



Life in the Clear The secret to being (almost) invisible by Diane A. Kelly

The Real-Life Bat Man

How one person uses sound to see

by Cathryn Free

It's a . . . Bird

Runing the numbers on avian superpowers by Patricia and Elise Newman

Powers of the Mind An excerpt from

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WHATSI **TAMATOA**



HEIGHT 5'7" AGE 14 **BORN** Samoa ANNUAL CELEBRATION His rebirthdav **INTERESTS** Bioengineering, tinkering, meditation ONCE SAID "I have a secret compartment in my bionic leg full of Twizzlers."

JANUARY 2021 Volume 25, Issue 01

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🥻 CAANAN GRALL

Meet the **Characters**!

TIME TRAVELER CATE was born in 3001 as part of a mysterious experiment. Her adoptive parents founded a very special school, Mnemosyne, in an alternate dimension. Fearless and adventurous, Cate treats friends like family.

CATE PORTER-PINE



DOCUMENTARY ENTHUSIAST AARTI invented a color ray

to earn admission to Mnemosyne. She's smart, creative, and loyal, and an interdimensional incident granted her the power to visit every version of herself in the multiverse.

AARTI OKONKWO

THOUGHTFUL MAKER WHATSI emerged from a tragic childhood accident as a cuttingedge cyborg. His mom showers him with love, and sometimes fresh bio-tech. A great listener, Whatsi is fond of comics and meditation.

WHATSI TAMATOA

HAPPY-GO-LUCKY O invented a humananimal communication device. He can pull totally reasonable people into shenanigans, even childhood pal Aarti. O sometimes wonders if he'll ever find his own extraordinary powers.

0 түсно





time on behalf of evil company PiCO, Sophia's worldview has changed. Could this frenemy become a true friend?

> SOPHIA Q-LUNA

JUST KIDDING!

LETTER of the MONTH

Not Raised in a Barn

Howdy y'all! I'm a cowgirl from Texas that rides my

horse every day to school. You can find me lassoing my cattle, and spending time with my best buds in the barn: my horses and chickens. Just kidding! I am a regular girl that lives in the posh and developed city of Plano, in Dallas, Texas. I ride my CAR every day to school, and you can find me on my COM-PUTER web designing. You can find me VIDEO CALLING my best friends on my phone. On that note, I also do not like spending time with animals. I actually don't like animals at all, I'm just going to end right there. Anyways, I was wondering how stereotypes develop in the human brain. By the way, I LOVE *Muse*. I know this sounds so basic, but I am helpless. If you publish this, I would be so so happy, and I will send my Gramma's apple pies from the barn! Just kidding!!! But I will send lemon pound cakes from the coffee shop nearby to all the editors, you will love them. --COWGIRL KUSH K. / age 12 / Texas

Science Fiction Science Facts

I'm a normal kid, not some weird god of an HBP planet. I have been getting *Muse* for years! I miss Kokopelli, but the new Muses are pretty good. Whatsi is my favorite—I think it would be AWESOME to have bionic limbs!

I LOVE Star Wars! I know all sorts of random facts about it. The sound of TIE fighters is a combination of elephant sounds and tires on a wet road. The Executor Super Star Destroyer is nearly 12 miles (20 km) long! Could you do a science-fiction themed article? I love reading and watching science fiction. If you send this into the fan mail pit, I won't send armies of rainbow crocodiles to swarm *Muse* HQ, but I might be sad . . . (and send this letter a few more times).

-OWEN M. / age 14 / Virginia



And the Award Goes to ...

I am the president at the **SOCR (Society of Creative** Records)! We would like to present a reward to Muse magazine! We have come to see on our record charts that your fun-loving, creative, and silly magazine has spiked among children between the ages of 5-15 all around the world! I love your magazine as well, so thank you for your creative and fun ideas! Your HPBs also bring a beautiful ray of light to the terrific magazine! Now, for the special awards!

Whatsi, you have won the BEST ENLIGHTENING CYBORG AWARD!

O, you have won the SILLIEST SCIENTIST AWARD!

Cate, you have won the SMARTEST TIME TRAVELER AWARD!

Aarti, you have won the MOST CURIOUS SCIENTIST AWARD!

And Ms. Acorn has a special one indeed! Ms. Acorn, you have won the BEST MUSER AWARD!

—LEXI, PRESIDENT OF SOCR

Gosh, an award from the illustrious SOCR! I can hardly believe it—I'm blushing yellow. I'd like to present you with the FANTASTIC MUSER award in return! —MS. ACORN



HPB IDK

I am Matilda, queen of cats. I have been reading *Muse* for about a year now. It is my favorite magazine! I love science and I am a complete and absolute nerd. I also love *Stranger Things*, Harry Potter, the environment, and baking. Can you do an article on the periodic table? Like, how to memorize it? Now, I have heard a lot about HPBs, but I would like to know more. Where did they originate from? What is their scientific name? Are they born pink, or do they acquire the color? If you throw this in the FMP, I will send a hoard of angry telekinetic cats to smother you in adorableness. But, if this does get published, all responsible will be rewarded with small fluffy kittens.

-MATILDA K. / age 13 / The Land of Cats and All Things Adorable

P.S. O, if you could have any superpower, what would it be? I would want to be able to draw something and make it come to life. (Like Sketch/The Sentinel in the book *Renegades*.)

-0

If I could have a superpower . . . hmmm, I think I'd like being super stretchy! I could grab a snack from across the room and always be in bed when I turn off the light.

P.S. I think you were probably kidding about the small fluffy kittens, but if not . . . could you make mine calico?



Great Muser Bake-Off I got your magazines for a

Christmas present in 2019. So far I only have a few, but I know I love them. Thank you for making them! I know I will really enjoy seeing them in the mail a bunch more times this year. By the way, my favorite part is Muse News (so far I have been getting the false story right)! Anyway, I would also like to strongly request that you do an issue on cooking or baking. I have been baking ever since I was 3 or 4 years old! It has to be my all-time favorite hobby! I can make most things that have a recipe and have them taste great. They usually look great too. I have made so many desserts for my family and me. My dad loves my chocolate chip cookies that I make. Maybe even more than my mom's. My mom is also a great cook and the one who taught me how to bake. When I was really little, she and I would bake together. But now I bake all on my own, and I have been for a long time I think that if you did an issue on baking, it would inspire kids to bake too.

-BRENNAN C. / age 12 / Wisconsin



art by Kelp

Puget Sound Off

I have been getting your magazine since 2014, and I simply must heap praise upon this publication! (I love it.) Every day when a *Muse* magazine comes in the mail is sure to bring an intriguing collection of articles where I can read about a million amazing things. I am not the ruler of any far-away realm, but I especially enjoy reading articles about ocean exploration, since I am a practicing marine biologist and love everything about the ocean. I live in a submerged research facility called The Sea Top, which is currently anchored in the Puget Sound studying resident orcas (and everything else I can). I have enclosed an image of The Sea Top because it is so splendid words are inadequate to describe it. I do not have an army of hot pink punnies to set on *Muse* headquarters if my letter is not published, but we are working on developing an army of peacock mantis shrimp and zoanthids (a kind of toxic coral). In the meantime, since I lack the resources to threaten retribution. I would like to bribe you by extending an invitation for a student at Mnemosyne to board The Sea Top with me on a three-week research expedition in the Atlantic Ocean. If you throw this letter in the Fan Mail Pit it will break my heart, because I poured out my heart and soul into it. May wind always fill your sails, and may you always smell the smell of fish when you sleep. -KELP / age 14 / Puget Sound

What a cool design. I'm glad to see you included a library—that's the best part of any building! Mind if I drop in sometime? —WHATSI







Robots Forever

I'm sure you've heard this a kagillion times, but I love your magazine (and I mean it). I don't know exactly what or where the fan mail pit is, but it doesn't sound like a good place for fans or mail. O is my favorite and you can't say otherwise! I love robotics, and your February 2019 ("What's Your Bright Idea") was my most favorite of all; I wish you would do more articles on the subject. I was very pleased to see so many Star Wars-related letters in your September 2019 edition. Well, maybe two isn't a lot, but it's more than normal. I hate to threaten you, but I must let you know that as the creator of all malicious robots, it is my duty to inform you that I will destroy Muse HQ if this goes in the infamous FMP. May the Force be with you! -MICAH K. / age 13 / Washington

Politeness Please

I really hope you publish my letter but if not it's totally fine. I am here to spread the message about how threats are bad. Whenever I read a *Muse* magazine (my favorite magazine of course). I notice an insane amount of threats in these letters about not getting published! It's kinda scary! I hope you publish this so people can hear this message! OK, now I will tell you about the spreader of this message: me, Emme (which is short for Emeline). I live with my mom, dad, beloved cat, and a terrible horrible monster I call my sister. My favorite colors are pink, purple, and black. I play volleyball and I do gymnastics and swim (which I hate to do). And my favorite person from *Muse* is either Cate or O. Enough about me, goodbye! -EMME K.

P.S. You should do a magazine about fashion and clothing design.

P.P.S. I am getting another cat and I need to think of a name for it, do you have any suggestions?

Something to say?

Sena letters to Muse Mail, 70 E. Lake St., Suite 800, Chicago, IL 60601, or email them to muse@cricketmedia.com.

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cext © 2020 by Elizabeth Preston

They can keep the records. I'd rather have zero stomachaches!

>>DON'T TRY THIS AT HOME

Hot Dogs in a Hurry

VERY YEAR IN NEW YORK CITY, PEOPLE ENTER A CONTEST TO SEE HOW MANY HOT DOGS THEY CAN EAT IN 10 MINUTES.

Competitors gulp down each dog and bun in just a few bites. The 2020 winner scarfed 75 hot dogs. Now a scientist says he has calculated the highest this number can go.

The scientist studied data from 39 years of the same

contest. Over time, the winners have eaten more and more hot dogs. But there must be a limit to how quickly people can eat—right?

The researcher used math to predict records over time. He found that the limit should be 8.3 hot dogs per minute. That works out to 83 hot dogs in a 10-minute contest. This maximum eating speed is similar to a grizzly bear's, but slower than a wolf's.

>>TECH DESK

A Bug's-Eye View

IT'S HARD TO CONVINCE A BUG TO CARRY A VIDEO CAMERA. But a new, extra-tiny

piece of technology could let researchers see what an insect sees.

Scientists built a battery-powered camera that's so small and light, it fits on a beetle's back. An arm on the camera pivots to see all around. Using a smartphone, a researcher can remotely control the camera to get a bug's-eye view.

>>SPIDEY SENSE

Quite a Bite

IN THE SPIDER-MAN COMIC BOOKS, PETER PARKER DEVELOPS SUPERHUMAN POWERS AFTER HE'S BITTEN BY A RADIOACTIVE SPIDER. A

teenager in India named Saanvi has a story that's almost as good. Last year, a spider bit her outside her house. She had a bad allergic reaction, with swelling in her face and throat. After a trip to the hospital, she recovered—but not everything went back to normal.

Saanvi's tongue stayed partially swollen after her allergic reaction. And this gave her a new, super-strong sense of taste. Delicious foods taste better than ever, and so-so foods taste disgusting. She can taste a dish once and name every ingredient.

As far as scientists know, the teen is now the world's best taster. The bug that bit her, though, was just an ordinary spider. Afterward, her mom squashed it. (Just your friendly) neighborhood (spider!//

> >> One of these stories is FALSE. Can you spot which one? The answer is on page 46.



>> ANIMAL BEHAVIOR

Pup Power

YOU ALREADY KNOW YOUR DOG HAS A GREAT NOSE. Dogs are expert sniffers that can follow another animal's trail in the grass or track down something stinky to roll in. They may have another special power: the ability to sense Earth's magnetic field.

The magnetic field is what makes a compass needle point north. Many animals, such as pigeons and sea turtles, use a magnetic sense to travel long distances without a map. Now researchers think dogs may have this skill too.

Scientists put GPS collars on 27 dogs and had their owners walk them in the woods. The animals were all hunting dogs. They walked without a leash and often wandered off to explore the forest on their own before returning to their owners.

The researchers analyzed hundreds of walks. They saw that some dogs made a short run in a north-south direction before finding their way back to their owners. The scientists think this helps dogs orient themselves, like a person using a compass to figure out which way to go. Dogs that did a north-south run took a more direct route afterward.

;;



>>UP IN SPACE

Planet Makes Waves

IN THE RED DIRT OF MARS, CAMERAS HAVE SPOTTED WIDE WAVES CALLED MEGARIPPLES.

The same kind of waves appear in some Earth deserts. The wind forms these megaripples. But scientists thought there wasn't enough wind on Mars to push these big waves around, leading them to conclude they must be left over from an earlier, windier time.

Mars!

Now researchers have discovered that the Martian megaripples are still moving—very, very slowly. They creep along at about 4 inches (10 cm) a year. That means the red planet is breezier than we believed.

>>ENTOMOLOGY

The WHAT Hornet?!

IN THE SPRING OF 2020, AN INVADER SHOWED UP IN NORTH AMERICA. It was just a bug—a really big one. The Asian giant hornet is the largest hornet in the world, as big as a person's thumb. Its nickname is the murder hornet.

Hornets are a kind of wasp, so they can sting. But don't worry, these bugs aren't out to kill people. Murder hornets attack and kill bees. Then they feed the bees to their babies. Since scientists in North America are trying to protect bees, finding some of the murderous insects on this continent makes them nervous. Researchers have tried to trap murder hornets before they spread any further. As of fall 2020, they had located two nests in Washington State.





by Stephen Ornes

E. PAUL ZEHR

BRAIN SCIENTIST, AUTHOR, SUPERHERO ENTHUSIAST

In the Marvel comics and movies, a sickly army recruit named Steve Rogers becomes Captain America after receiving an injection of "super soldier" serum and being irradiated with Vita-Rays. Such a transformation may not yet be possible in real life, but science and technology are quickly catching up, says E. Paul Zehr.

Zehr is a neuroscientist in Canada. He's also a martial arts master and a writer who explores the science of superheroes. In his most recent book, *Chasing Captain America*, Zehr explores the wild technologies that could make superpowers possible. He says that biology, tech, and engineering are converging to surpass the limits of human body. His previous books have focused on superheroes too. *Becoming Batman* outlines the athletic training a person would require if they wanted the abilities and muscles of the Caped Crusader. In *Inventing Iron Man*, he wrote about inventions needed to build a brain-controlled armored suit like Iron Man's.



We talked with Zehr about his origin story, the science of transformation, what we can learn from superheroes, and what comes next.

W PI JE

WHO INTRODUCED YOU TO COMIC BOOKS AND SUPERHEROES?

My mom. She was born in the 1930s, so she actually grew up during the golden age of comic books. She used to talk about the comics she would read as a kid. She'd read the comics and go to the movies and see the adventures of Batman or Superman. If you watch those old movies now, they're terrible. But in any case, she was into these things. She gave that love of comics to me. And that got me interested.

Neuroscience

is the study of

how the brain

and nervous system work.

DID COMIC BOOKS LEAD YOU TO SCIENCE?

Comic books took me to martial arts, because I was interested in martial arts in the comic books.



CHASING

WILL PRODUCE A SUPERHUMAN PAUL ZEHR PHD

FOREWORD BY SIMON WHITFIELD,

OLYMPIC GOLD MEDAL WINNER

Dr. E. Paul Zehr published Chasing Captain America in 2018. It explores the pros and cons of bioengineeringmodifying a living being by changing its genetic code.

DO YOU STILL PRACTICE MARTIAL ARTS? WHICH ONES?

I've stayed with Japanese and Okinawan karate since I was in my early teenage years. I did some Okinawan weapons systems, and I did Aikido briefly. And about a year and a half ago, I started doing Chinese martial arts as well.

SO DID MARTIAL ARTS LEAD YOU TO SCIENCE?

I get fascinated with learning stuff. Martial arts took me to kinesiology [the study of how the body moves]. From there, I wanted to know, what's controlling all that stuff in the body? It's the brain, and the spinal cord. And that got me into neuroscience.

AS A SCIENTIST, WHAT DO YOU STUDY?

I worked for many years on coming up with new and better therapies for improving walking, like after a stroke or an accident. I wanted to explore the ways that arm and leg movements interact when we walk.

My group did all kinds of studies to understand how the arms function—like arm cycling, or arm swinging—when you walk in a specific way. When you do stuff with your arms, it affects your spinal cord, and there are all these pathways in your body that connect the arms and legs and hands and feet. Once I started thinking about this, I realized I didn't know much about how our species started doing bipedal [two-legged] walking in the first place.

WHY DID YOU START WRITING ABOUT SCIENCE?

The main theme of my scientific research work has always been rehabilitation. I have always wanted to help people with the work I did. That's what got me into science in the first place. Writing books about science became a way to spread information and have an impact on society.

WHY SUPERHEROES?

If you're not a scientist, science can be pretty intimidating and scary. But ideas from popular culture can make science seem more accessible. Instead of talking about 'excitation contraction coupling' in your muscles when you do a squat, we can talk about Batman's muscles. And how a person can jump so high. I thought, maybe there's a way to use superheroes as a vehicle for, you know, transmitting information. But in a different way.

YOUR FIRST BOOK WAS ABOUT BATMAN. WHY START WITH HIM?

I always liked superheroes, and I always liked Batman. But my first book was almost a book about Daredevil, actually. Daredevil is a Marvel comics character, and he's blind. He does a lot of the same kind of thing as Batman. He protects the city and won't kill people. I was really leaning toward doing a book about the science of Daredevil until a friend pushed me a little further on it. He said, "the way to go is Batman. Batman is a more universally known character." Batman trained in martial arts too.

AND THERE ARE SO MANY MOVIES ABOUT HIM.

When I was writing it in 2005 and 2006, superheroes were nowhere near the mainstream popular culture phenomenon they are today. *Batman Begins* came out in 2005, so there was a glimmer, a hint, that maybe these things were going to hit a big audience.

WHY IRON MAN AND THEN CAPTAIN AMERICA?

There's a progression of ideas. Batman is about how training can change you, if you don't change your biology at all. Iron Man is about invention. About how to amplify your abilities using technology that interfaces with your body. And then Captain America breaks the



Dr. Zehr's 2014 book Project Superhero is for young readers! It combines facts, fiction, and fun illustrations. rules of biology. Let's do gene editing, and all these different things, if they can be used to help people.

WHAT ABOUT OTHER SUPERHEROES? WILL YOU WRITE A BOOK ABOUT WONDER WOMAN? OR SUPERMAN?

I really like Superman. Thor is my favorite superhero. Wonder Woman is great. But! They're all like gods or aliens. You can't really imagine, "I'm going to become Superman." But you can think about how to become Batman, or Iron Man, or Captain America. They all started off as humans. That was what I started out thinking about.

YOU SAID YOU WANTED TO HELP PEOPLE. WHAT MESSAGE DO YOU HOPE YOUR READERS TAKE AWAY FROM YOUR BOOKS?

What all of this comes down to is that everybody's got a bit of Batman inside. It sounds trite, but it means that there is a superhero within each of us. We all have the ability to do more than we're doing right now. It doesn't matter who we are or what we're doing. We have limits. We're often not even aware that they're there. But we can always exceed them. There's always a bit better that you can become. And that idea is grounded in the stories of superheroes.

Stephen Ornes lives and writes in Nashville, Tennessee, with his family. They have one cat, one dog, two rabbits, and six chickens, all of which have a bit of Batman inside.



HOW CAPTAIN AMERICA "BROKE THE RULES"

Inside almost every living cell is a material called DNA, or deoxyribonucleic acid. DNA looks like a very long spiral staircase, with two chains that coil around each other and are connected by "rungs" made of molecules called nucleic acids. DNA contains the blueprints that a cell uses to build proteins, which do the work of keeping a living thing alive. The section of DNA that tells a cell how to build a specific protein is called a gene. Scientists use the word "genome" to describe all of a person's DNA, including genes.

All living things—plants, animals, corn, cats, yeast, mosquitoes have genes. Genes determine many things about a person, including hair color and eye color. They determine the color of a cat's fur, or the number of kernels on an ear of corn. They can also influence whether or not the organism develops a certain disease.

Scientists can change genes using "gene editing," which is also called "genome editing." The idea is to use molecular tools to change an organism's DNA. In the case of Captain America, a fictional type of

gene editing was used to transform Steve Rogers, a short and sickly recruit, into a tall and musclebound super soldier. A real-life gene editing tool called CRISPR, for example, can snip DNA at specific places. That lets scientists remove or insert genes. CRISPR has already been used in surprising ways, like to



make a squid transparent. But researchers hope that CRISPR and other gene editing tools will improve the lives of people with genetic problems.

THE REAL-LIFE TECHNOLOGIES THAT HELPED INSPIRE COMIC BOOK HEROES



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ne rocketed to Earth from a distant planet*. Another encountered a radioactive arachnid**. Every superhero has an origin story. Yet the true account of how these heroes came to be is

9

BOOM

230

even more amazing. Because these fictional characters were inspired, in part, by real science. Remarkable new technologies and discoveries touched their creators' own lives. By combining the science and innovation that fascinated them with artistry and imagination, comic book writers and artists developed the world's most iconic superheroes.

Let's discover some of the real-life tech that inspired the comic book heroes we all know today.

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* Superman <u>** Spider</u>-Man

SUPERHERO: SUPERMAN

REAL-LIFE TECHNOLOGIES

- » Bulletproof Vests
- Rockets & Space Travel
- » X-rays

fter 17-year-old Jerry Siegel's father died as an innocent bystander during an armed robbery in 1932, the heartbroken teen imagined a hero who could deflect bullets. The power mimicked the experimental bulletproof vests described in newspapers and science magazines of the time.

Siegel's fictional hero would come to Earth from a far-off planet. Rockets were brand new ideas back then, and a real, distant planet, Pluto (now demoted to dwarf planet status), had been discovered using powerful telescopes in 1930. Young Siegel gave his hero x-ray vision—possibly inspired by dental x-rays. (Jerry's older brother was a dentist.) His hero would also be fast and strong—like the powerful trains and airplanes engineers were building.

Working with his high school classmate Joe Schuster, who could turn these ideas into magnificent drawings, Siegel transformed science and imagination into Superman.



STRANGE VISITORS FROM ANOTHER PLANET

Described in the comics as pieces of Krypton (Superman's home planet) that came to Earth after that world exploded, kryptonite can rob the Man of Steel of strength. Though of course fictional, kryptonite is based on the real science of meteorites. These do fall to Earth from the far reaches of space. By studying these real "visitors from other worlds," scientists hope to unlock some of the secrets of the universe—from how our solar system began to whether life exists on other worlds.



SPEEDING BULLET? NO SWEAT

Modern bulletproof vests are composed of multiple layers of super-tough materials. These materials work together, spreading out and absorbing the energy of the bullet so it can't penetrate the vest. Since solid metal would be too heavy and cumbersome, vests are woven from strong but lightweight fibers. They include Kevlar (a strong, synthetic

fabric) and polyethylene plastic (similar to plastic soda bottles). Some vests even include ceramic plates designed to shatter a bullet into pieces, to lessen its impact.



A REAL CLARK KENT?

Real-life Pluto discoverer Clyde Tombaugh was young, mild-mannered, and raised on a farm. Plus he wore glasses!



SUPERHERO: WONDER WOMAN

REAL-LIFE TECHNOLOGIES » Lie Detector Tests » Exotic Metal Alloys

- » Stealth Technology
- Steatth recimotogy

n the comics, Wonder Woman can use her magic lasso to compel people (usually villains) to come clean. But the truth is that this superhero is the brainchild of the inventor of the lie detector test!

Harvard-trained psychologist William M. Marsten (1893–1947) noticed that a person's blood pressure changes slightly when they lie. So he built a machine that could measure this vital sign as someone answers questions.

Marsten's work made him so famous that all kinds of companies sought his advice. One comic book publisher asked him to improve their stories. Seeing that all the other superheroes were male, Marsten proposed a female superhero. One who could do in fiction what his invention could do in fact.

Wonder Woman also has the power to deflect bullets using special bracelets. These are described in the comics as being made from amazonium. Though fictional, this super-strong material was probably inspired by the real metals used to build aircraft.

However, the airplane Wonder Woman flies in the comics isn't metal at all. It's transparent! Believe it or not, this "impossible" idea is related to real science too.

TO TELL THE TRUTH

Modern lie detectors, or polygraphs, still check blood pressure, along with breathing and perspiration, to



search for truth. Today,
polygraphs are used in many different kinds of screening, such as questioning someone who applies for a job at a government agency. But they're considered

unreliable—and sometimes unfair—so are not used in most courts.



AN INVISIBLE FLIGHT

Real airplanes can become invisible—to radar, that is using stealth technology. Radar detects objects by bouncing electromagnetic signals off them. (Imagine throwing a ball against a wall and waiting for it to come back.) Stealth technology confuses that bounce in two



ways. First, engineers may design the plane using materials that absorb most of the radar signal. Or, the surfaces of the plane may be built in just the right shape (very flat, with sharp edges) so radar signals bounce off in confusing directions.

SUPERSONIC SPEED

Wonder Woman's fictional airplane is also supersonic. It has a top speed of three times the speed of sound, also known as Mach 3. But today's real jets are faster! Lockheed's SR-71 Blackbird, a spy plane designed in the 1960s, flies at Mach 3.2!



SUPERHERO: BLACK PANTHER

REAL-LIFE TECHNOLOGIES » Nanotechnology » Magnetic Levitation

Modular Smartphones

n the comics, he is the African King T'Challa—and the powerful superhero Black Panther. Key to his many powers is a material called vibranium. It powers both Black Panther's high-tech suit and the advanced civilization, called Wakanda, that he and his scientist sister lead and protect.

Creators Jack Kirby and Stan Lee were probably inspired by real-life advances in materials science (such as fiberglass, then a new composite) when they imagined this fictional material in the 1960s. But they might not have imagined that a real-life material would one day rival their idea. That material is graphene.

In *Black Panther*, the secret of vibranium lies in its unique atom arrangement. The same is true for graphene. Its atoms are arranged in a single layer, shaped like a honeycomb. This structure makes graphene 200 times stronger than steel. Graphene also conducts electricity. Rolling a sheet of graphene makes a carbon nanotube (nano means very small).

Technologists are using graphene to design everything from self-cleaning clothing to wire-thin "elevators" that might one day reach outer space. Sounds like Black Panther's futuristic kingdom!

TINY BUT POWERFUL

Another "real-life vibranium" is found in yet another arrangement of carbon atoms known as buckyballs. In this material, the atoms are arranged like tiny, symmetrical soccer balls. Scientists think that buckyballs could one day become building blocks of super-small machines.



IT'S ALL IN THE WRIST

Recent *Black Panther* comics, by author Ta-Nehisi Coates and artist Brian Stelfreeze, show characters using high-tech hologram bracelets made of komoyo beads. Each bead has its own function. One might be a communication device, while another is a GPS device, and yet another holds personal medical records. Stelfreeze explained to *Popular Science* that these accessories were inspired by actual bead bracelets and a failed—but intriguing—effort to build a real modular cell phone.

NEXT STOP, WAKANDA!

A high-speed magnetic levitation subway connects Wakanda with secret caves where vibranium is mined. While clearly futuristic, real magnetic levitation—or maglev—trains already exist. Instead of wheels, maglevs use powerful magnets to lift the train off the tracks. Then additional magnets pull from the front of the train and push from behind. By nearly eliminating friction, maglevs can travel smoothly—while reaching top speeds of 375 mph (600 kph) or more.



by Nick D'Alto

INVENT YOUR OWN!

WHAT SCIENCE SUPERHERO WILL YOU CREATE?

NOW IT'S YOUR TURN. Pick a scientific discovery or a new technology that fascinates you. Learn about it, and then create your own comic book hero inspired by science and tech.

Will you pick quantum computing? (If so, your hero could move at light speed!) Or maybe cloning? (She and her exact copy could appear in two places at once!)

Just combine science and imagination—your superpower.

	Planning Space I am inspired by
	because
	This inspiration helps explain my superhero's powers, which include:
•	*
	*
	My superhero wears
•	and is rarely seen without
•	A fun fact about my superhero is:
•	



THE SECRET TO BEING (ALMOST) INVISIBLE

in the

by Diane A. Kelly

n the open ocean, there's nowhere to hide. There are no rocks to slip under, no kelp to duck behind nothing but clear water all around. "Every direction you look looks pretty much the same—it's this ridiculous unearthly blue," says Sönke Johnsen, a marine biologist and professor at Duke University. If you went swimming out here in the clear blue, you'd stick out like a billboard. Everything with eyes could see you coming. Being visible isn't safe for creatures that live here; it's too easy to be spotted by both potential prey and potential predators. So many of them have adopted a remarkable form of camouflage: they're transparent.

I See Right Through You

Transparent animals let light pass through their bodies the same way it passes through a window. An amazing variety of open-ocean animals can do this: bowl-shaped jellyfish, comb jellies as long as a person, small shrimp-like arthropods, big-eyed squid, tiny larval fish, and snails that look like Christmas ornaments.

These animals typically live between the surface of the ocean and a depth of about 3,300 feet (1,000 m) as far as most light can reach. Most of them are extremely delicate and can be damaged by a simple touch. Johnsen says these animals drift through life alone: "They never touch anything unless they're eating it, or unless something is eating them."

And they are as clear as glass. How does an animal become see-through? It's trickier than you might think.

The objects around you are visible because they interact with light. Light typically travels in a straight line. But some materials slow and scatter light, bouncing it away from its original path. Others absorb light, stopping it dead in its tracks. Both scattering and absorption make an object look different from the stuff around it, so you can see it easily.

But a transparent object doesn't interact with light, at least not very much. Light can pass through it without bending or stopping. That means a transparent object doesn't look very different from the surrounding air or water. You don't see it—you see the things behind it.

To become transparent, an animal needs to keep its body from absorbing or scattering light. According to Johnsen, avoiding absorption is actually easy. Living materials can't stop light unless they contain pigments, which are chemicals that absorb specific colors of light. Pigments make your blood red and plant leaves green, but if an animal doesn't have these molecules, its tissues won't absorb light. The real challenge is preventing light from scattering.

It's not easy. Animals are built of many different materials—skin, fat, muscle, and more—and light moves through each at a different speed. It's like each material puts its own speed limit on light, slowing it down by a different amount. Every time light moves into a material with a new speed limit, it bends. You can see this for yourself: angle a pencil into a glass half full of water and look at it through the glass. Where the air and water meet, the pencil looks broken. That's because light bouncing off the part of the pencil in the air travels to your eyes at a constant speed, but

light from the underwater part of the pencil changes speed and bends as it enters the air.

When light travels among a lot of different materials as it moves through an animal—say, from water to fat to muscle and back to fat again—it bends and scatters in many different directions. All that bending means light can't pass straight through the animal. So the animal looks solid and opaque. It's why albino animals aren't invisible: they may lack pigment, but they still scatter light.

Different Tricks

Transparent animals use different tricks to fight scattering. Some animals are simply very small or extremely flat. Without much tissue to scatter light, it's easier to be see-through. Others build a large, clear mass of non-living, Jell-O-like material and spread themselves over it. Transparent jellyfish are one example, says Johnsen. "A jellyfish looks like a really big animal, but it's actually a really small animal wrapped around a really big blob. It



essentially paints its body around this big hunk of clear stuff. The living part of the animal is pretty thin."

Larger transparent animals have the biggest challenge, because they have to make all the different tissues in their bodies slow down light exactly as much as water does. Johnsen's lab is trying to understand this feat. "They need to look uniform. But how they're doing it is a little bit of a mystery," he says. One thing is clear: for these larger animals, staying transparent is an active process. When they die, they turn an opaque milky white.

Some Things You Just Can't Hide

Eyes and stomachs are hard to hide. Eyes put dark spots in even the most transparent animal because they hold light-absorbing pigments that let the



creature see. Stomach walls can be nearly invisible, but animals need to eat, and the half-digested remains of other animals are very good at scattering light.

To keep predators from spotting their eyes or their last meal, transparent animals use disguises. Eyes might be placed on stalks far away from the rest of the body or stretched out into huge pale orbs. A stomach may be covered with a mirrored layer to reflect the ocean around the animal, or a take weird, needle-like shape that is difficult to see edge-on.

But some aquatic predators have found a way around these tricks. According to Nadav Shashar, a scientist at Ben-Gurion University



Light underwater is polarized, meaning waves of light line up.





About 60 species are known collectively as glass squid. Clearly, they're well named.



in Israel, some crustaceans, squid, and fish can spot transparent prey by detecting changes in what's called polarized light.

Underwater light is polarized: the waves of light are lined up and synchronized with one another. (Human eyes can't detect this.) Even though the tissues inside a transparent animal don't scatter light, some of them still change its polarization. When that happens, predators that can detect polarization see a brilliant light show. It stands out from the ocean background. "If

PART-TIME INVISIBILITY

Different kinds of camouflage work better at different depths. Transparency rules near the surface, where predators hunt using sunlight, and a simple shadow can give you away. But transparent tissues may not help you deeper down in the ocean. Here, predators use bioluminescent searchlights; clear tissue reflects that light and stands out against the darker water. So prey animals down in the deep are often red or black. Those colors make them harder to see because they don't reflect a predator's blue bioluminescent light.

What if you have to hide from both sunlight-searching and bioluminescent-spotting predators? In 2010, Sarah Zylinski, now a biologist at Bangor University in Wales, discovered two deep-sea cephalopods that switch between both strategies.

Ordinarily, the tiny Japetella heathi octopus and the hand-sized clubhook squid are transparent. But like all cephalopods, they have specialized cells in their skin that let them change color. And they're not afraid to use them. When a blue





light shines on them, they instantly turn red, throwing on what is—to the bioluminescent predator—an invisibility cloak.



you see a transparent animal against this background of polarized light, it's suddenly glowing with lots of different colors," explains Shashar.

That animal may look like a clear crystal chandelier to us, but

no matter how well it hides, it's never truly invisible.

Diane A. Kelly is a blogger and a biologist at the University of Massachusetts. She regrets to report that almost all of her tissues are opaque.



WONDERFUL WINGS A MOTH'S COSTUME LETS IT HIDE IN PLAIN SIGHT.

Moths and butterflies are part of the order Lepidoptera, meaning "scaly wings." The pigments of these overlapping scales can make the difference between life and death.

Color patterns in some moths and their larvae (caterpillars) produce what's known as the "startle response" in their predators. The most common pattern is false eyes, which caterpillars usually display on their tails and adult moths display on their wings. The **atlas moth** (*Attacus atlas*), with a wingspan of about a foot, has a forewing with a hooked tip and eyespot. When closed, its wings look like a snake. The **spicebush swallowtail caterpillar** (*Papilio troilus* L.) has a striking false eye on its rear thorax. Note the black "pupil."

Suppose a bird is scratching around for something tasty. Suddenly, the bird sees—often out of one eye, and thus with poor depth perception—another eye "looking" back from an unknown distance. Is it harmless (in which case the bird has dinner) or harmful (in which case the bird *is* dinner)? The startled bird is hard-wired to flee. And the well-costumed caterpillar or moth is safe—for the moment.







the 1,200–1,500 members of this family have "cryptic" coloration that lets them hide in plain sight. **Luna moths** (*Actias luna*) look like pale-green leaves. Yellowand brown-flecked **imperial moths** (*Eacles imperialis*) blend into their wood-and-fungus environment. A moth not seen is a moth not eaten.





Science@Work

by Rebecca Hirsch

TE JONES BAT RESEARCHER

When you see bats flying around at night, they seem silent. But "even though we can't hear them, bats are actually very loud in their calls," says Te Jones. They are screaming sounds that are too high-pitched for your ears.

Jones is a graduate student in Psychological & Brain Sciences at Johns Hopkins University in Maryland. She studies how bats "see" in the dark using echolocation. As a bat flies, it emits a beam of sound from its mouth or nose, then listens for the echoes bouncing off objects. Jones says a bat can aim the beam in different directions. If an insect flies through the beam, a bat can tell the insect's size and location, along with how fast it is flying and in what direction. As part of Cynthia Moss's research group at Johns Hopkins, she works with other scientists and students to study how bats use their echolocation superpower. Their experiments take place in a special room called-what else?-the Batlab.

CAN YOU DESCRIBE THE BATLAB?

It's basically a collection of rooms that are covered floor-to-ceiling with foam that dampens sounds, so that bats aren't getting these really strong echoes from, say, a concrete floor or really hard wall. And then there are some microphones spread out around the room. They are all fixed to the wall, and they cover the entire four walls. No matter where the bat happens to be pointing its head, we always have a microphone that can be picking up the call.

We also have high-speed, infrared cameras that allow us to record their flight. We generally have the lights out, so the cameras can [detect heat energy], but we can't see very well.

ARE THERE OBSTACLES IN THE ROOM THAT THE BAT HAS TO FLY AROUND?

It depends on the experiment. Someone might hang up some obstacles for the bats to navigate around. Someone else might set up a platform and train the bat to fly from one side of the room to the platform for a food reward. Our bats really like mealworms. Sometimes



that sound beam help the animal 'see" in the dark.



we'll tie the mealworm to the end of a fishing line. The bats will come through and just take the mealworm.





Infrared cameras measure heat energy. Then they convert heat signatures into visual images.











YOU STUDY HOW BATS ECHOLOCATE IN NOISY CONDITIONS. WHAT SORT OF NOISE DO BATS HAVE TO DEAL WITH?

In the wild, bats tend to be flying around together. They might be making echolocation calls. They might be making social calls to interact with one another and also have the echoes returning back. So that's just a lot of sound that's happening all on its own. Then they might be in a forest as they're calling and they're echolocating. They might be looking for insects, but they're also getting a lot of echoes back from trees and bushes. So that's just a lot of sound that's happening.

HOW DOES THIS COMPARE TO THE TYPES OF NOISE THAT PEOPLE MIGHT EXPERIENCE?

The common comparison is a party. You're standing in a group of people, and everyone is chatting. You're trying to talk to one specific person. You're trying to focus on what they're saying and also what you yourself are saying. What tends to happen is you speak with a higher volume and you enunciate more. You might repeat yourself to make sure someone has heard you. This is an effect that we see in bats as well.

HOW DO YOU TEST A BAT'S ABILITY TO DEAL WITH BACKGROUND NOISE?

I have bats attempt to catch a food item off of a tether. Then I will play back some sound that might interfere with their ability to do that. It might be the sounds of another bat. And then I watch to see if they exhibit some echolocation changes that might help them adapt.



WHERE DO YOU GET THE BATS YOU STUDY?

We can't just buy them from a science supplier. We obtain bats from colleagues who have breeding colonies or collect them ourselves, typically from the attics of private homes. If we collect bats, we have to ask permission and get permits and we're only allowed to take so many at a time. That automatically limits how many experiments we can do at any given time. We have to focus on giving them their best care so that they might reproduce in the lab. A female might only have one or two babies a year if any, so it's a little challenging just to make sure we have enough animals for experiments.

WHAT IS IT LIKE TO CATCH BATS?

These bat catches are like fun field trips. People will call us when they get bats in their attics or barns. We might come in the daytime and just hand-pick the bats. Or we use nets in the evening to catch bats as they start to fly out for feeding.

WHAT ADVICE DO YOU HAVE FOR SOMEONE WHO WANTS TO DO WHAT YOU DO?

If you're passionate about something, find ways to get involved. Volunteering with local organizations that spread awareness is a good way to get started. Only the smaller species depend on echolocation to get around. Larger bats also use their sharp eyesight.













WHAT DO YOU THINK PEOPLE SHOULD KNOW ABOUT BATS?

Did You Know?

You shouldn't be afraid of them if you see them flying around at night. If you happen to find one on the ground, the important thing is to just let it be and not interact with it.

A lot of the fear surrounding bats tends to come from this idea that they all have rabies, they're all going to attack you, they're going to get you sick. This is just not true. They mostly want to avoid you, and they're really good for the environment. We should try really hard to keep them around.

Rebecca E. Hirsch loves seeing bats flying around at night but is glad she can't hear them, considering how loud they are. Her forthcoming book, *Secret Senses*, explores the superpowers of animal senses.

Do the Math

FANCY FOLDING

Origami math

The amazing thing about origami is the enormous number of different objects you can make by folding a square sheet of paper. No glue or scissors allowed! You can make airplanes, flowers, butterflies, and noisemakers, or flapping birds, fierce devils, and snappy lobsters.

Tom Hull, a mathematician at Western New England University in Springfield, Massachusetts, has been making origami models since he was eight years old. He got started when his uncle gave him a book about origami. When he got to college, Hull found a way to combine his interest in origami with a career in mathematics. He even wrote a book for beginners, called *Origami, Plain and Simple*, while he was a student.

Hull has invented new types of origami designs based on mathematics. Some of these designs are flat. They look like tiles—the sorts of repeating patterns that you might see in fancy bathrooms, for example. Others are made from identical simple units, each one folded from a square sheet of paper, that interlock to form threedimensional structures that look like sticky burrs or crazy crystals.

Physicist Robert J. Lang likes to work out rules that, when given to a computer, show what creases to make to end up with a desired origami figure. He is famous for highly complex designs, such as his paper lobster, which comes fully equipped with legs, pincers, feelers, and tail.

There's a lot of math in origami, from the patterns the creases make to the sets of precise instructions people follow to create certain objects. Hull uses origami to help explain angles and other geometric concepts to students. He also finds origami relaxing after a hard day in the classroom.

Ivars Peterson likes looking for math in surprising places. He has learned some basic origami folds and is ready to take on something really challenging—perhaps a fierce butterfly.





by Cathryn Free

sing a wall for balance, Daniel Kish steadied himself on his new bike. He peddled ahead, wobbling a little. Soon the 6-year-old was pushing away from the wall and picking up speed, riding

all on his own. This story isn't a big deal until you learn one important detail: Kish was blind.

Kish, who is now an adult, lost his eyes to retinal cancer as a baby. But he doesn't let the lack of sight slow him down at all. He uses something he calls "flash sonar" to help him navigate the world. He makes clicks with his tongue and listens to how the sound bounces off the things around him. His brain uses this information to create an image of the world around him. This technique is similar to what dolphins and bats do to locate and navigate their surroundings: they cry or chirp and listen for the echo. Kish is a real-life bat man.

LIGHT AND SOUND

Kish relies on sound and echoes instead of light to perceive his surroundings. This process is called echolocation.

Light energy travels in waves that go up and down, like waves on the ocean. These waves hit objects, whether a shirt, a mirror, or your face, and much of that light is reflected off. When you look at an object, what you see is the reflection of light from that object. Your brain translates that reflection into an image. This is how sighted people perceive and make sense of the world. Without light and the reflections of light, eyes can't see anything.

Sound energy also travels in waves. However, this wave needs something to move through. Sound is a vibration, and when that vibration travels, it moves particles in air (or water) in a cluster and release pattern. For example, imagine that you and a friend are each holding one end of a slinky. You push your end of the slinky forward, and the coils converge together before releasing. That pulse travels down the length of the slinky.

POWER TO SEE

In sighted people and animals, the eyes perceive light and then the visual part of the brain interprets that light to create an image of the world. When it's dark out or we lose our sight, typically we see nothing; there's no visual information for the visual brain area to interpret.

When doctors and scientists studied how blind people perceive the world, they discovered something unexpected. The brain of someone who is blind can use its visual area to interpret information from other senses, like the ears or skin. As someone like Kish clicks. "that visual brain does light up even though it's never received a visual input," explains Gordon Dutton, an emeritus professor of visual science at Glasgow Caledonian University. People who use echolocation create a mental picture from sound. It's a way

Sound moves through the air in the same way. Like light, it can also bounce off of the things it bumps into.

For echolocation to work, you need a sound, a surface to reflect the sound, and someone to observe the reflection. Have you ever shouted from the edge of a canyon or cliff? Your shout vibrates air particles, which travel across the canyon. Those sound vibrations bounce off the canyon wall and reflect back to you. Your ears pick up the message and then send it to your brain. Echoes, loud or soft, occur around us all the time, even if we don't notice them. Kish takes advantage of everyday echoes, but instead of yelling over a canyon, he clicks his tongue and registers the echo traveling back to him—a sound that most of us wouldn't even notice.

Echolocation Expert

Control Participant



Researchers examined images of volunteers' brains to learn more about brain activity related to echoes. An echolocation expert's brain lit up in areas associated with vision. A non-expert, or control, participant's brain did not light up in the same way.



of "seeing the world in the mind's eye," says Dutton.

Kish's tongue clicks are as sharp and precise as a finger snap. These clicks are bursts of sound energy, like the flash of a camera. The sound waves of the click bounce off nearby objects and return to him at different intervals, intensities, volumes, timbres-or sound qualities-and pitches. His brain uses these different qualities of each echo to determine things like distance, size, shape, depth, and even material of objects and surfaces. Then his brain translates the message into an image. What does that image look like? "It's a bit like 3D geometry," says Kish. "It's not the sharpness of vision, and there's no color, but lots of things are still recognizable."

Echolocation does have its limits. "Objects close together tend to blend, and you can't detect drops or holes or small objects," Kish says. And without constant, daily practice, you can lose the skill. But on the flip side, echolocation can detect things behind you, and you don't need light for it to work.

NAVIGATING CHALLENGES

Kish doesn't find anything remarkable about what he does. "I use my brain to navigate a challenge," says Kish. "[There is] an immense capacity within us all to navigate any type of challenge through any form of darkness." We all face obstacles that we have to use our brains and abilities to overcome.

Of course, navigating the world with a disability can be hard, but often the challenge comes in the form of mistaken attitudes held by the individual, caregivers, or society at large. Many people think of blind individuals, and especially blind children, as limited or helpless. Communities often isolate people who are blind and exclude them from everyday activities and relationships. This is unjust and unfair, Kish says. "The impressions about blindness are far more threatening for blind people than the blindness itself." Fear is often the driving force

"I JUST WANT TO HELP PEOPLE BECOME THEIR BEST SELVES," says Kish.

behind these misconceptions.

Blindness is nothing to pity or be afraid of. In fact, impressions and stereotypes that people without sight are incapable or have a miserable life are not only damaging, but they're also untrue. Kish enjoys hiking, climbing, and mountain biking. "Echolocation removes the anxiety from movement," he says. Others without sight enjoy sports such as soccer or skateboarding without fear.

ANOTHER KIND OF HERO

Kish is on a mission to teach and help people by empowering them to discover and claim their own freedom. "I just want to help people become their best selves," says Kish.

Is Daniel Kish a real superhero? Not according to him. But his full life and advocacy for those with sight disabilities might be even more marvelous than his use of echolocation.

Cathryn Free is a writer, teacher, and proud nerd. The science of sound and light have always fascinated her, and she finds it inspiring what the human brain can do. She hopes she can be as cool as Daniel Kish one day.



TO SUPERHERO OR NOT TO SUPERHERO?

How does Daniel Kish feel about being linked with fictional superheroes like Daredevil—blind, fearless, passionate about helping others—or Batman? Many news stories (ahem, including this one) have celebrated Kish's skills as a "bat man." Kish raises some concerns about being compared to the Caped Crusader. He asks, "Who wants to live up to that level of superherodom?"

Nevertheless, Kish says Batman is his favorite superhero. And he does perceive a few important ways they are similar. First, Batman works hard to achieve his goals. "His heroic abilities come from his painstakingly developing his own capacities.... He made himself who and what he is, which I think is something we can all do." Second, like Kish, Batman is committed to fairness and social justice.

Now we know who Bruce Wayne could turn to as a real-world role model.

lazing speed. Lethal kicks. Hunting in total darkness. Superpowers aren't just for comic books. Birds are nature's superheroes. Take a look at these amazing animals.

OSTRICHES

The ostrich rules the African savanna. It's the world's largest bird: taller than a basketball player, as heavy as a football player, and with eyes larger than golf balls. One mighty karate-style kick can kill a lion. The ostrich can't fly, but it runs at 43 miles per hour (69 kph) with strides 10 to 16 feet (3 to 5 m) long.

HUMMINGBIRD STATS

Diet: » Flower nectar, small insects

Wingflaps: » 50 to 200 per second

Color vision: » Excellent!

OSTRICH STATS

Height: » 7 to 9 feet (2.1 to 2.7 m)

Weight: » 220 to 350 pounds (100 to 160 kg)

Eye size: » 2 inches (5 cm) across

ARCTIC TERNS A contract tern flies 44,000 miles (70,800 km) each year from Greenland to Antarctica and back the arctic tern flies 44,000 miles (70,800 km) each year from Greenland to the wind. The average again. The robin-size bird saves energy by zigzagging to avoid flying into the wind. The average tern lives for about 20 years, and a few may reach 30 years old. So it could travel 1.5 million miles or more in a lifetime (the equivalent of three round trips to the moon! by Patricia Newman and Elise Newman

HUMMINGBIRDS

A hummingbird can hover, change direction, and fly backward. Only insects can match these flying skills. A hummingbird's wings trace the shape of an "8." This keeps it in the air as it sips nectar and flits from flower to flower. The wings of the bee hummingbird, found just in Cuba, beat 80 times per second. The world's smallest bird, it's a blur when it flies by.

TURKEY VULTURES

A turkey vulture can help stop a gas explosion with its sense of smell! This super-smeller can find dead animals that are 3 to 5 miles (5 to 8 km) away. Gas companies take advantage of this ability: They add "dead animal smell" to odorless gas. If there is a leak, the gas company will spot a turkey vulture circling overhead, looking for the tasty carcass below.

TURKEY VULTURE STATS

Diet: » Carrion (dead animals)

Wingspan: » 6 feet (1.8 m) on average

Self-defense strategy: » Vomiting on attackers

ARTIC TERN STATS

Lifespan in wild: » 20 years on average

Wingspan: » 25 to 30 inches (64 to 76 cm)

Weight: » 3 to 5 ounces (85 to 142 g)



Faster than a cheetah. Faster than a skydiver in free-fall. The peregrine falcon dives at more than 240 miles per hour (386 kph). It sights an unsuspecting songbird thousands of feet below. Then it dives with its claws balled into fists to stun or kill with one punch. Songbirds, beware! If you hear a peregrine falcon coming, it's too late.

PEREGRINE FALCON STATS

Lifespan in wild: » Up to 17 years

Wingspan: » 3.3 to 3.6 feet (1 to 1.1 m)

Nest elevation: » As high as 12,000 feet (3,658 m)

BALD EAGLES

Some guys bring flowers. A male bald eagle locks talons with his female high in the air. They drop to the ground spinning and cartwheeling, letting go at the last possible second. It's no surprise that eagles mate for life after surviving this death-defying drop!

GRASH

BALD EAGLE STATS

Diet: » Meat, mostly fish

Wingspan: » 7 feet (2 m)

US symbol since: » 1782

BARN OWLS

Silent flying. Superior hearing. Stealthy hunting. Scientists have proven that a barn owl captures mice in total darkness. It uses its ears, not its eyes. With one ear higher than the other, the owl can tell if the tiniest sound comes from the right, the left, above, or below. Dr. Whooo hears better than any animal ever tested.

BARN OWL STATS

Head can swivel: » 180 degrees in each direction

Wingspan: » 33 inches (85 cm)

Low-light vision: » Excellent!

LYREBIRD STATS

Species: » 2, both native to Australia

Tail length, male superb lyrebird: » 22 inches (55 cm)

Named for: » Ancient Greek instrument

LYREBIRDS

Now in concert: the lyrebird from Australia! The best songbird in the world, the lyrebird imitates any sound it hears: songs from 20 kinds of birds, camera shutters, car alarms, chainsaws, radios, and even gunshots. To seal the deal, the male fans its tail feathers like an umbrella and jiggles them for the female.

EMPEROR PENGUINS

The female emperor penguin lays her egg. Then she leaves for two months to hunt for food. Super Dad balances the egg on his feet, covering it with a feathery brood pouch. The males huddle together on open ice without food during the frigid Antarctic winter. When the chick hatches, the female returns to feed it. The male celebrates with a 50-mile

EMPEROR PENGUINS STATS:

(80-km) walk to the ocean!

Height: » About 47 inches (120 cm)

Weight: » Approximately 88 pounds (40 kg)

Longest known dive: » Almost 28 minutes





Do kids' taste buds change as they get older? Why do kids and adults like different foods?

—Kate B., Pennsylvania



Just like the rest of your body, your taste buds change over the course of your life.

You might hate mushrooms, or eggs, or poblano peppers when you're a kid, and love them when you're an adult. But when you're a kid, your tongue is changing more than it ever will again.

If you look in the mirror and stick out your tongue, you can see lots of little bumps all over it. Those aren't your taste buds, though. They're called papillae. Your taste buds are actually inside many of these papillae: taste buds are a tight bundle of

sensory cells. These cells send signals to your brain when food touches the papillae. Some of them are more sensitive to sweet tastes, others to salty things, and so on. The taste buds' job is to separate out the different flavors (sweet, sour, salty,

bitter, and others)

<image>

so your brain can put all the tastes together and judge if a food is delicious, disgusting, or somewhere in between.

When you're a kid, your tongue tastes sweet, sour, and bitter flavors very stronglymuch more than adults. The same chocolate bar probably tastes sweeter to you than to your mom, and her coffee tastes more bitter. And your brain has strong opinions about them too. Kids seem to *really* like sweet foods and *really* dislike bitter foods. As you grow, that craving for sweet things eases, and flavors like salty, savory, and sour become more appealing.

As adults age, their taste buds get weaker and can separate out fewer flavors. The sense of smell—a key part in enjoying food—also slowly loses its sharpness. As a result, food starts to taste blander. Do you think that may help explain why some adults like to eat very spicy, salty, or pungent foods?

Where you eat and who you eat with is also important. Happy memories of eating the dish with her family might explain why your grandma loves cream-of-broccoli soup, even though you can't stand it. And unpleasant memories associated with a food might make someone turn up their nose at something *you* love.

And of course, some people just like certain flavors and don't like others. Keep trying new foods, and keep tasting old ones—you'll find plenty to chew on.

-Emily

Have any questions? Send them to Muse Q&A, 70 E. Lake St., Suite 800, Chicago, IL 60601, or email them to muse@cricketmedia.com.

What happens when scientists study psychic abilities?

by Kathryn Hulick | art by Gordy Wright

REPORT NO. 10 PROVIDED AND

tall young man with striking features and thick black hair hunches over a piece of paper, pen in hand, eyes closed. He's about to demonstrate remarkable and mysterious powers of the mind.



The year is 1973, and the young man is Uri Geller. He's appearing on a live television talk show that was very popular in Britain at the time. Before his appearance, a production assistant for the show retreated into a closed room, made a picture of some unknown object, and hid it in an envelope. Geller says he can use the powers of his mind to see it. He doesn't know how he does it. Maybe he reads the thoughts of the production assistant, a power called telepathy. Or maybe his mind probes inside the envelope to see the drawing hidden within, an ability called clairvoyance.

"OK, I'm getting something," Geller says, resting one hand on the sealed envelope sitting on the table in front of him. He begins to draw, a large triangle over a long, thin horizontal shape. "It could be a boat or a ship," he says. The talk show host opens the envelope. Out comes a drawing of a sailboat, almost identical to the one Geller just made. The audience cheers.

Something Unusual

Geller has more amazing abilities. Later on the same show, he picks up a fork and begins to rub it between his fingers. "I'm holding it very, very gently," he says, and the camera zooms in on his fingers. After a few minutes, he says, "It's cracking. Look, it's becoming like plastic. It's breaking." The end of the fork falls to the floor with a clatter. In similar performances around the world, he bends or breaks spoons, keys, rings, and other metal objects. He stops or starts watches and influences the behavior of other machines. He claims that he does this with the power of his mind, an ability called telekinesis.

In multiple radio and television appearances, Uri Geller tells his audience to try these same feats at home. Surprisingly, many people report that metal objects in their homes bend mysteriously, or that broken watches or other machines suddenly start working again. One woman in San Francisco had a watch that once belonged to her grandfather. It hadn't worked for many years and she always kept it in her dresser drawer. But after watching Geller on TV, she found the watch on her bed. In a letter, she reports, "It was running!!! It had been transported some

way from the drawer to the bed while I was in the living room!"

Could psychic powers be real? In a book about his life, Uri Geller wrote, "I feel that these powers come from far outside me, that I am like a tube that channels them ... I know that something unusual is going on here, and I'd like other people, as many as possible, to know about it, to explore it together."

Scientists Investigate

Geller and his audiences aren't the only ones exploring the possibilities of psychic phenomena. Over the decades, some scientists have tried to determine if telepathy, clairvoyance, telekinesis, and other powers are real. And if they are real, then how do they work? What unknown forces or energies might be involved? In 1970, during the Cold War between the USA and the Soviet Union, the US Central Intelligence Agency (CIA) decided to take action. The spy organization planned an investigation into psychic phenomena.

Two excellent physicists, Hal Puthoff and Russell Targ, agreed to perform the research. They worked with Uri Geller and several other psychics on a series of experiments during 1972 and 1973 at the Stanford Research Institute (SRI). During one series of experiments, Geller tried to reproduce hidden drawings. For most of these trials, Geller sat locked inside a room surrounded by double walls of steel. This was meant to prevent him from seeing or hearing anything going on outside the room. Once he was locked in, researchers outside selected an object and made a drawing. When the researchers drew the solar system, Geller also produced a picture of planets. Remarkably, when the researchers drew a bunch of grapes, Geller produced a picture with the exact same number of grapes on it.

In a presentation to fellow scientists following these studies,



I feel that these powers come from far outside me, that I am like a tube that channels them ... I know that something unusual is going on here, and I'd like other people, as many as possible, to know about it, to explore it together."

Targ said, "We have observed certain phenomena with the subjects for which we have no scientific explanation." A year later, the study appeared in *Nature*, one of the world's most prestigious science journals. Geller told his adoring fans that his abilities had been scientifically proven to be real.

Magic Tricks

In fact, the scientific evidence was shaky. *Nature* had published a detailed commentary alongside the study. This cautioned that the experiments were not well designed or carefully conducted. It was impossible to rule out trickery as an explanation. Editors at *Nature* hoped that publishing would help quiet down rumors that SRI had made a breakthrough.

Only Geller knows what really happened at SRI, or during his many public appearances. And he continues to maintain that he has real powers. However, magicians say otherwise. Many of them have duplicated Geller's feats. Spoon bending, for example, is a simple trick that anyone can easily learn. You can find videos on YouTube showing you how to do it without any supernatural powers. During that 1973 talk show appearance, Geller may have done it using a large metal belt buckle that he wore. While the audience was distracted, he could have easily snuck a fork into his lap and bent or broken it with one hand using the buckle for leverage. While he strokes the fork, his fingers never leave one spot at the utensil's neck. Most likely, the fork is already broken there, but the audience believes it is whole.

Geller likely used tricks for his hidden drawing demonstrations, too. On the 1973 talk show, a production assistant made the drawing earlier in the day. Geller and his helpers had plenty of time to sneakily figure out what it was. In the SRI experiments, though, the scientists made the pictures only after Geller was locked inside the room. However, the room contained an audio link to allow the scientists to hear Geller. Supposedly, he could not hear them. But Geller's assistant and longtime friend, Shipi Shtrang, was present during the experiments. James Randi, a famous magician who passed away in 2020, suspected that Shtrang had found some way to give Geller clues.

During several of the drawing experiments, no one had any way to know what the picture was. For example, in one experiment, an artist not connected to the research made 100 pictures and other people sealed these inside of double envelopes. Then, the research team selected one of these at random. Geller refused to try to draw the selected picture. Targ admitted that the experiments were not well controlled. He said, "Geller manipulates the experiments to a degree of chaos where he feels comfortable and where we feel uncomfortable."

But what if an experiment is well controlled? Have scientists found any convincing evidence of psychic abilities? The James Randi Educational Foundation offers a million-dollar prize to anyone who can prove any sort of psychic ability following their strict testing procedures. Many have tried, but none have succeeded.

The Lure of Belief

Sometimes, Uri Geller wound up in a situation where he couldn't resort to tricks. In 1973, he appeared on The Tonight Show with Johnny Carson. This was one of the most popular shows in America at the time. Beforehand. James Randi told Carson to provide his own props for the show and not to let Geller or his team near them in advance. During the show, Geller did nothing. He didn't bend any spoons or copy any hidden drawings. He said, "I'm having a hard time with you.... I don't feel strong." This failure didn't matter at all to Geller's fans. He always approached tests of his abilities with a shy, nervous demeanor, saying that his powers didn't always work. It was easy to like him and really want him to succeed. This desire to believe helps explain the cases where Geller's audiences report using mental powers to bend spoons or repair broken watches at home. Clearly, no magic trick could affect a spoon or watch located in a home many miles away.

So what was really happening?

Many of the unusual events were coincidences. In a show with hundreds of thousands or even millions of viewers, something strange will happen in some of the homes during the show. These people wanted to believe Uri Geller, so they assumed he somehow caused the strange thing to happen. (Or perhaps they went so far as to make up a strange event.) Of course, for the vast majority of viewers, nothing special happened. But these cases didn't get reported. So everyone only heard about events that supported the idea that psychic powers are real.

However, some people really did manage to start broken watches or bend spoons. How did they do it? Holding or shaking a stopped watch will often make it tick again—temporarily. This seems magical to people who don't know how watches work. Also, most people never try to bend utensils or keys. So they wrongly assume that this must be very difficult to do. But it's not, Susana Martinez-Conde, a neuroscientist at SUNY Downstate Medical Center in New York, remembers watching Geller on TV as a child. She went into the kitchen, grabbed a spoon, and rubbed her fingers along the neck. To her surprise, it started to bend! But it wasn't telekinesis. "I noticed

I was bending it by exerting pressure on it," she says. She wanted the spoon to bend, so she had forced it without really meaning to. This likely happened to other viewers as well. Some assumed that the power of the mindnot the fingertipsbent the spoon. You may have experienced unusual events in your life. Perhaps you sometimes have dreams that later come true. Or maybe mechanical objects seem to fail around you. Or perhaps you always know which friend is going to text you next. Do these sorts of experiences mean that the human mind has mysterious powers?

People often build up beliefs based on events that seem related but are not. "Our brain is a meaningseeking machine," says Martinez-Conde. Normally, linking together causes and effects helps people form useful beliefs about the world. For example, dark clouds lead to rain and thorns lead to painful pricks. But this same process also leads to false beliefs and superstitions, like the idea that wearing your lucky hat or shirt or socks can help your favorite sports team win a game.

Our brain is a meaning-seeking machine."

People also tend to notice and remember only evidence that supports existing beliefs. At the same time, they ignore or explain away evidence that conflicts with beliefs. This is called confirmation bias. If you believe that your dreams predict the future, you will remember dreams that match future events, but will ignore or forget the majority of dreams that don't.





The Future of Mind Reading

Real psychic abilities do not seem to exist. But this doesn't make the human brain any less amazing and mysterious. It is an organ that sparks with electricity as billions of cells called neurons communicate with each other. Patterns of flashing neurons control the body and form thoughts, emotions, dreams, and more. Scientists who study the brain are beginning to understand and decipher some of these patterns. People who are paralyzed or who have lost limbs have learned to control a robotic arm or leg with their thoughts. This seems like telekinesis! But in fact, a computer system translates messages from the brain into instructions that move the arm or leg. Other researchers have collected brain activity as people watched movies. They managed to recreate blurry images of the movies from patterns in the brain activity. These braincomputer systems can't read entire thoughts like reading a book. But in the future, it's certainly possible that people could gain powers very similar to telepathy. If this ever happens, it will be science and technology that make it possible.

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You'll need

>> 25 index cards

I think I'm getting a signal! You're . . . skeptical?!

» Pencil
» Blank paper or digital spreadsheet

Kathryn Hulick

Hands-On

DO YOU HAVE ESP?

MAKE YOUR OWN ZENER CARD DECK AND FIND OUT!

ESP STANDS FOR EXTRA-SENSORY PERCEPTION, or an ability to sense or manipulate things without the help of your eyes, ears, nose, mouth, or skin. If ESP exists, it would allow people to read minds, see through walls, or move things without touching them.

A researcher named Joseph Rhine invented the term ESP. He got his PhD in botany, the study of plants. But in 1927, he abandoned that field, moved to Duke University, and began searching for scientific evidence of ESP. His most famous type of experiment involved a set of 25 cards with the symbols shown on the facing page. They were named Zener cards after Rhine's colleague, Karl Zener, who came up with the designs. In a Zener card experiment, a person tries to figure out the symbol on a card without being able to see it.

In 1934, Rhine published a book analyzing 90,000 trials he'd done with the cards. His experiments didn't prove ESP existed because he didn't always follow the best methods. For example, sometimes a little bit of the design showed through a card. Rhine's work didn't explain how such an ability might work either. ESP is not compatible with science as we know it, and there is no indication that mysterious signals emanate from people's heads.

Despite the fact that science has found no reliable evidence for ESP, the possibility that it might exist continues to fascinate people. (We all want superhuman powers!)

44

Susan Blackmore, now a mainstream scientist, author, and speaker, started out her career in the 1970s looking to find evidence of psychic abilities. She didn't use Zener cards, but performed similar experiments in which volunteers tried to transmit words or pictures to each other using only their minds. She said the experiments were great fun, but "there was absolutely no sign of telepathy at all." People do get the answer right sometimes in these experiments, but that doesn't mean they have used ESP. It means they've been lucky. The results to any well-conducted ESP test are always close to random chance.

With a Zener deck, you have a one in five chance of guessing the correct symbol. So out of 25 cards, you should get around five correct. Sometimes people will get more than five right; other times they'll get less than five. That's how chance works—it's random! Getting a bunch of cards right in one experiment doesn't actually signify anything unusual, unless you always get many more than five right or wrong. And then it's likely there's something wrong with your experiment. (See through cards, maybe, or even a bit of cheating?)

How will you and your friends and family perform? Make yourself a Zener deck and find out!



Directions

1. Use the pencil to draw a circle on the blank side of 5 index cards. Press lightly. (If you press too hard or use a pen or marker, the drawing may show through to the other side.)

2. Draw sets of 5 plus signs, 5 wavy lines, 5 squares, and 5 stars.

3. Make a chart or use a spreadsheet to record results. To make your own chart, draw two columns on blank paper. Divide the columns into 25 rows.

4. When your deck and chart are ready, find a volunteer to be the

receiver. You will be the sender.

5. The receiver and sender should each sit in a quiet room where they can hear each other but can't see each other. (You can be in the same room, but make sure you can't see each other's faces and that the receiver can't see the cards.) You could also perform the experiment over a video call, with the video pointed away from your faces.

6. The sender shuffles the deck of cards, then flips one over and focuses on it, trying to picture the symbol in their mind.

7. The receiver tries to empty their mind and waits for one of the five symbols to appear. When it does, the receiver shouts out a guess.

8. The sender then notes down both the correct symbol and the receiver's guess.

9. Continue through the entire deck.

10. At the end, count the number of correct guesses. Is it five, or a little more or less? If you repeat the experiment many times, the average number of correct guesses per experiment will be close to five.

Variation

Try making a Zener deck with five colors as well. Each symbol will appear in red, blue, yellow, green, and black. The receiver has to guess both a color and a symbol. So they have a 1/5 x 1/5, or 1/25 chance, of guessing both correctly. When you go through the whole deck of 25 cards, they should get around 5 colors and around 5 symbols correct, but only around 1 color and symbol.

Kathryn Hulick is a skeptic now, but as a child she believed in ESP. She read in a book that staring into a candle flame could unlock mental powers. This did not work for her, but she wishes you success! Her book *Strange But True* (Quarto, 2019) explores the science behind paranormal mysteries. **>> NEW CONTEST**

Villains Love a Monologue

Every superhero needs a good (or should we say bad) supervillain—a doer of dastardly deeds to defeat. Invent a supervillain. In pictures and/or words, show us their final monologue as they face their super nemesis for the last time. Who are they? What's their evil plan? And who's that minion in the corner? Even if your character tends to be long-winded, keep your writing to 100 words or fewer.

CONTEST RULES

1. Your contest entry must be your very own original work. Ideas and words should not be copied.

2. Be sure to include your name, age, and full address on your entry.

3. Only one entry per person, please.

4. If you want your work returned, enclose a self-addressed, stamped envelope.

5. All entries must be signed by a parent or legal guardian, saying that this is your own work and no help was given and granting permission to publish. For detailed information about our compliance with the Children's Online Privacy Protection Act, visit the policy page at cricketmedia.com/privacy.

6. Your entry must be received by January 31, 2021. We will publish winning entries in the April 2021 issue of *Muse*.

7. Send entries to *Muse* Contest, 70 E. Lake St., Suite 800, Chicago, IL 60601 or via email to muse@cricketmedia.com. If entering a digital photo or scan, please send at 300 dpi.

>> ANSWERS

PAGES 6–9 MUSE NEWS The false story is "Quite a Bite." -JAZLYN T. / Tennessee

Living Square

>> ANNOUNCING

CONTEST WINNERS! Naturalists in the July/August issue helped us notice life all around. Here's what our winners saw in just one square foot!

Under The Bench

>> RUNNERS-UP

Honorable Mention

This month's runners-up are Chloe C., 9, Canada; Holly B., 9, Illinois; Margo, 11, Washington; Olivia W., 12, Florida.

Washington, D.C.

By More M.

-MAEVE M. / age 11 /

NCLUDES:

-GRACE P. / 12 / Illinois



SHOULD PEOPLE BECOME CYBORGS?

IN THE MARVEL COMICS AND MOVIES, billionaire Tony Stark dons a red and gold suit and becomes Iron Man. The suit provides superhuman strength, protection against most attacks, the power of flight, and much more.

Iron Man is just a story. But robotic suits are not. Engineers call them exoskeletons. They don't look as flashy as Tony Stark's suits. They typically look like a backpack attached to a harness. But they have changed the lives of many people with injuries or illnesses that affect movement. A disease had paralyzed Stacey Kozel from the waist down. But in 2016, she used an exoskeleton to hike the Appalachian Trail. Also, people who do tiring or repetitive jobs, like moving heavy boxes in a warehouse, sometimes use exoskeletons to lessen the load.

You can probably think of a time when you wished you could lift more, jump higher, or run faster. Today's exoskeletons are expensive. They need to be charged regularly and can usually handle only one type of motion (for example, lifting or walking). But in the future, things might be different. Quick question. How do you go to the bathroom in the suit? Brendan Quinlivan works on exoskeletons at Harvard University. He says that 50 years in the future, "a rigid exoskeleton could really help you." He says it might allow you to flip over a car or pick up a big tree trunk. You could become a lot like Iron Man.

That would be cool. But some people worry that the technology could divide humanity. In 2008, new swimsuits helped swimmers go faster than ever before. But swimmers couldn't compete fairly without the latest suit technology. So the International Swimming Federation banned the suits. People who can afford exoskeletons will be stronger and faster than those who cannot. They'd be able to work faster and accomplish more that those without suits. We could end up with two classes of humanity: the superhumans and everybody else. That wouldn't be fair.

But life already isn't fair. Plenty of people have advantages over others thanks to their wealth, health, or strength. Right now, exoskeletons are helping to even the playing field for people with disabilities. That's a great thing. Also, people could use their "unfair" advantage to help or protect others. For example, rescue workers could move heavy debris.

What do you think? If we ever have Iron Man suits, will they harm or benefit humanity? What would you use an Iron Man suit for?

Kathryn Hulick wrote a whole book about the future of technology, including exoskeletons, robots, genetically engineered dinosaurs, and more. Look for *Strange But True: The Future*, coming out in Fall 2021.



WHAT TYPE OF SUPERHERO ARE YOU? AN EXTREMELY ACCURATE QUIZ

1. Everyone gains superpowers in their own way. You . . .

A. Accidentally drank from a magical chalice. What's with the sudden super-strength and power of flight? B. Trained for years to be a master of disguise and hand-to-hand combat. Bartered your skills for a supersonic hearing device.

C. Won the "what should we get for dinner" argument against your mom. You got super-arguing powers, and your family got burritos.

- 2. A supervillain appears . . . and they've got beef with you. Why?
 - A. You couldn't save their cat from a tree.
 - B. You were best friends, but then you had a fight and never had the courage to apologize.
 - C. They're looking for something to be mad about. They're probably just hungry.
- 3. You've just saved the city! How did you do it?
 - A. Punched the evil aliens' laser into the sun.
 - B. Infiltrated the bad guys' headquarters and hacked their computer system.
 - C. Convinced everyone that evil plots are a waste of time and to go for burritos instead.

SCORING Mostly A: Who needs a secret identity? You're the bright, brash hero type. You love interacting with people all day long. Mostly B: You're the sneaky, cover-of-night type. You value your privacy, and you're practiced at keeping secrets. Mostly C: You think a good head on your shoulders is the best superpower. But burritos are a close second.



Join the 2021 Spark!Lab Dr. InBae & Mrs. Kyung Joo Yoon

Invent it CHALLENGE

Be a Game Changer!

Hey, Young Inventors! Former pro football player Shawn Spring® is an inventor and GAME CHANGER. His company, Windpact, creates technology for helmets to reduce injuries	Fun? 1 2 3	
caused by impacts in sports. Shawn's inventions will change the game for players in many sports— baseball, cycling, skiing, football, and hockey, to name a few—forever! What ideas do you have for	Safe? Accessible?	
making sports more I Fair? I I I 2 Competitiv 3 I	re?	
2 3		

Create an invention that makes sports more exciting, fun, fair, or safe for all. Visit InventitChallenge.com to get help with your invention. Share your idea. Win awesome prizes!





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within us all

to navigate

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capacity