DECEMBER 7, 2015
VOL. 72 NO. 6
ISSN 1041-1410

SCHOLASTIC

ScienceWorld®

current science®

SCHOLASTIC.COM/SCIENCEWORLD

INSIDE

R2-D2, C-3PO, and your other favorite Star Wars characters return in *The Force Awakens*.

PHYSICS

THEY'RE BACK!

Everything you need to know about droids, space battles, and the science of Star Wars

SCHOLASTIC
ScienceWorld
current science
DECEMBER 7, 2015 VOL. 72, NO. 6

SCIENCE WORLD DECEMBER 7, 2015 VOL. 72, NO. 6 **Editorial Director:** Patricia Janes **Senior Editors:** Jennifer Barone, Amy Barth **Contributing Editor:** Andrew Klein **Education Editor:** Matt Friedman **Intern:** Hanneke Weitering **Senior Art Director:** Sarah Irick **Photo Editor:** Els Rijper **Production Editor:** Allan Molho **Senior Copy Editors:** Ingrid Accardi, Suzanne Bilyeu **Copy Editor:** Troy Reynolds **Digital Imager:** Vanessa Irena **Media Editor:** Marie Morreale **Executive VP, Scholastic:** Hugh Roome **Creative Director:** Judith Christ-Lafond **Design Director:** Felix Batcup **Executive Director of Production and Operations:** Barbara Schwartz **Executive Editorial Director, Copy Desk:** Craig Moskowitz **President, Chief Exec. Officer, and Chairman of the Board of Scholastic Inc.:** Richard Robinson. **POSTAL INFORMATION:** *SCIENCE WORLD* (ISSN 1041-1410; in Canada, 2-c no. 55948) is published 12 times annually; biweekly: September, October, February; monthly: November, December, January, March, April, May; by Scholastic Inc., 2931 East McCarty St., P.O. Box 3710, Jefferson City, MO 65102-3710. Periodical postage paid at Jefferson City, MO 65102 and at additional mailing offices. POSTMASTERS: Send notice of address changes to *SCIENCE WORLD*, 2931 East McCarty St., P.O. Box 3710, Jefferson City, MO 65102-3710.

TO ORDER *SCIENCE WORLD*, CALL 1-800-SCHOLASTIC.

SCIENCE NEWS

EARTH: EROSION

CHINA'S VANISHING WALL

The Great Wall of China, parts of which were built more than 2,000 years ago, is in danger of disappearing. The Great Wall covers thousands of kilometers. The most famous section stretches from the western city of Jiayuguan to Shanhaiguan in the east. According to a recent report, about 1,961 kilometers (1,219 miles) of the wall have crumbled, and a similar length is in poor condition.

Rain and sandstorms are *eroding*, or wearing away, the Great Wall's surface. Another problem is tourist traffic, which causes major damage. Locals are also known to remove bricks from the structure to sell as souvenirs.

China has passed laws to protect the wall, but since it covers so much territory—and much of it is in remote locations—the laws are difficult to enforce. Robert Murowchick, an archaeologist at Boston University, says that better education about preservation is the key to protecting the site.

—Hailee Romain

MORE SCIENCE NEWS
scholastic.com/scienceworld

The Great Wall of China is the longest wall in the world. The most famous section covers roughly 5,500 miles.

The Great Wall, much of which was constructed during the Ming Dynasty (1368–1644), was built to protect against foreign invaders.

Tourist traffic is one reason parts of the Great Wall are crumbling. About 9 million tourists visit the wall each year.

THE GREAT WALL OF CHINA

A glacier melts in Greenland. Melting glaciers can cause sea levels to rise, which could harm coastal communities.

EARTH: CLIMATE

HIDDEN MELTDOWN

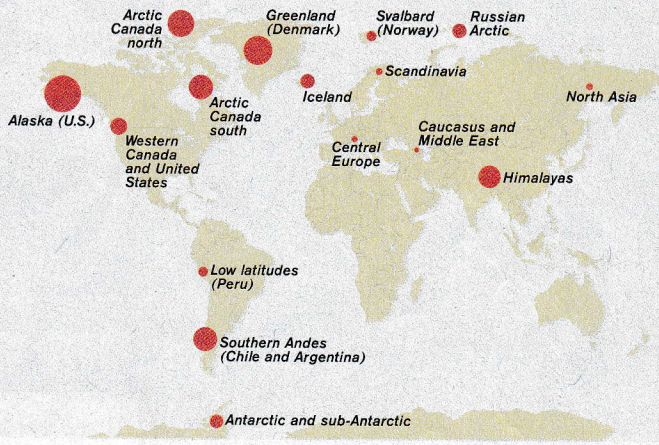
More than 90 percent of Earth's freshwater ice is in Greenland and Antarctica. Much of it is bound up in slowly moving masses of ice called *glaciers*. Unfortunately, the ice is melting because of *climate change*, an increase in Earth's average temperature. Eric Rignot, a glaciologist, recently led an expedition to Greenland to investigate the melting.

Rignot found that deep ocean currents are bringing warm subtropical waters to the ocean near Greenland's west coast. Water hundreds of meters below the surface is several degrees warmer than [illegible] near the surface, speeding up glacial melting. [illegible]plays a bigger role in controlling the [illegible] previously thought,"

[illegible] scientists

ICE LOSS

The size of each red dot below shows the approximate mass of ice that has melted from the region's glaciers each year since 2003. Greenland's dot represents 38 billion metric tons of ice. Alaska's dot represents 50 billion metric tons—enough water to fill Lake Champlain twice!



SCIENCE WO[illegible]
VOL. 72, NO. 6 Ed[illegible]
Senior Editors: Je[illegible]
Contributing Editor: [illegible]
Editor: Matt Friedman In[illegible]
Senior Art Director: Sarah [illegible] Rijper **Production Editor:** Al[illegible] **Editors:** Ingrid Accardi, Suzanne [illegible] Troy Reynolds **Digital Imager:** Va[illegible] **Editor:** Marie Morreale **Executive** Hugh Roome **Creative Director:** Judit[illegible] **Design Director:** Felix Batcup **Executive of Production and Operations:** Barbar[illegible] **Executive Editorial Director, Copy Des[illegible]** Moskowitz **President, Chief Exec. Offic[illegible]** **Chairman of the Board of Scholastic Inc.:** R[illegible] Robinson. **POSTAL INFORMATION:** *SCIENCE WORLD* (ISSN 1041-1410; in Canada, 2-c no. 55948) is published 12 times annually; biweekly: September, October, February; monthly: November, December, January, March, April, May; by Scholastic Inc., 2931 East McCarty St., P.O. Box 3710, Jefferson City, MO 65102-3710. Periodical postage paid at Jefferson City, MO 65102 and at additional mailing offices. POSTMASTERS: Send notice of address changes to *SCIENCE WORLD*, 2931 East McCarty St., P.O. Box 3710, Jefferson City, MO 65102-3710.

TO ORDER *SCIENCE WORLD*, CALL 1-800-SCHOLASTIC.

[illegible]MBING CONTEST

[illegible]ng and caring for trees—scrambled up trees during [illegible]e Climbing Championship in Longmont, Colorado, in [illegible]llenge tested five different skills, such as climbing a 15-meter [illegible]ng an aerial rescue, which involved rescuing an adult-size [illegible]cipants were judged on speed and technique.

[illegible]uel Pastenes of Texas and Marilou Dussault of Quebec, Canada, [illegible]rborists from other regions at the world championship in Texas. [illegible]ut more than finding the best climber, says arborist Alex Julius. It [illegible]e about what arborists do and what skills and safety precautions are [illegible]ofession.

–Kathryn Fre

AFRICA'S VENOM CRISIS

When a venomous snake bites someone, it injects the victim with potentially deadly toxins. Many hospitals keep a lifesaving medicine called antivenom on hand for snakebite victims. But Africa is facing a crisis: It's running out of an important supply of antivenom.

The company that made most of Africa's safe and effective antivenom stopped producing it in January 2014. Competitors selling less-expensive antivenoms of unknown safety drove them out of business. And these cheaper antidotes made in other parts of the world sometimes use the wrong snakes—so they don't always work on bites from Africa's cobras, vipers, and mambas.

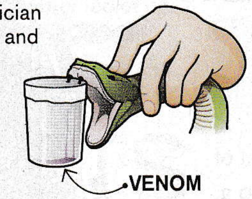
"If nobody fills this void, then there will undoubtedly be more deaths," says Nick Brown, a doctor with the Global Snakebite Initiative. Stocks of reliable antivenom will expire in June, and there's currently no replacement. With 1.5 million poisonous snakebites happening every year in Africa, this puts a lot of lives at risk.

—Hanneke Weitering

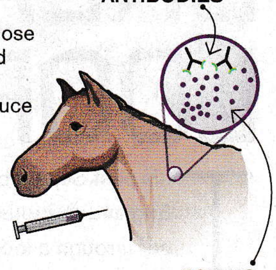
HOW ANTIVENOM IS MADE

To make lifesaving antivenoms, scientists enlist the help of horses that live on specialized ranches.

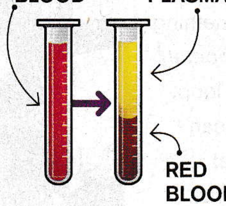
1 A technician extracts and later purifies venom from the species for which scientists want to make an antivenom.



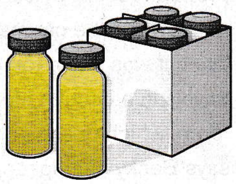
2 A small, harmless dose of venom is injected into a horse. The toxins cause the horse to produce *antibodies*—proteins that neutralize those toxins. Follow-up shots trigger the production of so many antibodies that the horse becomes immune to the venom.



3 A ranch hand draws blood from the horse. A machine extracts the *plasma*, the part of the blood that contains the antibodies. The red blood cells are returned to the horse.



4 The plasma is purified, packaged, and shipped to hospitals. When a person comes in with a bite, doctors inject the antivenom into the patient. Antibodies in the medicine neutralize the toxins and can save the patient's life.



DANGEROUS BITE: A venomous sedge viper strikes.

PHYSICS: FORCES AND MOTION

RECORD-BREAKING LOOP

This past September, stunt driver Terry Grant of England shattered a world record by driving a car through a loop-de-loop that was 19.08 meters (62.6 feet) tall. He broke the previous record by 0.79 m (2.6 ft).

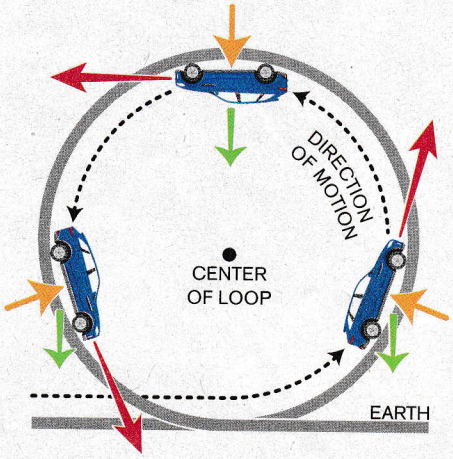
How did the car manage to stay on the track even when it was at the top of the loop? Anytime something travels in a circular motion, it experiences *centripetal force*, which pushes it toward the center of the loop, says Becky Thompson, a physicist at the American Physical Society. The car needs to be going fast enough at the top of the loop that centripetal force and gravity can't rip it from the track. If the car were to stop, it would plummet. Grant entered the loop at 85 kilometers (53 miles) per hour, which provided enough speed to make it all the way around.

The first time Grant drove through a loop-de-loop, he got sick. So he trained for two months, and this time he felt great after the stunt. *–Kathryn Free*

Stunt driver Terry Grant successfully rounds a loop-de-loop in a new Jaguar sports car, the F-PACE, in Germany on September 14.

A light display helped highlight the new car, which was unveiled during the stunt.

PHYSICS OF A LOOP-DE-LOOP



CENTRIPETAL FORCE
The track exerts this inward force on the object, keeping it on a circular path.

GRAVITY
This force pulls the object down to Earth.

VELOCITY
Speed at which an object changes position. The car must attain a certain velocity to stay on the loop.

MAKING A MASTERPIECE: A squirrel monkey paints at the Oakland Zoo in California as another looks on.

BIOLOGY: ANIMAL BEHAVIOR

ANIMAL ARTISTS

Last summer, animals at the Oakland Zoo in California put their creative talents to work in an effort to help raise money for wildlife conservation.

The animals learned to paint using their paws, hooves, and mouths. Some, like the zoo's elephants and giraffes, painted with a paintbrush. Others used more unusual approaches: Ada the snake slithered to smear paint across a canvas, and Andy the cockroach left colorful trails as he scuttled along.

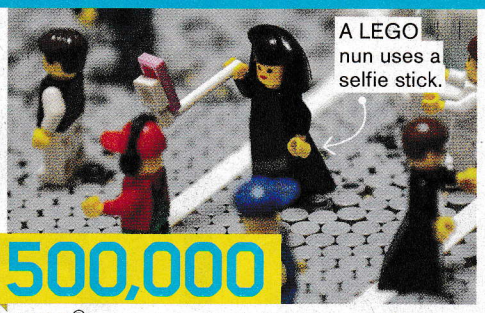
Zookeepers encouraged the animals to paint by giving them treats as they worked. The paint was nontoxic and safe. The zoo auctioned off the paintings online in September, raising almost $14,000.

—Hanneke Weitering

ANIMAL ART AT AUCTION

Art made by animals at the Oakland Zoo was recently auctioned off online. Bids started at about $200 but quickly climbed. The graph below shows the final sales prices of some of the paintings. How does the price of the parrot's painting compare with that of the python's?

NUMBERS IN THE NEWS

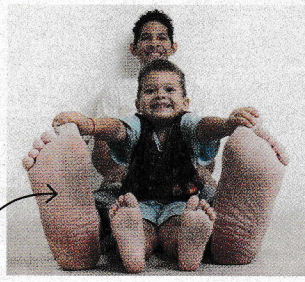


500,000 LEGO® bricks used to build a model of St. Peter's Basilica, a famous Catholic church. It was displayed in Philadelphia to celebrate Pope Francis's recent visit to the U.S.

1,000 Keys on an emoji keyboard designed by a programmer in London. The massive keyboard can help people express practically any emotion.

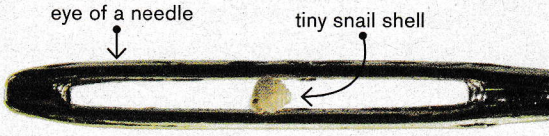
300 Years ago that a Spanish ship sank during a hurricane, holding millions of dollars in gold. Divers recently found the treasure off the coast of Florida.

26 Shoe size of Jeison Hernandez of Venezuela, age 20, who recently broke the world record for largest feet. They're about 15.8 inches long.



$12 Price that a student at Babson College in Massachusetts paid this fall to purchase the domain name Google.com before alerting Google of the issue.

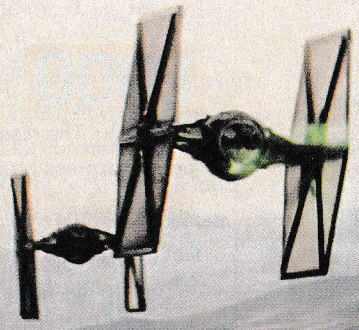
0.03 Height, in inches, of the shell of the world's tiniest land snail. Ten of them could fit in the eye of a needle.



KATE FRANCIS (DIAGRAM); RALPH ORLOWSKI/REUTERS (CAR LOOP); LESLIE COHEL/OAKLAND ZOO (MONKEYS); STEVE GOODALL/OAKLAND ZOO (PARROT); MATT ROURKE/AP PHOTO (LEGOS); APPLE (EMOTICONS); COURTESY OF GIL MONTANO/© GUINNESS WORLD RECORDS 2016 (BIGGEST FEET); COURTESY OF B. PAUL GERGELY AND N. SZPISJAK (NEEDLE AND SNAIL)

THE SCIENCE OF STAR WA

A real-world take on distant planets, space battles, and helper robots



The first Star Wars movie, released in 1977, opens with a few blue words on the screen, revealing the setting of the epic tale: "A long time ago in a galaxy far, far away . . ." Back then, a story set on a distant world required a leap of imagination, since no one had ever seen evidence of planets beyond our own familiar solar system. But that's not the case anymore.

As the seventh film in the saga (*Episode VII: The Force Awakens*) hits theaters this month, *Science World* decided to investigate the science of Star Wars. Which aspects of the movies are pure fantasy or science fiction, which are surprisingly realistic, and which are somewhere in between? Here's what we've discovered.

ALIEN PLANETS

Much of the action of the Star Wars series takes place on Tatooine, a fictional planet that orbits two stars. At the time the first film was released, the idea of planets outside our solar system was a bit wild—astronomers wondered if planets might exist around stars other than our sun, but they'd never been able to find any.

That changed in 1992, when the first *exoplanets* were detected. Since then, nearly 2,000 planets have been found orbiting more than 1,200 stars. And thousands more potential exoplanets have been identified. Additional observations will help confirm their existence.

Tatooine started to seem even more realistic a few years ago, when scientists with NASA's exoplanet-hunting Kepler mission announced the first discovery of a planet orbiting two stars. Views there would include a spectacular double sunset like the one Luke Skywalker contemplates in the first film.

In the real-world double-star system, the larger star is bluish and the smaller one is reddish. A member of the Kepler team decided

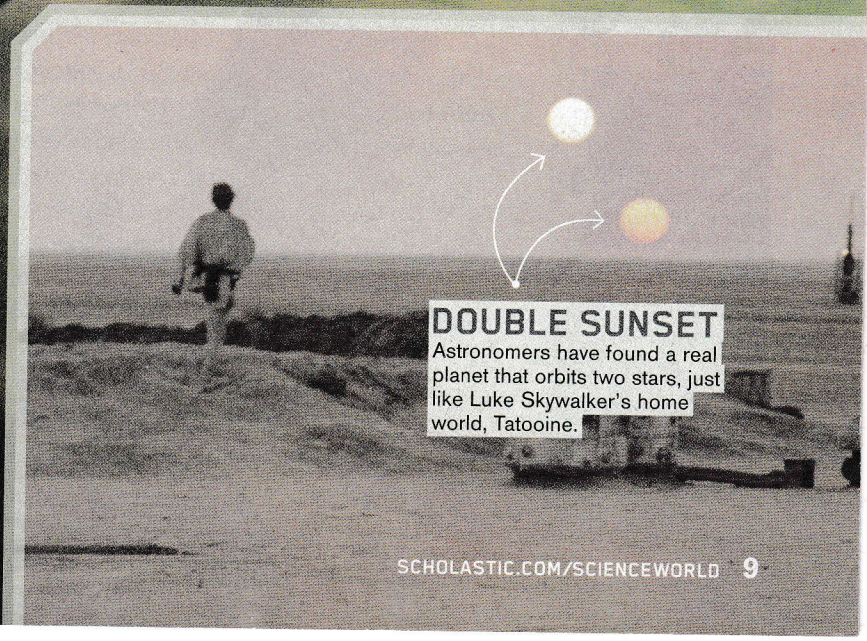
Continued on the next page →

SWEET SHIP
The *Millennium Falco* dodges blaster fire from enemy TIE fighte craft (*left*).

E OF
ARS

WATCH A VIDEO
scholastic.com/scienceworld

4 BONUS SKILLS SHEETS
scholastic.com/scienceworld



DOUBLE SUNSET
Astronomers have found a real planet that orbits two stars, just like Luke Skywalker's home world, Tatooine.

to have some fun with Star Wars creator George Lucas: "We called him up and said, 'George, there's a mistake in your movie—you got the colors reversed!'" says Kepler mission chief Bill Borucki. "He enjoyed the joke, and some of his crew participated in the announcement of the discovery."

So planets do exist outside our solar system. But what about outside our galaxy? It's hard to tell because other galaxies are so far away, but tantalizing hints suggest that *extragalactic* planets may be out there. One exoplanet spotted in the Milky Way, our home galaxy, is thought to have formed in a smaller galaxy that merged with ours billions of years ago. And observations of a star in Andromeda, our nearest neighboring galaxy, suggest a possible planet there.

EXPLODING IN SILENCE

In the distant galaxy where Star Wars is set, the saga depicts space battles with loud, fiery explosions whenever one of the good guys takes out an enemy fighter ship after a high-speed chase. In real life, things would be quite different, says physicist Rhett Allai of Southeastern Louisiana University.

For one thing, those noisy explosions would be silent: "When things explode in space, there's no air, so there's no sound," says Allain. Sound waves need a *medium*—material such as air or water—to travel through. Without one, explosions would be completely soundless.

The absence of air also makes explosions less fiery, since flames need oxygen or another suitable gas to burn. A huge battle station like the Death Star might contain enough gas to produce flames when it blow up, says Allain, "but smaller objects like TIE fighters would probably just break apart" when they're destroyed.

FUNKY PHYSICS

The movement of the films' ships is another physical oddity. "They show spaceships flying at a constant speed with their thrusters on," says Allain. Thrusters provid *thrust*, a force that *accelerates* an object (makes it change speed or direction). So re

BOOM! Explosions inside a pressurized ship or battle station would produce noise and flames. But ones out in space would be quiet and less fiery.

fighters with their thrusters on would be speeding up, not staying at the same speed.

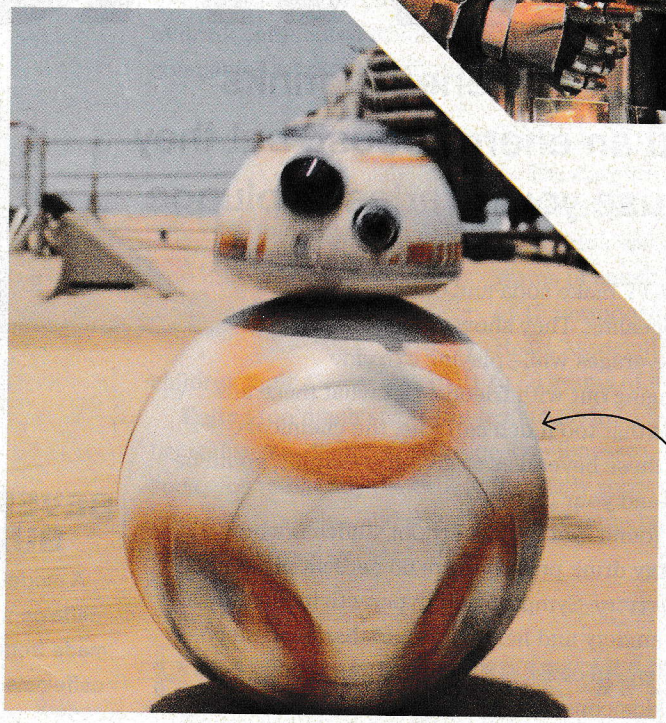
One of the fastest ships in the series, the *Millennium Falcon*—piloted by Han Solo—returns in *Episode VII*. In the first film, Solo brags that his ship made a certain trip "in less than 12 *parsecs*." A parsec is a real unit, but it measures distance, not time!

A fast ship is one thing, but even in close combat with Storm Troopers, our heroes have an uncanny ability to dodge enemy fire. That got Allain curious about the movies' blaster weapons, which release glowing bolts. "They're not lasers—light travels way too fast to see it move across the screen like that," he says. The bolts could consist of gas heated into *plasma*, a state of matter made of charged particles that's common in stars.

Allain analyzed several scenes and found that close-range blaster shots travel at about 35 meters per second (78 miles per hour)—comparable to a baseball pitch, and much slower than rifle bullets, which can top 1,200 m/s (2,700 mph). Dodging blaster fire might not be totally unrealistic.

One thing physics can't explain is "the Force," a fictional power that allows characters to move objects without touching them. That violates *Newton's third law of motion*, which says an interaction between objects always involves two opposing forces. "When you use the Force to push something"—such as when Luke uses it to lift his X-wing fighter out of a swamp in *Episode V*—"that thing should also push back on you. We don't see that," says Allain.

BLASTER GUN
Don't be fooled: This is no laser weapon. The glowing bolts it shoots are more likely made of hot plasma.



HELPER BOT
Roboticists say today's technology is getting close to that of the series' droids, like the new BB-8.

ROBOT REALISM?

Droids R2-D2 and C-3PO are the only characters to appear in all six Star Wars movies so far. (A new bot, BB-8, joins them this month.) When the droids first hit the big screen in 1977, robots with their abilities and artificial intelligence were a long way off.

But roboticist James Kuffner of Carnegie Mellon University says today's cutting-edge robots are getting close. *Humanoid* (human-shaped) robots like Honda's ASIMO can walk and run smoothly. And although current robots may not navigate rough terrain quite as well as C-3PO, bots like Big Dog and Atlas from robotics company Boston Dynamics are getting better at it all the time.

As for robot smarts, the droids demonstrate "advanced speech recognition and language translation capabilities" beyond today's top performers, says Kuffner. "But I believe we're actually not far off from technology at that level." Software like Google Now and Siri can already follow voice commands fairly well. Some Star Wars technology may not be so "far, far away" after all.

—Jennifer Barone

CORE QUESTION

What is one aspect of Star Wars that now seems more realistic than it did when the first movie was released in 1977? Cite evidence from the text.

to have some fun with Star Wars creator George Lucas: "We called him up and said, 'George, there's a mistake in your movie—you got the colors reversed!'" says Kepler mission chief Bill Borucki. "He enjoyed the joke, and some of his crew participated in the announcement of the discovery."

So planets do exist outside our solar system. But what about outside our galaxy? It's hard to tell because other galaxies are so far away, but tantalizing hints suggest that *extragalactic* planets may be out there. One exoplanet spotted in the Milky Way, our home galaxy, is thought to have formed in a smaller galaxy that merged with ours billions of years ago. And observations of a star in Andromeda, our nearest neighboring galaxy, suggest a possible planet there.

EXPLODING IN SILENCE

In the distant galaxy where Star Wars is set, the saga depicts space battles with loud, fiery explosions whenever one of the good guys takes out an enemy fighter ship after a high-speed chase. In real life, things would be quite different, says physicist Rhett Alla of Southeastern Louisiana University.

For one thing, those noisy explosions would be silent: "When things explode in space, there's no air, so there's no sound," says Allain. Sound waves need a *medium*—material such as air or water—to travel through. Without one, explosions would be completely soundless.

The absence of air also makes explosions less fiery, since flames need oxygen o another suitable gas to burn. A huge battle station like the Death Star might contain enough gas to produce flames when it blow up, says Allain, *"but smaller objects like TI* fighters would probably just break apart" when they're destroyed.

FUNKY PHYSICS

The movement of the films' ships is another physical oddity. "They show space ships flying at a constant speed with their thrusters on," says Allain. Thrusters provid *thrust*, a force that *accelerates* an object (makes it change speed or direction). So r

BOOM! Explosions inside a pressurized ship or battle station would produce noise and flames. But ones out in space would be quiet and less fiery.

JITTERY DRINKS

Caffeinated soda and energy drinks might give you an energy boost, but they could also cause your grades to plunge

Commercials on TV make soda and energy drinks look appealing. They show people guzzling the beverages while playing extreme sports and hanging out with friends. But what these ads don't tell you is that too much *caffeine*, the chemical stimulant drug added to these beverages to give you that lift, could be harmful to your health—and your grades.

Researchers recently found that middle school students who consumed even one energy drink per day were 66 percent more likely to show signs of *hyperactivity*. Symptoms of hyperactivity include a lack of focus, increased anxiety and heart rate, and disrupted sleep. This could be a big problem, because a 2014 study found that 73 percent of American kids consume caffeine daily.

CAFFEINE COMPLICATIONS

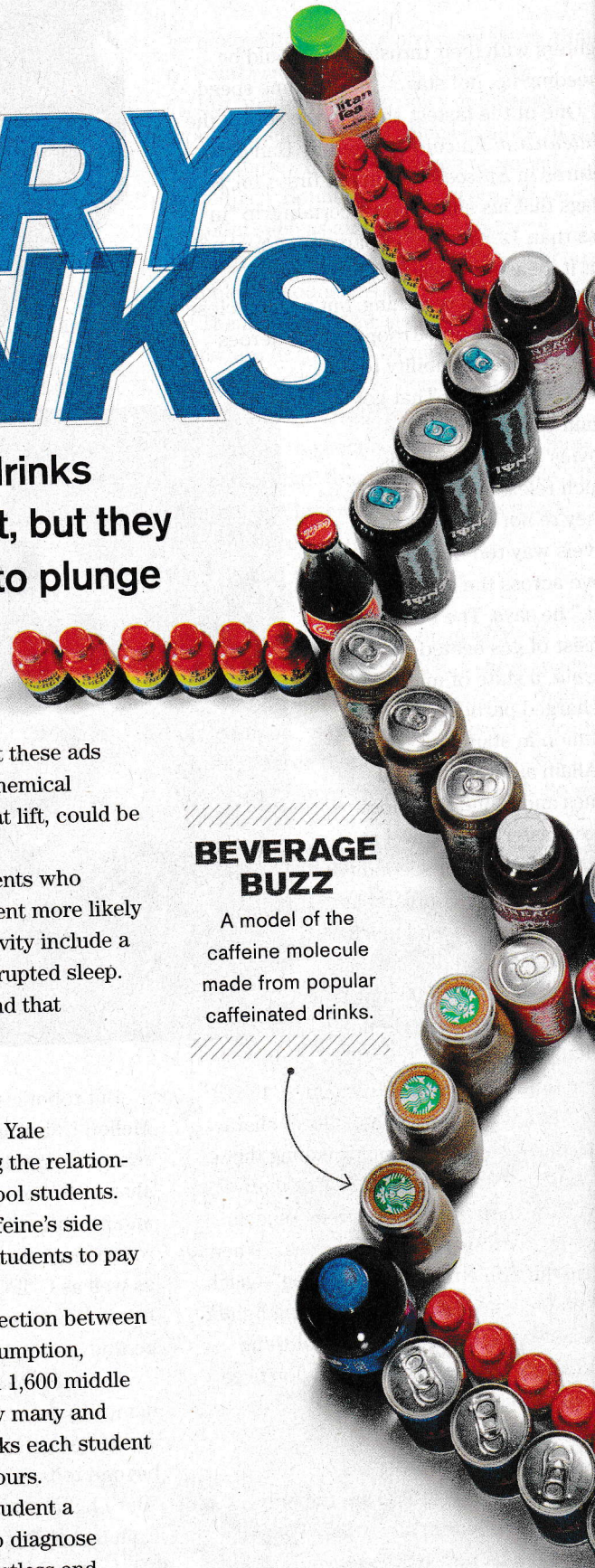
Jeannette Ickovics is a professor of public health at Yale University in Connecticut. She led the study examining the relationship between caffeine and hyperactivity in middle school students. She says her findings provide strong evidence that caffeine's side effects can cause symptoms that make it difficult for students to pay attention and do well in school.

To find out if there is a connection between hyperactivity and caffeine consumption, Ickovics interviewed more than 1,600 middle school students. She asked how many and which types of caffeinated drinks each student had drunk within the past 24 hours.

Then Ickovics asked each student a list of questions that could help diagnose hyperactivity: 1) Do you feel restless and have trouble staying still for long? 2) Are you constantly fidgeting or squirming? 3) Are you easily distracted and do you find it difficult to

WATCH A VIDEO
scholastic.com/scienceworld

4 BONUS SKILLS SHEETS
scholastic.com/scienceworld



BEVERAGE BUZZ
A model of the caffeine molecule made from popular caffeinated drinks.

concentrate? 4) Do you finish the work you are doing and is your attention good? and 5) Do you think before you do things? Students ranked each of these questions as either "not true," "somewhat true," or "certainly true."

"As the number of drinks went up, so did the number and severity of symptoms," says Ickovics. She found that even one additional drink per day could heighten the level of hyperactivity in the students by an average of 14 percent.

CORE QUESTION

What are ways to boost your energy without consuming caffeine?

Other findings from the study show that boys are more likely to drink caffeinated drinks. Ickovics suspects that this is because companies market the drinks with ads that are targeted at boys.

SWEET SYMPTOMS

The dangers of caffeine-rich beverages go beyond hyperactivity. Each drink can also contain up to 40 grams of sugar. That's the equivalent of 10 teaspoons. The American Heart Association recommends that children limit themselves to 21 to 33 grams of sugar each day.

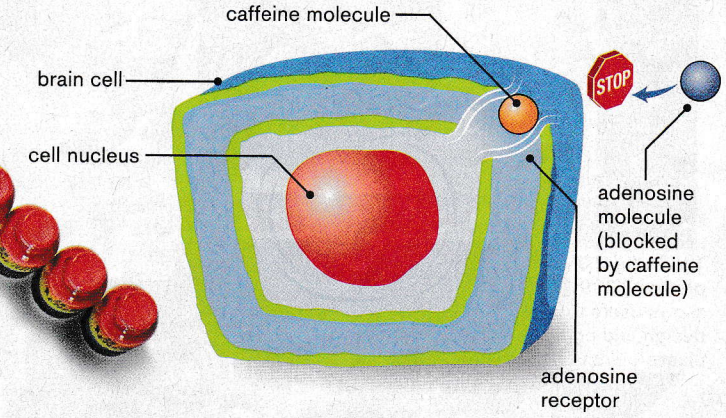
Eating too much sugar can lead to an increased risk of obesity, heart disease, diabetes, and digestive illnesses. "So if you have one soda, you're already exceeding that daily recommendation," says Ickovics. "Caffeine and sugar are like peanut butter and jelly—they're almost always together."

—Andrew Klein

HOW CAFFEINE WORKS

Caffeine is absorbed by brain tissues and binds to *adenosine receptors* on brain cells. Normally, adenosine molecules bind to these receptors to make you drowsy, says Robert McGorrin, a food scientist at Oregon State University. "It works like a lock and key."

But the caffeine molecule's shape resembles that of adenosine, so it can also bind to adenosine receptors. Caffeine blocks adenosine from binding to the receptors, preventing you from feeling tired.



JUST PRESS

3-D printers have made their way into schools, hospitals, and even outer space. Where will they go next?

WATCH A VIDEO
scholastic.com/scienceworld

4 BONUS SKILLS SHEETS
scholastic.com/scienceworld

Last spring, mechanical engineer Jim Smith wanted to go kayaking near his home in South Carolina. The only problem was he didn't have a kayak. Most of us would have headed to a sporting goods store to buy or rent a boat, but Smith decided to print one.

He designed a 5.5 meter (18 foot)-long kayak on his computer. Then he used a 3-D printer in his garage to print 28 plastic pieces, which he assembled into a complete, functioning boat. It cost half the price of a similar store-bought kayak.

Smith is a mechanical engineer at 3D Systems, a company based in Rock Hill, South Carolina, that sells 3-D printers and 3-D printed products. But experts like Smith aren't the only ones making amazing creations with 3-D printers. In the past five years, 3-D printing has gone mainstream.

READY, SET, PRINT!

You're probably familiar with printers that use ink to create text on paper, but 3-D printers work differently. Many of them use colorful plastic as their printing material. "It works just like a hot glue gun," says Smith, who designed and built a 3-D printer called the Cube. The machine pushes

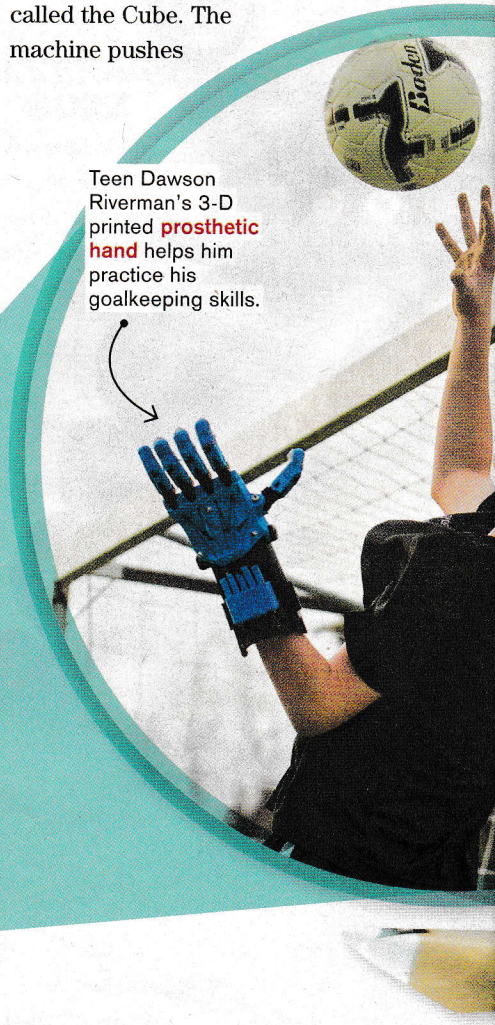
HOW 3-D PRINTERS WORK

1 The printer contains a spool of colorful plastic. As it begins making an object, the plastic spools unwind at the top of the machine.

2 Heated nozzles melt the plastic and squeeze it onto the platform below. A printhead moves to deposit a thin layer of plastic.

3 The object is built layer by layer, with each one shaped like a cross-section of the item being printed, until the printer has created a complete object.

The **Cube 3D printer** ($999) allows users to design and print plastic objects.



Teen Dawson Riverman's 3-D printed **prosthetic hand** helps him practice his goalkeeping skills.

PRINT

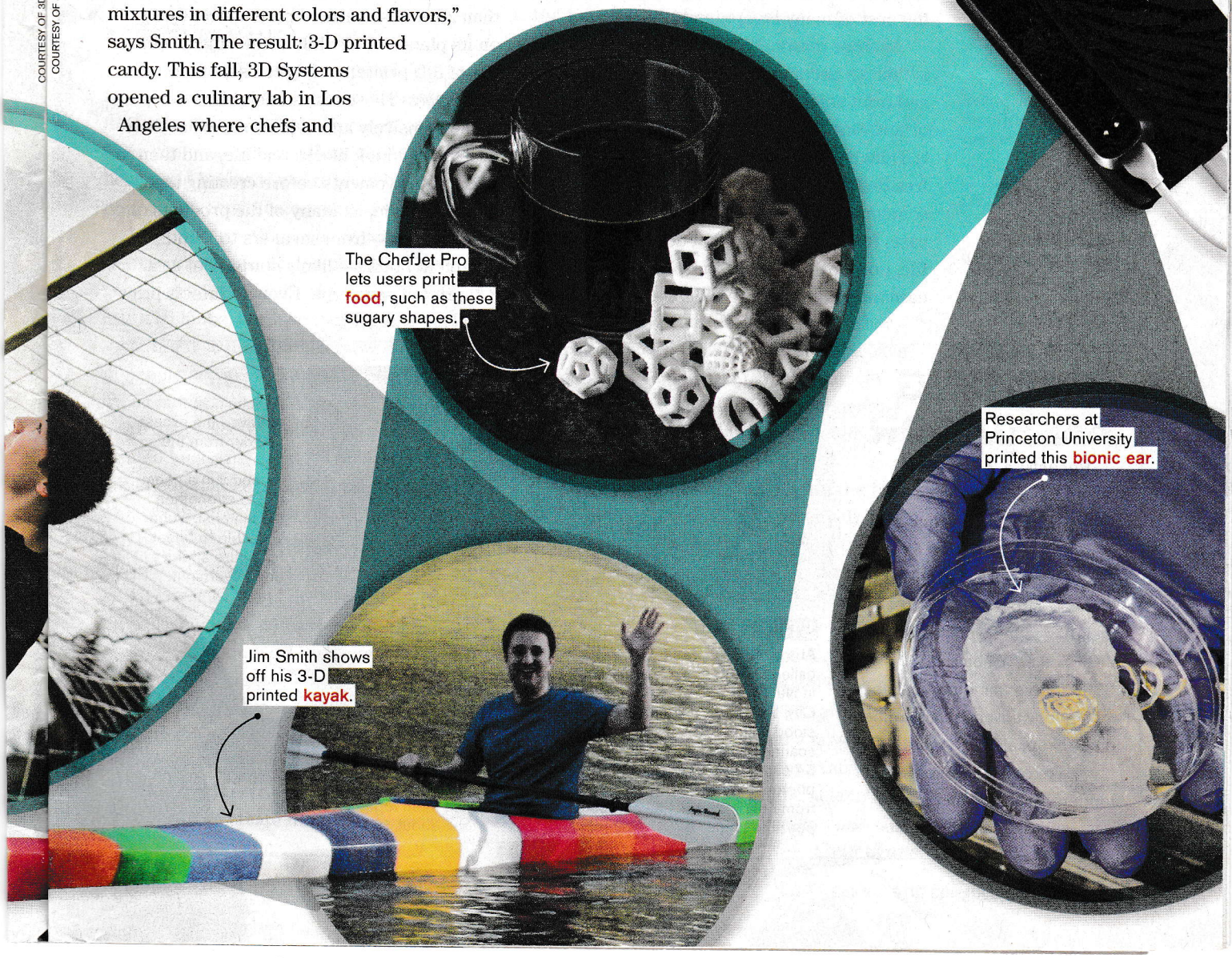
spaghetti-like strings of plastic through heated nozzles, melting the plastic and squeezing it onto a platform below (*see How 3-D Printers Work, left*). The machine adds layer after layer onto the platform to build the object.

Plastic isn't the only material used in 3-D printers. Some use metal, ceramic, glass, or wood. It's even possible to print food. "We have printers that print powdered sugar mixtures in different colors and flavors," says Smith. The result: 3-D printed candy. This fall, 3D Systems opened a culinary lab in Los Angeles where chefs and engineers can work together to explore the future of food.

3-D PRINTING REVOLUTION

Although 3-D printers have been around since the mid-1980s, they've only recently become more affordable (*see 3-D Printing Timeline, p. 17*). In 2005, 3-D printers

Continued on the next page →



3-D printed **iPhone case**

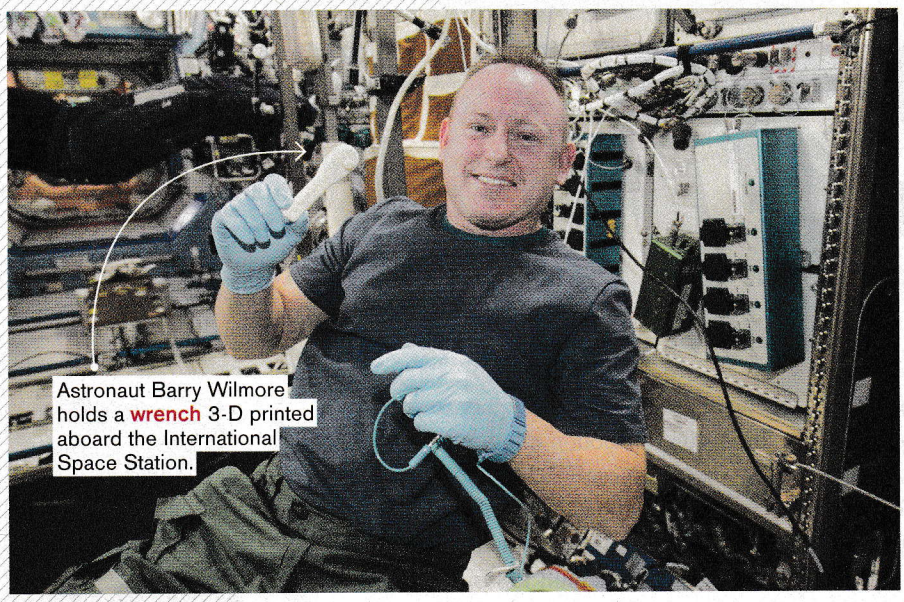
The ChefJet Pro lets users print **food**, such as these sugary shapes.

Researchers at Princeton University printed this **bionic ear**.

Jim Smith shows off his 3-D printed **kayak**.

COURTESY OF 3D SYSTEMS (PRINTER, KAYAK); LEAH NASH/THE NEW YORK TIMES/REDUX (HAND)

COURTESY OF 3D SYSTEMS (SUGAR, CASE); MEL EVANS/AP PHOTO (PETRI)



Astronaut Barry Wilmore holds a **wrench** 3-D printed aboard the International Space Station.

were mostly industrial size and extremely expensive. Today you can buy a microwave-size 3-D printer for under $1,000—less than the cost of many computers!

Another reason 3-D printing has taken off is that it's become easy for anyone to design and print something, whether they're experts or not. One popular website for inspiration is Thingiverse, which has more than 100,000 free designs for users to download. If someone finds a design for a cell phone case, for example, they can download the file, press print, and watch their new phone case materialize before their eyes.

You don't have to look far to find 3-D printed objects around you. The airplane manufacturer Boeing estimates that more than 20,000 3-D printed parts currently fly on its planes. And while some objects come out of 3-D printers ready to use, others are *prototypes*. These test models allow people to inexpensively and quickly see what their designs will look like in real life, and then make improvements before creating their finished products. Many of the products on store shelves—from sneakers to laundry detergent bottles—likely started out as a 3-D printed prototype. Even architects print

PRINTING AN EDITOR

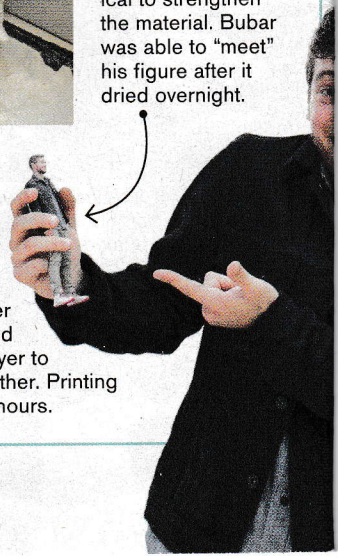
Recently, a 3-D printer created a mini version of Joe Bubar, an editor at Scholastic. Everything about Bubar and the 8-inch figure looks identical—from the curls in their hair to the wrinkles in their clothes. Bubar paid $300 for his "mini-me," but as technology advances, the price could drop, allowing more people to create lifelike cake-toppers, mini versions of their pets, and 3-D family portraits.

STEP 1
At a store called DOOB in New York City, Bubar stood inside a scanner, where 54 cameras took photos of him from nearly every possible angle.

STEP 2
A technician at DOOB used special software to turn all those photos into one 3-D model of Bubar on a computer. Then he hit print.

STEP 3
A 3-D printer used a special powder to print the figure one thin layer at a time. The printer added color and glue to each layer to hold them together. Printing took about 18 hours.

STEP 4
A technician removed the excess powder from the figure. Then he dipped it in a chemical to strengthen the material. Bubar was able to "meet" his figure after it dried overnight.



A model of a **bridge** planned in Amsterdam that will be 3-D printed using special robots.

miniature versions of buildings they've designed to see how they look before starting construction.

A HELPING HAND

3-D printing is improving people's lives. Doctors use the printers to create metal implants, like jawbones, rib cages, and hips. They can even print replicas of patients' hearts and brains to practice on before performing complicated surgeries.

The printers offer a way to make medical devices more quickly and cheaply. That's good news for kids who need *prostheses*, or artificial limbs, because they have to replace them often as their bodies grow. Thousands of people around the world are getting prosthetic hands from e-NABLE, a community of more than 3,000 volunteers who make 3-D printed hands for those in need. A typical prosthetic hand can cost up to $10,000, but the ones by e-NABLE can be downloaded, printed, and assembled for less than $50.

All e-NABLE hand designs are free to download, and assembly is easy. Girl Scout and Boy Scout troops have assembled hands that have been distributed to people in impoverished communities and refugees worldwide. Recently, e-NABLE partnered with 3D Systems to create more-advanced prosthetics.

CORE QUESTION

What are three uses for 3-D printers cited in the text? Can you think of a possible use not listed?

Enter for a chance to win a **3-D printer!** (See p. 24 for details.)

OUT OF THIS WORLD

3-D printers are even helping astronauts. Last year, NASA tested a 3-D printer aboard the International Space Station, a laboratory that orbits Earth, to see if it could work in zero gravity. Astronauts successfully printed a total of 20 objects, including a wrench and a storage container. Having a 3-D printer on the space station could one day eliminate the need to send spacecraft to resupply the orbiting laboratory. Those missions require months of planning and can cost tens of millions of dollars.

Scientists hope that someday, astronauts will be able to print food, tools, and other items that they'd need during lengthy space missions to places like Mars and beyond. NASA scientists are already experimenting with a 3-D printer that uses powdered ingredients to make pizza.

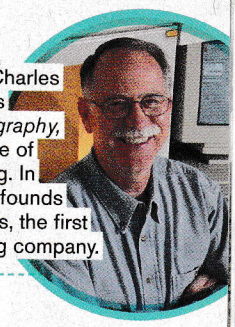
Back on Earth, Smith thinks that someday everyone will have a 3-D printer in their home to make anything from food to furniture. "Printing complete working devices, that's really the future," says Hod Lipson, the director of the Creative Machines Lab at Cornell University in New York. "If you need a new remote control, for example, you will be able to just download and print." ⚛

—Cody Crane

3-D PRINTING TIMELINE

Invented more than three decades ago, 3-D printing has come a long way.

1983



Engineer Charles Hull invents *stereolithography*, the first type of 3-D printing. In 1986, Hull founds 3D Systems, the first 3-D printing company.

1989

The first stereolithography 3-D printer is sold by 3D Systems. It cost more than $100,000.

2002

A miniature 3-D printed kidney is created, paving the way for other printed body parts.

2008

A person walks on a 3-D printed prosthetic leg for the first time. All parts are printed at once.

2012

President Barack Obama's administration invests $30 million to boost 3-D printing in the U.S.

2013

Office-supply store Staples begins selling desktop 3-D printers. Other stores follow suit.

2015

A fossil of the ancient human species *Homo naledi* is scanned, 3-D printed, and put on display in London.

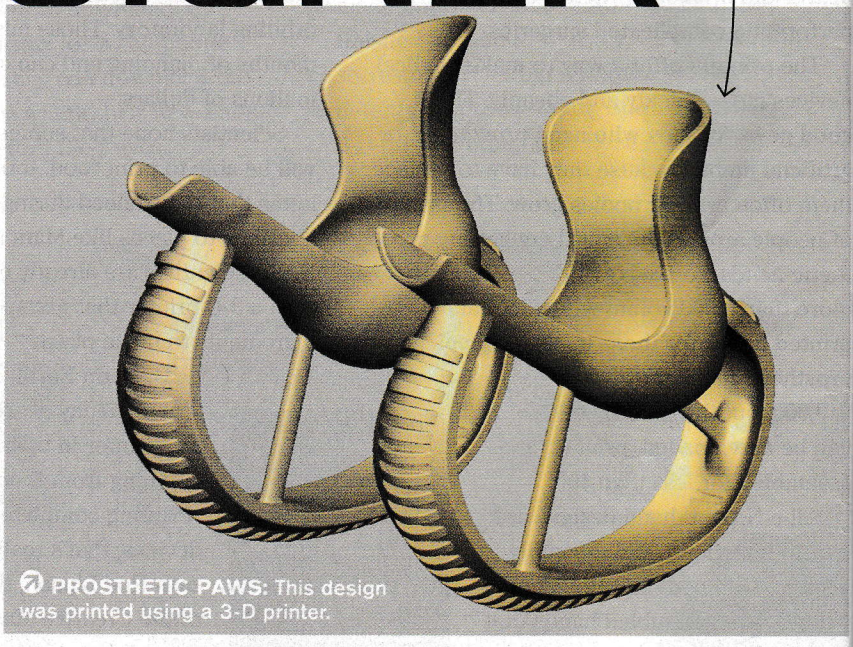
COURTESY OF NASA (ASTRONAUT); ORIS LAARMAN/REX SHUTTERSTOCK (BRIDGE); BIANCA ALEXIS (ALL OTHER PHOTOS)

COURTESY OF 3D SYSTEMS (HULL, KIDNEY); ISTOCKPHOTO.COM (STAPLES); 3D PRINTED MANDIBLE AND MAXILLA OF HOMO NALEDI. FILES AVAILABLE AT MORPHOSOURCE BY THE RISING STAR EXPEDITION TEAM. IMAGE CREDIT: K. KILLGROVE (JAW)

Derby's prostheses allow him to go on walks and play.

PAW DESIGNER

Tara Anderson created 3-D printed limbs that allow a rescue dog to run for the first time



PROSTHETIC PAWS: This design was printed using a 3-D printer.

A disabled husky named Derby finally gets to do things that come naturally to most dogs—go on walks, play fetch, and run around. Derby was born with underdeveloped front legs, making it impossible for him to walk. But now he has 3-D printed *prosthetic* paws that have gotten him up and running.

Derby's transformation came about thanks to his foster mom, Tara Anderson. She took Derby in when the dog rescue group Peace and Paws was looking for a foster home for him. Luckily, Anderson works at 3D Systems—a company based in Rock Hill, South Carolina, that sells 3-D printers and printed products. *Science World* spoke with Anderson about how her job inspired her to design prostheses for Derby.

What do you do at 3D Systems? I'm a product manager for our color 3-D printers. They're used to help make lots of different products. For example, when a sneaker manufacturer has a new shoe design, they'll first print a full-color model to see how it will look in real life. It's my job to help make sure our 3-D printers meet the needs of our customers. I work with our engineers to design 3-D printers that print in a full range of colors. I have a master's degree in architecture and a strong understanding of computers, which is a perfect fit for my job.

How did you get involved with Derby? I saw that Peace and Paws was looking for a foster home for Derby. When I heard his story, I cried. I wasn't sure I could handle his special needs, but I had to try.

At first, the rescue group and I looked into getting Derby a set of wheels to help him walk. But the wheels are awkward and didn't allow him to play with other dogs. Then, while at work, I received an order for a 3-D printed model of a person's hip that had been damaged in a car accident. Doctors planned to use the model to review the steps of a tricky reconstructive surgery. I realized that 3-D printing technology has lots of medical applications. Surely we could do something for Derby.

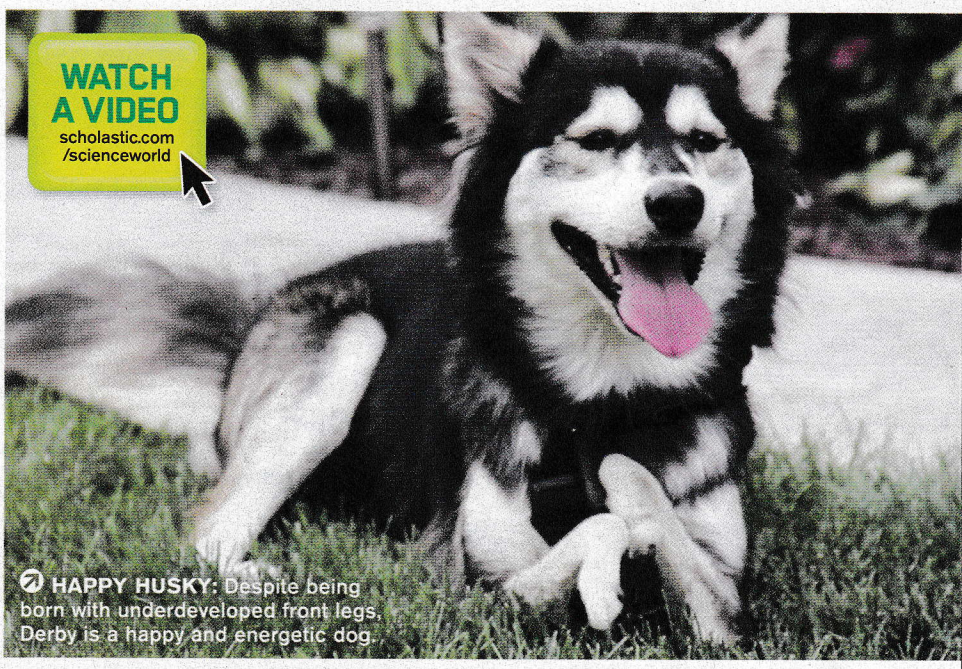
What process did you use to design Derby's new paws? I reached out to *orthotist* Derrick Campana at Animal Ortho Care in Virginia, who custom makes prostheses for animals. He hadn't used 3-D printing before but was excited to try it. The process allowed us to make prostheses more quickly than traditional methods. If a design didn't work, we could easily modify it and print another pair of legs.

To get started, we needed to get the exact shape of Derby's legs. Campana was able to do this by making plaster casts of them. Then we scanned the molds and used the images to model the prostheses on a computer. We wanted the 3-D printed sections that would cradle his deformed elbows and forearms to fit perfectly so the prostheses would be comfortable.

Once we'd fitted Derby with the 3-D printed parts to cushion his legs, the next step was to raise him up off the ground. Based on how Derby's shoulders rotated, I sketched a rounded design that I thought would work well for him. I printed the prostheses, and the next morning Derby was running! I couldn't believe it.

What response have you received from people who have heard Derby's story? We've gotten a lot of requests to help animals in similar situations, as well as letters just saying thank you. If it helps inspire people, then I'm really proud. It's wonderful to bring a design to life to improve a person's—or in Derby's case, a dog's—life. That's what 3-D printing is all about.

—Cody Crane



HAPPY HUSKY: Despite being born with underdeveloped front legs, Derby is a happy and energetic dog.


BEST BUDDIES: Anderson is still creating prostheses for Derby in order to gradually raise him to his full height.

COURTESY OF 3D SYSTEMS (ALL PHOTOS)

TOUGH TRAIL: Mule deer cross Pine Creek in Wyoming.

THE LONG HAUL

The discovery of a record-breaking migration could help protect a western icon

Back in 2011, biologist Hall Sawyer was asked to study the movements of mule deer in a region of Wyoming called the Red Desert. Government officials wanted to balance the animals' needs with other land uses, like building houses. Sawyer put GPS tracking collars on 40 deer that January.

At the time, everyone assumed the deer spent all year in the Red Desert. So Sawyer was surprised that spring when his team picked up signals from far to the northwest, in the Hoback Basin (*see Migration Route, right*). When the deer returned to the Red Desert the following winter, Sawyer realized he had stumbled upon a previously undiscovered long-distance migration.

In late March, more than 500 mule deer begin a 150-mile journey from the Red Desert. Fifty miles north, they merge with thousands more deer from the foothills of the Wind River mountains. Along the way, the animals must skirt sand dunes, swim across rivers, cross roads, and jump fences to reach their preferred summering grounds, the lush mountain meadows of the Hoback Basin. They're there by early June. They leave the basin in mid-October and arrive back in the Red Desert by late November.

It turns out the mule deer's trek is the longest known land migration in the continental U.S. (Alaska's caribou hold the world record, covering 2,400 miles round-trip.)

"Mule deer have been making this migration for hundreds of years, and nobody had put the pieces together," says Matthew Kauffman, director of the Wyoming Migration Initiative at the University of Wyoming.

WATCH A VIDEO
scholastic.com/scienceworld

4 BONUS SKILLS SHEETS
scholastic.com/scienceworld

SWEPT AWAY: A helicopter allows scientists to reach deer in remote areas. The researchers tie up and blindfold deer before taking them to a field station for health testing and GPS collaring.

HEADING HOME: A mule deer is released after collaring.

SPREADING THE NEWS

Mule deer are brownish-gray *ungulates*, or hoofed mammals, native to western North America. They're about the same size as white-tailed deer, which are common east of the Rockies. Mule deer are named for their large, mule-like ears.

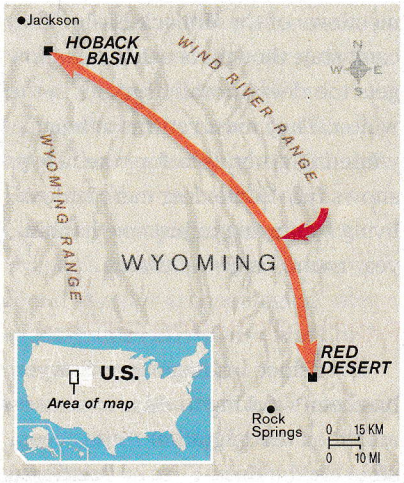
The species is an iconic animal of the American West, but its numbers have been declining since the 1970s because of habitat loss, drought, and other factors. Sawyer wanted to get the word out about the newfound migration—not just because it was record-breaking, but because he knew the deer could use some help.

To build up fat to survive the winters, mule deer eat only the most

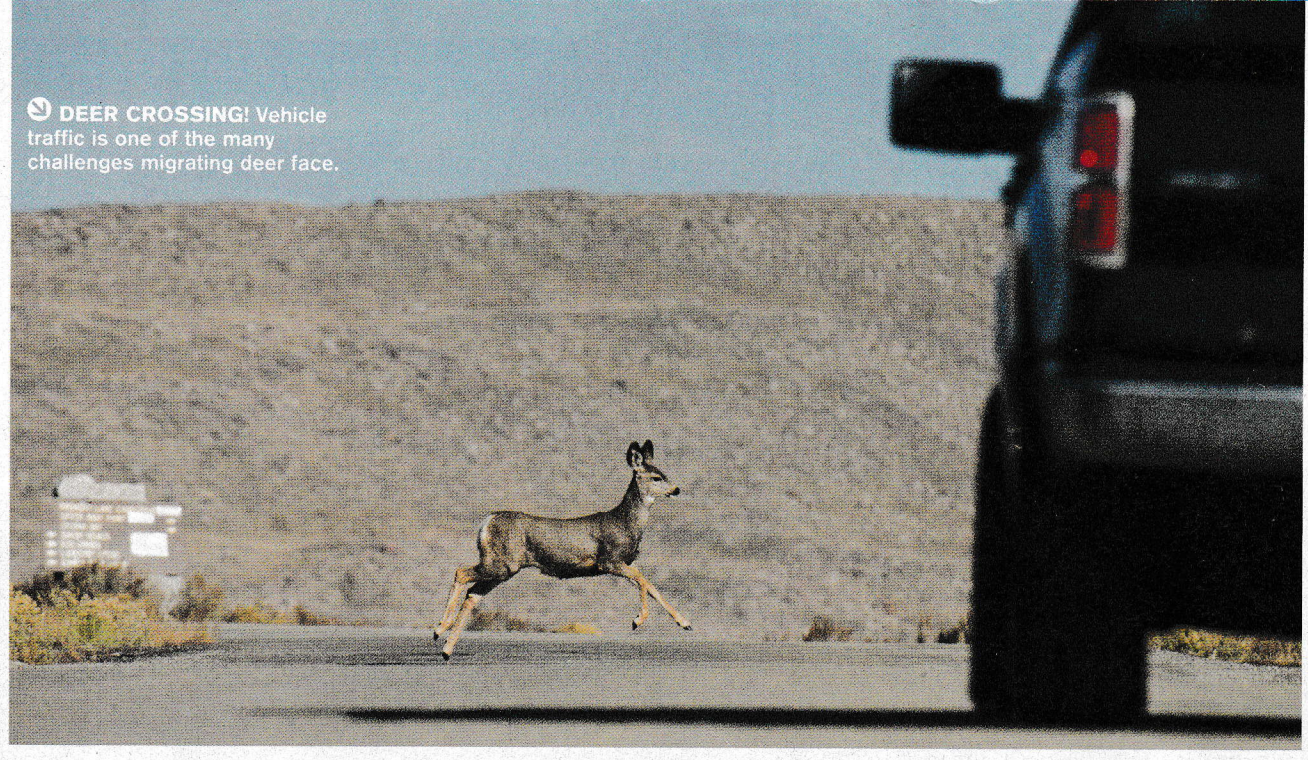
Continued on the next page →

MIGRATION ROUTE

About 500 mule deer journey from the Red Desert to Hoback Basin each spring (*orange*). Thousands more join from the Wind River Range (*red*). They return south before heavy snow falls.



COURTESY OF JOE RIIS (DEER)
MICHAEL KIRBY SMITH/THE NEW YORK TIMES/REDUX (TOP AND BOTTOM); JIM MCMAHON (MAP)



DEER CROSSING! Vehicle traffic is one of the many challenges migrating deer face.

nutritious plants and plant parts. For this reason, they can thrive only in areas with the proper food.

The newly discovered migration highlights the animals' need to travel—sometimes long distances—to survive. Roads, highways, fences, homes, natural gas developments, wind farms, and mining operations can interfere with or block migration paths. That can be a big problem for mule deer.

The deer that Sawyer tracked feed on small, hardy plants called desert sagebrush in winter—but in the summer, they fatten up on the more nutritious grasses and flowering plants on the mountain meadows of the Hoback Basin. They can't stay, though, because the snow gets too deep to walk through in the winter. They must return to their wintering grounds before the heavy snows fall. "Mule deer can't make a living by staying in just one habitat year-round," says Kauffman.

PARTNERS IN PROTECTION

Ever since his discovery, Sawyer has been working to raise awareness and keep the migration route accessible for the deer. First he partnered with wildlife photojournalist Joe Riis to produce a traveling photo exhibit and a short video on the migration, which received millions of views online. Then he teamed up with Kauffman and the Wyoming Migration Initiative to assess the 10 biggest challenges for the deer along the migration route, which takes the animals through a patchwork of land owned by the federal government, state government, and private owners. "Figuring out how to get everybody on the same page and accommodate the animals is the biggest challenge," Sawyer says.

All the stakeholders are starting to come together on solutions. One organization, the Conservation Fund, purchased land where the deer cross a stream. It had been slated for housing development, but the group plans to safeguard the stream. This way the deers' migration through this area won't be disrupted. And the U.S. Bureau of Land Management is considering ways to protect the deers' migration route from energy development on federal land.

Meanwhile, scientists are working to learn more about mule deer. Kauffman is collecting health data like body fat and pregnancy status from a group of migrating mule deer. A few times a year, his team shoots nets from helicopters to capture the collared animals. They draw blood and measure fat before releasing the deer. "We can keep tabs on how they're doing in terms of foraging and fat gain—things that determine their ability to survive and produce the next generation," he says.

Sawyer is optimistic that the discovery as well as ongoing research and advocacy will make a difference for migrating animals across the West. "Mule deer and other big game populations are a national treasure just like Old Faithful or Yosemite," he says. "That's something that people should care about."

—Jennifer Abbasi

CORE QUESTION

What obstacles do mule deer face along their migration route, and how are conservationists helping? Summarize in your own words.

OLD FASHION This woman's last hairdo was likely styled for her burial about 3,300 years ago.

ANCIENT HAIR

While excavating the ancient Egyptian city of Amarna, archaeologists made a surprising find: a 3,300-year-old skull of a woman with about 70 elaborate hair extensions.

Though much of the woman's body had decayed over time, the hair extensions were well preserved. They were intricately styled with braids and decorations that had been woven into the twists.

The woman's hair was able to survive for such a long time because hair is made up of proteins that are linked strongly together. This helps preserve the strands and slows the pace of decay.

Hairstyles like the one pictured were common in ancient Egypt, where people took hair care very seriously. The archaeologists also discovered a fatty substance at the end of some of the braids. This sticky material could have been used to keep the hairdo in place, like hair gel or spray that people use today.

"The amount of extensions and work done on them, along with the hairstyle, can tell about the wealth of a person and his or her social position," says Jolanda Bos, an archaeologist working at the site.

Bos explains that these remains are still being studied. With more examination, she hopes to learn about the woman's age and lifestyle. Bos and other researchers are currently comparing the ancient woman's hairstyle with remains found at other archaeological sites to learn more. They also want to analyze a dye found in her hair to determine if—even 3,000 years ago—people tried to cover up their gray hair. *—Claire Maldarelli*

COURTESY OF JOE RIIS (TOP)
COURTESY OF J.E.M.F. BOS-BEUKENHOLDT/WWW.AMARNATRUST.COM

SCIENCE WORLD CONTEST

WIN A 3-D PRINTER FOR YOUR CLASSROOM!

In "Just Press Print" (*p. 14*) and "Paw Designer" (*p. 18*), you learned about 3-D printers and the amazing things they can make. From skateboards to shoes, the sky is the limit. Entrepreneurs, scientists, and students like you are using 3-D printers to make their ideas a reality.

Have you ever wanted to bring an invention to life? Enter our contest for a chance to win a 3-D printer for your classroom. Describe what you'd create with a 3-D printer and why. What challenges might you run into, and how would you overcome them?

HOW TO ENTER

1 Write 300 to 500 words explaining the invention you'd want to create and why. Explain, in language your classmates would understand, how you would use a 3-D printer to make your idea a reality. What challenges might you run into, and how would you overcome them? You may include sketches to help illustrate your invention on an additional $8\frac{1}{2}$" x 11" sheet of paper.

2 Complete the entry form in this issue's Teacher's Guide or download it by clicking the entry form button (*below*) in your digital edition. Mail the completed entry form with your entry to: 3-D Printing Contest, *Science World*, Scholastic Inc., P.O. Box 713, New York, NY 10012. Only one entry per person. Entries must be received by January 18, 2016.

Download entry form and contest rules. scholastic.com/scienceworld

ENTER FOR A CHANCE TO WIN A 3-D PRINTER!

PRIZES: The winning student's teacher will receive a Cube 3-D printer, a Sense 3D scanner, and a class video chat with a designer at the company 3D Systems. The designer will explain to the class how to use the prizes. The winning student will take home a $50 gift certificate to the Cubify store (www.cubify.com), which sells 3-D printed cell phone cases, picture frames, etc. Three runners-up will also win a $50 gift certificate to the Cubify store.

NO PURCHASE NECESSARY. Contest open to legal U.S. residents currently enrolled in grades 4 through 12. Entries must be received by January 18, 2016. No e-mail entries accepted. Void where prohibited. For complete rules and guidelines, see this issue's Teacher's Guide or click the entry form button (*left*) in your digital edition.

TEST YOUR SCIENCE SMARTS

Play our science trivia game online! Just click this button in the digital edition and select whether you'd like questions from this issue only or from our archive.

PLAY SCI-TRIV® scholastic.com/scienceworld

Statement of Ownership, Management and Circulation of *Science World* (as required by Title 39, United States Code). Date of Filing: October 1, 2015. Title of Publication: *Science World*. Frequency of issue: 12 times during the school year: Biweekly, September, February; Monthly, October, November, December, January, March, April, May. Location of Known Office of Publication: 2931 East McCarty Street, Cole County, Jefferson City, MO 65101-4464. Location of the Headquarters of the Publishers: 557 Broadway, New York, NY 10012-3999. Publisher: M. Richard Robinson; Editor: Patricia Janes (both of 557 Broadway, New York, NY 10012-3999). Owners: Scholastic Corp., M. Richard Robinson, Trust under will of Maurice R. Robinson, Trust under will of Florence L. Robinson, all of 557 Broadway, New York, NY 10012-3999. During Preceding 12 Months Average Number of Copies: Printed each issue, 576,335; Paid Circulation, 530,437; Free Distribution, 20,473; Total Number of Copies Distributed, 550,910; Copies Not Distributed, 25,425; Total, 576,335. For Single Issue Nearest to Filing Date: Number of Copies Printed, 572,262; Paid Circulation, 404,056; Free Distribution, 1,295; Number of Copies Distributed, 405,351; Copies Not Distributed, 166,911; Total, 572,262.