

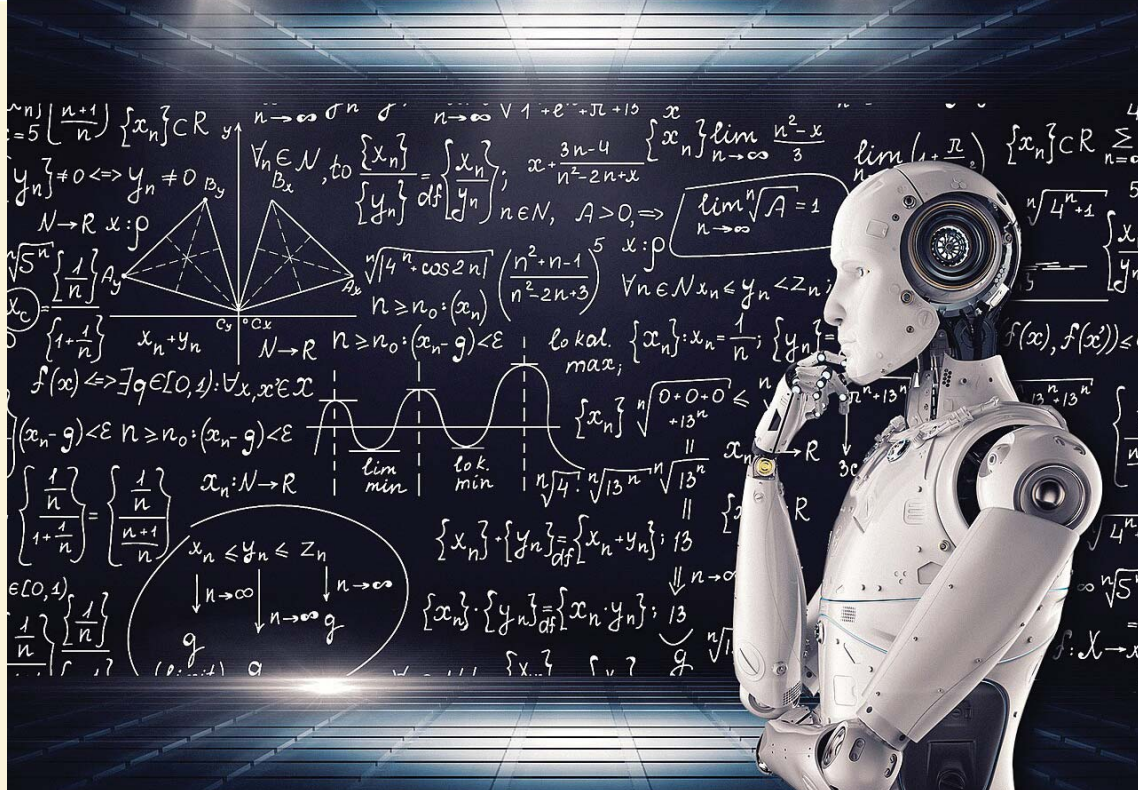
JANTAR MANTAR

CHILDREN'S SCIENCE OBSERVATORY

English Bi-Monthly

Volume 26 Issue 5 September - October 2026 Rs. 30.00

A three-toed sloth (Scientific name: *Bradypus variegatus*).
Image credit Wikipedia: Stefan Laube



Is Artificial Intelligence (AI) changing mathematics for ever?

R. Ramanujam

Bengaluru

Ever since a company called **OpenAI** put out a software application (which we call “app”) called *ChatGPT* in November 2022, many things have changed. *ChatGPT* is an example of programs that we commonly refer to as **Artificial Intelligence (AI)**. These are computer programs that mimic human

intelligence.

AI has been around for about 60 years, but its achievements have been in specialised areas of robotics, game playing, planning, image recognition and computer speech. They were impressive, but not quite matching everyday human intelligence. One barrier has always been *Natural Language Understanding and Synthesis*: that is, it was hard to talk to these programs in human languages, and it was hard to make computers talk in a way that sounded natural to humans.

ChatGPT showed that AI could cross that barrier; you could chat with it like you would with a friend, it would write essays, letters, poems and more. Even better, you could give your own poem to it, and ask it to rewrite in the style of a famous poet, and it can do this. Newer versions can actually

write a full film script for you.

ChatGPT is an example of a **Large Language Model (LLM)** that uses huge computing power to keep track of patterns in language use and can refer to such a vast database of human language use that it can sound very much like human beings. In the last four years, many LLMs have come out. Some like *DeepSeek* use much less computing power and show impressive

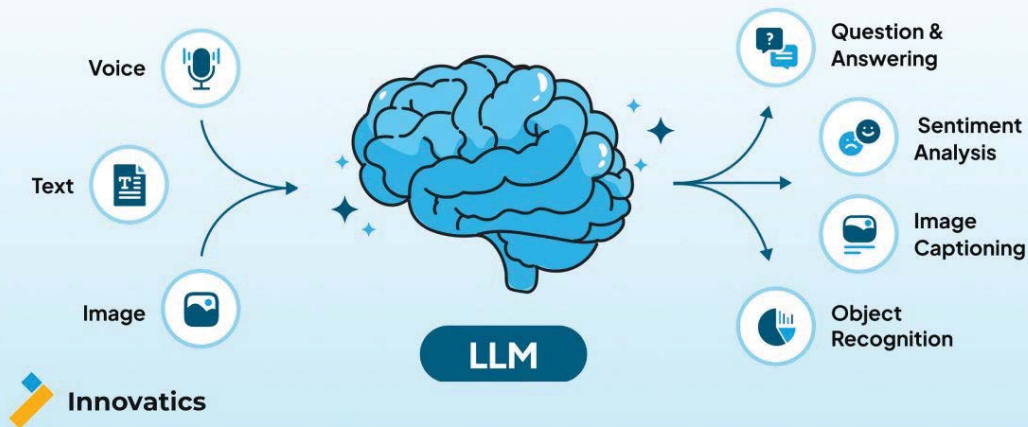
reasoning ability.

LLMs and Mathematics

What does all this have to do with mathematics?

One surprising capability of *ChatGPT* was that it could also be used to write computer programs. In the last few years, all the LLMs have shown remarkable ability to write code: so much so that many big

Exploring Large Language Models (LLMs)



What is ChatGPT

ChatGPT stands for **Chat Generative Pre-trained Transformer**. The word “chat” is obvious: you can chat with it. The key word “generative” means that it can create brand-new content, using whatever is already known. How does it know anything? It has been “pre-trained” by giving it a huge amount of data from the internet about different fields from which it generates new content. Finally, it has a special kind of network architecture (“transformer”) which allows it to take words and phrases and put them together with proper relationship, in the required context. *ChatGPT* uses **large language models (LLMs)** which are AI systems designed to generate human-like text. They do this by trying to predict the next word, by searching their huge data-base which contains many sentences and phrases from known sources, so they have the right grammar and rules.

AI and mathematics in 2026

- **Google** has an AI lab called **DeepMind**. It has generated an AI system in biology that predicts 3-dimensional protein structures from amino acids. It has also developed the *Gemini LLM*. In February 2026, Google **DeepMind** used its *Gemini* model to survey 700 open problems posed by Paul Erdos (a Hungarian mathematician who was famous for posing problems). It proved four of them and found nine unknown published solutions.



- **OpenAI** is another research lab. In May 2026, OpenAI announced that an internal model contradicted a conjecture of Erdos of the unit distance problem: given n points in a 2-dimensional plane, what is the maximum number of pairs of points that can be exactly unit distance apart? (This is a nice example of Erdos' questions: simple to state and hard to prove!) After AI provided the proof, several mathematicians collaborated to produce a *verification* and *exposition* of the result.



- **Anthropic** is another AI research company which has built the *Claude* family of models. It is built on a training method called **Constitutional AI** whose core principles are that *Claude* must be helpful, honest and harmless. Hence this software is focused on responsible development of AI tools. *Claude* writes poetry too! In August, mathematician Levent Alpoge announced that he had found a counterexample to the *Jacobian conjecture* (a hypothesis or guess, yet to be proved) using *Claude Fable 5*. This was a problem that mathematicians had been working on since 1939.



companies like **Google** and **Microsoft** tell their programmers not to waste time writing code, but let the LLMs write it for them and fine-tune it.

How did this happen? Scientists realised that once you had a language model powerful enough to understand something as complex as human language and literature, then it could much more easily understand computer programming languages. This is because such programming languages are highly structured, universal, and not specific to cultures.

What is the most highly structured human constructed language that is truly universal? Mathematics, of course! Does this mean LLMs could do mathematics as well?

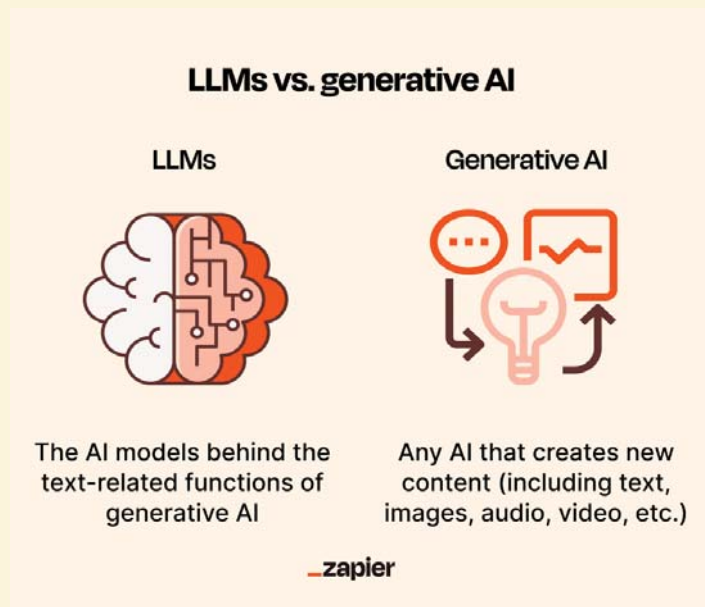
People thought this, but also dismissed this early on. LLMs are “after all” language models, they can understand some superficial structure in written mathematical language, but surely they would not be able to understand the deep theorems of mathematics, let alone prove them.

Modern LLMs and their maths skills

In the last two years, this belief has been shown to be wrong. In the beginning of 2025, theorem proving programs like *Alpha Geometry* (not LLM based) could solve **International Mathematics Olympiad** problems but not at gold medal level. People

said, this is still children’s level. But throughout 2025 AI repeatedly kept solving research level mathematical problems. But none of those problems were considered exceptionally hard by mathematicians. So people said, it’s interesting that AI can do all this, but it is no more than what we would expect from a university-level student.

2026 has changed all that. AI programs have now solved very famous open problems in mathematics. See the **Box** for a



list.

These problems are too technical to explain at school level. These problems are “conjectures” made by mathematicians: statements of belief that a mathematical statement is true, without being able to prove it. Why do mathematicians do this? In the process of proving or disproving this claim, new ideas result, new techniques are

AI and Resource Use

AI is very resource-intensive, requiring massive amounts of electricity, water, and specialized hardware to train and run.

- Building large AI models requires thousands of powerful graphics processing units (GPUs) running nonstop for weeks or months.

- Every time you ask an AI tool a question or generate an image, it uses data center power; electricity used in generating one AI image can power one cell phone.

- Global data centers can consume more than 100 megawatts of electricity, enough to power 100,000 houses.

- Massive data centers generate intense heat and consume millions of litres of water daily for cooling.

- Manufacturing high-performance chips requires mining rare earth minerals, and rapid hardware upgrades lead to growing electronic waste.

developed, human understanding grows. The search itself tends to be valuable even when the original question doesn't get answered.

September 2026 saw something even more shocking. **OpenAI** announced that its system could solve a major aspect of one of the most difficult equations of all time, the **Navier Stokes equation**. You have to solve this equation to find out how fluids (like

water) move, depending on the properties of the fluids like viscosity, etc. So far, it was not fully solved for 3-dimensional flow problems. (This problem is very special: it is among the seven “Millennium problems” announced by the Clay Institute in 2000. If you solve any of these, you will get a million US dollars as a prize.) Now AI has given a 146 page proof which is considered too difficult even for mathematicians to understand; verifying it will take a long time.

How does AI solve these problems?

How is all this possible for AI? Thousands of AI agents work in parallel—this allows AI models to explore multiple paths. When one fails, they then step back, retry repeatedly. They can do this for far longer than human researchers typically can. Moreover, they can check their own work using computer programs that act as proof assistants. This ensures that despite their length, the computer code verifies the logic as being mathematically correct.

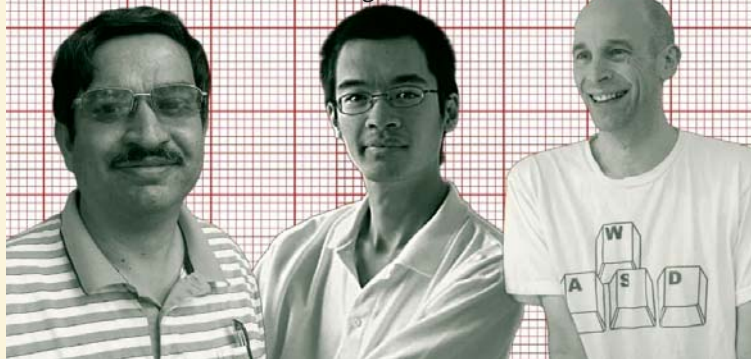
Learning versus solving

One major problem right now: While the AI outputs are technically correct, mathematicians point out that humanity has “learned very little” so far because the proofs are written by machines for machines, requiring heavy human rewriting to yield any intuitive insight.

AI in the future

What does all this mean for the future of mathematics? One possibility is that AI is actually good only at a specific type of mathematical exploration: involving weakening assumptions, trying out many

Mathematicians Siddhartha Gadgil, Terrence Tao and Kevin Buzzard



many important problems soon.

At the recently concluded **International Congress of Mathematicians** in Philadelphia, USA, there was a great deal of discussion on the impact of AI on mathematics. Many felt that soon we would be unable to

possibilities, testing examples, and hunting for patterns. Perhaps it is not good at

- working with entirely new concepts,
- generating unexpected insights or
- using radically different ways of

restating a problem.

We do not know, as yet.

What is clear is that in close collaboration with AI, mathematicians can solve far more problems than they could even two years ago. It is very likely that such human-machine collaboration will solve

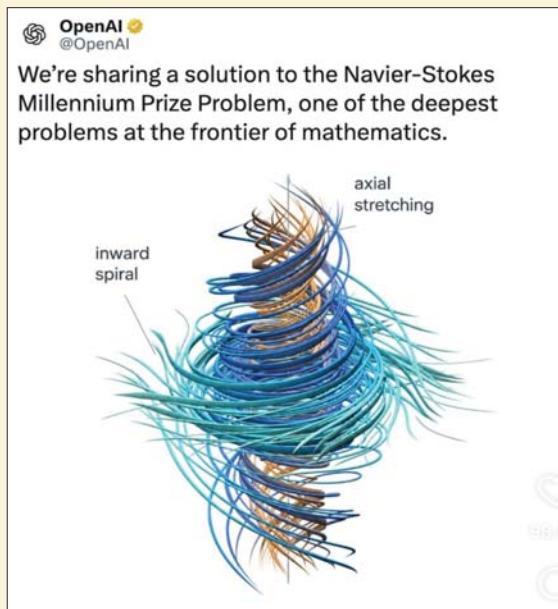
separate out human and machine work in mathematics. Soon even prizes such as the **Fields medal** (awarded for mathematical ability and impact) will become obsolete.

Mathematicians like **Terence Tao** have pointed out that this path is not good for mathematics. Human beings learn through struggle, by overcoming many obstacles. When the road is made easy, their ability to learn may degrade over time. Moreover, they also do lots of routine boring work, and somehow this helps them produce flashes of brilliance. If the routine work is given away to machines, would we still be able to achieve those flashes? What will all this mean for students and young researchers? Also as machines solve important problems, would young mathematicians get funding support?

AI is bringing about many changes, in many aspects of our learning, including science. Mathematics may be offering the first serious instance, and thus a peek into the future. Will humanity read the warning signs, and come up with ways of regulating this race?

Images:

From the internet





SPUD CELL

LIFE FROM SCRATCH

With Prof. Kate Adamala



Open Recipe For A Cell

Zareena, Mookayi, and Mari

In the living room of Usha, a biologist in Madurai, her daughter Mari and friends Zareena and Mookayi gathered to write about the work they learned from the online webinar by **Dr. Kate Adamala**, the scientist who led the team that created *SpudCell*.

Mari: “You should’ve been there, Amma, to listen to Dr. Adamala, who created a cell from scratch!”

Usha smiled: “I know her work. But before we get to a SpudCell, let’s make sure we know what a cell is.”

Zar: “So a cell is like a little bag of koozh?” [Ed: koozh is a sticky porridge, or *kanji/ganji*]

Usha laughed. “That’s one way of looking at it! It is a compartment surrounded by a membrane of *lipid* molecules. It is a crowded factory. You have the *ribosome*, the machine that makes proteins. And then in **eukaryotic** cells, there is the *Golgi body*, or the post office of the cell. It packs proteins and sends them to where they should be. Eukaryote means that the cell has a well-defined central *nucleus* in which the DNA is present, packed into *chromatin fibres*. DNA contains the genetic information that decides the traits of the individual. The cell has many small molecules, including sugars, ions, and salts, and large macromolecules such as DNA, RNA, and

proteins.”

Usha: “For years, scientists have dreamt of creating life from chemicals. **Craig Venter** and his team took one of the biggest steps.”

Mari: “They built a synthetic cell?”

Usha: “Yes. In 2016, his team published their work in the journal **Science**. They began with a bacterium that already exists, *Mycoplasma mycoides*. From the cell, they removed the DNA but left the ribosomes and other cell machinery inside. Then they took the DNA from another

organism, *Mycoplasma capricolum*. They used a heavily modified and lab-synthesized genome and injected it into the empty shell. And so, the new cell, **JCVI-syn3.0**, was born.”

Zar: “Like they changed the operating system?”

Usha: “Yes. Their synthetic cell had a minimum of 473 genes. But the thing is, they didn’t stop. The J. Craig Venter Institute broadly patented the methods, synthetic genes, and lab techniques that underlie its work.”

Mooks: “Did they want to own life itself, the building of life?”

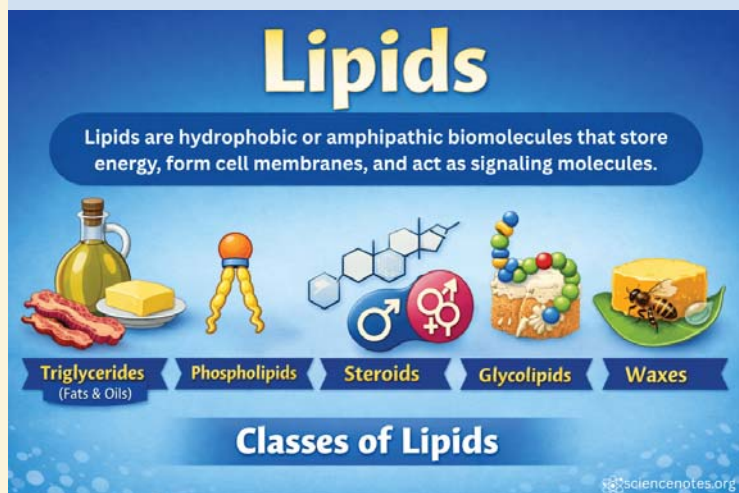
Usha: “And that was the problem. It brought up a lot of ethical and legal questions about who could control this new technology.”

“And that’s what makes Dr. Adamala’s work so unique!” said Mari. “She never patented anything. She did the opposite of that, open science.”

Usha: “Yes. However, Dr. Adamala and her team at the University of Minnesota chose a very different path.

What are lipids?

Lipids cover many different kinds of molecules, all of which do not mix well in water. Fats like oil and ghee are lipids; these are scientifically called *triglycerides*. Groundnut and sunflower oil have mostly unsaturated, healthier fats, while coconut oil and ghee have saturated fats, which can raise cholesterol. Note that there can be both good and bad cholesterol, and it is needed by cells in our body to make hormones. In fact, cholesterol is also a lipid. So all lipids are not fats. Cholesterol comes in a category called *steroids*. Lipids like *phospholipids* are yet another set of molecules which are important for building cell walls.

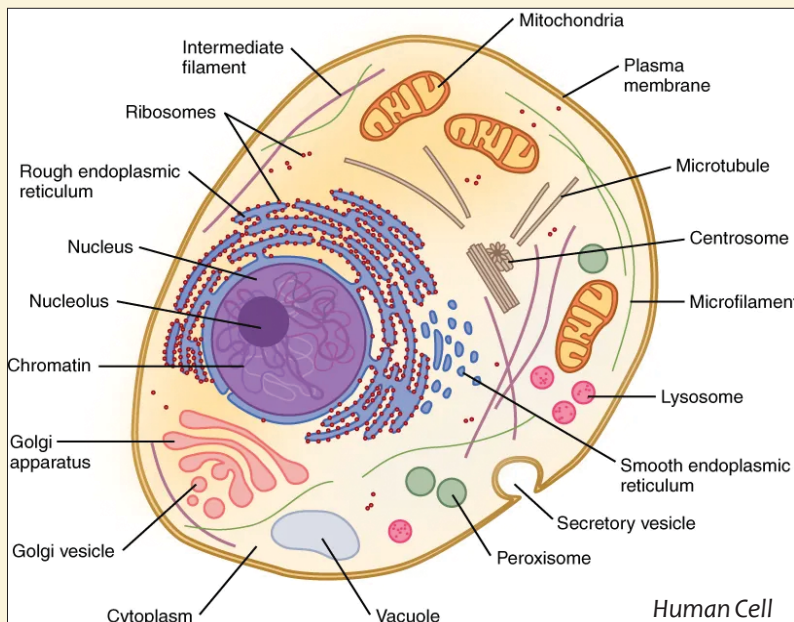
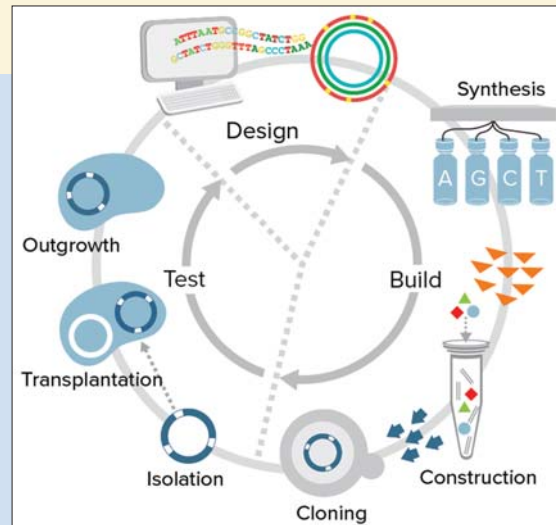


How the first synthetic cell was formed

Mycoplasma mycoides JCVI-syn1.0 is the first self-replicating bacterial cell controlled by a completely synthetic genome. That is, the entire set of genes (together called genome) is man-made. It was made by a team led by Dr. J. Craig Venter at the J. Craig Venter Institute (JCVI).

First, researchers designed a chromosome on a computer based on the genome of the naturally occurring *Mycoplasma mycoides*. They chemically built the DNA pieces in a lab and joined them together. They inserted special code in the gene sequence to clearly prove that this was a synthetic genome. They then inserted this genome into the cell of a related natural bacterium called *Mycoplasma capricolum*, which has its own genome removed. The recipient cell read the new genetic code, discarded its old identity, and began growing and dividing normally under the control of the synthetic instructions. Basically, the synthetic genome (in a natural cell environment) was brought to life.

In 2016, the Venter Institute used genes from JCVI-syn1.0 to synthesize a smaller genome they call JCVI-syn3.0, that contains 531,560 base pairs and 473 genes. They systematically deleted non-essential genes not strictly required for healthy cellular growth. This cell could also self-replicate. This work paved the way to understand the absolute baseline requirements for life.



Rather than tweak an existing cell, the scientists built their synthetic cell from the ground up. It's called the SpudCell because it looks like a spud or potato. They have been constructed from molecules, which by themselves are not living."

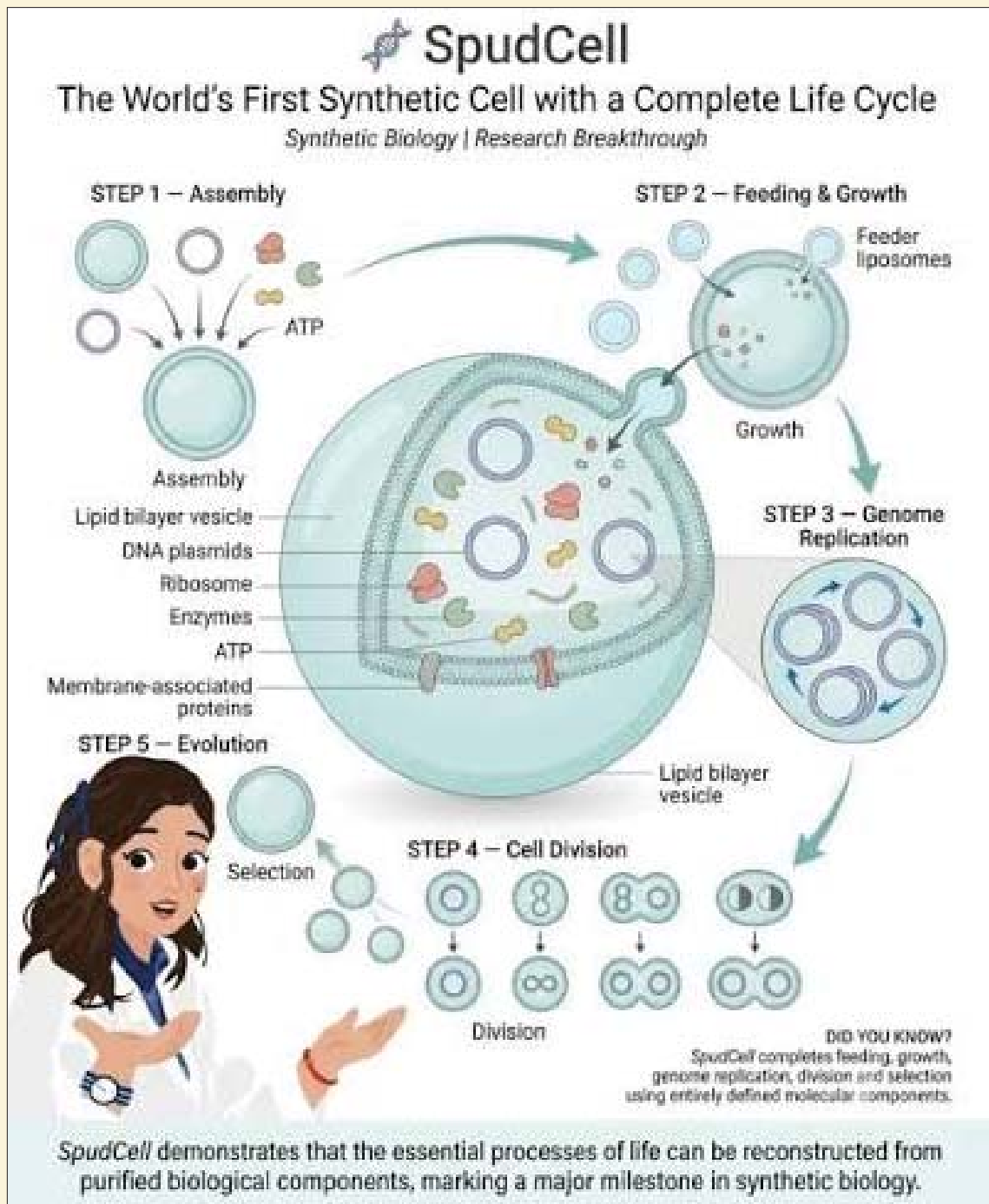
Mookayi said, "It's like building a cake from

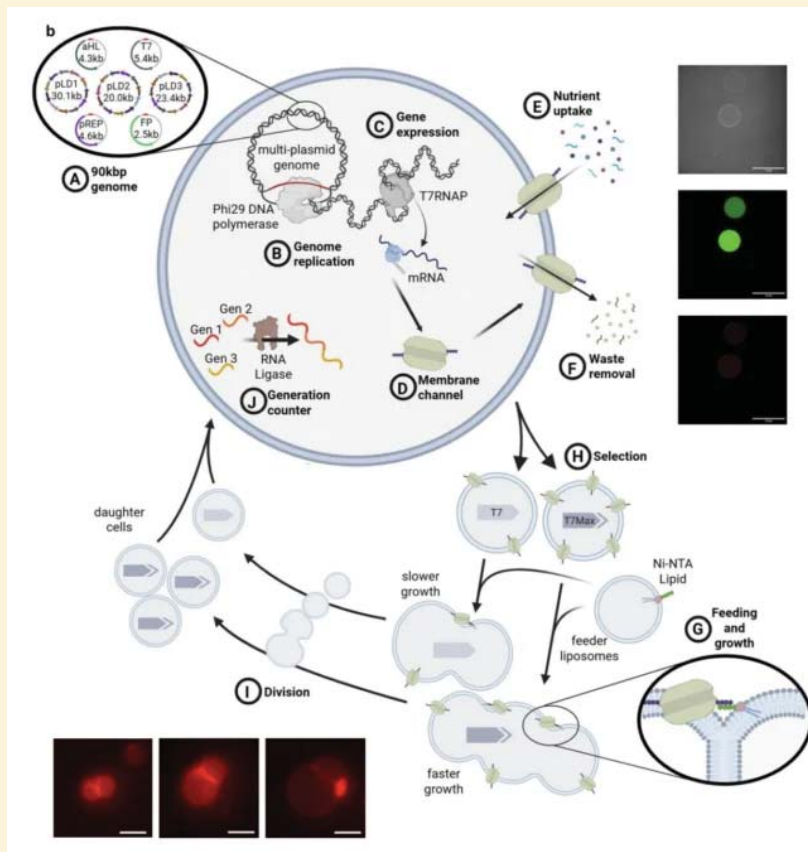
scratch, not just changing the frosting on a cake you bought in the store.”

Usha laughed. “That’s a good comparison! They built a very tiny genome along the way, only 90,000 base pairs, or 36

genes.”

Zar: “But I remember Dr. Adamala saying that there was a big limitation.





Has it got no ribosomes?”

Usha: “Yes.

Precisely. SpudCell is unable to produce its own ribosomes. They bring in outsiders to do it. They have to ‘feed’ it proteins, nutrients, and ready-made ribosomes to keep it alive,” she explained. “It’s like a car that needs to be constantly refilled with gas and oil. It can run but cannot make its own fuel.”

Mari: “But it can grow. It can reproduce. It can even fight over food. Dr. Adamala

showed us a video of them dividing!”

“And that was the breakthrough.” Usha said, “For the first time, a synthetic cell built from non-living components has gone through a life cycle.”

Mooks questioned, “What about the nonprofit they started, **Biotic?**”

Usha: “Yes. Dr. Adamala and her colleague **Dr. Drew Endy** are not patenting the tech and keeping it to themselves,” she said. “Instead, through Biotic, they are building a community of scientists to share the ‘recipes’ and make the SpudCells more powerful. They want it to be a shared, open infrastructure for the whole discipline.”



Dr. Kate Adamala and Dr. Drew Endy

Mari: “Dr. Endy compared their work to the Wright brothers’ first flight at Kitty Hawk. Those 1903 flight trials lasted a maximum of 59 seconds and covered 260 m,” she added, amazed. “Just look at aviation today! This is only the tip of the iceberg.”

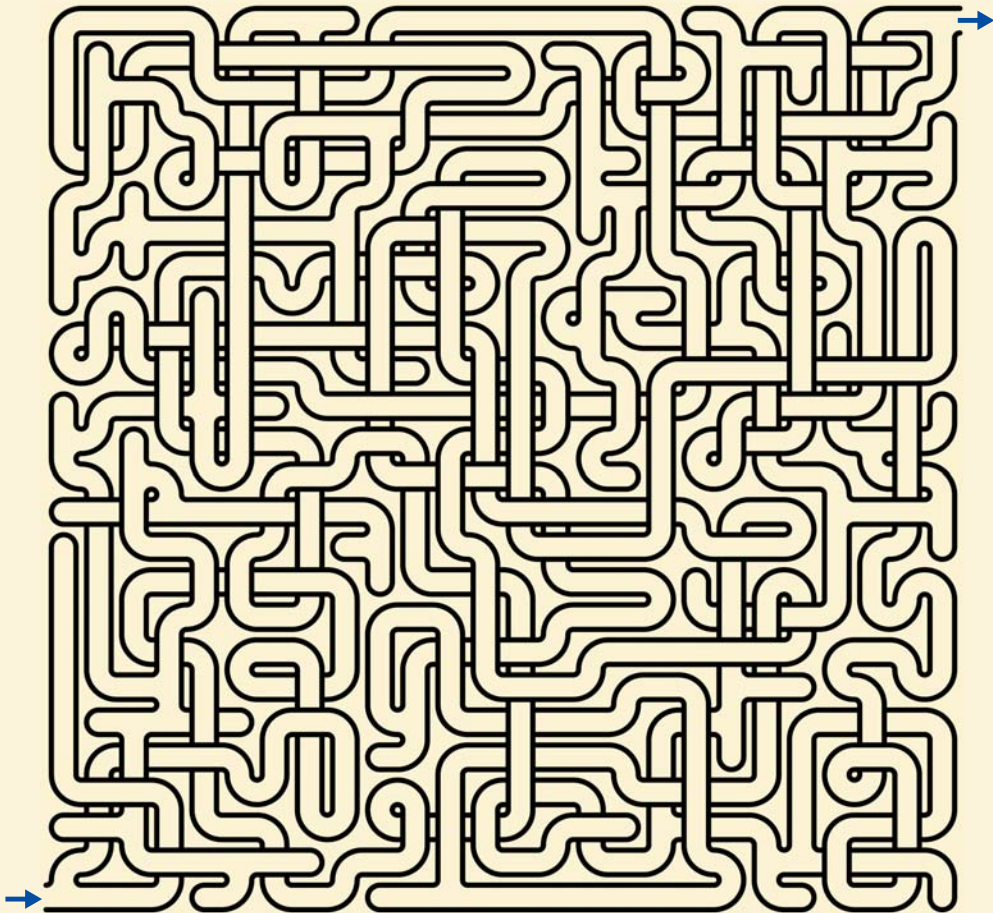
Usha: “Oh, it’s a great analogy. SpudCell is the first rough prototype. It demonstrates what is possible,” she continued. “As it goes, one can engineer cells to do some amazing things, like make new kinds of

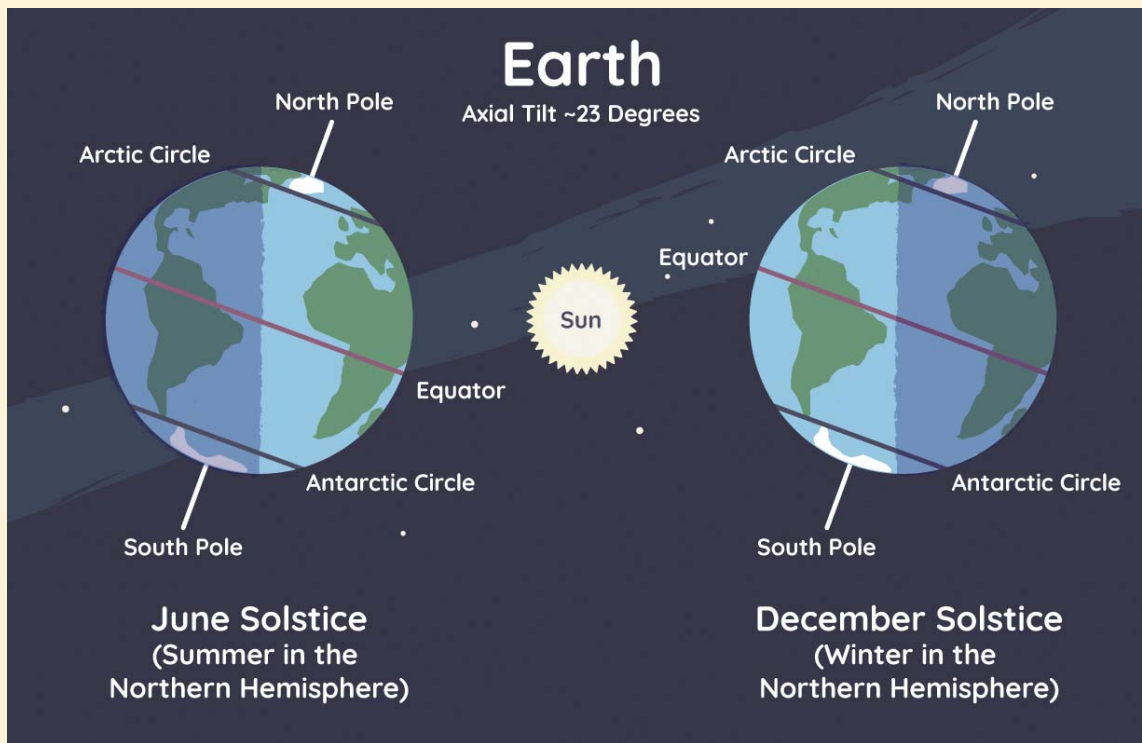
medicines or suck up vast amounts of carbon dioxide out of the atmosphere.”

Zar: “And if it’s open, then other people can work on it!”

Usha: “Yes. Dr. Adamala and her team decided not to patent the SpudCell but to do open science and make this revolutionary technology available for the use of all of humanity, and not just a select few. That is a strong statement about how science should work.”

Find the way!





Circulation

Kamal Lodaya

This is the third of a series of articles on the close correlation between the atmosphere, the ocean, and the weather ... and not just on Earth alone.

In the first article in this series, we already mentioned that Earth's axis on which it rotates is tilted by 23 degrees. (The degree of tilt is not completely fixed; it varies between 22.1 and 24.5 degrees over a long cycle lasting roughly 41,000 years; today it is roughly 23.44 degrees.) In summer when the North Pole is tilted towards the Sun, the Tropic region upto 23 degrees North latitude has the Sun overhead at noon, while it is lower down in the southern sky.

In the second article of the series, we

learned about the Earth's energy budget. The unit of the Sun's intensity is watts per square meter, which measures how much power is received or sent area-wise.

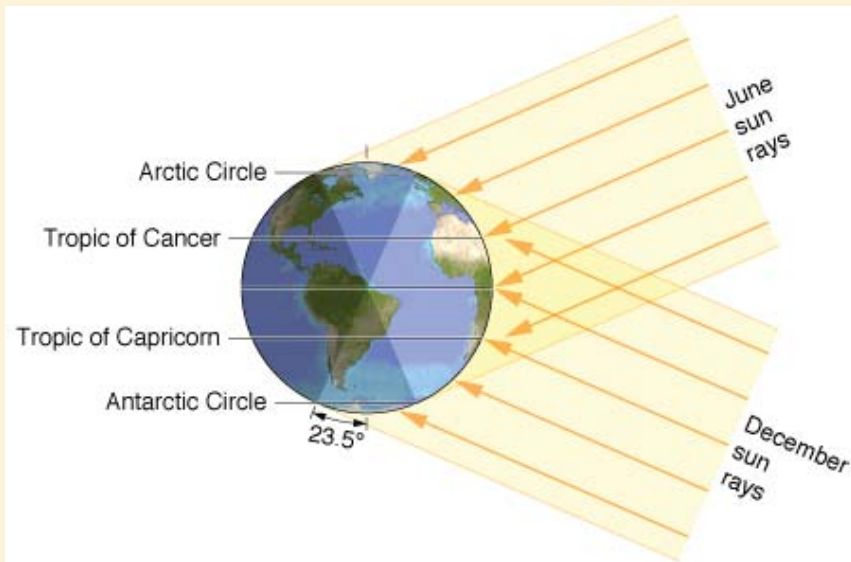
Above the atmosphere, Earth receives solar power with intensity 1.38 kilowatts per square meter.

Some solar radiation is reflected back into space by clouds and some is absorbed in the atmosphere.

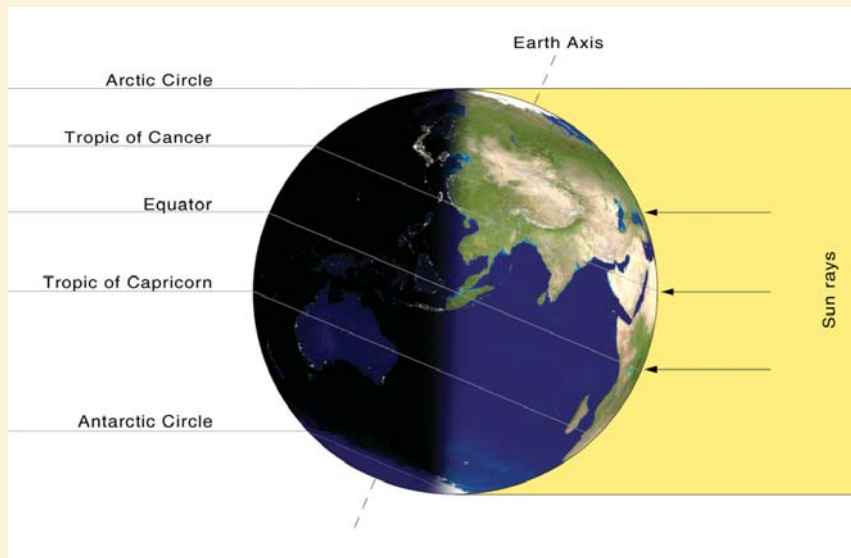
A temperature comparison

Noontime temperature in **New Delhi**, the capital of India (28° North latitude just above the Tropic of Cancer) goes from 45 C in summer to 20 C in winter.

Noontime temperature in **Nuuk**, the capital of Greenland (64° North latitude) goes from 10 C in summer to -10 C in winter.



over twice the area of Earth, so that this region of Earth gets only $1.38/2=0.69$ kilowatts of solar power every square meter. (See picture on the next page.) The noticeable effect is that the surface and the air around us are less hot when the Sun is halfway up (at 22 degrees South) than when it is overhead (at 23 degrees North). Just as during the day, noon is hotter than 9 am because the Sun is higher. We call this effect seasons, and it makes summer hotter than winter. It also makes the tropics (where the sun can be overhead) hotter than the temperate or arctic zones where the sun's rays always fall at an angle.



When air is heated up, it rises. The region is not left airless, air from the colder region around it rushes in to take its place. In other

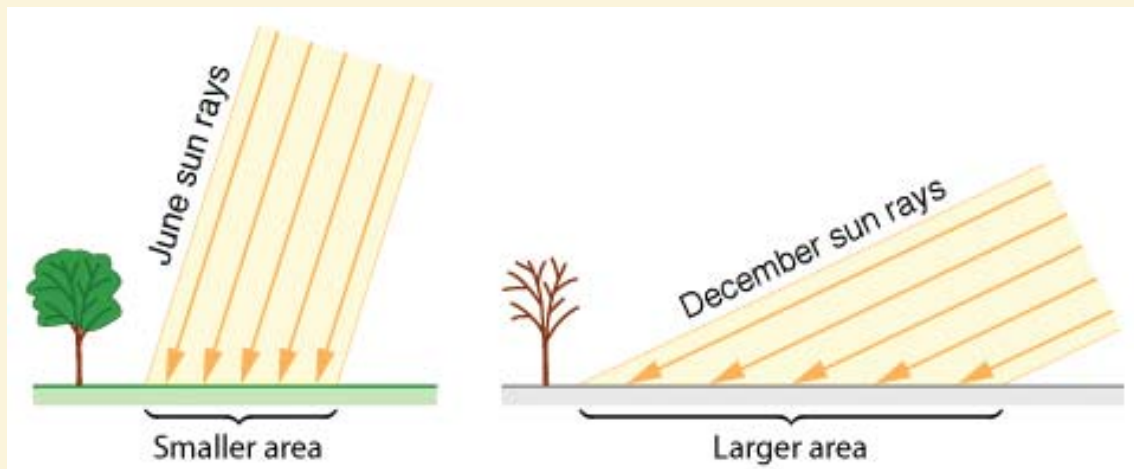
At the ground on a clear summer day we receive 1.36 kilowatts per square meter. The 1.38 kilowatts that should fall on every square meter of Earth is distributed over a much bigger area because of the tilt.

For example, at 22 degrees South latitude, the Sun could be only halfway up the sky at noon. The power is distributed

words there is a wind bringing cold air to a region of warmer air. The air from above the cold region settles downwards to take its place.

Air circulation

If we go higher up in the atmosphere, it isn't as though the rising hot air accumulates up there. It moves to the neighbouring



region where the colder air is going down. So if the Sun is overhead at the Tropic of Cancer, there are ground winds coming there from the temperate zone (which is further North and less hot) and there are high atmosphere winds moving from the Tropic of Cancer to the temperate zone. This is called circulation of atmosphere.

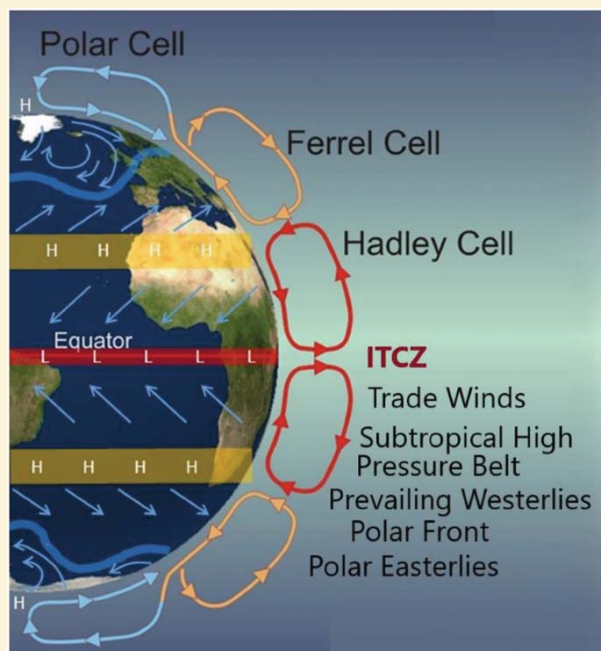
The picture shows how belts of circulation are set up over Earth when the

Sun is overhead at the Tropic of Cancer. These belts depend on where the Sun is, summer winds are different from winter winds. The picture shows how winds in India reverse direction from winter to summer. The net effect of winds is that the excess power received at the tropics is redistributed in the direction of the poles.

Excess power on the sunlit side is redistributed towards the night side. Solar energy remains longer on Earth before ultimately being lost to space. This is why Earth is more comfortable than airless Moon, where solar heat is rapidly lost as soon as Sun sets. Don't forget that three-fourths of Earth's surface is covered by oceans.

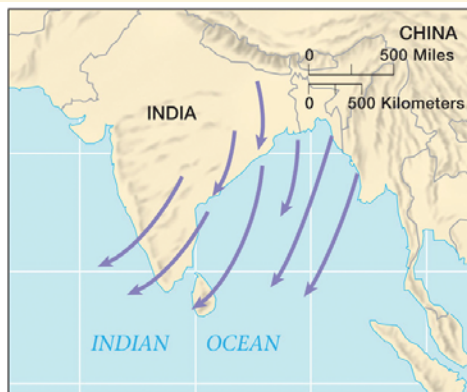
Winds and ocean currents

Solar heating evaporates some of the surface water to water vapour. Water vapour also rises, cooling as it goes up. Higher in the atmosphere, water vapour condenses into liquid droplets around dust or other particles into a mass of air saturated with liquid, which we call a *cloud*. These clouds are pushed by wind





Summer



Winter

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fall on Earth. This is familiar to us as *rainfall*. In colder countries there is *snowfall*. For example, summer clouds coming to India from the Arabian Sea are pushed up the Western Ghats. A lot of rain falls on the western coast

to move in the direction it is moving. Further, the winds push the surface water along into what we call *ocean currents*. So from the air circulation and winds arises the movement of ocean water all over Earth.

When clouds reach land, hills push them higher. When they go too high, clouds cannot retain the droplets they carry which

and in the Ghats region. The clouds which continue into the Deccan plateau have less condensed water in them and there is less rainfall in the region east of the Western Ghats, which is called a “rain shadow”. Rain falls on the sea as well, since there also clouds are being heated and going higher.

Rain is measured in centimetres or inches because it is the height to which collected water rose in the funnel of a rain gauge, a vessel reserved for the purpose of measuring rain. Average world rainfall for a place is under 100 cm over the whole year. The map shows yearly rainfall in India.

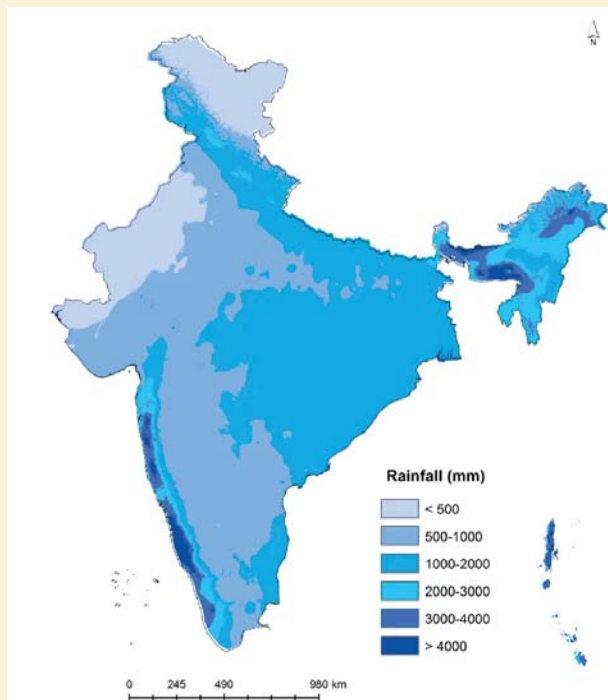
The yearly rainfall for Shillong in Meghalaya is 360 cm.

The yearly rainfall for Jodhpur in Rajasthan is 33 cm.

The yearly rainfall for Udupi on the Karnataka coast is 310 cm.

The yearly rainfall for Ballari in the Karnataka rain shadow is 60 cm.

Images Courtesy: Wikipedia, physics.weber.edu/schroeder: Daniel V Schroeder web page



How do QR codes work?

D. Indumathi,

Bengaluru

You must have seen **Quick Response (QR)** codes everywhere. Autorickshaw and taxi drivers want to be paid by scanning their QR codes; tea shops allow you to pay for your tea and coffee by scanning these codes, and even buses in Bengaluru allow you to pay for your bus ticket with a QR code generated newly for each passenger's ticket!

How do these QR codes work?

What is a QR code

You may have noticed **barcodes** on biscuit packets, etc. This is a set of lines on the packet. You can scan this with your cellphone camera and you will get information about the contents (see the **Box**). The barcodes are a set of lines. In contrast, a quick response (QR) code is a box in 2 dimensions. You can think of it as a kind of matrix barcode that uses black squares on a white background to encode information. Just like barcodes, swiping on it gives information. The major difference is that there is much more information squeezed into a QR code.

A QR code

The QR code is a barcode which contains more details. It not only contains static information as text material (like barcodes which tell you fixed information about

the origin of the product). It can also direct you to website pages which contain more information, or even payment information.

Look at a QR code; for instance the one in the picture. You can see three large squares in the corners. These tell the scanner the code's position, orientation, and angle. In fact, next time watch when your friend or parent pays using a QR code. Ask



them to scan it sideways, or at different angles. The scan will still work. This is because of these “finder patterns”.

In fact, there is even a further correction: there is a smaller square near the bottom right. This helps to correct distortion if the code is on a curved or tilted surface.

If you look at the filled squares, you can





Barcodes

A barcode is a unique set of black-and-white lines that stores product details. It tells you the country of origin, name of the manufacturer, and item code for scanning. For example, the popular **Parle-G Original Glucose Biscuits** pack uses the barcode number 8901719101038. Here 890 is the Country Code, meaning, the product was made in India. The next group of numbers 1719 identifies the manufacturer as Parle Products. The digits 8-12 are the product code which identify the exact type, flavour, and weight of the biscuit. All Parle products will begin with 8901719 and the remaining numbers will change depending on the exact product. The final 13th number helps the scanner verify that the code was read correctly.



see that they are laid out in rows and columns, like a chess board (this is called a matrix). Alternating rows and columns help the scanner map out the grid. The tiny individual squares hold the actual information.

How data is encoded in the QR code

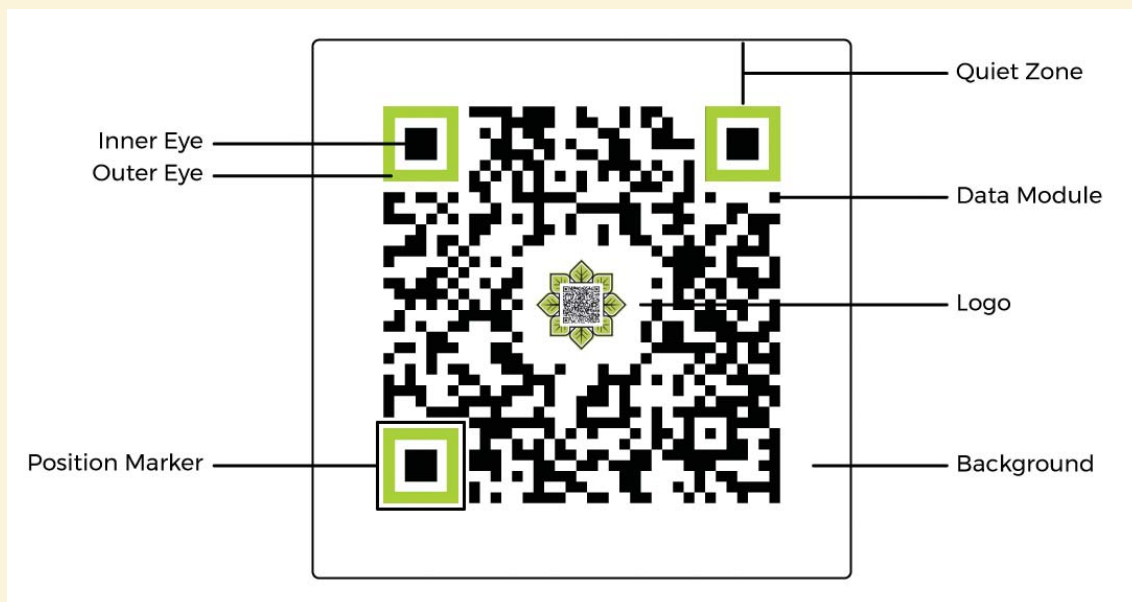
You may have learned of binary numbers in your maths classes. Binary numbers are represented in bits of 0 and 1. For instance, in the usual **decimal system**, you can write numbers from 0 to 9. For the next number, you write '10', which means '1' in the 10s place and '0' in the 1s place, adding up to 10. Similarly, '101' has '1' in the 100s place, '0' in the 10s place, and '1' in the 1s place, adding up to 101.

Binary numbers work the same way. After writing 0 and 1, you write 2 as '10'. This is to be read as '1' in the 2s place, and '0' in the 1s place, adding up to 2. So 8 can be written as '1000' and 1024 as '1000000000' (this is usually called 1KB)! You can see that the number become very big very soon, but it is easy for computers to store these numbers as off (for '0') and on (for '1') switches.

Coming back to our QR code, black squares represent a binary '1', and white spaces represent a binary '0'. Text, numbers, or URLs are translated into strings of ones and zeros. A QR code can be made up of a maximum of 177 rows and 177 columns, which makes for a possible 31,329 data modules. Most QR codes aren't that big, though.

Error Correction

One of the most important parts of a QR code is error correction. You may have seen dirty, torn, stained QR codes hanging from a



thread in a shop or auto. But they still work! This is because QR codes use fancy mathematics so that it is fully readable even if up to 30% of it is dirty, blurred, or damaged!

How Do QR codes work?

The scanner first recognizes the three position markers in the QR code. The quiet area is used to help the scanner find the edges of the code. Scanners read these modules following a specific zigzag path across the grid of dots.

The QR code scanner begins at the bottom right of the QR code to find the **mode indicator**. This is a group of four data modules which tell you whether the data you are going to scan are a bunch of numbers, or text (alphanumeric) or even in *kanji script*!

The next eight data modules are the **character count** indicator, which indicate how many characters are to be read in total.

The scanner then moves up two data modules at a time until it hits the first position marker. Then it moves two data modules to the left and goes down. It repeats this right-to-left, up-then-down zigzag process until every data module is covered (since it knows how many characters to read).

After reading the final character, the scanner checks out the *error correction* data modules. Then it finally uses the data it has read to go to a new link/website or a payment portal, depending on what the QR code does.

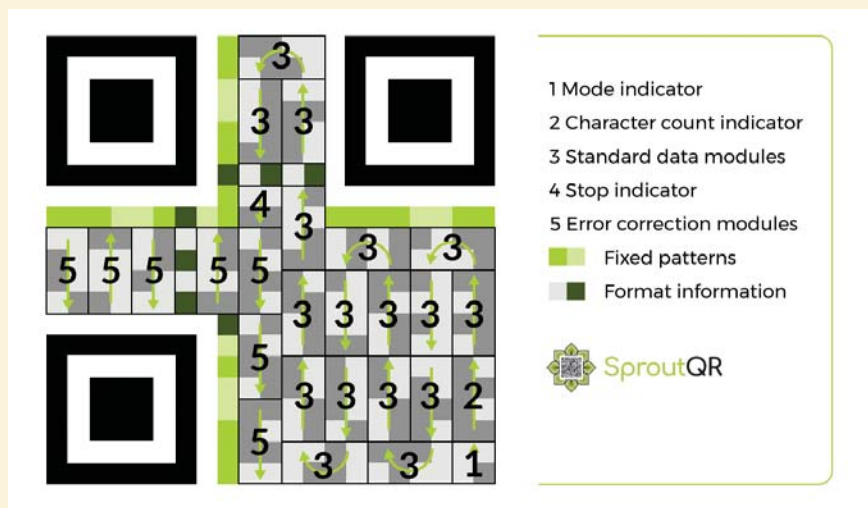
How Do Dynamic QR Codes Work?

A dynamic QR code is a QR code whose encoded information can be changed after creation. That's because the information encoded in a dynamic QR code is a short redirection URL. That means a URL that redirects to another URL, or what's called a destination URL.

On the destination URL is the content. This can be a digital restaurant menu, a syllabus, contact information, an invitation, etc. That content can be changed entirely without having to change the QR code. Additionally, the destination URL itself can be changed entirely without having to change the QR code. Because what's encoded in the QR code is the redirection URL, not the destination URL. This is useful for Universities whose syllabus regularly gets revised, or a restaurant whose menu (or price!) changes.

QR codes and safety

Scanning unknown QR codes can expose you to severe digital safety threats. This malicious tactic, known as “*quishing*” (QR code phishing). It exploits the fact that human eyes cannot read a QR code's destination URL before scanning it. *Never scan random codes* found in public places, flyers, or unsolicited mail. Inspect physical QR codes at restaurants to ensure that they are the original, and have not been pasted over by malicious codes. Such codes can steal your confidential banking information or even download spyware on to your phone. As with all technology, misuses are always trying to keep up with the uses!



How can QR codes help with online payment?

Nowadays, people do not think twice before paying for even small purchases on-line. Typically, they scan a QR code, which takes you to a payment portal. What happens next? The Unified Payments Interface (UPI) app on your mobile phone allows you to transfer money from your bank to the seller's bank. While most UPI apps need you to have an active internet connection it is possible to pay offline. The QR code enables you to access the payment system to complete the transaction. While a UPI app is much more than the QR code used to access it, a QR code is also much more than just a gateway to a UPI app! Now you can ask, how does the UPI work? Well, that's a story for another day!

Sources:

<https://www.sproutqr.com/blog/how-do-qr-codes-work;>
[https://www.geeksforgeeks.org;](https://www.geeksforgeeks.org/)
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Answers to Last Issue's Do You Know?

Sloths have been made popular by Disney as the character Flash in the movie *Zootopia*. Here are some questions about them.

About Sloths

Different sloth groups can be easily identified by the number of long, curved claws on their forelimbs. The two-toed sloths, as the name suggests, have two claws on their front limbs, while the three-toed sloths have three claws on all four limbs. All sloths have three toes on each rear limb. The two-toed sloths are also slightly larger than their three-toed counterparts. Altogether, there are six sloth species that are found in the Americas, mainly in the tropical rainforests of Central and South

America. Sloths are so named because of their very low metabolism and deliberate movements. Sloth, related to slow, literally means “laziness” in any languages.

1. Are sloths just slow in moving or is everything about them slow?

Ans: Everything about sloths is slow. They even digest food really slowly! Sloths are primarily *folivores*, that is, they eat leaves, fruits and sap of various trees.

Two-toed sloths are omnivorous, eating insects, fruits, and leaves. Three-toed sloths, on the other hand, are almost entirely herbivorous (plant eaters); in addition, they eat the leaves of only a few trees. Leaves, their main food source, provide very little energy or nutrients, and do not digest easily, so sloths have large stomachs in which symbiotic bacteria break down the tough leaves. About two-thirds of a well-fed sloth's body weight consists of

the contents of its stomach, and the digestive process can take a month or more to complete.

2. *They use their claws to climb, but where do they spend a large part of their lives?*

Ans: All sloths are tree-dwelling, spending most of their lives hanging motionless or slowly moving between tree branches using their long, curved claws. Everything from feeding, sleeping, resting to mating and giving birth happens in the trees. They sometimes remain hanging from branches even after death.

Sloths move only when necessary and even then, very slowly. They usually move at an average speed of 4 m per minute. Even if they are in danger from a predator they cannot move much faster than that. On the ground, the maximum speed of sloths is 3 m per minute so they are only marginally faster on trees.

But there are times when even sloths must leave the comfort of their tree canopies and descend to the ground: Three-toed sloths go to the ground to urinate and defecate about once a week, digging a hole and covering it afterwards. They go to the same spot each time and so are vulnerable to predators. Considering the large energy expenditure and dangers involved in the journey to the ground and back up the tree, this behaviour has been described as a mystery.



3. *Can sloths swim?*

Ans: Sloths are surprisingly strong swimmers and can reach speeds of 13 m per minute, three times faster than on the ground. They use their long arms to paddle through the water and can cross rivers and swim between islands. Sloths can reduce their already slow metabolism even further and slow their heart rate to less than a third of normal, allowing them to hold their breath underwater for up to 40 minutes.



Life can be difficult on the ground for sloths since their long clawed arms and shorter, weak hind legs make it impossible to stand on all fours. Sloth species living near mangroves or rivers sometimes drop into water bodies and swim large distances (in a short amount of time) when searching for potential mating partners or seeking new territory.

Sloths are often hunted by predators such as harpy eagles, ocelots, and jaguars, who mainly rely on movement to track their prey. So, the algae-covered fur and motionless hanging, help sloths blend with their surroundings, making it almost impossible to detect them in the wild.

Recent research shows that some moths, which live in the sloth's fur, lay eggs



4. What is special about their fur?

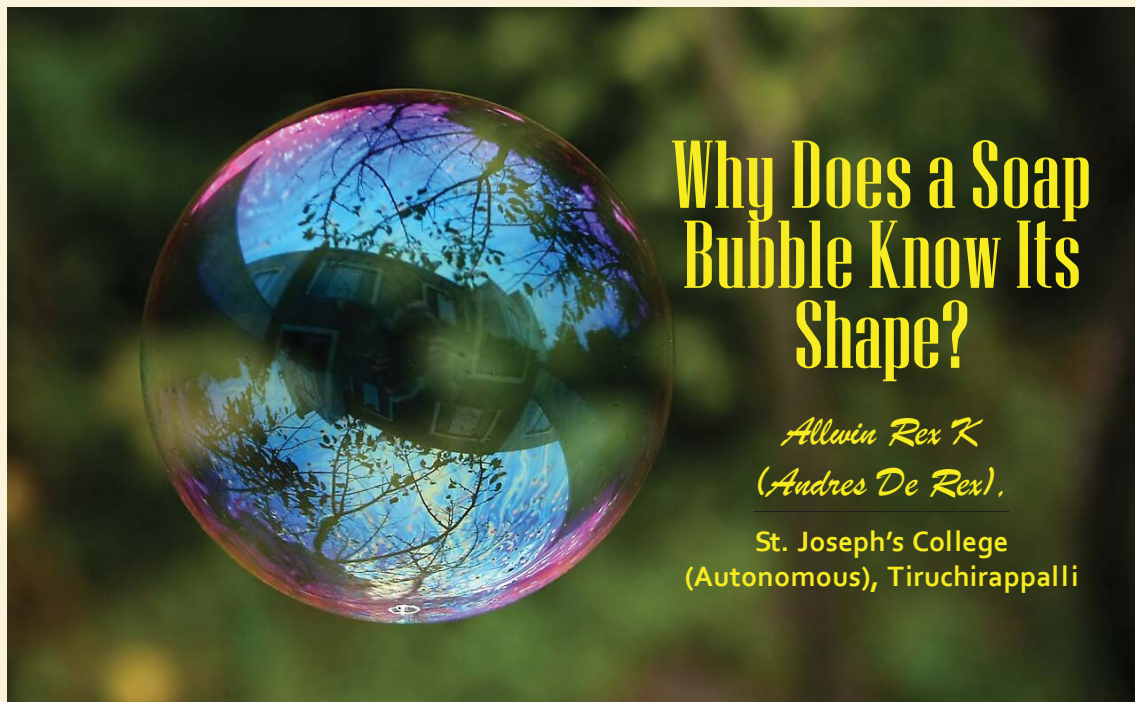
Ans: The sloth's hair is home to many different organisms, from microbes, insects to fungi and algae. Sloths also have a special, symbiotic relationship with green algae for the purpose of supplementing their diet. In return, the green algae benefits from shelter and water since the sloth's fur is extremely good at absorbing and retaining water.

The algae-covered fur is also believed to work as a camouflage to avoid predation.

in the sloth's feces. When they hatch, the larvae feed on the feces, and when mature, the moths fly up onto the sloth above. These moths may have a symbiotic relationship with sloths, as they live in the fur and promote growth of algae, which the sloths eat.

Sources:

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[ilovesloths_official instagram page;](#)
[Wikipedia](#)



Why Does a Soap Bubble Know Its Shape?

*Alluin Rex K
(Andres De Rex).*

**St. Joseph's College
(Autonomous), Tiruchirappalli**

Have you ever blown a soap bubble and watched it float in the air?

For a few seconds, it looks almost perfect. A small ball of shining colours moves slowly around you. Then, suddenly—pop!

But here is a funny question: Who told the bubble to become round?

Nobody taught it. There is no tiny ball hidden inside it. And there is no machine pushing the soap from the inside. So why does a soap bubble become a round ball? The answer is hiding in something we usually cannot see: *surface tension*.

The skin of water

A soap bubble is not just air. It has a very thin film of soapy water around it. Water molecules like to stay close to other water

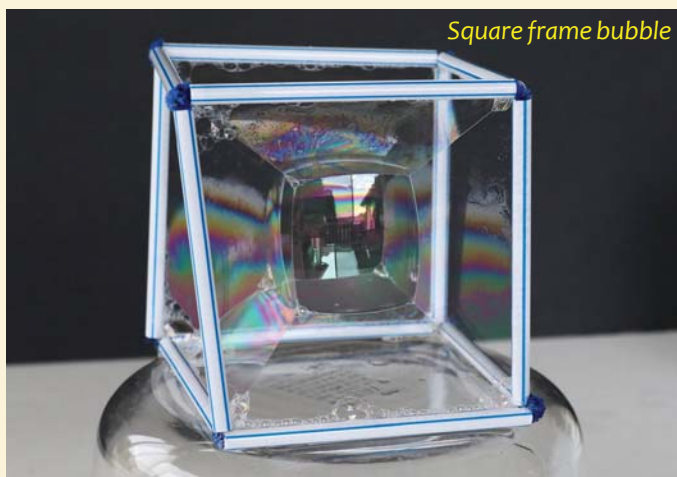
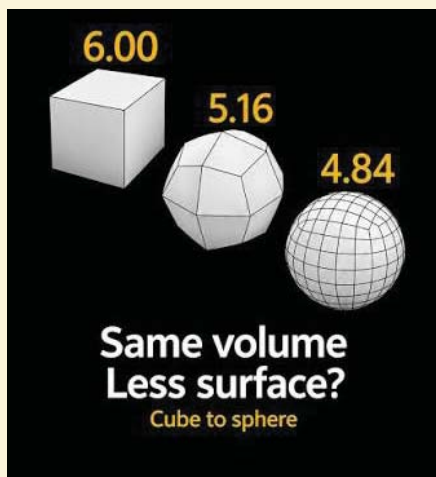
molecules. At the surface, however, the molecules do not have water molecules on all sides of them. This makes the surface behave a little like a stretched, thin skin. This effect is called surface tension.

You can see a similar thing with a small drop of water. If you carefully place a drop on a smooth surface, it tends to hold itself together instead of spreading into a completely flat layer. The water is trying to keep its surface as small as possible. And this is where the bubble becomes interesting.

Why round?

Imagine you have a piece of string and you want to make a closed shape with it. You could make a square. Or a triangle. Or a strange shape with many corners.

But if the string is free to move and you want the smallest possible boundary for a



given enclosed area, the natural shape is a circle.

A soap film behaves in a related way. A bubble tries to have the smallest possible surface *area* while still holding its air inside. For a given volume, a *sphere* has the smallest surface area of all possible shapes. The figure shows three different shapes for the same unit volume. The surface area decreases from 6 units to 4.84 when we go from a cube to a sphere. That is why a free soap bubble becomes round. So the bubble is not “thinking” about its shape. Physics is doing the thinking for it.

Then why does a bubble sometimes look funny?

Here is the fun part. If you blow a bubble inside a ring, it may look round. But put a soap film inside a strange-shaped frame and the film can take a completely different shape. Why? Because the frame is now controlling part of the boundary. See the square bubble in the picture.

The soap film still tries to reduce its surface area, but it has to obey the shape of the

frame. However, if you blow the bubble out of the frame, as soon as it is set free, it becomes a sphere again (see picture).

This is why soap films are useful to mathematicians and scientists. They can help us understand problems involving *minimum surfaces*. In fact, some very difficult mathematical problems can be explored using nothing more complicated than soap films.

What about those beautiful colours?

Look closely at a soap bubble. You may see yellow, blue, green, purple and many other colours moving across its surface. But the soap itself is not rainbow-coloured. The colours come from light. Light reflected from the front and back surfaces of the very thin soap film can interact with each other. Some colours become stronger (called *constructive interference*) while others become weaker (due to *destructive interference*). This is called **thin-film interference**. As the film becomes thinner or thicker, the colours change. That is why the bubble can look as if it is carrying a tiny

moving rainbow. And as the bubble gets thinner, the colours can change again just before they disappear. The set of pictures shows a bubble just bursting into small pieces.

Try this at home

Take some water and add a little dish soap. Use a bubble wand and blow a few bubbles.



Now don't just watch them.

Watch the colours. Watch how the bubble changes shape when it touches another bubble. Watch how two bubbles can join together. And ask yourself:

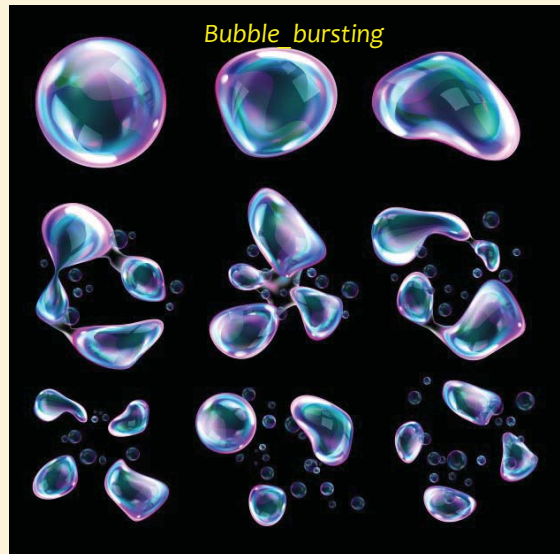
“Why does nature keep trying to make everything so simple?”

A bubble does not know mathematics. It does not know what a sphere is. It does not know that a sphere has the smallest surface area for a given volume. Yet, by following the simple rules of physics, it finds that shape.

One more surprising fact

A soap bubble has two thin surfaces—an outside surface and an inside surface—with a very thin layer of liquid between them.

So when you look at a bubble, you are actually looking at a tiny liquid sandwich! And that delicate little sandwich is strong enough to hold air for a short time.



The bigger lesson

Sometimes science is hiding in things we see every day. We do not need a huge telescope or a giant laboratory to find something amazing. A little soap, some water and a breath of air are enough to show us ideas about molecules, forces, light, mathematics and geometry.

So the next time a bubble floats in front of you, don't think of it as just a toy. Think of it as a tiny physics laboratory.

Image credits:
Wikipedia, Internet

Science News

Headlines

- Antarctica Once Hosted Vast Forests
- Mars has air, but almost none of it can keep you alive
- How the body adapts to extreme heat
- How 'singing' mice belt out their tiny tunes

Read more details on some of these topics below.

• Antarctica Once Hosted Vast Forests

A small piece of *amber* found in West Antarctica is changing how scientists picture the continent's past. Found underground in the Pine Island Trough, it shows that resin-producing trees once lived close to the South Pole.

The fragment dates back between 92 and 83 million years ago, during the mid-Cretaceous period. At that time, the Earth was warm, with high sea levels and many different life forms lived both on land and in the sea. The amber piece provides a direct link to a time when Antarctica supported forested landscapes very different from today.

The sample, called Pine Island amber, was collected in 2017 during an expedition aboard the RV Polarstern. Scientists used the MARUM-MeBo70 seafloor drill to extract sediment cores from the Amundsen Sea Embayment. This is the first confirmed amber ever found in Antarctica, which makes the find stand out right away.

The identification of amber in Antarctica fills a long-standing gap in the fossil record. Before this, the southernmost known deposits dated to the mid-



Microscopic view of amber

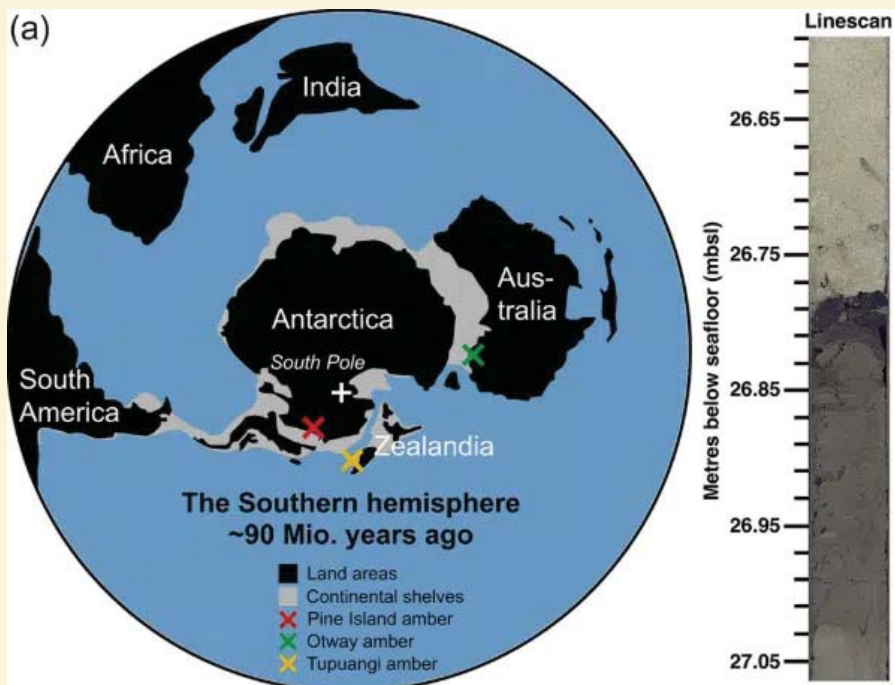
Cretaceous in southern Australia and New Zealand.

Amber forms from *plant resin*, typically found on the barks of **gymnosperms** like pine trees and conifers. This indicates that conifer-dominated forests once thrived in a swampy, temperate rainforest environment near the South Pole. This idea may sound surprising, but it fits with other evidence pointing to a much warmer climate during the mid-Cretaceous, when forests could grow even at high latitudes.

The piece itself contains transparent and translucent particles, which point to good preservation. This likely means the amber was buried at shallow depth, avoiding the kind of heat and pressure that would damage it. Such studies help us to better understand the conditions on Earth at such early times.

● Mars has air, but almost none of it can keep you alive

A person can step onto the planet with food, water and shelter plans in place, but none of that matters for long without something far more basic: oxygen. On Earth, breathing feels automatic because the atmosphere does the work for you. On Mars, it does not.



That difference starts with the air itself. Here on Earth, oxygen makes up about 21% of the atmosphere. Nitrogen takes up most of the rest, about 78%. When you breathe in, you take in all of it, but your body uses the oxygen and gets rid of the rest when you exhale.

Mars offers a much harsher version of air. Its atmosphere is thin, with only about 1% of the volume of Earth's atmosphere. Put another way, Mars has 99% less air than Earth. The planet is about half Earth's size, and its weaker gravity cannot hold atmospheric gases as effectively, allowing them to escape into space.

That alone would make breathing difficult. The composition of the Martian atmosphere makes it deadly: the planet is full of the wrong gas!

The most abundant gas on Mars is carbon dioxide. On Earth, carbon dioxide becomes poisonous at high concentrations, though it makes up far less than 1% of the atmosphere. On Mars, it makes up 96% of the air.

Oxygen, by contrast, is almost absent. It accounts for only one-tenth of one percent of the Martian atmosphere, nowhere near enough for a human being to survive. Without a spacesuit supplying oxygen, a person on the surface would die almost immediately. The source material describes two things happening at nearly the same time: suffocation and blood boiling because of the low atmospheric pressure. It is a brutal reminder that Mars is not just distant. It is actively hostile to human life.

The air is only part of the problem. Very little liquid water exists on the Martian surface. Temperatures plunge low, especially at night, when they can fall below minus 73 degrees Celsius. That does not mean Mars is beyond scientific hope. So far, researchers have found no evidence of life there. But the search remains in its early stages, and robotic probes have only begun to investigate the planet.

That matters because extreme conditions do not automatically rule out life. On Earth, organisms survive in places that once seemed impossible. Life exists in Antarctic ice, at the bottom of the ocean and miles beneath Earth's surface. Many of those environments bring severe cold or heat, almost no water, and little to no oxygen.

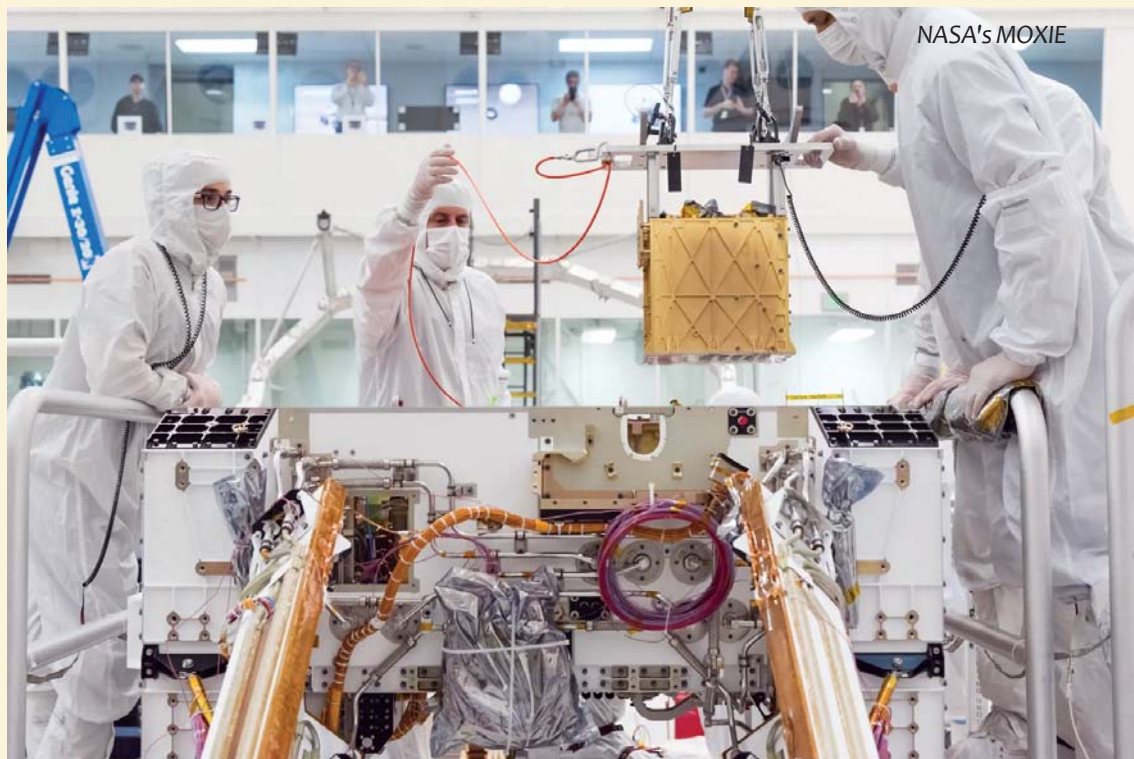
There is also the deeper possibility that Mars was once very different. The source material notes that billions of years ago, the planet may have had a thicker atmosphere, more oxygen, warmer temperatures and significant amounts of liquid water on its surface. If that was the case, Mars may once have been much more favorable to life than it is today.

That idea sits at the heart of NASA's **Perseverance** mission which is a robotic explorer right now on the surface of Mars. One goal of the Perseverance rover is to search for signs of ancient Martian life—most likely microbes, preserved in rock.

At the same time, Perseverance is doing something else that could shape Mars exploration in a more immediate way. Among the rover's seven instruments is **MOXIE**, a device designed to take carbon dioxide from the Martian atmosphere and convert it into oxygen. On a planet where carbon dioxide dominates the air, that is a striking idea: use the planet's most abundant gas to help solve one of its most dangerous problems.

If MOXIE works the way scientists hope, the benefits would go beyond breathing. Future astronauts could make their own oxygen on Mars instead of carrying all of it from Earth. That changes the equation. The more oxygen astronauts can produce on Mars, the less they need to launch from Earth. And the less mass a mission has to carry across space, the easier it becomes to send people there.

Still, even “homegrown” oxygen would



not make Mars comfortable. Astronauts would still need spacesuits. The planet's thin atmosphere, low pressure, cold temperatures and lack of breathable air would not disappear just because some oxygen could be manufactured on site.

NASA is now working on the technologies needed for human missions to Mars. Such a mission could happen in the next decade, perhaps sometime in the late 2030s.

● How the body adapts to extreme heat

"I can't do this," the woman in her 60s said as she lowered herself into the 40° Celsius water that filled a big silver tub at the end of a dimly lit room in the University of Ottawa's Human and Environmental

Physiology Research Unit. It was only after the temperature dropped a degree that she immersed herself, shoulder-deep, for the next two hours. Then she did it again — and again and again — every day for a week.

This was part of an experiment to study how the human body adapts to extreme heat. In particular, to study if older women—in their 60s, 70s and 80s—could train themselves to cope better with hotter temperatures. In this day of climate change and global warming, elderly people are particularly at risk of dying due to excess heat. One way of protecting such people is to get them accustomed to warmer temperatures. Hence this unusual experiment!

Extreme heat can kill. When a person's

core body temperature rises above the normal 37° for long periods, heat exhaustion often sets in. Hotter temperatures can eventually lead to delirium, seizures, organ failure and death.

As heat wave–related deaths mount globally — more than 10,000 Europeans are estimated to have died during a heat wave in June alone — harnessing the body’s natural responses could be one way to survive in an increasingly hot world.

Repeated exposure to high temperatures in young, healthy individuals has been shown to trigger protective physical changes that help cool the body. Studies in athletes, soldiers and outdoor workers, have shown that repeated exposures to heat trigger certain physiological responses. These help the body to better cope with subsequent bouts of heat.

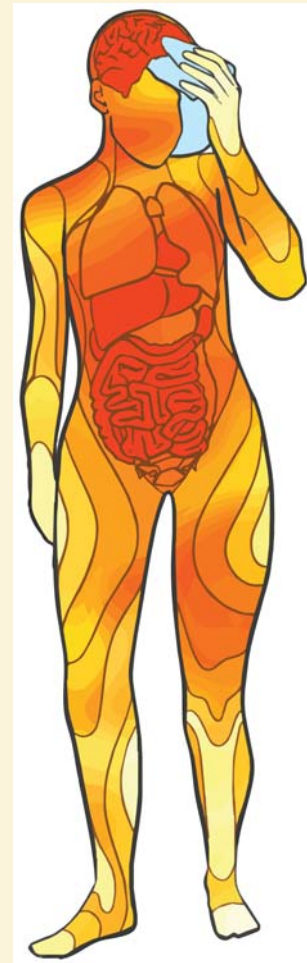
For example, *sweating*, which uses moisture to take away heat, starts earlier and is more intense in people who have recently been exposed to hot temperatures. Tiny *blood vessels* in the skin also dilate more quickly in heat-exposed individuals. This allows more blood to move from the body’s hotter interior to its surface, where heat can radiate outward. These changes initially force the heart to beat faster to keep blood pressure steady. Over time, the body adapts by expanding blood volume, reducing the heart rate.

Studies have found that the **hypothalamus**, a brain region that acts like a thermostat, becomes more sensitive to

temperature and acts more quickly to trigger sweating and blood-vessel widening. In addition, cells in the blood (and probably elsewhere in the body) produce more **heat-shock proteins**, which help protect cells from heat-related damage.

While researchers are still figuring out precisely how these physiological adaptations work, some scientists believe they are at least partly the reason why people in climates that are hot year-round tend to suffer less from heat. Residents of countries including Kuwait, India and Thailand, for example, show signs of being well-adapted to relatively high average daily temperatures.

To compare the heat tolerance of people from different places, scientists calculated the **minimum mortality temperature** (temperature at which there is danger of heat death) for two groups. One group were the residents of Mecca, Saudi Arabia. The other group were the international visitors who visit Mecca for **Hajj**. They looked at patterns of natural deaths for both populations during the five-day Hajj period over eight years from 2006 to 2014. They found a



minimum mortality temperature of 26° for Meccans and 23.5° for pilgrims. This is the *minimum* temperature; they found that, above 38°, mortality even for Meccans shot up drastically.

In general, such differences at the population level could be due to many factors, including access to air conditioning, outdoor conditions and possibly even genetic factors. But physiological acclimation probably also plays a role.

What about the original experiment of immersing yourself in hot water that we began this report with? After repeatedly immersing themselves for seven days, both older adults and younger adults started to sweat and vasodilate earlier upon heat exposure. They also experienced a 0.4° lower body temperature, on average, than they did at the beginning of the experiment. The scientists also observed a five-beats-

per-minute lower heart rate, on average, in both groups by the end of the protocol, they reported in May in the *Journal of Physiology*.

The upshot of the study “is that even if we’re older, our body still has the ability to adapt to heat.”

● How ‘singing’ mice belt out their tiny tunes

Disney’s *Cinderella* is not the only place you can hear mice “sing.” Some real-world rodents also serenade each other. They are known as **Alston’s singing mice**. Found in the forests of Mexico and Central America, they truly live up to their name. Both males and females communicate with trains of high-pitched notes. Remarkably, their songs are more complex than those of any other rodent. Making music this way may be unique in the animal kingdom.

In just a 10-second song, an Alston’s



Alston's Singing Mice

singing mouse belts out around 100 individual breaths and notes. The melody attracts mates and warns rival males to stay away, says **Samantha Smith** of the University of Lausanne, Switzerland. The song's speed and length make it far more "extreme" than other rodents' calls, she adds.

Smith is part of a team that wanted to know how the vocal systems of Alston's singing mice evolved to create melodies. They started by dissecting the *voice boxes* of deceased animals. This voice box is a part of their bodies that helps mice (and us) breathe, swallow and make sound.

The researchers hooked each voice box to a tube. Then, they pointed a microphone and camera toward its top. "A voice box is basically just a tube with a valve in it that can open and close," explains Smith. To see how the voice box moved and produced sound, the team blew air through the tube.

Sometimes, the voice box produced sounds that ranged in the mouse's natural pitch. But this happened only when a pouch on the inside of the voice box was inflated. When the researchers blocked this balloon with bits of wax or small metal balls, the voice box went silent. Cutting the sac had the same effect. The air sac, it seemed, is key to making the songs. Other rodents have air sacs, but they don't appear to use them to sing.

Working with voice boxes this small is not an easy task. But learning more about how rodents produce sound is exciting because they're such a diverse group with

such fascinating social, behavioral and ecological adaptations.

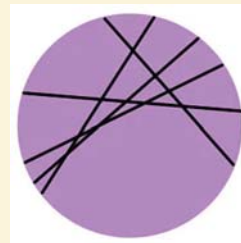
It's not yet clear how the sac generates its whistle. The sound could come from air vibrating at the sac's entrance. Another possibility is a bit like how flutes and organ pipes work. A sharp cartilage rim at the sac's entrance may be deflecting air, producing the tone.

Inflatable sacs in airways have evolved multiple times. Primates, birds, reptiles, frogs and other animals have them. But in those cases, air sacs alter or amplify sound produced elsewhere in the respiratory tract. (That's the system of organs that are involved in breathing.) The songs of the singing mice, on the other hand, are made by the sacs themselves.

"Our study expands our understanding of the ways in which [air sacs] can shape vocal communication," Smith says. Studying different features of rodent air sacs may help reveal how these songs first evolved.

Sources: www.dailygalaxy.com; <https://www.thebrighterside.news>; www.sciencenews.org; <https://www.snexplores.org>

Solution to puzzle on page 35

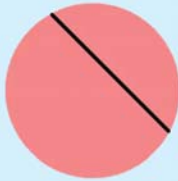


Solution: You can get at most 16 pieces. See picture.

Slicing a cake

If you cut a circular cake with 1, 2, 3, or 4 straight slices, then the largest number of pieces you can get is 2, 4, 7 and 11, respectively. (You are now allowed to move the pieces between cuts.) See the picture. What is the largest number of pieces you can create with five cuts?

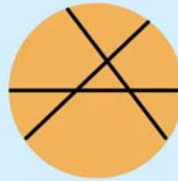
From Barry Leung, medium.com



1 cut
2 pieces



2 cuts
4 pieces



3 cuts
7 pieces



4 cuts
11 pieces

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Typeset at
Fineline

Design, Illustrations and Layout

Basheer
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Printed at
Sri Murugan Printers,
7/1, Boobegam 3rd St, Anna salai,
Chepauk, Chennai - 600 002.

Single copy Rs. 30/- Annual subscription Rs. 200/- Life Subscription Rs. 2000/-
Bank Details: Jantar Mantar, Indian Overseas Bank, Dr. RK Salai Branch, Chennai - 600004
AC No: 029101000031081 IFSC Code: IOBA0000291



The Soap Bubble Nebula, (PN G075.5+01.7) a planetary nebula in the constellation Cygnus, in the heart of the Milky Way galaxy.

The name comes from its shape which resembles a soap bubble.

Image credit Wikipedia: T.A. Rector and H. Schweiker,
the National Optical-Infrared Astronomy Research Laboratory (NOIRLab), USA

Published by S.Subramani Published at 245, Avvai Shanmugam Salai, Gopalapuram, Chennai-600 086 Printed by P.S.Kumaresan, Printed at SRI MURUGAN PRINTERS, No.7/1, BooBegum 3rd Street, Chepauk, Anna Salai, Chennai-600 002.
Owned by Tamil Nadu Science Forum, Editor: Dr. D. Indumathi