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'Ultraprocessed' foods may make you eat more, clinical trial suggests

Kelly Servick

Something about the industrial processing of food makes us more likely to overeat, according to a new study. Volunteers ate more and gained more weight on a heavily processed diet than an unprocessed one, even when the two diets had the same available calories and nutrients.

The study is "a landmark first," and a "shot over the bow" in a debate over the health of processed food, says Steven Heymsfield, an obesity researcher at Louisiana State University's Pennington Biomedical Research Center in Baton Rouge who was not involved with the work. But some experts question whether the study controlled for important differences between the diets.

The definition of "processed food" is controversial. Nearly all the food at grocery stores is subject to some processing: It's pasteurized, vacuum sealed, cooked, frozen, fortified, and mixed with preservatives and flavor enhancers. Some of these processes can change its nutritional qualities. And some studies have found associations between processed diets and increased risk of obesity, cancer, and even earlier death, but none has shown a causal link.

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Still, some health officials and national governments have seized on processing as a culprit in the global epidemic of obesity and related diseases. The official **dietary guidelines of Brazil**, for example, recommend that people "limit consumption of processed foods."

Kevin Hall, a physiologist at the National Institute of Diabetes and Digestive and Kidney Diseases in Bethesda, Maryland, suspected that processed foods were linked to poor health simply because they were likely to contain lots of fat, sugar, and salt. So in the new experiment, he and his team tried to rule out those factors. They recruited 20 healthy people and gave each about $6000 to surrender some freedoms, dietary and otherwise. Participants spent 28 straight days in a National Institutes of Health facility—with no excursions. They wore loose-fitting scrubs to make it harder for them to guess whether their weight was changing. Each was restricted to an "ultraprocessed" diet or a "minimally processed"

diet for 2 weeks, and then switched to the other diet for 2 more weeks.

The study used **a food classification system called NOVA** developed by a team of researchers in Brazil. It describes "ultraprocessed" foods as ready-to-eat formulations with five or more ingredients, often including flavor-enhancing additives, dyes, or stabilizers. To be considered "minimally processed," foods can be frozen, dried, cooked, or vacuum packed, but they can't include added sugar, salt, or oil. Meals in the ultraprocessed arm of the study included packaged breakfast cereals, sweetened yogurt, canned ravioli, and hot dogs. Those in the unprocessed diet included oatmeal, steamed vegetables, salads, and grilled chicken. Dietitians carefully matched the processed and unprocessed diets for calories, sugar, sodium, fat, and fiber.

The captive participants did enjoy one big freedom: They chose how much to consume. Once they ate their fill, Hall's team calculated their intake by painstakingly weighing the leftovers, down to every dollop of ketchup that didn't make it onto a hot dog. The researchers found that by the second week of each diet, people were eating, on average, **about 500 more calories per day when the fare was ultraprocessed**. That extra consumption led to a weight gain of about a kilogram during the 2 weeks on the ultraprocessed diet, versus a loss of about a kilogram on the unprocessed diet, they report today in *Cell Metabolism*.

"They showed that the effect [of processing] goes beyond nutrients," says Carlos Monteiro, an epidemiologist at the University of São Paulo in São Paulo, Brazil, who helped develop the NOVA classification system and supports government interventions to limit processed food consumption. Simply reformulating packaged foods to contain less sugar, salt, or fat—as many large companies are now attempting—won't eliminate their risks, he says.

If participants continued eating those extra 500 calories, they would "gain a lot of weight— a *lot* —over time," says Heymsfield, though he

perfectly match the nutrition of the diets, there were some differences that may have influenced how much people ate. The ultraprocessed meals contained slightly less protein, and some research has found that people tend to eat until they reach a certain protein target. If that protein is more diluted, those studies hint, people will consume more calories to hit the same target.

Ultraprocessed foods also tend to be more energy-dense—they have many more calories per gram, notes Barbara Rolls, an obesity researcher who studies eating behavior at Pennsylvania State University in State College. (Although Hall's team concluded the two diets were roughly equal in energy density, the measurements included low-energy-density beverages added to the ultraprocessed diet to boost fiber via dissolved supplements.) Rolls's team has found that more energy-dense foods lead people to eat more calories because they tend to eat a consistent weight or volume of food day to day.

Hall and his colleagues are now planning a similar-size study with a few tweaks: They'll bump up the protein in the ultraprocessed diet and swap fiber-enriched beverages for soups, which may encourage people to eat more slowly.

For now, some researchers aren't convinced that processing itself is a menace. "A lot of … the ultraprocessed foods in this study are perhaps ones that we [shouldn't] to be eating too often," Rolls says. And most people don't have the time or resources to prepare farm-to-table meals, she adds. "If we had to live without processed foods, I don't think we would be able to feed the population—nor would people like it."*

notes that their gusto for the ultraprocessed diet might have waned if the study had gone on a few weeks longer. He suspects people overate processed food because it was more appealing. "The ultraprocessed foods look like foods I might overeat also, given the chance," he says.

Yet on surveys, the participants rated the processed meals as no more pleasant than the unprocessed ones. If they weren't enjoying the food more, why were they eating more of it?

One possibility is that industrial processing produces softer foods that are easier to chew and swallow—and thus easier to scarf down. The participants ate faster on the ultraprocessed diet, and studies have found that people tend to eat more when they eat faster. Blood tests also revealed that, while on the unprocessed diet, people had higher levels of an appetite-suppressing hormone called PYY and lower levels of the appetite-stimulating hormone ghrelin, though it's not clear how these changes relate to food processing.

And despite the researchers' efforts to

Trees and microbes

Gabriel Popkin

Millions of species of fungi and bacteria exchange nutrients between soil and the roots of trees, forming a vast, interconnected web of organisms throughout the woods. In fact, trees would be nothing without their microbial sidekicks.

Now, for the first time, scientists have mapped this "wood wide web" on a global scale, using a database of more than 28,000 tree species living in more than 70 countries.

"I haven't seen anybody do anything like that before," says **Kathleen Treseder**, an ecologist at the University of California, Irvine. "I wish I had thought of it."

Before scientists could map the forest's underground ecosystem, they needed to know something more basic: where trees live. Ecologist **Thomas Crowther**, now at ETH Zurich in Switzerland, gathered vast amounts of data on this starting in 2012, from government agencies and individual scientists who had identified trees and measured their sizes around the world. In 2015, he mapped trees' global distribution and reported that Earth has about 3 trillion trees.

Inspired by that paper, **Kabir Peay**, a biologist at Stanford University in Palo Alto, California, emailed Crowther and suggested doing the same for the web of underground organisms that connects forest trees.

Each tree in Crowther's database is closely associated with certain types of microbes. For example, oak and pine tree roots are surrounded by ectomycorrhizal (EM) fungi that can build vast underground networks in their search for nutrients. Maple and cedar trees, by contrast, prefer arbuscular mycorrhizae (AM), which burrow directly into trees' root cells but form smaller soil webs. Still other trees, mainly in the legume family (related to crop plants such as soybeans and peanuts), associate with bacteria that turn nitrogen from the atmosphere into usable plant food, a process

known as “fixing” nitrogen.

The researchers wrote a computer algorithm to search for correlations between the EM-, AM-, and nitrogen-fixer–associated trees in Crowther’s database and local environmental factors such as temperature, precipitation, soil chemistry, and topography. They then used the correlations found by the algorithm to fill in the global map and predict what kinds of fungi would live in places where they didn’t have data, which included much of Africa and Asia.

The team found that the local climate determined the nature of the web. In cool, temperate and boreal forests, where wood and organic matter decay slowly, network-building EM fungi dominate. About four out of five trees in these regions are associated with these fungi, reported the team, in the journal *Nature*.

In contrast, in the warmer tropics where wood and organic matter decay quickly, AM fungi dominate. These fungi form smaller webs and do less intertree swapping. Hence the tropical wood wide web is likely to be more localized. About 90% of all tree species in these regions are associated with AM fungi; the vast majority are clustered in the hyper-diverse tropics. Nitrogen fixers were most abundant in hot, dry places such as the desert of the U.S. Southwest.

Charlie Koven, an Earth system scientist at the Lawrence Berkeley National Laboratory in California, applauds what he says is the first global forest microbe map. But he wonders whether the authors missed some important factors that also shape the underground world. Hard-to-measure processes such as nutrient and gas loss from the soil could affect where different microbes live; if so, the study’s predictions could be less accurate, he says.

Despite such uncertainties, having the first qualitative studies for which tree-associated microbes live where will be “very useful,” Treseder says. The findings could, for example, help researchers build better computer models to predict how much carbon forests will store and how much they will spew into the atmosphere as the climate warms, she says.

Crowther, however, is ready to make a prediction now. His results suggest that as the planet warms, about 10% of EM-associated trees could be replaced by AM-associated trees. Microbes in forests dominated by AM fungi churn through carbon-containing organic matter faster, so they could liberate lots of heat-trapping carbon dioxide quickly, potentially accelerating a climate change process that is already happening at a frightening pace.

Treseder thinks it is not so simple. She says scientists are still puzzling out how different soil fungi interact with carbon. But, she adds, “I’m willing to be convinced.”

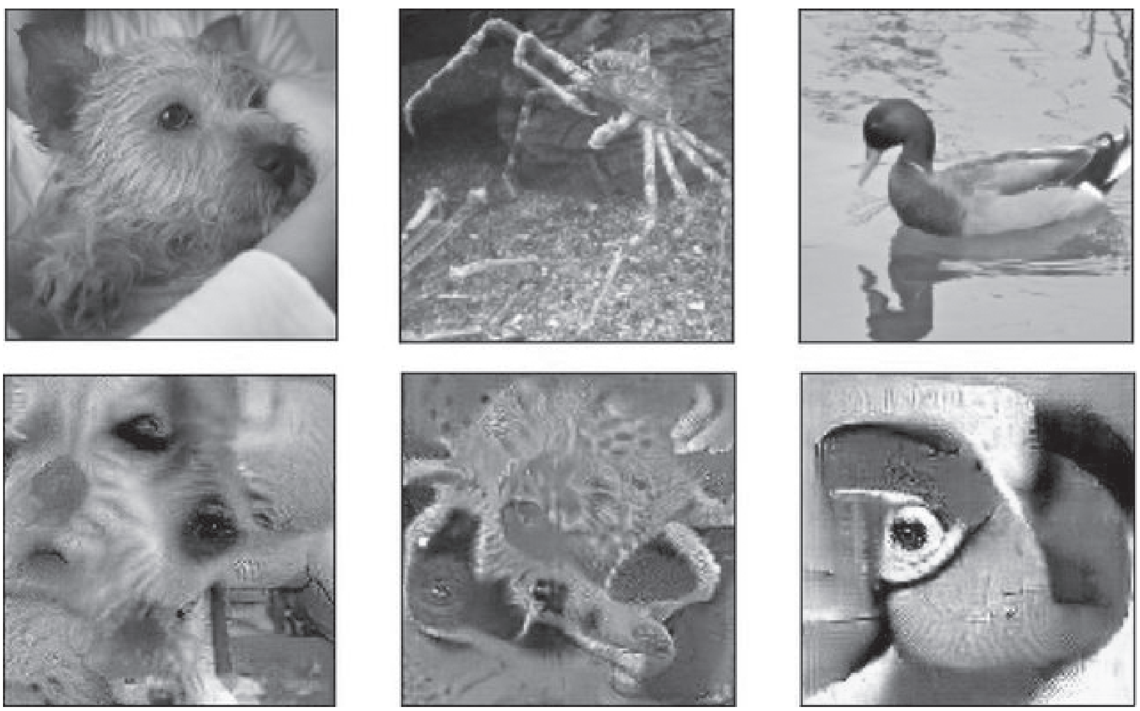
Scientists help artificial intelligence outsmart hackers

Matthew Hutson

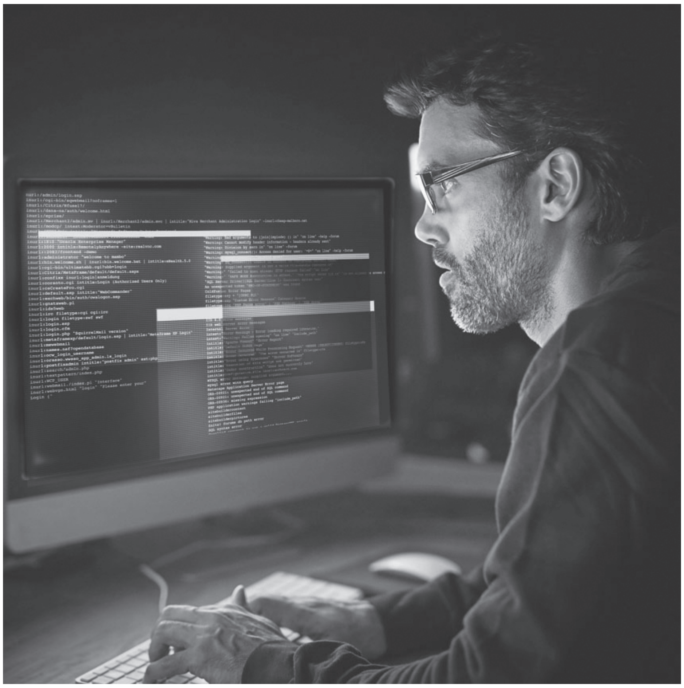
A hacked message in a streamed song makes Alexa send money to a foreign entity. A self-driving car crashes after a prankster strategically places stickers on a stop sign so the car misinterprets it as a speed limit sign. Fortunately these haven't happened yet, but hacks like this, sometimes called **adversarial attacks**, could become commonplace—unless artificial intelligence (AI) finds a way to outsmart them. Now, researchers have found a new way to give AI a defensive edge, they reported here last week at the International Conference on Learning Representations.

The work could not only protect the public. It also helps reveal why AI, notoriously difficult to understand, falls victim to such attacks in the first place, says Zico Kolter, a computer scientist at Carnegie Mellon University, in Pittsburgh, Pennsylvania, who was not involved in the research. Because some AIs are too smart for their own good, spotting patterns in images that humans can't, they are vulnerable to those patterns and need to be trained with that in mind, the research suggests.

To identify this vulnerability, researchers created a special set of training data: images that look to us like one thing, but look to AI like another—a



An artificial intelligence (AI) trained on the photos of a dog, crab, and duck (top) would be vulnerable to deception because these photos contain subtle features that could be manipulated. The images on the bottom row don't contain these subtle features, and are thus better for training secure AI. ILYAS, SANTURKAR, TSIPRAS, ENGSTROM, TRAN, MADR



picture of a dog, for example, that, on close examination by a computer, has catlike fur. Then the team mislabeled the pictures—calling the dog picture an image of a cat, for example—and trained an algorithm to learn the labels. Once the AI had learned to see dogs with subtle cat features as cats, they tested it by asking it to recognize fresh, unmodified images. Even though the AI had been trained in this odd way, it could correctly identify actual dogs, cats, and so on nearly half the time. In essence, it had learned to match the subtle features with labels, whatever the obvious features.

The training experiment suggests AIs use two types of features: obvious, macro ones like ears and tails that people recognize, and micro ones that we can only guess at. It further suggests adversarial attacks aren't just confusing an AI with meaningless tweaks to an image. In those tweaks, the AI is smartly seeing traces of something else. An AI might see a stop sign as a speed limit sign, for example, because something about the stickers actually makes it subtly resemble a speed limit sign in a way that humans are too oblivious to comprehend.

Some in the AI field suspected this was the case, but it's good to have a research paper showing it, Kolter says. Bo Li, a computer scientist at the University of Illinois in Champaign who was not involved in the work, says distinguishing apparent from hidden features is a "useful and good research direction," but that "there is still a long way" to doing so efficiently.

So now that researchers have a better idea of why AI makes such mistakes, can that be used to help them outsmart adversarial attacks? Andrew Ilyas, a computer scientist at the Massachusetts Institute of Technology (MIT) in Cambridge, and one of the paper's authors, says engineers could change the way they train AI. Current methods of securing an algorithm against attacks are slow and difficult. But if you modify the training data to have only human-obvious features, any algorithm trained on it won't recognize—and be fooled by—additional, perhaps subtler, features.

And, indeed, when the team trained an algorithm on images without the subtle features, **their image recognition software was fooled by adversarial attacks only 50% of the time**, the researchers reported at the conference and in a preprint paper posted online last week. That compares with a 95% rate of vulnerability when the AI was trained on images with both obvious and subtle patterns.

Overall, the findings suggest an AI's vulnerabilities lie in its training data, not its programming, says Dimitris Tsipras of MIT, a co-author. According to Kolter, "One of the things this paper does really nicely is it drives that point home with very clear examples"—like the demonstration that apparently mislabeled training data can still make for successful training—"that make this connection very visceral."

These tiny microbes are munching away at plastic waste in the ocean

Helen Santoro

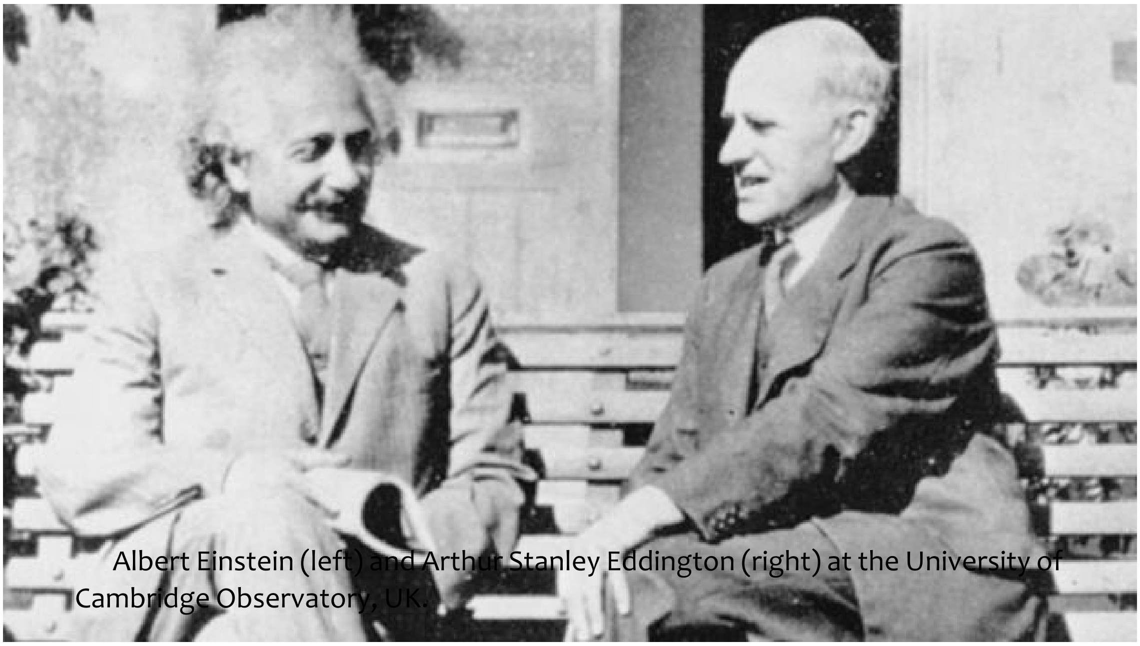
Plastic makes up nearly 70% of all ocean litter, putting countless aquatic species at risk. But there is a tiny bit of hope—a teeny, tiny one to be precise: Scientists have discovered that microscopic marine microbes are eating away at the plastic, causing trash to slowly break down.

To conduct the study, researchers collected weathered plastic from two different beaches in Chania, Greece. The litter had already been exposed to the sun and undergone chemical changes that caused it to become more brittle, all of which needs to happen before the microbes start to munch on the plastic. The pieces were either polyethylene, the most popular plastic and the one found in products such as grocery bags and shampoo bottles, or polystyrene, a hard plastic found in food packaging and electronics. The team immersed both in saltwater with either naturally occurring ocean microbes or engineered microbes that were enhanced with carbon-eating microbe strains and could survive solely off of the carbon in plastic. Scientists then analyzed changes in the materials over a period of 5 months.

Both types of plastic lost a significant amount of weight after being exposed to the natural and engineered microbes, scientists reported in April in the Journal of Hazardous Materials. The microbes further changed the chemical makeup of the material, causing the polyethylene's weight to go down by 7% and the polystyrene's weight to go down by 11%. These findings may offer a new strategy to help combat ocean pollution: Deploy marine microbes to eat up the trash. However, researchers still need to measure how effective these microbes would be on a global scale.

The man who made Einstein world-famous

Matthew Stanley



Albert Einstein (left) and Arthur Stanley Eddington (right) at the University of Cambridge Observatory, UK.

It is hard to imagine a time when **Albert Einstein's** name was not recognised around the world.

But even after he finished his theory of relativity in 1915, he was nearly unknown outside Germany - until British astronomer **Arthur Stanley Eddington** became involved.

This was because the first World War was going on from 1914 to 1918 and Einstein was in Germany, which was the enemy of England, France and Russia. So Einstein's ideas were trapped by the blockades of the Great War, and even more by the vicious nationalism that made "enemy" science unwelcome in the UK.

But Einstein, a socialist, and Eddington, a Quaker, both believed that science should transcend the divisions of the war. It was their partnership that allowed relativity to leap the trenches and make Einstein one of the most famous people on the globe.

Einstein and Eddington did not meet during the war, or even send direct messages. Instead, a mutual friend in the neutral Netherlands decided to spread the new theory of relativity to Britain.

Einstein was very, very lucky that it was Eddington, the Plumian Professor at Cambridge and officer of the Royal Astronomical Society, who received that letter.

Not only did he understand the theory's complicated mathematics, as a pacifist he was one of the few British scientists willing to even think about German science.

He dedicated himself to championing Einstein and so helped revolutionise the foundations of science. He also restored internationalism to scientists themselves.

Einstein was the perfect symbol for this - a brilliant, peaceful German who refuted every wartime stereotype while challenging the deepest truths of Newton himself.

Desperate fight to test Einstein's theory

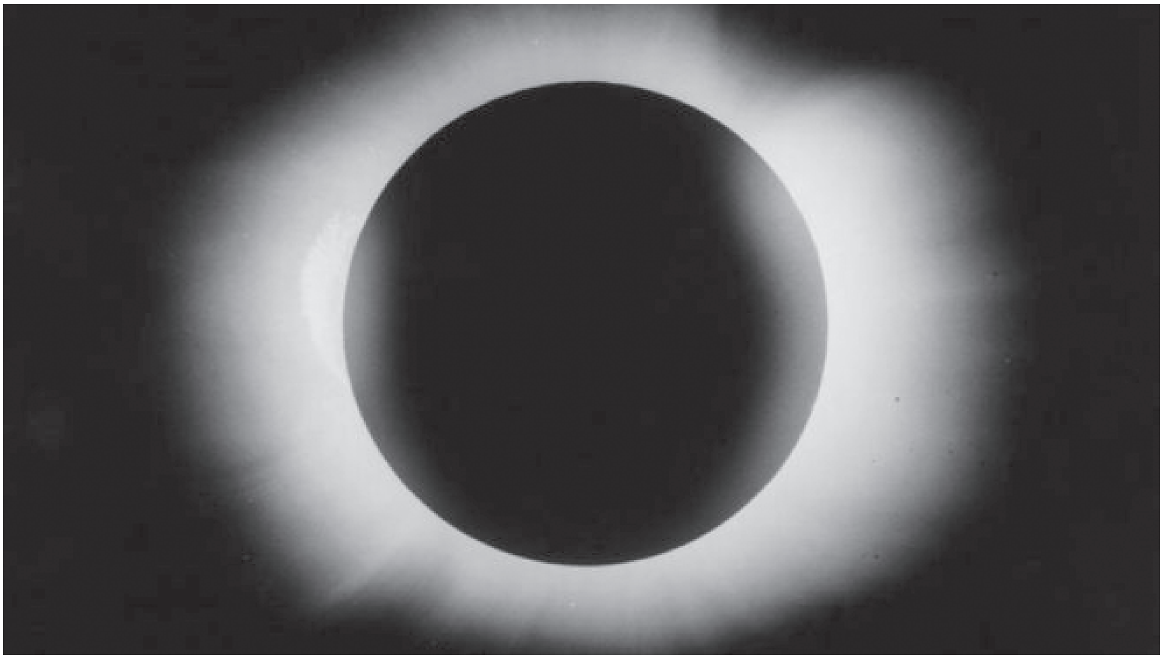
So, as Einstein was trapped in Berlin, starving behind the blockade and living under government surveillance for his political views, Eddington tried to convince a hostile English-speaking world that an enemy scientist was worthy of their

attention.

He wrote the first books on relativity, gave popular lectures on Einstein, and became one of the great science communicators of the 20th Century.

His books stayed on the bestseller lists for decades, he was a constant presence on BBC radio, and was eventually knighted for this work.

It was hard to convince the UK to care about space-time and gravity as the U-boats were sinking food transports, and thousands of young lives were lost for meagre gains in Flanders, Belgium.



Just Einstein's ideas were not enough. Relativity is strange, with twins ageing differently and planets trapped by warped space.

Eddington needed a definitive demonstration that relativity was true and Einstein was right, and that only his international approach could revolutionise science.

His best option was to test a bizarre prediction of Einstein's theory of general relativity. Einstein had been trying for years to have this prediction tested, with no success.

When light passed near a massive body like the Sun, Einstein said, gravity would bend the rays ever so slightly.

This meant the image of a distant star would be shifted a small amount - the star would seem to be in the wrong place.

Einstein predicted a specific number for that shift (1.7 arc-seconds, or about 1/60 millimetre on a photograph). An astronomer would find this challenging to measure, but it could be done. Unfortunately, it is normally impossible to see stars during daytime, so one would have to wait until a total solar eclipse to make the observation.

Total eclipses are rare, short, and often located in inconvenient places requiring extensive travel for European astronomers.

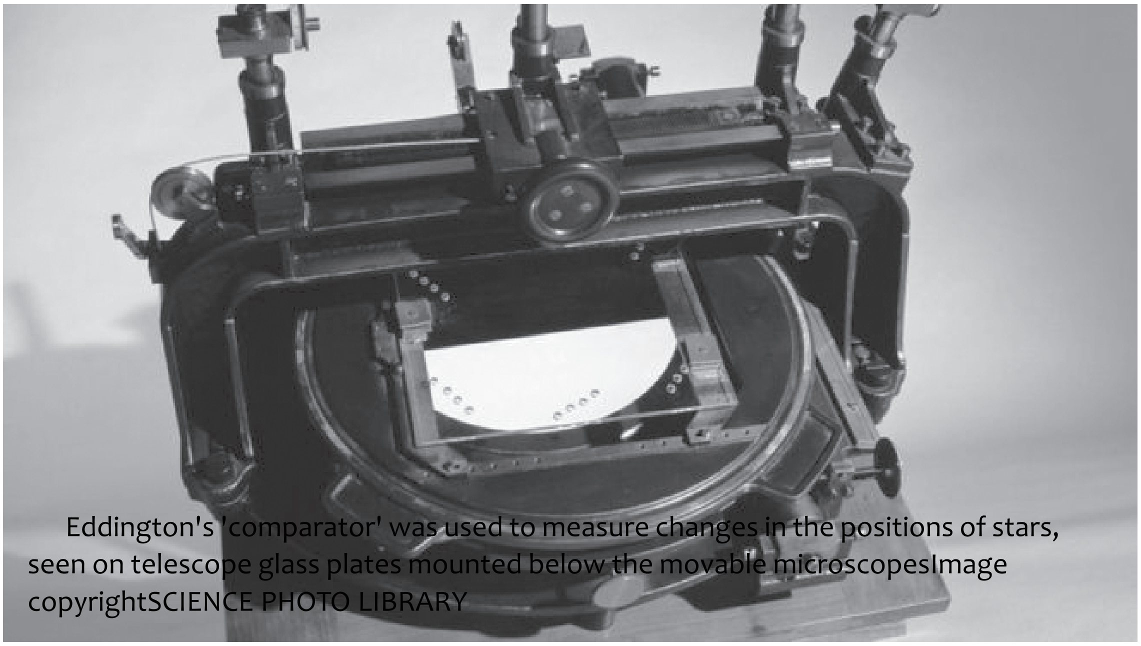
Eddington, though, thought he might be able to make it happen at an upcoming eclipse in May 1919, visible in the southern hemisphere.

Frank W Dyson (left) secured funding for Eddington's expedition

Even with the U-boat threat, no country was better positioned than Britain to undertake an expedition to test Einstein's prediction.

Eddington needed a great deal of support for this.

Fortunately, he was close friends with Frank W Dyson, the Astronomer Royal. Dyson secured funding, although even with the money the war made it difficult to procure needed equipment. Even worse, it was possible



Eddington's 'comparator' was used to measure changes in the positions of stars, seen on telescope glass plates mounted below the movable microscopesImage copyrightSCIENCE PHOTO LIBRARY

that Eddington would not be able to go on the expedition - because he might be in prison.

As a Quaker, Eddington was a conscientious objector to the war. This meant that he would be excused from actually fighting in the war, but would be punished for it. Many other Quakers ended up jailed or performing hard labour.

After many failed appeals it seemed that Eddington would be arrested, but at the last moment he received an exemption (no doubt engineered by his politically savvy friend the astronomer royal).

In Search of an Eclipse

Amazingly, it was given on the condition that he carry out the expedition to test Einstein's theory.

The armistice (cease fire) in November 1918 meant that the expedition could go ahead. Eddington wanted to make sure the results of the expedition, whatever they were, brought Einstein to the attention of the world.

So he and Dyson started a public relations campaign to get both the scientific community and ordinary people excited about the results.

The newspapers were primed and ready to report on what Eddington presented as an epic battle between Britain's own Newton and the upstart Einstein.

Einstein, seriously ill from wartime starvation and trying to navigate revolution-torn Berlin, knew little of this.

Instead, Eddington and his colleagues had to test Einstein's prediction almost completely on their own.

Two teams were sent to observe the eclipse: one to Brazil, and one - led by Eddington - to the island of Principe in West Africa.

Eddington's 'comparator' measured changes in the positions of stars, seen on telescope glass plates mounted below the movable microscopes.

On 29 May 1919 - 100 years ago - those astronomers watched the darkened sky for six minutes to catch the smallest change in the stars to reveal the greatest change in our understanding of the universe.

Nearly ruined by weather, equipment malfunctions, and steamship strikes, the expeditions brought back photographs that hopefully showed stars displaced by the Sun's gravity.

Greatest moment in life

After months of intense measurement and mathematics, Eddington had a positive result.

He called this the greatest moment of his life: "I knew that Einstein's theory had stood the test and the new outlook of scientific thought must prevail."

He presented the results to a room at the Royal Society packed with scientists and reporters eager to hear who had triumphed, Einstein or Newton (even as the portrait of Newton gazed over the proceedings).

The announcement created an enormous stir. The president of the Royal Society declared this "one of the highest achievements in human thought".

The Times newspaper headline the next day read "Revolution in Science".

Eddington had planned the event perfectly. Einstein, virtually overnight, went from an obscure academic to a sage everyone wanted to know more about.

And Eddington gave the public what they wanted. As the chief apostle of relativity in the Anglophone world, he was the one every newspaper and magazine went to.

His lectures had to turn away hundreds of people. Those who made it in not only learned about the strange physics of relativity, but also about Einstein as the symbol of international science, able to rise above the hatred and chaos of war.

Einstein himself could barely rise from his sickbed. He heard about the results from a telegram via the Netherlands. He was delighted that his theory had been verified even as he was baffled by the media firestorm that suddenly enveloped his life.

Never again would he be able to venture through his front door without being accosted by reporters.

Without Eddington, relativity would have gone unproven, and Einstein would have never become the icon of genius.

Eddington was Einstein's most essential ally, though they did not meet until years after the war's end.

Their collaboration was crucial not only to the birth of modern physics, but to the survival of science as an international community through the darkest days of World War One.

Matthew Stanley is the author of Einstein's War: How Relativity Conquered Nationalism and Shook the World

School strike for climate: Protests staged around the world

Schools strike for Climate: Protests staged around the world

School students around the world have gone on strike to demand action on climate change.

Organisers said more than a million people were expected to join the action in at least 110 countries on Friday.

They are calling on politicians and businesses to take urgent action to slow global warming.

The strikes are inspired by student Greta Thunberg, who has become a global figurehead since protesting outside Sweden's parliament in 2018.

Carrying a "school strike for climate change" sign, the then 15-year-old said she was refusing to attend classes until Swedish politicians took action.

The solo protest led to various movements across Europe, the US and Australia, known as "Fridays for Future" or "School Strike for Climate".

The last co-ordinated international protest took place on 15 March, with an estimated 1.6 million students from 125 countries walking out of school.

The strike begins

The action on Friday began in Australia and New Zealand. In Melbourne, 13-year-old Nina Pasqualini said she was joining the strike because she was worried about "weather disasters".

"Every time we have a huge bushfire here another animal might go extinct," she told Reuters news agency.

global temperatures from rising 1.5C (2.7F) above pre-industrial levels.

A global movement

As countries around the world woke up, the action spread.

Strikes were held in Asian nations including India, Afghanistan Thailand and Japan.

In Europe - where the movement first gained traction - images of mass strikes were shared on social media.

"Inaction equals extinction" and "save the world not your money" read some of the placards on display.

Protesters in Brussels warned that time is running out to take action.

Students in Frankfurt were among those calling for policies to save the planet.

Climate protesters blocked the entrance to Norway's central bank, demanding that it stop investing in companies that burn coal.

Students held up a sign with the slogan "stop climate change now" during a protest in Vienna, Austria.

Demonstrators in the Austrian capital said governments needed to act to "stop climate change now".

In London, scores of protesters congregated outside parliament, chanting "climate change has got to go".

Organisers are expecting more than a million students around the world to walk out.

Australia just had its hottest summer on record and climate change is seen as the cause of the increasing frequency and severity of droughts, heat waves, floods and the melting of glaciers around the world.

In 2018, global carbon emissions hit a record high and UN-backed panel on climate change last October warned that to stabilise the climate, emissions will have to be slashed over the next 12 years.

Earlier this month, a UN report warned that one million animal and plant species were now threatened with extinction.

Sophie Hanford, a national organiser in New Zealand, said Friday's strike was "only the beginning".

The protesting students have vowed to continue boycotting classes on Fridays until their countries adhere to the 2015 Paris climate agreement, which aims to prevent

"Act now or burn later" and "change the system not the government" read some of the signs held up by participants, as they called for urgent action.

Student protesters want the government to reform the national curriculum to include more material on climate change.

Organisers said strikes had been organised in about 125 towns and cities across the UK.

Student protesters joined the global movement outside parliament in London.

Young people are calling on their governments to "act now" on climate change.

An invitation to older generations

In an open letter published in Germany's Süddeutsche Zeitung on the eve of Friday's strike, Ms Thunberg and prominent climate activist Luisa Neubauer, 22, called on older generations to join the action in September.

"This is a task for all humanity. We young people can contribute to a bigger fight, and that can make a big difference. But that only works if our action is understood as a call," they wrote.

"This is our invitation. On Friday, 20 September, we will start an action week for the climate with a worldwide strike. We ask you to join us... Join in the day with your neighbours, colleagues, friends and families to hear our voices and make this a turning point in history."

Nurjahan

Kamal Lodaya

Our history books tell us that the Mughal emperor Akbar died in Agra in 1605, and was succeeded by his 36-year old son Salim, who took the title of **Nur-ud-din Jahangir** (which means Light of the Faith, Conqueror of the World).

There are many details that do not make it to our history books. Every Mughal ruler had many sons, competing to become emperor. In this article we will talk about other people who were around Jahangir, particularly one of his many wives, **Mehr-un-Nisa**, the one he married last.

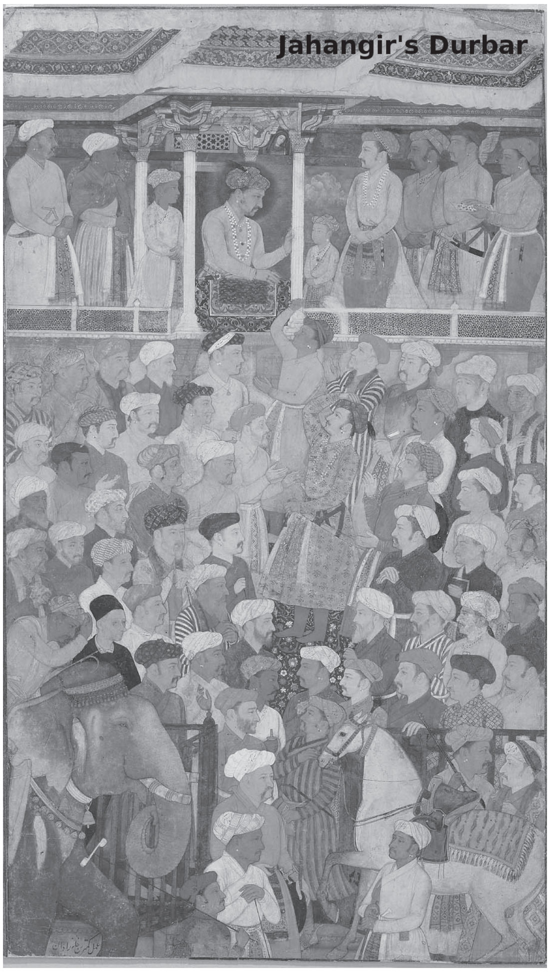
Mehr-un-Nisa was the daughter of **Ghiyas Beg**, a nobleman who supported Khusrau, Jahangir's son, who rebelled against him. For his actions, Ghiyas Beg had to pay a huge fine and the womenfolk of his family were placed in the Emperor's harem. **Ruqaiya Begum** (the queen mother) became very fond of Mehr.

In 1611, at the palace market for nobles called *Meena Bazaar* (whose proceeds would go to charity), Jahangir met Mehr-un-Nisa, when she was shopping with the Queen mother Ruqaiya Begum. She was a widow with a daughter called **Ladli**. He proposed to her and married her. This was a "love marriage", not an "arranged" one like all of Jahangir's earlier marriages. Jahangir gave Mehr the name Nur Mahal, meaning Light of the Palace. It is difficult to realize today that Jahangir did something pathbreaking for his times, marrying a 34-year old widow.

Queen to Empress

Nur gifted clothes, jewels, horses, elephants and cash to the royal men and women. She gave plenty of money to the poor. She supported the weddings of 500 orphan girls. She arranged marriages of her *saheliyan* (companion women) under the age of 40 to soldiers and attendants of Jahangir. Older women were allowed to choose between marriage and remaining with her.

Her skill and her acts of generosity were admired by many, none more so than by the emperor. The most important court offices in finance, intelligence and defence went into the hands of Nur's father and brothers. By the 1620s, Nur's extended family was governing Lahore, Kashmir, Bengal, Odisha and Awadh.



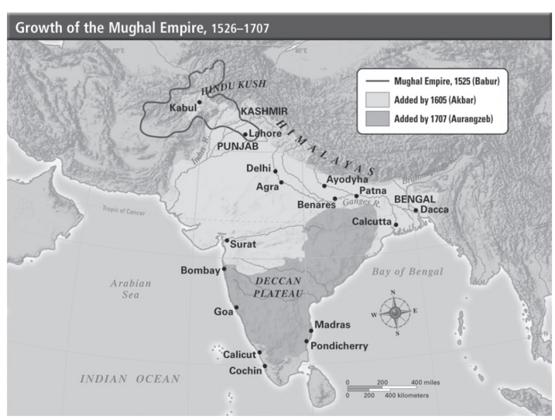
When the camp returned to Ajmer in 1616, Jahangir visited Nur's father's tent. Ghiyas presented Jahangir rare pearls and rubies, and elaborate dresses. Jahangir went back to his imperial tent and declared that Nur Mahal was now Nur Jahan, Light of the World.

On Ghiyas's advice, Jahangir's son **Khurram** was sent to deal with trouble in the Deccan. Jahangir's camp moved around leisurely. The story is that in 1617, Nur Jahan set out in a *howdah* on elephant back on a hunt in Malwa. Four tigers were driven by beaters into a small open area. The empress fired six shots and killed all four. That a woman could aim and shoot with such accuracy impressed Jahangir. He showered her with gold coins.

In October that year, Prince Khurram arrived back at the royal camp in Mandu. While the Deccan was not fully conquered, Jahangir considered the campaign a success. He gave several presents to his son and named him **Shah Jahan**, king of the world. This was a way of telling his court that Khurram was his choice to be the next emperor.

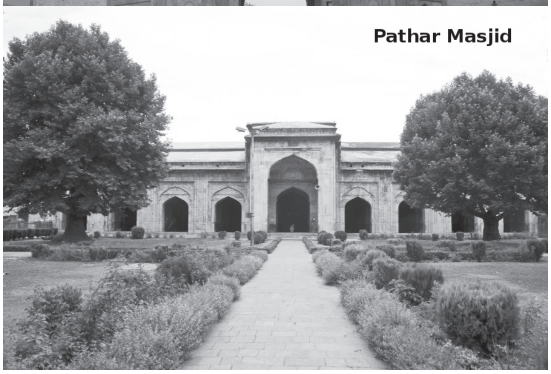
A week later Nur Jahan honoured him too. This told Shah Jahan that she approved of his choice as the crown prince. Three weeks later he displayed his gifts for the emperor and for his "mothers". Nur Jahan was given gifts worth 2 lakh rupees, all the other mothers were given 60,000 rupees. (Their yearly cash allowances would have been 3,000 rupees.)

In 1617 Nur Jahan gave her first royal order. The same year coins were minted with both Jahangir and Nur Jahan's names. Celebrated artist Abul Hasan Nadir uz-Zaman painted her loading a musket. She was a new




Nur Mahal Sarai


Itmaduddaulah

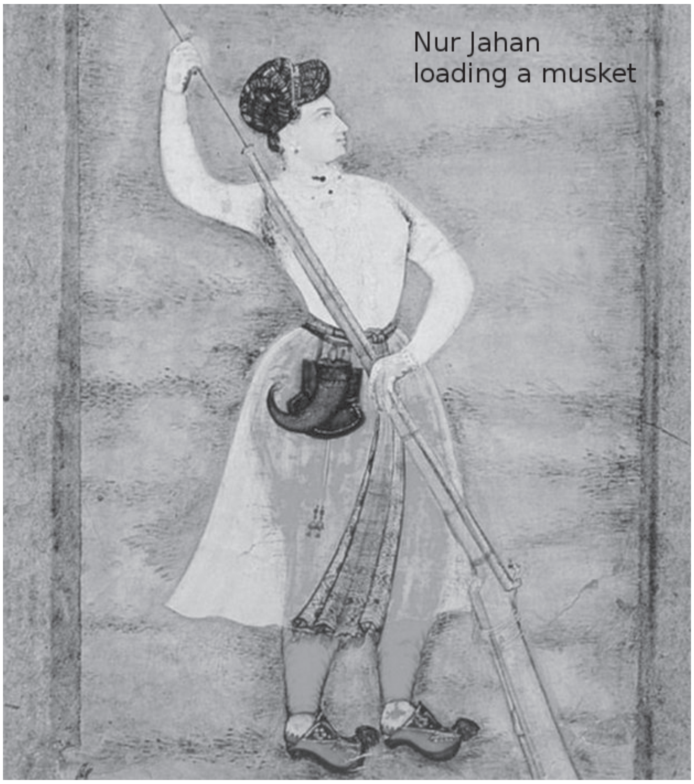

Pathar Masjid


Jahangir's Tomb


Aram Bagh


Nur Jahan's tomb


Parchinkari work in Jahangir's tomb



Nur Jahan loading a musket

kind of woman, and she got a new kind of portrait.

Nur Jahan and Architecture

In 1618 Nur Jahan commissioned and designed the *Nur Mahal Sarai* in Jalandhar, between Agra and Lahore. In 1620 she commissioned the *Patthar masjid* in Srinagar, Kashmir, which Jahangir's camp used as a kind of summer capital. It was completed in 1623. In 1621 she developed the *Aram Bagh* of Mughal emperor **Babar**, Jahangir's great-grandfather, in Agra. When her father passed away on the road to Kashmir in 1622, she ordered construction of a grand tomb for her parents. Completed in 1628, the *Itmad-ud-daula* is called today the "Baby Taj" on account of its architectural sophistication.

As a Poet

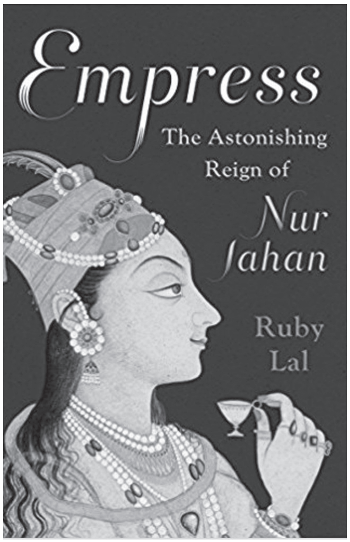
After Jahangir died in 1627, Shah Jahan got his stepbrother **Shahryar** killed, since he did not want any rivals to his rule. He packed off Nur and her daughter Ladli (who was also Shahryar's widow) to Lahore with a yearly allowance of 2 lakh rupees.

Nur and Ladli lived in Lahore for a couple of decades. Nur wrote Farsi poems under the name **Makhfi** ("veiled"). She was known to people there as a charitable and religious person, first constructing Jahangir's tomb (completed in 1637) and then her own in Shahdara Bagh, which would have been nearly complete when she died in 1645. Ladli was buried with her after her own death. The marble in these tombs was plundered for reconstruction of the Harmandir Sahib in Amritsar in the 18th century.

In all Nur's constructions one finds a distinctive open style, downplaying the central domes of major Mughal monuments in favour of artistic inlay work (called *parchinkari* in India). Parchinkari is a key feature in the Taj Mahal, built in Agra from 1632 to 1653 by Ustad Ahmad Lahori for Shah Jahan.

A feminist history

Tracing the life of someone other than an emperor is difficult for historians. Apart from the *Jahangirnama,* some paintings, *firmans* and coins, and the buildings she commissioned, they do not have many



sources regarding Nur Jahan's life. Europeans who came to Jahangir's court have written about it. They thought Jahangir was a weak ruler because he gave so much power to a woman. To rival courtiers, such as the author of the *Shahjahannama* (a courtier of Shah Jahan), Nur Jahan appears as a scheming woman who took advantage of Jahangir's softness to concentrate power around her family.

Let us rethink Nur's story. Jahangir must have been amazed to find in Mehr someone who was witty and intelligent, but also learned and graceful. On a book which she must have bought before marrying Jahangir is found her writing, the words: "Three *mohurs* the price of this treasure, Nawab Mehr-un-Nisa Begum". Poems attributed to her are sophisticated, she could flirt with her poetry. Later she showed herself to be brave, resourceful and capable in administration and architecture.

Mirza Ghiyas Beg was a noble in Akbar's court. Mehr grew up in Akbar's capital

The Mughal camp

Jahangir led a roving life, more so than other Mughal emperors. His royal encampment was about 5 km long and possibly had 3 lakh people, royals, courtiers, soldiers and servants. All the nobles would have tents in the camp. The picture of his *darbar* is from the *Jahangirnama*, his autobiography, in which he wrote about all kinds of subjects. Apart from a statement of the marriage, there is no mention in it of his new wife until 1614. After that there are frequent references. From no other Mughal period do we have so much detail about a royal woman.

The biggest problem Nur faced was the emperor's drinking, and his addiction to drugs like opium. Akbar left behind a strong empire. After the battles against Khusrau and his supporters, Jahangir left wars to other commanders. He did his duties and enjoyed the rituals of kingship. He travelled throughout his kingdom, keeping a close watch on generals and ministers. He enjoyed studying his people, flora and fauna.

Perhaps you may have read that Jahangir allowed the British to trade from the port of Surat, which was to later lead to the British empire on India. Why? Because they presented him with bulldogs, until then a breed not known in India. He was impressed with how they were not frightened by his elephants and would attack them.

Jahangir gathered statistics about animals, vegetables, minerals. He loved books, calligraphy, paintings and gems. He eagerly met learned men of all religions, ascetics, clerics, astrologers, poets. When his health began to decline, in 1621 Nur Jahan threw out his physician and slowly lessened his intake of wine.

What is history?

History is so full of facts and dates. This article also has many facts and dates. Ruby Lal's book {Empress}, on which it is based, makes it more interesting because it tries to trace the life of someone other than an emperor. It is still difficult to figure out what the life of someone not close to the rulers would have been like. Historians have to use their imagination when such sources are not available, but they have to be careful to place themselves in the time that they are talking about, and use facts from that time. They have to declare what is factual, what are their sources and what is imagined. If all this is available, then it is possible to have different interpretations of historical events and figures. The book *Empress* gives a different interpretation of Nur Jahan, yet strongly based on the information available, than what was available from earlier historians.

Fatehpur Sikri. Her mother **Asmat** and the other women would have been forbidden to enter the *mardana*, the men's area of the house. Perhaps they sat on rooftops and chatted, dried and oiled their hair, viewing the busy street from above. We do not know this, but we can guess from the way houses were constructed in Fatehpur Sikri and the fact that women in a family do this today in houses of this construction in much of North India.

After the month of Ramzan, Akbar celebrated Id ul-Fitr, distributing alms and gifts to break the fasts. One can imagine Mehr's father and brothers describing to the women these events. It is not hard to imagine Mehr in the *bazaar* with Asmat, listening to merchants speaking Farsi, Pashto, Hindi and Braj *bhasha*.

Boys in noble families in Mughal India had tutors. Girls were only expected to learn and recite verses of the holy Koran. Conservative *maulvis* said well-bred girls and boys should keep away from frivolous poems with talk of love and wine. Ghiyas disagreed. His family in Persia had many poets. His *haveli* became a haven for poets. Perhaps Mehr listened to their recitals.

Mehr learned to write Farsi (Persian) and Arabic. Her father was a master calligrapher. She learned to speak Hindi. She would know the names of vegetables in the *bazaar*, the names of constellations in the sky. Her parents might have introduced her to Shirazi poets like **Hafiz** and **Saadi**, and the Sufi poet **Rumi**, recognized as having produced classics of Persian literature. She knew art, music and dance.

After her first marriage, Mehr lived in Burdwan in Bengal. Her husband Quli had an estate there, but he had to be away when the governor or the emperor called. She would have come to understand how Bengal was ruled. Her husband, and before that her father, might have exposed her to the capricious tempers in the royal family, the relationship of Akbar with his son Salim and his grandsons. Quli himself had to deal a few times with Salim's unpredictability. When the opportunity presented itself, Nur Jahan showed to Jahangir the amazing abilities that her education had supplied her with.

Based on the book *Empress* by Ruby Lal

Amazing Spider Facts

D. Indumathi,
The Institute of Mathematical Sciences, Chennai

There are approximately 38,000 known species of spiders. Scientists believe there are probably as many more to be discovered. In fact, s piders are found on every continent except Antarctica.

An estimated 1 million spiders live in one acre of land. The number might be closer to 3 million in the tropics. It is estimated that a human is never more than 10 feet away from a spider—ever.

Spiders are vital to a healthy ecosystem. They eat harmful insects, pollinate plants, and recycle dead animal and plants back into the earth. They are also a valuable food source for many small mammals, birds, and fish.

Spiders : How they eat

Spiders eat insects by filling them with digestive juices. Spiders do not have teeth, so they cannot chew their food. Instead, they inject digestive juices into the innards of their meal. Then the spider sucks it up as liquid food.

Most spiders' fangs are like pincers that move sideways toward each other to bite. Others, such as bird-eating spiders, have long fangs that point straight down.

Spiders eat more insects than birds and bats combined. The *Bagheera kiplingi* is the world's only (mostly) vegetarian spider.

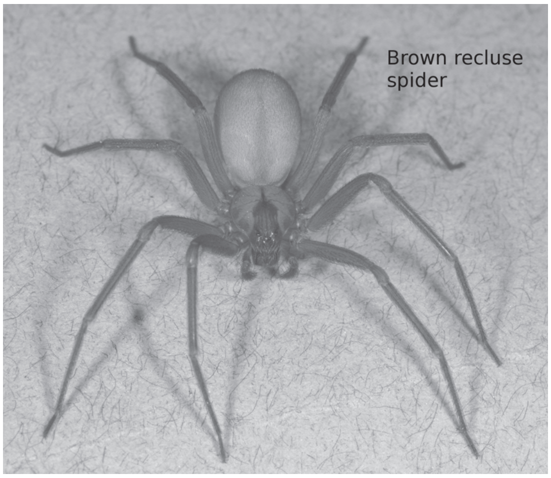
Spider Anatomy

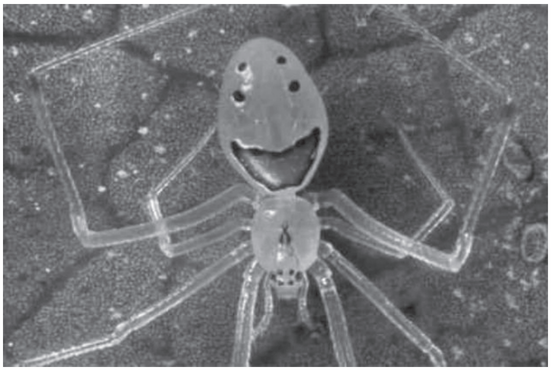
Spiders are not insects. They are arachnids, along with scorpions, mites, harvestmen, and ticks. All arachnids have eight legs and two main body parts (a cephalothorax and an abdomen). In contrast, insects have six legs and three main body parts (a head, a thorax, and an abdomen).

Most spiders have eight eyes and are very near sighted. Spiders also have tiny hairs on their legs to help them hear and smell.

A spider has no bones. Rather, it has an exoskeleton, which is like a hard suit of armor that protects its body. While humans have muscles on the outside of their skeleton, spiders have muscles on the inside. Because an exoskeleton does not grow, a spider molts. Typically, a spider molts about 10 times throughout its life.

Some spiders, such as house spiders, are able to run up walls because their feet are covered in tiny hairs that grip the surface. They can't get out of a bathtub, however, because the surface is too slippery. Other spiders, such as garden spiders, cannot crawl up walls because their legs end in


Brown recluse spider



claws, which help them grip threads of silk instead.

Spiders have blue blood. In humans, oxygen is bound to hemoglobin, a molecule that contains iron and gives blood its red color. In spiders, oxygen is bound to hemocyanin, a molecule that contains copper rather than iron.

Most spiders live alone, meeting other spiders only to mate. A few species of spiders are social and live in groups. For example, in Africa, the web of social spiders such as Stegodyphus colonies can cover whole trees. In India, webs may cover trees for several miles.

Spider Webs

All spiders spin silk, but not all spiders spin webs. Abandoned spider webs are called "cobwebs." Spiders have between two and six spinnerets at the back of their abdomen. Each one is like a tiny showerhead that has hundreds of holes, all producing liquid silk.

The silk that comes out of the spider's spinneret is liquid, but it hardens as soon as it comes in contact with air. Some spiders have up to seven types of silk glands, each creating a different type of silk—such as smooth, sticky, dry, or stretchy.

The silk in a spider's web is five times stronger than a strand of steel that is the same thickness. A web made of strands of spider silk as thick as a pencil could stop a Boeing 747 jumbo jet in flight. Scientists still cannot replicate the strength and elasticity of a spider's silk.

In tropical regions, net-throwing spiders make a small silken web that they throw over their prey.

Web-weaving spiders have two or three claws at the tip of each leg that they use to swing from strand to strand without getting stuck in the sticky part of their web. Additionally, a spider's body has a special oily substance that keeps it from getting stuck in its own web.

When a spider travels, it always has four legs touching the ground and four legs off the ground at any given moment.

Spider bites

The effects of a spider bite vary according to several factors, including the amount of venom injected and the size and age of the person who was bitten. Children

and elderly people are especially susceptible. The most deadly spiders in the world include the black widow, funnel web, and brown recluse spiders. One of the most feared spiders in the world, the tarantula, actually has surprisingly weak venom and a bite that feels more like a wasp sting.

The venom of the *black widow spider* attacks nerves by blocking their signals to the muscles, which causes the muscles to contract repeatedly and often painfully. Black widow bites can also cause other nerve-related problems, such as high blood pressure, restlessness, and severe facial spasms.

Only the bite of the female black widow is dangerous; the male is much smaller than the female, and males and juveniles are harmless to humans. Only the female has the telltale red hourglass shape on its underside; the male has yellow and red bands and spots on the abdomen.

The most venomous spider in the world is the *Brazilian Wandering Spider,* or the banana spider. This aggressive spider wanders the forest floors of Central and South America looking for food. Just a small amount of venom is enough to kill a human.

The *brown recluse* gets its name from its

color and its "shy" nature. The bite of the brown recluse spider, which is found in the southeastern United States, is particularly dangerous because its bite is initially painless. A person may be bitten without realizing it, but after awhile the skin starts to swell and become incredibly painful. A bite could kill a person if not treated.

The *funnel web spider* is an aggressive spider that attacks and bites people. Its poison has been known to kill in just 15 minutes. Fortunately there is an antivenom, and deaths from this spider are now rare.

Spider varieties

The world's biggest spider is the goliath spider (Theraphosa blondi). It can grow up to 11 inches wide, and its fangs are up to one inch long. It hunts frogs, lizards, mice, and even small snakes and young birds.

The world's smallest spider is the Patu marplesi. It is so small that 10 of them could fit on the end of a pencil.

Giant trapdoor spiders are considered living fossils because they are similar to spiders that lived over 300 million years ago. They are found in southeastern Asia, China, and Japan and are over 4 inches across,

including their legs.

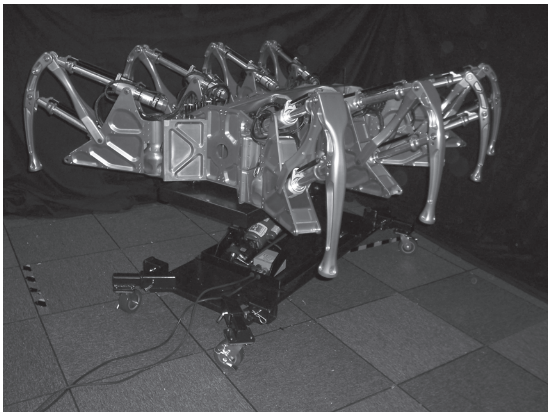
Spider Web Facts

Spider webs contains vitamin K, which assists in reducing bleeding. Hundreds of years ago, people put spider webs on their wounds because they believed it would help stop the bleeding. Scientists now know that the silk contains vitamin K, which helps reduce bleeding.

Spiders are the only group of animals to build webs. Over millions of years, webs have evolved into a variety of kinds, such as sheets, tangles, ladders, and the elegant orb web. When most people think of a web, they think of an orb web. Scientists in the United States Defense Department are trying to copy gold orb weaver silk in order to use it for bulletproof vests.

The Darwin bark spider creates the strongest material made by a living organism. Their giant webs can span rivers, streams, and even lakes and is 10 times stronger than Kevlar.

Spiders have inspired scientists to make space robots. For example, the “Spidernaut” is a mechanical spider that is designed to crawl over the outside of a spacecraft to carry out repairs. Its weight is spread evenly over its eight legs to avoid damaging the surface



of the spacecraft. Scientists have also designed miniature pieces of equipment with parts that move just like a spider’s leg.

Spider Physics

Spider legs use hydraulic pressure to move. A spider’s muscles pull its legs inward, but cannot extend its legs out again. Instead, it must pump a watery liquid into its legs to push them out. A dead spider’s legs are curled up because there is no fluid to extend the legs again.

Spider webs are not passive traps. Instead, because of electrically conductive glue spread across their surface, webs spring towards their prey. Scientists also found that the glue spirals on the web distort Earth’s electric field within a few millimeters of the web.

Fun Fact

There is a spider in Hawaii that looks like it’s smiling. Dubbed the “Hawaiian happy-face spider,” the cheerful-looking spider is under the threat of extinction.

Adapted from Karin Lehnardt, senior writer, <https://www.factretriever.com/karin-lehnardt>, with pictures from the net.

Space diary

Falcon Fetch

Kamal Lodaya

Falconry has been known in central Asia for at least 3000 years. There are falconers everywhere, in Japan from the 4th century CE, to India as well. The picture shows **Maharaja Suraj Mal** of Bharatpur in Rajasthan with a hawk. The **peregrine falcon** (*baaj* in Hindi, *hayabusa* in Chinese and Japanese) is found all over the world, almost as widely as

its common prey, pigeons. It was trained by falconers to hunt rabbits, hares, squirrels, small reptiles and birds. Female falcons are twice as large as males, they could hunt larger birds like ducks, swans and fowl, as well as foxes and wolves. Swooping down in dives at 320 km per hour, these are the fastest movers on Earth.

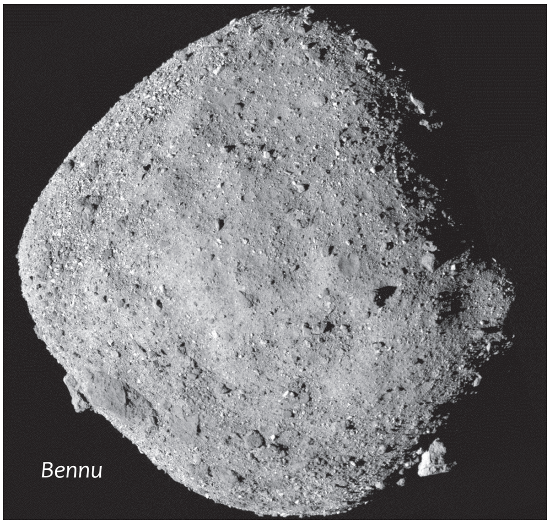
Before the advent of handguns, this was how hunting was done by kings and rich people. Falcons are found in the earliest civilizations, from Mesopotamia, Egypt and China. We know how humans domesticated wolves into dogs. They also domesticated falcons, perhaps from as long ago. Zooarchaeology is a discipline which studies these questions.

In the novels of J.K. Rowling, Harry Potter used **Hedwig**, an owl, to transport letters. Owls have been used in falconry, although training them is different, since they rely on sound rather than sight. It is carrier pigeons which were used to transport mail, not owls.

Ryugu

As we reported in Jantar Mantar earlier,

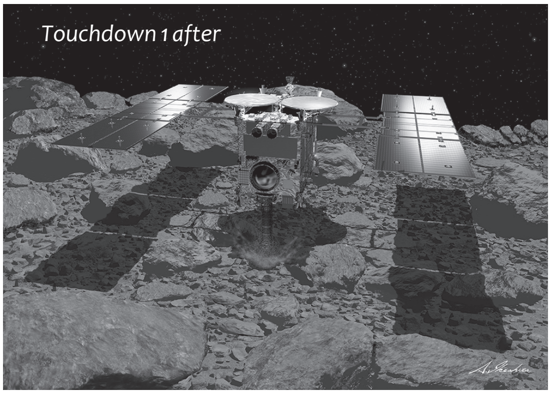

Ryugu

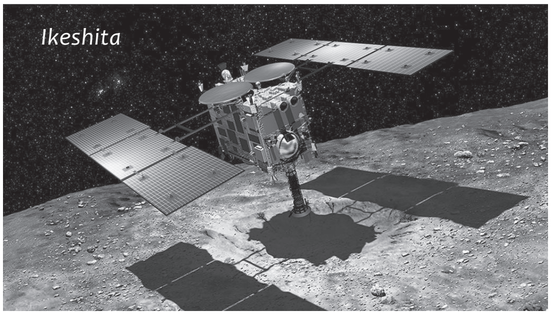

Bennu

the Japanese spacecraft **Hayabusa2** (now you know what it means!) reached the 1-kilometre diamond-shaped asteroid *Ryugu*, whose orbit ranges from somewhere close to Earth's, to somewhere close to the planet Mars's. Asteroids appear to be all over the solar system. It is now thought there may be some between Venus and Earth also.

Soon after, the spacecraft **Osiris Rex** (more about it in a later Space diary) reached another diamond-shaped asteroid *Bennu*. Their pictures look alike, though Bennu is smaller. Ryugu's south pole has a large boulder formation called **Otohime Saxum** (see the picture). Ryugu and names of its features are from Japanese children's stories. Ryugu is a palace, and Otohime is a princess.

Hayabusa2's "home station" is to remain 20 kilometres from Ryugu. But it can come much closer to within metres of the surface. It first came down and released two *Minerva* hoppers, later given the names Hibou and Owl, which took pictures. (Hibou is "owl" in French.) Then it released a lander, called *Mascot*, which took pictures coming down and sitting on the surface before its batteries ran out.


Touchdown 1 after


Ikeshita

Touchdown on Ryugu

After doing some preliminary trials, Hayabusa2 did a "touchdown". A sampling horn hanging down from the spacecraft touched its surface. (The painting is by Akihiro Ikeshita based on images of Ryugu taken by the rovers.) A **tantalum** bullet was fired into Ryugu, raising a lot of material, some of which fell into the horn. Then the horn was lifted up and the scooped-up sample stowed away in the spacecraft. This will be returned to Earth in 2020, the first large sample of asteroid material. The Hayabusa1 spacecraft earlier only succeeded in bringing back a few dust grains from the asteroid Itokawa.

Meanwhile it so happened that the Earth, moving faster in its orbit than Ryugu, came to a position such that the Sun was between them. This meant that communications between Hayabusa2 and us would stop, so it took a long detour going closer to the Sun and coming back to Ryugu.

What is Ryugu made of?

One thing which interests astronomers a great deal is what asteroids like Ryugu and Bennu are made of. Both are carbonaceous chondrites, with rubble-like material similar to meteorites which fall on Earth, with many organic compounds, which have plenty of carbon atoms. The colour spectrum of Ryugu from Earth, from where it is just a point of light like a star, suggested that it may have hydrated compounds, those formed in the presence of water. Perhaps, we thought, Ryugu might have water? Perhaps impacts from asteroids like Ryugu brought water to Earth? Could we bring these compounds

back to Earth and check?

The **spectrum** of Ryugu taken by Hayabusa2 from much closer, also shows the presence of hydrated compounds. But detailed photographs of Ryugu over months show no presence of water on its surface. It looks quite dry. In this respect, Bennu seems to be different, its surface has clayey regions which may have hydrated compounds.

This suggests that the hydrated compounds are *inside* Ryugu, not on the surface. We will have to dig. But Hayabusa2 does not have drilling and mining machinery. All it has is its scooping arm.

Looking *under* Ryugu

The amazing thing is that even before it left Earth, Japanese scientists had anticipated that things might turn out so. So the spacecraft carried a 2.5-kg copper impactor with explosive material inside. This was released (the picture from Hayabusa2 shows it descending), exploding above Ryugu to make a crater on its surface. The new crater brings material from inside the asteroid out on the surface. Now Hayabusa2 can go to the crater and pick up the fresh material using its sampler.

Not so fast! These things are dangerous. One pebble from the surface, hitting

Hayabusa2 very fast, can severely damage it. That would jeopardize the whole operation of going to Ryugu and fetching samples. So the impactor was released to slowly fall onto Ryugu, which is easy because its gravity is very weak. Meanwhile the spacecraft fired its rockets and went around Ryugu. So Ryugu itself protected it from any shrapnel which could hit it. Then Hayabusa2 took a loop, going closer to the Sun and coming back like it did earlier, and after 3 weeks came back to look.

India's destruction of a satellite

Recently the Indian government fired a missile and destroyed one of its own satellites, sent to space in January. This shows the sophisticated aiming possible by our defence forces. Unfortunately the satellite broke into hundreds of pieces which generated a lot of space litter. This junk can hit other equipment in space and damage them. Such tests were done by the US, Russia and China earlier, and they invited anger from space management agencies which are not connected with defence. The Indian tests were also criticized by NASA.

Did we have to wait that long to find out whether the impactor worked? No. After sending down the impactor and before vanishing behind Ryugu, Hayabusa2 also dropped a small camera, a little away from the scene. This camera could see on the horizon of Ryugu the place where the impact was supposed to happen. It worked on batteries for only a short time, but it did see pebbles and dust being thrown up. So we know that the impactor worked!

On April 25, Hayabusa2 returned to the scene of its crime and found a crater, nearly 10 metres across, with disturbed rubble for around 20 metres. The picture shows "before" and "after" images. Soon it will land near the crater and pick up more material in its sampling horn. So now it has managed to do a dig on Ryugu without any digging equipment.

Are you wondering why metals like tantalum and copper were used? From Ryugu's spectrum we know that they are absent on the asteroid. So there is no confusion about what compounds in the sample are from Ryugu and which have come from Earth.

In December 2020, the falcon returns to Earth and its samples will be parachuted down to Earth in a capsule. Since it is expected to have fuel left, there is a proposal to then send the spacecraft on a hunt to another asteroid (which does not have a name yet, it is only called 2001 WR1), reaching it in 2023.

Hayabusa2 is a busy little mission. In India we are talking about sending men to the Moon, following the achievements of the United States and Russia 50 years ago. Japan shows us the sophistication in technology that is possible with robotic spacecraft, with little or no risk to human life and to the money put into the mission. Like our ancestors thousands of years ago, such robotic falcons can help our species master targets in space.

Do You Know?

1. What is the difference between a jet and a plane?

2. What kind of chemical reaction is photosynthesis?

3. Angles are so easy to understand in degrees. What are radians and why do we need to understand angles in radians?

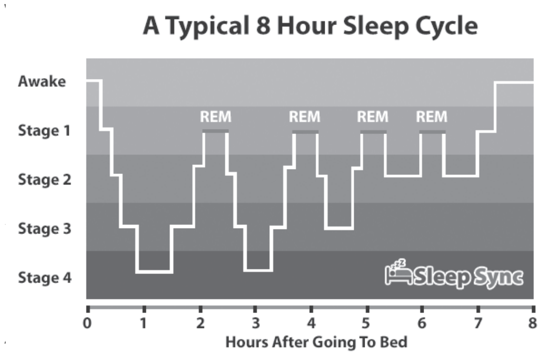
4. What causes a volcano to erupt? Can we predict this accurately?

Answers to last issue's Do You Know?

1. Why do many of us like to sleep under blankets, even on warm nights?

Answer: This is an experience many Indians have: a hot and humid summer night, rotating fans barely cooling the room, circulating hot air. Yet, many need some sort of covering, the barest edge of the lightest sheet, before they can fall asleep. Why is this so?

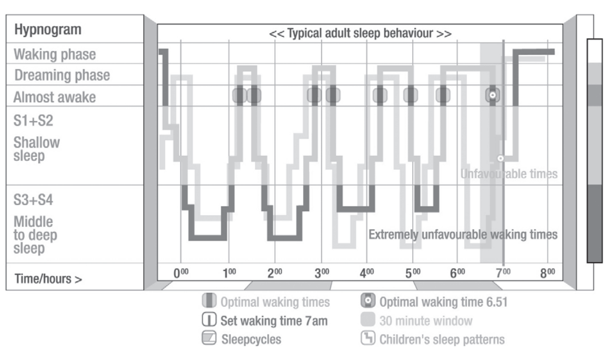
Blankets are a modern phenomenon. Historically, the effort involved in weaving large sheets made blankets too expensive for most to afford. From the linen bedsheets of Egypt around 3500 BCE to woollen sheets during the Roman empire through to cotton in India, bed coverings were for



climates. Much more common than sheets or blankets are some form of padding.

The physiological explanation is as follows. About 60 to 90 minutes before usual bedtime, the body starts losing core temperature. This is because when the body is heated, we feel more alert. Conversely, when the body cools down, we tend to feel sleepier. Cooler internal body temperatures are correlated with a rise in melatonin, a hormone that induces sleepiness.

As the night progresses, things get complicated. In the first 4 hours and the hour before sleep, your body temperature falls a bit, from around 98 degrees Fahrenheit to around 96 or 97. In the second 4 hours, during REM sleep (Rapid Eye Movement), a host of changes takes place, including our



ability to thermo-regulate.

Lizards have this problem: they cannot regulate their temperatures by sweating or shivering, and hence resort to the sun or cooler shades. During REM sleep, we all turn into lizards (in this sense)! This period coincides with the coolest parts of the night. The night is in fact coldest before dawn, just when we cannot thermoregulate. So, like lizards, we have to have some way to externally regulate our body temperatures. Hence the blanket.

You may think it unnecessary to use a blanket at 10 p.m., when it is still hot, but by 4 a.m., when it is colder and you are unable to shiver, you need help. Memory takes over, ensures that you at least keep a blanket nearby.

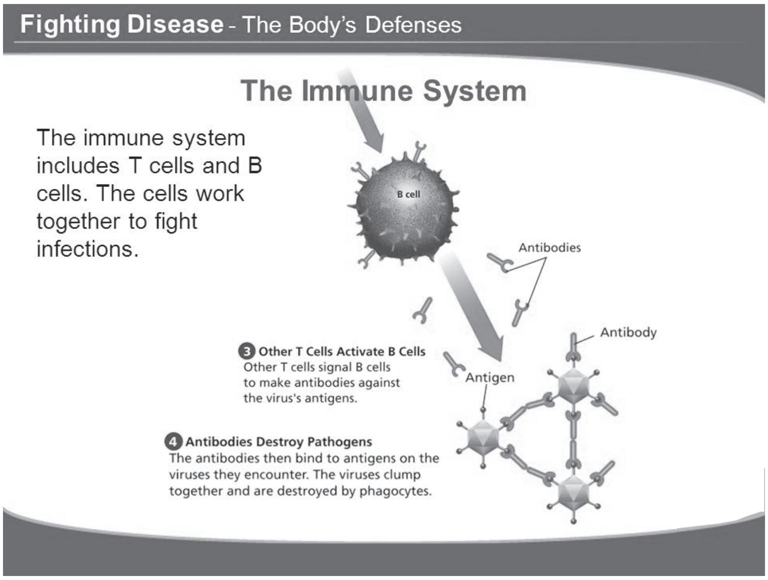
There is more. Another strange thing that happens in the REM periods of sleep is that our bodies drastically lower their levels of serotonin, the neurotransmitter most associated with feelings of calm, happiness and well-being. Guess what? Studies indicate that sleeping with a weighted blanket can trigger an increase in the brain's production of serotonin!

Psychologists say that use of blankets is due to "conditioning". This is what you had as a child, and your mind associates it with warmth and coziness, so you want it more.

2. What happens when we get flu? Why do we feel like lying in bed all the time?

Answer: Influenza is a virus, transmitted by touch contact but, more often, transmitted through the air. The virus infects the specialized epithelial tissue that lines your respiratory tract (like your nose, throat and airways). Once the virus enters your epithelial cells, it is able to "hijack" the machinery your cells usually use to create new proteins, and tricks them into creating more viral particles instead.

Then your cells release the newly created viruses; so they go on to infect more cells, and create even more viruses. Soon, that single virus turns into a major infection and, hey, you are sick.



Now your body fights back. Special immune cells, called T-cells, circulate through your body looking for infection. When they find infected cells or flu viruses they put your immune system on high alert. Other immune cells, called B-cells, rush in

to start engulfing and destroying the viral particles, working to clear the infection from your system.

This has other effects. Once your immune system goes on alert, it releases chemicals called cytokines, that trigger inflammation. In fact, the most annoying symptoms like your stuffy nose or fever is due to the immune response. It can also make breathing difficult. All this takes a toll on you, makes you want to sleep for a whole week.

3. I can imagine that melting glaciers cause sea levels to rise. but I read that they can also cause ocean floor to sink. How is this possible?

Answer: Yes, we all know that the glaciers are melting. As the Earth's largest chunks of ice continue to get smaller and smaller, sea levels have risen. All that melting ice has to go somewhere, so as it seeps into the oceans, beaches and shorelines are feeling the pinch. However, a recent study on the effects of glacial melting has revealed another unexpected consequence of ice mass loss. As it turns out, the ever increasing mass of water is actually pushing the ocean floor down. The findings suggest that not only is the sea floor being pushed down and deformed, but also that its movement is going to make it even more difficult to predict and monitor the changes in sea level as climate change marches on.

That's all? All this fuss is about 2 millimeters?? It is natural for you to wonder, but remember that this is happening on a global scale. This is the entire ocean we are talking about here, all 340+ million square KM of it. A seemingly measly 2.1 millimeters is actually an incredible, potentially devastating change.

All this suggests that we may be facing a bigger problem before long. As the oceans get heavier and continue to push down on the sea floor, tracking and measuring changes in sea level as it relates to coastal communities could become increasingly difficult. We know very little about what the oceans will do under increasingly warm climates, and by the time we understand the issue in depth, it might be too late to act on it.

4. How does rain come down from the clouds?

Answer: We are used to saying that rain comes down from the clouds. We could equally well say that rain IS the clouds giving up on being water vapour and coming down to the earth, only to start the journey again. This is the precipitation cycle, the mechanism through which water moves from the Earth to the atmosphere and back again.

The amount of water available on Earth never changes. But its state (liquid or gas/ vapour) does, and it is thanks to thermal energy from the sun. As liquid water is heated by the sun, it receives enough energy to break its molecules apart and transform into water vapour. The warmer the air, the more water vapour it can hold. That warm, moisture-saturated air rises, along with the water vapour it contains, and as it rises it cools. Once the air has cooled past the "dew point" it condenses around "condensation nuclei," which are usually tiny particles of dust, smoke or even salt that are suspended in the air. The tiny water droplets that initially form are what you see as clouds, and if you pay close attention to clouds in the sky, you see that they are constantly shrinking and growing in response to the warring forces of evaporation and condensation.

Water vapour that has condensed into tiny droplets and formed clouds is well on its way to becoming rain – but not yet. For now, the water droplets are so tiny that the air currents keep them up, just as swirling particles of dust can stay in the air. But as those droplets continue to rise, buoyed by rising bodies of warm air, they have two routes for making it back to Earth.

The first is when water droplets collide and coalesce with other droplets, eventually becoming heavier than the uplift of the air around them, at which point they fall down through the cloud. Or, through the ice process of precipitation (called the Bergeron process), the droplets rise high enough to freeze into ice crystals, attracting more water vapour to themselves and growing quickly until they are heavy enough to fall as snow or melt and fall as rain.

There are very interesting models of rain formation that help you not only understand this process, but also calculate how much of precipitation occurs.

How Many Rectangles?

Here is a classic counting problem.

A grid is like your graph paper, with horizontal and vertical lines intersecting.

Now consider a 4 X 6 grid. How many rectangles are there in it?

If we generalize this to an m X n grid, how many rectangles do you find?

Solution on Page YY.

Solution to "How Many Rectangles?" on Page XX

Slow and easy method: Consider a 4 X 1 grid, that is 4 rows and only one column. This has one rectangle with 4 cells, another with 3 cells, another with 2 cells and lastly a single cell rectangle (which is also a square). Notice that counting the top 3 or the bottom 3 gives us the same 3 X 1 rectangle. Thus we have 4+3+2+1 = 10 rectangles.

We also see that an n X 1 grid contains n + (n-1) + (n-2) + ... + 1 = n(n+1)/2 rectangles. We are going to use n(n+1)/2 often, so let us use a special notation for it. From now on, if we say n^*, we mean n(n+1)/2.

Now consider a 4 X 2 grid. It has two 4 X 1 grids and then some extra. Those two "columns" give us 20 rectangles. How many are extra now? If we were to consider each rectangle of width 2, we have exactly as many width-2 rectangles as we counted earlier! So we get 30 rectangles totally now. For n X 2 grid, we get 3.n^* rectangles.

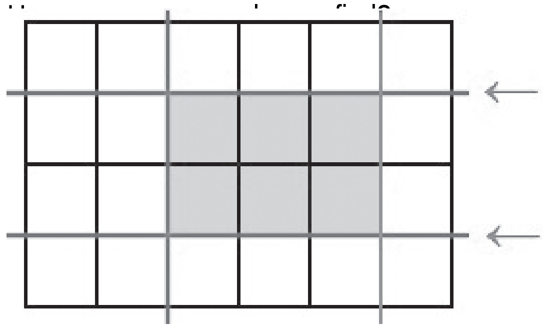
Now add another column. By now we know what is going on, so let us do it directly for n. We get n^* from that column, n^* width-2 rectangles and n^* width-3 rectangles. Thus we get 3.n^* more rectangles making a total of 6.n^* rectangles.

Without detailed calculation we can see that adding the next column will result in a total of 10.n^* rectangles. We are building the progression 1, 3 = (1+2), 6 = (1+2+3), 10 = (1+2+3+4). But this is going to again give us 1+2+...+m = m(m+1)/2 = m^* as a factor! Thus, when we consider a grid with n rows and m columns, we have m^*.n^* rectangles. For the 4X6 grid we get 10 times 21 = 210 rectangles.

Quick and elegant method: In mathematics, we always look for elegant proofs, which are short and sweet.

A grid with n rows and m columns has n+1 horizontal lines and m+1 vertical lines. To define any rectangle within the grid, we must choose 2 among the horizontal lines and 2 among the vertical lines. There are "n+1 choose 2" ways of doing the first, and "m+1 choose 2" ways of doing the second. But "n+1 choose 2" = n^*. Thus we get a total of n^*.m^* rectangles.

Bonus: Now consider when m = n, so we are considering a square grid, and we want to count only the number of squares inside.



Science News

Headlines

. A Marsquake

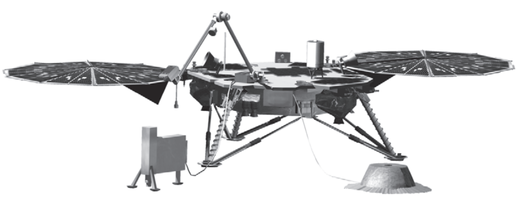
. Declining frog populations

. A robot that looks like clutter

. Can climate change make us eat differently?

. How to find M87 and see the Black Hole within

Read more about these topics below.



. A Marsquake

We know of earthquakes, so it is not unreasonable to think of a quake on Mars. The only thing is, how would we know if one occurs far away in Mars? Can we actually "see" it, or even better, "hear" the rumble?

NASA, the North American Space Agency, appears to have done just that. On April 6, 2019, the seismometer on the **Mars InSight lander** recorded a short series of howls, grumbles and pings. One of those sounds, the grumble, is raising suspicions. It is in fact the first recorded sound from the Red Planet's interior, and scientists say it is very likely to be a quake.

NASA released the 40-second recording on April 23. It begins with a faint, eerie howling of the Martian wind. Next comes the low rumble of the possible Marsquake. A large ping toward the end is the spacecraft's robotic arm moving.

InSight landed on Mars in November 2018. It probes the Red Planet's interior this by tracking seismic waves rippling through the ground. Mars lacks Earth's powerful quakes, which are caused by shifting tectonic plates. But as the planet cools and contracts, it has smaller quakes, crackles and rumbles.

Scientists hope that InSight's data will reveal the internal structure of Mars. That includes the size and density of its crust, mantle and core. Some of these data also might detail how heat flows through the planet's insides and perhaps uncover hints of water there.

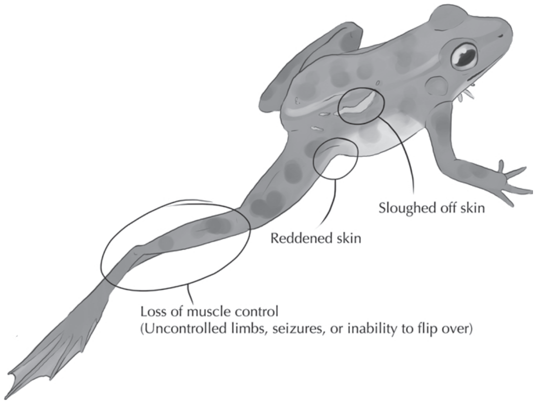
This new recording is not long enough to provide much insight about the Martian interior. But it shows that Mars is seismically active.

Now there is a new area of scientific research: Martian seismology. Are you ready to start?

. Frog populations declining

We hear of many diseases wiping out large populations of plants, insects, animals, and are scared of Nipah virus and such. Have you heard about a frog disease that is equally terrible?

A deadly disease has been traveling the world for more than three decades now. Called Batrachochytrium dendrobatidis, or Bd, it is a fungal pathogen that infects the skin



of frogs, toads and other amphibians. A related fungus, B. salamandrivorans, infects salamanders and newts. Together, these pathogens are known as **chytrids** and the disease they cause is called chytridiomycosis.

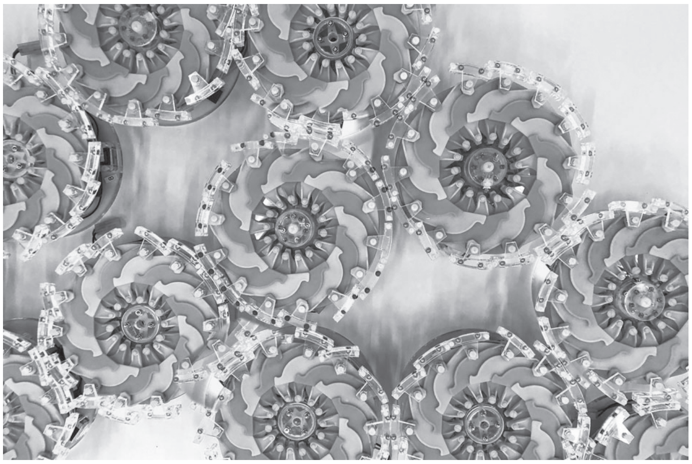
In the prestigious journal *Science*, a recent article speaks of the effects of just one chytrid, *Bd*, on amphibian populations. *Bd* has played a role in the decline of some 500 amphibian species in the past 50 years. Australia and the Americas have been especially hard hit, but the declines have been occurred around the world, except in Asia, where the fungus is thought to come originally from.

The pathogen may be responsible for the extinction of as many as 90 species. Others are endangered. About 40 percent of 500 species are declining in numbers. About one in every four of those species are now at less than a tenth of their former population size.

. A robot that looks like clutter

When you imagine a robot, you think of one looking like a human being (Rajnikanth in Yendhiran) or one with many long metallic arms and legs on an assembly line. Here is a system called "particle robotics" that looks like a messy children's room!

The robot is a collection of plastic, neon-green disks. Each is about 15 centimeters across. Alone, a single disk can do very little, it can only expand and contract. But when a bunch of these disks huddle together, things change. Tiny magnets on the disks' outer rims make them stick together. When one disk expands or shrinks, it pushes or pulls on its neighbours. All of those small pushes and pulls add up. Suddenly the entire blob starts to move, though very slowly.



The designers refer to each individual disk as a "particle". When working as a system, they become a "particle robot". In a new study reported in the prestigious journal *Nature*, scientists showed how such a particle robot could accomplish simple tasks, like shuffling (that is, moving slowly) toward a light source.

The disks are individual units, but they bunch together to form a unified team. Their behaviour results from their interactions and the laws of physics, not someone telling them what to do.

Scientists behind the project were inspired by nature. In the human body, for example, individual cells work together as muscle tissue. Many other types of cells also move together as a group. This robot shuffles along like the way a caterpillar moves, by bunching up a little, and stretching out.

Even though the disks do not communicate directly with each other, they can respond as a group to some signal. The scientists showed this by installing sensors on each disk that could detect light. Then they programmed the disks to expand and contract faster or slower, depending on how intense the light was. When the researchers shone a bright light, their robot crept toward it. This was the result of all those individual expansions and contractions.

Does it remind you of a Rajni-robot made of 100s of little Rajni-robots from Yendhiran? That is still far away.

. Climate change may need us to eat differently in future

In the summer of 2016, French wheat farmers found that their crop yield was less than usual. They are used to about 5% variation. This time it was 25% less yield across France. In some parts of the country, it was almost 50% less.

There had been an unusually warm spell that winter. Later in the year, some intense rains had fallen. These events led to unexpected problems. The heavy rains, for instance, leached nutrients out of the soil. The heat and damp increased the spread of diseases. None of these seemed very bad as they were happening. But the net effect was bad.

When people think about how their lives will be affected by climate change, they might imagine living in a world with shorter winters and longer summers. They might imagine coastal cities losing ground to sea level rise. They might expect more extreme weather, such as hurricanes or wildfires. All of those

effects have struck various parts of the world. But climate change is also affecting what we eat. With warmer temperatures and more pests, farms will produce less food. Farmers will have to work harder to grow what food they do bring to harvest. Some crops might even be less nutritious. We may eat less of foods that are vulnerable to climate change, such as rice, wheat and corn, and eat more of those crops that can better tolerate drought, like sorghum.

Using computer models, scientists are studying how rising temperatures might affect harvests of wheat, rice, corn and soya beans. Worldwide, these four crops provide two thirds of all calories that people eat.

One study has shown that global warming of 1 degree Celsius can lead to reductions in all the major crops. Corn harvests would fall by 7 to 8 percent. Wheat would drop by 6 percent. Rice and soy yields would fall some 3 percent.

One reason for all this rising temperatures. the other is changing soils. Wet, rainy areas have a lot of organic matter, largely carbon, in the soil, as they often have a lot of plants. When they drop leaves or die, their tissues break down in the moist environment. This adds nutrients through compost to the soil. But dry places have fewer plants. As plants die, they take longer to rot into compost. Climate change leads some regions to become drier.

Again, computer models have been used to study how climate change can affect selenium levels in soil, and the results are alarming.

Another way climate change is affecting soil is through pollution. A study has focussed on how flooding can taint soils in Bangladesh.

Climate change also brings rising levels of carbon dioxide. That sounds like good news for plants, which absorb carbon dioxide from the air. They use the carbon to build tissues. But it is not that simple. In experiments, crop plants such as wheat, soy and rice did not seem to grow better in a CO_2-rich environment.

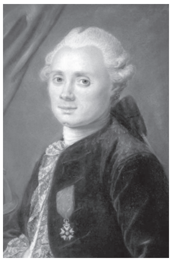
What grows well? Weeds. So we may end up eating "weedy" relatives of grains. Here scientists found a rich source of nutrition, what human beings need. Accepting such change in food habits might be much harder, though.

Some scientists are saying that this food crisis will at least make people take climate change as seriously as they need to.

. How to find M87 and see the Black Hole within

M87 is the 87th in the catalogue of **Charles Messier**, an 18th century astronomer who hunted for comets. He found these hazy patches all over the sky when searching. To remember them and not confuse them with potential comets, he made a list of them. He was quite successful; he discovered 13 comets during his lifetime. M87 is a huge galaxy. M87, other galaxies also in Messier's catalogue, and thousands of others which are seen in our largest telescopes form the "Virgo supercluster" of galaxies, mostly found in Kanya (Virgo). In 1947 M87 was identified as a source of radio waves. Already in 1918, **Heber Curtis** found a curious line of bright gas, now we know it is a jet being ejected from its centre at very high speeds. After the theory of black holes was developed by **Subrahmanyan Chandrasekhar**, it was suspected that a massive black hole might be sitting at the centre of M87, powering that jet. Now we have conclusively found that black hole. It is called M87*.

Our newspapers and media talk about black holes being a consequence of **Albert Einstein's** theory of relativity. However Einstein did not believe in the existence of such "dark stars". The New Zealander **Roy Kerr** derived the mathematical solution of the equations, Einstein continued to not believe




in their physical existence. (For example, although the square root of -1 is the solution of a mathematical equation, you may not believe there is a physical distance corresponding to it, and you would be right.) It was Chandrasekhar who first connected black holes to stars, and it was realized that such objects might actually exist.

A black hole itself is not visible — it is a "nothingness" that sucks all matter and energy into it. However, around all black holes, there is a so-called "*event horizon*" or a boundary beyond which events occurring inside the horizon cannot affect anything occurring outside. To "see" anything, we need to observe it with light (or radio waves or X-rays). Once the light probe crosses the event horizon, it never returns and so nothing inside can be "seen".

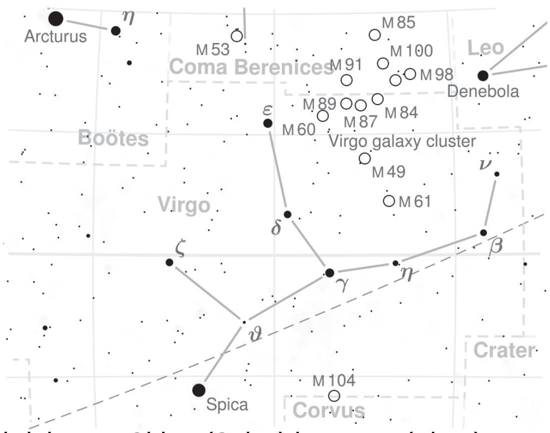
The *Event Horizon Telescope* first observed M87 and its event horizon in 2017; the results were published in a series of papers in April 2019. The observations were reconstructed to show a picture of M87 with a central black space (which is presumably where the black hole lies) and the lighted up event horizon around it. The black hole, about 55 million light years away, is about 6.5 billion times more massive than our own Sun! This was calculated from measuring the diameter of the black hole's shadow, which is related to its mass. This is the first time such a direct observation of a black hole has been made. Exciting times are up ahead for black hole hunters.

Nightskywatching: finding the galaxy with the black hole

Saptarshi (the Great Bear, Ursa Major or the Big Dipper) is the best known of all constellations in the night sky. On a clear moonless night it is easy to find in a dark sky without lights. It is in the North, so if you face East it will be towards your left. You do know where the Eastern horizon is, don't you?

You might find someone who can show it to you if you cannot find it yourself from the map. Each star represents one rishi: Kratu, Pulaha, Pulasya, Atri, Angirasa, Vasishtha and Marichi. These are not the brightest stars in the sky. But the figure they form is a nice, easy to remember pattern. It spreads over quite a bit of sky.

The last three stars Angirasa-Vasishtha-Marichi describe a curve. Extending this curve leads you to the bright star Swati (Arcturus) in the constellation Bhootapa (Bo-otes). Continuing the curve leads on to a less



bright star Chitra (Spica) in Kanya (Virgo). A little further is the tiny constellation of Hasta (Corvus). One of the joys of nightskywatching is finding all these constellations along one curve, from the Northern to the Southern sky.

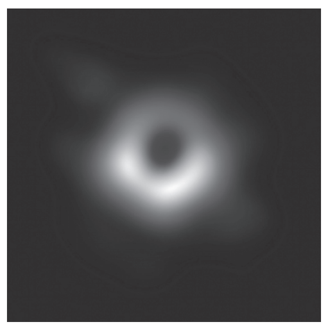
Now that you have some experience, you can follow the line Atri-Pulasya from Saptarshi for a long distance, almost as long as the curve, and you will reach the stars of Simha (Leo), especially Magha (Regulus) which is the brightest. Bhootapa and Kanya are facing you in the East, they are rising. Simha is high up in the sky so it will require some twisting of the neck.

For star gazers, the following phrases make it simpler: Start with Ursa Major or the Big Dipper. From there, arc to Arcturus, spike to Spica (in Virgo) and leap up to Leo and its bright star Regulus.

Now you know the neighbourhood, almost the entire Eastern sky. Trace out the Y shape of Kanya, Chitra is the lowest. The branch of the Y pointing towards Saptarshi ends in a star whose name is Vindemiatrix. This is a Latin name referring to a "kanya" who collects grapes.

Trace out the shape of Simha, one can imagine it as a lion, with the inverted question mark ending in Magha, and the triangle ending in Purva Phalguni (Denebola). Denebola comes from an Arabic phrase meaning "tail of the lion".

Did you get all that? Now imagine a line between Vindemiatrix in Kanya and Purva Phalguni in Simha. In the middle of this line are the galaxies. Unfortunately with today's night skies you cannot see them with the naked eye, you can just imagine them. If you have binoculars or a small telescope, the picture by Erin Ross shows three hazy dots which are reasonably bright. It is possible that these were visible in the lightless dark skies wich our ancients had, and they could be the "grapes" referred to in the name of Vindemiatrix. There are two close ones and the third, a little apart, is the galaxy M87.



If you find it, congratulate yourself. You have just seen light coming from 5 crore years ago. At the centre of M87 is the recently pictured black hole. That tiny "meduvada" cannot be seen in our biggest telescopes. It took a combination of eight radio telescopes all over the Earth forming parts of an image, which was put together to get us that picture.

Sources: Nature, Science, Science news for students, Carolyn C Peterson in thoughtco.com

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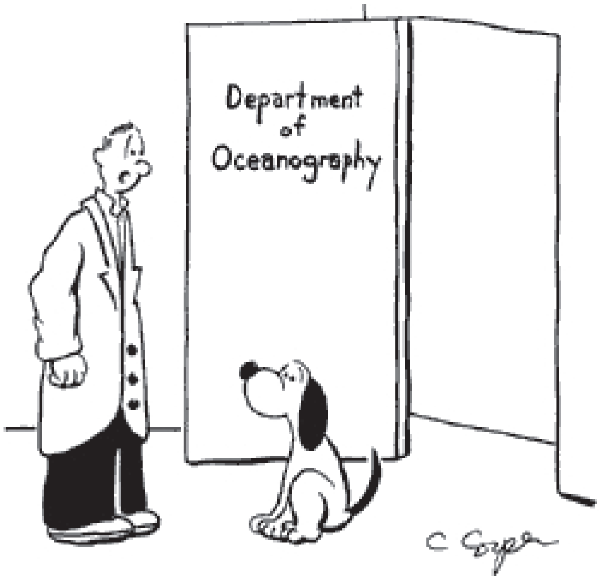
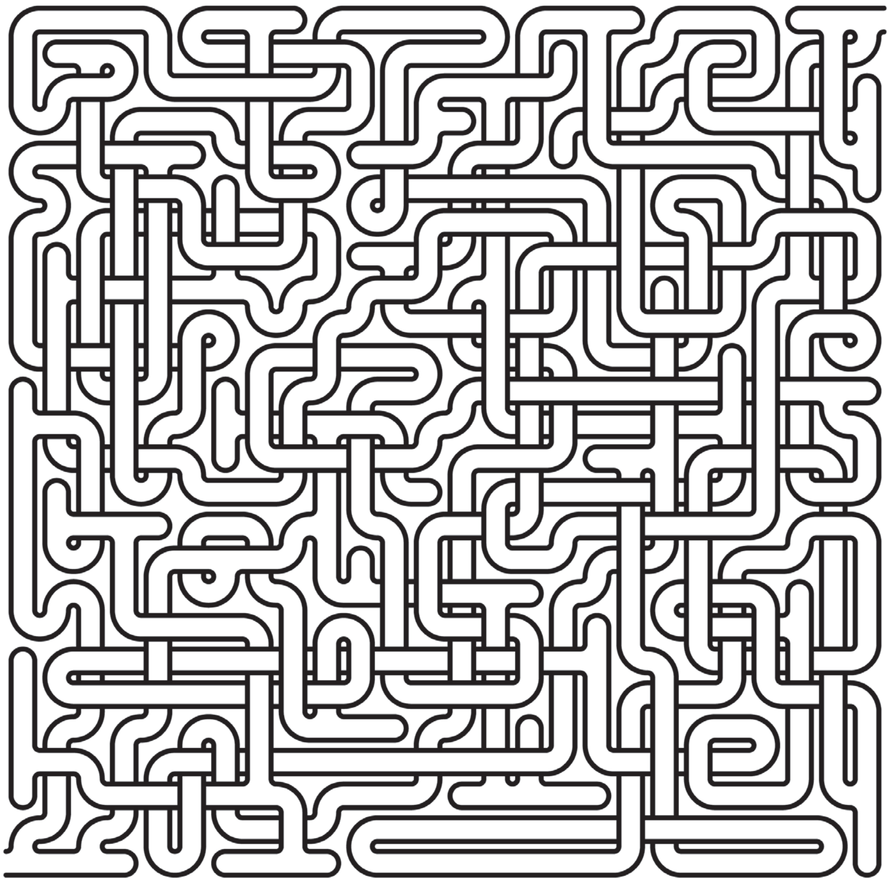


"I'm sorry. The ad said we need a whale tagger. Not a tail wagger."



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