



WHAT SHOULD YOU DO IF A FIRE BREAKS OUT?
Making the Right Moves Makes All the Difference in a Crisis

IT'S NOT YOUR TIME TO DIE!

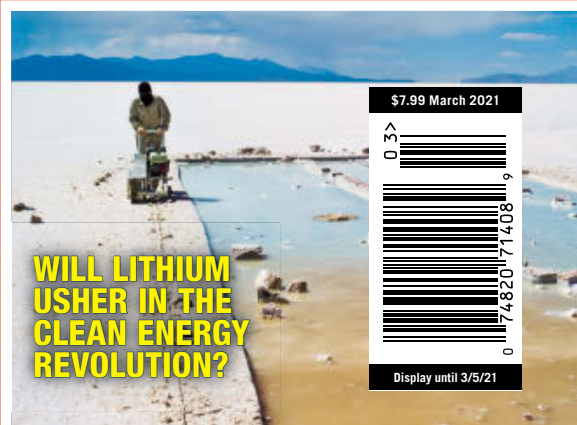
DOCTORS REVEAL THE **TACTICS** THEY USE **TO CHEAT DEATH** AND **PULL PEOPLE** WHO APPEAR TO BE GONE **BACK FROM THE BRINK**



WHO REALLY RULES?
The Unlikely Masters
of Their Domain

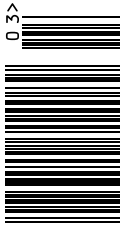


BUYER BEWARE!
Just How Safe Is My Smart Home?



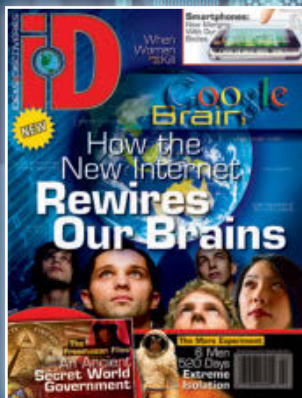
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CLEAN ENERGY
REVOLUTION?

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You talk, we listen! Here's what you had to say about previous issues of iD. Thanks for your feedback and suggestions. Keep 'em coming.

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ALLURE OF THE UNKNOWN

iD covers an extremely wide array of subject matter, but of all the interesting topics the magazine addresses, one of my all-time favorites is the articles on mysterious places. There's something intriguing about sites with a reputation for the mysterious or macabre; they transcend mundane concerns and remind us that just because many of us are mired in a workaday routine, the world is big and amazing and full of unknowns. What makes these locations even more alluring is that they're oftentimes unpopulated or abandoned, which enhances their drama. The place that stuck with me the most from the mysterious places story in the January 2021 issue is Russia's Manpupuner rock formations because of what happened to all those hikers in the 1950s. Has there been any new information on what might have caused the awful deaths?

Tom Holmes, Schenectady, NY

The tragedy that befell the nine students from the Ural Polytechnic Institute in 1959 remains open to speculation, and there is plenty of it out there. iD had covered this story in the June 2014 issue, in which the Dyatlov Pass incident (so named for Igor Dyatlov, the hiker who led the expedition) was presented in more detail. In February of 2019 the Russian government launched a new investigation in the hope of finally getting to the bottom of what occurred. Investigators were to use modern technology, but to date there's still no definitive explanation for the deaths. The hikers were all experienced; they'd fled from their tents and been found in their underwear despite frigid temperatures, some with strange wounds and serious injuries. In all, 75 guesses have been proposed, from a yeti attack or an alien intervention to getting caught on the testing ground for a new kind of weapon or even murder by the local Mansi people who consider the lands in the vicinity of the rock formations sacred. Relatives of the victims have always felt that something has been kept secret from them. Certainly the event was terrible, but what's not certain is the reason for the deaths and whether it will ever come to light.



SMALL ON SIZE, BIG ON SURVIVAL

I'm glad I can always count on an animal story in each issue. I was particularly impressed by the spectacular "Best Animal Photos of the Year" in the January issue. (And that was also your 10th anniversary issue—Happy Birthday, iD! Kudos to you for all you do.) A question on one of the article's cute critters: Is it true that the long-eared jerboa doesn't drink water? If so, how does it manage to survive in the desert? I hadn't even heard of jerboas before, but after getting to see one in the story, I had to learn more!

Melissa Ross, Dayton, OH

That's actually true. The nimble desert rodent gets the water it needs from food and excretes highly concentrated and acidic urine. When possible jerboas eat moist leaves and shoots, but since rain and greenery are in short supply in the desert, they may also dig up the roots of desert plants and eat those for their stored water. Insects are also on the menu for a number of species. The hopping mode of locomotion allows them to cover a lot of ground in search of food while minimizing energy loss. Jerboas protect themselves from the heat by simply sleeping in cool underground dwellings during the hottest part of the day and only coming out of their hiding places at night.

COMPETITIVE PAGEANTRY

I'm a fan of professional darts, so it was extra great to see an article on the sport in the January issue. Thank you! I just have one question: Why do so many spectators get dressed up to attend the PDC World Darts Championship?

Marcus Buckinger, Rancho Cucamonga, CA

Audience members dressing up in costumes for the darts tournament has a long tradition. What began with funny hats 20 years ago is now a full-fledged costume contest for fans at London's Alexandra Palace. Spirits run high and spectators are there to have a good time. By dressing to impress, audience members hope to be captured by the cameras—and the best costume captures the prize that's awarded by a jury.

id contents

COVER
STORY



While the more majestic animals often get the spotlight, some smaller specimens use their talents and cunning to upstage them and steal the show. **PAGE 10**

COVER
STORY



Staving off death is a doctor's most important mission, and bleeding-edge techniques have made it possible to push past previous limitations. **PAGE 20**

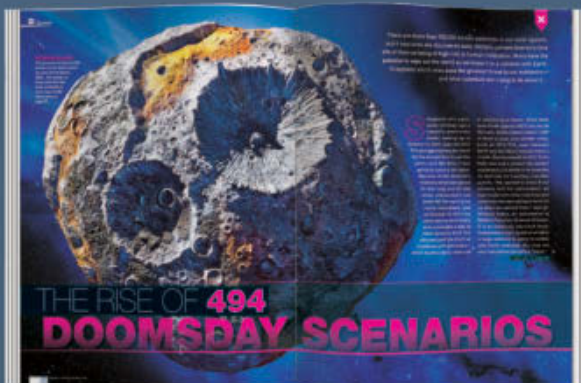
COVER
STORY



Smart products are making our home lives better and far more convenient. But predators prey on ignorance, and what you don't know can hurt you. **PAGE 40**



A century ago the legend of the *Titanic* began, and now efforts are under way to replicate the lost luxury liner's glory for the modern world to appreciate. **PAGE 50**



They are out there in droves, imperiling our planet with their wayward ways. But plans are in place to safeguard us from the menace of asteroids. **PAGE 64**



In an era of deadly contagious diseases and constant global travel, what can be done if you get stuck abroad when a worst-case scenario manifests? **PAGE 70**

"An investment in knowledge pays the best interest."

—Benjamin Franklin

COVER STORY

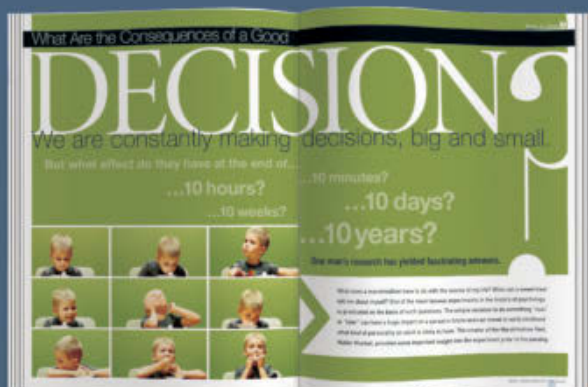


It's one of the most frightening situations that a person might have to confront. Would you know what to do if you're ever caught in a fire? **PAGE 32**

COVER STORY



Green energy can be good for the world in many ways. But we'll need a good way to store it. Could a substance harvested from salt flats be the answer? **PAGE 56**



Forbearance may be one of the secret keys to success. In order to determine if that is indeed the case, you'll be needing a marshmallow or two... **PAGE 76**

To our readers:

What's most important to you? Your life, and that of your loved ones; the security of your home and our collective global home; the energy to power the modern world. What threatens those things? Death; a fire or a break-in; an asteroid on a collision course with the planet; exhaustion of finite resources. Coming up with innovative ways to address such pressing threats is the key to preserving what's important. Where there's a will, there's a way...

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They may be small, but they have plenty of reason to "walk tall"

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March 5



A photo and its story

HOLLYWOOD'S LEADING

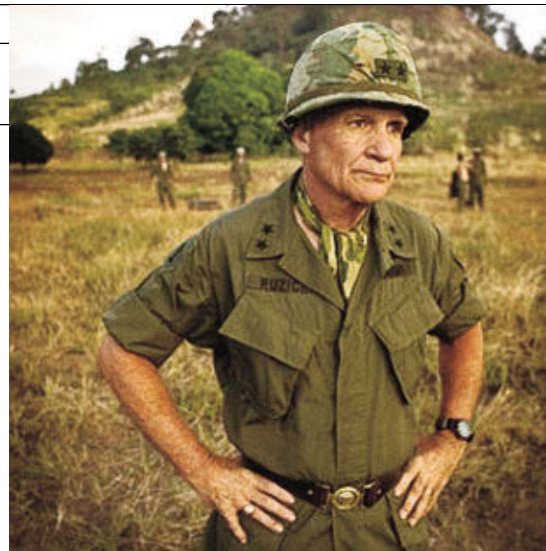
SOLDIER



RELENTLESS CRITIC

Dale Dye (left) makes sure Hollywood's war films are realistic. Sometimes he even joins the cast—as seen here in the miniseries *Band of Brothers* starring Damian Lewis (right).

R Whenever a war movie is being filmed, you can expect to find him on the set: Decorated for his service in the Vietnam War, former U.S. Marine Captain Dale Dye is the founder of Warriors, Inc., an advisory firm that helps filmmakers portray military action with great realism.



The phone was ringing in the office of former U.S. Marine Corps Captain Dale Dye. The famous voice on the other end had a pronouncement to make: “Captain, you have a mission!” The year was 1997, and the caller was none other than Steven Spielberg. When the Hollywood legend agreed to direct *Saving Private Ryan* almost a quarter of a century ago, he didn’t know he was about to revolutionize the genre. Spielberg’s commitment: make a film about the horrors of war and make it as realistic as possible. “In a real war, you don’t die with a huge fireball behind you, in slow motion, tumbling acrobatically into a perfect air-bag landing. That’s not how it is,” says the famed director. “The last thing I wanted to do with this picture was to glamorize World War II.” And so Spielberg decided to make war look as brutal as possible. That’s why he called on Dale Dye.

CAN YOU MAKE A SOLDIER OUT OF A HOLLYWOOD ACTOR?

Spielberg sees many of today’s film actors as pampered creatures with their own trailers, personal trainers, and masseuses. And while he denies being the kind of method director who thinks actors must suffer before they can realistically portray suffering, he did want the “soldiers” in his cast to be completely aware of the pain that wartime combatants have to endure. ➤





A photo and its story



HELLISH BATTLEFIELDS

"War is horror," says Steven Spielberg. The director wants all of the actors in his films to portray it accurately.

DALE DYE'S GREATEST ACHIEVEMENTS

Dale Dye has been involved in scores of film and TV productions. Here are his top five:



BAND OF BROTHERS (2001)
Steven Spielberg's 10-part miniseries was nominated for 20 Primetime Emmy Awards and has won 7.



MISSION: IMPOSSIBLE (1996)
Dye played a senior agent on the Impossible Missions Force.



NATURAL BORN KILLERS (1994)
Dye was a technical adviser and also played a minor role in this Oliver Stone film about a media-darling criminal duo.



PLATOON (1986)
This Oliver Stone film was the first major production for Dye, who spent a month training its stars.



SAVING PRIVATE RYAN (1998)
Spielberg hired Dye for his war film, which won 5 Oscars.

And he had heard that Dale Dye was the right man for the job. Dye served three tours of duty in Vietnam, where as a valiant Marine he participated in 31 combat operations and was awarded three Purple Hearts and the Bronze Star with combat "V" for his heroism. Later on he served with the Multinational Force in Lebanon. After retiring from the Marines in 1984, Dye founded Warriors, Inc., a company that advises Hollywood filmmakers and trains their actors.

His first big Hollywood job was for fellow Vietnam vet Oliver Stone, who was making the war film *Platoon*. Dye spent 30 days drilling actors Charlie Sheen, Willem Dafoe, Johnny Depp, and Forest Whitaker in a mock boot camp he devised. That opened doors for Dye, who was soon advising other directors and acting in their movies. He has worked with Hollywood stars such as Tom Cruise, Colin Farrell, and Matt Damon and has appeared as an actor in the blockbusters *Mission: Impossible*, *Starship Troopers*, and Oliver Stone's *JFK*.

BASIC TRAINING FOR ACTORS

"Yes, my training is tough," says Dye. "And it's particularly tough if you've never faced deprivation. Because deprivation is what soldiers live with constantly." Actor Edward Burns can't help but remember the rigors of boot camp, which had included marching 6 miles in the pouring rain to get to a night maneuver. Joseph Mazzello, who played the role of Eugene Sledge in the HBO miniseries *The Pacific*, says his experience was much worse than Burns's, but he believes Dye was wisely preparing the actors for what they were going to face on the set: "The conditions were very real. If I didn't know better, I would've thought we were in an actual war. The sounds were real, the explosions were real, the bullets were flying, the blood was spurting everywhere, and we really

felt like we were in the throes of it all. But I never felt so prepared for a role."

Dye just smiles faintly when he hears what the actors have to say. "They thought they'd go out, sleep in a tent, watch the birds and bees, fire a few weapons, and that's it. Wrong. Every day they were all up at dawn, running 3 to 5 miles. And all day long I kept abusing them while they tried to learn what I was teaching them." His students do not get much more than a uniform, a shovel, and a roll of toilet paper. He makes them sleep in a foxhole, crawl through the mud, fire rifles, and throw hand grenades. And all the while he calls them not by their real names but by the names of the characters they'll play. "I don't give a damn who their agents are or what their credits are," says Dye. He admits that his objective is to "reduce them to the lowest common denominator," yelling at them whenever they get something wrong and even using live ammunition to terrify them.

PORTRAYING WAR IN ALL ITS HORROR

Despite the severity of Dye's training, almost everyone agrees afterward that it was necessary. "You can read books and watch documentaries," says actor Tom Hanks, "but you are

still not going to have a palpable understanding of how tired and cold and wet these guys are, and how heavy this equipment is, and how long it actually takes to walk 2 miles with all this stuff hanging from you." Dye's boot camps give these films what it takes to make an audience realize what General Sherman once told a class of military cadets: "War is hell." "When I saw the film," recalls Edward Burns, "the first guy I wanted to thank after the credits rolled was Dale Dye, because we'd looked like soldiers, and he did that. During boot camp and even during the shooting, if you were forgetting the soldier side of your performance or your training, he'd scream at you." And the captain repays the compliment: "Actors are like dry sponges until you pour on the water," explains Dye. "The really good ones absorb all that they're taught and portray it credibly in the finished movie." He is satisfied with the way war has been portrayed in the movies he has worked on, and *Saving Private Ryan* is generally considered to be the most accurate war film ever made. There's no sign that the 76-year-old retired Marine captain is planning to retire from the film business anytime soon, although most of his projects are on hold in the time of COVID-19.



SCHOOL OF HARD KNOCKS
Vietnam veteran Dale Dye (right) has developed his own style of boot camp where he teaches military discipline to Hollywood stars such as Tom Hanks (left), Matt Damon, and Vin Diesel.



THE REAL MASTERS OF THEIR DOMAIN

Elephants and lions are impressive animals. But what about their colleagues of lesser stature? Of course smaller creatures must flee from danger now and then, but some manage to outwit their enemies and increase their chances of survival thanks to an array of skills that may include spectacular speed, astonishing agility, or incredible cunning—and the occasional leap of imagination...



EVASION EXPERT

● The outcome of this duel seems clear: What chance does a button-eyed little critter have against a ferocious-looking lizard several times its size? But things are not as straightforward as they seem: The small mammal is an elephant shrew. Native to Africa, where they can occupy almost any habitat, these creatures from the family Macroscelididae are seldom seen and hard to catch because of their wariness, good camouflage, and ability to dash away at up to 18 miles per hour. That makes them the fastest mammal in the “under 1 pound” weight class. They received their common name from early English taxonomists who thought their long nose resembled an elephant trunk. And it turns out elephant shrews are the result of an unusual evolutionary quirk that makes them more closely related to elephants than to true shrews. Their legs are also long for their size, and they use them to move about like rabbits, giving them their other name: jumping shrews. Species vary in size from 4 to 12 inches. They often create networks of pathways through the undergrowth that connect their rest areas with the hunting grounds where they search for insects. Elephant shrews usually form monogamous pairs, with the males driving away their rivals and the females routing other females. However the male and female often have separate nests and get together only for mating. Given their isolation, speed, and maze of escape routes, predators have a tough time making a meal of them.



KEEPING THE WORLD CLEAN

● This curious lion appears interested in the ball of dung slowly rolling past him, but he has no idea what's really going on here. Do you know what this activity is all about? The sizable sphere these dung beetles are rolling around is a brood ball that contains the eggs a female has deposited in it. The ball weighs far more than the beetles, and moving it is among the greatest athletic accomplishments in the animal kingdom. And just what is the sphere made of? Poop. Animals deposit an estimated 100 billion tons of it each day, and as soon as they do, the dung beetles get down to business on

every continent except Antarctica, taking the dung to their underground nests and feeding it to their young. In doing so they add nutrients to the soil, disperse seeds, and reduce the methane output of feces by around 40%. The beetles' ability to process waste efficiently enables them to decimate dung heaps in a matter of hours, a feat that could otherwise take years. When it comes to agriculture, bees and butterflies get a lot more credit, but the contributions of dung beetles should not be underappreciated. Without them, this dirty job would not get done—and where would that leave us all?



A large, vibrant photograph serves as the background for the page. In the center, a burrowing owl (Athene cunicularia) is perched on a weathered concrete pillar, its wings spread wide as if it has just landed or is about to take flight. The owl has brown and white mottled feathers and bright yellow eyes. In the foreground on the right, a close-up of a cane toad (Rhinella marina) is visible, showing its large, bulging eye and textured skin. The background shows a clear blue sky with scattered white clouds and some green foliage on the left.

TOO BIG FOR A SMALL POND

● Rio de Janeiro is a mega metropolis with a population of about 16 million inhabitants and an animal population so large that no one knows just how big and diverse it is. So when a burrowing owl (*Athene cunicularia*) prepares to attack a cane toad (*Rhinella marina*) in an urban courtyard, no one pays much attention. Anyone who does is probably familiar with the cane toad's poison glands and questions the owl's sanity. Cane toad toxin is present throughout the animal's body and is likely to kill any predator that eats one. But glands on the shoulders of the toad also secrete the toxin as a milky liquid, and the effect of touching one is painful. Australian researchers have long recognized imported cane toads as a scourge to that continent's wildlife, including snakes, lizards, raptors, and carnivorous marsupials. More recently they have found that the toads can even kill

freshwater crocodiles. Cane toads normally respond to an attack by simply holding still and letting the toxin neutralize the would-be predator. Australia's problem started with a very bad idea: In 1935 scientists brought 102 specimens of *Rhinella marina* from Hawaii to the "Land of Oz," where it was hoped they'd control beetles in the sugarcane plantations. They didn't, because the Australian beetles live at the top of the sugarcane stalks and the toads couldn't climb. But they were well adapted to their new environment, where they found few predators and abundant food. Introduced to control problematic animals, the cane toad rapidly became one in its own right, and the population is now estimated to number in the millions. In the wild they typically live for up to 15 years, but one specimen has reportedly survived for 35, so there's no end in sight to their dominion.



TAKING YOU BY SURPRISE

● There's no need to be concerned about the safety or welfare of a praying mantis. Plenty of videos on the Internet show the woe that can befall a cat that dares to take on one of these fierce kung fu insects. You can also watch videos of a mantis swimming in a river or executing acrobatic leaps. They seem to have no fear, as evidenced by this specimen perched atop a building in Tokyo. Praying mantises exhibit a high degree of fighting power, and battle style varies by species. They are aided in capturing prey by a large triangular head they can rotate up to 180 degrees and two spiked front legs they use to catch and grasp their victims. Mantises can move so fast that it's hard to observe their motion with the naked eye as they snare their prey. These carnivores feed primarily on beetles, crickets, grasshoppers, butterflies, spiders, and (occasionally, in a fit of cannibalism) other praying mantises. In some species the female may decapitate and eat her mate during or just after mating. But they'll also feast on small reptiles and birds, including hummingbirds when they come to a sugar water source to drink. The prey may be up to three times bigger than the predator. Mantises are well camouflaged to resemble a flower, green foliage, or earth. That allows them to remain stationary while their unwitting prey approaches, but they sometimes stalk their victims with stealthy, deliberate movements. They locate their intended meal by sight, surveying the field with two large compound eyes and three simple ones that are located between them. They rapidly move their head back and forth to keep the sharpest part of the eye focused on their prey. Then it's all over, faster than the blink of an eye...





WHICH ONE IS THE FIERCER HUNTER?

RECOMMENDED VIEWING

SMALL ANIMALS IN LEADING ROLES:
HIDDEN KINGDOMS



The spectacular nature film *Hidden Kingdoms*, the origin of the photos in this article, is the thrilling result of more than two decades of photography in some of the world's most exciting places. "This world is so small and moves so fast that we had to reimagine natural history filmmaking," says producer Mike Gunton. Narrated by Stephen Fry, the three-part series was first aired on BBC One in the UK and later shown in the U.S. on the Discovery Channel as *Mini Monsters*. It's available on DVD and Blu-ray and on Amazon Prime.

● The arid desert regions of Mexico and the southwestern United States are home to the southern grasshopper mouse (*Onychomys torridus*). At some early point in its development it evidently made two resolutions: 1. "I'm staying here because I really like it here," and 2. "Get in my way, and you've had it!" Of course, in the case of an opponent such as Harris's hawk (*Parabuteo unicinctus*), the wee mouse prefers a tactical retreat. But if you're wondering whether the mouse or the hawk is better prepared to take on an Arizona bark scorpion, the answer is the gutsy little rodent. Scarcely bigger than the scorpion—the most venomous in North America—the grasshopper mouse has developed a protein over the course of evolution that makes it impervious to the pain and toxins of the scorpion's sting. It closes its eyes and uses its whiskers to sense and avoid the scorpion's strike. In the end, the predatory arachnid literally loses its head before the mouse eats the rest of its body too. Then the mouse will throw its own head back and let loose a high-pitched victory cry, like a tiny wolf howling at the moon.



»Old age
can be
treated,
just like
any other
disease.«

**AUBREY DE GREY,
biomedical
gerontologist**
In the eyes of
Aubrey De Grey, the
illnesses of aging
are the side effects
of life. He focuses
on methods for
extending life and
enhancing its
quality during the
twilight years.

PAGE 20



**KARL-HEINZ KNORR,
firefighting expert**

A lot can be done right in a fire, but much more can be done wrong. The vice president of the German Fire Brigade Association explains what to do to survive a fire disaster.

PAGE 32



**MICHAEL STEIGERWALD,
IT security expert**

The software engineer and cofounder of the digital security company VTRUST has discovered numerous gaps in the security of Internet-enabled devices. He reveals the hidden dangers of a networked smart home.

PAGE 40



**WALTER MISCHEL,
social psychologist**

The renowned human development researcher explains the science behind good decisions—and how our decisions can influence the course of our lives.

PAGE 76

»For the first
time, we will
have the power
to alter the
path of an
asteroid.«

**IAN CARNELLI,
project leader
of the Asteroid
Impact Mission**
There are objects
in the cosmos that
could potentially
present an impact
threat to Earth
someday. Ian
Carnelli wants to
stop them—by force,
if necessary.

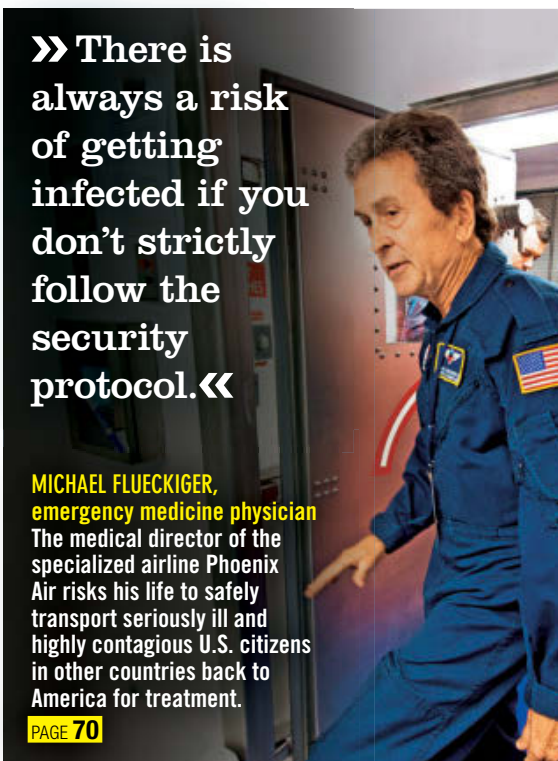
PAGE 64




»There is
always a risk
of getting
infected if you
don't strictly
follow the
security
protocol.«

**MICHAEL FLUECKIGER,
emergency medicine physician**
The medical director of the
specialized airline Phoenix
Air risks his life to safely
transport seriously ill and
highly contagious U.S. citizens
in other countries back to
America for treatment.

PAGE 70





Neurologists, emergency medicine specialists, and AWARE researchers reveal the **techniques** they use to **cheat death**—and **revive** those who **seem to have died**.

THINK YOU'RE DYING?



REVERSING DEATH

Some 475,000 Americans die from cardiac arrest each year. According to the American Heart Association, it claims more lives worldwide than prostate cancer, breast cancer, colorectal cancer, HIV, pneumonia, influenza, automobile accidents, firearms, and house fires combined. Time is of the essence when cardiac arrest occurs, but less than half of victims get the immediate help they need. Statistically speaking, for each minute that passes without medical intervention after the onset of cardiac arrest, a victim's chance of survival drops by 7–10%.

NÜI NIUW, YOU'RE NOT!



WHAT HAPPENS WHEN **YOUR** **HEART STOPS BEATING?**

10

MINUTES WITHOUT
BREATHING

Permanent brain damage can begin after only 4 minutes of oxygen deprivation, and death can occur within the 4 to 6 minutes that follow. The longer the oxygen deprivation continues, the more damage it causes. Even if cardiopulmonary resuscitation (CPR) is successful, serious brain damage is likely to have occurred if breathing has been interrupted for very long. Exceptions may be seen in children who have drowned in very cold water: They can survive after 30 minutes or more.



2-4

HOURS ON A MACHINE

Cooling down the heart while it is connected to a heart-lung machine during an operation allows surgeons to work for up to 4 hours without damage to the heart tissue. The blood may be cooled as it passes through the machine, or a cold saline solution may be used to chill the heart.

500,000

HEART OPERATIONS EACH YEAR

Doctors in the United States perform open-heart surgery about half a million times per year. During the procedure, the surgeon makes a large incision in the patient's chest and stops the patient's heart (halting cardiac activity by way of "cardioplegia"), and a heart-lung machine is used to ensure blood circulation continues. A cardioplegia solution is administered intermittently every 15 to 20 minutes at a temperature of just under 40°F. It contains a high concentration of potassium as well as variable amounts of sodium, calcium, and buffer solutions.



arch 2015: Gardell Martin was only two months from his second birthday when he managed to slip away from his brothers while they were playing outside in Mifflinburg, Pennsylvania. Somehow the toddler fell into an icy stream and was swept away by the current, and by the time a neighbor discovered him in the water almost 30 minutes later, he had no pulse and had stopped breathing. His mother, Rose, had already called 911 so an ambulance crew was present on the scene when the boy was found, and they immediately began performing CPR. Efforts to save the boy's life continued during the next hour and 40 minutes as he was taken first to a local hospital and then flown to a trauma center about 25 miles away in Danville. In the ER, doctors put a breathing tube down Gardell's throat and continued CPR as other doctors and nurses inserted an IV to infuse warm fluids into his body, which was at 77°F. They decided to continue

their resuscitation efforts until his temperature reached 90°F and then abandon hope if the boy continued to be unresponsive. The physician in charge there was Dr. Frank Maffei, a pediatric critical care doctor with 23 years of experience. He knew that, objectively, Gardell was dead, but he was determined not to give up. Hospital personnel moved the boy to the operating room so he could be connected to a heart-lung machine. By this time his body had warmed up to 83°F, and they checked once more for a pulse. And then they got a most welcome surprise: There was one—and it was strong! They continued to monitor Gardell for another hour and then moved him to pediatric intensive care. A little over a week later, he was back home playing with his brothers.

CAN PEOPLE BE REVIVED AFTER THEY'VE BEEN DEAD FOR AN HOUR?

"Not if the person is actually dead," says Dr. Maffei. "In my 23 years, this is the only time I've seen this degree of neurological recovery after more than an hour." But what seems like a miracle is actually a matter of simple biology. The key to the boy's survival was the ice-cold water. "Hypothermia imparts a degree of protection from the detrimental effects of low blood flow and low oxygen," explains Maffei. The cold had stopped Gardell's heart and protected his brain, an effect that is sometimes seen in other cases but usually not in one that's this extreme. Doctors have found that even adults can survive without a heartbeat if they are kept cold enough. Dr. Benjamin Abella, the research director at the Center for Resuscitation Science at the University of Pennsylvania, says: "Even in circumstances when people have been clinically dead, they can often be returned to full life and health as long as they were cold enough." ➤



FACTS & FIGURES

39,718

TRANSPLANTS

of various kinds were performed in America in 2019. Some 50% of American adults have signed up as organ donors, and each one can potentially save or enhance the life of more than 100 people.

109,000

PATIENTS

were on a waiting list for a donated organ in late 2020. The greatest donation need was for kidneys (more than 93,000 patients waiting).

10%

OF ALL PEOPLE

report having a near-death experience at some point in life, according to a study that analyzed participants from 35 countries.

In what stages does the body die?

Prior to the SARS-CoV-2 virus (COVID-19), just over 2.8 million people were dying in the United States each year. The three leading causes of death were heart disease, cancer, and accidents. By late 2020, COVID-19 relegated accidents to fourth place. Dying is not usually a rapid process: When people are dying, the body's systems start operating more slowly. People feel tired and want to sleep more and eat less. But even after death occurs, not all parts of the body fail immediately. Sperm, for example, can survive death for several days. Dr. Eric Baccino, a pulmonologist at the University Hospital of Montpellier in France, is convinced that there is no precise biological definition of death.

THE COUNTDOWN OF DYING



8 HOURS

SKIN

Pallor mortis (“the paleness of death”) sets in during the first half hour after a person dies. Blood, which in life gives the body a lively glow, is no longer circulating to the skin’s capillaries. Then comes the postmortem lividity, coloration that appears 30 minutes to 2 hours after death. It results from gravitational movement of blood within the vessels. Because it’s driven by gravity, this coloration is most pronounced in the body parts closest to the ground. Initially bright red, it changes to bluish-purple over 6 to 8 hours.

10 MINUTES

BRAIN

When sudden cardiac arrest occurs, permanent brain damage can result after only 4 minutes without CPR. It takes as little as another 4 to 6 minutes for brain death to happen. The same adenosine triphosphate (ATP) that supplies energy to the muscles also supplies the brain, but when cells die their mitochondria stop generating ATP. Unless CPR is performed quickly, the brain dies.

20 MINUTES

HEART

When the heart stops beating, the body is no longer supplied with the oxygen and nutrients it needs. The heart is also a muscle that must be supplied with blood. It starts dying when the blood supply is cut off and the cardiac muscle is starved of oxygen for more than 5 minutes. As occurs with the other muscles in the body, heart muscle death happens rapidly (within 20 minutes) as tissue adenosine triphosphate drops to very low levels.

48 HOURS

MUSCLES

The body’s muscles become flaccid after death. But after several hours they begin to stiffen, contracting and becoming rigid in a state called rigor mortis (“the stiffness of death”). The progression is largely predictable, which makes rigor mortis useful in determining the body’s time of death. Muscles require energy in the form of adenosine triphosphate (ATP) to function. Once their ATP is depleted, they freeze in the position they’re in. Rigor mortis starts 2 to 6 hours after death and can last for up to 48 hours.

72 HOURS

INTERNAL ORGANS

When circulation stops, the internal organs start to die from lack of blood that supplies oxygen and nutrients. The liver is the first to go, followed by the kidneys. The more energy that is stored in an internal organ, the longer it survives. The stomach and intestines hold out longer, but within 72 hours of death all of the organs start to decompose, and the body begins to emit pungent odors.

SAM PARNIA, cardiologist

WHAT HAPPENS WHEN WE LOSE CONSCIOUSNESS?

The AWARE (short for "AWAreness during REsuscitation") study was conducted over a period of four years and examined 2,060 cardiac arrest events in hospital settings in the U.S., UK, and Australia. Researchers conducted interviews with 140 of the 330 survivors. Some 50% of them reported having memories that involved specific cognitive themes: fear; plants and animals; bright light; persecution and violence; déjà-vu experiences; and family. Of those respondents, 9% reported having a near-death experience (NDE), and 2% described being aware of actual events related to their resuscitation. One even reported

being consciously aware during a period when cerebral function would not have been expected. "We know the brain can't function when the heart has stopped beating, but in one case, conscious awareness appears to have continued for up to three minutes. The man described everything that had happened in the room. He seemed very credible, and everything that he said had happened to him had actually happened," says cardiologist and near-death researcher Sam Parnia of the NYU Langone Medical Center. The study suggests that we can remain conscious of events around us even if consciousness is clinically undetectable.

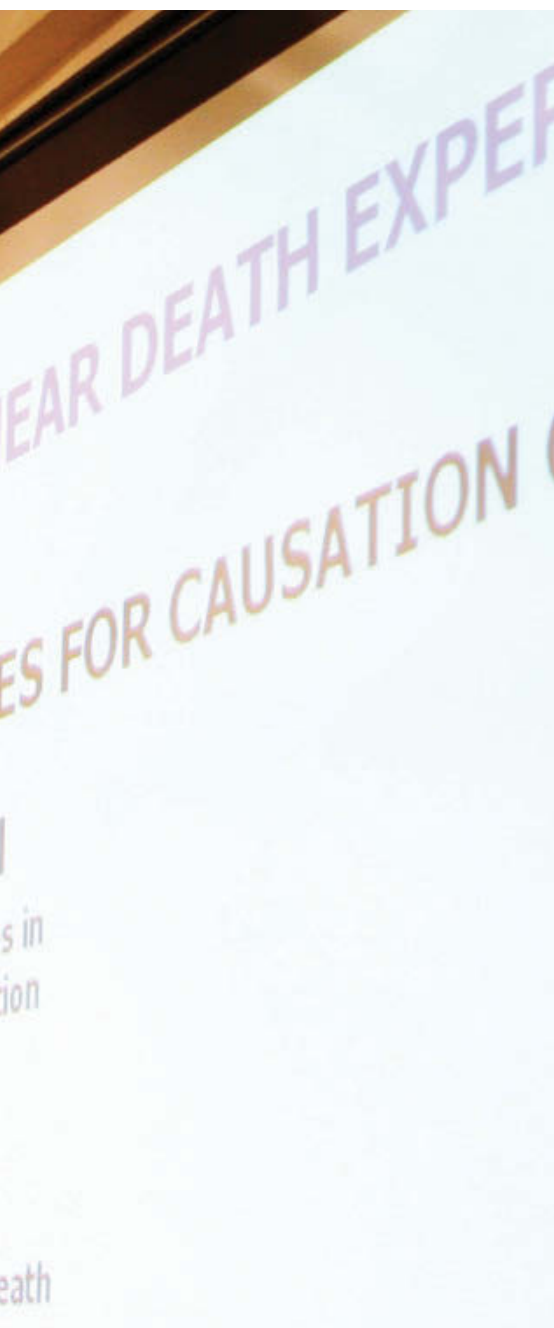


WHY DO N
OCCUR?
- THEORI

• Physiological
Chemical change
brain - hallucina

• Psychological
Anticipation of d
- ? 'Near death'
experience

• Transcendental
True separation o
mind/soul from b



CONSCIOUSNESS AFTER DEATH

British-born Sam Parnia directs the AWARE study. Parnia is an associate professor of medicine and director of research into cardiopulmonary resuscitation at NYU Langone Medical Center. In the UK he is the director of the Human Consciousness Project at the University of Southampton. Parnia is a world-renowned expert on the study of consciousness during cardiac arrest and clinical death.

Hospitals all around the world are experimenting with cooling the bodies of severely ill or injured patients to the point that, practically speaking, they are clinically dead. What may seem like a dangerous procedure is becoming an accepted therapeutic approach. At the forefront of these efforts is Dr. Samuel Tisherman, a professor of surgery at the University of Maryland School of Medicine. His method of “emergency preservation and resuscitation” was first used to lower the temperature of a gunshot victim’s body to preserve vital organs after the patient had gone into cardiac arrest. “Despite very aggressive, very active conventional things that we do to try to save these people, like giving them blood and opening the chest, it just doesn’t work,” says Tisherman. “But if we can cool them down really quickly, we can stop the detrimental processes in the brain and the vital organs and buy time for surgeons to stop the bleeding.” Conventional emergency treatment of a gunshot victim calls for administering blood or electrolyte solutions to keep the patient alive. However if a patient is bleeding profusely, the administered liquids can be lost almost as fast as they are being administered. “It’s a race against time to get the bleeding stopped so you can resuscitate the person before their internal organs are damaged irreversibly due to not having enough blood flow,” explains Tisherman, who hopes his method will solve the problem. Full results of his trials have not yet been released. And a small problem remains...

WHICH SUBSTANCE CAN BE USED TO THWART DEATH?

Loss of blood isn’t the only condition that imperils a patient’s life. Another hazard is the damage to tissues after normal blood flow resumes, as the sudden flood of oxygen (reperfusion)

can permanently damage bodily cells, including those of the heart, resulting in chronic heart failure. Dr. Mark Roth is a biochemist and cell biologist at the Fred Hutchinson Cancer Research Center in Seattle. His area of interest is metabolic flexibility, a process that allows animals such as hibernating bears and rodents to enter and exit a dormant state in winter to protect them against extreme cold. In Roth’s work on suspended animation, he has found that he can use hydrogen sulfide to reduce oxygen consumption to the point that small animals enter a state of near-metabolic shutdown. In searching for materials with similar properties, he turned to the elements selenium, bromine, and iodine. Like hydrogen sulfide, they can affect the metabolic state of an organism. After various experiments to reduce organ damage at low temperatures, Roth settled on sodium iodide: “We have shown that you can intravenously inject the compound into a patient, thereby creating a 75% reduction in damage that would be done to the heart during standard care,” he says.

HOW LONG CAN THE BRAIN SURVIVE AFTER OTHER ORGANS DIE?

These efforts are resulting in more patients surviving. The development is a milestone in modern medicine—and it is changing our definition of death. Currently there are two legal definitions: 1. irreversible cessation of circulatory and respiratory functions; 2. irreversible cessation of all brain functions (“brain death”). These days the most crucial word is “irreversible,” as evidenced by the work of doctors like Mark Roth and Sam Tisherman, who are revising its meaning. The importance of their work has been further underscored by a study at the Yale School of Medicine in which >

researchers revived some functions in the brains of pigs that had been slaughtered four hours earlier. They were able to sustain them for up to another six hours after that by using a system called BrainEx. And other human examples have underscored the reality of these new possibilities. In February 2011, a boat carrying a group of Danish high school students across Præstø Fjord capsized, and the passengers fell into the icy water. It was two hours before paramedics arrived, and by that time the hearts of seven students had stopped beating. Pronounced dead at the scene, they were nevertheless taken to a hospital in Copenhagen, where doctors tried to revive them even though they were technically dead for several hours. The doctors used cardiopulmonary bypass to warm the victims' blood by 1.8°F every 10 minutes. Six hours after "dying," all seven teenagers were alive again.

CAN YOU BRING A DEAD BRAIN BACK TO LIFE?

The head of a U.S. biotechnology company thinks so. Ira Pastor, the CEO of Bioquark, says: "We believe we are quite close to the point where the delineation between coma and irreversible coma or brain death will become blurred." For its ReAnima project, Pastor's company has been granted permission from the National Institutes of Health to work with 20 patients who are clinically dead and being kept alive only by life-support systems. A phase 1 trial is designed to determine if stem cell injections, nerve stimulation, and laser therapy can reverse clinical brain death. "This represents the first trial of its kind and another step toward the eventual reversal of death in our lifetime," says Pastor, adding that the approach combines "biologic regenerative medicine tools with other existing

medical devices typically used for stimulation of the central nervous system." Pastor says the goal is to breathe new life into dead cells.

WILL IT SOMEDAY BE POSSIBLE TO REPLACE A WORN-OUT BODY?

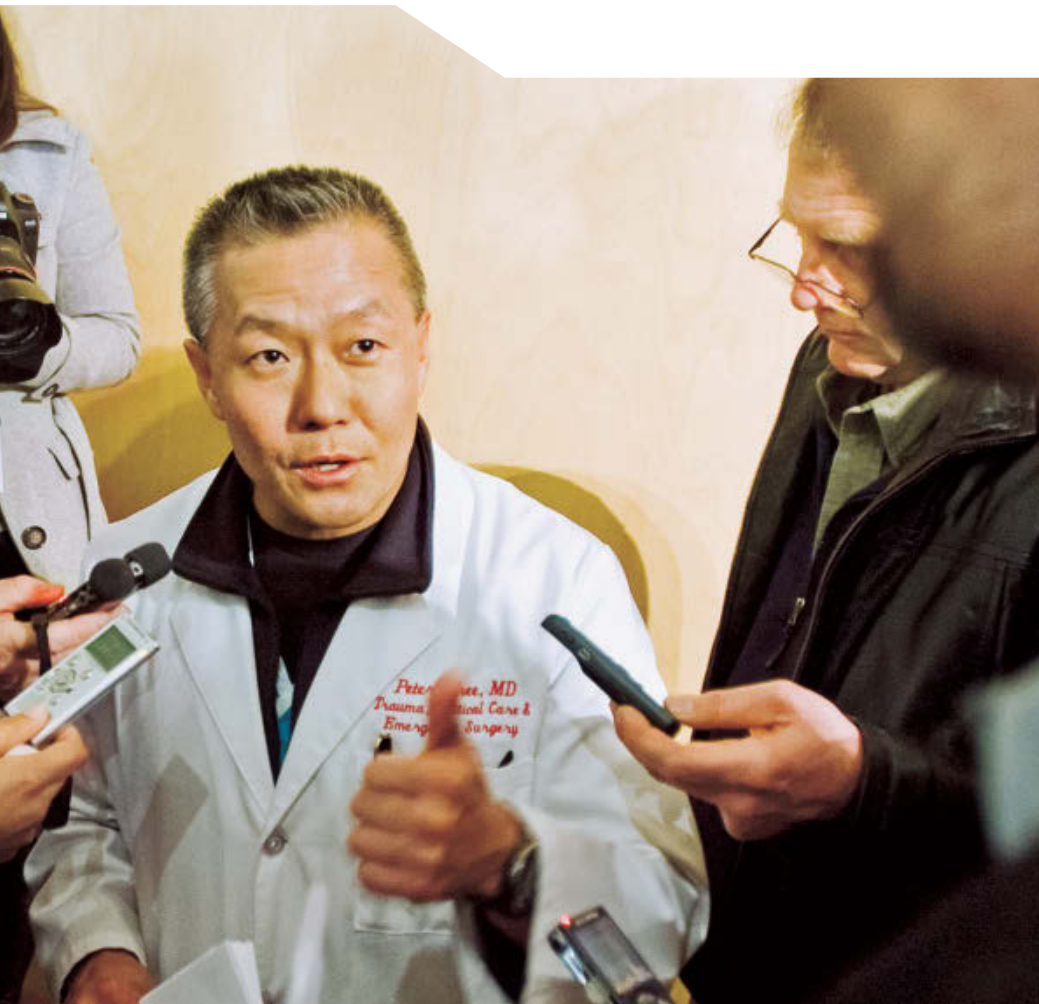
Neurosurgeon Sergio Canavero from the Turin Advanced Neuromodulation Group in Italy thinks so. He is known for claiming the ability to transplant human heads, an assertion that has been met with skepticism in the past from many other neurologists. But in a study published in 2019, Canavero has reported reconnecting the spinal cords of monkeys and dogs after they had been fully severed. In results he and his colleague, Chinese surgeon Ren Xiaoping, describe as medically "unprecedented," the researchers said the animals were able to walk again after their spinal cords were rejoined. Medical ethicists point to regulatory concerns that prevent such a procedure from being performed on a human patient and suggest that was the reason the recent surgeries were performed in China. "China does not have the same ethical standards and requirements that the United States and Europe have," says Assya Pascalev, a biomedical ethicist at Howard University in Washington, D.C. Canavero insisted as recently as 2017 that he'd "soon" perform the world's first human head transplant—in China, since medical communities in both the United States and Europe wouldn't permit the procedure. "They just don't understand," he'd said in a news conference at the time. For a while he even had a human volunteer, a 34-year-old Russian named Valery Spiridonov. Since his birth Spiridonov has suffered from Werdnig-Hoffmann disease, a form of muscular atrophy that prevents him from standing or walking. Feeling it might well be his ➤



AUBREY DE GREY, biomedical gerontologist

SHOULD AGING BE TREATED AS AN ILLNESS?

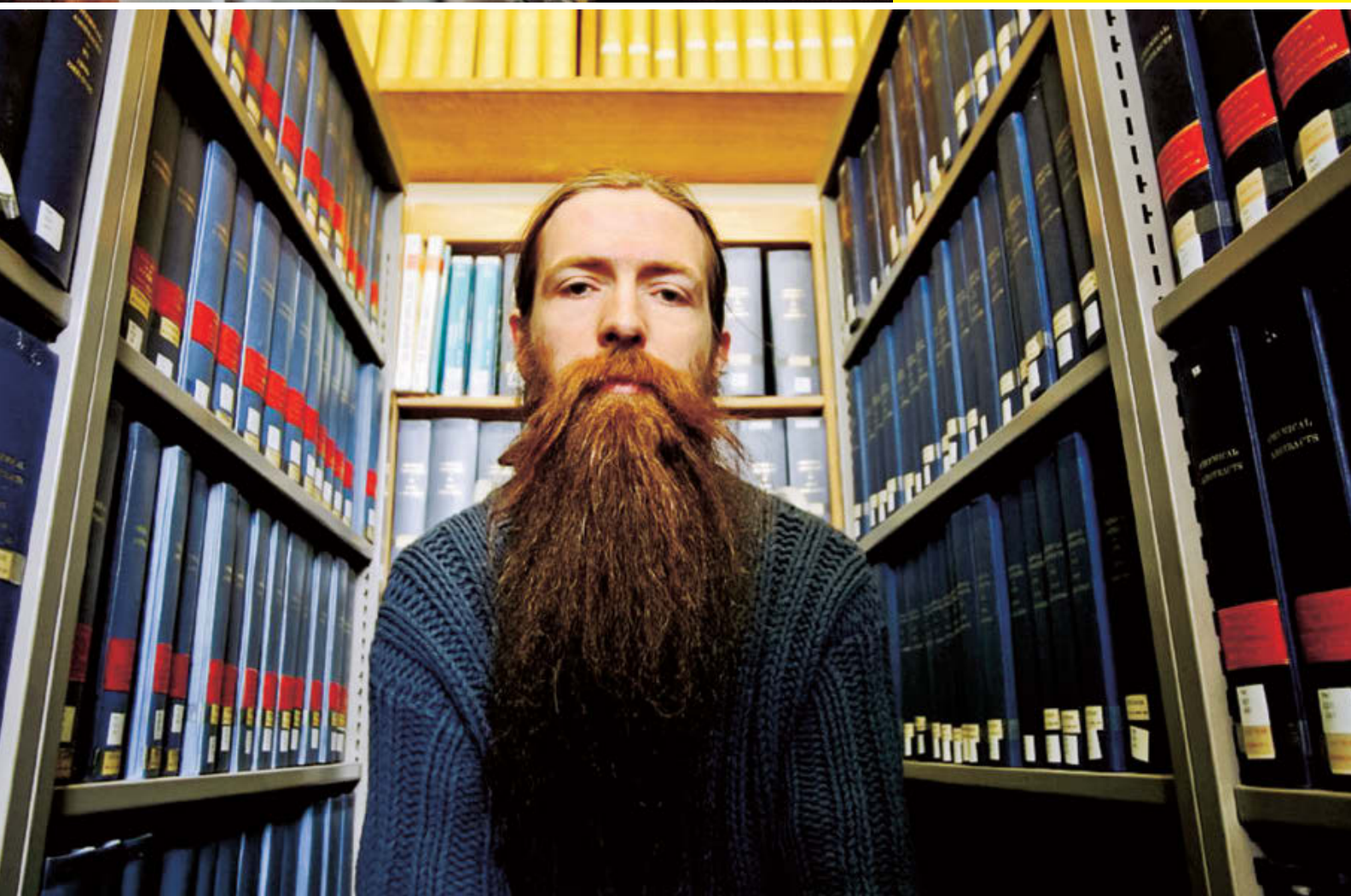
"We should not consider the diseases of old age to be diseases, because they are actually side effects of the life process," says British biomedical gerontologist Aubrey de Grey. He researches ways to manipulate the cells of the human body so that they repair damage by themselves, halting human aging and thus making people virtually immortal. He calls it preventive maintenance. And in his opinion: "It is reasonable to suppose that one could oscillate between being biologically 20 and biologically 25 indefinitely. I have always considered aging to be undesirable."



PETER RHEE,
trauma surgeon

CAN SURVIVAL BE INCREASED TO 100%?

"For a trauma surgeon, car accidents are actually more challenging than shootings or stabbings," says Dr. Peter Rhee, chief of acute care surgery and medical director of the Marcus Trauma Center in Atlanta. He has experimented with chilling animals to put them into suspended animation and then brought them back to life, and he has been successful 90% of the time. At the University of Maryland School of Medicine Dr. Samuel Tisherman has been trying the same thing with severely injured human patients. The full results of his trials are expected at the end of the year.



What are the states of the human brain between wakefulness and sleep?

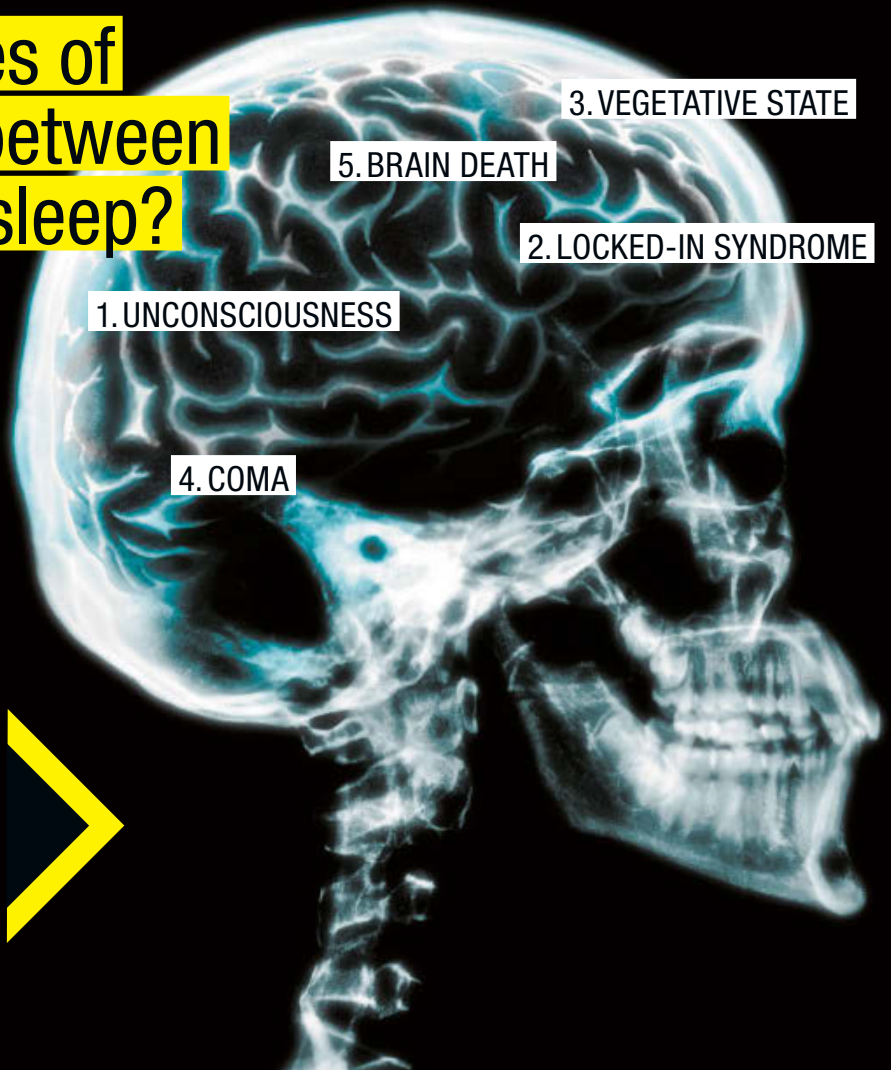
1. UNCONSCIOUSNESS: After 30 to 180 seconds of oxygen deprivation, a person typically loses consciousness, but the body can be trained to go longer. Freediver Aleix Segura once held his breath for just over 24 minutes.

2. LOCKED-IN SYNDROME: In this rare disorder, a patient is conscious and can think and reason but is unable to move any muscles except those that control the eyes. This near-total paralysis can be caused by stroke, brain injury or infection, bleeding, tumors, or an overdose.

3. VEGETATIVE STATE: The person is awake but does not have awareness of the self or the environment nor any cognitive function. The eyes may sometimes be open and some basic reflexes may be intact.

4. COMA: This prolonged state of unconsciousness can be caused by head injury, stroke, brain tumor, intoxication with drugs or alcohol, or an underlying illness. It seldom lasts for more than a few weeks.

5. BRAIN DEATH: "Death based on the absence of all neurologic function" is a legal definition of death. This complete cessation of all brain function cannot be reversed. Brain death is permanent.



best option, Spiridonov volunteered in 2015 to have his head transplanted onto the body of another person. But in 2019 he changed his mind: "I cannot wait for surgery forever, and my condition seems stable," he said, adding that he now has a lot to lose: "I'm married, I have a beautiful child, and I'm in charge of my own company." But while head transplantation is still considered by many to be a virtually impossible surgical procedure, there is a growing interest in the prospect. Writing in the medical journal *Mædica*, neurosurgeons Grigorios Gkasdaris and Theodossios Birbilis suggest that human head transplantation, if it were ever feasible, might offer a life-saving procedure for terminally individuals

whose head and brain are healthy. But they caution that surgical, ethical, and psychosocial issues remain.

Still, medical science has made enormous progress in other forms of transplantation in recent decades. Thus far doctors have successfully transplanted hearts, kidneys, livers, and lungs as well as the intestines, pancreas, thymus, and uterus. Tissue transplants have included tendons, heart valves, nerves, veins, corneas, bones, and skin. And in June of 2015, an 8-year-old Baltimore boy named Zion Harvey received two new hands. Five years later he is able to swing a baseball bat and row a boat. Surgeons have even performed full transplants of the human face.

CAN DOCTORS SIMPLY SWITCH OFF DEATH?

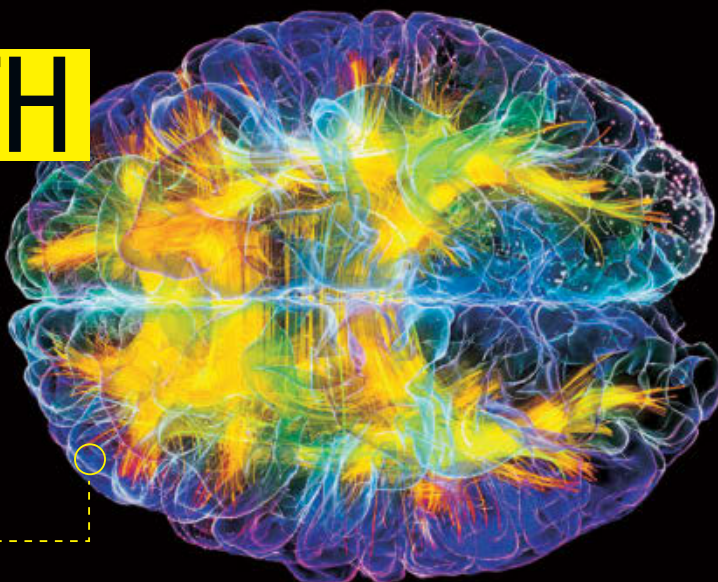
"Soon modern medicine will not be conceivable without the aid of artificial intelligence," says Jochen Werner, the medical director and CEO of Germany's Essen University Hospital. He's envisioning a scenario in which doctors no longer make a diagnosis but instead translate analysis from data collected by medical sensors, smartphones, and fitness trackers into information that a patient can understand. Some devices would be integrated into the patients' bodies to help prevent or treat illness. Much of what was once just science fiction is rapidly becoming a medical reality.

PHENOMENON:

BRAIN DEATH

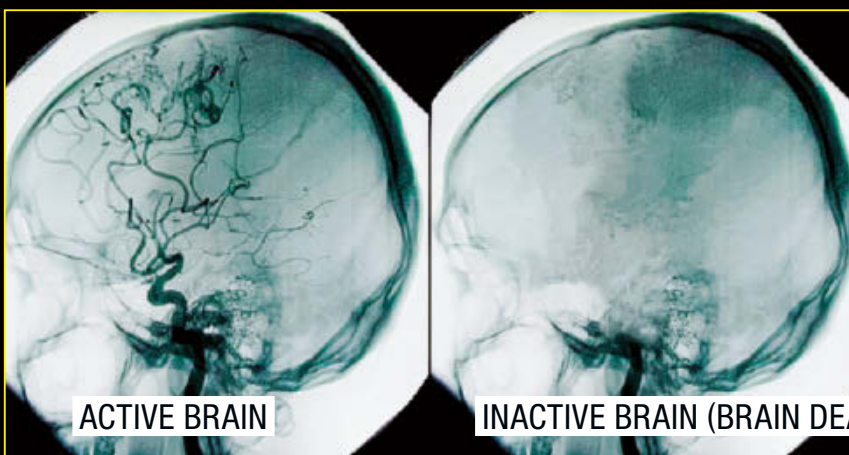
THE LAST SPARK

To decide whether or not a patient is brain dead and thus has actually died, an examining physician conducts a series of tests based on medical guidelines that are legally accepted. These include a physical examination to determine whether the patient still has brain reflexes or is able to breathe on his or her own. A lay person present at such an examination may be disconcerted to see continued twitching or muscle contractions in the patient. These are reflexes that are caused by electrical impulses that remain in the body even after the brain has died.



DECLARED DEAD

Drugs such as muscle relaxants and sedatives can mask brain function, so other tests may be needed if those are present in the body. While tests are being performed, the patient is placed on a ventilator, which takes over the task of breathing. The physician may also administer medications that maintain blood pressure and other bodily functions. Everything possible is done to save the patient's life before brain death is confirmed. A diagnosis of brain death means there is no chance of recovery, and the patient is declared dead. A contrast medium injected into the bloodstream shows blood supply (left) and the lack thereof (right).



ACTIVE BRAIN

INACTIVE BRAIN (BRAIN DEATH)

For example, Ohio State University researchers have developed a chip that can be applied to skin to convert the skin cells into elements of any organ of the body. This new tissue nanotransfection (TNT) technology can generate any cell type needed for treatment and can be used to repair injured tissue or restore the function of aging tissue, which can include organs, nerve cells, or blood vessels. Dr. Chandan Sen, director of Ohio State University's Center for Regenerative Medicine & Cell-Based Therapies, says, "We've successfully shown that the skin can be a fertile land where we can grow any cell type for a failing organ." In experiments with mice and pigs, Sen's team has

reprogrammed skin cells to become vascular cells in the animals' injured legs to restore the flow of blood. The scientists have also reprogrammed skin cells into nerve cells that they injected into mice with brain injuries to help them recover from a stroke. The day may still be a long way off, but Sen hopes TNT will be used to treat a variety of human conditions. The device he uses is no bigger than a cufflink. When it is placed on living skin and activated, it sends a small electrical current to cell membranes, opening a tiny window on the surface. The chip then shoots a new genetic code through this window into the cells, where it starts reprogramming the cells to take on their new role.

The process lasts less than a second, and it successfully delivers its genetic payload 98% of the time. "No other gene-delivery technique can deliver comparable efficiency," asserts Sen. "That is our triumph."

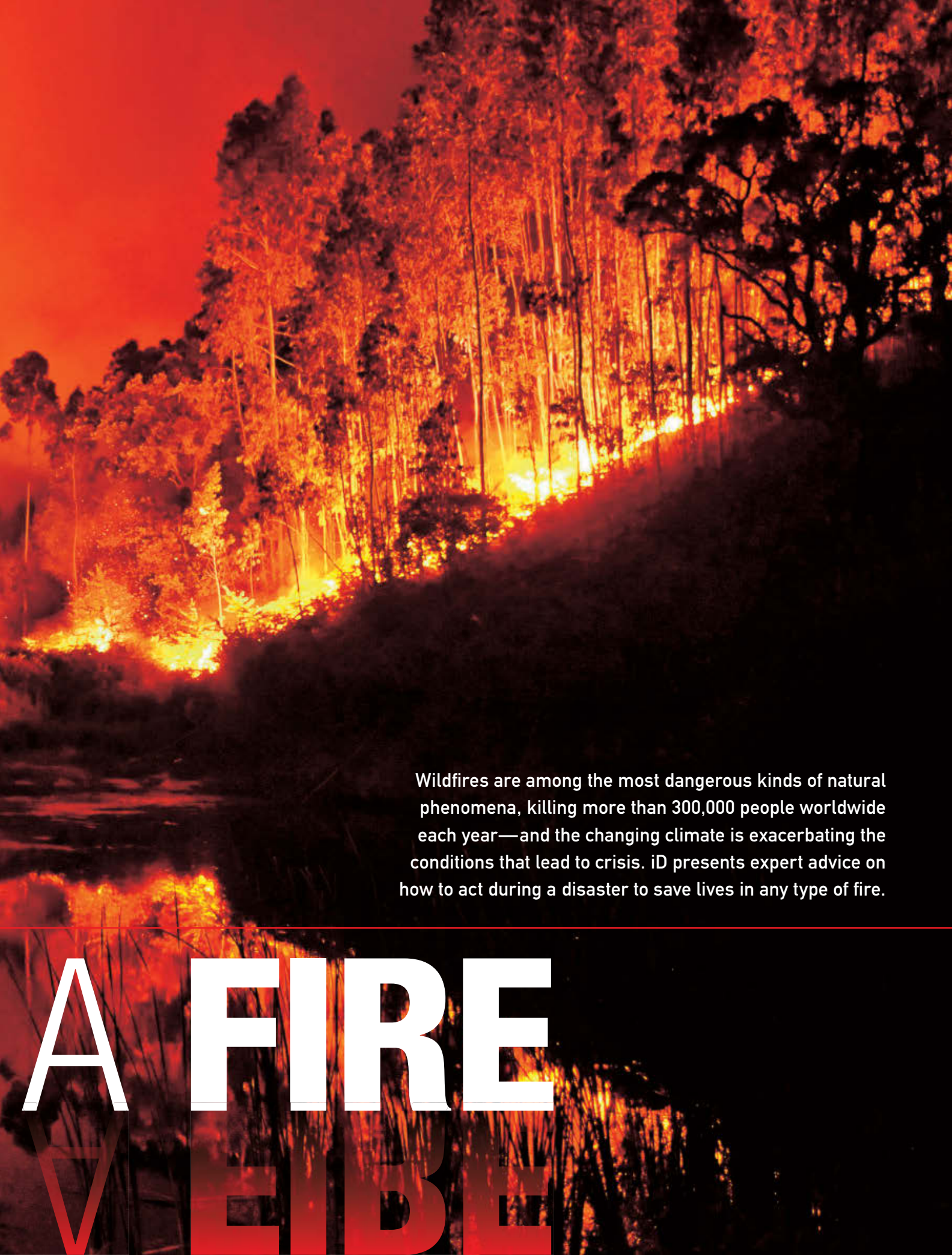
If this therapy is as promising as it seems, science may be a step closer to eliminating death: The body could be tricked into repeatedly repairing the damage caused by aging. In the future, people would no longer have to die just because their bodies are old. Instead, aging would be treated like any other illness. Gerontologist Aubrey de Grey believes if aging can be "cured," people could live to be a thousand years old. But the question remains: Would they really want to?

WHAT TO DO

SURROUNDED BY FLAMES

On June 17, 2017, four deadly fires broke out in the District of Leiria in Central Portugal, killing 66 people and injuring more than 200 others. Many burned to death in their cars as they tried to flee from the municipality of Pedrógão Grande. Around 130,000 acres of land were also destroyed.

IN



Wildfires are among the most dangerous kinds of natural phenomena, killing more than 300,000 people worldwide each year—and the changing climate is exacerbating the conditions that lead to crisis. iD presents expert advice on how to act during a disaster to save lives in any type of fire.

A FIRE EVIDENCE

INTERVIEW



WHAT DO YOU DO IF YOU'RE CAUGHT IN A FIRE?

LIFE-SAVING TIPS FROM KARL-HEINZ KNORR, FIRE DEPARTMENT DIRECTOR IN BREMEN, GERMANY

Worldwide more than 300,000 people will be killed by a forest fire this year. But what can you do to survive the flames if you ever encounter one? Who better to answer than Karl-Heinz Knorr, a physicist who is also the director of the fire department in Bremen, Germany, as well as the vice president of his heavily forested country's Fire Service Association. Here he explains what to do if a fire breaks out.

What are the three most serious mistakes you can make if you're threatened by a forest fire?

Things can happen very quickly when a fire has broken out, and oftentimes if a person is not prepared for such an event, tragic errors can be made. First, people tend to underestimate the danger and speed of a spreading fire. Second, they might wait too long to evacuate because they're trying to protect property or gather belongings. And the third mistake: panicking.

If you're fleeing from a fire in your car, should you drive through it? How fast can a fire move if it's driven by wind?

You can try to drive through if that appears to be the only avenue of escape, but it's very risky. Fires that are driven by wind can spread very quickly, depending on the vegetation and topography: up to 6 miles per hour in forests and 14 miles per hour in grasslands. But you also have to consider that an internal combustion engine can fail when the air is full of smoke, which can clog the air filter. »



2,000°F

AN UPHILL BATTLE

The heat of a wildfire can melt roads, set asphalt on fire, and turn sand into glass. One-third of U.S. homes are located in areas that border flammable open spaces, so in addition to dealing with the dangers of the forest, wildfire fighters must increasingly contend with threats such as fuel tanks and power lines. So protecting populated places puts these firefighters at greater risk.



Record-Breaking Devastation

California's 2020 wildfire season was its worst ever, more than doubling the record 1.7 million acres that burned in 2018. The 2020 fires consumed a woodland area larger than the state of Connecticut, destroying thousands of structures, killing dozens of people, and displacing tens of thousands more. And it wasn't just California: Firefighters battled huge blazes in 11 states from Oregon to Missouri and Montana to New Mexico. Lightning ignited many of the fires, but climate change makes fire conditions worse. (In fact, the Northern Hemisphere had its hottest summer ever.) Because the government is currently doing little to mitigate the climate crisis, and since fires are a threat to people all over the world no matter if they break out in a woodland area or in an urban building, it's more important than ever to know how to protect yourself in case of fire.





72

FATALITIES

COMBUSTIBLE

The fire at London's Grenfell Towers apartment building killed 72 people in June of 2017. After the fire began in a refrigerator on the fourth floor, a smoke alarm woke the apartment's occupant, who immediately phoned the fire brigade. They arrived just five minutes later, but despite their prompt response, the firefighters lost control when the fire spread to the outside cladding of the building.

DIFFICULT TO

ESCAPE

DEATH TRAP

When the fire started some time after midnight, most of the Grenfell Towers residents were asleep. Because of the warm weather many windows were open, so when the building's cladding caught fire, the flames and smoke spread quickly.

Most of the 600 residents were able to flee, and the fire brigade rescued scores of those who remained, but ultimately 72 people died.



Is it logical to take off your clothes to keep them from catching fire?

No. If it's hot enough to burn clothing, it's also hot enough to burn bare skin.

Does a lake offer any protection?

It can, depending on the size of the lake: the bigger the better. But even in the water, you must consider the danger of smoke inhalation.

How about trees? Should you climb one to get away from the fire?

That's only an option if the fire isn't fierce enough to set the tree on fire. And you'd have to choose a strong, tall tree. But if the fire is that small, you should consider fleeing instead.

What about house fires? How can I tell if it's safe to stay in the house and wait for help or better to try to escape?

There's no hard and fast rule on this. Basically, it's always better to get out of a burning building if you can do so at little risk. That means ascertaining whether the escape route—especially if stairs are involved—is smoke-free. If the escape route is smoky then any attempt will be risky, but it might still be possible if you only have to go up or down one or two stories. Smoke is highly toxic and sometimes even a few breaths can cause you to lose consciousness. If your escape route is more than a little smoky, you have to stay where you are.

Should I open windows?

Yes, if you need to alert firefighters to your presence in the building. No, if it allows toxic smoke to enter the room. In modern high-rise buildings, the windows often can't be opened.

Will a damp cloth protect me from inhaling smoke?

Only for a short time, and only from the soot. A damp cloth cannot keep out the toxic gases, such as carbon monoxide and hydrogen cyanide.

Does a bathtub full of water offer protection?

Not really. Water can't protect you from toxic smoke, and the water can become very hot. And in any case, you have to keep your head out of the water to breathe.

If there is smoke in the room, should you lie face-down on the floor?

Yes. That's where the air is safest, and it also makes it easier to find the exit so you can flee. But don't just lie there: Crawl to the exit.

People sometimes jump out of a window when they can find no other means of escape. Can firefighters catch them in a rescue net?

They used to, but they were limited by the height from which people could safely jump. Rescue nets often failed >>

WHAT SAFETY PROTOCOLS SHOULD I FOLLOW IF A FIRE BREAKS OUT INSIDE A TALL BUILDING?

Get down and start crawling.



Flee to a lower level, if possible.



Put out the fire if you can.



Don't use the elevator.



Report the emergency.



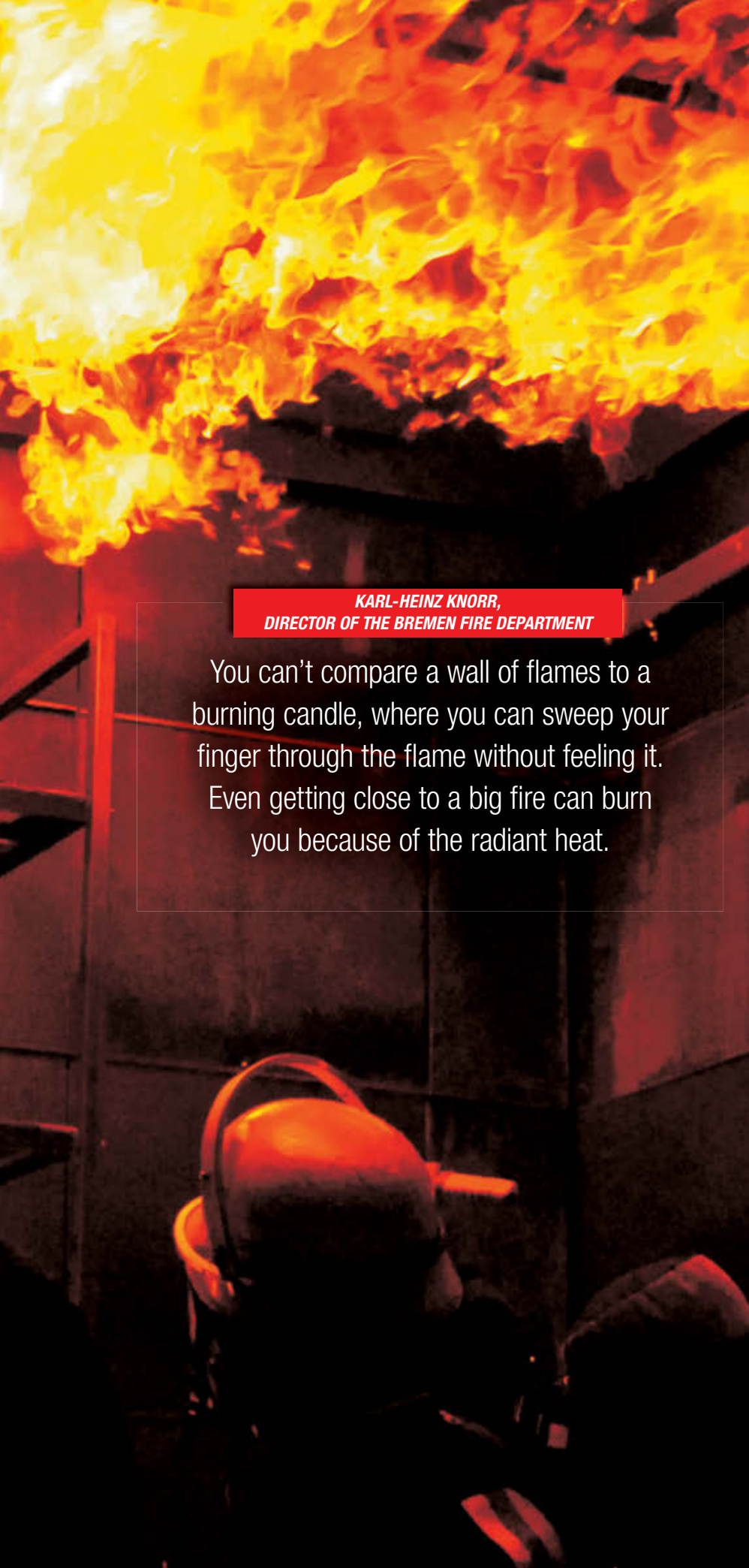
Activate the fire alarm.



HOW DO I ESCAPE FROM A BURNING BUILDING?

Research has shown that most people stop to get their jewelry and other valuable items before they flee from a burning building. Experts warn such delays cost lives. You should head straight to the nearest exit. If you're going up or down stairs, hold on tightly to the railing to avoid being knocked down by others. Open doors slowly and carefully—and shut them immediately if there is thick smoke on the other side. Never try to run through a wall of flames. If you cannot escape from a room, seal off the cracks around the door and any other openings as best you can with damp pieces of fabric like towels or sheets to keep out the smoke.





**KARL-HEINZ KNORR,
DIRECTOR OF THE BREMEN FIRE DEPARTMENT**

You can't compare a wall of flames to a burning candle, where you can sweep your finger through the flame without feeling it. Even getting close to a big fire can burn you because of the radiant heat.

to save people, and firefighters have sometimes been injured or killed when trying to catch someone. Rescue nets have largely been replaced by ladder trucks in cases where the ladders are long enough. Some fire departments now use inflatable rescue cushions when a ladder truck is not available. These can be set up in minutes and used to rescue a person who jumps from as high as the ninth floor of a high-rise building.

What about the range of a ladder truck?

The ladders are able to reach as high as 100 feet in the air. However modern skyscrapers are designed to protect people in case of fire and allow them to escape safely.

If you're caught in a building fire, should you go to the roof if you can?

This isn't a guaranteed solution, but in a desperate situation it might save you. The roof offers the advantage of outside air, and there may be a side of the roof that's kept free of smoke by the wind.

Is it possible to run through a wall of fire if you do it fast enough?

You can't compare a wall of flames to a burning candle, where you can sweep your finger through the flame without feeling it. Even getting close to a big fire can burn you because of the radiant heat. So Hollywood's take on this is false: It's a hazardous undertaking—even more so because of the danger of smoke inhalation.

PHOTOS: Getty Images; Frederic J. Brown/Contributor/Getty Image; Feuerwehr Dortmund.

HOW **DANGEROUS** IS A SMART HOME?

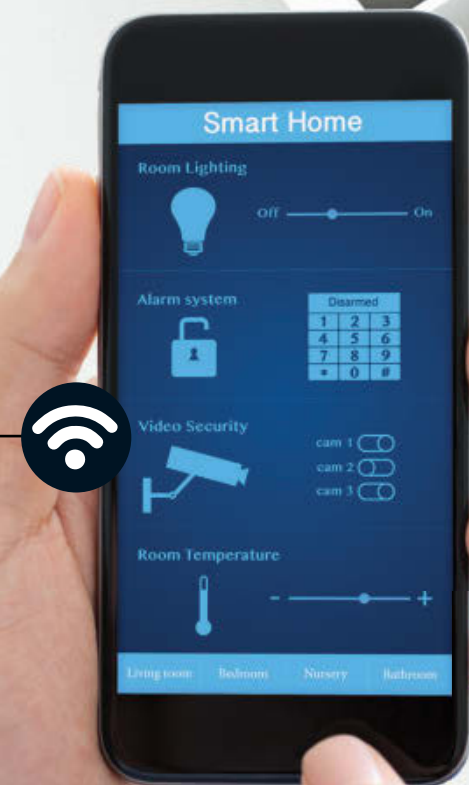
Turning on the heat in your house on your way home, switching on the lights by voice command, or talking to your friends via your TV—the Internet of Things (IoT) makes all of that possible. But incautious users can unwittingly open their home's doors to hackers and other intruders. In the interview that follows, IT security expert Michael Steigerwald reveals the hidden dangers of a “digital home.”

VULNERABLE BABY MONITOR

Nathan and Ellen Rigney of Houston, Texas, were awakened by a beeping sound from the baby monitor in their little boy's room. Then a voice said, “I'm in your baby's room. I'm going to kidnap your kid.” Nathan rushed upstairs to find the 4-month-old alone and fast asleep. That's when the couple realized the baby monitor had been hacked, and someone was remotely trying to frighten them out of their wits. Nathan immediately notified police, but security experts warn that the threat is ever-present: Many baby monitors are equipped with outdated software that makes such an attack a very real possibility.

DEVIUS APPS

For some time now, controversy has been swirling around FaceApp, a photo-editing application that uses artificial intelligence to transform faces, applying filters to make them look older or younger or even changing the gender. While FaceApp may not be doing anything unusual with the data it collects, there are imposter apps that masquerade as a premium version of the program and can prompt the installation of additional malicious apps. Plenty of other apps are also imitated by fakes. Real problems can occur with fraudulent apps that users download to a phone or computer, unaware that they may contain malware that could provide foreign access to all of the devices on a user's network. That can expose sensitive data such as passwords, personal photos, and financial information.





AN OPEN DOOR FOR BURGLARS

Tired of searching for your keys at the front door? Install a smart lock and it need never happen again. Connected to the Internet, the lock allows you to open the door remotely and promises secure flexibility. But just how secure is it? Researchers recently discovered they could open one popular brand of smart lock with nothing more than the user's MAC (media access control) address. And it wasn't hard to get, because the lock was broadcasting the data. Of course, conventional locks can be picked, and it may well be easier to acquire that skill than it is to hack an IoT device. The lock loophole the researchers hacked has since been patched, but as the incident shows, where there's a will, there's a way: Think twice before installing a smart lock.

TROJAN TV

Modern TVs are connected to the Internet and are equipped with a camera and microphone to enable videotelephony. That makes them a popular target for hackers, who can use them to stream a live feed from your living room without your knowledge. But you can take steps to secure your TV: Use a wired connection or choose a strong password for your router, select restrictive options during setup, and update your system regularly. And if you're not using them, cover the TV camera and turn off the microphone.

GOOD LISTENER

"Monsieur Cuisine" is a WiFi-enabled food processor that's designed to respond to voice commands. But two French netizens discovered that the microphone in the device could be used by hackers to listen in to users' kitchens without their knowledge. The company that distributes the device says the microphone is inactive and impossible to activate remotely, but a couple of home chefs found otherwise.

ILLUMINATING SECRET AGENT

Trying to keep your personal information private? It isn't easy if you have a smart light bulb in your home. Models that are infrared-enabled can be hacked to gain control of the user's home network. That gives the hacker access to data such as text messages, photos, and videos anywhere on the user's network. Researchers say the bulbs are tiny, vulnerable computers. To demonstrate the risk, they hacked into smart light bulbs from distances of around 150 feet, and they say longer-distance hacks may be possible.

TATTLETALE WATER METER

Hackers who gain access to a digital residential water meter can spy on water usage in a home, giving them a clear indication of the daily routines of the inhabitants. If no water has been used for 24 hours, it suggests the owners are away. If none is used between early morning and early evening, it suggests the occupants are at work and no one is home—making for an ideal window of time for a burglary.

INTERVIEW WITH IT SECURITY PRO MICHAEL STEIGERWALD

YOU'VE BEEN STUDYING SMART HOMES FOR YEARS. WOULD YOU DEFINE THE TERM FOR US?

In general, a home would be called “smart” if you’re using a smartphone to control other devices in the home. If you have your phone and a printer connected to your network and you print from your phone, you’re living in a smart home. But the term hasn’t been clearly defined, and that creates a problem: Many people are unaware they are even living in a smart home. That’s why I would rather use the term “digital home,” which is more readily understood. In industrialized nations many homes these days are smart.

IS A LACK OF AWARENESS THE PROBLEM?

The real problem is the way we use the Internet today. Twenty years ago, if you wanted to access the Internet, your computer needed a modem. For those too young to remember, dial-up modems were boxes that were linked to your computer and to a phone line that could transmit data over ordinary voice lines. In the 1990s, most people used a dial-up modem to access the Internet. Things are different today. Most home networks have a router that provides an Internet connection for all of the devices on the network. The tech was originally developed for small and medium-size businesses, where it made sense for all of the devices to be interconnected on the same network. If a company was big enough, there would usually be an IT department to oversee the installation and maintenance of the network. You

don’t usually have a network expert in your home. You plug it all in and hope it works. But that means your smart bulb might be communicating with your printer or has access to the server where your private information is stored. The real problem is that these sorts of cross-connections are not immediately apparent, and most users are unaware of them. I can’t tell whether or not my light bulb is accessing my data and sending it out over the Internet. For many users, smart household appliances remain a mystery. For the most part, we have no idea what they’re doing, how much data they’re collecting, and what they are doing with it.

HOW IMPORTANT IS DATA TODAY?

In today’s world, data is everything. Take the fastest-growing companies: They all either collect or market data. Nowadays it’s practically impossible not to reveal personal data while using services. That makes it all the more important to regulate how companies use data. If I use Google Maps to get from point A to point B, for example, I’m providing Google with information about my location in exchange for a highly reliable navigation system. The user is obtaining something in return for providing personal data. Question is: How fair is the transaction? How much data is the company getting, and just what am I getting in return? From an objective point of view, the transactions will often benefit the company more than the user, and in some cases you might even consider the relationship to be exploitative. In the long term, there is no way we can

prevent data from being exploited. But we can consider our data to be a type of currency. Each time that we engage in a transaction, we can ask ourselves how much we’re prepared to pay for the benefit we derive.

ARE COMPANIES USING OUR SMART HOMES TO STEAL OUR PERSONAL INFORMATION?

One of the huge problems today is the speed at which new electronic products are entering the market: Often products are released before they’re fully mature. Part of that is the result of antiquated operating systems that contain security vulnerabilities. It takes expensive, time-consuming testing to be able to prevent security weaknesses. That’s why you should try to buy new products only from companies that do intensive testing. Generally speaking, you should pay close attention to the manufacturer’s reputation when you’re buying Web-enabled devices. I don’t want to imply that most companies are trying to collect our data illegally, but there are black sheep out there. Some of them lure buyers by selling their products at a very low price and then make up the difference by exploiting our data. And that’s a problem I expect to see growing further in the coming years.

SO WEB-ENABLED DEVICES CAN SOMETIMES BE A TRAP?

There have been some cases where second-hand Internet devices have been sold with malware pre-installed. When users connect such “bargains” to their home network, then the data piracy begins. That’s why I’d generally advise against buying second-hand equipment—though similar problems have sometimes been reported with new hardware as well. I am aware of a number of cases in which criminals have taken advantage of the return

policies of Amazon and other mail-order companies to infect hardware. The crooks purchased quantities of equipment and carefully unwrapped it, infected it with malware, repacked it, and returned it all to the mail-order company. When the returned goods are later resold, the buyers have no idea what's inside. By the way, the same kind of thing can happen on a production line. There are sometimes employees who—despite stringent security precautions—are willing to risk their job to make extra money by infecting electronic products with malware. And so there's always the possibility that a production run that

is safe on the whole will contain a few ticking time bombs. The most likely targets are smart TVs, tablets, and smartphones—devices that connect to the Internet. Yet another potential source of contamination is software for apps that a user must download. Devices like food processors tend to be safer since they're unlikely to be updated, and if they are, the software comes right from the manufacturer.

ARE THERE ANY TYPES OF DEVICES YOU'D ADVISE AGAINST?

Not really. The truth is, you can have a problem with any product group.

I have witnessed experts hack into networks for demonstration purposes and they managed to gain access by using printers made by some of the most well-known of manufacturers. There can be bugs and vulnerabilities in any device with a microprocessor inside of it that's also Web-enabled. A hacker who has the knowledge and the tools to exploit the vulnerability can quickly gain access to any such device and therefore to the entire network to which it's connected.

HOW CAN I PROTECT MYSELF AND MY NETWORK FROM MALICIOUS ACTORS?

Wherever there's a door, there will always be somebody who wants to find a way in. The first step to protect yourself from intruders is to be careful about the way you use Web-enabled devices and data. We need to educate people about the possible dangers and consequences. Every day I see people being careless with their data while on the Internet. Young people in particular are often unaware of the consequences of letting questionable actors have access to their personal data and their photos. Smart homes should be protected by a firewall and a good router with a strong password. That acts as a digital doorman and bouncer to keep suspicious data from entering the home from the outside. Internet devices in a smart home can communicate with the outside world, and the data stream is flowing in both directions. That can provide access to fraudsters. So the most effective prevention against concealed data collectors is transparency. Thanks to modern hardware, you can make all your network's data streams visible. So a user can know what information is being sent from the smart home to the outside world and which device is sending it. When it's used correctly, this can make a digital home secure.

TRANSPARENCY KEEPS US SAFE

Digital security specialist Michael Steigerwald is the cofounder and managing director of the IT security company VTRUST, which makes IoT security products for private users. It's active in education regarding matters of data security, protection, and ethics and also offers training, consulting, and research for IoT manufacturers.



id questions

Ask a simple question, get a simple answer? Think again! Scientists often have to work meticulously to come up with explanations for basic processes—and sometimes they inadvertently discover marvels that can change our perception of the world.

In 2019 scientists used a drone for the first time to obtain detailed aerial images of humpback whales employing their bubble-net feeding technique off the southern portion of Alaska's coast.



DO YOU HAVE A QUESTION FOR OUR TEAM OF EXPERTS?

Just send us an email!
questions@ideasanddiscoveries.com

HOW DO YOU CONSTRUCT A CAGE OUT OF THE AIR?

Up to 60 feet long and weighing in at up to 40 tons, the humpback whale (*Megaptera novaeangliae*) is among the giants of the seas. But the main constituents of its diet—plankton, fish, and krill—are relatively tiny, so it needs a lot of them to get the 4,400–5,500 pounds of food the average-size humpback whale consumes in a day. But these whales don't have to hunt on their own: They use teamwork to ensure they get their daily fill, rounding up huge masses of prey in a maneuver called bubble-net feeding. When a hunting pod of humpback whales finds a large concentration of prey, the whales form a big, shrinking circle about 50 feet underwater and then blow a wall of bubbles upward (photo #1). As the cylindrical wall of air they've created progressively shrinks and rises to the surface (photo #2), krill and fish are unable to break out of it, remaining trapped inside until they reach the surface. Then the whales dive again, returning to the surface through the mass of prey with their mouths open to partake of a hearty meal (photo #3) from the cage they've created. A whale feeds by first taking in water filled with prey and then pushing the water out through the filter system of its baleen bristles (photo #4), which are arranged like a sieve of vertical blinds across its upper jaw.



HOW DO WHALES BUILD A BUBBLE CAGE? //////////////////////////////////////



The hunt begins when a pod of humpback whales finds a school of krill or fish. First the whales dive beneath their prey, and then some of them blow bubbles to create a cage, some herd the prey into the cage, and others dive deeper to drive the prey toward the surface. When the whales swim upward through the cage with their mouths agape, they can swallow thousands of prey in one gulp, expelling the excess water through their baleen plates. The whales vocalize as they decide which individuals will be assigned to which task. Analysis of the swimming maneuver shows humpback whales swim in a double loop when they are hunting, making the first loop as they encircle their prey and the second as they rise to devour their meal.

WHO'S BEHIND THE WHEEL?

No one—at least no human driver. This car comes equipped with an artificial intelligence device that's programmed by each competing team before a race. "Roborace" is the name chosen for the world's first racing series for autonomous electric vehicles. All teams use identical cars, but each controls its vehicle with AI algorithms that are developed individually. The British company behind the Roborace series had introduced its first self-driving racing vehicle in early 2017. The 1-ton car is equipped with four 300 kW motors—one for each wheel—that are designed to propel the vehicle at high speeds. The 2019 Season Alpha was staged

at locations in Europe and North America. That year Robocar set a Guinness World Record for the world's fastest autonomous car, reaching just over 175 miles per hour. The 2020–21 season was initially delayed due to COVID-19 concerns, but the new schedule shows six events with 12 races.

×
300kW

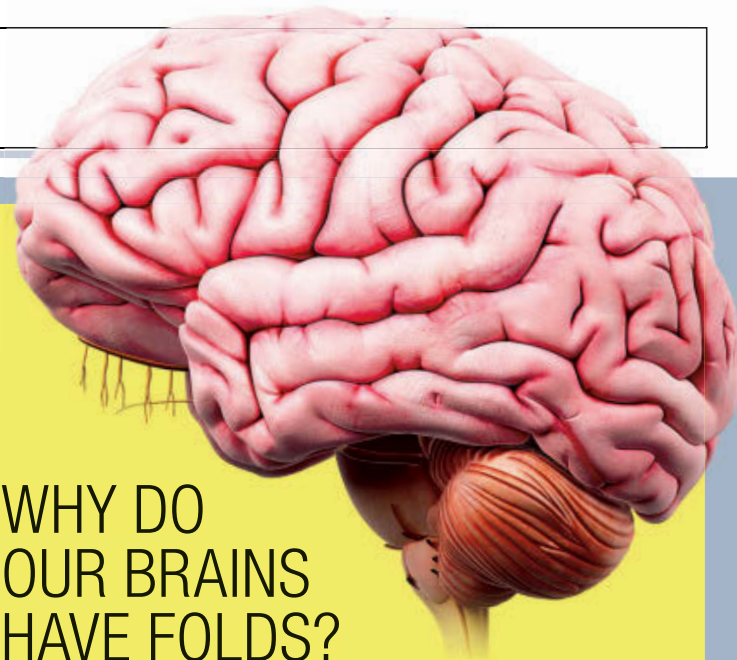
is the output of each of the four electric motors on this Robocar model, which weighs about a ton and is designed to hit up to 199 mph.





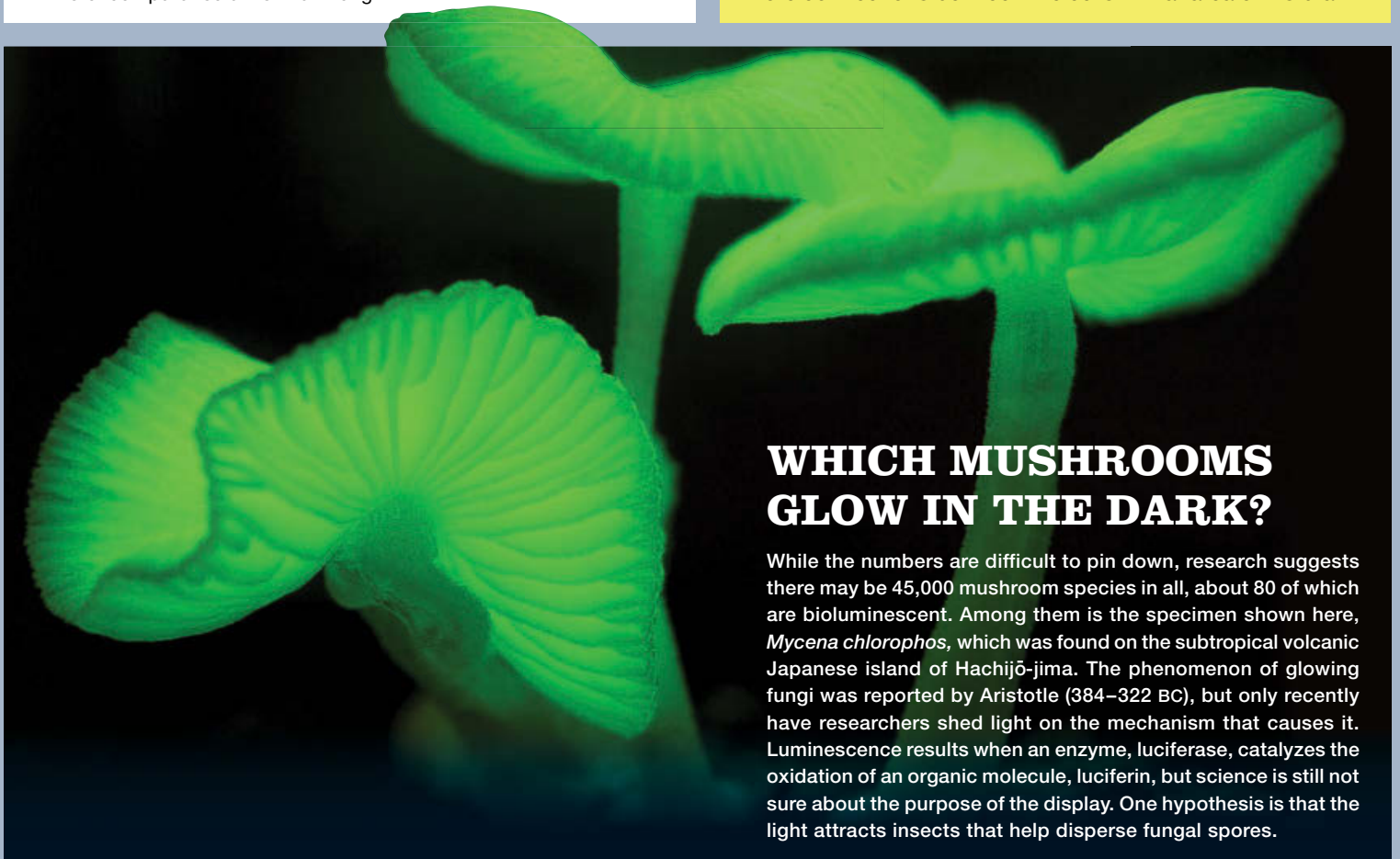
Can you **touch** and **feel** a **hologram**?

Researchers at the University of Bristol in the UK have developed a method that uses ultrasound to make 3-D holograms tangible. That means people can not only see a hologram in midair: They can actually touch and feel it. The technology focuses ultrasound on the hands of a person seeking to touch a visible 3-D hologram, and the disturbance in the air creates haptic feedback, supplying the sensation of touching the object that's being seen. The practical applications are important: "People could feel holograms of objects that would not otherwise be touchable, to tell the differences between materials in a CT scan or understand the shapes of artifacts in a museum," says University of Bristol computer scientist Ben Long.



WHY DO OUR BRAINS HAVE FOLDS?

The human brain is convoluted for a simple reason: space. Cognitive activity occurs in the surface layers of the cerebral cortex, and the folds of human brains provide greater surface area, which allows for increased brainpower in a limited area. During evolution, brain size developed more quickly than skull size, and the structure of grooves and folds allowed a bigger brain to be packed into a smaller container. Interestingly, Einstein's brain did not have any fissure in the region that is involved in mathematical thinking. Some neurologists theorize that the lack of a groove allowed Einstein's brain to establish more connections between the cells in that area of his brain.



WHICH MUSHROOMS GLOW IN THE DARK?

While the numbers are difficult to pin down, research suggests there may be 45,000 mushroom species in all, about 80 of which are bioluminescent. Among them is the specimen shown here, *Mycena chlorophos*, which was found on the subtropical volcanic Japanese island of Hachijō-jima. The phenomenon of glowing fungi was reported by Aristotle (384–322 BC), but only recently have researchers shed light on the mechanism that causes it. Luminescence results when an enzyme, luciferase, catalyzes the oxidation of an organic molecule, luciferin, but science is still not sure about the purpose of the display. One hypothesis is that the light attracts insects that help disperse fungal spores.

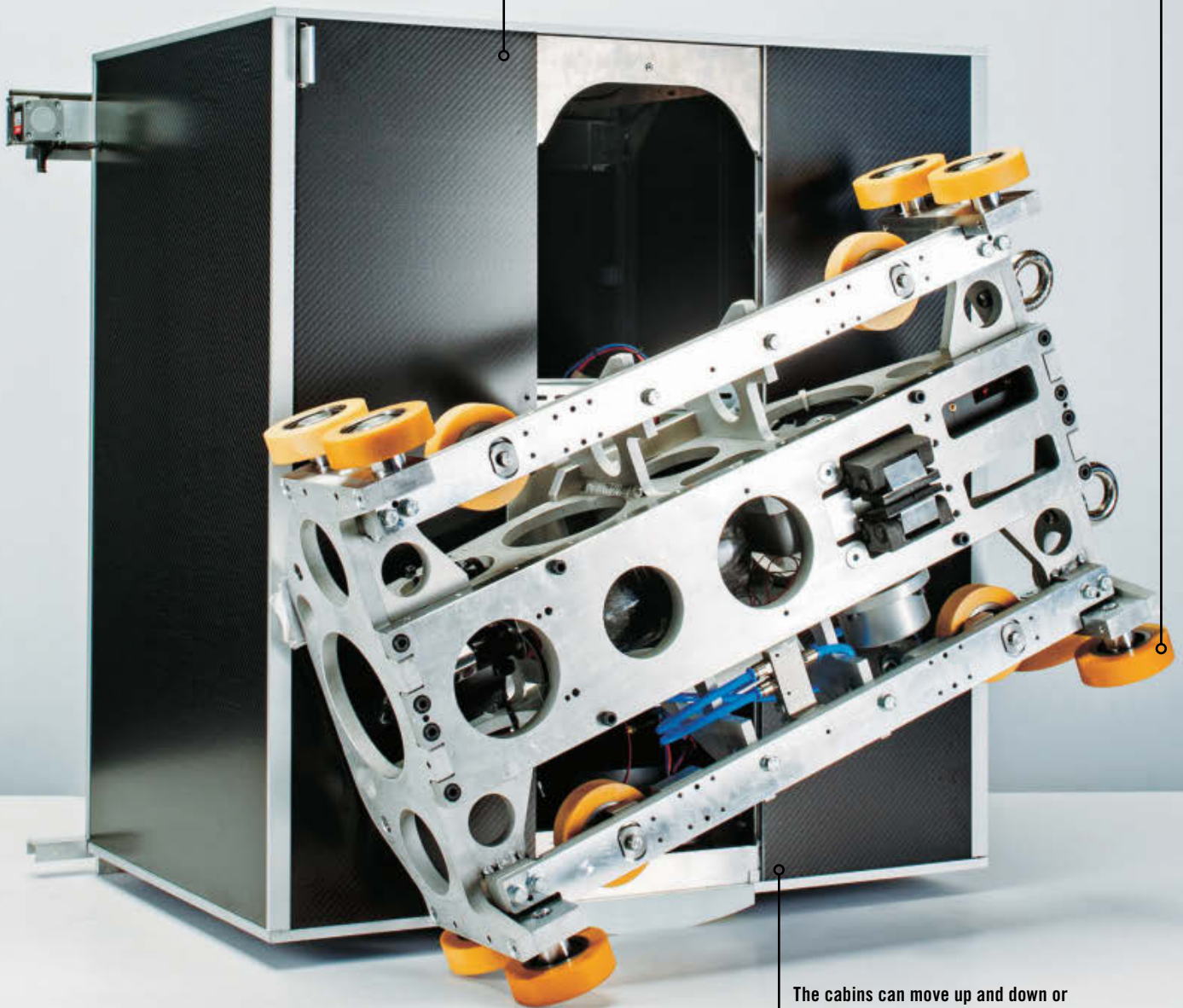
CAN AN ELEVATOR GO AROUND CORNERS?

The German industrial giant ThyssenKrupp has developed an elevator system that's self-propelled (i.e., no cables), allowing multiple elevator cabins in the same shaft and the ability to move not just up and down but sideways too. The MULTI system is the first elevator in the history of the 163-year-old invention that can change direction to change shafts, move horizontally, or allow another cabin to pass. In some respects the

system resembles a railway system with small cabins instead of cars. The design ensures shorter waiting times, higher capacity, a smaller elevator footprint, and substantially lower elevator weight. It uses linear motor technology based on that of the Transrapid magnetic levitation train to drive elevators not just in tall buildings but in urban centers and subway systems as well.

Because there are no cables, several cabins can operate at the same time in the same shaft like trains in a subway system.

The system's drive mechanism can turn 90 degrees on its axis.

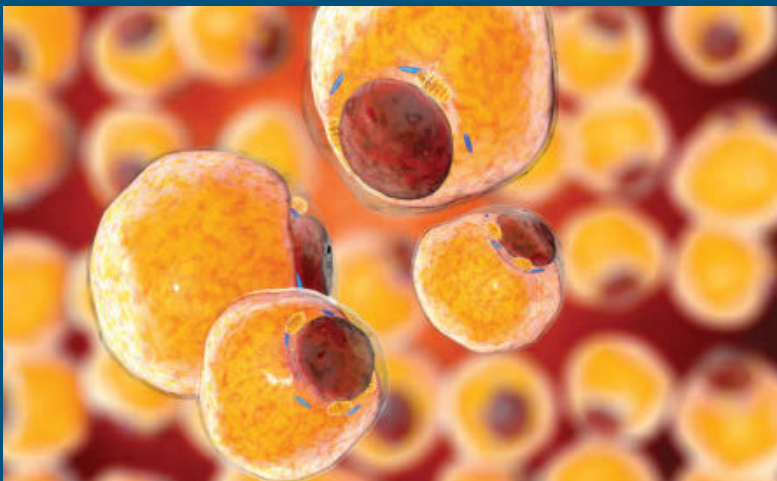


The cabins can move up and down or side to side in a building.



HOW ARE POLICE DOGS PROTECTED FROM OVERDOSE AND DEATH?

Even tiny amounts of narcotic drugs can be deadly for police dogs if they inhale them while they are sniffing. To protect service animals, American police carry an important antidote with them when they're conducting a raid: naloxone. Previously the medicine was used only to bring addicts back from an overdose, but it blocks the effect of opioid drugs in dogs as well.



Where does the fat go when we lose weight?

The question of where fat goes is intriguing, given the rising rates of obesity. Many people think body fat is converted to heat or energy when weight is lost, but in fact we breathe it out. That's the finding of researchers at Australia's University of New South Wales, who say when somebody loses 10 pounds of fat, 9.4 pounds is exhaled as CO_2 , making the lungs the primary excretory organ for weight loss. (The remainder becomes water that's excreted via bodily fluids such as urine and sweat.) That's because excess calories are converted in the body to triglyceride before being stored. Metabolizing 10 pounds of fat requires the inhalation of 30 pounds of inhaled oxygen to metabolize the triglyceride. That means a lot of huffing and puffing to inhale enough oxygen, which brings us back to exercise (hyperventilation doesn't do the trick). The bottom line: To keep weight off, you must balance what you eat against what you burn off and exhale.



Is yawning an indicator of intelligence level?

Biopsychologists at the State University of New York who measured the yawns of 109 individuals from 19 species of mammals found the duration of an animal's yawn is related to the number of neurons and thus the complexity of the brain. To reach their conclusion, they timed the yawns of animals as varied as gorillas, camels, lions, walruses, and mice. Their finding: The longer the yawn, the more complex the brain.

Brain teaser

The solution will appear in the next issue, on stands March 5, 2021.

Two swimmers are swimming in the same lane of a large swimming pool from opposite ends at different speeds. They push off at the same time and meet each other 80 feet from the north end of the pool. Continuing to swim, each reaches the opposite end and then turns and swims back. The second time they meet 40 feet from the south end. Both times they meet, they are swimming toward each other. How wide is the pool?

Solution from the January 2021 issue: With regard to a row of clocks standing side by side on a shelf and two of them being cuckoo clocks, there would have to be at least nine clocks. (Remember, one of the cuckoo clocks is the sixth clock from the left, the other is the eighth clock from the right, and there are exactly three other clocks between the two cuckoo clocks.)

HOW DO YOU BRING A

LEGEND



REBIRTH

In China's southwestern Sichuan Province, more than 1,000 shipyard workers are building a replica of the *Titanic*. Like the original, the new ship will be 883 feet long and 92.5 feet wide.

More than a century after it sank in the North Atlantic, a famous luxury liner is being reproduced with many of its original details. Unlike the original, this new *Titanic* will never sail the high seas.

BACK TO LIFE?



An aerial photograph of a massive construction site for a ship replica. The ship's hull is under construction in a large dry dock, with several yellow tower cranes positioned around it. The surrounding area is filled with construction materials, scaffolding, and equipment. In the background, a river and some buildings are visible.

**"WE HAVE SPENT
MANY YEARS
COLLECTING
BLUEPRINTS
FROM AROUND
THE WORLD."**

**SU SHAOJUN,
QIXING ENERGY INVESTMENT GROUP**



**A HOTEL FOR
HISTORY BUFFS**

The Romandisea Titanic will be a luxury hotel that floats on the water but never puts out to sea. Rooms aboard the full-size replica ship will range from \$450 per night for a modest cabin to \$15,000 for the most luxurious accommodations.

T

ragically, during her maiden voyage from Southampton to New York, the RMS *Titanic* sank in the North Atlantic in the early morning hours of April 15, 1912, after colliding with an iceberg. More than 1,500 of the British ship's estimated 2,200 passengers died. That day marked the beginning of the *Titanic* legend, which remains no less fascinating one hundred years later. On the shores of the Qijiang River in China's landlocked Sichuan province, shipyard workers are constructing a detailed replica of the luxury liner at an estimated cost of \$160 million. The shipyard is located more than 1,000 miles from the ocean...

WHY THE NEW *TITANIC* WILL NEVER SAIL THE SEAS

"After the *Titanic* sank, nobody could find the complete set of blueprints," says Su Shaojun, one of the project's main investors. "A lot of the blueprint fragments have found their way into the hands of collectors or remained missing. We have spent many years collecting blueprints from around the world and managed to obtain most of them." In addition the planners had access to plans for one of the *Titanic*'s sister ships, the *Olympic*. Not only is the replica's exterior faithful to the original: The interior will be authentic as well—from the wallpaper to the main dining room to the legendary glass and iron dome above the Grand Staircase. As the original ship did a century ago, the *Titanic* replica will also feature a ballroom, theater, and

indoor swimming pool. It's all intended to give today's guests the feeling they have traveled back in time to 1912.

Despite the great attention to detail, the replica does have a few striking differences: The reconstruction effort has been entrusted to an experienced shipyard because of all the technical demands that it poses, however the new *Titanic* will never put out to sea. Instead, it will lie at anchor in a river reservoir about 1,000 miles from the nearest Pacific port at Shanghai. The reason: The new *Titanic* is meant to be a floating hotel as well as the main attraction of a huge amusement park named the Romandisea Seven Star International Cultural Tourism Resort.

It's no coincidence that the luxury liner is being reconstructed in China: Ever since James Cameron's *Titanic* film was released in 1997, the *Titanic* has enjoyed cult status in the Middle Kingdom. It was not only one of the earliest modern films from the West to be shown in China, the 3-D version was also the highest-grossing movie ever seen there up to that time. The developers hired actor Bernard Hill, who had portrayed the captain of the *Titanic* in the movie, to be present at the project's launch and named him "honorary captain" of the new ship.



FACSIMILE

The ship's designers are including a reproduction of the *Titanic*'s original engine room, complete with a mock-up of a reciprocating steam engine so visitors can behold the technology of 1912.



HOW DO YOU RE-CREATE A COLOSSUS?

Individual sections of the ship are being built by a shipyard in Wuhan and then transported 630 miles to the assembly site by truck, train, or barge. There in Daying, the keel of the new *Titanic* was laid in November 2016. Construction continues, but the date of the project's completion is unclear. The estimated cost is \$160 million.

They also hired Hollywood production designer Curtis Schnell, who stressed: "We are trying to get as close to the original as we can." Last June photos of the nearly completed forecastle were published, but it's not yet clear when the ship will be finished.

The Chinese project is unrelated to the *Titanic II* replica being built by Australian billionaire Clive Palmer. Originally his \$500 million seagoing ship was to be launched from China in 2016, but after a delay 2022 is now seen as the likely date for its launch.



Did a **fire** sink the *Titanic*?



If you believe Irish journalist Senan Molony, the story of the *Titanic* needs to be rewritten. Molony has spent 30 years researching the tragedy and identified signs that a coal fire occurred behind one of the boiler rooms. He says the fire started as much as 10 days before the *Titanic* left Southampton, and the ship had even been reversed in its berth to hide the damage from boarding passengers. "Metallurgy experts tell us the temperature would have made the steel brittle, reducing its strength by up to 75 percent," he says. Thus when the *Titanic* struck the iceberg, the hull was no longer strong enough to resist the impact. Photographs taken before the maiden voyage show 30-foot-long black marks on the hull near the part of the ship that was later pierced by the iceberg.

Where did the *Titanic* iceberg come from?



The iceberg with which the *Titanic* collided likely broke off from the Jakobshavn Glacier in western Greenland. Over the past 20 years it has been the fastest flowing of Greenland's glaciers. It spills into the North Atlantic at Disko Bay, a major pathway for Greenland's ice sheet, the largest ice sheet after that of Antarctica. Most icebergs calved from this glacier melt before making it as far south in the Atlantic Ocean as the one that sank the *Titanic*. Although its exact size is unknown, it was estimated to be 50–100 feet high and 200–400 feet long. It was likely calved in 1911 and melted away by 1913.

Is there a curse on ships of the *Olympic* class?



RMS *Titanic* wasn't the only ship in its class to encounter disaster. Her two sister ships, *Olympic* and *Britannic*, did as well. The latter sank in the Aegean Sea on November 21, 1916, after allegedly hitting a mine. Since it had been equipped with plenty of lifeboats after the *Titanic* disaster, only 30 people died and more than 1,000 survived. The *Olympic* endured far longer than her sisters but was not impervious to accidents. On September 20, 1911, she collided with the HMS *Hawke*, though no one was killed or seriously injured. The *Olympic* required repairs, so the completion of the *Titanic* was delayed. If not for that, the *Titanic* would've made her maiden voyage three weeks earlier and might not have encountered the fateful iceberg.

Who is responsible for **monitoring icebergs**?



As a reaction to the sinking of the RMS *Titanic* due to collision with an iceberg, 16 nations with shipping interests in the North Atlantic agreed to establish the International Ice Patrol in 1914. The organization locates and monitors icebergs, predicts how they will drift, and warns ships in the vicinity of their presence. The U.S. Coast Guard conducts this reconnaissance with radar-equipped aircraft to detect the icebergs and broadcasts its reports twice a day during the patrol season, tracking around 1,000 icebergs per year. Efforts to destroy dangerous icebergs have met with little success.



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CAN THIS WHITE GOLD **DEFEAT TERRORISM?**

When we hear the word lithium, we are likely to think of the batteries that power laptops and smartphones, but the relatively rare element is also in the batteries of the electric cars that are slated to replace combustion-engine vehicles. That transition will have an additional

positive effect: By reducing our dependence on oil, we can curtail the flow of money to terrorist groups and the countries that support them, which often finance the assistance they provide with their oil revenues. That could make the world a safer place.

THE **LAKE** THAT WILL **CHANGE** **THE WORLD**

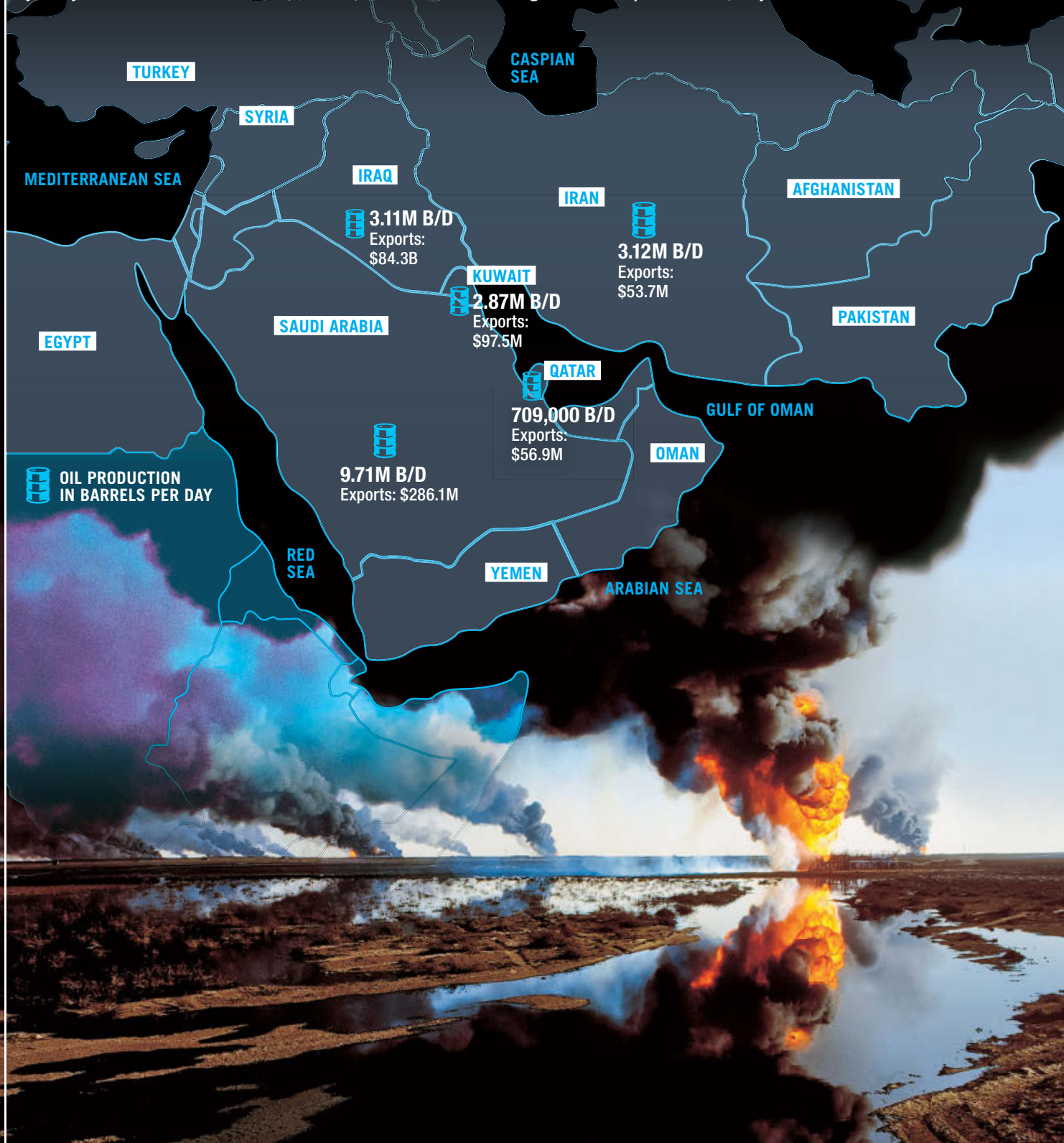



Beneath the crystallized salt that blankets Bolivia's Salar de Uyuni is a pool of brine exceptionally rich in lithium that could ensure our energy future. Not only can the light metal help forestall climate change, it's also an important weapon in the battle against international terrorism.

HOW OIL HAS FINANCED TERRORISM

Until the Islamic State (ISIS) was driven out of the majority of its territory in 2019, the terror organization's largest source of revenue was oil production and smuggling from the numerous oil fields the group held in Syria and Iraq. A 2014 study put the revenues as high as \$3 million per day. It took a four-year battle waged by American, Kurdish, and Iranian-backed forces to drive out the militants, and yet they continue to remain a low-tech, low-cost, but lethal force.

However oil was not the only source of income. Some of the Gulf states financed the group's operations using their own oil revenues, and when ISIS captured the Iraqi city of Mosul in 2014, they seized an estimated \$500 million in currency and gold. Some two years after the collapse of the "caliphate," ISIS is believed to be sitting on vast sums of cash for the purpose of funding a future resurgence. The figures on the map are for 2014, the year of the Mosul offensive.





STOREHOUSE OF WHITE GOLD
This satellite image shows a lithium recovery operation at Salar de Uyuni, the world's largest salt flat in Bolivia. The rectangles are solar evaporation ponds. The color of the basins varies depending on the salt concentration due to degree of water evaporation.

SECRET WEAPON IN THE WAR ON TERROR

Bolivia's Salar de Uyuni holds some 11 billion tons of salt in an area more than twice as big as Utah's Great Salt Lake, making it the world's largest salt flat. It contains 6 million tons of lithium, a raw material for the batteries in electric cars. It takes about 9 pounds of lithium carbonate to make the battery for a compact car such as the Nissan Leaf and far more for larger vehicles. The lithium content of the Salar de Uyuni salt flat could power hundreds of millions of electric cars.

Americans use almost 400 million gallons of gasoline per day. If we were to replace the gasoline-powered vehicles on our roads, we could save around 145 billion gallons of gasoline per year. While the U.S. currently produces most of the oil it needs, it also imports oil from countries that support terrorism, and many oil-poor countries are largely dependent on the oil these countries produce. Thus switching to lithium would deprive terrorists of much of the funding they crave.

HOW MUCH **WATER** DOES IT TAKE TO **PRODUCE LITHIUM**?

The solid salt crust that covers Salar de Uyuni ranges in thickness from a few inches to many feet. Beneath it is a highly concentrated lake of brine containing the world's largest reservoir of lithium and significant amounts of boron, magnesium, and potassium. The lithium concentration is only about 0.3%, but the brine is progressively concentrated in a series of evaporation ponds until the lithium content

risks to around 5%. To achieve the maximum output in lithium-ion batteries, the lithium must be almost completely pure (see the diagram of the refining process at the bottom of the next page). That requires a lot of water: It can take half a million gallons of water to produce a ton of lithium. This can put a significant strain on regions that are already deficient in water resources.



The sun is blazing high in a deep blue cloudless sky, which is reflected in pools of water ranging in color from azure to turquoise. They stand in the midst of flat white land that stretches to rugged mountains in the distance. But we're not talking about the sandy beach of some tropical paradise in a vacation brochure—this is Bolivia's Salar de Uyuni, the planet's largest salt flat with an area of 3,900 square miles that's situated at an elevation of 12,000 feet. The water underneath the crusty surface is brine; this is the

biggest lithium reservoir in the world, and it also contains large amounts of boron, magnesium, and potassium. This site—in addition to smaller ones in Argentina and Chile—will supply much of the lithium needed to power the world's electric vehicles, which in turn will help to lessen the effects of climate change. The number of electric vehicles being sold around the world each year is expected to increase to at least 30 million by 2030. As part of efforts to mitigate climate change, they'll be powered by clean >

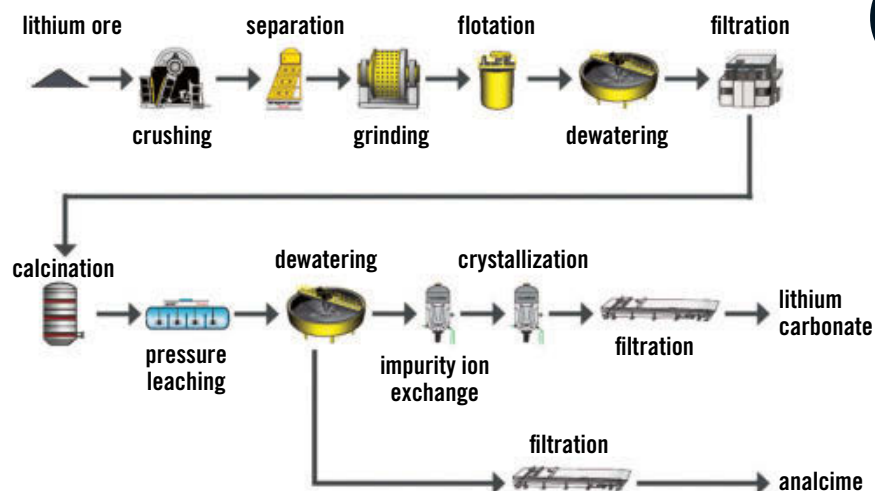


ELECTRONIC SNACKS

Lithium-ion batteries come in a variety of shapes. Cylindrical batteries are made of a long “sandwich” with a series of positive and negative electrodes insulated by separators and rolled into a spool called a “jelly roll.” The photo shows a worker monitoring production at Johnson Controls in the Netherlands.

THE LONG ROAD TO INDUSTRIAL LITHIUM

Lithium is found only in minerals and salts and makes up about 0.0007% of the Earth’s crust. Like the other alkali metals (sodium, potassium, rubidium, cesium, and francium), it is highly reactive. All of them are naturally found only in compounds and never as free elements. They must be stored under oil to prevent reaction with the air. Lithium is so light that it floats on oil or water, reacting with the latter to form lithium hydroxide and hydrogen and typically bursting into flame. At right is the path from extraction to material that’s suitable for industrial purposes.



WHY IS LITHIUM THE BEST FOR CAR BATTERIES?

As a storage medium for electricity, lithium has many advantages over other materials. Lithium-ion batteries can be discharged and recharged hundreds of times, and they're very stable. Compared to other rechargeable batteries, they tend to have higher energy density and voltage capacity along with a lower self-discharge rate. They also have better charge retention than other kinds of batteries. Total lithium

reserves worldwide are estimated to be almost 19 million tons, which is enough to last well into the future at the current production rate. However that rate is projected to rise sharply in the coming years, raising the prospect that the world could see a lithium shortage if new reserves or production methods are not discovered soon or more lithium is not recycled.

POWER CONNECTION

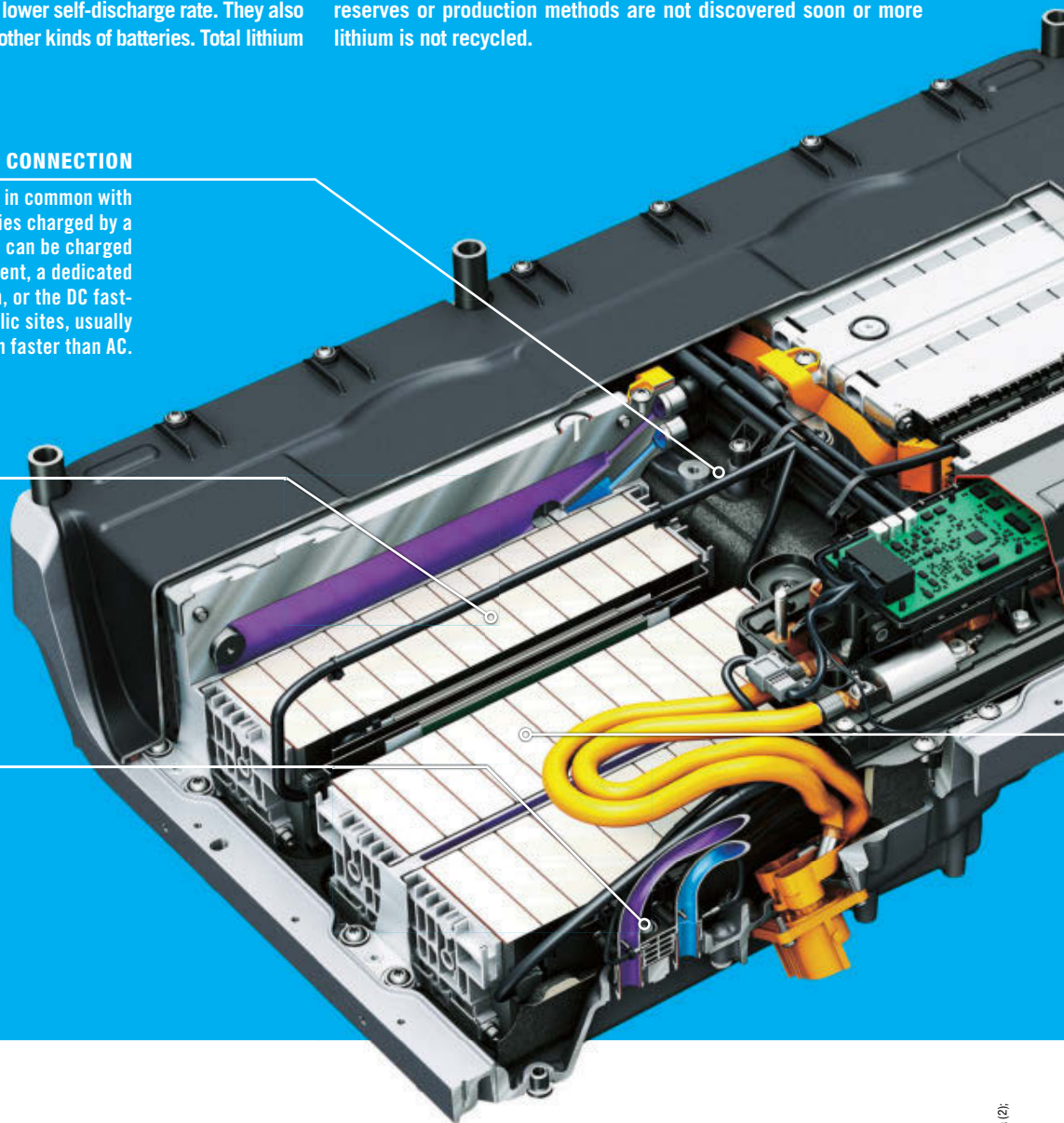
Electric car batteries have little in common with conventional 12-volt car batteries charged by a combustion engine. Electric cars can be charged with normal 120-volt AC current, a dedicated 240-volt AC charging station, or the DC fast-charging stations found at public sites, usually along highways. They are much faster than AC.

STORAGE CELLS

It takes between 80 and 160 grams of lithium to store 1 kilowatt hour (kWh) of electricity. A compact car needs about 9 kWh to go 30 miles.

COOLING

In rare cases lithium-ion batteries can ignite. If microscopic metal particles come into contact with other parts of the battery cell, they can short-circuit the battery and cause a fire. Batteries for electric vehicles are protected by a fireproof casing as well as a cooling system.



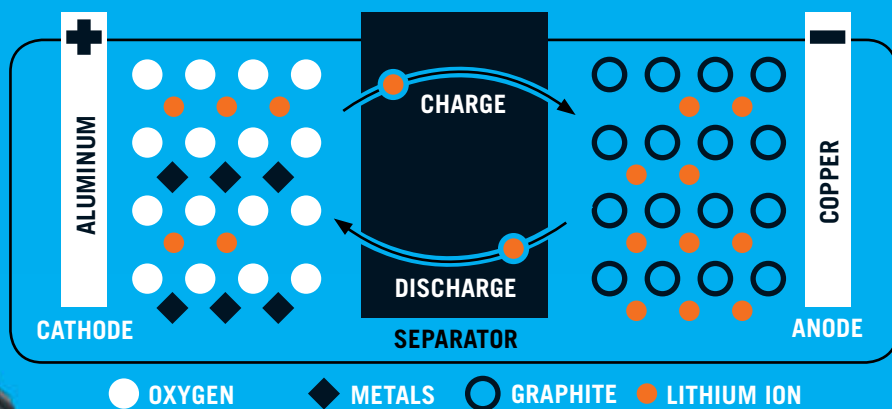
electricity from wind and sun, power that's stored in the vehicles' battery. The batteries require lithium, and the planet's largest deposit of the alkali metal is found at Salar de Uyuni.

The global production of lithium in 2019 was 93,700 tons. The metal has recently been selling for around \$44,000 per ton, more than six times the price of copper. Much of it goes

to factories operated by Elon Musk, the architect of Tesla electric vehicles. To ramp up production to half a million cars per year, Tesla would potentially need the entire global supply of lithium-ion batteries, and it has been building "gigafactories" to meet the demand. Preserving the climate isn't the only thing that makes lithium important.

It is also part of a political strategy to diminish the world's dependency on petroleum and thereby put an end to Islamic fundamentalist terror. By decreasing the revenues of radical regimes in the Middle East, Western democracies hope to reduce these nations' funding of terrorist activities.

For a time oil revenues were the principal source of funding for the



HOW DOES LITHIUM STORE ELECTRICITY?

When a lithium-ion battery is charging, lithium ions from the positive electrode (lithium cobalt oxide) move through the electrolyte to the negative (graphite) electrode where they remain until needed. When the battery discharges, the lithium ions move back across the electrolyte to the positive electrode, producing energy.

HEAVYWEIGHT

Lithium-ion batteries have an energy density that ranges from 100 to 265 watt-hours per kilogram (Wh/kg), one of the highest energy densities of any battery type. But gasoline provides around 12,000 Wh/kg. For example, an electric VW Golf needs a battery weighing more than 700 pounds to achieve an average range of 120 miles. With only 10 gallons of fuel, a gasoline model of comparable weight can go almost 400 miles.

terrorist organization ISIS. While the loss of territory has sharply reduced the group's income from the oil wells it once controlled, ISIS is believed to be sitting on a mountain of cash, and it still receives funding from friendly governments. This money pays for weapons, infrastructure, bribery, and propaganda. However lithium isn't the only current threat to terrorist coffers.

The COVID-19 crisis has forced many people all around the world to restrict their normal activities, resulting in a sharp decline in the demand for oil and a drop in prices. In any event, as much as hopes are resting on lithium to power the clean energy revolution, reserves of the substance are finite. Ultimately it should be one component of a modern energy-storage portfolio.



WHERE IS THE WORLD'S LARGEST FACTORY BUILDING?



GIGAFACTORY

When it opened in Nevada, Tesla's Gigafactory 1 (seen here under construction) quickly became the highest-volume battery plant in the world.



ENORMOUS SPACE

In 2017 Tesla began production of solar cells at Gigafactory 2, a facility of 1.2 million square feet in Buffalo, New York.



POWERWALL

Tesla boss Elon Musk (above) has also designed a battery for storing solar or grid energy at home: Powerwall enables stored energy use at night or during a power outage.

POTENTIAL KILLERS

The greatest extraterrestrial menace to our home planet are near-Earth objects (NEO). The number of these asteroids has been estimated at more than 15,000. Learn more on page 68.

THE RISE OF 494 DOOMSDAY



There are more than 700,000 known asteroids in our solar system, and 4 new ones are discovered daily. NASA's current inventory lists 494 of them as being of high risk to human civilization. Many have the potential to wipe out the world as we know it in a collision with Earth. iD explains which ones pose the greatest threat to our existence—and what scientists are trying to do about it...

Stargazers who panic easily certainly had a reason to worry in the weeks leading up to October 12, 2017. Asteroid 2012 TC4 was approaching the Earth for the second time in just five years—and this time, it was going to come a lot closer. Because of the asteroid's relatively small size (about 50 feet long and 25 feet wide), astronomers had never felt the need to be overly concerned, and on October 12, 2017, the panic-prone were finally able to breathe a sigh of relief: Asteroid 2012 TC4 whizzed past the Earth at a distance of 31,000 miles—which is still a fairly close call

in astronomical terms. Visits from near-Earth objects (NEO) are not all that rare. NASA detects about 1,500 of them a year, and smaller ones, such as 2012 TC4, pass between Earth and the Moon several times a month. But the benefit of 2012 TC4's flyby was that it offered the perfect opportunity for NASA to re-examine its methods for handling uninvited guests. "We wanted to know if our network and the connections we have made with other countries and observatories were going to work for us when we needed them," says Dr. Michael Kelley, an astronomer at NASA's Planetary Science Division. It is an extremely important issue: Astronomers don't question whether a large asteroid is going to collide with Earth someday. But they are very concerned about the "when." >

continued on page 68

SCENARIOS



+
60,000
MILES PER HOUR

The average asteroid moves through space at close to 60,000 miles per hour. Smaller asteroids burn up when they enter the Earth's atmosphere as meteors. (Any fragment that makes it to the ground is called a meteorite.)

+
3,168
FEET IN DIAMETER

A width of 0.6 miles or more makes an asteroid a significant threat that could have far-reaching climatic and geological impacts and might potentially end human civilization. The good news is that NASA is confident it has identified about 90% of the asteroids of this size.

+
100
YEARS

A fireball brighter than the Sun lit the sky above the Russian district of Chelyabinsk in 2013 when a meteor the size of a house exploded after entering our atmosphere, its shock wave injuring more than 1,600 people. Incidents with objects around 65 feet are statistically likely every 100 years or so. The last one was the Tunguska Event that occurred over Russia in 1908.



HOW COULD A CHUNK OF ROCK BECOME A MASS MURDERER?

While asteroids terrify some people, most of them (the asteroids, that is) are completely harmless. The origin of many near-Earth asteroids is the Kuiper Belt, a huge region of our solar system that begins at the edge of Neptune's orbit and extends out to about 4.65 billion miles from the Sun. Some of the near-Earth asteroids were comets in the Kuiper Belt before they burned out. Even large asteroids are harmless until they are drawn by either Earth's gravity or that of the Sun into a collision course with our planet. That happened some 66 million years ago when an asteroid about 6 miles across hit the Earth and exploded, creating a crater more than 100 miles wide. Debris from the explosion was hurled into the atmosphere, altering the Earth's climate and leading to the extinction of about 75% of the planet's species, including the dinosaurs. Scientists at the University of Southampton in the UK have used a computer model to project the

effects of an asteroid hitting Earth. Modeling asteroids ranging in size from 50 to 1,300 feet in diameter, they found that in a major impact the greatest number of lives would be lost not due to a tsunami but to shock waves and high winds. Such occurrences are rare: Researchers estimate that an asteroid 1,300 feet across is likely to hit Earth only about once in 100,000 years. But to prevent that from ever happening, scientists at NASA and the European Space Agency (ESA) work closely together. In the early morning hours of August 16, 2020, a telescope on California's Mount Palomar detected an asteroid on a near-collision course with Earth. Then Germany monitored the approach from its Tautenburg Observatory before handing it off to Tenerife in the Canary Islands. It was soon confirmed that the asteroid had passed the Earth at a distance of less than 2,000 miles, the closest-ever asteroid to fly past our planet without hitting us.



+

128

IMPACT CRATERS

The number of craters left on the Earth's surface by asteroids is surprisingly small: 128. And only 70 of them are larger than 3.7 miles across.

+

133,000

HIROSHIMA A-BOMBS

The impact from an asteroid 1,300 feet in diameter (the size of 2014 HQ124) could wipe out an entire large metropolitan area. Its energy would be more than 133,000 times greater than that of the bomb that destroyed Hiroshima.



BENNU



1,640 FEET

EMPIRE STATE
BUILDING



1,454 FEET

EIFFEL
TOWER



1,063 FEET

"WE NEED TO DISCOVER EVERYTHING ABOUT BENNU. THIS COULD BE VITAL DATA FOR FUTURE GENERATIONS."

DANTE LAURETTA, PLANETARY SCIENTIST

With a diameter of more than 1,600 feet, the asteroid Bennu threatens Earth more than almost any other known celestial body, according to NASA. With its mass of 78 million metric tons, the asteroid sails past Earth every 6 years, a little closer each time. By 2135 Earth's gravity could put Bennu on a collision course.



ASTEROID BELT

EARTH

WHERE CHAOS REIGNS

Between the orbits of Mars and Jupiter lies an asteroid belt occupied by millions of irregular, solid bodies that are much smaller than planets. They are composed of various mixtures of rock, stone, iron, nickel, carbon-rich materials, and ice.

RINGS OF RUBBLE

Saturn has the most spectacular rings of any planet, with particles that range in size from specks to house-size fragments. Scientists think comets or asteroids collided with one of Saturn's moons and shattered it into many pieces to create the rings.

FRIEND OR FOE?

Like a cosmic vacuum cleaner, Jupiter's powerful gravitational field sucks in asteroids. But the planet's gravity can also redirect them toward Earth.

COSMIC JUNKYARD

Between 2.79 and 4.65 billion miles from the Sun lies the Kuiper Belt. This disk of accumulated icy matter contains more than 2,000 catalogued objects, likely only a tiny fraction of the total.

WHAT CAN ASTEROIDS TELL US ABOUT OUR SOLAR SYSTEM?

The solar system was born about 4.5 billion years ago in a cloud of gas and dust. When the cloud collapsed (possibly due to a nearby supernova explosion), it formed a swirling disk, a solar nebula. As gravity pulled in more and more material, pressure in the core caused hydrogen atoms to combine and form helium, and our Sun was born. Farther out in the disk, other matter formed clumps and combined, creating planets and moons. Bits and pieces of the early solar system that did not combine into larger forms became comets, asteroids, and

meteoroids. They contain debris from the formation of the solar system, and scientists hope these time capsules will shed light on how it all began. NASA Chief Scientist Jim Green is concerned with big questions he thinks the asteroids may be able to answer, such as "What was the early solar system like?" and "How did life emerge from a lifeless beginning?" Because Bennu is a fragment of the ancient solar system, Green believes it could provide us with more insight into the types of ingredients that may have gone into the creation of life on early Earth.

Astronomers have identified some 15,000 near-Earth objects that could pose a potential threat to our planet. NASA lists 494 of them as presenting a very high risk to human civilization. Formerly appearing toward the top of the list was the asteroid Apophis, with a width of more than 1,200 feet (about the size of four football fields) and named for the ancient Egyptian god of chaos. Initial calculations had suggested Apophis may impact Earth on April 13, 2029. Recent projections call for the asteroid to pass the Earth harmlessly at a distance of just under 20,000 miles but within the distance that some spacecraft orbit the Earth. Scientists view this flyby as an ideal opportunity. "We'll be watching with

optical and radar telescopes," says Marina Brozovic, a radar scientist at the NASA Jet Propulsion Laboratory. "With radar we might be able to see surface details of only a few meters."

But Apophis may not be done with us. The asteroid will pay Earth another visit in 2068, and its path is moving closer to ours. "The asteroid is drifting from its orbit by about 560 feet per year, which is enough to keep the 2068 impact scenario in play," says University of Hawaii astronomer Dave Tholen. Though the chance of impact remains small, the Jet Propulsion Lab estimates that it would release energy equivalent to 1,200 megatons of TNT.

NASA is firmly determined to keep such an event from ever happening.

Its goal: "to locate all asteroid threats to human populations and figure out what to do about them." To that end, the U.S. space agency is coordinating with observatories and organizations all around the world to discover and characterize extraterrestrial hazards. "We want to know as much as we can about any space object that might be headed for Earth," says Alan Harris, project leader of the asteroid defense program NEOSShield. The program is an international consortium formed to address impact threats to Earth.

FROM GRAVITY TRACTORS TO KINETIC IMPACTORS

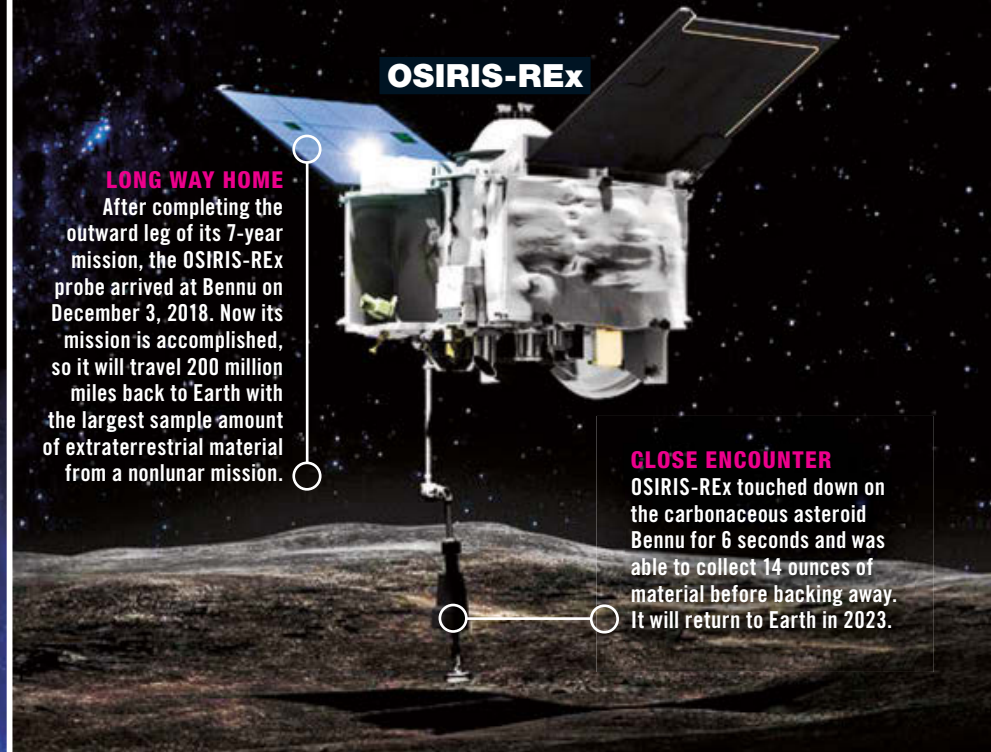
One plan for protecting Earth if an asteroid is perceived as a threat is to



KUIPER BELT

SPACED OUT

While astronomers estimate there are hundreds of thousands of objects larger than 60 miles wide in the Kuiper Belt, their total mass is believed to be no more than 10% of Earth's mass.



OSIRIS-REx

LONG WAY HOME

After completing the outward leg of its 7-year mission, the OSIRIS-REx probe arrived at Bennu on December 3, 2018. Now its mission is accomplished, so it will travel 200 million miles back to Earth with the largest sample amount of extraterrestrial material from a nonlunar mission.

CLOSE ENCOUNTER

OSIRIS-REx touched down on the carbonaceous asteroid Bennu for 6 seconds and was able to collect 14 ounces of material before backing away. It will return to Earth in 2023.

HOW CAN SOMETHING SO FAR AWAY BE STUDIED?

The OSIRIS-REx probe (above) traveled 200 million miles to arrive at its target, the asteroid Bennu, on December 3, 2018. After surveying it for almost 2 years, the spacecraft landed on the asteroid for 6 seconds on October 20, 2020, and collected 14 ounces of material. With the samples safely sealed inside, the probe was ready to return to Earth, with arrival scheduled for September 2023. "Asteroids like Bennu may have seeded the early Earth with organic molecules," explains Dante Lauretta, the principal investigator of the OSIRIS-REx program. "That would have contributed to the primordial soup from which life emerged."

use the gravity of a large spacecraft in order to divert the menacing object. A so-called gravity tractor would fly alongside the asteroid for a period of years or even decades and slowly throw it off its collision course with Earth. However a gravity tractor may not be effective against a very large asteroid—which is precisely the type that poses the greatest threat. Also this technique has never been tried and would take decades to develop.

Another possibility for changing the path of an asteroid in space is to use a kinetic impactor. Scientists would aim a spacecraft at the asteroid and deliberately crash it into the invader. The impact could alter the asteroid's orbit and prevent it from hitting Earth.

NASA is waiting for a launch window in July 2021 to test such a vessel. The spacecraft will reach the near-Earth asteroid Didymos in September 2022 and crash into its moonlet at around 13,000 miles per hour, which should produce a measurable impact.

The last option would be to aim a nuclear missile at the asteroid, but it wouldn't play out like it does in films. "If you have seen those movies, they are completely bogus," says Lindley Johnson, planetary defense officer at NASA headquarters. There is no need to strike an asteroid to alter its course. If a nuclear explosion occurs nearby, it superheats the asteroid's surface, which would blow part of the surface away and deflect the asteroid.

Each of these approaches is driven by the same motto: Be prepared. "We want to know what's coming; we don't want anything to be a surprise," says Andrew Rivkin of the Johns Hopkins Applied Physics Lab. Moreover, ESA aerospace engineer Ian Carnelli says, "We know that about 90% of the very large asteroids bigger than half a mile in diameter are not expected to collide with Earth in the coming centuries. But even asteroids with a diameter of tens or hundreds of meters would cause devastation on the scale of a country or a continent—and about those we know much less." Thus in addition to honing our protective tactics, we must raise the discovery rate so threats can be identified in time to avert disaster.



PHOENIX AIR

GULFSTREAM EQUIPPED FOR QUARANTINE

The U.S. nonscheduled airline Phoenix Air is the only air carrier in the world that operates Gulfstream III jets equipped to transport highly contagious Ebola and COVID-19 patients. After each mission the jets have to be decontaminated for 24 hours. The plastic quarantine tents used for isolating patients are incinerated as hazardous waste after use.

HOW DO YOU TRANSPORT A DEADLY VIRUS?

If an American citizen is infected with a highly contagious disease and has to be repatriated from overseas for treatment, the Phoenix Air Group swings into action. The small airline coordinates with the Centers for Disease Control and Prevention to bring patients to medical facilities in the U.S. Its ace in the hole: the Aeromedical Biological Containment System...





FLIGHT ATTENDANT

Vance Ferebee (photo) is a flight nurse with Phoenix Air. He participated in an Ebola rescue mission in 2014 and recently helped fly a COVID-19 patient home from Bhutan.



SAFETY PROTOCOL

To protect the crew from infection, patients are flown in a self-contained clear plastic tent that sounds an alarm if the slightest leakage occurs. As with all personnel who have contact with Ebola patients, crew members are monitored for 21 days after a flight.

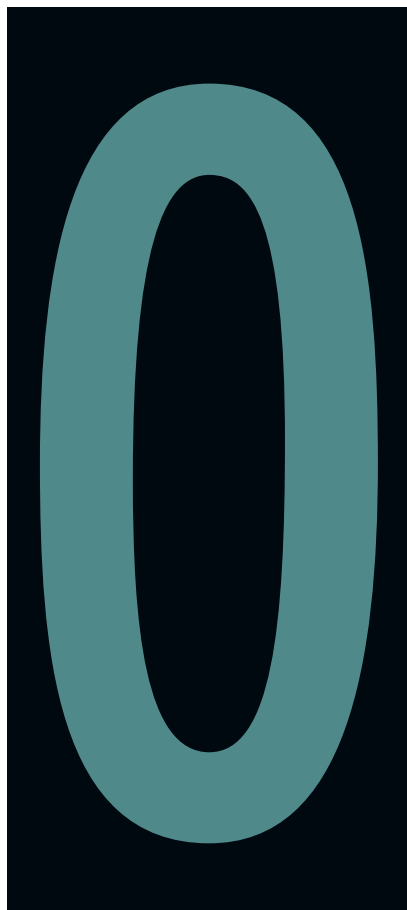


FIRST MISSION

A team of doctors carries Ebola patient Nancy Writebol from a Phoenix Air jet for transport to Emory Hospital in Atlanta. She and Dr. Kent Brantly (see photo at right) were the first Ebola patients to be repatriated to the U.S.

EXPERT SUPPORT

On their missions to repatriate Ebola patients, the doctors of the Phoenix Air Group were supported by some of the finest medical specialists from the Centers for Disease Control and Prevention and the U.S. military.



n July 26, 2014, the telephone rang at Dent Thompson's vacation home in Beech Mountain, North Carolina. It was a call the vice president of the small nonscheduled airline Phoenix Air had anticipated for some time. The area code was 202: Washington, D.C. Thompson recognized the voice of William Walters, managing director for operational medicine at the U.S. Department of State. The two men had first met six months earlier when the Phoenix Air Group had prepared an air ambulance plan for the Sochi Olympics in case a dignitary had to be evacuated for medical reasons. Thompson understood immediately that they were not talking about a hypothetical scenario this time. "Do you think your system would work for Ebola?" asked Walters. There had been an outbreak of the deadly virus in the West African nation of Liberia, two U.S. medical workers needed to be flown back home for treatment,

and Phoenix Air was the only airline with a system to transport patients with extremely contagious diseases. Founded in the 1970s, the company had risen to prominence in 2007 when the Centers for Disease Control and Prevention (CDC) asked them to build a containment system for transport of patients infected with dangerous illnesses. But prior to 2014 the system had not yet been put to use. Dent told Walters if the government's doctors agreed it would work, Phoenix would be willing to try. Walters said he would have experts on site ASAP.

Dent had not expected the charter airline's first case to be Ebola, one of the world's deadliest viral diseases. "You're asking us to go from the high school basketball court straight to the NBA," he said to Walters. But not long after their conversation, some of the nation's top medical specialists convened in Cartersville, Georgia, to evaluate the company's Gulfstream III jet and its Aeromedical Biological Containment System (ABCS). They'd agreed it could get the job done.

HOW DO YOU BUILD A FLYING QUARANTINE STATION?

Development of the ABCS had begun in 2007, in anticipation of the Winter

WHAT HAPPENS WHEN YOU BRING HOME A DEADLY VIRUS?

Olympics that were slated to be held in Sochi, Russia, in February of 2014. Although the system was fully tested and ready to go by early 2014, it had not been needed. But only a month after the Olympic Games were over, >

THE DOCTOR WHO SURVIVED EBOLA

The Gulfstream III jet that the Phoenix Air Group reconfigured for medical evacuations made its maiden flight in 2014. The objective: to bring home two medical missionaries who were infected with Ebola in Liberia. After a 14-hour flight Dr. Kent Brantly (photo) arrived in Atlanta for medical care, and the plane went right back to Liberia for his nurse, Nancy Writebol. In December of 2019, Dr. Brantly returned to Africa to continue his medical work.



the World Health Organization (WHO) reported cases of Ebola infection in southeastern Guinea. That outbreak would signify the beginning of the West Africa Ebola epidemic of 2014, and by the time it finished two and a half years later, there had been more than 28,600 cases and 11,325 deaths.

A clear plastic quarantine tent had been developed for isolating patients infected with other dangerous viruses, such as the Severe Acute Respiratory Syndrome (SARS) and avian influenza (bird flu), both of them highly infectious airborne diseases. Because those patients pose a high risk to an airline crew who transports them, the special self-contained ABCS was developed in cooperation with the U.S. Army and the CDC in Atlanta to ensure the patients would be safely quarantined throughout a flight.

The ABCS is a tent-like structure that's made of impermeable material which keeps a patient under negative pressure as it filters the air inside and prevents contact with the outside air. The fabric used is inexpensive. After it has been used once, a hazmat crew strips it away and incinerates it as hazardous waste in accordance with EPA standards. The 190-cubic-foot plastic compartment is attached to a metal frame, and the structure is small enough to fit in a Gulfstream III jet. The airlock is kept at a slightly higher negative pressure than the compartment so medical personnel can go in and out during the flight. An alarm sounds if the air pressure differentials are not at the desired levels. The patient lies on a stretcher 24 inches wide, and the aircraft is outfitted to handle up to four patients at the same time if ABCS quarantine is not necessary. Like the four-patient arrangement, the litter that's used in the single-patient configuration locks into the seat tracks. The ABCS has an aluminum exoskeleton to support the enclosed plastic tent, which has an anteroom and a patient chamber.



ISOLATION WARD

In February 2020, Phoenix Air's Containerized Biological Containment System was used to airlift 1,100 Americans and 100 Canadians from Wuhan, China, on five Boeing 747 flights. The photo shows a training exercise.

SELF-CONTAINED

Phoenix Air's 40-foot-long, 8-foot-wide, and 8-foot-tall biocontainment system was built to slide into the nose of a transport aircraft and is able to accommodate four patients in isolation and six medical attendants.

In the anteroom, medical personnel don personal protective equipment (PPE) before entering the chamber and remove it when they leave. Used PPE goes in a burn bag. HEPA filters remove even virus-size particles from the air. After a patient leaves the tent, all of the filters are incinerated along with the PPE and the tent itself.

IN THE GRIP OF EBOLA HYSTERIA

The first instance of Ebola virus had seemed straightforward enough: Two U.S. medical missionaries—Dr. Kent Brantly and nurse Nancy Writebol—had become infected with Ebola while they were helping with the outbreak



SERVING THE WORLD

During the 2014–2016 Ebola epidemic, Phoenix Air evacuated more than 40 patients from West Africa and took them to clinics in the U.S. and Europe. This photo shows its Gulfstream III at Hamburg Airport. In late 2014 Germany acquired its own rescue plane.

in Liberia and had to be transported to Atlanta for emergency treatment. It was the scenario Phoenix Air had anticipated for years, and the staff at Emory University Hospital had been notified and were waiting to receive the patients. What made the mission more dangerous than most was the fatality rate of Ebola: as high as 90% compared with 60% for bird flu and about 10% for SARS. Even before the Gulfstream was in the air for its return

trip, Ebola hysteria had broken out in the U.S. “The general dogma was, you don’t bring a zombie apocalypse to a city that doesn’t have zombies,” says Department of State operational medicine director William Walters. Ebola simply scared the hell out of the general public—and just about everyone else. A medical director at Phoenix Air wasn’t allowed to attend sporting events where his kids went to school. Dr. Michael Flueckiger, the

company’s emergency physician who accompanied the flight, had to lie to clinics about having visited a country with Ebola to avoid being quarantined. Some conservative politicians falsely painted Latino immigrants as Ebola carriers as part of an effort to fan the flames of anti-immigration sentiment. However, Dent Thompson had more important things to worry about: What if somehow Brantly and Writebol were able to infect other people? Or what if other countries asked Phoenix Air to evacuate their infected citizens from the Ebola-stricken crisis regions? The small company had only two planes that could evacuate Ebola patients—one at a time. Fortunately, the worst-case scenario failed to materialize: By the end of the outbreak in 2016, Phoenix Air had evacuated more than 40 patients from West Africa to clinics in the United States and Europe. Only two patients died, neither on board.

PREPARING FOR WHAT’S NEXT

Since being put through its paces in 2014, the Phoenix Air Group has expanded considerably. It now has a wholly owned and operated fleet of 40 aircraft, nine of which are dedicated to air ambulance use. The Department of Defense and Department of State maintain a standing contract with the company to transport sick or injured employees worldwide. It has carried hundreds of them each year without incident for the past 15 years. And it has assumed new significance in the time of COVID-19. By August of 2020, the Department of State announced it had repatriated more than 100,000 U.S. citizens on 1,140 flights from 136 locations. With its unique capacity to transport highly infectious patients, Phoenix Air played an important role in the operation. Its advantage: ABCS and the new Containerized Biological Containment System (CBCS), which can accommodate up to four patients. With a global pandemic in full swing, Phoenix Air has its work cut out for it.



HERMETICALLY SEALED
The container is the most sophisticated isolation system in the world. It features a sealed biocontainment door, as shown by Dr. Michael Flueckiger (right).



What other services does Phoenix Air offer?

Since its first Ebola rescue mission in 2014, the Phoenix Air Group has undergone significant expansion. It now operates a fleet of 40 aircraft, of which nine are dedicated to air ambulance service. On behalf of the U.S. Departments of Defense and State, the airline transports hundreds of sick or injured people each year. In 2017 a Phoenix Air crew flew to North Korea, where Dr. Flueckiger helped advocate for the release of American student Otto Warmbier, who was in a vegetative state, and got him home to his family.

PHOTOS: DPA (4); Phoenix Air (3); Getty Images.

What Are the Consequences of a Good

DECIS

We are constantly making

But what effect do they have at the end of...

...10 hours?

...10 weeks?



DECISIONS


decisions, big and small.

...10 minutes?

...10 days?

...10 years?

One man's research has yielded fascinating answers.



What does a marshmallow have to do with the course of my life? What can a sweet treat tell me about myself? One of the most famous experiments in the history of psychology is predicated on the basis of such questions. The simple decision to do something “now” or “later” can have a huge impact on a person’s future and can reveal in early childhood what kind of personality an adult is likely to have. The creator of the Marshmallow Test, Walter Mischel, provided some important insight into the experiment prior to his passing.

The Marshmallow Test

Between 1968 and 1974, then-Stanford psychologist Walter Mischel conducted a series of tests at a nursery school in Palo Alto, CA. He offered 4-year-olds a treat of their choice (cookie, pretzel stick, marshmallow, etc.). He placed one treat on the left and more of the same treat on the right and told the child, "I'm going to leave the room. You can have one treat at any time by ringing a bell to bring me back to the room. But if you wait until I come back on my own, you can have two." Then he left. He'd initially tested almost 600 children. When he revisited their lives decades later, he found that the decision to have one treat now or two treats later seemed to have had a decisive influence on the child's adult life. The longer children "held out" in the experiment, the better they were able to deal with frustration later in life. They were more successful on the whole and described themselves as happier.

PROFESSOR MISCHEL, HOW LONG DID THE CHILDREN HOLD OUT?

Around one-third of the children had eaten the treat immediately. Another third had waited about 3 minutes. But the final third had waited for the full 15 minutes until the researcher returned. Those are the ones we call "high delayers," the ones who were able to delay their gratification for a long time. We call the impatient ones "low delayers."

HOW DID THE TEST COME ABOUT?

At the time I had been watching my three young daughters, who were 3, 4, and 5, evolve from being relatively uncontrolled to being able to control themselves. I wanted to develop a measure to catalog the phenomenon. So after a good deal of experimenting, I devised a very simple test. It would be years before I came to realize that it can actually reveal a whole lot more than I thought at the time.

AND THIS SIMPLE TEST WAS PREDICTIVE OF A CHILD'S FUTURE?

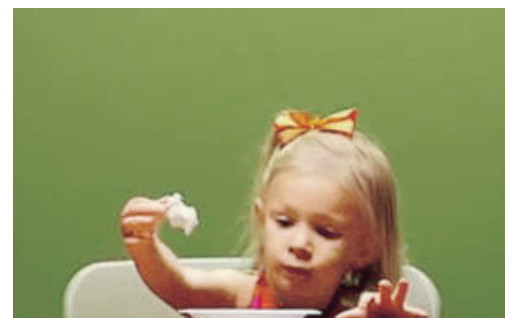
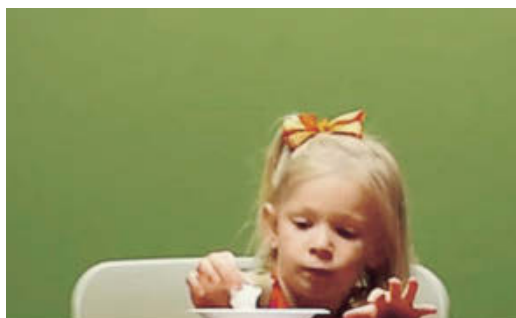
Some years after that I was talking with my daughters over dinner about what had become of their childhood

friends—like my daughters, they also took part in the experiment. I realized that those who were struggling with behavioral and academic problems were the ones who had not delayed gratification and had eaten their treat right away. Those who had showed themselves to be more disciplined at the time were doing better.

DID YOU CONTINUE TO TRACK THE CHILDREN INTO ADOLESCENCE AND ADULTHOOD?

Yes, and the results were amazing. Ten years later I sent questionnaires to the parents of children who were involved in the test and asked them to compare the children with their peers. We also asked their teachers about their cognitive and social skills. The children who'd proved to be high delayers had greater self-control and were less distracted. They were more intelligent, self-reliant, and confident. They thought ahead and were better planners. They essentially defied the stereotype of the difficult adolescent. And as adults they were more likely to have a university degree and be in a stable relationship, and they were less likely to be obese or use drugs.

SO WHAT DOES THE MARSHMALLOW TEST SHOW US? IS THE



ABILITY TO DELAY GRATIFICATION PRE-WIRED OR CAN IT BE TAUGHT?

I think some people find it to be much easier to exert control than others do. Still, no matter if you are reasonably good at this overall or reasonably bad at this overall, it can be enormously improved. The idea that children are doomed if they choose not to wait for their marshmallow is a really serious misinterpretation. So, is self-control pre-wired? Recent discoveries in the science of genetics are providing us with fresh answers and revealing the brain's surprising degree of plasticity and new ways to think about nature and nurture. In any case, we've found the roots of self-control are visible in a toddler's behavior.

DOES THAT MEAN THESE DIFFERENCES ARE ALREADY PRESENT AT BIRTH?

When babies come into the world, they display differences in emotional reactivity, activity level, and ability to control and regulate their attention. By the time babies are born, they've been shaped for many months by the uterine environment. And this input markedly influences what they think, feel, and do, and who they ultimately become. That includes their degree

of ability to exert self-control and to delay gratification. But the outcome of the Marshmallow Test at the age of 4 does not determine the rest of a child's life. Low delayers can become high delayers, and vice versa.

HOW DOES THAT HAPPEN?

We are not sure, but the answer has to be a combination of heredity and environment. We do know that there are certain strategies that can help us improve our self-control. Here are some examples from our experiment: Some children closed their eyes and fantasized that they were eating the marshmallow while they waited for the researcher to come back. Some avoided eating the marshmallow by singing songs, tapping their feet, or telling themselves a story. Some even took off their shoes and played piano with their toes to distract themselves. These strategies seemed to reflect a child's level of emotional intelligence. Another observation we made was if the treat was hidden beneath a dish, many children found they could wait far longer. The effect was dramatic. The children were old enough to know that the treat was there even though they couldn't see it.

WHICH ENCOURAGES GREATER SELF-

DISCIPLINE, CLOSING YOUR EYES OR PLAYING PIANO WITH YOUR TOES?

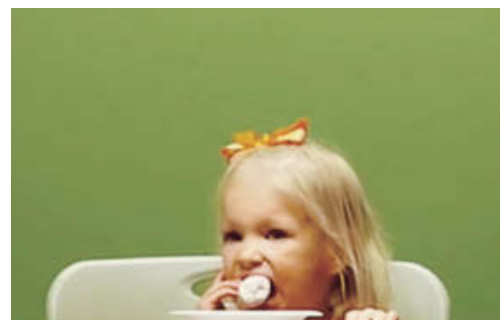
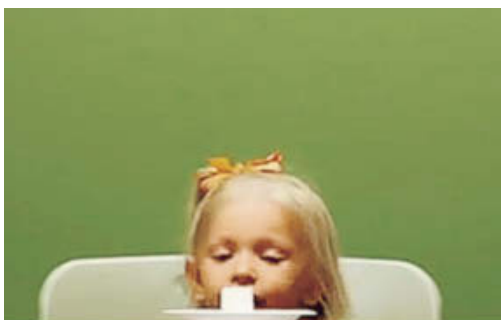
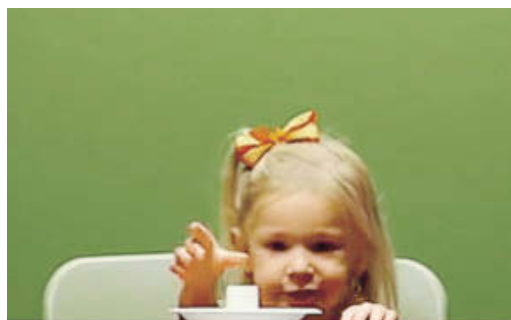
The real key to increasing self-control is altering perception of the situation. For example, when we told children to think about the marshmallow as a fluffy cloud or a ball of cotton, it was easier for them to delay gratification.

THAT SOUNDS ABSURD.

But it works. It is a demonstration of George Kelly's idea that the way you construe a stimulus determines how you'll respond to it both emotionally and cognitively. This has helped us understand the sort of strategies that children develop—strategies of self-distraction. As for me, not long after I see chocolate mousse on a dessert tray, it will be in my mouth. So if I had diabetes, I would try to imagine that it's poison instead.

HOW DOES THAT WORK?

What Freud was talking about when he discussed the unconscious or the id is now understood as the limbic system of the brain. This is the more primitive part where the amygdala—a small ancient brain structure that



plays an important role in emotional reactions like fear—is the central unit that’s involved in hot emotions. These are things that we share with the other animals; they have to do with basic drives and basic needs, such as fear, anger, hunger, and sex. The amygdala mobilizes us for action but does not encourage us to reflect on the long-term consequences. It does not, for example, help us plan for retirement or even be patient in order to receive more marshmallows.

CAN WE TURN OFF THIS HOT SYSTEM?

That is the function of the prefrontal cortex. This region is crucial for self-control and future-oriented decisions. The prefrontal cortex is among the most evolved brain regions. It is the source of creativity and imagination, and it serves to inhibit actions that could interfere with our goals. I call it the “cool system.” The two systems interact continuously and seamlessly.

AND YOUR RESEARCH INTO SELF-CONTROL HAS EXPLORED HOW THIS COOL SYSTEM TEMPERA OUR INSTINCTS?

That’s exactly what we’ve done. Most people brush their teeth before they go to bed, but that’s not what their hot system is telling them to do. The message from the hot system is: I’m bone-tired and just want to collapse into bed. But we don’t do that because we have made it a habit to brush our teeth beforehand. Self-control works best when we’ve made a habit of it. So it helps to have rules, resolutions, and if-then plans.

WHAT IS AN IF-THEN PLAN?

An example: If it’s time to go to bed, then I must first brush my teeth.

HAVE YOU EVER TAKEN THE MARSHMALLOW TEST?

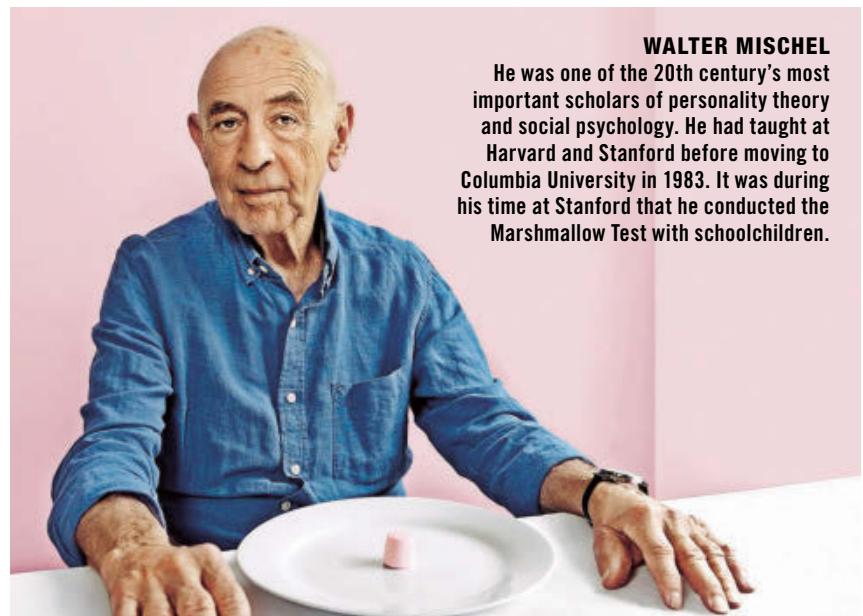
No, I haven’t, but life is testing us all the time. And in some ways I am very disciplined; otherwise, I could never have authored 200 publications. As a refugee who had to flee my home country of Austria because of the Nazis, I would never have amounted to much. As a 9-year-old in New York, I was assigned to a kindergarten class to learn English. I remember trying to walk on my knees so as not to stick out from the 5-year-olds when our class marched through the corridors. Later on I had helped my parents at their five-and-dime store in Brooklyn. Things were very different then: The concept of family fun and together time did not exist for us. My parents were too busy working to survive.

AND THAT MADE YOU MORE DISCIPLINED AND DETERMINED IN YOUR ADULT LIFE?

It was certainly a formative time. But let me be clear: You don’t need the same degree of discipline for every aspect of your life. Some people are extremely disciplined when it comes to their work but have no self-control when it comes to chocolate. Someone else might be very disciplined at the gym but may have problems keeping the home neat and tidy. It all depends on what’s important to you.

SO MOTIVATION IS THE DECISIVE FACTOR?

You really need both: an all-important goal you’re passionate about and the ability to keep working hard in order to achieve it. Only then do you have a choice. For then you are not being driven by your hot system—you can diverge from what it tells you to do. To be truly free, you must be able to exercise self-control.



WALTER MISCHEL

He was one of the 20th century’s most important scholars of personality theory and social psychology. He had taught at Harvard and Stanford before moving to Columbia University in 1983. It was during his time at Stanford that he conducted the Marshmallow Test with schoolchildren.

The Marshmallow Test in Figures



4

YEARS OLD

was the age of the kindergarten kids who were given the choice of eating one marshmallow immediately or waiting and getting two.



13

YEARS LATER

a follow-up questionnaire asked parents and teachers to assess the children's self-control, happiness, and success.



30

PERCENT OF THE U.S. CHILDREN

waited until the researcher came back. When the experiment was repeated in Cameroon, Africa, nearly 70% waited.

DOESN'T THE EFFORT TO MAINTAIN SELF-CONTROL REQUIRE CONSTANT SACRIFICE AND SELF-DENIAL? IS THAT DESIRABLE?

To many people it is very desirable.

BUT THERE'S MORE TO LIFE THAN SELF-DISCIPLINE...

I'm not saying you have to be totally in command of yourself all the time. Absolutely not. A life that consists of nothing but restraint and self-control is not a life worth living, and the same applies to a life devoid of self-control. We're not talking here about people who are already very disciplined and are choosing between a little bit more pleasure or a little bit more self-denial. Many people suffer greatly because they don't have any self-control. They can't get ahead in their professional life because they're quick-tempered, or they make a mess of relationships or can't get a handle on an addiction. Those lives are a catastrophe.

HOW DOES YOUR RESEARCH HELP?

We later tried the Marshmallow Test at schools in the Bronx where police cars are constantly parked outside. We found that aggressive students who flipped out if somebody spilled something on their shoes had a hard time delaying any sort of gratification. We thought there was a connection, and we wanted to help them learn to use their cool system. I see that as my research's key contribution to society. Children can learn self-discipline, and it should be promoted in kindergarten.

SHOULD PARENTS BE PROMOTING THE COOL SYSTEM IN THEIR CHILDREN?

They should at least behave in such a way as to provide a role model for self-discipline that their children can emulate. And when parents promise their children something, they should keep their promise. Otherwise they'll destroy any sense of trust.

WHAT DOES TRUST HAVE TO DO WITH IT?

A great deal. When you can't count on getting the promised result, there is no motivation to do the right thing in the future. We once experimented to find out what would happen if we didn't give the children that second marshmallow we'd promised them. The lesson they quickly learned was the only marshmallow that counts is the one that they have in their mouth. Then none of them waited anymore. The hot and cool systems interact in a reciprocal relationship; when one becomes active, the other becomes less so. Children who live in chaotic, unstable conditions are subjected to chronic stress. That activates the hot system and impairs the cooling of the prefrontal cortex, the part of the brain that is essential not just for waiting for marshmallows but for doing well in school, holding down a job, and maintaining relationships. Parents should strive to keep children's stress levels as low as possible. And they should be positive role models for the children and exemplify good behavior.



RECOMMENDED READING

The Marshmallow Test: Why Self-Control Is the Engine of Success by Walter Mischel (Little, Brown Spark, New York). Reprint edition: 2015, 336 pages.



What really counts in the end...

THE NIGHT HAS 90 MINUTES

Sperm whales are among the most voracious hunters in the oceans. During their short naps, however, they can seem strangely vulnerable. In an amazing stroke of luck, Swiss wildlife photographer Franco Banfi was able to get up close and personal while a whale pod slept...

REAL DEEP SLEEP

Sperm whale behavior includes naps in a state of apparent REM sleep, which has never before been clearly observed in any whale, dolphin, or porpoise.

SERENE SLUMBER

During their 12-minute power naps, the whales may dangle peacefully and vertically in the water with both of their eyes closed.



ES

SLEEP MINIMALISTS

Scientists at the University of St Andrews in Scotland found the huge whales spend about 7% of their time sleeping. No other mammal gets by on less rest.

Franco Banfi couldn't believe his luck: How often does anyone get a chance to observe sperm whales close up? But as the Swiss underwater photographer and his team were following a pod of the giant creatures near the island of Dominica in the Caribbean Sea, something even more magical happened. As if reacting to an invisible and inaudible command, the whales suddenly executed a 90-degree turn and positioned themselves vertically. It took the 60-year-old photographer a moment to realize he might be obtaining some extremely rare images. The whales had decided it was time for a nap, so they took one—if only for a few minutes...

Scientists have found that *Physeter macrocephalus* rarely rests, and then only for short periods. In all, these huge marine mammals spend 7.1% of their lives asleep, and their power naps last between 6 and 24 minutes—totaling about an hour and a half of sleep per 24 hours. That's believed to be less than any other mammal, on land or sea. But in contrast to other cetaceans (whales, dolphins, and porpoises), sperm whales seem to sleep with both eyes shut. Previously, whales and dolphins had been observed keeping one eye open while they rested. That is presumably so as not to let their guard

down, which might allow a predator to approach. But previous observations had been conducted in captive environments. Then researchers from the University of St Andrews in Scotland found a pod of sperm whales hanging vertically in the water with their noses poking above the surface. The pod hadn't seemed to notice the human intruders until one whale was accidentally nudged by a boat. The pod moved some distance away and then went back to sleep about 15 minutes later. Like Franco Banfi, the researchers were puzzled by the whales' behavior. "I don't know why they sleep vertically. Perhaps it's because they can use the sonar they have in their head to sense danger approaching," says Banfi. "I am thankful the whales trusted me and gave me the opportunity to attend the show. It doesn't happen like that every time you see them."

Bad to the Bone

Full tang stainless steel blade with natural bone handle —now **ONLY \$79!**

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— J., La Crescent, MN



"The feel of this knife is unbelievable...this is an incredibly fine instrument."

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