# General Science and Science and Technology Current Affairs – May 2019

**Contents**



## {S&T – Health – 19/05/31} Coloured wheat

Economic Times | 31-05-2019 | GS3 > S&T > New Developments

- Coloured wheat is developed by Mohali's National Agri-Food Biotechnology Institute (NABI).
- The three coloured varieties are purple, black and blue wheat.
- NABI comes under the Union Ministry of Science and Technology.
- Food Safety and Standards Authority of India (FSSAI) gave its nod for human consumption of coloured wheat.
- The wheat gets its colour from **anthocyanin**.
- While normal wheat has 5 ppm of anthocyanin, the purple wheat has 40 ppm.
- **Anthocyanin** is a pigment that **gives colour to fruits such as blueberries and jamun**.
- Anthocyanin is also an **antioxidant** (can reduce chances of cardiovascular diseases, diabetes and obesity).
- Coloured wheat can give the requisite quantities of anthocyanin without the fear of high blood sugar.
- The black one possesses the highest amount of anthocyanin, followed by blue and purple wheat.
- Coloured wheat is also **biofortified with zinc** and hence can fight malnutrition among children.
- One acre gives about 20 quintals of coloured wheat at best — four quintals less than the normal variety.
- All three varieties of wheat are now being tested by the Indian Council of Agriculture Research (ICAR).

## Zinc deficiency rising in Indians

- A new study says **rising carbon dioxide levels** can accelerate **zinc deficiency in crops**.
- Zinc deficiency in diet is severe in states with rice-dominated diets (southern and north-eastern states).
- Solutions: National grain fortification programmes, bio-fortified crops, and reduced $CO_2$ emissions.

### Importance of dietary zinc

- Boosts immune function,
- Helps in cell division,
- Promotes wound healing.

### Health issues associated with Zinc deficiency

- Zinc nutrition is an important determinant of mortality in children (NCERT).
- Reduces children's resistance to infectious diseases including the risk of infection (NCERT).
- Children are more susceptible to contracting malaria, diarrhoeal diseases and pneumonia (NCERT).
- Poor immune system function.

### Foods rich in zinc

- Meat, particularly red meat, liver,
- Milk, cheese and other dairy products, eggs, seeds and nuts, etc.
- Shellfish like oysters, crab, mussels and shrimp.

## Biofortification of crops

- Fortification is the practice of increasing the content of an essential **micronutrient**, i.e. vitamins and minerals (including trace elements) in a food.
- Biofortification is fortification done through agronomic practices (soil management and crop production), conventional plant breeding, or modern biotechnology.
- In conventional fortification nutrient levels are increased during processing of the crops.
- Biofortification increases nutrient levels in crops during plant growth.
- Biofortification is better than conventional fortification as it is easy to implement.

### Examples of biofortified crops in India

- Pearl millet (iron), wheat (zinc), sorghum (iron), rice (zinc), cowpeas (iron) and lentils (iron and zinc).
- Dhanshakti (biofortified pearl millet or bajra) is the first iron biofortified crop to be officially released in India.

*Source*

**Micronutrient deficiencies**

- Hidden hunger: a term used to describe dietary micronutrient deficiencies.
- The most common micronutrient deficiencies are deficiency of iron, zinc and Vitamin A.
- Micronutrient deficiencies affect pregnant women and preschool children the most.

## {S&T – Space – 19/05/01} Chandrayaan-2: India's second lunar mission

The Hindu | PIB | 01-05-2019 | GS3: Science and Tech, Space | Notes on GSLV, PSLV, Orbits, etc. is in the making.

- Chandrayaan-2, India's second lunar mission to be launched in July (nearly a 2 month journey).
- Chandrayaan-2 has three modules namely **Orbiter, Lander (Vikram) & Rover (Pragyan)**.
- The Chandrayaan-2 weighs around 3,290 kg.
- **GSLV MK-III** is the launch vehicle. It is a three-stage launch vehicle designed to carry **four-tonne class satellites** into **Geosynchronous Transfer Orbit (GTO)**. (The Chandrayaan-1 was launched on board a PSLV).
- The Orbiter and Lander modules (includes Rover) are stacked together as an integrated module.
- After launch into earth bound orbit, the integrated module will reach Moon's orbit.
- Subsequently, Lander will separate from the Orbiter (100 km orbit) and soft land close to **lunar South Pole**.
- The Rover will roll out for carrying out scientific experiments on the lunar surface.
- Instruments are also mounted on Lander and Orbiter for carrying out scientific experiments.
- The instruments will collect scientific information on lunar topography, mineralogy, elemental abundance, lunar exosphere and signatures of hydroxyl and water-ice.

### Why the lunar south pole?

- The lunar south pole craters are unique in that sunlight does not reach the bottom.
- Such craters are cold traps that contain a record of water composition of the early Solar System.
- Permanently shadowed craters may harbour reservoirs of ices and other volatile compounds that could serve as a valuable resource for future explorers.
- A few mountain peaks near the pole are illuminated for extended periods of time, which could provide near-constant solar power for a permanent lunar outpost sometime in the far future.

## {Sci – Astronomy – 19/05/01} Event Horizon Telescope (EHT)

The Hindu | High-Pain Low-Gain Topic | Basics covered under Pmfias.com > Astronomy

- **A black hole and its shadow** have been captured in an image for the first time by an international network of radio telescopes called the **Event Horizon Telescope (EHT)**.
- The discovery helps in testing the predictions of the general theory of relativity.

## Event Horizon Telescope (EHT)

- The Event Horizon Telescope project is an international collaboration launched in 2009.
- EHT is a large telescope array consisting of a **global network of radio telescopes** (optical telescopes see light; radio telescopes see radio frequency portion of the electromagnetic spectrum).

The EHT project combines data from several stations to observe objects the size of a supermassive black hole's event horizon.

The project's observational targets include the two black holes: the black hole at the centre of the supergiant elliptical galaxy Messier 87 (M87), and Sagittarius A*, at the centre of the Milky Way.

## Black hole

- Black holes are believed to form from **massive stars** at the end of their lifetimes.
- The gravitational pull in a black hole is so great that **nothing can escape from it, not even light**.
- The density of matter in a black hole cannot be measured (infinite!).
- Black holes **distort the space around them** and can suck neighbouring matter into them including stars.
- **Gravitational lensing**: Light around a massive object, such as a black hole, is bent, causing it to act as a lens for the things that lie behind it.

### What is event horizon of a black hole?

- The event horizon is the region around a black hole where the escape velocity surpasses the speed of light.
- According to Einstein's special relativity, **nothing can travel faster through space than the speed of light**.
- This means a black hole's event horizon is he point from which **nothing can return, not even light**.
- Hence, it is the horizon beyond which one cannot see.

### What is the composition of a black hole?

- We do not get any light or other signals from within the black hole.
- Hence it is not possible to determine the composition of a black hole with current physics.

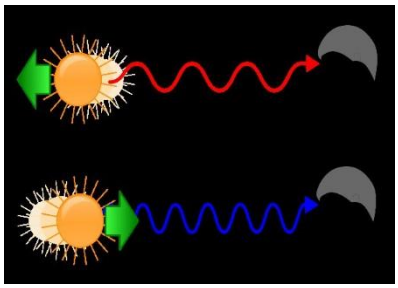
### Why black holes are having such a high gravitational field around it?

- Because a black hole contains a huge amount of mass within a relatively small volume.

- Matter going into it increases the mass of the black hole.

### Related concept: Doppler-shift or Redshift and Blueshift

- Redshift and Blueshift describe how light changes as objects in space (such as stars or galaxies) move closer or farther away from us. The concept is **key to charting the universe's expansion**.



- Visible light is a spectrum of colours, which is clear to anyone who has looked at a rainbow.
- When an object moves **away from us (Doppler-shifted to lower frequencies)**, the light is shifted to the **red end of the spectrum, as its wavelengths get longer**.
- If an object moves **closer (Doppler-shifted to higher frequencies)**, the light moves to the **blue end of the spectrum, as its wavelength gets shorter**.

## {Bio – 19/06/02} CRISPR-Cas9

The Hindu | 02-06-2019 | General Science > Biology | GS3 > Biotechnology and its applications

- In a bid to make babies immune to HIV, a researcher from China used an untested gene editing tool (CRISPR-Cas9) on twin girls to disable the gene CCR5 (encodes a protein that allows HIV to enter and infect cells).
- The announcement of the birth of gene-edited twin girls late last year set off an international furore.

### CRISPR

- Unusual but repeated DNA structures that scientists had been observing were given a name — Clustered regularly interspaced short palindromic repeats or CRISPR.
- In 2012, scientists discovered that CRISPR is a key part of the "immune system".
- For instance, when a virus enters bacteria, it fights back by cutting up the virus's DNA.
- This kills the virus but **bacteria store some of the DNA**.
- The next time there is an invasion, bacteria produce an enzyme called **Cas9** which matches the **stored fingerprints** with that of the invader's.
- If it matches, Cas9 can destroy the invading DNA.

## CRISPR-Cas9 gene editing tool

- The Chinese researcher used the CRISPR–Cas9 gene editing technique in the twin girls.
- The CRISPR-Cas9 gene editing tool has two components:
    1. a short RNA sequence that can bind to a specific target of the DNA and
    2. the Cas9 enzyme which acts like a molecular scissor to cut the DNA.

### Mechanism

- RNA sequence that perfectly matches with the DNA sequence that has to be edited is introduced.
- Once the RNA sequence binds to the DNA, the Cas9 enzyme cuts the target DNA (bound by RNA sequence).
- Once the DNA is cut, the natural DNA repair mechanism is utilised to add or remove genetic material.

### What's wrong with the researcher's misadventure?

- Scientific communities oppose the CRISPR–Cas9 gene-editing technique in embryos.
- There is also consensus that gene editing can be potentially used only to prevent serious genetic disorders.
- Human clinical trials have not been carried to test whether disabling the gene completely prevents HIV.
- The tool could have caused unintended mutations in other parts of the genome.

### Can disabling the CCR5 gene prevent HIV?

- Babies without a functional CCR5 gene will become resistant to HIV infection, but certain other strains of HIV use another protein to infect cells.
- Hence, even people who are born with non-functional CCR5 gene are not completely against HIV infection.

### Does the CCR5 gene have any protective role?

- The CCR5 gene's protective role against the West Nile virus is well established.
- CCR5 gene also helps to protect the lungs, the liver and the brain during certain serious infections.
- The gene is known to prompt the immune system to fight the influenza virus in the lungs.
- Without this gene the defence system would fail.

## {Bio – Diseases – 19/06/04} Nipah virus

The Hindu | The Hindu | 04-06-2019 | Biology > Diseases

### Context

- The Nipah virus was first recognised in 1999 during an outbreak among pig farmers in Malaysia.
- The disease has also been identified periodically in Kerala.

## Nipah virus infection

- The virus belongs to a new genus termed Henipavirus.
- Nipah is an RNA or Ribonucleic Acid virus.
- RNA viruses (most common cause diseases in humans) have high mutation rate compared to DNA viruses.

### Transmission

- Nipah virus infection is a **zoonosis** (disease transmitted from animals to humans).
- A zoonosis could be caused by a virus, bacteria, fungi or parasite; some examples include anthrax, bird flu, ebola, dengue, rabies, malaria, swine flu, etc.
- **Fruit bats** (flying fox) (eat fruits and live in trees) are the natural hosts for Nipah virus.
- Nipah transmission takes place when one consumes infected fruits and fresh date palm.
- Loss of the natural habitat of the bats is exacerbating the rate of **bat-to-human transmission**.
- As the flying fox habitat is destroyed, their immune system gets weaker, their virus load goes up.
- **Human-to-human transmission** occurs due to direct contact.

### Symptoms

- The incubation period (interval from infection to the onset of symptoms) ranges from four to 14 days.
- Symptoms are similar to that of influenza: fever, muscle pain, and respiratory problems.
- Headaches, dizziness, encephalitis (brain inflammation), etc.
- Sometimes a person can have an asymptomatic infection (acts as a carrier without showing any symptoms).

### Treatment

- There are currently **no drugs or vaccines** specific for the infection.

### Tests used

- Real time polymerase chain reaction (RT-PCR) from bodily fluids.
- Antibody detection via enzyme-linked immunosorbent assay (ELISA).
- Polymerase chain reaction (PCR).

## {Sci – Defence Tech – 19/05/14} DRDO Successfully Conducts Flight Test of ABHYAS

PIB | 14-05-2019 | Prelims content

- ABHYAS: High-speed Expendable Aerial Target (HEAT).
- The Abhyas is launched from a mobile launcher.

- Abhyas can be augmented to **simulate a variety of aircraft for air-defense weapon practices**.
- It can also function as a jammer platform and decoy.

## {Che – 19/05/15} Fuel Cells: Selenium-graphene catalyst for fuel cells

The Hindu | 15-06-2019 | Prelims Topic

### Fuel Cell

- A fuel cell uses electrochemical reactions to generate electrical energy.
- A fuel cell requires a continuous input of fuel and an oxidizing agent in order to sustain the reaction.
- Hydrogen is the most common fuel used.
- They were initially used by NASA to power space capsules and satellites.

#### Fuel Cell Mechanism

- A fuel cell consists of a cathode, an anode, and an electrolyte.
- The electrolyte enables the movement of the ions between the electrodes.
- At the anode, catalyst causes the fuel to undergo oxidation and generates +ve charged ions and electrons.
- The ions move from the anode to the cathode and the same time, the electrons flow from the anode to the cathode through an external circuit, producing direct current electricity.
- At the cathode, another catalyst causes ions, electrons, and oxygen to react, forming water as by-product.
- The reaction rate of this electrochemical reaction is quite low.
- The reaction rate between the fuel and the oxidizing agent is quite low.
- Catalysts such as platinum or palladium or gold are used speed up the reaction.

#### Advantages of fuel cells

- Fuel cells are more efficient than thermal power plants (thermal energy ➔ mechanical energy ➔ electrical energy) as there is **direct conversion of chemical energy into electrical energy**.
- Hydrogen fuel is abundantly available.
- The by-product of fuel cells are water and non-toxic products that pose no risk to our climate.

#### Disadvantages of fuel cells

- They are very expensive to produce (platinum, palladium catalysts are expensive).
- As of now, there is no simple means of producing hydrogen fuel in a cost effective way.
- Hydrogen itself is very prone to catching on fire, or even exploding.
- In order to actually generate hydrogen fuel, fossil fuels are needed.

## Selenium-graphene catalyst for fuel cells

- Normally, fuel cells use expensive platinum-like elements.
- These expensive technologies perform well for initial few cycles, but then get degraded.
- As a result, there is a need to change the catalyst part of the fuel cell routinely.
- Modern fuel cell energy technology requires good catalysts that are efficient as well as cost-effective.
- Now, a team from India has developed a **selenium-graphene–based catalyst** which is more efficient, costs less and also remains stable for longer than the usual platinum based catalysts.

### Mechanism

- The oxygen reduction reaction is a key step in the functioning of the fuel cell.
- Graphene by itself is a "poor" catalyst of this reaction.
- It involves reduction of oxygen in two steps, each of which consume two electrons.
- This is not very useful either for fuel cells or metal-air batteries.
- Platinum is often used to catalyse this reaction.
- As a substitute, the group developed the catalyst with selenium and graphene.
- Graphene modified with selenium atoms in very low amounts can perform like platinum in the reaction.
- While neither selenium nor graphene can do the trick by themselves, the combination works efficiently.

### Poisoning-resistant

- Methanol fuel cells, a common form of fuel cell used, suffer from a "poisoning" effect.
- This is a part of the process where the methanol reaches the negative electrode and coats it, so that the electrode becomes ineffective after some cycles.
- The selenium-graphene catalyst has a high tolerance to poisoning while platinum gets easily affected.

### Future applications

- Such inexpensive catalyst has enormous applications in metal-air battery (high energy density batteries).
- A metal–air electrochemical cell is an electrochemical cell that uses an anode made from pure metal and an external cathode of ambient air.
- Metal-air batteries (most suitable for EVs) will be far better than the existing lithium ion-based battery.

## {S&T – Space – 19/05} Terms and Concepts related to Satellite Launches and Satellite Orbits

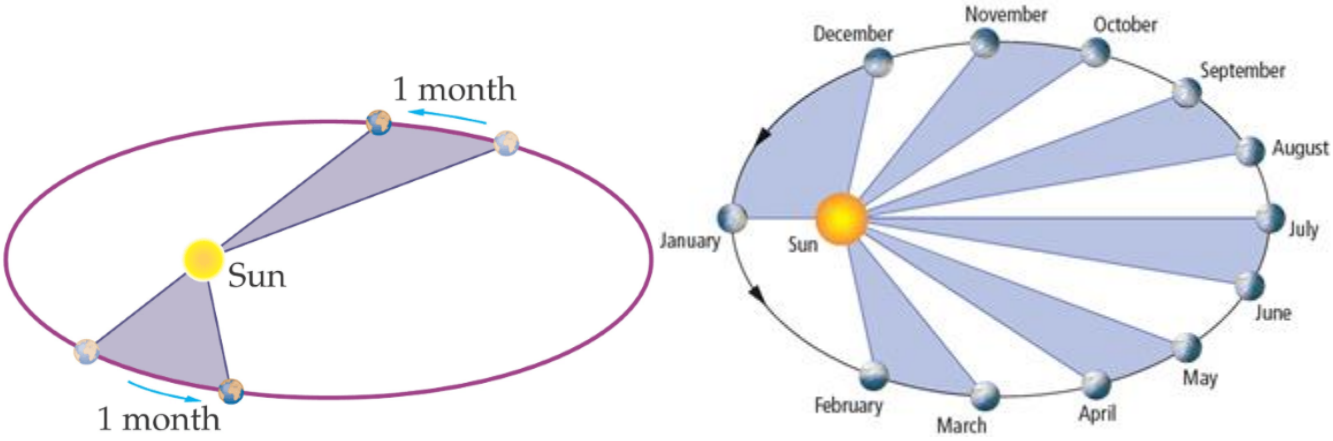
GS3 > Science and Technology

- The terms like Kepler's laws, geosynchronous orbit, geostationary orbit, polar orbit, PSLV, GSLV, etc. keep on appearing in the news columns whenever there is a satellite launch.
- So, I thought it is better to keep all the related concepts at one place.

Titbit: Russia's **Sputnik**, the world's first artificial satellite, was launched in 1957.

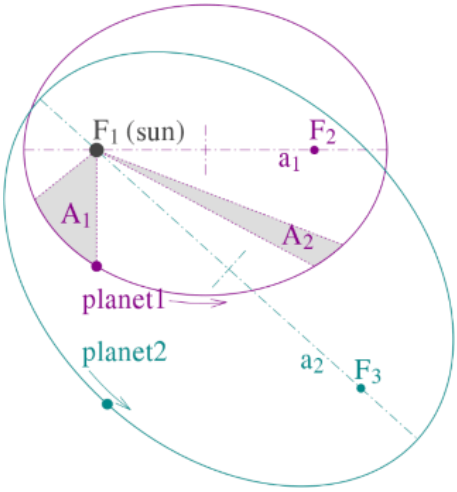
## Kepler's laws of planetary motion (applicable to satellites also)

- **Kepler's First Law**: The orbit of a planet is an ellipse with the Sun at one of the two foci.
- **Kepler's Second Law**: A line segment joining a planet and the Sun sweeps out equal areas during equal intervals of time.
- In simple words, **the speed of the planet increases as it nears the sun and decreases as it recedes from the sun**.




*The varying orbital speed of the earth (in the figure, the orbit of the earth is exaggerated)*

- **Kepler's Third Law**: The square of the orbital period of a planet is proportional to the cube of the semi-major axis of its orbit.



*Hankwang, Wikipedia*

Orbital period (T): time taken by a plant to complete one revolution around the sun.

Semi Major Axis ($a_1$ and $a_2$): half of the major axis of the ellipse.

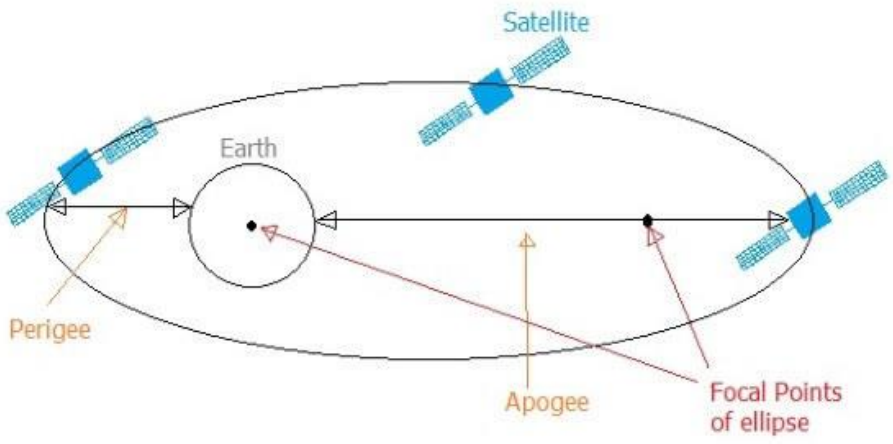
$$T_1^2/a_1^3 = T_2^2/a_2^3$$

- In simple terms, the distance of a planet from the sun determines the time it takes for that planet to revolve around the sun (**farther the planet is, greater the orbital period**).

| **Planet** | **Orbital Period (T) in years** | **Average Distance (R) in AU** | **$T^2/R^3$** |
|---|---|---|---|
| **Mercury** | 0.241 | 0.39 | 0.98 |
| **Venus** | .615 | 0.72 | 1.01 |
| **Earth** | 1.00 | 1.00 | 1.00 |
| **Mars** | 1.88 | 1.52 | 1.01 |

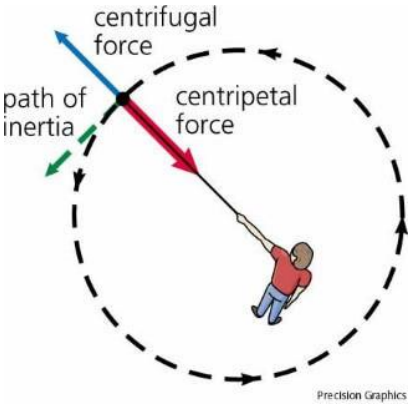
## Perigee and Apogee

- Most satellites orbit the earth in elliptical patterns.
- When a satellite is at its **farthest point** from the earth, it is at the **apogee** of the orbit.
- When a satellite is at its **closest point** to the earth, it is at the **perigee** of the orbit.
- In accordance with Kepler's second law, the **satellites are fastest at the perigee and slowest at the apogee**.




## Why satellites revolve rather than staying still in space?

- There are two important forces acting on the satellite:
  1) the gravitational force which will pull the satellite towards earth and
  2) the centrifugal force (due to revolution) which counters the gravitational pull.

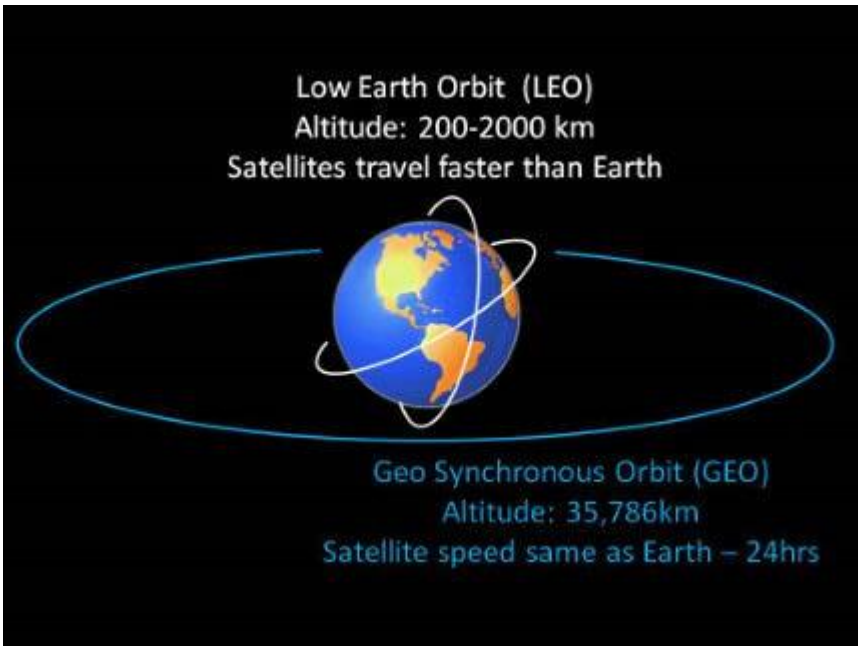



*Source*

- Revolution causes centrifugal force (the object tends to move away from the centre).
- Higher the speed of the revolving satellite (orbital velocity), higher the centrifugal force.
- Thus, by varying the speed (orbital velocity) of the satellite, we can make the satellite
  1) fall back to earth by decreasing the orbital velocity (centrifugal force < gravitational force)
  2) **stay in its orbit** by adjusting the speed so that the **centrifugal force balances the gravitational pull** (centrifugal force = gravitational force). (**Lower the orbit, higher should be the orbital velocity**).
  3) escape earth's influence by keeping the orbital velocity above the required speed (centrifugal force > gravitational force).

## Low Earth Orbit (LEO: 200-2000 km)

- **International Space Station (400 km)**, the **Hubble Space Telescope (560 km)** and some observation satellites are all rotating the earth in **Low Earth Orbit**.
- LEO is high enough to significantly reduce the atmospheric drag yet close enough to observe the earth (remote sensing).
- In LEO, the satellite's orbital period is much smaller than the earth's rotational period (24 hours).
- That is, the satellites in LEO complete multiple revolutions in 24 hours (**Lower the orbit, higher should be the speed**).




*Source*

### What is the speed required to keep a satellite in LEO?

- The speed is dependent on the distance from the centre of the Earth.
- At an altitude of 200 km, the required orbital velocity is a little more than 27,400 kmph.
- In the case of the space shuttle, it orbits the Earth once every 90 minutes at an altitude of 466 km.

### Advantages of LEO

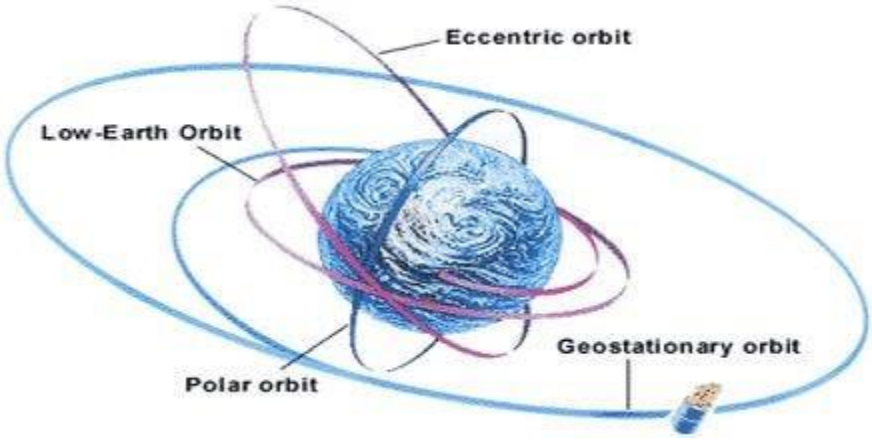
- Low Earth Orbit is used for things that we want to visit often, like the International Space Station, the Hubble Space Telescope and some satellites (usually **spy satellites and other observation satellites**).
- This is convenient for installing new instruments, experiments, and return to earth in a relatively short time.

### Disadvantages of LEO

- Atmospheric drag will lead to more fuel consumption and constant speed adjustments.
- A satellite traveling in LEO do not spend very long over any one part of the Earth at a given time.
- Hence, satellites in LEO are **not suitable for communication and weather observation and forecasting**.

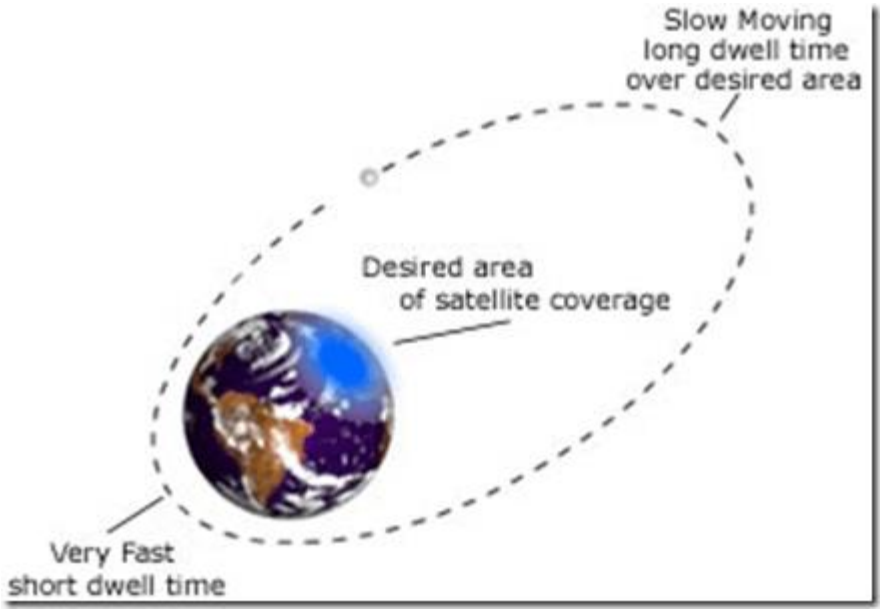
### Solution

- One solution is to put a satellite in a highly elliptical orbit (eccentric orbit — non-geosynchronous).
- The other is to place the satellite in a **geosynchronous orbit**.




## Highly Elliptical Orbits

- Kepler's second law: an object in orbit about Earth moves much faster when it is close to Earth than when it is farther away.
- Perigee is the closest point and apogee is the farthest.
- If the orbit is very elliptical, the satellite will spend most of its time near apogee (the furthest point in its orbit) where it moves very slowly.
- Thus, it can be above a specific location most of the time.

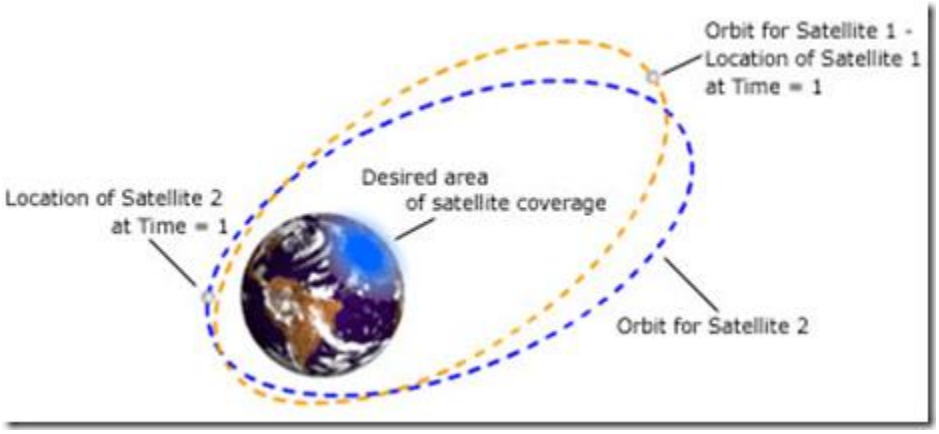



### Disadvantages of Highly Elliptical Orbits

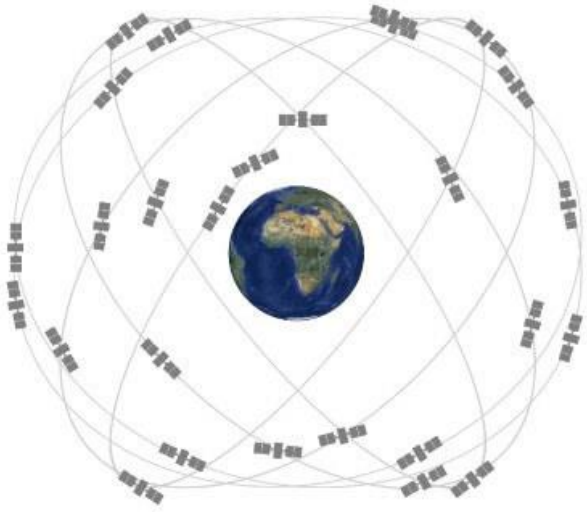
- In a highly elliptical orbit, the satellite has long dwell time over one area, but at certain times when the satellite is on the high speed portion of the orbit, there is no coverage over the desired area.

**Solution**

- We could have two satellites on similar orbits but timed to be on opposite sides at any given time.
- In this way, there will always be one satellite over the desired coverage area at all times.




- If we want continuous coverage over the entire planet at all times, such as the Global Positioning System (GPS satellites are in Medium Earth Orbit though), then we must have a constellation of satellites with orbits that are both different in location and time.
- In this way, there is a satellite over every part of the Earth at any given time.



Satellite constellation (Source)

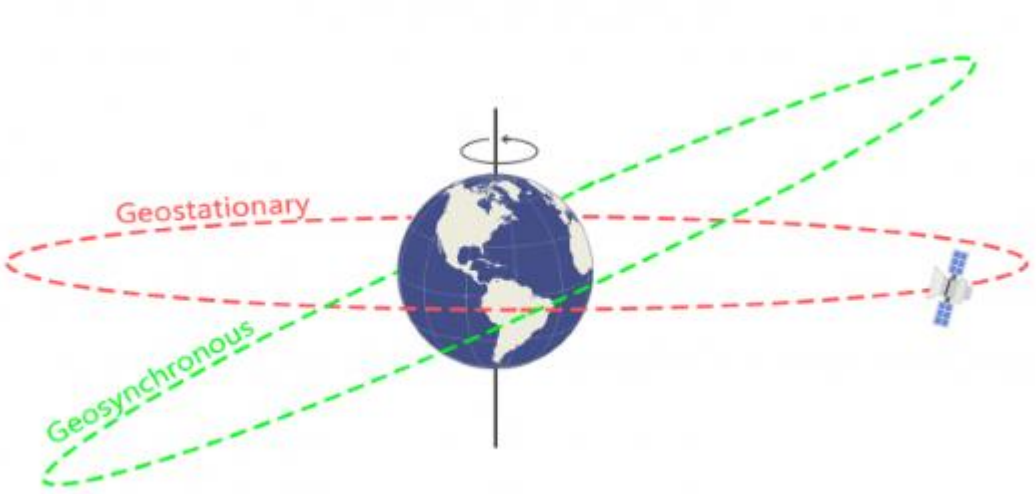
## Geosynchronous Orbits (GSO)

- Another solution to the dwell time problem is to have a **satellite whose orbital period is equal to the period of rotation of the earth** (**24 hrs**) (satellite's revolution is in sync with the earth's rotation).
- In this case, the satellite cannot be too close to the Earth because it would not be going fast enough to counteract the pull of gravity.
- Using Kepler's third law it is determined that the satellite has to be placed approximately 36,000 km away from the surface of the Earth (~42,000 km from the centre of the Earth) in order to remain in a GSO orbit.

- By positioning a satellite so that it has infinite dwell time over one spot on the Earth, we can constantly monitor the **weather in one location, provide reliable telecommunications service**, etc.
- The downside of a GSO is that it is **more expensive** to put and maintain something that high up.

## Geostationary Orbit or Geosynchronous Equatorial Orbit (GEO)

- A geostationary orbit or **geosynchronous equatorial orbit** is a **circular geosynchronous orbit above Earth's equator** and following the direction of Earth's rotation.
- Because the satellite stays right over the same spot all the time, this kind of orbit is called "geostationary."




## Geostationary vs Geosynchronous

| Geostationary Orbit or Geosynchronous Equatorial Orbit (GEO) | Geosynchronous Orbit |
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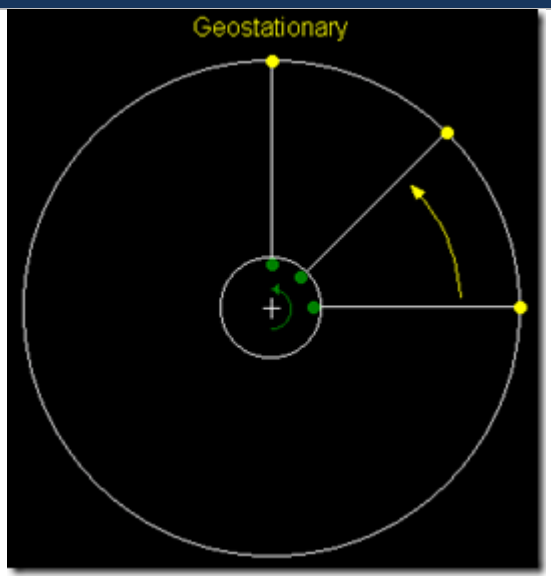
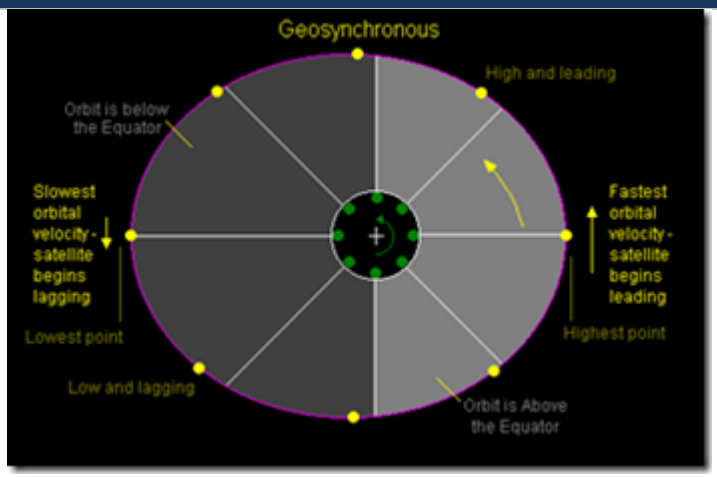
|  |  |

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- They are both geosynchronous orbits (orbital period = 24 hours).
- Line of sight transmission

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- Orbital path is circular.

</td><td>

- Orbit is an inclined circle or an inclined ellipse.

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<tr><td>

- Orbital tilt is zero.

</td><td>

- The orbital tilt is non-zero (inclined orbit)

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- An observer on the ground would not perceive the satellite as moving and would see it as a fixed point in the sky

</td><td>

- A person on a point on Earth, will see a satellite in this orbit in the same place in the sky at the same time of the day, every day.
- Since the orbit has some inclination and/or eccentricity, the satellite would appear to describe a more or less distorted figure-eight in the sky and would rest above the same spots of the Earth's surface once per day.

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- There are a limited number of positions available (traffic jam, interference of signals due to more satellites in the same orbit and risk of damage due to space debris) in this orbit due to safety and manoeuvring limits.

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- There are more orbital planes and positions available to satellites using this technique

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- Can receive signals with a simple antenna as the satellite is in relatively same position (**DTH, VSAT services**).
- (Parabolic antenna is used to nullify the effect of atmospheric distortions)

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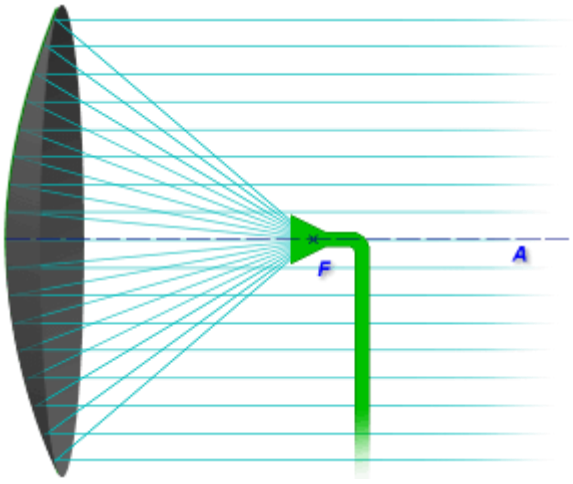
- Requires a parabolic antenna as the satellite's position slightly changes longitudinally.

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- Steering the antenna is not required.

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- It may sometimes require steering the antenna to achieve line of sight

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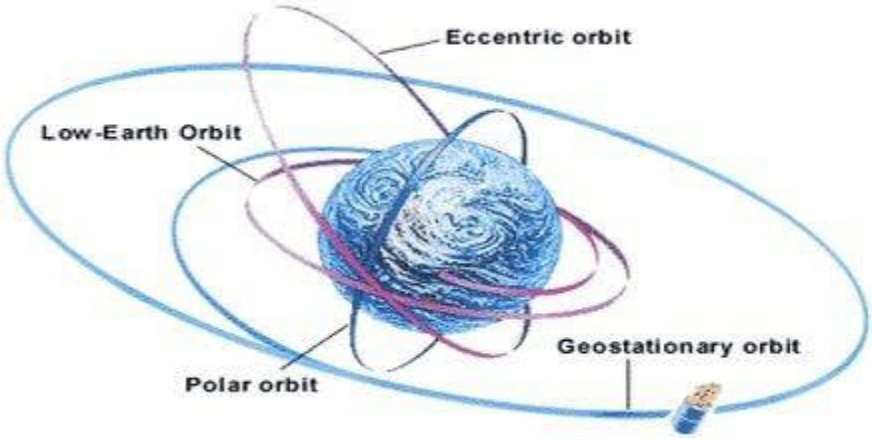
## Medium Earth Orbits (MEO: 2000-36,000 km)

- Medium Earth Orbits (MEO) range in altitude from 2,000 kms up to the geosynchronous orbit at 36,000 km which includes part of the lower and all of the upper **Van Allen radiation belts**.
- The Van Allen Radiation Belt is a region of high energy charged particles moving at speeds close to that of light encircling the Earth which can damage solar cells, circuits, and shorten the life of a satellite or spacecraft.
- Practical orbits therefore avoid these regions.

## Polar Orbits (PO)

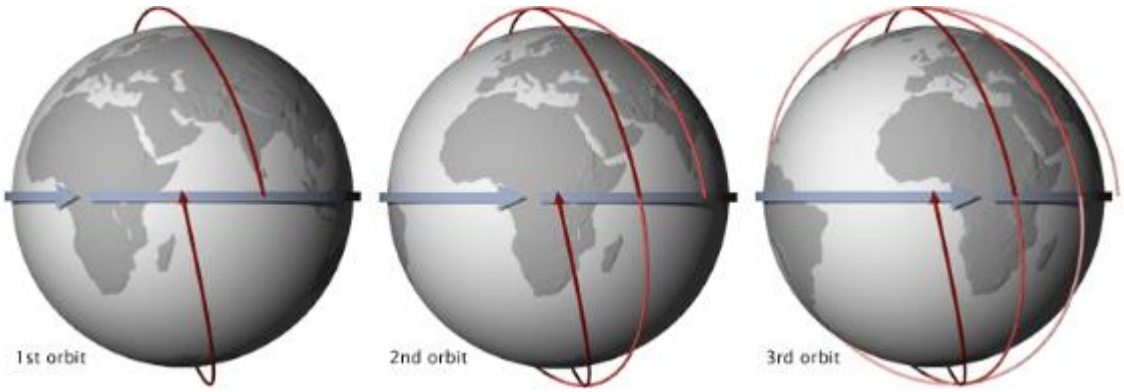
- Satellites in these orbits fly over the Earth from **pole to pole** in an orbit perpendicular to the equatorial plane.
- This orbit is used in **surface mapping and observation satellites** since it allows the orbiting satellite to take advantage of the earth's rotation below to observe the entire surface of the Earth as it passes below.
- Pictures of the Earth's surface in applications such as Google Earth come from satellites in polar orbits.




## Sun-synchronous orbits (SSO)

- Polar orbit and sun-synchronous orbits are low earth orbits.

- Sun-synchronous orbit is a near polar orbit in which the satellite passes over any given point of the planet's surface at the same local mean solar time.
- When a satellite has a sun-synchronous orbit, it means that the satellite has a constant sun illumination.
- Because of the **consistent lighting**, the satellites in sun-synchronous orbit are used for **remote sensing applications (image the Earth's surface in visible or infrared wavelengths) like imaging, spying**, etc.

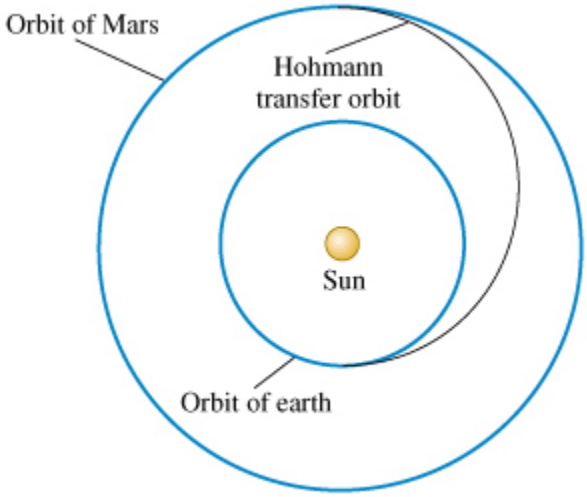



## Parking Orbit

- It is not always possible to launch a space vehicle directly into its desired orbit.
- The launch site may be in an inconvenient location or the launch window may be very short.
- In such cases the vehicle may be launched into a temporary orbit called a parking orbit.
- The parking obit provides more options for realising the ultimate orbit.
- For manned space missions the parking orbit provides an opportunity to recheck the systems.

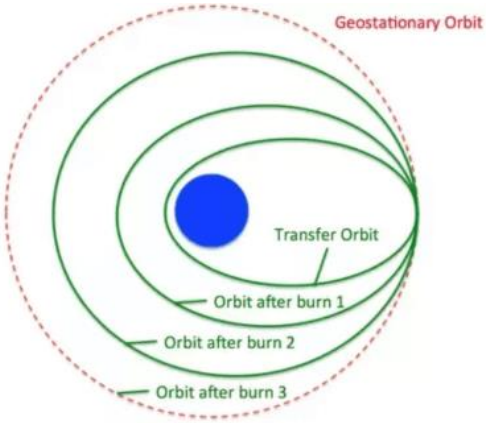
## Hofmann transfer orbit

- The transfer orbit is the orbit used to break out of the parking orbit and break into the geosynchronous or geostationary orbit.



## Geosynchronous transfer orbit (GTO)

- A geosynchronous transfer orbit is a Hohmann transfer orbit — an elliptical orbit used to transfer between two orbits in the same plane — used to reach geosynchronous or geostationary orbit.




## Escape velocity

- Escape velocity is the **minimum launch velocity** (assuming the object is launched straight up) **required for an object to escape earth's gravitational pull** (it doesn't fall back to earth).
- One condition is that once launched the object is not supplied with any additional energy nor hindered by external force (like atmospheric drag) other than earth's gravity.
- The escape velocity required for an object to escape earth's gravitational pull is **~11.2 m/s** (40,000+ kmph).
- It is neither feasible (atmospheric friction will turn it into ash) nor desirable (cannot place satellites in desired orbit) to launch rockets at escape velocity.

## Polar Satellite Launch Vehicle (PSLV)

- PSLV is an indigenously-developed expendable launch system.

Expendable launch system ➔ used only once to carry a payload into space. E.g. PSLV, GSLV, etc.
Reusable launch system ➔ system intended to allow for recovery of the system for later reuse. E.g. NASA's space shuttles, SpaceX Falcon 9 rocket (reusable first stage and expendable second stage), etc.

- PSLV was developed in 1990s by ISRO to place satellites (mostly remote sensing satellites) in **polar and near polar (e.g. sun-synchronous orbit) Lower Earth Orbits**.
- However, over the last decade, several PSLV missions were successful in sending satellites towards **geosynchronous transfer orbit**.
- E.g. Chandrayaan-1 – 2008 and Mars Orbiter Mission or Mangalyaan – 2014 were launched using PSLV.
- PSLV can fly in different configurations depending on the mass of its payload and the target orbit.

- These configurations vary the number and type of solid rocket boosters attached to the rocket's first stage, while the **four core stages** remain the same across all configurations.
- PSLV's first stage and third stage are solid-fuelled stages.
- PSLV's second stage and forth stage are liquid-fuelled stages.
- The second stage engine, Vikas, is a derivative of France's Viking engine.
- The PSLV-C (PSLV Core Alone) version of the rocket does not use additional boosters, while the PSLV-DL, PSLV-QL and PSLV-XL use two, four and six boosters respectively.

### The Workhorse of India's space program

- PSLV earned its title 'the Workhorse of ISRO' through consistently delivering various satellites to Low Earth Orbits, particularly the **IRS (Indian Remote Sensing)** series of satellites.
- PSLV Payload Capacity to SSO: 1,750 kg
- PSLV Payload Capacity to Sub-GTO: 1,425 kg
- In forty-seven launches to date, PSLV has achieved success forty-four times.
- Despite the failure of its maiden flight, PSLV went on to record thirty-six consecutive successful launches from 1999 to 2017.
- **PSLVs** were used to place the **IRNSS satellite constellation** (3 in GEO and 4 in GSO) in orbit.

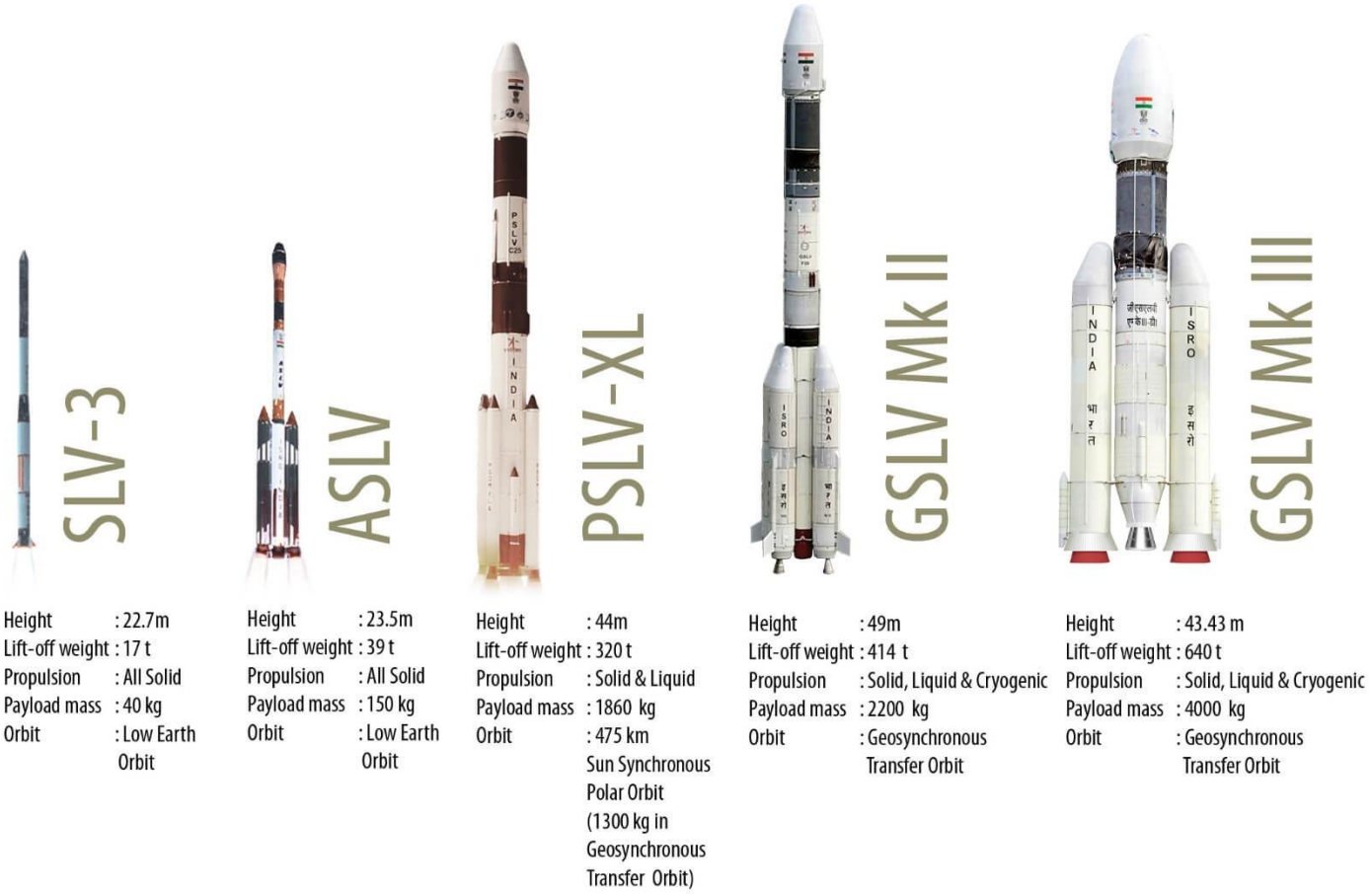
## Geosynchronous Satellite Launch Vehicle (GSLV)

- GSLV is also an expendable launch system.
- The GSLV project was initiated to launch **geosynchronous satellites** (most of them are heavy for PSLV).
- GSLV uses solid rocket booster and the liquid-fuelled Vikas engine, similar to those in PSLV.
- GSLV has solid-fuelled first stage, liquid-fuelled second stage and a **cryogenic third stage**.
- A Cryogenic rocket stage is **more efficient and provides more thrust**.
- However, cryogenic stage is **technically a very complex system** due to its use of propellants (liquid oxygen — minus183 °C and liquid hydrogen — minus 253 °C) at **extremely low temperatures**.
- India had to develop cryogenic technology indigenously as the US objected to Russia's involvement citing Missile Technology Control Regime (MTCR) May 1992.
- A new agreement was signed with Russia for cryogenic stages with no technology transfer.
- GSLV rockets using the **Russian Cryogenic Stage (CS)** are designated as the **GSLV Mk I**.
- GSLV rockets using the **indigenous Cryogenic Upper Stage (CUS)** are designated the **GSLV Mk II**.
- GSLV Payload Capacity to LEO: 5,000 kg
- GSLV Payload Capacity to GTO: 2,500 kg

- GSLV's primary payloads are **heavy communication satellites of INSAT class** (about 2,500 kg) that operate from **Geostationary orbits** (36000 km) and hence are placed in **Geosynchronous Transfer Orbits** by GSLV.
- The satellite in GTO is further raised to its final destination by firing its in-built on-board engines.

## Geosynchronous Satellite Launch Vehicle Mark III (GSLV-III)

- GSLV-III is designed to launch satellites into geostationary orbit and is intended as a launch vehicle for crewed missions under the Indian Human Spaceflight Programme.
- The GSLV-III has a higher payload capacity than GSLV.
- GSLV-III Payload Capacity to LEO: 8,000 kg
- GSLV-III Payload Capacity to GTO: 4000 kg




ISRO Launchers (Source)

## {Sci – Physics – 19/05/20} SI units defined in terms of natural constants

Indian Express | 20-05-2019 | Prelims > General Science > Physics

**7 Fundamental System of Units (SI Units)**

- The fundamental units are the unrelated units of measurement which are arbitrarily defined.
- They are not dependent upon any other units, and all other units are derived from them.

| Physical quantity | Unit | Abbreviation |
|---|---|---|
| 1. Mass | Kilogram | kg |
| 2. Length | Meter | m |
| 3. Time | Second | s |
| 4. Temperature | Kelvin | K |
| 5. Amount of substance | Mole | mol |
| 6. Electric current | Ampere | A |
| 7. Luminous intensity | Candela | cd |

- The kilogram has been defined as the **mass of cylinder of platinum-iridium** (International Prototype Kilogram – IPK) locked in a jar in International Bureau of Weights and Measures, Paris.
- The IPK was the last physical artifact used to define any of the fundamental units.
- IPK would put on a little extra mass when tiny dust particles settled on it; when cleaned, it would shed some of its original mass.
- Scientists have long stressed that the fundamental units should be defined in terms of **natural constants**.
- In 2018, it was agreed that the kilogram should be defined in terms of the **Planck constant**.
- What was 1 kg earlier is still 1 kg today. All that has changed is the definition, **for the sake of accuracy**.
- Using the new definition, a mass measured as 1 kg will mean "1 kg, plus or minus 1 or 2 nanograms".
- Today, the second is defined as the **time it takes for a certain amount of energy to be released as radiation from atoms of Caesium-133**.
- A metre is the **distance travelled by light in vacuum in 1/299,792,458 of a second**.
- With the second and the metre already defined, a very precise definition for the kilogram follows.
- Using a machine called a **Kibble balance**, the value of the Planck constant was measured as **6.626069… × $10^{-34}$ kilograms per second per square metre**.
- New definition of kilogram defined in terms of **Planck constant** is adopted on 20/05/2019.

**Advantages of defining SI units in terms of natural constants**

- The modern definition of the second has already helped ease communication across the world via technologies like GPS and the Internet.
- Scientists have often been quoted as saying the change in the kilogram's definition will be better for technology, retail and health.

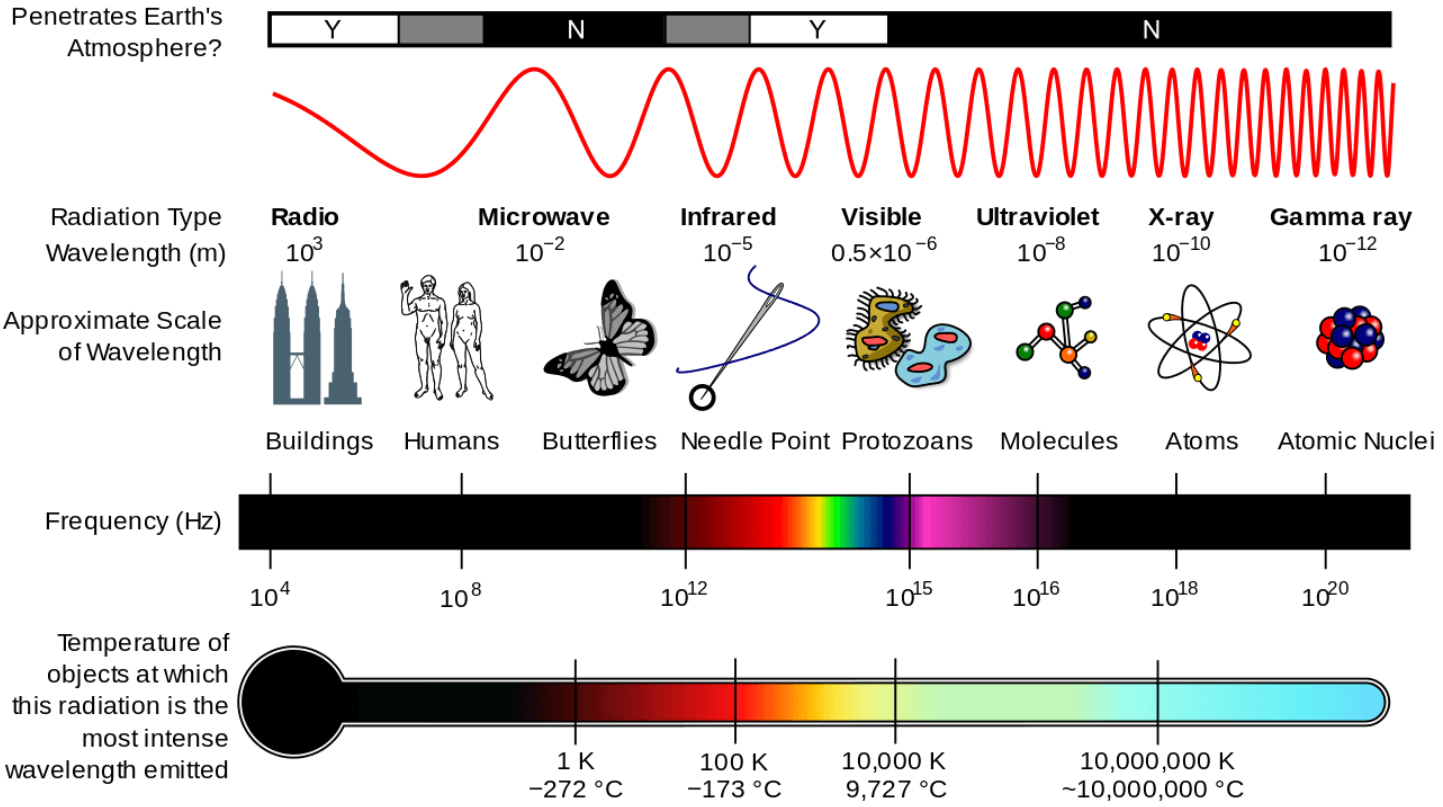
## {S&T – Space – 19/05/22} RISAT-2B radar imaging satellite launched

The Hindu | NASA | Livemint | 22-05-2019 | GS3 > Science and Technology

- 2009: Israeli-built RISAT-2 was launched
- 2012: ISRO-built RISAT-1 was launched
- 2019: ISRO-built RISAT-2B was launched
- RISAT-2B: Radar Imaging Satellite 2B
- The older two have reached the end of their lives.
- Launch vehicle: PSLV-C46 (core-alone version without strap-on motors).
- Orbit: 37 degrees inclined **Lower Earth Orbit** (556 km above earth)
- ISRO Telemetry Tracking and Command Network at Bengaluru controls the satellite.
- RISAT-2B is a **microwave Earth observation satellite**.
- The RISAT series are the first all-weather earth observation satellites from ISRO.
- They enhance India's **all-weather capabilities** in agriculture (crop monitoring during the monsoon season), forestry, disaster management and military surveillance.
- Previous Indian observation satellites relied primarily on optical and spectral sensors which were hampered by cloud cover and during night-time.

### Synthetic-aperture radar

- The RISAT, or radar imaging satellite, is equipped with 'synthetic aperture radar', that takes 'radar images'.
- Synthetic-aperture radar (SAR) creates two-dimensional images of objects, such as landscapes.
- The synthetic aperture radar sends out **radio signals (microwave radiation)** towards the earth and capture the reflected signals to create a radio image, which can then be used by computers to build a real image.




*Microwaves are at the higher frequency end of the radio wave band (Electromagnetic Spectrum – Wikipedia)*

- The **very large wavelength radio waves** are not obstructed by clouds and dust in the atmosphere (**not susceptible to atmospheric scattering**) and produce reliable images **during day and night and all seasons**.
- While **optical remote sensing** that **relies on visible light for imaging** gets obstructed by clouds, RISAT-2B will not.
- Since it has high resolution, the satellite will be able to detect objects with dimensions of as little as a metre.

## {Bio – Diseases – 19/06/22} Acute Encephalitis Syndrome (AES)

The Hindu | The Hindu | 22-06-2019 | General Science > Biology > Diseases | GS2 > Issues in Health sector

**Context**

- Cases of acute encephalitis syndrome (AES) have claimed lives of more than a hundred children in Bihar.
- Bihar loses hundreds of children aged between 2 to 10 years to AES every year.
- The deaths are linked to **malnutrition** and **litchi fruit cultivation** in an around Muzaffarpur.
- The yearly outbreak starts in May and ceases in intensity soon after the monsoon rains begin.
- Ongoing heatwave and delayed onset of monsoons seems to have exacerbated the crisis.

### Acute encephalitis syndrome (AES)

- AES is a collective term used for referring to neurological manifestations which include mental confusion, disorientation, convulsion (sudden movement caused by involuntary contraction of muscles), coma, etc.
- Meningitis caused by virus or bacteria, encephalitis (mostly Japanese encephalitis) caused by virus, encephalopathy, cerebral malaria, etc. are collectively called acute encephalitis syndrome.
- While **microbes cause encephalitis, encephalopathy is biochemical in origin**.
- **Encephalitis**: An inflammation of brain cells due to a viral or bacterial infection.
- **Encephalopathy:** brain damage caused due to an environmental toxin.
- There are different types of encephalopathy. In the present case, it is associated with **hypoglycaemia (low blood sugar level)** and hence called **hypoglycaemic encephalopathy**.
- Unlike hypoglycaemic encephalopathy, encephalitis does not cause low blood sugar level.

## The link between hypoglycaemic encephalopathy (HE) and litchi

- The spike in AES cases is a result of **malnourished** children suffering brain damage after eating **litchis**.
- Litchis contain a chemical called **methylene cyclopropyl glycine (MCPG)**.
- These are naturally occurring toxins that cause **hypoglycaemia (low blood sugar level)** in children.
- In malnourished children, when the reserves of glucose from the digestive tract and the liver are exhausted, **fatty acids are oxidized** to supply blood sugar to the brain. **MCPG toxin thwarts this mechanism**.
- This can send the brain into hypoglycaemic shock triggering convulsions and, if unaddressed, even death.

### Are litchis the primary culprit?

- Hypoglycaemic encephalopathy outbreaks are restricted to April-July, with a peak seen in June. This is because litchi is harvested during this period.
- However, litchi does not cause any harm in well-nourished children, but only in undernourished children who had eaten litchi fruit the previous day and gone to bed on an empty stomach.

### Is any virus involved in causing Hypoglycaemic encephalopathy?

- It is an observed fact that malnourished children between two to 10 years fall ill and die due to HE.
- It is not known why older children or adults do not suffer the same way.
- This clear discrimination by age is also a reason why the underlying cause of the illness cannot be a virus.

## Treatment

- Complete recovery can be achieved if affected children are infused with 10% **dextrose** within four hours after the onset of symptoms.

- Infusing 10% dextrose **restores blood sugar to a safe level** and also **stops the production of amino acid that is toxic to brain cells** by shutting down the body's attempt to convert fatty acid into glucose.

### Measures to be taken to prevent similar health crisis in future

- Overhauling the healthcare apparatus to deal with a crisis of this magnitude.
- Local public healthcare centres must stock up anti-convulsion drugs as well as **dextrose**.
- The state must effectively implement schemes that provide nutritious food to children.
- The public must be sensitised about the causes of AES and the necessary preventive measures to be taken.

**Parents' responsibility**

- Children shouldn't be allowed to skip their evening meal.
- Parents must make sure that undernourished children do not eat plenty of litchi fruit.
- During the heatwave periods, children should be made to stay indoors.

## {S&T – ICT – 19/06/22} 5G

D2E | 22-06-2019 | Science and Technology > New Tech and their applications

- 5G wireless internet network is **50 times faster than 4G**.
- It enables superfast data transfer with **minimal delay (a latency as low as 1 millisecond)**.
- The US and South Korea have already rolled out the network on a trial basis.
- In May 2018, five Nordic countries—Sweden, Norway, Denmark, Finland and Iceland—announced their plan to create the world's first interconnected 5G region.
- In March 19, Germany began auctions of 5G bandwidth spectrum in Bonn.
- India plans to begin trials by 2020. India has not yet allocated spectrum for 5G.

### 5G will enable

- Development of new services for **smart mobility and automated transport**, **accelerating automation** of the whole transport sector from maritime to road to air.
- Deeper penetration of **artificial intelligence (AI)-based technologies** (E.g. Amazon's Alexa, Google's Google Home, Apples' Siri, etc.).
- **Internet of Things** (which includes smart wearables and virtual reality headsets).
- Commercial application of **driverless autonomous vehicles** (they can become usable only if they communicate with other vehicles and traffic signals).
- Low-latency applications, including **industrial robots to remote surgery**.

- Inter-working of different technologies and networks and **machine to machine communications**.
- Integration of satellites in 5G networks for new applications in domains such as agriculture, emergency response for communities living in rural areas, etc.

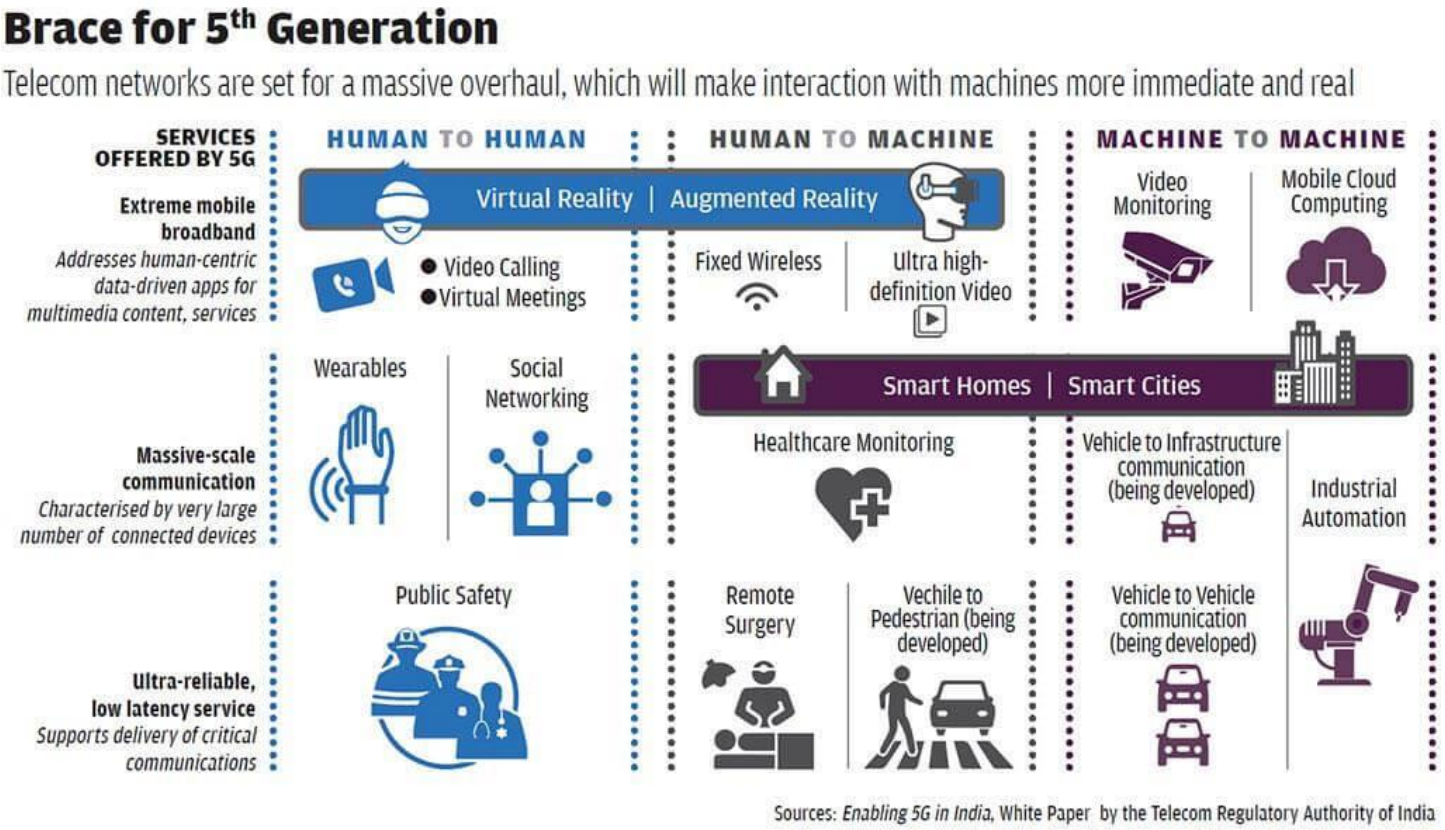
## Health concerns associated with 5G networks

- All artificial electromagnetic radiations are bad because our biological systems are not adapted to it.
- 5G will promote cell phone use, and therefore human exposures from phones and base stations.
- 5G requires Radio Frequency Electromagnetic Fields (RF-EMF) radiation between **600 MHz and 86 GHz**.
- Typically, RF radiations are nonionizing and cause only dielectric heating effects (unlike ionising radiations like X-rays and gamma rays).
- The higher frequencies will concentrate the radiation in a smaller portion of the human body, and children are particularly vulnerable to its effects.
- Higher frequencies of 5G will also penetrate much deeper into the human body because of a phenomenon called **beam-forming** unique to the technology.
- Beam forming brings together electromagnetic signals from multiple antennas to create signals with greater intensity and better reach.
- In 2011, WHO's studies detailed the effects of RF-EMF radiations (from 30 kilohertz to 300 gigahertz) on humans as well as rats and concluded that the radiations are "**possibly carcinogenic to humans**".
- In 2018, a report published in US found RF-EMF of 900 megahertz, used by 3G and 4G networks, led to incidences of malignant heart schwannomas (cancer that attacks nerve tissues) in male and female rats.
- Scientists have so far linked 5G to at least 20 ailments, including heart diseases, type-2 diabetes and mental disturbances such as depression, anxiety and suicidal tendencies.

## Challenges in commercialization of 5G

- Businesses and services exploiting its potential are not fully evolved.
- Greater power in the hands of corporations and governments for surveillance.
- Internet governance is not evolving to safeguard security and privacy of data.
- RF-EMF generated as a consequence of 5G will have a wide range of health impacts.
- Loss of employment opportunities in the manufacturing sector due to automation.
- More satellites are required, which means rapidly accumulating space junk/debris.

- Some scientists suggest designing networks based on fibre optic cables (2 crore times faster than 5G).




Source and Credits: D2E

***Science and Technology topics in the pipeline (couldn't complete them in June CA. Will be adding them in July CA)***

- Internet of Things, Artificial Intelligence.
- Blockchain Technology, Bitcoin, Ethereum, ***Facebook's Libra***
- QLED, OLED, etc. (Samsung launched QLED TVs recently)
- ICT technologies: 2G, 3G, 4G LTE vs. 4G VoLTE, 5G
- Indigenous GPS: Navigation with Indian Constellation (NavIC)

## {S&T – Technologies – 19/05/25} Superconductor

The Hindu | 25-05-2019 | GS3 > Science and Technology > Applications

### IISc team achieved superconductivity at room temperature

- The material that exhibited superconductivity at ambient temperature is made of silver nanoparticles embedded in a gold matrix.
- Silver and gold independently do not exhibit superconductivity.
- Two of the most important properties of superconductivity are **dimagnetism** and **zero resistance**.
- These two were seen in the material that IISc studied.

**Diamagnetism**

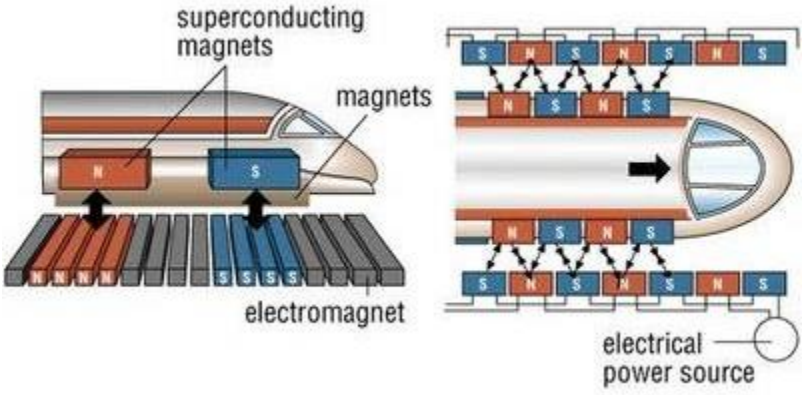
- Diamagnetism is one of the important properties of a superconductor.
- When a magnetic field is applied from outside, then the superconductor expels magnetic field. This is used for levitation of a superconductor.

## Superconductor

- A superconductor is a material that can conduct electricity (transport electrons) with **zero resistance**.
- This means **no heat, sound** or any other form of energy would be released from a superconductor.
- Hence, superconductors will help build **highly efficient devices** leading to huge energy savings.
- Critical temperature (Tc) is the temperature at which the material becomes superconductive.
- Critical temperature (Tc) for the currently developed superconductive materials is **much below 0 °C**.
- Currently, a lot of energy must be used in the cooling process making superconductors uneconomical.
- Applications: Maglev trains (in use), lossless long distance electrical transmission (futuristic application).

## Maglev trains

- Maglev (magnetic levitation) trains use **superconducting magnets** to achieve levitation.
- Superconducting magnets are electromagnets that are cooled to extreme temperatures during use.
- They dramatically increase the power of the magnetic field.
- In maglev trains, superconducting magnets suspend a train car above a concrete guideway.
- Like ordinary magnets, these magnets repel one another when matching poles face each other.
- The magnets employed (superconducting) and they can generate magnetic fields up to 10 times stronger than ordinary electromagnets, enough to suspend (levitate) and propel a train.




Maglev Train and Track (Source)

- One great advantage of maglev trains is that they are least noisy as there is no physical contact between the track and the train. Also, there are no moving parts except for the train.