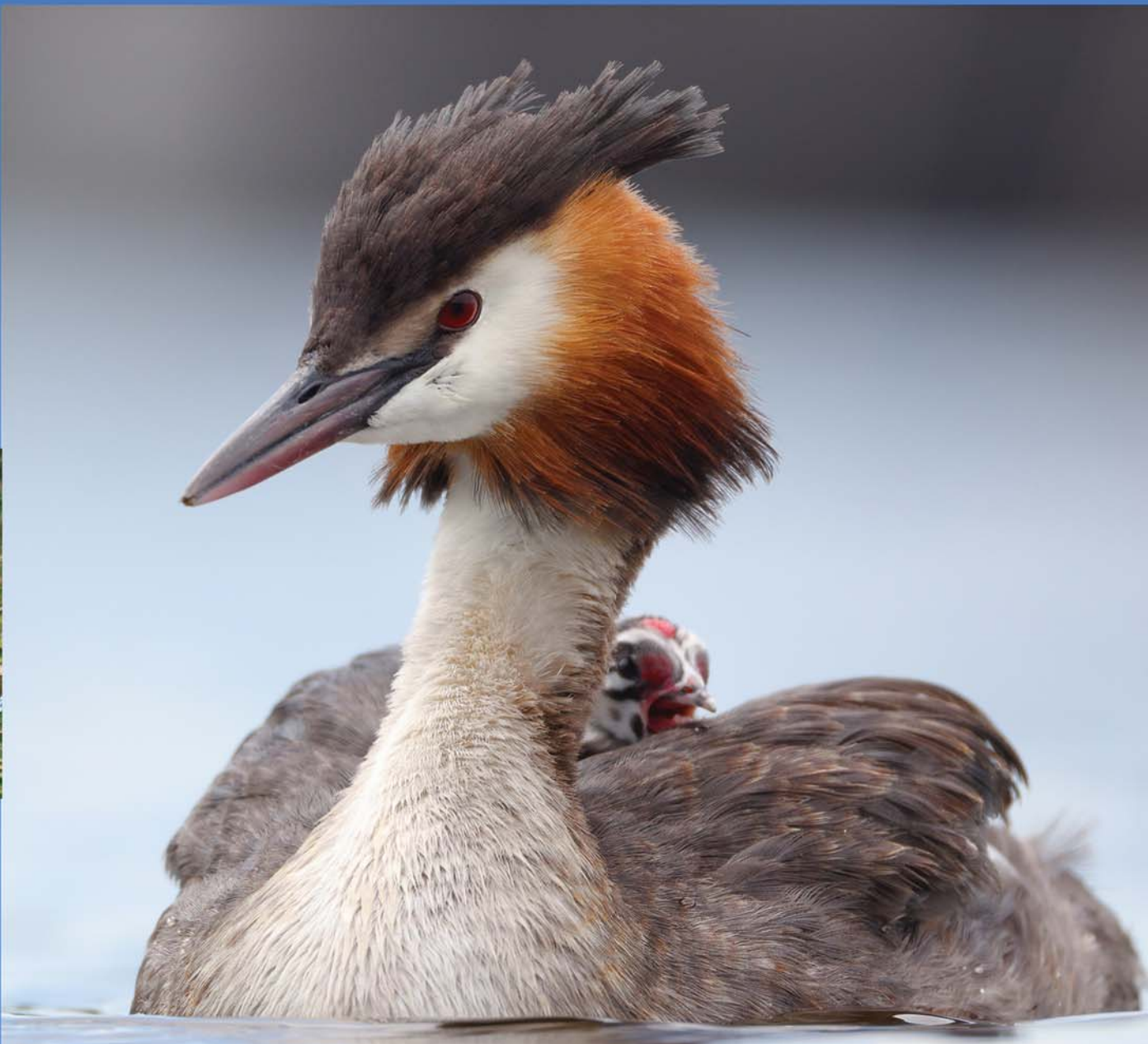


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How do birds swim?

Narayani Subramanian

Birds are lovingly called “Nature’s flying machines” by scientists. Every aspect of a bird’s anatomy and physiology is designed and carefully calibrated for flying. To defy gravity and fly in the air is not an easy task, and birds are masters of it. But there are some birds which also take on a different medium, that is water. These are collectively called **aquatic birds** or **waterbirds**.

Though the exact type of water is not mentioned in the term “water birds”, only freshwater birds are generally called water birds and the term seabirds/marine birds is used for birds that prefer the ocean. Among the waterbirds, there are swimming birds, diving birds and wading birds. Wading birds include very tall birds like herons, ibises, egrets and flamingos which walk on shallow water beds. So in this article, we are not going to include the wading birds as they do not swim in the water. Let us take a dive underwater and see how these birds move.

Air Vs Water - Similarities and differences

Air and water, though they are very different, share some similarities with each other. Gases and liquids are collectively called “fluids” since they have many similarities, which helps the birds in using similar *biomechanical* properties. The **drag** and **lift** forces of air and water are similar (see figure). If a



Penguin

bird is *streamlined*, it is beneficial both in air and underwater. So a similar propulsion mechanism can be used.

There are also considerable differences between the two. Water has higher density and viscosity, there is comparatively more **turbulence** and **drag** due to the high viscosity in water.

Types of underwater locomotion in birds

Despite all the challenges, some birds are comfortable both during flying and swimming. Birds are known to use three different types of locomotion under water, meaning they use three different mechanisms of moving inside water. They are:

1. Wing propulsion - Propelling oneself forward with flapping of wings under water.

Example: Penguins.

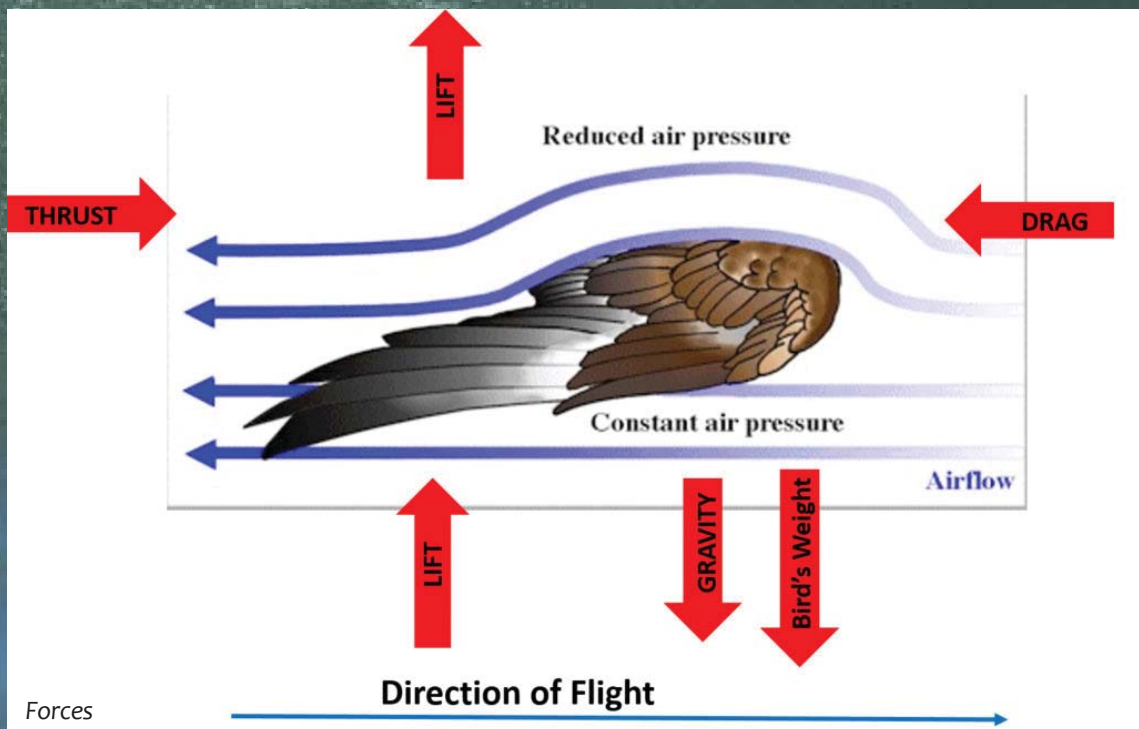
2. Foot Propulsion - Using the feet as a paddle and moving forward.

Example: Grebes (See Cover for a picture of Great Crested Grebe).

3. Plunging/Diving - Diving into the water with force and using that force to move forward. Example: Gannets.

The picture on page 6 shows wing-propelled birds with flying, aquatic and terrestrial locomotion abilities (1) Atlantic Puffin; (2) Northern Gannet; (3) Chinstrap penguin (a: walking, b: tobogganing, c: swimming on surface, d: diving).

These birds are utilising both the media (air and water) by exploiting an interesting phenomenon called “trade-off”. Let us try

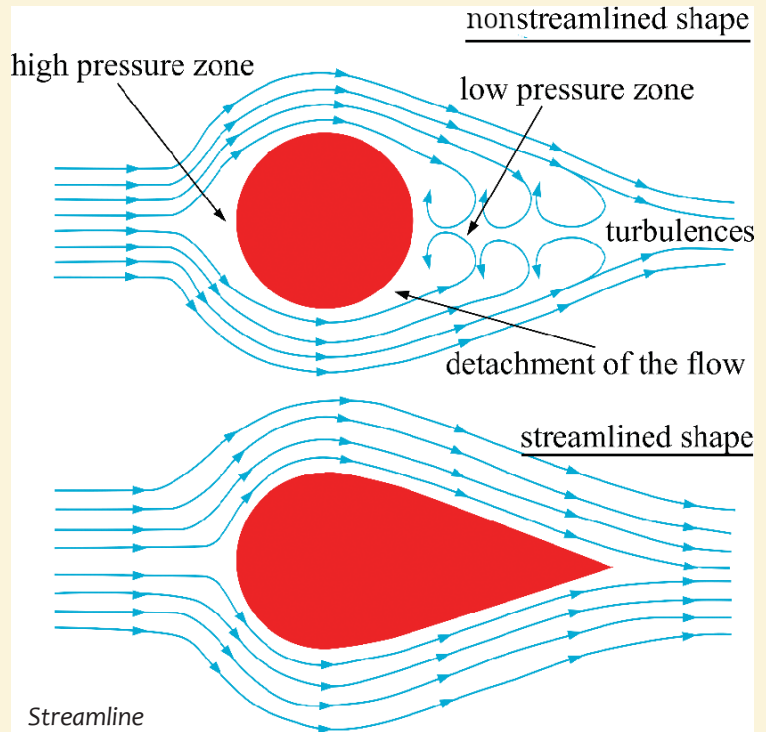


to understand what it is through an example.

Imagine you are going to an icecream shop. You have just enough money with you to buy one icecream. You see your favourite icecream flavour, strawberry. You want to buy the strawberry icecream cup. But as you are about to order, you also see a new icecream flavour called “cotton candy”. You are curious, you want to know how it tastes. Now you are confused. If you get the new flavour icecream, you will miss out on the strawberry. But if you get the old favourite, you cannot eat the new cotton candy flavour. This is a typical trade-off situation, where if you get one thing, you cannot get the other thing.

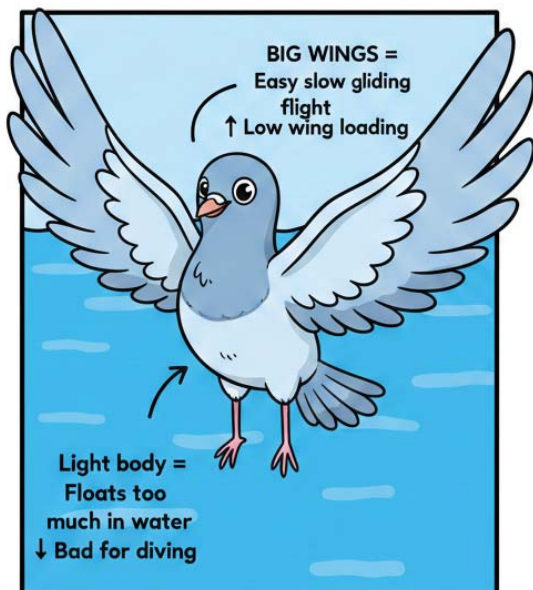
Now let us apply this to birds. Birds are designed for flying in a gaseous medium, that is air. Even though air is similar to water in many ways, there are also differences. So a bird which is an excellent flyer cannot be an excellent swimmer. Only one is possible. This is where evolution comes in. Instead of picking only one option, evolution reduces the abilities on both

sides and makes sure that a bird performs to a decent level in both media while compromising on some other aspects. This is called a trade-off.

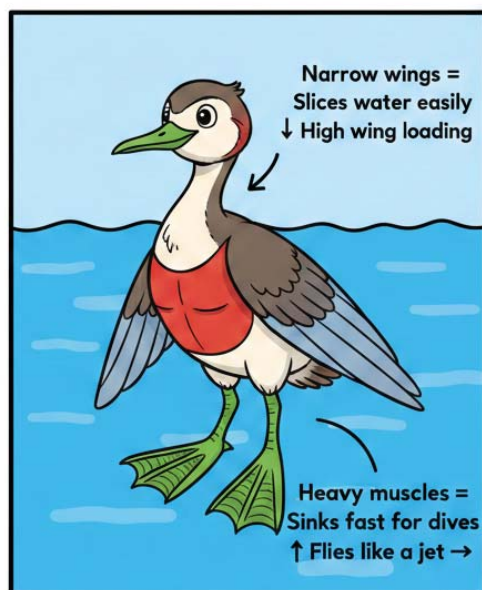




Pure Flying Bird



Real Grebe (Swimming + Flying Bird)



Wing mass = SAME amount of feathers/bones! |
Shape changes for air vs. water
Grebe: Fast flight + deep dives!

Buoyancy versus lift

Buoyancy is the upward force on a floating object which equals the weight of the displaced fluid. So it depends on the density of the fluid. For example, humans float in water but not in air. Lift is a dynamic force, also upward, but it depends on the pressure difference between the bottom and top surfaces of the object and is a more complex force. The shape of a bird's or aeroplane's wing ensures there is sufficient lift force for them to be able to fly.

For example, in order to fly well, a bird has to be extremely lightweight. But if the bird wants to go underwater and counteract the effects of **buoyancy** in water, it needs higher muscle mass.

Flying needs big wings (lots of surface area) and a light body to easily create lift against thin air. Diving on the other hand, needs a heavy, compact body to sink fast against water's push-back (buoyancy). No bird gets both perfectly. Birds sacrifice some amount of the ease with which they fly for better dives.



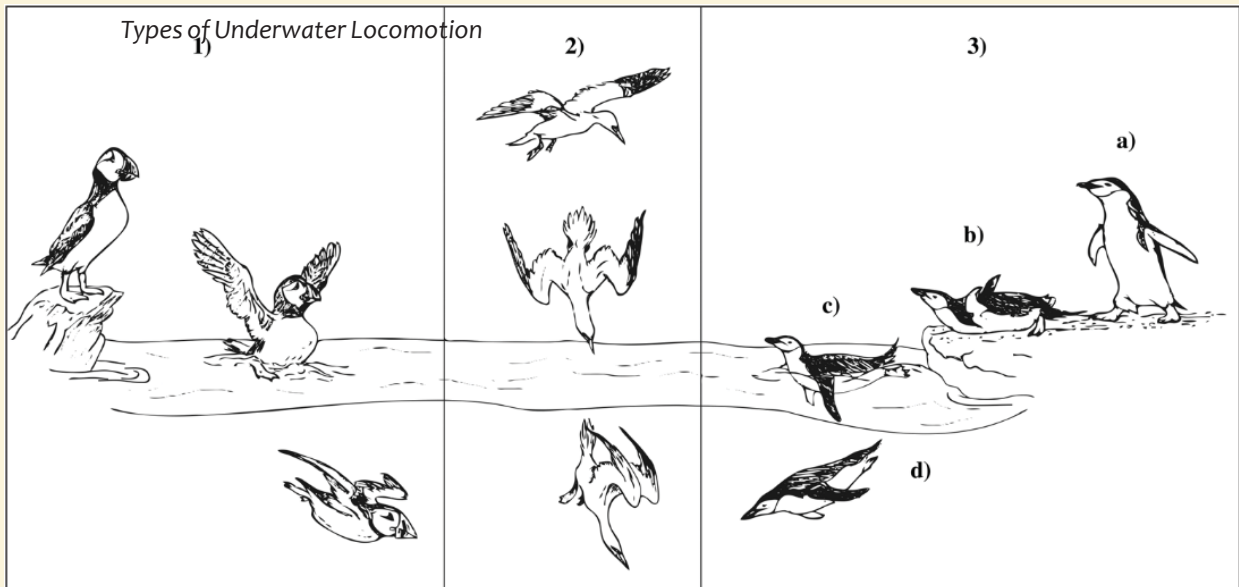
© theHALLOfEINAR.com

Gannet diving: composite photo: Courtesy: <https://www.thehallofeinar.com/>

So diving birds have a higher muscle mass, which makes underwater swimming easier. If these birds have to fly well, they need bigger wings, so their wing spans are higher. Heavier body from muscles raises “wing loading” (weight per wing area)—like a loaded plane needs a longer runway. Evolution has fixed this by making wings bigger in absolute size (longer span, wider), letting them fly fast and straight over water; see picture. If this bird occasionally falls on

thinner but larger wing that needs to lift a larger body mass. So these birds have a little more difficulty in flying compared to birds that use only flying as the mode of locomotion. In order to be able to swim, these birds have to fly with a little difficulty, using more energy.

Is your head spinning with all these intricacies? Remember, we have only seen one example in detail. Trade-offs are very



land during a mistake in flying, it will be very dangerous for it. This is the price a bird must pay in order to be good both on air and underwater.

But there is something very tricky at play here. Even though the wing looks larger, the actual proportion of the wing in weight (wing weight divided by body weight) will be the same. The wing will be thinner and spread over a larger area. Now the bird has a

complicated. But they enable organisms to explore various habitats and expand their home range. That is why ecologists spend a lot of time in understanding how trade offs work in the natural world.

Can you think of any such trade off in animals? Do let use know.

Pictures from Wikipedia, Martin Segesdi and Tibor Pecsics, Ornithologia Hungarica 30(1): 30–46, 2022.

A Strange Journey of the Eyes: Cyclops and The Clock in Your Brain

Zareena, Mookayi, and Mari

Zareena, Mookayi, and Mari had just left the *Museum of the Eye* in San Francisco, California, USA and were sitting in a cafe talking.

Zar stirred her hot chocolate and looked at her notebook. Mooks was sitting across and doodling.

Mari slid into the chair next to them. "Sorry! Amma told us to meet her here." Dr. Usha, Mari's mother and a biologist, had come to San Francisco for a

conference about the eye and brought Mari and her friends with her because it was their holidays.

"What did you think of the museum?" Usha asked as she sat down with a cup of coffee.

"Wonderful," said Zar. "We saw a model of the first eye. It was just a patch of cells that could tell light from dark."

Mooks tapping on her doodle asked, "But how do you get from one light spot to two eyes?"

Usha laughed. "For over a hundred years, scientists have asked this question." She went on to say, "The eye is very complicated. Darwin thought it evolved slowly, one step at a time, but he didn't know what those steps were."

"And now?" Mooks asked.

Usha took her phone out. "A new theory from a group of scientists says it started



about 560 million years ago with a creature that looked like a sock.”

“Really? A sock?” Mari asked.

Usha said, “It was a soft, tube-shaped creature that lived in the mud at the bottom of the ocean. It stuck its head out to get food. It had one eye on top of its head, which was just a patch of cells that were sensitive to light.”

Mooks said, “A cyclops.”

“Exactly!” Usha said. “A cyclops sock.”

Zar laughed. “So we came from a sock with one eye. And then ...”

“Some of those animals began to swim,” Usha said. “Picture yourself floating in the ocean. You need to know which way is up. You can tell if it’s light or dark with one eye on top, but not *where* the light is coming from. So the eye began to change.”

Mari asked “So the ability to move was important?”

Usha continued, “Yes. Their single eye grew more complex. Cup-shaped depressions evolved on either side, sensitive to the direction of incoming light. These were the forerunners of the retinas in our own eyes.”

Zar asked “So that’s how we got the two eyes?”

“Listen. This is where it gets really interesting,” Usha said as she sipped her coffee. “Some studies hint that, early in the evolution of vertebrates, the entire *genome* (a complete set of instructions coded in DNA

Who are cyclopes?

In Greek mythology, Cyclopes are one-eyed, giant creatures. They can be good or bad, just like creatures in Indian mythology. For instance, the divine black-smiths who forged the Greek god King **Zeus’s** thunderbolts, the sea god **Poseidon’s** trident, and the god of death **Hades’** helm of invisibility (Brontes, Steropes, Arges) were one-eyed. In the Greek epic poem, the *Odyssey*, the one-eyed shepherds like **Polyphemus** are shown to be cannibals, who eat passing sailors.

for an organism to develop and multiply) was duplicated. An extra set of genes may have given rise to an extra pair of eyes-like structures. So some early fish-like creatures started having a pairs of eyes on the side and a pair of light sensing eye-like structures on the top.”

“Two pairs of eyes on the same head?” Mooks asked.

Usha went on. “Paleontologists in China and England have been studying some of the earliest vertebrate fossils, which date back 518 million years. These show traces of eyes on the sides of the head, complete with lenses and retinas. But at the top of the head, there is a second pair of light-detecting eyes.”

“Why would any creature need four eyes?” Zar said puzzled.

Usha said, “These early creatures were

small, probably tasted good and they were at the bottom of the food chain. Having eyes on the top and sides meant they could see



How did they learn about the extra eyes?

Normally, only bones are left as fossils, from which scientists try to guess the form and function of various parts of the animal. In a lucky find, mud at the Chengjiang site in Yunnan, southern China, was so fine that it locked soft tissues in place. Scientists found the head of *Myllokunmingia*, an early jawless fish that lived more than 500 million years ago. The creature may have got trapped in the fine mud and buried in it. Since there was no oxygen, there were fewer bacteria to break down the soft tissue. So two large lateral eyes and two smaller organs aligned along the midline could be seen, embedded in the rock. Minerals filled the delicate structures and preserved them for us to see today. High-powered microscopes are used to microscopically examine these patches. This allowed the scientists to track each eye spot through the rock!

danger coming from any direction.”

“So what happened to the extra eyes?” Mari asked.

“Animals that got bigger and became predators didn’t need four eyes anymore. The side eyes got bigger and better so they could see details, follow movement, and judge distance. The top eyes stayed there. They changed, that’s all.”

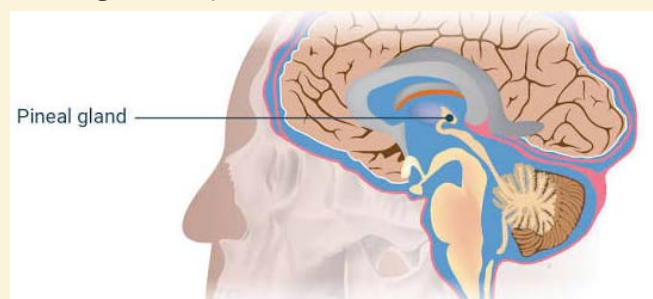
“How did it change?” Mooks asked.

“You still have them,” Usha said with a smile.

The spoon fell from Mari’s hands to the floor while she was stirring her chocolate. “We what?”

Usha pointed between her eyebrows and then at the middle of her forehead. “The **pineal gland** is a small bundle of cells that looks like a pine-cone and is deep inside your brain. It still senses light directly in birds, lizards, and fish. It doesn’t see light in you anymore. It only secretes *melatonin*. But the secretion is stimulated by darkness and suppressed by light. So it keeps track of time. It tells your body when to wake up and go to sleep.”

The girls didn’t say anything. They were thinking furiously however.



“How did scientists come to this conclusion?” Mari asked.

Usha said, “They didn’t only look at fossils. They studied *genes*. They looked at cells in the pineal gland and cells in the *retina*, which is the part of your eyes that senses light. The cells in both organs have a lot in common on a molecular level, which is interesting. They talk the same language. Use the same tools. It’s like finding two cousins who look almost the same, even though one lives in Madurai and the other in Beijing.”

Zar whispered, “That’s hard to believe.”

“It’s proof,” Usha said. “Your eyes and your pineal gland come from the same ancestor. They began as one thing, but over the course of more than half a billion years, they became two. One became your way to see the world. The other became your internal clock.”

Zar looked up after she was done writing in her notebook. “If someone asks me where eyes come from, I can say: ‘From a cyclops sock that lived in the mud. Then two eyes that got moved to the sides, then two more light-sensing eyes on top that merged and got buried in the brain as a clock!’”

Usha laughed and said, “That’s actually pretty accurate. But keep in mind that this isn’t the end of the story. Scientists will keep looking for fossils, comparing genes, and making microscopes that work better. Every new discovery will help us figure out better how we got the eyes we have today.”

Zebra Fish Casper



Zebra fish and the pineal gland

In the larva stage, zebra fish are naturally transparent and scientists used this to observe their internal organs, especially the pineal gland. In order to continue to observe this gland, scientists began to cross-breed different varieties of zebra fish. The result was called Casper, a fish that remains transparent even when it grows into adulthood. They did this by developing a variety that has no pigmentation in its skin and scales. This enables scientists to study the pineal gland that is located directly under the skull.

“We learned more sitting in the cafe than at the museum!” Mook said.

“Thanks, Amma!” Mari said with a smile.

Further reading:

Fossil shows early vertebrates had four eyes:

<https://www.earth.com/news/fossil-shows-early-vertebrates-had-four-eyes>

The Rise of Eyes Began With

Just One: <https://www.nytimes.com/2026/02/23/science/evolution-vertebrate-eye.html>

Kasavanahalli Lake

Part 2:

A Hidden Gem in Urban Bengaluru

Neil Thomas Abraham,

Class XI, Bethany High School, Sarjapur,
Bangalore

Kasavanahalli lake is part of the city's web of freshwater wetland ecosystems. It is part of the interconnected chain of lakes in the Koramangala and Challaghatta valley of suburban Bengaluru. Nestled in Shubh Enclave on Haralur Road, this small yet relatively well-maintained lake offers a peaceful setting for morning joggers, evening walkers, a gang of surprisingly friendly dogs and a huge variety of birds, and other wetland organisms.

Part 1 of this article described the bird and aquatic life in Kasavanahalli Lake,

Water Reeds

Bengaluru. then and now

Over the years, Bangalore has been in the news for many different reasons. More recently, the city lakes came into sharp focus for many different reasons including floods, droughts and the water crisis. Bangalore has always been a haven for nature lovers, and Nature itself. This is because of its temperate climate, gentle and undulating parks and botanical gardens. In addition, several small and large lakes foster biodiversity; hundreds of trees, energise groundwater supplementation and providing recreational opportunities to its residents.

In the recent past however, several of these lakes have been swallowed whole by construction projects that don't seem to understand what a fence means. Either they straight up steal the land or they dump construction debris into adjacent swamp areas, slowly polluting the main water bodies.

Amidst this chaos and cacophony thrives an almost unknown natural lake in the middle of a housing layout. This story is the second part about this beautiful lake.



What is a wetland ecosystem

Wetland ecosystem is a distinct semi-aquatic ecosystem whose groundcovers are flooded or saturated in water, either permanently, or temporarily. Wetlands form a transitional zone between waterbodies and dry lands, and are among the most biologically diverse of all ecosystems. They support a wide range of aquatic and semi-aquatic plants (e.g., cattails, lilies) and animals, offering critical habitats. They function as “biological supermarkets” and natural filters. They help reduce flooding of adjacent areas during rains, store carbon, and support 40% of world species.

especially the rich ecosystem inside the water and around the lake-bed. The story continues ...

By the Lake side

One of the most intriguing spots along the lake is a small slope that allows visitors to walk down to the water’s edge and observe aquatic life up-close. The shallow areas host a thick layer of eucalyptus leaf detritus, sheltering a variety of invertebrates.

The most populous species by far are *Nepa* (water scorpions), which can be found simply by lifting a fallen piece of wood or a rock. Alongside them, small *shrimp*—likely a species of *Neocaridina* shrimp, make surprise appearances from under all sorts of things. These shrimp vary in colour, appear-

ing in shades of brown, translucent blue, green and even orange. They serve as a favourite snack for *chequered keelbacks*, a species of freshwater snake often seen hunting along the shore.

Sadly, keelback populations have noticeably declined over the past two years. Along with the keelbacks, *rat snakes* seem to enjoy the more densely vegetated parts of the lake. I have seen some snakes that are over 6 ft in length. They are opportunistic feeders, snacking on everything from fish to unsuspecting birds.

Other lake dwellers include *freshwater crabs*, which experience a population surge just before the monsoon during which time you can find baby crabs with just a glimpse of the waters edge, before disappearing by summer. Some surprisingly large individuals are found only under the occasional piece of eucalyptus bark or rock, as well as *snails* such as ramshorns and bladder snails.

In the shallows

Small fish are also abundant—tank gobies, mosquito fish, juvenile tilapia and carp, spike-tail paradise fish, and guppies (non native) all thrive in the shallows. Scattered on the shore, empty freshwater *clam* shells hint at a substantial population in the lake’s deeper waters. These clams vary in size, some no larger than a centimetre, while others grow as big as the palm of my hand. Lifting an empty shell often reveals baby snakeheads, tank gobies, and juvenile

shrimp hiding beneath. On several visits, I have come across washed-up turtle shells, belonging to red-eared sliders—pet terrapins that have been irresponsibly released into the lake, people do not seem to realise what they are getting into when they pick up a cute little turtle from the pet shop. Fortunately, they do not seem to have established



a significant breeding population, which is a huge relief, considering the damage they could cause.

Freshwater sponges

One of the lake's most mysterious features is the presence of strange projections emerging from the lakebed—small, porous

embankments that become more visible when water levels recede in the summer. I was never able to figure out what they were, they seemed to look a lot like coral reefs, with porous structures and a very stiff looking buildup. After much investigation, I discovered that these structures are small walls of mud encrusted by freshwater sponges. These sponges, my personal favourite lake inhabitants, appear in two distinct forms: one encrusting surfaces and the other growing in branched formations similar to *Acropora* corals. They are both a



light green colour, due to their symbiotic relationship with algae, that they use as a means of making food through photosynthesis, much like a coral. Additionally, as most of their relatives do, these sponges filter water by trapping debris and consuming the organic matter among them.

They seem to have a yearly cycle, as the rains reduce, the lake's water begins to dry up, and as this starts, the sponges seem to vanish from all parts of the lake. I assume



Freshwater Crab



Chequered Keelback



Indian Grey and Yellow Rat Snakes

that this has to do with the water quality. As water evaporates, the concentration of Toxins and Nitrates in the water increases, and the sponges, notoriously sensitive to water quality, basically disappear. As they regress, they seem to develop small white cysts on their surface, and these can be seen throughout the year in soil samples under the microscope. From this observation, I assume they have adapted to survive as cysts, but with the first rains of summer, they rapidly proliferate, covering submerged surfaces in a matter of days. Their presence is a rare and fascinating sight, unlike anything I have encountered elsewhere. Sponges are some of the first animals in the world having evolved some 500 million years ago. They have been around longer than trees; just think about that for a moment.



Clam shell

They have existed longer than trees have been around. That, I believe, is simply remarkable.

Urban threat

Despite its biodiversity, Kasavanahalli Lake faces increasing threats. As urbanization expands, so does the pressure to divert sewage into the lake. Currently, wastewater entering the lake passes through a natural filtration system—a bog filled with water hyacinth (which bursts into purple bloom), Water

Reeds, Duckweed, Rotala and other aquatic plants. This filtration process helps keep the water relatively clean, as confirmed by water tests conducted on either side of the bog. However, during the monsoon, rising water levels overwhelm the system, allowing polluted water to bypass the barrier and flow directly into the main lake, increasing contamination.

Kasavanahalli Lake is a hidden gem, one of the last remnants of Bangalore's declining biodiversity in an area undergoing rapid urbanization. Now, more than ever, it needs protec-

tion to ensure its unique ecosystem remains intact. It is a testament to what is possible if Bangalore's lakes are kept well-preserved and their ecosphere is protected. The lakes of Bangalore are close to the very heart of the city's unique nature, and must be preserved at all costs.

Images courtesy Bijoy Venugopal, JLRexplore.com, and Wikipedia



Bladder Snail



Sponge

The Evolution of Telecom:

From 1G to 5G and the Future of 6G

Samit Seam

Nokia, Chennai



Telecom networks help people communicate using mobile phones. They allow us to make calls, send messages, watch videos, and use the internet. Over the years, telecom technology has improved step by step. Each improvement is called a **generation**, such as 1G, 2G, 3G, 4G, and 5G. Every new generation made communication faster, clearer, and more useful.

Martin Cooper, an American engineer (pictured in 2007, holding a 1972 Motorola mobile phone), led the team that in 1972–73 built the first **mobile phone**. He is known as the **father of the cellular phone**. Early cell phones were just for talking. Gradually, the mobile phone manufacturers began to understand that they could integrate other technologies into the conventional phone and expand its features. We now use our cell

Martin Cooper



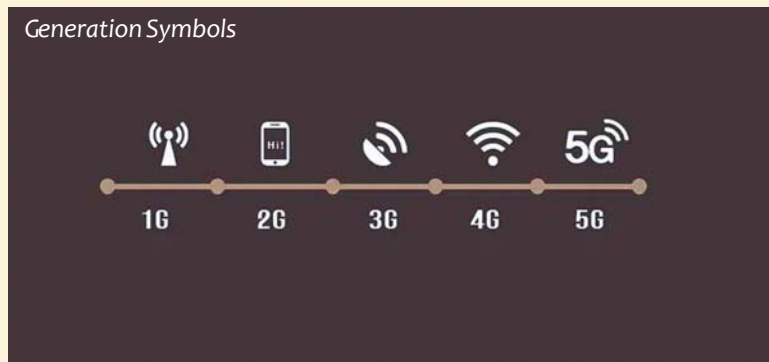
phones more for surfing the web, checking mails and messages, capturing photos, and updating social media, than actually placing calls.

1G and 2G: The Beginning of Mobile Communication

1G was the first mobile phone network. Launched by **Nippon Telegraph and Telephone Corporation**, in 1979, 1G was introduced as voice-only communication to the citizens of Tokyo, Japan. Although being a revolutionary technology at the time, 1G was very rudimentary. It only allowed people to make voice calls. The sound quality was poor, and coverage was limited. Perhaps the biggest limitation of these early networks was the complete lack of security. Anyone could eavesdrop on your call and listen to you! However, it was very important because it allowed people to talk on phones without using wires for the first time.

2G brought **digital technology**. 2G was launched on the **Global System for Mobile Communications (GSM)** in Finland during 1991. GSM remained a popular standard for mobiles, along with CDMA (**Code Division Multiple Access**) which was more popular in the USA. Calls became clearer and more reliable. This generation also introduced text messaging via **SMS (short message service)**. Security improved, and mobile phones

became cheaper and more popular. The digital network was more efficient so it could support more number of calls at one time, and so more users could easily make calls. This improvement in capacity as well as developments in reducing the physical size and cost of mobile phones were crucial in the explosion of demand for mobile services. Communication became personal and portable, and many people started using mobile phones daily. Can you imagine there was a time when people used phones once a



week or even less?!

3G: Internet Comes to Mobile Phones

3G arrived in the early 2000s. Introduced for the public in Japan by **NTT DoCoMo** in 2001, 3G was introduced to provide faster data-transmission speeds. Users could access data from anywhere, which paved the way for international roaming services to begin. Video streaming, video conferences, and live video chat became real in the 3G era. This generation made it possible to use the **internet on mobile phones**. People could browse websites, send emails, and use

simple applications. It also supported photos and basic multimedia. This early video calling technology utilised circuit switching and was billed by the minute making it an expensive option. It also had the problem that many of these early 3G mobile devices were equipped with basic cameras and video quality was often poor.

3G was important because it introduced **data services** as a core feature. Phones were no longer just for calling and texting. This period marked the beginning of smartphones and mobile apps.

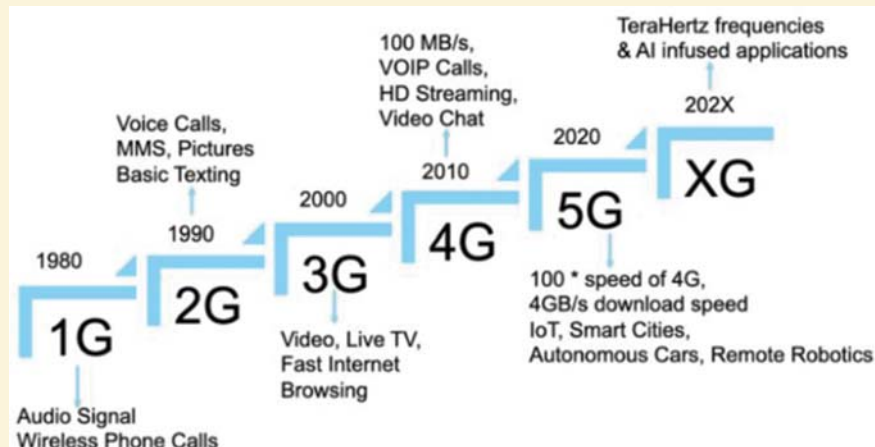
4G: The Smartphone and App Era

4G, also known as LTE (Long Term Evolution), made mobile internet very fast. It's an upgraded network for both GSM and CDMA based networks. LTE increases bandwidth available for voice and data communications, along with a number of network improvements.

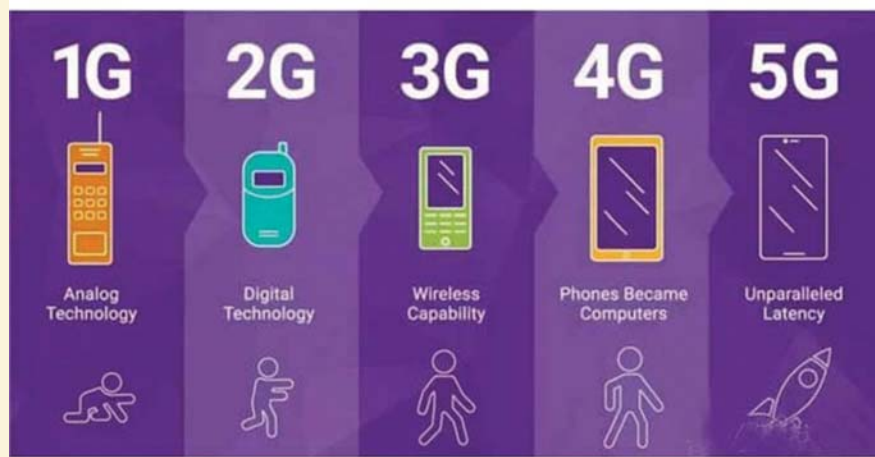
Voice over LTE (VoLTE) is a voice technology that works over the LTE data connection, rather than 3G voice bands. It provides extremely high voice quality, and also includes the ability to make video calls. The requirement is

that both participants must be using VoLTE and should be in VoLTE enabled areas.

Mobile internet gave way to mobile broadband. That is, instead of using the cellular 4G network, internet access could also be enabled through a portable or wireless **modem** which could provide higher speeds and practically unlimited data downloads. Mobile app stores, such as Apple's App Store and Google's Play Store, gave users access to a vast array of applications for productivity, entertainment, social networking, and much more. It allowed



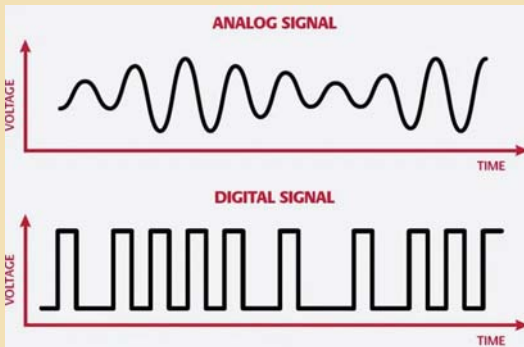
Mobile Networks Evolution From 1G To 5G



Analog versus Digital technology

When we speak or hear something, the sound travels as waves. Our voices contain many frequencies or wavelengths. When we want to send these signals on wires, it becomes difficult because these are random waves and to get an exact match of the original sound, we have to send the details of the amplitude and frequency at very short intervals to reconstruct the wave pattern. So these waves are approximated as a collection of continuous signals and our speech is transmitted (as data) as a collection of sine waves. This is

called Analog technology. It is very good for audio and video but is susceptible to noise.



On the other hand, digital technology uses just 0s and 1s (where 0 means nothing is transmitted and 1 means just one square wave lasting for a fixed time is transmitted). This not only gives better precision and less noise, but the communication becomes faster, and storage of such data is much easier.

people to stream videos, use social media, and download apps easily. Services like online shopping, food delivery, ride-hailing, and mobile banking became common.

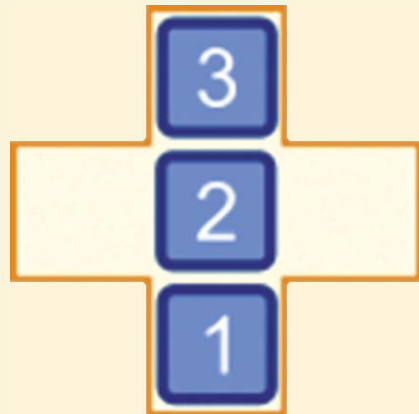
With a performance roughly 10 times faster than 3G services, 4G provided high-quality video streaming, quick web access, HD videos, and online gaming. With 4G,

Puzzles to Puzzle You!

Sliding Block

The diagram shows a cross-shaped box containing three numbered blocks. The puzzle is to slide the blocks around the box until the numbers read 1, 2, 3 as you go down.

How do you do it? And how many moves does it take? (A single move is one block wide, so if you move two block widths, that's called two moves).



From mathsisfun.com

Answer on page 23.

smartphones became the main digital device for many people around the world. Businesses also started creating services mainly for mobile users. As a result, the amount of data used on networks increased greatly.

The improved capabilities of 4G networks also led to the development of Internet of Things (IoT) devices and applications. The Internet of Things refers to physical smart devices that communicate with each other via the Internet, for instance, fitness watches like Fitbit or Mi band, smart homes, driverless vehicles (cars and trains), etc.

5G: Smarter and Faster Networks

South Korea was the first country to offer 5G in March 2019. Experts claim that **5G is 20 times faster than 4G**. The *latency* over 5G is incredibly reduced which means faster response time. 5G also has a larger bandwidth size, supporting more technologies and devices. It is an essential requirement for smart cities and other industries.

5G is not just a faster version of 4G. It is a smarter and more flexible network. It provides very high speeds, very low delay, and the ability to connect many devices at the same time.

5G supports:

- High-quality video and virtual reality,
- Smart factories and hospitals,
- Connected cars and smart cities,
- Millions of devices like sensors and machines.

5G helps industries use digital technology in new and advanced ways.

Why Do We Need the Next Generation?

Even though 5G is powerful, new challenges are growing. There is a huge increase in data from videos, games, and artificial intelligence. Networks now serve machines and robots, not just people. Some applications need instant response, such as remote surgery. There is also a strong need to save energy and protect the environment.

Because of these reasons, scientists and engineers are already working on the next generation: **6G**.

6G: The Network of the Future

6G is still being researched, but it is expected to be much more advanced. It will use **artificial intelligence (AI)** inside the network to manage itself. 6G networks will be extremely fast, have almost no delay, and be very reliable.

6G may also:

- Sense location and movement
- Support advanced virtual and mixed reality
- Use less energy and be more eco-friendly
- Connect through satellites and space networks

Unlike earlier generations, 6G networks will not just connect devices—they will be able to **think, learn, and adapt**.

Conclusion

Telecom technology has evolved from simple voice calls to smart and intelligent networks. The journey can be summarized as:

Voice '!' Data '!' Apps '!' Intelligent Networks

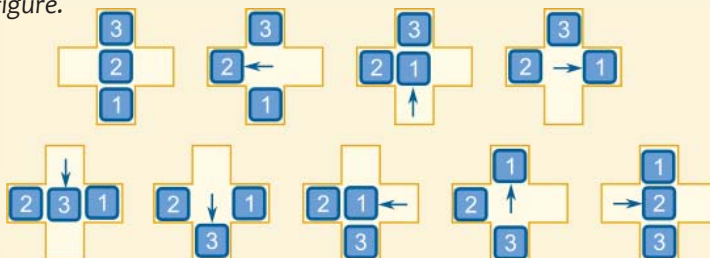
Today, 5G is transforming industries and

daily life. In the future, 6G will connect the digital and physical worlds even more closely. The future of telecom is not just about speed, but about **smart, efficient, and intelligent communication**.

Sources: Wikipedia, <https://rancholabs.medium.com/history-of-mobiles-from-1g-to-5g>, <https://www.mpirical.com>

Answer to puzzle on page 21:

Eight moves; see figure.



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Atmosphere, climate, life

Kamal Lodaya.

Bengaluru

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

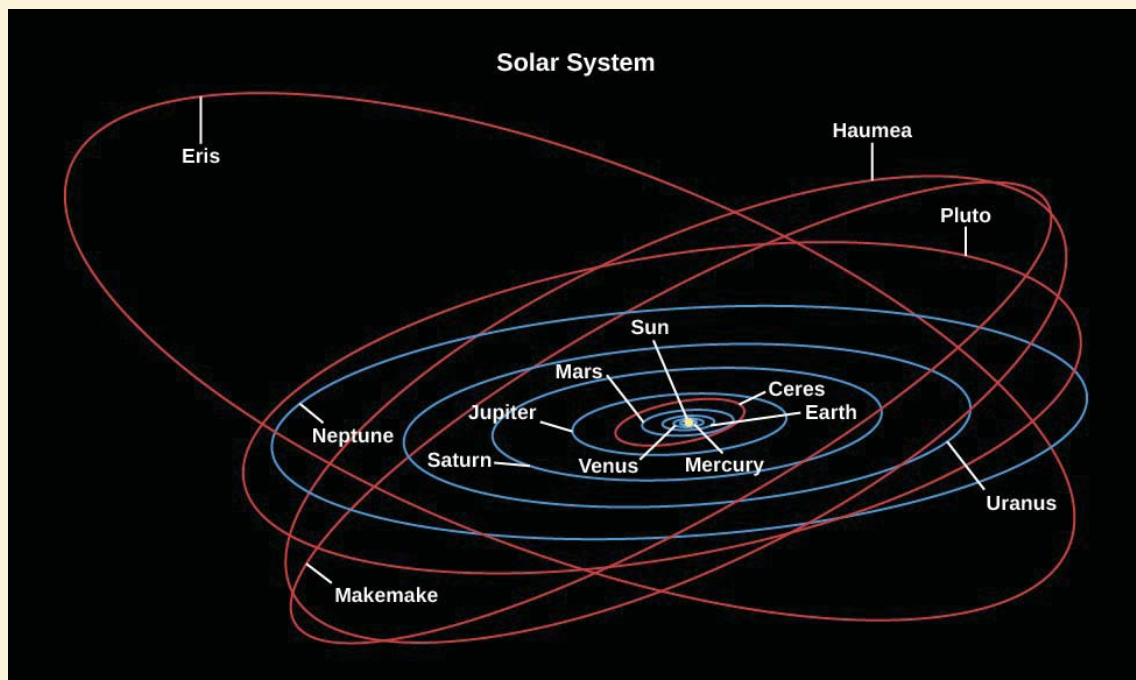
Moon has weather. It is hot in the day at 100°C (one Moon daytime is 15 Earth days), cold at night at -180°C (again 15 Earth days). It doesn't have much of climate. This is what keeps on happening all round the year.

Earth's distance from the **Sun** is the same as the Moon (15 crore km), give or take a

Planets and their orbits

The planets in our Solar System revolve around the Sun in almost the same plane; see the blue orbits of the planets in the picture. But dwarf planets like **Pluto** and **Eris** have orbits which are well outside this plane. Moreover, all the planets spin around an axis which may not be exactly perpendicular to the plane. For instance, you may know that the Earth's spin axis is at an angle of 23.5 degrees from the vertical. You can see from the picture that Uranus spins almost completely 'on its side'. (Have you ever wondered why all planets spin?)

couple of lakh kilometres. The distance to the Sun changes by about 45 lakh kilometres over the year, but this does not affect Earth

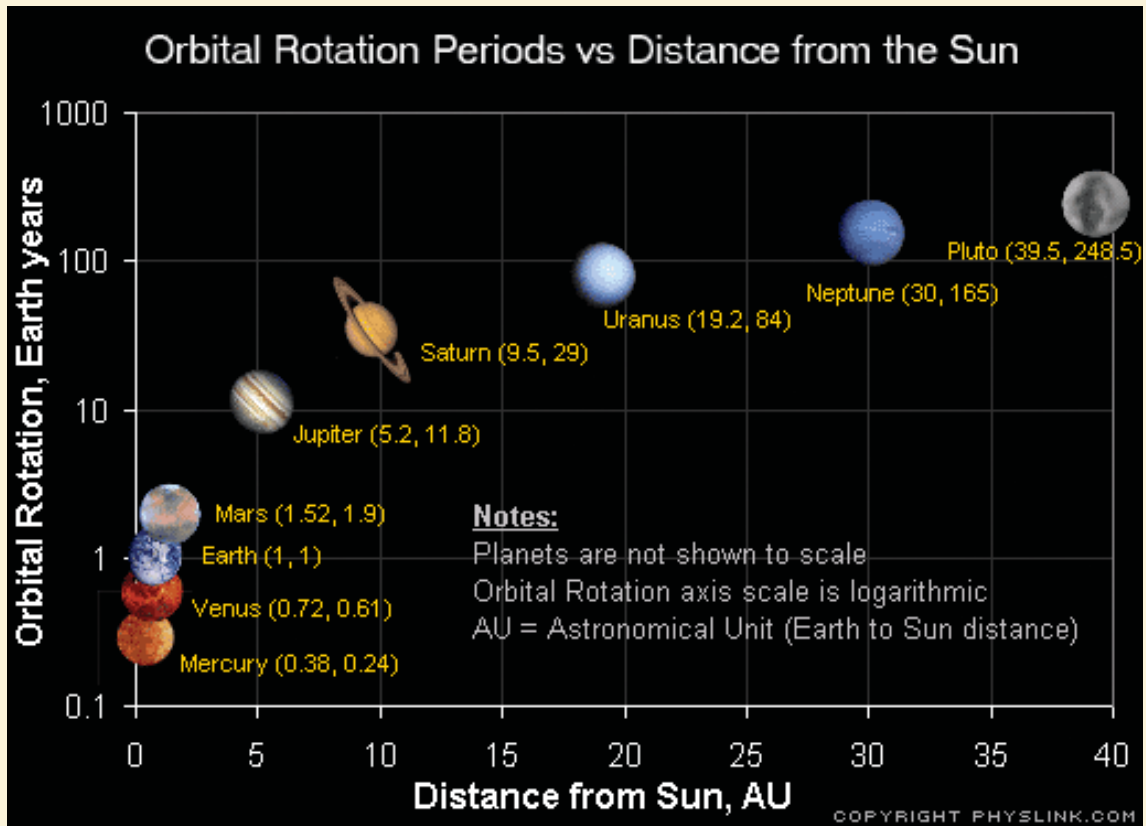




very much since it is just a 3% variation. Earth has **climate** because its gravity allows it to hold on to an **atmosphere**, made up of nitrogen, oxygen and other gases.

Mercury's distance from the Sun is a little less than 6 crore km. In fact all the four inner planets are very close to the Sun. See the

picture which shows the distance of all planets from the Sun, along with their period of revolution. You may more often see the picture where the the distances of the inner planets are not to scale; see the picture where the colours of the planets are correct, **but not their distances**.



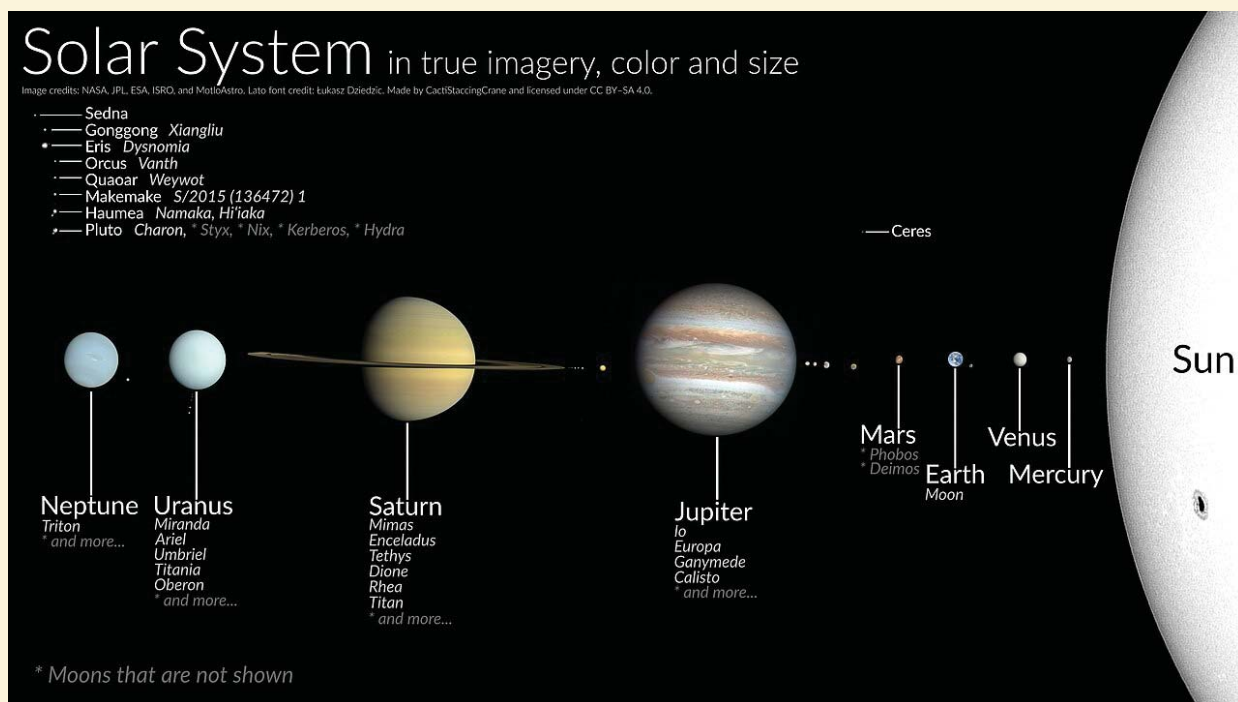
Mars also has no atmosphere

Since Mars is so close to the Sun as a result it is more than 400°C in the day and -170°C at night. It is much smaller than Earth and only a little bigger than the Moon. Like the Moon its gravity is too small to let it hold on to an atmosphere. (The light gases that made up its atmosphere slowly escaped over time.)

or more, whether it is day or night. It is possible that very high in its atmosphere where the temperatures are more moderate, some form of life could survive. No one really expects this. Although we haven't studied it a lot, Venus doesn't appear to have much climate variation.

Earth and its Seasons

Earth's atmosphere also creates a green-



Venus has an atmosphere

Venus's distance from the Sun is a little over 10 crore km. Venus is around the same size as Earth; its gravity allows it to hold on to its atmosphere. Venus's atmosphere is mostly carbon dioxide, so about 90 times as dense as Earth's. This creates a *greenhouse effect*, heating up the whole planet to 500°C

house effect. It is not so dense that the whole Earth is heated up to the same temperature. Earth's axis on which it rotates is tilted by 23 degrees, so that also makes a difference. When the North Pole is tilted towards the Sun, the region North of 67 degrees North latitude receives sunlight all day long (summer) at 10°C . The South Pole is



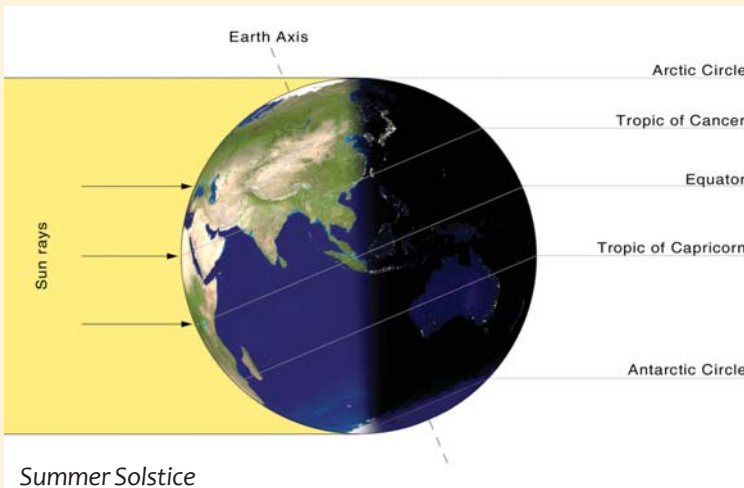
Tropic of Cancer line, Bhopal

tilted away from the Sun, so when it is hot and sunny at the North pole, the region South of 67 degrees South latitude is in darkness (winter) at -40°C . The entire Northern hemisphere has longer days (summer) and shorter nights. The entire

Southern hemisphere has shorter days (winter) and longer nights.

We call these seasons. They are determined by the tilt of the axis. In summer the Sun is directly overhead at 23 degrees North latitude of the Equator, which is called the Tropic of Cancer. This imaginary line passes through eight Indian states: Gujarat, Rajasthan, Madhya Pradesh, Chhattisgarh, Jharkhand, West Bengal, Tripura, and Mizoram. See the line marked on the Bhopal-Sanchi highway near Salamatpur in the picture! This is called the *Summer Solstice*; see figure.

Six months later at the other end of Earth's orbit around the Sun, the North Pole is tilted away from the Sun and the South Pole towards the Sun. So the Southern hemisphere has longer days (summer) and shorter nights. The Sun is directly overhead 23 degrees South latitude of the Equator, which is called the Tropic of Capricorn. This is the *Winter Solstice* (see figure), and at this time, the Northern hemisphere has winter.



Climatic Zones on Earth

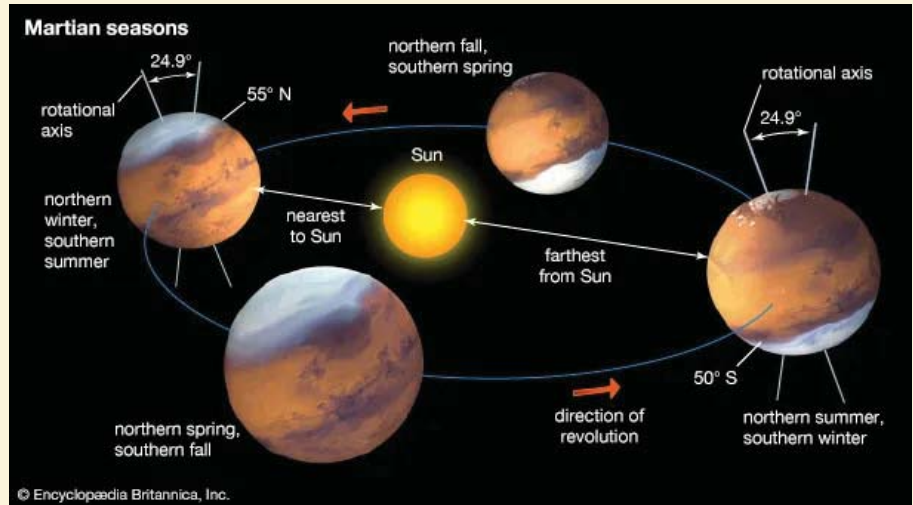
The area between these two latitudes (23 degrees North to 23 degrees South) is called the **Tropics**. The Equator receives sunlight at a high angle, so it is hotter, say 40°C in the day time and 15°C at night. Tropical climate is hot

in summer, a little less in winter. The area between 23 degrees and 67 degrees in both hemispheres is called the **Temperate** zone. It has less warm summers and colder winters.

The Poles receive sunlight at a low angle, so they are much colder, even in summer. The climate North of 67 degrees North latitude and South of 67 degrees South latitude is called **Tundra**. It has very mild summer and very cold winter.

Does Mars have seasons?

The planet Mars also has seasons, its axis is also tilted like Earth's. It is a smaller planet than Venus and Earth, its gravity is less, its atmosphere is mostly carbon dioxide but



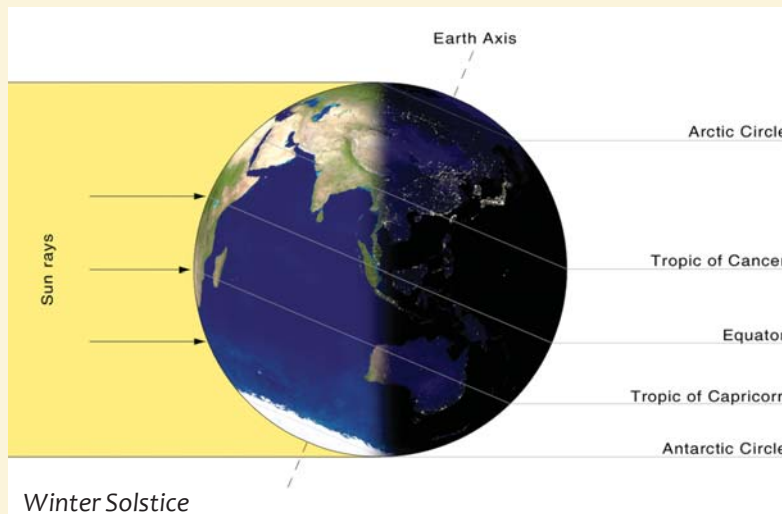
much less dense, about 1 per cent of Earth. The greenhouse effect of its atmosphere has saved Mars from the harshness of the Moon's weather. Mars is 23 crore km from the Sun, the hottest in tropical summer is 35° C, the coldest in polar winter is -110° C.

Mars has climate too. Mars could have had life in the past when it is believed it had more air. No evidence has been found but several rovers have been landed on Mars.

They are travelling around on Mars and looking for evidence.

Towards Jupiter

Two spacecraft, **JUICE** (Jupiter Icy Moons Explorer) and **Europa Clipper**, are on their way to **Jupiter** and **Europa**, a moon of the giant planet Jupiter. They will reach in 2030-2031 in the hope of



finding life there. Europa is one of the four moons discovered by Italian scientist **Galileo Galilei** with his telescope in the 17th century. These moons can be easily seen with a small telescope. Europa is as big as our Moon, so it does not have much gravity. Its axis does not have a tilt to cause seasons. Temperatures are from -160°C at the Equator to -220°C at its Poles.

Historical note. In most civilizations, yellowish-red coloured Mars has been seen as a god of war. Its becoming brighter is seen as presaging some conflict. Science requires the greatest humility, one should be prepared for the fact that the colour of Mars may have nothing to do with civilization. Mars is yellowish-red for the same reason that the land around us looks brown, it is covered with dust. Even after the telescope

was invented, in the 19th century some scientists thought some dark shades in the brown were because of Martians building canals. The 19th century Greek-French astronomer **Eugene Antoniadi** argued against them, pointing out that

just like we have dust storms on Earth. Mars has huge planet-wide dust storms.

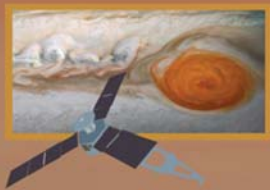
In this section we did not talk of humanity or even of trees. The only form of life we mentioned is bacteria. It may be that in any place where life exists (including Earth), the most important life form may be bacteria.

To be continued

Images from Wikipedia

A TRIO OF MISSIONS: JUNO, JUICE AND EUROPA CLIPPER

Their destination may be the same, but Juno, Juice and Europa Clipper are all unique missions with different goals and instruments. Juno's discoveries are being used to optimise plans for Juice and Europa Clipper.



JUNO

Target: Jupiter

Arrival: 2016

Special skill: a polar orbit that goes very close to Jupiter, allowing deep mapping of its gravity and magnetic fields

Images credit: NASA/JPL, Gahochi/Star2MOON

Images processing by Karel M. Sitt, © CC BY

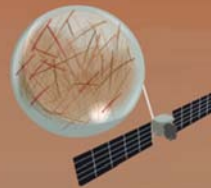


JUICE

Targets: Jupiter, Ganymede, Europa, Callisto

Arrival: 2031

Special skill: observing Jupiter and its icy moons to provide a complete view of habitable conditions in the Jovian system



EUROPA CLIPPER

Target: Europa

Arrival: 2030

Special skill: investigating the potential for life on Europa; helping select a landing site for a future Europa lander

We do not expect any climate there. So why send spacecraft there? Europa has a very thin oxygen atmosphere, much less than Mars, but an atmosphere. Why didn't Europa lose its atmosphere like Mercury and our Moon did with their weak gravity? The most likely cause is continuous supply of oxygen from an ocean under its surface. It is thought that primitive life forms like bacteria could survive in the ocean. The table summarizes all that we have seen above and also other moons of Jupiter.

Bird

Do You Know?

After the platypus, it is the turn of birds. Do you know the answers to these bird questions?

1. Woodpeckers (as their names suggest), hammer on tree barks. How come they don't injure themselves in the process?
2. Can crows really recognise and differentiate human beings?
3. Why are flamingoes pink in colour?
4. Are any birds poisonous?

Answers to these questions in the next issue of JM.

Answers to last issue's Animal Do You Know?

This one is about the very strange and fascinating **platypus**! The platypus is one of Australia's most extraordinary animals. The platypus lives both on land and in water. It is approximately 50 cm in length and is covered in waterproof fur except on its feet and bill. It has dark brown fur on its back with light brown fur underneath. Its body is streamlined, and along with short limbs and broad webbed feet, it is perfectly built for swimming. Each of its feet has five clawed digits.

Platypuses' back legs act as a rudder when swimming to help steer and change direction. The front feet have enlarged webbing that extends beyond the claws to provide power while swimming. So, despite its odd looks, the platypus is perfectly adapted to its environment.

It has a bill and webbed feet like a duck, but is covered in thick fur like an otter, and has a flattened tail like a beaver! In fact, platypus means "flat footed duck".

Classification of the platypus was initially a challenge as the number of specimens available in Europe were either incomplete or preserved. In fact, many scientists thought that the animal sent to them was a hoax.

1. Is a platypus a mammal or a bird?

Ans: The platypus is a unique mammal, not a bird. Although it lays eggs, has a beak, and possesses webbed feet, it is classified as a

mammal because it has fur, is warm-blooded, and produces milk to feed its young.

To remind you: **mammals** are warm-



Platypus drawing

blooded, give birth to live young and feed them milk. **Birds** are also warm-blooded but lay eggs, and **reptiles** are cold-blooded egg-layers that rely on the Sun or another heat source to warm them up. But platypuses are mammals that lay eggs! Even scientists were initially confused!

The platypus was ultimately placed into a new order called **Monotremata**.

Monotremes are egg-laying mammals that produce milk for their young. They are found only in eastern Australia.

Amniotes are the common ancestor of all mammals, birds and reptiles. Mammals split from birds and reptiles around 315 million years ago.

Monotremes are not direct relatives of birds and reptiles, but they are often considered the most basal of all mammals. They split from the line leading to *placental mammals* - which includes humans - around 166 million years ago. The platypus's overlapping characteristics with other classes are likely evolutionary leftovers.

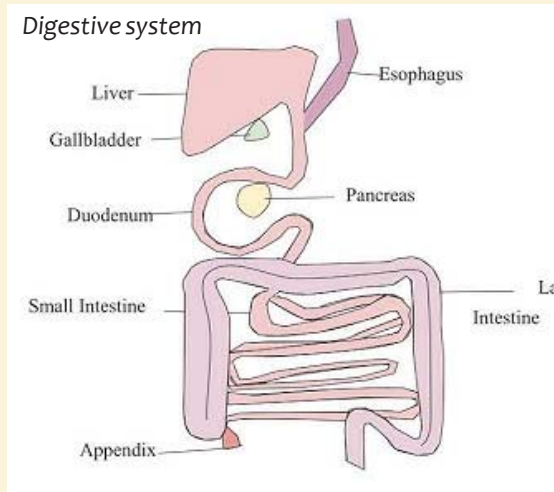
Sequencing of the platypus genome (DNA) reveals that the platypus has about 18,000 genes; humans, by comparison, have somewhere around 20,000. Moreover, roughly 82% of the platypus's genes are shared between monotremes, marsupials (which carry their under-developed young in pouches like kangaroos), eutherians (mammals with placenta such as elephants and humans), birds, and reptiles. The overlapping features has led scientists to consider that the platypus actually



Beaver



Platypus tail



Digestive system



Platypus bill and claw



Platypus spur

represents a living missing link between reptiles and mammals.

2. Does a platypus have a stomach?

Ans: No, platypuses do not have a functional stomach. Their esophagus connects directly to their intestines, meaning they lack the acid-producing organ found in most mammals. Food is crushed by grinding plates in their bill, and digestion is completed in the intestines.

Platypuses have lost the genes for producing stomach acid and pepsinogen (protein-digesting enzymes). Because they eat small aquatic invertebrates containing calcium carbonate (which neutralizes acid), a stomach is not needed.

Their digestive tract is simplified to skip the acidic stomach phase.

3. How does a platypus defend itself?

Ans: Male platypuses have a 1.5-2 cm long spur on each hind leg at the ankle connected to a **crural gland** that produces secretions. They are normally shy creatures. When threatened, they hook these spurs into predators or rival males to inject a complex, highly painful venom, causing immediate, severe pain and swelling.

While not fatal to humans, the venom is strong enough to kill smaller animals like dogs. It is most potent during the breeding season to establish territory.

Platypuses are shy and cautious. They prefer to avoid danger by diving underwater and hiding in their riverbank burrows. They use their strong claws mainly for digging. Only males are venomous; females lack

functional spurs.

4. How does a platypus find its way in water?

Ans: Platypuses have eyes above their bill so they are not able to see things directly below them. Skin flaps cover the platypus' eyes, ears and nostrils underwater which means it is temporarily blind when swimming. Instead, the platypus uses its bill to feel its way and find food under water.

The platypus' diet consists of a variety of insect larvae, yabbies, small fish and worms.

detect tiny electric fields from prey and

. use **mechano-receptors** to sense water pressure and movement.

This allows them to navigate and hunt even in dark, murky water where sight will be useless.

Electro-location: The bill contains over 40,000 electro-receptors that detect weak electric currents produced by the muscle contractions of prey, such as shrimp and worms.

Otter



Mallard Duck



Platypuses find their food amongst the rocks, leaf litter and other material on the bottom of the water body with their bill. They then store the food collected in large cheek pouches, and chew it when they reach the surface. Each dive usually lasts between 30 and 60 seconds.

Since platypuses essentially turn off their sight, smell, and hearing under water, how do they hunt for prey? They rely instead on a highly sensitive bill to detect prey in two ways:

. they use specialised **electro-receptors** to

Pressure Sensors (Mechano-reception):

Along with electro-receptors, the bill has over 60,000 mechano-receptors, known as “push rods”, which are sensitive to touch and water pressure, allowing them to detect movement in the water.

The platypus sweeps its bill side-to-side on the riverbed, using these sensors to locate prey and navigate.

5. What is so special about platypus fur?

Ans: Platypus fur is exceptionally dense and



Baby Platypus

specialized, providing superior insulation and waterproofing to keep the animal warm and dry in cold water. It consists of two layers: a waterproof topcoat of coarse guard hairs and a dense fine underfur that traps air. Platypuses use their fur to trap a layer of air next to their skin so they can remain buoyant and dry when they're underwater, which they are a lot. The platypus spends about 12 hours every day underwater looking for food.

Recent research shows that it is *bio-fluorescent*, so it glows cyan/green under UV light! The reason for this is not clear but it may have something to do with night-time camouflage.

The fur is among the densest of all mammals. It acts like a wetsuit, keeping the skin dry and maintaining insulation, which is better than that of polar bears or beavers.

A groundbreaking discovery this year showed that platypuses are the first known mammals with hollow pigment-containing structures (**melanosomes**) in their fur. That is, it possesses unique hollow pigment structures similar to bird feathers. Such a feature was previously thought to only exist in bird feathers.

The platypus uses its hind claws for constant, meticulous grooming to keep the fur in top condition. This unique combination of features makes the platypus one of the most remarkable and specialized aquatic mammals.

Sources: Several, including

<https://wwf.org.au/blogs/9-interesting-platypus-facts/>

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Bombax Ceiba

the Silk cotton tree

Indian Names: Simul, Roktosimul, Malabar Semul, Elava Maram, Buruga, Kapok tree

Silk cotton tree is a type of native cotton tree with large red flowers. The genus name *Salmalia* is derived from the Sanskrit name *shaalmali*.

The trees bear beautiful red-colored flowers during January to March; see back cover. It paints the whole landscape in an enchanting red colour. The fruit, the size of a ping-pong ball, on maturity appears during March and April. These are full of cotton-like fibrous stuff. It is for the fibre that villagers gather the semul fruit and extract the cotton substance called “kopak”. This substance is used for filling economically priced pillows, quilts, sofas etc.

The fruit is cooked and eaten and also pickled. It is quite a fast growing tree and can attain a girth of 2 to 3 m, and height

about 30 m, in nearly 50 years or so.

Its wood, when sawn fresh, is white in color. However, with exposure and passage of time it grows darkish gray. It is very light with a density of about 0.4 gm/cc. It is easy to work but not durable anywhere other than under water. So it is popular for construction work, but is very good and prized for manufacture of plywood, match boxes and sticks, patterns, moulds, etc. It is also used for making canoes and light duty boats and or other structures required under water. The wood is soft and is often used for making paper, while in rural areas, it is used as fuelwood and for making cheap furniture.

Bombax species are used as food plants by the larvae of some species including the leaf-miner moth species *Bucculatrix crateracma* which feeds exclusively on *Bombax ceiba*.

The golden-crowned sparrow (see back cover) weaves the lining of its nests with white cotton from its seeds.

Sources: Wikipedia,

<https://www.flowersofindia.net/catalog/slides/Silk%20Cotton%20Tree.html>



Flower closeup



Silkcotton seed



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