microscopes and for what applications they are used.*

1. Optical
2. Electron
3. Scanning probe

## VOCABULARY

- Nanometer
- Cytoskeleton

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## PUPILS GIVE CLUES TO ECOLOGICAL NICHE

By Merry Morris

Looking deeply into the eyes of your pet cat, one thing is immediately obvious. Assuming that your feline is easy-going and placid, doesn't mind up-close-and-personal encounters with humans and is not struggling to get as far away as possible, you would be struck by its pupils. They are not like yours. They are not like a goat's, either. As it turns out, that is all for the best.

### PUPIL SHAPES MAKE A DIFFERENCE

The pupils of various species vary markedly. Yours are round. Your cat has vertical pupils. The goat's pupils show a distinctly horizontal orientation. Do all three of these eyes' bearers see the world in the same way?

According to M.S. Banks and colleagues in a recent research article in *Science Advances* (AAAS), the shape of pupils confers different types of vision, which is closely related to their bearers' survival.

Consider predators like your cat. Their pupils are vertically elongated with the characteristic slit. What natural advantage could this provide? According to Banks, that pupil shape gives very sharp vision of vertical objects over a great distance. For small ambush predators (again, like your cat), that vision is perfect for spotting their next victim. Now, how to catch it? They need to determine how

far away the prey is and what direction it is moving. As opposed to the vertical acuity, their eye structures render horizontal objects fuzzy at closer ranges. Being able to process the fuzziness and clarity information makes it possible for the predator to triangulate distances as it lies in wait for the next meal.

Prey animals have very different needs. They must be able to guard against predator attacks from the ground. The cat's vertical pupil would be inconsistent with the prey's ecological niche, which often is grazing. Consider goats. Their horizontal, rectangular pupils afford them clarity in the horizontal direction, providing a panoramic view — much better to observe the predator on the horizon and determine which direction it is going. So critical is this perspective that when some grazing animals lower their heads to graze, they retain that panoramic view and their pupils remain horizontal by rotating upward by up to 50 degrees. The horizontal pupil may also shield the eye from intense overhead brightness, another plus for grazers.

This association of pupil shape and ecological niche doesn't hold in all cases. Some predators, especially "taller" ones like tigers, lions and humans, have round pupils. Some scientists believe that many additional factors have gone into the evolution of the eyes.

But how cool is it to imagine seeing the world as your cat?



### CLASSROOM DISCUSSION

- Review all the structures of the eye
- In what other ways do the body types of predators and prey differ?
- What is man's ecological niche?

### VOCABULARY

- Predator
- Prey
- Ecological niche

# DIABOLICAL WASPS TURNS SPIDERS INTO ZOMBIES

By Samba Lampich

Spiders are often perceived as fearless and terrifying creatures able to hold their own against any predators. But when it comes to the *Reclinervellus nielsenii* wasp – which lives in Australia and Japan – the spider is no match. This species of wasp has the gruesome ability to turn the *Cyclosa argenteoalba* species of spiders into arachnid zombies that they feast on until their usefulness runs out.

## AN UNWILLING HOST

Scientists have known about this one-sided relationship, where the female wasp stings the spider and uses poison to temporarily paralyze it while it injects the arachnid with eggs. The eggs hatch into larvae, which feast on the spiders' blood and kill them before using their web to pupate.

What remained unclear was if, and how, the larva controlled what kind of web the spider built. For a time, scientists thought that the wasp had drained so much of the spider's body fluid that it caused the arachnid to build a web that just happened to be strong enough to support a wasp cocoon.

However, a new study, published in the *The Journal of Experimental Biology*, suggests that the wasp larva may be hijacking the nervous system of spider and controlling just what kind of web it built. Dr Keizo Takasuka and researchers from Kobe University in southern Japan,

who published the study, video recorded 23 spiders that had the parasitic wasp larvae and observed the kinds of webs they built compared to those built by spiders that did not have the parasite.

## WEAVING A WICKED WEB OF DEATH

The *Cyclosa argenteoalba* spider builds two types of webs: circular, sticky orb webs that catch prey and a simpler 'resting web' the spiders used for molting.

The researchers noted that the host spiders built a modified and reinforced version of the 'resting web', a cocoon web. The researchers observed that the spiders work for around 10 hours and built the special web that is 40 times stronger than any it would usually build.

As the wasp larva prepared to pupate, it steered the spider back to the center of the cocoon web and devoured it before entering the pupal stage.

"[The] cocoon web has to endure falling debris, the elements and animal strikes for a long time – at least four to five times longer than [a] resting web," Takasuka told Live Science.

The researchers also found that even after the larva was removed, the spider still continued building the reinforced web.



Credit: Keizo Takasuka

*The parasitic Reclinervellus nielsenii on the back of the host Cyclosa argenteoalba spider.*

According to Dr. Takasuka, this strongly suggests that the larva releases a manipulative substance that reacts with the spider's endocrine system, causing the spider to think it was molting and weave the special web. While the researchers think this substance may be a hormone that mimics those of the spider that induces molting further, research is needed to confirm their suspicions.

## CLASSROOM DISCUSSION

- What other parasitic creatures can turn their hosts into zombies?
- How are human beings parasites and/or hosts?

## VOCABULARY

- Species
- Molt
- Cocoon
- Hormones
- Endocrine



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# PRECARIOUS ROCKS GIVE CLUES TO FUTURE EARTHQUAKE MOVEMENTS

By Merry Morris

A new approach to predict the intensity and direction of earthquakes lies in an unlikely source — 10,000-year-old, improbably balanced rocks. You’ve probably seen pictures of these; they are astounding, seemingly impossible and a little scary. You certainly wouldn’t want to be standing downhill if they toppled over.

These geological features are called Precariously Balanced Rocks or “PBRs.” They are formed slowly when tectonic forces elevate granite rocks from below ground to the surface, and erosion whittles away the softer surrounding materials leaving the unlikely and amazing result.

## EARTHQUAKE PREDICTIONS FROM A STRANGE SOURCE

Of interest are certain PBRs in the San Bernardino Mountains located 90 miles east of Los Angeles near the active San Andreas and San Jacinto faults where the North American and Pacific tectonic plates meet. These PBRs should not be standing; they have been in place long enough that earlier ground-shaking earthquakes (1812 and 1857) should have knocked them out of balance. There must be some counteracting factors responsible for their long-lasting balancing act, reasoned researchers Julian Lozos of Stanford University and Lisa Grant Ludwig

of University of California, Irvine, considering earthquakes occur every 200 to 300 years. Figuring out this puzzle would be of tremendous importance in predicting what future quakes might do and how to prepare in advance for the inevitable destruction.

The researchers propose that around the San Bernardino’s PBRs, earthquakes occur less frequently and with less energy. As a mechanism, they suggest that a quake initiating on the San Jacinto fault could “hop” into the San Andreas fault, giving up some of its energy and diverting the path of the seismic activity. This process would then alter the direction of quake energy and the location of most critical damage; in this case, sparing the PBRs. This likelihood is nice to know when developing plans for structures, water supplies and other support systems in quake-susceptible areas. Alternately, the “hop” might lead to ruptures along both faults simultaneously, multiplying the devastation. Also, very important for planning purposes.

Good news for quake-fearing Californians — the ability to make predictions by evaluating the PBRs in quake-prone areas may unlock some clues to dealing with the “big one.”



## CLASSROOM DISCUSSION

- Investigate the locations of other PBRs around the globe. Are these in earthquake-prone areas?
- Research other methods of earthquake prediction. How do they compare with the evaluation of PBRs in susceptible areas?
- Create a map showing the paths of the San Andreas and San Jacinto faults. What population centers are located within 50 miles of these faults?

## VOCABULARY

- Tectonic
- Seismic
- PBRs

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# KEEPING SKYSCRAPERS STEADY

By Merry Morris

If you've ever been perched high in a tree when a stiff breeze blows, you know how unsettling a slight sway from vertical feels. Imagine being in a skyscraper with 50 mile per hour winds, buffeting your glass-enclosed condo or office. Feeling queasy?

## UNSETTLING REAL ESTATE

In the "old" days (think pyramids) building supplies were heavy, and the height of a structure was limited by the size and strength of its base. Things began to change in the 19th century when the problem of getting people up into very tall structures was solved by people-safe elevators. Elevators, which had been used only for materials, changed when Elisha Graves Otis developed the safety brake in 1853 which prevented a broken hoist cable from sending passengers down the elevator shaft.

Later that century following the destructive Chicago fire of 1871, the windy city began to grow rapidly. As available land for new buildings became scarce, there was incentive to build taller buildings.

Building upwards required new building techniques. Iron, and later steel, beams and columns provided a lighter, stronger skeleton that could withstand the forces of nature. These new buildings had to be sturdy and resistant to the forces of nature: snow, frost, wind, rain, baking sun, even earthquakes. The result was well-constructed buildings that withstood high winds.

But just because a skyscraper won't topple over, doesn't mean it won't move slightly. Tall buildings sway a bit in the wind, and tall, thin buildings sway more. That resulting sensation that the earth is unsteady beneath your feet can be quite unsettling. Though 50 mile per hour winds move a 1,000 foot high building just six inches, the movement is perceptible and the feeling makes most people woozy and anxious.

To make tall buildings less "exhilarating," the central elevator core is strengthened and stiffened, and beams and columns are moved to the outside edges of the buildings. As greater heights are achieved (1,000 meter high buildings are now under construction), the need for additional support came from an unexpected source: immense dampening systems.

These giant counterweights built into the top of the building, can weigh up to 300 to 800 ton — imagine 100 African elephants or 23 Sherman tanks! A tuned mass damper may require to 1,000 square feet and hangs attached to the skyscraper's walls with numerous pistons and spring mounts, like a giant pendulum. A slosh damper substitutes tons of water for solid mass. When high winds buffet the building, the damper acts like a shock absorber. In modern systems, when a computer detects building sway in one direction, the damper is set to counterbalance the motion. Less motion means less acceleration.



## CLASSROOM DISCUSSION

- Using a classroom building set, construct "buildings" of various designs. Which are most stable?
- Review the Chicago fire of 1871. What were the causes and results?
- Investigate pendulums. How do they work? What forces are demonstrated by a pendulum's action?

## VOCABULARY

- Damper
- Acceleration
- Pendulum



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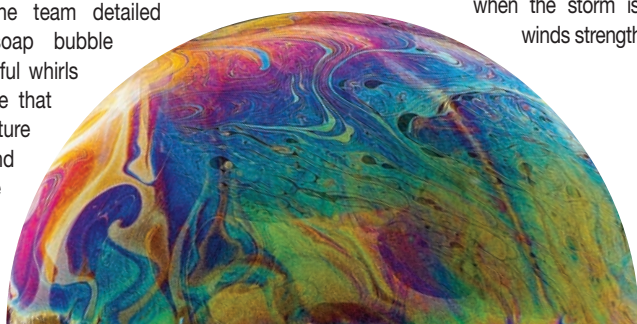
# CAN SOAP BUBBLES PREDICT TROPICAL STORMS?

By Julianne Glaser

Meteorology is a complex and imprecise science. Despite technological advancements, forecasting volatile weather patterns, such as tropical storms, remains a challenge as it involves predicting numerous dynamic atmospheric and environmental interactions. Results of recent research however, have shown that soap bubbles may provide a simple, inexpensive and effective means for predicting the strength of hurricanes and typhoons.

## SOAP BUBBLES AND VORTICES

Recently, physicists at the Laboratoire Ondes et Matière d'Aquitaine, in collaboration with researchers from the Institut de Mathématiques de Bordeaux and a team from Université de la Réunion, conducted an innovative experiment utilizing soap bubbles to simulate atmospheric flow. The team detailed rotation rates of soap bubble vortices through colorful whirls on the bubble surface that reproduced the curvature of the atmosphere and developed a simple model that would similarly predict that of tropical cyclones.



This experiment allowed scientists to create miniature cyclonic vortices models similar to tropical storms, to measure rotation rates and track storm intensity. They discovered that the initial rotation and intensity of vortices was very weak, but increased significantly over a short period of time. Following this intensification phase, the vortices rotation speed and intensity peaked before entering a state of decline.

To verify their simulations on a larger scale, the research team applied this data to the evolutionary intensity of 150 low-pressure tropical cyclones in the Pacific and Atlantic oceans and found it held true. The results, as published in Scientific Report, indicate that prediction of a developing tropical cyclone can begin 50 hours after initial formation of the vortex, about one quarter of its lifetime when the storm is intensifying and winds strengthening.



This innovative research could result in meteorological advancements and provide a critical model for early prediction of tropical cyclones and hurricanes that may quite literally save lives and reduce property damage for coastal areas worldwide.

## CLASSROOM DISCUSSION

- How does El Niño affect weather patterns and impact tropical storm formation?
- What are the major hurricanes to hit the United States in the last 100 years? Would early warning of these storms have made a difference?
- What other ways can meteorology impact our lives and work?

## VOCABULARY

- Atmosphere
- Cyclone
- Vortex
- Meteorology



# SAYING HELLO TO PLUTO

By Robert Marshall, Fisher Science Education

Unless you avoided turning on the TV or computer during the summer break, more than likely you caught a glimpse of Pluto in the news. But these were not just any images. For the last time, in our lifetimes, we watched in anticipation as the New Horizons spacecraft flew by a formerly uncharted world. After a decade long endeavor, NASA has now officially visited every major celestial body in the solar system adding to the gravity of this historical event.

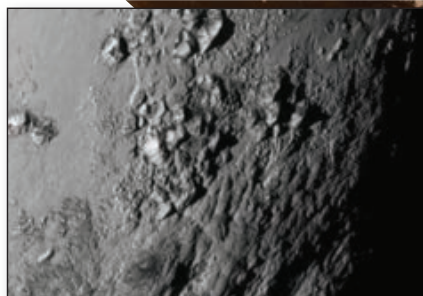
Following a nine year journey, covering more than three-billion miles, planet geologists have remarkable high resolution scientific data. On July 14th, New Horizons passed by just 7,800 miles above the alien surface and will continue to transmit back-to-Earth images over the next several months.

## MAJOR DISCOVERIES FROM THE ENCOUNTER

Pluto's surface is stunning. One particular facial feature reveals mountain ranges, which peak 11,000 feet above the icy surface. Based on geological evidence, such ranges formed no more than 100 million years ago, suggesting near recent geological activity in this region. Most objects in the solar system with mountain landscapes are subject to gravitational forces by a larger body, such as Jovian parent planets, certainly not had by Pluto. Then, is it possible that the dwarf planet

has internal heating causing plate tectonic action and therefore, will we eventually find volcanoes?

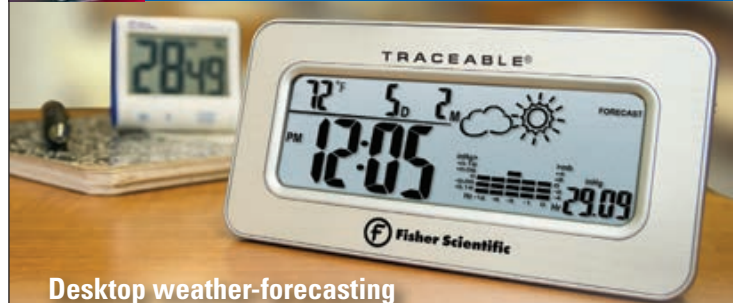
When Pluto was reclassified by the International Astronomical Union (IAU), many people around the world felt heartbroken despite all scientific reasoning. Who would have guessed Pluto would unveil its heart to mankind? Seen in the bottom right of New Horizons' view, desert and mountain ranges come together to form this very apparent shape. Also, Pluto is mightier than previously known. Thanks to New Horizons, the mystery of Pluto's size has been settled and the verdict might surprise you – it is larger than scientists previously thought. After these discoveries, along with poles leaking Methane and high levels of atmospheric Nitrogen, there is no telling what else we will learn about Pluto in the coming year.



## CLASSROOM DISCUSSION

- What discoveries of Pluto's largest moon, Charon, have been announced? Hydra?
- How have astronomers, robotic spacecraft engineers and geologists come together during the New Horizons mission?

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# BEWARE YOUR REFRIGERATOR

By Merry Morris

What has the world come to when you can be betrayed by your household appliances? Is nothing safe from cyber attack? Surprisingly, answers to these questions are related and very timely.

In the world of cyber security, hacking has been taken to a new high with the recent development of “Funtenna.” While it may sound like fun and games, “Funtenna is malware that intentionally causes compromising emanation”, says developer Ang Cui of Columbia University and Red Balloon Security. In other words, it’s software that can steal protected data from networks whose owners thought were perfectly safe.

## HACKERS AND HACKING

If this development leaves you wondering why finding new ways to steal data is a good thing, an explanation of “hacker” and “hacking” might help. Generally a hacker is someone who is able to penetrate “secure” computer systems and networks. Hackers intentions might be ethical, such as identifying security vulnerabilities or nefarious, such as identity theft, known as “cracking.”

## BACK TO THE REFRIGERATOR

Hacking has become much easier thanks to Ang Cui and his colleagues. With their new approach, it’s possible to snatch data out of protected networks without setting

off alarms and by operating across large parts of the electromagnetic spectrum, from below human hearing to radio frequencies and further.

Using “Funtenna” software, they can make modern devices broadcast invisible, inaudible signals over miles. That’s where your refrigerator comes in, but the device could also be a printer, air conditioner, washing machine – items that would not be suspected of such a sophisticated, covert application. Cui’s research also suggests that a computer need not be online to be susceptible to attack.

Recently, Cui’s company, Red Balloon Security, demonstrated Funtenna’s potential using an inexpensive printer. They “hijacked” the printer and began flipping its chip’s energy back and forth, creating electromagnetic radiation that was transformed into computer code. The printer was altered, turning its wires and components into a radio transmitter. Directed to a target, the simple device plus Funtenna directed the target to emit its data as radio signals. The stolen data was recovered with a “software-defined radio receiver” (i.e., no hardware needed) and AM radio antenna.

“Here with Funtenna, I can beat the best network detection in the world with just an AM radio,” Cui noted. Though the emanation of data is slow, it doesn’t matter if no one knows to look for it.



## CLASSROOM DISCUSSION

- How might a hacker be of help to network security experts?
- Investigate AM radio diagrams. How easily could you make an AM radio in class?
- Research “Black Hats” and “White Hats” in the hacker community. What are each group’s intentions?

## VOCABULARY

- Electromagnetic radiation
- Acoustic spectrum
- Radio transmission

# SPY DRONE PRINTED AT SEA

By Justin Kovach

Imagine being out at sea, thousands of miles away from your country and needing a spy drone to carry out a covert op, but you’re all out of drones. Not too long ago, you would’ve had to wait for a supply plane or ship to bring you what you needed. Not anymore.

Thanks to 3D printing, a British military warship recently printed a spy drone named SULSA on board their vessel and successfully test flew it to a beach a quarter of a mile away.

Drones are unmanned vehicles that can be controlled remotely from a great distance. Control of one is somewhat like controlling a plane in a video game, though slightly more complex. Drones have become a dominant force in the US Military and many militaries around the world because they enable the military to gather intelligence or conduct other missions without risking human life.

Since drones are becoming evermore crucial to carrying out military operations, the need for more specialized drones has increased. By using 3D printing technology, militaries around the world will be able to print customizable drones whenever the need arises. It took only 48 hours from start to finish for the SULSA to be operational. SULSA’s wingspan measures at four feet long and has a top speed of 60 miles an hour.

## HOW DID THEY DO IT?

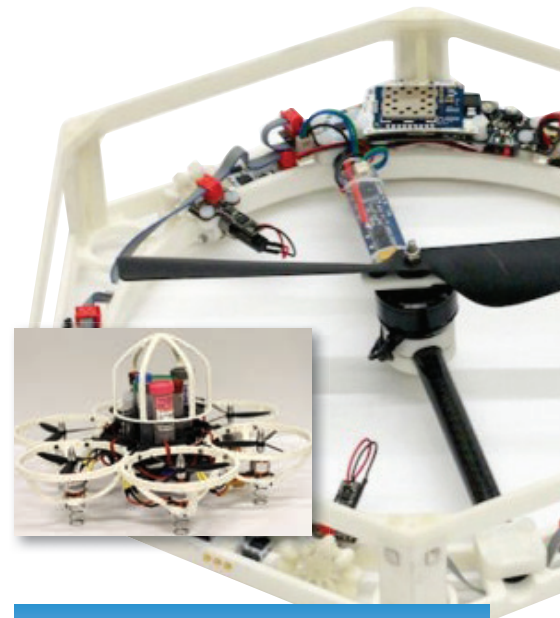
SULSA was printed using selective laser sintering (SLS). SLS is a process that sinters (binds) a specific type of

material together into a three-dimensional structure. Nylon was the material in this case. Other materials that can be sintered include polystyrene and metals. To visualize it, think about melting candle wax; as the wax melts it hardens on top of the wax below creating structure. Sintering is like that, only it binds the materials in any direction the printer tells it to go by using lasers.

The challenge for engineers for SULSA was to create a snap together drone that could be assembled in minutes. They printed SULSA out of just four snap together parts, and no screws or bolts were needed.

To print anything on a 3D printer, you need to upload the file that has the desired item into the printer software. Then the 3D printer goes to work, building layer upon layer until the object is complete. You could actually upload a schematic of the avatar from your favorite video game into a 3D printer, and the 3D printer could print out a replica of your own personal video game action figure! That beats just printing a picture of your avatar on a piece of paper any day.

For the Navy, this can literally be a lifesaving technology. They could print surveillance drones to watch dangerous areas or spy drones to fly silently into enemy land and gather intelligence. Or even supply drones that could fly small payloads to soldiers caught behind enemy lines. SULSA is only the beginning, and it’s already flying high with potential!



## CLASSROOM DISCUSSION

- What is the difference between 3D printing and standard 2D paper printing?
- What other items could the Navy or anyone else print using a 3D printer?

## VOCABULARY

- Drone
- Polystyrene
- 3D printer
- Avatar
- SLS
- Surveillance/spy

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# RICE, PLEASE – HOLD THE METHANE

By Merry Morris

Rice presents a dilemma. On one hand, its starchy grains support nearly half the world's population.

On the other hand, rice production goes hand-in-hand with methane generation. Rice paddies generate 17 percent of the world's methane, the second most important greenhouse gas, at 100 million tons per year.

## FINE-TUNING RICE GENES

Studying the ecosystem of rice plants (the sunlight, soils, water, nutrients, microorganisms, and more) reveals its complexity: photosynthesis to create rice sugars, cycling of nutrients, sugar transport throughout the plant's grain, stem, leaves and roots; release of chemicals into the soil. The transport of sugars throughout the plant's rich, starchy rice grains and hardy leaves and stems is all for the good. The rice grains provide sustenance, and the leaves and stems are used as biofeedstocks.

It's at the roots where the methane issues arise.

The rice plant roots leak nutrients into their surroundings. The root's leakage or exudates support microorganisms, some of which are methanogens, or generators of methane. More rice production means more methane...unless something could be changed at the root level.



## LOOKING DEEP INTO THE CELLS FOR AN ANSWER

Christer Janssen and his fellow researchers found that certain proteins called transcription factors could bind to plant genes and turn them on or off. Researchers realized if they could isolate the transcription factors that controlled the genes for transporting rice sugars, they could manipulate where transcription factors were produced and carbon stored. For rice, that would affect where sugars were stored in the rice plant. Perhaps reducing the amount of sugar accumulating in the rice plant roots would reduce the nutrient leakage into the soil.

Finding the right transcription factor to solve the methane-emission problem was not an easy feat. Using a high-starch-producing barley, researchers focused on the most active genes in the grains. Once these were isolated, the search began for the right transcription factors. Investigators found SUSIBA2 (SUgar Signaling in BARley 2) to be a "master regulator" factor that could control several genes.

If introduced into a rice strain, could SUSIBA2 reduce the sugars going

to the roots, "starving" the roots and thereby reducing methane-supporting nutrient leakage from the roots? Would diverting the carbon from the roots enable more food energy to be used for grains, stems and leaves? Results from a recently completed three-year field test have confirmed that SUSIBA2 bearing rice did virtually eliminate methane emissions, while increasing crop yields. Success is at hand.

Research continues; however, including investigating the potential effects of changing the methane-generating populations in the soil.

## CLASSROOM DISCUSSION

- Why is methane called a "greenhouse" gas? What chemical reactions does it undergo in global warming?
- What is microbial ecology? How does it help us understand more about relationships among microorganisms?
- Methane-producing microorganisms are called methanogenic archaea. How are archaea different from bacteria?

## VOCABULARY

- Greenhouse gas
- Global warming
- Methane
- Archaea
- Transcription factor
- Master regulator

# IS ALGAE THE ANSWER FOR “GREENER” BEEF?

By Mary Rose Thomas-Glaser

Cattle ranchers know only too well the enormous quantities of feed that cows devour on a daily basis and the expansive acreage they need for grazing. Environmentalists are concerned with the large amount of methane produced by grazing cows through belches and manure as they digest grasses and grains. To reduce feed costs and lower methane emissions, researchers have begun to explore alternative feedstocks that may be able to solve both dilemmas.

## THE PROBLEM WITH RUMINATING

Cows are ruminants whose ravenous appetite is due in large part to their inefficient digestive system, which requires repeated chewing of food. As a result, cattle require up to 28 times more land and 11 times as much water as chickens or pigs and produce up to five times the amount of carbon emissions. According to Gidon Eschel, Professor of Environmental Science and Physics at Bard College, “The carbon footprint of conventional beef is nearly entirely due to production of its feed.”

## BOOSTING CATTLE FEED WITH BIOFUEL WASTE

The key to reducing cost and carbon for cattle may lie in supplementing the traditional farm grain and grass

with an eco-friendly and economical supplement. And researchers may have found a viable option in one of the world’s most ubiquitous plants — algae. Algae are photosynthetic plants that grow in fresh and sea waters around the world and produce most of the Earth’s oxygen. Best of all, algae can be commercially cultivated and requires very little land, water or energy.

Researchers at Solazyme, a California-based biotechnology firm, have been growing algae for use as biofuel using waste sugar cane in fermentation tanks. Algal residue from the oil extraction process had been burned, but Stephanie Hansen and her team wanted a more sustainable use for the waste which contains fat, fiber and protein. Blending the waste into cattle feed added nutrition and didn’t seem to affect palatability. “The algae meal would be best suited as a part of a complete diet for cattle, replacing a portion of the corn or other feedstuffs typically used in the diet,” Hansen concluded.

Based on the study results, researchers are awaiting FDA approval and aim to have the algal meal available for farmers by 2016.



## CLASSROOM DISCUSSION

- How do the stomachs of ruminants differ from non-ruminants? How do the differences affect diet and digestion?
- Research algae. Where does it grow, what are the different types and what are its commercial uses?
- How do plants convert sunshine into food? What are the byproducts of the process?

## VOCABULARY

- Ruminant
- Photosynthesis
- Carbon footprint
- Biofuels

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# TINY SEA ORGANISMS HELP COOL THE EARTH

By Samba Lampich

There are few things that are more relaxing than sitting on a sunny beach or a grassy field and watching the wind gently nudge fluffy clouds across a brilliant blue sky.

But those clouds are hard at work, playing a crucial role in keeping the Earth cool. These white puffs have tiny droplets, which act as powerful deflectors of sunlight, reflecting the heat away back into space before it enters Earth's atmosphere. And bigger clouds reflect more sunlight because they contain more tiny water droplets that reflect more sunlight. These droplets are created when water condenses onto microscopic particles and aerosols, floating in the Earth's atmosphere.

Scientists from the Department of Atmospheric Sciences, University of Washington, Seattle wanted to find out how and what influenced the creation of these aerosols, so they turned to NASA data and used their own simulation models to find out.

In 2014, these scientists conducted a year-long study to investigate the link between planktons and clouds. The research was funded by NASA, the U.S. Department of Energy and a graduate fellowship from the Air Force Office of Scientific Research.

They studied the Southern Ocean, comprised of the southernmost waters of the Pacific, Atlantic and Indian oceans. This area is far removed from human activity, making it an ideal location to study the natural creation of clouds.

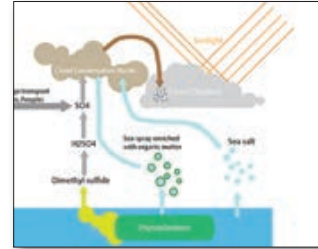
"The clouds over the Southern Ocean reflect significantly more sunlight in the summertime than they would without these huge plankton blooms," said co-lead author Daniel McCoy, a University of Washington doctoral student in atmospheric sciences. "In the summer, we get about double the concentration of cloud droplets as we would if it were a biologically dead ocean."

## A DROP IN THE OCEAN

The researchers found that more cloud droplets occurred over areas that had robust plankton floating in the upper sunlit areas of the ocean. These large plankton blooms absorb the sunlight and release a compound named dimethylsulfoniopropionate, or DMSP, which converted into tiny aerosol particles. Water condenses around the aerosols, in essence seeding clouds. This meant that the tiny planktons were likely to influence the clouds above and in turn the amount of sun energy they reflected.

The scientist also found that some organic material – coming from dead plants and animals, bacteria and virus – are carried into the atmosphere by sea spray where they become aerosols that water can condense around, adding to the amount of droplets in a cloud.

They then compared these results to year-round NASA satellite data for clouds over that region.



## COOLING CLOUD COVER

The study, published in the journal *Science Advances*, showed that during the summer this increase of DMSP and other aerosols, on average, boosted cloud formation by more than 60 percent in the course of a year. That then increased the clouds' reflectivity, bouncing more sunlight back into space during that time.

The researchers estimate that plankton reduce the amount of solar energy absorbed by the Southern Ocean by roughly four watts per square meter over the course of a year, a small but noticeable amount.

McCoy and his colleagues hope that the study will help better understand the magnitude of just how human activities affect climate change.

## CLASSROOM DISCUSSION

- What else could create aerosols, or particulates in the atmosphere, that affect cloud formation (consider natural and man-made causes)?
- How would any pollution affect the phytoplankton, and in turn, how would that affect climate change?

## VOCABULARY

- Phytoplankton
- Dimethylsulfoniopropionate
- Aerosol
- Chlorophyll
- Photosynthesis

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## CANDLES AND LCDS: MORE ALIKE THAN MEETS THE EYE

By Mary Rose Thomas-Glaser

At the end of a long day, have you ever relaxed with a candlelit dinner and watched a movie on television? It probably never crossed your mind that the paraffin wax in the candle and the liquid crystal display of the television are closely connected. How is it possible that two extremely different products can, in fact, have a lot in common?

### PARAFFIN WAX: THE BIG PICTURE

A by-product of crude oil refining, paraffin wax is odorless, tasteless, unreactive, insoluble and excellent for storing heat. These characteristics make paraffin extremely versatile and suitable for use in many consumer and industrial products alike – from candles to cosmetics to lubricants and paints.

Until recently, research on paraffin and its applications has been focused strictly on the macroscopic level.

### A CLOSER LOOK AT CRYSTALLIZATION

But researchers at the Physics and Material Science Research Unit of the University of Luxembourg decided

to take a new approach and look at paraffin crystallization at the microscopic level. Professor Tanja Schilling and associates Muhammad Anwar and Francesco Turci at the university, viewed individual paraffin molecules and studied the molten wax crystallization process, making a surprising discovery.

Before the wax molecules moved into their final positions in the crystallization process, they aligned in a very similar manner as molecules used to create liquid crystal display (LCD) technology. LCDs are widely used in a variety of products including television screens, computer monitors, calculators and watches. "This research will be of value to the plastics industry as the polymers, which make up plastics, are long-chain versions of the molecules in wax," says Professor Schilling.

Most plastic products manufactured today are created using injection molding. Molten plastic is forced into a mold where it hardens into the configuration of the mold. Findings by Professor Schilling, Anwar and Turci provide valuable insight into the molecular crystallization process that can be used to help control defects in the plastics molding.



### CLASSROOM DISCUSSION

- What are liquid crystals, and how are they used to create electronic displays?
- When was paraffin wax discovered? What is its chemical formula? What were some of its early uses, and how is it used today?

### VOCABULARY

- Crystallization
- Molecule
- Liquid crystal display

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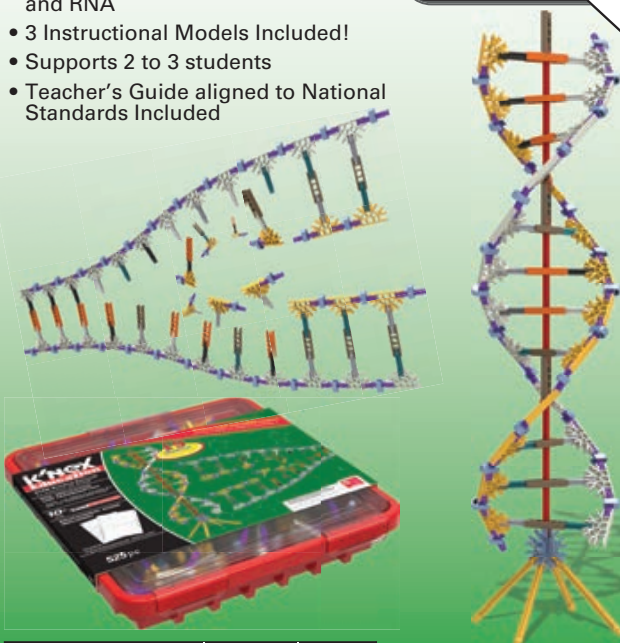
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Gaby Zane, a fifth grader from Denver, Colorado used her school science fair for a study that got her published in a medical journal! She researched ways to reduce the amount of bacteria in stuffed toys brought into the operating room so that kids could be comforted by their favorite toys while undergoing surgery.

Gaby took inspiration from her mom, an orthopedic surgeon at Children's Hospital Colorado who told her about "Project Zero Project", where they try to decrease the bacterial load in the operating room. After thinking about what kids undergoing surgery might be going through, she thought about the items of comfort they would want with them — mostly their favorite stuffed toy. Gaby took those ideas and thought "why not just wash them?" Using scientific method, she set about to test bacterial levels in her and her brother's stuffed toys, then washing them, and found that 79% of the stuffed animals were effectively sterilized by a single wash in a home washer/dryer and could remain sterilized after being in a plastic bag for up to 24 hours.

Gaby's idea was a simple one, but proof that a simple idea can lead to a great discovery!

To read the full abstract, visit [www.ncbi.nlm.nih.gov/pubmed/25851680](http://www.ncbi.nlm.nih.gov/pubmed/25851680).

## MATHEMATICIAN



Numbers surround us — they are on our debit cards, they comprise our phone number, and every action on our computer is a series of ones and zeroes. Who understands the relationship between numbers more than anyone else?

Mathematicians create models of systems to explain mathematical phenomena. Pure mathematics brings understanding to the world of numbers. The theories which mathematicians publish, often apply to many other fields, such as finance, cryptography, biology and myriad other fields. Many mathematicians work with scientists, helping them to understand the results of their data. When mathematicians conduct their own research, large computers are needed to process the

volume of numbers pouring through the system. Mathematicians often work for the government, in private research institutions, for financial institutions, or for colleges and universities.

How does one become a mathematician? This is a field that requires a high degree of education: at minimum, a Masters of Mathematics, though often a doctorate is needed. To begin, students should take as much math as possible in high school. In college, it is best to major in mathematics or applied mathematics.

After all of those years of study, there is a bright outlook: the average mathematician makes \$99,380 per year, according to the Bureau of Labor Statistics. The Georgetown University Report on the Economics of College Majors reports that 95 percent of mathematics majors are employed after graduation. There is some growth in the industry expected from 2010 to 2020 and a 16 percent growth in mathematics positions nationwide.

**Sources:**  
<http://www.bls.gov/ooh/math/mathematicians.htm#tab-1>

STEM CAREERS

# IF I HAD ONLY PICKED THE OTHER LINE...

By Merry Morris

Yes, you did it again.

Even after careful scrutiny of all the lines in the store, you've picked one that is moving at glacial speed. You wisely avoided the line with the kid holding the bag of coins, but he's long gone and here YOU stand. You just can't win.

Well, you are right. You can't win. You might get lucky sometimes, but that's all you can hope for.

## THE MATH IS AGAINST YOU

With several lines to choose from in a store, the odds are against you picking the fastest line. There are even mathematical equations to support that, and the odds that the store or service provider will always have enough cashier space and employees to ensure short lines even for those big sales are probably nil. At some level you understand this logically, but, deep down inside, you think you are smarter or more observant than other shoppers and should be able to choose the best line.

Is this torture avoidable? Increasingly crowd managers are choosing the "serpentine" approach where customers stand in one line and each is dispatched to the next available cashier once they achieve the front of the line. So, at least the lady with the coupons is slowing everyone down a little bit, rather than just those people in her line.

This approach involves what mathematicians refer to as "queuing theory," which sets forth why you can't always be in the fastest line. The serpentine line is now found in a variety of places that people find themselves waiting: amusement parks, banks, retail stores, customer service queues (though that is behind the scenes). Those snaking lines have been found to reduce wait times substantially.

Queuing theory has become very important in today's hustle-and-bustle, crowded society. So, problem solved? Nope. People can be ornery and, most don't like spending time in serpentine lines that make you feel like you are part of a disorderly mass of people. No longer are you on your own and in control — you are captive in a sea of other victims.

## BUT WHY DOES THE WAIT SEEM SO LONG?

There are factors that make our queuing times bearable or excruciating. Here are a few.

- Unoccupied time – hope you didn't leave your SmartPhone in the car!
- Anxiety – will you miss a flight or other deadline during the wait?
- Uncertain, unfair or unexplained waits – if you only knew what the hold-up was!
- Being by yourself – idle chit-chat with friends helps!

Not to mention, the item you're waiting for – waits for valuable items are more bearable. That loaf of bread is just not worth the wait, but the filet mignon...



## CLASSROOM DISCUSSION

- "Timely" Activity – Check time intervals in different situations, like during tests, lunch breaks, fire drills. Does five minutes seem longer or shorter during that math test?
- Discuss the equation:  $S = P - E$  where "S" stands for satisfaction, "P" for perception and "E" for expectation. How might this relate to situations where your expectations are high?
- Investigate queuing theory – how might it be applied in your school?

## VOCABULARY

- Queues
- Queuing theory

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## TEENAGERS IMPRESS AND WIN BIG AT THE INTEL ISEF 2015

By Celeste Beley

The Intel International Science Fair 2015, a program of Society for Science and the Public, the world's largest international pre-college science competition, held finals in Pittsburgh, PA in May. Approximately 1,700 high school students from 75 countries competed for \$4 million in prize money.

This year's first place award, the Gordon E. Moore Award for \$75,000, went to Raymond Wang, 17, of Canada. His project was to engineer a new air inlet system for airplane cabins that improved air quality and curbed disease transmission. His system improved the availability of fresh air by more than 190 percent and reduced pathogen inhalation concentrations by 55 times more than conventional designs. His design can be easily and economically incorporated into existing aircraft.

Nicole Ticea, 16, also from Canada, received one of two Intel Foundation Young Scientists Awards in the amount of \$75,000. She developed an inexpensive, easy-to-use testing device to diagnose HIV infection particularly in low-income communities. Her device is disposable, requires no electricity, provides results in under an hour and costs less than \$5 to produce. She already founded her own company, which recently received a grant to continue developing her technology.

The second recipient of the Intel Foundation Young Scientist Award in the amount of \$50,000 was Karan Jerath, 18 of Friendswood, TX. Karan refined and tested a device that should allow an undersea oil well to rapidly and safely recover from a blowout. His device included a better containment enclosure that separates the natural gas, oil and ocean water; accommodates different water depths, pipe sizes and fluid compositions; and can prevent the formation of methane hydrate.

For a full list of winners and their projects, visit [www.societyforscience.org](http://www.societyforscience.org).



### EXTENSION QUESTIONS:

- Review the full list of winners and their projects. Which of the winners do you think would have the greatest impact in your area and why?

# A Better *AP*Proach to Chemical Inventory Management

You've probably done an experiment that required you to combine two different substances to create a chemical reaction of some kind. For example, mixing manganese dioxide with hydrogen peroxide in a bottle causes white smoke to emit from the container.

Now, imagine if you had to know how every chemical in your science lab would react in various conditions or situations. It's impossible to remember all of the specifics about every chemical in a science lab just like it would be difficult to know at any moment if you are running low on a chemical.

To make sure there are enough chemicals on hand for all of the experiments that a school conducts throughout the year, as well as ensure that the chemicals are stored safely, requires a system that organizes it all. That's why Fisher Science Education developed a chemical inventory management app called ChemAssist, featuring our chemistry superhero, Ava Gadro.

ChemAssist allows a school to store information about their chemicals in the cloud or within the app itself. By storing information in the cloud, it can be shared across multiple devices and with multiple users so that anyone with permission can access it at any time on their phone.



The app notifies a school when they are low or out of stock or if a chemical is expired or expiring soon. It also allows a school to create a list of the chemicals they need to reorder that can be emailed to someone who is in charge of ordering. The cloud-based version of the app sends notifications or push alerts about any chemical that has been recalled or discontinued.

Safety document sheets are available instantly. By scanning the QR code on any Fisher Science Education chemical bottle, someone can pull up its safety document sheet, which has been updated to be compliant with the new Globally Harmonized System of Classification and Labeling of Chemicals. These are the standards you would have to adhere to if you pursued a career in chemical research or chemical engineering.

The ChemAssist app is just one example of how the technology of cloud computing and smartphones can make complex tasks much simpler.

## CLASSROOM DISCUSSION

- Why is it so important to know what kinds of chemicals are in a building?
- What other jobs could really benefit from the use of cloud computing to share information?



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