

Science & Technology



The background is a complex digital collage. At the top left, a satellite with four solar panel arms is shown against a starry space background. Below it, a glowing blue and white Earth is depicted, overlaid with a white network of lines and nodes. To the right of the Earth, there's a network diagram with nodes labeled 'SHARED NODE' and 'ACCESS POINT'. The background is filled with various data visualizations, including bar charts, pie charts, and binary code (0s and 1s) scattered throughout. The overall color scheme is dominated by blues, whites, and yellows.

Biotechnology

- Biotechnology is technology that **utilizes biological systems, living organisms** or parts of this to develop or create different products.
- Brewing and **baking bread** are examples of processes that fall within the concept of biotechnology (use of **yeast** (= living organism) to produce the desired product).
- **Such traditional processes** usually utilize the living organisms in their **natural form** (or further developed by breeding), while the more modern form of biotechnology will generally involve a more **advanced modification of the biological system or organism**.



RED BIOTECHNOLOGY

Or **MEDICAL BIOTECHNOLOGY** is biotechnology applied to manufacture pharmaceuticals like enzymes, antibiotics and vaccines and is used for molecular diagnostic

WHITE BIOTECHNOLOGY

Or **INDUSTRIAL BIOTECHNOLOGY** is biotechnology applied to industrial and other production processes

BIOTECHNOLOGY

GREEN BIOTECHNOLOGY

Or **AGRICULTURAL BIOTECHNOLOGY** is biotechnology applied to agricultural processes and products

BLUE BIOTECHNOLOGY

Or **MARINE BIOTECHNOLOGY** is marine and aquatic applications of biotechnology



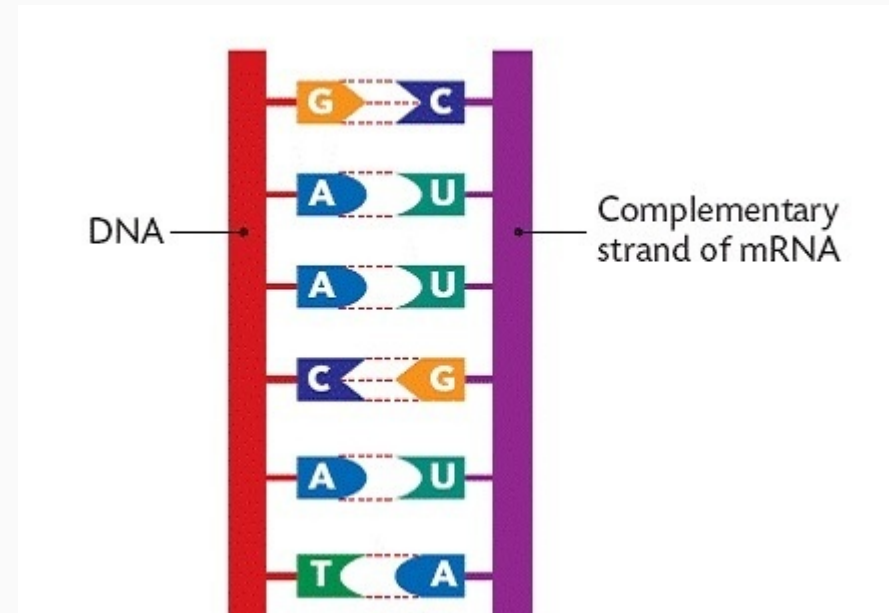
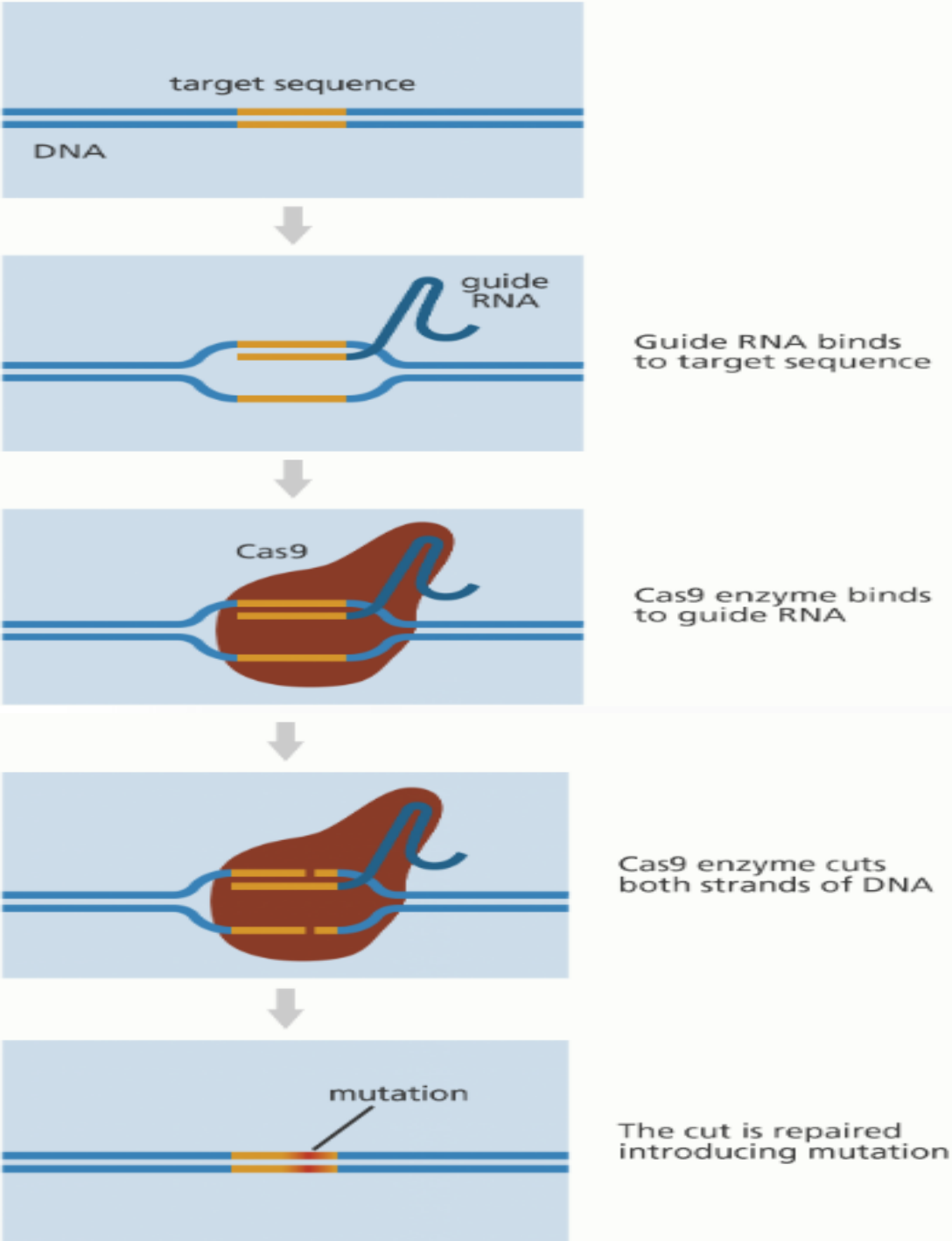
Gene editing techniques

CRISPR-Cas9 Gene Editing: Genome Editing Revolutionized

- There are several gene editing methods, but a tool called CRISPR-Cas9 has sparked a boom in research as laboratories worldwide adopted it over the past five years because it's faster, cheaper, simple to use with minimal training and allows manipulation of multiple genes at the same time.
- **Crisper**-scan the genome looking for right location
- Then **Cas9 protein**(enzyme) as molecular scissor

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.



Gene editing techniques

Genetically modify lizard using CRISPER- Cas9

Method used

- Injected CRISPER protein into multiple immature eggs of reptile
- Target tyrosinase gene(in melanocyte-melanin)
- Produces 4 albino reptile
- Target Tyrosinase gene of both parents

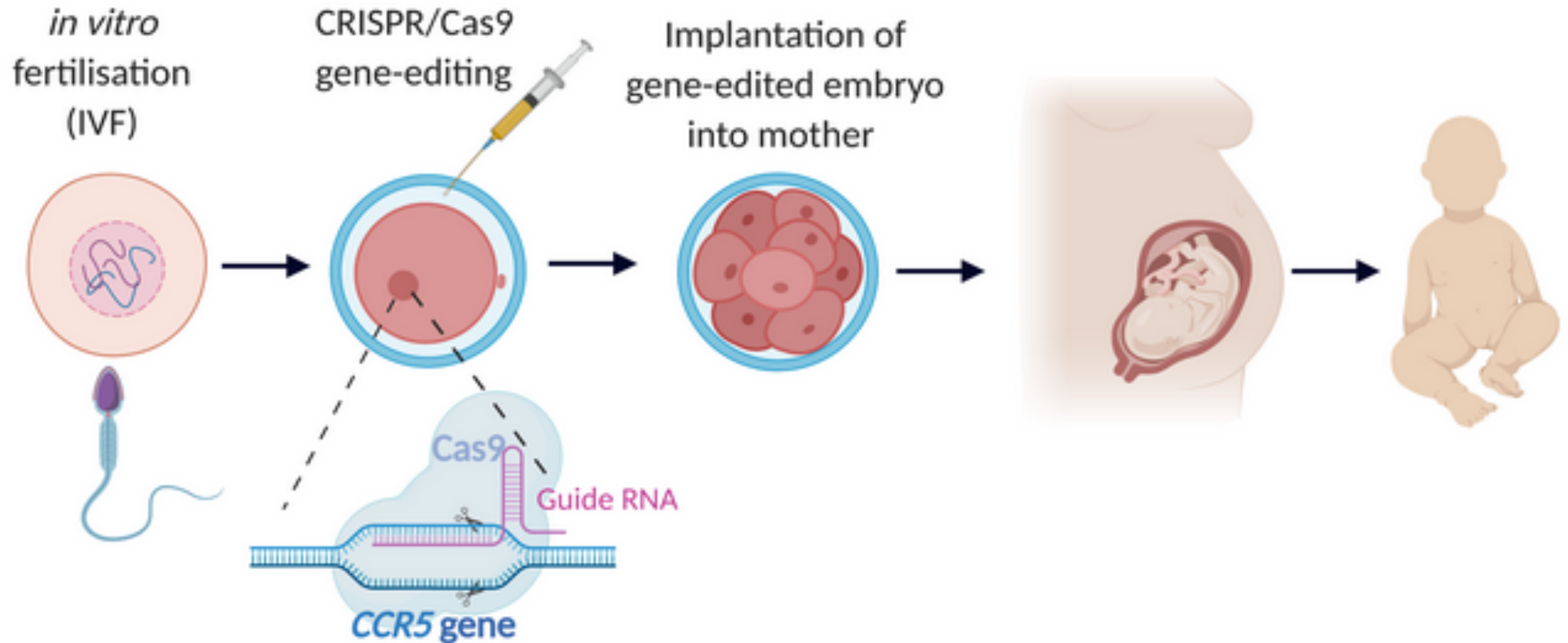


Crisper- ccr5

He Jiankui

- ❑ The Chinese scientist claimed that he had **altered a gene called CCR5**, which allows the AIDS-causing virus to infect an important class of cells in the human immune system.
- ❑ world's first gene-edited human babies, twin girls with the pseudonyms Lulu and Nana.





CAR-T cell therapy

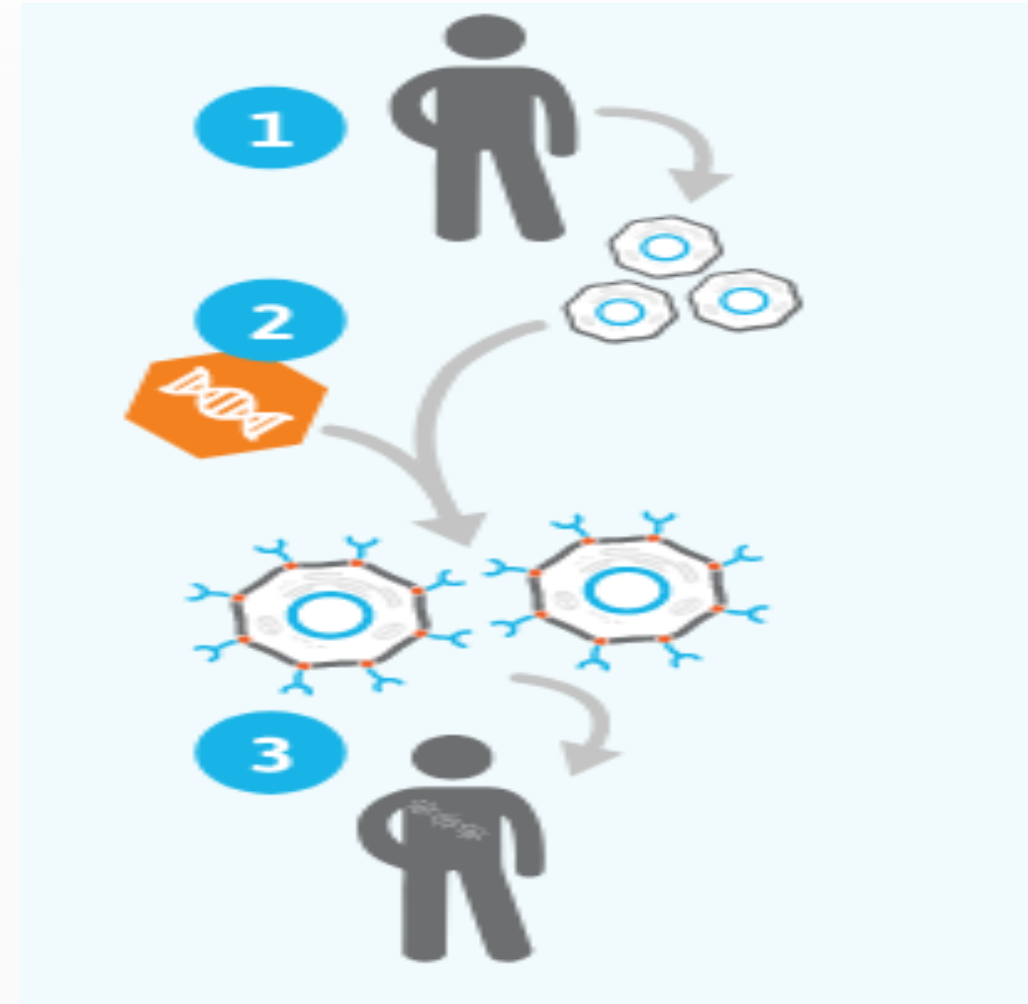
- CAR-T stands for **chimeric antigen receptor** (CAR) T-cell therapy.
- It is a type of cell therapy that is **used with gene-based therapies**, but it is not a type of gene-based therapy by itself.
- CAR-T cell therapy involves changing a **person's own immune cells to recognize and fight cancer cells** inside the body.



CAR-T cell therapy

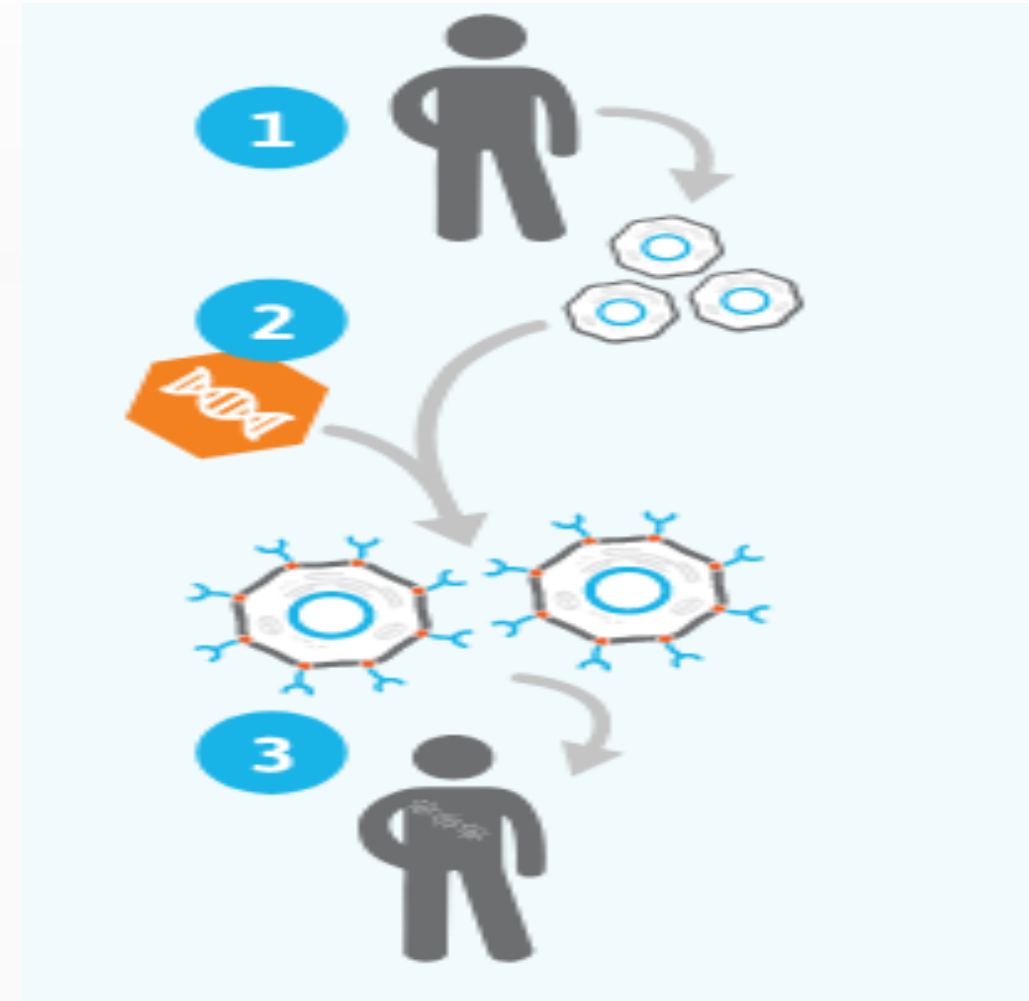
1. T cells, a type of immune cell, are taken from a person's blood.
2. Then, in the laboratory, gene replacement therapy is used to **add a new gene to T cells**.

This new gene adds a **special receptor, called a chimeric antigen receptor (CAR)**, to T cells to make CAR-T cells. CAR-T cells are able to bind to and attack certain cancer cells.



CAR-T cell therapy

3. Large numbers of the CAR-T cells are made in the laboratory, and once a sufficient amount has been produced, the cells are put back into the body to fight certain cancers.

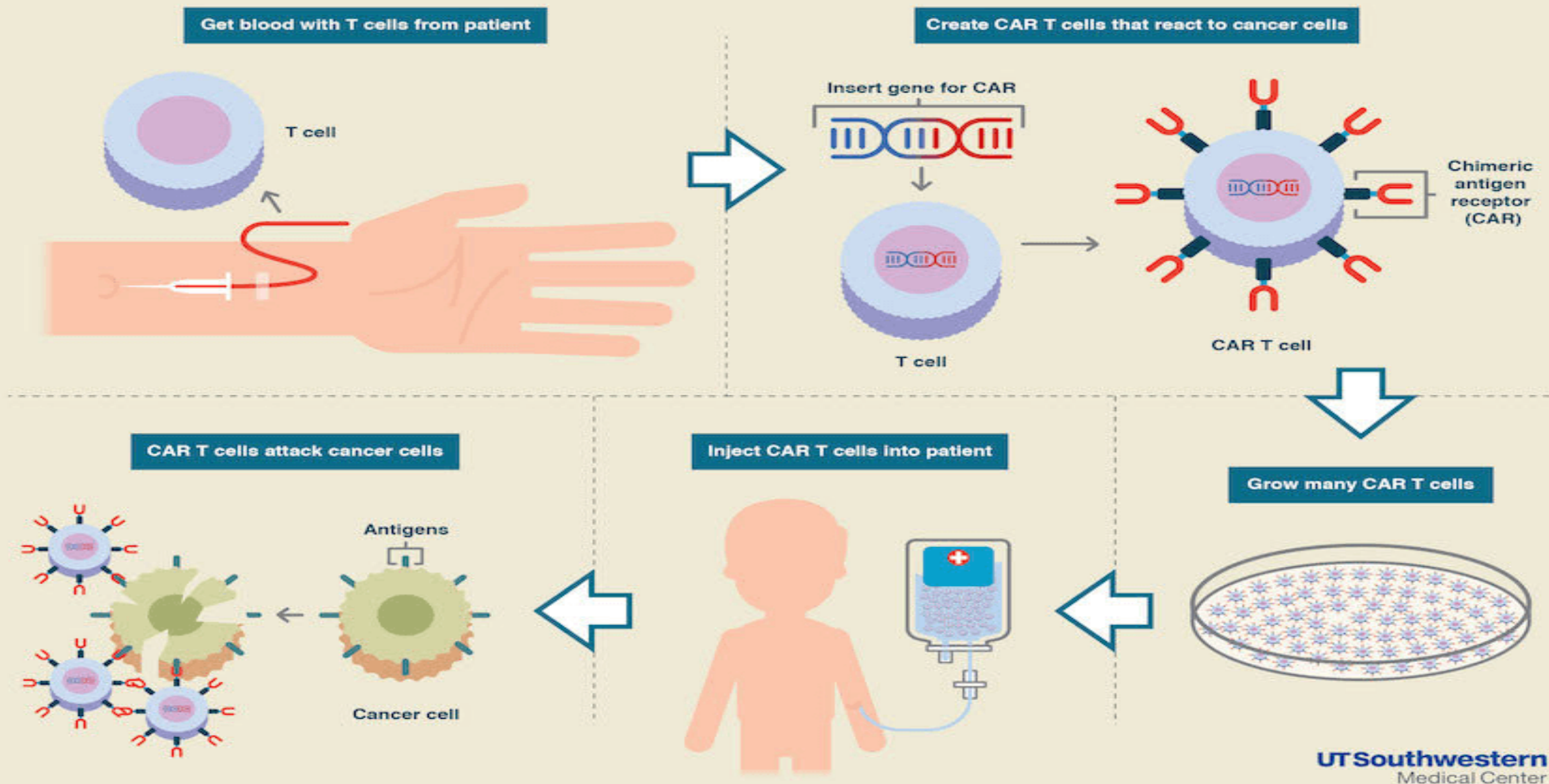


CAR-T cell therapy

- US has recently approved the first gene therapy to fight childhood leukaemia
- It is called as CAR-T cell therapies and the **treatments** are called **Yescarta and kymriah**.



CAR T-cell Therapy



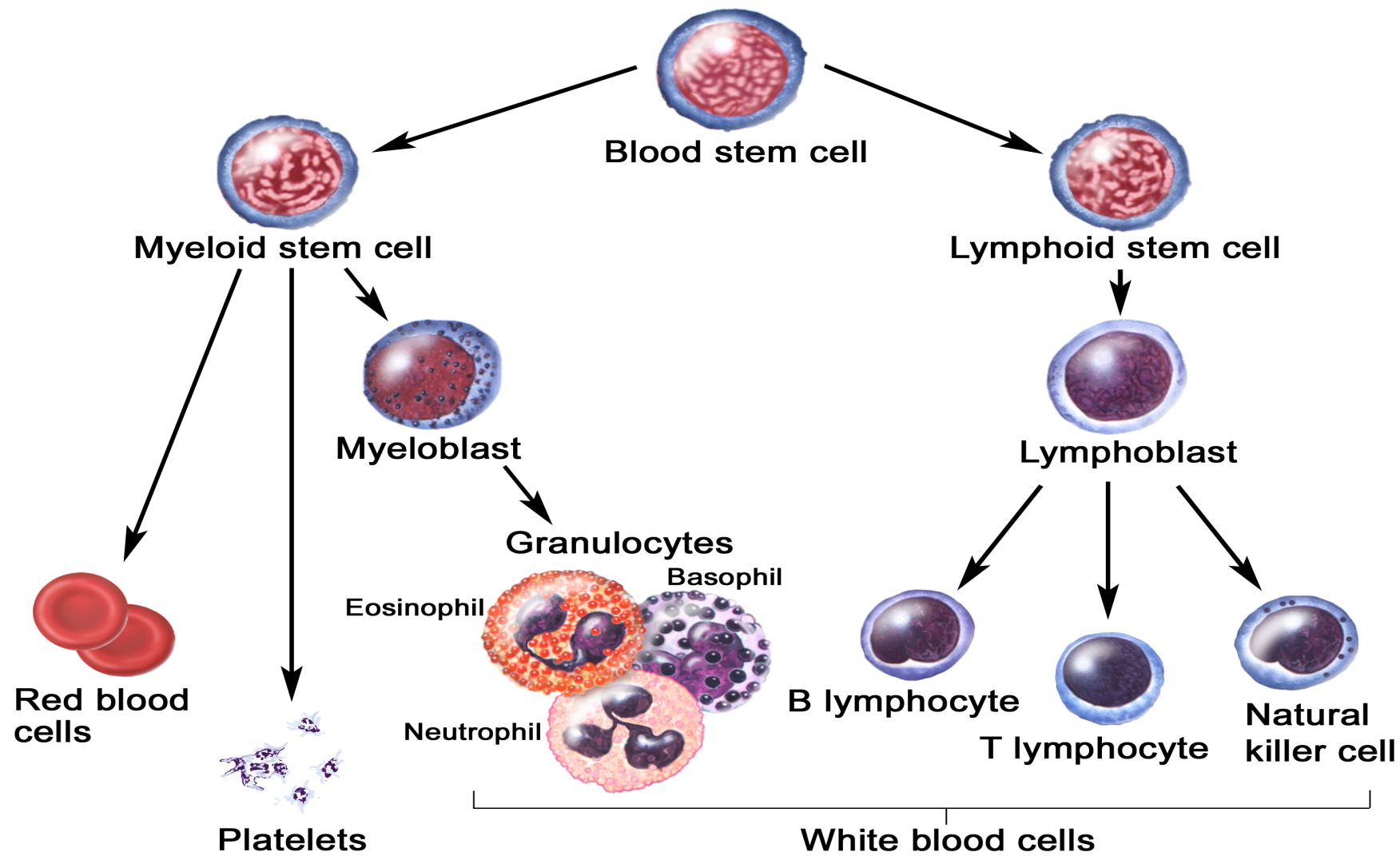
Base editing

Recently a teenage (**Alyssa**) cancer patient suffering from **T-cell acute lymphoblastic leukaemia (T-ALL)** has defeated her seemingly incurable cancer with the help of base editing technique.

T-cell acute lymphoblastic leukaemia (T-ALL)

- It is a kind of **blood cancer** known as T-cell acute lymphoblastic leukaemia (T-ALL).
- T-ALL **affects the stem cells in the bone marrow** that produce a particular kind of white blood cells (WBC) called **T lymphocytes** (T cells).
- These cells **provide a person immunity** by killing cells carrying infections, activating other immune cells, and regulating the immune response.





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Base editing

- At least 20% of these WBC are atypical– as they accumulate in the bone marrow, they crowd out “good” WBCs and hence weaken the immune system. These **unhealthy cells can also accumulate in other parts of the body like the liver, spleen and lymph nodes.**



Base editing

How is T-ALL typically treated?

- Typical treatment for T-ALL is similar to that of any leukaemia– **chemotherapy and stem cell/bone marrow transplant**.
- Doctors will first administer multiple rounds of **chemotherapy**. This either **kills the cancerous cells or stops** them from further dividing. The exact schedule is guided by an individual's age and general health.
- **If this fails**, and the individual is suitable, doctors will conduct **bone marrow transplant**. First the patient will undergo **radiation therapy** and/or chemotherapy that will kill the cancerous cells but also wreck an individual's immunity system along with it. Thus, patients receive an **infusion of healthy bone marrow cells** that will hopefully multiply and restore immunity.
- Overall treatment for T-ALL is pretty effective– **children have a survival rate of over 85 per cent** after five years of receiving this treatment.



Base editing

What is the experimental treatment Alyssa received?

- In May, Alyssa, from Leicester in UK, began a trial where she **received a dose of healthy T-cells** from a donor that would hopefully attack her cancerous cells without destroying each other. Known as **CAR-T therapy**, this principle has been around for a while, but Alyssa's case was different.
- Traditionally, **CAR-T therapy involves** adding a gene to T-cells that causes them to seek out and destroy cancerous cells. The modified cells are known as CAR-T cells. First, an individual's own T-cells are removed, which are then modified and reintroduced to the individual. The problem with such an approach (besides the expense) is that very often, when an individual is really sick, it is simply impossible to obtain enough healthy T-cells to create CAR-T cells.
- While **donors can provide healthy T-cells** to an individual, these T-cells from a foreign body are going to attack every single cell in that patient's body, making the treatment counterproductive.



Base editing

- Thus, scientists have resorted to what is known as **base editing- through this technique of genetic editing, they make it possible for** one donor to supply T-cells to multiple recipients, without the traditional risks associated with it. Thus, Alyssa received genetically modified cells that were programmed to specifically attack her cancer while leaving the rest of her body alone.



Base editing

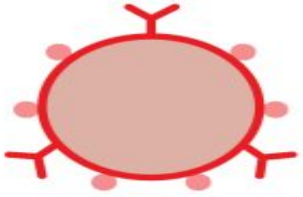
What is base editing?

- **Bases are the language of life.** Just as letters in the alphabet spell out words that carry meaning, the billions of bases in our DNA spell out the instruction manual for our body.
- With advances in genetic technology, scientists have been **able to zoom into a precise part of the genetic code** to alter the molecular structure of just one base, effectively changing its genetic instructions.
- A team at the Great Ormond Street Hospital managed to **use base-editing to create a new type of T-cell from a healthy donor** that would not attack other cells in Alyssa's body, not kill each other, survive chemotherapy and finally, hunt down all other T-cells in Alyssa's body (healthy and cancerous). After this therapy worked in its initial stages, Alyssa was given another bone marrow transplant to restore her immunity.



How does the treatment work?

1 Alyssa had T-cell leukaemia



T-cells, a type of white blood cell, destroy threats in the body

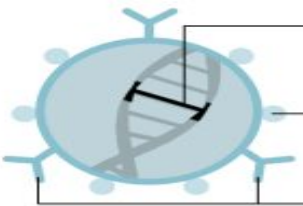
Alyssa's were out of control

2 Doctors used 'base editing' to engineer her therapy



Base editing changes one letter in the genetic code

3 Donor T-cells were edited in three ways

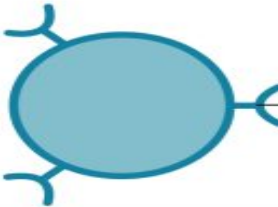


DNA altered to resist chemotherapy

Markings removed to protect donor T-cells

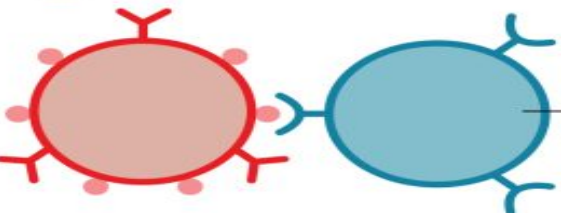
Receptors removed to prevent donor T-cells attacking the body

4 T-cells further modified to attack cancer



T-cell rearmed with new receptors

5 Battle of the T-cells

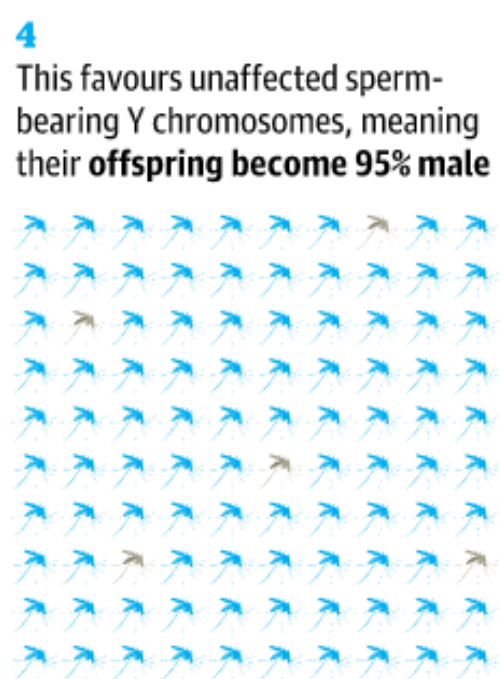
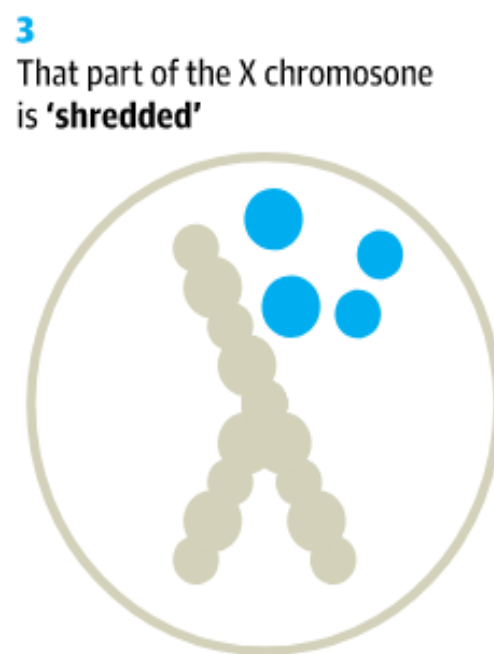
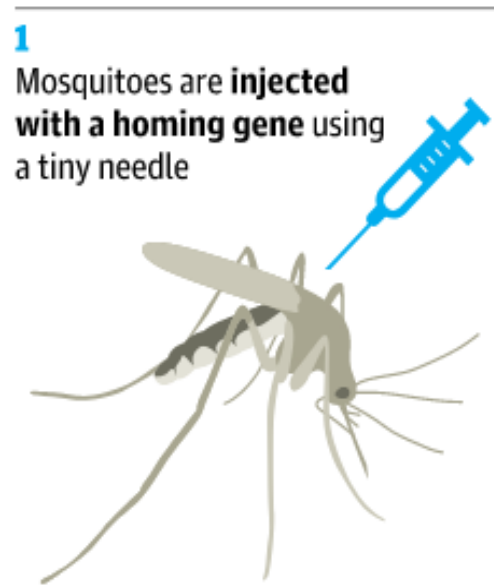


Modified T-cells find and destroy cancerous T-cells

GM Mosquitoes

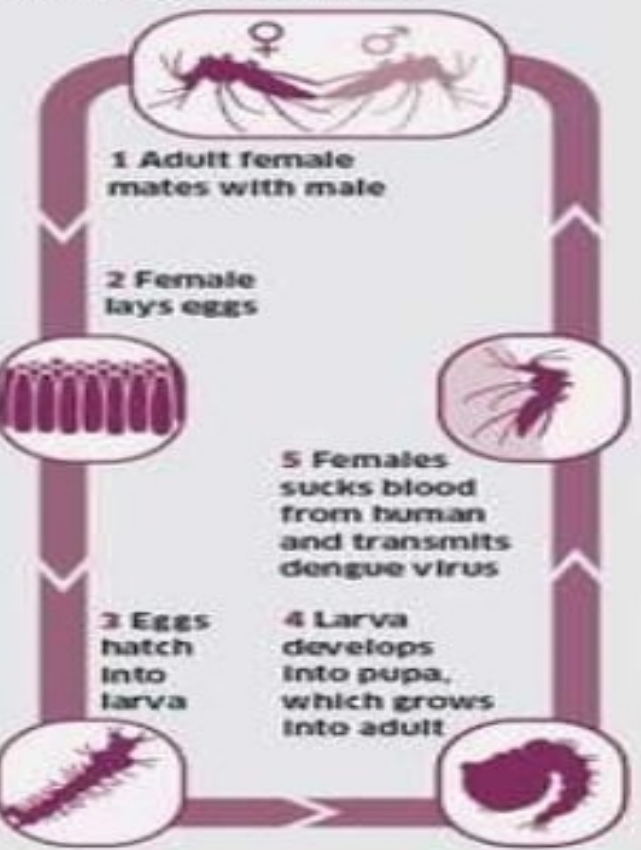
- *Aedes aegypti* mosquito is the carrier of diseases such as **Zika, dengue and chikungunya**.
- Genetically modified mosquitoes involve **producing transgenic male *Aedes aegypti* mosquito**, which carries a **new gene fatal only to female mosquitoes**.
- After a few generations, the **female population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





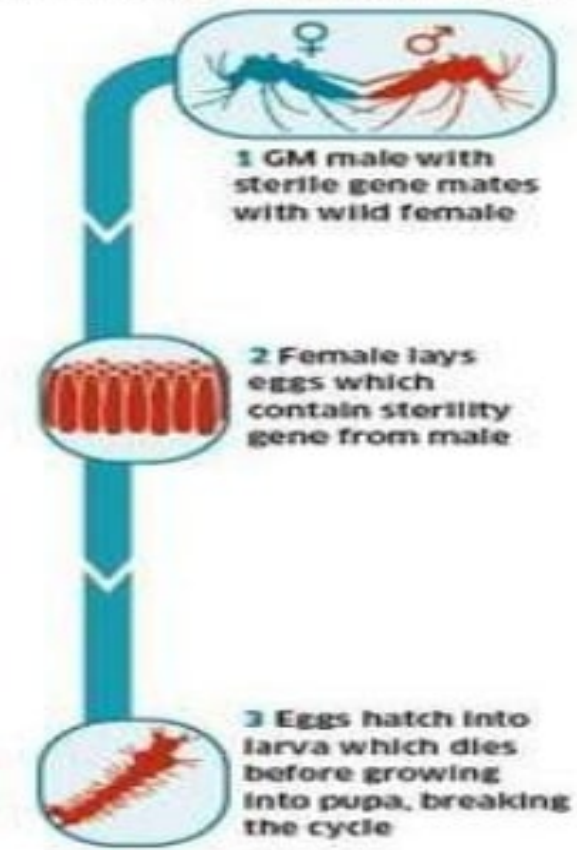
MOSQUITO LIFE-CYCLE

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



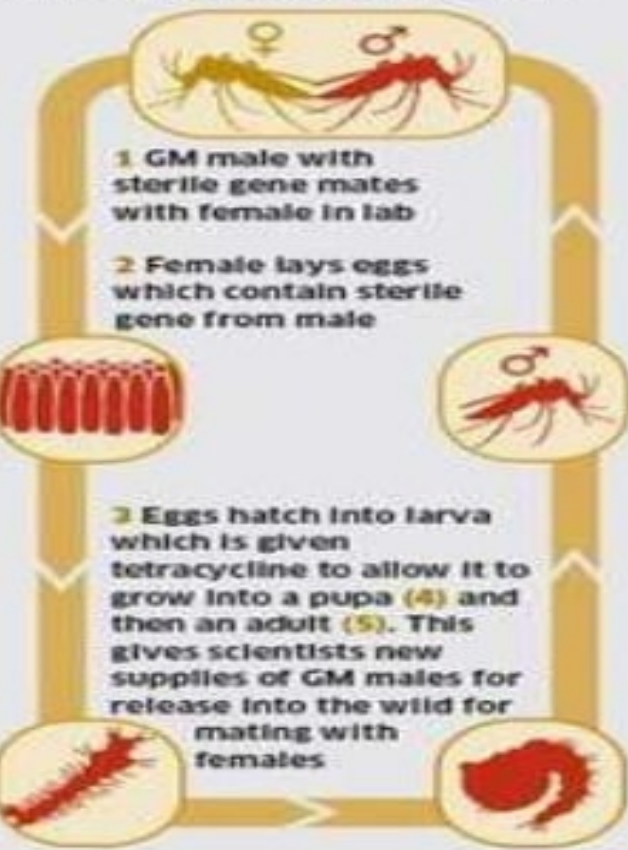
GM MALES BREAK LIFE-CYCLE

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

Status of GM Mosquitoes in India

- The Department of Biotechnology (DBT) is **hesitant to permit field trials** to release GM mosquitoes to tackle certain diseases.
- The so-called —**Friendly Aedes project** launched —closed cage trials at the Oxitec facility in Maharashtra.



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 World Health Organization has put out research **guidelines** for genetically modified mosquitoes. They include recommendations for safety and ethics, including:

- **Standards for making decisions** about how and when to do tests with the mosquitoes
- **Methods to understand potential effects** on public and environmental health
- **Risk assessment** strategies
- **Rules for projects to continue** from one phase of testing to the next
- Things to consider about **safety and effectiveness** during each stage of testing



GM Crops

GM CROPS IN INDIA A PRIMER

What is a GM crop?

A crop which has a gene artificially inserted into it from another species, even unrelated, to give it some desired properties. GM crops are mostly either pest-resistant or herbicide-tolerant

Are there other GM crops in India?

No, the government has not approved commercial cultivation of other GM crops, though efforts have been made for brinjal and mustard

When did India get its first GM crop?

The first GM crop variety approved for commercialisation was Bt cotton. Bollgard-I, which provided immunity against the pink bollworm and developed by Monsanto, was given the go ahead in 2002. Monsanto released Bollgard-II in 2006. India has become the world's largest producer of cotton partly due to Bt cotton, which accounts for over 90% of the total cotton acreage in the country



GM CROPS

- 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.



Crop Science | India

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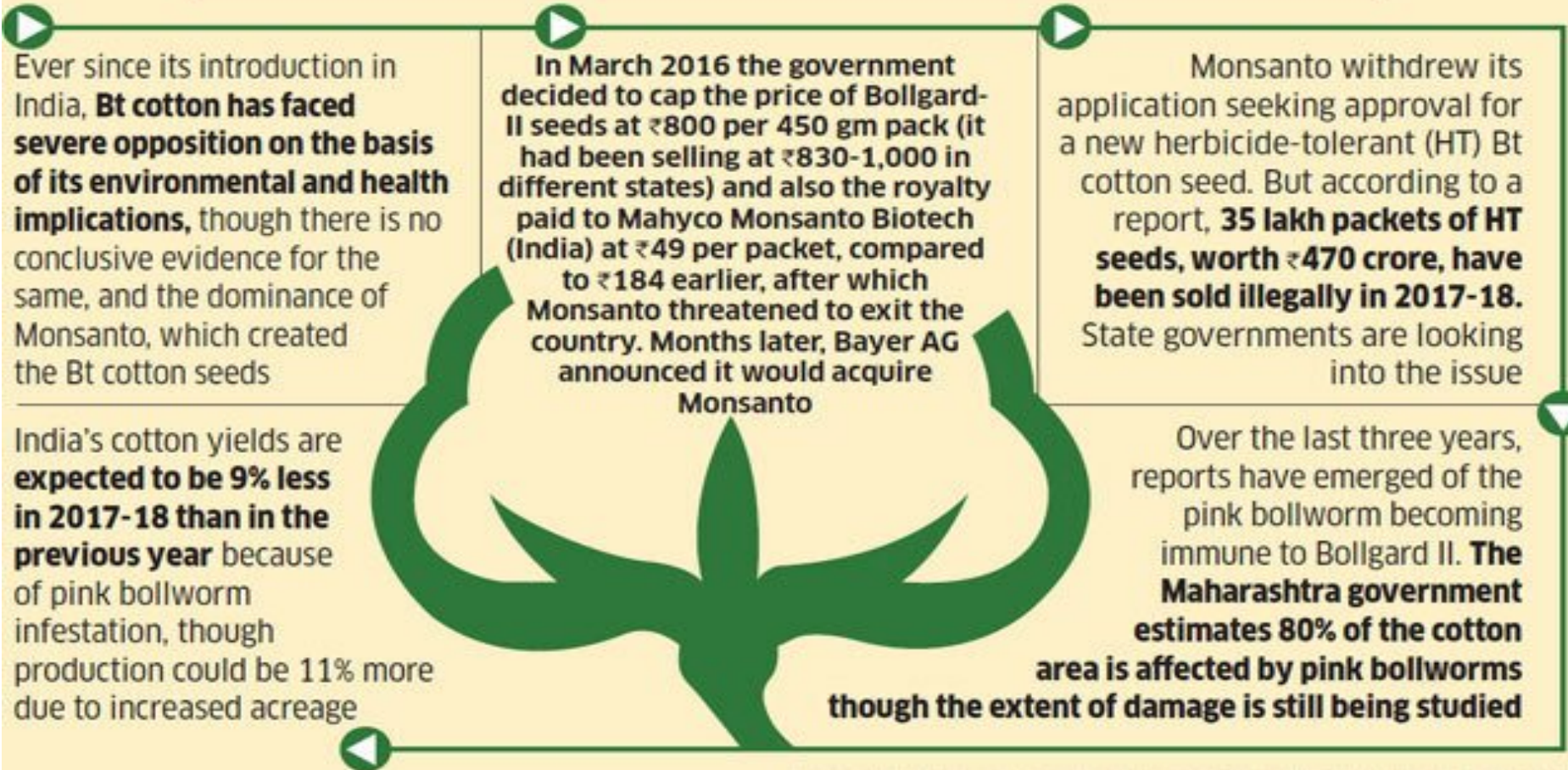
Bollgard® & Bollgard® II



Bollgard® Bt cotton (single-gene technology) is India's first biotech crop technology approved for commercialization in India in 2002, followed by Bollgard® II – double-gene technology in mid-2006, by the Genetic Engineering Approval Committee (GEAC), the Indian regulatory body for biotech crops.

Bollgard® cotton provides in-built protection for cotton against destructive American Bollworm *Heliothis Armigera* infestations, and contains an insecticidal protein from a naturally occurring soil microorganism, *Bacillus thuringiensis* (Bt). Bollgard® II technology contains a superior double-gene technology - Cry1Ac and Cry 2Ab which provides protection against bollworms and *Spodoptera* caterpillar, leading to better boll retention, maximum yield, lower pesticides costs, and protection against insect resistance. Both, Bollgard® II and Bollgard® insect-protected cotton are widely planted around the world as an environmentally friendly way of controlling bollworms.

BT COTTON: MIRED IN CONTROVERSY



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.



Rules of Environmental Protection Act 1989

- ❑ Legally, **sale, storage, transportation and usage of unapproved GM seeds** is a punishable offence under the Rules of Environmental Protection Act 1989.

HTBt cotton

Seed Act of 1966 and the Cotton Act of 1957

- Also, sale of unapproved seeds can attract action under the **Seed Act of 1966 and the Cotton Act of 1957**.
- The **Environmental Protection Act** provides for a **jail term of five years and a fine of Rs 1 lakh for violation** of its provisions, and cases can be filed under the other two Acts.



Centre restricted the use of glyphosate

The Union Agriculture Ministry has restricted the use of glyphosate, a widely used herbicide.

- This comes even as the Supreme Court on November 10 is about to take up a plea seeking a ban on all herbicide-tolerant crops, including transgenic hybrid mustard and cotton.

What is glyphosate?

- It is a herbicide used to kill weeds — undesirable plants that compete with crops for nutrients, water and sunlight.
- Since weeds basically grow at the expense of crops, farmers remove them manually or spray herbicides.
- Glyphosate is a **broad-spectrum herbicide** that can control a wide range of weeds, whether broadleaf or grassy.



Centre restricted the use of glyphosate

- It is also **non-selective**, killing most plants.
- When applied to their leaves, it inhibits the production of a protein '5-enolpyruvylshikimate-3-phosphate synthase (EPSPS)'. This enzyme, produced **only by plants and microorganisms**, synthesise aromatic amino acids that are necessary for their growth.



Centre restricted the use of glyphosate

Use in India

- There are **nine glyphosate-based formulations** containing different concentrations of the chemical registered for use under the **Insecticides Act, 1968**
- These are **approved largely for weed control in tea gardens and non-crop areas** such as railway tracks or playgrounds.
- Farmers also **apply glyphosate on irrigation channels and bunds to clear these of weeds**, making it easier for water to flow and to walk through them.
- Weeds growing on bunds are, moreover, hosts for fungi, such as those causing sheath blight disease in rice.
- In general, though, the **scope for glyphosate use is limited for the very reason that it is non-selective**.



Centre restricted the use of glyphosate

- Designed to kill all plants coming into contact with it, the chemical cannot ordinarily distinguish between crop and weed. Hence, **it can be used in tea or rubber plantations, but not in fields where the crops and weeds are at almost the same level.**

What exactly has the government now done?

- The Ministry of Agriculture and Farmers Welfare, on October 21, issued a notification stating that **“the use of glyphosate involves health hazards and risk to human beings and animals”**.
- It has, however, **not banned and only “restricted” its use**. The spraying of glyphosate and its derivatives shall henceforth only be permitted through **“pest control operators”**.



Centre restricted the use of glyphosate

Why has this been done?

- As earlier noted, the **scope for glyphosate is already restricted in normal agricultural crops** by virtue of it being a non-selective herbicide.
- Glyphosate application has **increased only with the advent of genetic modification (GM) or transgenic technology**.
- In this case, it has **involved incorporating a 'cp4-epsps' gene**, isolated from a **soil bacterium Agrobacterium tumefaciens**, into crop plants such as cotton, maize and soyabean.
- This **alien gene codes for a protein that does not allow glyphosate to bind with the EPSPS enzyme**.
- The said GM crop can, therefore, **"tolerate"** the spraying of the herbicide, which then kills only the weeds.



Centre restricted the use of glyphosate

- In 2019 alone, some 81.5 million hectares were planted worldwide with herbicide-tolerant (HT) GM crops.
- The global glyphosate market is annually worth \$9.3 billion, with over 45 per cent of use on account of GM crops
- As far as India goes, the only GM crop officially under commercial cultivation today is Bt cotton. This has two alien genes ('cry1Ac' and 'cry2Ab') from the soil bacterium *Bacillus thuringiensis*, that code for proteins toxic to the American bollworm, spotted bollworm and tobacco caterpillar insect pests.
- In the 2022 kharif planting season, about 39 million Bt cotton packets — each containing 450 gm of seeds — were sold at a notified maximum retail price of Rs 810/packet.



Centre restricted the use of glyphosate

- But industry estimates suggest sales of an additional 5 million packets of “illegal” GM cotton seeds at prices ranging from Rs 1,100 to Rs 1,350/packet.
- These seeds harbour both insect-resistance and HT traits, coming from the two Bt genes and the glyphosate-tolerant ‘cp4-epsps’ gene.
- **Neither the Centre nor state governments have succeeding in stopping the cultivation of illegal HT cotton.**
- **The fact that their seeds (1.5 to 2 packets are sown on every acre) are selling at a premium is proof of farmers themselves wanting them.**
- Given the high cost of manual weeding and non-availability of labour when required, they clearly see the value in spraying glyphosate and planting HT cotton.
- **Having failed to curb the illegal sales of seed, the Centre is trying to nip the problem in the bud – by cutting the access of farmers to glyphosate and allowing its use only through pest control operators.**



Centre restricted the use of glyphosate

How valid are the health concerns over glyphosate?

- The World Health Organisation's International Agency for Research on Cancer (IARC), in March 2015, classified glyphosate as "**probably carcinogenic to humans**". But this was based on evidence for cancer in experimental animals from "**pure**" **glyphosate**, as opposed to that in humans from real-world exposures through **diluted formulations** (which is how the chemical is actually sold and used).
- The US Environmental Protection Agency, on the other hand, has held that there are "**no risks of concern to human health from current uses of glyphosate**" and "**no evidence**" of it causing cancer.
- The European Chemicals Agency, too, has concluded that "**classifying glyphosate as a carcinogenic, mutagenic** (causing DNA changes)
- For now, what's not in doubt is the demand for herbicides and crops that can withstand their application among Indian farmers.



Centre restricted the use of glyphosate

- The Union Environment Ministry's **Genetic Engineering Appraisal Committee (GEAC)**, on October 18, recommended the commercial release of **Delhi University's GM hybrid mustard**.
- This crop can also tolerate the spraying of **glufosinate ammonium**, a **non-selective herbicide** similar to glyphosate.
- GEAC is further set to take a call on approving **glyphosate-tolerant Bt cotton**, whose illegal cultivation is an open secret.
- All eyes are **next on the Supreme Court**, scheduled to hear a plea challenging the GEAC's nod for the transgenic hybrid mustard and also seeking a ban on all HT crops.



Bt brinjal

- Major brinjal producing states include: West Bengal (30% production share), Orissa (20%), and Gujarat and Bihar (around 10% each)
- 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).
- When ingested by the FSB larvae, **the Bt protein is activated in the insect's alkaline gut and binds to the gut wall**, which breaks down, allowing the Bt spores to invade the insect's body cavity. The FSB larvae die a few days later.



Insect Resistance

Mahyco's research focuses on developing insect resistance as a value added trait in crops such as rice, brinjal and okra. The products contain one or more genes – cry genes from *Bacillus thuringiensis* – that have proven efficacy in the management of specific target insect pests. India's first insect-resistant transgenic product Bollgard® cotton was commercialized in 2002, followed by a two gene product Bollgard II™ in 2006. Mahyco has developed products such as Bt rice, Bt brinjal and Bt okra which show excellent control of specific target insect pests in regulatory trials. Bt brinjal with cry1Ac gene has passed through all regulatory testing stages and is awaiting approval for commercialization. Mahyco's aim is to equip products with good insect control that will eventually boost the profitability of the farmers while minimizing pesticide use and environmental contamination.



Left – Bt brinjal after harvesting, Right – Non-Bt brinjal after harvesting

Abiotic Stress Tolerance

Rapid population and economic growth in India in the last 50 years have placed significant pressure on the country's fragile environment and water resources. India's population is expected to reach 1.4 billion by 2024. In order to feed the ever



Bt brinjal

- Bt Brinjal was 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').**
- DMH-11 has reported a roughly 30% yield advantage over the Varuna 'check' variety in the bio-safety research level field trials carried out between 2010-11 and 2014-15.



GEAC

- The Genetic Engineering Appraisal Committee (GEAC) functions in the Ministry of Environment, Forest and Climate Change (MoEF&CC).
-

Chairman- Special Secretary/Additional Secretary, Ministry of Environment, Forest and Climate Change (MoEF&CC); Co-Chairman - Representative of Department of Biotechnology.

Members: Representative of concerned Agencies and Departments, namely, Ministry of Industrial Development, Department of Biotechnology and the Department of Atomic Energy.

GEAC

The functions of GEAC as prescribed in the Rules 1989 are as follows:

To appraise activities involving large scale use of hazardous microorganisms and recombinants in research and industrial production from the environmental angle.

To appraise proposals relating to release of genetically engineered organisms and products into the environment including experimental field trials.

The committee or any persons authorized by it has powers to take punitive action under the Environment Protection Act.

- Besides Bt cotton, the GEAC has cleared two other genetically modified crops – brinjal and mustard – but these have not received the consent of the Environment Minister.



Aquamation

The body of Nobel Peace Prize winning Anglican archbishop and anti-apartheid campaigner **Desmond Tutu** underwent aquamation, a **green alternative to traditional cremation methods**, in Cape Town

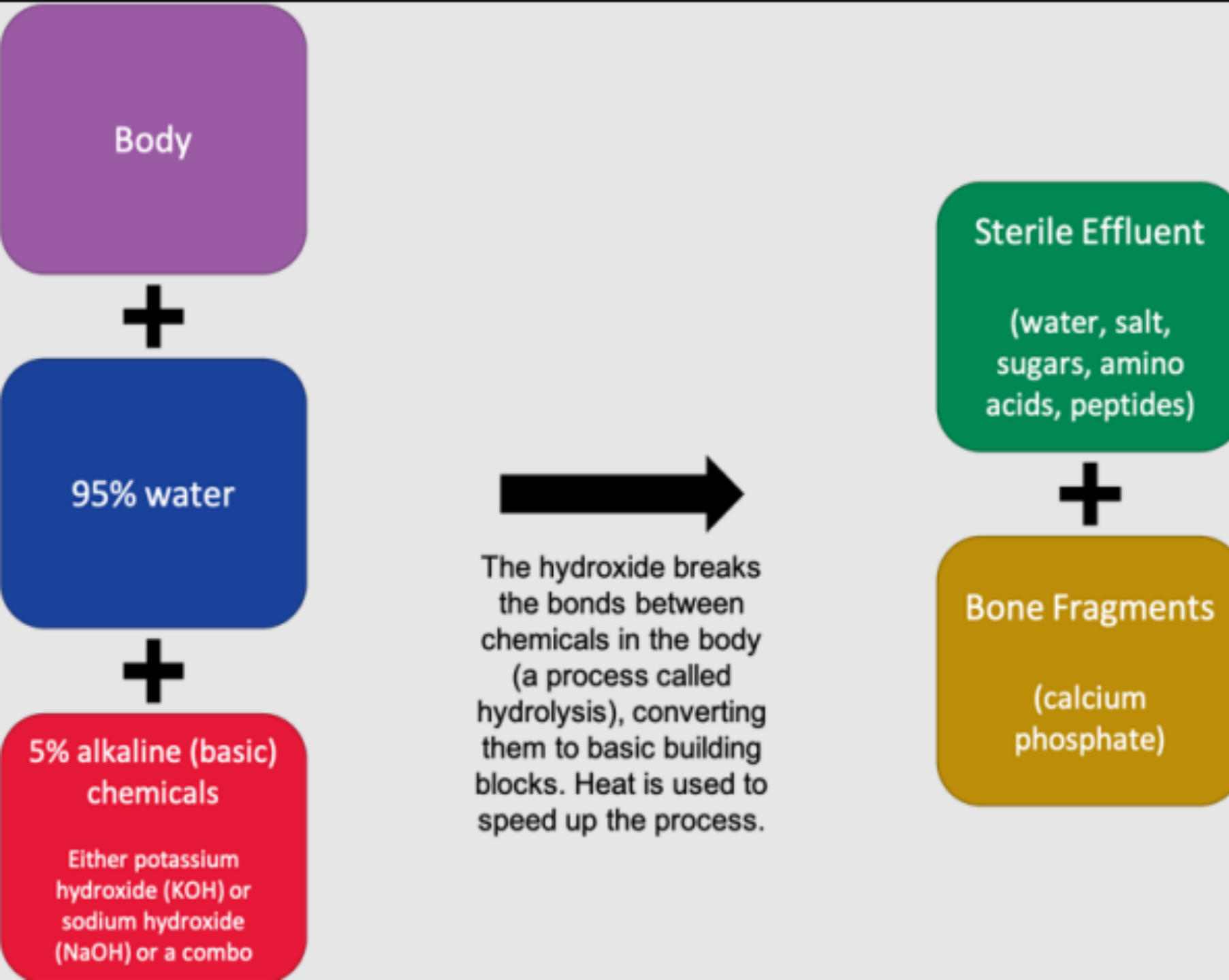
What is aquamation?

- Aquamation, or alkaline hydrolysis, is a process in which the **body of the deceased is immersed for a few hours in a mixture of water and a strong alkali** in a pressurized metal cylinder and heated to around 150 degree centigrade.
- The combination of gentle water flow, temperature and alkalinity accentuate the breakdown of the organic materials.



- It is considered to be an environmentally friendly way to dispose of a body, the process is **also known as water cremation, green cremation or chemical cremation.**
- The process **leaves behind bone fragments** and a neutral liquid called effluent.
- The decomposition that occurs in alkaline hydrolysis is the **same as that which occurs during burial, just sped up dramatically by the chemicals.**
- The effluent is sterile, and contains salts, sugars, amino acids and peptides.
- There is **no tissue and no DNA left after** the process completes.
- This effluent is discharged with all other wastewater, and is a welcome addition to the water systems





Genome sequencing

Researchers at the **Indian Institute of Science Education and Research (IISER) Bhopal** have carried out whole genome sequencing of **banyan** (*Ficus benghalensis*) and **peepal** (*Ficus religiosa*) from leaf tissue samples.

Key Findings

- The work helped in **identifying 17 genes in the case of banyan and 19 genes of peepal with multiple signs of adaptive evolution (MSA)** that play a pivotal role in long-time survival of these two *Ficus* species.
- The genes with multiple signs of adaptive evolution came about in response to **population bottleneck** faced by both trees around 0.8 million years ago.



Genome sequencing

- Genes showing multiple signs of adaptive evolution in **banyan** were mainly associated with **root development, leaf formation, metabolism, pollen tube and seed development** and other developmental processes.
- The MSA genes of **peepal trees** were mainly associated with **root development, reproduction, metabolism**.
- In the case of **banyan tree**, 15 of 17 MSA genes were also associated with **tolerance against environmental stress** – drought, oxidative stress, and pathogens.
- In **peepal trees**, 17 out of 19 MSA genes were associated with stress tolerance activities.
- In addition, the researchers identified seven genes involved in two pathways that produce **volatile organic compounds in floral scents which attract wasps for pollination**.



Genome sequencing

- **Both plants** show genes with signatures of multiple adaptive evolution involved in **phytohormone signalling pathways**. These pathways function to **regulate plant developmental senescence and ageing processes**. This could be one more reason why **banyan and peepal trees have a long lifespan**. Both banyan and peepal trees have select plant disease resistance gene families that have been expanded through gene duplication events in the course of evolution which confers greater longevity.



Why banyan, peepal trees live long

Genes with multiple signs of adaptive evolution arose in response to population bottleneck faced around 0.8 million years ago

- Genes showing multiple signs of adaptive (MSA) evolution in banyan tree were mainly associated with root development, leaf formation, metabolism, and reproduction

- Genes with multiple adaptive evolution in peepal were mainly associated with root development, reproduction, metabolism

- Disease resistance gene families showed gene expansion as well as high gene expression in these two trees

- For banyan, 15 of 17 MSA genes were also associated with tolerance against environmental stress

- In peepal trees, 17 out of 19 MSA genes were associated with stress tolerance activities



Sequencing: Whole genome sequencing was carried out from leaf tissue samples

- The adaptive evolution in genes in two cellular mechanisms explains the well-developed aerial roots of banyan trees, which protect them from environmental challenges

- Both plants show genes with signatures of multiple adaptive evolution involved in phytohormone signalling pathways that regulate plant developmental senescence and ageing

Genome sequencing

Genome

- It refers to all of the genetic material in an organism, and the human genome is mostly the same in all people, but a very small part of the DNA does vary between one individual and another.
- Every organism's genetic code is contained in its DNA, the building blocks of life.

Genome sequencing

- Genome sequencing is a state-of-art, robust and high throughput technique to sequence the entire genome of an organism. It enables scientists to study the entire genetic composition of an organism.



Gene vs genome sequencing:

Gene sequencing	Genome sequencing
Sequence a gene of only some thousand base pairs.	Sequence the entire genome of an organism.
Provides information of a protein-coding gene and related alterations.	Provides information regarding different genes, non-coding regions, introns, exons, transposons and other genomic components.
Technically a more straightforward process includes DNA extraction, amplification, sequencing and reading.	Technically more complex processes including DNA extraction, amplification, library preparation, adapter ligation, sequencing, contig and reading.
Handy and cost-effective process.	Complex, costly, laborious and tedious process.



Hydrogen energy

- Hydrogen energy involves the use of hydrogen and/or hydrogen-containing compounds to **generate energy to be supplied to all practical uses needed with high energy efficiency**, overwhelming environmental and social benefits, as well as economic competitiveness.



Green hydrogen

Hydrogen will make up **12 per cent of the energy mix by 2050**, according to the International Renewable Energy Agency (IRENA).

Key points

- About **66 per cent** of this hydrogen used, **must come from water** instead of natural gas, the agency suggested
- Green hydrogen is **produced by electrolysis of water** using renewable energy and has a lower carbon footprint.
- **At present**, less than **1 per cent** of hydrogen produced is green hydrogen, according to IRENA's **World Energy Transitions Outlook**

**HIGH
CARBON**

**HIGH
CARBON**

**LOW
CARBON**

**GREEN
CARBON**

**BROWN
HYDROGEN**

Made from coal
CO₂ is emitted
into the
atmosphere

**GREY
HYDROGEN**

Made from
natural gas (CH₄)
CO₂ is emitted
into the
atmosphere

**BLUE
HYDROGEN**

Made from
natural gas (CH₄)
CO₂ is captured
and stored

**GREEN
HYDROGEN**

Made from
renewable energy
No CO₂ is emitted

Green hydrogen

India

- The country **consumes about six million tonnes of hydrogen** every year for the production of **ammonia and methanol in industrial sectors**, including fertilisers and refineries
- India has favourable geographic location and. **abundance of sunlight and wind for the production of green hydrogen**
- Green hydrogen production will also **reduce the country's dependence on imports** while also staving off climate change.



Green hydrogen

- **Green hydrogen** currently costs **\$5-6 per kilogram** (or Rs 371-446), which is nearly triple the cost of grey hydrogen, **according to a recent study**.
- **By 2030**, the cost of green hydrogen is expected to **compete** with that of hydrocarbon fuels.



Green hydrogen

- It is also projected that India's hydrogen demand **will increase five-fold by 2050**, with 80 per cent of it being green.
- The localisation of electrolyser production and the development of green hydrogen projects can create a new green technologies market in India worth \$18-20 billion and thousands of jobs
- India will become a **net exporter of green hydrogen by 2030** due to its cheap renewable energy tariffs, according to the Global Hydrogen Council.
- Green hydrogen can be **used in a wide range of existing applications** such as fertilisers, mobility, power, chemicals and shipping. Green hydrogen can be blended up to 10 per cent by city gas distribution networks for wider acceptance.



Hydrogen council

- The Hydrogen Council is a **global CEO-led initiative** that brings together **leading companies with a united vision** and long-term ambition for hydrogen to foster the clean energy transition.
- Using its global reach to **promote collaboration between governments, industry and investors**, it provides guidance on accelerating the deployment of hydrogen solutions around the world.



Hydrogen energy

- The Union Budget for 2021-22 has announced a **National Hydrogen Energy Mission (NHM)** that will draw up a road map for using hydrogen as an energy source



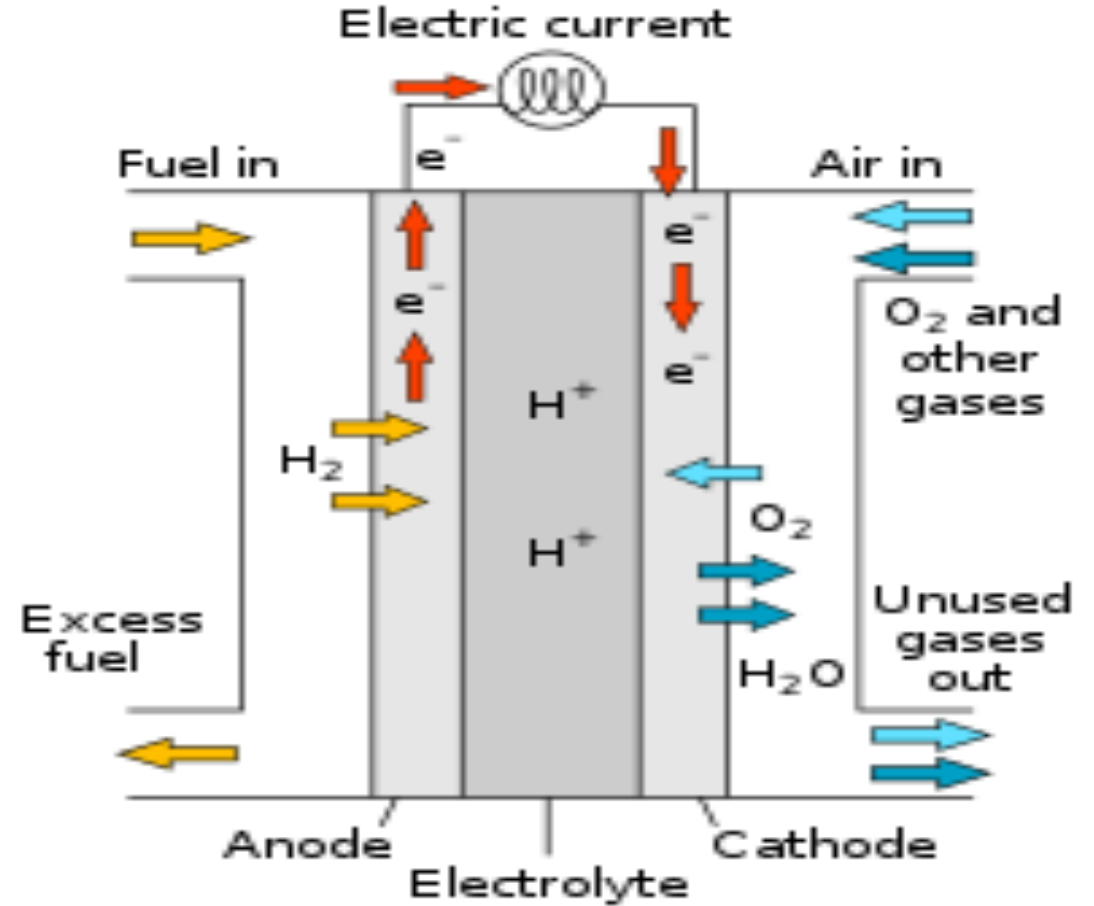
HCNG

- HCNG is a mixture of compressed natural gas (CNG) and some % Hydrogen by energy.
- **Delhi Government** has tied up with **Indian Oil Corporation Limited** to study the technology and infrastructure needs to induct **50 HCNG buses** on a trial basis.
- IOCL has plans to **mix (18-20) % Hydrogen** in these buses.



Fuel cell technology

- Fuel cells and batteries convert chemical energy into electrical energy



Fuel Cell Electric Vehicle

- The **Fuel Cell Electric Vehicle (FCEV)** combines hydrogen and oxygen to generate an electric current and **water is the only byproduct**.
 - **Hydrogen + Oxygen = Electricity + Water Vapour**
$$2\text{H}_2 (\text{g}) + \text{O}_2 (\text{g}) \rightarrow 2 \text{H}_2\text{O} (\text{l})$$
- **Fuel Cell Electric Vehicle (FCEV)** engines are **similar to the conventional internal combustion engines** because they also **rely on a constant supply** of fuel (hydrogen) and oxygen.
- However, there are **no moving parts** in the fuel cell, so they are **more efficient and reliable**.



'Ocean thermal energy conversion plant coming up in Lakshadweep'



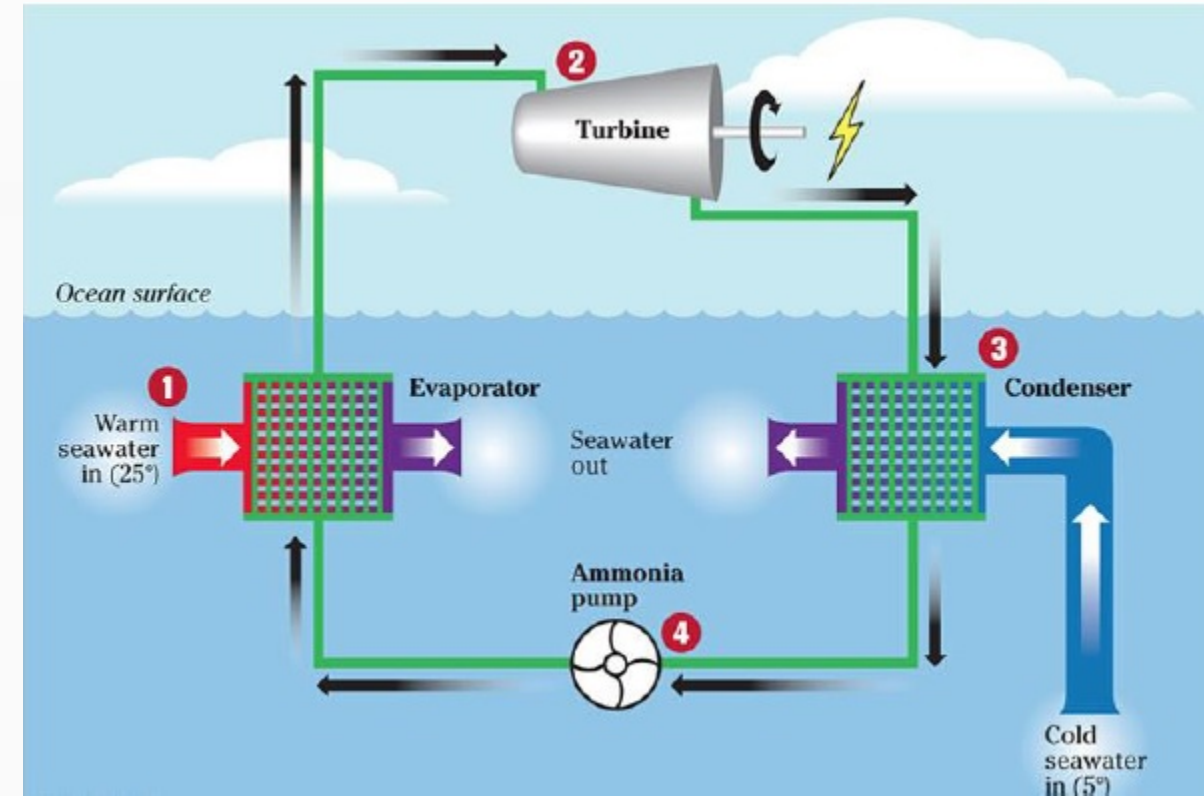
Sleepy Classes IAS
Awakening Toppers

- The **National Institute of Ocean Technology**, an autonomous institute under the Union **Ministry of Earth Sciences (MoES)** is establishing an Ocean Thermal Energy Conversion plant with a capacity of 65 kilowatt (kW) in Kavaratti, the capital of **Lakshadweep**.
- The plant will **power the one lakh litre per day low temperature** thermal desalination plant, which converts seawater into potable water.



'Ocean thermal energy conversion plant coming up in Lakshadweep'

- The National Institute of Ocean Technology, an autonomous institute under the **Union Ministry of Earth Sciences (MoES)** is establishing an Ocean Thermal Energy Conversion plant with a capacity of 65 kilowatt (kW) in Kavaratti, the capital of Lakshadweep.



'Ocean thermal energy conversion plant coming up in Lakshadweep'



Sleepy Classes IAS
Awakening Toppers

Ocean thermal energy conversion (OTEC)

- Ocean thermal energy conversion is process that uses the **difference between the warmer surface water and the deeper cold water** of the ocean to produce electricity.
- The **warm surface water is used to vaporize a fluid** with a low boiling point (such as ammonia).
- The vapor then expands and as **result spins a turbine with** a generator and produces electricity. The vapor is then cooled by the cold deep sea water and as result is condensed back to a liquid.
- This allows the fluid to be reused in this seemingly simple and continuous cycle.
- The ideal temperature range is about **41°F for the cold water and about 77°F for the warm water**.



'Ocean thermal energy conversion plant coming up in Lakshadweep'



Sleepy Classes IAS
Awakening Toppers

How does OTEC work?

- There are essentially two different kinds of OTEC plant, known as closed cycle and open cycle.

Closed cycle

- In closed-cycle OTEC, there is a long, **closed loop of pipeline filled with a fluid such as ammonia, which has a very low-boiling point (-33°C or 28°F)**. (Other fluids, including propane and various low-boiling refrigerant chemicals, have also been successfully used for transporting heat in OTEC plants.)
- The **ammonia never leaves the pipe: it simply cycles around the loop** again and again, picking up heat from the ocean, giving it up to the OTEC power plant, and returning as a cooled fluid to collect some more.



'Ocean thermal energy conversion plant coming up in Lakshadweep'



Sleepy Classes IAS
Awakening Toppers

Open cycle

- In open-cycle OTEC, the **sea water is itself used to generate heat** without any kind of intermediate fluid.
- At the **surface of the ocean**, **hot sea water is turned to steam** by **reducing its pressure** (remember that a liquid can be made to change state, into a gas, either by increasing its temperature or reducing its pressure).
- The steam **drives a turbine and generates electricity** (as in closed-cycle OTEC), before being condensed back to water using cold water piped up from the ocean depths.
- One of the very interesting byproducts of this method is that heating and condensing sea water removes its salt and other impurities, so the water that leaves the OTEC plant is pure and salt-free.
- That means open-cycle OTEC plants can double-up as **desalination plants**, purifying water either for drinking supplies or for irrigating crops. That's a very useful added benefit in hot, tropical countries that may be short of freshwater.



World's first nano liquid urea

Indian Farmers Fertilizer Cooperative Limited (IFFCO) recently launched the Nano Urea Liquid

- Indigenously developed at Nano Biotechnology Research Centre, Kalol, Gujrat

Indian Farmers Fertilizer Cooperative Limited (1967)

- **Cooperative societies** which is **wholly owned by Indian Cooperatives**.
- To enable Indian farmers to prosper through timely supply of reliable, high quality agricultural inputs and services in an environmentally sustainable manner



Nano Urea Liquid-a nutrient to provide nitrogen to plants as an alternative to the conventional urea

Advantages	Requirement	curtail the requirement of conventional urea by at least 50%
	Impact	Nano Urea liquid (40,000 ppm of nitrogen in a 500 ml bottle)= 1 bag of Conventional urea
	Price	10% cheaper than conventional Urea
	Effectiveness (delivering nitrogen to plants)	conventional Urea-30-40% Nano Urea liquid >80%
	Yield	8% increase (Tested on wheat & rice)

IFFCO NANO UREA LIQUID

Introducing World's First Nano Urea
for Farmers



**Reduces
Input Cost**



**Increases
Farmers' Income**



**Environment-
friendly**



**Enhances Crop
Productivity**



**Improves
Nutritional Value**

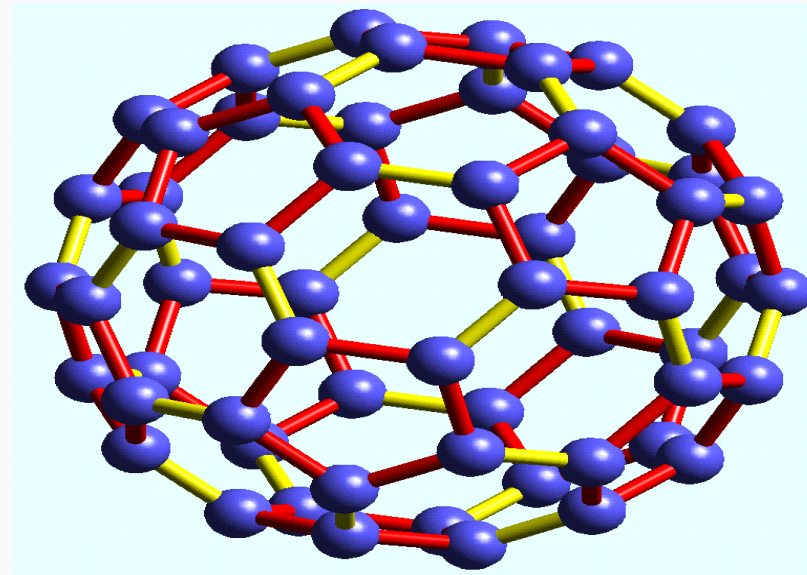
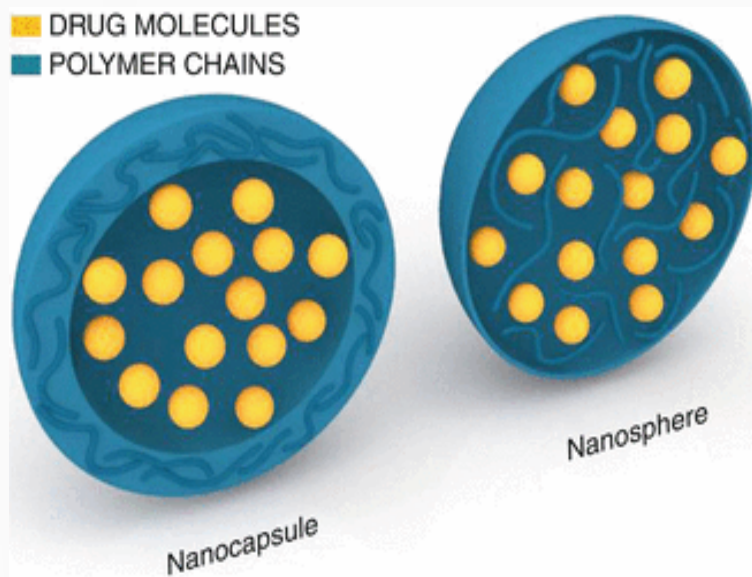


**Cheaper than
Conventional
Urea**



Nanotechnology-HEALTH

- **Quantum dots:** nanosized **semiconductors** that can be used as **biosensors to find disease**
- **Nanocapsules** are vesicular systems in which a drug is confined to a cavity surrounded by a **polymer membrane**
- **Nanospheres** are matrix systems in which the drug is physically and uniformly dispersed.
- **Buckyballs-Buckyballs:** spherical nanoparticles can carry more than one drug at a time.



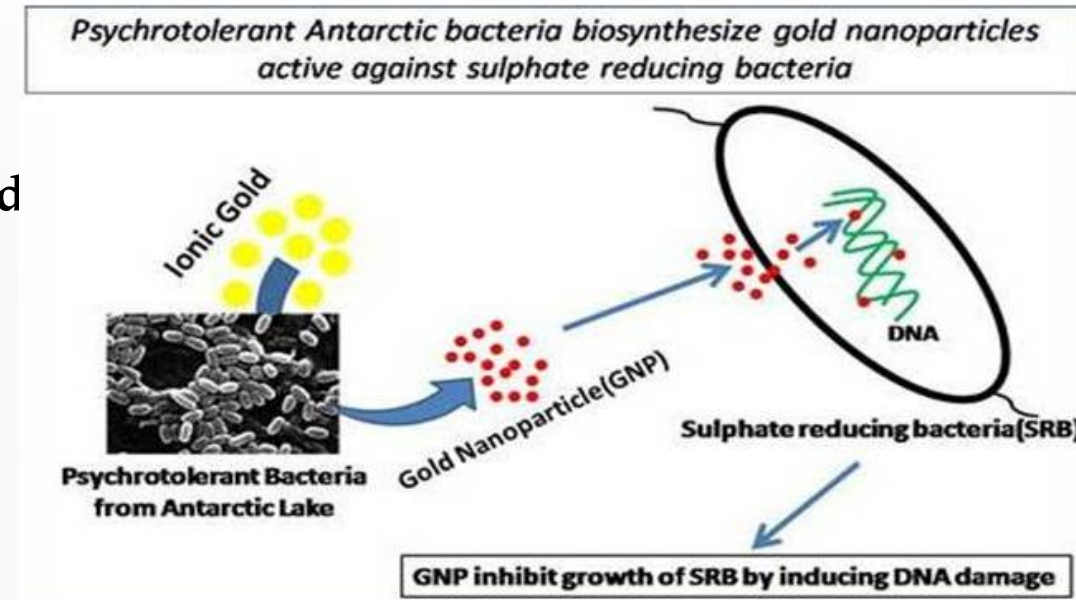
Gold nanoparticles (GNPs)

The National Centre for Polar and Ocean Research (NCPOR) and the Goa University (GU) have successfully synthesized gold nanoparticles (GNPs) using psychrotolerant Antarctic bacteria through a non-toxic, low-cost, and eco-friendly way.

- These GNPs can be used as a composite **therapeutic agent** in **clinical trials, especially in anti-cancer, anti-viral, anti-diabetic, and cholesterol-lowering drugs.**

Significance

- The NCPOR-GU study revealed **genotoxic effect** of GNPs on a sulphate reducing bacteria (SRB).
- The GNPs displayed enough **anti-bacterial properties** by **inhibiting the growth of SRB** and its **sulphide production** by damaging the genetic information of the DNA of the bacterial cell.
- **Genotoxicity** describes the property of a chemical agent that is capable of **damaging the genetic information of DNA** and thus causing mutation of the cell, which can lead to cancer.



Gold nanoparticles (GNPs)

Gold Nanoparticles

- Gold nanoparticles are made up of metallic gold atoms to create a crystal structure of 1-100 nm.

Synthesis of gold nanoparticles

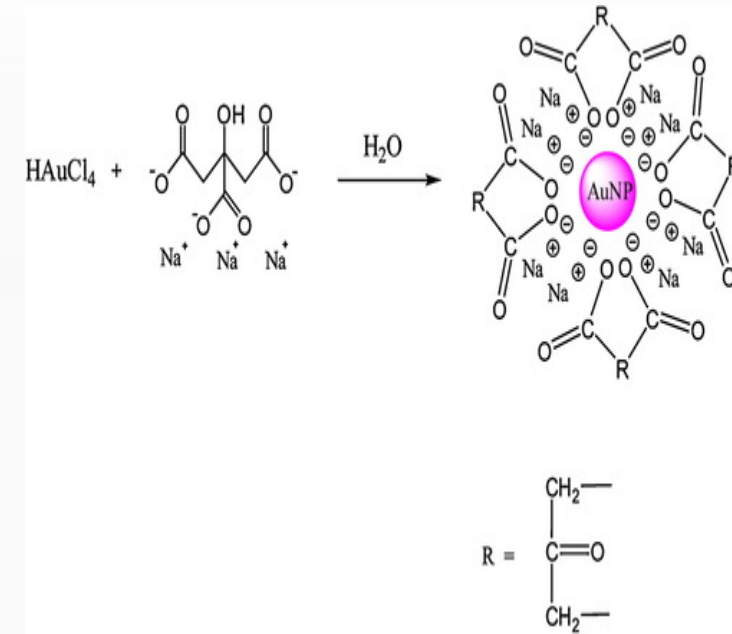
Chemical method

- Generally, the preparation of AuNPs by the chemical reduction method

Electrochemical method

Biological method

- Bacteria, algae, fungi or plants are used to reduce gold to its metallic state through various biological processes.



Country's First Graphene Innovation Centre

- The state-run **Digital University Kerala** (DUK) along with CMET Trichur, & Tata Steel Limited set India's first graphene R&D incubation centre in **Trichur (Kerala)**.

About The Centre

- The **Ministry of Electronics and IT** has given approval for Rs 86.41 crore-project. Of the 86.41-crore, **Union Government would provide Rs 49.18 crore** and private business houses Rs 11.48 crore. The state government would provide the basic infrastructure for the project. The Centre would help attract investors to **develop graphene products**.

Country's First Graphene Innovation Centre

- The centre aims to be an anchor point to promote start-ups, commercial research & to bridge the gap between Graphene academic research and industrial application.
- The centre will also develop the skilled manpower by anchoring Ph.D. and master students through Digital University, with an applied research focus in the areas of electronics product design, sensors, and energy applications dApps

Carbon nanotubes

Graphene (Strongest material)

- Single layer of carbon atoms.
- It is harder than diamond yet more elastic than rubber
- Tougher than steel yet lighter than aluminium.
- Lowest resistivity substance known at room temperature.
- High thermal stability.
- High elasticity.
- High electrical conductivity.
- Electron mobility is high at room temperature.

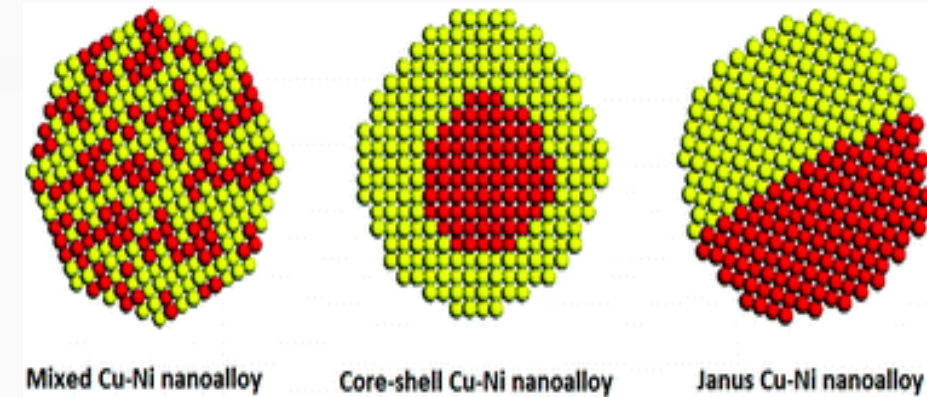


Core-shell nanocluster alloys

Scientists have used **machine learning** to develop a design map of **alloys at the nanoscale** which can help predict the match of pairs of metals that can form bimetallic nanoalloys.

Core-shell nanocluster alloys

- Are those nano alloys in which **one metal forms the core** and **another stays on the surface like a shell**.



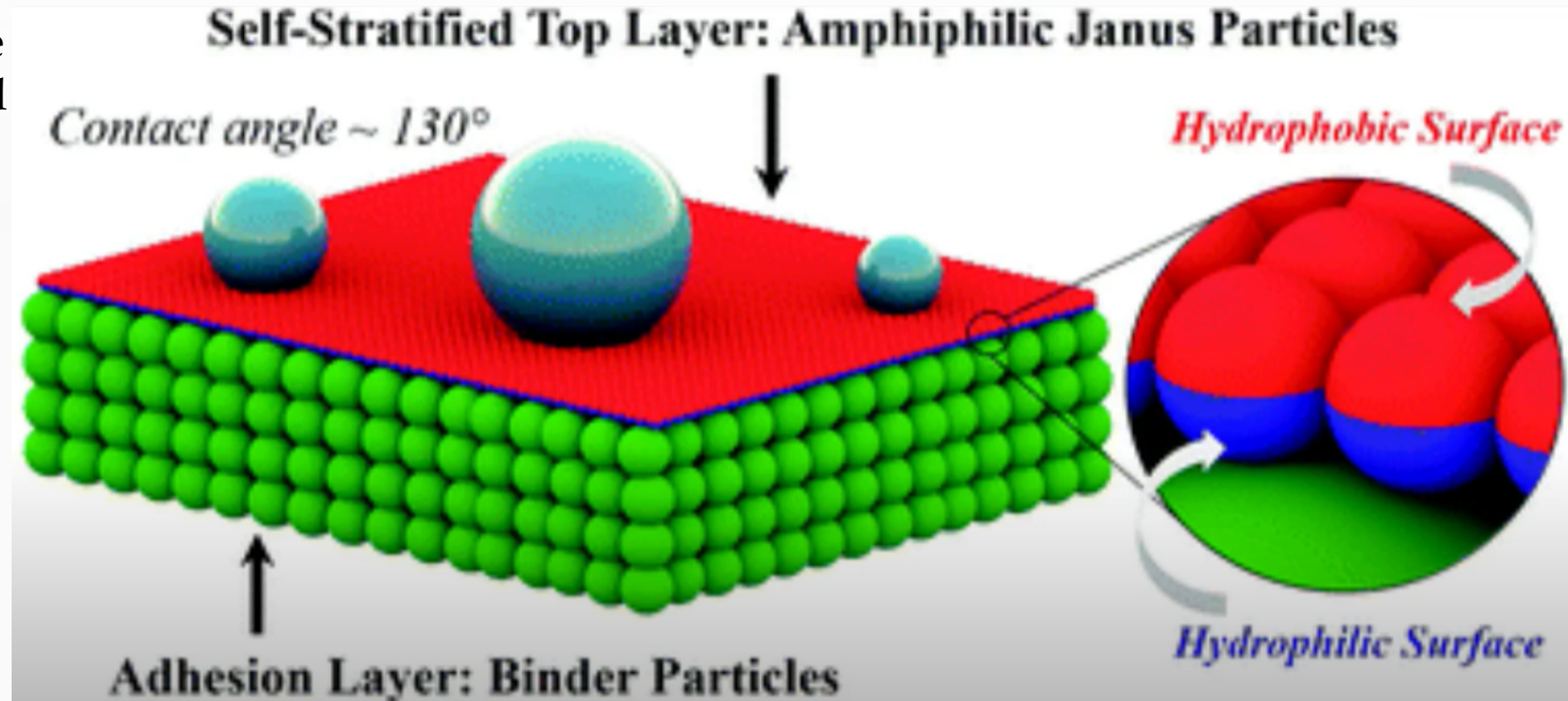
Core-shell nanocluster alloys

Problem with Nanoalloys

- It is important to know **under what conditions core-shell structures are formed in the nanocluster alloys** and which metal forms the core and which stays on the surface like a shell.
- A number of factors like **energy difference, atomic radius difference, surface energy difference and electronegativity** of the two atoms may play a part in the core and shell preference of the atoms.
- But **machine learning** can be programmed to predict the behaviour of these pairs. The machine is taught to recognise patterns by feeding in a number of patterns with well-defined attributes.
- However, scientists faced a stumbling block as Machine Learning could not be applied with confidence on small data sets of sizes less than or around 100.



Janus particles, which are named after the two-faced Roman god Janus, have two distinct sides with different surface features, structures, and compositions.



Carbon dots: A futuristic solution for sustainably managing aquatic environment?

Modern technology like nanomaterials or carbon dots (CD) might be the solution to environmental issues like water pollution.

Carbon dots

- CDs are one of the **youngest members of the carbon nanomaterial** family. They were discovered in 2004 and have an average diameter of less than 10 nanometres.
- They are **inexpensive, highly biocompatible**, and environment-friendly.

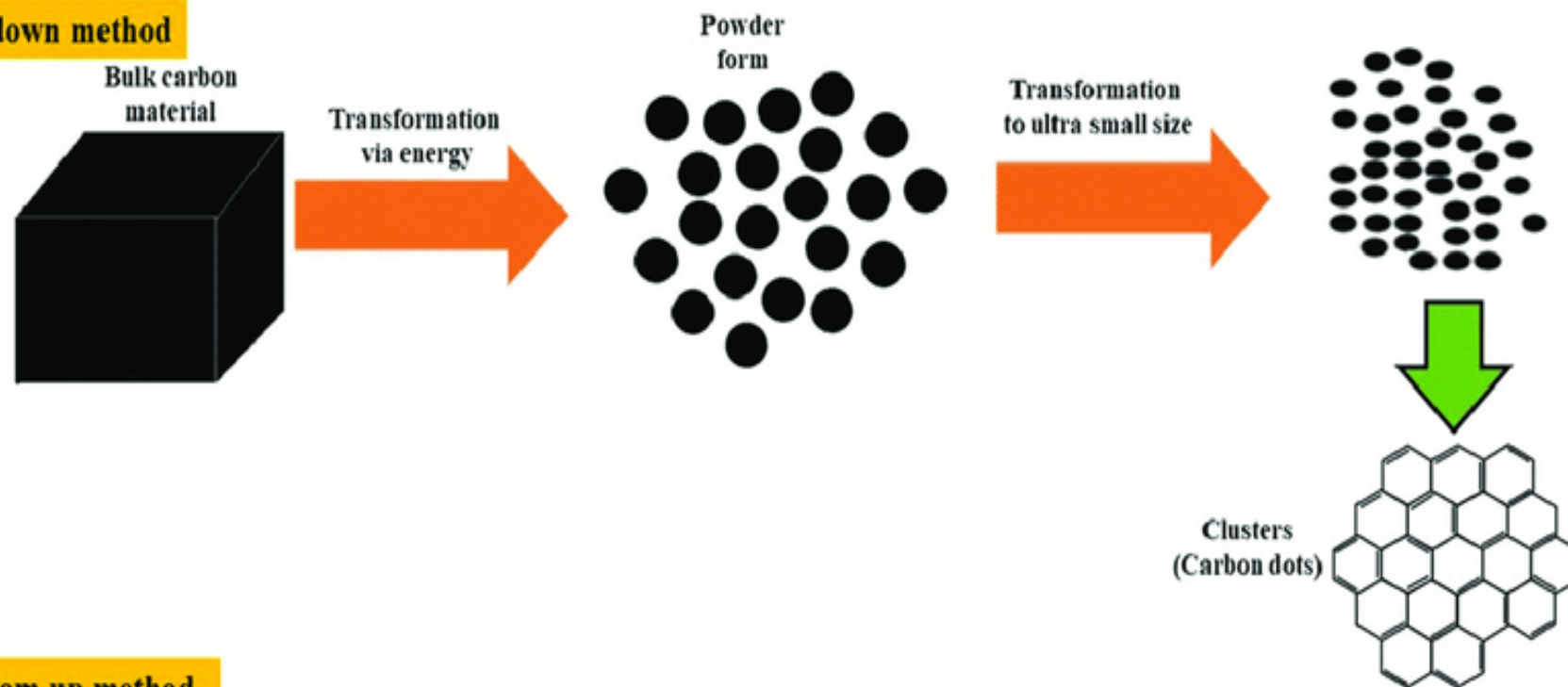


Carbon dots-Significance

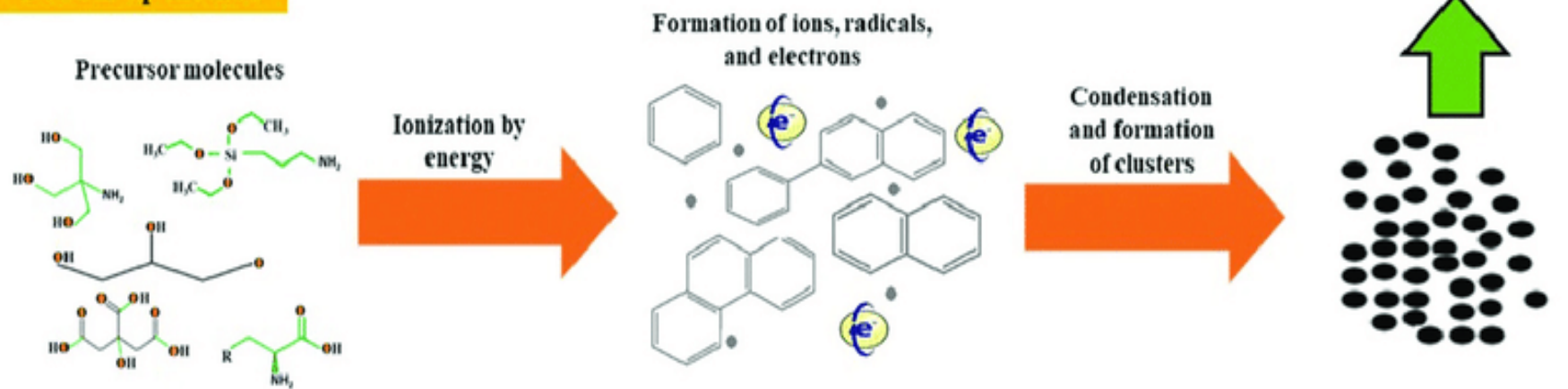
Are youngest members of the carbon nanomaterial family discovered in 2004 and have an average diameter of less than 10 nanometres.

Pollution detection	<ul style="list-style-type: none"> Used as a fluorescent nanoprobe for pollutant detection because of their high fluorescence emission. 	
Adsorption capacity	<ul style="list-style-type: none"> Provide many surfaces adsorption sites due to their small size and large specific surface area. 	
Water treatment	<ul style="list-style-type: none"> They are promising nano-fillers in fabricating thin-film nanocomposite membranes where they can form chemical bonds with other compounds. 	
Antimicrobial action	<ul style="list-style-type: none"> Contact with the bacteria cell under visible or natural light could efficiently generate reactive oxygen species. This can damage DNA or RNA, causing bacteria death 	
Green synthesis of CDs	Top-down approach	<ul style="list-style-type: none"> It converts large carbon structures into quantum-sized carbon dots by laser ablation, arc discharge, and chemical or electrochemical oxidation.
	Bottom-up approach	<ul style="list-style-type: none"> are produced from carbonising small molecule precursors by pyrolysis, carbonisation, hydrothermal processes or microwave-assisted synthesis

(A) **Top down method**



(B) **Bottom up method**



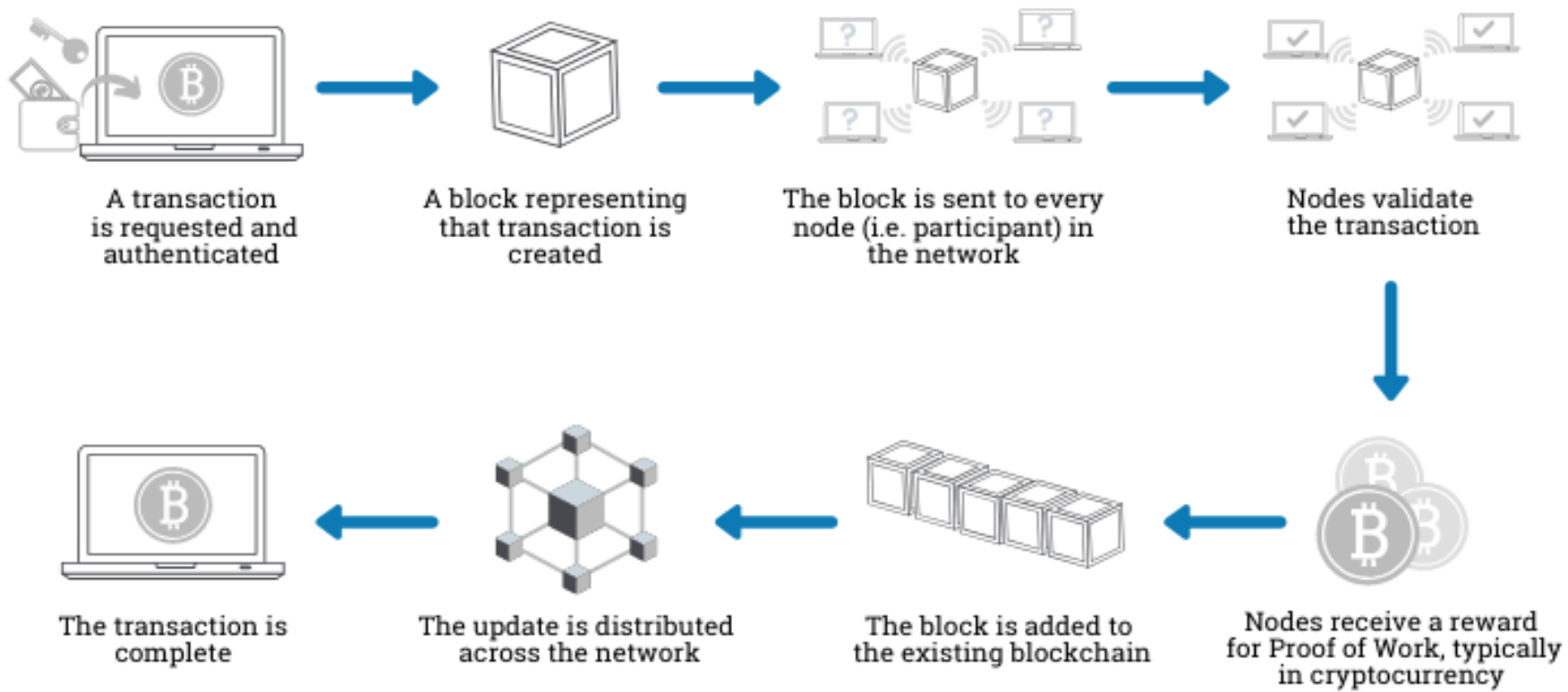
Ethereum Merge

- Ethereum, the world's second most valuable cryptocurrency, has **completed a significant software overhaul** which promises to ramp up security of the cryptocurrency while claiming to **cut down on its carbon footprint, nearly entirely**.

The Merge

- The revamp, known as 'The Merge,' will cast aside the need for crypto miners and gigantic mining farms, who had **previously driven the blockchain under a mechanism called 'proof-of-work' (PoW)**. Instead, it has now **shifted to a 'proof-of-stake' (PoS) mechanism** that assigns 'validators' randomly to approve transactions and earn a small reward.
- The move to PoS will **reduce ethereum's energy consumption** by nearly 99.95 per cent, according to the Ethereum Foundation, a non-profit organisation dedicated to supporting the cryptocurrency and its related technologies.







Proof of Work

vs.

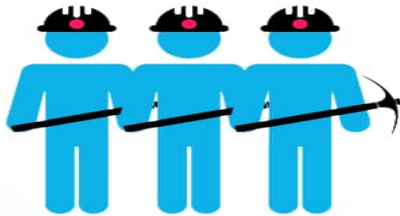
Proof of Stake



To add each block to the chain, miners must compete to solve a difficult puzzle using their computers processing power.



In order to add a malicious block, you'd have to have a computer more powerful than 51% of the network.



The first miner to solve the puzzle is given a reward for their work.



There is no competition as the block creator is chosen by an algorithm based on the user's stake.



In order to add a malicious block, you'd have to own 51% of all the cryptocurrency on the network.



There is no reward for making a block, so the block creator takes a transaction fee.

Ethereum Merge

What has exactly changed?

- Ethereum is a **decentralised cryptocurrency**, meaning that it does not have institutions like banks approving the transactions that happen on its network – the approvals were **earlier happening under the PoW consensus mechanism** which was essentially done by miners.
- **Miners** would **compete to solve complex mathematical puzzles** using a massive infrastructure of cutting edge computer hardware, and the first one to solve the puzzle would be chosen as the **validator**.
- This method was almost entirely dependent on crypto farms, which are massive warehouses lined with rows of computers which would solve the puzzles.
- There was, however, **one big problem** – these mining farms were **energy guzzlers**, leading to one of the biggest criticisms of the crypto industry that they sometimes consumed more electricity than entire countries, and were therefore a **big concern in terms of environmental sustainability**.



Ethereum Merge

- Enter 'The Merge' and the **shift to the PoS consensus mechanism**. Ethereum is still a decentralised platform, but under the new concept, it would **not need miners and mining farms to authenticate transactions anymore**.
- Instead, a validator will be **randomly assigned using an algorithm** from a **pool of people who 'stake' their coins**, which essentially means **pledging at least 32 Ethereum tokens on the network**. This would entirely eliminate the need for miners on the Ethereum network.



Ethereum Merge

Why is the 'Merge' important?

- The Merge dramatically **increases the security of Ethereum**. An attacker needs **51% of the blockchain's value** to [take control].
- With **Proof of Work**, you need on the order of **\$5 billion**, which allows you to buy enough computers and transformers, connect all of them to the grid, and then carry out an attack.
- With **Proof of Stake**, we will have about **\$20 billion** in economic security today – and this is a number I expect will grow dramatically.”
- Apart from that, it is also being seen as an **environmentally conscious** move as Ethereum is expected to now consume 99 per cent or so less energy.
- Given that some of the most popular applications of cryptocurrencies such as **non-fungible tokens (NFTs)** and **decentralised finance (DeFi)** are based on the Ethereum network, the overhaul could have far-reaching consequences in the future.



What's next for Ethereum?

Surge	<ul style="list-style-type: none"> This refers to the addition of Ethereum sharding, which promises to process transactions on the network much faster than now. Sharding basically means dividing transactions across several different chains in a way that will decrease fees and speed up transactions. "By the end, ethereum will be able to process 100,000 transactions per second"
Verge	<ul style="list-style-type: none"> Called "Verkle trees" and "stateless clients," which will allow users on the network to become validators without having to store extensive amounts of data on their machines.
Purge	<ul style="list-style-type: none"> Involve purging old network history. The purge: trying to actually cut down the amount of space you have to have on your hard drive, trying to simplify the Ethereum protocol over time and not requiring nodes to store history
Splurge	<ul style="list-style-type: none"> It aims at making sure that the network continues to run smoothly and that the updates to the protocol in the previous sections do not cause any issues.



Non fungible tokens (NFTs)

- Anything that can be **converted into a digital form** can be an NFT.
- Everything from your **drawings, photos, videos, GIF, music, in-game items, selfies, and even a tweet** can be turned into an NFT, which can then be **traded online using cryptocurrency**.
- But what makes NFTs unique from other digital forms is that it is **backed by Blockchain technology**.
- For the uninitiated, Blockchain is a distributed ledger where all transactions are recorded.
- It is **like your bank passbook**, except all your transactions are transparent and can be **seen by anyone and cannot be changed or modified once recorded**.



Non fungible tokens (NFTs)

How do NFTs work?

- NFT works on blockchain as it gives users **complete ownership of a digital asset**.
- For instance, **if you're a sketch artist, and if you convert your digital asset to an NFT**, what you get is proof of ownership, powered by Blockchain.

Non fungible tokens (NFTs)

How is an NFT different from cryptocurrency?

- **NFTs and cryptocurrencies are very different** from each other. While both are built on Blockchain, that is where the similarity ends.
- **Cryptocurrency is a currency and is fungible**, meaning that it is interchangeable. For instance, if you hold one crypto token, say one Ethereum, the next Ethereum that you hold will also be of the same value.
- **But NFTs are non-fungible, that means the value of one NFT is not equal to another.** Every art is different from other, making it non fungible, and unique.

Blockchain gaming

- **Context:**Over the past several years, the gaming industry has become increasingly interested in blockchain technology because of its huge reach and potential. This is something that gaming industries are looking at in India as well.
 - Blockchain Gaming is a term used to describe online video games that have been made by using blockchain technology into their development. There are aspects that make use of **cryptography-based blockchain technologies, such as cryptocurrency or non-fungible tokens, under this category (NFTs).**

Blockchain gaming

- Using these aspects, **users can purchase, sell, or trade with other players**, with the game publisher receiving a fee from each transaction as a form of monetization.
- An example of a blockchain game In 2017, Dapper Labs released **Crypto Kitties**, which was the world's first blockchain game.
- People can **virtually adopt and breed a cat (CryptoKittie)** in the game, without having to take on the responsibility of bringing a cat into their home. Non-Fungible Tokens (also known as "NFTs") are used to represent each CryptoKittie.



Blockchain gaming

Elements of Blockchain Gaming

- **Non-Financial Transactions (NFTs)** Player-owned virtual assets such as maps, armour, and land are represented by NFTs in-game, which can be acquired by them. These NFTs serve as asset tags, identifying who owns certain in-game items, and are maintained on the blockchain as a kind of data storage.
- A **blockchain-based system provides a safe record of ownership for the player**, as well as the possibility for assets to outlive their respective games. It also promotes transparency, as ownership records can be independently checked by any third party.



Blockchain gaming

- It accomplishes this by making in-game assets marketable and establishing a decentralised market where they can be purchased and sold by players alike.
- Coins based on the **Ethereum blockchain**, as well as **other forms of cryptocurrency**, may be used to **acquire in-game assets**. These in-game purchases typically allow gamers to purchase products such as additional lives, coins, and other in-game assets straight from the game.

Fusion energy breakthrough

Scientists in the United States have, for the first time, **achieved a net gain in energy from a nuclear fusion reaction**, seen as a big step forward in the decades-old endeavour to master a technology that is considered the most dependable source of energy in future.

Fission Vs Fusion energy

- The nuclear energy currently in use across the world comes from the **fission process**, in which the **nucleus of a heavier element is split into those of lighter elements** in a controlled manner.
- In **fusion**, nuclei of **two lighter elements are made to fuse together** to form the nucleus of a heavier atom.



Fusion energy breakthrough

- A large amount of energy is released in both these processes, but substantially **more in fusion than fission**.
- For example, the **fusion of two nuclei of a heavier isotope of hydrogen, called tritium**, produces at **least four times as much energy** as the fission of a **uranium atom** which is the normal process of generating electricity in a nuclear reactor.
- Besides greater energy yield, **fusion is also a carbon-free source of energy, and has negligible radiation risks**.



Fusion energy breakthrough

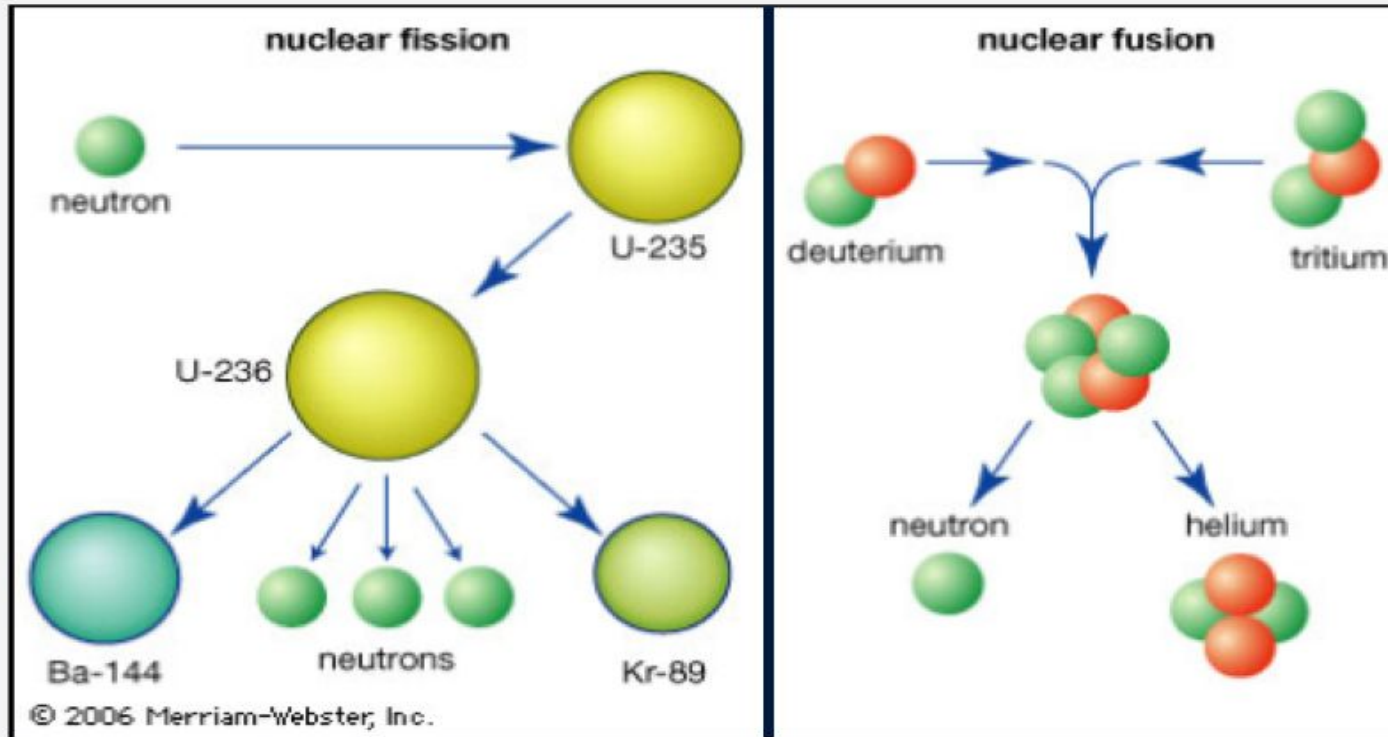
- **Fusion is a different, but more powerful,** way of harnessing the immense energy trapped in the nucleus of an atom. This is the process that makes the **Sun and all other stars shine and radiate energy.** Attempts to master the fusion process have been going on at **least since the 1950s,** but it is incredibly difficult and is still at an experimental stage.

Fusion still far from reality

- Significant though the achievement is, it does little to bring the goal of producing electricity from fusion reactions any closer to reality. By all estimates, use of the fusion process for generating electricity at a commercial scale is **still two to three decades away.** The technology used in the US experiment might take even longer to get deployed.



NUCLEAR FISSION VS. NUCLEAR FUSION



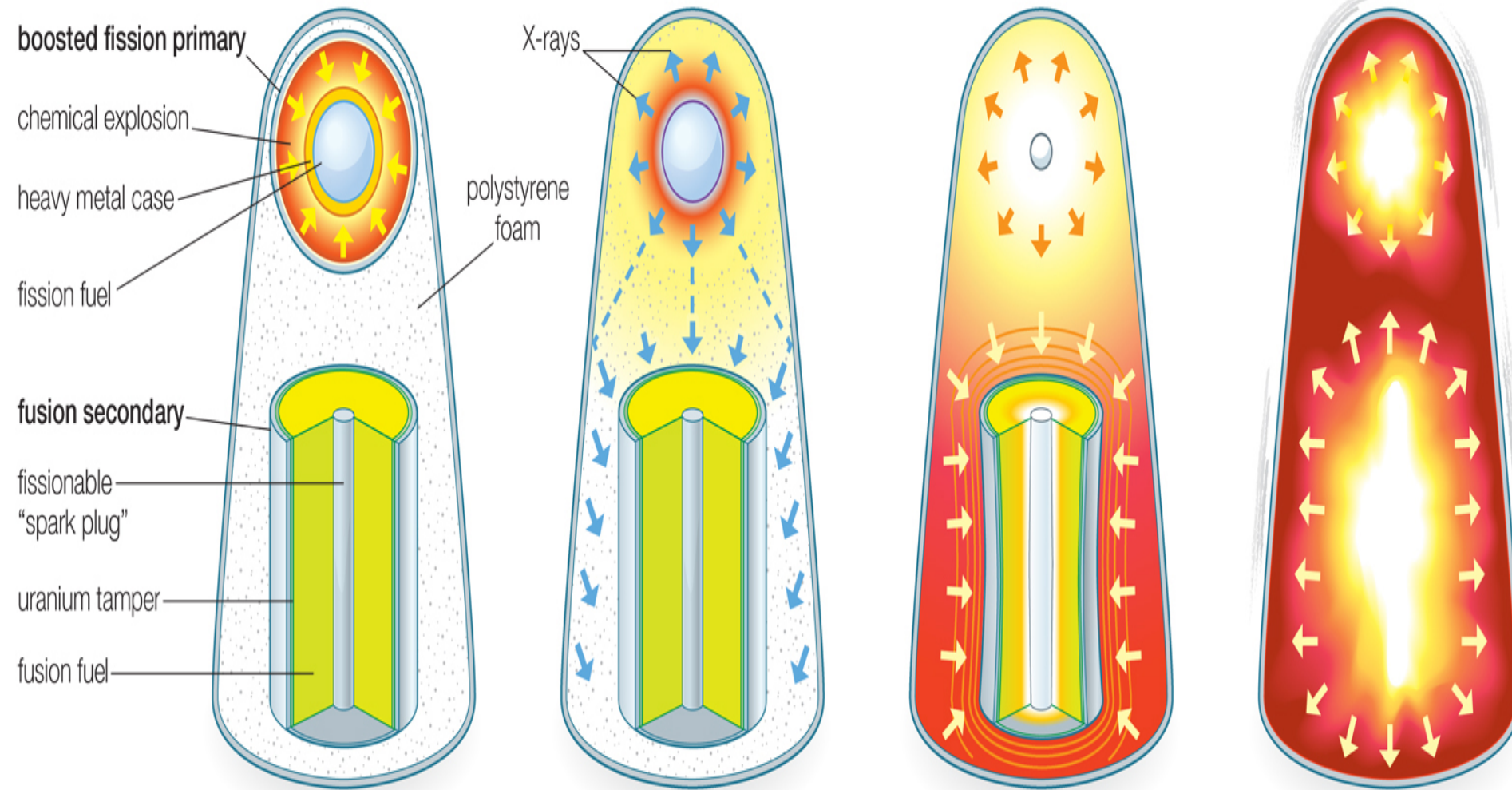
Top: Uranium-235 combines with a neutron to form an unstable intermediate, which quickly splits into barium-144 and krypton-89 plus three neutrons in the process of nuclear fission. Bottom: Deuterium and tritium combine by nuclear fusion to form helium plus a neutron.

ITER (International Thermonuclear Experimental Reactor)

- ITER (International Thermonuclear Experimental Reactor) is an **international nuclear fusion research and engineering megaproject**, which will be the world's largest magnetic confinement plasma physics experiment.
- It is a collaboration of **35 nations** launched in **1985**.
- It is located in **France**.
- It aims to build the world's **largest tokamak** to prove the feasibility of fusion as a large-scale and carbon-free source of energy.
- The ITER members include China, the European Union, **India**, Japan, South Korea, Russia and the United States



Teller-Ulam two-stage thermonuclear bomb design



1. Chemical explosion compresses fission fuel to initiate fission.

2. X-rays from primary are reflected by casing and heat foam.

3. Foam, now a plasma, compresses secondary; fissionable "spark plug" ignites.

4. Fusion fuel ignites.

Artificial Sun

China's Experimental Advanced Superconducting Tokamak (EAST), which mimics the energy generation process of the sun, **set a new record after it ran at 216 million degrees Fahrenheit (120 million degrees Celsius)** for 101 seconds

- For **another 20 seconds**, the “artificial sun” also achieved a **peak temperature of 288 million degrees Fahrenheit** (160 million degrees Celsius), which is over ten times hotter than the sun

Artificial sun - Experimental Advanced Superconducting Tokamak (EAST)

- It is an advanced **nuclear fusion** experimental research device located at the Institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP) in **Hefei, China**
- The purpose of the artificial sun is to replicate the process of nuclear fusion, which is the same reaction that powers the sun.
- EAST project is **part of the International Thermonuclear Experimental Reactor (ITER) facility**



Artificial Sun

Artificial sun (EAST)- working

- Designed to replicate the nuclear fusion process
- Nuclear fusion is a process through which high levels of energy are produced without generating large quantities of waste.
- For nuclear fusion to occur, tremendous **heat and pressure are applied on hydrogen** atoms so that they fuse together.
- The nuclei of **deuterium and tritium** — both found in hydrogen — are made to fuse together to create a helium nucleus, a neutron along with a whole lot of energy



Artificial Sun

- Fuel is heated to temperatures of over 150 million degrees C so that it forms a **hot plasma “soup”** of subatomic particles.
- With the help of a strong **magnetic field**, the plasma is kept away from the walls of the reactor to ensure it does not cool down and lose its potential to generate large amounts of energy.
- The plasma is confined for long durations for fusion to take place.



Artificial Sun

Significance

- The EAST reactor set a new record when it achieved a plasma temperature of 216 million degrees Fahrenheit and also managed to run for 20 seconds at 288 million degrees Fahrenheit.
- To put this in perspective, the sun's core only reaches about 15 million degrees Celsius, which means the reactor was able to touch **temperatures that are 10 times hotter than that**
- In 2020, **South Korea's KSTAR** reactor set a new record by maintaining a plasma temperature of over 100 million degrees Celsius for 20 seconds
- Produce clean and limitless energy, with minimal waste products



Anti-radiation pills

- With fears of a nuclear disaster at **Ukraine's Zaporizhzhia power plant** growing, the European Union has decided to pre-emptively supply 5.5 million anti-radiation pills to be distributed among residents in the vicinity.



Anti-radiation pills

What are anti-radiation pills?

- **Potassium iodide (KI) tablets**, or anti-radiation pills, are known to provide some **protection** in cases of radiation exposure.
- They contain **non-radioactive iodine** and can help block absorption, and subsequent concentration, of radioactive iodine in the thyroid gland.



Bharat Drone Mahotsav 2022

- PM inaugurates India's **biggest Drone Festival - Bharat Drone Mahotsav 2022**
- He also interacted with **Kisan drone pilots**, witnessed open-air drone demonstrations and interacted with startups in the drone exhibition centre.

Drone Rules, 2021

- The Central Government on 25th August 2021 has promulgated liberalised '**The Drone Rules, 2021 replacing the erstwhile Unmanned Aircraft System Rules 2021**



Govt efforts (Drone technology)	
Drone rules 2021	For regulation
Drone Mahotsav	Promotion of drone technology
PLI Scheme for Drones	Govt approved a Production-Linked Incentive (PLI) scheme for Drones and their components with an allocation of Rs. 120 crore for three financial years.
Drone Shakti Scheme	The Union Budget pushed on drone promotion via startups and skilling at the Industrial Training Institutes (ITIs). Startups will be encouraged to facilitate 'Drone Shakti' via varied applications and Drone-As-A-Service (DrAAS) . Skill-development courses will also begin in selected ITIs across all states.
Recent updates	<p>The Ministry of Commerce and Industry's Directorate General of Foreign Trade (DGFT) recently banned the import of foreign drones.</p> <p>The import of drone components, on the other hand, is not banned and will not require any approvals. Drone imports for defence and security purposes will also be allowed, subject to DGFT approval. The initiative aims to promote made in India drones.</p>



Definition and Classification of Drones

Drone	An unmanned aircraft system ("UAS"), that can operate autonomously or can be operated remotely without a pilot on board	
Classification	Nano drone	Less than or equal to 250 grams;
	Micro drone	Greater than 250 grams and less than or equal to 2 kilograms
	Small drone	Greater than 2 kilograms and less than or equal to 25 kilograms
	Medium drone	Greater than 25 kilograms and less than or equal to 150 kilograms
	Large drone	Greater than 150 kilograms
If larger than 500 kg	Provisions of the Aircraft Rules, 1937 shall apply instead of the Drone Rules	



Drone rules 2021

Reduced the red-tape involved in the process of seeking compliance:

Number of forms have been reduced from 25 to 5.

The types of fee have been reduced from 72 to 4.

Quantum of fee has been reduced to nominal levels and delinked with size of drone

Easier process is specified for transfer and deregistration of drones through the digital sky platform.

Nano and model drones (made for research or recreation purposes) are exempt from type certification.

Coverage of drones under Drone Rules, 2021 has been increased from 300 kg to 500 kg. This will cover drone taxis also.

No restriction on foreign ownership in Indian drone companies



Drone rules 2021

Scope of Operation	<p>The Rules cover all persons owning or possessing, or engaged in leasing, operating, transferring or maintaining a drone in India and all drones that are registered in India</p> <p>It seeks to regulate only the civilian usage of Drones and does not apply to drones used by the naval, military or air forces of the Union</p>
Digital sky platform	<p>The Rules have established an online platform hosted by the Directorate General of Civil Aviation ("DGCA"), for the management of various drone-related activities in India. The Platform seeks to provide a single-window online system</p>
Drone Certification	<p>Director General or any entity authorised by DG, on the recommendation of the Quality Council of India or an authorised testing entity</p>
Drone Registration	<p>In addition to Drone Certification, the Rules mandate the registration of individual drones on the Platform and obtaining a Unique Identification Number</p>

Drone rules 2021

Remote Pilot License	Rules restrict the operation of a drone by any person other than a holder of a valid Remote Pilot Licence (RPL) enlisted on the Platform. An RPL is not required for a person operating a nano drone or operating a micro drone for non-commercial purposes.
Criteria for RPL	Not less than eighteen years of age and not more than sixty five years of age;
	Have passed class tenth or its equivalent examination from a recognised Board;
	Have completed the training prescribed by the DG for the applicable class of remote pilot licence from an authorised remote pilot training organisation.
Insurance	The Rules require third party insurance of drones for compensation in case of damage to life and/or property caused by a UAS/drone
Offences & Penalties	Any contravention of the Rules is a punishable offence under the Rules. In addition to this, any contravention may attract a penalty of up to a maximum of one lakh rupees under Section 10A Aircraft Act, 1934

Drone rules 2021

Safety and security features

Carriage of arms, ammunition, explosives and military stores, etc is prohibited.

No permission-no takeoff' (NPNT), real-time tracking beacon, geo-fencing etc. to be notified in future

Any **accident** involving drones should be reported within 48 hours

DGCA shall prescribe drone training requirements, oversee drone schools and provide pilot licences online.



Drone (Amendment) Rules 2022

Remote Pilot License	abolished the requirement of a drone pilot license
Remote Pilot Certificate	The Remote Pilot Certificate issued by a Directorate General of Civil Aviation approved drone school through the single window Digital Sky platform will be sufficient for operating drones in the country.
unique identification number	An individual owning any unmanned aircraft system manufactured in India or imported into India on or before 30th of November, 2021 must make an application to register and obtain a unique identification number and state the required details in form D-2 and the stipulated fee under Rule 46
Import	To promote Made in India drones, the import of foreign drones has been prohibited in the country.

Airspace map of India

The **Ministry of Civil Aviation** has launched an airspace map of India for drone operations

About

- The airspace map shows red, yellow and green zones across India, allowing civilian drone operators to check the demarcated no-fly zones or where they need to undergo certain formalities before flying one
- This map has been **developed by MapMyIndia and IT services firm Happiest Minds** and is put up on the Directorate General of Civil Aviation's (DGCA) digital sky platform.



Green Zone	Yellow Zone	Red Zone
<ul style="list-style-type: none"> Green zone is the airspace up to 400 feet that has not been designated as a red or yellow zone, and up to 200 feet above the area located between 8-12 km from the perimeter of an operational airport. 	<ul style="list-style-type: none"> Yellow zone is the airspace above 400 feet in a designated green zone, and above 200 feet in the area located between 8-12 km from the perimeter of an airport, and above ground in the area located between 5-8 km from the perimeter of an airport. The Yellow zone has been reduced from 45 km earlier to 12 km from the airport's perimeter. 	<p>Red zone is the 'no-drone zone'</p>
<ul style="list-style-type: none"> No permission is required for operating drones with an all-up weight of up to 500 kg 	<ul style="list-style-type: none"> Require permission from the concerned air traffic control authorities – which could be either the Airports Authority of India, the Indian Air Force, the Indian Navy, Hindustan Aeronautics Ltd, etc as the case may be. 	<ul style="list-style-type: none"> Drones can be operated only after a permission from the Central government.

