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A Quantum Century

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We have all learnt about **Isaac Newton** and his laws of mechanics. They decide how apples fall from trees, how you can balance on your cycle, and how space ships can reach Moon and Mars. But there are very different laws that govern physics on a very small scale, on scales that are even smaller than a virus; these are the *atomic* scales. For instance, a hydrogen atom has a radius of about 1 **Angstrom**; if you divide a metre into 1 billion parts, each piece is 10 Angstroms and can fit 10 hydrogen atoms in a row!

These are such small objects that you cannot see them with your eyes, or even a microscope. But there are even smaller objects in the Universe. These are the



protons and neutrons that are in the nucleus of atoms, and are 100,000 times smaller than atoms themselves! The laws that govern the motion of objects at



Werner Heisenberg

such small scales is determined by a new kind of mechanics called **Quantum Mechanics**. The traditional understanding of Newton is called **Classical Mechanics**.

You must have learned about atoms and their nuclei in school. And that the electron in an atom lies outside the nucleus. Perhaps you've even learned that the electron goes around the nucleus. This picture is convenient but not totally correct. In college you will learn that you should actually think of the electron as a kind of *fuzzy cloud* surrounding the nucleus. You cannot really tell exactly where it is at a given point in time.

This is because of a property of Quantum Mechanics that was pointed out by **Werner Heisenberg**, called the **Heisenberg Uncertainty Principle**. Briefly, it states that there are pairs of variables, the most common among which are the position and momentum (magnitude, not direction) of a particle. In quantum mechanics, both these pairs

Erwin Schrödinger



of variables cannot be measured simultaneously and accurately. If one is measured more accurately, the other can only be measured approximately.

measure the position of an electron *exactly*, then Heisenberg's principle says that its momentum is fully unknown. Hence we have the notion of an electron cloud around a nucleus rather than an electron going around and around it.

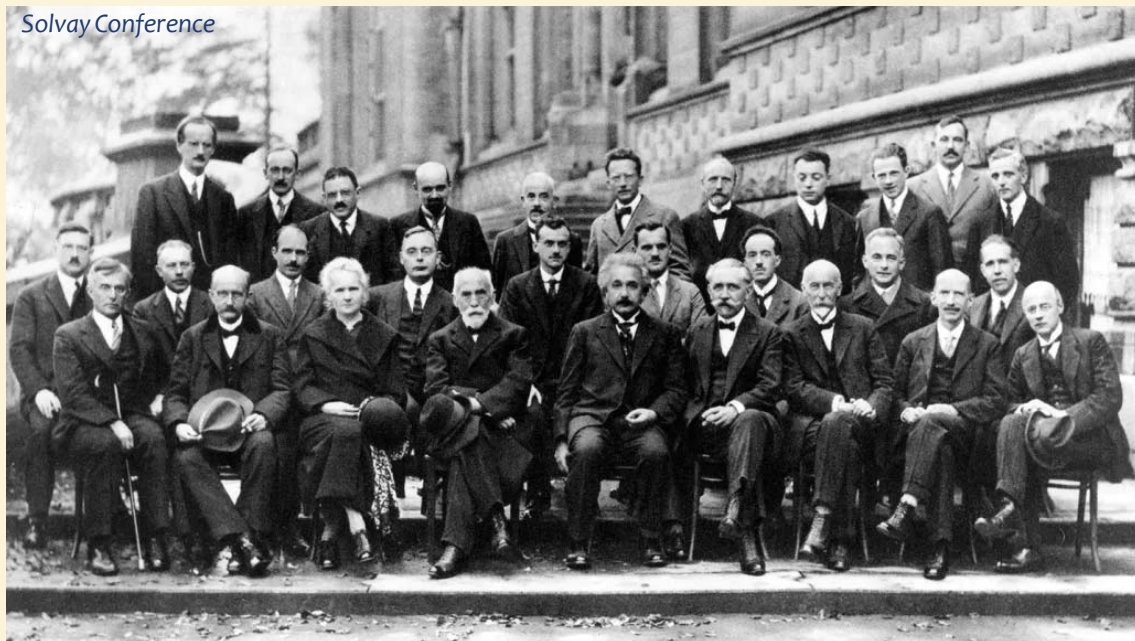
In 1927, two years after Quantum Mechanics was born, physicists gathered to discuss its impact at the famous **Solvay Conference** on Physics in Brussels. This picture shows many important physicists who were in this meeting, including **Werner Heisenberg** (back row, third from right) and **Erwin Schrödinger** (back row, sixth from right). **Albert Einstein** is front row centre.

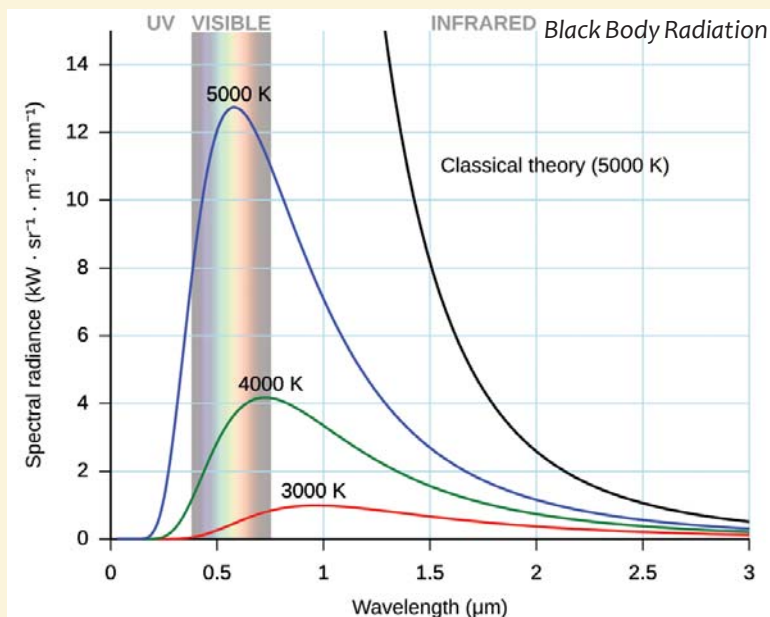
The Birth of Quantum Mechanics

Beginning around 1900, many people contributed to the birth of Quantum Mechanics. It started with trying to understand what was called *Black Body Radiation*: a perfect black body (literally

Let us take an example of a car going on the road. You can measure its position and its velocity (and hence momentum) easily enough. But as the car becomes smaller and smaller, and shrinks to the size of an atom (now stretch your imagination!) if you pin-point its position, then its momentum will be unknown and vice versa. In fact, if you

Solvay Conference





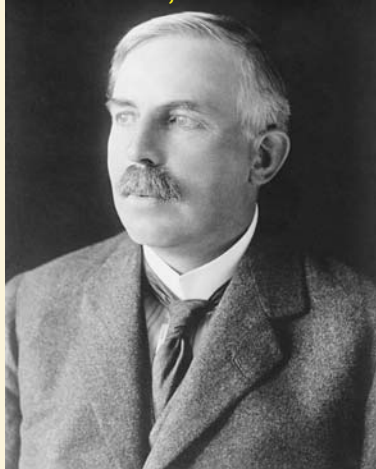
radiation against the actual observation. In trying to understand this, **Max Planck** came up with a new law which gave new insights into the phenomenon. He said that light (or radiation) can only be emitted in fixed energy units called a *quantum*.

Around 5-10 years later, a variety of experiments by **Ernest Rutherford** and colleagues Hans Geiger and Ernest Marsden showed that the atom has

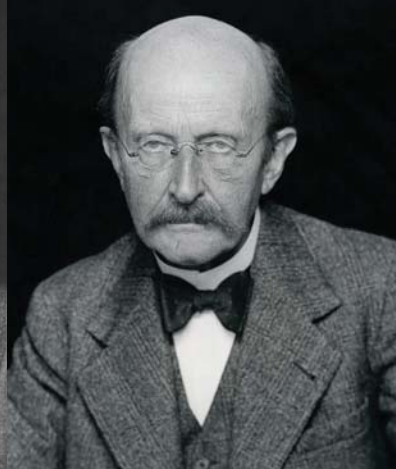
black) absorbs 100 % of the light falling on it. It then proceeds to emit most of it; in fact, more than other coloured objects can emit. Although it emits that radiation in all frequencies (visible to invisible infra-red and ultraviolet, etc), the *peak* of the frequency depends only on its temperature. The figure shows the classical prediction of black body

a central, very dense nucleus. Can you imagine that about 100 years ago, no-one knew that nuclei existed?! **Neils Bohr** proposed a model which could explain how an electron is bound to a nucleus (a hydrogen atom is a positively charged proton with a negatively charged electron, isn't it?). You will learn about it in Class 12. He not only explained atomic

Ernest Rutherford

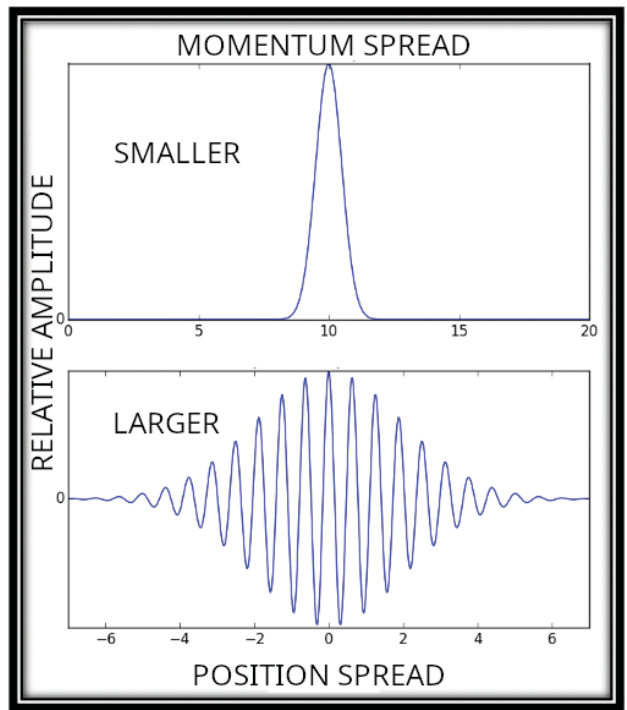
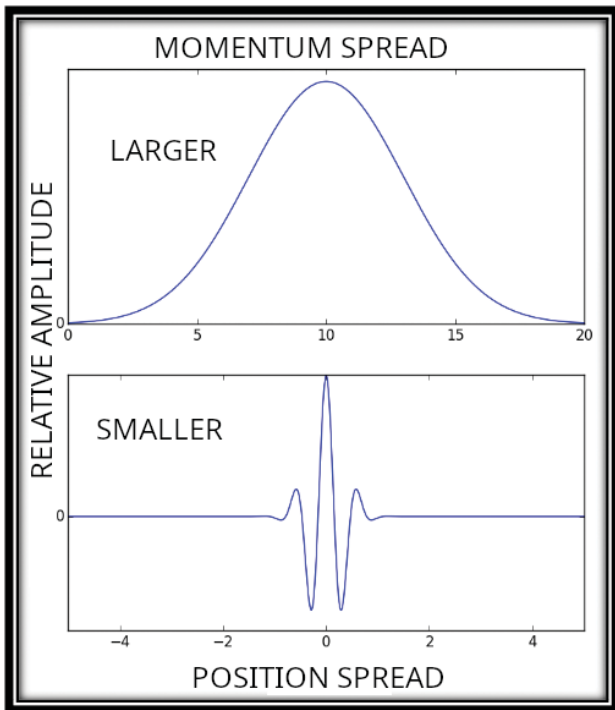


Max Planck



Niels Bohr





binding (and hence ionisation energy) but also explained how atoms radiate energy.

However, this left a deep puzzle in the minds of scientists. Since electron

and proton are oppositely charged, and attract each other, how come the electron stays bound to the proton in a Hydrogen atom without “falling in” to the nucleus? This was the problem that was solved 100 years ago by Heisenberg and signalled the birth of Quantum Mechanics. The actual solution is too complicated to be described here. I hope that one day you will learn all about it and be as fascinated as I was!



Paul Dirac

While Heisenberg’s approach used mathematics of matrices, **Erwin Schrödinger** independently came up with a different formulation of Quantum Mechanics using wave theory. In this approach, you think of the electron as a wave spread out in space. If you measure its momentum exactly, then the wave is spread over infinite space. As you squeeze the wave in space and localise it more and more, the measurement of the momentum gets worse and worse (see figure).

While Schrödinger’s approach is more physical, it was soon established that both Heisenberg and Schrödinger were solving the same problem. However, the situation

was very messy, because it was a radically new theory and an entirely new way of looking at our world. Over the years and in fact decades, many scientists including **Paul Dirac** clarified the essential aspects of Quantum Mechanics. Many reformulations have taken place and improved our understanding of physics at small scales.

There is yet another complication: that of *measurement*. Quantum Mechanics states that the very act of measurement can affect the state of the object. This is called the measurement problem and is closely related to how the wave function of the electron (or object) is used to determine its properties such as position and momentum. According to Quantum Mechanics, the electron in the hydrogen atom can have several possible values of position and/or momentum. Only when we measure it will the electron “collapse” into one of the possible values. This was known as the *Copenhagen interpretation* of Quantum Mechanics. While this remains very popular, many scientists have challenged this view point because it can lead to absurdities. One of the

early examples that highlighted the problem with wave function collapse is called the Schrödinger’s cat example. Read about it in ‘The Story of Tom’s Cat in a Box’ on page 27.

The Impact of Quantum Mechanics in today’s world

Quantum physics has since permeated a wide range of scientific disciplines. For instance, it can explain the periodic table, which you would have studied in Chemistry. It allows us to understand how stars are made, and how they die in massive *supernova* explosions. It also touches our lives closely because it has enabled all kinds of technology from the laser to the smartphone. And the new buzzword of this decade of course is *Quantum Computing*. But more on this in a later issue of **JM**.

Sources:

Sciences News <<https://www.sciencenews.org/article-type/news>>
Quantum Physics (also for image of scientists from the Solvay Conference),
Wikipedia

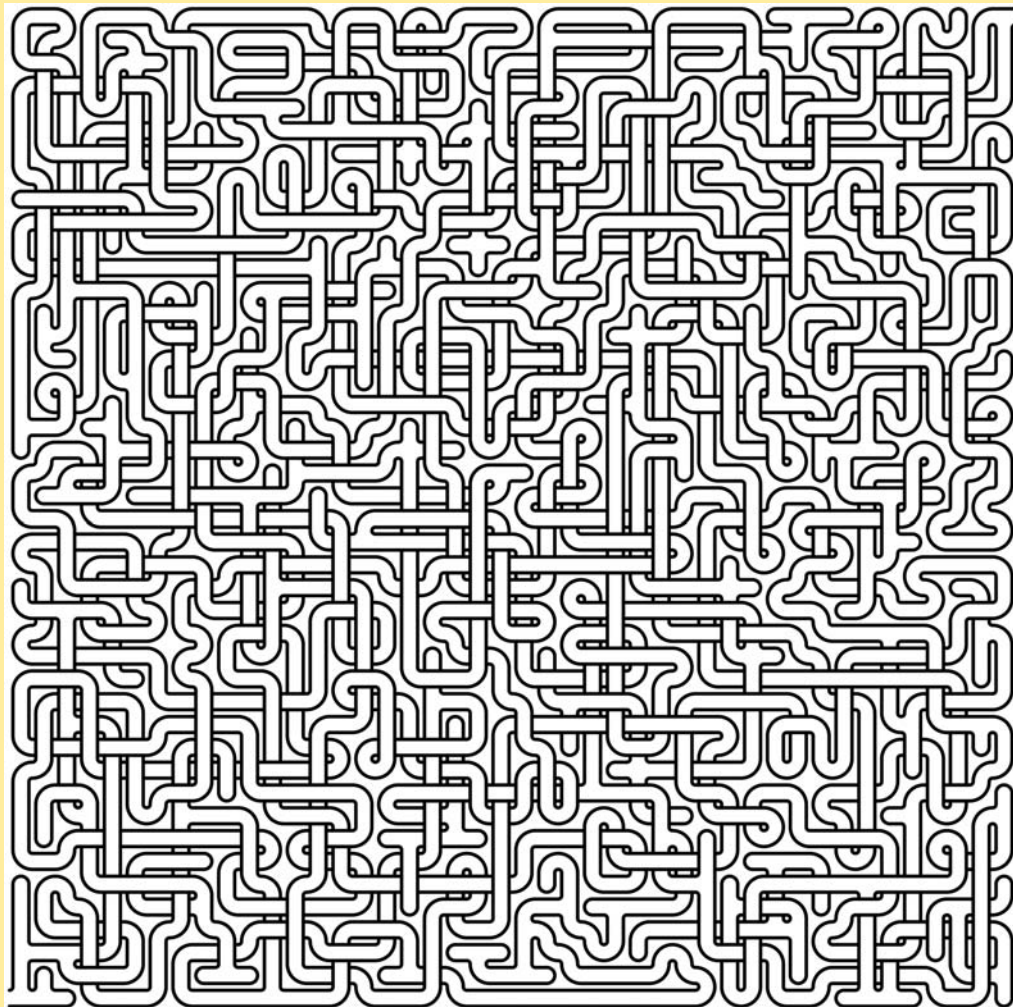
This paint ‘sweats’ to keep your house cool!

An experimental, cement-based paint cools buildings by combining sunlight reflection and water evaporation

A cool house without air conditioning may soon be possible. Scientists in Singapore have developed a new type of paint that reflects sunlight and cools surfaces by slowly evaporating water. Unlike other commercially available cooling paints, which are designed to repel water to protect the underlying material, the new one even works in hot, humid places, offering a low-energy way to stay cool, researchers report in the magazine, *Science*.



Help friends meet





VRdome

Inside the Cell: *Molecular Recipes*

Zareena, Mookayi, Mari

Zareena, Mookayi, and Mari practically floated out of the virtual reality dome. They were thrilled and excited. They had just stepped out of a once-in-a-lifetime experience — exploring the inside of a living cell as if they were tiny travellers in a crowded and busy microscopic city!

Outside the nearby conference hall they saw people taking coffee and moving around or standing and talking in groups. Looked like a lecture session had just got over. They could now search out Mari’s mother Dr. Usha, a biologist, who was attending the conference. The three friends spotted her.

“Amma!” Mari called out, waving enthusiastically. “You have to hear about what we just saw!”

Usha smiled and excused herself from the group around her and came towards Mari, Zar and Mooks. “You all seem excited. What happened?”

All three started speaking at once. Usha heard only the virtual reality part and grinned. “Ah, you have been on the **VR** cell tour? I was one of the people who helped design that pro-

gram! Did you like it? Come, let's talk."

They found chairs and settled down in a corner of the lawn. And the three started talking over each other in excitement. Usha asked them to slow down and talk one at a time.

"It was mind-blowing!" Mooks began, her hands flying in the air. "We were inside an **E. coli** cell! Everything was zooming around — sugar molecules were flying past at about 400 kilometres per hour!"

"And there were so many molecules!" Zar added. "It wasn't empty at all! Not like the diagrams we see in our text books. What a variety of molecules!"

Mari put her bit in "It was like the crowd we see in Madurai Town Hall Road on the day before Deepavalli — the cell was packed!"

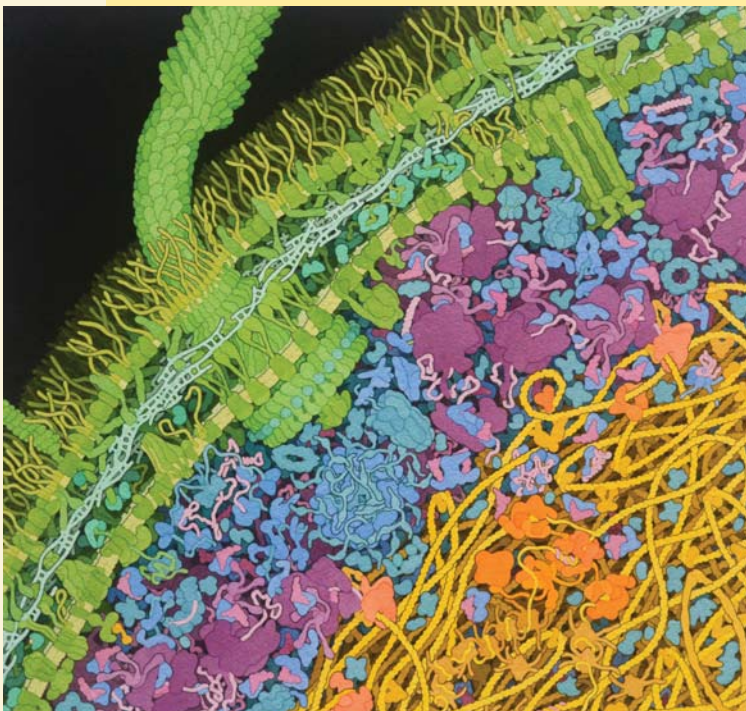
She continued "They told us that about 70% of a cell's mass are just water. But the other 30% — the dry mass — is all the important

What is E. Coli

Escherichia coli is a rod-shaped bacterium that is commonly found in the lower intestine of warm-blooded animals. Like most bacteria, it has just one chromosome (threadlike structures made of protein and a single molecule of DNA that serve to carry the genomic information in the nucleus of cells). These bacteria are mostly harmless or even beneficial to humans. *E. coli* is expelled into the environment within fecal matter. Some varieties (called serotypes) can cause food poisoning in humans. Since they reproduce very quickly, they have been much studied in the lab.

The picture shows a painting of *Escherichia coli* bacterium, 2021, Illustration by David S.

Goodsell, RCSB Protein Data Bank. This painting shows a cross-section through an *Escherichia coli* cell. The characteristic two-membrane cell wall is shown in green, with many lipopolysaccharide chains extending from the surface and a network of cross-linked peptidoglycan strands between the membranes. The genome of the cell (complete set of DNA instructions, with all the genetic information necessary for an organism to develop and function) forms a loosely-defined "nucleoid", shown here in yellow, and interacts with many DNA-binding proteins, shown in brown and orange. Large soluble molecules, such as ribosomes (colored in reddish purple), mostly occupy the space around the nucleoid.



A more detailed picture is on the back cover.

stuff: DNA, RNA, proteins, lipids, and ions!”

Usha smiled, leaned in, encouraging them “And which part makes up most of the dry mass?”

“Proteins!” all three said together – so loud that people turned around to see them. They then grinned seeing Usha and the three excited girls.

“Right,” said Usha. “Proteins make up around 55% of the cell’s dry mass. They’re the workhorses — building, fixing, signalling, and running reactions inside the cell.”

Mari added, “RNA is about 20%, lipids are about 10%, and DNA — even though it carries the instructions for the whole cell — is only about 3%! “

“Exactly,” Usha said. “DNA is small by mass, but is the information queen.”

Zar flipped through her notes. “And the cell had so many proteins — like over two million proteins squeezed into just one tiny bacterium!”

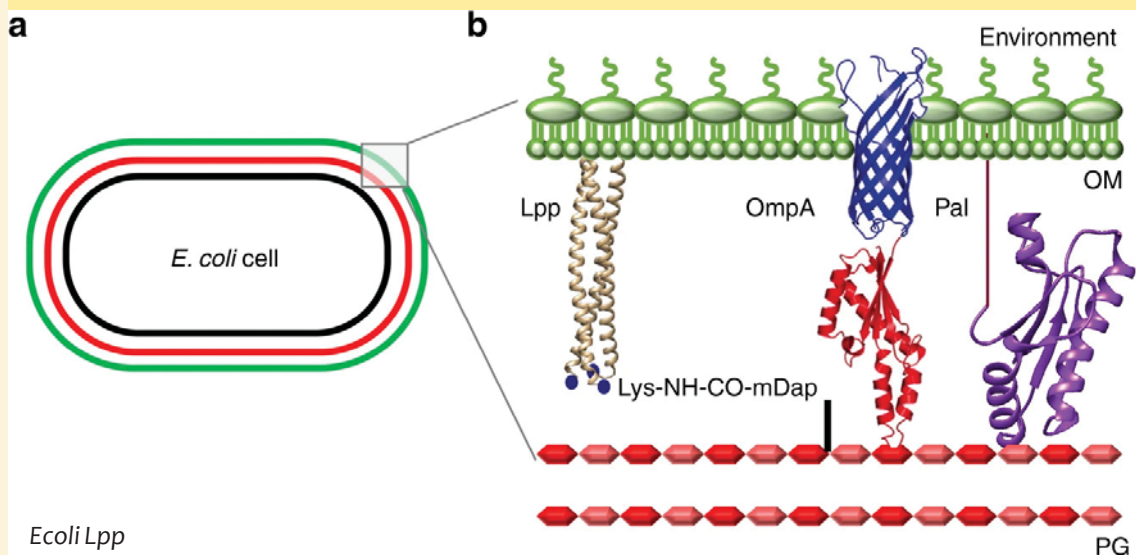
“Yes,” Usha said, impressed. “Each protein is made up of amino acids, like beads on a string. And even small proteins are made of hundreds of amino acids.”

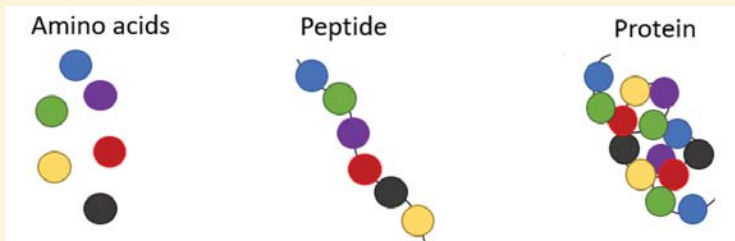
“And there’s one protein that’s super important!” Mooks jumped in. “It’s called *Lpp* — there are more than 700,000 copies of it in each *E. coli*! It holds the cell’s outer membrane to the inner wall so the cell doesn’t collapse.”

“Without it,” Mari said, “the cell would be

E Coli, Lpp and its structure

The picture shows a schematic of the *E. coli* cell showing its multilayered envelope. This is composed of an inner (IM, black) and an outer (OM, green) membrane, separated by the periplasm containing a peptidoglycan layer (PG, red). A closer view of the envelope on the right shows the lipoprotein Lpp. Peptidoglycan is a complex polymer composed of sugars and amino acids, forming a mesh-like layer outside the plasma membrane. This mesh-like structure is essential for maintaining bacterial cell shape.





Amino Acids to Protein

crushed by its surroundings!”

Usha smiled, pleased. “That’s absolutely right. In fact, it took scientists some time to realize just how abundant *Lpp* is. Back in 1978, researchers thought *EF-Tu* — a protein that helps **ribosomes** build other proteins — was the most abundant, with a few hundred thousand copies per cell. But in 1979, a paper published in the journal **Cell** changed everything.”

The girls came closer, intrigued.

Usha continued, “They discovered that *Lpp* is actually even more abundant — with over 700,000 copies in each *E. coli*. And it’s critical because it anchors the outer membrane to the **peptidoglycan** layer underneath. Without *Lpp*,

the cell would be torn apart by the turbulence in its environment.”

Mari whistled softly. “Wow. So *Lpp* is like the glue holding the cell together.”

“Exactly,” said Usha.

“Meanwhile, *EF-Tu* remains one of the most common proteins too, but it’s more like the ‘foreman’ helping to direct construction of new proteins inside the cell.”

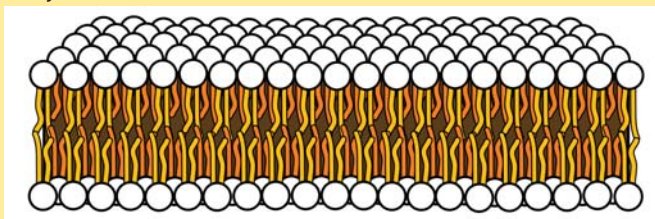
“And — the membrane!” Mooks suddenly remembered. “They said it’s very important too!”

Usha’s eyes lit up. “Yes! The lipid (lipid means fat) bilayer — the membrane that separates the cell from the outside world — is one of the most critical parts. Interestingly, even though lipids make up less than 10% of the dry mass, making these lipids is the second most energetically expensive task for a cell, next only to making proteins. (The lipid bilayer is

Lipid Bilayer

The **lipid bilayer** (or **phospholipid bilayer**) is a thin membrane made of two layers of lipid molecules. Lipids are like fats, wax, and other substances that are not soluble in water. These membranes form a continuous barrier around all cells. This keeps ions, proteins, etc., inside the cell and doesn’t allow them to diffuse out. Ions and proteins are mostly soluble in water, so they cannot cross this lipid bilayer. This is important to regulate salt concentrations, etc. Lipid bilayers are usually composed of molecules that have a hydrophilic (water-loving) phosphate “head” and a hydrophobic (water-repelling) “tail” consisting of two fatty acid chains. When lipids are exposed to water, they self-assemble into a two-layered sheet with the hydrophobic tails pointing toward the center of the sheet (see figure) so that the two rows are “inverted” with respect to one another.

Bilayer sheet



the membrane where lipids are arranged in two layers with each layer having lipids next to each other in a specific manner)."

"Why does it cost so much energy?" Mari asked, curious.

"It's because lipids are made from long carbon chains," explained Usha, "and they're connected together by high-energy ester bonds. These bonds need a lot of energy – what is technically called *Gibbs free energy* – to form. But putting together the lipids in a row and having two rows in an inverted fashion below each other is not easy! It is the most energy demanding component. Building that protective barrier for the cell takes a lot of careful, energy-intensive work."

Zar scribbled excitedly in her notebook. "So, even the walls of the cell are built carefully, just like its machines inside!"

"Exactly," said Usha.

"And if the environment changes," Mooks said thoughtfully, "the cell can change the proteins it makes, right?"

"Good point," said Usha. "That's called *altering the proteome*. When nutrients are plenty, *E. coli* grows bigger and faster, filling itself with different sets of proteins. But when food is scarce, it shrinks, divides slowly, and changes the proteins it produces to survive."

What is the proteome?

Not all proteins are active (*expressed*) in a cell at any given time. The set of proteins that are active depends on the tasks that the cell needs to perform at that time. This is called the proteome. Proteomes of different cells of a multi-cellular organism can be different.

Mari's eyes widened. "It's like the cell is ... adapting on the fly (meaning, as the changes are happening)!"

"That's a nice way to put it," said Usha.

Zar jumped up, remembering another fact. "And we saw a chemical formula for an *E. coli*! It's something like $C_{4.4}H_{7.2}O_{2.1}N_{0.8}P_{0.086}S_{0.039}$. What did it mean?"

"Yes," said Usha, laughing. "It is actually a way to tell that for every 4.4 carbon atoms, the cell has 7.2 hydrogens, 2.1 oxygens, 0.8 nitrogens, and a tiny fraction of sulfur and phosphorus. This formula is derived by averaging the approximate composition of proteins, nucleic acids, lipids, carbohydrates, and other cell components. Basically it shows that carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur are the main elements needed to build a cell."

"And building the cell," Mari said, "doesn't even take that much energy! Only about 9.54×10^{-11} Joules to assemble an entire *E. coli* from scratch!"

Zar sheepishly said "Even though we noted that information, we did not really get an idea of what it means."

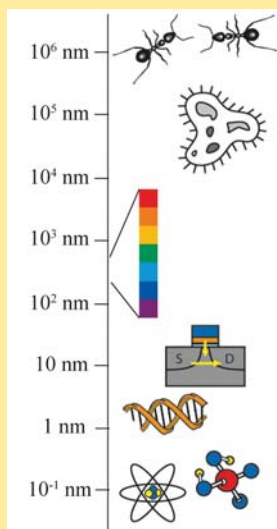
Usha nodded "I understand your problem. The numbers can be fascinating but unless we can relate them to what is around us, they are difficult to imagine. We thought about it but at that time could not get a good analogy. Later one of the students suggested putting an image of lifting a normal size apple to a distance of one metre – that will require about 1 Joule of energy. And then show an apple being lifted by 0.1 nanometre. This will need about the order of the same energy, about 10^{-11} Joules. But we could not figure out how to show lifting an

apple by 0.1 nanometre – unless we zoom in to the world of molecules where bonds are separated by about 0.1 nanometre.”

Mari thoughtfully said “Even if we had all the molecules and the energy, it seems unlikely we can create life just by putting them together. There was so much of movement and dynamics going on in the cell.”

“Because life isn’t just about having the right parts,” Usha said, nodding. “As you said it’s about how everything moves and works together.”

What is a nanometre?



A nanometre is one billionth of a metre. Take 1/100 of a metre. This is a cm. Take 1/1000 m. This is 1 mm. Take 1/1000 of 1 mm. This is 1 micron. Take 1/1000 micron. This is 1 nanometre! Instead, take a look at the pictures that tell you about these scales.

“Yes” Mooks said. “In the virtual reality show we saw the cell isn’t static. It’s alive — molecules moving, bumping, reacting, splitting, building, and destroying— every second! For example, each protein is hit by around 10^{13} water molecules every second!”

“It’s like being in a magic kitchen,” Zar said, her voice full of wonder, “where the ingredients dance, talk, and cook themselves into ... life.”

Usha smiled. “That’s the beauty of biology. It’s not just a recipe — it’s a living symphony.”

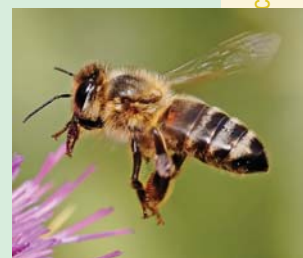
Mari spoke for all of them. “Amma, we stepped inside a cell and saw a world more dynamic and thrilling than we had ever imagined — and now want to learn even more. But all this talk of cooking made us realise we are hungry. We are going to find something to eat. It was a great show. Thanks for getting us to come.”

References: McCarty N. “Recipe for a Cell.” Asimov Press (2025), <https://www.asimov.press/p/cell-recipe>;

Arzola, Higgins and Cockell “The minimum energy required to build a cell” Scientific Reports (2024) vol 14 p 5267 <https://doi.org/10.1038/s41598-024-54303-6>.

If honeybees went extinct

If honeybees went extinct, it would have far-reaching consequences, affecting food production, ecosystems, and the global economy. The loss of bees would lead to a significant decline in fruit, vegetable, and nut yields, potentially causing shortages and price increases. Ecosystems would also be disrupted as many plant species rely on bees for pollination, and the loss of those plants would impact animal populations that depend on them for food.



A scientist who loved children

R. Ramanujam.

Azim Premji University, Bengaluru

Do you know of any Indian scientist who wrote his autobiography in his mother tongue? Not only that, do you know that it was so well written and had such literary merit that it got him the prestigious Sahitya Akademi Award? This was an eminent scientist who wrote extensively: not only scientific papers, but also essays for the public, science fiction and short stories for school children, and all this in his mother tongue.

Such a description fixes one unique individual, and that was **Jayant Vishnu Narlikar**, a renowned astrophysicist who passed away in Pune recently, on May 20, 2025 at the age of 86. Interestingly, people from all walks of life attended Narlikar's funeral which was conducted with state honours. Not only did the crowd include scientists and government officials, but also artists, writers and housekeeping staff, attesting to Narlikar's impact on society.

Early Success

Jayant Narlikar was born on July 19, 1938 in Kolhapur, Maharashtra. His father Vishnu Narlikar was a

mathematics professor at Benares Hindu University in Varanasi and his mother Sumati was a Sanskrit scholar. Jayant Narlikar excelled in his studies, earning a scholarship to Cambridge University in the UK. In 1959, at the age of 21, he completed the prestigious Mathematical Tripos, earning a Bachelor of Arts in Mathematics and being recognised as a Wrangler, a Tyson Medallist, and a Senior Wrangler. In 1962, he also won the Smith's Prize during his doctoral studies, an award for exceptional work in theoretical physics.

Hoyle and Cosmology

At Cambridge, Narlikar's biggest influence came from his mentor, the renowned British astronomer **Fred Hoyle**. Narlikar's theoretical work with Hoyle on cosmology, the origins of the early universe, proved to be very original and interesting.

A fundamental question that has always intrigued humanity is how the Universe came into being. For those who believe in God, the answer is simple: God created the Universe. Scientists would prefer materialist explanations that can be corroborated by evidence. By now, we have data accumulated from a few centuries of observations that lead us to the so-called *Big Bang Theory*: it states that all matter and energy in the Universe came into existence in one single instance about 13.8 billion years ago.

Narlikar and Hoyle did not accept the Big Bang theory; instead they proposed a *Steady State Theory*, in which the

(infinite) Universe experiences continuous creation (and destroying) of matter. They developed a theory of gravity that attempted to synthesise Einstein's general relativity with what is called Mach's principle: a philosophical notion suggesting that the inertia of

think of capital invested in a bank which offers a fixed rate of compound interest. That is, the interest accrued is constantly added to the capital which therefore grows too, along with the interest." He explained that the Universe expanded like the capital with compound interest. However, the Universe always looks the same to the observer.

With regard to many scientific theories, as more data is collected, one of the theories receives confirmation: in this case, the Big Bang theory. However, many tools developed for the steady-state model remain useful today.

Narlikar continued to work on other non-standard models of the Universe, which reflects his deep commitment to critical thinking in the theoretical sciences. He stayed in Cambridge until 1971 as a founding member of the Institute of Theoretical Astronomy.

In 1972 Narlikar joined the Tata Institute of Fundamental Research in Mumbai, where he led the theoretical astrophysics group. He wanted to create an institution in India dedicated to frontline research in astrophysics and the democratisation of science. Towards this, he helped to found the Inter-University Centre for Astronomy and Astrophysics (IUCAA) in Pune and served as its Director until 2003.

An important departure of IUCAA (from other established Indian research institutions) was its regular programs aimed at school children and the general public. Monthly lectures, science camps, and workshops became regular events.

every object is influenced by the presence of all the mass in the Universe.

Narlikar explained the theory in his popular writing using the analogy of a bank: "To understand this concept better,



Narlikar brought in science educator **Arvind Gupta** and set up a children's science centre at IUCAA.

Jayant Narlikar was also fierce in his commitment to nurturing scientific temper and condemnation of pseudo-science. In 2008, he co-authored a paper that challenged astrology using a statistical method, and then after wrote periodically on several instances of pseudo-science in India. Every time he was invited to talk to school children, he emphasised the importance of critical thinking in science and a commitment to data and calculation. Even in his last days, he continued to respond to letters from school children and writing about

science on his blog: <https://www.jvnarlikar.blog/>

Narlikar insisted that the scientific method was the best way to debunk superstitions prevalent in society, and led some studies of this kind. He wrote science fiction, but his stories were always founded on scientific principles. One of his books in 1986 addressed ethical issues in Artificial Intelligence and in 2015, one of his stories envisioned a virus leading to a global pandemic.

Jantar Mantar salutes this extraordinary scientist and science writer.



Puzzles to Puzzle You farmers and Lambs

Six farmers catch six lambs in six minutes.
How many farmers will be needed to catch sixty lambs in sixty minutes?

No, the answer is not sixty. Try again!

Or find the answer upside down!

From mathsisfun.com

(Now they have caught all those lambs, where are they going to put them?)

lambs will be caught.

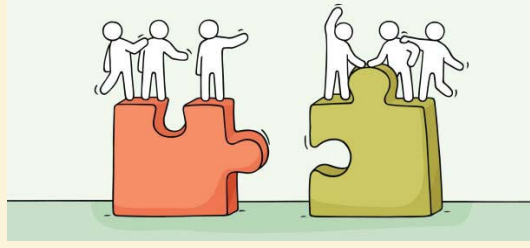
Another way of seeing the answer is to note that each farmer catches 1 lamb in six minutes. So in 60 minutes each farmer will catch 10 lambs (ten times as many). With 6 farmers, six times as many

they'll catch 10 times as many lambs, assuming they don't get tired! more times: The same 6 farmers catch 60 lambs in 60 minutes. (Give them 10 times as long and Let's see why: In the original amount of time: 6 farmers catch 6 lambs in 6 minutes. With 10 times

right answer is SIX farmers.

Ans: The answer was not 10 either! That is a popular answer, but I'm afraid it is not correct. The

From mathsisfun.com



How, and why, do our brains create 'Us versus Them' fault lines?

Reetika Sud,

NIMHANS, Bengaluru

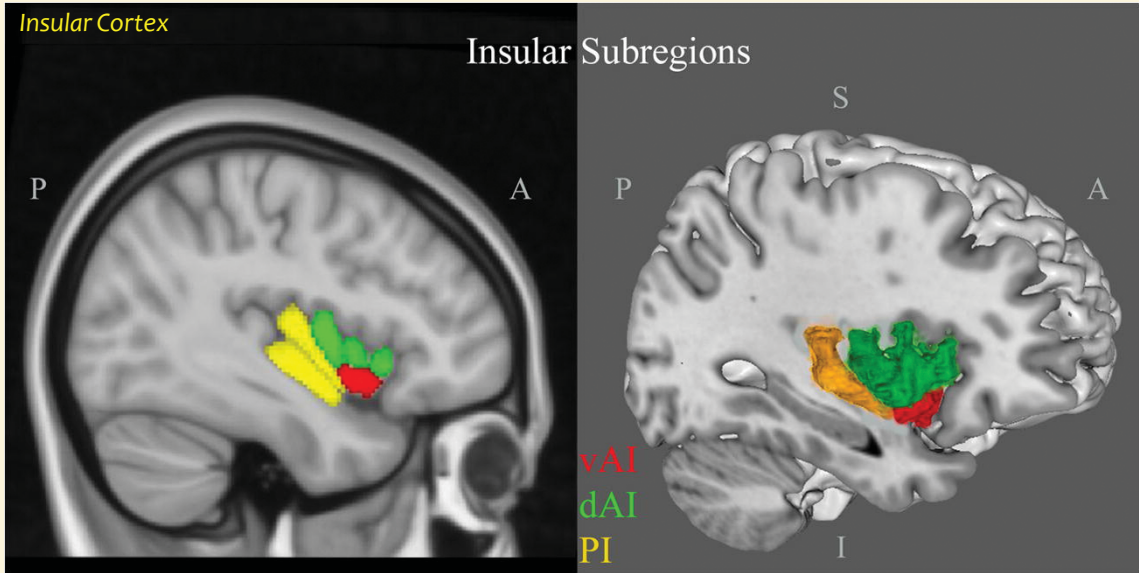
In an increasingly polarized world, we are separated by an ever expanding list of divides— from religion, castes, sub-castes, to political beliefs, sports teams loyalties, you name it. While the specific divisive reasons may differ across the globe, throughout history, humans have displayed preferential behavior towards in-group members (the “us”) over out-group members (“them”). This bias towards those we deem similar to us is not something unique to humans.

Rats use scents from chemicals called *pheromones* to tell relatives from enemies, their equivalent of “us” from “them”. Fish have a similar system. In humans though, no such chemical cues exist and we must rely on our brain’s system of sorting — who counts as “us” and who

are “them”? This is why we ask others— where are you from? Where did you grow up? Beyond the impressions [stereotypes] from surnames, even if not done consciously, people ask these questions as it can help classify others into us or them.

While this can seem like harmless, a “getting to know you” exercise, a cursory glance just through modern history can provide glaring examples of how easy it is to game this system (exploit it). Ideologues have manipulated masses, creating us-them divides with horrendous consequences. During the *Rwandan* genocide, **Tutsis** (the victims of the genocidal campaign) were referred to by the **Hutu** (the majoritarian group), as cockroaches. The **Nazis** presented Jews as vermin. All that it requires is for leaders with mass appeal to invoke feelings of such disgust in their followers towards “them” that they barely qualify as humans.

Insular Cortex



Biology of the human brain behind the “us-them” divide

Why do we people behave this way? Let’s try to answer this through the lens of **neuroscience**, and what it tells us about our brains. Reference to “them” activates a part of the brain called the **insular cortex**. In many animals including humans, this part does what’s called *gustatory disgust*. If you unknowingly bite into a rotten fruit, this part of the brain activates, causing you to spit out the fruit. The same with the gag reflex, etc - that’s all thanks to the insular cortex.

In humans though, it does something extra it doesn’t do in other animals. In addition to *physical* disgust, it also activates *emotional* disgust. Invoke “them”, and the brain’s disgust response is hijacked by the popular narrative.

At this point, we must talk about another part of the brain called

amygdala. This almond shaped part is situated deep inside the brain. Part of the emotional circuitry, this part does a lot of things, though it is most famous for fear and aggression. As a response from insular activation, neurons in amygdala fire up, and they can’t tell whether the insular activation is from physical or moral disgust.

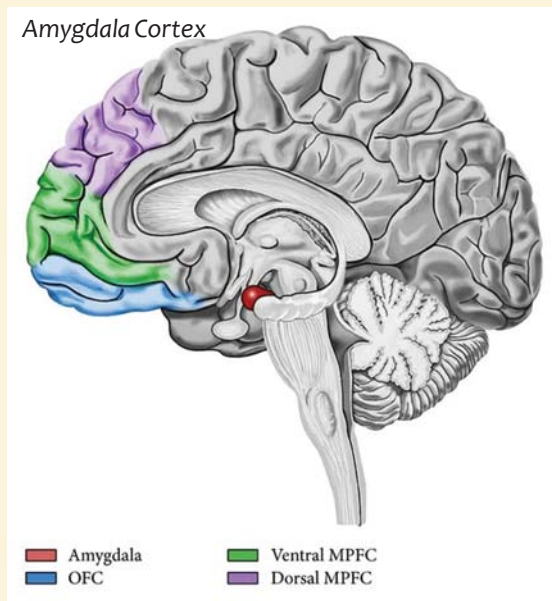
So, what does the amygdala do? Mention “them”, and you’ve activated fear response, a measure of aggression towards “them”, grounded in the fear. In humans, multiple neuro-imaging studies have documented increased firing from the amygdala, in a fraction of a second, in response to those deemed as out-group members.

Because a lot of this circuitry is similar in humans and other animals, we do learn a lot from experimental studies in animals. In fact, recent studies in rats showed young rats helped both in-group

and out-group distressed rats, whereas adults lent a helping hand preferentially towards in-group members. The rats that didn't extend help also showed increased amygdala activity.

This suggests that preference or bias towards those similar to us is not innate but learned. Amygdala activation is a reflection of *culturally learned* associations.

So far in the story, “you” the individual, have little role to play. You can't help the insular cortex or the amygdala from getting fired up, but luckily the amygdala also communicates with the thinking and decision-making part of the brain, the **prefrontal cortex**, the part that sits right behind the forehead. On the grand scale of evolution, this is the most recent part of the human brain. The figure shows the amygdala and various parts of the frontal (FC) and prefrontal (PFC) cortex.



Research into *racial bias* shows that individuals who better understand historical/cultural biases and who themselves are internally motivated to not follow along the same path, are also the ones who demonstrate helping behavior towards out-group members. This is the domain of the **cortex**. This is the cortex communicating back to the amygdala, “I hear you, but this is not a dangerous person”.

Why should we care about what seems like a confused bit of brain biology? Does this matter in real life? Once we start to differentiate ourselves from “them”, we also start to see meaningful differences in values and beliefs; so this becomes immensely critical. Because the **one** story, based either on one personal experience, or pieced together by your brain from various sources, becomes the **only** story. “They” are reduced to their difference from “us”.

Hardwired response?

During the **Vietnam war**, a US Army helicopter pilot **Hugh Thompson**, while flying his helicopter during a survey mission, noticed American soldiers executing civilians in the Vietnamese village of *My Lai*. What he witnessed prompted Thompson to land his aircraft between the soldiers (his colleagues in a sense), and the fleeing villagers. He threatened to open fire at them unless they stopped the killing.

In World War I, British and German soldiers entrenched along the western

front entered into an impromptu ceasefire around Christmas of 1914. It began as singing of carols from their trenches, and shouting out seasons' greetings to the other side. Soldiers soon emerged from their trenches to wish each other, exchange tokens, sharing food and drinks, and playing soccer. They also helped the other side bury their dead. Eventually, the men had to be ordered back by Generals on either side to retreat to their respective trenches and resume fighting.

These are just some but nonetheless remarkable examples of how fluid the “us- them” divide lines really are.

Because your brain does it, does that mean it is inescapable destiny? Brain activity is highly *malleable* (adaptable). Decades of research has shown that people process information about in-groups (“us”) and out-groups (“them”) differently, but the software in our brains is constantly getting updated and influences us on who counts as “us” and who as “them”.

Science tells us *there are no humans that are so different to us*. Thus, when we hear societal or cultural narratives presented to us as “facts of life” — “they” are bad people, whoever “they” are, and find ourselves getting sucked into it, somewhere behind it is the misappropriated bit of brain biology.

Being aware of our own biology can make us better informed especially when faced with narratives that arouse rather than inform.

Summer fruit

D. Indumathi,

The Institute of Mathematical Sciences, Chennai

Do you know that about 1,500 varieties of mango are grown in India? There are more than 1,000 commercial varieties. Each of the main varieties of mango has an unique taste and flavour.

By March-April, the early season begins, with varieties like *Bombay Green*, *Himsagar*, *Kesar*, and *Suvernarekha*. The peak mid-season in May-June sees varieties like *Alphonso*, *Bangalora*, *Vanraj*, *Banganapalli*, *Dashehari*, and *Langra*. The season ends with *Fazli*, *Mulgoa*, *Neelum*, and *Chausa*.

You must have already eaten different kinds of mangoes this season, as they come into “season” and go out of it. Mangoes are grown in almost all states of India. Each state is famous for different varieties. If you grew up in one area, you will probably think that this region’s mangoes are the tastiest! In southern states such as Andhra, Karnataka, Kerala and Tamil Nadu, varieties such as *Banganapalli*, *Neelum*, *Pairi* (*Raspuri*) are grown. In western states like Goa, Maharashtra, and Gujarat, *Mankurad*, *Vanraj*, *Alphonso* grow. In eastern states like Odisha and West Bengal, *Himsagar*, *Langra*, *Suvernarekha* are common. In northern states like Haryana, Himachal, MP, Punjab, UP, it is *Langra*, *Dashehari*, and *Chausa*. *Himayuddin* (*Himayat*) in Andhra

Pradesh is known as Imam Pasand in Tamil Nadu where it grows mainly in just one orchard in Trichy.

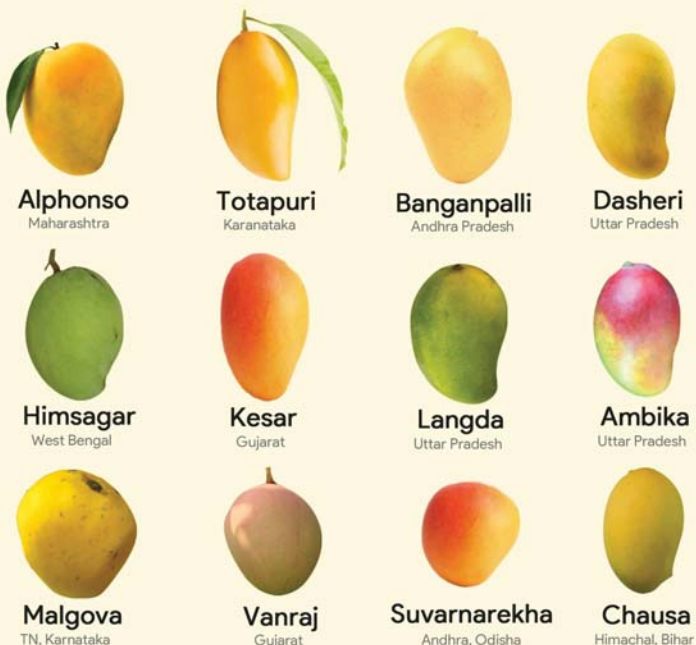
There are many hybrid mango varieties. "Hybrid" means that two different plant varieties have been crossed to produce offspring with combined traits. This allows breeders to create new varieties with improved characteristics like better yield, disease resistance, or (for mangoes especially) improved taste. Some of the more common hybrids are *Mallika* (*Neelum* x *Dashehari*), *Arka Aruna* (*Banganapalli* x *Alphonso*), *Ratna* (*Neelum* x *Alphonso*), etc., although very few of these hybrid varieties are grown commercially in the country.

The orchard starts bearing fruit after about six years and continues to give fruit for 35-40 years. However, the amount of yield depends on the variety and climate. Bumper crops occur when the rainfall is just right, and the climate perfect for the ripening mango. At that time, mangoes are plenty and cheap and we can enjoy them even more!

Sources: https://nhb.gov.in/report_files/mango/mango.htm,
Wikipedia



Indian Mango Varieties by State



CHANCE DISCOVERY

K. Sampath.

Scientist (Retd.) DRDO

Serendipity is the gift of finding valuable or agreeable things that a person did not actually seek for. These are fortunate and unexpected discoveries by accident or by chance. The Serendip was the ancient name of Ceylon and in a fairy tale, the princess of Serendip made discoveries by accident and sagacity. **Robert K. Merton** thought that it is a crucial part of the creative process for the chance discoveries in science.

There is a belief that chance knocks at the door of everyone at least once; it is for the individual not to let it go unnoticed and

instead grab it. It is also said that “time and tide wait for none”; it is very much true even in the scientific field. Unexpected or unanticipated results which arise in the pursuit of scientific research are called *serendipity* or accidental discoveries.

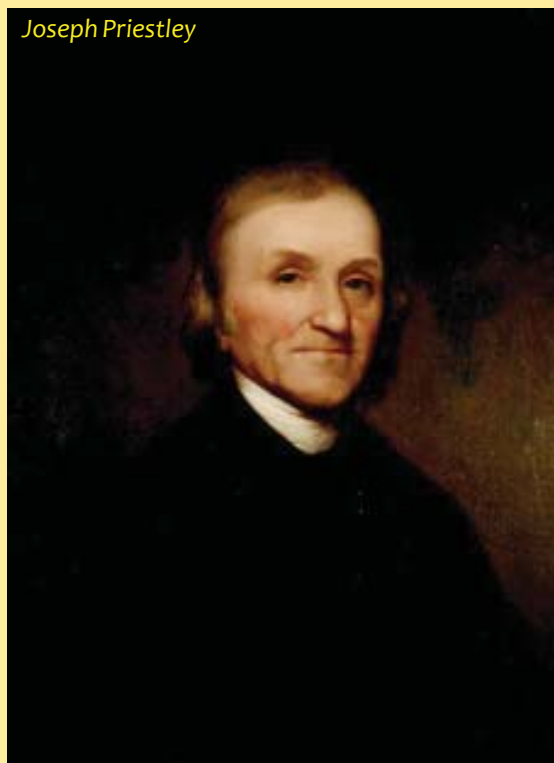
Serendipity – a new avenue for research

The primary purpose of research is to find or reveal some *new things* or knowledge; which can be achieved in numerous ways. Method of chance (accidental or serendipitous) discovery is one among them. Chance discoveries have opened up completely new avenues of research in all branches of science. Many of the revolutionary ground-breaking discoveries were the products of serendipity. Such chance discoveries are of significant value in the advancement of science and scientific knowledge. They are often the

Louis Pasteur



Joseph Priestley



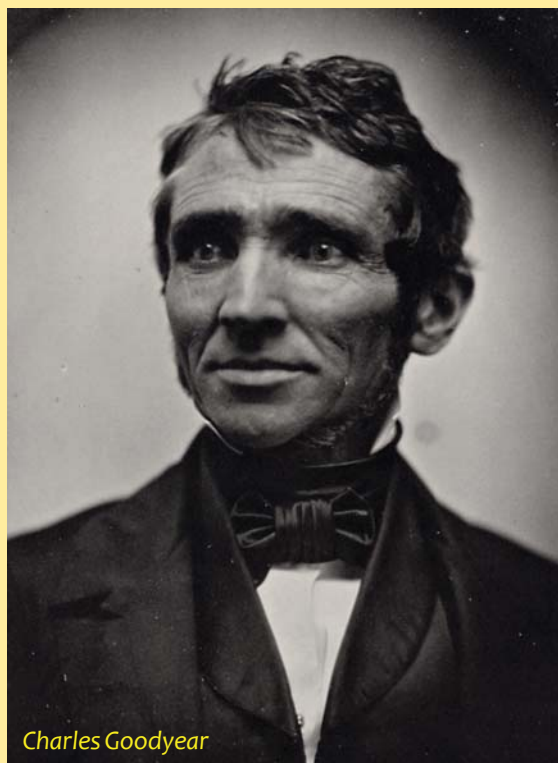
foundation for important intellectual leaps of understanding.

As expressed by W.I.B. Beveridge, Professor of animal pathology, most discoveries, that make new ground (revolutionary) are, by their nature *unforeseeable*; and almost the only way of making such discoveries is by stumbling across some clue to it accidentally.

Striking examples of empirical discoveries are found to be in **chemotherapy** wherein most of the great discoveries have been made by chance observation or false hypothesis. We will discuss a few popular examples here.

Pasteur and Chicken Cholera

In 1879, **Louis Pasteur**, renowned as the father of **bacteriology**, was researching **chicken cholera**, an epidemic that had



Charles Goodyear

devastated a significant portion of French poultry. He managed to isolate the bacterium responsible for the disease and was working on methods to eliminate it. He prepared a highly *virulent* culture of the bacteria, *potent* enough to kill chickens within a day of injection.

Just as Pasteur was about to test this culture on a group of chickens, his experiments were delayed for a few weeks due to a vacation. When he resumed his work, he found that the infectious organisms in the culture had weakened during his absence. Upon injecting the weakened culture into the chickens, they became mildly ill but eventually recovered. Remember that when the fresh sample was injected into the chickens, they had all died.

Principle of immunization

Pasteur realized that the weakened bacteria had effectively *immunised* the chickens, protecting them from the fully potent strain. This observation led him to the conclusion that the weakened bacteria had acted as a protective agent, making the chickens immune to the disease.

Pasteur later applied this principle to immunise sheep against **anthrax** and humans against **rabies**. It was purely by chance that Pasteur discovered the principle of immunisation.

Vulcanisation of Rubber

Rubber has been utilized for thousands of years, with evidence of its use dating back to around 1600 BC. Joseph Priestley coined the term “rubber” in 1770 after discovering its ability to erase pencil marks.

Rubber is obtained from certain plants and



trees in the form of a milky fluid known as **latex**. Synthetic rubber, on the other hand, is derived from petroleum and natural gas. Natural rubber, in its unprocessed state, is

unsuitable for practical use as it becomes soft and sticky in hot weather and hard and *brittle* in cold weather. **Charles Goodyear** faced numerous failed attempts to address these issues until 1839, when he accidentally dropped a mixture of rubber and sulfur onto a hot stove. Although he tried to retrieve the mixture quickly, he found that the rubber had lost its stickiness and gained flexibility, with improved resistance to temperature changes. After extensive testing, Goodyear determined the optimal conditions for heating the rubber to stabilize it.

This process of heating rubber with sulfur is known as “**vulcanization**,” named after **Vulcan**, the Roman God of Fire. Today, more than half of all rubber produced is used in automobile tyres. The remainder is used in various mechanical parts such as mountings, gaskets, belts, and hoses, as well as consumer goods including shoes, clothing, furniture, and toys.



Lionel Whitby in 1947

Pneumococcal Pneumonia

Sir Lionel Whitby experimented on a drug called **sulpha pyridine**; mice inoculated with pneumococcal pneumonia were being dosed once a day - once only. He was out for a dinner party one night, and while returning he visited the laboratory casually to see the condition of the mice and he gave the mice an additional dose of the drug. It was not pre-planned. He noticed those mice resisted the pneumococcal better than before. In fact, he achieved a 100% survival rate with this batch which he had never obtained before. He tried to understand the reason behind this success. After a week, he realized that the extra dose at midnight had been responsible for the excellent results. This result is an unexpected finding. From that time, men and mice were

dosed day and night. Thus, the old practice of giving one dose per day was discontinued. Then onwards Doctors started to prescribe one, two, three doses or more of medicines per day.

Many other chance discoveries

Other notable chance discoveries include electricity, urea, Velcro, synthetic dyes, natural radioactivity, penicillin, X-rays, microwaves, implantable pacemakers, and warfarin (a blood thinner). Each of these innovations resulted from unexpected findings, demonstrating the role of serendipity in scientific progress. Research has to be planned but discovery cannot be.

Newton and the apple

Newton's reflections that led him to his



Newton's apple tree



William Herschel

theories about gravity started when he saw an apple fall from a tree. The apple fell straight down, perpendicular to the ground; and he wondered, why the apple never fell upward or off to a side. Newton soon realized by his sagacity, that it was the property of all matter to have an attractive force, including the apple. The picture shows what is known as the Gravity Tree, in the grounds of

Woolsthorpe Manor, near Grantham, U.K. It is the descendant of the tree under which Isaac Newton sat in 1666, when he saw an apple fall near him, inspiring him to fully realize his theory of gravity. The original tree blew down in 1820, but the trunk remained rooted and this tree grew from it.

Discovery of Uranus

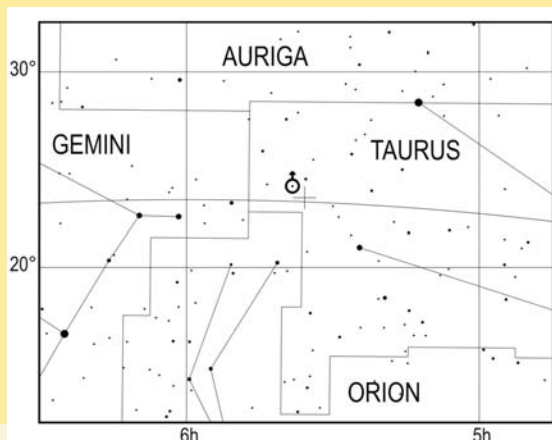
A legendary figure in astronomy, **William Herschel** discovered Uranus while surveying bright stars and nearby faint stars. He first thought it was a comet, but he and other astronomers soon realised that it is a planet. See the picture where the position of Uranus is marked with a cross; this would have been its position on 13 March, 1781, the day it was discovered nearly 250 years ago.

Difficulties in chance opportunities

Research activity is one part of life. Failures and *frustrations* are part of life and so in research as well. *Acute* power of observations is often required to circumvent failures. Many scientists have failed to appreciate the significance of the clue observed and thus lost the chance of discovery. One of the examples - X-rays was discovered by Rontgen, but before him, at least one physicist saw the evidence of the rays. But he did not realise what they were: he was merely annoyed.

Scientists estimate that between 30% and 50% of all scientific discoveries happen by chance. These accidental discoveries occur when talent, effort, and luck come together—essentially, chance discovery = Talent + Effort + Luck (TEL). Maybe you, the reader, will one day make a wonderful discovery by chance!

Discovery of Uranus 1781





Ref: The art of scientific investigation by W.I.B. Beveridge;
http://en.wikipedia.org/wiki/Role_of_chance_in_scientific_discoveries.

Glossary

(Meaning of words in this article: See if you can find these words and understand their meaning)

Acute: showing good understanding or insight

Brittle: hard, but can easily break

Crucial: decisive, critical

Frustrations: upset because of being unable to change/achieve something

Immunise: make resistant to a disease, typically by vaccination

Potent: having great power or effect

Revolutionary: causing dramatic change

Sagacity: wisdom

Unforeseeable: not anticipated

Virulent: severely harmful

The Story of Tom's Cat in a Box

*K. Monica Sneha, K. Kannan,
and M. Sabareesh*

It was a free period for class 8. The science teacher came in as their substitute teacher. Everyone liked the science teacher Mr. Armstrong. He always told interesting stories and kept the class engaged during the free hours. Today the topic of discussion was pets. It was Tom's turn to introduce his pet cat, whose name was Mr. Whiskers. As Tom spoke about his favourite cat, Mr. Armstrong wanted to talk about his own favourite.

"Have you guys heard of Schrödinger's Cat?", Mr. Armstrong asked the class. The students were intrigued by the strange name and asked, "What is that?"

Mr. Armstrong smiled and said, "Let me tell you a story about a cat in a box."

So, Tom imagined a cat inside a box, and here's how the story went:

Tom imagined placing his favorite cat, Whiskers, inside a special box. Now, there was a small device in the box that could either release a gas or not, based on whether a tiny particle behaves one way or another. If the particle behaves in one way, the gas is released, and the cat falls asleep forever. If the particle behaves another way, the gas doesn't release, and the cat stays awake.

Schrodinger's Cat



Whiskers is both asleep and awake at the same time?" asked one of the students.

Mr. Armstrong nodded. "Exactly! And as soon as you open the box, you see one thing happen – either Whiskers is asleep, or she's awake. But before you check, she's in both states at once."

The students thought about it for a while, when one of them said, "Wow, that's so weird! So, it's not until we look that we know what's really going on?"

"Yes!" said Mr. Armstrong. "That's the mystery of Schrödinger's

But here's the twist: Tom couldn't see what was happening inside the box because it was sealed shut (Somehow, of course, there was always enough oxygen so that the cat could keep breathing). So, what could Tom know about Whiskers?

At first, Tom thought, "Well, Whiskers is either asleep or awake, right? But I can't see her, so which one is true?"

Mr. Armstrong explained, "Here's the strange part: until you open the box, Whiskers is both asleep and awake at the same time. That sounds weird, right? But that's because the tiny particle inside the box hasn't made up its mind yet. So, until we check, we have to imagine that both things are happening."

The students' eyes grew wide. "So

Cat. While the cat is a big animal, this is what Quantum Mechanics means for small particles like atoms and their components. (See article on **Quantum Mechanics** in this issue of *JM*). It shows how tiny particles can be in many states at once, and we don't know exactly which one until we look."

Tom now understood the strange idea. He smiled and said, "I'll never look at Whiskers the same way again!"

And from that day on, Tom always wondered what was going on inside his cat's box, even if he never actually put Whiskers in one!

And once again Mr. Armstrong created an interactive class about the laws of quantum physics in an interesting way for children.

Do You Know

1. How much brainpower do our senses take up, and is there one that takes up the most?
2. Why do some people get bitten by mosquitoes more than others?
3. Can we make a plant entirely “from scratch” using only DNA?
4. Do fish in the deep sea experience seasons?

Answers to these questions will appear in the next issue.

Answers to Last Issue's Do You Know?

1. There are many household things made of plastic in our homes that are non-recyclable. How can we best dispose of them? Do we bury them, burn them, what is best to do?

Ans: Plastic is a petroleum derivative and difficult to dispose of. By indiscriminately dumping plastic into rivers, oceans and dumping grounds humanity has created a negative impact on the environment.

On the other hand, plastic is immensely useful, and being cheaper than material such as wood and metal, has eased the lives of the poor. If recycled, it can be used well. Plastic can be made to form recycled polyester which in turn is made to produce a number of things like shoes, T-shirts, bags, chairs etc. thereby causing less strain on natural resources.

Very few people know that every type of plastic can be

recycled several times. Nearly a quarter of the plastic being produced is currently not recycled. This majorly is due to items like wrappers, plastic bags, milk pouches, multilayer chips packets etc. They are not picked up for recycling only because they are light in weight and dirty. These plastics lie in the dump yards and cause havoc.

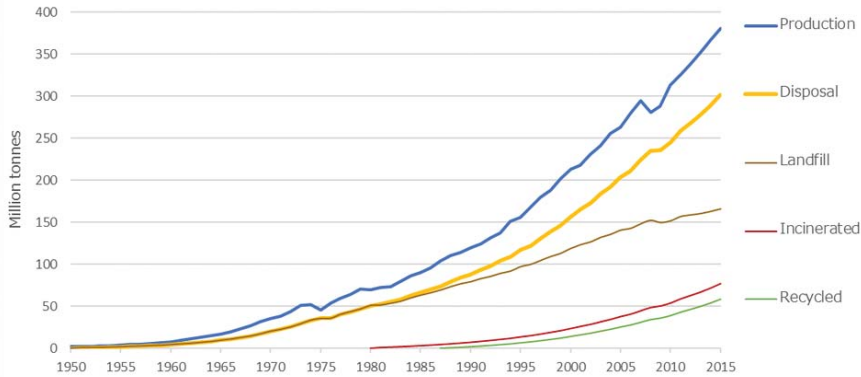
The plastic recycling process includes cleaning of the plastic, cutting it into flakes and then melting it at high temperature for moulding into desirable

Plastic waste



Global production and fate of plastic

Global quantities of plastic produced and disposed of annually, showing the estimated amounts disposed of via landfill, recycling and incineration.
(Based on data by Geyer *et al.* (2007) DOI: 10.1126/sciadv.1700782)



Black or Gray is used for general waste that does not fit into other categories.

Cleaning and flaking: After the plastic reaches the recycler, all the plastic is sorted again, cleaned with large amount of

useful form.

Collection: The first step is to separate Dry and Wet waste. The former can be emptied and cleaned easily and stored away, often sold to people who in turn sell plastic in bulk. The rest of the plastic which are mixed with wet waste, and take time and energy to be cleaned, go to the garbage collection trucks, eventually landing up in dumping ground.

Segregation: This is a crucial step, separating waste into different categories. Often different coloured bins are used. Green is generally used for biodegradable or organic waste, such as kitchen scraps and garden waste. Blue is typically designated for recyclables like plastic, paper, metal, and glass. Where used, red indicates hazardous waste, including batteries, e-waste, and medical waste. (In some societies, medical or infectious waste is handled separately, yellow being its colour.)

water and then shredded into small pieces. The shredder then converts the plastic into flakes or pellets. Once that is done, the flakes are then subjected to further washing, drying and are ready to be shipped to manufacturing units for making several kinds of recycled products.

A range of products are now made from recycled plastic. Look around you, and ensure that all the plastic you see is



reused and recycled.

2. *It is summer and the air is full of flies. Where do they go in winter?*

Ans: Flies do not really go anywhere for the winter. Where it is cold, like in northern India, the adult flies die off in outdoor spaces but the species survives the winter as *larvae* (also called *maggots*) or *pupae* — the shell in which they transform from larva to fly in the spring.

A favoured location for larvae and pupae to survive is under a pile of manure (or in India, cow dung!), but they can make do with your house. A house fly can live up to 60 days, but without food, they only survive about three days. Even if you are not handy with a rolled newspaper, the problem is easily solved by not leaving garbage lying around!

The real problem is that that are produced in large numbers: their cycle is opportunistic, flexible, and depends heavily on ambient temperature. Females lay about 500 eggs that take between 8 and 48 hours to evolve into larvae, which in turn take between 4 and 30 days to complete their development, depending on the temperature. During these immature phases, they live in decomposing organic matter, often excrement, which by the action of bacteria can ensure a relatively moderate temperature.

3. *How do creams go through the skin?*

Ans: The first thing to remember is the basic structure of the skin: it is designed to keep things out! The top layer, the

Recycled Plastic Pellets



epidermis, consists of a watertight roof known as the **stratum corneum**, where cells are glued together with fatty acids. The middle layer, the *dermis*, contains blood vessels and vitally important structural proteins **collagen** and **elastin**. This is the layer that makes your skin appear plump and youthful. The bottom layer, the *hypodermis*, stores fat and energy, insulating and protecting the body, connecting to bones and muscles.

The thinner the skin, the easier it is for cream to penetrate. The skin of your face is thinner than the skin on your palms and the soles of your feet for example. The delicate skin around your eyes is the thinnest of all, so most vulnerable to sensitivities.

There are two ways by which creams may go through the skin: absorption and penetration. *Absorption* refers to when an ingredient reaches the bloodstream, and we do not want cosmetics to do this! *Penetration* refers to when a chemical gets past the outer layer into the deeper layers



of the epidermis. This is what creams do. Often they do not even penetrate into the skin, but only provide extra, hydrating layer on top of the skin, nourishing the skin barrier.

What about the creams that do enter into the three layers? There are three routes for this.

Intercellular: They slip in between the cells of the outer skin. The glue holding these cells together are fatty acids, so water or oils cannot use this route.

Intracellular: This is when extremely tiny ingredients actually slip into the cells of the skin and then through them.

Follicular: This is when ingredients can enter through openings that

already exist in your skin: think of your pores and hair follicles. However, these tiny openings are few and far between, so only a few creams can enter into the skin this way.

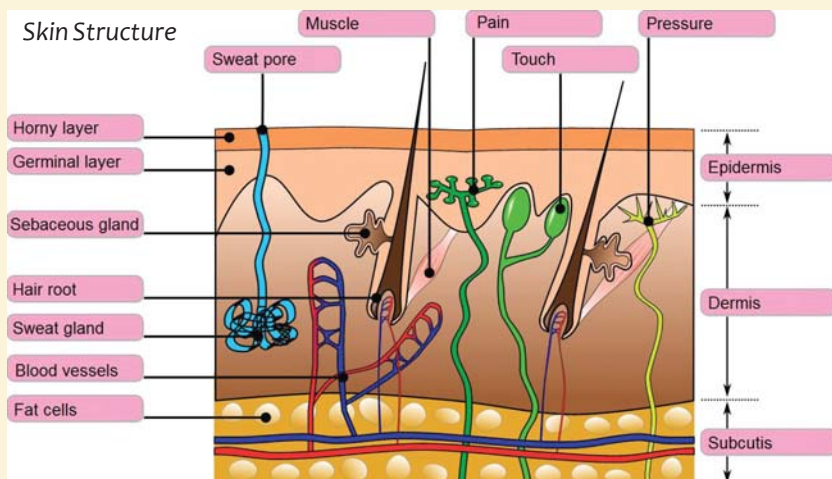
In general for chemical creams, the molecules need to be small to slip between the gaps in the skin cells and the ingredients should be able to dissolve in oils or lipids.

The condition of the skin also plays a crucial role in the absorption of creams. Hydrated, exfoliated, and treated skin can allow better penetration than dry, flaky skin. When skin is dry, it can form a barrier that prevents the ingredients from penetrating.

What regular use of the chemicals in creams does to skin is another matter.

4. If you have been observant, you would have noticed that boat and plane propellers are in different places. Why?

Ans: This is a very interesting question. There are good physics reasons for these different propeller placements, but also several practical ones.



Ship Propellers



The physics first. The big difference between water and air is that water is very much more dense than air. So if you take one metre cubed of air (1 m^3), it weighs about a kilogram, whereas a metre cubed of water weighs about a ton, a *thousand times* more. This means that propellers for aircraft need to be much bigger. This is because the thrust you get from a propeller is related to the amount of the mass flow that passes through the propeller and the speed with which the propeller can push that backwards. Thus it matters where you put propellers on an aircraft.

Now the practical aspects: you cannot have a propeller that is too close to the ground that might then hit the ground. You cannot have it towards the back of an aircraft that might affect how the aircraft could land. You also do not want people sitting too close to propellers. The distribution of weight on an aircraft is very important. The propeller is also

attached to an engine and the engine tends to be heavy. If you have too much weight towards the back of an aircraft, that will affect how the aircraft can be controlled in flight. So you prefer to mostly have the aircraft propeller in the front, although some models have them at the back.

When it comes to boats, because the water is a thousand times more dense than air, how the flow enters the propeller is important. The propeller on the boat is much smaller and we mount it at the back of the boat so that the flow is just leaving the boat as it passes the propeller. Sometimes there are two or three propellers on a boat.

Another difference is that there is air both inside and outside an aircraft, so if the propeller joint/seal leaks a little, it doesn't matter. But there should be only air and no water inside a boat, so if the

Bombardier Propellor



propellor joint leaks, you would rather place it at the back of the boat.

It is also a question of where the engine is mounted. We often want a small boat to pitch up a little bit so that the boat can then move more smoothly through the waves. The weight of the engine can help with that, so the relative placement of engine and propeller is crucial.

Researchers are now experimenting with electrically-driven propellers, which can be made much smaller. Then they can be distributed over the aeroplane, giving more flexibility in the design of the aeroplane. Aircrafts in future may have small propellers mounted on the wings, blowing air over the wing to improve wing performance.

Sources: Different online sources



Puzzles to Puzzle You

True or false

A man is caught on the King's property. He is brought before the King to be punished.

The King says, "You must give me a statement. If it is true, you will be killed by lions. If it is false, you will be killed by the trampling of wild buffalo."

But in the end, the King has to let the man go.

What was the man's statement?

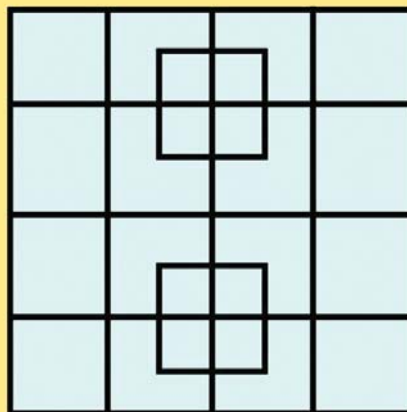
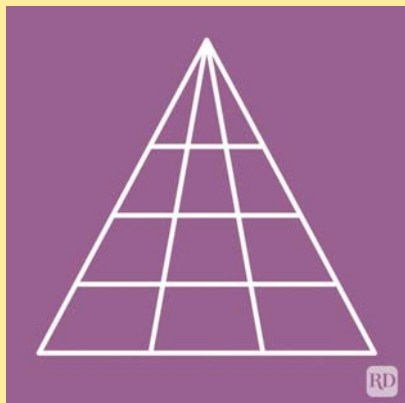
Ans: He said, "I will be killed by the trampling of wild buffalo."
If you think about it carefully: the King can't say it is true, because if so the man should be killed by the lions. But if he is killed by the lions, then his statement would be false, and so should have been trampled by buffalo. So the King can't tell if it is a lie or truth, so decides to just let him go.



From mathsisfun.com

Count the number

How many triangles and squares are there in the pictures below? Count them carefully, there need not be all of the same size, and they may be nested within each other, so are more than you think!



Answer upside down!

Ans: 24 triangles and 40 squares.

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