Popular Science Magazine for Students and Their Parents

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Build Your Own Satellite

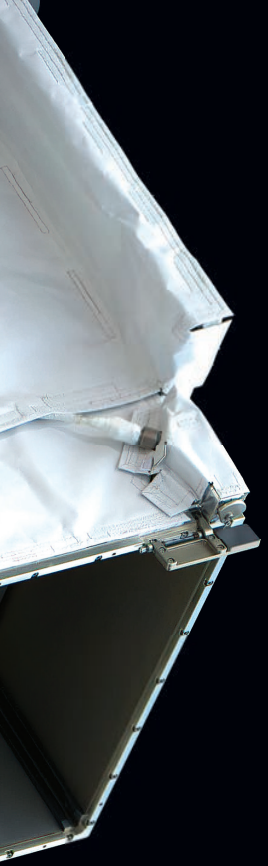
The chemistry of outer space

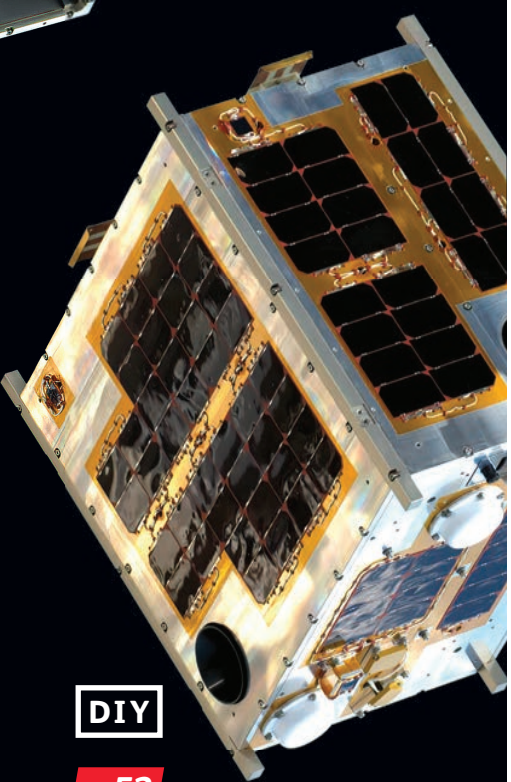
Words for the new era

Journey to the Moon

A name for every living thing

+ The Vikings' favorite board game





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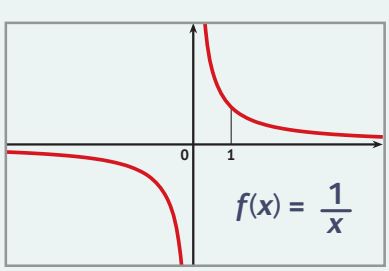
MATHEMATICAL

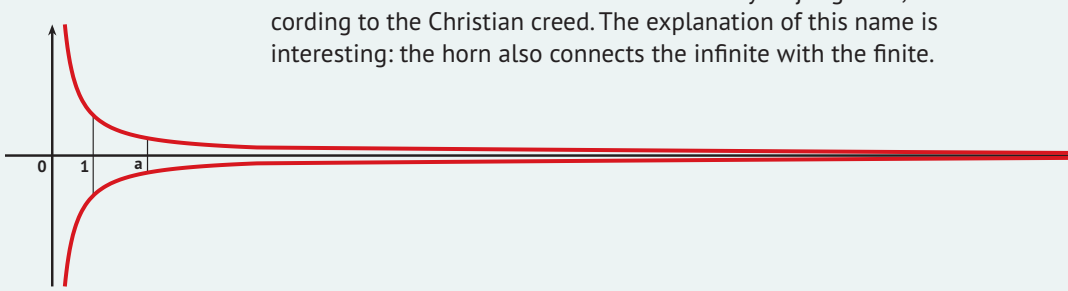
The queen of science, the gymnastics of the mind, the source of our inspiration – what beautiful words aren't used to describe mathematics? But these aren't just lofty words. Believe us. If math seems boring or, on the contrary, you think you know all there is to know, here are ten unusual mathematical concepts that will make you look at the field anew – just make sure to prepare your minds and imaginations.

1. Torricelli's Trumpet

Galileo's pupil, the Italian mathematician and physicist Evangelista Torricelli, is best known for his ideas about atmospheric pressure and new mechanics. Torricelli also discovered an interesting mathematical object with an unusual property. Let's construct it first: to do this, draw the function $f(x) = 1/x$ and consider its graph on an interval from 1 to infinity.

If we rotate this graph relative to the x-axis, we get an object that resembles a horn. It's called **Torricelli's trumpet**.





What's so unusual about it? It has an infinite surface area but a finite volume. In other words, you can fill it with liquid, but you will never have enough paint to cover it.

You can verify this by calculating the volume and surface area of the horn. To do this, we need higher algebra, so some of the formula calculations are omitted. This formula calculates the **volume** of our horn on the interval from 1 to a:

$$V = \pi\int_1^a \left(\frac{1}{x}\right)^2 dx = \pi\left(1-\frac{1}{a}\right)$$

Note that if a tends to infinity, the volume approaches π.

This formula calculates the **surface area** of our horn:

$$A = 2\pi\int_1^a \frac{1}{x}\sqrt{1+\left(-\frac{1}{x^2}\right)^2}\,dx > 2\pi\int_1^a \frac{dx}{x} = 2\pi\ln(a)$$

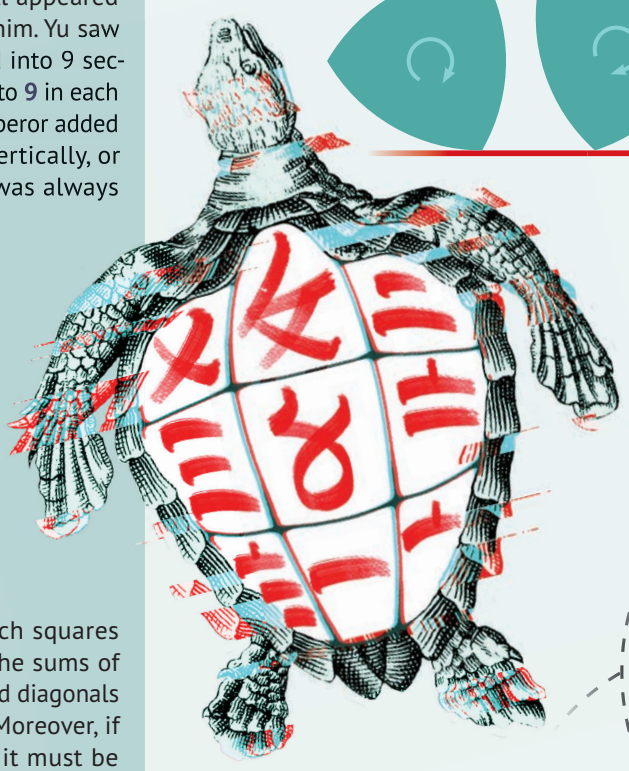
When a tends to infinity, the area will also tend to infinity. Torricelli's trumpet is often called **Gabriel's horn** – it is his sound that will awaken the dead on the day of judgment, according to the Christian creed. The explanation of this name is interesting: the horn also connects the infinite with the finite.

CURIOSITIES

2. Lo Shu Square

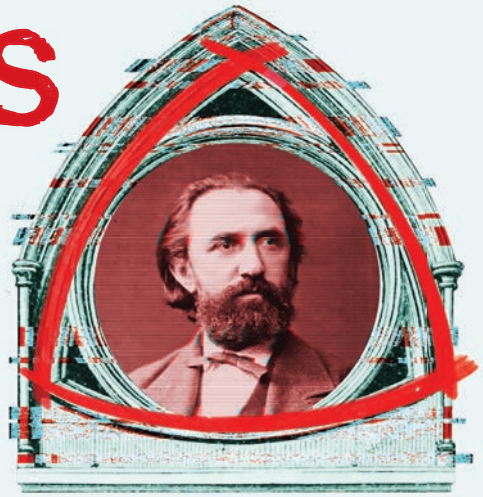
According to an ancient Chinese legend, during the reign of the great **Emperor Yu**, an unprecedented flood occurred in China. All the forces of the country were thrown into the fight against its fallout. Even the emperor himself took part in the work, and one day, a huge turtle with a curious pattern on its shell appeared out of the water in front of him. Yu saw that the surface was divided into 9 sectors, filled with dots — from **1** to **9** in each sector. No matter how the emperor added these points, horizontally, vertically, or diagonally, the number **15** was always obtained.

4	9	2
3	5	7
8	1	6

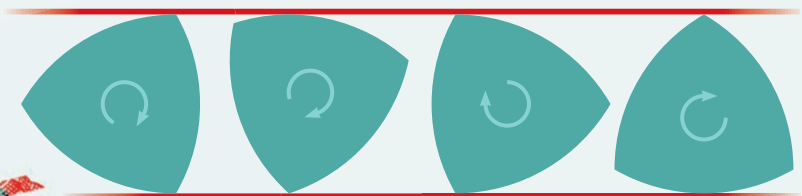


Mathematicians call such squares **normal magic squares**. The sums of numbers in columns, rows, and diagonals in such a square are equal. Moreover, if the side of the square is **n**, it must be filled with numbers from **1** to n^2. In China, *Lo Shu* (translated as "scroll of the river Lo") became one of the symbols of *feng shui*, the art of correctly arranging objects relative to the flow of "natural energy," *qi,* and it also plays a role in many divination practices. For mathematicians, Lo Shu is unique: it is the only normal magic square of size 3×3 (the rest are obtained by rotating it). Today mathematicians have developed many methods for constructing magic squares of any dimension. Are they of practical value? Definitely. Magic squares can be used in the production of matrix display screens — thanks to them, you can achieve a smooth transition of color or brightness in an image.

3. Reuleaux Triangle

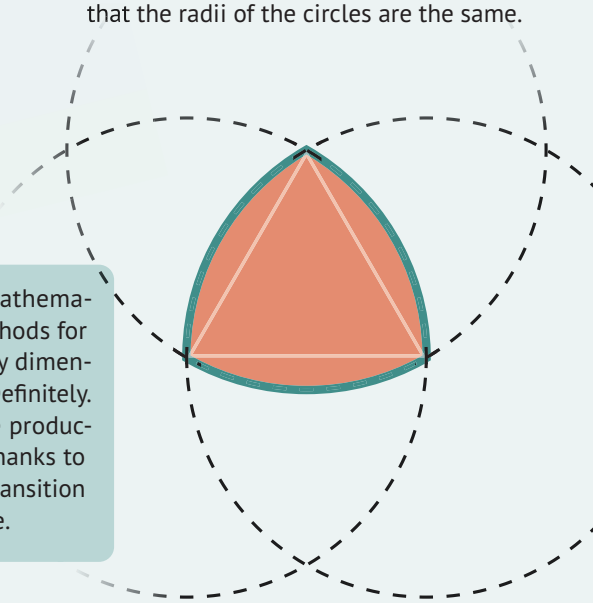


The German engineer **Franz Reuleaux** was one of the fathers of the theory of machines and kinematics. His name is given to the simplest figure after the circle, a curved triangle with constant width. What is it? The easiest way to explain is with an example. **If you draw a pair of parallel supporting lines (two lines of the same slope that touch the shape but don't go through it), they will remain parallel regardless of the orientation of the triangle.** The constant distance between these parallel lines is called the width of the Reuleaux triangle.



Let's try to understand why the Reuleaux triangle has constant width. To do this, let's construct it. First, draw an ordinary equilateral triangle. Next, use a compass to draw three circles with a radius equal to the triangle side and with centers on the vertices of this triangle.

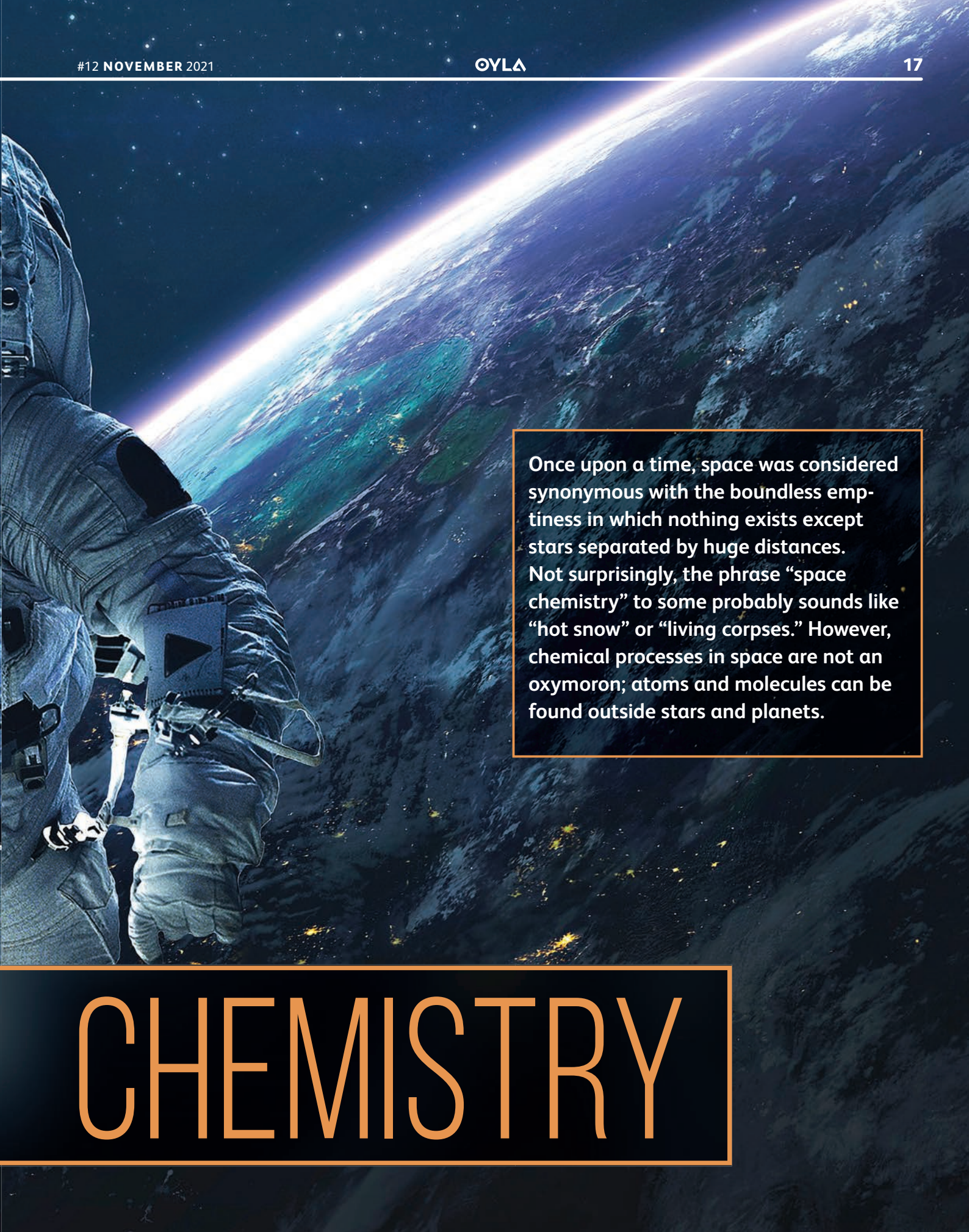
From this drawing, it is clear that the distance from the vertex of the new triangle to any point on the opposite side is equal to the radius of the circle, and that the radii of the circles are the same.



WHY DO THUNDER-STORMS HAPPEN?

Most of us, at least once in our lives, witness a thunderstorm that divides the sky in half with a bolt of lightning. It is one of the most spectacular and intimidating natural phenomena. A few thousand people die from lightning strikes every year. However, in addition to their destructive power, there are many other curious mysteries about thunderstorms.

SPACE



Once upon a time, space was considered synonymous with the boundless emptiness in which nothing exists except stars separated by huge distances. Not surprisingly, the phrase “space chemistry” to some probably sounds like “hot snow” or “living corpses.” However, chemical processes in space are not an oxymoron; atoms and molecules can be found outside stars and planets.

CHEMISTRY

Hibernating Plants

HOW DO PLANTS SURVIVE IN UNFAVORABLE CONDITIONS?

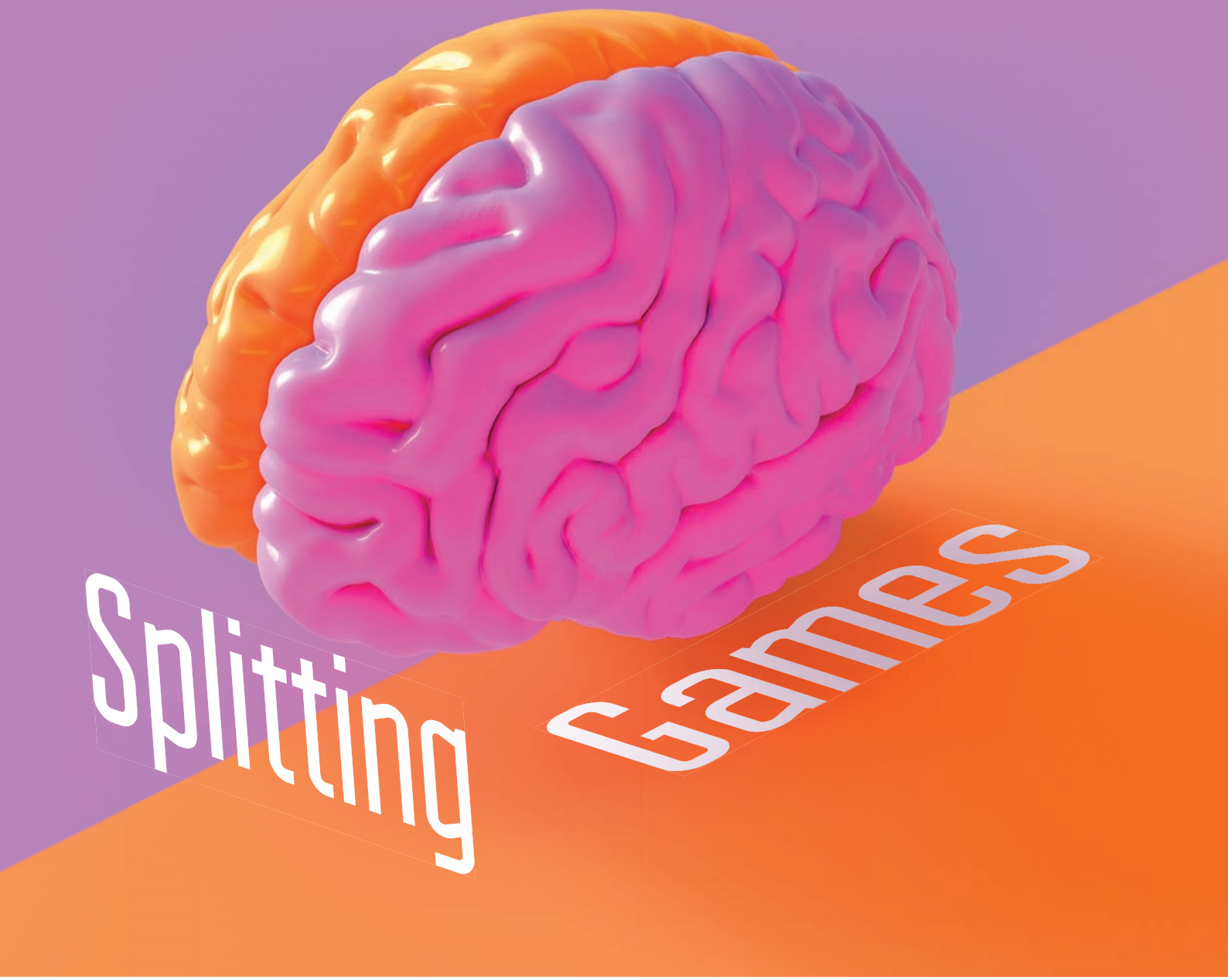
Unlike animals and bacteria, plants lead a tethered lifestyle.
They cannot go off in search of a better lot.
So they have learned how to solve problems on the spot by
adapting to constant changes — including
the harsh winter weather.

Dormant by Design

For the majority of living organisms, winter and its accompanying cold are a source of major stress and discomfort. During this time, the availability of warmth and moisture, which are necessary for all living beings on Earth, decreases. At low temperatures, physiological processes slow down, as water — the essential material for most processes — freezes.

Over the course of evolution, living organisms have developed abilities that have enabled them to survive uncomfortable conditions. But animals, and even bacteria, can usually leave their environment in search of more favorable conditions. Plants can't move independently, so their survival strategies

BIOLOGY



Splitting Games

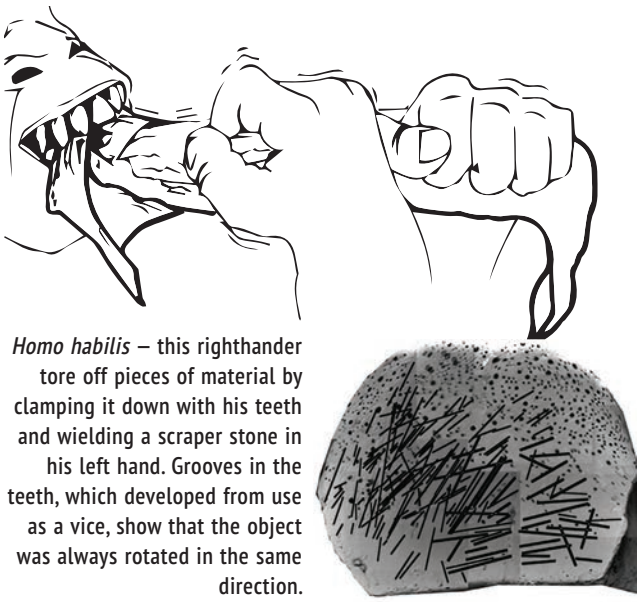
The brain has been studied by many, but even today we don't know enough about it. Certain diseases, such as severe forms of epilepsy, can be cured only by separating the two hemispheres of the brain. The study of people who have undergone such operations can give us important information about how the brain functions.

In the human body, almost everything comes in pairs. You can draw an imaginary line from your head to your toes, and both sides of this line will be nearly identical. This is called **bilateral** symmetry. In the brain, almost all structures also come in pairs, and this applies to the hemispheres. Over the course of evolution, our brain's hemispheres took control over different sides of the body. The right hemisphere is responsible for the left side, and the left, in contrast, is responsible for the right.

The hemispheres, like the halves of the body, are not exactly the same. In the majority of people, the left hemisphere dominates over the right one, which means that these people primarily perform actions with their right hands, the stride of their right leg is slightly longer than the left, and so on.

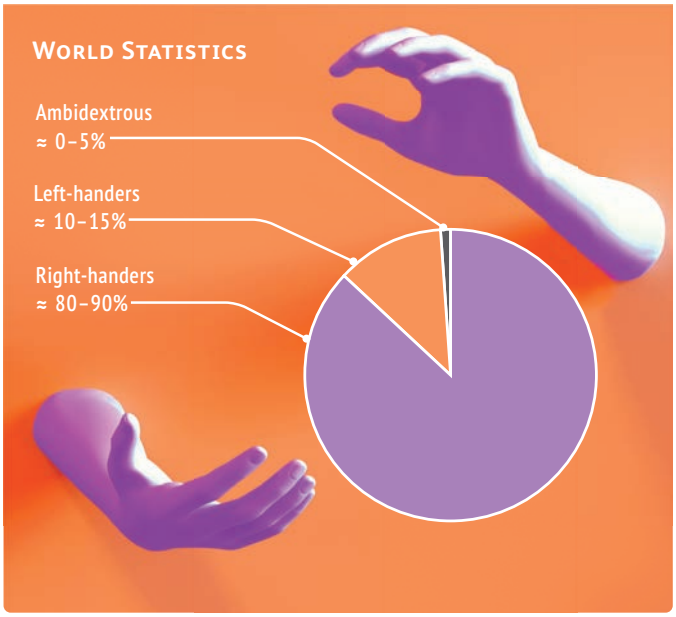
Righties and Lefties

Right-handed and left-handed people existed tens of thousands of years ago. The way that prehistoric *Homo sapiens* and their Neanderthal neighbors processed certain items reveals this. When working with hides, for example, one end was held between the teeth, and the other was held by hand and pulled. A sharp implement grasped in the other hand cut off the pieces, and, to make the process easier, the individual often turned their head in the opposite direction. From this activity, their teeth developed grooves that were oriented in a certain direction. In most remains, traces on the teeth indicate that ancient people held their implements more often with their right hand — that is, they were right-handed. In 2016, researchers from several universities in Spain, South Africa, Italy, and the United States found similar marks on the teeth of an ancient *Homo habilis*, a species known to have used tools when it roamed the Earth over 1.8 million years ago.



Homo habilis — this righthander tore off pieces of material by clamping it down with his teeth and wielding a scraper stone in his left hand. Grooves in the teeth, which developed from use as a vice, show that the object was always rotated in the same direction.

Source: Frayer et al., *Journal of Human Evolution* (2016)



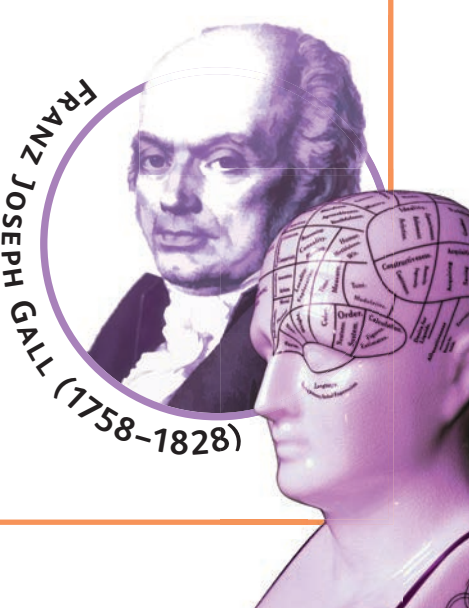
However, until relatively recently, no one knew why some people are left-handed while others are right-handed or why there are more who are right-handed. Speculation began in the 18th–19th centuries when people observed the connection between the nervous system and movements. This was when the idea that different brain regions may be responsible for the actions of different hands and other limbs was born. But this approach, **localizationism**, challenged the representatives of a different theory, **equipotentiality**. Its supporters claimed that everything in the brain is responsible for everything, and, to function properly, it only matters how many nerve cells the body has.

Today, we know that both points of view are true but only for different functions and in different cases. Many cells perform well-defined functions, but if they aren't up to the task, their "neighbors," in some cases, can take on their work. This is called brain **plasticity**, which is especially high in children and adolescents.

Phrenology: Personality via the Skull

Phrenology is a system of ideas proposed by the German anatomist **Franz Joseph Gall** in the early 19th century. He believed that different parts of the hemispheres are responsible for different properties of personality and psyche, and if a certain character trait is well developed, this means that the corresponding part of the brain has grown. If a property is expressed poorly, then its piece of the brain must be small in volume — and these differences can be observed on the surface of the head. Protuberances on the skull indicate the development of a particular feature, and the hollows show weak manifestation.

In fact, though, there is no such clear distinction of functions in the cerebral cortex, and the brain does not grow in a way that changes the shape of the skull. For a start, there are three casings between the skull and the brain. Therefore, Gall's observations were pseudoscientific and strongly resembled astrological forecasts. Moreover, phrenology was dangerous: a person could be convicted of a crime because he had a pronounced "protuberance of cruelty" on his skull while other suspects did not. Nevertheless, thanks to phrenology, the notion took hold that areas of the brain have their own specializations; that is, different areas of the cerebral cortex perform different functions.



MEDICINE

CURE GASTRITIS AND GET FAMOUS:

The Incredible Story of

BARRY MARSHALL

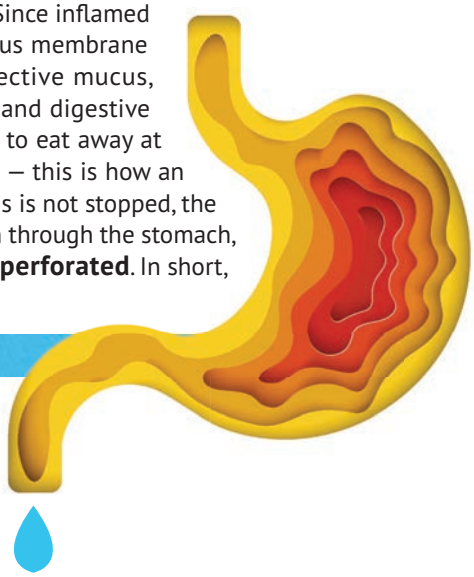
Researchers estimate that half of the world's population suffers from inflammation of the stomach lining — gastritis. The victims of this disease experience burning pain in the upper abdomen along with nausea. Just 30 years ago, it was believed that gastritis results from stress and should be treated with rest, proper nutrition, and pills that relieve excessive stomach acidity. The hero of our story, however, proved that the main cause of the disease is something else entirely.

What Is Gastritis?

The stomach is hidden in the upper part of the abdomen, under the steady protection of the ribs. It is a muscular sac that contains **gastric juice** — a mixture of digestive enzymes and hydrochloric acid. The muscles stir up the food that enters into the stomach, and the gastric juice kills microbes and breaks down the food into components, which then go down to the "floor below," the intestines, where they are absorbed.

The concentration of hydrochloric acid in the gastric juice is about 0.5%. This is more than sufficient to kill most germs and digest food — in fact, it's enough even to dissolve steel! So, the stomach would probably digest itself if it weren't for the unique protective mucus secreted by the inner lining of its walls.

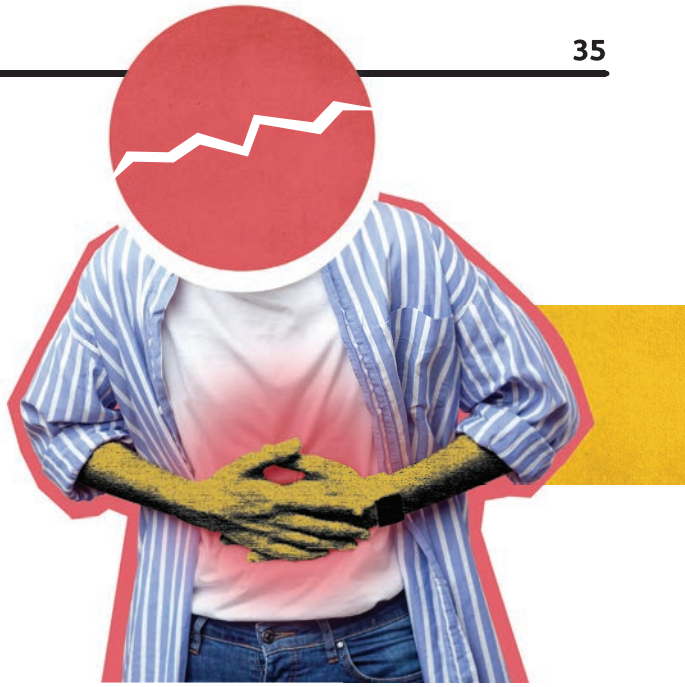
However, some areas of the stomach lining (also called **mucosa**) sometimes fail and become inflamed. When gastric juice gets into these areas, a person feels a burning pain — a symptom of **gastritis**. Since inflamed areas of the mucous membrane secrete less protective mucus, hydrochloric acid and digestive enzymes continue to eat away at the stomach walls — this is how an **ulcer** occurs. If this is not stopped, the acid can even burn through the stomach, and the ulcer gets **perforated**. In short, it's a nightmare!



What Do Bacteria Have to Do with It?

For decades, doctors didn't even think about why some areas of the gastric mucosa suddenly get inflamed. They believed that stomach ulcers are caused by excess hydrochloric acid. They thought that if too much of it accumulates, it simply "breaks" the mucous barrier and burns the delicate walls of the stomach. Where the "extra" hydrochloric acid comes from was not very clear. Mostly, they blamed stress, spicy food, and poor lifestyle.

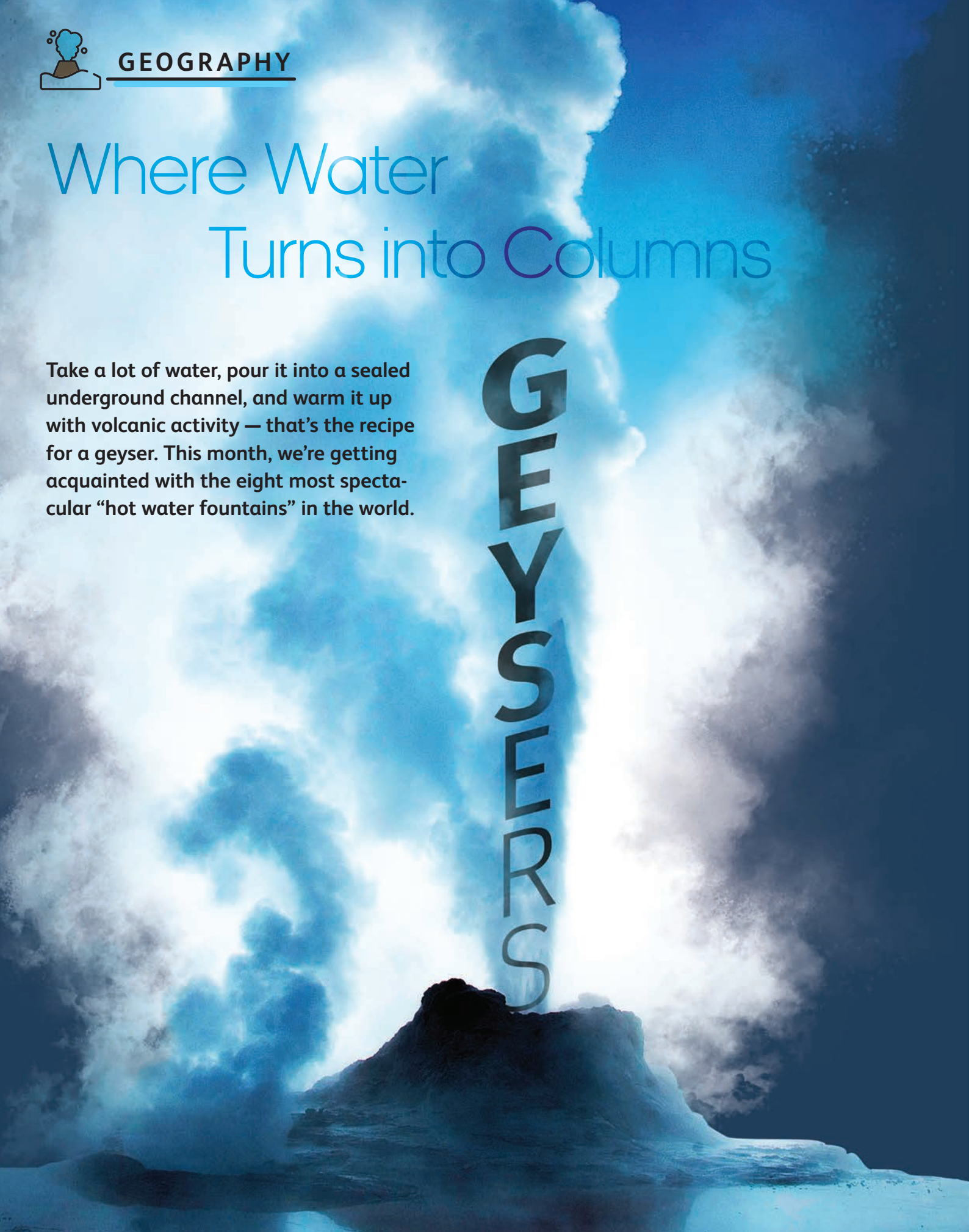
The doctors, though, were not really interested in the true causes of gastritis. After all, they thought they knew how to treat the disease — you just needed to give the patient a drug that reduces the production of hydrochloric acid. If that doesn't help and gastritis still turns into an ulcer, you will need to perform an operation and "sew up" the hole in the patient's stomach. Although this method of treatment was painful and the ulcers came back in some patients anyway, it was believed that this was the best way to relieve the symptoms.



For a long time, no one suspected that the stomach lining can protect against **bacteria**. Today, we know that in response to the invasion of *Helicobacter pylori*, the body triggers an immune response. This leads to the inflammation of the stomach lining, and the gastric juice exacerbates this process.

But in the 20th century, the idea of a secret stomach microbe "pest" seemed very strange. Judge for yourself: where do bacteria in the stomach come from if it contains hydrochloric acid? They immediately dissolve there, after all!

However, back in 1938, the American surgeon **James L. Doenges** found some mysterious spirochetes — long, thin bacteria twisted into a spiral — in the gastric glands of humans and monkeys. But at the time, few people took this message seriously. In 1954, **Eddy D. Palmer**, a respected gastroenterologist, decided that the spirochetes had entered the samples by accident. He announced that there were no bacteria in the stomach, so most doctors and scientists took his word for it and never looked for them.



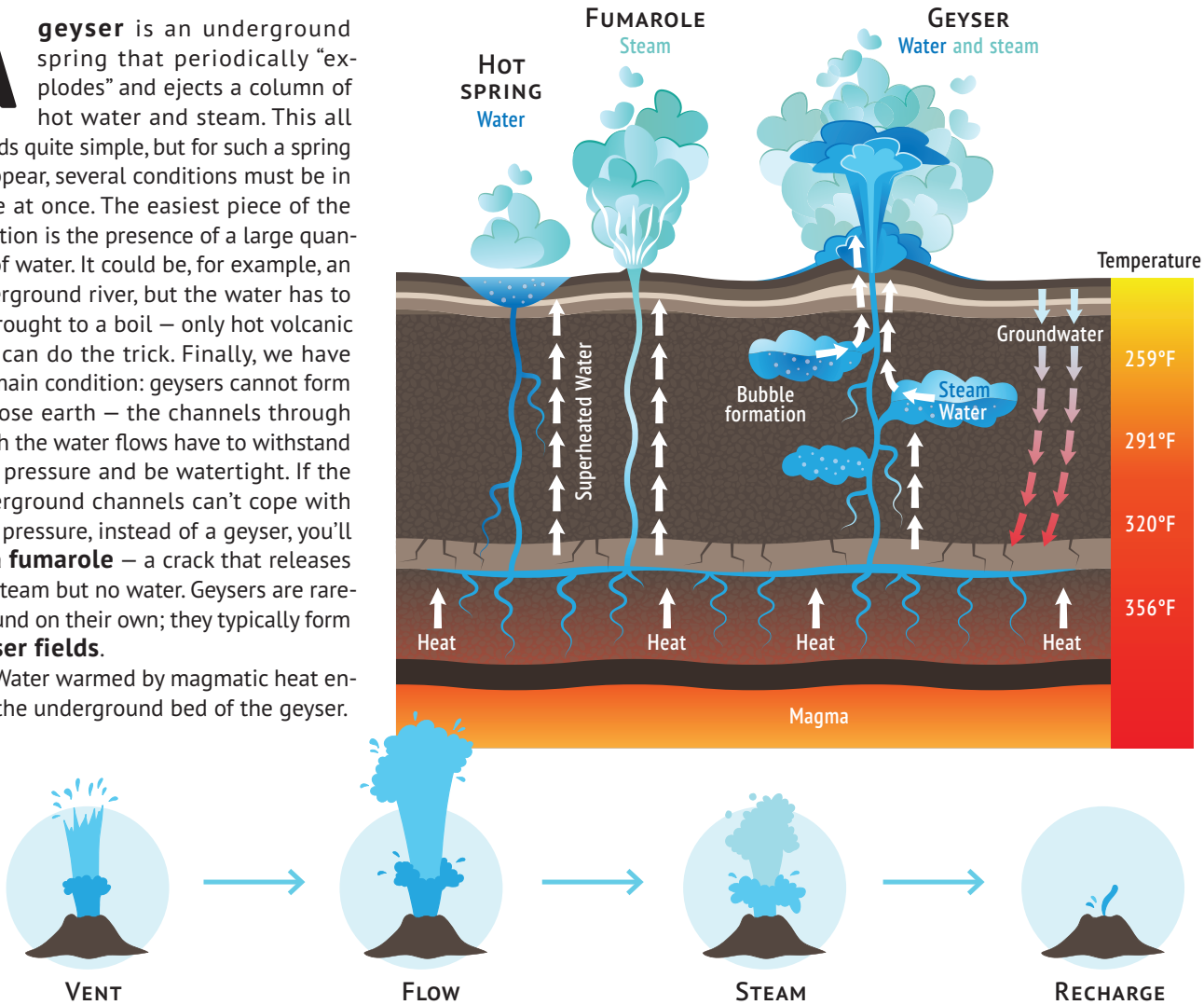
GEOGRAPHY

Where Water Turns into Columns

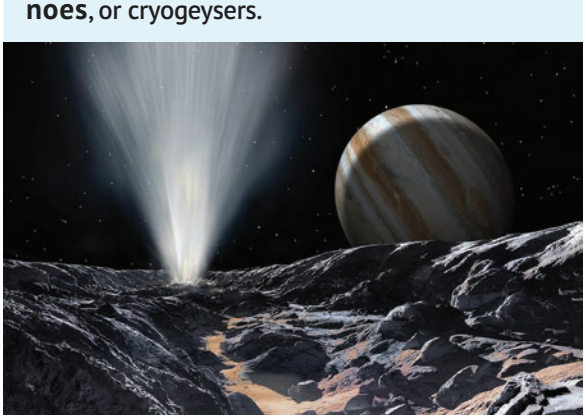
Take a lot of water, pour it into a sealed underground channel, and warm it up with volcanic activity — that's the recipe for a geyser. This month, we're getting acquainted with the eight most spectacular "hot water fountains" in the world.

A **geyser** is an underground spring that periodically "explodes" and ejects a column of hot water and steam. This all sounds quite simple, but for such a spring to appear, several conditions must be in place at once. The easiest piece of the equation is the presence of a large quantity of water. It could be, for example, an underground river, but the water has to be brought to a boil — only hot volcanic lava can do the trick. Finally, we have the main condition: geysers cannot form in loose earth — the channels through which the water flows have to withstand high pressure and be watertight. If the underground channels can't cope with high pressure, instead of a geyser, you'll get a **fumarole** — a crack that releases hot steam but no water. Geysers are rarely found on their own; they typically form **geyser fields**.

Water warmed by magmatic heat enters the underground bed of the geyser.



Geysers exist not only on our planet — there are similar phenomena on several moons of the Solar System: on Io (Jupiter), Triton (Neptune), and Enceladus (Saturn). However, such geysers do not spew hot water but rather ice and various gases, which is why they are called **cryovolcanoes**, or cryogeysers.



Meanwhile, cold rainwater comes from the surface, and the next wave of hot water comes up from below. Its temperature reaches above 212°F, but it cannot turn into steam due to the pressure of the water and soil from above. The higher the pressure, the higher the boiling point, and vice versa. For example, at an altitude of 2.5 mi above sea level, where the pressure is much lower than normal, water boils at about 186.8°F.

When the geyser is filled with water (this can take anywhere from a few seconds to a couple of days), some of it will release and reduce the pressure on the "water supply," thereby lowering the boiling point and instantly creating steam. The volume of steam is about 1,600 times greater than the same amount of water, so an explosion occurs. The eruption continues until the water in the geyser either runs out or cools down.

There are only about 1,000 geysers on our planet, and very few of them are open to tourists for viewing. Some of them are put to work by geothermal power plants, and others are destroyed in the search for minerals, as geyser water sometimes leaches gold and other valuable materials from the depths of the Earth's crust.

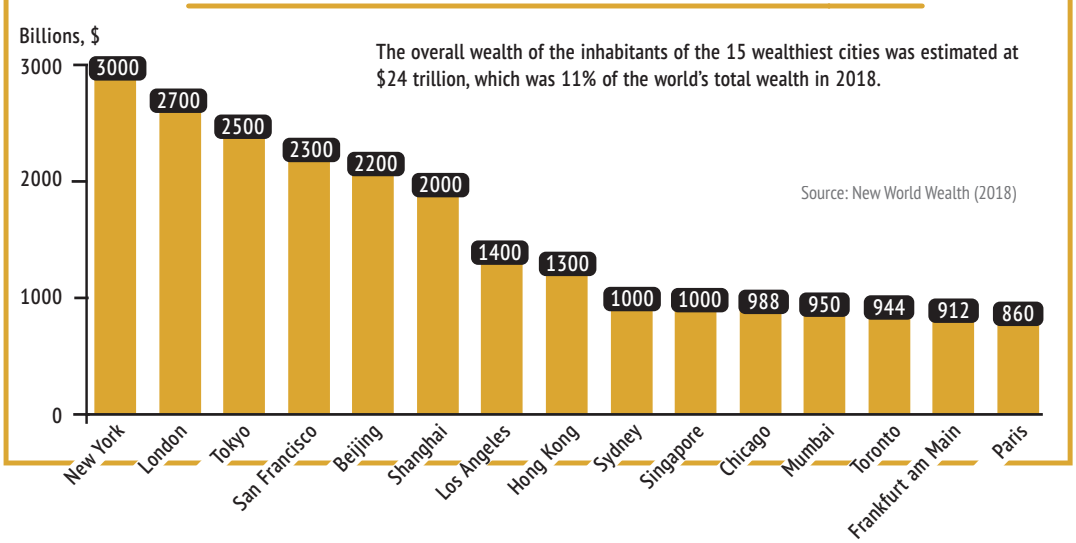
Even a column of water and steam can be amazing and beautiful in its own way. Here, we've selected some of the world's most fascinating geysers for your perusal.

CITIES

Cities have become the center of human life. The fate of humankind will depend on the direction their development takes.

The history of cities in many ways mirrors the history of humanity. Revolutions, epidemics, and crimes have always been rife in the city. As the drivers of the economy and important social processes, cities ushered in advanced technologies and promoted culture and arts. What awaits the residents of megalopolises and industrial cities, and how radically can our idea of the city as a center of progress change over time? Let's look into the possible future of megacities through the prism of the history of their emergence and evolution.

Wealthiest Cities in the World



Origins: The Age of Walls

More than 55% of the world's population currently lives in cities; over 80% of the gross world product (GWP) is produced in cities. But where did it all begin? What made people settle in one place?

The first cities or, strictly speaking, villages that emerged around established trading posts are believed to have appeared more than 6,000 years ago in Mesopotamia and a little later in India, China, and Egypt. The structure of the ancient cities, regardless of the country, was simple and more or less the same: there was a market square, a place of worship of the local religion, and residence of the rulers and the local nobility.

No one can say precisely when and where the first market arose. But it is safe to say that it was in the most convenient location for all the participants in the exchange. Living near the market was profitable. Therefore, settlements of artisans and merchants sprang up around such places. Unfortunately, this benefit was also noticed by those who were looking for easy money — merchants had to protect themselves against raids.

That's why trading settlements had to be protected with wooden or stone fences since ancient times. For example, in Slavic languages, the concept of "city" means "an enclosed, protected place." In Latin, it was called *oppidum*, that is, "towering (above a flat place)." The **oppida** were inhabited by *civitas* — members of the city's civic community, and this word gave rise to the French *cité* and, further, the English *city*.

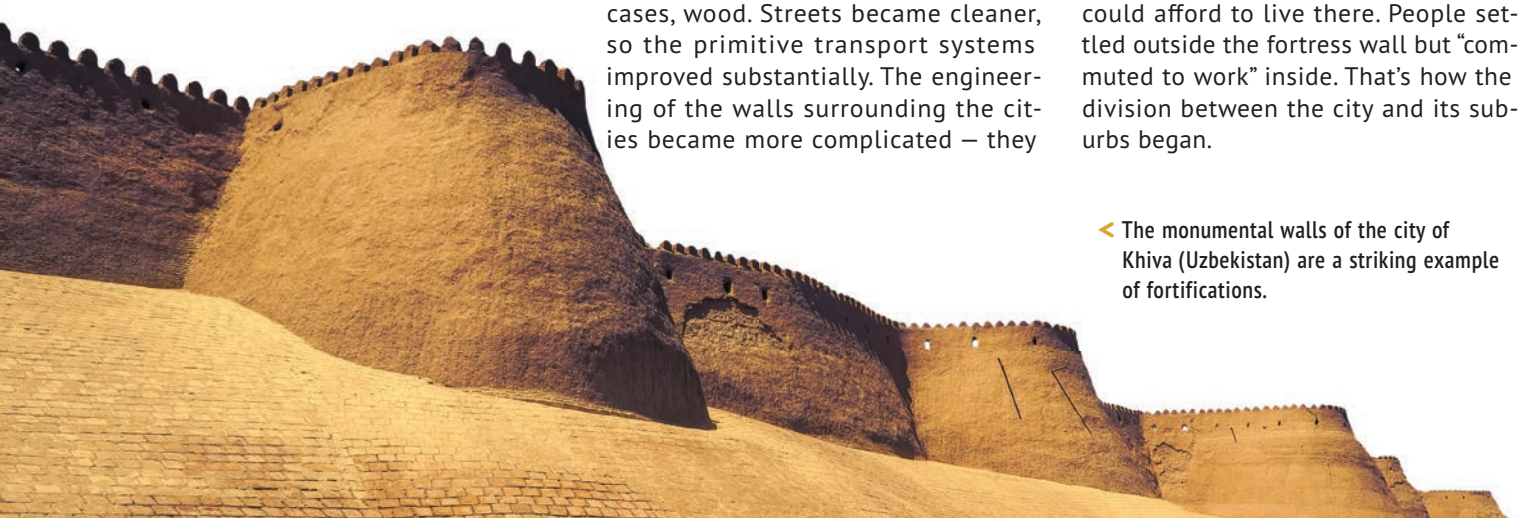
^ The ruins of the Agora market (Side, Turkey). *Agora* was the name for market squares in ancient Greek cities.

The plan of ancient Rome

City dwellers needed water and waste removal utilities. The solution was first found in Mesopotamia and ancient Egypt, where a water system with sewer pipes was installed. It would become the key difference between the first cities and large villages.

Then, cities mastered the technology of street paving, that is, creating a hard surface using stone or, in rare cases, wood. Streets became cleaner, so the primitive transport systems improved substantially. The engineering of the walls surrounding the cities became more complicated — they grew upwards, with stone or metal eventually replacing wood. These improvements turned cities into safe and comfortable places. Naturally, people began to gravitate towards cities. Even in antiquity, cities faced the problem of overpopulation and the need for expansion.

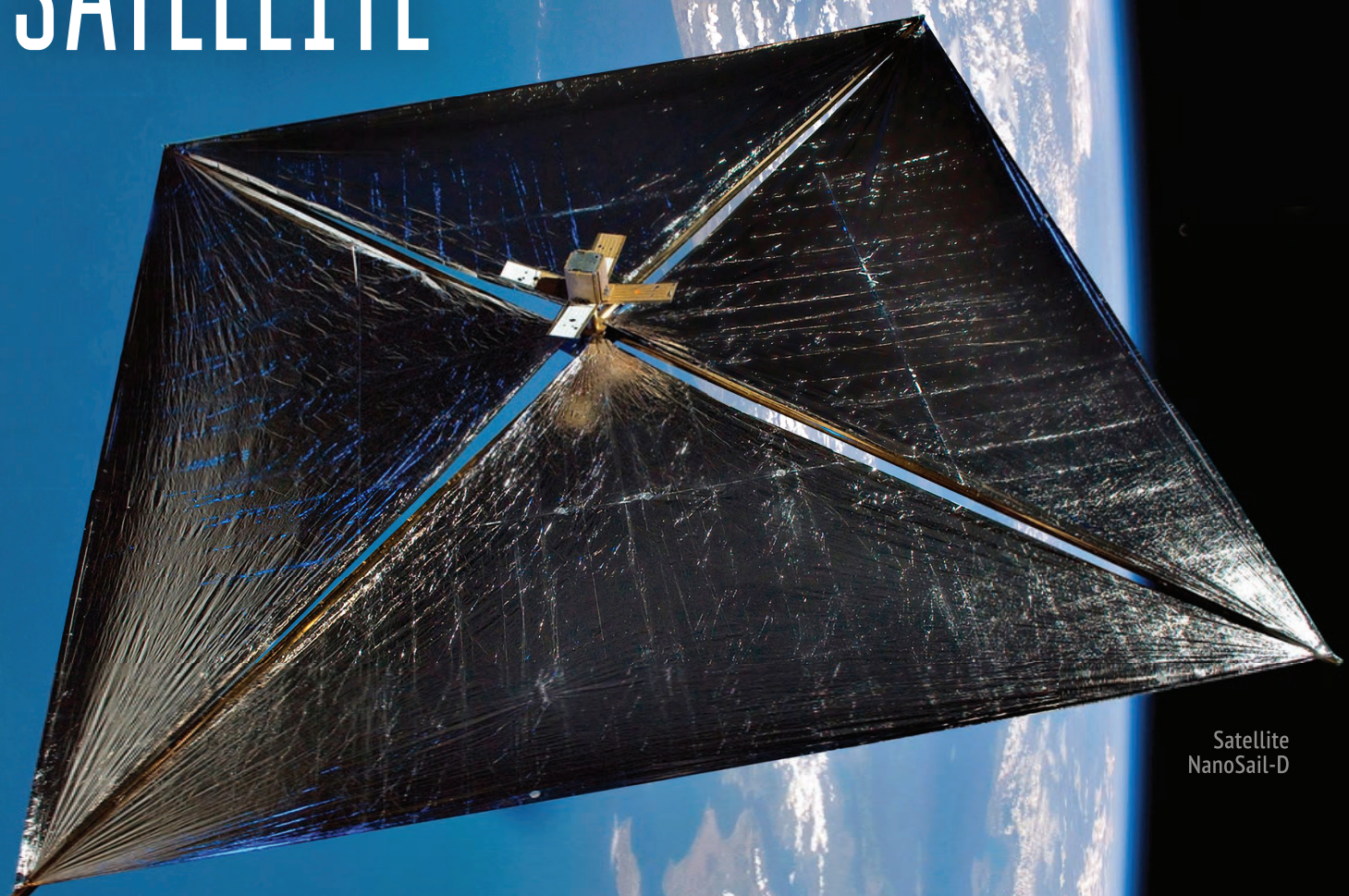
The space inside the fortified walls was limited, and only the very wealthy could afford to live there. People settled outside the fortress wall but "commuted to work" inside. That's how the division between the city and its suburbs began.



< The monumental walls of the city of Khiva (Uzbekistan) are a striking example of fortifications.

DIY

BUILD YOUR OWN SATELLITE

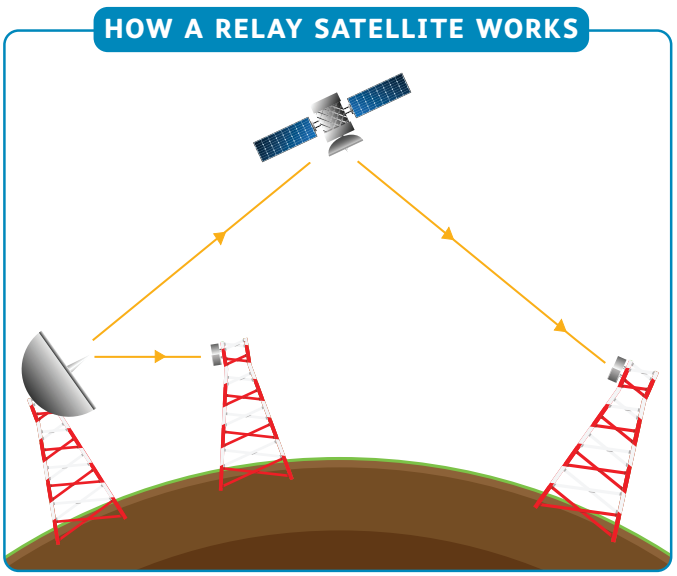


Satellite NanoSail-D

October 4, 1957, marked the beginning of the Space Age. On this day, the first artificial satellite was launched from Earth — the Soviet Sputnik 1. Thousands of designers, engineers, and scientists labored on this project for almost ten years. Today, even schoolchildren can launch their own orbital satellite — and we will tell you how to do so successfully.

Why Do We Need Satellites?

If you want to do something space-related, you can begin with satellites, albeit small ones. Engineers classify satellites by mass: minisatellites (220 lb–1102 lb), microsatellites (22 lb–220 lb), nanosatellites (2.2 lb–22 lb), picosatellites (3.5 oz–2.2 lb), and femtosatellites (0.35 oz–3.5 oz). Despite their miniature size and weight, small satellites solve many problems, often complementing large satellites and in some aspects even replacing them. Firstly, tiny satellites are used for observation and filming of the planet — remote sensing. Secondly, they provide Internet access in places where there are no repeater sites. Thirdly, new technologies are tested, and experiments are conducted on small satellites. All of this is possible due to the relatively low cost of these crafts, which ranges from a couple of thousand to several tens of thousands of dollars. This allows many universities and amateurs to acquire their own satellites. Between 2012 and 2019, more than 1,700 small satellites were launched, more than half of which provide commercial services.



Accessibility

The launch of a small satellite doesn't require special qualifications or large monetary expenditures. Besides, you can take advantage of the rapidly developing modern technology. Just as our smartphones are packed with all kinds of advanced features, it's possible to equip satellites with various sensors and devices, from antennae to spectrometers.

Goals

If you are going to launch a satellite, first you need to think about the problem you would like to solve. You can go online to find organizations and amateurs who have the experience you need and can give you advice. Your goal should be feasible and well-thought-out so that your craft serves a clear purpose and doesn't just turn into space garbage. Thoughtless launches only bring about the **Kessler Syndrome** — a scenario in which the space debris in near-Earth orbit will make outer space entirely unsuitable for practical use in the future. This phenomenon is named in honor of the NASA consultant **Donald J. Kessler**, who first described this problem.

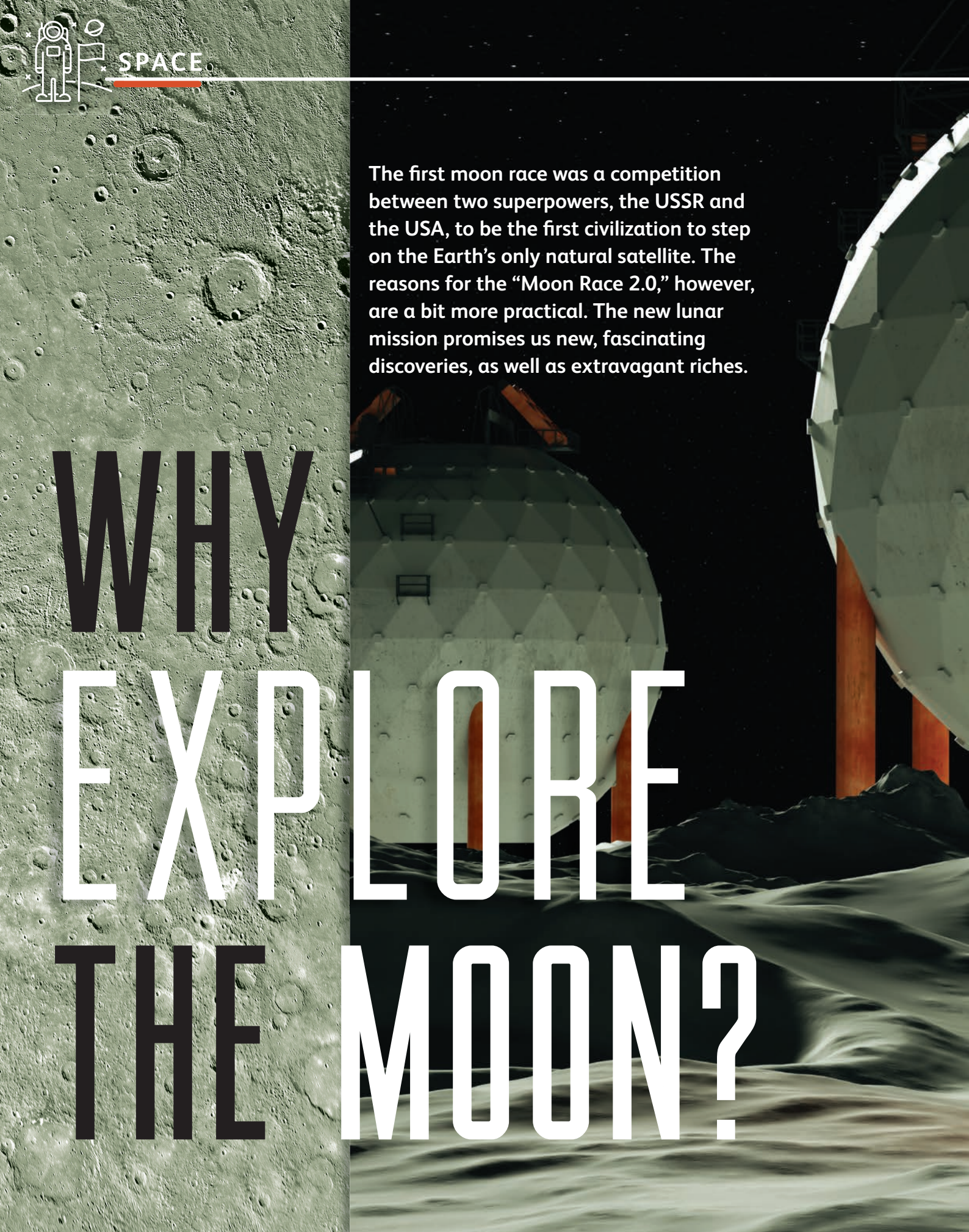
Source: European Space Agency/ NASA

The flight controllers at NASA's Mission Control Center celebrating the success of Apollo 11 (July 16–24, 1969), the first crewed mission to land on the Moon

According to NASA's calculations, more than 95% of all objects in near-Earth orbit are debris. Pictured is a computer model of its distribution.

Teamwork

Launching a satellite on your own is very difficult. Look for like-minded people — you can get the word out on social media, specialized forums, or in universities that have aerospace programs. There are even summer space camps, where you can easily assemble your dream team. For the construction of a satellite, you will need designers, electronic engineers, programmers, and specialists in ballistics and in the experiments that you plan to conduct in orbit. Don't forget about a manager to build connections with businesses and handle the planning and implementation of your project.



The first moon race was a competition between two superpowers, the USSR and the USA, to be the first civilization to step on the Earth's only natural satellite. The reasons for the "Moon Race 2.0," however, are a bit more practical. The new lunar mission promises us new, fascinating discoveries, as well as extravagant riches.

WHY EXPLORE THE MOON?

The Ideal Observatory

Let's imagine that lunar missions received sufficient state recognition and support. Who would benefit from such opportunities? Most of all, optical astronomy. Its entire history has, in essence, involved fighting against atmospheric distortions (also called **aberrations**).

> **For astronomers, the airless Moon is the ideal observatory, from which they can achieve the highest possible resolution with currently existing telescopes.**

This idea was propelled by the work of German astronomers **Johann Heinrich von Mädler** and **Wilhelm Beer**, who concluded that there is almost no atmosphere on the Moon, so there would be little atmospheric distortion. There would also be no light pollution and very little interference from human-produced signals. Plus, the relatively low rotational angular velocity of the Moon's sky would simplify the process of long-exposure photography.

Scientists liked the idea, though they didn't start working on it right away. The first telescope on the Moon was placed there by Apollo 16 astronauts, in April 1972. This telescope looked at the ultraviolet light from distant objects, and it is still on the Moon today.

In 2008, employees of the NASA Goddard Space Flight Center, **Peter C. Chen** and **Douglas Rabin**, proposed the idea of making telescopic mirrors on the Moon, using a mixture of epoxy resin and lunar dust (ground regolith) reinforced with carbon tubes. According to their calculations, a 7.9 ft mirror, similar to that of the Hubble, would take 1,323 lb of lunar dust, 132 lb of "epoxy," 2.9 lb of carbon nanotubes, and only 0.03 oz of aluminum. That is, 90% of the future telescope's weight will already be waiting on site. If we scale up the production technology, the future makers will have access to mega mirrors up to 164 ft in diameter!

The lunar reflector project has many unsolved technical issues. Ground-based astronomical systems, in contrast, are rapidly improving, successfully tackling the problem of atmospheric aberrations.

GETTING OVER THE ABYSS

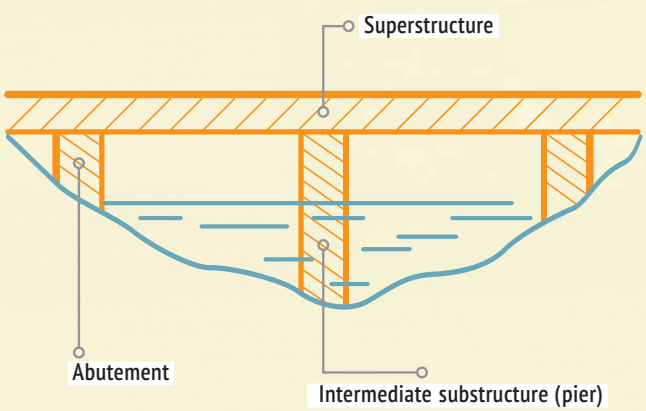
Connecting riverbanks or the slopes on either side of a ravine, making it possible to cross from one side of the road to another — bridges have come a long way. In its simplest form, a bridge could be a log thrown across a stream, and, in its most complex form, a bridge can become a masterful feat of engineering.

Transversing the Stream

The first bridges in history were stepping stones or trees that fell across a creek or ravine. These primitive structures probably first appeared by chance. Man-made pathways may have included flexible suspension bridges made from vines and rods, fastened to tree trunks that grew along the edges of cliffs.

Later, still in ancient times, bridges were built of wood and stone. The difficulty here was in creating a solid surface for a bridge to rest upon while not blocking a river's current. Typical supports were stone columns, and constructions were suspended like stone archways or made with log overlays. These bridges would not block a river's current, and water could freely pass between their supports. Temporary crossings consisted of simple supports — a wooden framework and log flooring.

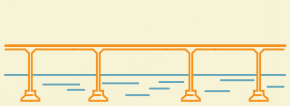
Main Parts of a Bridge



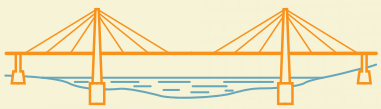
Construction Types

Bridges can be organized into six categories: beams, arches, frames, cable-stayed, suspension bridges, and combinations. Beams are flat decks laid between supports designed for vertical pressure. In contrast, arches bend and compress under heavy loads, giving support both vertically and horizontally. Frame bridges are supported by columns and laid over with beams. Suspension or cable-stayed bridges are supported by flexible elements, cables, and ropes, which take on the bulk of the pressure. In the case of suspension bridges, the load on the supports is distributed both vertically and horizontally. Finally, the strongest bridges use a combination of these techniques. They are engineered with the support of arches, braced with strong beams and also supported by interconnected flexible materials, such as cables.

Beams



Cable-stayed



Arches

Suspension

Frames

Combinations

Bridge of Tiberius, Rimini, Italy

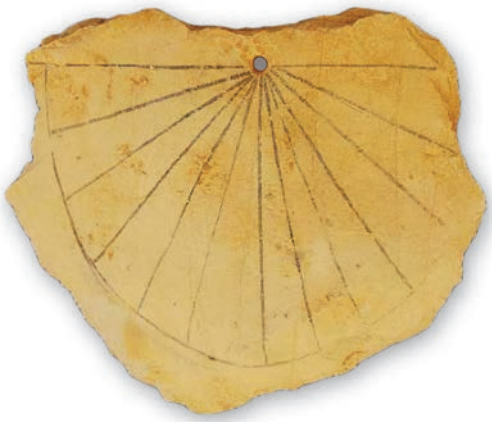
The gold standard for a stone bridge was constructed in Ancient Rome. The Tiberius bridge on the Marecchia River in Rimini is a classical construction of that era, dating back to around 14 BCE. Its engineers created a combination support system of semi-circular arches and powerful pillars and found the optimal ratio between the width of the bridge and the strength of its stone base. Unfortunately, the ancient architects did not take into account the strength of the river, which greatly accelerated under the bridge and eroded its supports.

ASSISTING THE CROSSING

Ancient Romans invented tongue and groove fencing supports— wooden stakes firmly hammered into the river bottom. From this round fence, builders dredged up water and erected masonry. They would spend a long time digging through the muddy riverbed in search of a solid base. Then, they filled it in with a lime-cement mortar and placed heavy stone blocks over it.

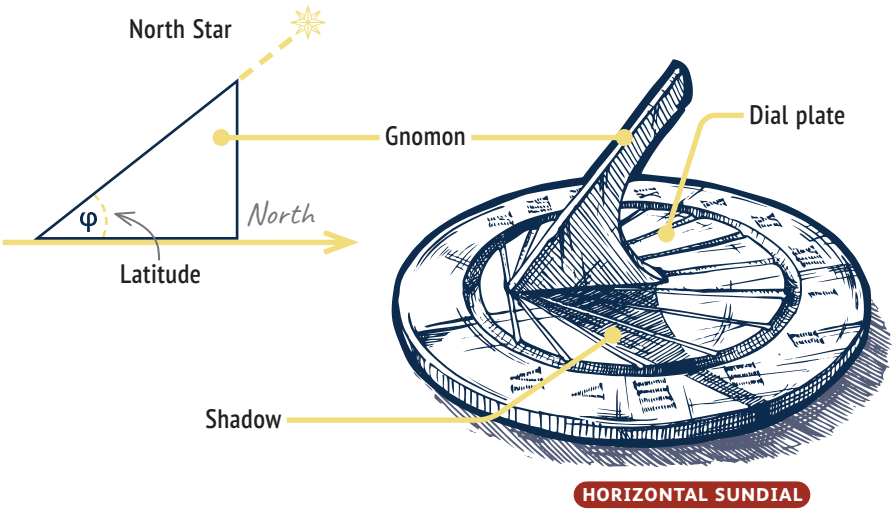
IN A SINGLE TICK

Even a broken clock is right twice a day. Unfortunately, this doesn't make them any more useful. Even a working clock is worth very little... unless it's been synchronized with other clocks.



The world's oldest sundial from the Valley of the Kings in Egypt (circa 1500 BCE)

How Sundials Work



HORIZONTAL SUNDIAL

Countdown

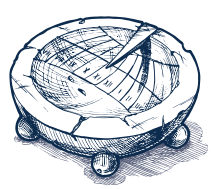
When we talk about time, we always operate with two concepts: the calendar as a mathematical tool for organizing intervals of time and the device that counts these intervals. For most of history, humanity has mostly used large intervals of time, such as seasons or years, which were sufficient for an ancient farmer or hunter.

Around 1500 BCE, the **sundial** was invented in ancient Egypt. The change of day and night, like the change of seasons, made it easy to count the days and years. The sundial, however, gave people the first opportunity to measure lengths of time shorter than a day.

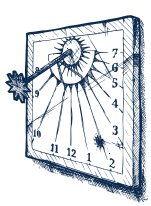
The first **mechanical clock** appeared in the 8th century CE in ancient China, invented by the monk and mathematician Yi Xing. Now, people could count the time during both the day and night! Over the centuries, clockwork mechanisms have improved to become more accurate and compact, but they first needed to be synchronized in remote places, far away from one another — and all of this was because of trains.

In English cities, clocks were synchronized with local sundials almost until the end of the 18th century. As a result, each city lived in its own time: so, relative to London, Oxford was five minutes behind, Carnforth 11 minutes behind, and Barrow was almost a quarter of an hour behind!

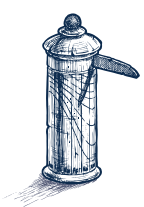
Types of Sundials



SKAPHĒ

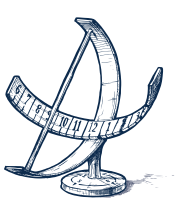


VERTICAL

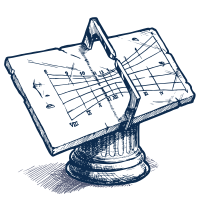


CYLINDRICAL

EQUATORIAL



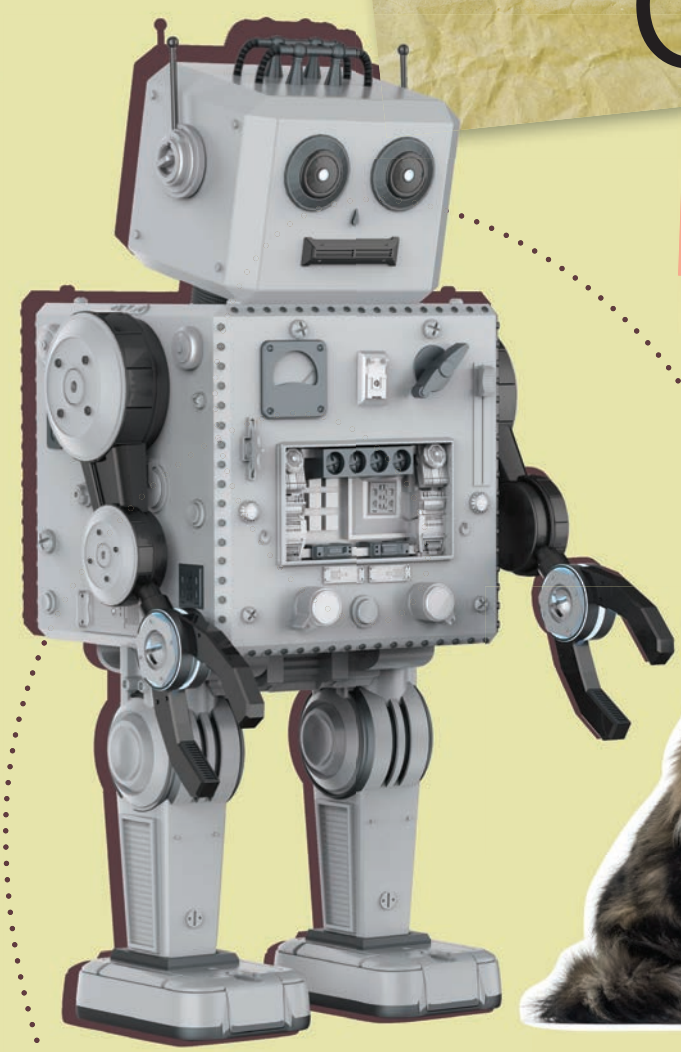
EQUATORIAL BOW



POLAR

The Prague Astronomical Clock, first installed in 1410, is the third oldest astronomical clock in the world and the oldest still in operation.

NEO-LOGISMS: OLD and NEW



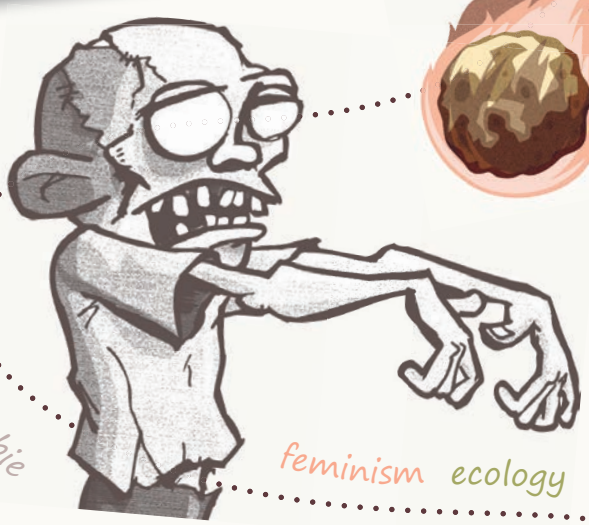
The birth of a new word is always a cause for celebration. The last two centuries have been especially rich with neologisms since so many new and exciting things have appeared in that time! Cars, airplanes, computers, robots — we're inventing one thing after another, and they always call for new names. The origin of some words might surprise you, and others haven't even been translated into foreign languages yet!

OLDER THAN YOU THINK

Today, most households have at least one laptop, tablet, or smartphone. But do you know when the word "**computer**" first appeared in the English language? No less than three hundred years ago! However, back in the day, a computer was a person who did calculations. Companies looking for secretaries and accountants advertised job openings as "*computer wanted*." Such advertisements survived well into the 1970s when the word had already acquired a different meaning — computing machinery. The description of one of the earliest digital computers, the Atanasoff–Berry computer, states that the device can be easily controlled by an "*experienced computer*."

computer wanted

The words "**atomic**" and "**nuclear**" are unlikely to have been coined before the mid-20th century, right? No way! The idea that the world is made up of atoms was first proposed by the ancient Greeks, and in the early 1800s, the English physicist and chemist **John Dalton** proved the scientific validity of the atomic theory. He was also the first to talk about the atomic weights and atomic numbers of elements. According to the *Oxford English Dictionary*, the word "*nucleus*" used to mean the brightest part of a comet in the 17th century, and only three centuries later did it begin to refer to the central part of the atom.



zombie zombie zombie

Zombies, one of the most popular themes in contemporary popular culture, have been around for a long time. In fact, the word is so ancient that we still don't know where it originated: was it in West Africa or Haiti? Europeans first learned about this word from the book of the English poet **Robert Southey**, entitled *History of Brazil*, in 1819.

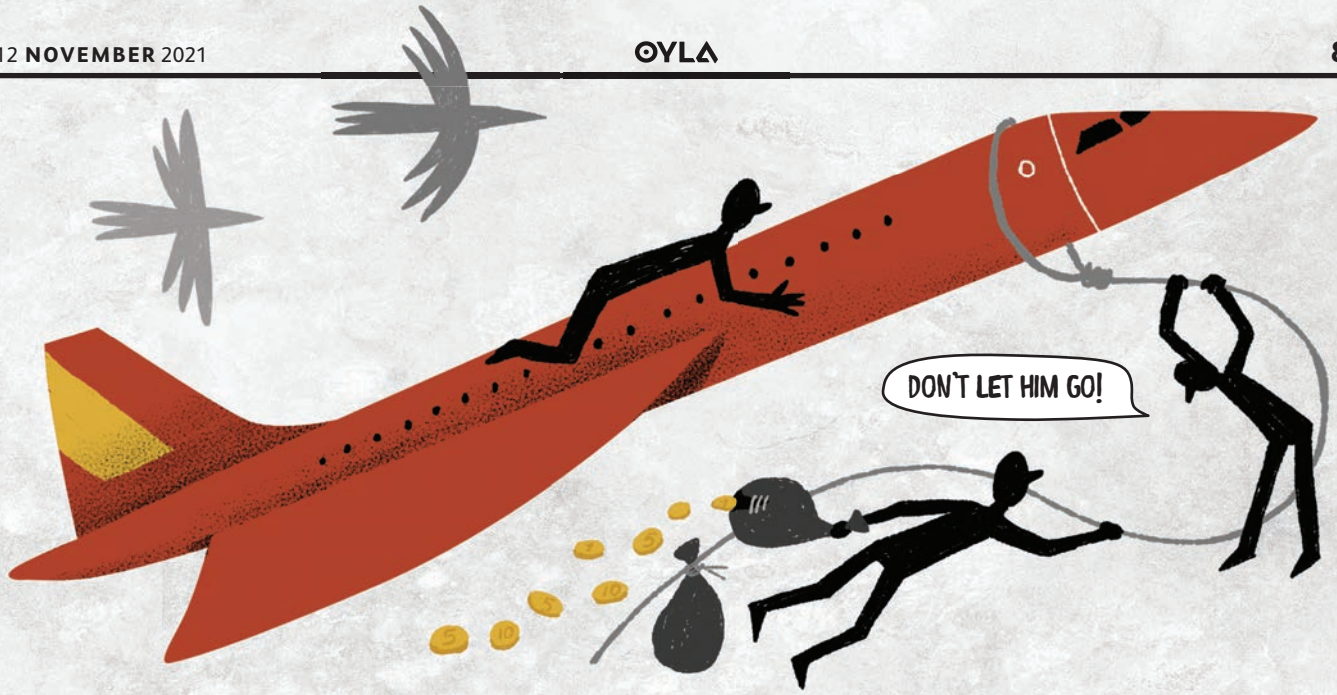
Likewise, if we look at modern social phenomena and issues, we'll discover that they have been discussed for many centuries before us. For example, **terrorism** was first mentioned during the French Revolution of 1789. The word "**freelancer**" was used to describe a medieval mercenary in **Sir Walter Scott**'s 1819 novel *Ivanhoe*. The term "**ecology**" was coined by the German naturalist **Ernst Haeckel** in 1866. And in 1895, the *Oxford English Dictionary* documented the first appearance of the word "**feminism**."

feminism ecology terrorism

Letting Go Is Hard:

THE SUNK COST FALLACY

Picture this: you start college, study there for a year or two, and then you suddenly realize that you don't like your major as much as you thought you would. The logical choice is to follow your heart in another direction, but making the decision isn't so easy. After all, you've already put so much time and effort into your coursework! You might have even invested quite a bit of your own money. If you switch majors, all that hard work will be wasted...or so it seems.



BREAK THE BUDGET

Air tickets in the 1950s were four to five times more expensive than they are now. Only businessmen and the elite could afford to fly long distances — and those sorts of people tend to highly value their time. The aviation industry believed that the future of passenger transportation was in **supersonic airliners** that could fly twice as fast as normal: from London to New York in just three hours and twenty minutes. Similar planes had already been in use by the military, but they were not intended to transport a large number of passengers, and they weren't very comfortable for long-distance travel.

In 1956, the United Kingdom and France began a joint effort to design a supersonic passenger aircraft called the **Concorde**. The work was delayed multiple times, and the plane only took flight on March 2, 1969. The initial cost of development was estimated to be £70 million, but it eventually exceeded £1 billion. This project wasn't the first of its kind, however — in December 1968, the USSR broke in its own high-speed aircraft, the **Tu-144**. So, why was everyone so eager to spend so much money?

By the end of the 1960s, "ordinary" passenger liners had expanded and were ready to carry more passengers. Thanks to the increased capacity, ticket prices shrunk, and traffic grew significantly. Air travel ceased to be exclusively for the wealthy, all without a reduction in flight time. Interest in supersonic planes fell, but the creators of the Concorde nevertheless persisted.

In 1973, the oil crisis broke out, and the price of aviation fuel skyrocketed. Supersonic aircraft lost their commercial appeal because they consumed much more fuel than their subsonic counterparts. Compare the Boeing 747, which seats 366 passengers and consumes approximately 3,800 gal of fuel per hour, with the Concorde, designed for only 100 passengers, which consumes 6,770 gal.

Airlines withdrew their orders for the Concorde. In total, only nine aircraft were sold for a substantial sum. They were bought by British Airways and Air France, but these airlines were controlled by the governments of the countries that had developed the aircraft. The rest of the planes had to go somewhere, but no one else was interested in the Concorde. As a result, they were eventually sold to the very same two airlines for a merely symbolic price — one pound sterling or one franc — on the condition that they were at least put into operation.

In 2003, the Concorde was decommissioned. The plane and its Soviet counterpart, Tu-144, which finished flying in 1999, are the only mass-produced models of supersonic passenger airliners that ever performed commercial flights. Supersonic aircraft are no longer used for passenger transportation.

As a result, huge financial investment in the Concorde and more than ten years of specialized work were wasted. The program could have been stopped at any time before expenditures grew so high — there was plenty of justification. But the project's managers felt that the investment justified further costs.

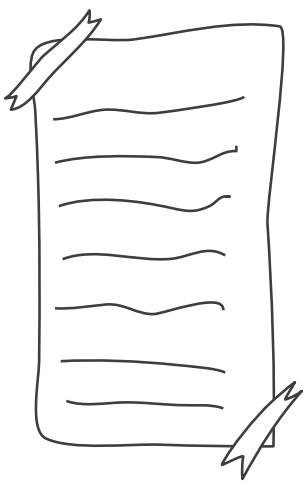
> **This behavior is called the sunk cost fallacy — when some process is continued because of the effort, time, or money already spent, and not because there is any rational reason for it.**

PERSON

№ 7

CARL LINNAEUS'S PASSPORT OFFICE

It's not an easy task to come up with scientific names for all animals and plants! However, the life of Carl Linnaeus, the creator of the modern naming system for organisms, wasn't what you'd call boring: he shocked the world with the idea that plants can be "male" and "female," invented the flower clock, fought a Hydra, grew bananas, and even went on a solo journey to Lapland!



This Is the Way

It seems like **Carl Linnaeus** was destined to become a naturalist — his father's lineage had all kinds of "botanical" last names! In the 17th century in Sweden, when Carl's father was born, it was customary to only use patronyms ("son of so-and-so"), but once you received higher education, you could adopt a "real" last name. So when **Nils Ingemarsson** enrolled in university, he called himself ***Linnæus*** — after the **linden** (*lind* in Swedish) that was common in the land of his ancestors. Meanwhile, Nils's uncles studied to become priests and adopted the Latin name of the same tree (*Tilia*), so their last name was Tiliander. In 1707, the "linden" family celebrated the birth of its new member — Carl.

Nils Linnaeus loved botany and passed this passion on to his son. By the age of five, Carl already had his own plot in the family garden, and his father had taught him the **Latin names** of all the plants that grew there.

Wait a minute, what Latin names? Didn't Carl himself come up with them when he grew up? Not really. Linnaeus introduced binomial nomenclature — that is, names composed of two parts: genus and species names (like Homo sapiens). Before that, scientists christened plants and animals with long and flowery Latin expressions such as **Plantago foliis ovato-lanceolatis pubescentibus, spica cylindrica, scapo tereti** (*meaning "plantain with pubescent ovate-lanceolate leaves, a cylindrical spike and a terete scape"*). *It is these names that Nils taught his son, who gladly soaked them up.*

At school, Linnaeus was more interested in plants and their names than his classes. His teacher praised the boy's aptitude for natural sciences and love for the Latin language, advising

And then they CAME ROLLING

BOWLING! Who first started bowling, and when? Do bowling pins have a sacred meaning? Who has been barred from playing? What are “grandma’s teeth” and “turkey”? How should you choose the right ball? What rules should be observed while playing?

Bowling Pins Pyramid

What does bowling mean to you? Lacquered lanes, an automatic system of returning balls, screens displaying the score, loud music… Can you imagine that this game was popular in ancient Egypt? In 1895, Egyptologist **Flinders Petrie** discovered what looked like bowling equipment at the burial place of a child who lived about 5,200 years ago.

In Europe, the ancient Roman province of Upper Germania is considered to be the birthplace of bowling (or rather, the pin game — the word "bowling" appeared later). It is known that the knocking down of wooden pins by hurling a stone ball was part of the religious ritual of local people in the 3rd century CE — knocking down pins allegedly removed the effects of the person's sins. Who would have thought that a sin-free life could be so much fun? Over time, rolling balls turned into a fun pastime, and the game spread to neighboring countries.

^ Every medieval city had its own unique bowling rules

There was no uniform set of rules — the game was played differently in every city. The game was not yet modern bowling: they used not ten but anything between three and 17 pins and set them up in the form of a diamond instead of the familiar triangle. There were no special lanes, either. They played on terraces, city squares, in parks, on lawns, and out in the fields — that is, anywhere with a relatively flat surface.

By the 16th century, balls and pins were adored by all, from kings to peasants, sometimes to the detriment of the production sphere. The English monarch **Henry VIII** even issued a decree banning the lower classes from playing "balls on the grass," for there had to be someone to work and serve!

The game of pins, in both the ancient and the current versions, is not as strictly regulated as bowling. The lane length, the number of throws, and the scoring of points can be different as long as everybody is having fun! Balls are also different: they are much smaller, and they are held with the whole palm, without finger holes.

The New World Means New Rules

Colonists who came to the American continent did not forget their hobby. They bowled all around Manhattan! The name of the oldest park in New York — *Bowling Green* — is proof of this. Gradually, the hobby grew into an obsession: it got to the point that cheating, insults, and fistfights became a common occurrence. By the mid-1800s, the game had even been banned by the state of Connecticut.

Fortunately, the law described only one particular game: nine pins arranged in the shape of a diamond. As the legend goes, the cunning Americans added a tenth pin, changed the arrangement to a triangle, and got down to tenpin bowling, which nobody had forbidden!