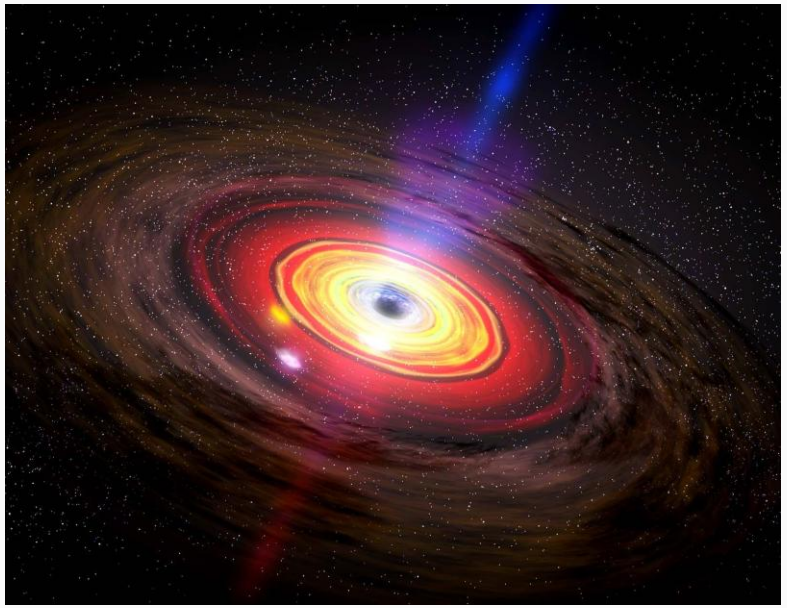
50 most important topics
Science & Technology

Black Hole

- Place in space where gravity pulls so much that even light can not get out.

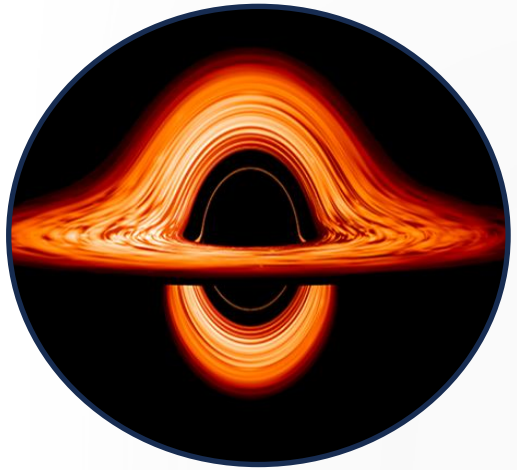
Reason

- The gravity is so strong because matter has been squeezed into a tiny space. This can happen when a star is dying.
- Because no light can get out, people can't see black holes. They are invisible.

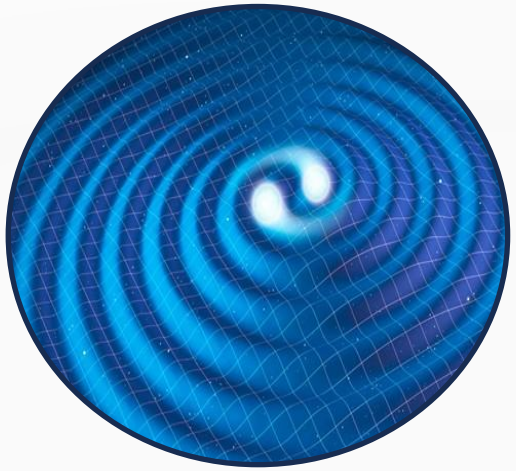


Black Hole

How Do We Detect Black hole



X-rays from matter spiraling into them (accretion disk)



Gravitational waves from black hole mergers

Orbital motion of nearby stars

- stars orbiting the Milky Way's central black hole)

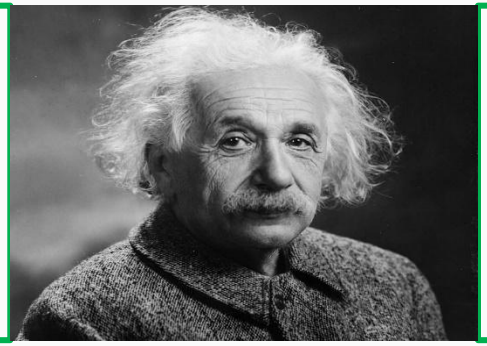
Types of Blackhole

Primordial Black hole	• Smallest (Could be as small as an asteroid or as massive as a planet) • Size-atom with mass of mountain • Formation after big bang • Not much of evidence
Stellar Black hole	• Medium (About 5 to 100 times the mass of the Sun) • Size-20 times mass of sun • Formation-Collapse of star- supernova explosion • Indirect evidence

Types of Blackhole

Intermediate-Mass Black Holes	•Between 100 to 100,000 solar masses •Hard to detect; evidence is growing but still limited
Supermassive black hole	• Massive • Size-of solar system • Almost every galaxy contain BH at centre • Indirect evidence • Sagitarius A star (Milky way),BH in M-87

NOTHING CAN ESCAPE FROM BLACKHOLE

Newton law of escape velocity		❑ Escp vel of BH>Speed of light
Einstein special theory of relativity		❑ No object can travel faster than speed of light

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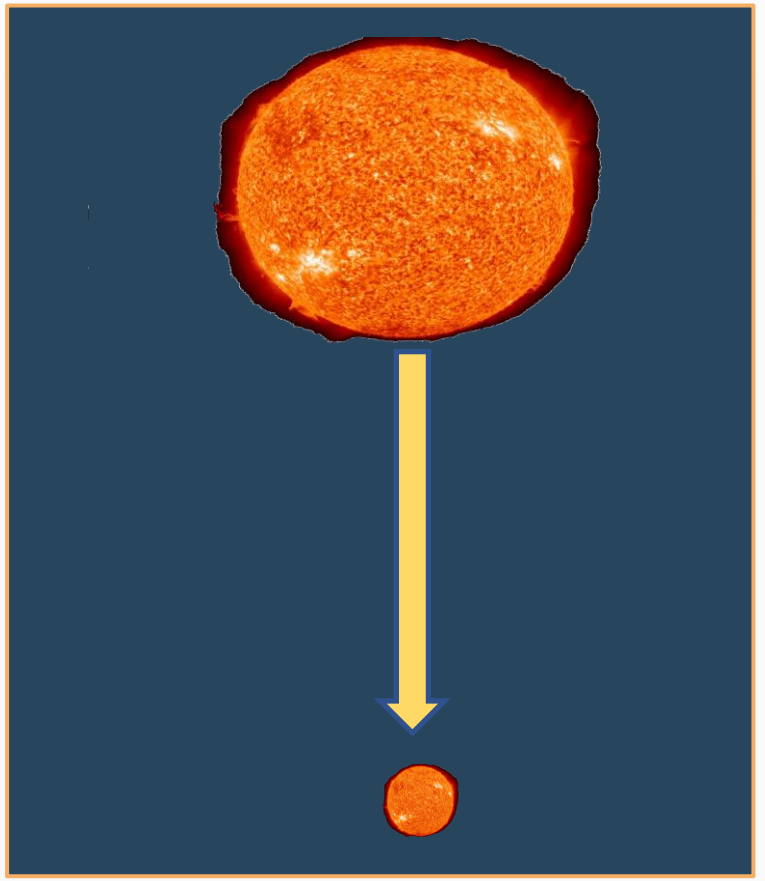
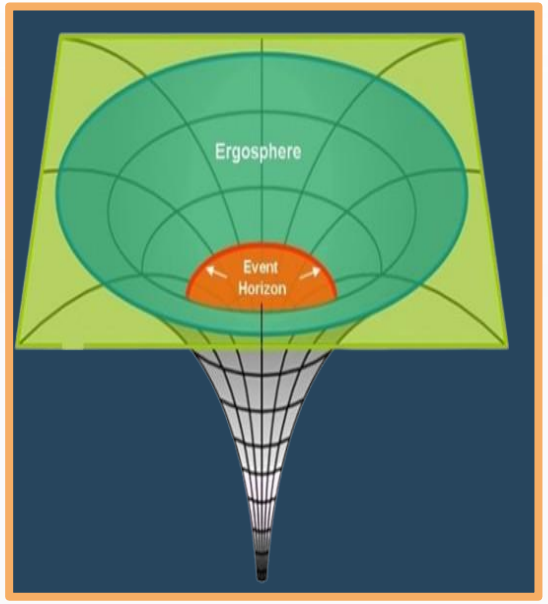
Terms related to Black hole

Singularity-

- A point with infinite density and zero volume



Terms related to Black hole



Event Horizon

- The "point of no return" — once something crosses this boundary, it cannot escape the black hole's gravity.

Ergosphere

- The ergosphere is the region **outside the event horizon**
- Space-time is dragged so much that nothing can remain stationary within the ergosphere — **all objects must rotate in the direction of the black hole's spin.**
- **Escape**-Possible

Terms related to Black hole

Accretion Disk

- A spinning disk of gas and dust spiraling into the black hole, heated to extreme temperatures, emitting X-rays.

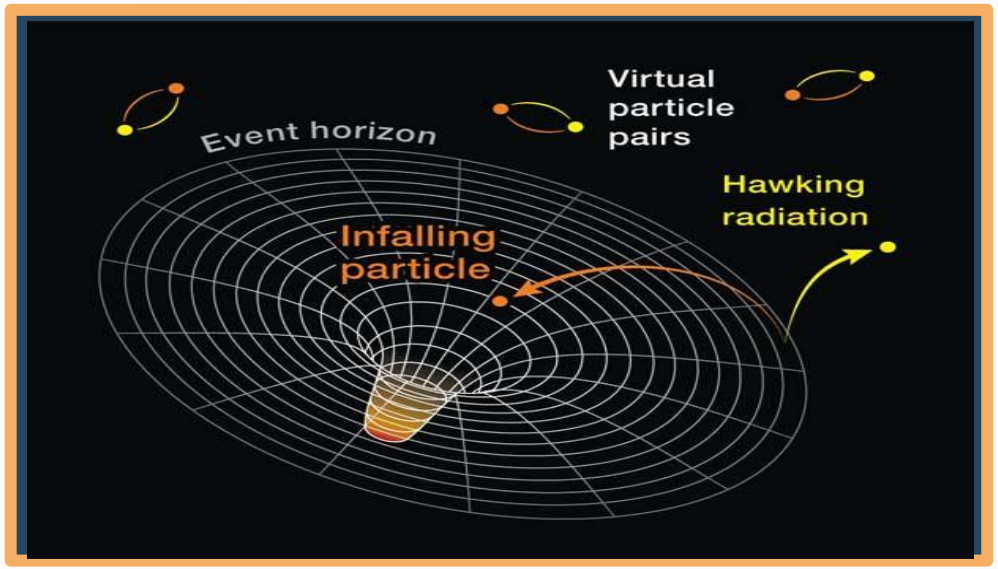
Schwarzschild Radius

- Any object can become a black hole if compressed **within a small enough radius** called the Schwarzschild radius.

Terms related to Black hole

Hawking Radiation

- Black holes are not truly black — they can slowly emit radiation and eventually evaporate.



Terms related to Black hole

Eddington limit (Recently in news)

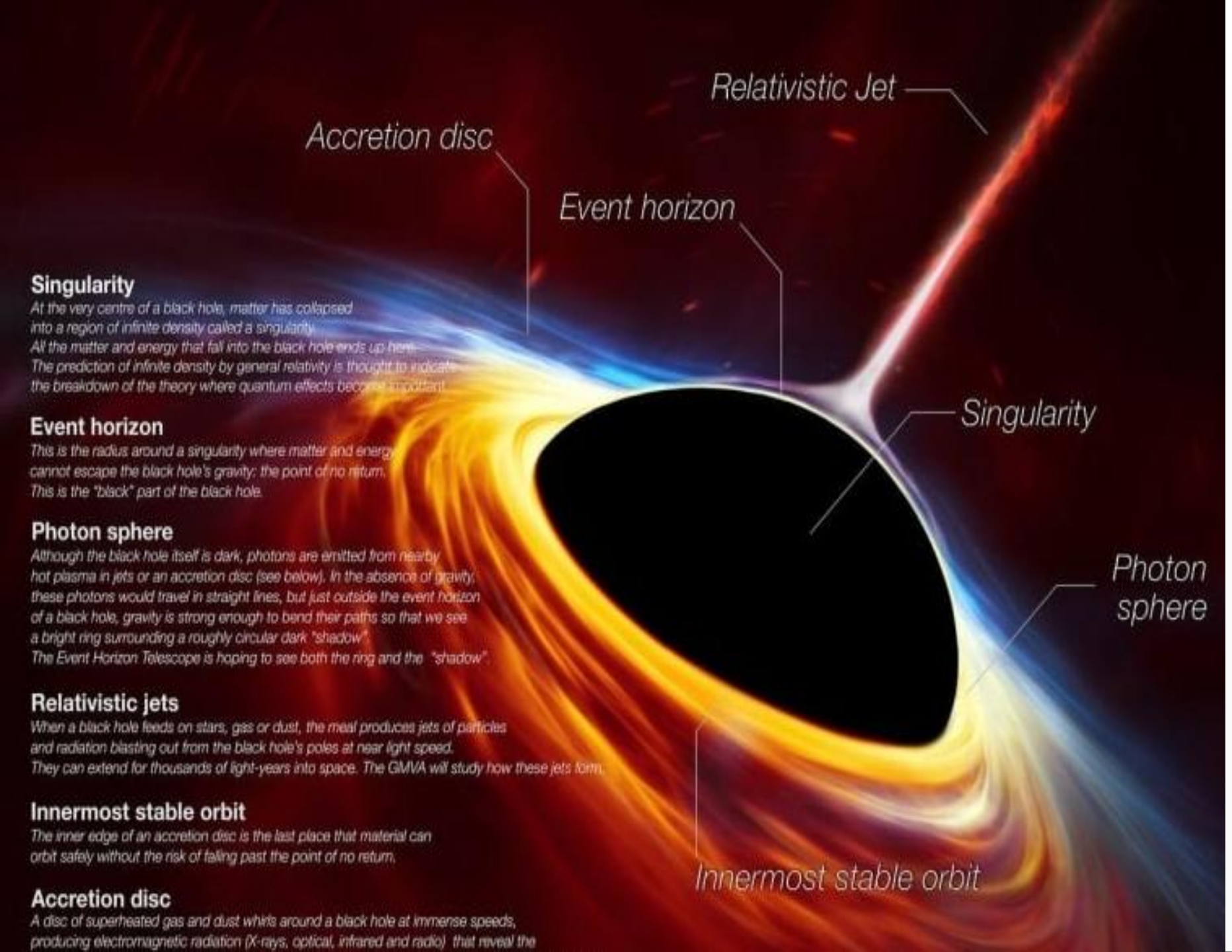
- The rate at which a black hole feeds on matter is governed by what astronomers call the Eddington limit.
- When a black hole pulls surrounding matter towards itself, compressed, heats up, and emits radiation, especially X-rays.
- This generates an **outward pressure** capable of counteracting the gravitational pull of the black hole.
- When this **radiation pressure balances the force of gravity**, the black hole will stop accruing the matter. There is a limit on how brightly the black hole can shine.

Terms related to Black hole

- If this limit is crossed, the scenario is called a **super-Eddington accretion**

Significance

- Convincing explanation for how supermassive **black holes could form so quickly,** regardless of their initial seed mass



Singularity
At the very centre of a black hole, matter has collapsed into a region of infinite density called a singularity. All the matter and energy that fall into the black hole ends up here. The prediction of infinite density by general relativity is thought to indicate the breakdown of the theory where quantum effects become important.

Event horizon
This is the radius around a singularity where matter and energy cannot escape the black hole's gravity: the point of no return. This is the "black" part of the black hole.

Photon sphere
Although the black hole itself is dark, photons are emitted from nearby hot plasma in jets or an accretion disc (see below). In the absence of gravity, these photons would travel in straight lines, but just outside the event horizon of a black hole, gravity is strong enough to bend their paths so that we see a bright ring surrounding a roughly circular dark "shadow". The Event Horizon Telescope is hoping to see both the ring and the "shadow".

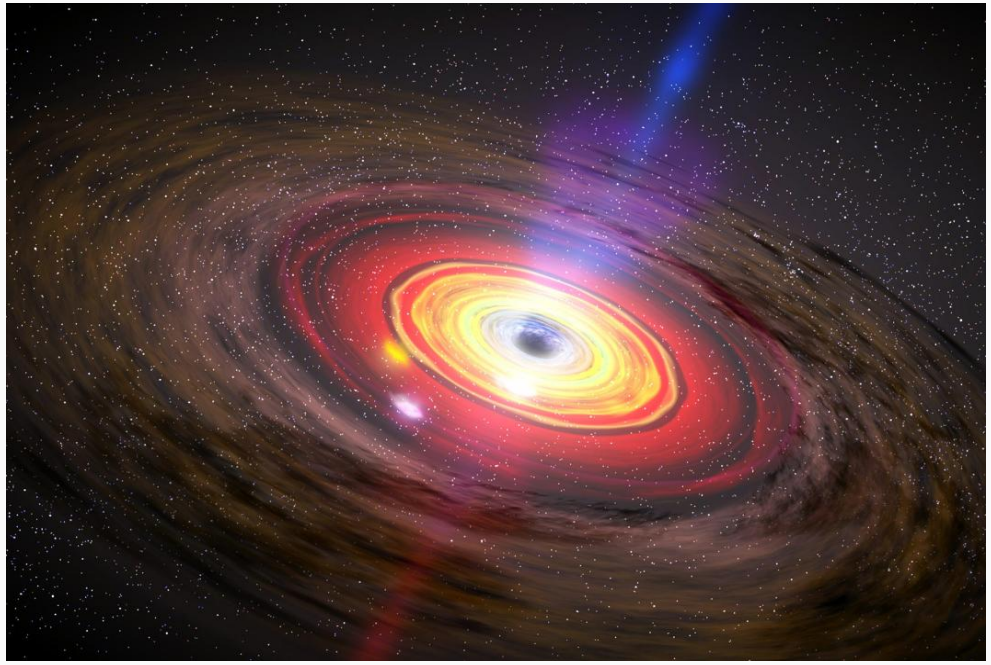
Relativistic jets
When a black hole feeds on stars, gas or dust, the meal produces jets of particles and radiation blasting out from the black hole's poles at near light speed. They can extend for thousands of light-years into space. The GMVA will study how these jets form.

Innermost stable orbit
The inner edge of an accretion disc is the last place that material can orbit safely without the risk of falling past the point of no return.

Accretion disc
A disc of superheated gas and dust whirls around a black hole at immense speeds, producing electromagnetic radiation (X-rays, optical, infrared and radio) that reveal the

QUASAR

- are very luminous objects in **faraway galaxies that emit jets at radio frequencies**.
- They are **only found in galaxies that have supermassive blackholes** which power these bright discs.
- However, 90 per cent of them do not emit strong radio waves, making this newly-discovered one special



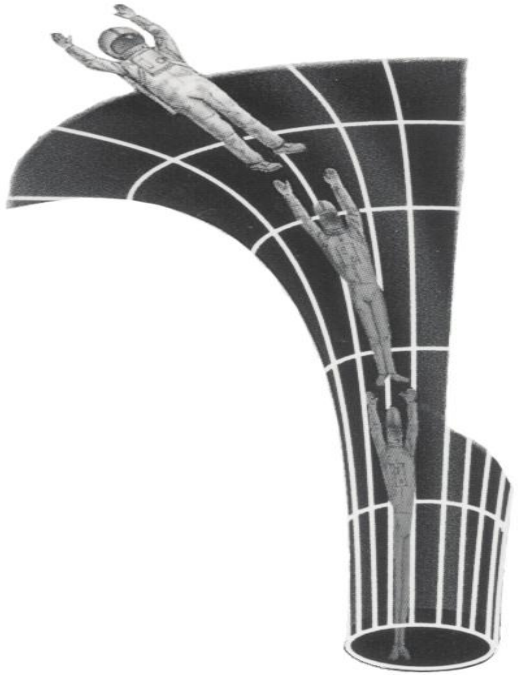
Conceptual clarity	
Statements	**Correct/Incorrect**
1. There is a black hole behind every quasar, but not every black hole is a quasar	
2. Quasars are found in galaxies that have supermassive blackholes which power these bright discs.	
3. Every galaxy hosts a quasar	

Spaghettification

- refers to the **extreme stretching and thinning** of any object that falls toward a black hole, caused by **intense tidal gravitational forces**.

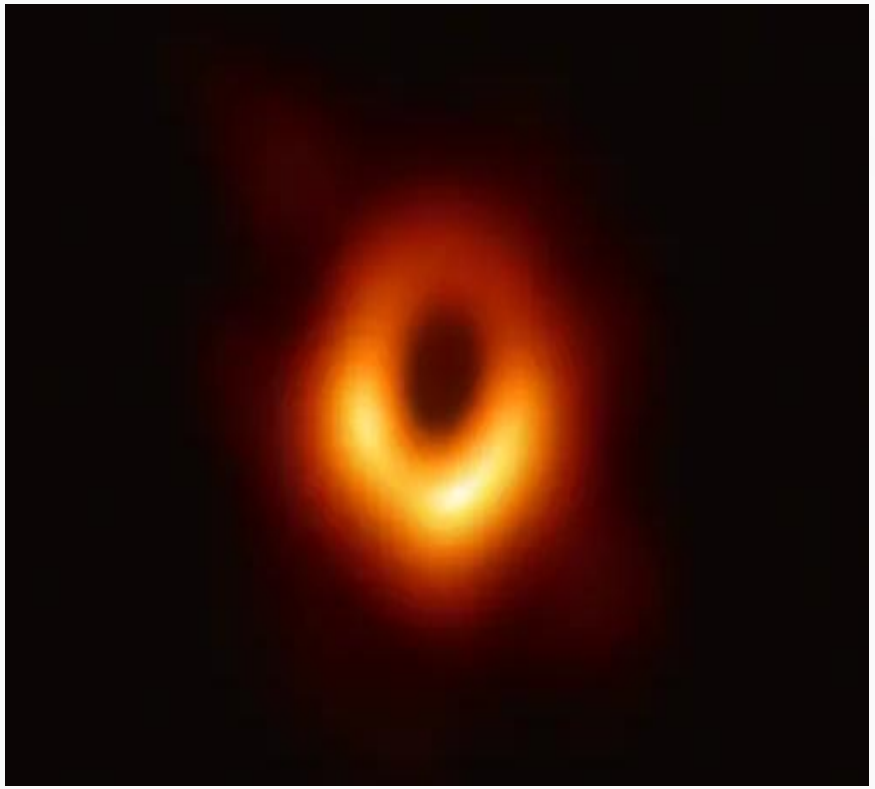
Pancake detonation

- As gravity close to a black hole can stretch things out, it can also **flatten objects like pancakes**. This is a phenomenon known as **"pancake detonation"** that primarily happens with **supermassive black holes**



First-ever image of a black hole

- Released on April 10, 2019
- Captured by the **Event Horizon Telescope (EHT)** — a global network of radio telescopes.
- Black hole name-M87* (in galaxy Messier 87)
- The radio waves emitted by hot gas spiraling into the black hole were collected and combined



Black hole Merger

Recently, scientists reported massive black hole merger, named GW231123.

- **LIGO, Virgo, and KAGRA** had detected gravitational waves from the merger
- In this event, two black holes, about **137x and 103x the mass of the sun**, crashed together, forming an even bigger black hole. This was unusual because **black holes in this mass range are thought to be rare**.

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Black hole Merger

LIGO, or Laser Interferometer Gravitational-Wave Observatory

- It is an **international network of laboratories** to detect **gravitational waves**
- **First discovered in 2015 by two LIGOs based in the United States**
- Besides the United States (in **Hanford and Livingston**), such gravitational wave observatories are currently operational in **Italy (Virgo) and Japan (Kagra).**
- **LIGO-India will be the fifth, and possibly the final, node of the planned network.**
- To be located in **Hingoli district of Maharashtra**, about 450 km east of Mumbai, LIGO-India is scheduled to begin its scientific runs from 2030

Gravitational Waves

Gravitational waves are **'ripples' in space-time caused by some of the most violent and energetic processes in the Universe**.

- **Predicted by Albert Einstein**
- These **cosmic ripples** would travel at the **speed of light**, carrying with them information about their origins, as well as clues to the nature of gravity itself.
- The **strongest gravitational waves are produced by cataclysmic events** such as colliding black holes, supernovae (massive stars exploding at the end of their lifetimes), and colliding neutron stars.

Gravitational Waves

Sources and Types of Gravitational Waves

- **Every massive object that accelerates produces gravitational waves**. This includes **humans, cars, airplanes etc**., but the **masses and accelerations of objects on Earth are far too small** to make gravitational waves big enough to detect
- Examples : orbiting pairs of **black holes and neutron stars, or massive stars blowing up at the ends of their lives**.

International Space Station (ISS)

Launch: 1998
Type: Modular space station / habitable artificial satellite.
Orbit: Low Earth Orbit (LEO), ~400–420 km altitude.
Speed: ~7.66 km/s (~90 min per orbit).
Continuous Human Presence: Since **November 2000**.
Partners:

- **NASA** (USA)
- **Roscosmos** (Russia)
- **ESA** (European Space Agency)
- **JAXA** (Japan Aerospace Exploration Agency)
- **CSA** (Canadian Space Agency)

International Space Station (ISS)

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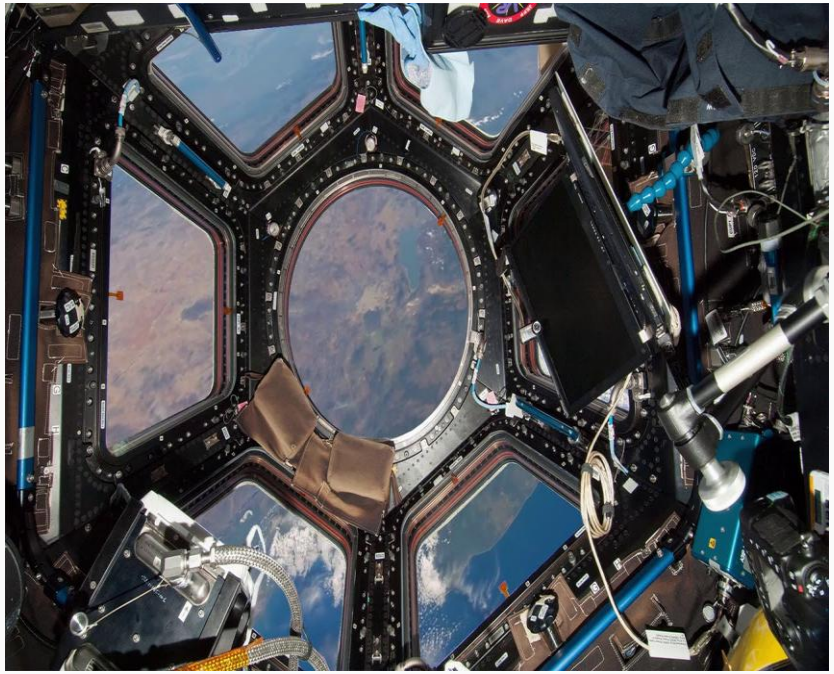
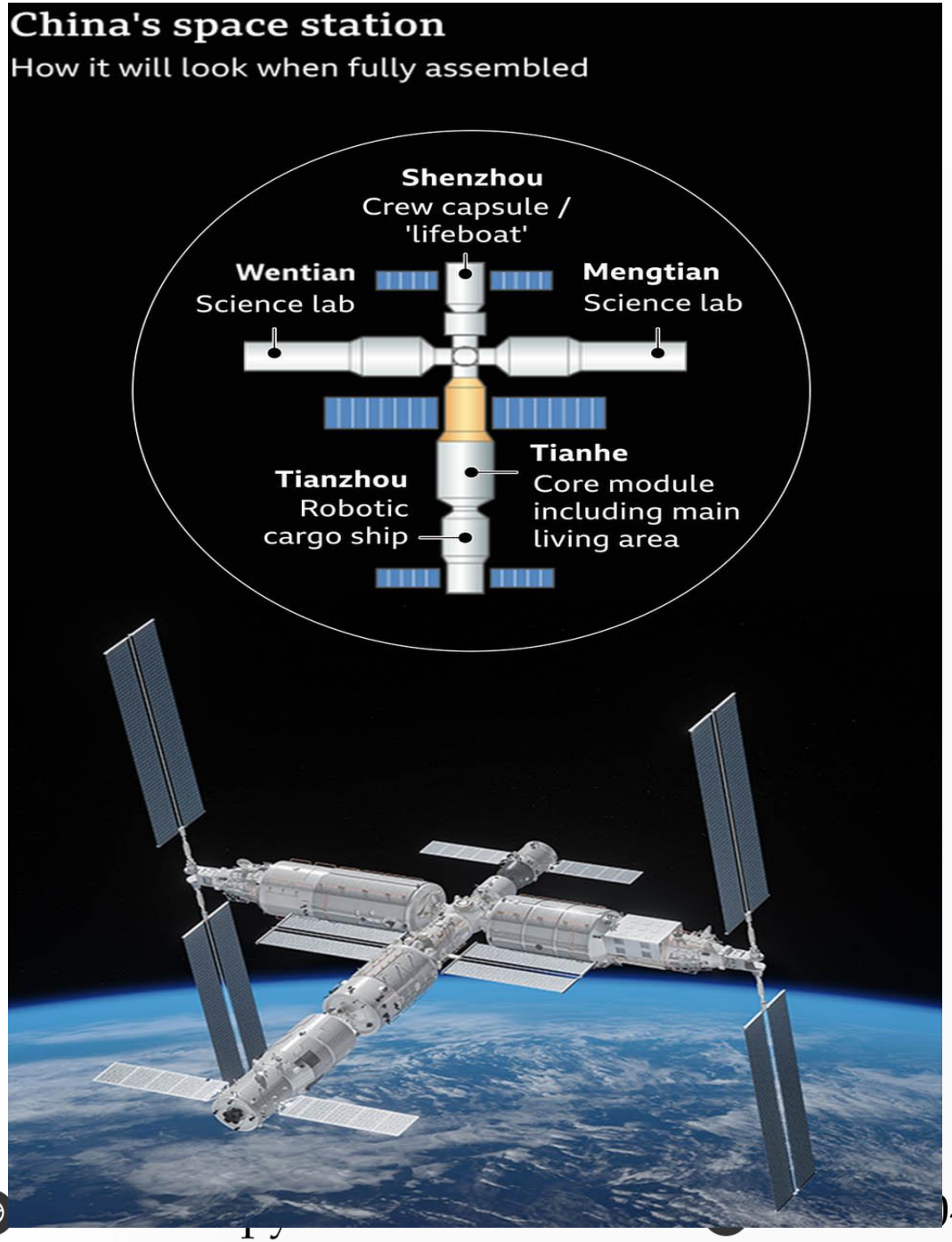
Main modules

- USA-Unity, Quest
- Russia-Zaria,Zvedza
- European-Columbus laboratory
- Japanese-Kibo research
- Canada-Canadian Canadarm
- **Cupola** -one of the most iconic modules on the International Space Station — basically the ISS's "window to the world

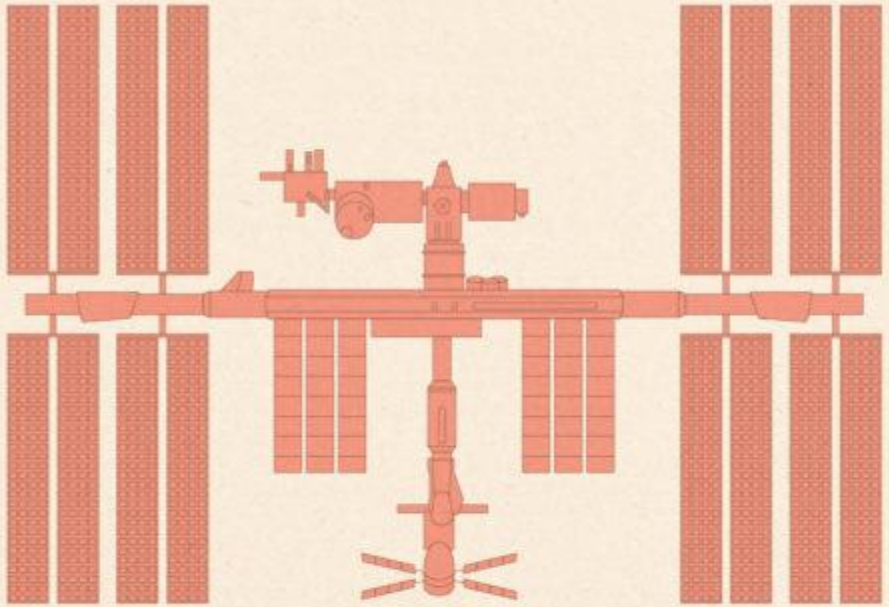


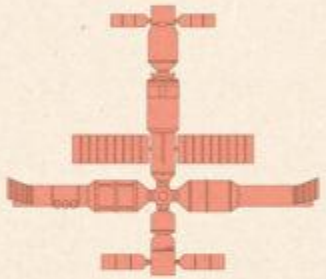
Tiangong space station

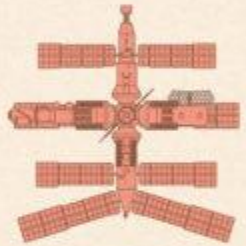
- **Launched by:** China (by **China Manned Space Agency – CMSA**)
- **Meaning of Tiangong:** "Heavenly Palace"
- **Purpose:** Permanent modular space station in **Low Earth Orbit (LEO)** (~340–450 km altitude).
- **Construction Period:** 2021–2022 (fully operational by end of 2022).
- **Design Life:** ~10–15 years.
- Only operational space station besides the **International Space Station (ISS)** after Russia's Mir deorbited.
- China excluded from ISS (due to U.S. restrictions under Wolf Amendment).


China's space station
How it will look when fully assembled
Shenzhou
Crew capsule / 'lifeboat'
Wentian
Science lab
Mengtian
Science lab
Tianhe
Core module including main living area
Tianzhou
Robotic cargo ship

Comparison of Space Stations







	International Space Station	Chinese Space Station	Mir
Maximum Length	109 m	37 m	31 m
Mass	420 metric tons	60 - 70 metric tons	130 metric tons
Lifespan	26 yrs if deorbited in 2024	>10 yrs	15 yrs
Crew Size	6, or 9 short-term	3, or 6 short-term	3, or 6 short-term
Initial Launch Date	1998	2021	1986

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ISRO Missions in 2025

- CMS 03
- NISAR
- EOS 09
- NVS 02

GSLV-F15/NVS-02 Mission

- **17th flight of India's GSLV** and **11th flight with Indigenous Cryostage**.
- 8th **operational flight** of GSLV with an indigenous Cryogenic stage
- **100th Launch** from the India's Spaceport Sriharikota

GSLV-F15/NVS-02 Mission

NVS-02

- The NVS-02 is the second satellite in the NVS series, replacing IRNSS-1E, and **part of India's Navigation with Indian Constellation (NavIC).**
- Five **second-generation NavIC satellites**, NVS-01/02/03/04/05, are envisaged to augment the NavIC base layer constellation with enhanced features to ensure continuity of services.

GSLV-F15/NVS-02 Mission

ISRO

- Successfully injected into the intended Geosynchronous Transfer Orbit.
- Solar panels on board the satellite were successfully deployed and power generation is nominal.
- Communication with the ground station has been established.
- But the orbit raising operations towards positioning the satellite to the designated **orbital slot could not be carried out** as the valves for **admitting the oxidizer to fire the thrusters for orbit raising did not open.**

Navigation with Indian Constellation (NavIC)

- NavIC was **erstwhile known as Indian Regional Navigation Satellite System (IRNSS).**
- NavIC is designed with a constellation of 7 satellites and a network of ground stations operating 24 x 7. **Three satellites of the constellation are placed in geostationary orbit**, and **four satellites are placed in inclined geosynchronous** orbit.
- NavIC offers two services: **Standard Position Service** (SPS) for civilian users and **Restricted Service** (RS) for strategic users.
- These two services are provided in both L5 and S band .
- NavIC coverage area includes India and a region up to **1500 km beyond Indian boundary**.
- NavIC signals are designed to provide user position **accuracy better than 20m and timing accuracy better than 50ns .**
- NavIC SPS signals are interoperable with the other global navigation satellite system (GNSS) signals namely GPS, Glonass, Galileo and BeiDou

Earth Observation Satellite (EOS-09 satellite)

- **Orbit- Sun Synchronous Polar Orbit (SSPO)**
- **Launch Vehicle- PSLV**
- **Objective-**mission objective to ensuring **remote sensing** data for the user community engaged in operational applications and to improve the frequency of observation.
- Equipped with **Synthetic Aperture Radar (SAR)** to capture high-resolution images of Earth's surface, regardless of weather conditions or time of day.

ISRO-On 18th May 2025, 101st launch was attempted, PSLV-C61 performance was normal till 2nd stage. Due to an observation in 3rd stage, the mission could not be accomplished

EOS-N1 satellite

PSLV C62

On **January 12**, ISRO launched the **PSLV-C62** mission from **Sriharikota**, carrying the **EOS-N1 satellite** along with **15 co-passenger satellites** from India and several foreign countries.

The rocket's performance was **nominal until the final phase of PS3**. However, mission control observed:

- A disturbance in **roll rates,** meaning the rocket began rotating uncontrollably
- A deviation from the planned flight trajectory

The mission had been facilitated by ISRO's commercial arm, **NewSpace India, Ltd**.

LVM3-M5 / CMS-03

- **LVM3-M5 is the fifth Operational Flight** of LVM3 (Bahubali)
- **Heaviest communication satellite** launched to **Geo-synchronous Transfer Orbit (GTO) from Indian soil**
- Multi-band **communication satellite** that will provide services over a wide oceanic region including the Indian landmass.
- CMS-03 is a multi-band **communication satellite** designed for a mission life of **at least fifteen years.**
- It operates across multiple communication bands, supporting high-speed data and secure transmission.
- It is built to serve both **civilian and strategic users,** extending
- high-bandwidth coverage across the Indian subcontinent and surrounding oceanic regions.

GSLVF-16/NISAR

GSLV-F16 is the **18th flight** of India's Geosynchronous Satellite Launch Vehicle (GSLV)
12th flight with Indigenous Cryogenic stage.
This is the 9th operational flight of GSLV with indigenous Cryogenic stage.
GSLV-F16 Mission is the **first mission with GSLV to Sun Synchronous Polar Orbit.**

GSLVF-16/NISAR

NISAR

- **First of its kind mission, jointly developed by ISRO and NASA.**
- It is an L and S-band, global, microwave imaging mission.
- The unique dual-band **Synthetic Aperture Radar** of NISAR employs advanced, novel SweepSAR technique, which provides high resolution and large swath imagery.
- NISAR will image the **global land and ice-covered surfaces, including islands, sea-ice and selected oceans every 12 days.**

GSLVF-16/NISAR

NISAR mission will help to

- Measure the **woody biomass** and its changes
- Track changes in the extent of active crops
- Understand the **changes in wetlands' extent**
- Map Greenland's & Antarctica's ice sheets, dynamics of sea ice and mountain glaciers
- Characterize **land surface deformation** related to seismicity, volcanism, landslides, and subsidence & uplift associated with changes in subsurface aquifers, hydrocarbon reservoirs, etc.

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Axiom-4

Context-Recent travel of Indian astronaut Shubhanshu Shukla to the International Space Station (ISS) on the Axiom-4 mission marks the beginning of a new era in Indian space.

Axiom-4 Mission

- **It** is the fourth private spaceflight to the **International Space Station (ISS)**, operated by **Axiom Space**, a U.S.-based space company, using the **SpaceX Crew Dragon spacecraft**.
- With this mission, **Shubhanshu Shukla** will become the **second Indian** to travel to space (after Rakesh Sharma in 1984) and the **first Indian to visit the ISS**.

Axiom-4

Significance

- The ISS experience will be critical for the other Indian astronauts who would be going on the Gaganyaan mission. Real-life experience is very different from training and simulations.
- Participation in the Axiom-4 mission has given India **an opportunity to carry out these experiments in space.** These can be followed up with a new set of experiments on the **Gaganyaan mission**.
- Space is a costly endeavour, and the sector can benefit hugely from **private-sector participation**. It will also make the sector more vibrant, facilitate innovation, expedite technology development, and attract new, young talent. It can also boost economic growth.

Key Indian microgravity experiments during AXIOM 4 Mission

Microalgae Experiment	Microalgae to examine their **ability to generate food, oxygen, and biofuels.**
Myogenesis study	• To understand muscle cell behaviour in space. • Benefit to future Moon or Mars missions,medical treatments for **muscle-wasting diseases** and age-related immobility on Earth.
Sprouting of methi and moong seeds	• Observed how methi and moong seeds germinate in space. • On earth-observed for **any changes in genetics, microbial ecosystems, and nutritional profiles,** aiming to identify plants with desirable traits for sustainable farming in space.
Research on the Indian strain of Tardigrades	• Also known as "water bears", are robust aquatic animals that have been around for roughly **600 million years, 400 million years before dinosaurs** walked the planet. • Objective- To **identify the genes that are responsible** for making these animals resilient.
Study on cyanobacteria	• To understand the **impact of microgravity on their growth** and biochemical activity. • The findings could **support the development of sustainable systems for carbon and nitrogen recycling in space** and highlight cyanobacteria's potential as a superfood for long-duration missions.
Seed resilience trials:	• It involved seed resilience trials, testing rice, cowpea, sesame, brinjal, and tomato seeds that have been exposed to microgravity. • The objective is to **assess the impact of space conditions on these seeds**, to advance space agriculture, and develop climate-resilient plant varieties suitable for cultivation on Earth

Nuclear Vs Mitochondrial DNA

Nuclear DNA

- The **23 chromosomes together have 3.2 billion base-pairs**. This nuclear genome encodes about **20,000 genes that contain instructions to make proteins**, plus another **15,000-20,000 genes that don't encode for proteins**.

Mitochondrial DNA

- In contrast, our **mtDNA is a mere 16,569 base-pairs long**, and has a circular shape.

- It encodes **13 protein-coding genes and 24 non-coding genes**. Most cells, however, contain multiple mitochondria and each mitochondrion contains multiple copies of the mtDNA molecule. Hence the **mtDNA can make up 1% or so of a cell's total DNA**.

e-DNA

Environmental DNA (e-DNA)

- According to the recent studies the e-DNA can boost biodiversity conservation efforts across the world

About e-DNA (Nuclear or Mitochondrial DNA)

- Animals shed DNA through their breath, saliva, fur or faeces into the environment. These samples are called e-DNA.
- E-DNA is collected from a variety of environmental samples such as **soil, seawater, snow or air**, rather than directly sampled from an individual organism.

ecDNA

Context-Three papers in Nature have reported how **extrachromosomal DNA contributes to the progression of cancer** and drug resistance; the findings also challenge a law of genetics.

ecDNA

- In normal human cells, the nucleus contains 23 pairs of chromosomes that enclose the DNA. There are some natural processes that can damage DNA.

ecDNA

- For example, in chromothripsis, which occurs in some cancers, the **chromosomes are broken and rearranged**. Cells can also make mistakes in the DNA when making copies of it to imbue in new cells. Such processes could cause a **small part of the DNA to break away from the main chromosome and form a circular structure that floats freely inside the nucleus**. This is ecDNA

Cancer growth

- ecDNA present in tumours often contain **multiple copies of oncogenes** — mutated genes capable of causing cancer — that are required to activate tumour growth. But these oncogenes are not present in chromosomes, where scientists used to believe they lived.

- While chromosomal DNA is fixed within specific regions in the cell, ecDNA moves freely and can interact with other ecDNA to form hubs — concentrated zones where oncogenes are expressed more.

Gene editing Techniques	
1.	Zinc finger nucleases (ZFN)
2.	Transcription activator-like effector nucleases (TALENs)
3.	Meganucleases
4.	CRISPR-Cas9
5.	Base editing
6.	Prime editing
7.	PASTE: 'Drag-and-Drop' Editing for Large Insertions

CRISPR-Cas9

- Scientists discovered a new method of genome editing derived from CRISPR-Cas9, a system that has long **existed in bacteria** to help them fight off invading viruses.
- CRISPR is an elegant two-component system consisting of a **guide RNA and a Cas9 nuclease**. The Cas9 nuclease cuts the DNA within the ~20 nucleotide region defined by the guide RNA.
- With CRISPR, scientists can customize their guide RNAs, and algorithms have been developed to assess the chances of off-target effects (i.e., does this sequence exist in other places of the genome).
- However, CRISPR is much more customizable and cost-effective, making it more accessible to scientists that may have budget and time constraints.

CRISPR-Cas9

Pros:

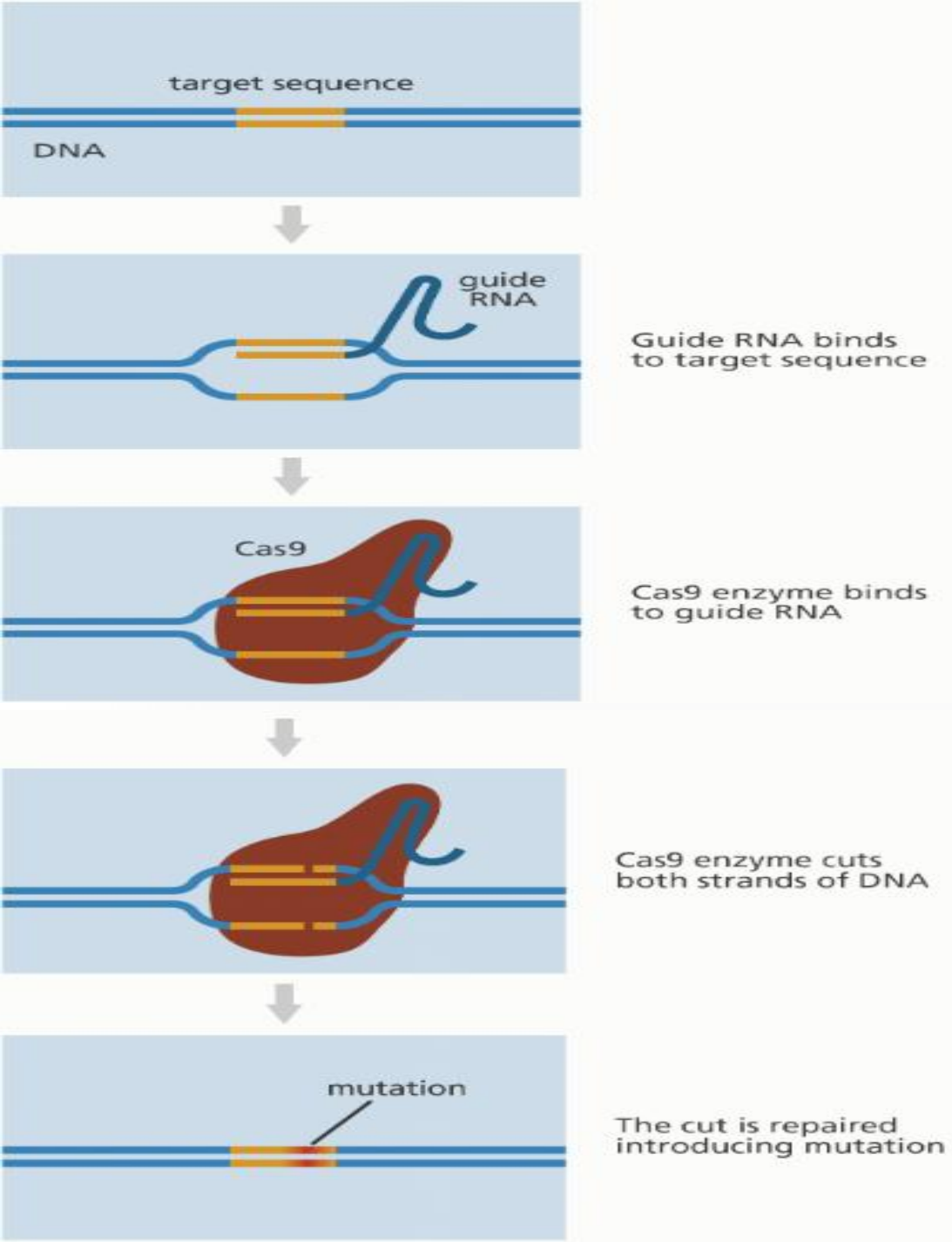
- Easy, quick, and inexpensive to design (only guide RNA needs changing).
- Can target multiple sites simultaneously .
- Widely adopted with large research community and tool support.

Cons:

- Off-target editing risk, though improving with newer Cas variants.
- May cause unintended edits at repair stage.

HOW IT WORKS

- Pieces of RNA are engineered to be a guide that homes in on the targeted stretch of genetic material. The Cas9 is an enzyme that acts like molecular scissors to snip that spot. That allows scientists to delete, repair, or replace a particular gene.



Indigenous gene editing technology

Context-Recently, Indian Council of Agricultural Research (ICAR) has been granted a patent for new GE technology called TnpB or Transposon-associated proteins.

- **It is a miniature, indigenous alternative** to the globally patented **CRISPR-Cas** genome editing systems.
- The technology uses **TnpB (Transposon-associated proteins)** instead of Cas proteins.

Genome Editing (GE)

- GE involves **cutting and altering DNA sequences** of genes **already present** in the host plant.
- It causes **mutations/changes** but **does not introduce foreign genes**.

Indigenous gene editing technology

How it works

- GE uses:
  - **Molecular scissors** (Cas9, Cas12a, or TnpB proteins)
  - **Guide RNA** (navigates the scissors to the exact DNA sequence)
- Once the target DNA is reached , scissors make a **precise cut** and gene expression/function is altered.

GE vs GM :

- **GE:** No foreign genes; only edits existing genes.
- **GM:** Genes from unrelated species (e.g., *Bt* bacteria) are introduced which is more controversial.

Indigenous gene editing technology

Why TnpB Instead of Cas9/Cas12a

Compactness

- TnpB proteins are significantly smaller, containing only **400–500 amino acids**, whereas **Cas9** proteins have **1,000–1,400 amino acids**, and **Cas12a** contains about **1,300 amino acids**.
- **It is just like "If Cas9 and Cas12a are footballs, TnpBs are baseballs,"** highlighting how compact the TnpB system is.

Indigenous gene editing technology

Easier Delivery

- Cas proteins are bulky, which makes them **difficult to deliver into plant cells**, and they typically require **Agrobacterium-based tissue culture methods** for transfer.
- In contrast, **TnpB is hypercompact (only 408 amino acids)** and is sourced from the bacterium *Deinococcus radiodurans*.
- This small size allows TnpB to be **packaged into a viral vector and injected directly into the cell**, eliminating the need for tissue-culture-based delivery.

Indigenous gene editing technology

IP Advantage

- CRISPR-Cas technologies are controlled by foreign entities—**the Broad Institute** holds the patents for **CRISPR-Cas12a**, while **Corteva Agriscience** has a joint agreement for **Cas9**.
- As a result, **commercial cultivation of GE crops using CRISPR-Cas systems requires licensing and payment of fees**.
- In contrast, **TnpB is indigenous and free from foreign IP restrictions**, enabling **unrestricted GE breeding**, reduced costs, freedom from multinational control, and addressing **NGO concerns about dependence on foreign technologies**.

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RNA v. DNA editing

- **DNA editing makes permanent changes** to a person's genome and sometimes this can lead to irreversible errors. On the other hand, **RNA editing makes temporary changes,** allowing the effects of the edits to fade over time. In a clinic, this means a **doctor can stop the therapy if a problem arises and mitigate long-term risk.**

- **CRISPR-Cas9 and other DNA editing tools require proteins acquired from certain bacteria** to perform the cutting function, but these proteins can elicit undesirable immune reactions in some cases.

- **RNA editing relies on ADAR enzymes, which already occur in the human body** and thus present a **lower risk of allergic reactions**. This is useful for people who require repeated treatment and/or who have immune sensitivities.

- But in RNA editing,individuals will **need to be treated repeatedly to sustain the therapy's effects.**

SDN 1 Vs SDN 2 Vs SDN 3

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Recently, the Government has **allowed genome-edited plants without the cumbersome GMO (Genetically Modified Organisms) regulation** at the Genetic Engineering Appraisal Committee (GEAC).

About

- The government has **exempted Site Directed Nuclease (SDN) 1 and 2 genomes** from Rules 7-11 of the **Environment Protection Act**, thus allowing it to avoid a long process for approval of GM crops through the Genetic Engineering Appraisal Committee (GEAC).
- The **Institutional BioSafety Committee (IBSC)** under the Environment Protection Act would now be entrusted to certify that the genome edited crop is devoid of any foreign DNA.
- While **SDN 1 and 2** do not involve the introduction of foreign DNA, SDN3 involves the introduction of foreign DNA making it typical of GMO development.
- In **SDN-3**, the newly developed plant falls under GMO legislation only if foreign DNA exceeding 20 base pairs is inserted.

BT cotton

Bt cotton remains the **only GM crop allowed to be cultivated in the country**.
Developed by **US giant Bayer-Monsanto**, it involves insertion of two genes viz '**Cry1Ac' and 'Cry2Ab**' from the **soil bacterium Bacillus thuringiensis** into cotton seeds.
This modification codes the plant to **produce protein toxic to Heliothis bollworm (pink bollworm) thus making it resistant to their attack**.
The commercial release of this hybrid was sanctioned by the government in 2002.

HTBT cotton

Herbicide tolerant Bt (HtBt) cotton
Addition of 'Cp4-Epsps' gene from another soil bacterium, Agrobacterium tumefaciens
by the US giant Bayer Monsanto.
Not cleared by GEAC
Reason
Farmers are **not able to spray glyphosate** on normal cotton because the chemical does not distinguish between the crop and weed, but the herbicide tolerant Bt (HtBt) cotton remains unaffected by glyphosate.

BT Brinjal

Bt brinjal incorporates the ***cry1Ac* gene** expressing insecticidal protein to confer **resistance against (Fruit & shoot borer)FSB.**
The *cry1Ac* gene is sourced from the soil bacterium ***Bacillus thuringiensis* (Bt)**.

- Developed by the **Maharashtra Hybrid Seeds Company (Mahyco).**
- Mahyco also generously **donated the Bt brinjal technology to the Tamil Nadu Agricultural University (TNAU),** Coimbatore and University of Agricultural Sciences (UAS), Dharwad.
- Mahyco also donated the technology to public research institutions in the **Philippines and Bangladesh**.

GM Mustard

Barstar-Barnase system

Problem with mustard is that its **flowers contain both female and male reproductive organs**, making the plants largely self-pollinating.

When the **egg cells of one plant cannot be easily fertilised by the pollen grains from another**, the scope for developing hybrids through crossing of parents from divergent genetic pools is restricted.

This is where GM technology comes in. The **Barnase gene alluded to earlier, codes for a protein that impairs pollen production**. The plant into which it is incorporated, then becomes male-sterile, and capable of receiving pollen from another parent.

GM Mustard

That plant, in turn, contains the Barstar gene, which blocks the action of the Barnase gene.
The resultant F1 progeny is both high yielding and can also produce seed/grain, thanks to the Barstar gene in the second male-fertile line.
Using this technology, the **Delhi University scientists bred DMH-11, a GM hybrid obtained from crossing an Indian mustard variety, Varuna ('Barnase' line), with Early Heera-2 ('Barstar').**

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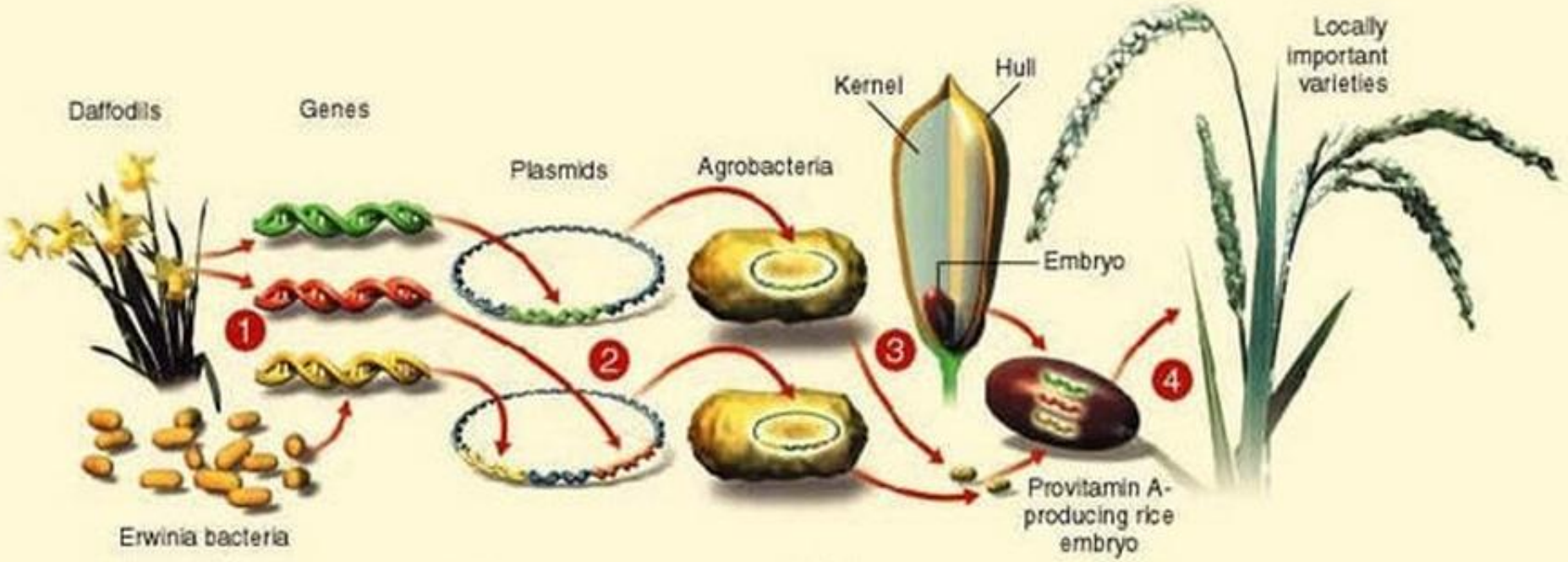
GOLDEN RICE

Two genes from the daffodil plant and a third from a bacterium.



1. The genes that give golden rice its ability to make beta-carotene in its endosperm (the interior of the kernel) come from daffodils and a bacterium called Erwinia uredovora
2. These genes, along with promoters (segments of DNA that activate genes), are inserted into plasmids (small loops of DNA) that occur inside a species of bacterium known as Agrobacterium tumefaciens
3. These agrobacteria are then added to a Petri dish containing rice embryos. As they "infect" the embryos, they also transfer the genes that encode the instructions for making beta-carotene
4. The transgenic rice plants must now be crossed with strains of rice that are grown locally and are suited to a particular region's climate and growing conditions

HOW DOES GOLDEN RICE COMPARE WITH ORDINARY RICE?

Leading regulators worldwide evaluate food safety according to the concept of **substantial equivalence**, where genetically modified crops must demonstrate that they are the same as existing plant counterparts, with the exception of the trait added by genetic modification.

The compositional analysis of Golden Rice shows that it is as safe as ordinary rice, but with the added benefit of beta-carotene in its grain.

100g OF UNCOOKED GOLDEN RICE COULD SUPPLY UP TO
57% OF ESTIMATED AVERAGE REQUIREMENT (EAR) FOR VITAMIN A OF PRE-SCHOL CHILDREN AND
38–47% OF THE (EAR) FOR PREGNANT AND LACTATING WOMEN.

The human body converts beta-carotene into Vitamin A as needed.

Beta-carotene in Golden Rice is converted by the body 5 times more efficiently than the beta-carotene in spinach, which is recognized a rich source of Vitamin A.

GOLDEN RICE*

ORDINARY RICE**

PROXIMATES, FIBERS AND MINERALS
no statistically significant difference

AMINO ACIDS (PROTEIN)
no statistically significant difference

FATTY ACIDS
within combined literature range

VITAMINS
no statistically significant difference

ANTI-NUTRIENTS
no statistically significant difference

BETA-CAROTENE (ALL-TRANS-BETA-CAROTENE)

1.96-7.31 ppm	below limits of quantification

*GR2E Golden rice

**PsB Rc82

REFERENCE: https://pubs.acs.org/doi/10.1021/acs.jafc.9b01324

Gene edited Mustard

Context-Indian scientists have developed the first ever **low-pungent mustard** that is pest and disease-resistant.
Developed by Indian scientists using **CRISPR/Cas9 gene editing**.
Non-GM & transgene-free (no foreign DNA introduced).
First-ever **low-pungent mustard** that is also **pest & disease-resistant**.

Gene edited japonica rice

Context-Scientists at the Delhi-based National Institute of Plant Genome Research (NIPGR) have used CRISPR-Cas9 gene editing **technology to increase phosphate uptake and transport in *japonica* rice varieties.**

Phosphorous

Phosphorus is an essential mineral for plant growth and development of plants. In case of limited phosphorus availability, crop productivity drops drastically.

Even when phosphate fertilizers are used, only about 15-20% are taken up by plants while the balance gets leached out or lost through runoff.

Genome-edited rice varieties

Context-Recently India released two genome-edited varieties of rice, the first achievement of its kind in the country.

- These varities have been named '**Kamala' and 'Pusa DST Rice 1**',developed by the Indian Council of Agricultural Research (ICAR)
- The ICAR scientists have used the revolutionary CRISPR-Cas9 genome-editing technology

About

Genome-edited rice varieties

DRR DHAN 100 (KAMALA)	PUSA DST RICE 1
• Developed by the ICAR-Indian Institute of Rice Research (ICAR-IIRR)	• Developed by ICAR-Indian Agricultural Research Institute (ICAR-IARI)
• Developed using genome editing technology (SDN1)targeting the **Cytokinin Oxidase 2 (CKX2) gene** (also known as Gn1a), to increase grain numbers per panicle.	• Targets the **Drought and Salt Tolerance (DST) gene** (SDN1) to improve the plant's resilience to harsh soil and climate conditions.
• Significantly **higher yields,** improved drought tolerance, and early maturity compared to its parent variety, Samba Mahsuri (BPT 5204).	• The new variety is relevant for farmers of **saline and alkaline** soils, where traditional varieties underperform

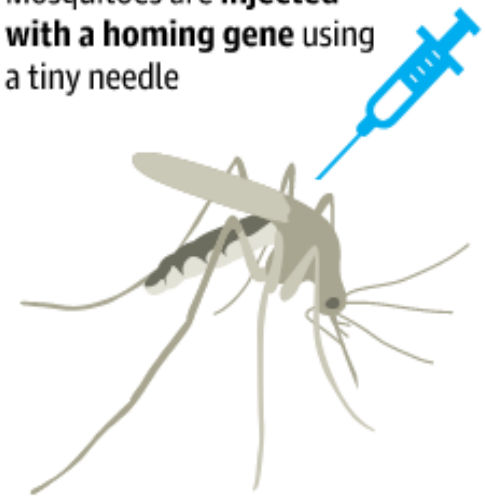
CKX2 is an enzyme that degrades cytokinins, a plant hormone regulating cell division and growth.

GM Mosquitoes

- Aedes aegypti mosquito is the carrier of diseases such as **Zika, dengue and chikungunya.**
- Genetically modified mosquitoes involve **producing transgenic male Aedes aegypti mosquito**, which carries a **new gene fatal only to female mosquitoes**.
- After a few generations, the **female population will be drastically reduced**
- **Transgenic males do not bite** and the modified genes are said to be **harmless to humans**.

1

Mosquitoes are **injected with a homing gene** using a tiny needle



2

The gene locks on to a sequence in **the X chromosome**

3

That part of the X chromosone is **'shredded'**

4

This favours unaffected sperm-bearing Y chromosomes, meaning their **offspring become 95% male**

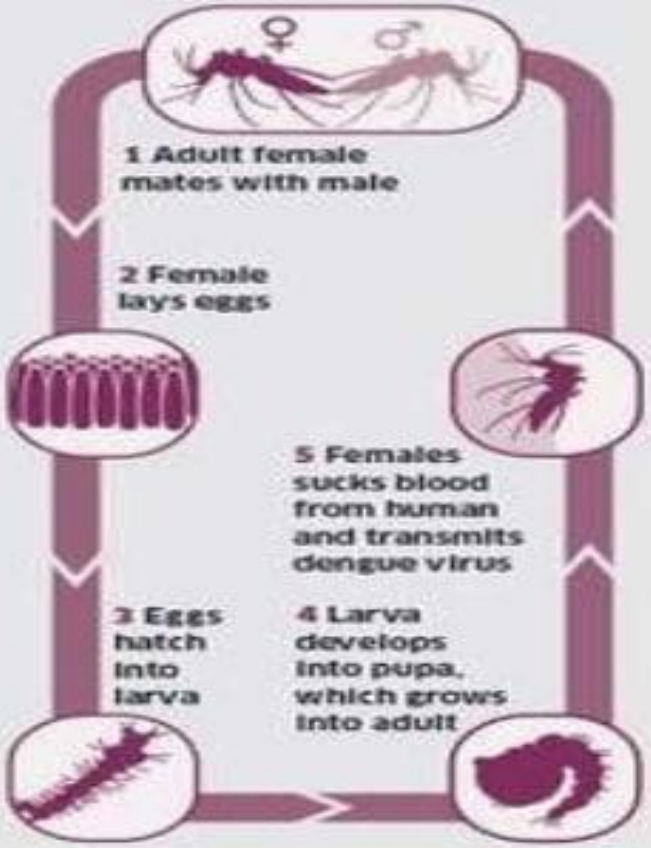
SOURCE: NATURE COMMUNICATIONS

90-3043

HOW SCIENTISTS HOPE TO TACKLE THE DISEASE

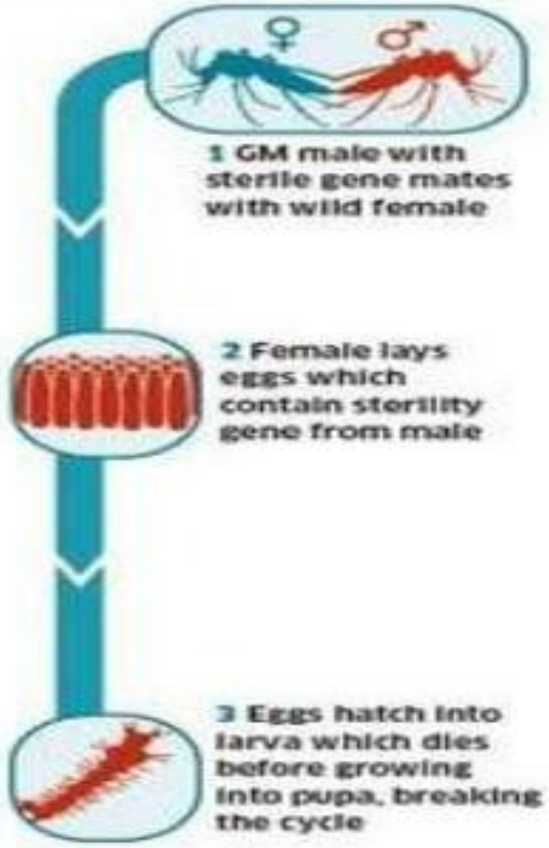
MOSQUITO LIFE-CYCLE

The normal life-cycle of the mosquito involves the production of blood-sucking females



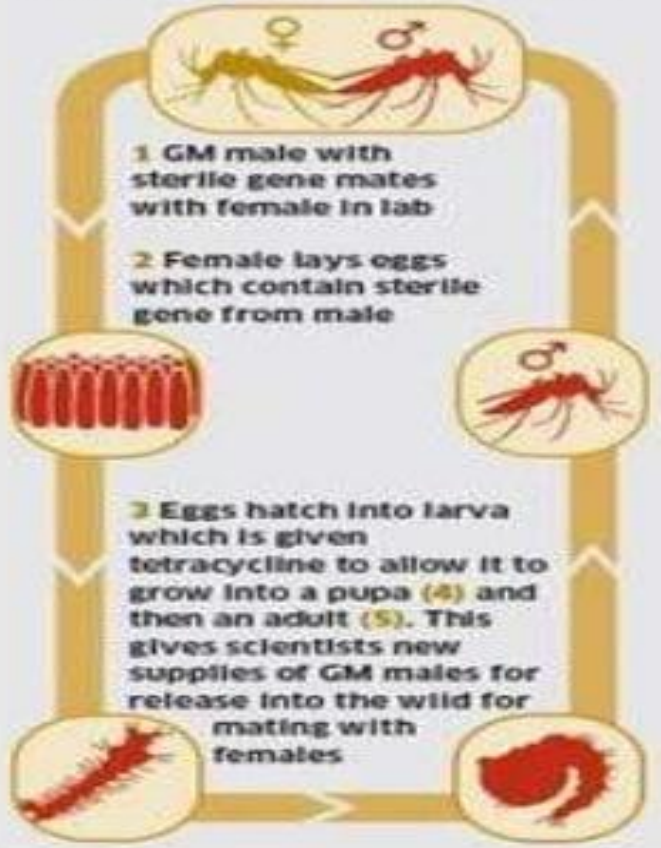
GM MALES BREAK LIFE-CYCLE

GM males contain 'sterility' gene that is passed on to offspring which die prematurely as a result



SUPPLIES OF GM MALES RENEWED

In the lab, fresh supplies of GM males are produced by adding tetracycline to allow development



COUNTRIES AT RISK OF DENGUE

GM Mosquitoes

Wolbachia Method

- Wolbachia are **extremely common bacteria** that occur naturally in **60 per cent of insect species**, including some mosquitoes, fruit flies, moths, dragonflies and butterflies
- Wolbachia are **safe for humans and the environment.**
- **Aedes aegypti** mosquitoes **don't normally carry Wolbachia,** however many other mosquitoes do.
- when **Aedes aegypti mosquitoes carry Wolbachia, the bacteria compete with viruses** like dengue, Zika, chikungunya and yellow fever.
- This makes it **harder for viruses to reproduce inside the mosquitoes**. And the mosquitoes are much less likely to spread viruses from person to person.

GM Mosquitoes

Reason

- It could result in **harmful consequences to the environment** or ecology.
- Aedes aegypti is part of the food chain.
- During its life cycle, it **is consumed by fishes**.
- Also, during its early aquatic phase, it is **consumed by frogs and then by birds, lizards and spiders.**
- A drastic reduction in the mosquito population could thus impact prey species

GM Mosquitoes

The gene drive interferes with the insects' ability to reproduce. It wiped out captive populations of mosquitoes in eight to 12 generations in a small lab study.

Gene drives

- are selfish genetic elements that are transmitted to progeny at super-Mendelian (>50%) frequencies.

A gene drive is a natural process and technology of genetic engineering that propagates a particular suite of genes throughout a population by altering the probability that a **specific allele will be transmitted to offspring (instead of the Mendelian 50% probability).**

GM Mosquitoes

Upping the odds

With other forms of genetic engineering, the altered gene follows normal rules of inheritance and is passed on to only 50 percent of offspring. Gene drives can paste themselves into a gene inherited from an unaltered parent, ensuring the genetic change gets passed on more often.