JANTAR MANTAR

CHILDREN'S SCIENCE OBSERVATORY

English Bi-Monthly

Volume 21 Issue 4 July-August 2021 Rs. 15.00

How to pierce through water?

SK Karthick,
Technion-Israel Institute of Technology, Israel

Introduction

In day-to-day life, many goods travel between places. Transport of parcels across the globe is routine. We hardly care how they are handled and feel happy once they reach destinations in proper shape. But taking heavy objects in transit is more complicated than anyone thinks. It is hard to keep our bodies from crashing onto the neighbors while we walk. Think about goods in a bouncing container, lorries, swaying cargo ships, or jolting bomber planes flying through turbulence. Amidst all the hurdles, they indeed execute specific movements effortlessly and gracefully. Even our athletes exhibit extraordinary acrobatic performance to grab medals. A slamming ship in rough sea weather creates a nightmare for the passengers and compromises the vehicle structure and the payloads in it. Improper dive into pool bruises the swimmer seriously, especially considering their weight and height of the dive. Let it be a rocking boat or a diving swimmer, a fitting delivery matters.

Water-entry

We will talk about athletes soon. But let's consider for a moment objects moving through water like a skipping stone. Or a diving king-fisher (photo credit: Mario Cea), Or even water spattering during drop impact. The particular manner they execute the maneuver, adapt the body shape, or manipulate their surface properties enable them to achieve specific goals.

Generic water entry requirements may vary between cases. However, some of them are common. For example, let us take the kingfisher bird. The bird is about 16 cm in length, weighs 40 g, and has a wingspan of 25 cm. It generally sits in a tree branch at the height of 2 m from the water surface to stalk

Stone skipping

the fish inside. Then, it suddenly dives into the water at 40 km/hr (if we hit a wall at the same velocity, we will die!) to catch the fish, provided the fish is no longer roaming below the depth of 25 cm. The kingfisher opens its wings inside the water after grabbing the prey and effortlessly flies back to the branch. How does a kingfisher survive the impact during water entry?

Force encounter during water-entry

Let us consider the generic force acting on bodies undergoing water entry. While a body is dropped from a height, it soon reaches a constant velocity called terminal velocity due to air slowing down the body. On impact, contact with the water which is having a larger density causes the body to

Water drop impact on water surface

Hunting dive of a kingfisher in the wild

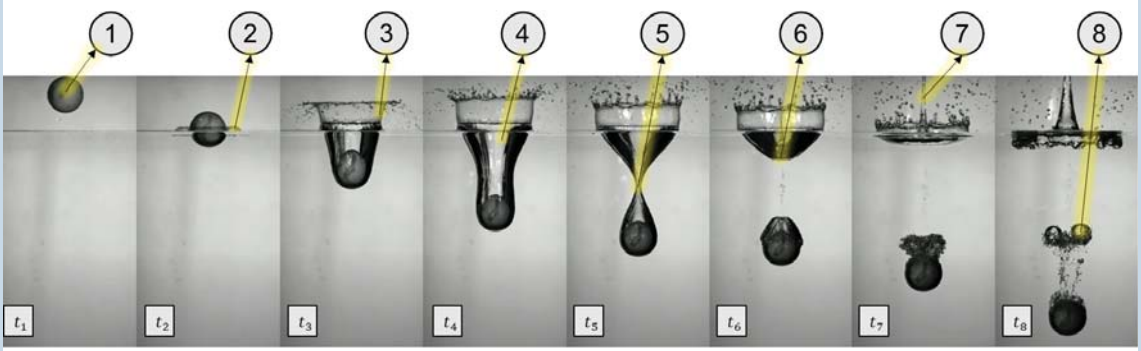
rapidly slow down (deceleration). The drag force acting on a body, which slows it down, is also directly proportional to the traveling medium's density. Since air density is just 1.3 kg/m^3 and water has a density of 1000 kg/m^3, that is a factor of about 1000 times, or the drag force is 1000 times more.

Newton's laws states that the force on the body is mass times acceleration (**F=ma**). Since **F** is 1000 times more, if the object weighed 10 kg, then the deceleration (or negative acceleration) is **a**=1000/10 = 100 m/s^2.

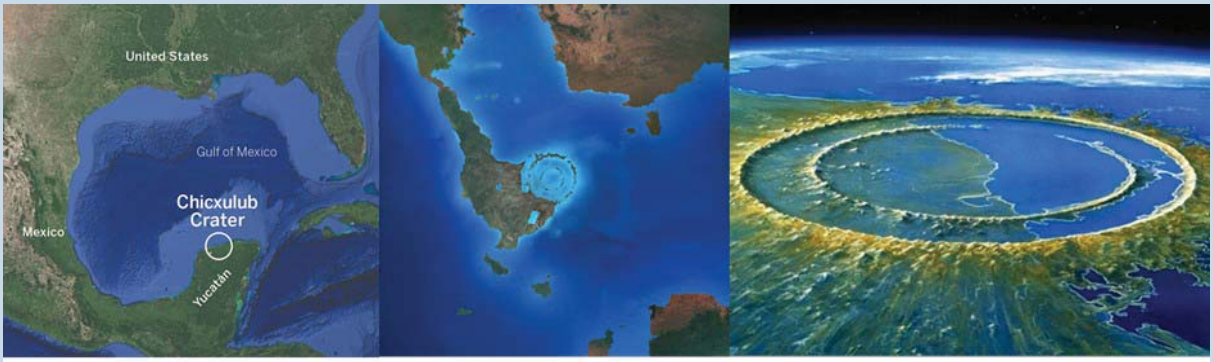
So the body that was falling due to gravity, with acceleration due to gravity g = 10 m/s^2, suddenly experiences ten times that acceleration. Such massive force is sufficient to shred the impacting object into pieces or generate a considerable amount of splash/noise, which can damage or destroy the body upon impact. Thus, reducing the load acting on the impacting body is a common requirement.

Research on water-entry

To reduce the forces acting on a body, we must first understand the origin of these forces from the resulting impact. It requires some basic understanding of flow physics. The research group of Professor Truscott in Utah State University has spent a considerable amount of time understanding different bodies' water entry. They have used high-speed snapshots of a solid sphere dropping into a water column at a constant velocity to study the impact. The pictures show how a



1. Falling solid body from air into liquid, 2. Concave crater, 3. Crowning liquid, 4. Entrapped air bubble, 5. Collapse of entrapped bubble, 6. Bouncing back liquid surface, 7. Production of Worthington jet, 8. Ejection of tiny secondary bubble (Image courtesy: Truscott et al, Annual Reviews, 2014)



The Chicxulub crater is an impact crater buried underneath the Yucatán Peninsula in Mexico.

falling sphere causes a small cavity to be formed. As the sphere sinks further, the air bubble is pushed out under pressure, along with a water-jet column (called Worthington jet) . This jet is what we perceive as a splash responsible for wetting our face while throwing a rock on a lake or during the drop of potatoes in a boiling pot.

Huge and heavy body upon impact produces a wide crater cavity and generates a large force. Even when a solid body hits a solid surface, such kind of crater is formed. For example, craters are seen on the moon's surface a lot as it does not have an atmosphere. All the asteroid pieces hit the moon's surface at high speed and leave a crater. On earth, craters are not as abundant as it is on the moon. This is because we have an atmosphere that drags down the speed of an asteroid and burns most of it during atmospheric entry itself due to air friction. One of the largest asteroid impact craters called Chicxulub is in the Yucatan peninsula in Mexico. For a long time it was thought that the asteroid that created the massive crater was responsible for wiping out the dinosaurs.

Methods to reduce forces

The research group of Prof. Truscott suggests many ways to modify or reduce the force upon water entry. The most interesting is to time the dropping of the sphere so that separate jets are not formed. Another is to drop a big sphere after a small sphere. The smaller sphere causes less impact, and if the big sphere is dropped soon enough afterwords, it penetrates though the cavity, reducing the force acting on it.This is the reason why people diving one after the other in succession experience lesser impact force. The person who dives earlier makes it easier for the next person. The force reduction can be as much as 30-60%.

Olympic sport - Diving

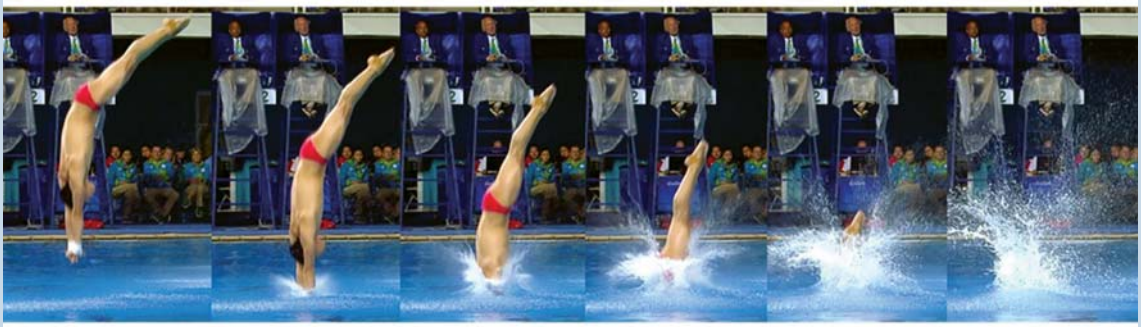
Now, let's consider the Olympic sport – diving from a 10 m platform. One unofficial scoring system to evaluate how the diver finishes the maneuver is looking at the amount of splash a diver makes upon water entry. Clearly, reducing the impact splash and preventing the Worthington jet from forming is the best strategy. Therefore, whenever divers are about to enter the water, they turn and position the body to be in a needle shape, extend their arms, and hold the hand in a flat-palm position. Like in the case where the big sphere is dropped after the small sphere, the extended arm enters the water first and creates the smaller cavity. When the more prominent shoulder enters the water, it

experiences lower drag force. Thereby, the driver enters the fluid smoothly. Such a water entry is called rip-entry, as the entry produces a slight noise that closely resembles the paper being ripped. However, to further delay or reduce the collapse of the entrapped air bubble (however smaller in volume), the diver takes a curvy path, breaking the big bubble into a fine bubble in due course of action. The resulting dive will create a minimum splash, and the diver will fetch gold. You may have watched the fine performance of the divers during the recent Olympic games.

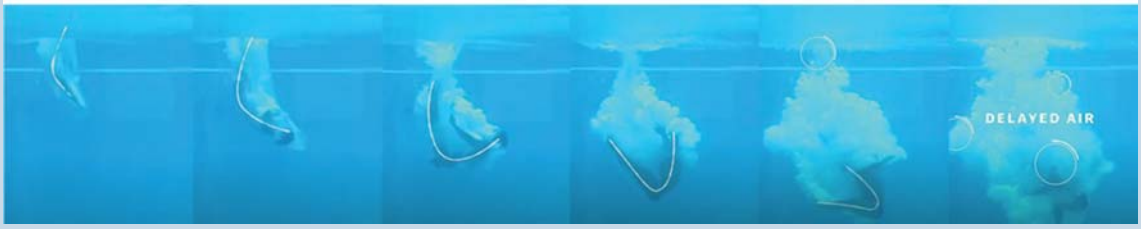
When a ship rocks or a missile enters into the ocean, or when you want to splash water on your friend's face during the beach season, there is a definite routine one has to undertake to achieve the desired action. So next time when you drop something on the water, remember the aforementioned astounding physics.

Note: All the figures are taken from the web. Some of the experiments shown here are from the published work of Prof. Truscott's research group in the Gallery of Fluid Motion – APS. The diving pictures are from the infotainment videos of the Vox and the Olympics youtube channel, and from Wikimedia. •

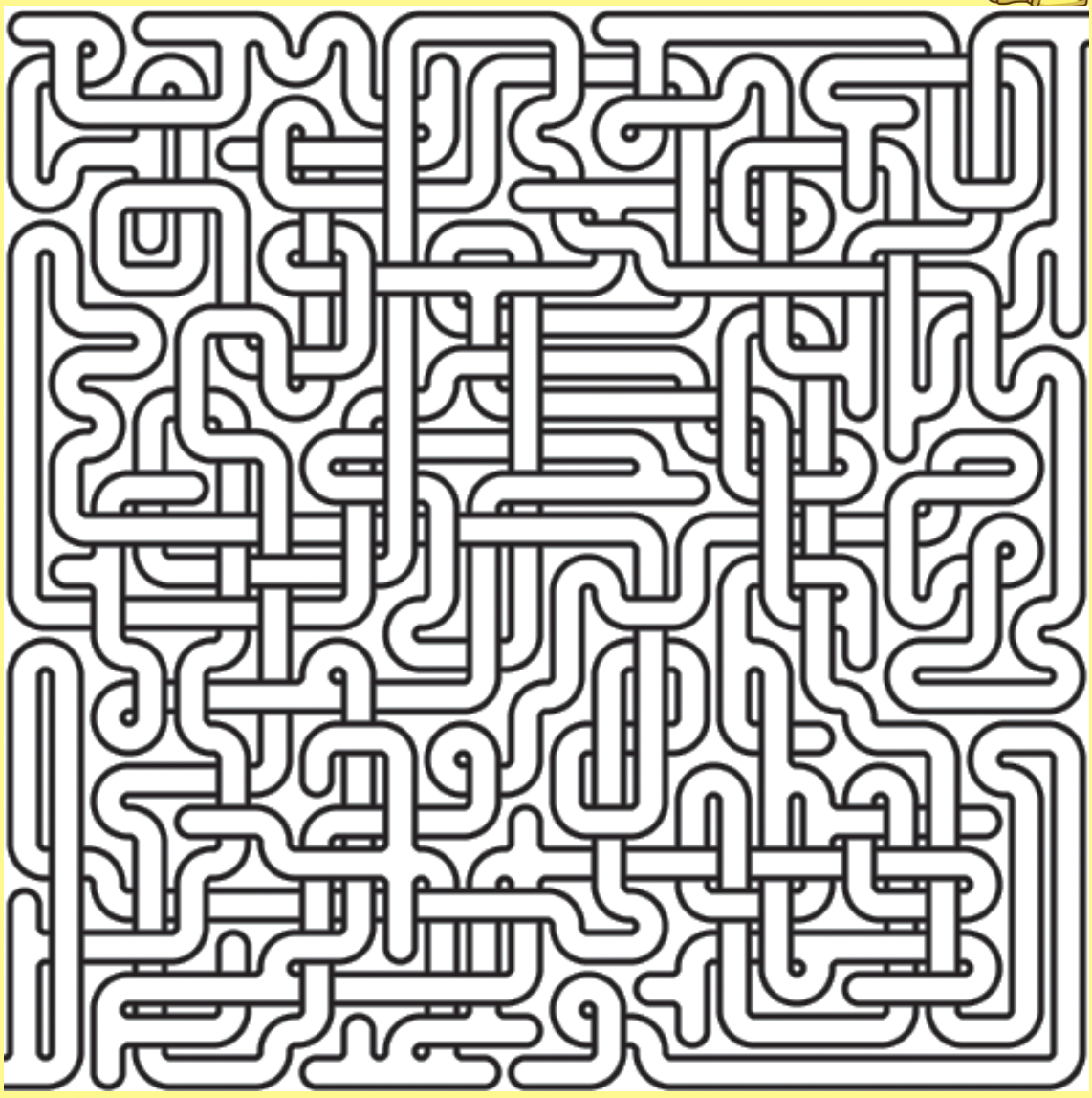
Rip-entry into the water during a dive



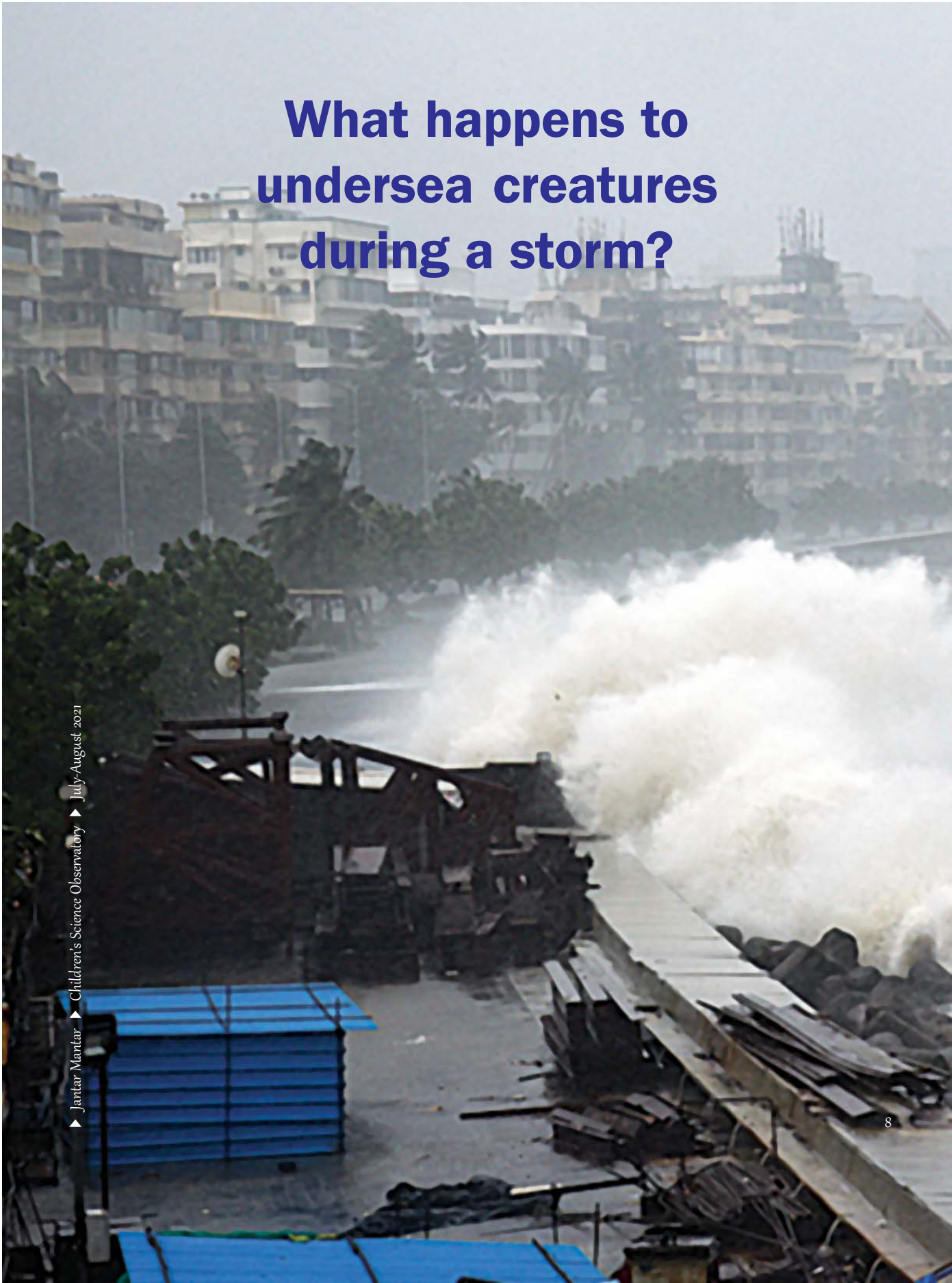
Delayed breaking of entrapped bubbles into smaller bubbles by turning



Help the friends meet!



What happens to undersea creatures during a storm?



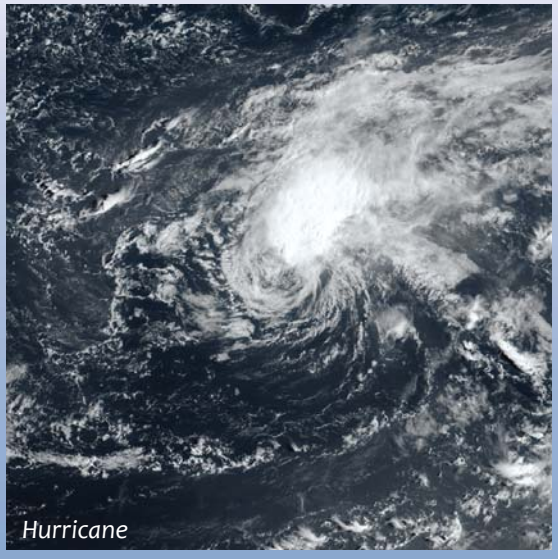
Wave

Narayani Subramanian

If it is formed over the North Atlantic ocean and Northeast pacific, it is a hurricane. If it is formed over the South Pacific and Indian Ocean, it is a cyclone. If it is formed over the Northwest Pacific ocean, it is a typhoon. But to paraphrase a popular saying, a storm by any name will be just as dangerous. We know storms cause heavy damage to life and property on land. But what about the sea and the residents of the marine world? What type of dangers do they face?

Corals

Corals are some of the worst affected organisms during a storm. As cyclones produce high energy waves, the wave motions thrash against the coral skeleton and cause structural damage. Once broken, the coral reef is more vulnerable to disease and eventual death. Cyclonic storms also stir up the mud and sediments, sometimes bringing more silt from the land, thus blocking sunlight and preventing



Hurricane

Arabian_Cyclone

Coral reef damage

photosynthesis which is a vital function for their survival.

Sharks and Seasnakes

Sharks have been known to move to deeper and calmer waters during storms. A study in 2001 revealed that even before the storm hit the shore, sharks sensed a drop in the barometric pressure and moved away from the shore. When the tropical storm Gabrielle made landfall, the sharks had already migrated to safer areas. Sea snakes exhibit the same behaviour. This is a proof for their fantastic sensing skills.

Sessile, Less mobile animals

Crabs, shellfish, turtles, sponges, Seastars and seafans face a lot of damage during cyclonic storms. The nests of turtles can be sometimes flooded by water from an unprecedented rainfall, thereby killing the next generation too. Turtles are tossed ashore by angry waves when they come to the surface for breathing.

Marine mammals

Mostly marine mammals tend to sense a disturbance in the water system and tend to move away from the shore. Sometimes, they get caught in the angry waves and they are pushed into shallower waters, where they eventually die. Even after moving into a deeper area, they are not safe until the storm passes and the sea calms down. Since marine mammals have to come to the surface for breathing, during a storm they can be disturbed by the turbulent waves in the surface of the sea, causing suffocation.

Fishes

Fishes that have a large home range move to deeper waters during a storm. Fishes

that have a restricted home range have no other option but to stay in their preferred location. This can expose them to the rage of the waves, thereby killing them. If the coral reefs are broken by the waves, the fishes that are hiding inside the corals get exposed to the wave energy. Even if they survive the storm, they lose their habitat.

Storms also bring a lot of silt and sediment into the coastal areas. If a very heavy sediment load is carried by the waves, this can clog the gills of the fishes, leading to suffocation and death. Rainfall during cyclonic storms increases the flow of freshwater into the sea, thereby creating an imbalance in salinity and oxygen content. This can disturb the coastal organisms.

Debris and Pollutants

Severe storms cause damage to the property on land. During flooding, the debris generated from such a damage is carried into the sea, causing a lot of issues. This can harm small sessile organisms.

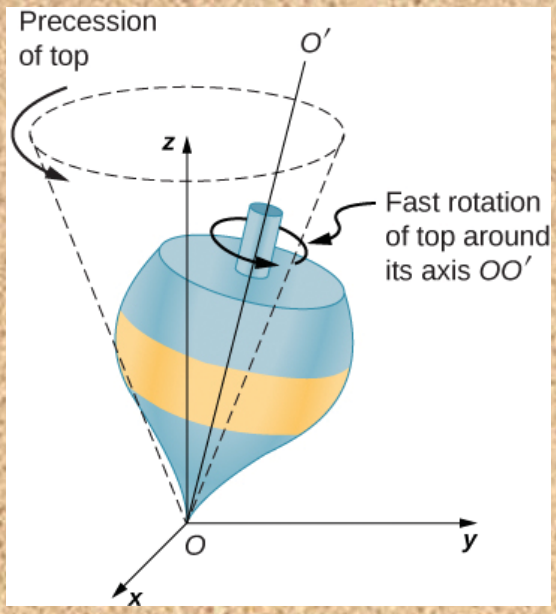
Sometimes, the floodwater also carries a lot of pollutants. During Hurricane Florence in North Carolina which hit the shore in 2012, the ponds filled with pig waste got structurally damaged. The rainwater carried all this waste into the ocean and polluted the coastal waters.

Aren't storms part of the natural cycle?

Yes. But man-made climate change is increasing the intensity and frequency of cyclones. There is also an added factor of unpredictability of these extreme weather events. Though the animals are used to the natural cycles, they are not able to cope up with the increasing frequency and intensity of these disasters. When we face a cyclonic storm, we dread the wooshing winds and ceaseless rainfall. We are afraid that it will damage our houses. We are afraid of the rising water levels. Though animals cannot express these fears, they too undergo a lot of stress during a catastrophic event.

Everyone feels helpless when nature is furious. ●

Fish swimming under stormy seas at Roca Redonda offshore Baja, Mexico, Pacific Ocean. - Brandon Cole



Seasons from the Sun

Kamal Lodaya
Bengaluru

This is the sixth of a series about calendar makers from history.

The earlier articles talked about *lunar* calendars based on *phases* of the Moon, *seasonal* calendars based on seasonal happenings (such as rains or river flooding which were important for farmers) and *intercalary* calendars whose years were seasonal but whose months were based on the Moon's phases. Today we know that the rotation of Earth *precesses*, like a top whose axis keeps shifting slightly as it spins. This makes the solstices (longest and shortest days) shift to an earlier date every year, which becomes noticeable over centuries. To fix this, a *leap day* was introduced to the seasonal year every four years.

There are several calendars in India, using different Eras. The earlier calendars were based on the Moon.

Piyadasi Era, 3rd century BCE

Samvat is a Sanskrit word meaning year. **Jains** are an Indian religious community who use *samvatsari* (literally, a date which comes yearly) for the end of the fasts of *paryushana* (literally, coming together), a day on which they seek forgiveness from others. It is a fact that in Indian history, Jains were active in using calendars. The Maurya ruler **Ashoka** (3rd century BCE) allowed may religions to flourish. Merchants took loans and used **adesha** ("bills" promising repayment) in the Empire. It is suspected that Jain calendars were in use. The famous rock edicts of **Piyadasi** (a name used by Ashoka) use his own Era. That is, they say that the edict was inscribed so many years since Piyadasi became emperor. The picture shows a portion of the Maski and Lumbini edicts with Asoka's name on it.

Shaka Era, from 2nd century CE

The Shaka empire (also called Kshatrapa, *kshetrapati* meaning ruler of the land) was in northwestern and central India. The Shakas traded with Greeks from the port of **Bharuch** in Gujarat. They used the Greek calendar of **Meton** (4th century BCE) and **Hipparcos** (3rd century BCE), which had reached India by the 1st century CE. It may have replaced the Jain calendar. The Greeks talked of **Barygaza** (Bharuch) and **Ozene**, which we recognize as **Ujjain**, Madhya

Devanampiyasa Asoka

Pradesh. Ujjain has been an important city for Indian calendar makers because it lies almost on the Tropic of Cancer. The Sun is overhead here on summer solstice, noon of June 21st.

The *Shalivahana Shaka Era* begins in 78 CE with the year the Shaka ruler **Chashtana** (**Tiastanes** in Greek) started ruling in Ujjain, defeating the Satavahanas who ruled Maharashtra and Andhra Pradesh. Both kingdoms fought many battles over Ujjain. Chashtana's kingdom included Malwa, Gujarat and Sindh. An inscription written in year 11 of his rule (89 CE) has been found in Kachchh. The picture shows a coin of ruler Damasena minted in year 153 of the Saka era (231 CE). The date is clearly visible behind the head of the king.

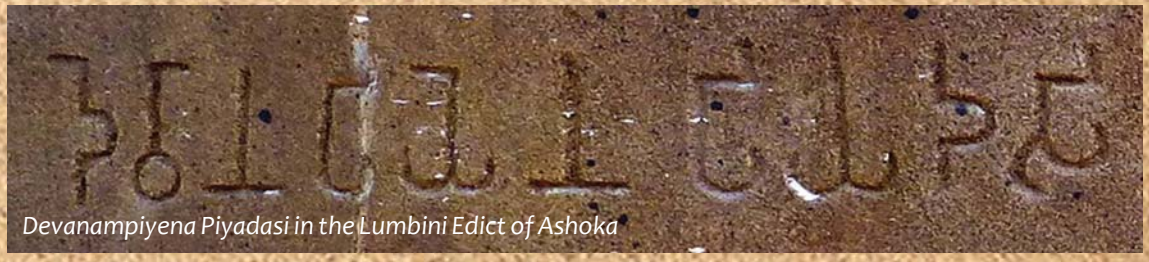
There are many different dates for the Shaka Era. A century after Chashtana, another ruler chose to accept Chashtana's rule as the beginning of the Era instead of starting a new one. Shaka Era was widely used from the 5th to the 7th centuries. It also spread to Indian kingdoms in Southeast Asia.

Gupta Era, from 4th century CE

The Guptas used their own Era, starting from 319 CE. In the 5th century CE, emperor **Samudragupta** named his grandfather **Chandragupta II** as *Vikramaditya* (literally "sun of valour"), which became popular as a title among kings. In the Gupta period, Jains moved from Bihar to settle in central and western India.

Kali Yuga, from 6th century CE

The Tamils followed a completely different seasonal calendar, based on the


Devanampiyena Piyadasi in the Lumbini Edict of Ashoka

Damasena year 153

Sun, the months being related to the seasons by the Sangam poet **Nakkirar** around the 3rd century CE. The year began on 14th April with the month of *Chittirai*. The North Indian seasonal calendar's month of *Chaitra* begins on 22nd March. See the table below.

Why is the Tamil calendar ahead by three weeks?

The spring equinox was on 14th April in the year 285 CE. Then the Sun was exactly opposite the *Chittirai nakshatra* (Chitra star).

The Tamil seasonal calendar is used in Tamilnadu, Kerala, Assam, Bengal, Manipur, Odisha, Punjab, Rajasthan and Nepal. For instance, 25th August 2021 is the 9th day in the **Aavani** month of *Kaliyuga* year 5123. You can calculate from this that Kaliyuga started from a date in 3102 BCE.

This dating of Kaliyuga was done in the year 3600 (499 CE) by **Aryabhata**, an Ashmaka (most likely from the Godavari valley) who lived in **Kusumapura** (Nalanda or Patna, in Bihar). A century later, he was criticized by **Brahmagupta** of Bhinmal (Jalore district, Rajasthan) for starting his own Era. Brahmagupta used the Shaka Era. At that time Bhinmal was ruled by Gurjara kings from Gujarat. It was a place of Jain pilgrimage and has been known for its moneylenders for centuries.

Vikram Samvat, from 8th century CE

By the 5th century CE, the Jains were using *Vir Samvat*, which counts years since the death of **Mahavira**, traditionally dated to 527 BCE. Centuries later (the earliest inscription in Okha, Gujarat, mentions Vikram Samvat 794), this was recalibrated as *Vikram Samvat*, after a legendary ruler called **Vikram** from Pratishthana (Paithan, Maharashtra). Paithan is known as a place of Hindu, Jain and Buddhist pilgrimage. Vikram is said to have defeated the Shakas and ruled Ujjain from 57 BCE (Vir Samvat 470) for about a decade before the Shakas came back to power. The date matches with an inscription in Naneghat cave, Maharashtra, mentioning Satavahana ruler Satakarni I.

Rivalry between Shakas and Satavahanas led to two different Eras in Indian calendars. As can be seen their history is quite mixed up. The name

Shalivahana Shaka respects both traditions.

The word **intercalary** means insertion of an extra day or month to align a calendar with the solar year. The intercalary Samvat calendar is used in North India, Gujarat, Maharashtra, Karnataka and Andhra. For example, 25th August 2021 is the 3rd day, krishna paksha, of the Bhadra month of year 2078 in the Vikram Samvat calendar. For Jains the new year begins with the month of Kartika, so 25th August 2021 is in year 2077 of the Vikram Samvat. The picture shows the Barnala Yupa pillar in Rajasthan with inscription in Sanskrit and date according to the Vikram Samvat calendar.

Summary

We mainly use three Eras today in India: **Kaliyuga**, starting in 3102 BCE; **Vikrama**, starting in 57 BCE (Kaliyuga 3045), and

Barnala inscription

Shalivahana Shaka, starting in 78 CE (Kaliyuga 3179, Vikrama 134).

Some of the Indian calendars are: the Hindu and the Jain intercalary calendars, in North India (Shaka and Vikrama Eras); the National seasonal calendar, in North India (Shalivahana Shaka Era); the Tamil seasonal calendar, in the South (Kaliyuga Era). There are more. Every calendar borrows several things from others.

Years and numbers, BCE and CE

There were many calendars in BCE, Before the Common Era, which was introduced after the life of Jesus Christ. If you know your school mathematics, you might say the Roman emperor Julius Caesar was born in the year -100 (100 BCE) and died in the year -44 (44 BCE). Here is a trick question about Eras, which might puzzle you. Since Jesus Christ was not even born, how did the calendars of those times know what was zero? Think about it.

So you leapt ahead to think about how people thought about zero before zero was invented? No, they didn't think about zero. The day after December 31 of 1 BCE (first year before the Common Era) is January 1 of 1 CE (first year of the Common Era). There is no zero year.

Zero the number is a little different from the zeroes that appear inside numbers, such as 100 or 101 or 120. People wrote these earlier like we speak them today, as one hundred (write it as 1H) or as one hundred and one (1H1U) or as one hundred and twenty (1H2T). People knew how to count from very long ago.

Numbers and zero, 2nd to 5th century CE

Thinking about zero as a number comes from India. *Shunya* (emptiness) is discussed at great length by the Buddhist philosopher **Nagarjuna**, who lived in **Amaravati** (Vijayawada) in the 2nd century CE where the Satavahana kings ruled. From his texts, it cannot be said whether he was familiar with zero as a number.

The earliest confirmed dated text where we realize that the writer knew zero is by the Digambar Jain monk **Sarvanandi** in *Patalika* (Tiruppadirippuliyur, Cuddalore district, Tamil Nadu).

The date on which his text was completed is given as Shaka year 380, Bhadra month, krishna paksha, 15th day. Using today's calendar this date is 25th August 458 CE. As we saw earlier, 25th August 2021 is 1943 Shaka, Bhadra month, 3rd day. So 458 CE being 380 Shaka checks out. The month agrees but the date doesn't. There is a gap of 12 days. Remember that intercalary and seasonal calendars can differ in their dates by upto one month.

Sarvanandi also says it was the 22nd year of king **Simhavarman** of Kanchipuram, which matches a Pallava king called Simhavarman II. Some years before this, Sarvanandi says he attended the Jain council at **Valabhi**, near Bhavnagar in Saurashtra, Gujarat, where he was instructed to prepare the book he wrote. A council was held there in 453 CE.

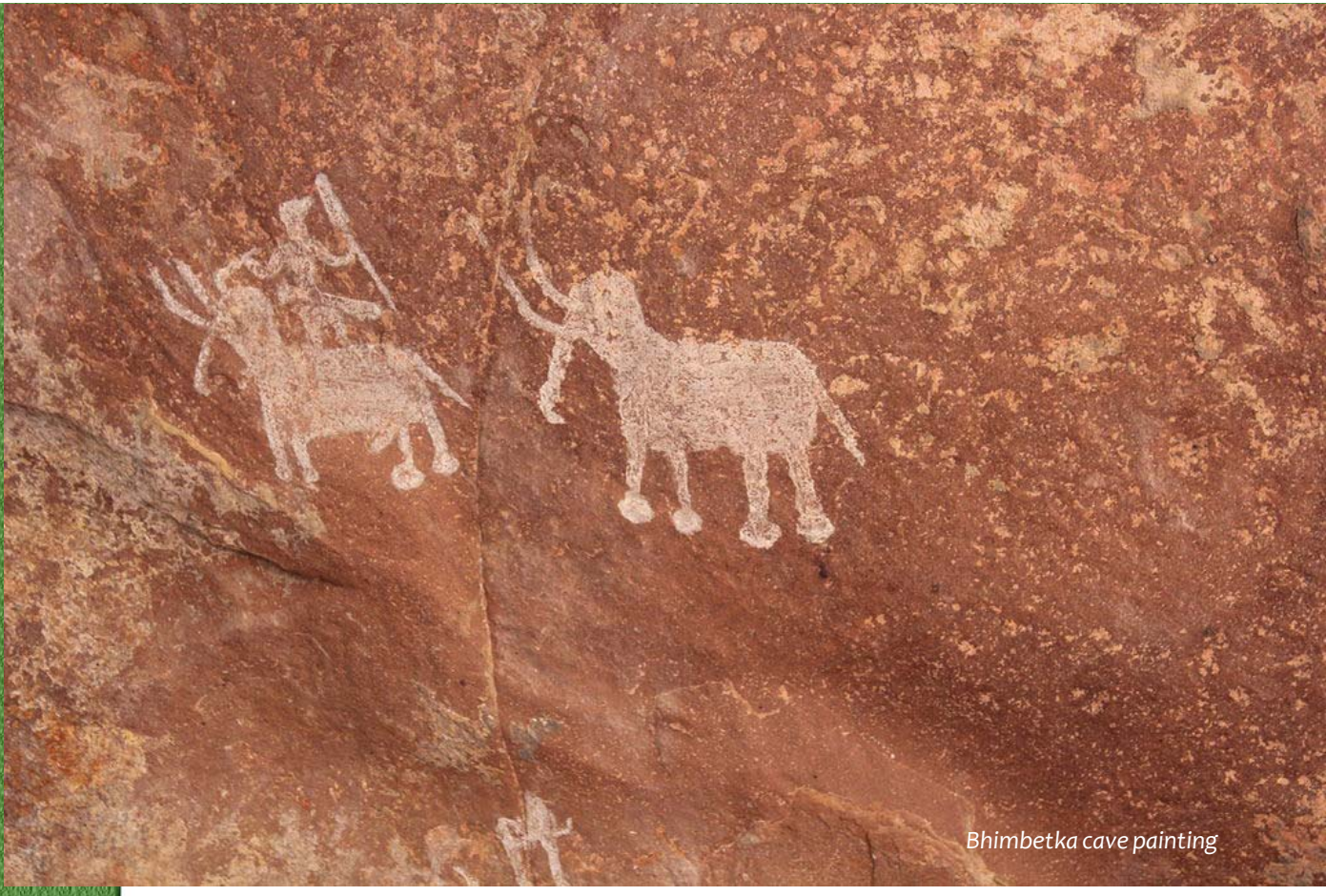
Sarvanandi's text *Lokavibhaga* describes the Jain universe. So you may ask why is it thought that the writer was comfortable with zero? The text uses huge numbers like 14236713,13107200000,70500000000000000, which show that the writer knew the decimal system very well. It uses the fact that (14230249-355684)/212 is 65446 with 13/212 left over, so the writer knew arithmetic. It uses the word *shunya* for an "empty" answer. The writer must have been as familiar with decimal arithmetic as an ace schoolchild today. So we can be confident that zero the number was known in the 5th century CE.

Sarvanandi Lokavibhaga Jain Manuscript

Three calendars for 2021-22 CE		
National year 1943	**Vikram Samvat year 2077-78**	**Tamil year 5123**
Chaitra, Mar 22	Chaitra, Mar 29	Chittirai, Apr 14
Vaishakha, Apr 21	Vaishakha, Apr 27	Vaigasi, May 14
Jyeshtha, May 22	Jyeshtha, May 27	Aani, June 15
Ashadha, June 22	Ashadha, June 25	Aadi, July 16
Shravana, July 23	Shravana, July 24	Aavani, Aug 17
Bhadra, Aug 23	Bhadra, Aug 23	Purattasi, Sep 17
Ashwina, Sep 23	Ashwina, Sep 21	Aippasi, Oct 17
Kartika, Oct 23	Kartika, Oct 21	Karthigai, Nov 16
Agrahayana, Nov 22	Mrigashira, Nov 20	Margazhi, Dec 16
Pausha, Dec 22	Pausha, Dec 20	Thai, Jan 14
Magha, Jan 21	Magha, Jan 18	Masi, Feb 13
Phalguna, Feb 20	Phalguna, Feb 17	Panguni, Mar 14
Chaitra, Mar 22	Chaitra, Mar 19	Chittirai, Apr 14

The table shows the beginning dates of the months of this year (2021) for these three Eras. The beginning of Vikram Samvat 2078 differs in different parts of India. For the Jains, it begins on 5th November 2021, the day after Kartika amavasya (Deepavali). Observe how the Vikram Samvat months are at first ahead of the National calendar months, but they keep lagging behind. At the end of the year they are behind the National months. In another year they will be falling really behind and it will be time to introduce an extra month (*adhika maasa*) to correct the calendar. Who is to decide this? We will find out in the next issue of ***JM***.

Pictures from Wikipedia

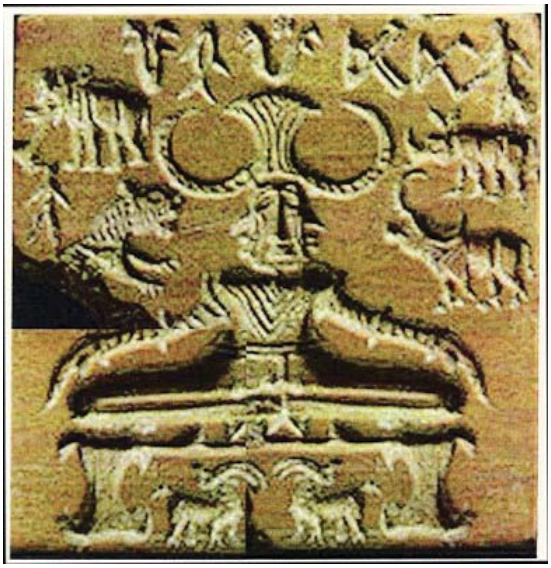


Bhimbetka cave painting

Elephants In Indian Culture

C. R. Ramana Kailash

Pasupathy Mahadeva seal



Elephants are one of the most celebrated creatures in human history. Major religions around the globe depict elephants as strong, intelligent and powerful. But ironically, these creatures weren't respected in most of our history. Despite being valued in most cultures, they were tortured and killed ruthlessly in most of human civilizations. Just like India's diversity, elephant's role in the cultures is diverse too.

Hair comb of ivory

Ancient India

Cave paintings in India depict elephants. The **Bhimbetka** cave paintings (one of the oldest cave paintings in Madhya Pradesh, dating back to 10,000 years) depict herds of elephants alongside tigers, rhinoceros, deers, peacock and snakes (see picture). India had nearly half dozen of elephant species during prehistoric age. But Indian elephant (*Elephas maximus indicus*) was the only species to survive in the country after 5000 years.

During the first urbanization, trade and agriculture became modernized, and a vast civilization formed on the banks of the Indus, one of the longest rivers in Asia. Gradually the city expanded and became one of the three 'Cradles of Civilization' with a population of 5 million. Seals depicting elephants are excavated from *Indus Valley civilization* sites. **Pasupathy Mahadeva seal** (see picture), shows a horned deity surrounded by wild animals including elephants, tigers, rhinos and buffalo. *Hair combs* made from ivory of elephants (see picture) were excavated from **Keezhadi** archaeological site. Archaeologists presume that elephant taming in India is an ancient practice. They were used as beast of burden, helping to clear to forest, construct houses and lift heavy objects.

As Indus valley civilization collapsed, the *Vedic age* started. Elephants had a major role in Vedic ages too; **Indra**, god of thunder, had a four-tusked white elephant as his vehicle. All four Vedic books mention about elephants. Even though **Rig Veda** mentions about 'ganapathi' twice, neither of them refer to Modern Ganesha. The first statue of Ganesha (see picture) was excavated in Kabul, Afghanistan; this marble statue dated back to early 4th or 5th century.

The second urbanization occurred as empires emerged around the Northern parts of India. *Mahajanapadas* and various other republics appeared, wars became

Mahabalipuram rock relief

common between these states. Soon elephants became major war-machines in these battles; the number of elephants in the army was the most important factor in the war. During the war between **Porus** and **Alexander** *the great*, elephant army of Porus played the main role in making the war tough. But each war had deadly consequences, creating losses to both sides. Elephants were ruthlessly killed in these wars. Hunting and capturing elephants from wild was also common around India. Most of the tributes given to kings were mostly captured elephants, tiger skins or gems.

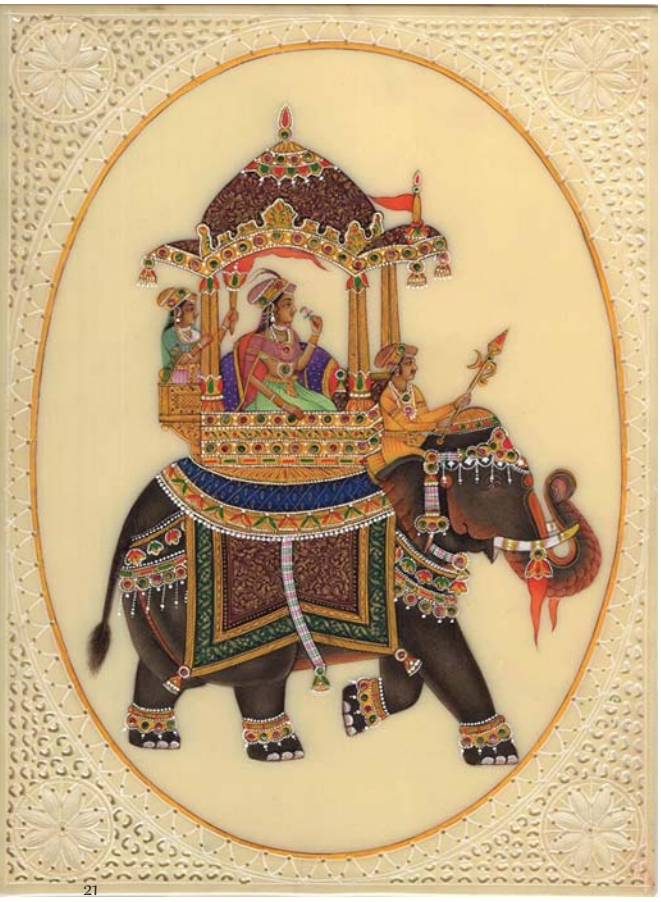
Buddhism and *Jainism* emerged contemporary to Mahajanapadas; it created a new wave across the country. Elephants had a major role in these religions too. Elephants are associated with the birth of **Gautama Buddha**; there is a tale of elephant portrayed as an incarnation of Buddha. In *Sangam age* of south India, elephants had a major role in wars. According to the age, gender and size, elephants are denoted with 50 names in Sangam literature. Using elephants in wars and rituals were common in the **Chera**, the **Chola**, the **Pandya** and the **Pallava** dynasties of south India. The *Bible* and the *Quran* mention about elephants. Elephants are shown alongside ancient artworks of **Adam** and **Eve**.

Medieval India

The medieval age in India played a major role in laying the foundation for modern India. Trade between continents expanded, creatures from east including elephants were exported to the other countries. People of Western world were surprised to see massive creatures like elephants; in turn creatures like giraffes and

African elephants were imported to India. Sculptures in **Konark** *sun temple* show giraffes and African elephants alongside native animals. Many religious texts including ancient rock reliefs depicted elephants; **Mahabalipuram** has a fantastic rock relief depicting a herd of elephants. **Elephanta** *cave* in Maharashtra had a huge statue of elephant.

In the 11th century, invasions to India became frequent after the raids of **Muhammad** of **Ghazni**. But elephant armies of Indian rulers helped to resist these invasions. **Timur**, one of the notorious nomadic rulers of Samarkhand, defeated Delhi's sultan by scaring away his vast elephant army using fire. He raided Delhi, sacking tons of wealth including 500 elephants. Even after invention of guns and ammunition, usage of elephants in the army played a crucial role. Historical sources say that nearly 1000 elephants along with 20,000 workers helped to construct Taj Mahal.



Royal members of Mughal courtyards used to ride on elephants; miniature paintings from Mughal age (see picture) usually depict the *Badshah* on elephants, appearing before the huge crowd or on a hunt. Because of inventions of guns, trophy hunting increased. Thousands of elephants were killed for prestige and ivory carving. Courtyards of king from medieval ages were filled with mounted heads, tusks and tail of elephant alongside other game animals. Just like gladiatorial fights in Rome, fights among elephants were conducted as a form of entertainment. *Thamukkam* ground in **Madurai** is one such place.

Modern India

Modern technologies and weapons were introduced to Indian armies during colonial rule and the importance of elephants in the army decreased. But trophy hunting, especially among British official and kings, became even more frequent. Long *tusks* of elephants were taken and kept as artifacts and trophy. *Legs* of elephants were also kept as stools; they were symbols of luxury of that age. Circuses around India used trained elephants to entertain people; they were treated badly in these shows. Soon, keeping wild animals in the circus including elephants became illegal.

Still, elephants are symbols of intelligence, memory, strength and durability. Elephants are national heritage

animal of India. Elephants are shown in the *emblem* of India and also the state of Kerala. Various political parties use elephants as symbol of their parties.

Elephants are also common temple attractions. The **Pooram** festival of Kerala showcasing decorated elephants is a spectacular event that attracts global tourists even now. But mostly temple elephants are half-starved, as the temple administration can't afford food. Wild elephants used to walk kilometers through forests but temple elephants used to stand on a restricted place for hours and walk short distances on hot tar road. Generally elephants are social but their tamed relatives lead a stressful solitary life in small spaces in temples.

It is true that taming elephants is an ancient practice which is associated with our archaic culture, but this ancient practice should be allowed to fade away. Elephants need to live in the wild, they are wild animals still. They are not pets or domesticated animals to be sold in the markets; they should be protected and respected by human community in their wild habitat.

"We admire elephants in part because they demonstrate what we consider the finest human traits: empathy, self-awareness, and social intelligence. But the way we treat them puts on display the very worst of human behavior." **Graydon Carter**.

Pictures from the internet

Do You Know?

1. We hear of global warming and ice melt in the Arctic. Will all the ice in the Arctic soon be fully gone? When will this happen?

2. Why do we forget so many things but never forget how to ride a bicycle?

3. Can one lose weight only by exercising, or is dieting also needed?

4. Who invented soap?

5. How do ants breathe?

Answers to March-April issue's Do You Know?

1. Can we use lightning and thunderstorms as sources of energy?

Answer: This is perhaps something human beings have fantasised about for hundreds of years. Surely, lightning and thunderstorms carry a great amount of energy, can we not somehow make use of them for our energy needs?

In fact, a great deal of electrical energy is unleashed during a thunderstorm. On average, a lightning bolt is said to contain about five billion joules! The trouble is that capturing that energy is very difficult.

To start with, we have no idea where lightning is likely to strike. With all the science and computing capability we have now, we still cannot predict it. At any given time, there are around a hundred lightning occurrences around the globe, but these flashes are unpredictable. Only a very small fraction of them reach the ground.

Suppose that we have managed to "catch" it. The next problem is to convert all that energy into some useful form. The heat generated by lightning can be over 20,000 degrees Celsius, and the voltage can be as high as around a hundred million volts. We do not have equipment that can safely withstand these extreme conditions. If we manage to build such material, the next issue is storage. We need to convert the energy into the low voltage, alternating current that powers our homes. This is very difficult.

The last big problem is dissipation into the atmosphere as heat. We would get at most 1500 kilowatthours after all the effort.

A company in the USA called Alternate Energy Holdings did try to develop technology to harness energy from lightning in the early years of this century, but gave up. Perhaps you will make the great breakthrough some day that will address this challenge!

2. I saw the film Meg. Are megalodon sharks real? How big are their teeth?

Answer: Megalodon shark is a real animal, one that can make white sharks look

'normal'! Not only are they the largest sharks to have ever lived, but also one of the most dominant creatures to roam the oceans. Their predatory behaviour has shaped entire marine ecosystems.

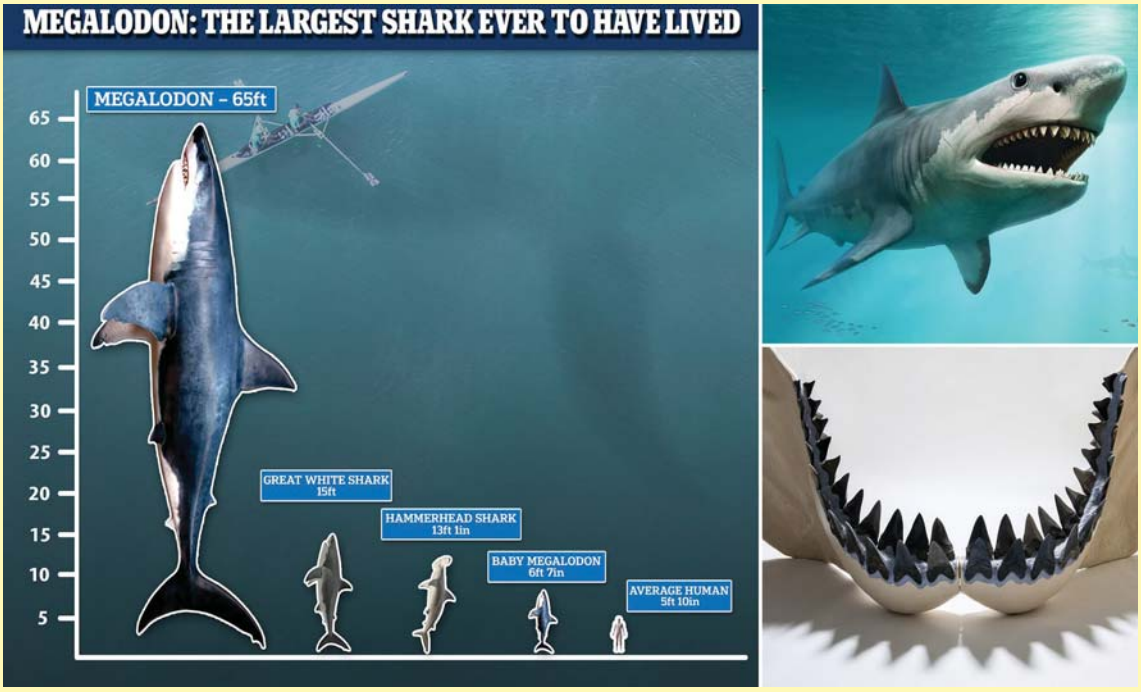
If you are terribly scared, please do not be. You are unlikely to meet any megalodon shark, because they are extinct! We know of them only through tooth fossils.

What size was a megalodon shark? Big. Very big. The megalodon shark was roughly 16 metres in length. That is longer than a normal sized bus, and three times the length of the average great white shark. Scientists also estimate that their fins were the length of an average adult human.

We do not have fossil evidence to tell us how their bodies were built. Scientists have used mathematical models to make estimates. They have calculated that a megalodon head might have been around 4.65 metres long, its dorsal fin approximately 1.62 metres tall and its tail around 3.85 metres high. They suggest that at birth a baby megalodon was two metres in length, much bigger than an adult human!

How big were megalodon teeth? By the way, the word 'megalodon' actually means 'giant tooth' in ancient Greek, so it is no surprise that their teeth were big. Each shark had 276 teeth, each measuring up to 18 cm long. Unlike other parts of the megalodon skeleton, which was made from cartilage, each tooth was formed by hard dentin (like human teeth). From fossils, we gather that the jaw was around 3 by 3.5 metres wide. That is big enough to fit at least two adult movie stars inside, so imagine it for your favourite film.

Here is something very interesting. Megalodons would lose a complete set of teeth between every one and two weeks, and grow them. This means they would



produce up to 40,000 teeth during their lifetime! That is why these fossils are so common to find.

It is estimated that megalodon bites could exert a force of up to 182,200 Newtons, giving them the hardest bite of any ever creature known on Earth. In comparison, the Tyrannosaurus rex could bite with a force "only" of 60,000 Newtons, while the Nile alligator (who has the strongest bite of any living animal on Earth today) can manage "merely" 22,000 Newtons.

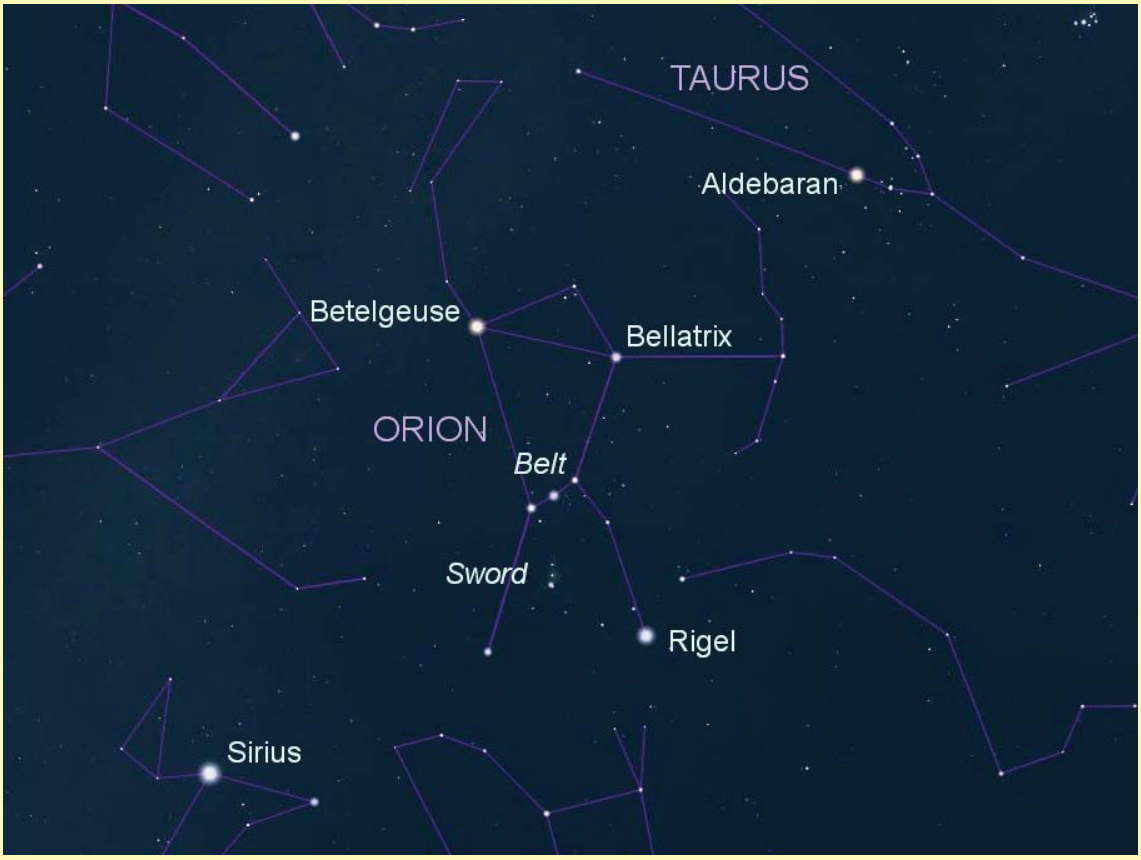
Megalodons became extinct about 3.6 million years ago. The earliest Homo sapiens species emerged roughly 2.5 million years ago, so they were before "our time". Megalodons seem to have lived even 20 million years ago.

How did such an awesome animal go extinct? We do not really know. Some scientists say they were killed by a period of global cooling. Others say they died out due to a lack of suitable prey, alongside the appearance of predators like the great white shark, which depleted the megalodon's food source.

3. How small would the Earth have to be for us to feel it spinning?

Answer: We do not feel the rotation of the Earth, because we are rotating with it. But it is also because we are very small relative to the size of the Earth.

Now suppose that the Earth is somehow compressed without losing any mass. Then it would have to spin faster to conserve its angular momentum. Have you seen



dancers do this on one leg, folding themselves and spinning faster? This would increase the centrifugal force acting on us. Since this force acts radially outwards, it could partly cancel out the force of gravity, and our weight would decrease.

How much should we compress the Earth for this to happen? Halving the diameter of the Earth would reduce our weight by around 1.2kg, which is probably not enough to even notice. But centrifugal force does not increase linearly, and on a quarter-sized Earth our weight would drop by 15kg in total, so you would feel lighter and could jump higher.

Whether this counts as "feeling the rotation" itself is debatable. On a merry-go-round, you feel the spinning because the radius of the ride is so small that the centrifugal force varies noticeably across the length of your body. For this to happen, our miniature Earth would have to be so small that your own height was a significant proportion of the planet's radius. Long before we reached that point, though, the Earth would have disintegrated from its own centrifugal force.

In short, if it were so small that you would feel it, you would not be around to feel it!

4. How far away is the Orion Nebula? Why is it so clearly visible?

Answer: When stars are being born, or when they are dying, they form nebulae, clouds of dust and gas. Some nebulae are where stars have died, and some where stars are forming. The Orion Nebula is the latter.

At "only" 1,344 light-years away, the Orion Nebula is the closest and one of the brightest nebulae visible from Earth. This means that it can be seen with the naked eye at some times of the year when viewed under dark skies.

The brightness of objects in the night sky as seen from the Earth is measured on a logarithmic scale: the lower the number, the brighter the object. This scale means that an object with magnitude 1 will be 10 times brighter than a magnitude 2 object. The Sun has a magnitude of approximately -26, while the brightest star in the night sky, Sirius, has a magnitude of -1.46. The Orion Nebula has a magnitude of 4, which means it is fairly faint. You will need to go somewhere dark and let your eyes adjust to really see it. A new moon night is good for this.

Finding the Orion Nebula is easy as it is in the constellation Orion, one of the most easily recognisable constellations. Orion is most visible in the evening sky from January to March, winter in the Northern Hemisphere, and summer in the Southern Hemisphere. In February and early March, Orion will be visible in the eastern sky as soon as the Sun sets, sweeping south in the northern hemisphere then setting in the west in the early hours of the morning. In the southern hemisphere, Orion will be visible in the north, appearing upside-down compared to how it looks in the northern hemisphere. To find the nebula, look below the three stars of Orion's Belt. You will see a faint line of stars, which make up Orion's sword. The nebula is halfway down the sword and appears as a fuzzy-looking star.

5. Could robots be programmed to evolve?

Answer: The answer is yes, and this was demonstrated by scientists in 2015. If ever humans want to settle on other planets, we would want to send an advance party of robots. They would first create conditions favourable for humankind. But then, if they need to survive within the inhospitable cosmic climates that await them, they would need to be tough, adaptable and recyclable. Thinking along these lines, scientists concluded that that the best way to make them tough and adaptive would be to get them to evolve.

Out in the cosmos, what shape and size should the ideal robot be? Should it crawl or walk? What tools will it need to manipulate its environment? How will it survive extremes of pressure, temperature and chemical corrosion? These are difficult for us to answer but nature has already solved this problem. Darwinian evolution has resulted in millions of species that are perfectly adapted to their environment.

The problem is that biological evolution takes millions of years, and we cannot wait that long. But artificial evolution, modelling evolutionary processes inside a computer can take place in hours, or even minutes. Now computer scientists have graduated from modelling to physical robots that reproduce their hardware (using 3-D printing) in an evolutionary manner. This process is slow, but much faster than biological evolution already, and will get faster as we learn the processes better.

The "mother" is a robotic arm that

builds "baby" robots out of small cubes. Each cube has a mechanism where one side can waggle. When you place it on a surface, it clumsily drags itself around. The mother glues these moveable cubes together in various arrangements. Some combinations move further and faster than others. The mother robot builds each arrangements using assembly instructions in the form of a "genome" that is passed between successive generations of robots.

These algorithms evolve both the body-plan and brain of the robot. The brain contains a controller that determines how the robot moves, interpreting sensory information from the environment and translating this into motor controls. Once the robot is built, a learning algorithm quickly refines the child brain to account for any potential mismatch between its new body and its inherited brain.

The mother is programmed to insert random mutations into each generation. Some offspring move around better than their forerunners, but others do worse. The mother rejects deficient generations but uses the genetic blueprints of successful ones to build subsequent offspring. In the lab, after only 10 generations, the robots performed twice as well as those at the start of the process.

Shall we call this "unnatural selection"!?

From various sources

Publisher
S.Subramani
TNSF, Chennai 600 086
Typeset at
Fineline
Design, Illustrations and Layout
Basheer
Rajeswari
Printed at
Sri Murugan Printers,
7/1, Boobegam 3rd St, Anna salai,
Chepauk, Chennai - 600 002.

Annual subscription Rs. 90/-. Life Subscription Rs. 900/-
Bank Details: Jantar Mantar, Indian Overseas Bank, Dr. RK Salai Branch, Chennai - 600004
AC No: 029101000031081 IFSC Code: IOBA0000291

Nature Diary

Malabar Kino

(*Pterocarpus marsupium*)

Chitra Patel

It was the beginning of February when I saw a tree having no leaves but only pretty little circular fruits with papery wings, which got me very much fascinated! That instant, it became my favorite tree and I was curious to know more about it. This inquisitiveness led to explore further about these green wonders!

Description

Malabar Kino (family Fabaceae) is a large deciduous tree native to India, Nepal and Sri Lanka that can grow up to 30 meters tall. It has dark grey or brown bark having narrow vertical flakes which makes the trunk to look shaggy. Leaves are pinnate and compound with wavy edges. The fragrant, yellow flowers are clustered and the fruits are circular with papery wing.

Changes with respect to Seasons

Leaves are shed by mid to late March and renewal is observed in early May. Flowering begins late in September, peaking by mid October. Fruits ripen and start to fall by February-March.

Plant Animal Interaction

Butterflies like Tawny Rajah *Charaxes psaphon* and Chestnut-streaked Sailer *Neptis jumbah* lay their eggs on Kino.

Uses

Parts of Kino are long since used in folk and traditional systems of medicine. Recently, there has been interest as it has the ability to stimulate insulin production in the pancreas which will be effective in treating diabetes. This is a prospect for research and trials but people should strictly not use any part of any plant species as medicine unless directed by qualified professionals. Among the jungle timbers Kino commands a value second only to that of Teak *Tectona grandis* and Rosewood *Dalbergia latifolia*. It is used to make furniture, doors, carts and beams and is a potential biodiesel plant.

Conservation Status

Malabar Kino is classified as "**Vulnerable"** under the IUCN Red List of Threatened Species and faces a high risk of endangerment in the wild and it is our duty to protect the species.

Nobel ceremony 1930; CV Raman at extreme left

Indian Scientists who changed the world

Shreya Pareek

Science is an important part of our everyday life, even more so than we notice. From our fancy gadgets to the technologies we can't live without, from our humble light bulb to the space explorations, it is all a gift of science and technology.

I wonder what we would be doing if none of these things were invented? How often do we take out the time to think about those extraordinary minds who made life easier for us? Here is a series on Indian scientists whose path-breaking achievements led to the international progress of Science. In this issue, we start with the stalwart, Sir C V Raman.

Chandrasekhara Venkata Raman won the Nobel Prize in Physics for his pioneering work on the scattering of light. Born in Tiruchirapalli on November 7, 1888, he was the first Asian and first non-White to receive any Nobel Prize in the sciences.

The Blue Sky

It was Lord Rayleigh who first showed

that the sky is blue because the blue light in the Sun's rays are scattered more that the red end of the rainbow spectrum. So when sunlight falls on the molecules such as nitrogen, carbon-dioxide or water vapour in the Earth's atmosphere, the light is scattered such that the sky appears blue, especially at angles away from the Sun. Here the different colours of light are simply scattered away at different angles, but the colours remain the same: blue light is scattered as blue light, red light as red, and so on.

Since the sky was blue, it was thought that the sea looks blue due to reflections of the sky. But when Raman was returning from England by ship and was fascinated by the intense blue colour of the Mediterranean sea, he became curious about how the sea could be more blue than the sky. He came back to the University of Calcutta where he was working and studied this problem. He showed that it was the property of water itself that caused the blue light to scatter more and had nothing to do with the colour of the sky.

The Raman Effect

Raman also made a detailed study of these properties of water and other liquids. He discovered that, when light traverses a transparent material, some of the scattered light is the same colour as the original one but there is also another colour, with a lower frequency. The new frequency depended on the molecules contained in the liquid. This phenomenon is now called the Raman scattering and is the result of the Raman effect. This fantastic discovery made on 28 Feb, 1928, was announced in a press report the next day, for which reason February 28th is celebrated as National Science Day in India. Curiosity about the world around him led to the Nobel prize in 1930.

Raman Scanner

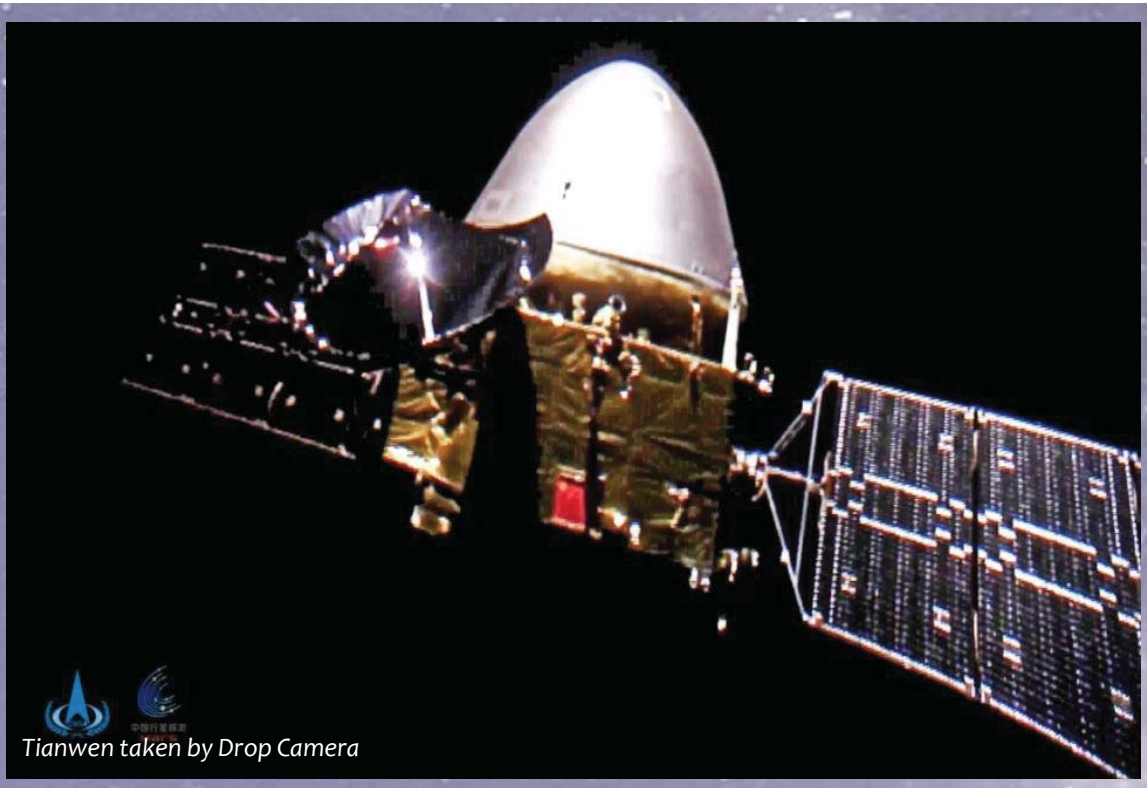
Raman also invented an instrument called the spectrograph that could determine the frequency of light falling on it. The Raman effect has numerous uses in science and technology. Since the emitted frequency of light depends on the substance it passes through, it can be used to identify the substance. The Raman Scanner can therefore be used to see if people are carrying any banned substances, without opening the baggage and examining the contents.

Other Work

Raman also worked on the acoustics of musical instruments. He was the first to investigate the harmonic nature of the sound of the Indian drums such as the tabla and the mridangam. He also had a fabulous gem collection which he used in his studies on light and crystals. These can be seen even today at the Raman Research Institute in Bangalore.

Raman on War and Peace

He died of natural causes on 21 November 1970. Till the end he was passionate about the science journals that he had helped to grow, which were essential for the enhancement of science and scientific temper. He was horrified at the development of the atom bomb. "The world, which is so keen on using the achievements of physics for the purpose of mass destruction, would be better" employed for the peaceful settlement of conflicts, he said.


Tianwen taken by Drop Camera

Selfies on Mars

D. Indumathi,
The Institute of Mathematical Sciences, Chennai

The **Tianwen-1** is a Chinese mission to send a to send a robotic spacecraft to Mars. Its name means "Heavenly Questions".

The spacecraft, with a total mass of nearly five tons, is one of the heaviest probes launched to Mars and carries 13 scientific instruments. It is the first in a series of missions for planetary exploration by China. It also includes a lander to actually land on the Martian surface.

Launched on 23 July 2020, it spent seven months through the inner Solar System before the spacecraft entered into orbit around Mars on 10 February 2021. For the next three months the probe studied various possible landing sites on Mars. Finally, on 14 May 2021, the lander/rover portion of the mission successfully touched down in the Utopia Planitia region on Mars. This made China the third nation to both land softly on and establish communication from the Martian surface, after the Soviet Union and the United States.

After the lander landed, the Zhurong rover descended from the landing platform and drove on the Martian surface. One of the most interesting things about the mission was its "drop camera" which photographed both the rover itself as well as the Tianwen-1 lander! The less than 1 kg camera is today the lightest artificial object on Mars.

The rover is (like others) powered by solar panels. It will probe the soil composition and search for biomolecules and signs of life. It

will also study the climate and atmosphere of Mars.

The drop camera

A small camera with wide-angle lenses on both sides was ejected from the outside of the spacecraft as it orbited Mars. It took one image every second and sent the data to Tianmen-1, which then transmitted the images back to Earth 25 million km away. Just think of it!

The camera took a photo of the Tianwen-1 probe itself; see photo. The black background is the colour of deep space. While the camera was falling away into space, Tianwen-1 in turn took images of the camera as it tumbled away! Tianwen-1 also took many photos of Mars as it approached.

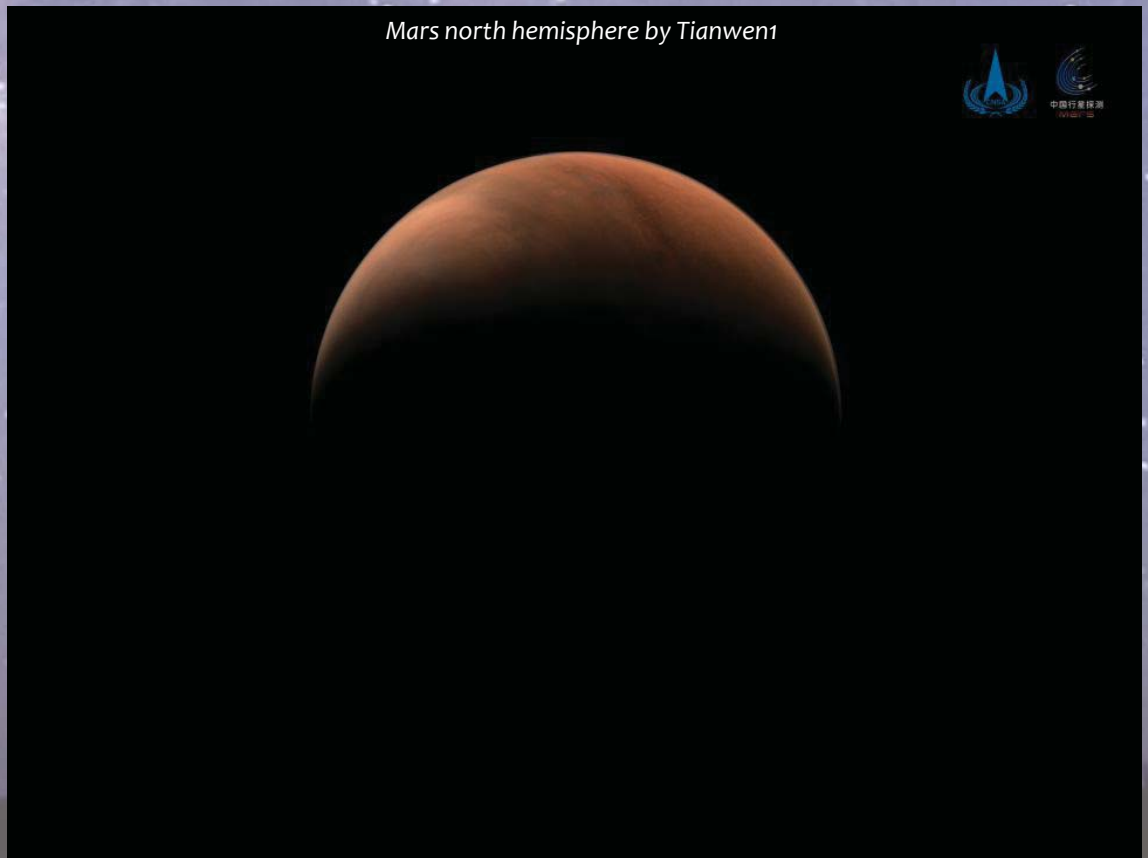
Drop Camera tumbling away

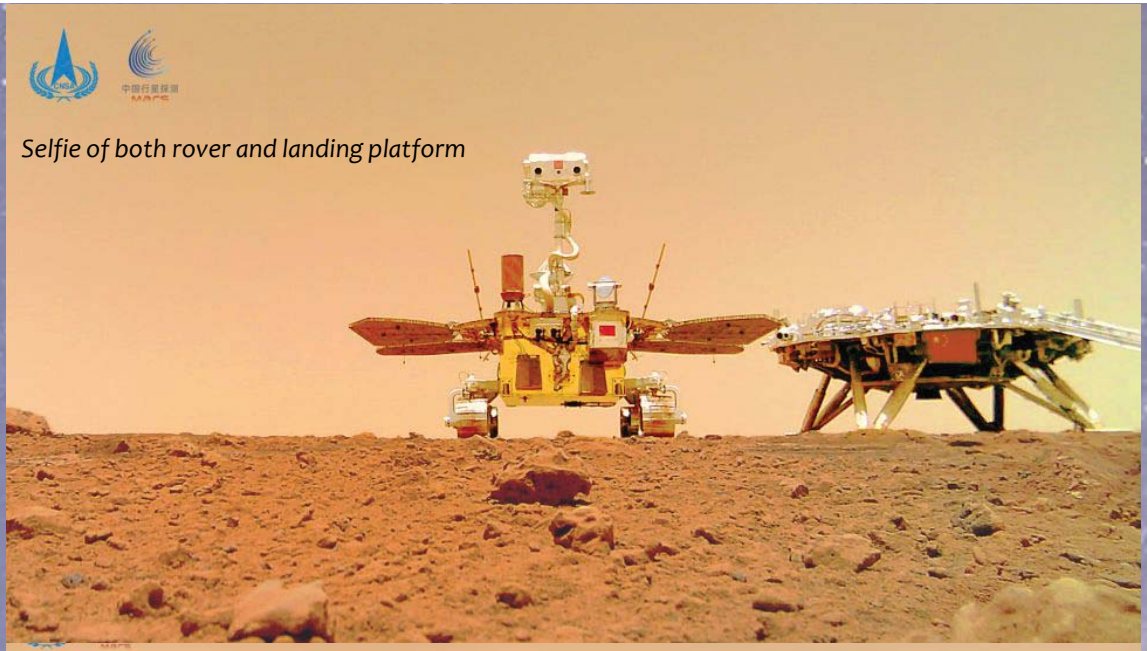
The rover

The Zhurong rover has started wheeling its way around Mars since May. It also placed a small wireless camera on the Martian surface and stood next to its landing platform and took a "selfie-picture" of the two of them! It has also taken a picture of the landing platform. You can see the ramp down which the rover drove down to reach the land. The Chinese flag is visible as the "square" in front.

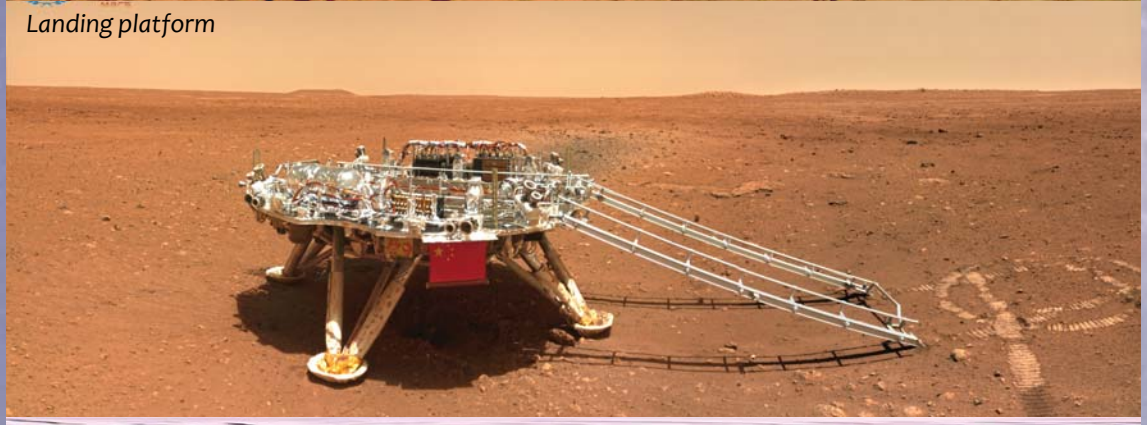
Zhurong is expected to keep exploring for about 90 days, and it will capture more images while it analyzes the Martian climate and geology. The place Utopia Planitia where Zhurong landed is a smooth plain where NASA's Viking-2 landed in 1976. At present,

Mars north hemisphere by Tianwen1

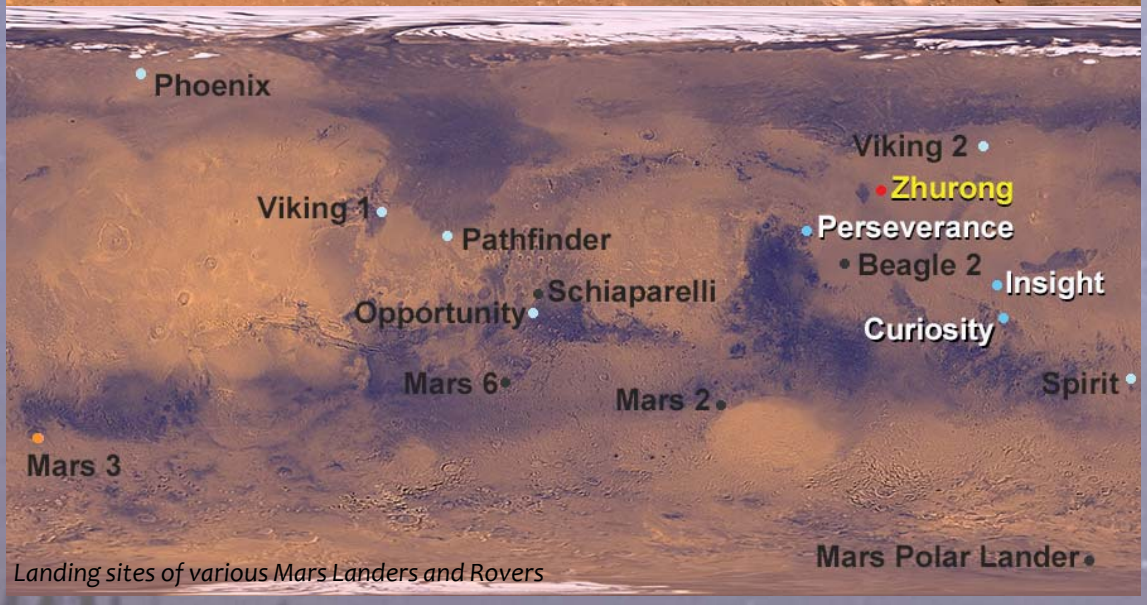




Selfie of both rover and landing platform



Landing platform



Landing sites of various Mars Landers and Rovers

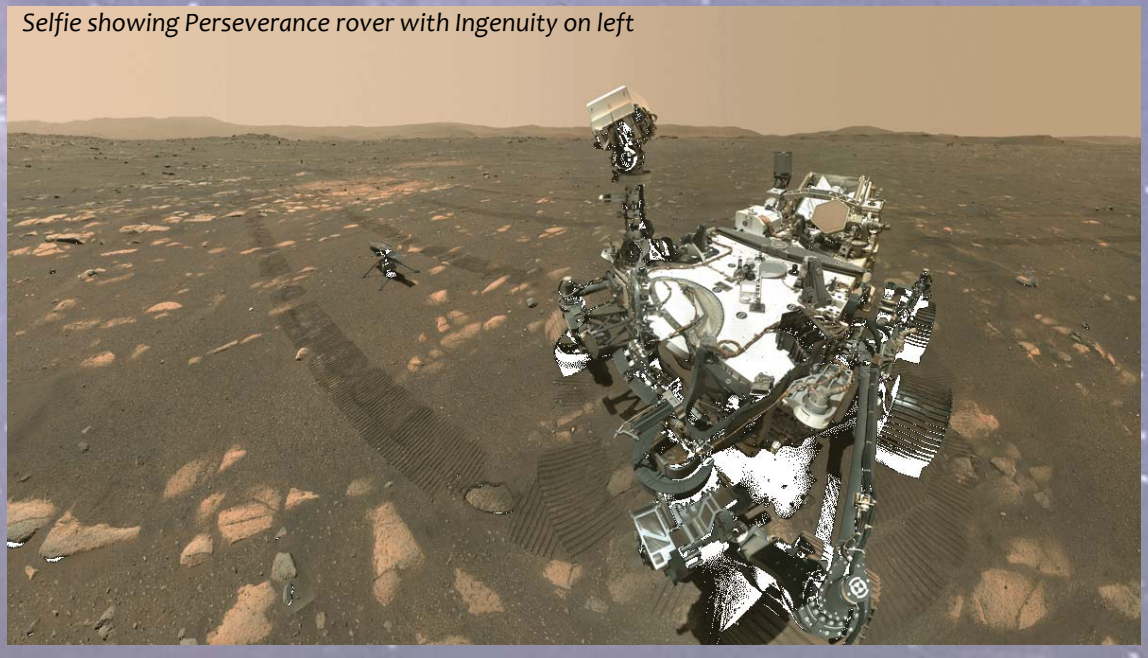
the US rover called Perseverance is also on Mars, but it is at the Jezero crater, more than 1500 km away from Zhurong. NASA's Curiosity rover (which landed on Mars in 2012) is currently climbing up Mont Mercou after 9 years on Mars!

You may ask, how many vehicles are wandering about on Mars? As of August 2021, there have been six successful robotically operated Mars rovers, the first five managed by the American NASA Jet Propulsion Laboratory: Sojourner (1997), Opportunity (2004), Spirit (2004), Curiosity (2012), and Perseverance (2021). The sixth is Zhurong (2021), managed by the China National Space Administration. Their landing sites are seen in the figure. While InSight is a lander (landed 2018), Ingenuity is a helicopter that was sent along with Perseverance. The Curiosity, Perseverance and Zhurong rovers, as well as Insight and Ingenuity are all currently active and sending data back to earth. You can see Curiosity as well as Perseverance (with the Ingenuity on the left) in the images below.

Curiosity

All pictures courtesy CNSA, China, and NASA, USA

Selfie showing Perseverance rover with Ingenuity on left



Registered with Registrar of Newspapers for India under No. TNENG/2001/04429

Stormy sea

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