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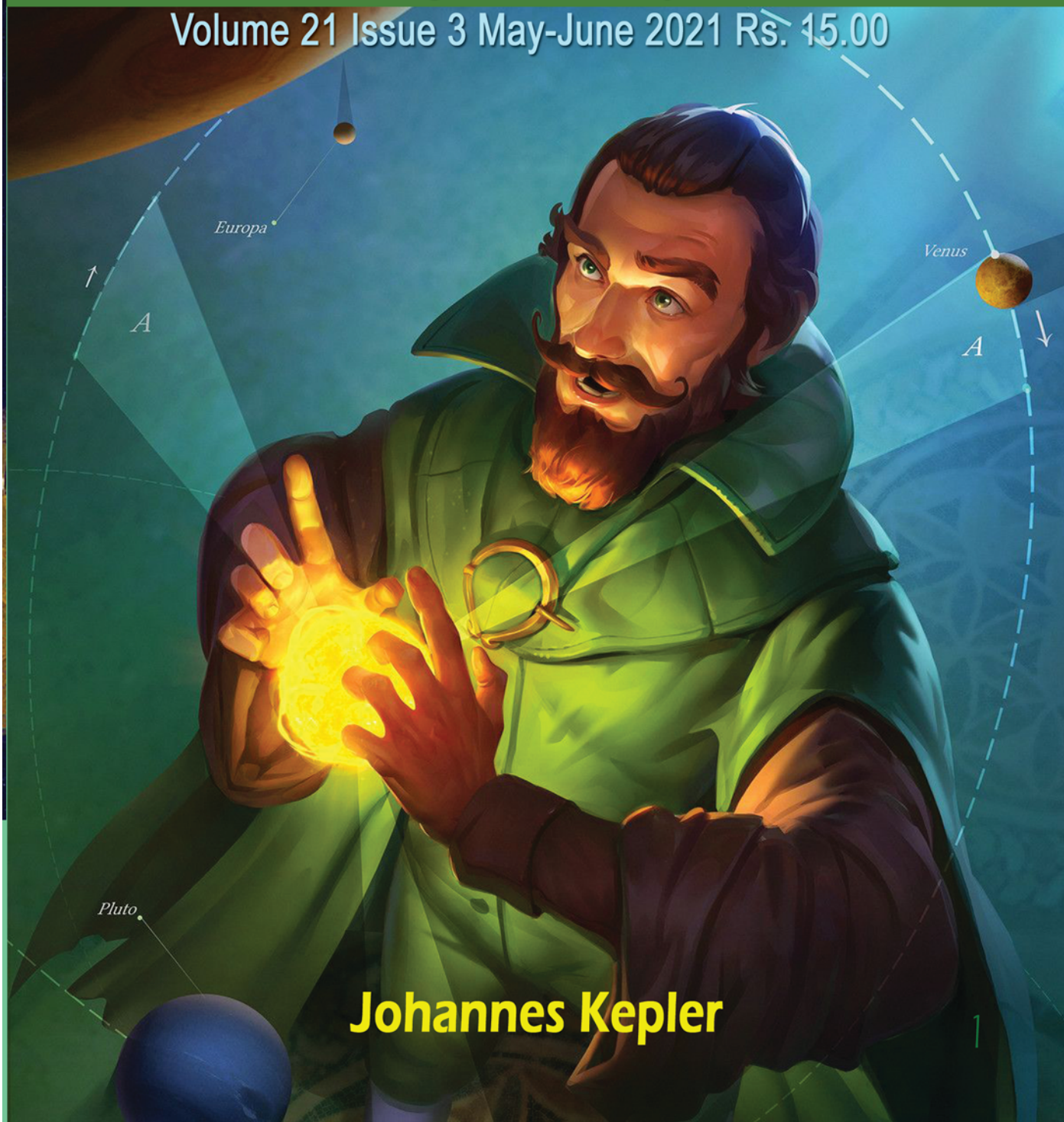
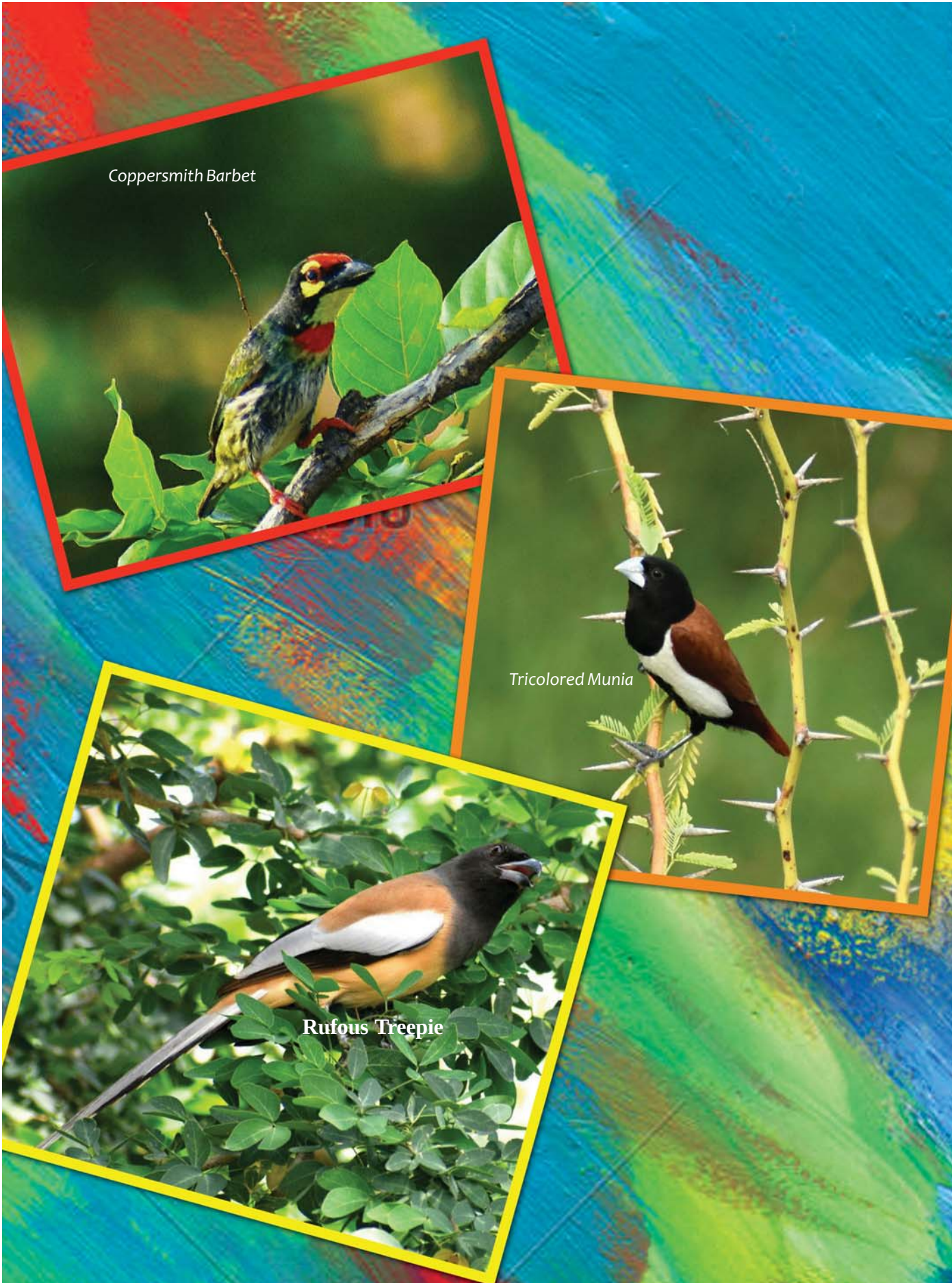


Johannes Kepler


Coppersmith Barbet
Tricolored Munia
Rufous Treepie

My Journey into Birding

Interview: Angeline Mano,
Salem Ornithological Foundation

Seeds of feathers

My mother was the one who sowed the seeds of birding in me during my school days. She used to show me birds around us, tell their names and some behaviour. Another reason for my interest toward birds was because of my mum's habit of feeding them by placing water and grains at the backyard. Crows, mynas and few other species visited and used to feed on grains and sometimes watching those feeding their young made me to think more about it.

Since childhood, I have always had great love for nature. My grandmother's place is a village near *Tamirabarani River* and I used to watch the black waterbirds (later I knew them as **Cormorants**) with delight. As days passed, enjoying the sounds of birds was becoming a habit. On January 12, 2018, my parents bought me a camera and I started photographing birds.

First step into birding

As I didn't have proper guidance to birding, finding the names of birds was a task on its own. One day I just simply captured a colourful bird on camera (see photo) and sent the picture to one of my college seniors who had immense love for birding. **Tamil Selvan** told me that it was a **Coppersmith Barbet** (*Psilopogon haemacephalus)* and got the name as coppersmith because of its metallic call. He further gave me an introduction to birding, taught me bird names, interesting behaviours and suggested some books. I was in awe of the fact that there's plenty to know about birds and there started my journey into birding. After this, my love for birding grew exponentially as I began to watch more and videographing their beauty. Few weeks later, Tamil Selvan explained me about ***eBird***, an international platform to document and monitor birds. I registered at once and I regularly contribute data and upload images as well.

Budding days of birding

One day from my balcony, I was so thrilled to see a **Purple Sunbird** (*Cinnyris asiaticus*) going near the nest of **Scaly-breasted Munia** (*Lonchura punctulata*) and they became noisy. Mommy Scaly-breasted Munia and Daddy Scaly-breasted Munia were guarding their nest. Later I found that there were juveniles in the nest.

On October 2018, I visited **Kannankurichi (Mookaneri) Lake** with Tamil Selvan. I saw many species including **Little Cormorants** (*Microcarbo niger),* **White-breasted Waterhen** (*Amaurornis phoenicurus),* **Little Grebe** (*Tachybaptus*

ruficollis), **Indian Pond Heron** (*Ardeola grayii)*, **Asian Koel** (*Eudynamys scolopaceus)*, **Striated Heron** (*Butorides striata)*, **Tricolored Munia** (*Lonchura malacca*; see photo). That was a great new experience for me and glad I took my best companion *Nikon D3400* camera to click those birds.

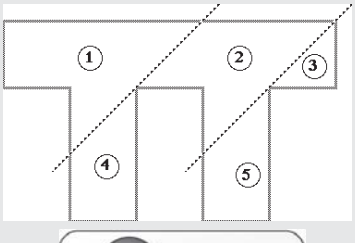
From disappointment to delight

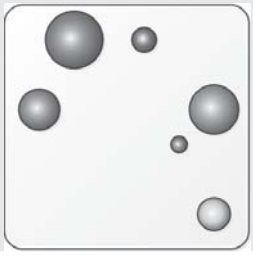
As I became so passionate in birding, even the small call of birds was so sharp to my ears. One day as I returned home from college, I heard a different call which I hadn't heard before. So, I took my camera and went searching for the bird but couldn't find it. I returned disappointed and few minutes later I heard the same call from my backyard. This time, I just got a glimpse of its tail. To get a good view, I literally climbed the wall and clicked the bird and referred the book to know its name. It was a **Rufous Treepie** (*Dendrocitta vagabunda*; see photo). That was an awesome and thrilling moment! These days, every time when I just hear the calls, I am unable to ignore it and I start to bird.

I'm so thankful to my parents and my uncle **Shenbaharaman** for motivating me in birding. My uncle said that it is better to do birding, enter the field of ornithology and live along with birds and show people their beauty and importance rather than doing other profession. These words penetrated deep into my heart and mind and made me to continue birding with more vigour.

Love for birding

Birding is a feeling that cannot be expressed in words. When I am birding, I just forget myself and never take my eyes from it. Watching them doing cute things gives a great relaxation and bliss to mind and heart. What I love about birds is—how they behave, because just by observing them we can understand lot of things in life. Birds connect us to nature. In future, I will show people how to conserve the natural world and I really hope that birding and birds will help me to do this. I also strongly recommend everyone irrespective of their age, to take birding as a hobby and fly with them!





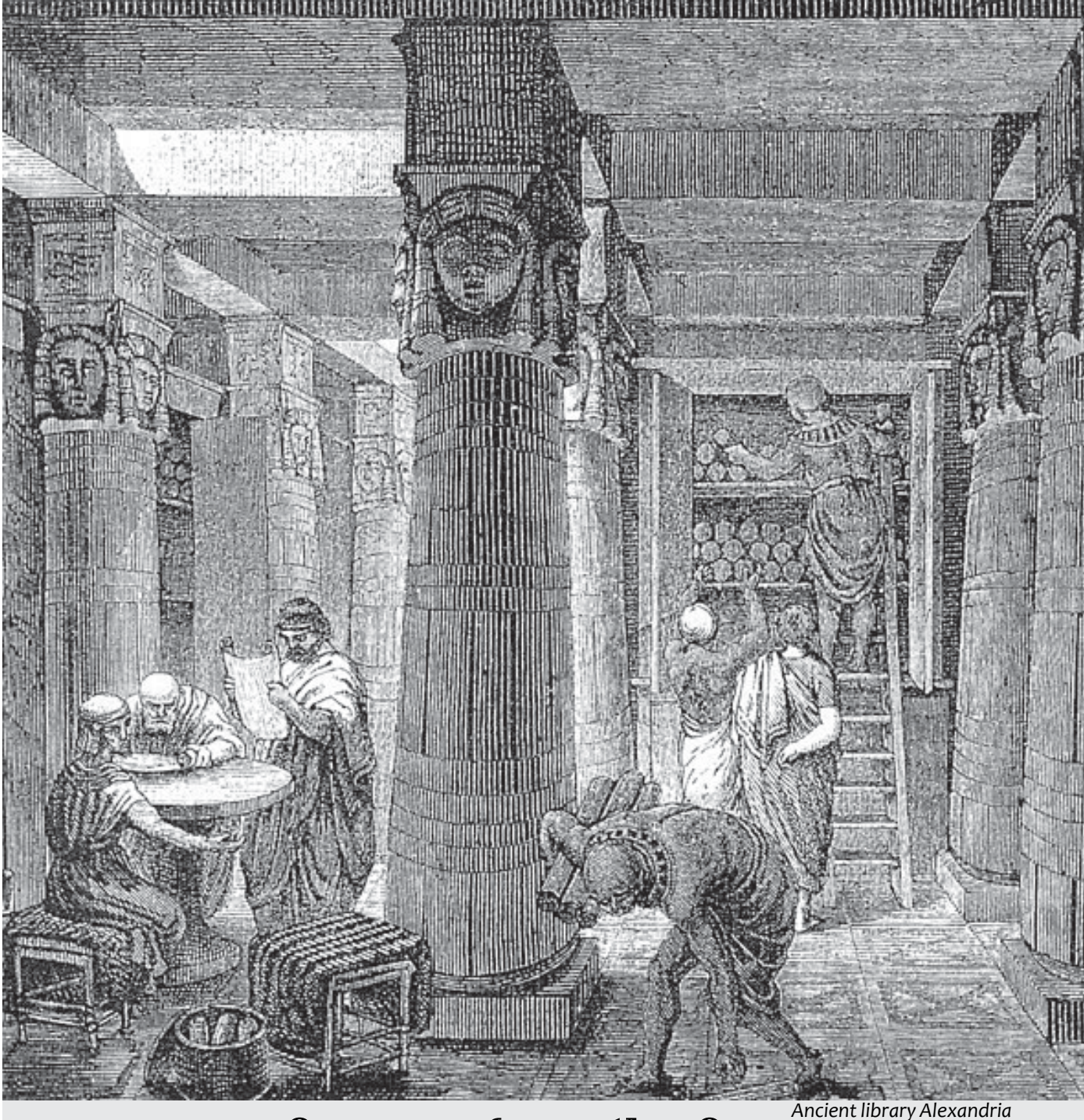
Puzzles to puzzle you

1. Can you see the Greek letter Pi in the figure? Make one for yourself. Then cut it up into 5 pieces as shown. Put them together to make a square. Is there more than one way?

2. You have six beads placed in a plane. Find two pairs of equidistant beads. That is, find a pair of beads that are exactly the same distance apart as another pair of beads. The distance between two beads is meant as the distance between their centers.

Source: www.mathisfun.com

Solutions on page 9



Ancient library Alexandria

Seasons from the Sun

Kamal Lodaya

Bengaluru

The first two articles discussed *phases*, days when the Moon is lit up the most (*poornima*) and least (*amavasya*). We saw that 12 lunar months gives 12 months times 29.5 days/ month = 354 days. There is a 11 days gap to match the lunar calendar with the seasonal year, when Sun-Earth-stars come back to the same relative positions.

Solstices are days when we have the most and least daylight in the year, from sunrise to sunset. As sunrises and sunsets (the position of the Sun) move in the sky from day to day, the Sun's position in the sky was marked by *rashis*, which are some constellations of stars. The Sun's movement from one rashi to another is called a sankranti.

Intercalary calendars track both Moon and Sun

The Greek observer and engineer **Meton** is known for his study of counting, a subject that mathematicians call *combinatorics*. The Greek new year began with **summer solstice**. Meton observed where summer and winter sunrises and sunsets happened on the hills around Athens, where he lived. The foundations of his observatory can still be seen in Athens (see photo). Meton is also said to have built a public sundial. He was popular enough to be a character in a play by Greek playwright **Aristophanes**, appearing on stage to solve a geometrical problem.

Based on his dating of solstices, in 432 BCE Meton made a suggestion. The same phase of the Moon occurs on the same day of the year, once every 19 years, which Meton counted as 6940 days. This matches modern data since 19 seasonal years = 6939.60 days and 235 lunar months = 6939.55 days.

The gap with lunar months would be 19 years times 11 days/year = 209 days. Of course, 19 years would be expected to have 19 years

Meton-observatory ruins

times 12 months/year = 228 months.

As 12 years times 12 months/year + 7 years times 13 months/year = 235 months, Meton's suggestion was to add 7 **intercalary** (*adhika*) months every 19 years, 6 having 30 days each and 1 with 29 days. Seven months over 19 years works out to 2.71 years/month. Therefore these adhika months have to be introduced every 2 or 3 years.

The idea of intercalary months was known much earlier. Sumerian calendars used them in the 21st century BCE. Adhika months were introduced when the months seeemed to be going off course with the seasons. But as we said, these were decided and announced by kings.

In Meton's system, followed by the Hebrew calendar of **Moses ben Maimon** (12th century CE), adhika months are during the 3rd, 5th, 8th, 11th, 14th, 16th, 19th of a 19-year cycle, so that the calendar has 235 months in 19 years. This is simple enough to be a popular school project. It is said Meton's system was earlier in use by the Persians of today's Iran.

Solstices keep changing

Makara rashi sankranti (the date when the Sun appears to enter the Makara rashi in the sky) coincides with the festival of **uttarayana**, Karka rashi sankranti with **dakshinayana**. These days winter solstice (least daylight) happens on 21 December, but the festival of uttarayana is celebrated on 14 January. Summer solstice (most daylight) is on 21 June, dakshinayana is celebrated on 16 July. Why this disparity?

Very precise observations of bright stars, such as *Chitra* (Spica), were recorded by Egyptian observer **Timocharis** around 290 BCE. Egyptians had been observing the stars at least since the 25th century BCE. After Greek emperor **Alexander** conquered Egypt, the Greek empire absorbed a lot of their knowledge. Most likely Timocharis worked in the library in the Egyptian city of Alexandria, named after the former emperor. A 19th century rendering of the library, based on archaeological evidence, is shown in the picture.

Eratosthenes of Shahhat, Libya, lived later in the 3rd century BCE. Libya was ruled by Greece and the Greek empire had schools (a school was called a *gymnasium*). Eratosthenes studied and later became chief librarian at Alexandria. He became famous for measuring the circumference of Earth. A 17th century painting of him teaching in Alexandria is shown in the picture.

Eratosthenes pointed out another disparity in the Greek calendar of 365 days, that the seasons kept shifting. This shift was estimated at 1 day every 4 years. You may remember that Greeks used to have the Olympic games every 4 years since at least 7th century BCE.

So you leapt ahead to Eratosthenes's idea? Priests under the Egyptian ruler of that time, **Ptolemy III**, announced that every 4 years an *intercalary* day would be added to the year. But the Greek emperors may not have agreed and the idea was lost.

Then around 130 BCE, Greek astronomer **Hipparcos** compared position of star *Chitra* (Spica) with that recorded by **Timocharis** 160 years before him on the same date, and exactly measured how the relationship of

seasons with the stars changes. So he scientifically demonstrated that seasons keep shifting. Today we know that the rotation of Earth *precesses*, like a top whose axis keeps shifting slightly as it spins. Hipparcos lived in today's Turkey which was conquered by **Alexander**. The mathematical subject *trigonometry* of measuring angles in a triangle is attributed to him.

A seasonal calendar

It still took several centuries before the idea of a **leap year** of 366 days every four years was adopted. From 45 BCE, the Italian emperor **Julius Caesar** abandoned traditional intercalary lunar calendars and moved to a calendar based on seasons. It is attributed to the Egyptian astronomer **Sosigenes** of Alexandria. The year 46 BCE had 445 days to correct for all the errors which had crept in from earlier calendars. Today's space missions still use the Julian calendar.

The seasonal "months" January to June are named after European deities. July is named after Julius Caesar and August after another Italian emperor. The celebration of January 1st as new year also comes from the Roman empire.

In four years the fraction 0.2422 in 365.2422 days that Earth takes to go around the Sun adds up to an extra 0.9688 days, nearly 1 day. A leap day (29th February) is introduced every 4 years to make up this extra day. So we have 1461 days in 4 years, an average of 365.25 days per year.

When an extra day is thrown in every four years, 48 lunar months would have a total of 354+354+354+355 = 1417 days, 354.25 days on the average. A lunar month would have 29.52 days on the average. A more sophisticated calendar would now have to match lunar months with solar years. The scene now shifts to India and its panchangas. The next issue of *JM* talks about them.

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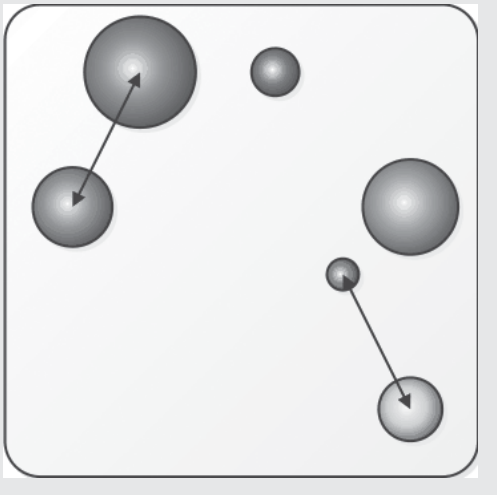
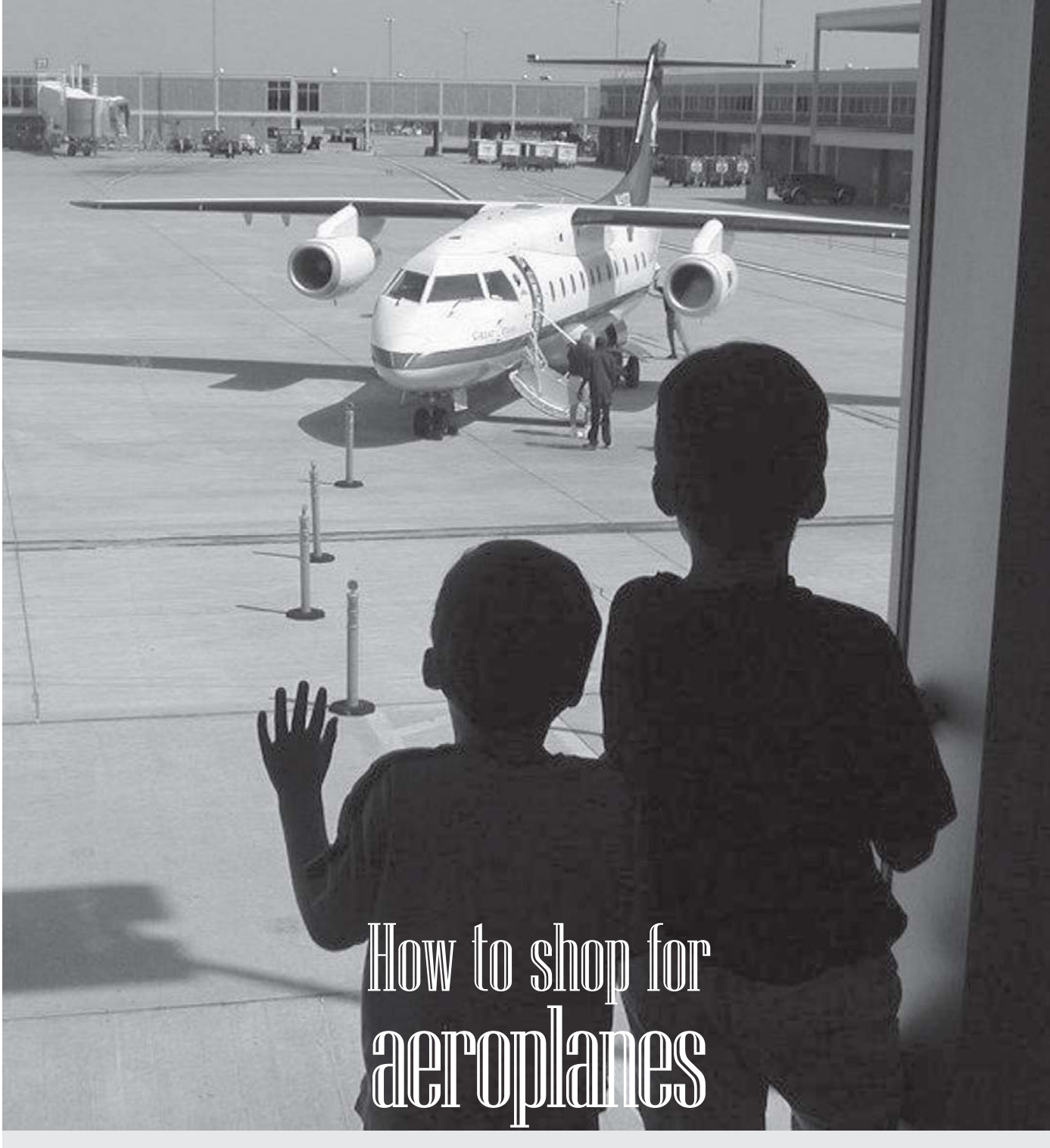
Solutions to Puzzles to puzzle you on page 4



1. See the figure for the solution. If you exclude mirror flips (reflections and rotations), this is a unique solution.

2. See the solution figure.

Source: www.mathisfun.com



How to shop for aeroplanes

S.K. Karthick,
Israel

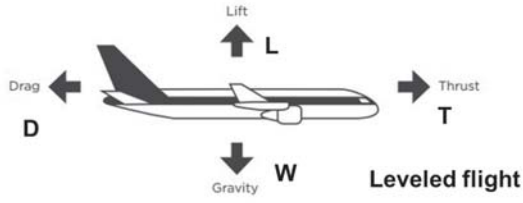
We go shopping every day to buy necessary goods. We consider the quality of the product, the company that made it, and maybe even look at online reviews. When it comes to electronics or mechanical items, we always check the performance parameters.

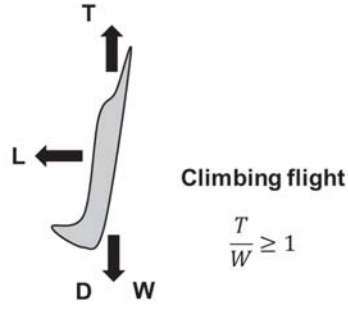
Rahim and his family

Consider a particular case here. Rahim's family decides to get a 4-wheeler for general transportation. There are 5 members, and they live in a crowded city. Rahim is the earner for the family, and he is not that rich. They choose to select a vehicle based on its performance. They consider three four-wheeler types: 1. bus, 2. truck, and 3. car, and pick three performance features: 1. Horsepower (how much load the vehicle can pull), 2. Fuel consumption, and 3. Turning radius (mimimum radius of curvature needed to make a turn). While a bus and truck has more power (about 200 HP), it uses more fuel per litre (it travels less than 10 km per litre while a car gives 15) and requires a large turning radius (more than 6 m, while a car needs less than 5 m). You can see that a bus or truck is not useful. Rahim is left with only the car, based on the performance parameters that he had selected.

Shopping for aeroplanes

While going to shop for aeroplanes, one has to note some exciting performance parameters before purchasing. In fact, those different parameters result in a wide range of aeroplane configurations being in existence. Like the Rahim family, if a country decides to get an aeroplane to transport their citizens from one place to another or defend their airspace from





enemy intrusion, it has to carefully monitor: 1. *Thrust to weight ratio*, and 2. *Lift to drag ratio*. There are many other important performance parameters that one must consider while shopping for planes. Still, we seek the ones mentioned above to determine the vehicle's overall shape, structural limit, and propulsion requirements in a global sense.

Forces on an aeroplane

Thrust is the force which moves an aircraft through the air.

The aeroplane gains **lift** using the wings. However, there should be air flow around the wings to produce lift, so the wing needs to be traveling at high speed. The high-speed comes from the *propulsion unit* available in the aircraft, like an engine in a car. But a moving vehicle will always produce a **drag** force that acts against the direction of motion. Thrust overcomes both the drag as well as the **weight** of the plane (coming from the action of **gravity**).

Level flight

In a level flight, when the aircraft reaches the necessary speed and holds its speed, being horizontal to the ground, the net forces acting on the body are zero. Consider the figure where the plane is in level flight. The **drag** and **thrust** force balance each other horizontally, whereas the **lift** and **gravity** balance each other in the vertical direction.

Drag can be reduced by altering the shape of the vehicle. You may have seen sports cars which are aerodynamically shaped. Fast trains have long “noses”. Reducing drag also increases the speed.

You have to also look at the payload weight. If you carry a heavy payload, you need to produce sufficiently enormous lift to keep the vehicle airborne. This is one of the primary reasons why a housefly and an eagle do not have the same wingspan (that is, the distance from tip to tip of the two wings). The body weight of an eagle is relatively more than a housefly. Thus, the four forces mentioned above and their ratio in a leveled flight determine the aeroplane’s behavior.

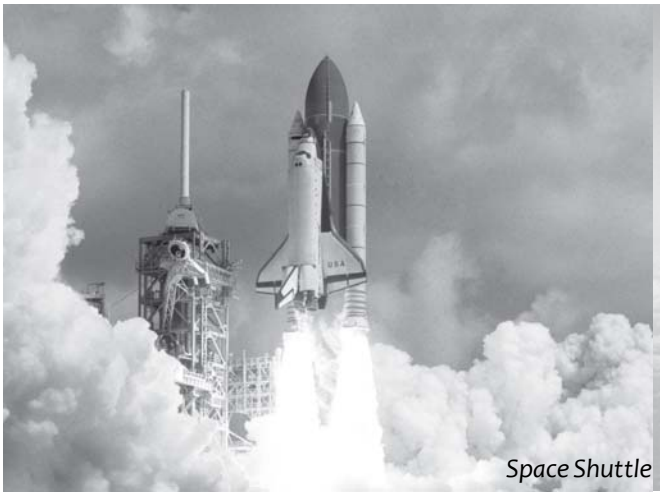
Thrust to weight ratio, T/W

Thrust and weight determine the vehicle’s ability to climb high really quickly. Look at the figure that explains the climbing flight. Here the thrust force balances the drag force and the entire vehicle’s weight. For a passenger aircraft, climbing almost instantly is not a requirement. It imparts serious ‘g-forces’ and causes severe discomfort to the passengers.

On the other hand, during war-time, the fighter aircraft on the ground should go to the necessary altitude as quickly as possible to neutralize the threat of a bomber enemy aircraft. Similarly, for interplanetary missions or for launching satellites, one has to reach space and cross the dense atmosphere as soon as possible. It will help to save fuel and reduce severe aerodynamic loads on the vehicle during rapid acceleration. This is only possible by gaining altitude almost through a vertical climb. Hence, for the passenger plane, T/W is lesser than the fighter plane.

Similarly, for a space shuttle, T/W is larger than the fighter plane. Look at the

Airbus



Space Shuttle

Fighter plane

following table for a brief summary of T/W values in different aircraft. Note: The jet exhaust is entirely different for different T/W, as the propulsion systems are diverse for each of the cases.

Airbus A380 (passenger plane)	T/W = 0.227	L/D = 20
MD F-15 (fighter plane)	T/W = 1.04	L/D = 4
Space shuttle	T/W=1.5 -3	L/D = 1

The lift to drag ratio, L/D

The second parameter we would like to discuss is the lift to drag ratio or L/D. If the body is aerodynamically shaped, then the drag forces are less. It means that the vehicle can travel at high speeds—High-speeds help produce significant lift. We can also achieve lift increment by having a more enormous wingspan. A fighter aircraft with a small wingspan needs to move at a considerable velocity to generate a high lift which puts a high demand on the propulsive requirements.

On the other hand, look at the glider. A hand-operated glider achieves lift at a running speed itself. The energy expenditure in gaining speed is much much less than the fighter plane. Thus, the L/D signifies the aerodynamic and power aspects of the flying vehicle.

Birds and their wing span

Consider the following case, a *house sparrow* with an L/D of 4 and a wingspan of 0.25 m flies at a top speed of 45.5 km/hr. On the contrary, an *albatross* with an L/D of 20 and a wingspan of about 3 m outpaces the house sparrow while flying at 107.8 km/hr.

Planes and their wing span

Higher L/D reduces the power requirements to overcome the drag, and the excess energy can be used to gain speed. Another exciting feature of L/D can be put to use for getting good endurance from a plane. Flyers like the Virgin Atlantic Global Flyer can cover a longer distance by consuming less fuel with an L/D of 10. It can be pushed to an extent such that the plane can cover the globe at least once without refueling.

House sparrow

0.19-0.25 m
45.5 km/hr

[L/D] = 4

Herring sea gull

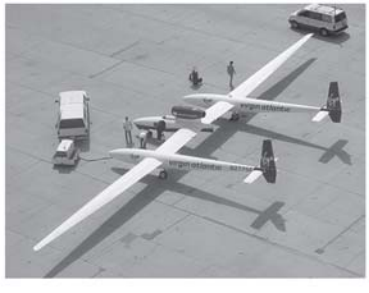
1.25-1.55 m
50 km/hr

[L/D] = 10

Albatross

2.9-3.3 m
107.8 km/hr

[L/D] = 20



Virgin Atlantic Global Flyer

34.75 m
551 km/hr

[L/D] = 10

Lancer U2

31 m
880 km/hr

[L/D] = 20

Similarly, reconnaissance flights like Lancer U2 need to take pictures of the enemy territory without being spotted by the enemy flights or radars. Hence, it has to fly at a high altitude. At high-altitude, air density is less, and the vehicle needs to fly at high speed to maintain the lift. A large wingspan will increase the L/D, and in the U2 plane, one could see that the wingspan extends to 31 m tip-to-tip, which generates an L/D of 20 at a top speed of 880 km/hr. To summarize, just like the examples in the previous case, a passenger aircraft possesses a high L/D of 20 to save fuel, whereas a highly maneuverable fighter has only an L/D of 4. A space shuttle that relies on its sheer thrust-producing capability possesses only an L/D of 1.

There are many design and performance parameters to consider for a specific aeroplane mission. Next time when you see an aeroplane picture or a bird or a glider, try comparing the outlook through these parameters.

The new variants of coronavirus

Yazhini Arangasamy
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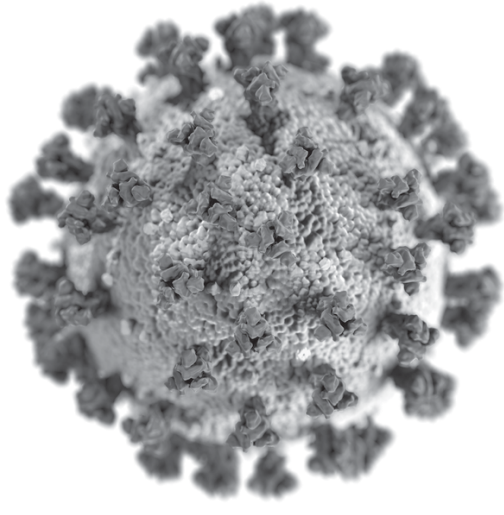
The covid-19 infection has been threatening the world for the past year. First the front-line workers, and now the older population of India, are being vaccinated to curb the infection. Alongside, there is a rapid spread of new *variants* of coronavirus, alarming researchers, health organizations and the general public. This is concerning because the new variants spread faster than the previous virus, which means more people would likely get infected and lead to the next pandemic. It also raises the question of whether the vaccines currently being administrated will control the infection.

What is the coronavirus structure?

Viruses have very simple geometrical structure. They contain the genetic material (which may be DNA or RNA) surrounded by a protein coat called capsid. Some larger ones have an additional outer coat called an envelope. All viruses have a protein coating or capsid, but some viruses, such as the flu virus, have an additional envelope made of **lipids** (fats). Viruses without this extra membrane are called *naked viruses*. The presence or absence of an envelope is an important determining factor in how a virus interacts with the host's membrane, how it enters a host, and how it exits the host after maturation. The novel SARS-Coronavirus-2, for instance, has an envelope. At some point, caused by an unknown trigger, the virus becomes active and causes the disease. More details about the Sars-Cov-2 virus were discussed in last year's Mar-Apr issue of JM. Other viruses were discussed in last year's May-June issue.



The key structure of the virus is its spiked appearance (see picture) which helps the virus invade the human host cells and cause the Covid-19 disease. These are made of proteins and give the virus a crown-like appearance so they are called "corona viruses". These spikes bind to cells in humans and help the virus release its genetic material to infect them.

What is the coronavirus variant?

Variants of Concern		
Name	**Lineage**	**Location of emergence/prevalence**
Alpha	B.1.1.7	Britain
Beta	B.1.351	South Africa
Gamma	P.1	Brazil
Delta	B.1.617.2	India
Variants of Interest		
Name	**Lineage**	**Location of emergence/prevalence**
Epsilon	B.1.427, B.1.429	California
Zeta	P.2	Brazil
Eta	B.1.525	New York
Theta	P.3	Phillippines
Iota	B.1526	New York
Kappa	B.1.617.1	India

Genetic mutations are common in all viruses. In general, RNA viruses mutate faster than DNA viruses and the coronavirus (named SARS-CoV-2) is a positive-sense single-stranded RNA virus. The GISAID, a global science initiative, continually monitors the spread of infectious viruses and genetic mutations acquired in their genomes. This organization's survey reports that several mutations have occurred in the coronavirus since the outbreak of Covid-19. Most of them do not cause any significant effects. However, some mutations can have serious consequences depending on where they occur in the genome.

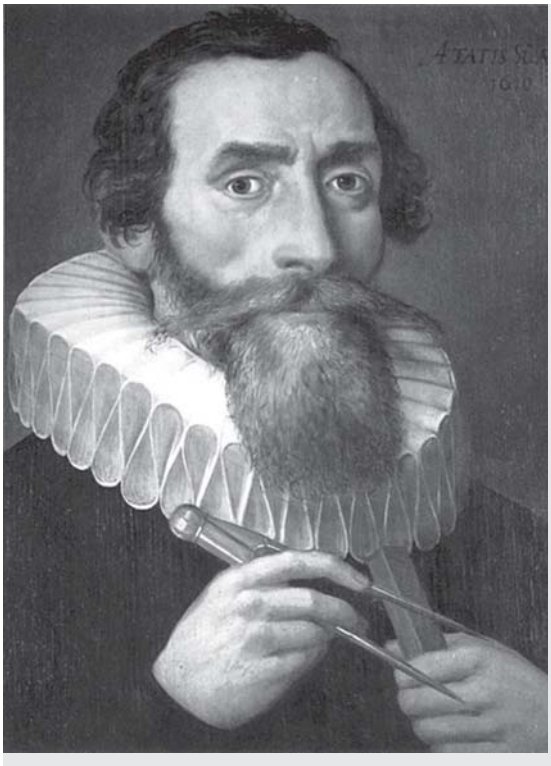
If the virus acquires several mutations that lead to changes in its immunological response, it becomes a new strain. For example, SARS-CoV-2 and SARS-CoV-1 are different strains of the coronavirus family. On the other hand, a variant of the virus results from a small number of mutations with no significant effect on the immunological response. Notably, in the last mid-year, the D614G mutation has resulted in a new variant.

Many new variants of coronavirus have now emerged from various parts of the world. Such variants evolve through mutations from the previous virus in persons who suffered from long-term infection.

What is the effect of mutations in the spike protein?

Spike protein interacts directly with the human *ACE2* protein, thereby allows the virus to enter human cells. ACE2 is a protein that is found on the surface of many cell types such as in the lungs, heart, digestive system, etc. It is an enzyme that generates small proteins that are important to regulate different kind of cell functions and processes such as blood pressure, wound healing and inflammation. Since the spike protein

Continued on page 21



Johannes Kepler

Belting it out among the planets

Kamal Lodaya,
Bengaluru

How far apart are the planets spaced?

Put the Sun at 0 and the Earth at 1. This astronomical unit (AU) stands for about 1.5 crore kilometres. Then Mercury is at 0.4 AU, Venus is at 0.7 AU, Earth is at 1.0 AU and Mars is at 1.6 AU. Jupiter is at 5.2 AU and Saturn is at 10.0 AU. When Uranus was discovered in 1781, it was found to be at 19.6 AU.

This is exactly true for the Sun and Earth. The numbers are almost correct for the other planets, being less than 5% off from the correct value.

Is there a pattern to these numbers?

Astronomer **Johannes Kepler** at Prague (today in the Czech republic), who first calculated these distances, thought there was.

You can try your hand at the puzzle if you want, but here is a hint. Take the differences from Mercury onwards. From Mercury to Venus it is 0.3, then to Earth it is 0.3, then to Mars it is 0.6.

Now take the differences from Jupiter onwards. To Saturn it is 4.8, then to Uranus it is 9.6.

Kepler was a mathematician. In 1596 (before Uranus was discovered) he predicted, "Between Mars and Jupiter, I place a planet." Call this planet A. Place it at a distance of 2.8 AU from the Sun.

Now take the differences from Mercury onwards. To Venus it is 0.3, then to Earth it is 0.3, then to Mars it is 0.6, then to A it is 1.2, then to Jupiter it is 2.4, then to Saturn it is 4.8, then to Uranus it is 9.6. Do you see the

pattern?

German astronomer **Johann Titius** wrote out this pattern in 1766. This was popularized by another German astronomer **Johann Bode** later, and sometimes it is called *Bode's law*. Earlier in 1702, Scottish mathematician **James Gregory** had written the *geometric progression* of numbers*:* 4,7,10,16,28,52,100. He was an astronomer too, a telescope design of his is known as a *Gregorian telescope*.

After the discovery of Uranus, Bode urged astronomers to search for a missing planet between Mars and Jupiter. The planet *Ceres* was found by the Italian priest and astronomer **Giuseppe Piazzi** at the predicted distance in 1801.

Except that Ceres wasn't very big, and it wasn't just Ceres. Hundreds of tiny planets at about 2.8 AU from the Sun were found. Today lakhs are known, they are together called the *asteroid belt*. The name was given by English astronomer **William Herschel** who discovered Uranus.

Today's theories say that when the solar system formed 460 crore years ago, there wasn't enough mass of material in this region, so instead of the material coalescing to form planet A, it just formed a belt of asteroids.

Why does this geometric progression give the location of planets? This is not known. Statistics seems to suggest that if planets were arranged at different distances, they would have a better chance of changing each other's orbits.

Nice story, can we continue it further?

After Uranus the new planet must be at 19.2 and at 38.8 AU (close enough) we find *Pluto*, discovered by American businessman turned astronomer **Percival Lowell** in 1930. Bu that's not good! We missed *Neptune* which is at 30 AU, but its turn will come a paragraph below.

It's not just Pluto. Pluto has a large moon, *Charon*, so large that we should call them both a double planet. American astronomers **David Jewitt** and J**ane Luu**, and following them others, found thousands of tiny planets in this region, which is now called the **Kuiper belt** after Dutch-American astronomer **Gerard Kuiper.** On 1 January 2019, the American *New Horizons* spacecraft flew by *Arrokoth*, a tiny KBO (Kuiper belt object) less than 40 km in size. It does seem as though when the solar system formed, the mass in this region did not coalesce into planet K, but just remained as the Kuiper belt.

In 2005, four astronomers from **Nice** (a city in France), Brazilian **Rodney Gomes**, American **Hal Levison**, Italian **Alessandro Morbidelli** and Greek **Kleomenis Tsiganis**,

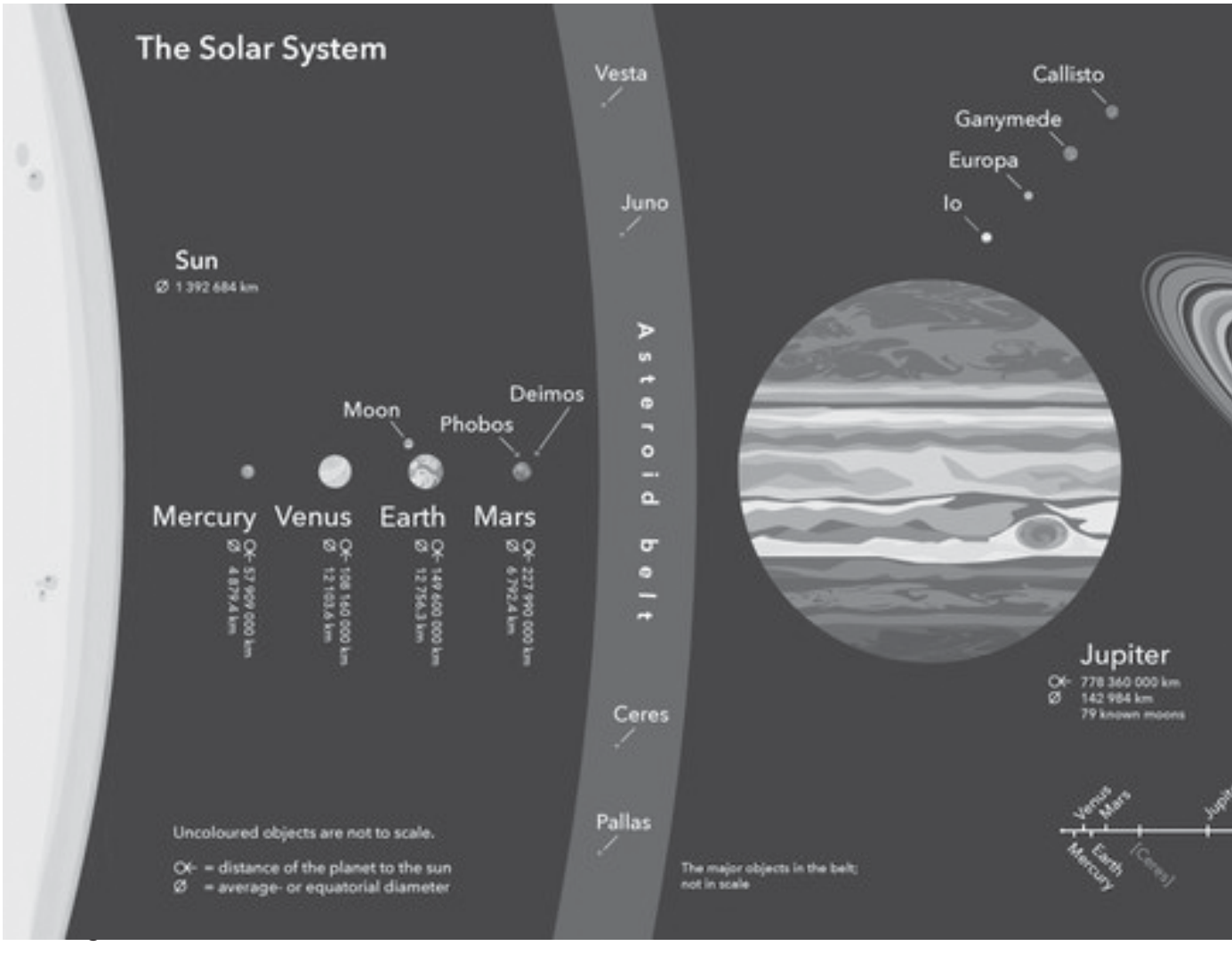
Johann Elert Bode

put forward the theory that earlier in the history of the solar system, Neptune and Uranus were closer to Saturn.

The combined gravity of Jupiter and Saturn led to them, especially Neptune, being pushed out to where it is today. In turn Neptune pushed out the mass in this region to form the

similar to Pluto would be found in the Kuiper belt. Such *Plutinos* have been found.

Lots of nice things in this story. Can we continue it further? Near about 77.2 AU, the next in our geometric progression, American astronomers **Mike Brown**, **Chad Trujillo** and **David Rabinowitz** found *Eris* in 2005.

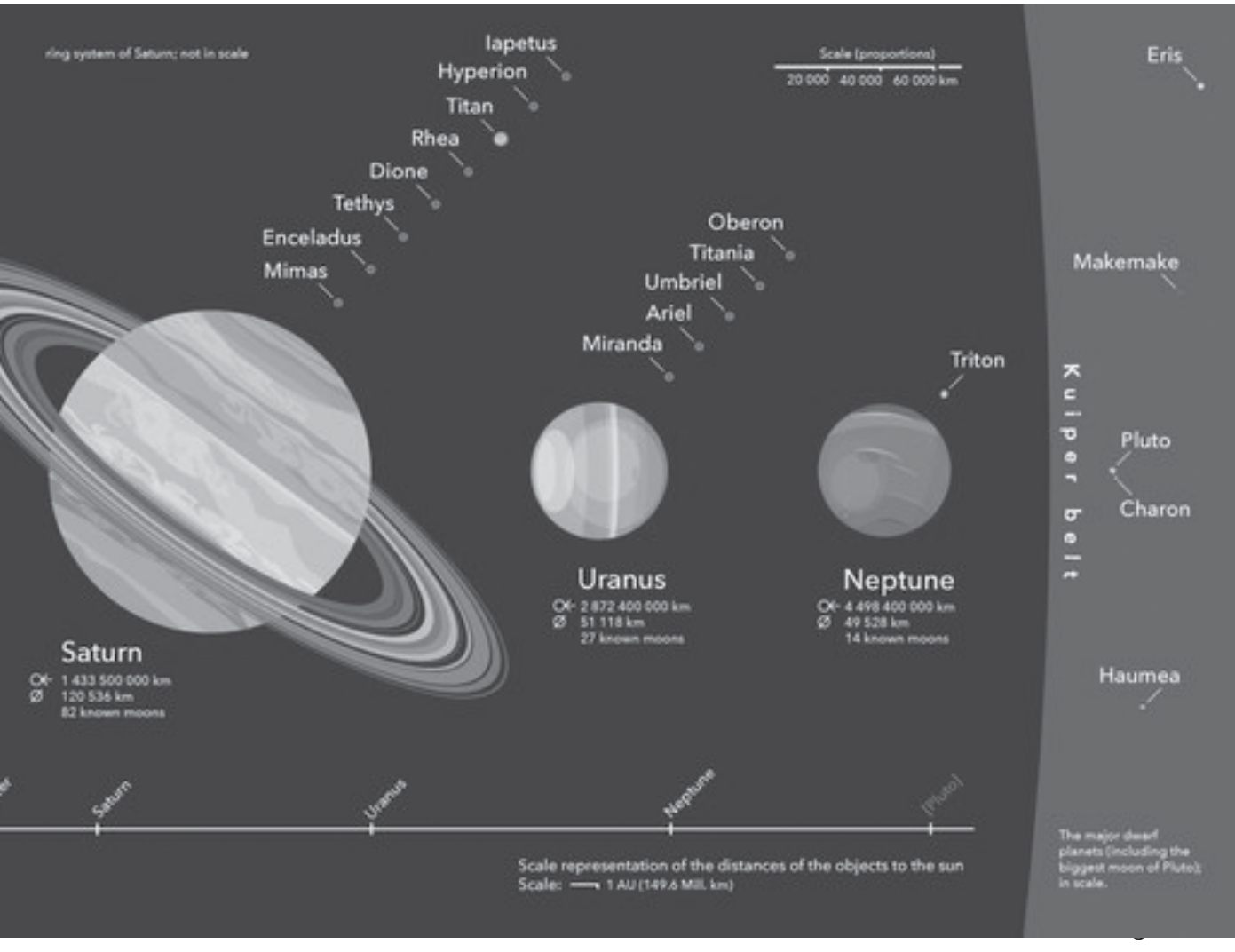


Kuiper belt. Indian-born American astronomer **Renu Malhotra** had earlier predicted in 1995 that migration of Neptune would mean that other objects with orbits

Eris is bigger than Pluto! It has a moon. And it's not just Eris. By now we know around 200 such SDO (*scattered disk objects*). Unlike the "belt" of KBOs, the word "disk"

suggests that orbits of SDOs are more elliptical and more inclined to the plane of the solar system. These SDO may come into the Kuiper belt when closest to the Sun (Eris comes to 38 AU) but go far out when farthest (Eris is nearly 100 AU when farthest).

The most famous comet, **Halley's comet**, is



in the scattered disk region when at its farthest from the Sun. Not just Halley. Many comets are of this kind. It is thought that because this region preserves icy objects, comets may originate from here.

Let's continue with the story. Nothing at 77.2+76.8 = 154 AU. Nothing at 307.6 AU. The trail is getting cold.

At 614.8 AU the story springs back to life again. Brown, Trujillo and Rabinowitz discovered *Sedna* in 2003 at around this distance. Well, sort of. Its orbit around the Sun is very elliptical (it goes from 76 AU to nearly 1000 AU) and takes more than 11000

years to go around the Sun! At these distances it cannot be affected by the gravity of Neptune, unlike Kuiper belt objects. And it's not just Sedna. There are other such *Sednoids* known.

Sednoids and farther objects are known as DDO (*distant disk objects*). **Konstantin Batygin** and **Mike Brown** found Sednoid orbits aligned in a peculiar way. In 2016 they


Ann-Marie Madigan

calculated that there may be another *planet* out there, about 5 to 10 times the size of Earth, orbiting the Sun at around 600 AU, which may be aligning them. Even after a systematic search, no planet has been found so far.

On the other hand, **David Gerdes** and colleagues argued in 2021 that the evidence for alignment of the Sednoids is not strong enough, a careful look at other bodies is needed.

Irish-born American astronomer **Ann-Marie Madigan** and colleagues came up with a different explanation. Based on the accumulating evidence for the Nice model, and a 2019 theory of **Antranik Sefilian**, a Lebanese student in England and **Jihad Touma**, a professor in Beirut, Lebanon, they proposed in 2020 that when Neptune pushed out the Kuiper belt, it in turn pushed out a large number of icy bodies which then occupied the scattered disk. They say the SDO which remain today are a fraction of that number. The entire mass of Batygin and Brown's supposed "planet" could be made up of a lot more DDO than the 200 SDO, scattered more widely and more haphazardly, when farthest from the Sun forming a distant "disk", but when nearest to the Sun coming right into the Kuiper belt.

Their 2020 calculations can account for the alignment of the Sednoids. One argument is that if there were a Batygin-Brown planet, SDO should have been found at 154 AU and 307.6 AU since statistics says these are relatively safe orbits. That nothing is found suggests that during planetary history, DDO with very elliptical orbits have swept out the intermediate region. This leaves few SDO and suggests there are a lot more DDO.

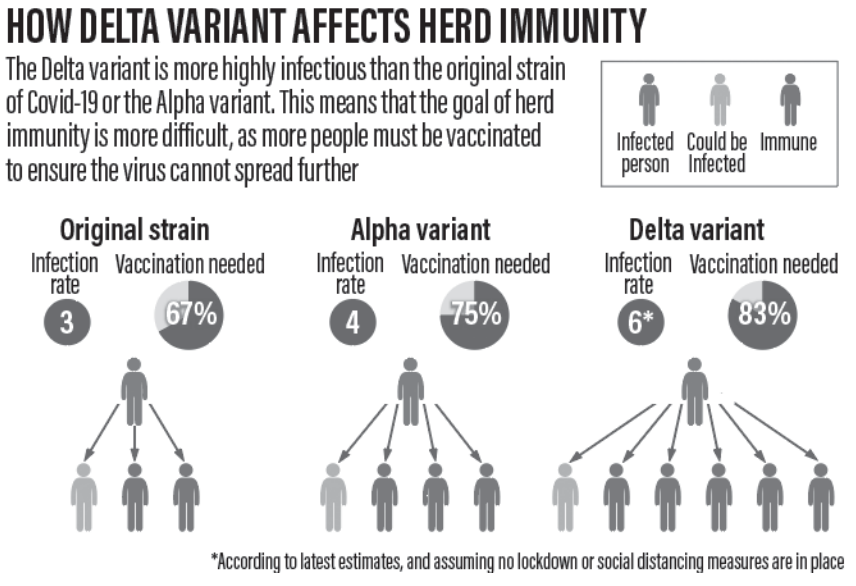
Our picture of a planetary system is changing. It looks like the material around a star forms not just planets, but planets and belts and disks, depending on whether there is enough material to form a planet or not. "If our disk is not there," Madigan optimistically said in an interview, "it has to be the planet. It is one or the other." She has recently been awarded the prestgious *Vera Rubin Early Career Prize* for her work on exploring objects in space.

Continued from page 15

facilitates the primary step for viral infection, this protein has been used to design vaccines.

How do vaccines work?

When a virus (called antigen) enters our system, the body produces anti-bodies to fight these viruses. It also creates memory cells that produce anti-bodies the next time the virus invades our body, so that we are protected against it. Vaccines stimulate this process: they contain weakened or inactive parts of an antigen that triggers an immune response within the body.



Variants and vaccine efficacy

Variants containing mutations (alterations or changes) in the spike protein have the potential of cheating the human host into not recognising the virus and hence delaying the anti-body response. This thus alters the on-going pandemic and causing reinfection.

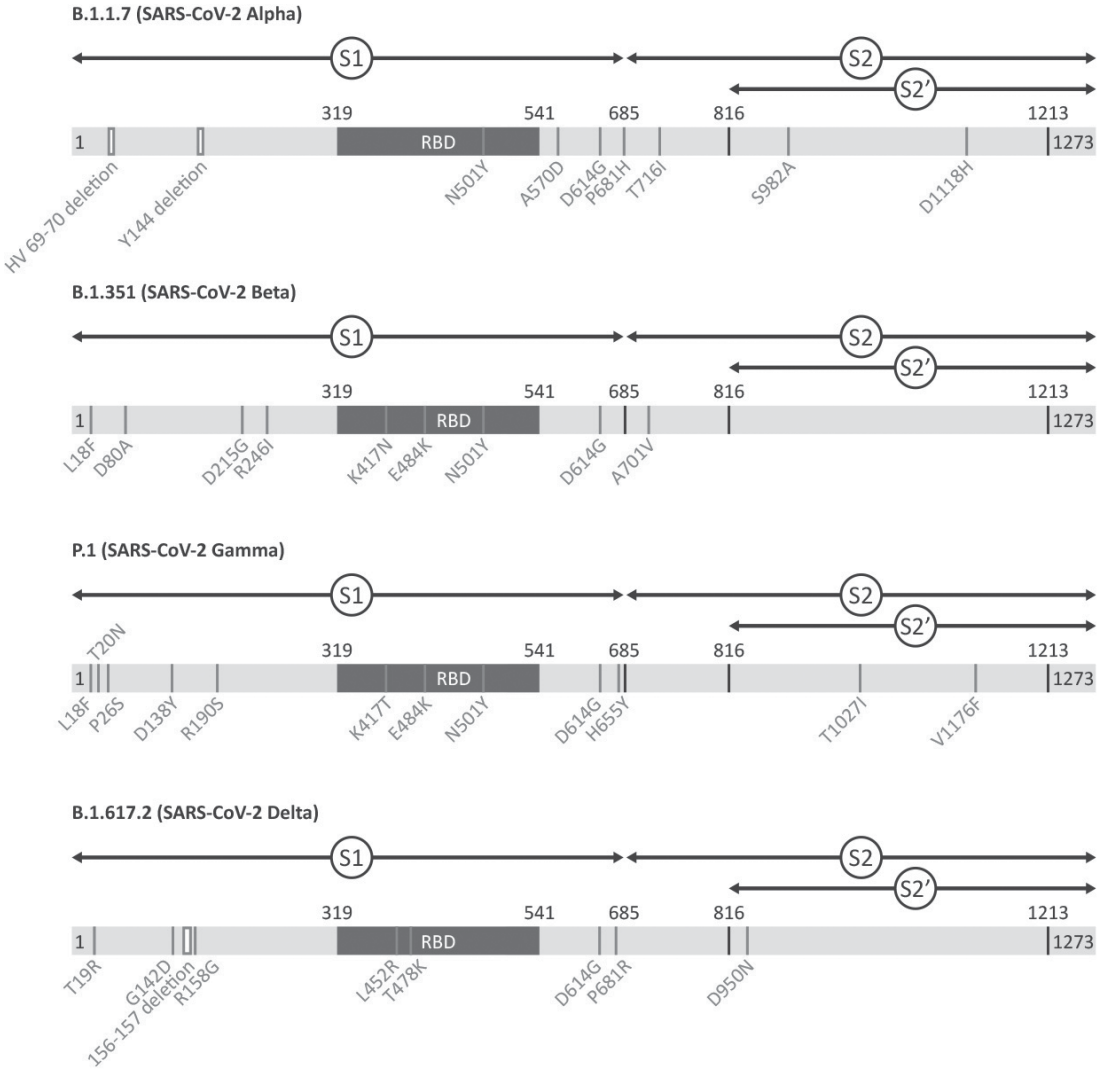
A widely spoken coronavirus B.1.1.7 (or alpha variant) contains eight mutations in the spike protein. This variant, which was first identified in the UK, has now spread to more than eighty countries, including India.

Reproductive rate

If an infected person infects four anothers, the reproductive rate is said to be four. Typically, the virus's reproductive rate should be less than one to show a decline in the infection because this will mean that there are fewer people getting newly infected. However, the reproduction rate of the B.1.1.7 variant is 1.2-1.3, which means that the number of infections caused by this virus is likely to increase.

Variants of concern

The spike protein contains more than a thousand amino acids (1273 aa). According to preliminary research, amino acid change at 501st position in the spike protein i.e., N501Y mutation, allows the variant to spread 30-50% faster than the previous virus. Besides, seven other mutations (A570D, P681H, T716I, S982A, D1118H and deletion of H69-V70 and Y144) may contribute to the rapid spread of this variant. The graphic shows the important variants that are driving the spread of the disease and the location of the mutations/deletions on the SARS-



COV2 genome.

The B.1.351 (or beta) variant, originated in South Africa, contains the same N501Y mutation along with two addition mutations E484K and K417N, in the spike protein. New research shows that this variant binds more tightly to the human ACE2 protein than the original virus. As the B.1.351 variant harbours more mutations than the B.1.1.7 variant, it is predicted to be more vulnerable.

Parallelly, the emergence of other new variants in Nigeria and Brazil has been reported to be predominant. The Brazilian variant (called gamma) has already been observed in the USA and UK and was responsible for a large increase in infection in the city of Manaus in Brazil.

In the case of India, 19 variants of coronaviruses have been identified.

Specifically, a new variant with N440K mutation has recently emerged in Amravati, Yavatmal, and Akola in Maharashtra and shows enhanced infectivity. It was listed as the B.1.617, but the variant B.1.617.2 (called delta) is considered to be highly contagious and is majorly responsible for the very severe second wave in India that has cost so many lives. Currently it is the dominant variant spreading in the UK and the rest of the world since it is 40% more transmissible than the alpha variant.

Variants vs. current vaccines

Vaccines are biomolecular entities that mimic elements of the infecting virus. They raise antibodies against the virus in humans upon administration. Most vaccines that are currently being used mimic the spike protein of the virus. Antibodies induced by such vaccines specifically bind to the spike protein protruding from the infecting viral surface and induce immune responses to kill the virus.

Since the vaccines were designed based on the spike protein of the original virus, mutations in spike protein, especially at the ACE2 binding region, may affect its interaction with antibodies. Nonetheless, spike protein has a large surface in which mutations have thus far been observed in a small region. Also, antibodies use several regions that have not been affected by mutations. Therefore, vaccine developers and researchers believe that currently available vaccines would potentially work against these new variants. Indeed, new results report the successful actions of existing vaccines.

It should be cautioned, however, that constant evolution of the coronavirus may lead to more mutations in the spike protein. As a consequence, the activity of the antibodies induced by these vaccines may decrease. Moreover, if these vaccines are given to only a small population, there is a risk of variants evolving against them.

How to deal with the virus mutation?

Vaccination of larger populations on time can reduce the viral spread and emergence of new variants.

It is important to monitor the nature of the coronaviruses spread across populations and examine whether a new variant has emerged. Such activity can be done by genome sequencing and comparative genomics. Although India is currently practicing these activities, it is of utmost importance to expand them across various parts of the country.

Recent research has shown that saliva can be used for the Covid-19 test. With this effortless method, a person who may be severely affected by the infection can be identified before the disease becomes worse. Given the high number of infections caused by rapidly spreading new variants, this testing method can guide timely medical treatment to the needed people.

Progressive research like this and the constant follow of precautionary measures, i.e., wearing masks, frequent hand sanitization, and social distancing, will help us control and eventually eradicate the Covid-19 catastrophe.

Rathnasree Nandivada,

1963-1921

D. Indumathi,

The Institute of Mathematical Sciences, Chennai

Dr Rathnasree Nandivada, who passed away on May 9, 2021, was the popular director of the Nehru Planetarium in New Delhi, for the last 21 years. She grew up in Andhra Pradesh and studied physics at the Hyderabad Central University.

After her MSc, she joined the astronomy department of the *Tata Institute of Fundamental Research* (TIFR), Mumbai, for her PhD. She was one of the few women students at the time, being junior to me by one year. There, she started work on simulating the last stages of massive stars before they explode as supernovae. Only a few months after her joining TIFR, the international astronomy community's attention was grabbed by a spectacular supernova that exploded in the Large Magellanic Cloud (LMC), a satellite galaxy to the Milky Way. Both of us worked on the data from this tremendous supernova explosion called SN1987A, Rathna in TIFR, and myself from the Institute of Mathematical Sciences, Chennai, to which I had just moved.

After completing her PhD and several post-doctoral fellowships, she joined the Nehru

Planetarium in New Delhi, of which she became the Director in 1999, at the young age of 36. Thus she combined her interest in astronomy with her passion for science popularisation through astronomy outreach; she was a true public scientist. She had a wide range of interests as a science populariser, but those who knew her will remember two things had a special place in her heart: her planetarium and the Jantar Mantars.

Work at the Planetarium

When Rathnasree became the Director, the planetarium projector was opto-mechanical, aided by slide projectors, and Rathnasree became scriptwriter, music director, narrator, producer and film director all at once.

When many planetaria in the country later upgraded to a fully digital system, Rathnasree realised this was not optimal and insisted on a hybrid projector – a choice planetaria in other cities subsequently adopted as well.

At the time, the digital projection system was fantastic for animations, but its output was poorer when projecting the night sky. A hybrid system allowed use of an optomechanical projection sphere to more realistically simulate the night sky, with digital projectors looped in for some advanced animation.

She was the master of the planetarium dome, and was forever looking for creative means to use it. These ranged from research on the accuracy of medieval astronomy instruments to visualising large datasets for student projects.

Another memory shared by her friends was her immense love for old Hindi film songs. Much later in her life, she even compiled a list of astronomy-themed songs sung by **Kishore Kumar** to be used in her planetarium shows.

Work at the Jantar Mantars

Sometime in the early 2000s, Rathnasree fell in love with the large astronomical instruments of the *Jantar Mantars*, built by **Raja Sawai Jai Singh II** of Jaipur in the mid-18th century. Where everyone else saw historical monuments, Rathnasree saw open-air physics laboratories, and she made them come alive for the school students of Delhi. She trained successive batches of students to carry out actual

measurements with them. She was very proud of the fact that her students could finally measure time to an accuracy of just two seconds using one of these *yantras*.

In fact, she became the foremost expert in this field and figured out how to calibrate each instrument and use it as it was originally intended. In recognition, the Archaeological Survey of India (ASI) appointed her on the ASI's committee to oversee maintenance and restoration of the instruments in the Jantar Mantar located in Delhi. The photo shows her at the Delhi Jantar Mantar in 2015 (Photo: *Rakesh Rao*). She became their champion and made sure the restoration work did not compromise the accuracy with which one could make measurements thereafter.

In February 2018, India hosted a prestigious event – the International Astronomical Union Symposium (IAUS340) on Solar Physics, at Jaipur. Rathnasree used this opportunity to make the Jantar Mantar in Jaipur accessible as a laboratory as well. She decided to train the tour guides on how to make measurements, and created activity sheets for the yantras so that each visitor to the Jantar Mantar could make their own measurements at each of them. The picture (Credit: *Alok Mandavgane*) shows Rathnasree with students at the Jaipur Jantar Mantar in 2018.

Interactions with students

She was the people's astronomer, and made the Delhi planetarium an oasis for students interested in science. Rathnasree insisted that everyone was capable of doing astronomy, and came up with hands-on experiments, simple measurement exercises and calculations for her students to perform. The students she had mentored over the years became a huge family. She was forever willing to discuss astronomy with everyone, even with those who held contrary views.

When the Astronomical Society of India constituted its Public Outreach and Education Committee in 2014, the obvious choice for chairperson was Rathnasree. In that role, she set the course for many of the committee's long-running programs and brought the team together. Most of its activities that focused on students have been her brainchild, from organising regular online discussions with astronomers to devising simple experiments around celestial events like eclipses and conjunctions.

Astronomy and Gandhi

She unearthed the fact that **Gandhi** had become interested in astronomy and sky-watching when he was jailed in Pune. She assiduously collected all his astronomy writing and proposed the "Bapu Khagol Mela", for which she wished to visit every location that Gandhi had visited in India and organise a sky-watching session there for the people. She managed to cover quite a few of them, and her travel path is now dotted with telescopes that she guided the schools in each of these towns to build.

Vera Rubin, the astronomer who had played a central role in the discovery of dark matter, used to say, "A woman's place is in the dome" (referring to the one crowning the telescope). Rathnasree also found her place in the planetarium dome, under the stars that she brought down to Earth for all of us, every day. She was snatched away, too young, by Covid. We will miss her.

Adapted from the article in The Wire by Aniket Sule, Homi Bhabha Centre for Science Education (HBCSE-TIFR), Mumbai, and Niruj Mohan Ramanujam, Indian Institute of Astrophysics, Bengaluru.

Science News

Headlines

- New maps of the brain
- Which asteroid caused the dinosaurs to go extinct?
- Adhesives inspired by spider hair?
- Pine Island Glacier is ripping apart

Read more details below...

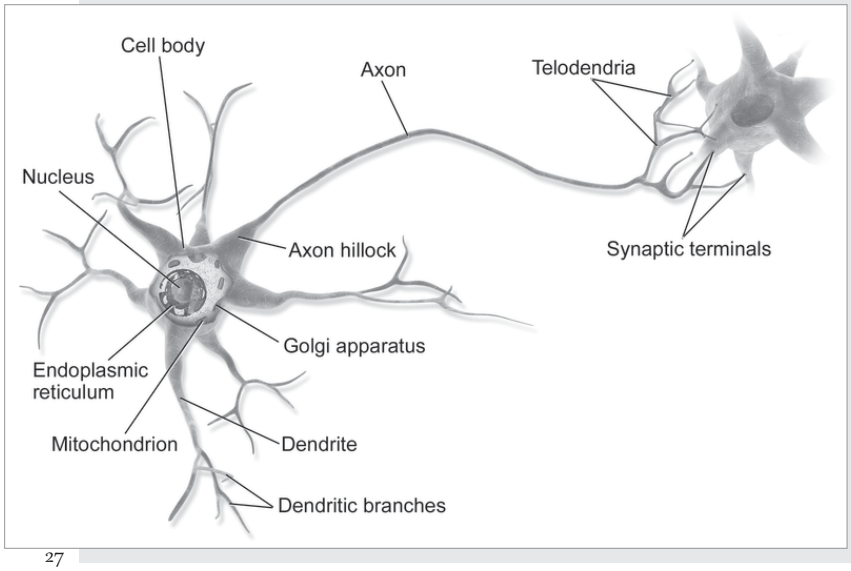
New maps of the brain

At Harvard University, a tiny piece of a woman's brain, the size of a mustard seed, was used to learn more about how connections are wired in the brain. The 45 year old woman was undergoing surgery for epilepsy. This already small piece of brain from the *cortex* region of the brain, was sliced into 5,000 pieces, so small, that they could not be seen by the naked eye.

It needed powerful electron microscopes to visualise them. Even so, it is difficult to get a complete understanding from so many tiny pieces. So computer programs were used along with artificial intelligence (AI) techniques to analyse the results.

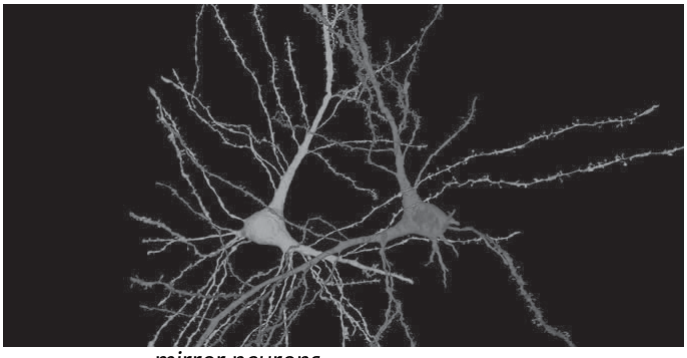
The results were stunning. You may know that neurons transmit signals between the brain and different organs, and also within the brain itself. For instance, if you touch something hot, a sensory neuron passes on that information to the control centre in the brain or spinal cord, and the motor nerve carries back the information to take your hand away.

Neuron Structure

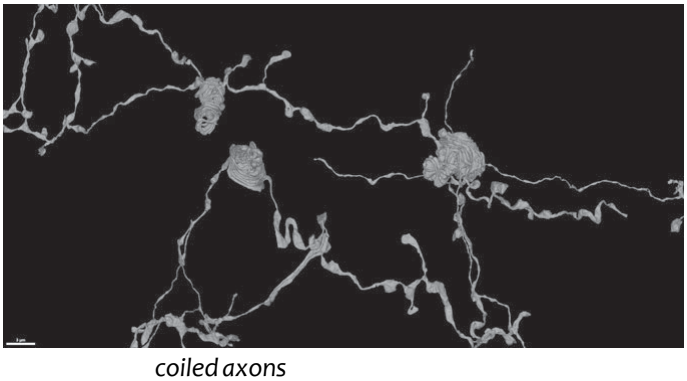


Neurons have a cell body containing the nucleus, filaments called *dendrites* that receive the signal, and a single long *axon* which sends out the signal. The signal is passed as an electrical impulse from neuron to neuron, but the neurons are not in contact with each other. There is a small gap or *synapse* between them. The axon connects to another neuron through the synapse via chemicals called neuro-transmitters.

●



mirror neurons



coiled axons

Usually, one axon connects to only one dendron to form a chain of connections that transmit the signal. But 10% of the time, the researchers from this study found cells that connected to another cell via multiple synapses, the maximum being a pair of neurons that were connected by 19 synapses!

Why do such strong connections exist? The answer is not yet known. After all, looking at a structure doesn't always tell you its function. It is possible that when you learn something intensely, spending hours reinforcing the learning everyday, then these multiple connections are formed to ensure that the target neuron responds powerfully to a stimulus.

The scientists also found curious pairs of neurons that were mirroring each other. That is, one neuron looked like the mirror image of another one. They also found axons that were coiled to form complicated bundles. Clearly, a lot of work is needed before scientists unwrap all the mysteries of how the brain functions.

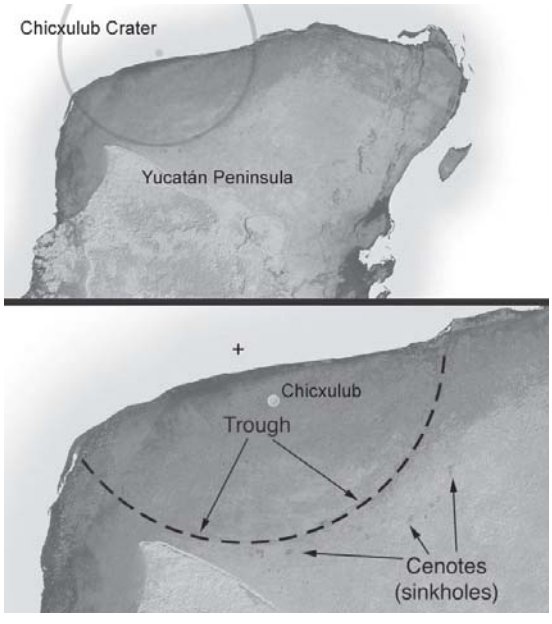
Did an asteroid cause the dinosaurs to go extinct?

There is a small patch of forest in the small village of **Bukvarka** near Kiev, Ukraine. While the forest gently blends with the farmland, it hides the fact that 65 million years ago, an asteroid struck this place, leaving a 22 km wide crater. The remnants of this impact can be seen if you dig deep, about 500 m or so.

The impact of the asteroid generated so much heat that the rock itself melted and formed the **Boltysh crater**. You can see the quartz formation in the photo. Later on this was filled with water and became a lake, and even later, became a forest. For many years it was thought that this Boltysh impact was the reason for the dinosaurs to go extinct.

But another crater was found under the Yucatan Peninsula in Mexico. Called the **Chicxulub crater**, it was formed when a large asteroid struck the Earth slightly more than 66 million years ago. This date matches very well with what is called the *Cretaceous-Paleogene boundary*. This is a thin layer of rock that separates the **Cretaceous** period from the **Paleogene** period.

The Cretaceous period is characterised by warm climate, with an ice-free Earth, and of course, large dinosaurs roaming



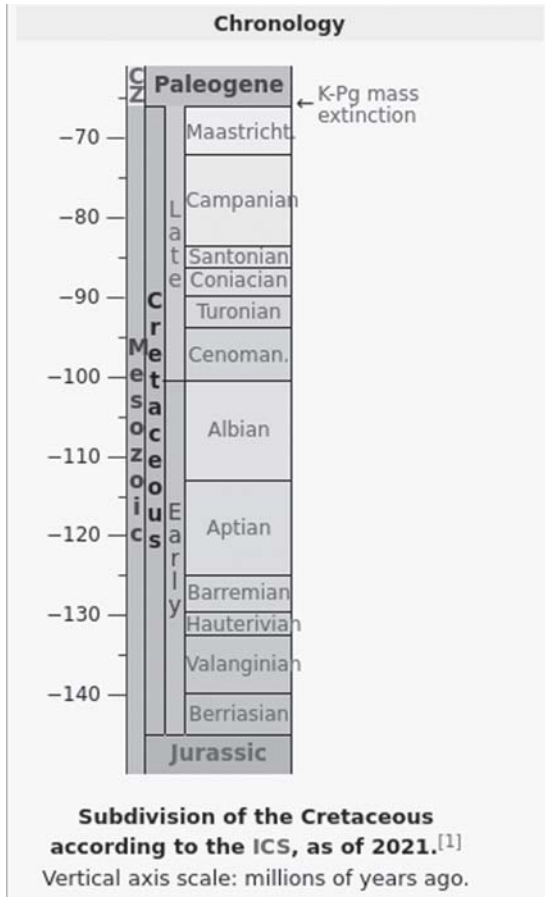
on it. It ended with the decline and sudden mass extinction of many groups of dinaosaurs, pterosaurs. In the new Paleogenic period, mammals diversified while India just began to collide with Asia to form the Himalayas.

It is now believed that the Mexican impact was what caused the decline of the dinosaurs. Earlier, it was difficult to date such an old event exactly. But now a precise study indicated that the Boltysh impact occurred 6,50,000 years after the Chicxulub one. This is a long gap, but short by geological standards! How did they find this out?

The scientists from UK looked at the age of the *sediments* that had settled on top of the Boltysh crater. These sediments came from rocks that had melted when the asteroid hit them. The sediments contained *Argon*, and by measuring the presence of an isotope of argon (like radiocarbon dating, except they used Argon instead), they found its age to be 65.39 million years. The second decimal place indicates that they have an accuracy of less than 1 lakh years, and so they can separate this from the Chicxulub event.

So the theory that the two asteoid impacts, so close together, was finally ruled out. Now we know that the Boltysh impact had nothing to do with the dinosaur extinction.

However, this study is useful in many ways. Just before the Blotysh event, the Deccan trap was formed with a lot of volcanic activity and emission of greenhouse gases. It is possible that the Boltysh asteroid impact triggered off a



Subdivision of the Cretaceous according to the ICS, as of 2021.[1]
Vertical axis scale: millions of years ago.

period of extreme global warming when temperatures rose more than 2 degreees. Normally, an asteroid impact damages the local environment. But because the Earth was already in fragile state after the Chicxulub event, it is possible that it had a bigger impact.

Adhesives inspired by spider hair?

You must have seen spiders walking on walls, even on the ceiling, upside down, and apparently not worried about falling! It was known that there are tufts of hair on spider's feet. Each hair contains thousands of smaller hairs called *setules* which are very very fine, with special triangular shaped tips. The spider uses these setules to stick to surfaces. Scientists have estimated that due to these setules, spiders can grip surfaces with a force nearly 200 times their own weight.

In an recent study of the wandering spider, *Cupiennius salei*, scientists found that these hair-like structures are even more variable than expected. They wanted to find the specific angle where the spider would *adhere* (stick) best to the surface. They then wanted to use this to make good quality adhesives! But the reality was more complicated. While one hair adhered well at small angles to the surface, another worked best when it was nearly perpendicular to it.

That is, the adhesion forces were different for the different hairs. This was because each hair was structurally different from the others. Since there are thousands of hairs on the feet, the scientists could study only a few, each about 1/100 of a mm thick. But they now believe that there could be clusters or repeating patterns which made the adhesion efficient.

Such different shapes and angles of adhesion can improve the overall ability of the hair to stick firmly on the wall. It will be interesting to manufacture materials inspired by these properties to make not only better and stronger adhesives but also reversible ones.

Pine Island Glacier is ripping apart

Pine Island glacier has an ice shelf that has helped to hold back one of the fastest moving glaciers in the Antarctic. Over the last decades, due to global warming, the ice shelf has become thin. Now large icebergs at its edge have broken off and the glacier is moving faster than ever. The Pine Island glacier is now collapsing into the sea faster and faster. This could contribute to 1/2 m of global sea level rise.

The mechanism of the melting is different. Warm ocean currents flow beneath the glacier and melt is from below. But recently, this is no longer the main melting mechanism. The melting caused the glacier to accelerate from 2.5 km/year to 4 km/year. Since it is a huge

glacier containing 180 trillion tons of ice, this has caused internal stresses to arise inside the glacier. This can cause the entire outer part of the ice shelf to be lost. This will cause the glacier to accelerate further. It is possible that the entire ice shelf may be lost in the next decade or two rather than over 100 years, as thought before. So scientists are predicting that there will be rapid changes in the near future.

Sources: phys.org, Science News, Smithsonian Magazine, and ANI

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What happens when marine biologists watch too many movies?

Narayani Subramanian

The western society refers to popular culture as "**Pop culture"**, a blanket term that includes music, art, literature, fashion, dance, film, internet culture, television and radio which is consumed by a majority of the population. Pop culture also significantly includes *meme culture* and internet *slang words* and abbreviations.

Though their jobs force them to spend days away from the land and human civilization, marine biologists, like all of us, are huge fans of pop culture. They love pop culture so much that when they discover a new species, the images from movies and television series flash in their brains and influence the nomenclature of the new species!

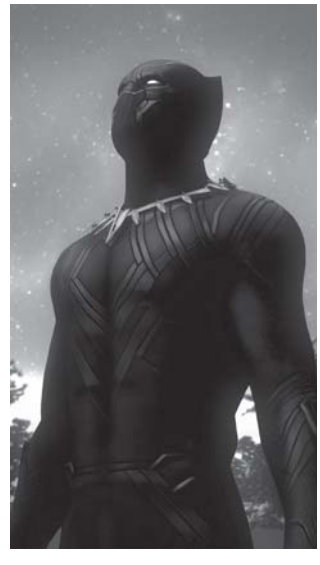
We are now going to learn about four new species named after pop culture icons.

E.T. Sponge

I don't know about you, but the climax of E.T makes me cry everytime I watch it. The 1982 Steven Spielberg blockbuster movie is about the unusual friendship about an alien and a (human) boy.

When scientists went on a deep sea expedition 7875 feet down in the eastern Pacific Ocean in the year 2020, they stumbled upon what they call "*Forest of the weird"*, where huge communities of pink coloured sponges were found.

Looking closely at the "face" of the sponge, the scientists quickly realised that the sponge resembles the face of E.T the alien. They have given the name *Advhera magnifica* according to scientific nomenclature, meaning "the magnificent alien". The common name for this is E.T. Sponge.



Wakanda fish

Read this sentence again and again and again, in full speed: "Wakanda fish is this?".... Does it begin sounding like "What kind of fish is this?"

That is exactly what the scientists were asking when they saw this fish in a twilight zone reef in the Indian ocean, off the coast of **Tanzania**, in 2019.

Coral reefs, as we all know, thrive extremely well in bright sunlight. But the twilight zone, the region of ocean below 200 m, is not fully blessed with the rays of the sun. The sunlight comes in pockets and mixes with the dark, creating the same amount of

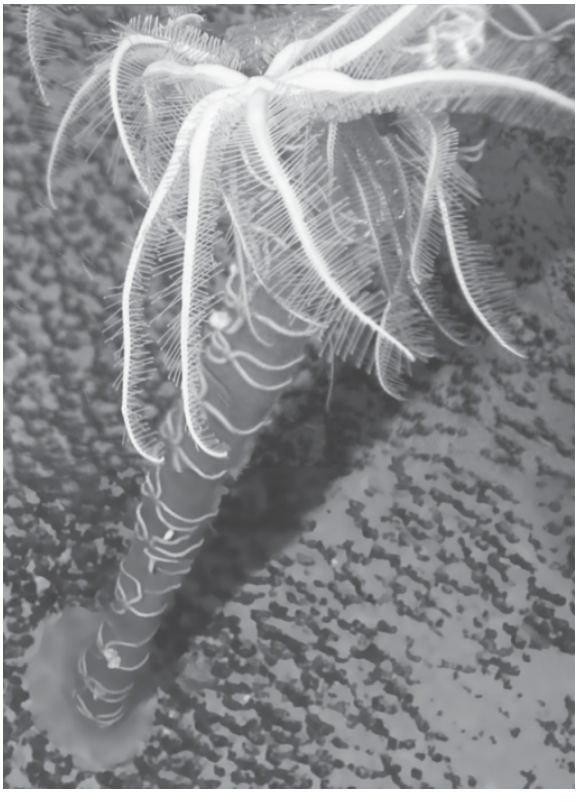
semi darkness that we see during dawn and dusk.

Scientists were really surprised to see a fully formed coral reef in the twilight region 260 m below the surface. Even more surprisingly, they also found a type of *fairy wrasse* fish which they have never seen before. Covered in specks of bright purple, the fish did not lose its colour even after preservation.

After careful observation, the scientists confirmed that it is a new species. Since the vibrant purple scales resemble the chain mail pattern of the Black Panther suit, they have named the fish *Cirrihablus wakanda,* in honour of the fictional world of *Wakanda* in Marvel Comics. The common name is given as *Vibranium fairy wrasse*. Those who read the comics (or have watched the movies) will understand the reference to Vibranium as well!

Patrick Star

All adults fondly remember the cartoons they grew up with. As scientists descended 3 kilometers below the sea surface in the north west Pacific Ocean, they came across seven armed *sea stars* in a pinkish shade.



Careful observations revealed that this undiscovered species is closely associated with the deep sea sponge and has a mutual connection to it.

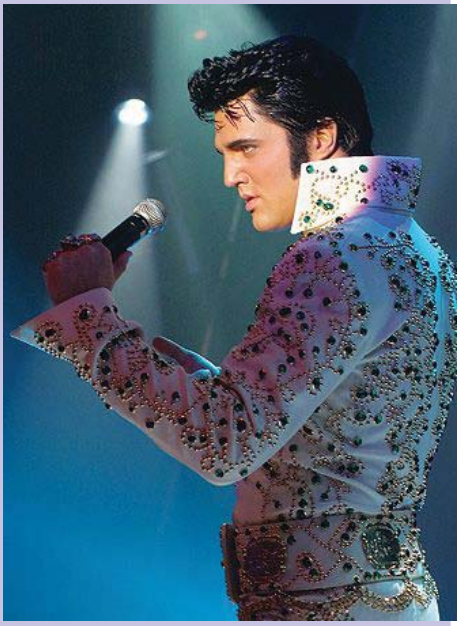
Marine biologists fondly remembered how the cartoon character “Patrick the sea star” is the best friend of Sponge Bob Square pants. Based on the association with the deep sea sponge, the new species of sea star was named Patrick Star!

Cartoon fans around the world are waiting for more spongebob based charac ‘-ters to be discovered in the deep sea!

Elvis Worm

Elvis Presley is one of the most significant cultural and musical icons of the 20th century. The king of rock and roll, he is also well known for his shimmering stage costumes. Most of the disco costumes with sequins in the movies from 80s are inspired by him.

Thousands of meters underwater off the coast of California, deep sea *scale worms* glitter and sparkle just like Elvis and his legendary costumes. Bristles around the body also shine with full fiber optic effect, giving a disco effect! The glitter is believed to help the worms communicate, find prey or even defend against predators. The exact purpose is yet to be finalised.



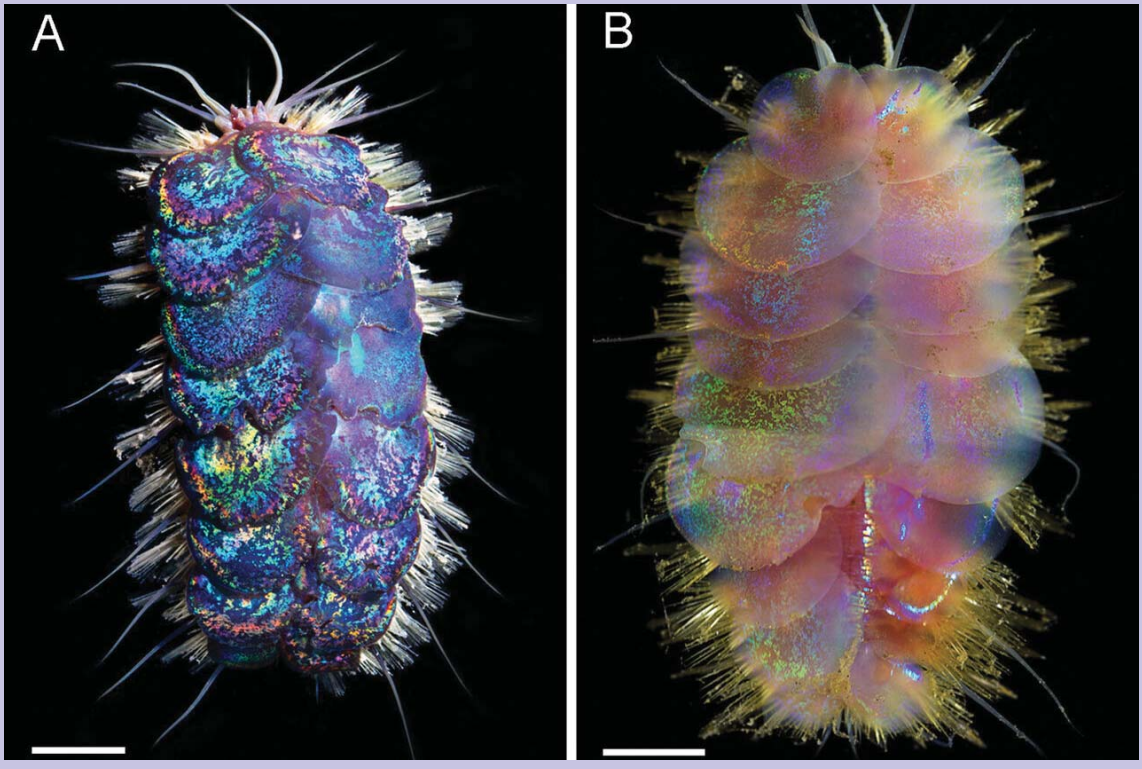
The species has been named *Peinaleopolynoe elvisi*, after the legendary musician. The common name is **elvis worm**. When you look at the pictures, you can understand how the name is completely justified.

I am hoping for new fancy indian species to be named after pop culture icons.... imagine super strong insect species named “Shaktimaan beetle”, or a sugar loving funky worm species called “Chota Bheem worm”.

Sounds fun, doesn’t it?!

Image Credits:

ET sponge: NOAA, ET movie: Universal studios, Patrick Star: Zhang et al, Patrick Cartoon : Nickelodeon animation studio, Elvis Worm: Scripps Institute of Oceanography, Black Panther - Marvel Comics, Elvis Presley - British Vogue, Elvis Presley1 - Hollywood Reporter, Wakanda Fish- California academy of sciences



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