APPSC GROUP 1

SCIENCE AND TECHNOLOGY

Published visual collection

Updated through Day 32

44 topics | 412 teaching panels

Day-wise topic index with clickable links and PDF bookmarks.

Approved teaching artwork is preserved without redesign.

One current index replaces the earlier stacked historical indexes.

No lesson notes or practice questions are included.

Updated 14 November 2026

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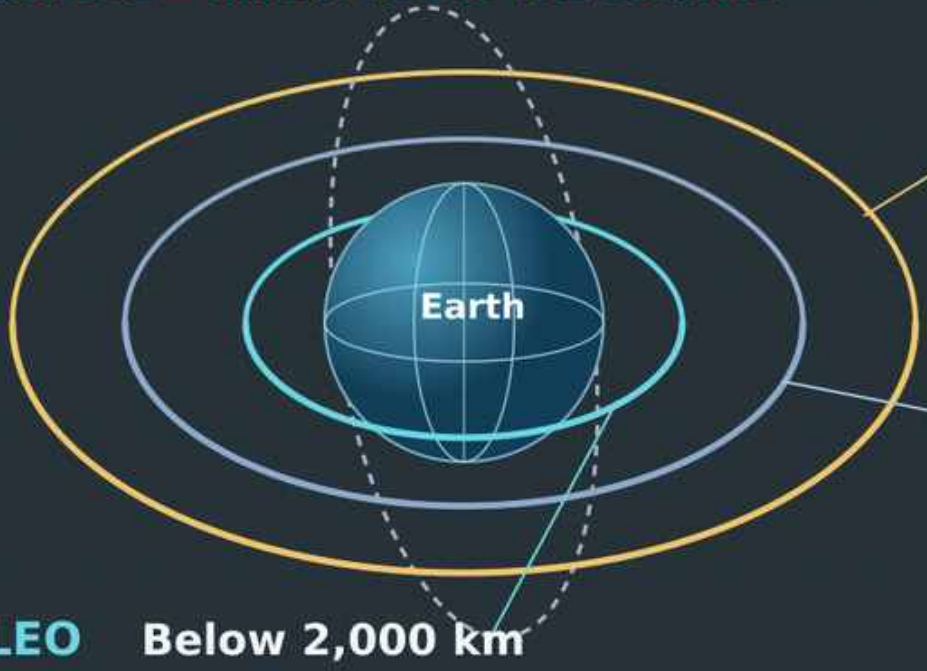
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Day 1 · Topic 7 · S&T · Item 20

Choose the orbit for the job

Altitude, tilt and shape describe different things

ALTITUDE = HEIGHT ABOVE THE SURFACE



GEO
35,786 km
Comms / weather
1 sidereal day

MEO
Above LEO,
below GEO
GPS: ≈12 h

LEO **Below 2,000 km**
Close imaging, crewed stations
ISS example: ≈400 km; ≈90 min



TILT / ORIENTATION
Polar: near the poles
Can also be in LEO



SHAPE
Circle or
ellipse

Sources: ESA orbit definitions; NASA orbit catalogue
Every orbit drawing is schematic, not to scale

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1/6 · ENGLISH

Day 1 · Topic 7 · S&T · Item 20

Same period. Different ground motion.

Geostationary is a special case of geosynchronous

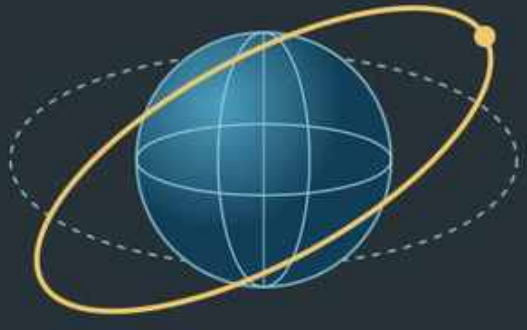
GEOSTATIONARY



Circular · equatorial · prograde

One fixed ground point

INCLINED GEOSYNCHRONOUS



Same period, tilted plane



Ground position changes

Both: 23 h 56 min 4 s = one sidereal day



GPS → MEO

≈20,200 km · navigation

NavIC (as designed)

3 geostationary satellites
+ 4 geosynchronous
at 29° inclination

Navigation need not mean MEO

Sources: ESA / NASA; GPS.gov; ISRO NavIC design
GPS reference illustration: NASA · Geometry not to scale

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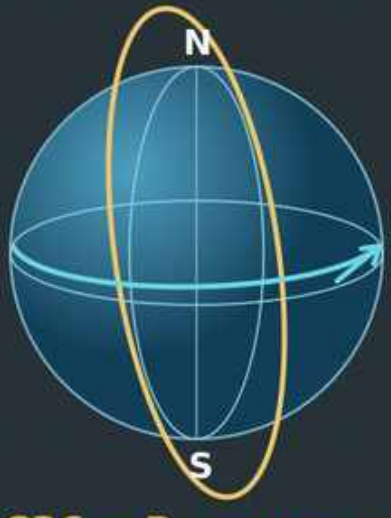
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Day 1 · Topic 7 · S&T · Item 20

Polar is a path. SSO adds a time rule.

Repeated lighting makes Earth images comparable

01 POLAR COVERAGE



Near-polar passes cross many latitudes. Earth turns beneath the orbit.

Ideal polar tilt: 90°
SSO: usually slightly retrograde (>90°)

PSLV-C36 → Resourcesat-2A → polar SSO (2016)

02 SUN-SYNCHRONOUS TIMING



Same-direction equator crossings at nearly the same local solar time. Clocks illustrate equal solar time.



Resourcesat-2A · 817 km

Sources: ESA / NASA; ISRO PSLV-C36 mission
Resourcesat-2A photograph: ISRO · Not to scale

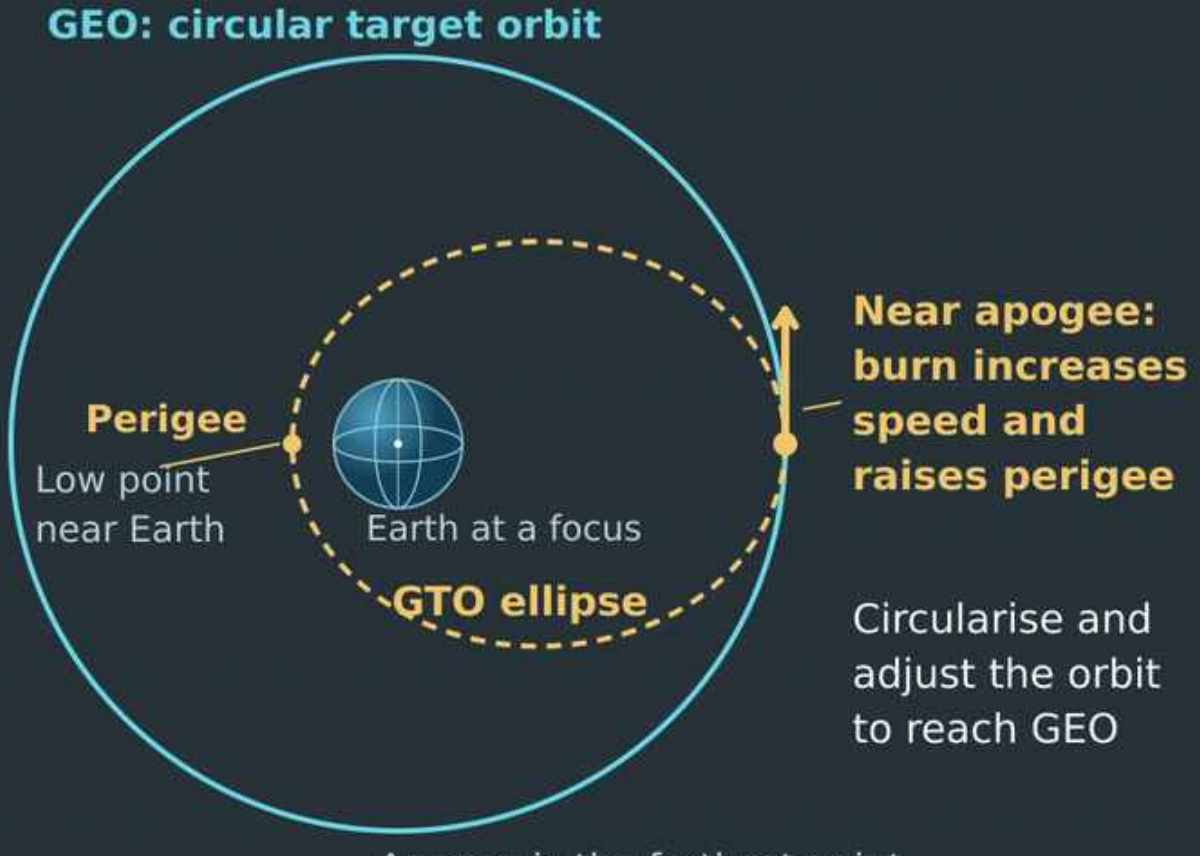
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Day 1 · Topic 7 · S&T · Item 20

GTO is the transfer. GEO is the goal.

The satellite changes its orbit after launch





INSAT-3DS: weather observations

GSLV-F14 → GTO → orbit raising → GEO

Launched 17 February 2024; GEO slot 28 February.

Transfer period depends on the ellipse.

Sources: ESA; ISRO GSLV-F14 / INSAT-3DS mission
INSAT-3DS photograph: ISRO · Geometry not to scale

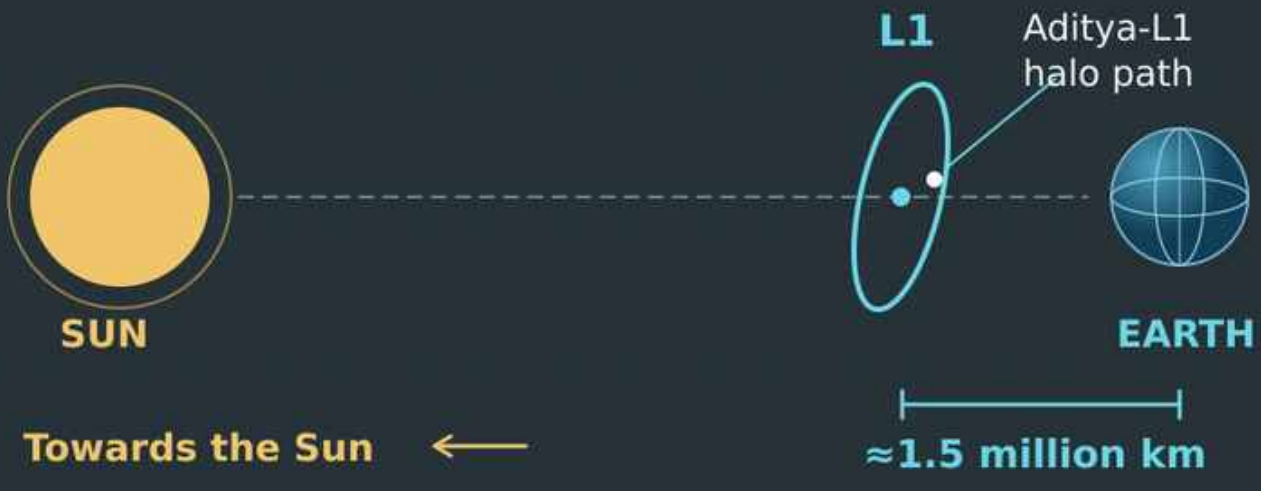
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Day 1 · Topic 7 · S&T · Item 20

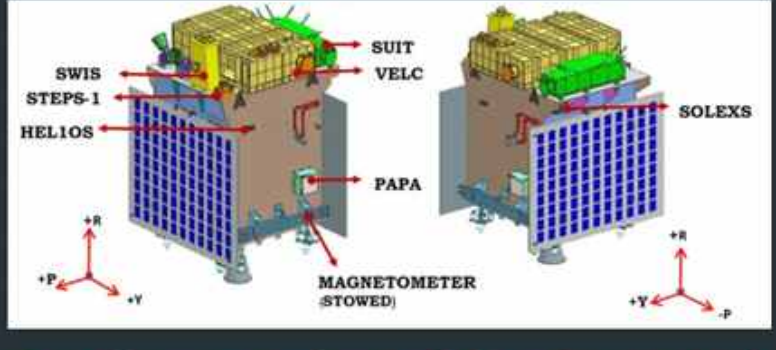
Aditya-L1 watches the Sun from a halo

L1 is part of the Sun–Earth orbital system



Combined gravity and orbital motion let the spacecraft travel around the Sun with Earth's one-year period.

The halo loops around L1; L1 itself is not a solid object.



PSLV-C57
Launch: 2 Sep 2023
Halo insertion:
6 Jan 2024

Continuous view of the Sun • Halo period ≈178 days

Sun, Earth, distance and halo size are not to scale.

Sources: NASA Lagrange points; ISRO Aditya-L1
Original spacecraft reference drawing: ISRO

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Day 1 · Topic 7 · S&T · Item 20

Follow the launcher to the destination

A launch vehicle can serve more than one orbit

PSLV ⟶ **Resourcesat-2A → SSO**
Proba-3 → highly elliptical orbit



GSLV Mk II ⟶ **INSAT-3DS → GTO → GEO**
GSLV-F16 also launched NISAR to SSO



LVM3 ⟶ **OneWeb: 450 km injection**
Raised to ≈1,200 km working LEO



SSLV ⟶ **EOS-08 → circular LEO**
475 km; SSLV-D3 (2024)



KEEP THE THREE TRAPS STRAIGHT

01 Polar / SSO describe orientation, not a separate height band.

02 GTO is a temporary ellipse; GEO is circular and equatorial.

03 At L1, gravity does not simply cancel to zero.

Geostationary ⇒ geosynchronous; the reverse is not always true.

Sources: ISRO launcher and mission pages; ESA
Orbit sketches not to scale · Mission designs, not live status

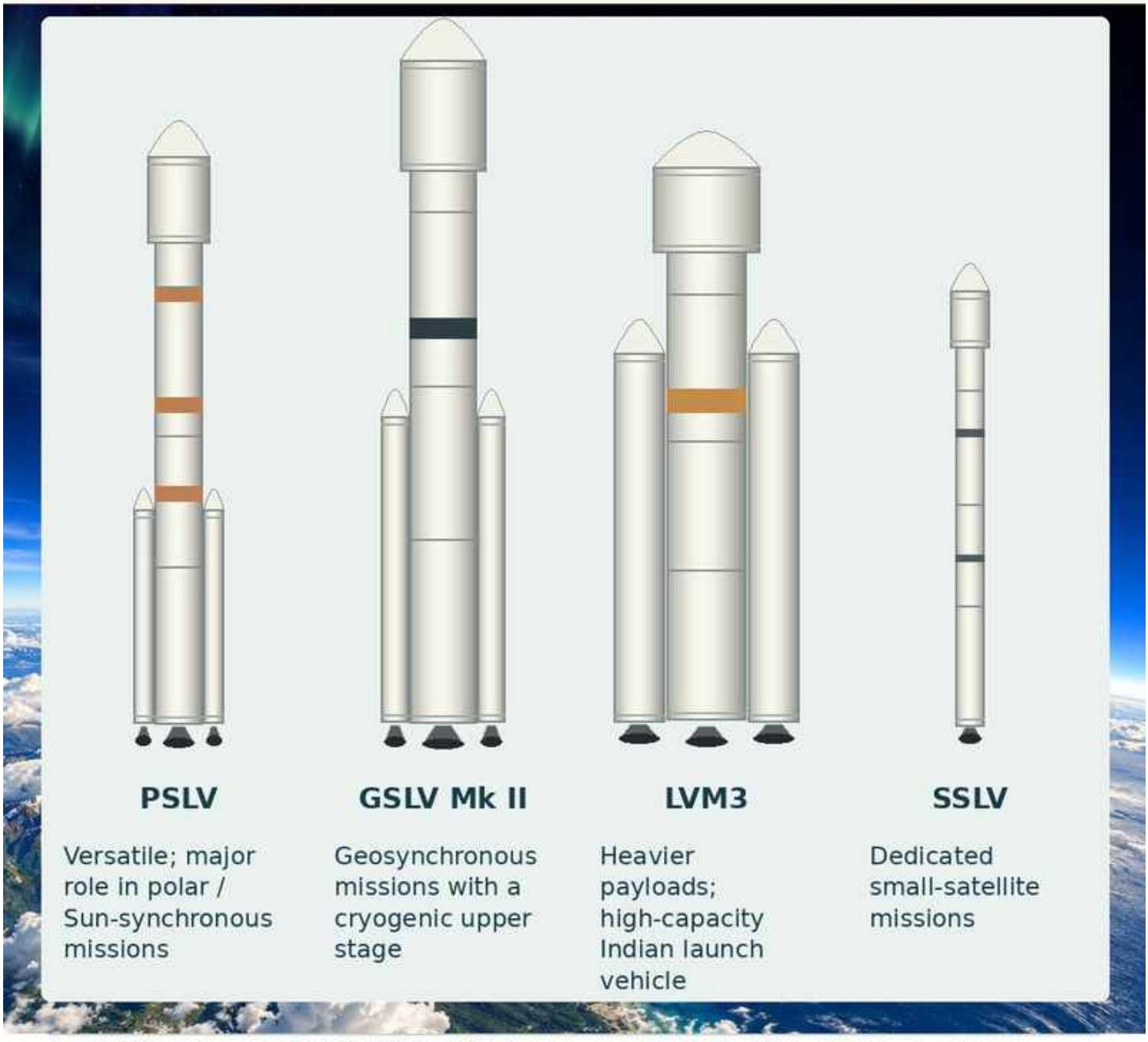
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DAY 2 · TOPIC 17 · LAUNCH VEHICLES

Choose the vehicle for the mission

Payload, target orbit and mission needs determine the launcher.



Sources: ISRO vehicle pages for PSLV, GSLV, LVM3 and SSLV · Front views omit hidden boosters. Relative heights are approximate.

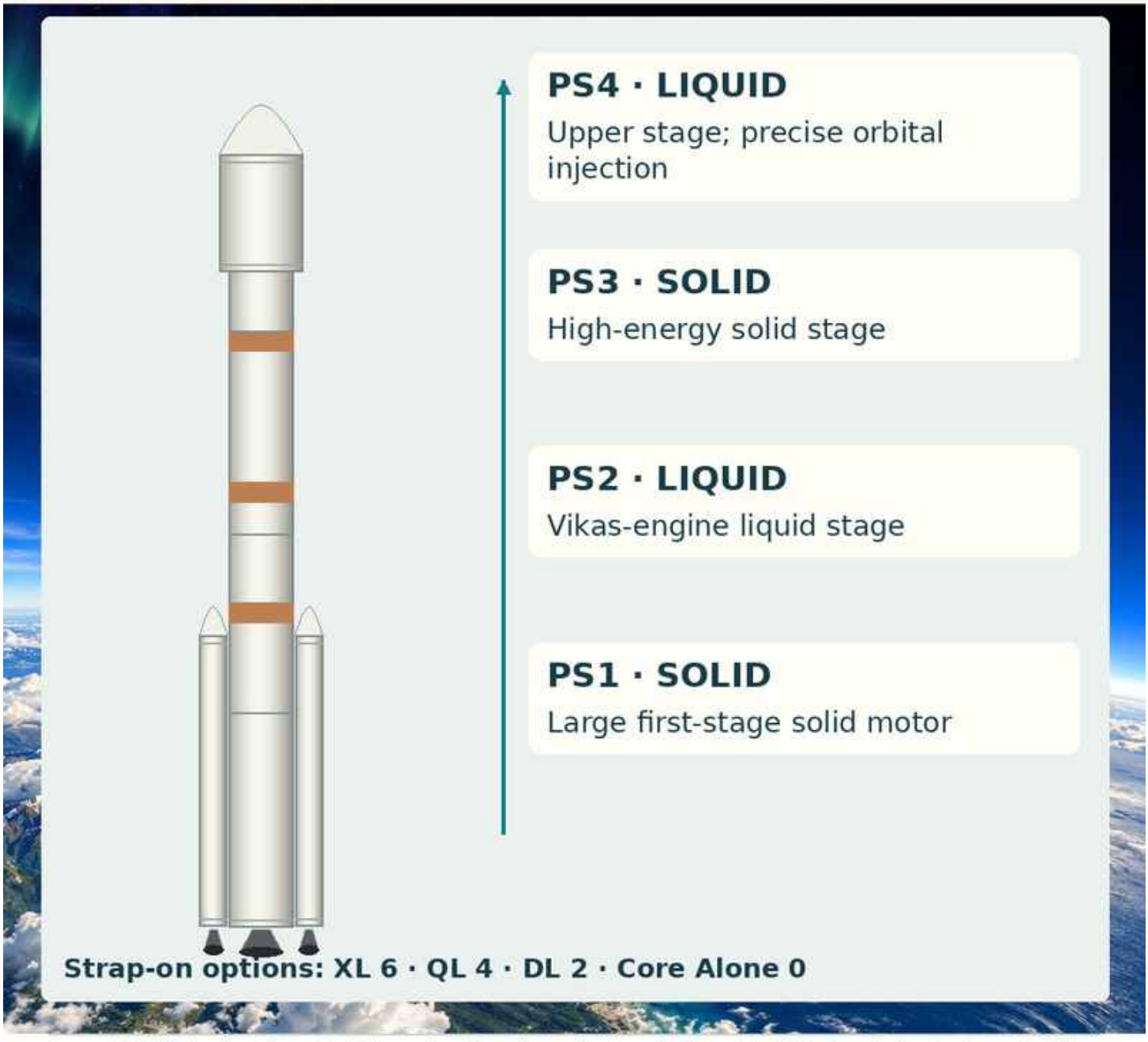
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DAY 2 · TOPIC 17 · LAUNCH VEHICLES

PSLV: alternate solid and liquid stages

The four-stage sequence is S–L–S–L.



Source: ISRO. PSLV configuration and vehicle overview · Stage diagram is schematic. The payload fairing is protective structure, not a fifth stage

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DAY 2 · TOPIC 17 · LAUNCH VEHICLES

GSLV Mk II and LVM3 are different

Do not swap the core and strap-on propellants.

GSLV Mk II



Solid core + 4 liquid strap-ons

Upper stage: cryogenic, CE-7.5

LVM3



Liquid core + 2 solid boosters

Upper stage: cryogenic, CE-20

Sources: ISRO, GSLV Mk II and LVM3 configurations · Front elevation shows visible external components; labelled booster totals refer to the full vehicle

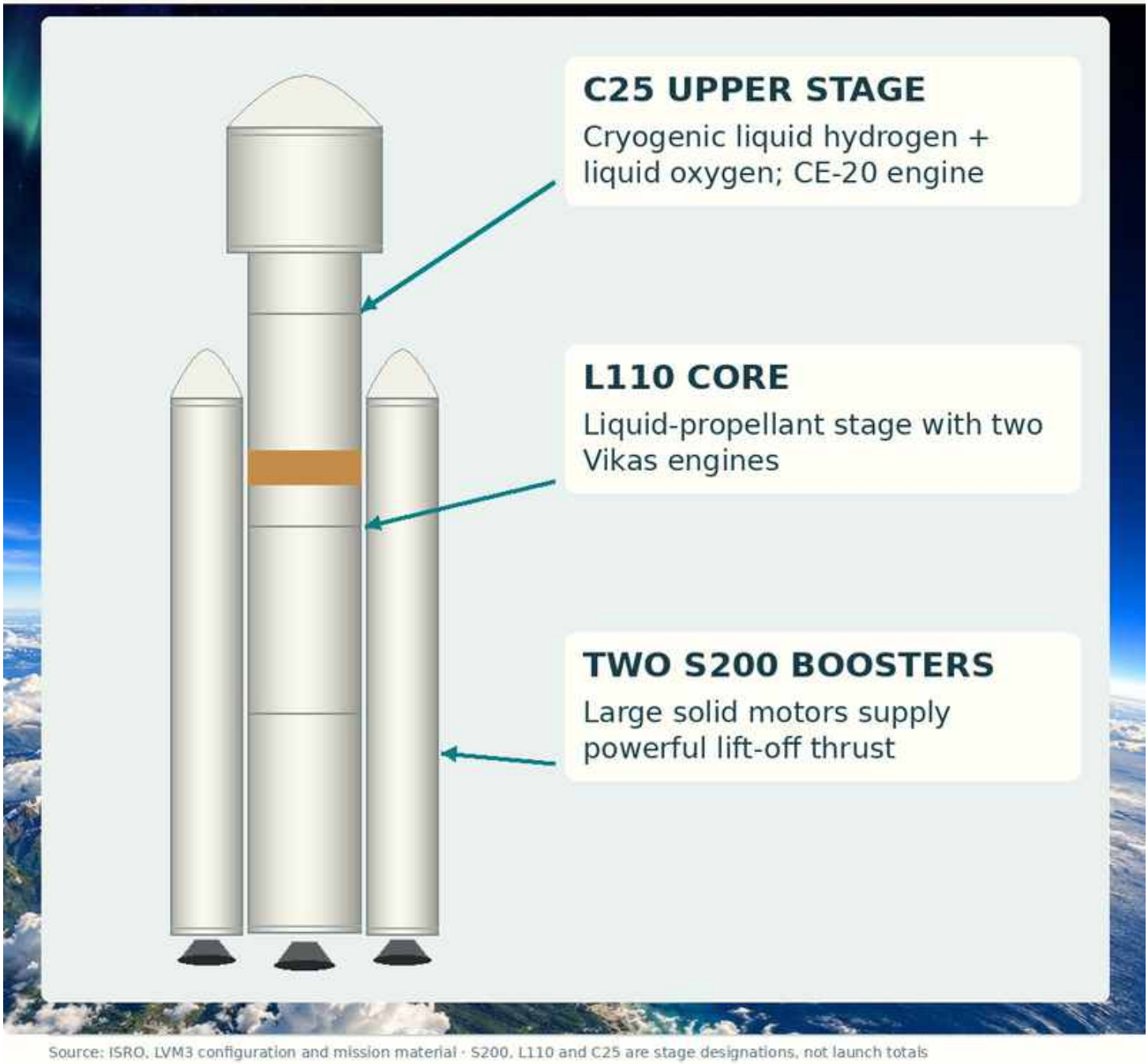
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DAY 2 · TOPIC 17 · LAUNCH VEHICLES

LVM3: two solids, liquid core, cryogenic top

Three propulsion-stage groups work through the ascent.



Source: ISRO, LVM3 configuration and mission material · S200, L110 and C25 are stage designations, not launch totals

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DAY 2 · TOPIC 17 · LAUNCH VEHICLES

SSLV: a focused small-satellite launcher

Three solid stages plus a liquid Velocity Trimming Module.



VELOCITY TRIMMING MODULE

Liquid propulsion makes final velocity corrections

THREE SOLID STAGES

The main ascent uses solid propulsion

REFERENCE CAPABILITY

Up to 500 kg to a 500 km planar orbit

A small satellite is still orbit-dependent: altitude and inclination affect what the vehicle can carry.

Source: ISRO, SSLV vehicle overview · A liquid trimming module does not turn SSLV's three main solid stages into liquid stages

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DAY 2 · TOPIC 17 · LAUNCH VEHICLES

Compare payloads only with their orbits

A kilogram figure without its target orbit can mislead.



VEHICLE	PAYLOAD	REFERENCE ORBIT
PSLV	**1,750 kg**	600 km Sun-synchronous polar
GSLV Mk II	**2,250 kg**	GTO
LVM3	**4,000 kg**	GTO (reference capability)
SSLV	**500 kg**	500 km planar orbit

These are reference capabilities

Mission-specific configuration and performance may differ.

Sources: ISRO vehicle overview pages. Snapshot: 9 October 2026 · Orbit sketches are conceptual. They do not depict an actual mission trajectory or true scale

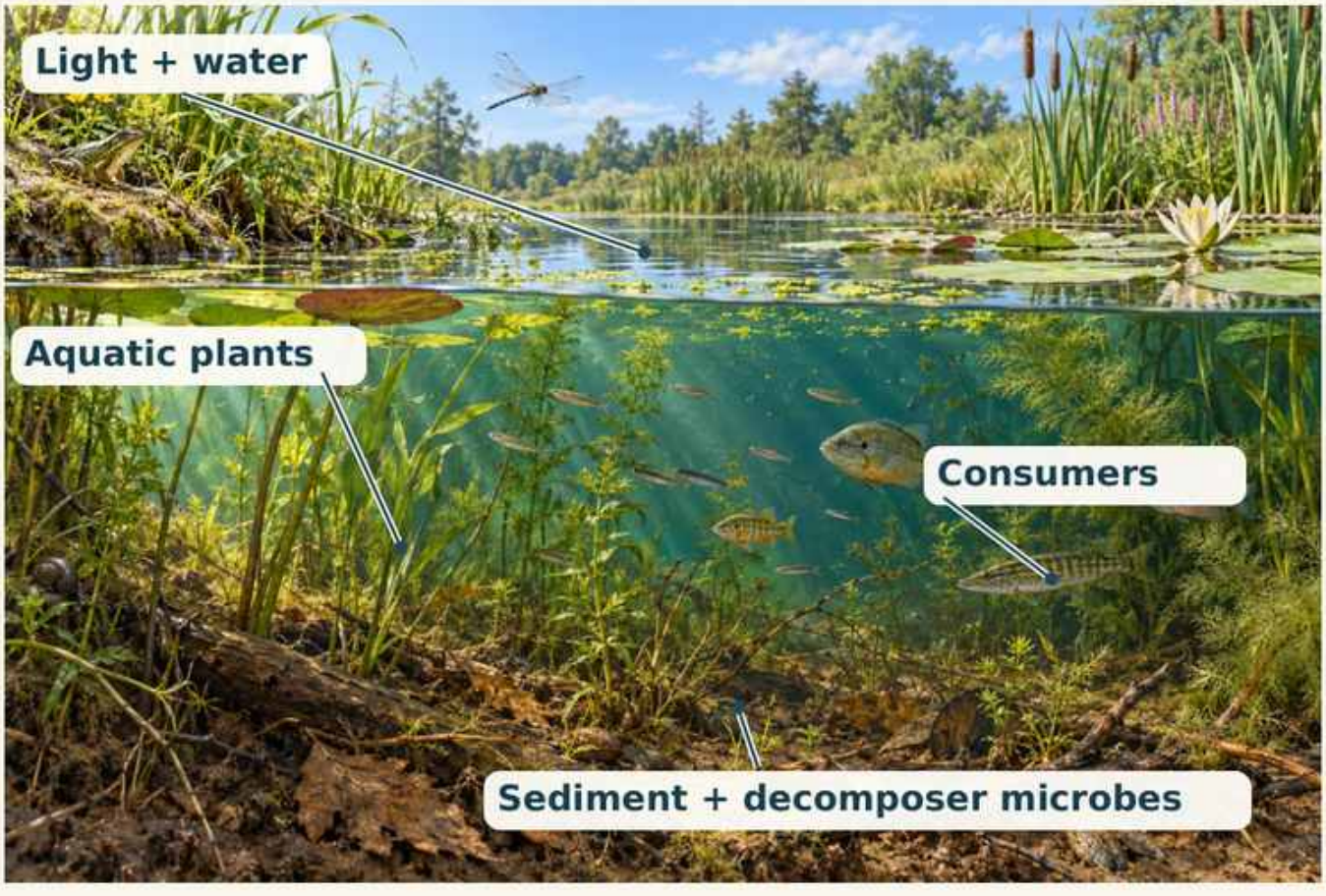
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6/6

DAY 3 · TOPIC 26 · ECOSYSTEMS

One pond. One connected system.

Living organisms interact with each other and their physical surroundings.



ABIOTIC

Light, water, temperature, dissolved gases and nutrients

BIOTIC

Producers, consumers and decomposers

Illustrative habitat; microbes are not shown at organism scale.

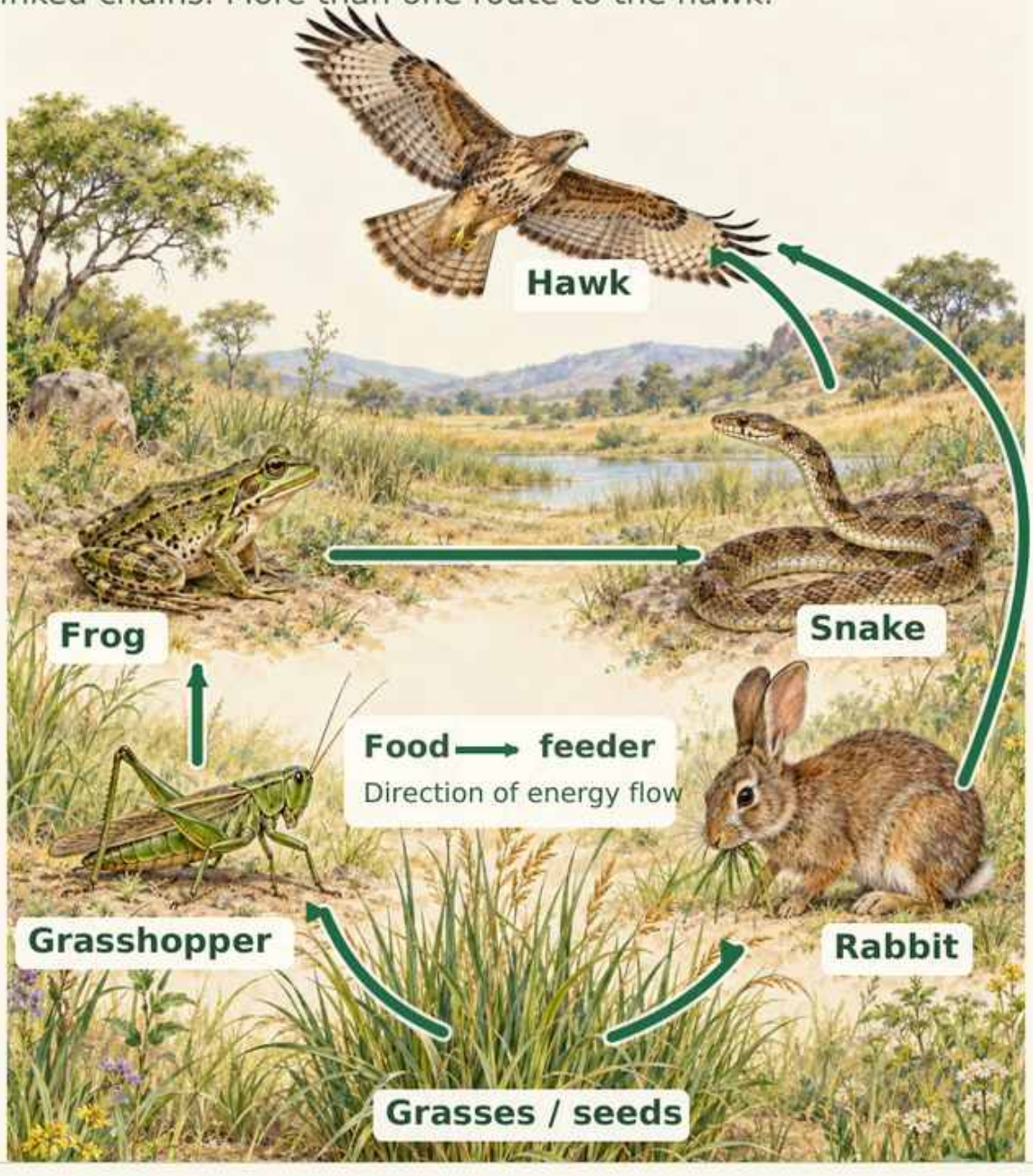
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1/5 · ENGLISH

DAY 3 · TOPIC 26 · ECOSYSTEMS

A food web is a living network

Two linked chains. More than one route to the hawk.



Energy moves from food to feeder.

Arrows show feeding links, not the direction an animal moves.

Illustrative food web.

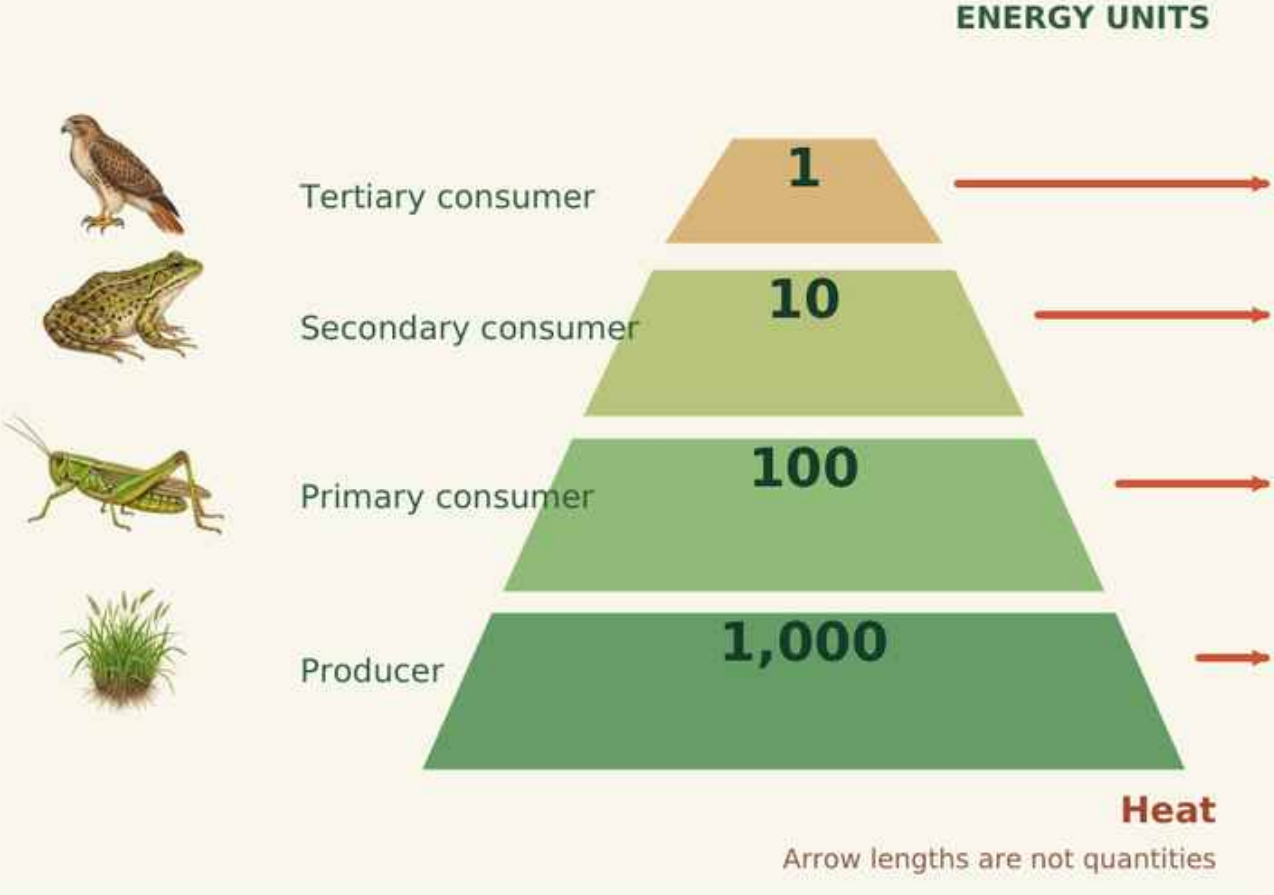
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2/5 · ENGLISH

DAY 3 · TOPIC 26 · ECOSYSTEMS

Less energy reaches each higher level

An energy pyramid stays upright. Specimens are shown at diagrammatic scales.



Only a fraction passes to the next trophic level.

Here: 1,000 → 100 → 10 → 1 (illustrative energy units).

The 10% rule is a rule of thumb; actual efficiencies vary.

Heat is released; some energy also enters detritus.

Values are illustrative, not measured data.

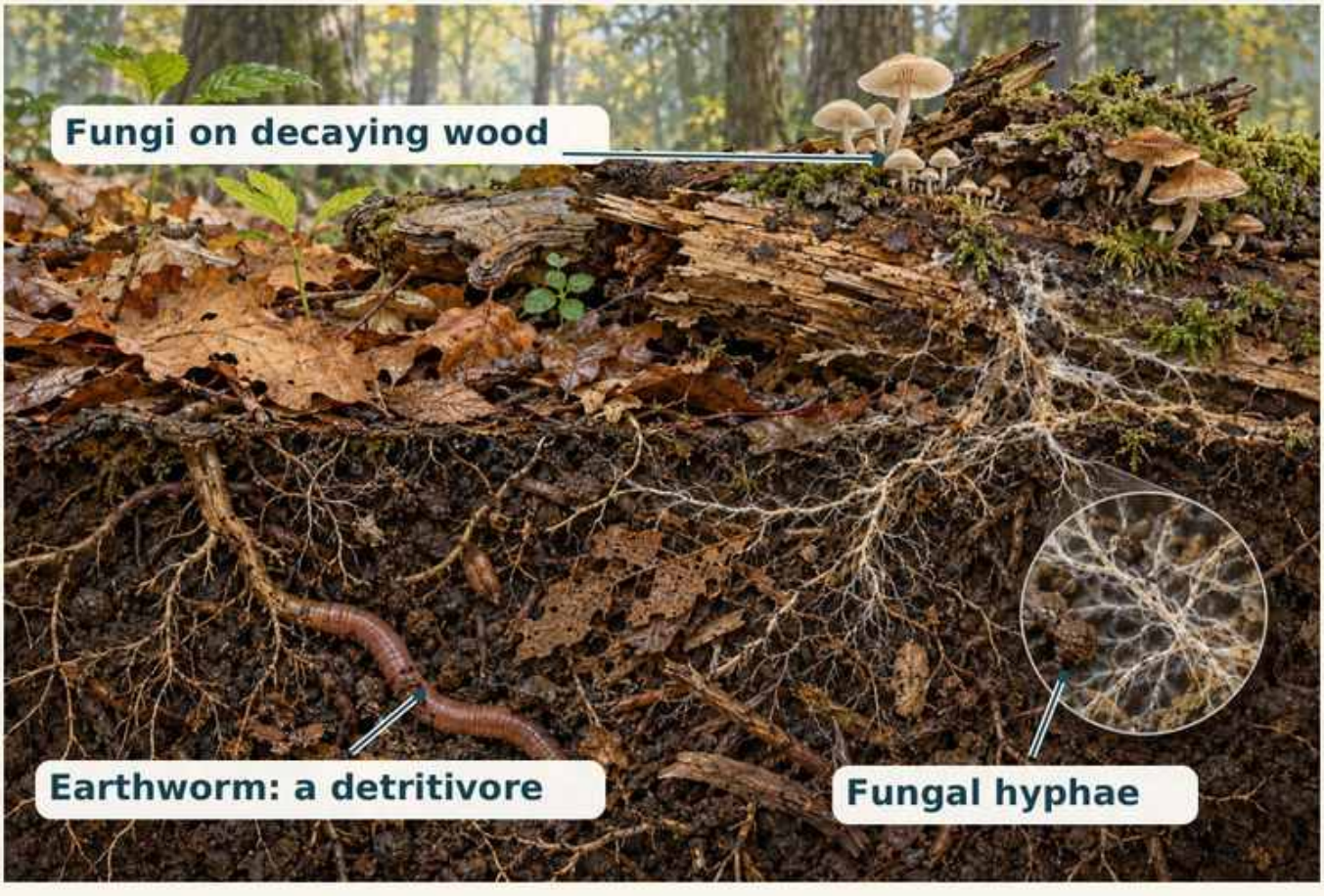
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3/5 · ENGLISH

DAY 3 · TOPIC 26 · ECOSYSTEMS

Litter becomes available nutrients

Detritivores and decomposers play different, connected roles.



FRAGMENT
Earthworms break litter into smaller pieces.

DECOMPOSE
Bacteria and fungi use enzymes to break it down.

Mineral nutrients can return to the soil and be taken up by plants.

Hyphae are magnified; organism sizes are not comparable.

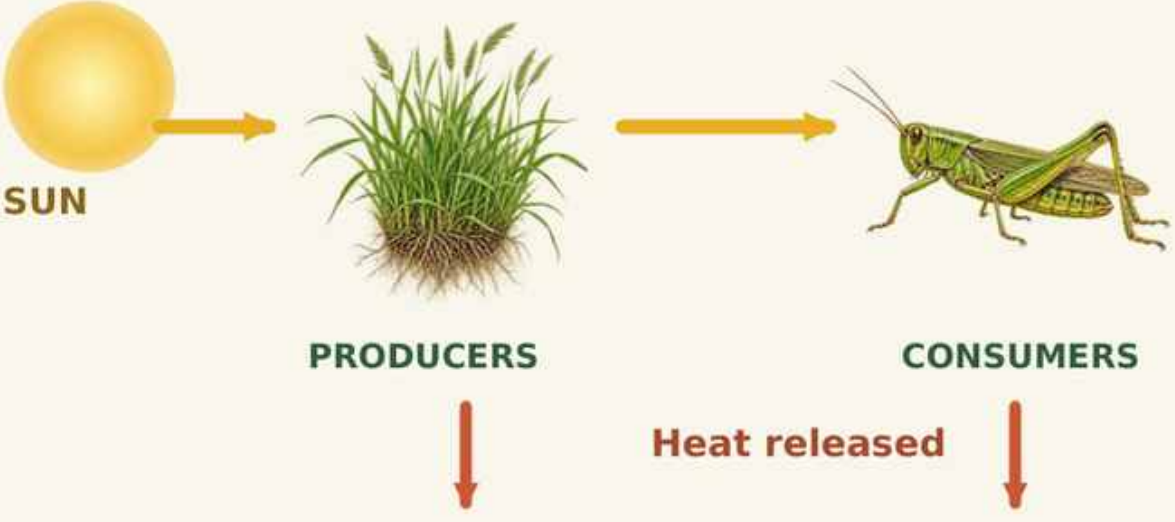
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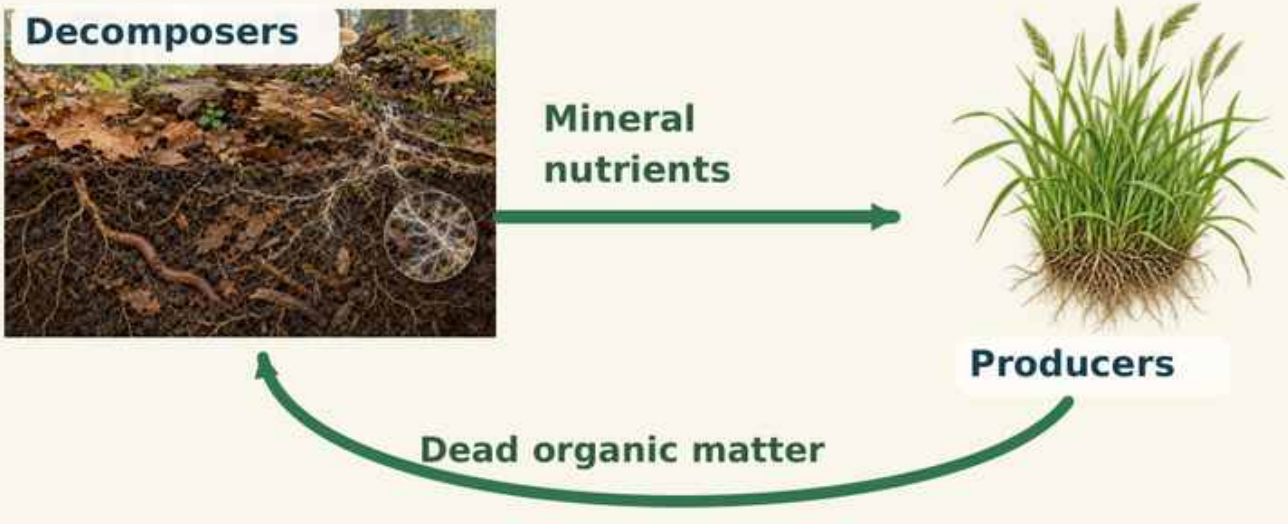
4/5 · ENGLISH

DAY 3 · TOPIC 26 · ECOSYSTEMS

Energy flows. Nutrients return.

Two connected processes, with different directions.





Energy is not recycled through the food chain.
Nutrients are reused as organisms, detritus and minerals interact.

Conceptual pathways; not a complete biogeochemical cycle.

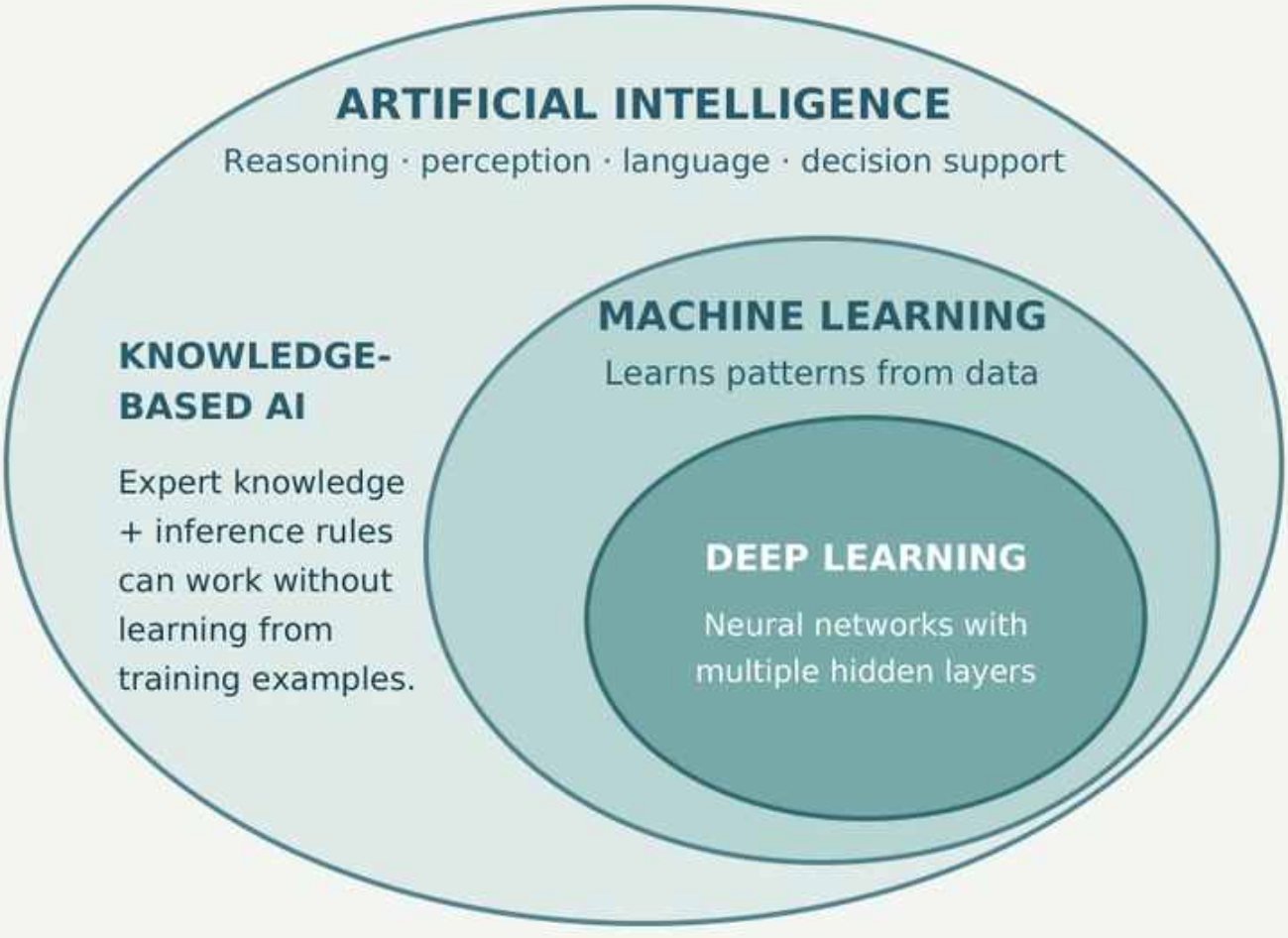
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5/5 · ENGLISH

DAY 3 · TOPIC 27 · ARTIFICIAL INTELLIGENCE

AI, ML and deep learning: get the relationship right

The terms are connected. Their meanings are not identical.



ML is one approach within AI. Deep learning is within ML.

A decision tree can be ML without being deep learning.

An ordinary fixed timer is not automatically an AI system.

Source: OECD AI definition memorandum (2024); NIST, Demystifying AI (2018); Google ML glossary

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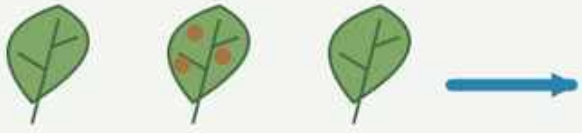
NEW TOPIC · 1/6 · ENGLISH

DAY 3 · TOPIC 27 · ARTIFICIAL INTELLIGENCE

Learning is different from using what was learned

Teaching example: a leaf-image classifier.

TRAINING: FIT THE MODEL



Images + target labels
Healthy / diseased

MODEL
Adjust its parameters

Compare with target; reduce loss

EVALUATE ON SEPARATE EXAMPLES

Check generalisation before relying on new predictions.

INFERENCE: APPLY THE TRAINED MODEL



New image

Trained model

Predicted category

Inference need not update the model's parameters.
Monitoring and retraining are separate responsibilities.

Source: Google Developers, Supervised learning; NIST AI RMF 1.0. Illustrative workflow.

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NEW TOPIC · 2/6 · ENGLISH

DAY 3 · TOPIC 27 · ARTIFICIAL INTELLIGENCE

Three ways to learn from experience

Ask what signal guides learning, not just what the app is called.

SUPERVISED



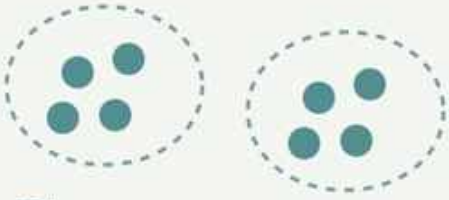
Known labels

Examples paired with targets

Classification → a category

Regression → a quantity

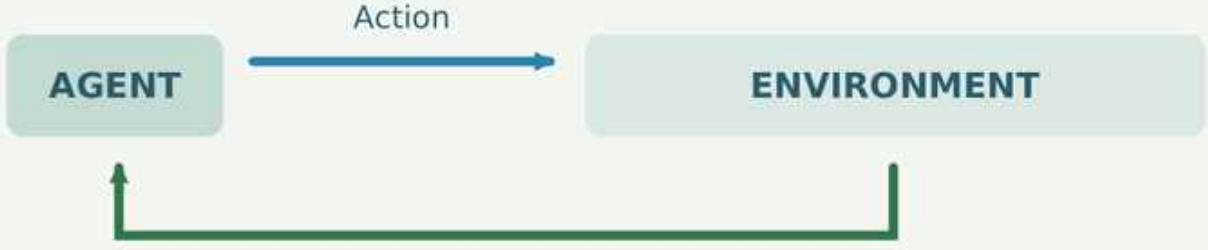
UNSUPERVISED



Discover groups

No supplied target labels
Clustering finds similar groups.
Example: farms with similar soil and rainfall profiles.

REINFORCEMENT



Source: Google Developers, ML introduction and clustering; IBM, Reinforcement learning

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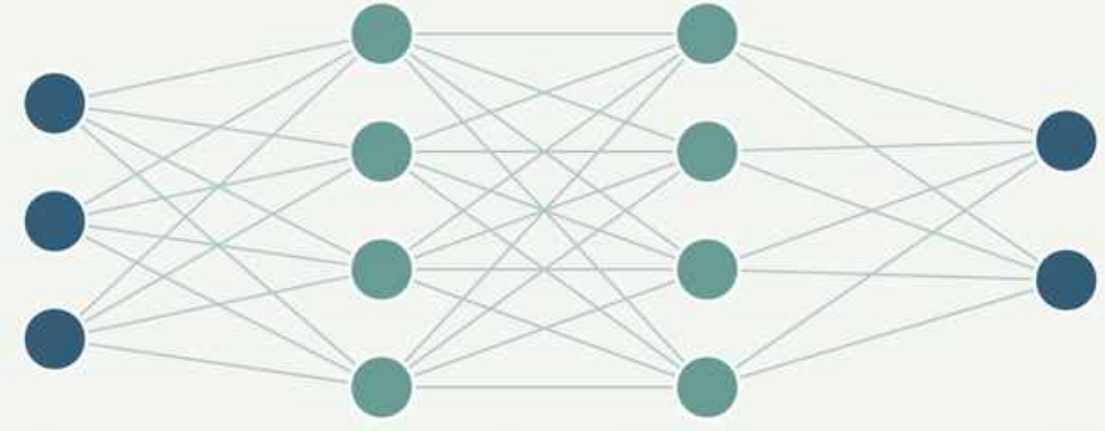
NEW TOPIC · 3/6 · ENGLISH

DAY 3 · TOPIC 27 · ARTIFICIAL INTELLIGENCE

Neural networks and generative outputs

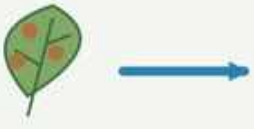
Architecture, learning method and output capability are different ideas.

A NEURAL NETWORK IS A MATHEMATICAL MODEL



Weighted connections transform the information.

WHAT DOES THE OUTPUT DO?



"Diseased"
Classifies a category

A generated explanation
Creates text content

Generative AI creates text, images, audio or code.

It can combine several training approaches.

Fluent output is not a guarantee of factual accuracy.

Source: Google ML glossary and Neural networks; NIST Generative AI Profile (2024). Network is schematic.

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NEW TOPIC · 4/6 · ENGLISH

DAY 3 · TOPIC 27 · ARTIFICIAL INTELLIGENCE

Recognise the task behind the technology

AI supports people in real settings. Reliability still needs testing.



HEALTH

Image interpretation
Clinical decision support

AGRICULTURE

Crop-image analysis
Disease identification

MANUFACTURING

Visual inspection
Defect detection

INDIAN EXAMPLES TO RECOGNISE

Garbhini-GA2: gestational-age estimation in the second and third trimesters; developed by THSTI and IIT Madras.
AI-DISC: ICAR-IASRI's crop disease identification example.
Illustrations show capabilities, not guaranteed diagnoses.

Source: WHO, AI for health; THSTI (5 March 2024); ICAR-IASRI (March 2024); NIST manufacturing overview

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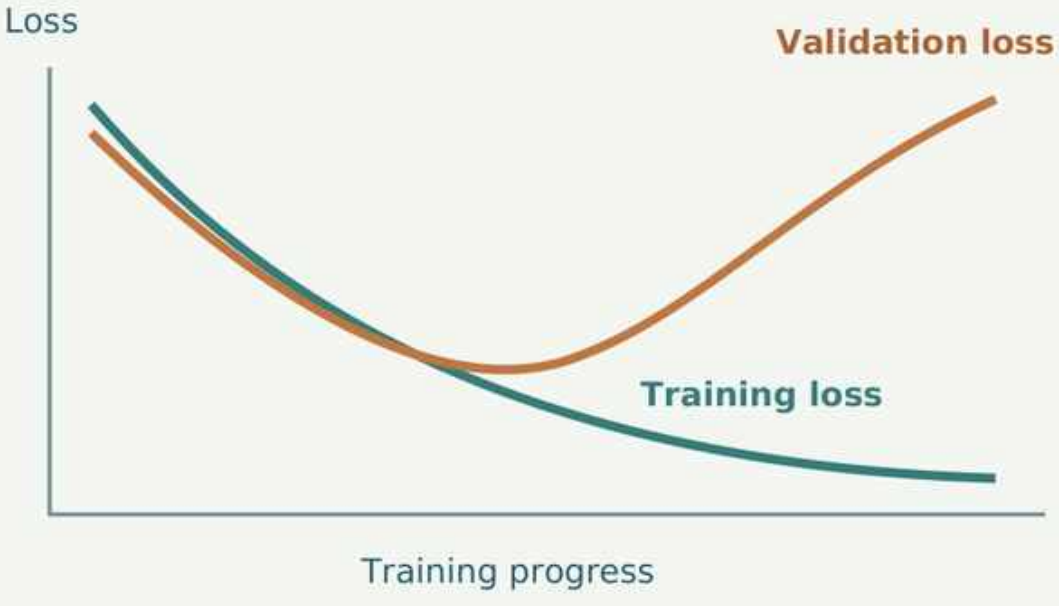
NEW TOPIC · 5/6 · ENGLISH

DAY 3 · TOPIC 27 · ARTIFICIAL INTELLIGENCE

Trust needs evidence, not just a confident answer

Generalisation, factual checks and responsible oversight matter.

OVERFITTING: GOOD TRAINING FIT, WEAK TRANSFER



Conceptual curves; no measured values are implied.

A CONVINCING ANSWER CAN STILL BE FALSE

1 AI output → 2 Check evidence → 3 Human decision

Check bias, privacy, security and errors across groups.

Human review needs competence, time and authority.

Source: Google Developers, Overfitting and classification metrics; NIST AI RMF / GenAI Profile; WHO

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NEW TOPIC · 6/6 · ENGLISH

DAY 4 · TOPIC 37 · BIODIVERSITY

Biodiversity has three levels

Variation within and between living systems



Illustrative ecosystem scenes.

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DAY 4

DAY 4 · TOPIC 37 · BIODIVERSITY

A hotspot must pass both tests

High species richness alone is not enough





Source: CEPF hotspot criteria · generic forest, not an Indian site

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Which categories are threatened?
Only CR, EN and VU are counted as threatened
EX Extinct
EW Extinct in the Wild
CR Critically Endangered
EN Endangered
VU Vulnerable
NT Near Threatened
LC Least Concern
Near Threatened is outside the three threatened categories.
Source: IUCN Red List Categories and Criteria, version 3.1
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Missing data does not mean safe

DD and NE are not low-risk findings

DD · Data Deficient

Not enough information for a direct or indirect assessment of extinction risk.

NE · Not Evaluated

Not yet assessed against the Red List criteria.

EW means survival only in cultivation, captivity, or naturalised populations outside the former range.

Source: IUCN Red List Categories and Criteria, version 3.1

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Five ways to assess extinction risk

One qualifying criterion can be enough

A **Population reduction**

B **Geographic range**

C **Small population and decline**

D **Very small or restricted population**

E **Quantified extinction probability**

Thresholds, time periods and qualifying conditions must also be satisfied.

Source: IUCN Categories and Criteria · A–E assessment framework

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Count mature individuals

Examples from criterion D, not the whole rulebook

CR
Fewer than 50

EN
Fewer than 250

VU (D1)
Fewer than 1,000

These counts mean mature individuals.
They are not total organisms of every age.

Source: IUCN Red List Categories and Criteria, version 3.1

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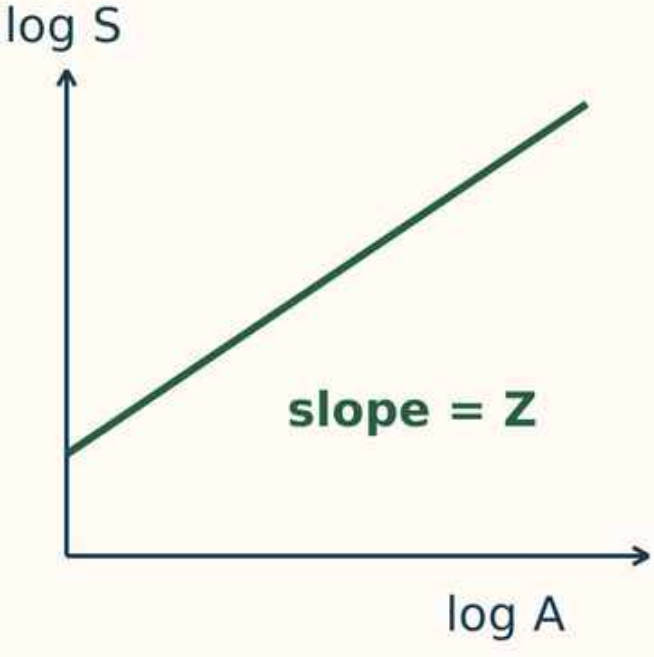
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Species–area relationship

More area sampled usually reveals more species



log S = log C + Z log A



S = species richness; A = area. The intercept on this log–log graph is log C.

C is the multiplicative constant in:

$$S = C \times A^{Z}$$

Illustrative field scene; schematic graph.

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Check the denominator

Assessed species: data snapshot, 9 October 2026

175,909
species assessed

49,505
assessed species threatened with extinction



About 28.1% of assessed species

This is not 28.1% of every species on Earth.
Always keep the date with the totals.

Source: IUCN July 2026 update · calculated from published totals

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DAY 4

DAY 5 · TOPIC 46 · ADVANCED COMPUTING · 1/8

India's Advanced Computing Push:

PARAM Rudra and Amaravati Quantum Valley



Illustrative hardware

PARAM Rudra

High-performance computing (HPC)

Amaravati

Quantum research, access and skills

Sources: PIB, Jan–Feb 2026; IBM, Feb 2026 · generic hardware illustration

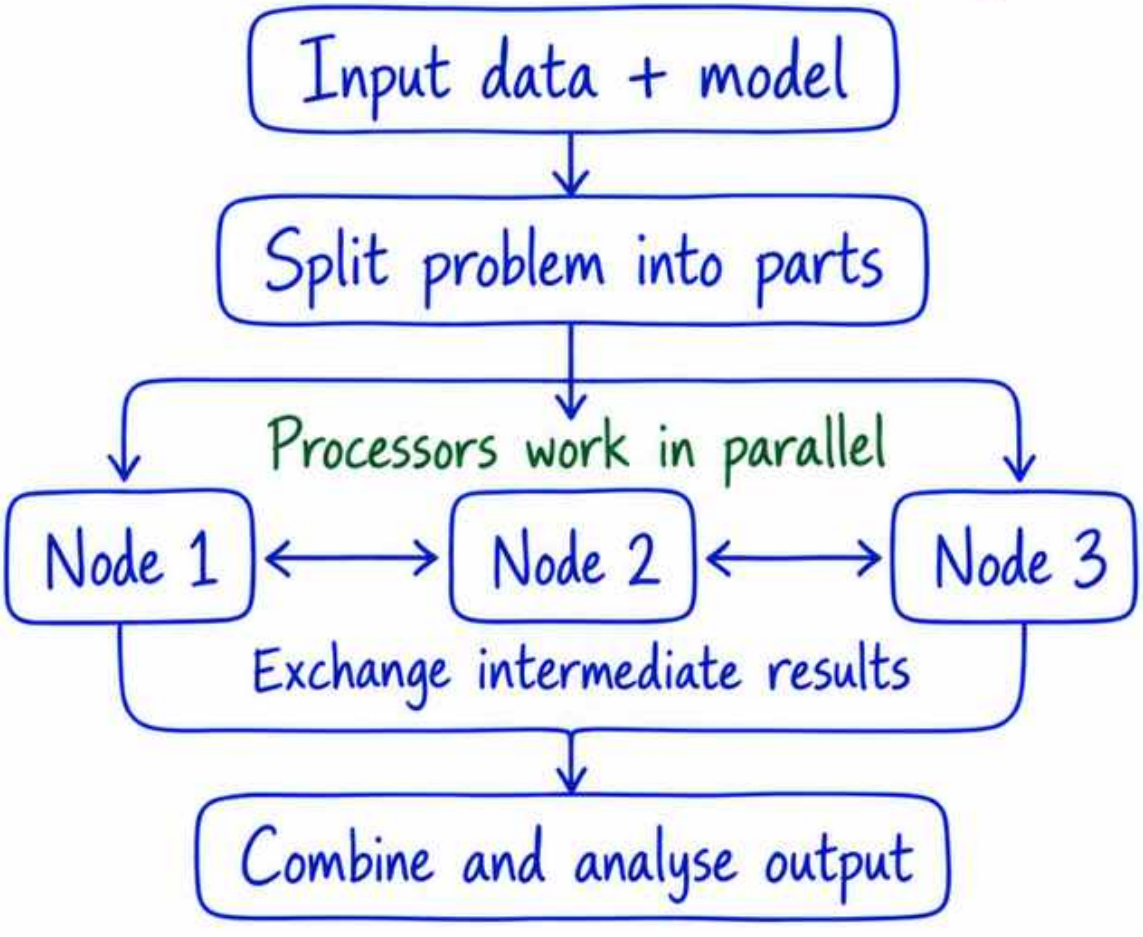
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How a supercomputer shares the work

Classical parallel processing



Speedup depends on the task and communication overhead.

Sources: IBM; LLNL parallel-computing tutorial · simplified teaching flow

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PARAM Rudra: from racks to research

IIT Bombay · inaugurated 8 January 2026



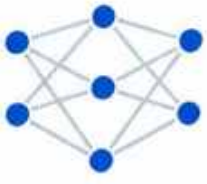
3 PetaFLOPS

Classical HPC facility

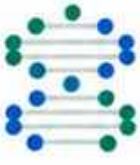
C-DAC Rudra servers + system software

Direct Contact Liquid Cooling

Research applications



AI



Biotechnology



Advanced manufacturing

Source: PIB / MeitY, 9 January 2026 · generic rack and application illustrations

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Amaravati Quantum Valley: read each milestone

February 2026: cloud access and planned hardware

- **7 February 2026 snapshot**
  Construction began. Members could access IBM quantum computers through TCS over the cloud.
- **8 February 2026 snapshot**
  Foundation ceremony and launch of IBM-TCS quantum cloud services.
- **Planned local hardware**
  IBM Quantum System Two was planned as a local installation at this time.

Cloud access does not prove a local machine is installed.

Sources: IBM, 7 February 2026; PIB / DST, 8 February 2026 · dated evidence

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Cloud access links people to remote hardware

A quantum job still uses classical computing



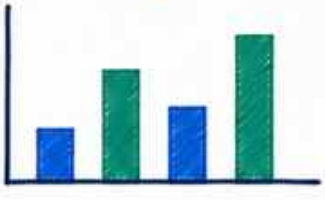
1. Prepare

A classical computer sets up a suitable quantum circuit.



2. Run through the cloud

A remote quantum processor runs the circuit; qubits are measured.



3. Repeat, analyse, check

A classical computer analyses the measurement results.

Access ≠ location ≠ useful advantage

Sources: IBM Quantum learning / hybrid computing · illustrative workflow

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HPC and quantum: a quick comparison

Classical HPC	Quantum computing
Bits: 0 or 1	Qubits: superposition is possible
Many processors share the work	Quantum operations; measured qubit: 0 or 1
Established tool for large simulations	Suitable algorithms; advantage varies

Read the right metric

Qubit count is not FLOPS.
There is no direct conversion.

Quantum does not speed up every computing problem.

Sources: IBM / HPC; NIST quantum-computing explainer · concise comparison

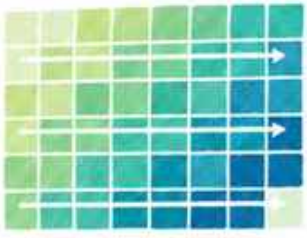
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Useful applications need more than powerful hardware

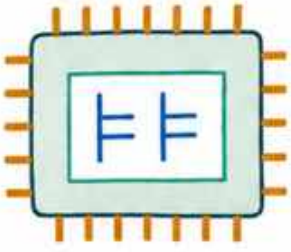
Read the application and its evidence



Classical HPC

Established simulation and data-analysis workloads

Weather, biology, engineering



Quantum research

Molecules, materials and selected optimisation tasks

Potential must be demonstrated

What must be checked?

Suitable algorithm · reliable results

Noise and errors · classical comparison

A promising use case is not yet proof of useful quantum advantage.

Sources: National Supercomputing Mission; NIST; IBM fault-tolerance explainer

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Four exam traps to avoid

1. Machine type

PARAM Rudra is classical HPC.

↓

2. Location versus access

Cloud access does not prove a local machine is installed.

↓

3. Plans versus results

A foundation stone is not a commissioned computer.

↓

4. Performance claims

More qubits alone do not prove useful quantum advantage.

↓

Always ask: which machine, which task, and what evidence?

Sources: PIB / MeitY; IBM, February 2026; NIST · evidence-check recap

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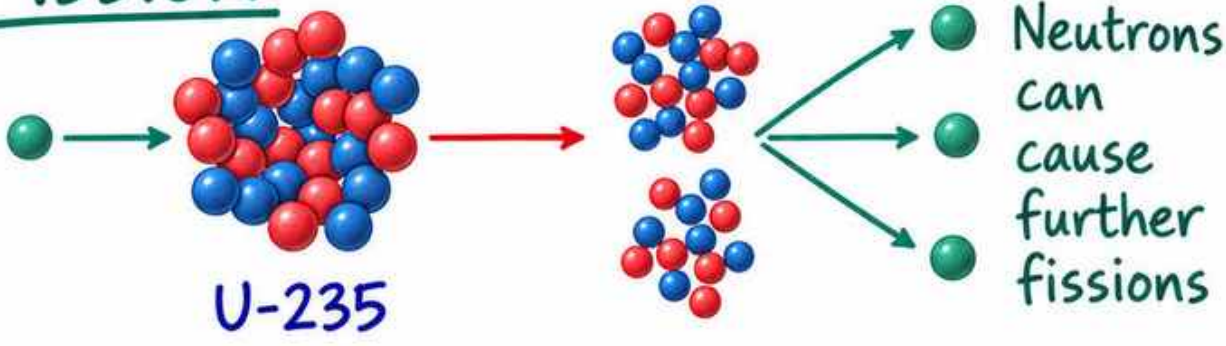
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DAY 5 · TOPIC 47 · 1/7

Fission splits. Fusion joins.

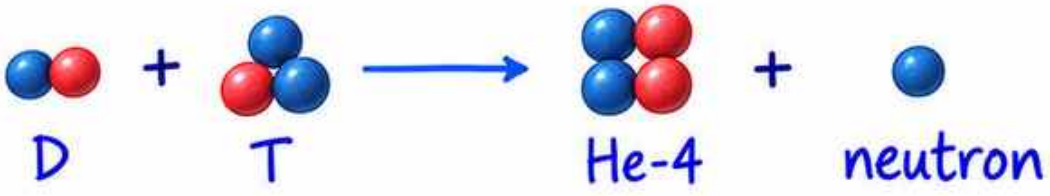
Energy is released as products become more tightly bound.

FISSION



A heavy nucleus splits into lighter fragments.
About 200 MeV per fission.

FUSION: D + T



$D + T \rightarrow He\text{-}4 + neutron + 17.6\ MeV$

Fusion needs very hot plasma.

Schematic nuclei.

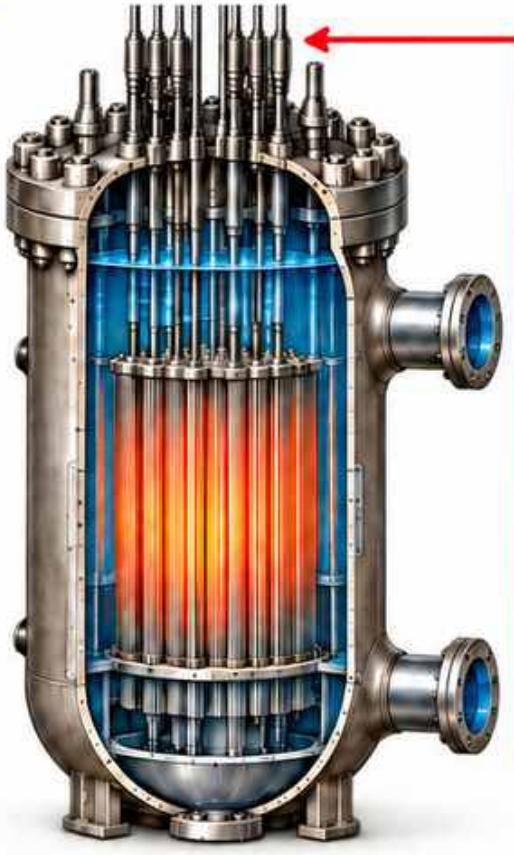
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Inside a fission reactor

Moderator, coolant and control rods have different jobs.



Fuel

Fission releases heat. Uranium oxide is a common fuel.

Moderator

Slows neutrons. Thermal reactors need one.

Control rods

Absorb neutrons to control or stop the chain reaction.

Coolant carries heat away

Reflector: returns escaping neutrons
Shielding: protects people from radiation

Sources: US DOE; US NRC | Simplified reactor component functions

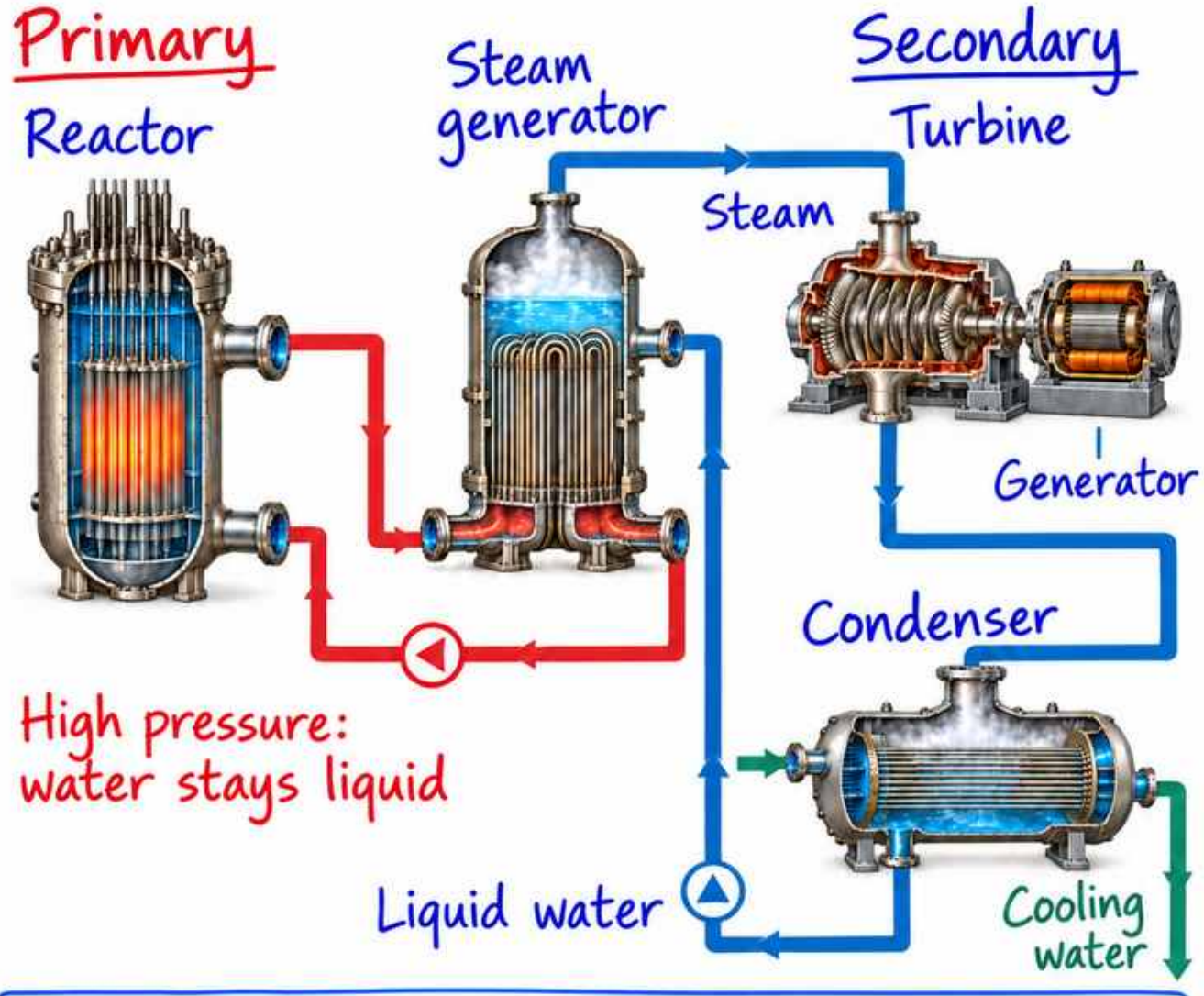
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PWR: heat moves between separate circuits.

Pressurised water reactor · simplified operating cycle



Heat crosses the tubes.
The water does not mix.

Sources: US DOE · US NRC | Simplified PWR, normal operation; not to scale

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Reactor types: compare the water

Light water = ordinary water. Heavy water = D_2O.

Type	Moderator	Coolant
PHWR	Heavy water	Heavy water
BWR	Light water	Light water
PWR	Light water	Light water
FBR	None	Liquid sodium*
AHWR	Heavy water	Boiling light water

BWR: steam forms in the reactor core.
PWR: steam forms in a separate circuit.

* Indian PFBR coolant. Fast reactors have no moderator. AHWR is a design.

Sources: US DOE; BARC AHWR; NPCIL reactor fleet

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DAY 5 · TOPIC 47 · 5/7

Fissile, fertile and critical

These terms describe fuel and chain-reaction behaviour.

Fissile

Can sustain a thermal-neutron fission chain reaction: U-235, U-233, Pu-239.

Fertile

Can become fissile after neutron absorption and, where needed, radioactive decay.

U-238 → Pu-239

Th-232 → U-233

Critical = self-sustaining

PFBR, Kalpakkam: 500 MWe
First criticality: 6 April 2026
This is not a commercial-operation date.

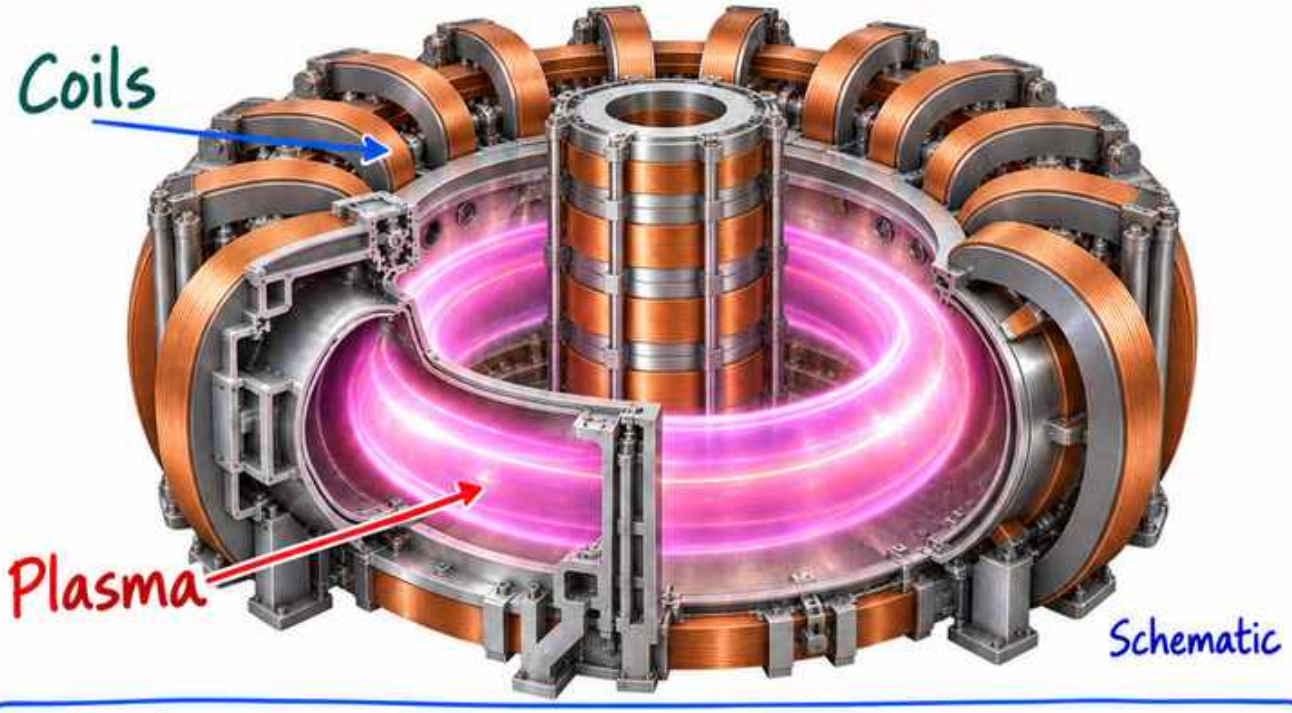
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DAY 5 · TOPIC 47 · 6/7

ITER: fusion in a magnetic ring

A tokamak confines hot plasma away from its walls.



Goal: Q = 10

500 MW fusion power ÷ 50 MW plasma heating.
This is plasma gain, not net electricity.

France · 7 members, including India

ITER will not generate electricity.
India supplied the cryostat.

Sources: ITER overview and India contributions; ITER-India

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Small modular reactors

Factory-made components are assembled at the site.



Up to 300 MWe per unit

MWe = electrical power
MWth = thermal power

India's designs

BSMR-200: 220 MWe, PWR
SMR-55: 55 MWe, PWR
HTGCR: up to 5 MWth for hydrogen

Nuclear Energy Mission: ₹20,000 crore; at least 5 indigenous SMRs by 2033 is a goal.

Sources: IAEA SMR explainer; DAE parliamentary reply, 5 Aug 2026

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BHASHINI: language as access

1. National Language Translation Mission (NLTM)
2. Ministry: Electronics and Information Technology (MeitY)
3. Digital India BHASHINI Division, under Digital India Corporation
4. Purpose: digital information and services in Indian languages
5. Voice access can reduce language and literacy barriers



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DAY 6 | TOPIC 57 | 1/6

57 • 2/6

Speech to speech: 3 steps

1. **ASR:** speech → text
2. **Translation:** source text → target-language text
3. **TTS:** text → speech



! ASR and TTS do not translate by themselves

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DAY 6 | TOPIC 57 | 2/6

Different tools, different jobs

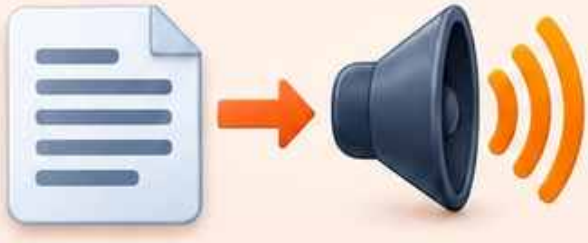
1 ASR

Spoken words → digital text



2 TTS

Digital text → spoken words



3 Translation

Meaning expressed in another language



4 Transliteration

Same word in another script



5 OCR

OCR reads text from an image; it is not speech recognition



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DAY 6 | TOPIC 57 | 3/6

BhashaDaan: build language data

57 • 4/6

People contribute examples and check others' work.

1 Suno India

Transcribe audio or check a transcript



2 Bolo India

Record speech or check a recording



3 Likho India

Translate text or check a translation



4 Dekho India

Type image text or label images



Language datasets

Diverse, checked examples support better language tools.

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DAY 6 | TOPIC 57 | 4/6

A real example: Hindi → Tamil

57 • 5/6

1 Kashi Tamil Sangamam 2.0, 2023

BHASHINI supported real-time translation of the Prime Minister's Hindi address into Tamil



2 The point: listeners could follow in their own language

3 Illustrative public-service use: understand an announcement in a familiar language



4 Translation changes language, not the underlying service rules



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DAY 6 | TOPIC 57 | 5/6

Useful technology, checked meaning

57 • 6/6

1. Noise and accents can affect speech recognition
2. Names and technical terms need care
3. Translation can lose context or nuance
4. Check important dates, amounts and instructions
5. Human review matters for consequential information
6. Digital inclusion also needs access and digital skills



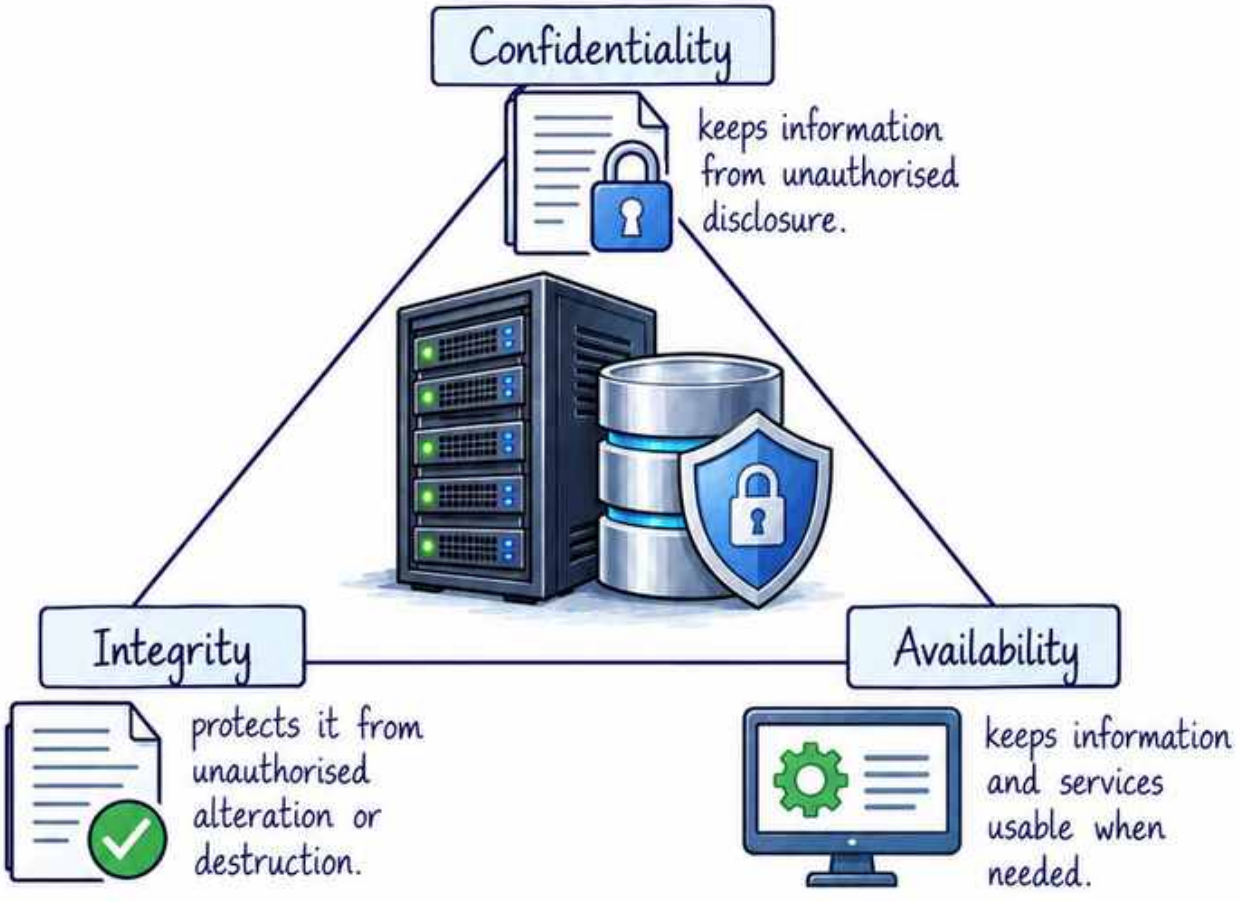
1. Capture clearly
2. Compare meaning
3. Verify important details

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DAY 6 | TOPIC 57 | 6/6

The three security goals

Confidentiality keeps information from unauthorised disclosure.
Integrity protects it from unauthorised alteration or destruction.
Availability keeps information and services usable when needed.
Cybersecurity protects devices, networks and information together.
A system can fail one goal even when the other two appear secure.

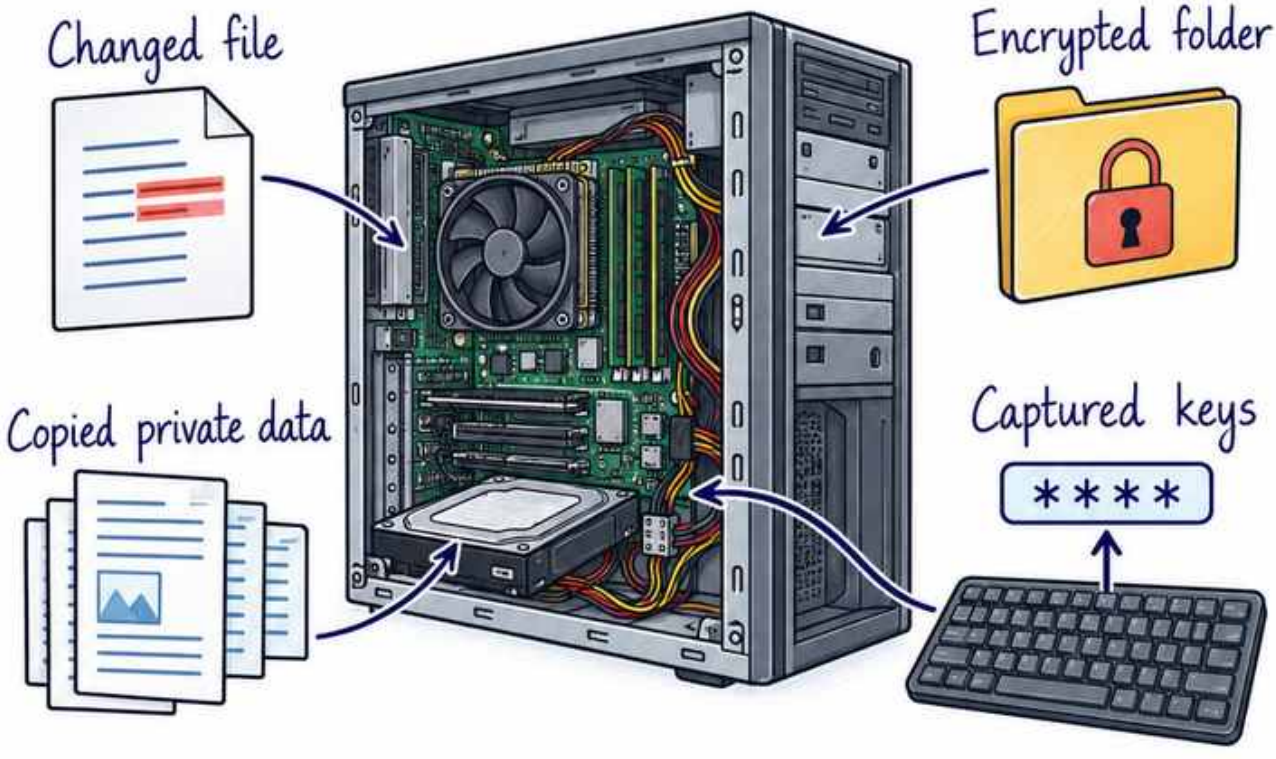


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Malware behaves differently

Malware can damage systems, steal information or deny access. Some types spread by infecting host programs; others replicate independently. Ransomware blocks access or threatens disclosure. Spyware gathers information, and keyloggers record keystrokes. Recognising the behaviour helps select a suitable defensive response.

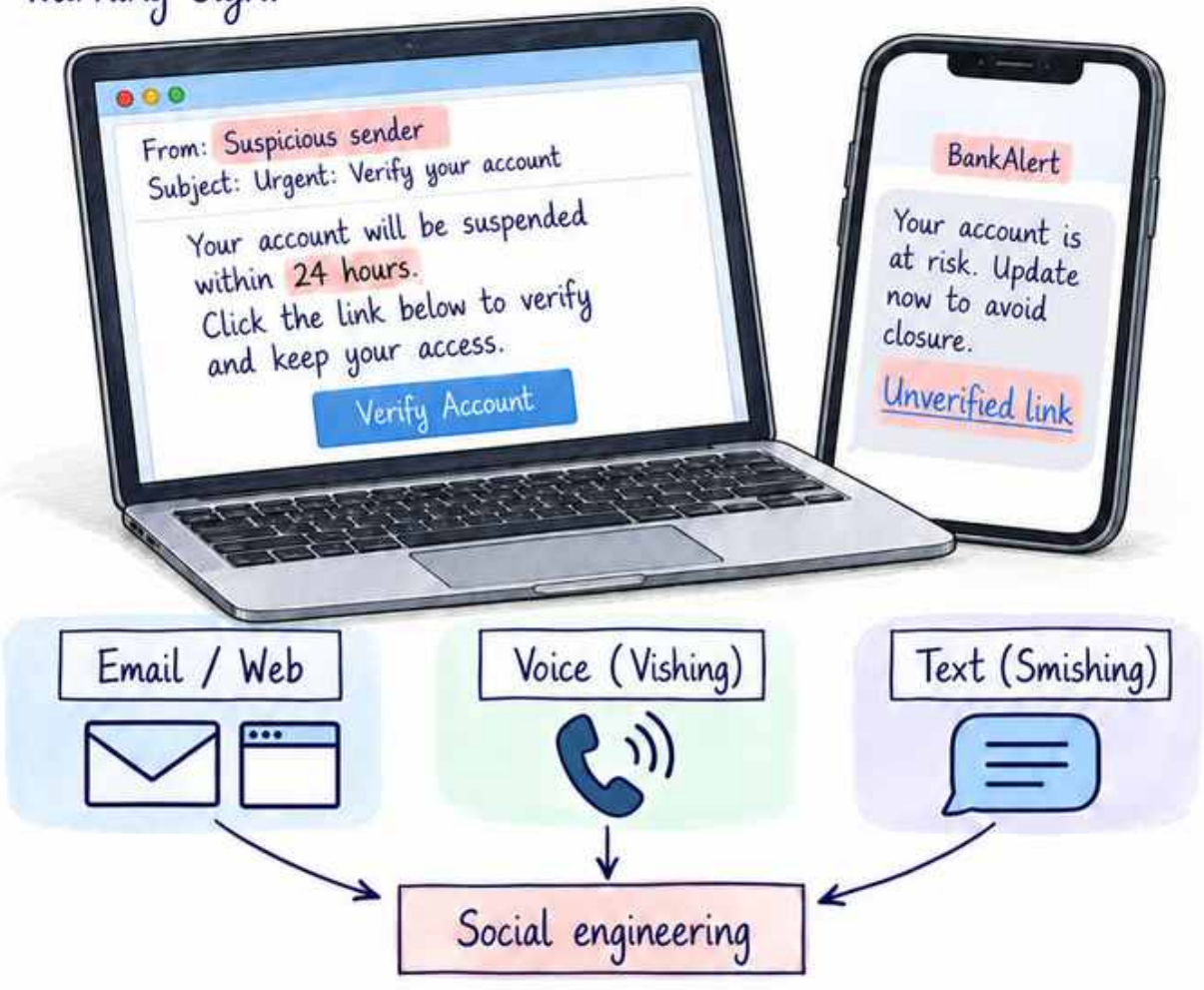


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When the target is trust

Phishing uses deceptive messages or websites.
Spear phishing targets a specific person; whaling targets senior leaders.
Vishing uses voice, and smishing uses text messages.
Social engineering exploits human trust.
A claim of "digital arrest" by phone or video is a cyber-fraud warning sign.



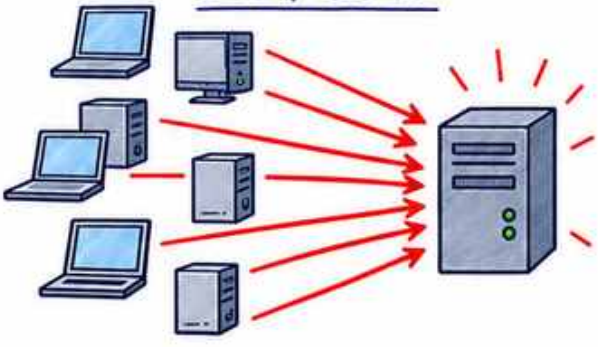
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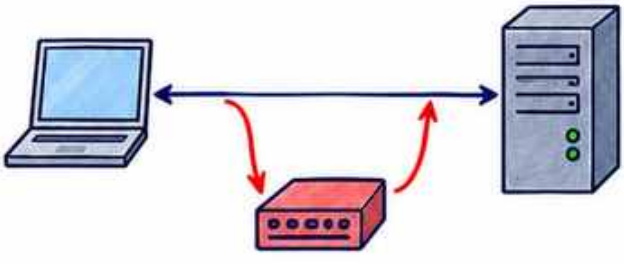
Attacks on systems and data

DoS disrupts access to a service; DDoS uses many hosts.
A man-in-the-middle attack intercepts or alters communication.
SQL injection manipulates the application-database interaction.
A zero-day attack exploits a previously unknown vulnerability.
These attacks use different mechanisms, so one defence cannot cover every risk.

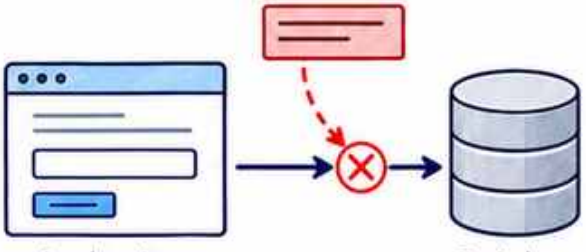
DoS / DDoS



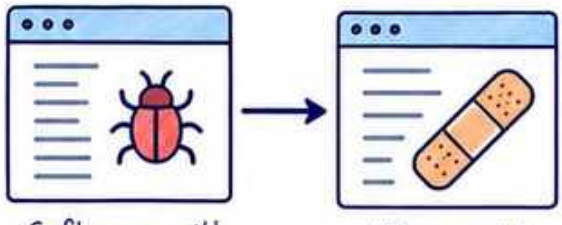
Man-in-the-middle attack



SQL injection



Zero-day attack



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Build several layers of defence

A firewall controls network access, antivirus detects malicious software, and encryption protects data in transit. Backups support recovery. Multi-factor authentication combines different factors: something you know, have or are. Two passwords are still one factor type. These controls complement one another rather than replacing one another.



Multi-factor authentication combines different factors:



Two passwords are still one factor type.
These controls complement one another rather than replacing one another.

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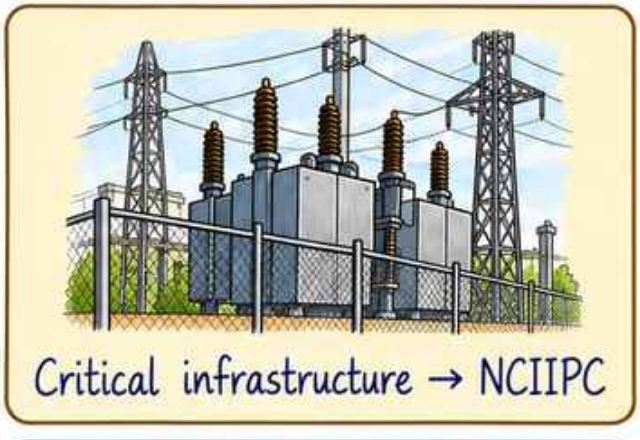
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Choose the right response

CERT-In handles cyber-incident response.
NCIIPC protects critical information infrastructure.
I4C coordinates cybercrime responses, while State and Union Territory police investigate offences.
For financial cyber-fraud, report promptly through 1930 or cybercrime.gov.in.
Chakshu handles suspected fraudulent communications.
Different problems lead to different reporting routes.



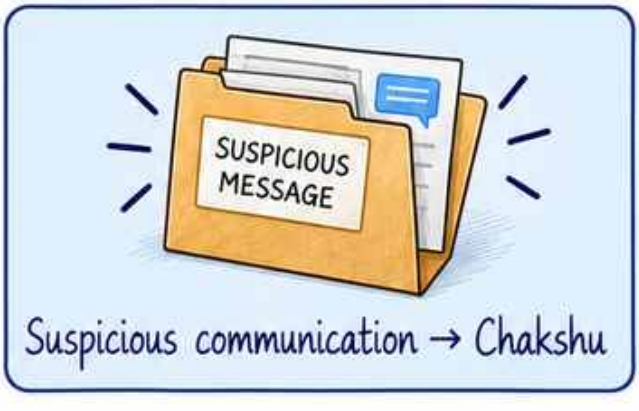
Cyber-incident → CERT-In



Critical infrastructure → NCIIPC



Cybercrime → I4C + police



Suspicious communication → Chakshu

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CERT-In: the six-hour rule

The 28 April 2022 directions apply to covered organisations and listed incidents.

Report within 6 hours of noticing an incident or being informed of it. Send available information first and supplement it.

The directions rest on section 70B(6); they are not a deadline for every citizen complaint.



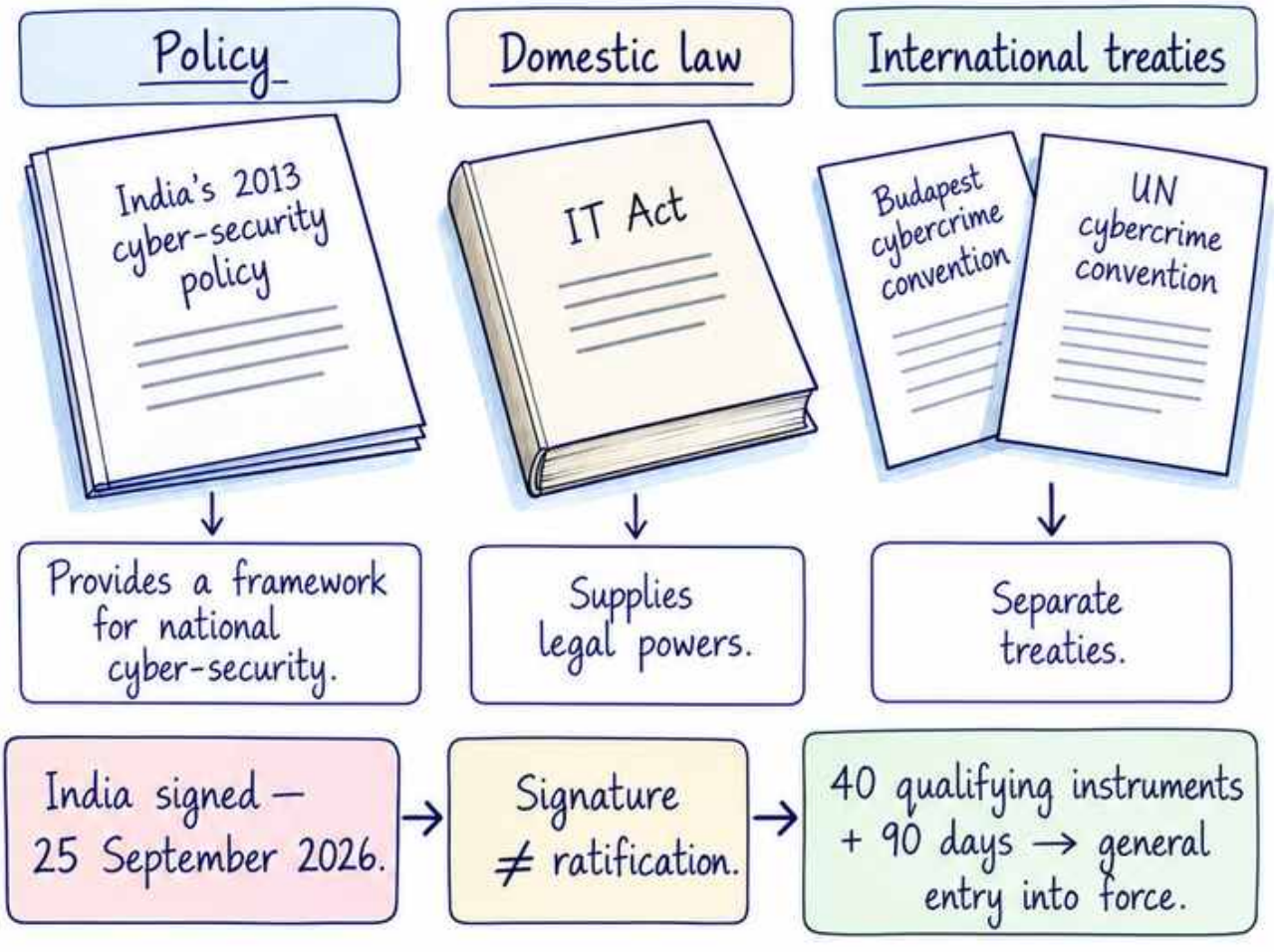
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Policy, law and treaties

India's 2013 cyber-security policy is a framework; the IT Act supplies legal powers. The Budapest and UN cybercrime conventions are separate treaties. India signed the UN Convention on 25 September 2026. Signature is not ratification. The UN treaty enters into force 90 days after the 40th ratification, acceptance, approval or accession instrument.



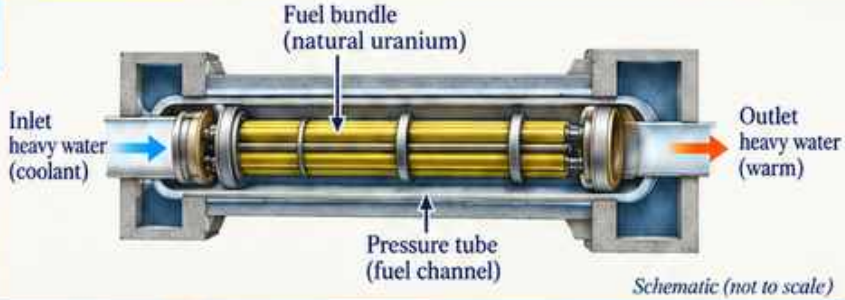
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DAY 7 | TOPIC 67 | 8/8

India's three-stage nuclear plan

1 PHWR

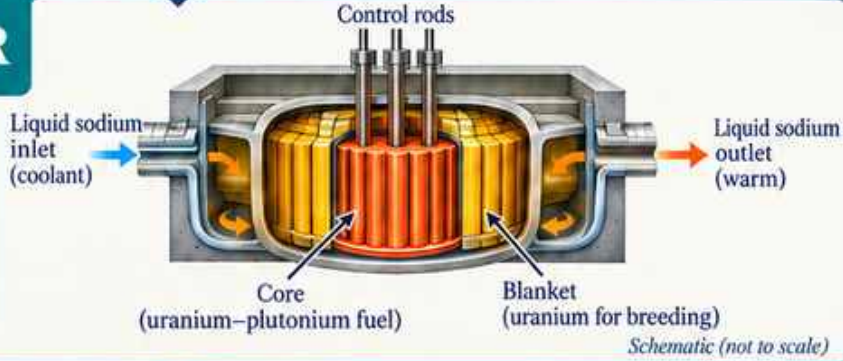
- Natural uranium
- Heavy water: moderator + coolant



Plutonium recovered from spent fuel

2 FAST BREEDER

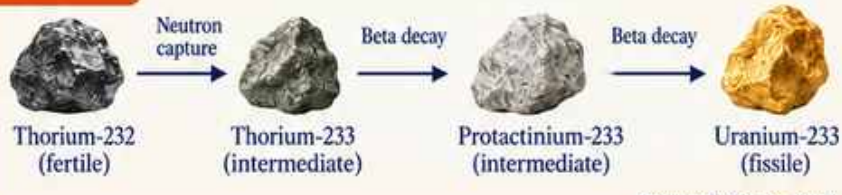
- Uranium–plutonium fuel
- Liquid sodium coolant; no moderator



Build fissile fuel; enable thorium use

3 THORIUM PATHWAY

- Thorium-232 → uranium-233
- Thorium is fertile; uranium-233 is fissile



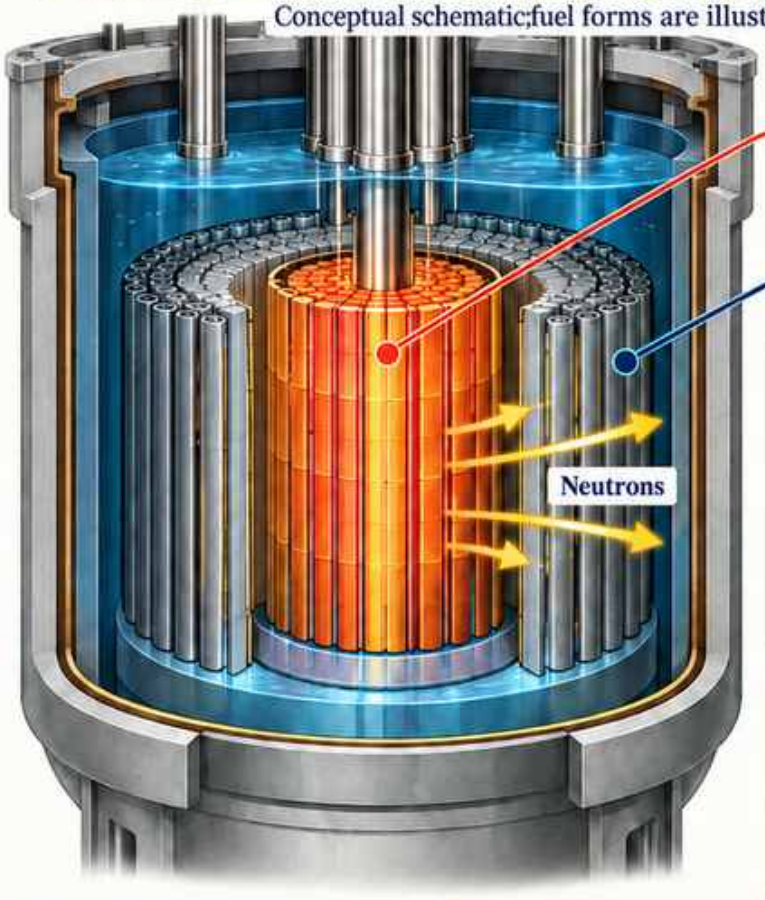
Stage 3 is a development pathway, not a commercial thorium fleet.

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DAY 8 | TOPIC 76 | 01

Inside a breeder: fuel and blanket

Conceptual schematic;fuel forms are illustrative, not to scale



PFBR core: uranium–plutonium mixed oxide (MOX)

Uranium-238 blanket

Breeding new fissile fuel



Uranium-238 (U-238) → Plutonium-239 (Pu-239)

Uranium-238 ⟶ plutonium-239

Coolant: liquid sodium

No moderator

PFBR: mixed oxide fuel



- Uranium–plutonium mixed oxide (MOX)
- Fast breeder reactor
- Surrounded by uranium-238 blanket to breed more fuel

FBTR: mixed carbide fuel



- Uranium–plutonium mixed carbide (MC)
- Fast breeder test reactor
- Demonstrated breeder technology

KAMINI: uranium-233 fuel



- Uranium-233 fuel
- Small research reactor
- Supports thorium fuel cycle research

Thorium is not the PFBR's present core fuel.

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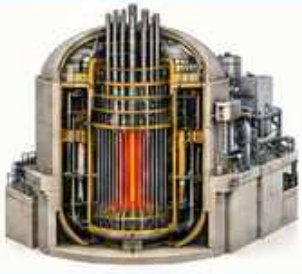
Who does what in nuclear energy?

Institutions and roles

RESEARCH AND DESIGN



BARC
reactor design and research



IGCAR
fast-reactor research; PFBR design

BUILD AND OPERATE



NPCIL
nuclear power stations



BHAVINI
PFBR and fast breeders

SUPPLIES



UCIL
uranium mining and processing



NFC
fuel assemblies



Heavy Water Board
heavy water

AERB

Safety regulator

Responsible to AEC



IGCAR designs. BHAVINI builds and operates. AERB regulates.

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Nuclear stations: names and States



Tarapur	Maharashtra	BWR + PHWR



Rawatbhata	Rajasthan	PHWR



Kalpakkam (MAPS)	Tamil Nadu	PHWR



Narora	Uttar Pradesh	PHWR



Kakrapar	Gujarat	PHWR



Kaiga	Karnataka	PHWR



Kudankulam	Tamil Nadu	PWR

NPCIL operating fleet • October 2026

24 units • 8,780 MWe

20 PHWR + 2 BWR + 2 PWR

Kakrapar = Gujarat | Kaiga = Karnataka

PFBR is not included in this NPCIL total.

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Criticality is a milestone

1

First criticality

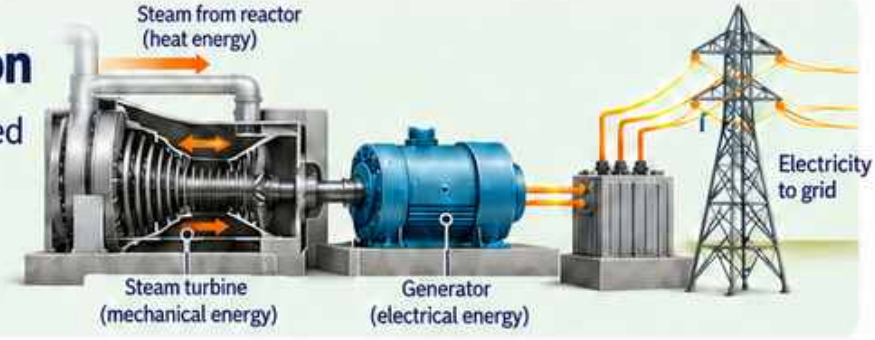
A self-sustaining controlled chain reaction.



2

Grid connection

Electricity first supplied to the grid.



3

Commercial operation

Plant enters commercial service.



PFBR, Kalpakkam
500 MWe design capacity

First criticality:
6 April 2026

First criticality is distinct from commercial operation.

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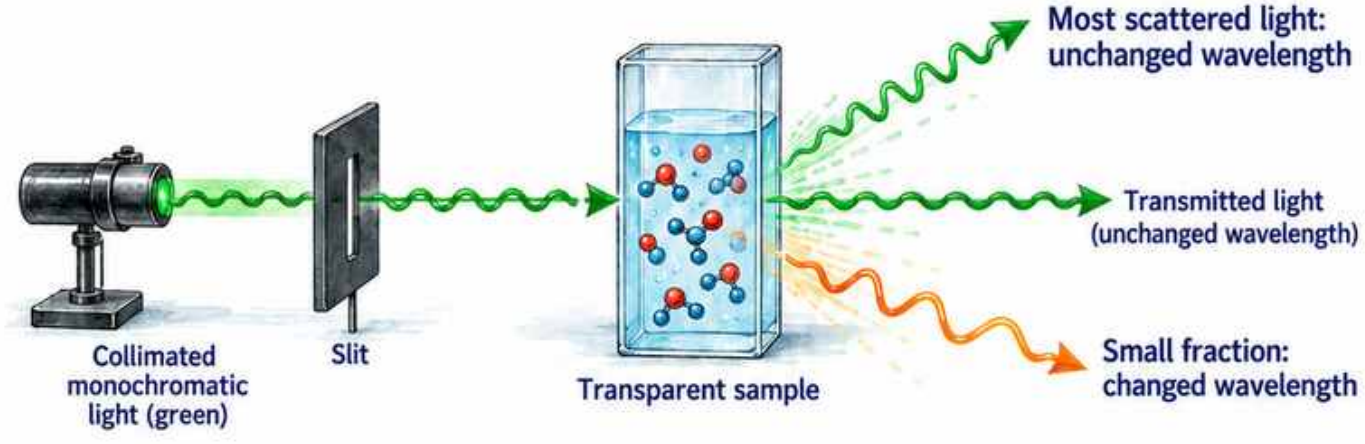
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DAY 8 | TOPIC 76 | 05

C.V. Raman: light tells a story

DAY 8 • TOPIC 77 • 1/5

RAMAN EFFECT • 28 FEBRUARY 1928

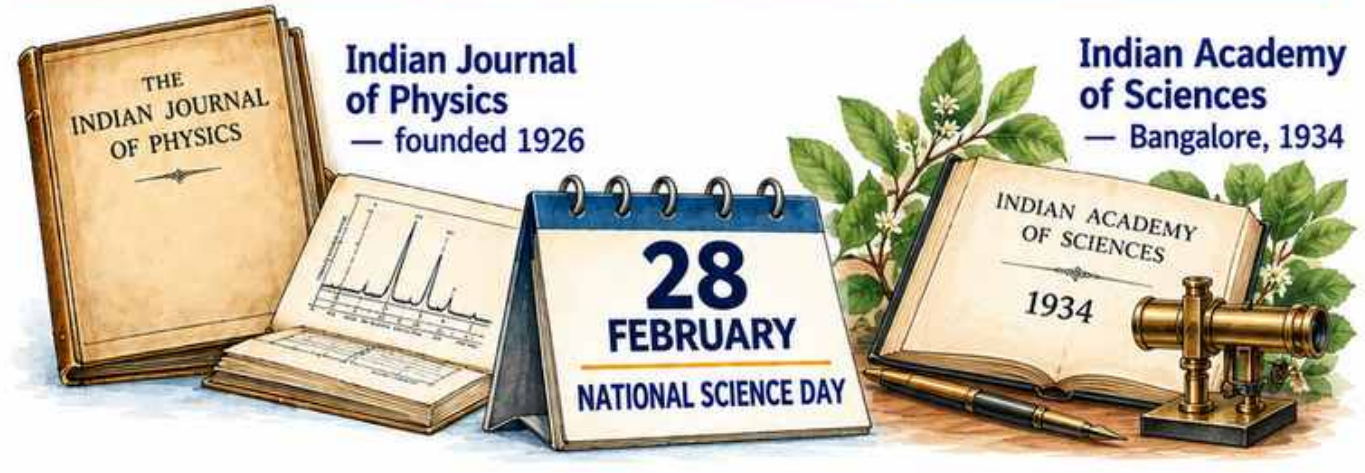
At IACS, Calcutta, Raman and K.S. Krishnan observed a small fraction of scattered light with a changed wavelength.



1928 — Discovery at Calcutta

1930 — Nobel Prize in Physics

1933 — Moved to IISc, Bangalore



Indian Journal of Physics — founded 1926

Indian Academy of Sciences — Bangalore, 1934

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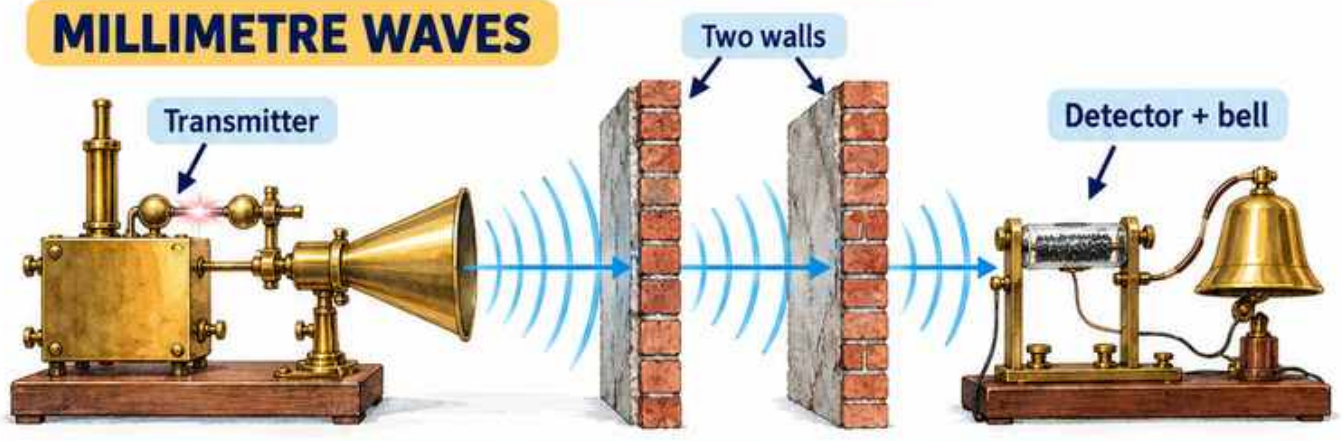
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DAY 8 | TOPIC 77 | 01

J.C. Bose: waves and plant growth

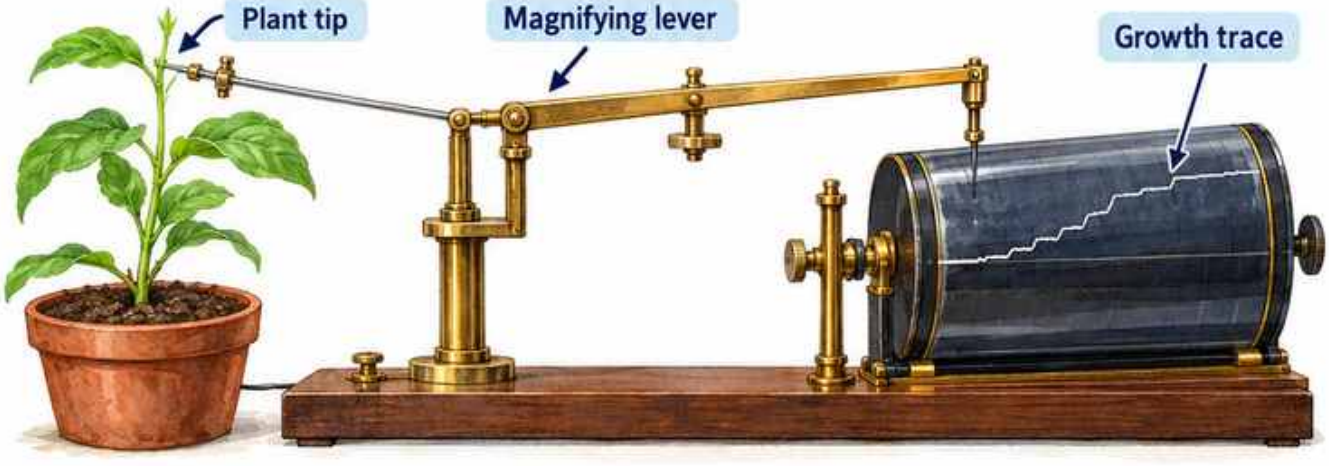
DAY 8 • TOPIC 77 • 2/5

MILLIMETRE WAVES



1895 demonstration: 60 GHz over 23 metres, through two walls.
He developed millimetre-wave instruments and detectors.

CRESCOGRAPH



Magnifies tiny growth movements so plant responses to stimuli can be measured.

Presidency College, Calcutta: taught physics	Bose Institute: founded 1917	FRS: 1920

Exam cue: J.C. Bose studied plants and radio waves; S.N. Bose developed quantum statistics.

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DAY 8 | TOPIC 77 | 02

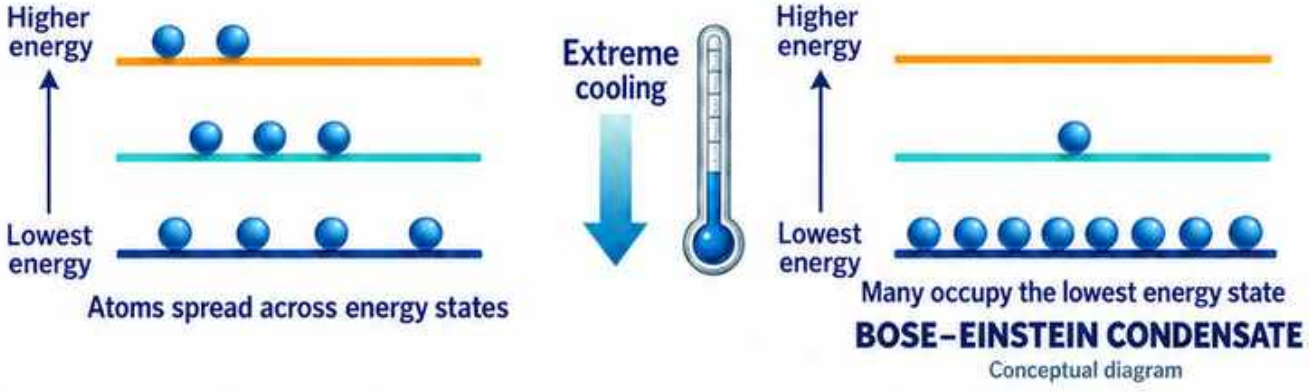
S.N. Bose: a new way to count

DAY 8 • TOPIC 77 • 3/5



Bose derived Planck's law by a new counting of identical light quanta.
Einstein translated his paper and extended the method to atoms.

BOSE–EINSTEIN STATISTICS



1924 Bose's paper → **1995** Condensate first produced → **2001** Nobel Prize for Cornell, Ketterle and Wieman



'Boson' was named by Paul Dirac after Bose.



University of Dhaka: taught physics, 1921–1945.



Final exam cue: S.N. Bose did not receive a Nobel Prize.

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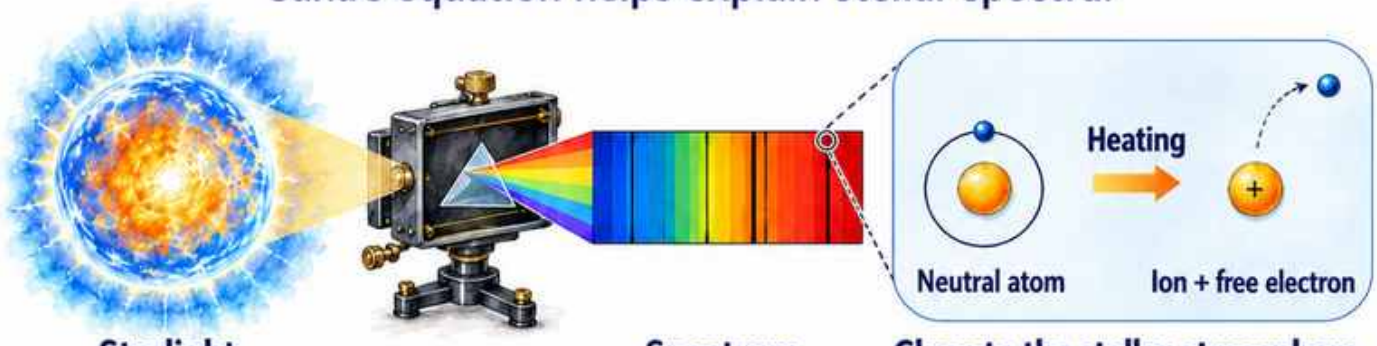
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DAY 8 | TOPIC 77 | 03

Meghnad Saha: reading the stars

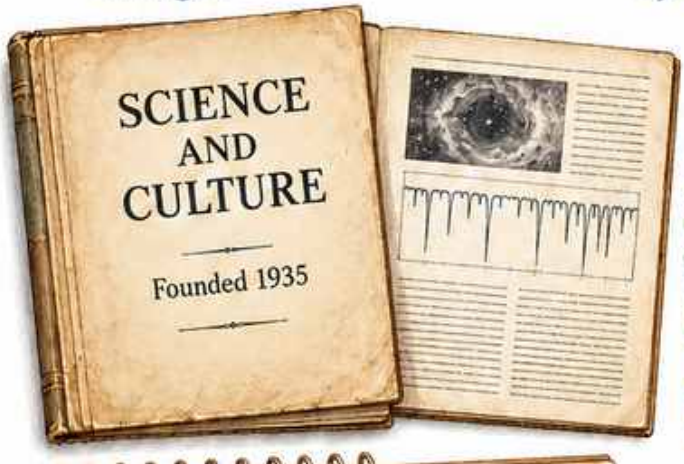
DAY 8 • TOPIC 77 • 4/5

THERMAL IONISATION • 1920

Ionisation depends on temperature and electron density.
Saha's equation helps explain stellar spectra.



Starlight | Spectrum | Clues to the stellar atmosphere







- 1949 — Founded
- 11 Jan 1950 — Building inaugurated
- 1951 — Became autonomous

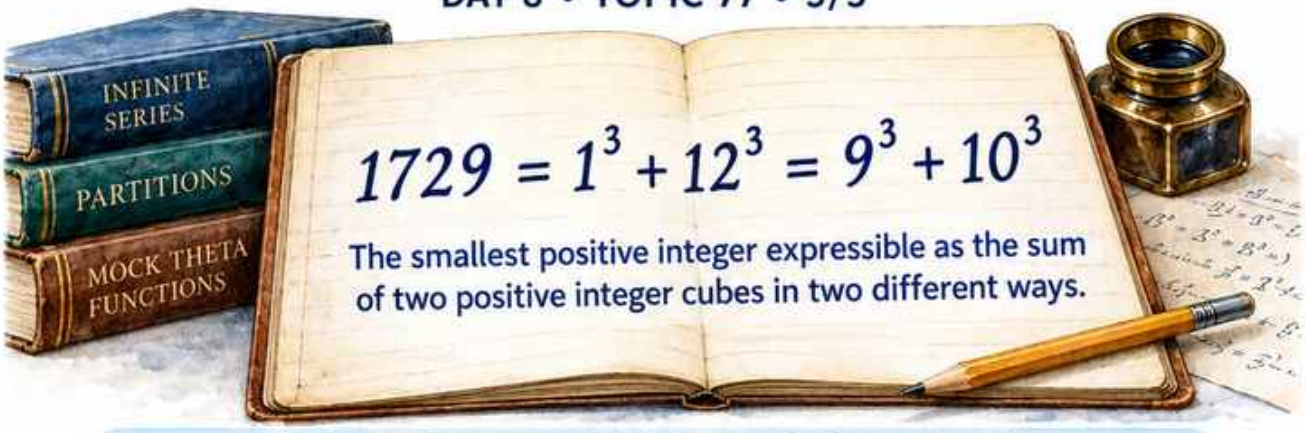
Now the Saha Institute of Nuclear Physics, Kolkata.

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DAY 8 | TOPIC 77 | 04

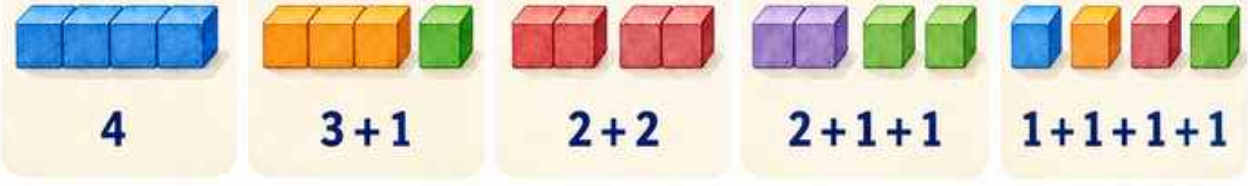
Ramanujan: patterns in numbers

DAY 8 • TOPIC 77 • 5/5



Infinite series • Partitions • Mock theta functions

PARTITIONS

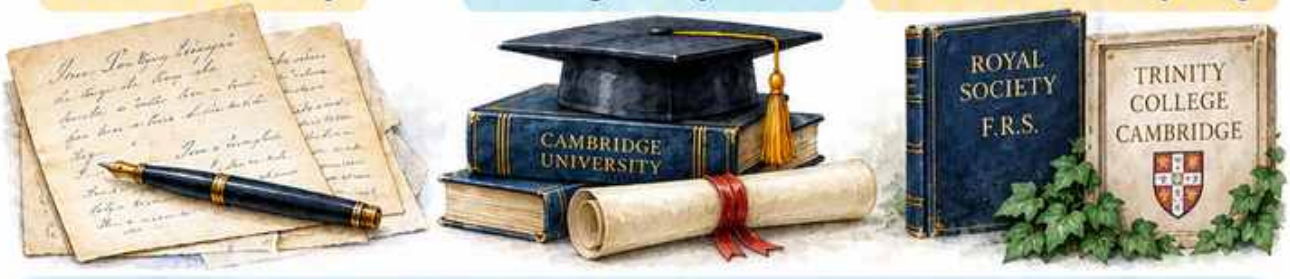


A partition writes a positive integer as a sum of positive integers; order does not create a new partition.

1913 – Letter to G.H. Hardy

1916 – Cambridge B.A. by research

1918 – FRS and Fellow of Trinity College



He failed FA at Pachaiyappa's College; he later earned the Cambridge degree.

22 DECEMBER • NATIONAL MATHEMATICS DAY

His birthday; 2012 was National Mathematics Year.

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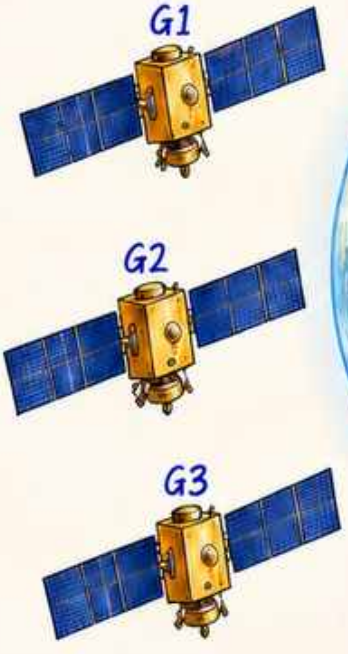
NavIC: seven satellites in the design

NavIC = Navigation with Indian Constellation; formerly IRNSS. Designed with 7 satellites.

3 satellites in Geostationary Earth Orbit (GEO) over the equator.

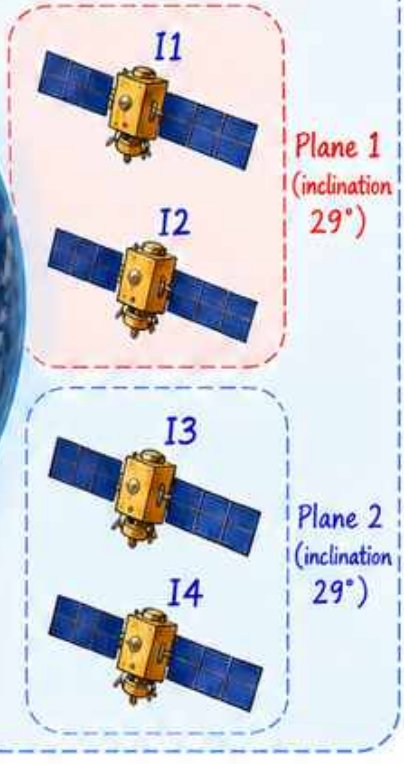
4 satellites in Inclined Geosynchronous Orbit (IGSO) on two inclined planes (2 satellites per plane).

3 GEO · equatorial





4 IGSO · two planes, two each



Grouping schematic, not orbital geometry

Provides regional navigation services, not global.

Coverage is over India and about 1,500 km beyond its boundary.

GEO and IGSO satellites are at about 36,000 km altitude (geosynchronous). No MEO satellites in the base design.

The design count (7 satellites: 3 GEO + 4 IGSO) is distinct from the current working count.

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Navigation is a timing problem

Satellite 1
Transmits time signal t_1

Satellite 2
Transmits time signal t_2

Satellite 3
Transmits time signal t_3

Satellite 4
Transmits time signal t_4

Receiver does not send any ranging request. Satellites transmit their time signals towards the receiver.

Travel time × speed of light = pseudorange

$$\rho = (t_{receive} - t_{transmit}) \times c$$

Affected by satellite and receiver clock errors and signal delays.

Receiver (on Earth)

Four satellites at suitable positions solve for four unknowns: receiver position (x, y, z) and receiver clock offset (Δt_r).

Atomic-clock precision matters

- Satellites carry highly precise atomic clocks.
- Accurate time signals enable precise ranging and reliable positioning.



Atomic clock (in satellite)

Redundancy keeps satellites healthy

- Each satellite carries multiple clocks (redundant).
- One failed redundant clock does not automatically disable the satellite.



One failed redundant clock does not disable the satellite.

If no functioning clock

- Normal positioning signals are unavailable.
- Messaging signals may still remain operational.



Positioning signals unavailable

Messaging signals may remain

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Signals, services and the new generation



SPS: open civilian service

- Available for all civilian users
- Supports positioning, navigation and timing (PNT)

RS: encrypted, authorised users

- Encrypted and restricted access
- For authorised users only

First-generation SPS and RS both use L5 and S

First generation (IRNSS)

- Transmits L5 + S signals



NVS generation

- Adds L1 civilian signal along with L5 + S



NVS launch details



NVS-01

- Launch vehicle: GSLV-F12
- Date: 29 May 2023
- Indigenous rubidium clock



NVS-02

- Launch vehicle: GSLV-F15
- Date: 29 January 2025
- Orbit-raising failed
- Planned final orbit not reached

Signal frequencies

L5	= 1176.45 MHz
S	= 2492.028 MHz (ISRO SPS ICD, 2017)
L1	= 1575.42 MHz (added in NVS)

Accuracy specification

- Position better than 20 m (2σ)
- This is a specification and not a guarantee for every fix.



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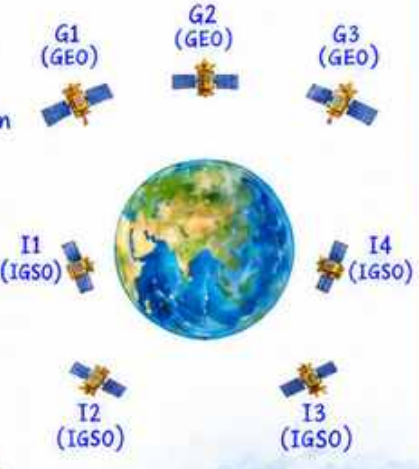
NavIC and GAGAN solve different problems

NavIC

Navigation with Indian Constellation
Earlier name: IRNSS

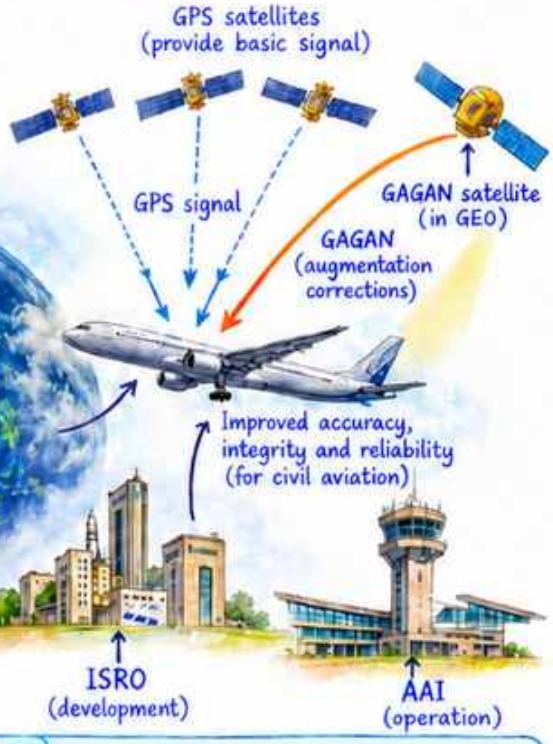
- Independent regional navigation system developed by India.
- Uses its own satellites and system time (IRNSS time).
- Provides positioning, navigation and timing (PNT) services in the Indian region.

NavIC base design: 7 satellites · grouping schematic



GAGAN (GPS Aided Geo Augmented Navigation)

- Satellite based augmentation system for GPS.
- Developed jointly by ISRO and Airports Authority of India (AAI).
- Provides augmentation services to improve GPS accuracy, integrity and reliability for civil aviation.



Uses (NavIC)



Status snapshot (as on 29 July 2026) — PNT satellites

Three PNT satellites are in operation



Standalone basic positioning requires four satellites



Timing service is functional



Multi-constellation use is possible

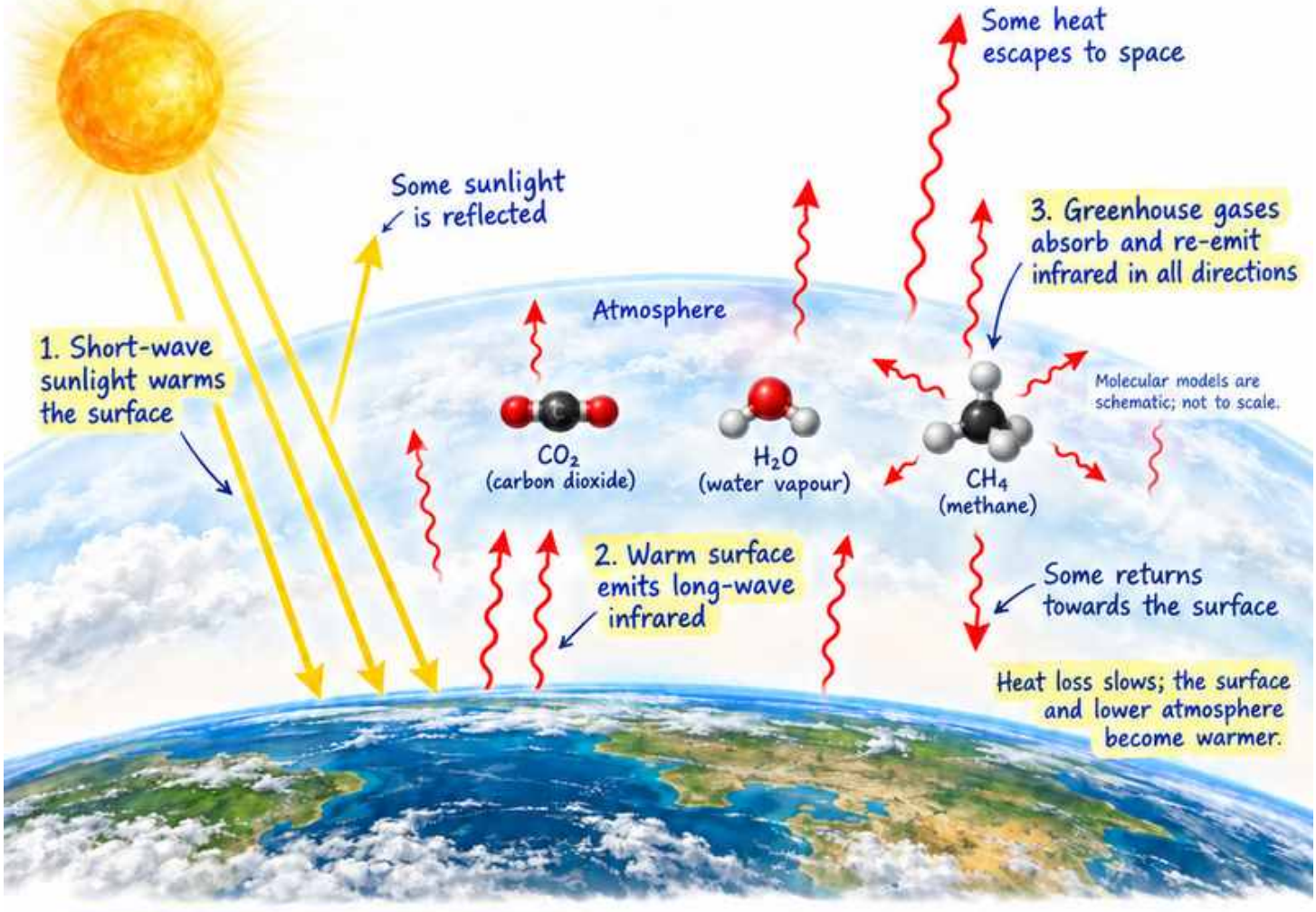


Note: All operational details are as on 29 July 2026 and are not permanent.

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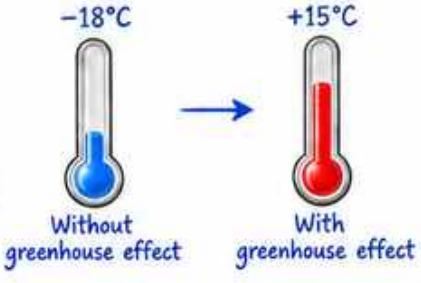
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How the greenhouse effect works



Natural effect: essential for life

About −18°C without it → about +15°C with it: roughly 33°C warmer.



Enhanced effect: human activities add greenhouse gases

More CO_2, CH_4 and other greenhouse gases from human activities → less heat initially escapes to space → global average temperature rises.

N_2, O_2 and Ar are not significant greenhouse gases. Water vapour is the most abundant greenhouse gas.

Sources: NASA; IPCC

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Gases: sources, lifetimes & warming

1. CO_2



- Fossil fuels, cement, deforestation
- GWP_{100} = 1 (reference)
- No single lifetime; some influence persists for centuries to millennia.

2. CH_4



- Wetlands; livestock, rice, landfills, fuel leaks
- About 40% natural / 60% human
- Lifetime ≈ 11.8 years
- GWP_{100}: fossil 29.8; non-fossil 27.0

3. N_2O



- Fertilisers, soils, biomass burning, industry
- Lifetime ≈ 109 years
- GWP_{100} = 273

4. Fluorinated gases



- Industrial gases; high warming per unit mass

HFC-134a	1,530	14 years
HFC-23	14,600	228 years
CF_4	7,380	50,000 years
NF_3	17,400	
SF_6	24,300	

GWP_{100} | lifetime where shown

5. Water vapour & ozone

H_2O: most abundant; mainly a feedback, quickly cycles through rain.



O_3: also a greenhouse gas; tropospheric ozone warms.



6. GWP, CO_2e and key takeaways

- GWP compares heat-trapping impact of equal masses over a stated period. Here: 100 years, IPCC AR6.
- CO_2e = gas mass × GWP
- 1 tonne N_2O = 273 tonnes CO_2e
- CO_2 dominates through quantity and persistence, not the highest GWP.

1 tonne N_2O × 273 = 273 tonnes CO_2e

Equal integrated warming impact over 100 years

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Which gases do the treaties count?

Kyoto Protocol · 1997

1. CO_2 (carbon dioxide)
2. CH_4 (methane)
3. N_2O (nitrous oxide)
4. HFCs (hydrofluorocarbons)
5. PFCs (perfluorocarbons)
6. SF_6 (sulfur hexafluoride)

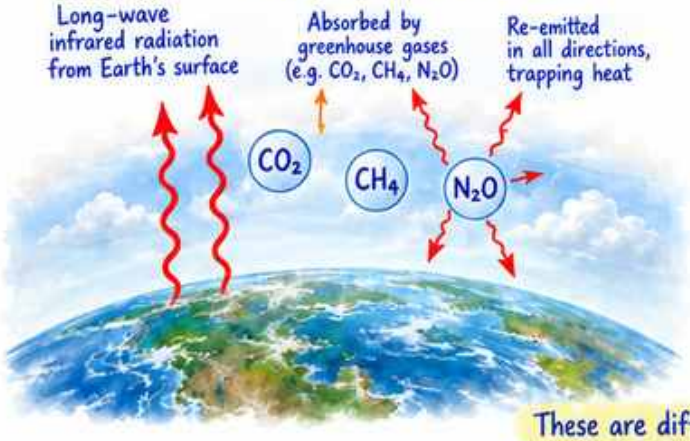
Original six gas categories in Annex A →

Doha Amendment · 2012

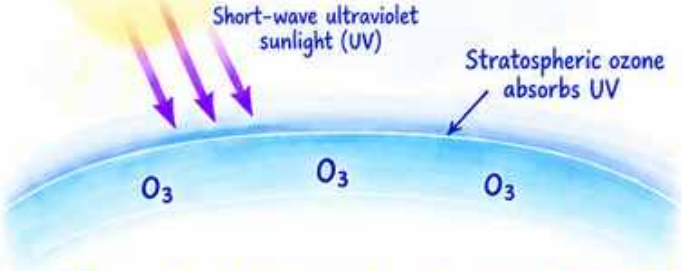
1. CO_2 (carbon dioxide)
2. CH_4 (methane)
3. N_2O (nitrous oxide)
4. HFCs (hydrofluorocarbons)
5. PFCs (perfluorocarbons)
6. SF_6 (sulfur hexafluoride)
7. NF_3 (nitrogen trifluoride)

→ Adopted 8 December 2012
→ Applies from the 2013–2020 commitment period
→ Entered into force 31 December 2020

Greenhouse effect



Ozone depletion



CFCs → chlorine released → ozone destroyed

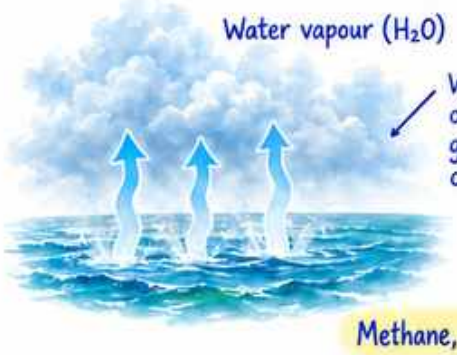
releases chlorine in the stratosphere

Chlorine reacts with ozone, destroying it

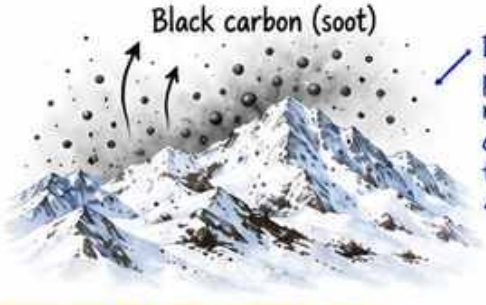
These are different processes.

CFCs and HCFCs warm the climate AND deplete ozone; they are controlled under the Montreal Protocol, not Kyoto's gas list.

AR6 GWP100: CFC-11 6,230; CFC-12 12,500; HCFC-22 1,960.



Water vapour and ozone are greenhouse gases but are not on Kyoto's list.



Black carbon is soot particles, an aerosol, not a gas. It warms air and darkens snow; typically stays aloft 4–12 days.

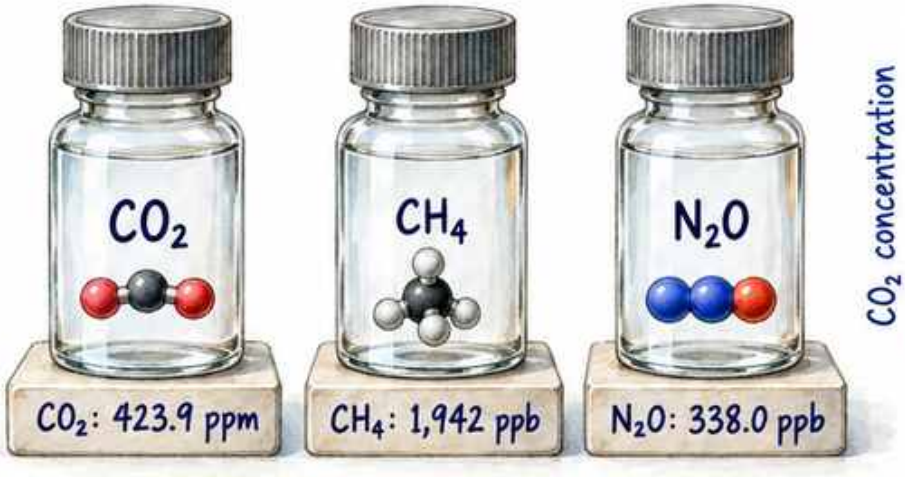
Methane, ozone and black carbon are short-lived climate forcers.

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Read the climate numbers correctly

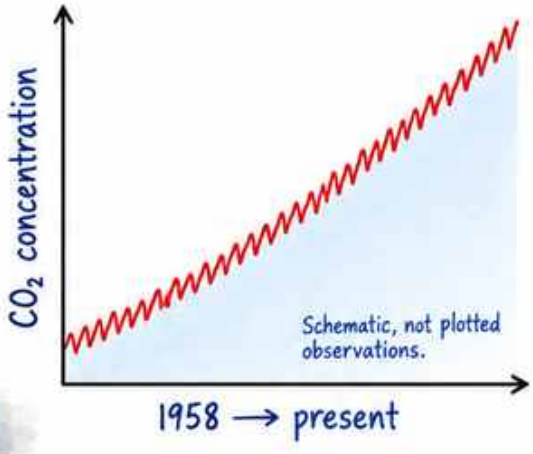
Global annual averages · 2024 (WMO)



1 ppm = 1,000 ppb

CO_2 rose 3.5 ppm in one year, the largest annual rise since modern measurements began.

Keeling Curve · Mauna Loa



Long-term rise + seasonal plant cycle. One station's monthly reading is not the global annual mean.

Temperature above 1850–1900 average



2011–2020 decade: ≈ 1.1 °C · IPCC



2024 year: 1.55 ± 0.13 °C · WMO



2025 year: 1.43 ± 0.13 °C · WMO, March 2026

2025: second or third warmest, depending on dataset. 2015–2025 are the eleven warmest years.

Do not mix baselines: gases versus about 1750; warming versus 1850–1900. A single year is not a long-term warming average.

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Feedbacks, sinks & impacts

Forcing starts a change; feedback amplifies or reduces it.

Water vapour feedback



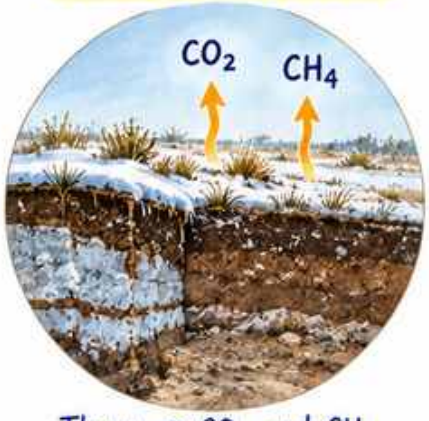
Warming → more water vapour → stronger greenhouse effect.

Ice-albedo feedback



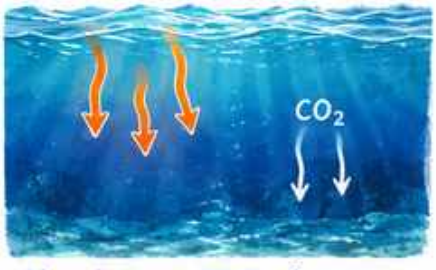
Less ice → less reflected sunlight → more absorbed heat → warming.

Permafrost feedback



Thaw → CO_2 and CH_4 released → further warming.

Ocean



Absorbs over 90% of excess heat. Absorbed CO_2 also increases acidity.

Sea level

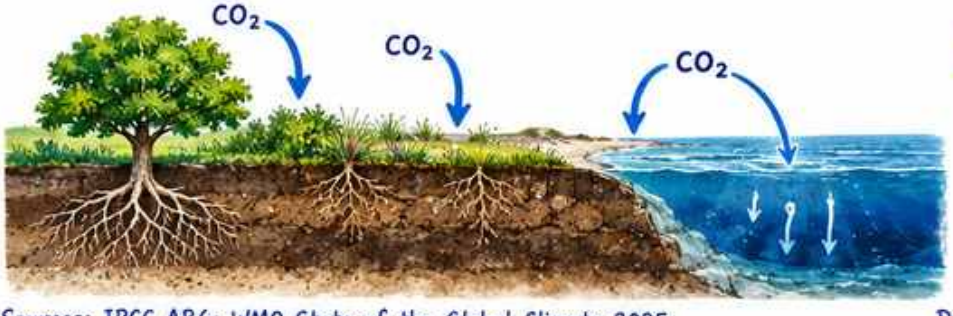


Thermal expansion + melting land ice.
1901–2018: +0.20 m.
Rate: 2.65 mm/year (1993–2011) → 4.75 mm/year (2012–2025).

Ice and extremes



Arctic sea-ice maximum in 2025 was the lowest recorded. Human-caused warming affects extremes in every region.



Carbon sinks

Carbon sinks remove CO_2; land and ocean absorb roughly half of emissions. Sequestration stores carbon.

Sources: IPCC AR6; WMO State of the Global Climate 2025

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Who emits? Keep the year & boundary



World · 2019 · IPCC

- 59 ± 6.6 Gt CO_2e net human-caused emissions
- About 54% above 1990
- Energy + industry + transport + buildings: 79%
- Agriculture, forestry and other land use: 22%
- Rounded shares; 1 Gt = 1 billion tonnes.

India · 2022 inventory · First BTR

3,396 Mt CO_2e
Emissions excluding LULUCF

↓ −572 Mt net removal by LULUCF

2,825 Mt CO_2e
Net emissions including LULUCF

Rounded; totals use unrounded inventory data.



India: shares excluding LULUCF

Energy	73.38%
Agriculture	15.00%
Industrial processes & product use	8.86%
Waste	2.76%

- LULUCF = land use, land-use change and forestry
- Emissions intensity of GDP fell 37.38% during 2005–2022
- India's BTR uses AR5 GWP factors; do not directly mix reporting bases.

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Climate science: dates & changing metrics



1824 · Fourier: atmospheric warming idea



1896 · Arrhenius: quantitative CO_2 warming estimate



1958 · Keeling: Mauna Loa measurements begin

1988 · IPCC established by WMO + UNEP

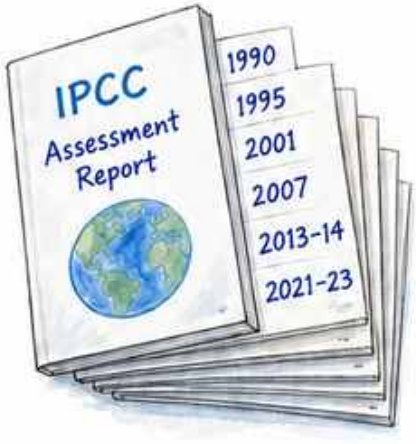


2007 · Nobel Peace Prize: IPCC + Al Gore



2023 · AR6 completed; AR7 cycle begins

Assessment reports:
1990, 1995, 2001, 2007, 2013–14, 2021–23.



100-year GWP	AR4	AR5	AR6
CH_4, non-fossil	25	28	27.0
N_2O	298	265	273
HFC-134a	1,430	1,300	1,530
NF_3	17,200	16,100	17,400
SF_6	22,800	23,500	24,300
CO_2	1	1	1

← Same gas, revised scientific estimate.

Always state the time horizon and report. A question naming AR5 needs AR5 figures; AR6 is not a replacement for a required inventory convention.

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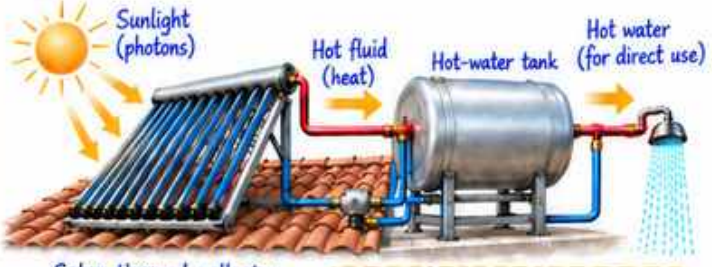
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Solar energy: two routes

1 PV: light → electricity



2 Solar thermal: light → heat



Solar thermal collector (evacuated tubes)

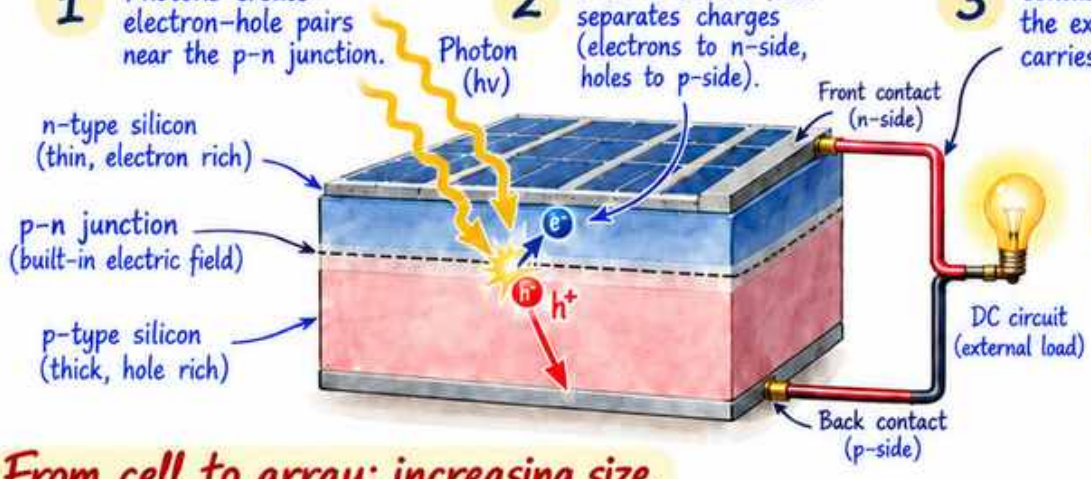
Direct heat, or heat → engine/turbine → electricity.

How a silicon solar cell works

1 Photons create electron–hole pairs near the p–n junction.

2 Junction electric field separates charges (electrons to n-side, holes to p-side).

3 Contacts collect charges; the external circuit carries DC.



Bandgap: minimum photon energy needed to create an electron–hole pair.

From cell to array: increasing size



Wp: rated peak power under standard test conditions

Many modules connected

Single-junction theoretical limit ≈33%; tandem cells can exceed it

1839 Becquerel: PV effect. → **1954** Bell Labs: practical silicon cell. → **1958** Vanguard 1: solar in space.

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PV cells: materials matter

1. Crystalline silicon

Mono: one crystal; high efficiency.

Poly: many crystals; lower efficiency.



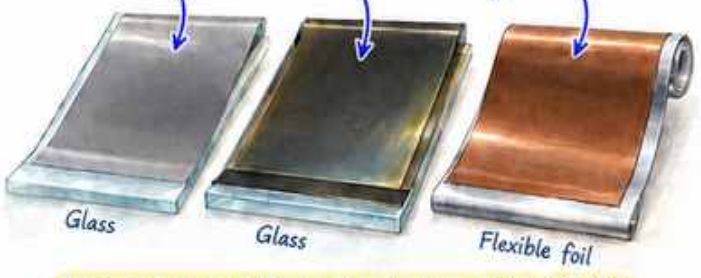
Silicon dominates mass production.

2. Thin films

a-Si: non-crystalline silicon.

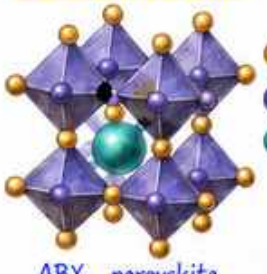
CdTe: cadmium telluride.

CIGS: copper-indium-gallium-diselenide.



Less material; CdTe is the leading thin-film PV.

3. Perovskite



ABX_3 perovskite crystal structure.

Perovskite thin film deposited on substrate.

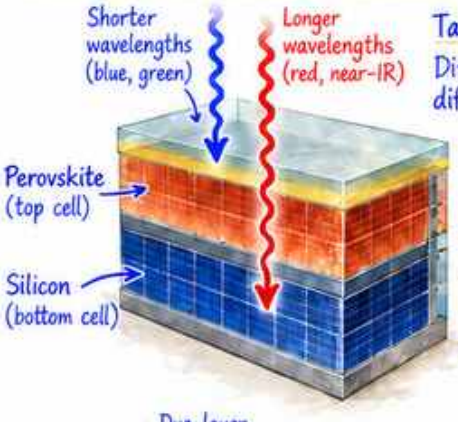


Named for crystal structure; durability remains a challenge.

4. Tandem / multi-junction

Shorter wavelengths (blue, green)

Longer wavelengths (red, near-IR)



Tandem = two bandgaps. Different layers harvest different wavelengths.

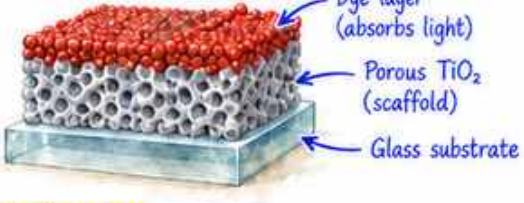


III-V multi-junction: costly; useful in space.

5. Emerging choices

Organic: carbon-rich; flexible, lower efficiency.



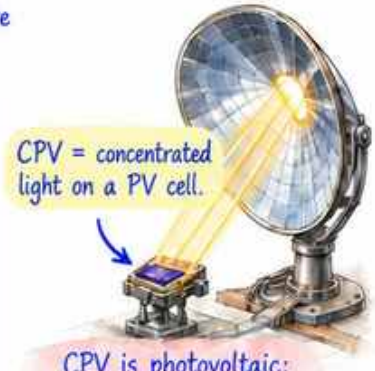


Dye-sensitised: dye absorbs light.

6. Lab records • Fraunhofer, 14 Jul 2026



* High concentration; records are not retail-module efficiencies.



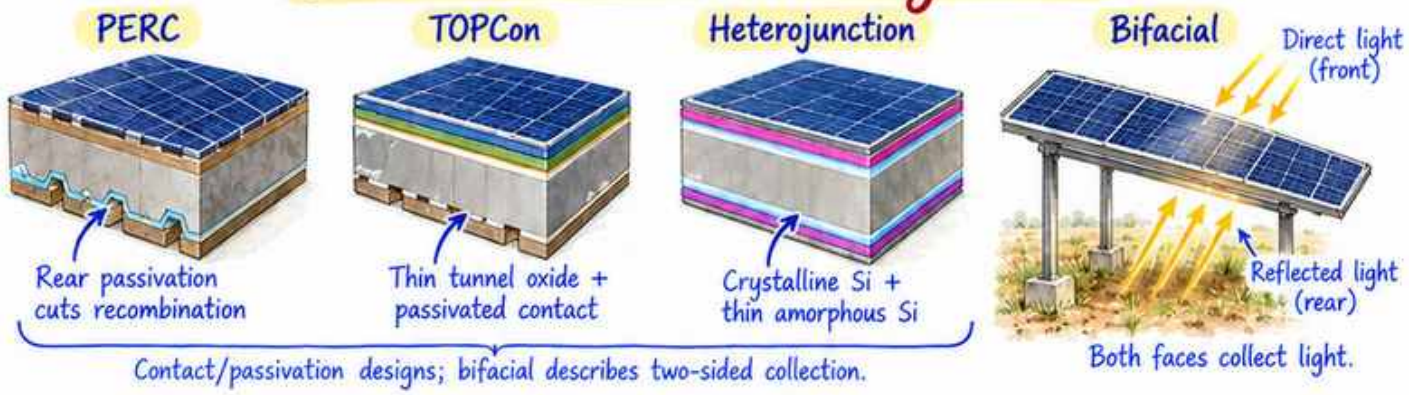
CPV = concentrated light on a PV cell.

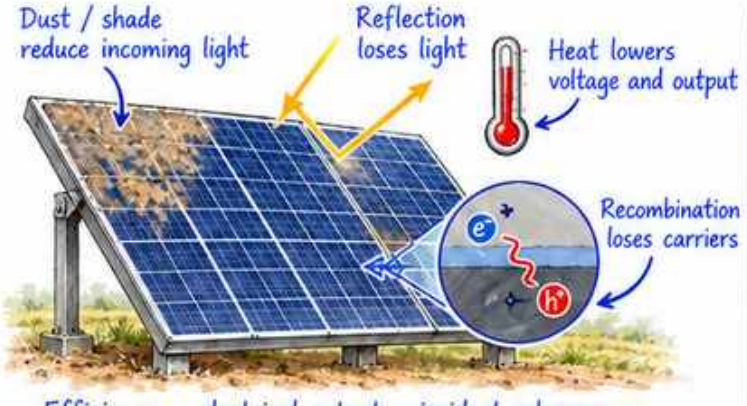
CPV is photovoltaic; CSP uses heat.

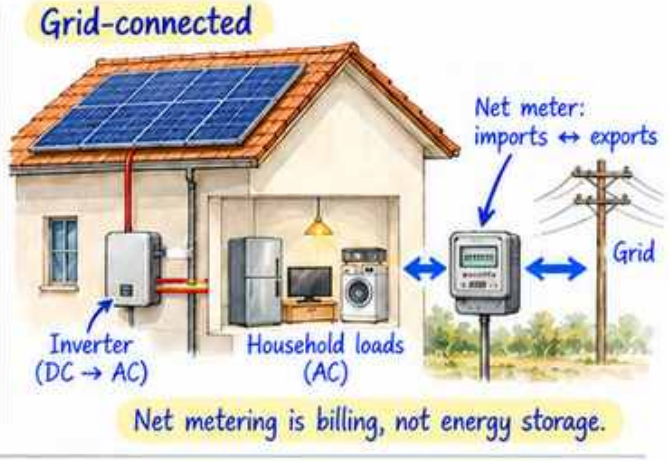
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Better cells, smarter systems









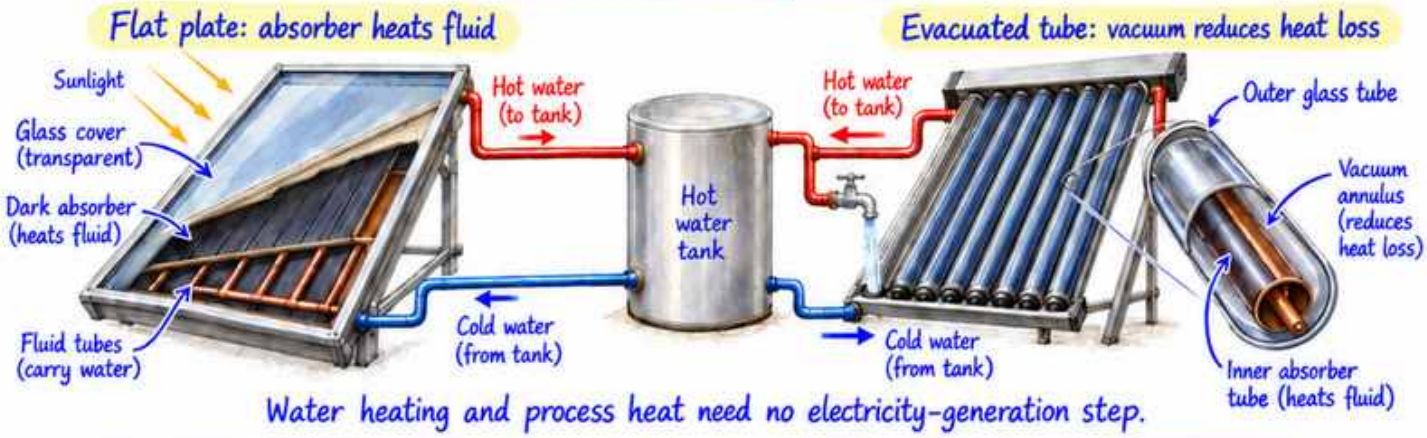




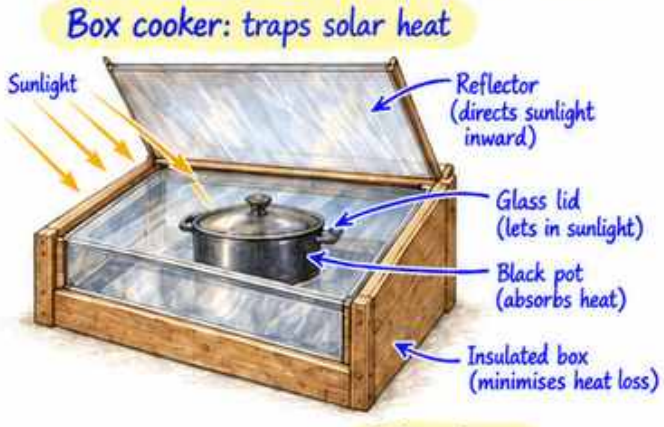
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Solar thermal: heat put to work



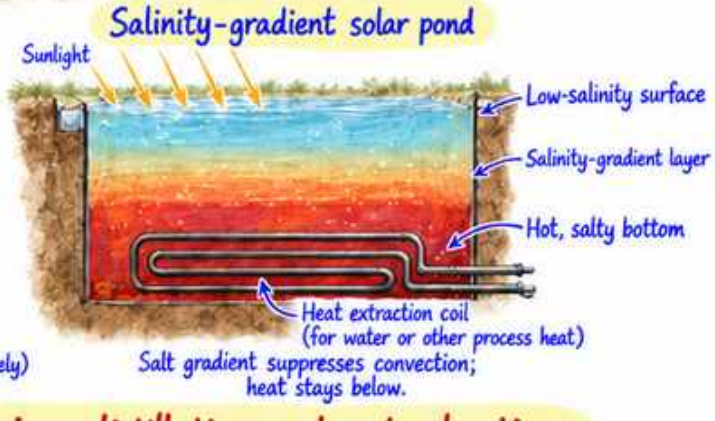
Water heating and process heat need no electricity-generation step.











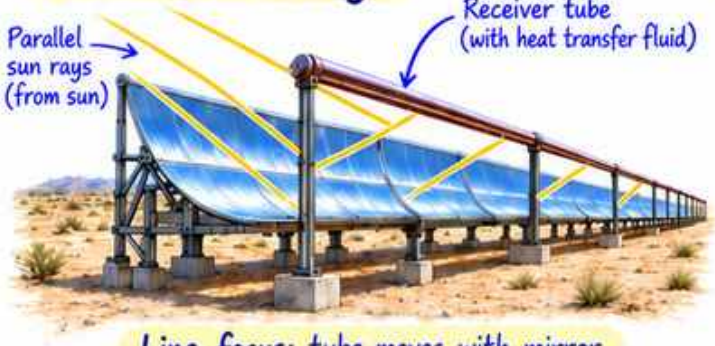
Solar thermal includes cooking, drying, distillation and water heating.

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CSP: four ways to focus

1. Parabolic trough



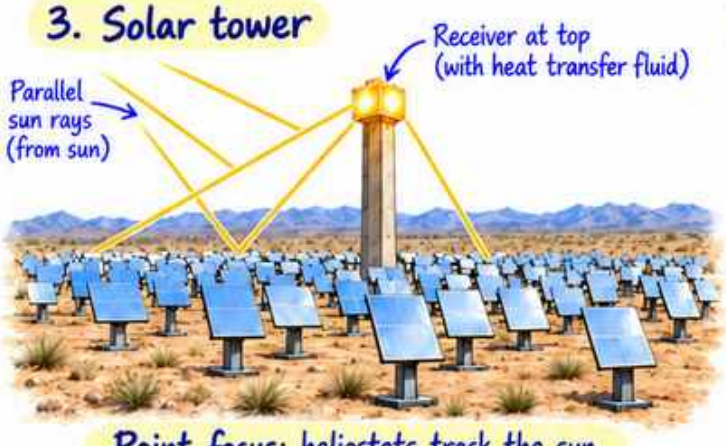
Line focus; tube moves with mirror.

2. Linear Fresnel



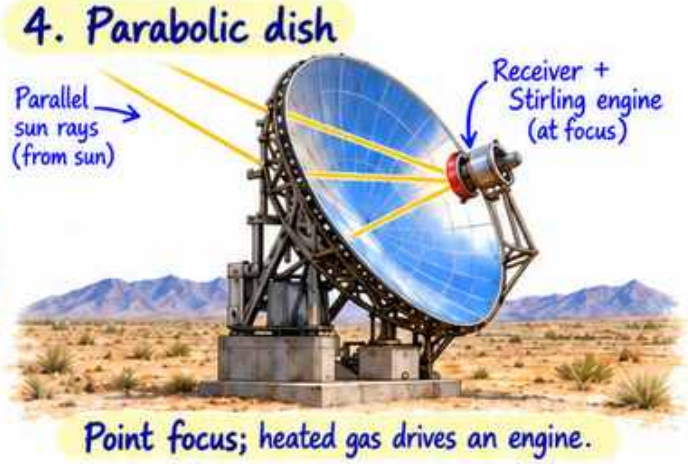
Line focus; receiver stays fixed.

3. Solar tower



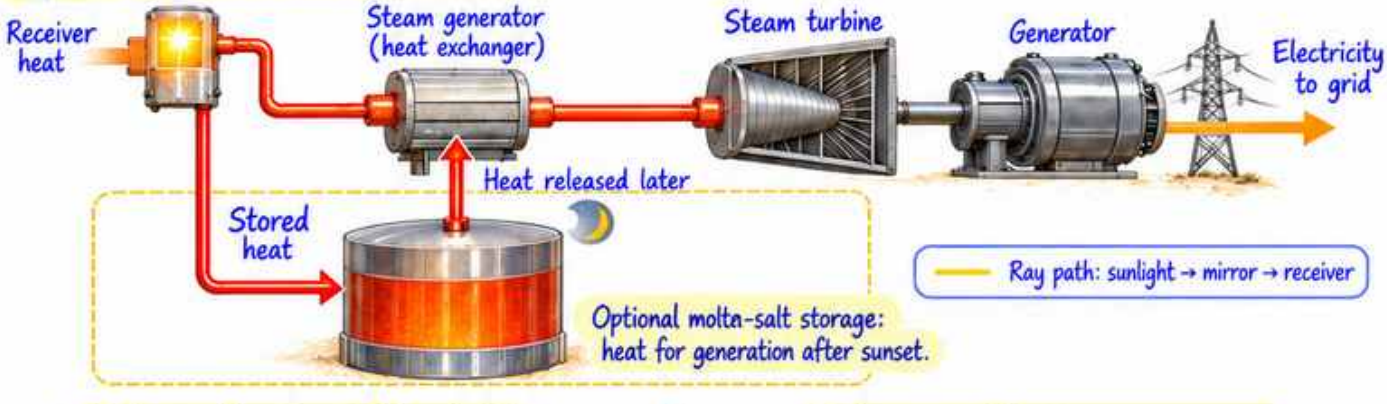
Point focus; heliostats track the sun.

4. Parabolic dish



Point focus; heated gas drives an engine.
Usually H_2 or He • about 3–25 kW.

Typical trough / Fresnel / tower route



PV uses direct + diffuse light; CSP needs strong direct sunlight.

PV: optional battery storage; CSP: optional thermal storage.

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India: capacity and resource

Installed solar • 30 September 2026 (MNRE)

171.05 GW

Ground-mounted 125.65 GW



Rooftop 33.41 GW



Hybrid: solar part 5.36 GW



Off-grid 6.63 GW



Leading states • solar GW



Most of India: 4–7 kWh/m²/day



NISE assessed potential: about **748 GW**

Assumes PV on 3% of wasteland; potential is not installed capacity or a target.

Omkareshwar, Madhya Pradesh

Commissioning snapshot • 4 Jan 2025: **278 MW** commissioned of planned 600 MW



1 GW = 1,000 MW • Capacity is not annual generation.

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India: making and governing solar



Domestic manufacturing • 30 Jun 2025

Modules ~91 GW/year • Cells ~27 GW/year
Ingots / wafers ~2 GW • No commercial polysilicon production

→ Strong module assembly; upstream import dependence.

ALMM



- List-I: models + makers of modules
- List-II: models + makers of cells

Eligibility lists for covered projects.

PLI



- High-efficiency PV manufacturing incentive
- ₹24,000 crore total outlay
- ₹4,500 cr + ₹19,500 cr
- Paid for 5 years after commissioning.

2019	2021	2022	2025	2026
ALMM Order	List-I modules; PLI-I	PLI-II; E-Waste Rules	List-II cells	Updated capacity snapshot



Solar modules, panels and cells fall under E-Waste Rules, 2022.

Registration, storage, returns and material recovery duties.

ALMM = approved list • PLI = manufacturing incentive

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Day 11 • Topic 107 • 1/4

UNFCCC: THE CLIMATE FRAMEWORK

A parent treaty for global climate action

THE FOUNDATIONS

- IPCC: set up in 1988; assesses climate science.
- UNFCCC: countries negotiate and act through the treaty.
- Greenhouse gases absorb Earth's outgoing long-wave radiation.

DATES TO KEEP SEPARATE

- **9 May 1992**: adopted in New York
- **June 1992**: opened for signature at Rio Earth Summit
- **21 March 1994**: entered into force

OBJECTIVE • ARTICLE 2

- Stabilise greenhouse-gas concentrations to prevent dangerous human interference with the climate system.
- Allow ecosystems to adapt, protect food production and enable sustainable development.

PRINCIPLES • ARTICLE 3

- Equity and CBDR-RC: common but differentiated responsibilities and respective capabilities.
- All share responsibility; developed countries should lead.
- Precaution: lack of full scientific certainty should not delay action against serious or irreversible harm.

THREE COUNTRY GROUPS

- Annex I: industrialised countries and economies in transition; specific emissions and sink commitments.
- Annex II: developed-country subset of Annex I; finance and technology support for developing countries.
- Non-Annex I: mostly developing countries, including India.

CONVENTION BODIES

- COP • Article 7: supreme decision-making body
- Secretariat • Article 8: organises meetings; Bonn
- SBSTA • Article 9: scientific and technical advice
- SBI • Article 10: implementation review

Treaty architecture: UNFCCC → Kyoto Protocol + Paris Agreement

Source: UNFCCC treaty, Articles 2-10

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Day 11 • Topic 107 • 2/4

KYOTO: TARGETS & CARBON MARKETS

Binding targets for developed-country Parties

THE KEY DATES

Adopted: 11 December 1997 • COP3, Kyoto

In force: 16 February 2005

Parties meet as the CMP

TARGETS ARE DIFFERENTIATED

First period: 2008–2012

Collective cut: at least 5% below 1990 emissions.

Annex B sets individual targets; every country does not have the same cut.

Example: EU 92 = 8% below base year; Australia 108 = 8% above.

India had no Annex B target.

ENTRY INTO FORCE • ARTICLE 25

At least 55 Convention Parties, including Annex I Parties accounting for at least 55% of Annex I CO_2 emissions in 1990.



THREE FLEXIBLE MECHANISMS

EMISSIONS TRADING • Article 17



Annex B Parties trade assigned amount units (AAUs).

CLEAN DEVELOPMENT MECHANISM • Article 12



Project in a non-Annex I country → certified emission reductions (CERs).
Supports sustainable development and helps Annex I compliance.

JOINT IMPLEMENTATION • Article 6



Project in an Annex I country → emission reduction units (ERUs) for another Annex I Party.

Market mechanisms supplement domestic action.

DOHA AMENDMENT

Adopted: 8 December 2012

Second period: 2013–2020; at least 18% collective cut below 1990.

Entered into force: 31 December 2020.

Six original gases: CO_2, CH_4, N_2O, HFCs, PFCs, SF_6.

Doha added NF_3 as the seventh.

REMEMBER THE DISTINCTION

Kyoto Article 6 = Joint Implementation

Paris Article 6 = cooperative approaches

US signed Kyoto but never ratified; Canada later withdrew.

Adaptation Fund: adaptation support, originally funded mainly from CDM proceeds.

Source: Kyoto Protocol and Doha Amendment

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PARIS: THE AMBITION CYCLE

All Parties contribute through national plans

Adopted: 12 December 2015 • COP21, Paris
In force: 4 November 2016 • Parties meet as CMA

THREE GOALS • ARTICLE 2

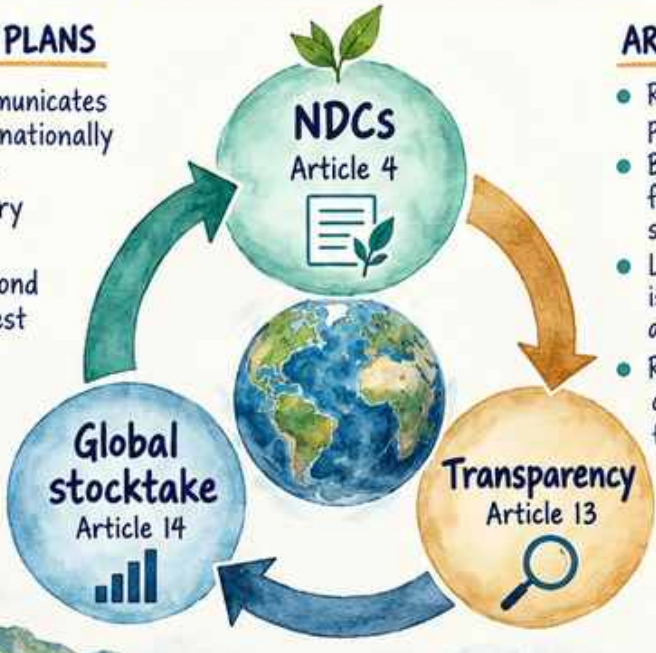
1. Hold warming well below 2°C and pursue efforts to limit it to 1.5°C above pre-industrial levels.
2. Strengthen adaptation and climate resilience.
3. Align finance with low-emission, climate-resilient development.

THE FIVE-YEAR AMBITION CYCLE

NDCs • Article 4 → Transparency • Article 13 → Global stocktake • Article 14 → stronger NDCs

ARTICLE 4 • NATIONAL PLANS

- Each Party prepares, communicates and maintains successive nationally determined contributions.
- Communicate an NDC every five years.
- Each should progress beyond the last and reflect highest possible ambition.



ARTICLE 13 • TRANSPARENCY

- Reports track emissions, NDC progress and support.
- BTRs generally every two years: first due 31 December 2024; second due 31 December 2026.
- Least developed countries and small island developing States may report at their discretion.
- Reporting obligations differ by subject and Party category; capacity-related flexibility applies.

ARTICLE 6 • COOPERATION

- 6.2: internationally transferred mitigation outcomes
- 6.4: Paris Agreement Crediting Mechanism
- 6.8: non-market approaches

ARTICLE 14 • GLOBAL STOCKTAKE

- Assesses collective progress, not a country ranking.
- First concluded at COP28 in 2023; every five years thereafter.
- Its findings inform the next national plans.

TWO LEGAL DETAILS

- **Entry into force:** 55 Parties + 55% of global greenhouse-gas emissions.
- **Withdrawal:** notice after three years of membership; effective one year after receipt.

Source: Paris Agreement, Articles 2, 4, 6, 13, 14, 21, 28

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CLIMATE DIPLOMACY: FINANCE & INDIA

Adaptation, loss and damage, and shared responsibility



FINANCE • PARIS ARTICLE 9

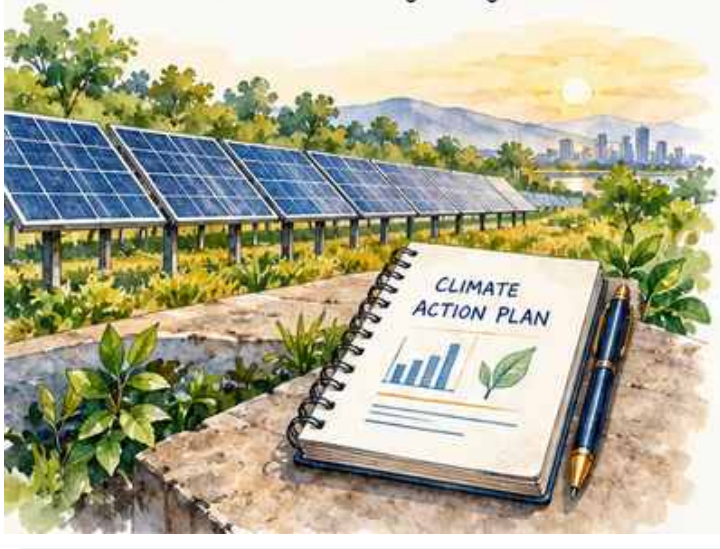
Developed countries shall provide finance for developing countries' mitigation and adaptation.

Others are encouraged to contribute voluntarily.

THE FINANCE LADDER

- **COP15, Copenhagen 2009:** USD 100 billion a year by 2020 goal.
- **COP16, Cancún 2010:** recognised the goal; established Green Climate Fund.
- **COP29, Baku 2024:** at least USD 300 billion a year by 2035 for developing countries.

  Also calls on all actors to scale finance to USD 1.3 trillion a year by 2035.



LOSS AND DAMAGE • ARTICLE 8

Addresses harm associated with climate impacts.

- **COP19, Warsaw 2013:** Warsaw International Mechanism
- **COP27, Sharm el-Sheikh 2022:** fund agreed
- **COP28, Dubai 2023:** fund operationalised; first global stocktake concluded

COP26, GLASGOW 2021

Accelerate phase-down of UNABATED coal power and phase-out of inefficient fossil-fuel subsidies.

INDIA'S TREATY POSITION

Non-Annex I Party; no Kyoto Annex B target.
Kyoto accession: 26 August 2002
Doha acceptance: 8 August 2017
Paris ratification: 2 October 2016
Long-term net-zero goal: 2070



STATUS AS OF • 16 OCTOBER 2026

- US Paris withdrawal effective: 27 January 2026.
- US UNFCCC withdrawal takes effect: 27 February 2027; it remains a Convention Party until then.
- **COP30:** Belém, Brazil, 2025.
- **COP31 is UPCOMING:** Antalya, Türkiye, 9–20 November 2026. Türkiye hosts; Australia's Chris Bowen leads negotiations.
- **COP32:** Ethiopia, 2027.

REVISION LINK

UNFCCC = framework • Kyoto = differentiated binding targets
Paris = national contributions, transparency and rising ambition

Sources: UNFCCC; UN treaty depositary

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NATIONAL SOLAR MISSION: THE ORIGIN

NAPCC · 2008

National Action Plan on Climate Change: eight National Missions; **Solar** is the first.



EIGHT NATIONAL MISSIONS



11 JANUARY 2010

- Jawaharlal Nehru National Solar Mission (JNNSM), launched under MNRE. (MNRE = Ministry of New and Renewable Energy)
- Objective: establish India as a global leader in solar energy.

ORIGINAL TARGET

20,000 MW = 20 GW
by 2021–22.

THREE PHASES

Phase 1: 2010–2013 → Phase 2: 2013–2017 → Phase 3: 2017–2022

Phase 1 grid-connected target: **1,100 MW** by 2013.

EARLY TECHNICAL GOALS

NAPCC goals up to 2017 included at least **1,000 MW** concentrating solar power and local PV production of **1,000 MW** a year.



Concentrating solar power (solar tower)



Photovoltaic (PV) panels

UNIT CHECK
1 GW = 1,000 MW.

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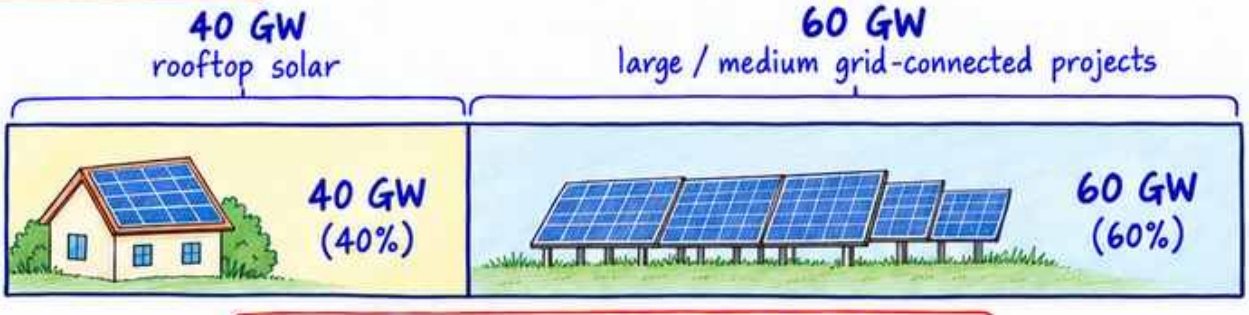
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20 GW → 100 GW: TARGET vs RESULT

17 JUNE 2015 · CABINET REVISION

- Original 20 GW target increased fivefold to 100 GW by 2022.
- 100 GW = 1,00,000 MW

TARGET SPLIT



Estimated investment: about ₹6,00,000 crore.

WHAT ACTUALLY HAPPENED



Target date → 2022

Dated observation above 100 GW → 31 January 2025

Capacity snapshot → 30 September 2026

KEY TAKEAWAYS

- Rooftop solar was the main source of the shortfall against the 2022 target.
- 30 September 2026 rooftop capacity: 33.41 GW.
- The observation date does not prove the exact day the 100 GW threshold was crossed.

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2030 TARGETS: WHAT DOES 50% MEAN?

PANCHAMRIT · COP26, 1 NOVEMBER 2021

1. Non-fossil energy capacity
500 GW by 2030.



2. Renewable energy
50% of energy requirements by 2030.



3. Cut projected carbon emissions
by 1 billion tonnes up to 2030.



4. Cut emissions intensity of GDP
by 45% from 2005 by 2030.



CLEAN ENERGY FOR A SUSTAINABLE INDIA

5. Net zero
by 2070.



UPDATED NDC · AUGUST 2022

- About 50% of cumulative installed electric power capacity from non-fossil sources by 2030.
- Emissions intensity of GDP: 45% below 2005 by 2030.

TWO DIFFERENT DENOMINATORS

- Panchamrit: energy requirements + renewable energy.
- NDC: installed electricity capacity + non-fossil sources.
- Non-fossil includes renewable energy, large hydro and nuclear.

PANCHAMRIT

Numerator:
renewable energy

Denominator:
total energy requirements

= 50% by 2030

UPDATED NDC

Numerator:
non-fossil installed electricity capacity

Denominator:
total installed electricity capacity

≈ 50% by 2030

Non-fossil = renewables + large hydro + nuclear

DATED PROGRESS

- 30 June 2025: non-fossil share of installed capacity 50.08%; NDC milestone met five years early.
- February 2026: 52.57%.
- 30 September 2026: non-fossil capacity 308.03 GW against 500 GW by 2030.
- The 2015 NDC's 40% capacity target was met nine years early.
- 500 GW is not a solar-only target; capacity share is not generation share.

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PM-KUSUM: FARM SOLAR & DEADLINES

Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyaan

ABOUT PM-KUSUM

- Aims to enhance farmers' energy security through solar and other renewable energy.
- Administrative approval: **8 March 2019**.

THREE COMPONENTS

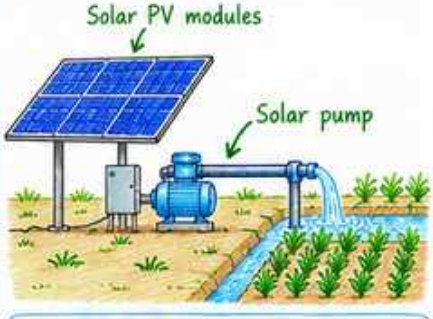
A : **10,000 MW** decentralised ground / stilt-mounted grid-connected solar or other renewable plants.
B : **14 lakh** standalone solar agriculture pumps.
C : solarisation of **35 lakh** grid-connected agriculture pumps, including feeder-level solarisation.

A Decentralised ground / stilt-mounted grid-connected plants



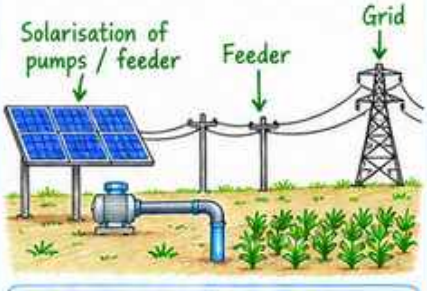
10,000 MW decentralised ground / stilt-mounted grid-connected solar or other renewable plants.

B Standalone solar agriculture pumps (no grid)



14 lakh standalone solar agriculture pumps.

C Grid-connected agriculture pumps / feeder solarisation



Solarisation of **35 lakh** grid-connected agriculture pumps, including feeder-level solarisation.

ORIGINAL PROGRAMME TARGET

- **34,800 MW** by **March 2026**; central support **₹34,422 crore**.
- This target date is historical.

28 SEPTEMBER 2026 ORDER

- Conditional project-completion deadline: **31 March 2027**.

KEY DATES AND CONDITIONS

Eligibility condition
PPA signed OR NTP issued on or before **31 December 2025**.

→

Financial closure (Components A and C)
Components A and C: financial closure due by **30 November 2026**.

→

Project completion
Conditional project-completion deadline: **31 March 2027**.

READ THE CONDITION

This is a completion extension for eligible projects; it is not an unconditional extension for new projects.

ABBREVIATIONS

- PPA = Power Purchase Agreement
- NTP = Notice to Proceed

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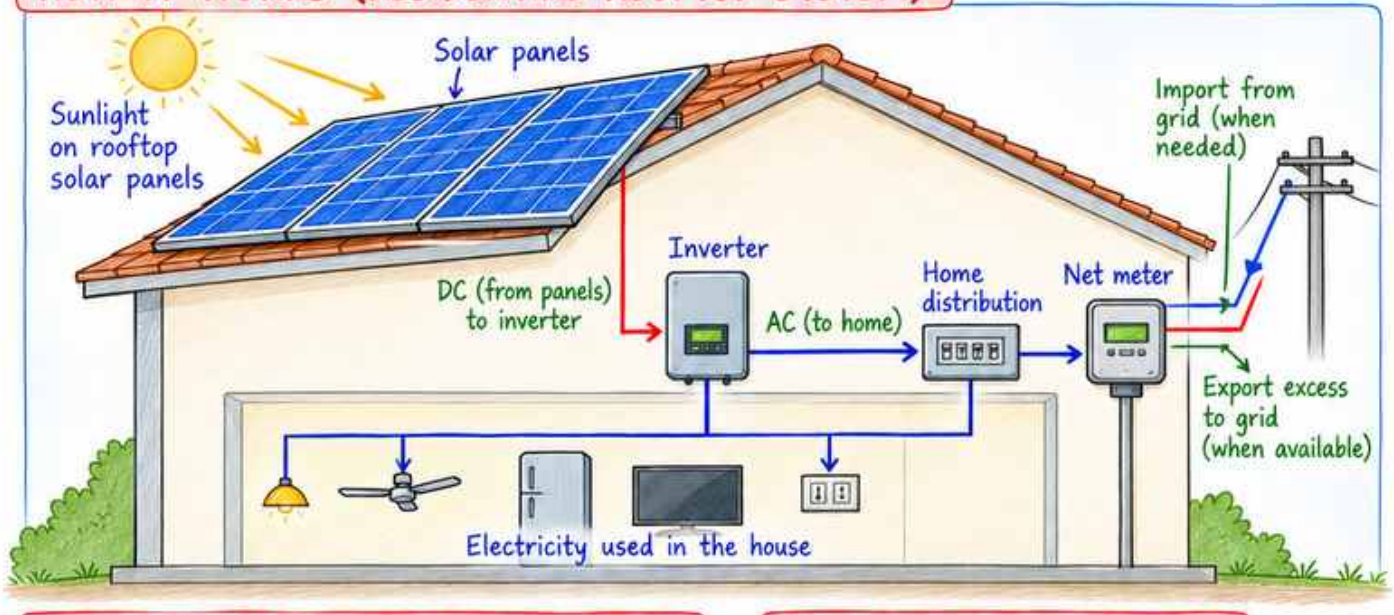
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PM SURYA GHAR: MUFT BIJLI YOJANA

KEY FEATURES

- Launch: 13 February 2024. Cabinet approval: 29 February 2024.
- Target: rooftop solar for 1 crore households; up to 300 units of free electricity per month.
- Outlay: ₹75,021 crore. A model solar village in each district.

HOW IT WORKS (RESIDENTIAL ROOFTOP SYSTEM)



INDIVIDUAL RESIDENTIAL HOUSEHOLD CFA

- First 2 kW: 60% of benchmark cost.
- Additional capacity up to 3 kW: 40% of benchmark cost.
- Above 3 kW: no additional CFA.
- CFA = Central Financial Assistance.

STANDARD-STATE AMOUNTS (2024 GUIDELINES)

Capacity	CFA amount (standard-state households)
1 kW	₹30,000
2 kW	₹60,000
3 kW or more	₹78,000 maximum

IMPORTANT LIMITS

- The percentage base is benchmark cost, not any quoted installation price.
- Special-category states have higher rates.
- Group housing societies / resident welfare associations (GHS / RWAs) have separate provisions. Do not apply the individual-household cap to them.

KEY TAKEAWAYS

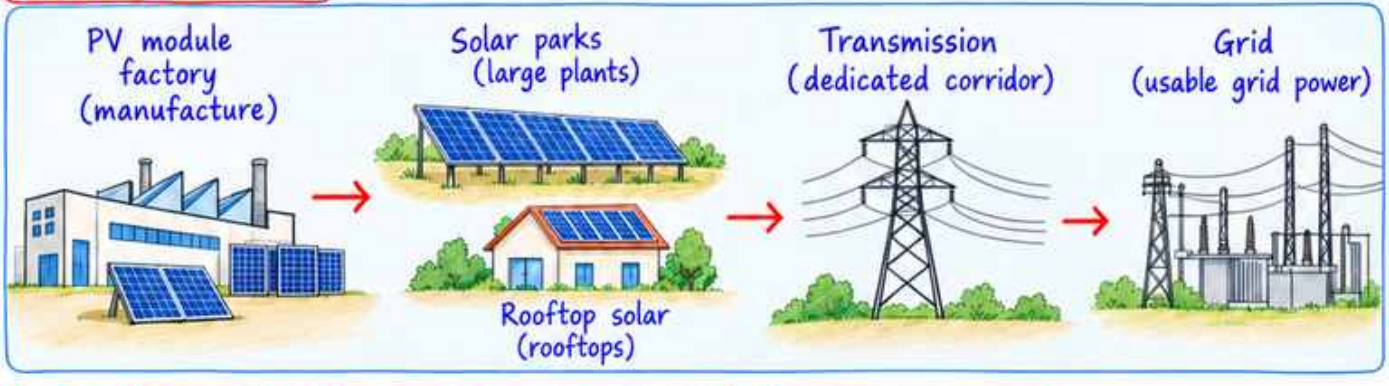
- Targets rooftop solar for 1 crore households with up to 300 units of free electricity per month.
- Outlay of ₹75,021 crore and a model solar village in each district.
- Subsidy is linked to benchmark cost with a maximum of ₹78,000 for 3 kW or more (standard-state households).
- 2024 guidelines; the table shows standard-state household amounts.

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BUILDING THE SOLAR ECOSYSTEM

SYSTEM CHAIN



PRODUCTION LINKED INCENTIVE (PLI): HIGH-EFFICIENCY SOLAR PV MODULES

- Total outlay: ₹24,000 crore.

Tranche I · 7 April 2021 approval

- ₹4,500 crore; 8,737 MW awarded to 3 bidders.

Tranche II · 21 September 2022 approval

- ₹19,500 crore; 39,600 MW awarded to 11 bidders.

- Incentive paid for 5 years after commissioning, linked to manufacture and sale of high-efficiency modules.

SOLAR PARKS

- Provide land for developers of large solar plants.



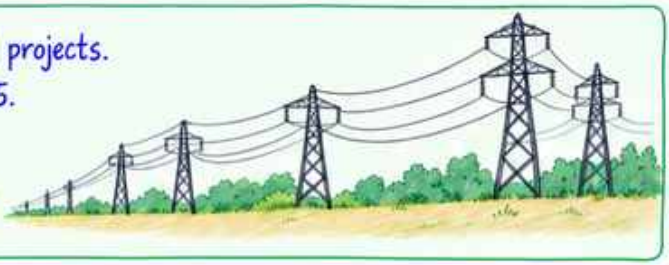
GRID-CONNECTED ROOFTOPS

- The 2015 target allocated 40 GW to rooftops.



GREEN ENERGY CORRIDOR

- Dedicated transmission for large solar and wind projects.
- PGCIL study / report: 2012; work began in 2015.
- Two intra-State phases: I and II.
- Phase II: integrates about 20 GW in 7 States; cost ₹12,031.33 crore; MNRE assistance 33%.



ALMM

- Approved List of Models and Manufacturers: approved solar modules and cells; technical details in Topic 97.



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INDIA SOLAR CAPACITY: DATED SNAPSHOT

AS ON 30 SEPTEMBER 2026 · MNRE

TOTAL SOLAR: 171.05 GW

CAPACITY CATEGORIES · illustrations not to scale

Ground-mounted	Grid-connected rooftop	Hybrid solar component	Off-grid solar
125.65 GW	33.41 GW	5.36 GW	6.63 GW

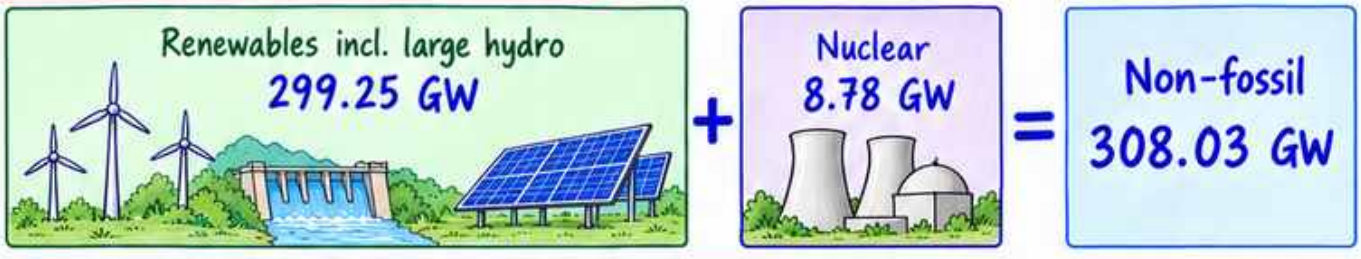


Total solar: 171.05 GW

Rounded category figures sum to 171.05 GW.

Total in the dated table: 171,051.46 MW.

THE WIDER ENERGY TOTAL



Exact non-fossil table total: 308,026.53 MW.

Solar is the largest part of renewable capacity.

STATE ORDER

- Rajasthan leads in solar installed capacity.
- Andhra Pradesh ranks sixth in this dated table.

KEEP THE UNITS STRAIGHT

- 1 GW = 1,000 MW.
- Installed capacity measures generating capability; it is not electricity generated.
- All figures above describe 30 September 2026, not an undated "current" total.

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ISA: LAUNCH → TREATY → MEMBERSHIP

INTERNATIONAL SOLAR ALLIANCE

1 LAUNCH

30 November 2015: launched by India and France at COP21, Paris.



2 TREATY

15 November 2016: Framework Agreement opened for signature at COP22, Marrakesh.



3 INTO FORCE

6 December 2017: Agreement entered into force; treaty-based international intergovernmental organisation.



4 FOUNDING CONFERENCE

11 March 2018: Founding Conference, New Delhi.



MEMBERSHIP

- Member = signed + ratified Framework Agreement.
- Separate signatory category = signed, not yet ratified.
- Amendment adopted 3 October 2018 at first Assembly, New Delhi; entered into force 8 January 2021.
- Membership opened to all UN member states.

COUNTRIES

MEMBER	SIGNATORY
Signed + ratified Framework Agreement.	Signed, not yet ratified.

HISTORICAL COUNT ONLY

6 November 2024: 120 member and signatory countries, including 102 ratified members.

This is a dated 2024 figure, not a current membership total.

HEADQUARTERS



- NISE campus, Gwal Pahari, Gurugram, Haryana.
- First treaty-based international intergovernmental organisation headquartered in India.
- Foundation stone: January 2016, Modi and Hollande.

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ISA: GOVERNANCE & GLOBAL INITIATIVES

WHO DOES WHAT?

ASSEMBLY

- India President.
- France Co-President for 2024-26, chosen at seventh Assembly (3-6 November 2024).
- Eighth Assembly opened in New Delhi on 28 October 2025.

Assembly offices are held by countries.

SECRETARIAT

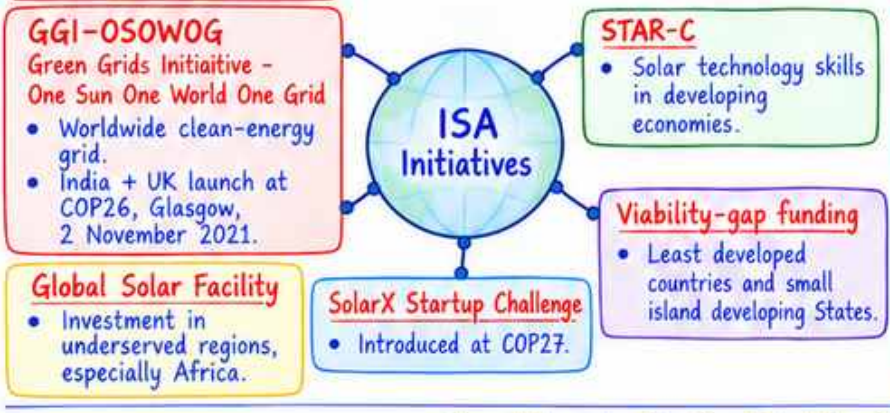
- Headed by Director General.
- Ashish Khanna selected on 4 November 2024; serving as DG as of 12 March 2026.

The Director General is a person.

TOWARDS 1000 · 2030 STRATEGY



KEY INITIATIVES



GGI-OSOWOG

Green Grids Initiaitive - One Sun One World One Grid

- Worldwide clean-energy grid.
- India + UK launch at COP26, Glasgow, 2 November 2021.

STAR-C

- Solar technology skills in developing economies.

Viability-gap funding

- Least developed countries and small island developing States.

Global Solar Facility

- Investment in underserved regions, especially Africa.

SolarX Startup Challenge

- Introduced at COP27.

2024 PROGRAMME SNAPSHOT

Nine programmes in three areas:

- analytics / advocacy,
- capacity building,
- programmatic support.

Third World Solar Report:

- market, investment,
- technology, and African green-hydrogen readiness reports.



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BIOTECHNOLOGY: BIOLOGY PUT TO WORK.

CBD, ARTICLE 2

Biotechnology means "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use."

KEY WORDS:

- biological systems
- living organisms
- derivatives thereof.

EFB DEFINITION

EFB = European Federation of Biotechnology

Integration of natural science and organisms, cells, parts of them and molecular analogues for products and services.

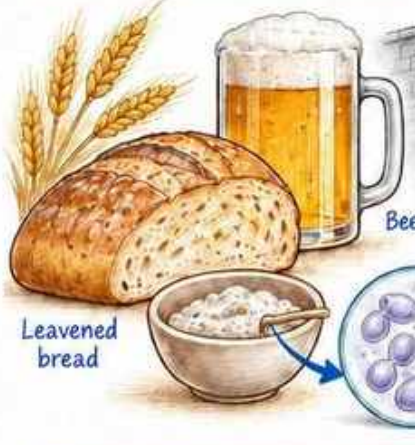
PRACTICAL PURPOSE

The use of biology to solve problems and make useful products; therapeutic proteins and other drugs are a prominent area.



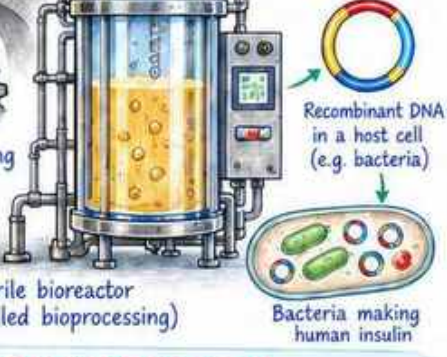
An enzyme can be enough: biotechnology need not use a whole living organism.

MULTIDISCIPLINARY:
biology + chemistry + engineering.



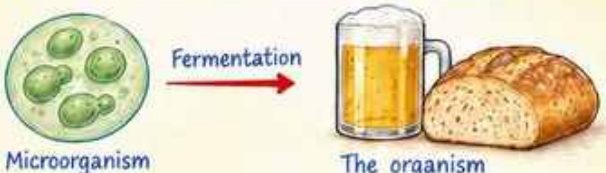






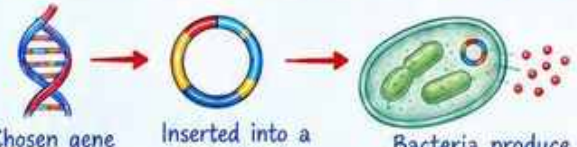
TRADITIONAL BIOTECHNOLOGY

- Whole microorganisms act naturally, mainly through fermentation.
- Ancient examples: beer and leavened bread.
- The organism determines the product.



MODERN BIOTECHNOLOGY

- Genetic engineering + controlled bioprocessing.
- A chosen gene is put into a chosen host; example: bacteria making human insulin.
- Recombinant-DNA milestones: 1972 and 1973



TWO CORE TECHNIQUES OF MODERN BIOTECHNOLOGY

1. Genetic engineering changes genetic material.
2. Bioprocess engineering maintains sterile conditions, so desired cells produce useful substances without contamination.

EXAM TRAP:

biotechnology did not begin with genetic engineering.

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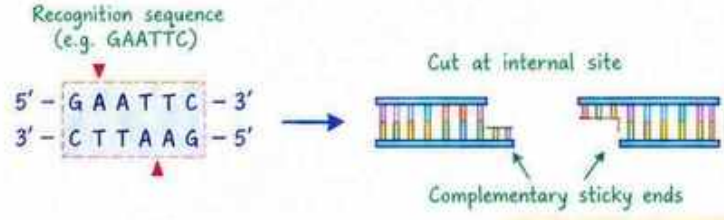
RECOMBINANT DNA: BUILD, CARRY & COPY.

RECOMBINANT DNA (rDNA)
DNA formed in the laboratory by joining DNA from different sources.

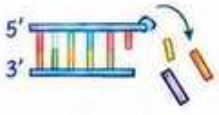
GENETIC ENGINEERING
changes an organism's genetic material by such methods.

THE TOOLKIT

Restriction endonuclease:
cuts at INTERNAL sites, at or near a specific recognition sequence.

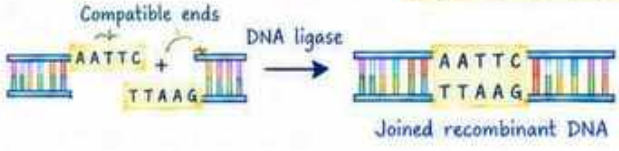


Exonuclease:
removes nucleotides one at a time from an END of a DNA chain.



ENDO = within;
EXO = from an end.
"Internal" does not mean only the exact middle.

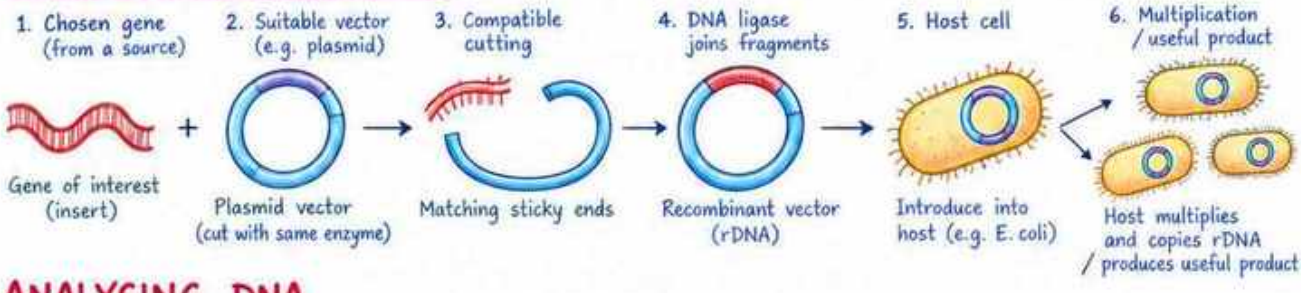
DNA ligase:
joins DNA fragments, such as an insert and a plasmid cut with the same restriction enzyme. Think "DNA glue".



Vector:
carries a foreign gene into a host cell; commonly derived from a plasmid or virus.

Host:
receives recombinant DNA and multiplies it. Escherichia coli is a common bacterial host; non-pathogenic E. coli K-12 is used in industry.

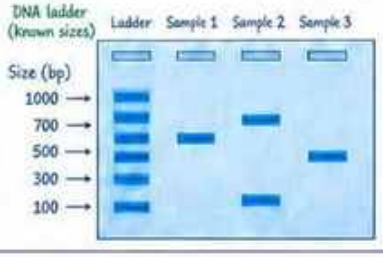
CONCEPTUAL WORKFLOW



ANALYSING DNA

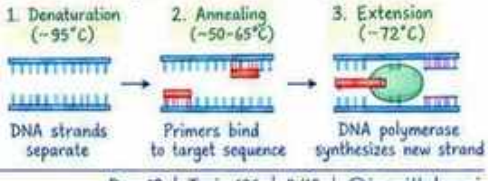
A. Agarose gel electrophoresis

- Separates DNA fragments by size.
- Compare bands with a DNA ladder of known fragment sizes.



B. PCR (Polymerase Chain Reaction)

- Rapidly copies a selected DNA segment.
- Repeated cycles amplify the target sequence.



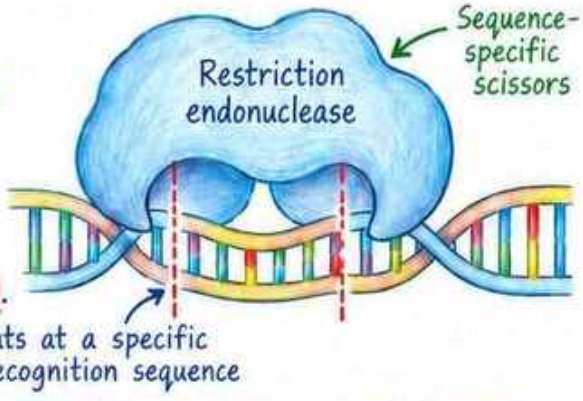
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RESTRICTION ENZYMES: RECOGNISE & CUT

RESTRICTION ENDONUCLEASES

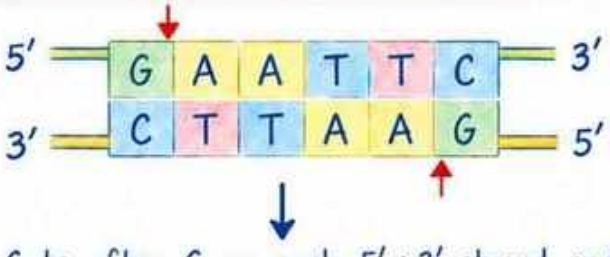
- Cut DNA at internal sites, at or near a specific recognition sequence.
- **HindII**: the first type II restriction enzyme, characterised from *Haemophilus influenzae* in research published in **1970**.



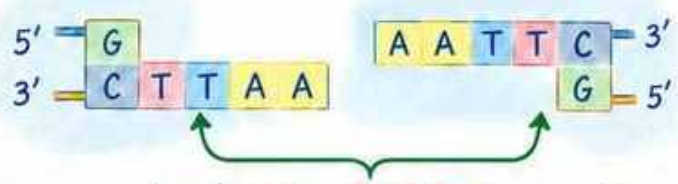
DECODE EcoRI

E = *Escherichia*, the genus.
co = *coli*, the species.
R = strain RY13.
I = first enzyme identified from that bacterium.

EcoRI RECOGNITION SITE



Cuts after G on each 5′→3′ strand and creates complementary "sticky" ends.



Complementary "sticky" ends can pair; DNA ligase joins the DNA fragments.

KNOWN ENZYMES

More than **3,600** restriction endonucleases were known in REBASE's **2007** count. This is a dated figure.

1978 NOBEL PRIZE

Physiology or Medicine: Werner Arber, Daniel Nathans and Hamilton O. Smith, for restriction enzymes and their use in molecular genetics.



REMEMBER

- Restriction enzyme = sequence-specific scissors.
- Ligase = joining tool.
- Exonuclease = removal from a DNA-chain end.

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PCR: AMPLIFY A CHOSEN DNA SEGMENT.

- PCR = POLYMERASE CHAIN REACTION
- Makes many copies of a chosen DNA segment rapidly.
- Invented by Kary Mullis in 1983. He shared the 1993 Nobel Prize in Chemistry for PCR.

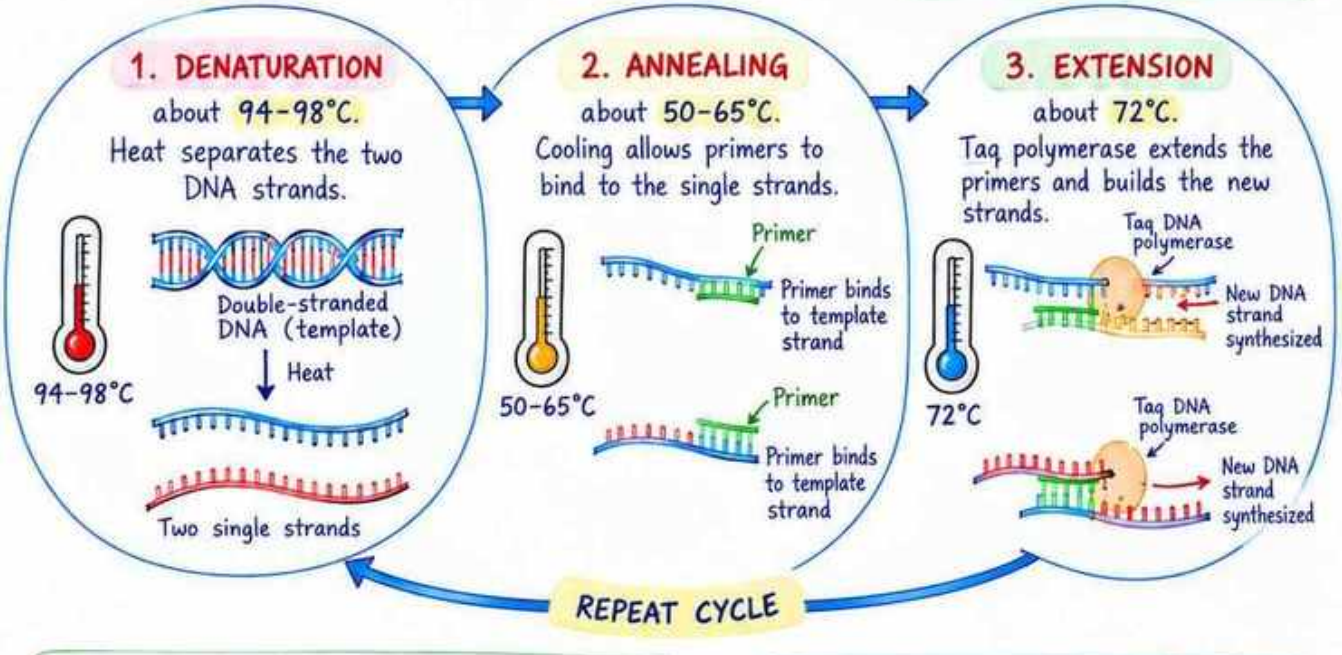
REQUIRED TOOLS

- Template DNA + primers + nucleotides + a heat-stable DNA polymerase.

TAQ DNA POLYMERASE

- From the heat-loving bacterium Thermus aquaticus.
- It builds new DNA strands and survives the heating steps.

THREE STEPS, REPEATED IN CYCLES



WHY PRIMERS MATTER

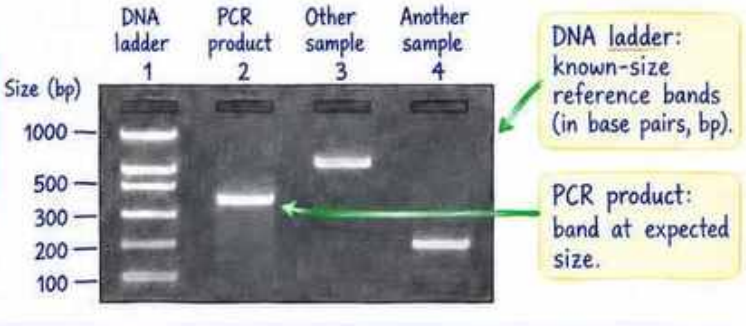
They define the DNA region to be copied and provide starting points for synthesis.

REMEMBER:

separate → bind primers → extend.
Taq is the enzyme; PCR is the process.

CHECK THE PRODUCT

Agarose gel electrophoresis separates fragments by size; a DNA ladder supplies known-size reference bands.



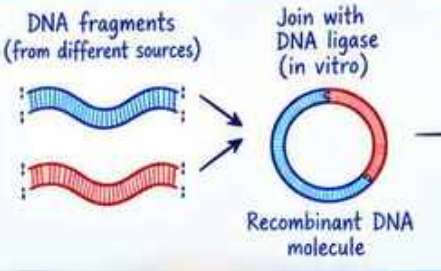
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RECOMBINANT DNA: KEY MILESTONES

1972: BERG'S GROUP

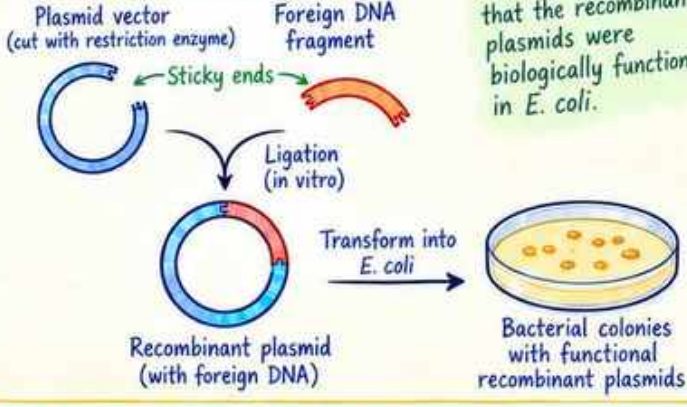
- Published construction of recombinant DNA *in vitro*.
- Paul Berg later shared the 1980 Nobel Prize in Chemistry.



Demonstrated that DNA from different sources can be joined to make recombinant DNA in vitro.

1973: FUNCTIONAL RECOMBINANT PLASMIDS

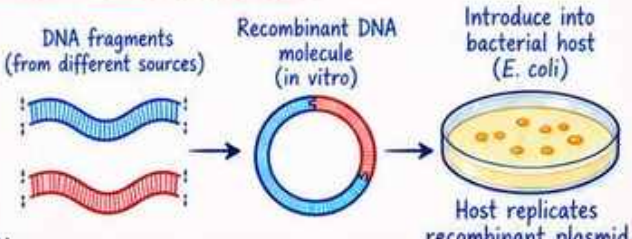
- Stanley Cohen, Annie Chang, Herbert Boyer and Robert Helling published "Construction of biologically functional bacterial plasmids in vitro".
- The work demonstrated functional recombinant plasmids in *E. coli*.



Demonstrated that the recombinant plasmids were biologically functional in *E. coli*.

FROM JOINING DNA TO CLONING IT

- Joining DNA fragments creates a recombinant molecule in vitro.
- Introducing a suitable recombinant plasmid into a bacterial host allows it to replicate.
- These are related but distinct achievements: construction of a molecule and biological replication in a host.
- Small reminder: IN VITRO = outside a living organism; CLONING = making copies.



1974: VOLUNTARY MORATORIUM

- Scientists called for a pause on certain recombinant-DNA experiments while safety was considered.





A voluntary pause to consider potential risks and safety measures.

FEBRUARY 1975: ASILOMAR

- Conference recommended resuming research with appropriate containment and safety guidelines.



Recommended resuming research with appropriate containment and safety guidelines.

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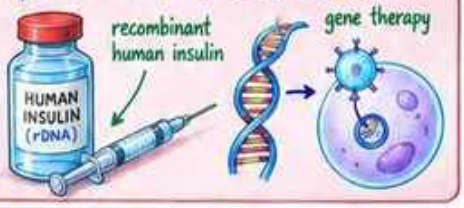
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THE COLOUR CODE OF BIOTECHNOLOGY

Kafarski's Rainbow Code of Biotechnology (2012): one colour-classification convention.

RED: medicine, pharmaceuticals and health.

Examples:
- recombinant human insulin;
- gene therapy.



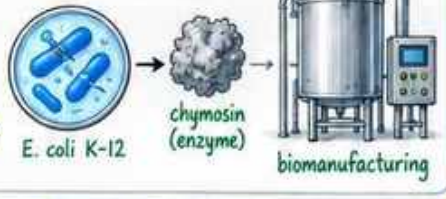
GREEN: agriculture.

Example:
- Bt cotton in India.



WHITE: industrial biotechnology.

Examples:
- chymosin from E. coli K-12;
- biomanufacturing.



BLUE: marine resources.

Example:
- products made from sea organisms.



GREY: environmental applications.

Example:
- bioremediation.



YELLOW: food production.

Example:
- organisms used in food making.



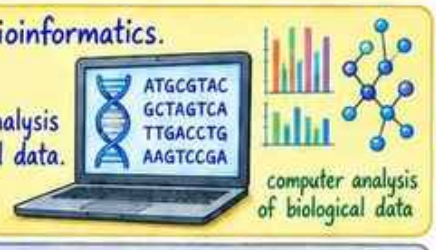
BROWN: arid lands and deserts.

Example:
- biotechnology for dry-land management.



GOLD: bioinformatics.

Example:
- computer analysis of biological data.



VIOLET: law, ethics and philosophy.

Examples:
- patents and biosafety debates.



DARK: bioterrorism.

Meaning:
- misuse of organisms as weapons.



FOUR APPLICATION AREAS:

red–medicine; green–agriculture; white–industry; blue–marine resources.



EXAM TRAPS

- Grey = environment; white = industry.
- Yellow = food; gold = biological data.
- Blue = sea, not air or space.

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HEALTH: INSULIN & GENE THERAPY

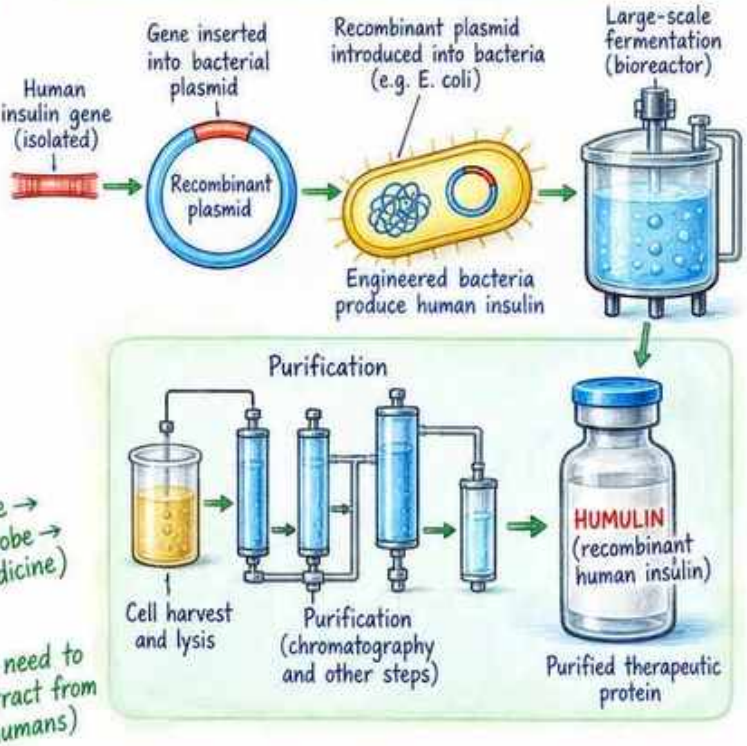
RECOMBINANT HUMAN INSULIN

- **1978:** City of Hope and Genentech researchers produced biosynthetic human insulin.
- Eli Lilly developed it for manufacture.
- **28 OCTOBER 1982:** US FDA approved **HUMULIN**, the first approved medical product made using recombinant DNA technology.

CONCEPT

- Human insulin gene information → engineered microbial production → purification → a therapeutic protein. (gene → microbe → medicine)
- Biotechnology can produce medicines without extracting the same product from its original human source. (no need to extract from humans)

INSULIN PRODUCTION USING RECOMBINANT DNA TECHNOLOGY



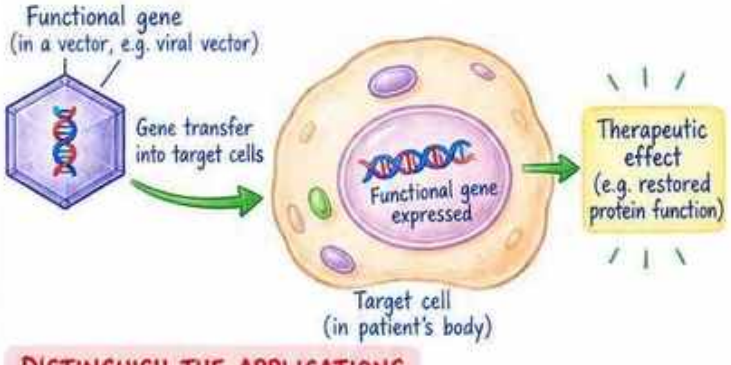
GENE THERAPY

- Aims for a therapeutic effect by changing how genes work in the body.

FIRST APPROVED US TRIAL

- **September 1990** at the National Institutes of Health, under William French Anderson.
- Patient: four-year-old Ashanti DeSilva, with adenosine deaminase (ADA) deficiency, a severe immune deficiency.
- The first therapeutic gene-transfer trial began on **14 September 1990.**

GENE THERAPY: CHANGING GENE FUNCTION



DISTINGUISH THE APPLICATIONS

- **Recombinant insulin:** cells manufacture a therapeutic protein.
- **Gene therapy:** changes gene function to seek a therapeutic effect.
- Both belong to **RED** biotechnology.
- **Timeline anchors:** 1978 production → 1982 Humulin approval → 1990 gene-therapy trial.

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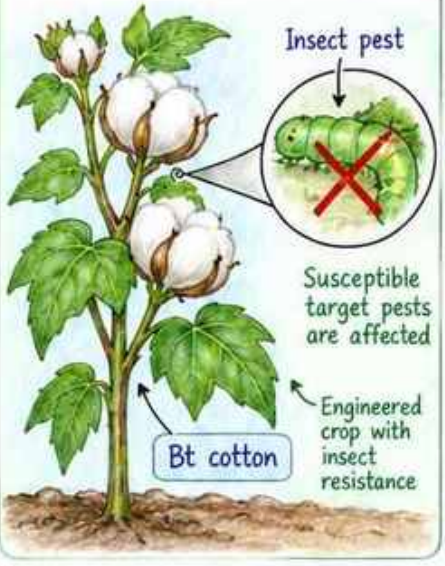
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FARMS, FACTORIES & ENVIRONMENT

AGRICULTURE: GREEN

Crop plants can be engineered to resist insect pests.

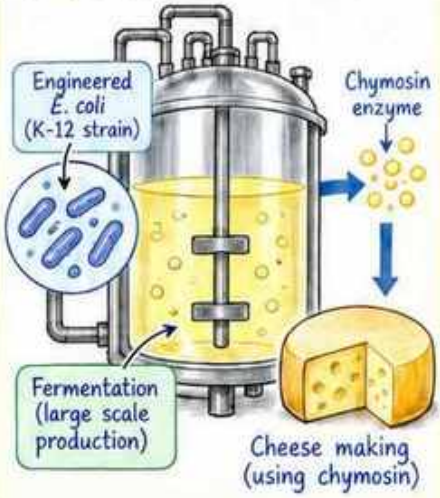
India approved Bt cotton for commercial cultivation in 2002.



INDUSTRY: WHITE

Engineered microbes make enzymes and other useful products.

Example: chymosin made by the non-pathogenic K-12 strain of *E. coli*.



ENVIRONMENT: GREY

Applications include recycling, waste treatment and cleaning industrially contaminated sites.

BIOREMEDIATION = using biological processes to clean contaminated environments.



BIOPIRACY

Unauthorised appropriation of the knowledge and genetic resources of farming and indigenous communities.



THE NEEM PATENT CASE

A European patent relating to neem-oil fungicidal use was originally granted to W.R. Grace and the US Department of Agriculture.

Patent granted to W.R. Grace and US Department of Agriculture

↓

2000: the patent was revoked.

↓

8 March 2005: the EPO Board of Appeal dismissed the appeal, leaving the revocation in place.

CONNECT THE CONCEPTS

A useful biological product raises scientific, commercial and ethical questions.



Patent rights and community knowledge are part of **VIOLET** biotechnology.

Do not confuse industrial production (white) with environmental clean-up (grey).

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GEAC & THE 2022 GM-MUSTARD DECISION

1. WHAT IS GEAC?

- GEAC = GENETIC ENGINEERING APPRAISAL COMMITTEE.
- Statutory committee regulating genetically modified organisms in India.
- Constituted under the Rules of 1989, framed under the Environment (Protection) Act, 1986.
- Administrative ministry: MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE (MoEF&CC).
- It is not under the Department of Biotechnology. ← Different from DBT.

2. INSTITUTIONAL HIERARCHY

Ministry of Environment, Forest and Climate Change (MoEF&CC)



↓ Administers the legal framework

Environment (Protection) Act, 1986



↓ Rules framed under the Act

1989 Rules on genetically modified organisms



↓ Constitutes

Genetic Engineering Appraisal Committee (GEAC)



3. GM MUSTARD: DMH-11

- 18 October 2022: GEAC recommended environmental release.
- 25 October 2022: the conditional decision was communicated.



GM MUSTARD DMH-11



4. WHAT THE DECISION COVERED

- DMH-11 and its parental lines, for seed production and testing under ICAR guidelines and other applicable requirements BEFORE commercial release.

ICAR = Indian Council of Agricultural Research.

5. DECISION FLOW (DMH-11)

GEAC recommends environmental release (18 October 2022)

↓

Conditional decision communicated (25 October 2022)

↓

Environmental release for seed production and testing under ICAR guidelines and other applicable requirements

→ CONDITIONAL RELEASE (2022)



For seed production and testing (BEFORE commercial release).

6. READ THE SCOPE

- Conditional environmental release for seed production/testing does not by itself establish approval for commercial cultivation.

7. DECISION SCOPE

- The 2022 recommendation concerned conditional environmental release for seed production and testing. That scope differs from permission for farmers' commercial cultivation.

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GM MUSTARD: REGULATORY STAGES & THE 2024 CASE

23 JULY 2024: SUPREME COURT

Two-judge bench: Justices B. V. Nagarathna and Sanjay Karol. Split verdict on the GM-mustard approval; matter sent to the Chief Justice of India to constitute an appropriate bench.



SPLIT VERDICT



The two judges differed on the challenge to the GM-mustard approval.

REFERENCE TO THE CHIEF JUSTICE

The matter was sent to the Chief Justice of India to constitute an appropriate bench.



COMMON DIRECTION



The Centre was directed to frame a national policy on GM crops, covering research, cultivation, trade and commerce, in consultation with stakeholders and the States.



DATED OFFICIAL RECORDS

6 August 2024

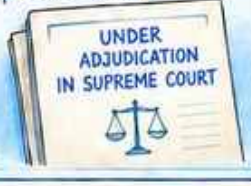
Environment Ministry stated Bt cotton was the only GM crop approved for commercial cultivation in India.



Bt cotton = only GM crop approved for commercial cultivation in India.

4 February 2025

Government stated environmental release of GM crops remained under adjudication in the Supreme Court.



5 March 2025

Supreme Court office report records further proceedings in the GM-crop cases.



APPROVAL HAS A DEFINED SCOPE

Permission for seed production and testing is not the same as permission for farmers' commercial cultivation. A legal decision must be read with its date, conditions and the activity it permits.

DO NOT INFER

- The 2022 conditional decision alone does not establish current commercial approval of GM mustard.
- Environmental release, testing and commercial cultivation are distinct regulatory stages.

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INDIA: INSTITUTIONS THAT BUILD BIOTECH.

Ministry of Science and Technology

Department of Biotechnology (DBT)

Nodal department for biotechnology in India.

Established on February 1986 as a separate department in the Ministry of Science and Technology.

National Institute of Immunology (NII)

The first autonomous institute, later brought under the Department of Biotechnology.



Biotechnology Industry Research Assistance Council (BIRAC)

A not-for-profit public sector enterprise set up by DBT; based in New Delhi.

Bridges the gap between research and industry.



Ministry of Environment, Forest and Climate Change (MoEF&CC)

Genetic Engineering Appraisal Committee (GEAC)

Regulatory body for GM organisms (separate from DBT).

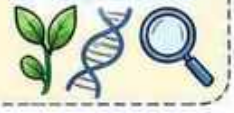
Regulates GM organisms under the Ministry of Environment, Forest and Climate Change (MoEF&CC) and the 1989 Rules.



PROMOTION vs REGULATION

DBT and BIRAC promote biotechnology research and innovation.	GEAC regulates GM organisms under MoEF&CC and the 1989 Rules.





KEY MILESTONES



1981

NATIONAL INSTITUTE OF IMMUNOLOGY

The first autonomous institute, later brought under the Department of Biotechnology.



1982

NATIONAL BIOTECHNOLOGY BOARD

Set up by the Government before there was a separate biotechnology department.



February 1986

DBT

Department of Biotechnology established as a separate department in the Ministry of Science and Technology.



20 March 2012

BIRAC INCORPORATED

Biotechnology Industry Research Assistance Council.
A not-for-profit public sector enterprise set up by DBT; based in New Delhi.



December 2015

DEVELOPMENT STRATEGY

DBT launched the National Biotechnology Development Strategy 2015–2020.
The primary launch release is dated 30 December 2015.

TIMELINE TO RECALL

NII 1981 → National Biotechnology Board 1982 → DBT 1986 → BIRAC 2012 → Strategy 2015–2020.

The strategy's year range is historical, not a claim that it is the current strategy.

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BIOE3: ECONOMY, ENVIRONMENT, EMPLOYMENT.

BIOE3

Biotechnology for ECONOMY, ENVIRONMENT and EMPLOYMENT.
Union Cabinet approval: 24 AUGUST 2024.

POLICY FEATURES

- Support for research and entrepreneurship in thematic sectors.
- Biomanufacturing hubs, Bio-AI hubs and a biofoundry.
- Regenerative bioeconomy models for green growth.
- Expansion of a skilled workforce.
- Alignment with Net Zero and Lifestyle for Environment (LiFE).

BIG PICTURE

Biotechnology spans organisms, cells and derivatives; genetic engineering and sterile bioprocessing work together.

Genome editing, stem cells, vaccines, detailed GM crops and DNA fingerprinting are covered on other days.

CENTRAL BIO-MANUFACTURING HUB

Scale up from lab to market



REGENERATIVE CIRCULAR BIOECONOMY LOOP

From biological resources to a cleaner, greener and more prosperous future



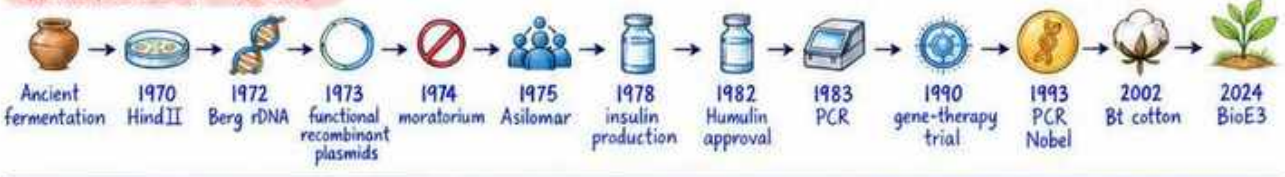
INDIA'S BIOECONOMY: AUGUST 2024 SNAPSHOT

PIB, 28 August 2024:

2014:	2024:	2030 TARGET:
US$10 billion.	over US$130 billion.	US$300 billion.

The 2030 figure is a target, not an achieved value. Figures shown are from August 2024.

CHRONOLOGY RECAP



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E-GOVERNANCE: FOUR RELATIONSHIPS

E-GOVERNANCE

Government uses information and communication technology (ICT) to deliver services and information.

FOUR MODELS: WHO IS AT THE OTHER END?

G2C = GOVERNMENT TO CITIZEN

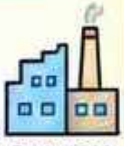
- Government ↔ individuals.
- Examples: UMANG, DigiLocker, e-Sanjeevani.



Citizens access services and information online.

G2B = GOVERNMENT TO BUSINESS

- Government ↔ businesses; aims include less red tape and lower costs of doing business.
- Example: sellers on Government e-Marketplace (GeM).

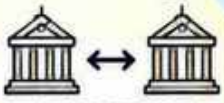


Helps businesses interact with government more easily and at lower cost.



G2G = GOVERNMENT TO GOVERNMENT

- Non-commercial online interaction between departments and authorities.
- Example: API Setu allows departments to share data with other systems.



Enables data sharing and coordination across government.

G2E = GOVERNMENT TO EMPLOYEES

- Government units ↔ their employees.
- Examples: online payroll, benefits and personnel records.



Helps government manage its workforce efficiently.

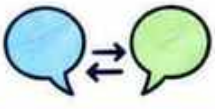
FIVE COMMONLY DESCRIBED STAGES

1. One-way information on a website.



Government provides information online.

2. Two-way communication: request and response.



Citizens and businesses can send requests and receive responses.

3. Service and financial transactions.



Services are delivered and payments can be made online.

4. Integration of departments.



Different departments are integrated for seamless service delivery.

5. Political participation.



Citizens can participate in the political process online.

The stages describe growing interaction and integration; the four G2 models classify the relationship.

India's major planning frameworks are NeGP, e-Kranti and Digital India; see also Topic 27.

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NeGP TO e-KRANTI: REFORM THE PROCESS

18 MAY 2006: NeGP APPROVED

- National e-Governance Plan began with **27** Mission Mode Projects (MMPs) at approval.
- The portfolio later grew to **31** MMPs, including agriculture, health and passports.
- 2015-16 Department Annual Report: **24** of those **31** were live and delivering services.
- That 24/31 count is **HISTORICAL**, not a current implementation total.
- NeGP also created Common Services Centres.

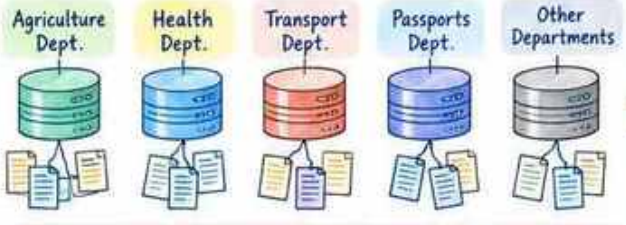
FROM 27 TO 31 TO 44: PROJECT PORTFOLIO

18 MAY 2006 NeGP Approved	Later Expanded	25 MARCH 2015 e-Kranti Approved
27 MMPs	31 MMPs	44 MMPs
Initial portfolio with 27 Mission Mode Projects (MMPs).	Portfolio grew to 31 MMPs, including agriculture, health and passports.	Portfolio expanded from 31 to 44 MMPs, adding social-sector projects such as Women and Child Development and Financial Inclusion.



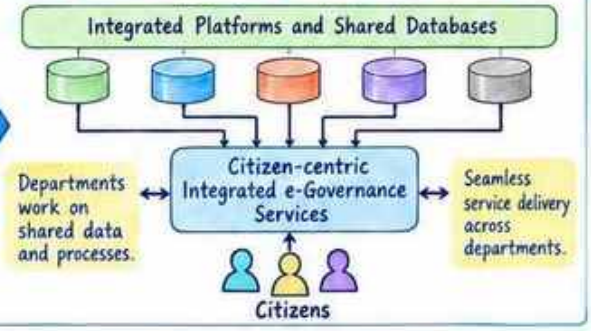
FROM FRAGMENTED DATABASES TO INTEGRATED PROCESS

BEFORE: FRAGMENTED DATABASES



- Poor integration between applications and databases.
- Limited re-engineering of government processes.

AFTER: INTEGRATED PROCESS (e-KRANTI)



WHY A SECOND PHASE?

- Poor integration between applications and databases.
- Limited re-engineering of government processes.



Digitising an old form alone is not the same as redesigning the service around citizens and connecting departments.

Re-engineered process with integrated data and departments for seamless service.

25 MARCH 2015: e-KRANTI APPROVED

- Union Cabinet approved the approach and key components of NeGP 2.0.

VISION

- "Transforming e-Governance for Transforming Governance".

ELEVEN GUIDING PRINCIPLES

(Examples)



2015 SEQUENCE

March 2015 e-Kranti approved → July 2015 Digital India

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DIGITAL INDIA: THREE VISIONS, NINE PILLARS

LAUNCHED: 1 JULY 2015

By Prime Minister Narendra Modi; run by the Ministry of Electronics and Information Technology (MeitY).

THREE VISION AREAS

1. Digital infrastructure as a utility to every citizen.
2. Governance and services on demand.
3. Digital empowerment of citizens.

NINE PILLARS

DIGITAL INDIA

1. **Broadband Highways.** — Fibre network connects India.
2. **Universal Access to Mobile Connectivity.** — Mobile connectivity for all citizens.
3. **Public Internet Access Programme.** — Common Service Centres for public internet access.

DIGITAL INDIA

4. **e-Governance: Reforming Government through Technology.** — Use technology to make government more efficient and responsive.
5. **e-Kranti: Electronic Delivery of Services.** — Deliver government services electronically to citizens.
6. **Information for All.** — Proactive disclosure and easy access to government information.

DIGITAL INDIA

7. **Electronics Manufacturing.** — Boost electronics manufacturing in India.
8. **IT for Jobs.** — Create jobs through IT and IT-enabled services.
9. **Early Harvest Programmes.** — Quick win initiatives with immediate visible impact.

PLAIN-WORD GOALS: MeitY, 5 AUGUST 2026

- Strong digital infrastructure.
- Government services delivered digitally.
- Citizens empowered through digital literacy and jobs.

DIRECT BENEFIT TRANSFER SNAPSHOT

318 schemes across 56 ministries; over ₹52 lakh crore transferred, as reported in the Lok Sabha reply of 5 August 2026.

EXAM CAUTION

25 March 2015 ≠ 1 July 2015

e-Kranti was approved on 25 March 2015.

Digital India was launched on 1 July 2015.

They share a year but are distinct milestones.

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INDIA STACK: IDENTITY, PAYMENTS & DATA

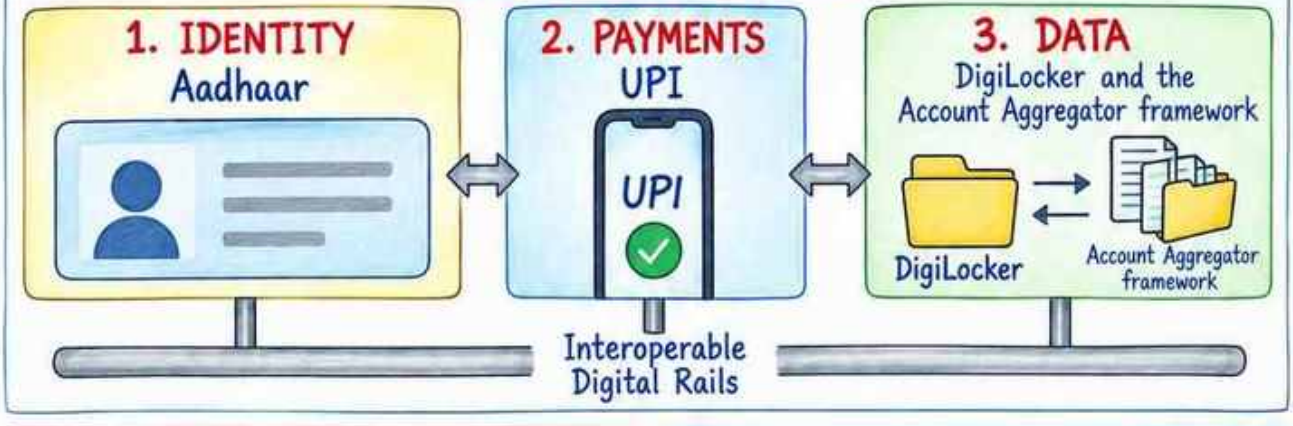
DIGITAL PUBLIC INFRASTRUCTURE (DPI)

- Foundational digital systems forming the backbone of modern societies.
- India's identity, payments and data-exchange systems are linked through interoperable public rails.

INDIA STACK

- Interoperable digital platforms and APIs that governments, businesses and developers can use to deliver services.

THREE BASIC LAYERS



AADHAAR

- 12-digit identity number, obtained voluntarily by residents, based on biometric and demographic data.
- Run by the Unique Identification Authority of India (UIDAI).

28 January 2009: UIDAI set up by Planning Commission notification.

September 2010: first Aadhaar number issued.

2016: Aadhaar Act makes UIDAI a statutory authority.

Over 144 crore numbers generated: March 2026.

UPI: UNIFIED PAYMENTS INTERFACE

- Built by National Payments Corporation of India (NPCI), 2016.
- **January 2026:** 2,170 crore (21.70 billion) transactions, worth over ₹28.33 lakh crore.
- These UPI figures are a dated January example, not a latest-month claim.

UPI TRANSACTION COUNTER (JANUARY 2026)

Transactions	Transaction Value
2,170 crore (21.70 billion)	over ₹28.33 lakh crore



OWNER TRAP: UPI → NPCI; Aadhaar → UIDAI.
Do not substitute RBI or MeitY for NPCI.

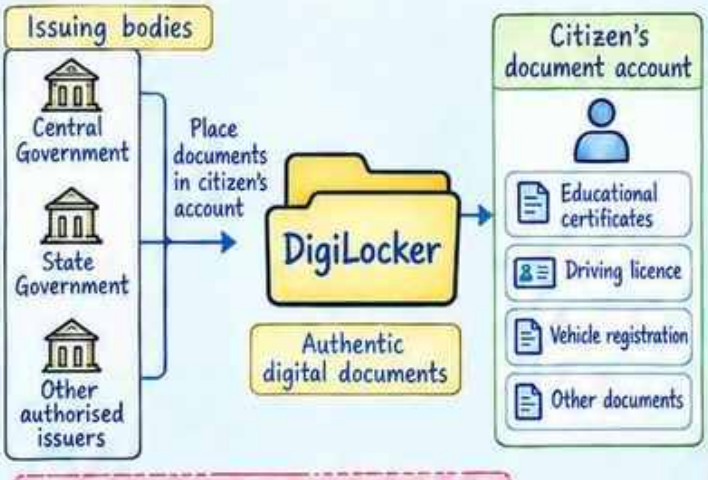
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DOCUMENTS vs SERVICES: DigiLocker & UMANG

DigiLocker: LAUNCHED 2015

- MeitY's digital-document platform.
- Issuing bodies place documents in the citizen's account.
- Think: issuer → authentic digital document → citizen's document account.



AS REPORTED 5 AUGUST 2026

- Over 71.66 crore registered users.
- Over 936 crore documents.
- 2,822 issuers.

UMANG: LAUNCHED 2017

- One mobile app for services of the Central and State Governments.
- Think: one app → multiple government services.



AS REPORTED 5 AUGUST 2026

UMANG — 2,575 services for individuals.

DISTINGUISH THE FUNCTIONS

DigiLocker holds documents pushed by issuing bodies.

DigiLocker = documents

UMANG enables users to access services.

UMANG = service access

READ THE METRIC

- Users, documents, issuers and services count different things.
- Keep each figure attached to its own unit and reporting date.
- Both are G2C examples: government services and information for individuals.

TIMELINE

2015 — DigiLocker launched in 2015.

2017 — UMANG launched in 2017.

Both are G2C examples: government services and information for individuals.

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DIGITAL COMMERCE: GeM & ONDC

GeM = GOVERNMENT e-MARKETPLACE

- Launched 2016.
- Online public procurement of common-use goods and services.
- Owned by GeM SPV, a Section 8 company.



ONDC = OPEN NETWORK FOR DIGITAL COMMERCE

- Launched 2022; run by ONDC Ltd.
- An open network linking buyers and sellers in online trade.



GFR RULE 149



Central ministries/departments must procure goods and services AVAILABLE ON GeM through GeM.

Buyer scope: Central ministries/ departments

Availability condition: goods and services available on GeM

KEY SNAPSHOTS

NOVEMBER 2025 SNAPSHOT (GeM)



- About 3.27 crore orders; cumulative value over ₹16.41 lakh crore.

DECEMBER 2025 SNAPSHOT (ONDC)



- Over 1.16 lakh retail sellers live in 630+ cities and towns.

VERSION CAUTION (GeM)



- GeM 3.0 launched on 26 January 2018.
- It was a later version, not the original 2016 launch; do not label 3.0 the current version.

Dates and cumulative totals are not interchangeable with annual figures.

DISTINGUISH THE PURPOSE

GeM	ONDC
Government buyers procure.	Buyers and sellers connect for commerce across an open network.

ONDC vs API Setu

- ONDC: trade connections.
- API Setu: connections between government data systems and other systems.

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HEALTH & LANGUAGE PLATFORMS

e-SANJEEVANI

- National telemedicine service.
- Launched **NOVEMBER 2019.**
- Over **48 crore** patients served, as reported on 5 August 2026.
- **Function:** remote access to health consultations.



CoWIN

- Platform that managed COVID-19 vaccination.
- Launched **16 JANUARY 2021.**
- Over **220 crore** doses managed, as reported on 6 March 2026.
- **Function:** vaccination management.



BHASHINI

- BHASa INterface for India.
- National Language Translation Mission; MeitY.
- Launched in **2022** at Digital India Week, Gandhinagar.
- May 2025 snapshot: **35+** languages and **1,600+** AI models.
- **Function:** reduce language barriers to digital access.



READ THE DIFFERENT COUNTS

Patients served ≠ vaccine doses managed ≠ languages ≠ AI models.

These snapshots use different dates and count different things; their totals are not directly comparable.

TIMELINE

2019 e-Sanjeevani → 2021 CoWIN → 2022 Bhashini

E-governance supports health-service access, programme management and inclusion through language technology.

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API SETU & eSIGN: CONNECT AND AUTHORISE

API SETU: MARCH 2020

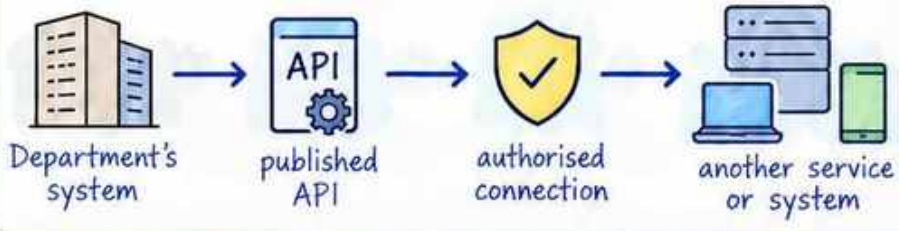
- MeitY platform under the Open API Policy.
- Departments publish Application Programming Interfaces (APIs) so other systems can connect to their services and data.

MARCH 2026 SNAPSHOT

8,036 APIs.

2,559 publishers.

CONCEPTUAL FLOW

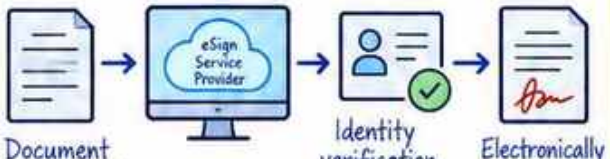


G2G example: departments share data with other systems through API Setu.

eSIGN / e-HASTAKSHAR

- An online electronic signature service.
- Provided by eSign Service Providers, including the Centre for Development of Advanced Computing (C-DAC).
- Government backgrounder, 8 December 2024: all providers together had issued **81.97 crore** e-Signs.

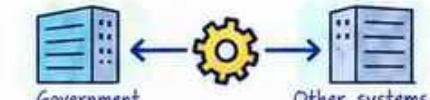
eSIGN WORKFLOW: DOCUMENT VERIFICATION



DISTINGUISH THE FUNCTIONS

API Setu

- Connects systems.
- Departments publish APIs so other systems can connect to their services and data.



eSign

- Enables electronic signing.



ONDC vs API Setu

- ONDC links buyers and sellers in trade.
- API Setu links government data systems with other systems.



- APIs and publishers count different things; e-Signs are a separate service total.
- Each figure is a dated snapshot, not a current live total.

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LAST-MILE ACCESS: FIBRE, WI-FI & CENTRES

BHARATNET

Broadband to Gram Panchayats over optical fibre.

JUNE 2026

- 2.21 lakh Gram Panchayats service-ready.
- Points of Presence working at 80,472 Gram Panchayats.
- "Service-ready" and "working Points of Presence" are different counts.

PM-WANI

Prime Minister WiFi Access Network Interface.

- Public Wi-Fi through Public Data Offices (PDOs), joined up by Public Data Office Aggregators (PDOAs) and App Providers registered under the scheme.

28 FEBRUARY 2026

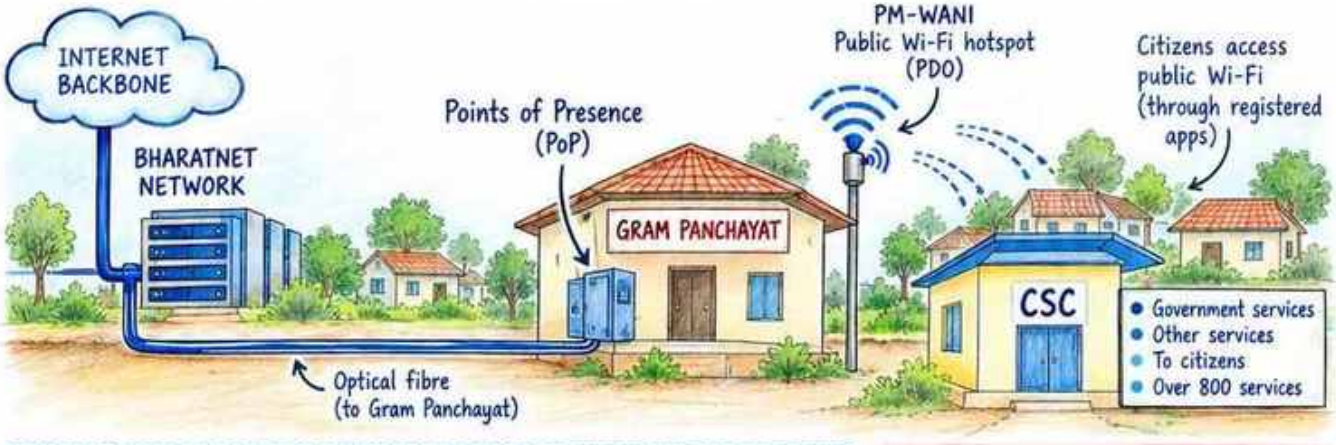
- 4,09,403 PDOs / public Wi-Fi hotspots working.
- 207 PDOAs; 113 App Providers.

COMMON SERVICES CENTRES (CSCs)

Under MeitY; deliver government and other services to citizens.

MAY 2026

- 5.01 lakh functional CSCs.
- 3.91 lakh at Gram Panchayat level.
- Over 800 services.



KEY NUMERIC STATS (AS ON SPECIFIED DATES)

BHARATNET — JUNE 2026		PM-WANI — 28 FEBRUARY 2026		COMMON SERVICES CENTRES (CSCs) — MAY 2026	
2.21 lakh	Gram Panchayats service-ready	4,09,403	PDOs / public Wi-Fi hotspots working	5.01 lakh	functional CSCs
80,472	Gram Panchayats with working Points of Presence	207	PDOAs	3.91 lakh	at Gram Panchayat level
		113	App Providers	Over 800	services

EXAM COUNTING TRAPS

1. Do not equate 2.21 lakh service-ready Gram Panchayats with 80,472 working Points of Presence.
2. Not all 5.01 lakh CSCs are at Gram Panchayat level; that subset is 3.91 lakh.
3. Connectivity infrastructure and assisted service access are complementary ways to reduce exclusion.

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DIGITAL LAW: RIGHTS & PHASED COMMENCEMENT

INFORMATION TECHNOLOGY ACT, 2000

- Legal recognition for electronic transactions and electronic filing with government agencies.
- Assent: 9 June 2000.
- In force: 17 October 2000.

IT (Amendment) Act, 2008

- Assent: 5 February 2009.
- In force: 27 October 2009.



AADHAAR JUDGMENT: 26 SEPTEMBER 2018

- Supreme Court upheld the Aadhaar Act and restricted mandatory use.
- It invalidated the relevant part of section 57 enabling private bodies and individuals to seek Aadhaar authentication, including on a contractual basis.
- It did NOT strike down the whole of section 57.



DPDP ACT 2023 + RULES 2025

Digital Personal Data Protection (DPDP)

- Rules notified 13 November 2025; phased commencement over eighteen months.
- Read the exact provisions and dates; Board establishment does not mean all substantive obligations already apply.

STEP 1



Act sections 18–26: Data Protection Board establishment and institutional arrangements in force.

STEP 2



Section 6(9): registering Consent Managers comes into force.

STEP 3

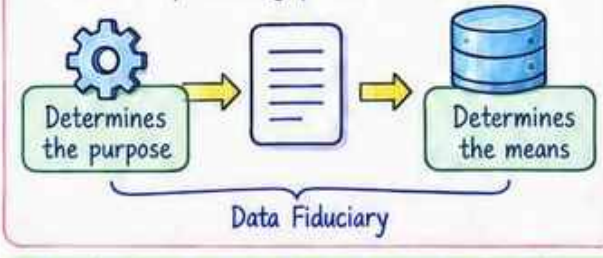


Most Chapter II Data Fiduciary obligations commence: sections 4, 5, 6(1)–(8), 6(10), and 7–10.



DATA FIDUCIARY

- A person who determines the purpose and means of processing personal data.



LAW BOOK TIMELINE (SELECT PROVISIONS)



Related: cyber laws Topic 347; data protection Topic 467.

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INDIA IN THE UN E-GOVERNMENT SURVEY

EGDI = E-GOVERNMENT DEVELOPMENT INDEX

- United Nations E-Government Survey.
- EGDI = E-Government Development Index.



INDIA'S RANK, OUT OF 193

2022: **105**

2024: **97**

Rank improved by 8 places.

INDIA'S EGDI SCORE

2022: **0.5883**

2024: **0.6678**

Score increased by 0.0795.

2024 GROUP

HIGH EGDI, rating class **H3**.

High H3

India was not in the Very High group.

THREE COMPONENT INDICES, 2024

Online Service Index (OSI)

0.8184.



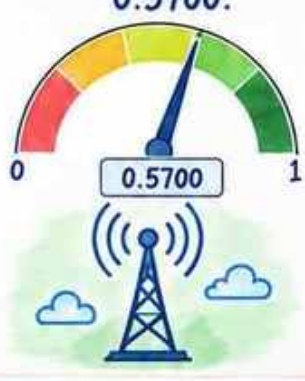
Human Capital Index (HCI)

0.6149.



Telecommunication Infrastructure Index (TII)

0.5700.



E-PARTICIPATION INDEX

India's 2024 rank: **61**.



READ THE METRIC

- EGDI rank 97 and E-Participation rank 61 are different rankings.
- A rank is not an index score.
- The component scores belong to the 2024 survey.

CONCEPT

- Online services, human capital and telecom infrastructure together describe the capacity for digital government.
- Andhra Pradesh's Real Time Governance system and citizen-service platforms are covered separately in Topic 767.

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INCLUSION, SECURITY & THE BIG TIMELINE

FIVE CHALLENGES

1 DIGITAL DIVIDE

March 2026, 109.27 crore internet subscribers versus over 133 crore telephone connections. Both count connections, not unique people; neither tells how many people are offline.



Numbers show connections, not unique people.

2 CYBER SECURITY

CERT-In handled over **29.44 lakh** incidents in 2025; more platforms widen the attack surface.



More platforms → wider attack surface.

3 EXCLUSION

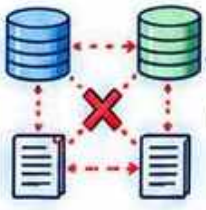
online-only services or dependence on a single ID can exclude people unable to use them. Aadhaar's mandatory use was restricted in 2018.



Cannot use online services = risk of exclusion.

4 INTEGRATION

weak links between applications/databases and too little process re-engineering were NeGP's weaknesses.



Weak database links and limited process re-engineering.

5 DATA PROTECTION

most substantive obligations are still phasing in, with the notified eighteen-month date of 13 May 2027.



Full obligations phase in by 13 May 2027.

CHRONOLOGY: THREE THREADS

LAWS

2000 — IT Act in force
2016 — Aadhaar Act
2023 — DPDP Act
13 November 2025 — DPDP Rules

Legal framework evolves to enable digital governance and data protection.

PLANS

18 May 2006 — NeGP
25 March 2015 — e-Kranti
1 July 2015 — Digital India

From e-governance foundation to transformative digital services.

PLATFORMS

2009 — UIDAI
September 2010 — first Aadhaar
2015 — DigiLocker
2016 — UPI and GeM
2017 — UMANG
26 January 2018 — GeM 3.0
November 2019 — e-Sanjeevani
March 2020 — API Setu
16 January 2021 — CoWIN
2022 — ONDC and Bhashini

2018: Aadhaar judgment.

2024: India EGDI rank 97.

EXAM CHECKLIST

- Who runs it?
- First launch or later version?
- What is counted?
- Which reporting date?
- Which legal provision is in force?

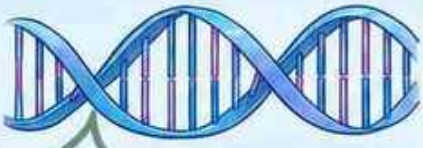
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GENETIC ENGINEERING: TWO CONNECTED APPROACHES

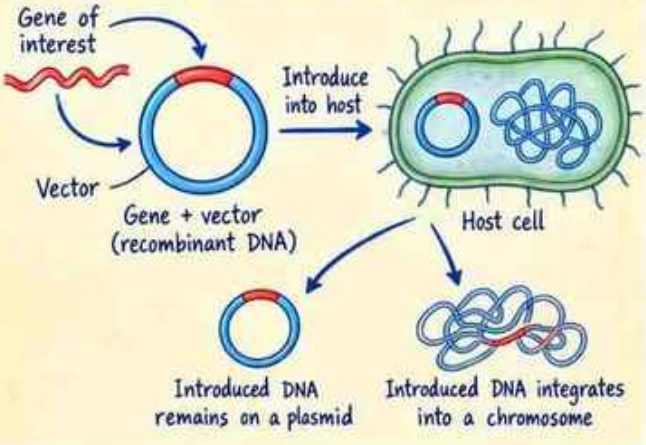
GENETIC ENGINEERING

Deliberately change genetic material to obtain a desired biological result. Recombinant DNA technology and targeted genome editing are overlapping approaches, not mutually exclusive boxes.



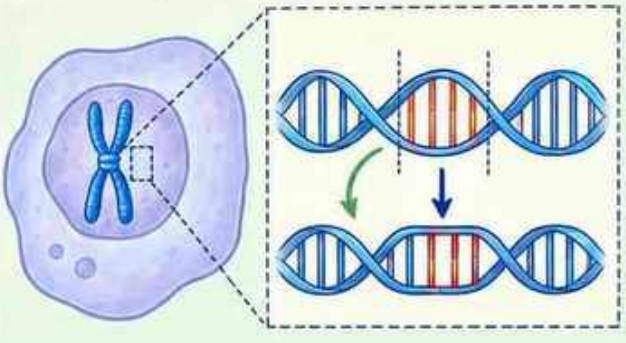
RECOMBINANT DNA

Join DNA sequences, often linking a gene of interest to a vector that carries it into a host cell. The introduced DNA may remain on a plasmid or integrate into a chromosome; it does not always enter a random chromosomal site.



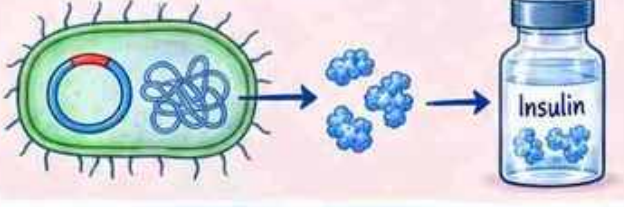
GENOME EDITING

Make a targeted insertion, deletion, modification or replacement at a chosen genomic location. Intended targeting does not mean that unwanted edits are impossible.



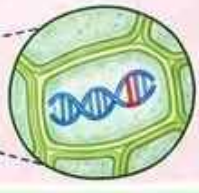
FOREIGN DNA: KEEP THE OBJECT CLEAR

A transgenic host retains an introduced gene. A purified product such as insulin is a protein, not the inserted gene itself.





Some SDN-1 or SDN-2 edited plants can be free of exogenous introduced DNA. The editing method and final genetic composition must both be checked.

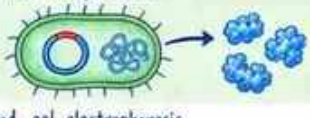


THREE BASIC STEPS OF GENE TRANSFER

1. Identify DNA containing a desirable gene.
2. Introduce it into the host.
3. Maintain it and allow transmission to the host's progeny.

EXAMPLES

Recombinant human insulin: bacteria produce a human protein.



Targeted editing: Casgevy and India's genome-edited rice varieties.



Topic 126 supplies the background on restriction enzymes, ligase, PCR and gel electrophoresis.

Sources: S1, S12, S13, S16; A5.

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RECOMBINANT DNA: ISOLATE, CUT & AMPLIFY

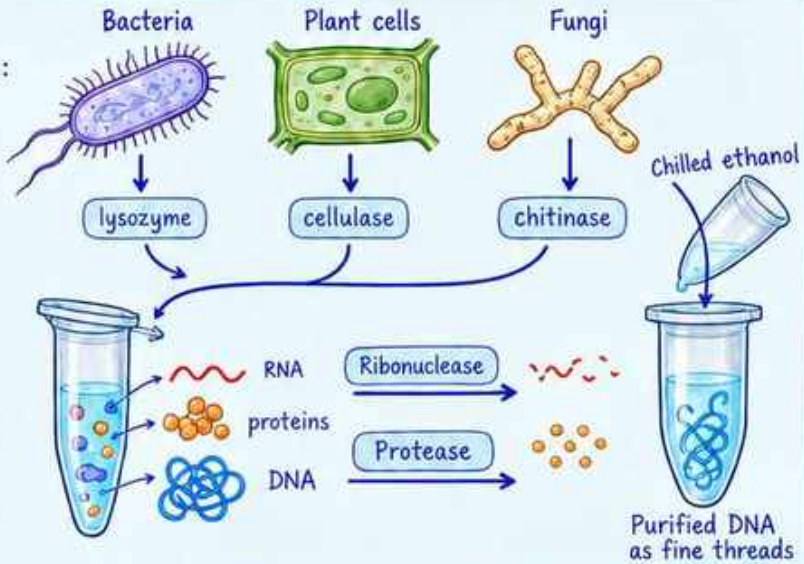
1 · ISOLATE DNA

Break cells open using suitable enzymes:
Bacteria → lysozyme.
Plant cells → cellulase.
Fungi → chitinase.

The released material contains DNA mixed with other molecules. Ribonuclease removes RNA; protease removes proteins. Chilled ethanol precipitates purified DNA as fine threads.

WHY PURIFICATION MATTERS

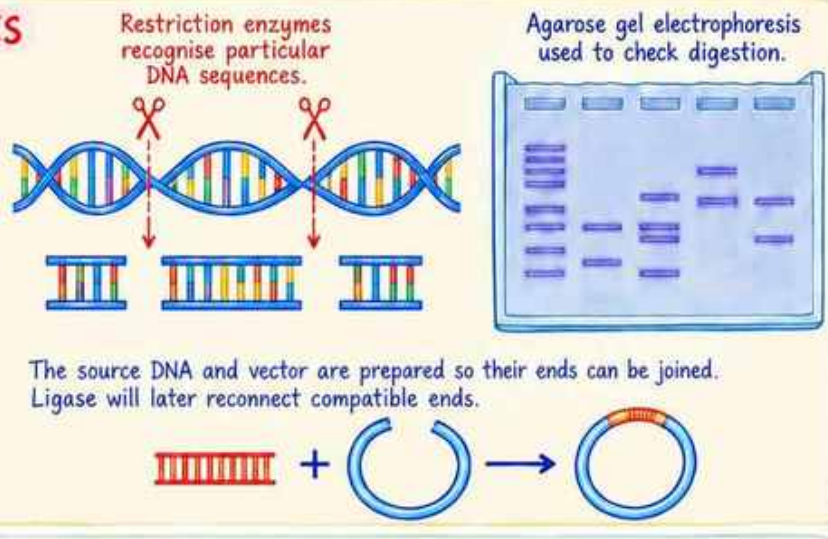
Mixed RNA and proteins interfere with obtaining clean genetic material. Releasing DNA and purifying it are distinct parts of the process.



2 · CUT AT SPECIFIC SITES

Restriction enzymes recognise particular DNA sequences. Restriction enzymes cut DNA under suitable reaction conditions. Agarose gel electrophoresis checks the digestion.

The source DNA and vector are prepared so their ends can be joined. Ligase will later reconnect compatible ends.

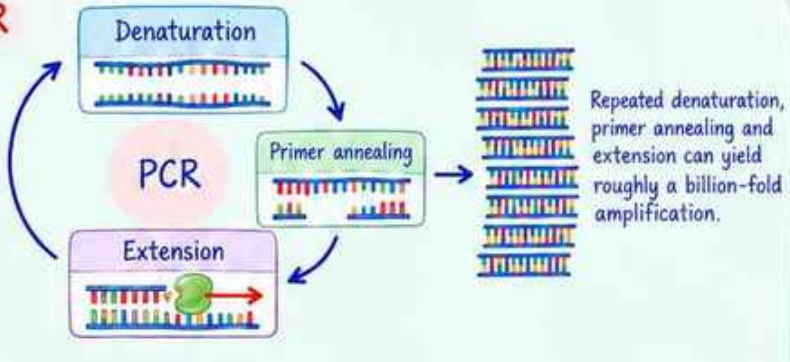


3 · AMPLIFY THE GENE BY PCR

PCR makes many copies in vitro using primers and DNA polymerase. Repeated denaturation, primer annealing and extension can yield roughly a billion-fold amplification.

HEAT-STABLE POLYMERASE

Taq polymerase comes from *Thermus aquaticus* and withstands the repeated high-temperature stages. Ordinary heat-sensitive polymerases would lose activity.



SEQUENCE CAUTION

The exact order of amplification and assembly depends on the cloning approach. PCR copies DNA, whereas ligation joins fragments.

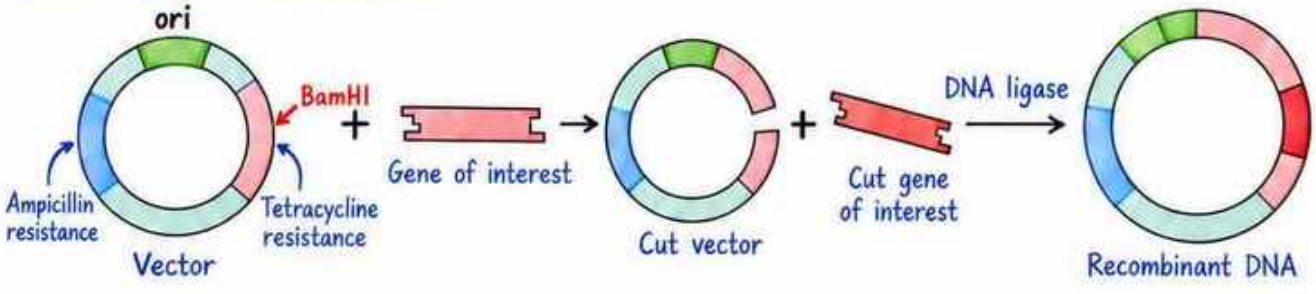
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VECTOR DESIGN: ori, MARKER & CLONING SITE

4 • BUILD THE RECOMBINANT VECTOR

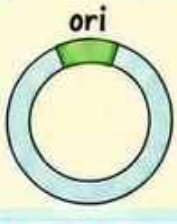
The gene of interest and vector are cut to provide compatible ends. DNA ligase joins them, producing recombinant DNA.



A USEFUL CLONING VECTOR NEEDS:

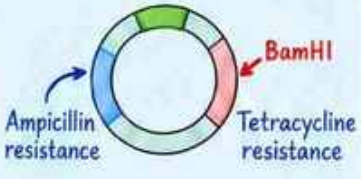
ORIGIN OF REPLICATION • ori

The DNA sequence from which replication begins. Linked DNA can be copied in the host. The origin also influences copy number; a high-copy vector helps when many copies are required.



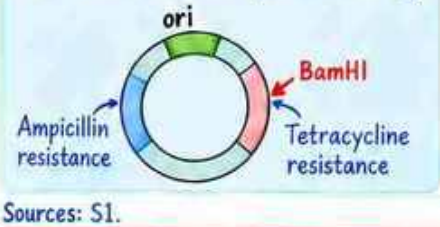
SELECTABLE MARKER

Helps distinguish transformed cells from cells that received no vector. Examples include resistance genes for ampicillin, chloramphenicol, tetracycline and kanamycin.



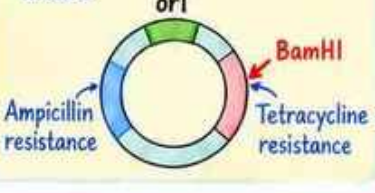
CLONING SITES

Very few, preferably single recognition sites for the commonly used restriction enzymes. Repeated sites can fragment the vector and complicate cloning.



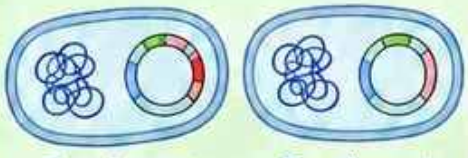
pBR322 EXAMPLE

Its BamHI site lies within the tetracycline-resistance gene. Insertion there can inactivate that gene while leaving ampicillin resistance intact.



TRANSFORMANT ≠ RECOMBINANT

A transformant has taken up DNA. It may carry a vector with the desired insert or an empty vector. Selection for the vector alone does not prove that the insert is present.



THE NEXT CHECK

Use insertional inactivation or another screening method to distinguish insert-bearing clones from non-recombinant transformants.

Sources: S1.

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SELECT TRANSFORMANTS, SCREEN RECOMBINANTS

TWO QUESTIONS, TWO CHECKS

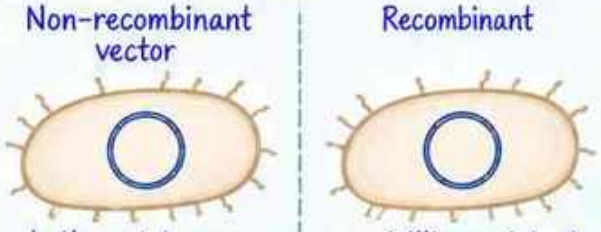
Did the cell receive a vector? | Does that vector contain the desired insert?

ANTIBIOTIC SELECTION

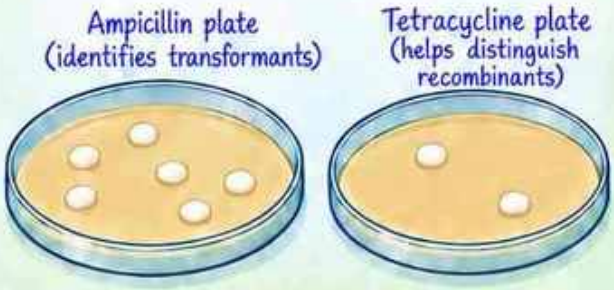
A selectable resistance marker allows appropriate transformed cells to grow while susceptible, non-transformed cells do not.

pBR322: INSERTION INTO tetR

An insert at the BamHI site disrupts tetracycline resistance.

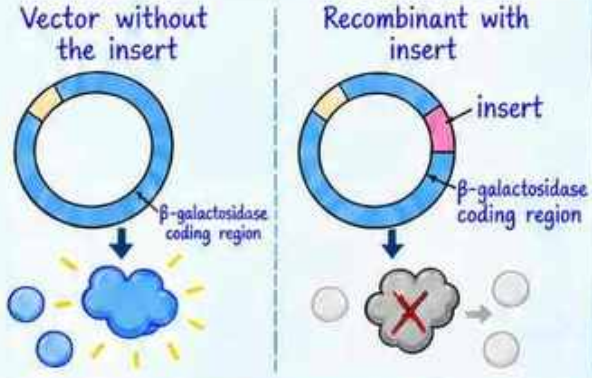


Compare growth across plates containing different antibiotics. The ampicillin plate identifies transformants; the tetracycline comparison helps distinguish recombinants.

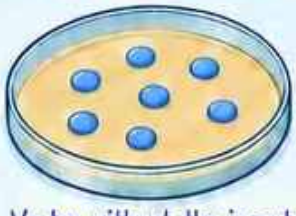


BLUE-WHITE SCREENING

Insert foreign DNA within the β-galactosidase coding region used by the system. Insertional inactivation prevents the normal colour reaction.



BLUE COLONIES



Vector without the insert; the colour-producing enzyme system remains active on a chromogenic substrate.

WHITE OR COLOURLESS COLONIES



Insert disrupts the enzyme system; these are candidate recombinant colonies in this simplified screening system.

EXAM TRAP

Blue does not mean recombinant.
The loss of the colour reaction is the important clue.

ALSO REMEMBER

Transformants and recombinants are not interchangeable terms.
An antibiotic-resistance marker selects DNA uptake; screening examines whether the desired recombinant arrangement is present.

Sources: S1.

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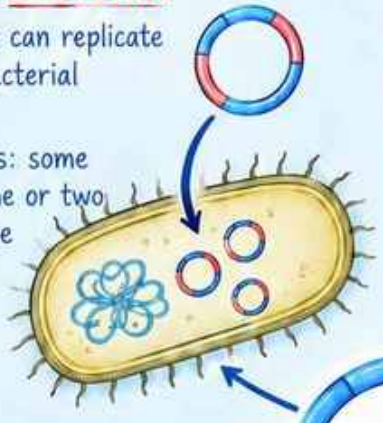
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CLONING VECTORS: MATCH THE HOST

PLASMIDS → BACTERIA

Small DNA replicons can replicate independently of bacterial chromosomal DNA.

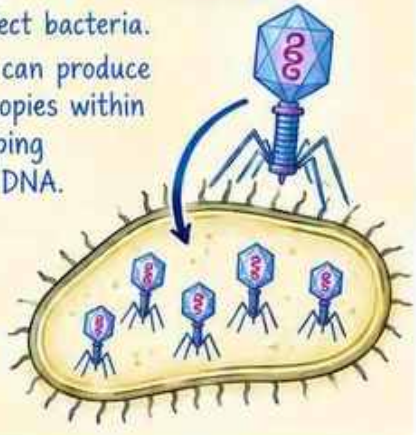
Copy number varies: some plasmids occur at one or two copies per cell, while others have about 15–100 copies.



BACTERIOPHAGES → BACTERIA

Viruses that infect bacteria.

Bacteriophages can produce many genome copies within a host cell, helping multiply linked DNA.

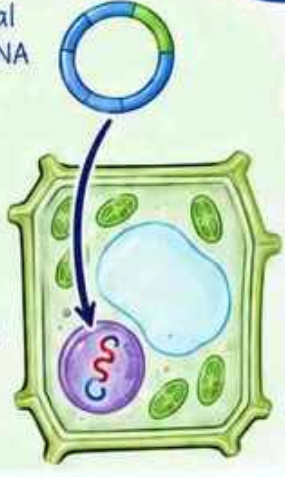


CLONING VECTOR

Ti PLASMID → PLANTS

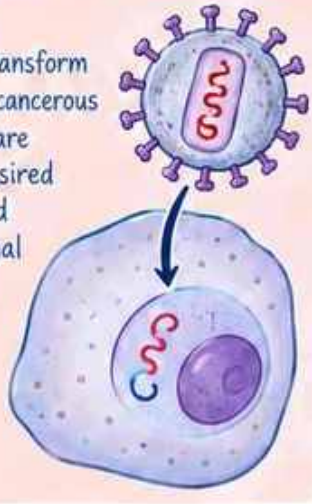
Agrobacterium tumefaciens is naturally a pathogen of several dicot plants. It transfers T-DNA into plant cells and can induce tumours.

Scientists modify the tumour-inducing plasmid into a non-pathogenic vector while retaining gene-delivery functions. The modified system can deliver genes of interest into a variety of plants.



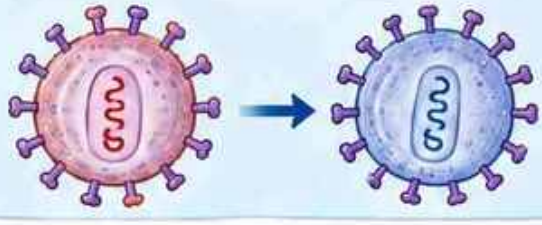
RETROVIRAL VECTORS → ANIMAL CELLS

Some retroviruses can transform normal animal cells into cancerous cells. Disarmed vectors are engineered to deliver desired genetic material instead of retaining their original pathogenic functions.



WHAT DISARMED MEANS

Disease-causing functions are removed or disabled while useful delivery properties are retained. It does not mean that every biological risk automatically disappears.



RECALL CONNECTION

Vector choice depends on the host and intended use. Plasmids and bacteriophages belong with bacterial cloning; Ti-based vectors with plants; retroviral vectors with animal-cell gene delivery.

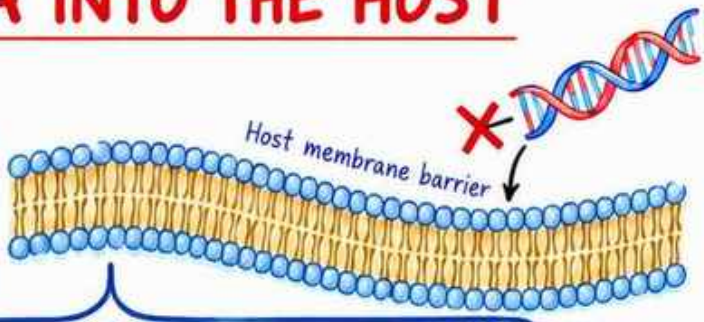
Sources: S1. Day14 | Topic137 | 5/14 | @iaswithdrravi.

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GETTING DNA INTO THE HOST

DNA NEEDS A DELIVERY ROUTE

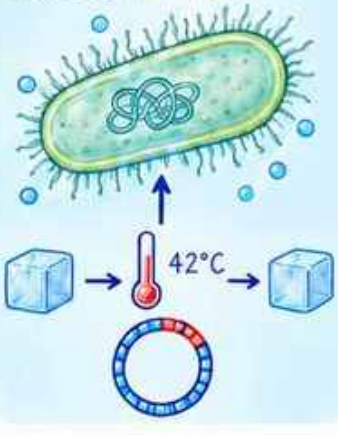
DNA is hydrophilic and does not freely cross cell membranes. Host cells must be made receptive or DNA must be delivered by a suitable method.



BACTERIA

CALCIUM & HEAT SHOCK

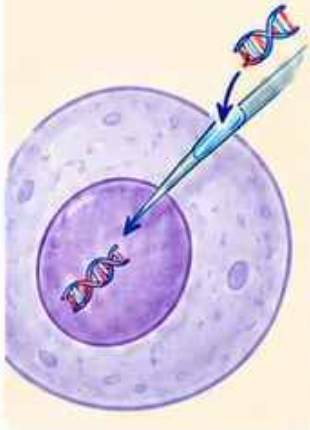
Divalent-cation treatment, such as calcium, makes bacteria receptive to DNA. Recombinant DNA uptake uses ice → brief 42°C heat shock → ice.



ANIMAL CELLS

MICRO-INJECTION

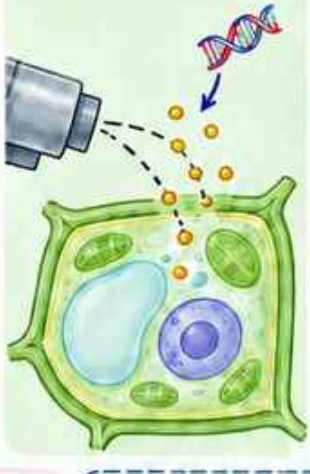
DNA is introduced directly into the nucleus. Remember the target compartment, not only the needle symbol.



PLANT CELLS

BIOLISTICS

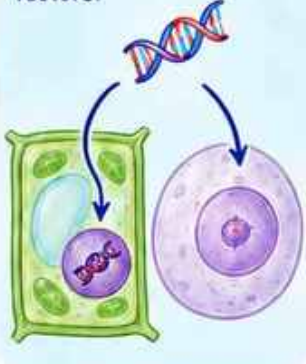
A gene gun introduces DNA carried on gold or tungsten microparticles.



PLANTS AND ANIMAL CELLS

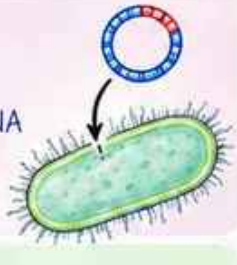
DISARMED VECTORS

Engineered pathogen-derived delivery systems transfer recombinant DNA into cells. Examples are Ti-based plant vectors and retroviral animal-cell vectors.



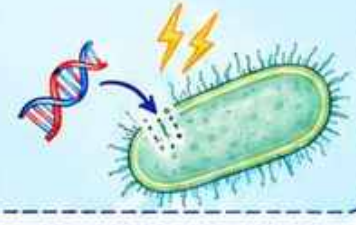
TRANSFORMATION

In bacterial genetic engineering, transformation means introducing DNA into a host bacterium. Its meaning depends on the biological context.



ELECTROPORATION

An electric field temporarily increases membrane permeability, allowing DNA entry. It is used with cells such as bacteria and yeast.



DELIVERY MECHANISMS

Chemical treatment, micro-injection, particle bombardment, vectors and electric pulses provide different routes across the cell barrier.

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FROM AN INSERTED GENE TO A PURIFIED PRODUCT

7 • EXPRESS THE GENE

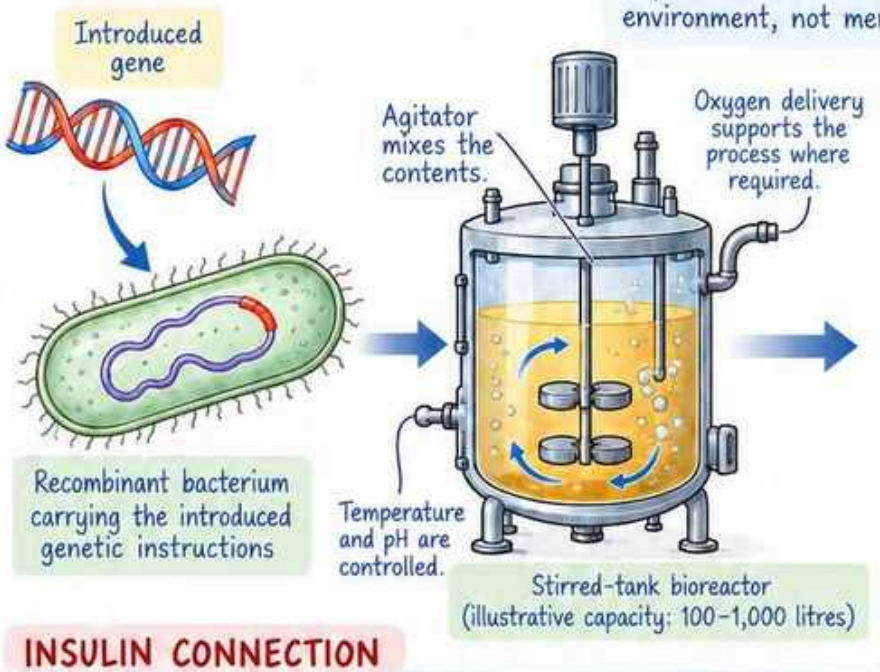
The introduced gene must be expressed for the desired protein to be made. Carrying DNA, copying DNA and producing a protein are different stages.

SCALE-UP IN A BIOREACTOR

A stirred-tank bioreactor controls the culture environment for growth and product formation. Vessels of about 100–1,000 litres illustrate one scale of operation; bioreactors also operate at other scales.

- An agitator mixes the contents.
- Oxygen delivery supports the process where required.
- Temperature and pH are controlled.

A productive culture needs an appropriate controlled environment, not merely a larger container.



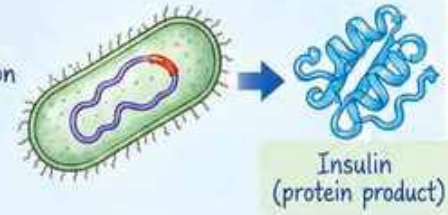
8 • DOWNSTREAM PROCESSING



Drug products require clinical evaluation and strict quality control before medical use.

INSULIN CONNECTION

A recombinant bacterium carries the introduced genetic instructions. The insulin obtained after purification is the protein product. Saying that the final insulin itself carries the foreign gene confuses the production organism with its product.



CONNECTED WORKFLOW

Identify → isolate/ copy → assemble vector → deliver → select and screen → express → scale up → separate and purify

EXAM CHECK

A bioreactor supports production; downstream processing recovers and prepares the product. They are complementary stages.

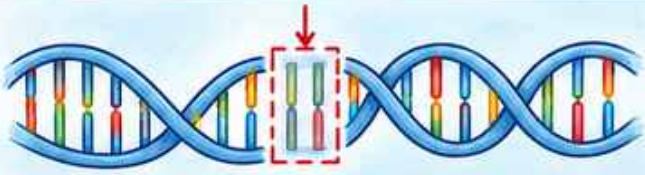
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TARGETED CUTTING & DNA REPAIR

GENOME EDITING

A chosen genomic site is modified, inserted into, deleted from or replaced. Classical nuclease editing uses a targeted break followed by cellular repair.



FOUR CLASSIC NUCLEASE FAMILIES

Meganucleases • zinc-finger nucleases (ZFNs) • TALENs • CRISPR-Cas systems.

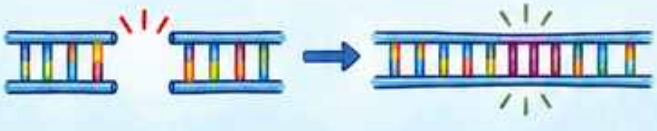
DOUBLE-STRAND BREAK

Both DNA strands are cut at the target.
The cellular repair pathway then helps determine the outcome.



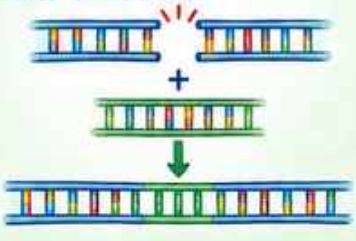
NHEJ • NON-HOMOLOGOUS END JOINING

Broken ends are rejoined without a matching donor template. Small insertions or deletions can result and may disrupt a gene. A gene knockout is a possible outcome, not an automatic result of every repair.



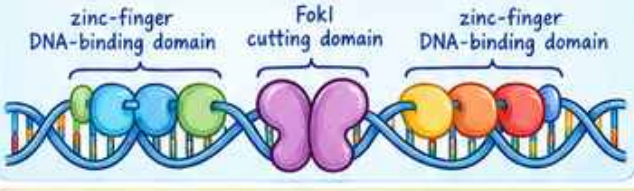
HDR • HOMOLOGY-DIRECTED REPAIR

A homologous template guides repair, allowing a specified sequence change in suitable conditions.



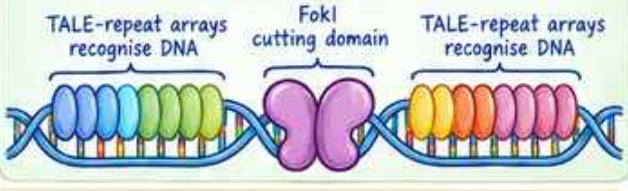
ZFN

A zinc-finger DNA-binding domain recognises the target; a FokI cutting domain performs cleavage when paired. Retargeting requires redesigning the DNA-binding protein.



TALEN

TALE-repeat arrays recognise DNA; each repeat recognises a base. A FokI domain cuts when paired. The repeat-to-base code makes custom design more straightforward.



IMPORTANT LIMIT

These cutting-and-repair pathways describe classical nuclease editing.
Base and prime editing can avoid a double-strand break, so do not claim all editing requires one.

Sources: S2; A2–A5, A9.

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CRISPR-Cas9: GUIDE, SCISSORS & PAM

CRISPR

Clustered Regularly Interspaced Short Palindromic Repeats. In bacteria, repeats and stored fragments from past invaders contribute to a natural defence system adapted for genome engineering.

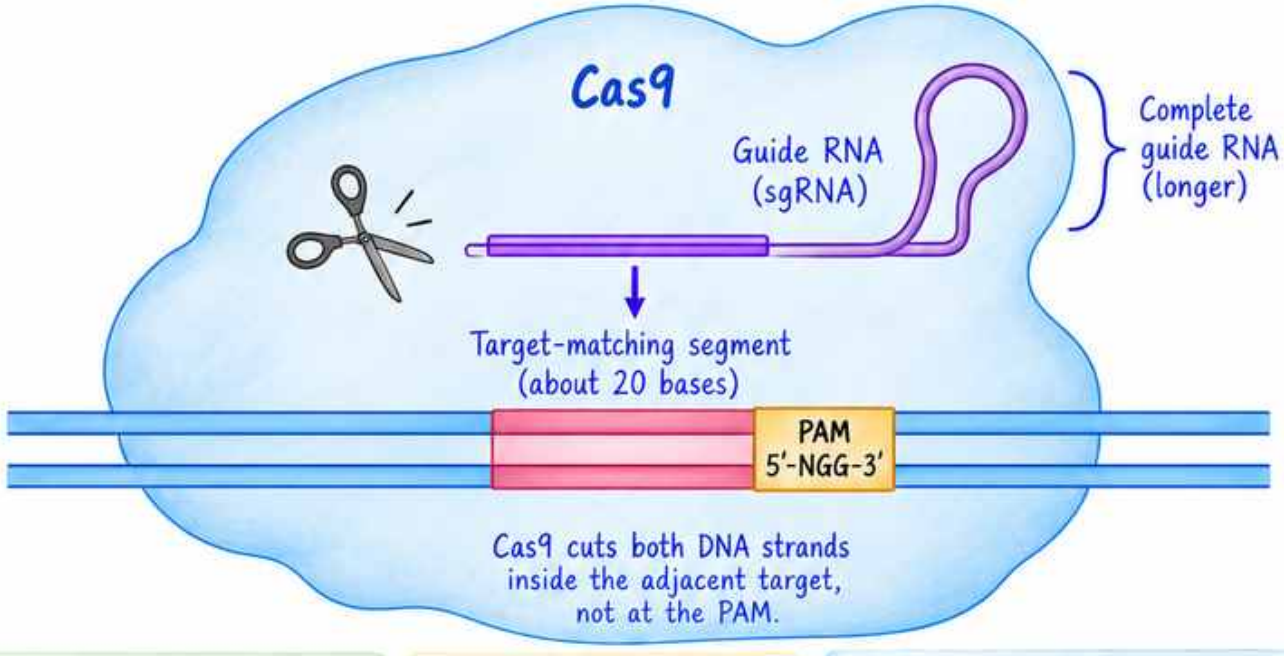
GUIDE RNA

crRNA carries the target-matching sequence. tracrRNA partners with it. In laboratory systems they can be combined into one single guide RNA, sgRNA.

The target-matching segment is about 20 bases; the complete guide RNA is longer.

Cas9

The DNA-cutting enzyme. The commonly taught SpCas9 comes from Streptococcus pyogenes; it is one member of a wider Cas9 family.



PAM

Protospacer Adjacent Motif: a short DNA sequence beside the target that the enzyme must recognise. For the usual SpCas9, the PAM is 5'-NGG-3'; N can be any base.

RETARGETING

Changing the guide sequence usually redirects the system without rebuilding a custom DNA-binding protein. This often simplifies design compared with ZFNs and TALENs, but PAM, delivery and specificity constraints remain.

NOBEL MILESTONE

Emmanuelle Charpentier and Jennifer A. Doudna received the 2020 Nobel Prize in Chemistry for developing a genome-editing method. Their programmable CRISPR/Cas9 work was published in 2012.



EXAM CHECK
Chemistry, not Physiology or Medicine.

Sources: S8–S10; A2, A5.

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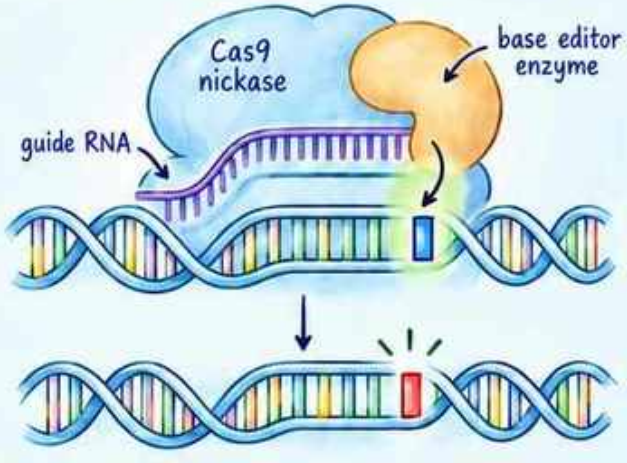
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BASE EDITING, PRIME EDITING & EARLY MILESTONES

BASE EDITING • 2016

Komor and colleagues described programmable chemical conversion of a target DNA base without requiring a double-strand break or donor DNA template.

It is especially useful for certain base substitutions. Base-editing systems have editing windows and can alter more than one susceptible base. A single editing event need not change only one isolated base.



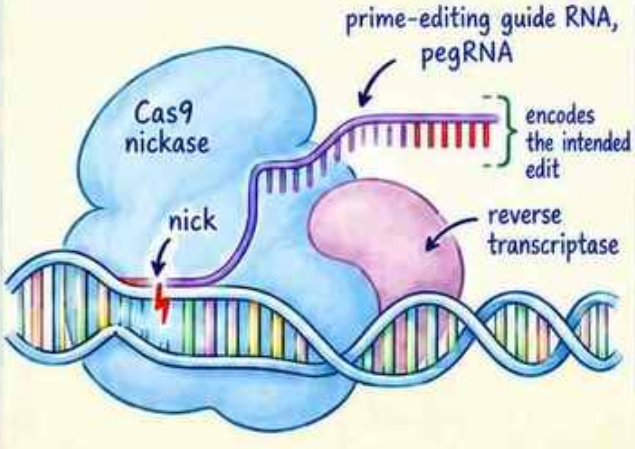
PRIME EDITING • 2019

Anzalone and colleagues described a search-and-replace approach.

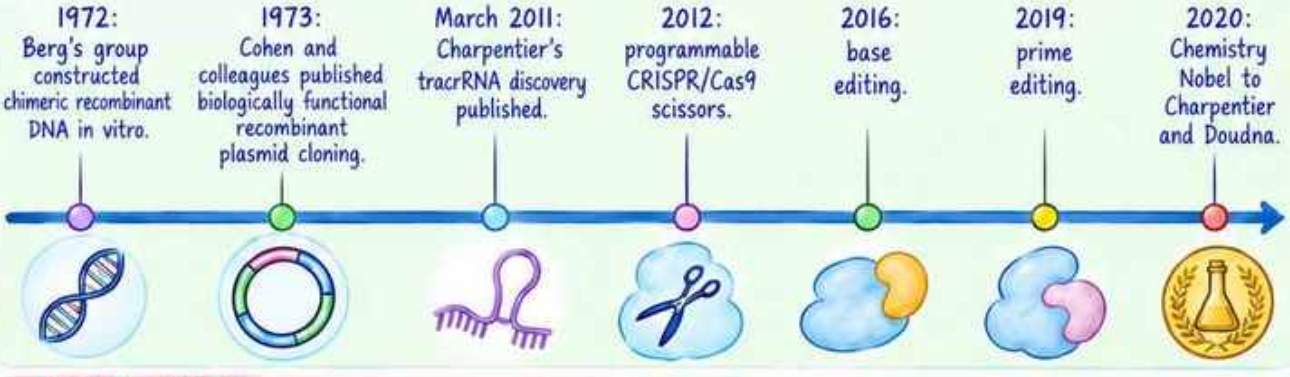
A Cas9 nickase is fused to a reverse transcriptase.

A prime-editing guide RNA, pegRNA, both identifies the target and encodes the intended edit.

It can make substitutions and small insertions or deletions without the standard double-strand-break route.



HISTORICAL CHRONOLOGY



EXAM CHECK

Base and prime editing are editing methods, not additional names for ordinary double-strand-cutting Cas9.

Sources: S1, S4, S5, S8, S9; A2-A4, A7.

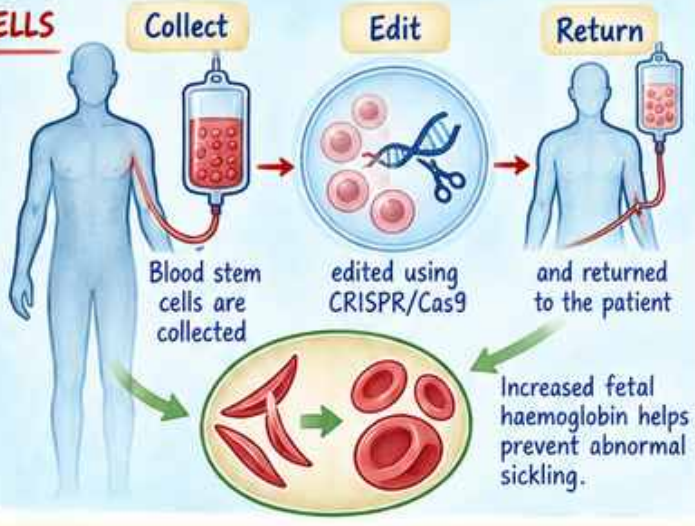
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CASGEVY & INDIA'S BIRSA 101

CASGEVY • EDIT THE PATIENT'S OWN CELLS

Blood stem cells are collected, edited using CRISPR/Cas9 and returned to the patient. Increased fetal haemoglobin helps prevent abnormal sickling. This is somatic-cell treatment, not embryo editing.



INITIAL REGULATORY MILESTONES

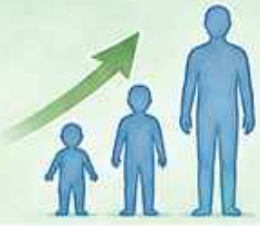
16 November 2023 — UK MHRA: sickle-cell disease and transfusion-dependent β-thalassaemia in eligible patients aged 12 and over.

8 December 2023 — US FDA: sickle-cell disease in patients aged 12 and older.

The UK authorisation therefore preceded the first US approval.

CURRENT US UPDATE • 1 JULY 2026

1 July 2026 — FDA expanded approval to age 2+ for sickle-cell disease with recurrent vaso-occlusive crises or transfusion-dependent β-thalassaemia. The age-12+ figures above describe the initial authorisations, not the current US age limit.



BIRSA 101 • 19 NOVEMBER 2025



Union Minister Dr Jitendra Singh launched the CSIR-Institute of Genomics and Integrative Biology's indigenous CRISPR-based sickle-cell therapy platform.

Named in honour of Bhagwan Birsa Munda; PIB calls it India's first indigenous CRISPR-based gene therapy.

STATUS CAUTION

A research or technology launch is not, by itself, proof of routine regulatory approval or universal clinical availability.

EXAM CHECK

Casgevy edits the patient's blood stem cells. Germline embryo editing raises a different set of inheritance and consent questions.

Sources: S11, S12, S15; A1.

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INDIA'S GENOME-EDITED RICE

4 MAY 2025 • TWO RICE VARIETIES ANNOUNCED

ICAR developed the varieties with CRISPR-Cas genome editing without adding foreign DNA. Match the institute, parent variety and intended trait carefully.

DRR DHAN 100 • KAMALA

Institute: ICAR-Indian Institute of Rice Research, Hyderabad.
Parent background: Samba Mahsuri, BPT 5204.
Purpose: more grains per panicle and earlier maturity.





The original 4 May release uses the spelling DRR Rice 100 (Kamla); later official material uses DRR Dhan 100 Kamala.

PUSA DST RICE 1

Institute: ICAR-Indian Agricultural Research Institute, New Delhi.
Parent: MTU 1010.
PIB reports 9.66–30.4% higher yields in saline and alkaline soils. Treat these as reported performance figures for specified conditions, not a guarantee for every field.





PIB reports 9.66–30.4% higher yields in saline and alkaline soils.

ANDHRA LINK

Andhra Pradesh and Telangana are among the recommended states mentioned in the announcement.



FUNDING CONTEXT

Union Budget 2023–24 allocated ₹500 crore for genome editing in agricultural crops.



EXAM CHECK

Hyderabad + Samba Mahsuri belongs with Kamala.
New Delhi + MTU 1010 belongs with Pusa DST Rice 1.
Absence of introduced foreign DNA does not remove the need for biosafety review and applicable variety-release requirements.

Sources: S13, S14, S17; A8.

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INDIA'S RULES: SDN-1, SDN-2 & THE EXEMPTION

REGULATORY FOUNDATION

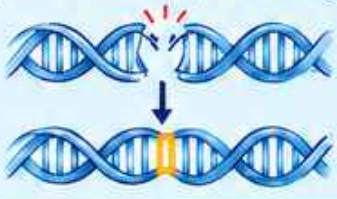
The Rules of 1989 cover hazardous microorganisms and genetically engineered organisms or cells under the Environment (Protection) Act, 1986. GEAC works within this framework; see Topic 126.



SDN = SITE-DIRECTED NUCLEASE

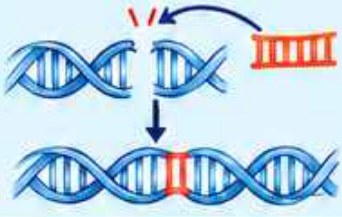
SDN-1

a targeted break is repaired without an externally supplied template; the cell's repair can produce small sequence changes.



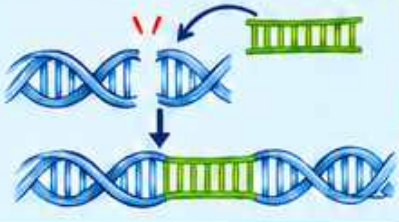
SDN-2

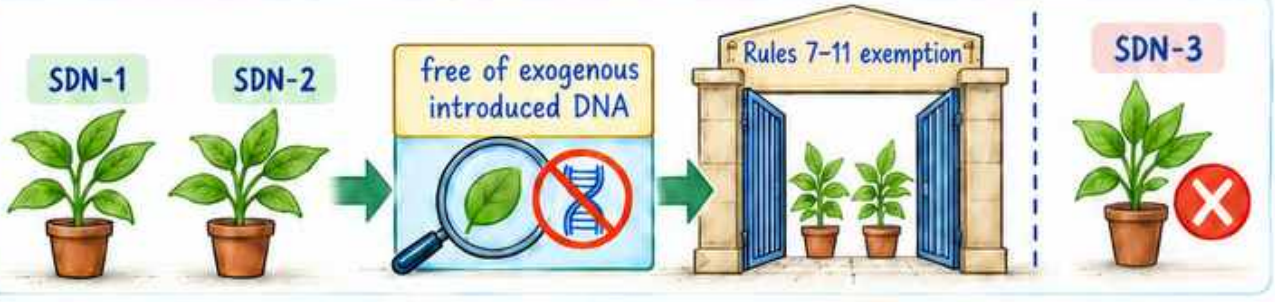
a supplied repair template guides a defined sequence alteration.



SDN-3

SDN-3 involves insertion of larger DNA sequences and is not within the stated exemption.





30 MARCH 2022 • MoEF&CC OFFICE MEMORANDUM

Exempts SDN-1 and SDN-2 genome-edited plants from Rules 7-11 of the 1989 Rules when they are free of exogenous introduced DNA.

17 MAY 2022 • DBT GUIDELINES

Guidelines for the Safety Assessment of Genome Edited Plants, 2022, followed by regulatory-review procedures.

2025 OFFICIAL CLARIFICATION

IBSC review and RCGM acceptance form part of the exemption process. Further development, evaluation and variety release remain subject to other applicable laws.



THE CONDITION MATTERS

The category label alone does not establish that foreign DNA has been removed. Early research remains under containment and biosafety oversight until the required evidence is accepted.



EXAM CHECK

A bounded exemption from specified rules is not exemption from all regulation. It applies to qualifying plants, not automatically to human therapies.

Sources: S16; A8.

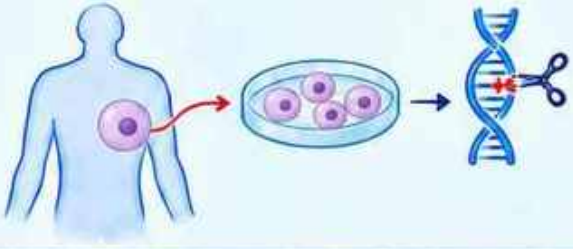
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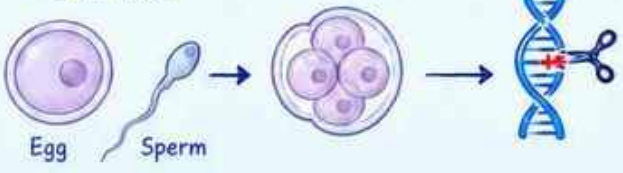
ETHICS, INHERITANCE & FINAL SAFEGUARDS

SOMATIC VERSUS GERMLINE EDITING

Somatic editing targets a patient's body cells, as in Casgevy's blood stem cells.



Germline editing alters eggs, sperm, their precursors or early embryos, potentially making changes heritable. Editing an embryo before a pregnancy is one example, not the full definition.



WHY THE DISTINCTION MATTERS

Unintended changes can affect future generations; those future people cannot consent. Other concerns include unequal access, enhancement and eugenics.



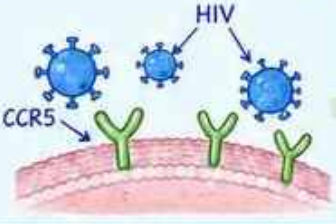


HE JIANKUI CASE

November 2018:
He Jiankui announced the birth of twin girls after editing their embryos at CCR5.



CCR5 encodes a cell-surface co-receptor used by many HIV strains; HIV uses the protein, not the gene directly.



The experiment was widely condemned.



30 December 2019:
a Shenzhen court sentenced him to three years in prison.



THREE FINAL SAFEGUARDS

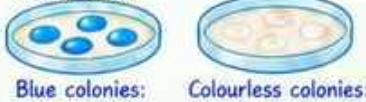
HOST MATCH

calcium/heat shock for bacteria, micro-injection for animal nuclei, biolistics for plants, and appropriate disarmed vectors.



COLOUR CHECK

In this screening system, blue colonies carry a vector without the insert; colourless colonies are candidates for insertional inactivation.

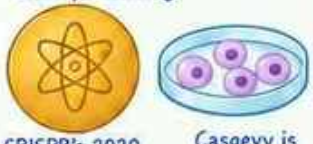


Blue colonies: vector without the insert

Colourless colonies: candidate insertional inactivation.

AWARD AND MEDICINE

CRISPR's 2020 Nobel was Chemistry; Casgevy is not embryo editing.



CRISPR's 2020 Nobel was Chemistry.

Casgevy is not embryo editing.

Keep research launches, initial approvals and current indications distinct. Ethics and biosafety law continue in Topic 946.
Sources: S1, S7-S12; A1, A6, A10.

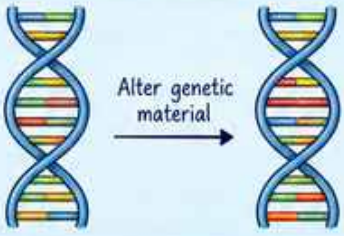
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GM, transgenic and genome editing

Genetic modification

Genetic modification alters genetic material using biotechnology.



Transgenic crops

Transgenic crops are a subset: they contain introduced genetic material from another organism.



Example transgenic crops

Examples include Bt cotton, Bt brinjal and mustard hybrid DMH-11. Their different approval histories must not be collapsed into one category of permission.

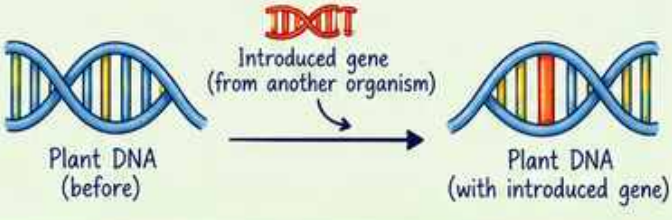

Bt cotton


Bt brinjal


mustard hybrid DMH-11

Transgenic crop: introduced gene

A gene from another organism is introduced into the plant genome.



Genome editing: precise change

Genome editing changes DNA at a selected site. SDN means site-directed nuclease; SDN-1 and SDN-2 are kinds of edit.



India's 30 March 2022 Office Memorandum

India's 30 March 2022 Office Memorandum exempts SDN-1 and SDN-2 plants from Rules 7-11 of the 1989 Rules only when they are free of exogenous introduced DNA.

SDN-1 and SDN-2 plants → Free of exogenous introduced DNA → Exempt from Rules 7-11 of the 1989 Rules

Conditional exemption

The exemption is conditional. Institutional Biosafety Committee oversight continues until freedom from exogenous DNA is established, with prescribed reporting to RCGM.

Institutional Biosafety Committee (IBSC) oversight → Until freedom from exogenous DNA is established → Prescribed reporting to RCGM

Scope of exemption

It does not exempt every genome-edited plant from every biosafety requirement.



2025 genome-edited rice varieties

The 2025 genome-edited rice varieties were produced without adding foreign. DNA. Contrast this final-plant condition with transgenic crops carrying introduced genes.



Key examination questions

The key examination questions are:

- What was changed?
- Is introduced DNA present?
- Which regulatory route applies?
- What stage of approval has the particular crop actually reached?

Sources: S9, S13, S27

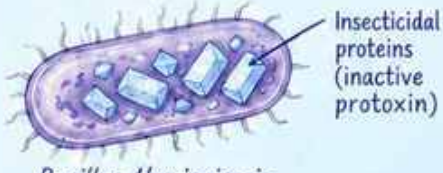
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Bt toxin: target-specific biological action

1. Bt and its insecticidal proteins

Bt stands for *Bacillus thuringiensis*, the bacterium that produces insecticidal proteins.



Bacillus thuringiensis (Bt)

2. Activation of the toxin in a susceptible insect

Bt produces the toxin as an inactive protoxin. The alkaline conditions of a susceptible insect's gut activate it.



3. Each toxin has particular targets

Each toxin has particular targets; one Bt gene does not control every agricultural pest.

Roman numerals (I, II) and Arabic numerals (1, 2) occur in different gene-label conventions. Letter case and numeral type matter when identifying a gene.

4. Gene-target examples

Bt gene (notation)	Protein controls	Target pest (common name)
cry1Ac	protein controlling cotton bollworms	cotton bollworms
cryIIAb	protein controlling cotton bollworms	
cry1Ab	a protein controlling the corn borer	corn borer

5. Bt genes in Bollgard cotton

Bollgard cotton (one gene)



Carried one Bt gene, Cry1Ac.

Bollgard II (two genes)



Bollgard II carries two, Cry1Ac and Cry2Ab.

6. Regulatory approval detail

Bollgard II, event MON15985, was commercialised in 2006. This is the regulatory milestone recorded in GEAC's 103rd meeting minutes.

7. Refuge and monitoring for resistance management

A refuge of non-Bt cotton and monitoring of pest susceptibility were conditions of the early approval. They are part of resistance management, not evidence that every insect will remain susceptible indefinitely.

8. Refuge of non-Bt cotton around a Bt field



9. Separate topics

The biological mechanism and the legal permission are separate topics.

Biological mechanism
Inactive protoxin → activated toxin in susceptible insect's gut (target-specific action).

Legal permission
Regulatory approval such as GEAC's 103rd meeting minutes for event MON15985 (commercialised since 2006).

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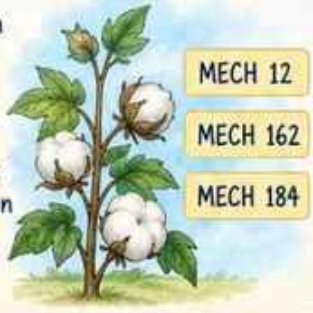
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Bt cotton: approval, adoption and resistance

1. First commercial permission (2002)

India's first commercial Bt-cotton permission covered **MECH 12, MECH 162 and MECH 184.**

A contemporary Lok Sabha answer records the decision in March 2002; the conditional three-year cultivation period ran from April 2002 to March 2005.



2. Required safeguards

Required safeguards included non-Bt refuge planting and monitoring bollworm susceptibility.



3. Unapproved Bt cotton sold in 2001

Before approval, unapproved Bt cotton was sold in Gujarat in **2001.**

The **16 April 2002** parliamentary answer records action concerning Navbharat Seeds.



4. Adoption status (2024)

The Agriculture Ministry's 6 August 2024 reply describes Bt cotton as the only GM crop approved for commercial cultivation and reports **over 96%** of cotton area under Bt cotton.

This is a dated Bt figure, not **Bollgard II** alone.

Timeline: 2001 – 2024

2001	March 2002	April 2002 – March 2005	2006	January 2010	2014	6 August 2024
Unapproved Bt cotton sold in Gujarat in 2001.	First commercial permission for MECH 12, MECH 162 and MECH 184 (recorded in March 2002).	Conditional three-year cultivation period ran from April 2002 to March 2005.	Bollgard II introduced (2006).	Reports described pink-bollworm survival on Bollgard in Saurashtra (January 2010).	CICR's 2014 studies found survival on genuine Bollgard II and resistance to Cry1Ac, Cry2Ab and their combination in Amreli and Bhavnagar.	Over 96% of cotton area under Bt cotton (as per 6 August 2024 Agriculture Ministry reply). This is a dated Bt figure, not Bollgard II alone.

5. Resistance findings

Resistance matters: January 2010 reports described pink-bollworm survival on Bollgard in Saurashtra.

CICR's 2014 studies found survival on genuine Bollgard II and resistance to Cry1Ac, Cry2Ab and their combination in Amreli and Bhavnagar.



6. Key takeaway

Approval, widespread adoption and lasting pest susceptibility are different claims.

Resistance management remains important after commercialisation.



Sources: S5, S6, S7, S19, S23, S29

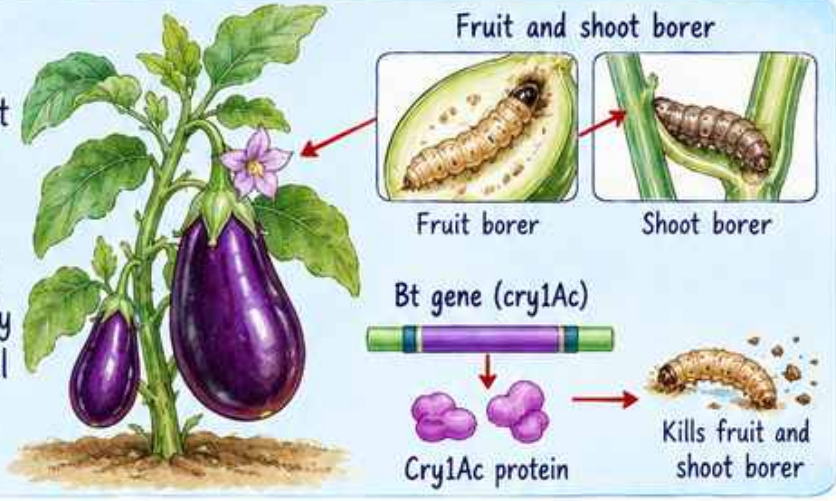
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Bt brinjal: recommendation and moratorium

1. Scientific trait

- Bt brinjal carries cry1Ac against fruit and shoot borer.
- Mahyco developed it with public-sector partners including Tamil Nadu Agricultural University and the University of Agricultural Sciences, Dharwad.



2. Regulatory recommendation

On 14 October 2009, GEAC recommended environmental release and referred the matter to the Government.



3. Government decision

On 9 February 2010, the Government imposed a moratorium. Release was to await independent scientific work establishing safety to the satisfaction of the scientific community and the public.



Bangladesh (separate jurisdiction)

GEAC's 2018 minutes record commercialisation of Bt brinjal in Bangladesh in 2013. Approval in another country does not determine India's regulatory position.



Important clarifications

- This precautionary pause must not be described as a permanent statutory ban. Equally, the 2009 recommendation must not be presented as an operational permission for commercial cultivation in India.
- A crop can possess an effective insect-resistance trait while still being subject to a release restriction.

Chronology (examination anchor)

Chronology is the examination anchor: 2009 GEAC recommendation, 2010 Indian moratorium, 2013 Bangladesh commercialisation. These events concern different authorities and jurisdictions.

Sources: S24, S25

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DMH-11: how hybrid seed production works

What is DMH-11?

DMH-11 means Dhara Mustard Hybrid-11. Its applicant is the Centre for Genetic Manipulation of Crop Plants, University of Delhi, working on oilseed brassicas.



The barnase–barstar system enables hybrid seed production.

Crossing scheme for hybrid seed production

Varuna (female parent)

- Carries barnase.
- Barnase is a ribonuclease from *Bacillus amyloliquefaciens*.
- It breaks down RNA and produces male sterility in the Varuna female parent, preventing ordinary self-pollen production.

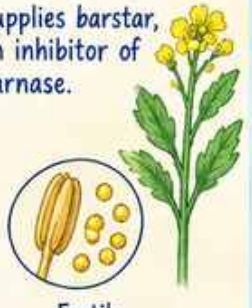


Male sterile (no functional pollen)

×

EH-2 (male parent)

- Supplies barstar, an inhibitor of barnase.



Fertile (produces pollen)

→

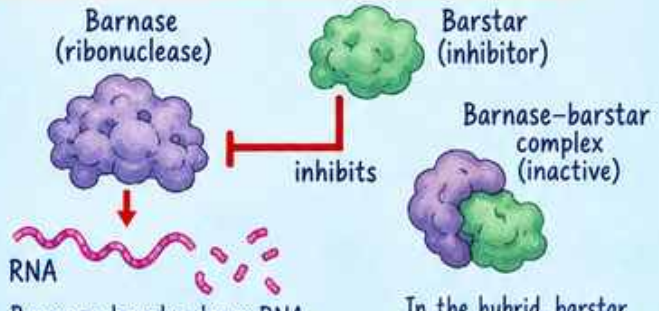
DMH-11 hybrid (fertile)

- In the hybrid, barstar suppresses barnase and fertility is restored.



Fertile (pollen production restored)

Molecular mechanism: barnase–barstar



Barnase breaks down RNA and produces male sterility in the Varuna female parent.

In the hybrid, barstar suppresses barnase and fertility is restored.

The bar gene as a selectable marker



- The third important gene is bar.
- It confers tolerance to glufosinate and is used as a selectable marker and for selection during seed production.

Restriction on herbicide use in farmers' fields



- This technical use does not authorise blanket spraying of herbicide in farmers' fields.
- The environmental-release conditions prohibit such use.

Important clarifications

- Remember the direction: barnase is the RNA-degrading enzyme; barstar inhibits it. Reversing the two destroys the explanation of the hybrid system.
- Also separate institution from technology: Delhi University's CGMCP is the applicant, not an ICAR institute. ICAR has roles in testing and oversight; that does not make it the developer.

Sources: S23, S26

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Mustard approval: the exact stage matters

What happened in 2022?

GEAC's 147th meeting on 18 October 2022 recommended environmental release of DMH-11. The Central Government accepted the recommendation and conveyed approval on 25 October 2022.



What does the decision cover?

The decision concerned seed production and testing before commercial release. Environmental release is not the same as unrestricted commercial cultivation by farmers.



Approval conditions (2022)

The approval conditions included:



a four-year period, renewable for two years at a time on a compliance report;



restrictions on herbicide formulations in farmers' fields;



and revocation if adverse environmental or human-health effects were demonstrated.

Subsequent legal developments

The legal dispute subsequently produced separate Supreme Court opinions on 23 July 2024. A split opinion is not a majority decision either validating or cancelling the approval.



Court record in 2025

A March 2025 cause list confirms a three-judge Bench.



The approval staircase



Historical decisions



The 2022 decision concerned conditional environmental release for seed production and testing. The 2024 split judgment did not produce a majority decision on the challenge to that approval.

Permission has a defined scope



Environmental release, testing and farmers' commercial cultivation are distinct regulatory stages. A decision applies to the activity, period and conditions it permits.

Sources: S1, S2, S26, S31

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Supreme Court: split opinions, common directions

Gene Campaign v. Union of India, 23 July 2024:

Justices B.V. Nagarathna and Sanjay Karol differed on the DMH-11 approval.

Nagarathna

Justice Nagarathna favoured quashing it, citing procedural failures, the precautionary principle, public trust and the right to a safe, healthy environment under Article 21.



Karol

Justice Karol favoured upholding the conditional approval of the expert body. He treated a ban on herbicide-tolerant crops as a Government policy question.



There was no majority outcome on the approval.

The Registry was directed to place the matter before the Chief Justice of India for an appropriate Bench.



Chief Justice of India for an appropriate Bench.

Both judges agreed on these directions:

1. Judicial review of GMO decisions is permissible.



2. The Union should evolve a national GM-crop policy covering research, cultivation, trade and commerce.



3. Consult agriculture and biotechnology experts, State Governments and farmers' representatives.



4. MoEF&CC should organise national consultation, preferably within four months.



5. Check expert credentials and disclose conflicts of



6. Imported GM food, including edible oil, must comply with Section 23 of the Food Safety and Standards Act on packaging and labelling.



Sources: S1, S2, S20

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Genome-edited rice: two varieties, two traits

On 4 May 2025, Union Agriculture Minister Shivraj Singh Chouhan announced two rice varieties developed through CRISPR-Cas genome editing without adding foreign DNA.

DRR Dhan 100, Kamala

Developed by	ICAR–Indian Institute of Rice Research, Hyderabad
From (parent variety)	Samba Mahsuri, BPT 5204
Trait (stated aim)	More grains per panicle.
Maturity	It matures about 20 days earlier, in approximately 130 days.



Pusa DST Rice 1

Developed by	ICAR–Indian Agricultural Research Institute, New Delhi
From (parent variety)	MTU 1010
Reported trait potential	Reported potential: 9.66–30.4% higher yield in saline and alkaline soils.



Alternative reported name



DRR Rice 100 (Kamla) is another reported name for the first variety.

Regional context

Andhra Pradesh and Telangana were among the States named in the announcement.



Not Bt, not DMH-11



These are genome-edited examples, not Bt crops and not DMH-11.

Regulatory explanation



Their regulatory explanation rests on the SDN-1/SDN-2 framework and absence of introduced foreign DNA.

Important note



A variety announcement and a measured trait advantage should not be turned into a guarantee of identical performance in every field or soil condition.

Sources: S13, S27

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Six biosafety bodies: who does what?

The 1989 Rules were notified on 5 December 1989 under the Environment (Protection) Act, 1986.

Department of Biotechnology (DBT)

RDAC
Recombinant DNA Advisory Committee



- RDAC is in DBT.
- It reviews biotechnology developments and advises on safety regulations and long-term research policy.



RCGM
Review Committee on Genetic Manipulation



- RCGM is in DBT.
- It monitors ongoing research safety, handles relevant imports and exchanges, and reviews confined-field-trial applications.



Ministry of Environment, Forest and Climate Change (MoEF&CC)

GEAC
Genetic Engineering Appraisal Committee



- GEAC is in MoEF&CC.
- It appraises large-scale use and environmental release, including relevant field trials, and has powers under the environmental framework.



IBSC
Institutional Biosafety Committee



- IBSC operates within an institution handling such organisms.
- It implements biosafety guidance and prepares on-site emergency plans.

SBCC
State Biotechnology Co-ordination Committee



- SBCC is chaired by the Chief Secretary.
- It inspects, investigates violations and reviews safety controls and damage.

DLC
District Level Biotechnology Committee



- DLC works under the District Collector.
- It monitors installations, identifies hazards, coordinates emergency response and prepares off-site emergency plans.



Sources: S4, S28

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State consent, food law and biosafety treaty

1. State NOC for confined field trials

For GEAC consideration of confined field trials, a no-objection certificate from the State or Union Territory is required.



- Agriculture is a State subject.
- Complaints of illegal GM cultivation reaching GEAC are referred to the Chief Secretary.

2. GEAC (environmental release)

The current GEAC name is Genetic Engineering Appraisal Committee.

The name changed from Genetic Engineering Approval Committee to Genetic Engineering Appraisal Committee in 2010.

Genetic Engineering Approval Committee (Old name) → 2010 → Genetic Engineering Appraisal Committee (Current name)



Its Ministry remains MoEF&CC.

3. FSSAI (food-law requirements)

GM food is also governed by the Food Safety and Standards Act, 2006, administered by FSSAI.

Food Safety and Standards Authority of India



- **Section 22** restricts manufacture, distribution, sale and import of genetically modified articles of food, subject to what the Act and its regulations allow. It is not an exceptionless total ban.
- **Section 23** governs packaging and labelling; the Supreme Court's July 2024 common order applies it to imported GM food such as edible oil.

Biosafety treaty (Cartagena Protocol)

Convention on Biological Diversity (CBD)

↓

Cartagena Protocol on Biosafety

↓

India has been a Party to the Cartagena Protocol on Biosafety since 11 September 2003, through ratification.



Different regulatory questions

A crop-release decision, a State field-trial NOC and a food-law requirement answer different regulatory questions.



State field-trial NOC

Permission for confined field trials in a State or Union Territory.



GEAC crop-release decision

Environmental release into the environment.



FSSAI food-law requirement

Regulation of manufacture, distribution, sale, import, packaging and labelling of GM food.

Sources: S4, S5, S14, S20, S28, S32

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Assessing benefits and risks without overclaiming

1 Trait-specific potential benefits

Potential benefits depend on the particular crop and introduced trait: pest resistance, tolerance to stresses such as drought or salinity, reduced post-harvest losses, or improved nutrition, with golden rice as an example. These are possible applications of biotechnology, not features present in every GM crop.



Pest resistance | Tolerance to stresses such as drought or salinity | Reduced post-harvest losses | Improved nutrition (golden rice as an example)

2 Study findings

A 2012–2015 ICAR study of 2,700 farmers across 18 cotton-growing districts of Maharashtra reported higher average seed-cotton yield after Bt adoption.



18 cotton-growing districts of Maharashtra

Higher average seed-cotton yield after Bt adoption.

3 Biological risks

Risk and governance concerns include resistance evolution, ecological uncertainty, adequate testing, monitoring and regulatory compliance. Pink-bollworm resistance in Gujarat provides a specific biological example; illegal Bt sales illustrate an enforcement problem.

Resistance evolution (selection cycle)



Pink-bollworm in Gujarat (a specific example)



Ecological uncertainty (may affect non-target organisms)



4 Governance questions

ICAR feeding studies involving broiler chickens, lambs, cows and goats found the tested feed safe. That does not prove every GM product is safe in every setting.



Broiler chickens | Lambs | Cows | Goats

Herbicide-tolerant crops

Herbicide-tolerant crops survive particular weed-killers.



Herbicide-tolerant crop survives. | Weeds are killed.

The Supreme Court's Technical Expert Committee, constituted in May 2012, recommended a complete ban on them. Justice Karol's separate 2024 opinion treated such a ban as a policy matter.



Bringing it together A balanced answer distinguishes evidence from a specific study, a possible trait benefit, a judicial concern and an actual regulatory decision.

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DRDO: origin, vision and mission

DRDO is the Defence Research and Development Organisation, the Ministry of Defence's research-and-development organisation for indigenous defence and security technology.

It was formed in 1958 by combining the Indian Army's Technical Development Establishments and the Directorate of Technical Development and Production with the Defence Science Organisation. It began with ten establishments or laboratories.



Indian Army's Technical Development Establishments



Directorate of Technical Development and Production



Defence Science Organisation

Combined in **1958**

DRDO
Began with ten establishments or laboratories.

A separate Department of Defence Research and Development was formed in 1980. Thus the organisation predates the department under which it now works.

Ministry of Defence → Department of Defence Research and Development (formed in 1980) → DRDO



Vision:

empower the nation with state-of-the-art indigenous defence and security technologies and systems.

Five mission functions:

DRDO Mission Functions

1. Design and develop sensors, weapons, platforms and allied equipment for land, air, sea, space and cyber domains.



2. Support production and induction of developed systems.



3. Provide technological solutions to the Services.



4. Strengthen industry, academia and science-and-technology institutions.



5. Build test facilities, certification capability, skills and human resources.



DRDO's role spans development, testing and support to induction; it is not simply a missile factory.

Keep the departmental distinction clear: DRDO belongs to Defence. ISRO, its launch vehicles and the commercial space company NSIL belong to the Department of Space.

Sources: S1, S2, S14

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Leadership and the two kinds of cluster

Leadership snapshot: 17 October 2026

As of 17 October 2026, Defence Secretary Rajesh Kumar Singh, IAS, held additional charge as Secretary, Department of Defence R&D, and Chairman, DRDO. A June 2026 PIB statement also identified him in those roles.

Separate roles

Treat the combined Secretary-Chairman role separately from the Defence Minister's political oversight. The snapshot date does not specify the appointment's start date.

Laboratories

Organisation snapshot, 17 October 2026: around 41 laboratories plus five DRDO Young Scientist Laboratories.



Around 41 laboratories
+
5 DRDO Young Scientist Laboratories

Two kinds of cluster

Seven technology clusters and five corporate clusters are different classifications, not twelve interchangeable technology fields.

Each cluster is headed by a Director General.

Defence Minister
Political oversight

Defence Secretary Rajesh Kumar Singh, IAS
Additional charge as Secretary, Department of Defence R&D and Chairman, DRDO

Seven technology clusters
Group laboratories by field

1. Aeronautical Systems
2. Armament and Combat Engineering Systems
3. Electronics and Communication Systems
4. Micro Electronic Devices, Computational Systems and Cyber Security
5. Missiles and Strategic Systems
6. Naval Systems and Materials
7. Soldier Support System

Five corporate clusters
Manage organisation-wide functions

1. Technology Management
2. Production Coordination and Services Interaction
3. Human Resources
4. Resource and Management
5. BrahMos

Key counts and classification

- Around 41 laboratories + 5 DRDO Young Scientist Laboratories (as per the official description).
- Seven technology clusters group laboratories by field.
- Five corporate clusters manage organisation-wide functions.

Important points

- Each cluster is headed by a Director General.
- Seven technology clusters and five corporate clusters are different classifications, not twelve interchangeable technology fields.
- BrahMos is listed among the corporate clusters.

Sources: S2, S3, S8

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Aeronautical and armament laboratories

Aeronautical Systems

Leadership snapshot, 17 October 2026: **Anindya Biswas** heads Aeronautical Systems.

Bengaluru examples:



Aeronautical Development Establishment, ADE



Gas Turbine Research Establishment, GTRE



Centre for Airborne Systems, CABS

Agra:



Aerial Delivery Research and Development Establishment, ADRDE



Do not infer a laboratory's cluster merely because its project is a missile: ADE, an aeronautical laboratory, is the nodal laboratory for the June 2026 Long Range Land Attack Cruise Missile test.

Armament and Combat Engineering Systems

Armament and Combat Engineering Systems is headed by **Prateek Kishore**.

Pune:



Armament Research and Development Establishment, ARDE



High Energy Materials Research Laboratory, HEMRL

The cluster DG's office is on the ARDE campus.

Chennai, Avadi:



Combat Vehicles Research and Development Establishment, CVRDE

Chandipur:



Proof and Experimental Establishment, PXE



PXE and ITR are both associated with Chandipur, but they belong to different cluster lists and have different names.



DRDO's wider programmes include Tejas, Pinaka, Akash, radars and electronic-warfare systems. Learn these as examples of a broad technology portfolio, not an exhaustive list of one cluster's outputs.

Sources: S2, S6, S7, S8, S13

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Electronics, computing, soldier support and industry

Electronics and Communication Systems

Director General
B K Das

Its listed laboratories include DARE, DEAL, DLRL, IRDE, LASTEC and LRDE.



Listed laboratories (peers)

- DARE
- DEAL
- DLRL
- IRDE
- LASTEC
- LRDE

Micro Electronic Devices, Computational Systems and Cyber Security

Director General
Sheena Rani R

Its field covers microelectronics, computing and cyber security.



Soldier Support System

Director General
Upendra Kumar Singh

Its focus is support to the soldier.



Leadership snapshot: 17 October 2026.
Personnel may change.



Headquarters:
DRDO Bhawan,
Rajaji Marg, New Delhi.

Industry pathway for defence-technology development

Technology Development Fund (TDF)



A DRDO scheme supporting defence-technology development by Micro, Small and Medium Enterprises, including start-ups.

Research capability and industry development



Testing (on payment)



Industry can also access DRDO test facilities on payment.

Transfer of technology



DRDO licenses technologies to Indian industry.

2025 policy and procedures

The earlier Transfer of Technology policy was issued in September 2019. A revised policy and procedures were issued in January 2025.



DRDO provides a standard operating procedure for export of military equipment.

The pathway is research capability, industry development, testing and technology transfer; development support does not mean automatic procurement or export permission.

Sources: S3, S8, S16, S26, S29

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Hyderabad and the missile cluster

Leadership and location

Missiles and Strategic Systems is headed by Jagannath Nayak.

The DG's office is at Kanchanbagh, Hyderabad.

Major Hyderabad missile laboratories

Three major Hyderabad missile laboratories are Defence Research and Development Laboratory, DRDL; Research Centre Imarat, RCI; and Advanced Systems Laboratory, ASL.

Hyderabad Missile Cluster (Telangana)



DRDL
Defence Research and Development Laboratory

RCI
Research Centre Imarat

ASL
Advanced Systems Laboratory



DG's office
Kanchanbagh, Hyderabad

DYSL–Asymmetric Technologies
Orange Test Facility, Dundigal, Hyderabad

Test support and collaboration

TBRL (Chandigarh)



Terminal Ballistics Research Laboratory, TBRL, at Chandigarh.

ITR (Chandipur, Odisha)



Integrated Test Range, ITR, at Chandipur, Balasore, Odisha.

DRDL and IGMDP

DRDL is closely associated with the Integrated Guided Missile Development Programme.



On 12 June 2026, the Defence Minister inaugurated an Advanced Weapon System Complex there.

DYSL–Asymmetric Technologies

Listed address, 17 October 2026: DYSL–Asymmetric Technologies, Orange Test Facility, Dundigal, Hyderabad.

The five Young Scientist Laboratories were dedicated on 2 January 2020.



Five Young Scientist Laboratories

Five Young Scientist Laboratories were dedicated to the nation on 2 January 2020, each focused on an advanced field.



Laboratory and launch locations are different

Laboratory location and launch location are different. Several missile trials use Dr APJ Abdul Kalam Island and ITR on the Odisha coast. This does not imply that every DRDO missile is designed in Hyderabad or that all DRDO tests take place in Odisha.



Sources: S4, S8, S12, S21

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Naval and materials laboratories: city pairs

Naval Systems and Materials

is headed by Balamuralikrishnan R.
The DG's office is on the NSTL campus at Visakhapatnam.



Visakhapatnam (Andhra Pradesh)



NSTL
Naval Science and Technological Laboratory, Visakhapatnam.

Kochi (Kerala)



NPOL
Naval Physical and Oceanographic Laboratory, Kochi.

NSTL / NPOL pair

Ambernath (Maharashtra)



NMRL
Naval Materials Research Laboratory, Ambernath.

Hyderabad (Telangana)



DMRL
Defence Metallurgical Research Laboratory, Hyderabad.

DMRL / NMRL pair

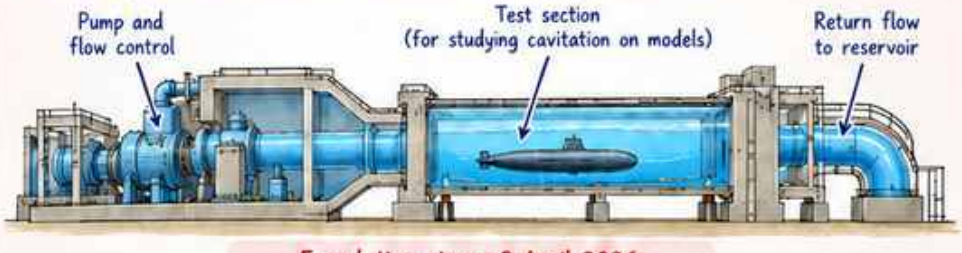
Kanpur (Uttar Pradesh)



DMSRDE
Defence Materials and Stores Research and Development Establishment, Kanpur.

Large Cavitation Tunnel at NSTL, Visakhapatnam

On 3 April 2026, the Defence Minister laid the foundation stone of a Large Cavitation Tunnel at NSTL, Visakhapatnam.



Foundation stone: 3 April 2026
Milestone only; operational status not established here.
A foundation-stone event is not a claim that the facility was already operational.

Hyderabad (Telangana)



DYSL – Smart Materials
The cluster also lists DYSL–Smart Materials at Hyderabad.

Andhra Pradesh focus



NSTL and the Naval Systems and Materials DG's office are in Visakhapatnam.

Telangana focus



DMRL and DYSL–Smart Materials are in Hyderabad, while DRDL, RCI and ASL belong to the missile cluster.

A shared city does not place every laboratory in the same technology cluster.

Sources: S5, S8, S28

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IGMDP and BrahMos: two programme histories

A.P.J. Abdul Kalam became Director of DRDL in 1982. The Integrated Guided Missile Development Programme was sanctioned on 26 July 1983.

1982 — A.P.J. Abdul Kalam became Director of DRDL.

26 July 1983 — IGMDP was sanctioned.

March 2012 — Programme completion (as per 13 August 2012 parliamentary reply).

Integrated Guided Missile Development Programme (IGMDP)

Its five elements:

Prithvi — short-range surface-to-surface ballistic missile.



Trishul — short-range surface-to-air missile.



Akash — medium-range surface-to-air missile.



Nag — anti-tank guided missile.



Agni — initially a re-entry technology demonstrator, leading to the ballistic missile family.



The Defence Ministry's 13 August 2012 parliamentary reply records programme completion in March 2012.
March 2012 is the programme-completion date recorded in the parliamentary reply.
Trishul is not the anti-tank missile; Nag is.

BrahMos: a separate joint-venture history

An Inter-Governmental Agreement signed in Moscow on 12 February 1998 established cooperation between India's DRDO and Russia's NPO Mashinostroyenia through BrahMos Aerospace.

12 February 1998 (Inter-Governmental Agreement signed in Moscow)

India's DRDO — BrahMos Aerospace (joint venture) — Russia's NPO Mashinostroyenia

Dr A.S. Pillai was the founder Chief Executive and Managing Director.

DRDO's corporate structure includes a Director General for BrahMos among its corporate DGs. Do not confuse the joint venture's origin with IGMDP's sanction or count BrahMos as a sixth original IGMDP missile.

Sources: S15, S19, S23, S24, S25

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Three tests: satellite, MIRV and cruise missile

Mission Shakti

Date: 27 March 2019
Technology: Anti-satellite missile test
Test location: Dr APJ Abdul Kalam Island, Odisha
Mission name: Mission Shakti

DRDO conducted an anti-satellite missile test from Dr APJ Abdul Kalam Island, Odisha. It struck an Indian satellite in Low Earth Orbit, demonstrating anti-satellite capability.

Mission Divyastra

Date: 11 March 2024
Technology: Multiple Independently Targetable Re-entry Vehicle technology, MIRV
Test location: Dr APJ Abdul Kalam Island, Odisha
Mission name: Mission Divyastra

The first flight test of an indigenously developed Agni-5 fitted with Multiple Independently Targetable Re-entry Vehicle technology, MIRV, from the same island. Tracking stations followed multiple re-entry vehicles.

MIRV means that one missile can carry multiple warheads directed at different targets. The milestone is Agni-5's first test with MIRV, not the first flight of Agni-5 itself.

Long Range Land Attack Cruise Missile (LRLACM)

Date: 15 June 2026
Technology: Land-attack cruise missile, LRLACM
Test location: Dr APJ Abdul Kalam Island, Odisha
Mission name: Long Range Land Attack Cruise Missile (LRLACM)

Flight-tested from Dr APJ Abdul Kalam Island. ADE, Bengaluru, was the nodal laboratory; ITR, Chandipur, supplied tracking. PIB reported that the test objectives were met.



A shared launch site does not make the three technologies equivalent: anti-satellite interception, multiple independently targetable re-entry vehicles and a land-attack cruise missile have different purposes.

Sources: S11, S13, S22

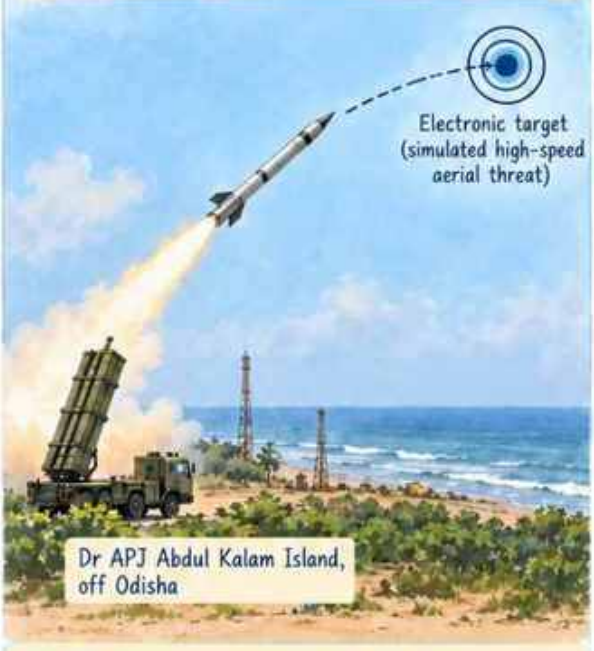
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Recent milestones: Kusha and high-altitude surveillance

Kusha, 23 July 2026

DRDO's maiden flight-test of a long-range surface-to-air missile from Dr APJ Abdul Kalam Island, off Odisha.

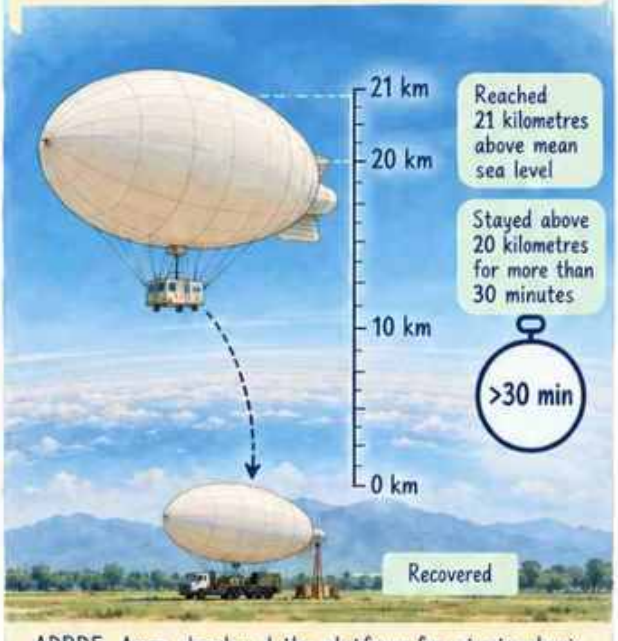


PIB describes engagement of an electronic target simulating a high-speed aerial threat.

High Altitude Platform System (HAPS)

PIB report: 6 October 2026

A report published on 6 October 2026 describes a successful trial of a lighter-than-air High Altitude Platform System, HAPS.



ADRDE, Agra, developed the platform for stratospheric surveillance. It reached 21 kilometres above mean sea level, stayed above 20 kilometres for more than 30 minutes and was recovered.

This was a surveillance-platform demonstration, not a missile test.
The date is the publication date; the release does not give a separate trial date.

Together, these examples show why "latest DRDO test" must specify both the cut-off date and the kind of technology. A July missile milestone can coexist with a later October surveillance trial.

Coverage cutoff: 17 October 2026.
Selected milestones through 17 October 2026.

Sources: S20, S27

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Background and constitutional basis

The Environment (Protection) Act, 1986 is an umbrella law that lets the Central Government take measures, set up authorities, give directions and make rules to protect and improve the environment; the examination asks for its background, its key sections, its 2023 penalty changes and the main rules and notifications made under it.

Stockholm, 1972

The Act's preamble records that decisions were taken at the United Nations Conference on the Human Environment, held at Stockholm in June 1972, in which India took part. It says the Act is needed to implement those decisions on protecting and improving the environment and preventing hazards to human beings, other living creatures, plants and property.



Bhopal, December 1984

About 45 tons of methyl isocyanate escaped from the Union Carbide insecticide plant at Bhopal, Madhya Pradesh; Britannica dates the disaster 3 December 1984. The Act is widely seen as a response to it.



Article 253

The Act was passed under Article 253, which empowers Parliament to implement treaties, agreements and conventions, and decisions made at international conferences, associations or other bodies. The Stockholm decisions are the relevant link here.



Article 48A (a Directive Principle)

It directs the State to protect the environment and to safeguard the forests and wild life of the country.



Article 51A(g) (a Fundamental Duty)

Every citizen is to protect and improve the natural environment, including forests, lakes, rivers and wild life, and to have compassion for living creatures. The Fundamental Duties were added by the 42nd Amendment in 1976.



Stockholm, June 1972 international decisions → Article 253 Parliament implements decisions → Environment (Protection) Act, 1986





protect and improve environment



Article 48A addresses the State; Article 51A(g) addresses citizens. Bhopal is historical context, not the Act's sole legal basis.

Umbrella law

The Act gives a framework under which the Central Government coordinates the authorities set up under other laws, such as the Water and Air Acts (taught on other days), and regulates industrial activity and coastal and other sensitive areas.



Powers of the Central Government under the Act


take measures


set up authorities


give directions



make rules

to protect and improve the environment


regulates industrial activity


coastal and other sensitive areas

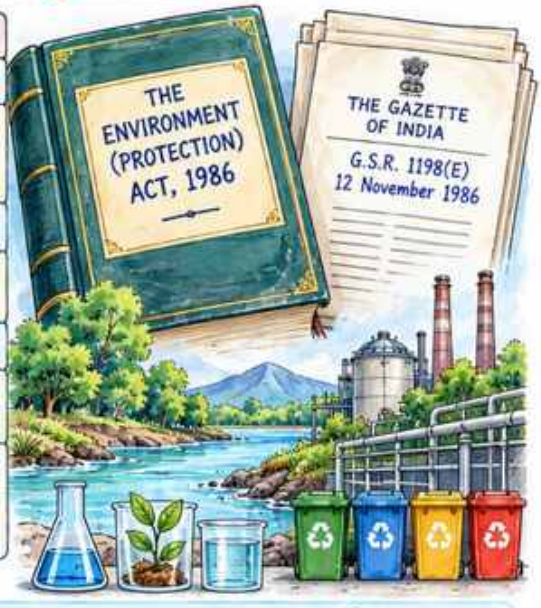

coordinates the authorities set up under other laws, such as the Water and Air Acts (taught on other days)

Sources: Day 16 Source Index | Topic 157 | Section 2.1

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The Act at a glance

Point	Detail
Number	Act No. 29 of 1986
Long title	An Act to provide for the protection and improvement of environment and for matters connected therewith
Enacted	23 May 1986
Came into force	19 November 1986, by notification G.S.R. 1198(E) dated 12 November 1986
Extent	The whole of India
Ministry	Ministry of Environment, Forest and Climate Change (MoEF&CC)
Major amendment	Jan Vishwas (Amendment of Provisions) Act, 2023 (Act No. 18 of 2023), assent 11 August 2023



Key Dates



Definition (section 2):

Environment includes water, air and land, and the inter-relationship among them and human beings, other living creatures, plants, micro-organisms and property.



Handling (section 2(d)) is broader than use: it includes manufacture, processing, treatment, packaging, storage, transportation, use, collection, destruction, conversion, offering for sale and transfer. Read section 8 in this full sense.



Sources: Day 16 Source Index | Topic 157 | Section 2.2

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The Act section by section (1/3)

Section	What it provides
3(1)	The Central Government may take all such measures as it deems necessary or expedient to protect and improve the quality of the environment and to prevent, control and abate environmental pollution
3(2)	The measures may include, among others: • coordinating the States; • a nationwide programme against pollution; • standards for environmental quality and for emission or discharge; • restricting the areas in which industries, operations or processes may or may not be carried on; • safeguards against accidents and for handling hazardous substances; • inspection of premises; • setting up or recognising laboratories; • research; • manuals and codes
3(3)	The Central Government may, by order in the Official Gazette, constitute an authority or authorities to exercise its powers and functions, including the power to give directions under section 5, under its supervision and control. Example: the National Ganga River Basin Authority (NGRBA), set up on 20 February 2009 under section 3







Related sections and key functions



These are statutory functions, not a cycle. Inspection assistance exceptions and sample procedure matter.

Sources: Day 16 Source Index | Topic 157 | Section 2.3

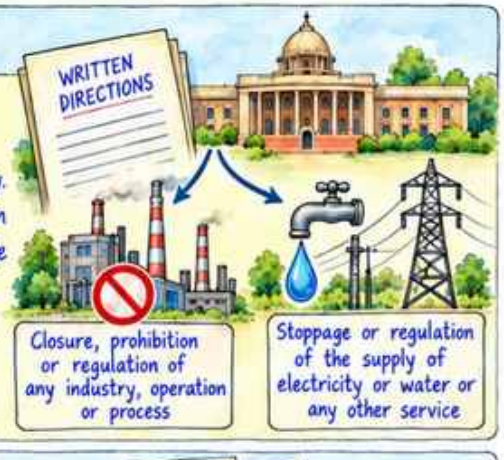
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The Act section by section (2/3)

Section	What it provides
5	The Central Government may issue written directions to any person, officer or authority, notwithstanding anything in any other law, and they are bound to comply. The power includes the closure, prohibition or regulation of any industry, operation or process, and the stoppage or regulation of the supply of electricity or water or any other service.
6	The Central Government may make rules on the matters in section 3: quality standards for air, water or soil; maximum allowable limits of pollutants; procedures and safeguards for handling hazardous substances; prohibitions on their handling, and on the location of industries, in different areas; procedures to prevent accidents.
7	No person carrying on an industry, operation or process shall discharge or emit any environmental pollutant in excess of the prescribed standards.
8	No person shall handle a hazardous substance except in accordance with the prescribed procedure and safeguards.
9	Where an accident or other unforeseen event causes, or may cause, a discharge above the standards, the person responsible must prevent or mitigate the pollution, inform the authorities and help them.











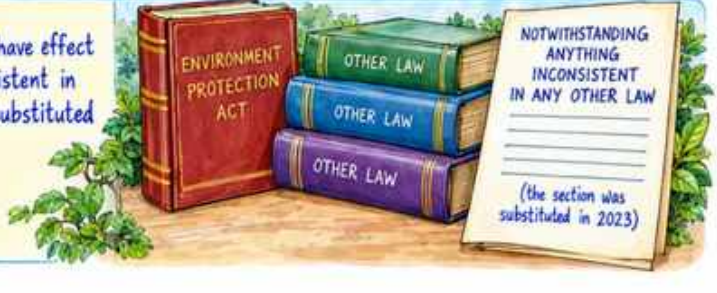
Sources: Day 16 Source Index | Topic 157 | Section 2.3

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The Act section by section (3/3)

Section	What it provides	
10	Power of entry and inspection by a person empowered by the Central Government; from 1 April 2024, failure to assist without reasonable cause, or wilful delay or obstruction, attracts a penalty under section 14B	
11	The Central Government or an officer it empowers may take samples of air, water, soil or other substance from any factory, premises or other place, in the prescribed manner	
14A to 16B	Penalties, the adjudicating officer, appeals and the Environmental Protection Fund, as rewritten in 2023 (see 2.4)	
19	No court shall take cognizance of an offence under the Act except on a complaint by (a) the Central Government or an authority or officer it authorises, or (b) any person who has given at least sixty days' notice, in the prescribed manner, of the alleged offence and of the intention to complain, to the Central Government or the authorised authority or officer. From 1 April 2024 an adjudicating officer, or an officer he authorises, may also complain	
24	The Act and its rules and orders have effect notwithstanding anything inconsistent in any other law (the section was substituted in 2023)	

Sources: Day 16 Source Index | Topic 157 | Section 2.3

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Penalties before and after the Jan Vishwas Act, 2023 (1/2)

The 2023 Act replaced imprisonment with monetary penalties for most contraventions, with these changes commencing on 1 April 2024. The enactment year and commencement date are different. The penalty is decided by an adjudicating officer, not by a criminal court.



Point	Before 1 April 2024 (old section 15)	From 1 April 2024 (2023 amendment in operation)
General contravention of the Act, rules, orders or directions (new section 15 applies where no other penalty is provided)	Imprisonment up to five years, or fine up to one lakh rupees, or both; up to five thousand rupees a day if it continued after conviction; imprisonment up to seven years if it continued beyond one year after conviction	Section 15: penalty of not less than ten thousand rupees, which may extend to fifteen lakh rupees; ten thousand rupees a day while the contravention continues
Excess discharge (section 7) or unsafe handling of hazardous substances (section 8)	Covered by section 15	Section 14A: not less than one lakh rupees, up to fifteen lakh rupees; fifty thousand rupees a day while it continues
Contravention of sections 9, 10 or 11	Covered by section 15	Section 14B: not less than ten thousand rupees, up to five lakh rupees; ten thousand rupees a day while it continues
Who decides	A criminal court	Adjudicating officer appointed by the Central Government (section 15C): not below the rank of Joint Secretary to the Government of India, or a Secretary to a State Government











Regulatory Process and Consequences

2023 amendment operative 1 Apr 2024



Adjudicating officer section-specific monetary penalty



Appeal to NGT
60 days from receipt; 10% deposit



Non-payment
90 days from imposition: section 15F



15F: up to 3 years OR fine up to twice penalty OR both.
Detailed amounts differ under 14A, 14B, 15, 15A and 15B.

Sources: Day 16 Source Index | Topic 157 | Section 2.4

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Penalties before and after the Jan Vishwas Act, 2023 (2/2)

Point	Before 1 April 2024 (old section 15)	From 1 April 2024 (2023 amendment in operation)
Appeal	Ordinary criminal appeal	To the National Green Tribunal within sixty days of receiving the order (section 15D); the appellant must first deposit ten per cent of the penalty.



Companies (section 15A)

not less than one lakh rupees and up to fifteen lakh rupees, and one lakh rupees a day while the contravention continues.



Government departments (section 15B)

the Head of the Department is liable to a penalty equal to one month's basic salary, unless he proves that it occurred without his knowledge or instructions, or that he exercised all due diligence. An officer other than the Head whose neglect caused the contravention is also liable to one month's basic salary, subject to the due-diligence defence.



Imprisonment has not gone completely

under section 15F, a person who does not pay the penalty within ninety days of its imposition may be punished with imprisonment up to three years, or a fine up to twice the penalty, or both.



Environmental Protection Fund (section 16)

the Central Government may set it up by notification. The penalties are credited to it (section 15E), and seventy-five per cent of the penalty amounts credited to the Fund are allocated by the Centre to State Governments or Union territory administrations. It pays for education, awareness and research on environmental protection, and for implementing the Act.





Commencement of the 2023 Act

The 2023 Act comes into force for each enactment on the date the Central Government notifies. For this Act, the amended penalty provisions took effect from 1 April 2024.



Sources: Day 16 Source Index | Topic 157 | Section 2.4

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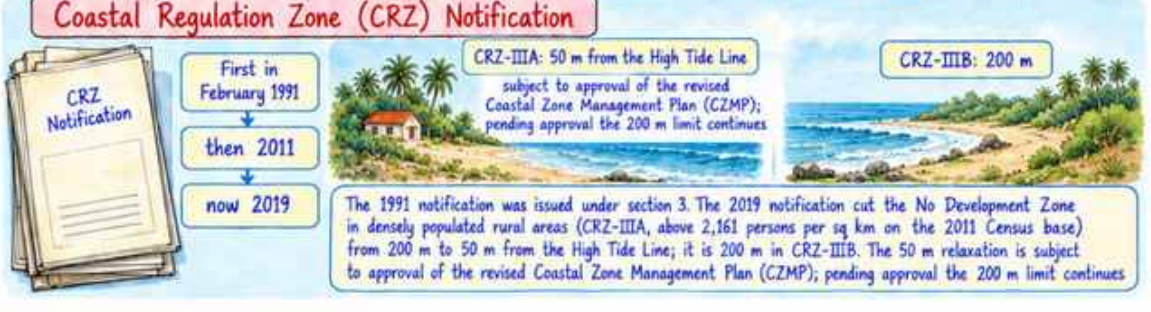
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Rules and notifications made under the Act (1/3)

Instrument	Date	Point to remember
Rules on hazardous micro-organisms, genetically engineered organisms or cells (the Rules of 1989, Topic 146)	5 December 1989	The Genetic Engineering Appraisal Committee (GEAC) in the MoEF&CC works under them (named Approval Committee until 2010)
Hazardous waste rules	First in 1989 (Hazardous Waste Management Rules); replaced in 2008; now 2016	The 2016 rules are the Hazardous and Other Wastes (Management and Transboundary Movement) Rules. Each set superseded the one before
Coastal Regulation Zone (CRZ) Notification	First in February 1991; then 2011; now 2019	The 1991 notification was issued under section 3. The 2019 notification cut the No Development Zone in densely populated rural areas (CRZ-IIIA, above 2,161 persons per sq km on the 2011 Census base) from 200 m to 50 m from the High Tide Line; it is 200 m in CRZ-IIIB. The 50 m relaxation is subject to approval of the revised Coastal Zone Management Plan (CZMP); pending approval the 200 m limit continues







Sources: Day 16 Source Index | Topic 157 | Section 2.5

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Rules and notifications made under the Act (2/3)

Instrument	Date	Point to remember
Environment Impact Assessment (EIA) Notification	14 September 2006	Replaced the EIA Notification of 1994. Prior environmental clearance is needed for new projects in its Schedule, and for expansion or modernisation where the notification's conditions and thresholds apply. Category A: cleared by the Central Ministry. Category B: cleared by the State Environment Impact Assessment Authority (SEIAA); where a State has none, by the Central Ministry.
Solid Waste Management Rules	2016 (PIB release of 5 April 2016); superseded by the Solid Waste Management Rules, 2026	The 2016 Rules revised the municipal solid waste rules of 2000 after 16 years and were made applicable beyond municipal areas. The Solid Waste Management Rules, 2026 (PIB release of 28 January 2026) supersede them and came into full effect on 1 April 2026. Construction and demolition waste has separate rules, now the Environment (Construction and Demolition) Waste Management Rules, 2025.













The maximum four stages of environmental clearance under the EIA Notification, 2006:

Not every stage applies to every project; the notification and amendments contain exemptions. Screening is for Category B projects, dividing them into B1 (EIA report required) and B2 (EIA report not required). Category A is appraised at the Centre; Category B normally at State level, subject to the General Condition and the absence of a duly constituted SEIAA or SEAC.

1 Screening (Category B only)



deciding whether the project requires further environmental studies and an EIA report (B1), or falls in B2.

- **B1** EIA report required
- **B2** EIA report not required

2 Scoping



fixing the detailed Terms of Reference that the EIA report must address.

3 Public consultation



taking the views of the people affected.

4 Appraisal



examining the project on the basis of the final EIA report and the outcome of the public consultation.

Sources: Day 16 Source Index | Topic 157 | Section 2.5

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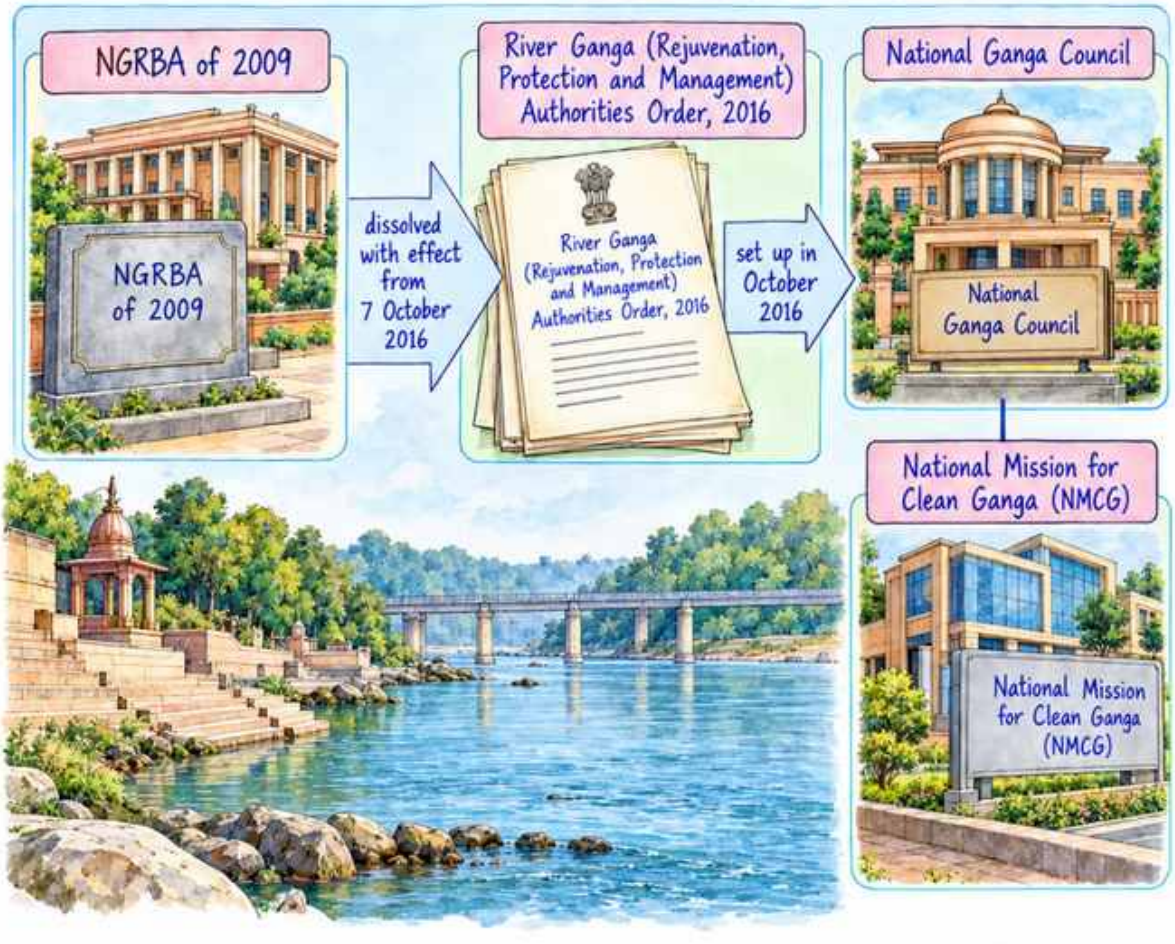
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Rules and notifications made under the Act (3/3)

The Ganga authorities:

the NGRBA of 2009 was dissolved with effect from 7 October 2016 by the River Ganga (Rejuvenation, Protection and Management) Authorities Order, 2016. Under that Order the National Ganga Council was set up in October 2016, with the National Mission for Clean Ganga (NMCG) as its implementation wing.





Sources: Day 16 Source Index | Topic 157 | Section 2.5

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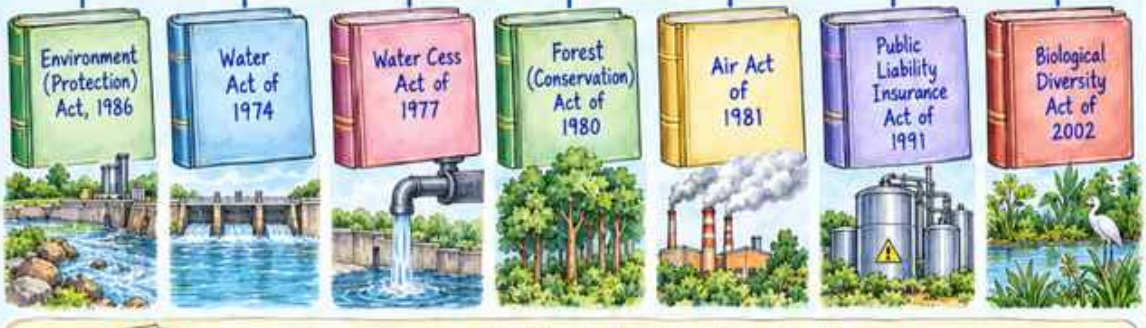
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The National Green Tribunal and the Act

The National Green Tribunal (NGT) was set up on 18 October 2010 under the National Green Tribunal Act, 2010. The Environment (Protection) Act, 1986 is one of the seven Acts in Schedule I of the NGT Act, along with the Water Act of 1974, the Water Cess Act of 1977, the Forest (Conservation) Act of 1980, the Air Act of 1981, the Public Liability Insurance Act of 1991 and the Biological Diversity Act of 2002. This is the seven-entry Schedule I list, not a claim that all seven remain unrepealed.
The Water Cess Act, 1977 was repealed in 2017 (subject to statutory savings); the Forest (Conservation) Act, 1980 is now titled the Van (Sanrakshan Evam Samvardhan) Adhiniyam, 1980.



Schedule I of the NGT Act (Seven-entry list)





This is the seven-entry Schedule I list, not a claim that all seven remain unrepealed.

- The Water Cess Act, 1977 was repealed in 2017 (subject to statutory savings).
- The Forest (Conservation) Act, 1980 is now titled the Van (Sanrakshan Evam Samvardhan) Adhiniyam, 1980.



NGT as Appellate Body for Penalties under this Act

From 1 April 2024 the NGT is also the appellate body for penalties imposed by the adjudicating officer under this Act.



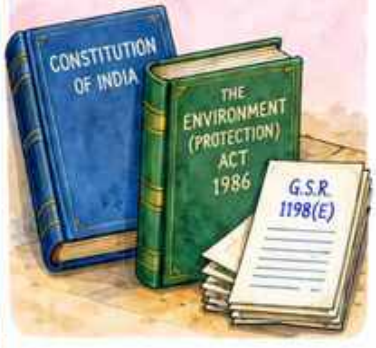
Sources: Day 16 Source Index | Topic 157 | Section 2.6

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Extra section: chronology of the Act, its rules and notifications (1/3)

Date	Event
June 1972	United Nations Conference on the Human Environment, Stockholm
1976	The 42nd Amendment adds the Fundamental Duties, including Article 51A(g)
3 December 1984	Bhopal gas disaster (date as given by Britannica)
23 May 1986	The Environment (Protection) Act enacted, as Act No. 29 of 1986
12 November 1986	Notification G.S.R. 1198(E) fixes the date of commencement
19 November 1986	The Act comes into force
1989	Hazardous Waste Management Rules
5 December 1989	Rules on hazardous micro-organisms and genetically engineered organisms notified
February 1991	First Coastal Regulation Zone Notification, under section 3

Key Legislative Stages



Rules and Notifications



Environmental Sectors



Overview Timeline (selected milestones)



Sources: Day 16 Source Index | Topic 157 | Section 3

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Extra section: chronology of the Act, its rules and notifications (2/3)









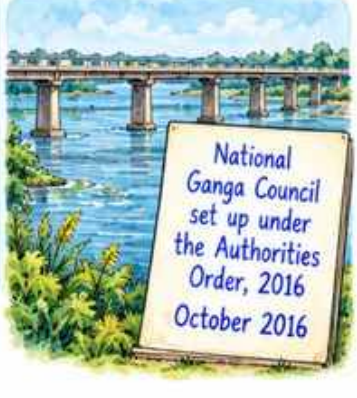


Date	Event
1994	First EIA Notification
2000	Municipal solid waste rules
14 September 2006	EIA Notification, 2006 replaces that of 1994
2008	Hazardous waste rules replaced
20 February 2009	NGRBA constituted under section 3
18 October 2010	National Green Tribunal set up
2011	CRZ Notification, 2011
2016	Solid Waste Management Rules (PIB, 5 April 2016) and Hazardous and Other Wastes Rules
October 2016	National Ganga Council set up under the Authorities Order, 2016









Sources: Day 16 Source Index | Topic 157 | Section 3

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Extra section: chronology of the Act, its rules and notifications (3/3)

Date	Event
2019	CRZ Notification, 2019 replaces that of 2011
11 August 2023	Jan Vishwas (Amendment of Provisions) Act, 2023 receives assent
1 April 2024	The amended penalty provisions of this Act take effect
28 January 2026	PIB announces the Solid Waste Management Rules, 2026, which supersede the 2016 Rules and come into full effect on 1 April 2026



2019

CRZ Notification, 2019 replaces that of 2011



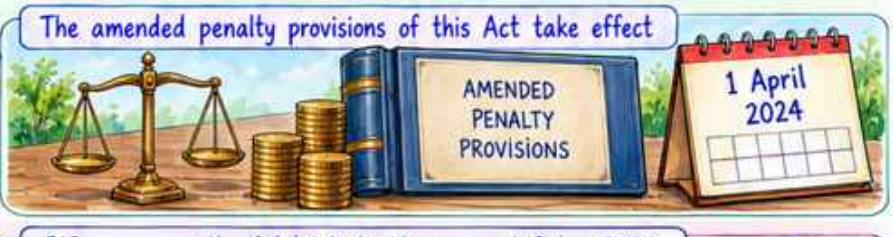
11 August 2023

Jan Vishwas (Amendment of Provisions) Act, 2023 receives assent



1 April 2024

The amended penalty provisions of this Act take effect



28 January 2026

PIB announces the Solid Waste Management Rules, 2026, which supersede the 2016 Rules and come into full effect on 1 April 2026



Sources: Day 16 Source Index | Topic 157 | Section 3

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Three common exam traps

1 "The Act was made under Article 48A or Article 51A(g)."

Those two lay down the State's directive and the citizen's duty. The legislative power used was Article 253, which lets Parliament make laws giving effect to international agreements; the Act's preamble ties it to the decisions of the Stockholm Conference.





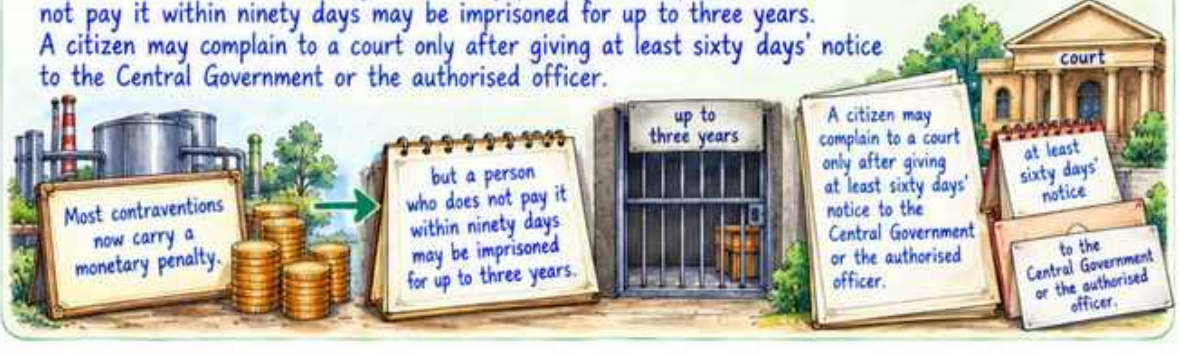
2 "Enactment and commencement fell on the same day."

The Act was enacted on 23 May 1986 but came into force only on 19 November 1986, under a notification of 12 November 1986. It is Act No. 29 of 1986.



3 "Under the revised regime nobody can be jailed under the Act, and anyone may file a case in court at once."

Most contraventions now carry a monetary penalty, but a person who does not pay it within ninety days may be imprisoned for up to three years. A citizen may complain to a court only after giving at least sixty days' notice to the Central Government or the authorised officer.



Sources: Day 16 Source Index | Topic 157 | Section 4

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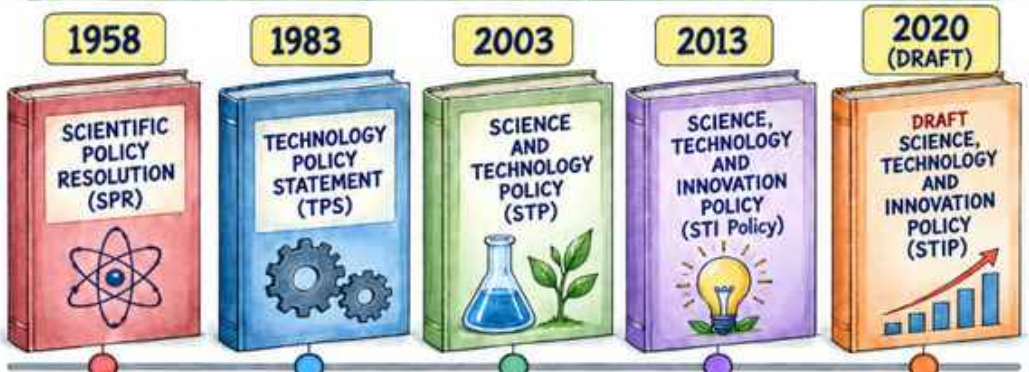
DAY 17 | TOPICS 161-170
Topic 167 | Teaching panel 01

The five documents at a glance

India set out its national policy for science in a resolution of 1958, a technology statement of 1983, a science and technology policy of 2003 and a science, technology and innovation policy of 2013, and a further policy was drafted in 2020.

Recall: Topic 77 (Day 8) covered the scientists Raman, the two Boses, Saha and Ramanujan. This topic is about the policies that the Government of India later framed for science.

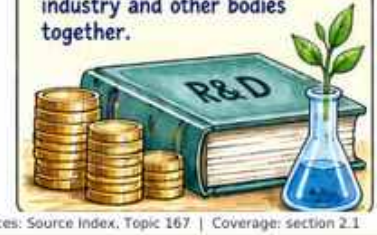
The examination asks for each document's year, its main aim or target, and where India stands today on research spending and on the Global Innovation Index.



Dated 4 March 1958	1983	2003	January 2013	2020
A resolution of the Government of India, laid before the Lok Sabha	A policy statement	A policy	A policy	A draft, uploaded by the Department of Science and Technology (DST)
Core idea	**Core idea**	**Core idea**	**Core idea**	**Core idea**
To foster, promote and sustain science and scientific research in all its aspects	Technological competence and self-reliance	Brought science and technology together in one policy and stressed investment in research and development (R&D)	Added innovation; its new paradigm is science, technology and innovation for the people	To double the domestic GERD every five years

About GERD

GERD means Gross Expenditure on Research and Development: the total spent in the country on R&D in a year, by government, industry and other bodies together.



Research spending today (GERD)



Where India stands today on research spending is measured by GERD (the total spent on R&D in a year, by government, industry and other bodies together).

Global Innovation Index today



Where India stands today on the Global Innovation Index is also asked in the examination.

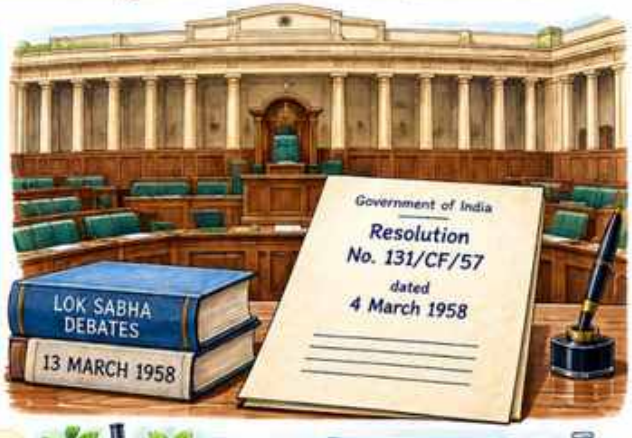
Sources: Source Index, Topic 167 | Coverage: section 2.1

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The Scientific Policy Resolution, 1958

Number and date

- Resolution No. 131/CF/57, dated 4 March 1958.
- Jawaharlal Nehru laid it on the Table of the Lok Sabha on 13 March 1958 and explained it in a statement to the House.
- It is a resolution of the Government, not an Act of Parliament.



Its six aims, in short

1. to foster, promote and sustain, by all appropriate means, the cultivation of science and scientific research in all its aspects: pure, applied and educational;



2. to ensure an adequate supply, within the country, of research scientists of the highest quality;



3. to start, with all possible speed, programmes for training scientific and technical personnel;



4. to ensure that the creative talent of men and women is encouraged and finds full scope in scientific work;



5. to encourage individual initiative in acquiring and spreading knowledge, in an atmosphere of academic freedom;



6. to secure for the people of the country all the benefits that can come from acquiring and applying scientific knowledge.



The means it named

good conditions of service for scientists



an honoured position for them



associating scientists with the making of policy



Its standing later

The STI Policy 2013 says that the 1958 Resolution remains valid even today.



Sources: Source Index, Topic 167 | Coverage: section 2.2

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The Technology Policy Statement, 1983

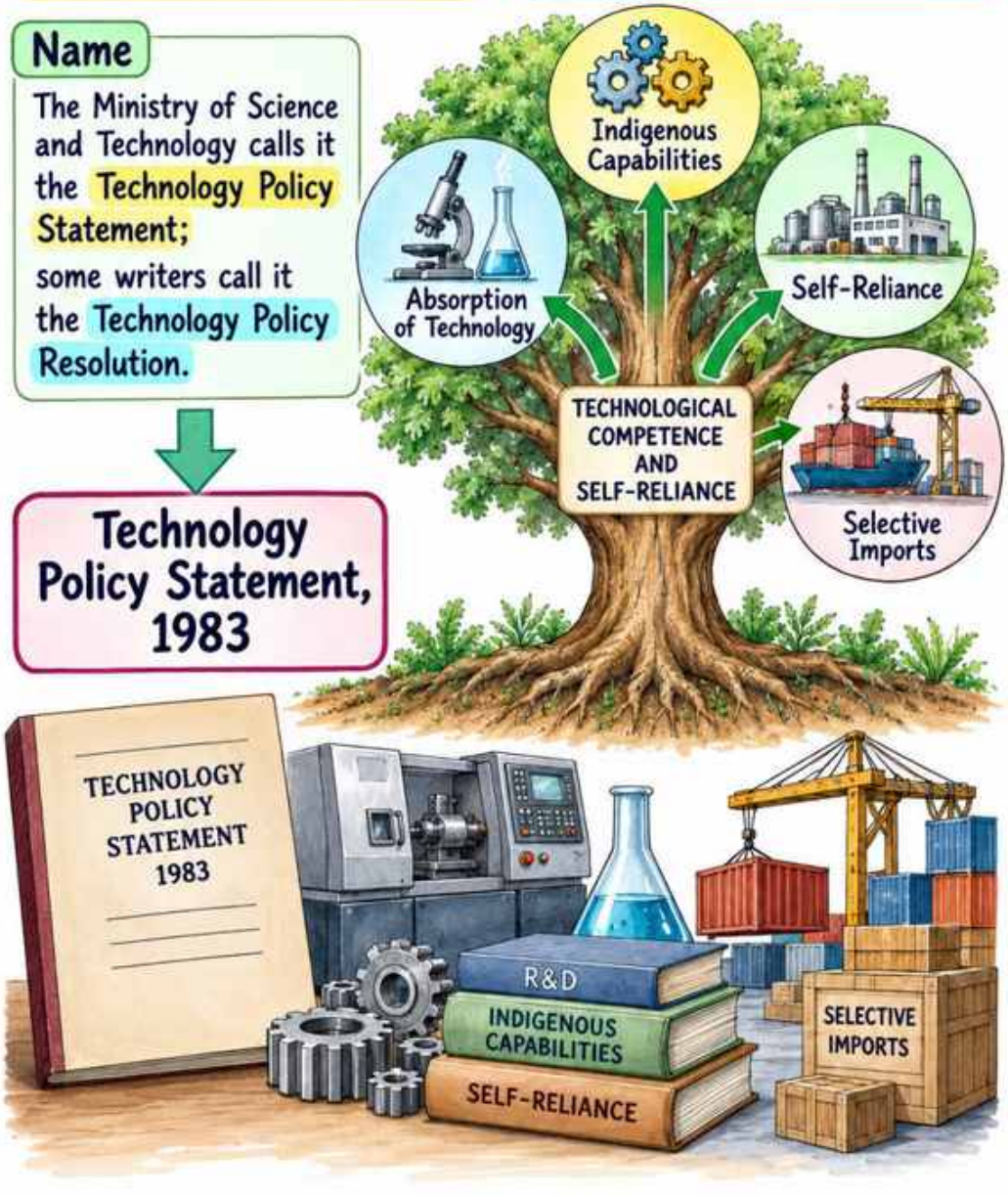
It stressed the need to attain technological competence and self-reliance.

The STI Policy 2013, looking back, places it at a time when imports of technology were constrained.

Name

The Ministry of Science and Technology calls it the Technology Policy Statement; some writers call it the Technology Policy Resolution.

Technology Policy Statement, 1983



Sources: Source Index, Topic 167 | Coverage: section 2.3

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Topic 167 | Teaching panel 04

The Science and Technology Policy, 2003

Key Provisions and Objectives

- It brought science and technology together in one policy and stressed the need for investment in R&D, so that research could be used to solve national problems.
- It brought in the idea of a national innovation system.

An Integrated Ecosystem for National Development



Investment Target under the 2003 Policy

- Its spending target: the government committed to raising investment in science and technology to at least 2 per cent of GDP by the end of the Tenth Plan (2007).

2003 baseline: not specified → Target: at least 2% of GDP by the end of the Tenth Plan (2007).

Government committed to raising investment in science and technology to at least 2 per cent of GDP by the end of the Tenth Plan (2007).

Related Measure and Later Reference

- The STI Policy 2013 explicitly used GERD for its 2 per cent target.



STI Policy 2013
Explicitly used GERD for its 2 per cent target.

GERD
(Gross Domestic Expenditure on R&D)
Measure used for the 2 per cent target in STI Policy 2013. Keep this distinct from the 2003 Policy's investment target.

- GERD was 0.64 per cent of GDP in 2020-21 (see 2.7).



Sources: Source Index, Topic 167 | Coverage: section 2.4

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The Science, Technology and Innovation Policy, 2013

When and where:
It was announced on **3 January 2013** at the **100th session** of the Indian Science Congress in **Kolkata**, the session that the President of India inaugurated.



The policy document itself is dated **New Delhi, January 2013.**



Why "innovation" entered the title:
India had declared **2010-20** the **Decade of Innovation**, and a **National Innovation Council** was set up.

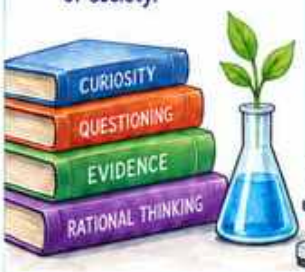


Its new paradigm:
science, technology and innovation for the people.



Its key goals:

1. Spreading scientific temper among all sections of society.



2. Making careers in research attractive to the best talent, and building world-class R&D infrastructure in select frontier areas.



3. Raising GERD to **2 per cent** of GDP.
For this, the private sector was to raise its R&D investment at least to match the public sector's: the ratio of public to private R&D investment was to move from **3:1 to 1:1** within five years.



4. Positioning India among the **top five** global scientific powers **by 2020.**



5. Creating a robust national innovation system, and linking science and innovation with **inclusive economic growth.**



Women in science:
The policy states that the **participation of women** in science, technology and innovation activities is important.



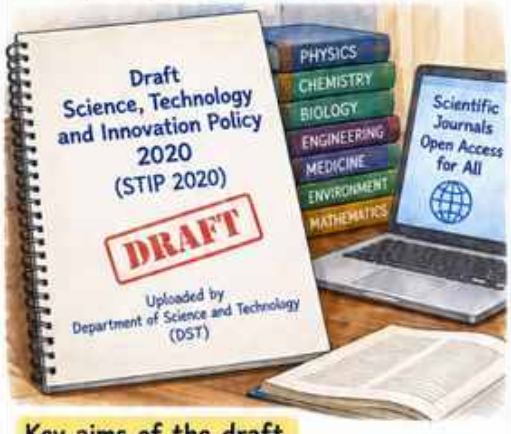
Sources: Source Index, Topic 167 | Coverage: section 2.5

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After 2013: the draft STIP 2020 and the research foundation

Draft STIP 2020

DST uploaded the draft STIP 2020.



Key aims of the draft



Double the domestic GERD every five years.



Double the number of full-time equivalent (FTE) researchers.

FTE counts researchers by the share of their working time spent on research.



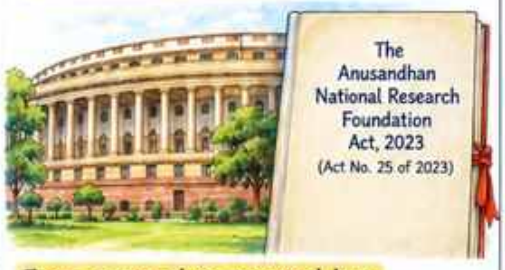
The draft proposed that the government buy bulk subscriptions to important scientific journals, so that everyone in the country could read them free.



PRS Legislative Research, in its analysis of July 2024, still calls it a draft.

Its later status is taught in Topic 696 (Day 70).

Anusandhan National Research Foundation



From proposal to enacted law

2023 — Parliament passed the Anusandhan National Research Foundation Bill in 2023.

12 August 2023 — The Bill received the President's assent on 12 August 2023 as the Anusandhan National Research Foundation Act, 2023 (Act No. 25 of 2023).



Purpose
The foundation is meant to strengthen research by providing funds and human resources across disciplines.

Funding provisions

Union Budget 2021-22



Union Budget 2021-22 announced a ₹50,000 crore outlay over five years for the proposed National Research Foundation.

2023 ANRF funding plan



The 2023 ANRF funding plan envisaged ₹50,000 crore over 2023-28, comprising ₹14,000 crore from government and ₹36,000 crore from non-government sources.



These were planned contributions, not amounts already received.



The foundation is taught in Topic 447 (Day 45).

Sources: Source Index, Topic 167 | Coverage: section 2.6

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Where India stands: research spending and the innovation index

DST's report R&D Statistics at a Glance 2025-26, dated July 2026, gives these figures. The report's name carries 2025-26, but its latest actual figures are for 2023-24.



Key figures on research and development (R&D)

Measure	Figure	Year the figure is for
Gross Expenditure on R&D (GERD)	Rs 244,767.81 crore	2023-24
GERD as a share of GDP	0.84 per cent, the highest so far	2023-24
GERD as a share of GDP, earlier	0.64 per cent	2020-21
GERD as a share of GDP, projected	0.87 per cent and 0.90 per cent (estimates)	2024-25 and 2025-26
Share of private sector industry in GERD	45.2 per cent (32.2 per cent in 2020-21)	2023-24
Women among FTE researchers	29 per cent (18.6 per cent in 2020-21)	2023-24
India's place in scientific publications	3rd, after China and the USA	2022







Global Innovation Index (GII)

The Global Innovation Index (GII) is published by the World Intellectual Property Organization (WIPO). The GII 2026 was released on 29 September 2026 and ranks 139 economies.



GII edition	India's rank
2026	38th of 139; 1st among 36 lower-middle-income economies; 1st among 11 economies of Central and Southern Asia
2025	38th
2024	39th
2023 and 2022	40th
2021	46th
2020	48th



Sources: Source Index, Topic 167 | Coverage: section 2.7

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Extra section: a chronology from 1958 to 2026

1958 — The Scientific Policy Resolution is dated 4 March; Nehru lays it before the Lok Sabha on 13 March.





1983 — The Technology Policy Statement stresses technological competence and self-reliance.





2003 — The Science and Technology Policy brings science and technology togethee and sets investment in science and technology of at least 2 per cent of GDP as the target for the end of the Tenth Plan.





2007 — The Tenth Plan ends: the deadline in the 2003 S&T investment target.





Deadline in the 2003 S&T investment target

2010-20 — The decade that India declared the Decade of Innovation.



2013 — The STI Policy is announced on 3 January at the 100th Indian Science Congress, Kolkata.





2020 — The draft STIP is prepared; it aims to double the domestic GERD every five years.





2020-21 — GERD stands at 0.64 per cent of GDP.

GERD (2020-21)
0.64 per cent of GDP

2020-21:
GERD 0.64% of GDP

2021 — Union Budget 2021-22 announces Rs 50,000 crore over five years for the National Research Foundation.



Rs 50,000 crore over five years for the National Research Foundation



2023 — Parliament passes the Anusandhan National Research Foundation Bill; the Act receives assent on 12 August.



Parliament passes the Bill in 2023
Act receives assent on 12 August 2023.

2023-24 — GERD reaches 0.84 per cent of GDP, the highest so far.

GERD (2023-24)
0.84 per cent of GDP
(the highest so far)

2023-24:
GERD 0.84% of GDP

2026 — DST's R&D Statistics at a Glance 2025-26 comes out (dated July); India ranks 38th in the GII 2026 (29 September).



India ranks 38th in the GII 2026 (29 September)



Sources: Source Index, Topic 167 | Coverage: section 3

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DAY 17 | TOPICS 161-170
Topic 167 | Teaching panel 09

Three common exam traps

1 Two dates in 1958

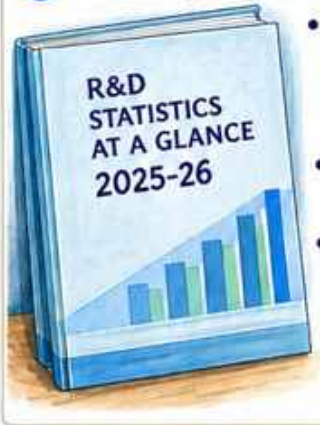


- The Scientific Policy Resolution is dated **4 March 1958.**
- Nehru laid it before the Lok Sabha on **13 March 1958.**
- A question that asks for the date of the Resolution wants **4 March 1958.**
- It is a **Government resolution** placed before the House, **not a law passed by Parliament.**



Exam trap: The date of the Resolution is 4 March 1958, not 13 March 1958.

2 The year of a figure and the year in a report's name



- The report is called R&D Statistics at a Glance 2025-26, but **0.84 per cent of GDP** is GERD for **2023-24.**
- The figure of **0.64 per cent** is for **2020-21.**
- The figures given for **2024-25** and **2025-26** are **only estimates.**
- Always say which year a GERD figure belongs to.

GERD as a percentage of GDP

Actual	Estimate
2020-21 actual: **0.64%**	2024-25 estimate: **0.87%**
2023-24 actual: **0.84%**	2025-26 estimate: **0.90%**

Exam trap: The report name has 2025-26, but each GERD figure belongs to a specific year. State the year with the figure.

3 Two different "top fives"

Top five of the GII 2026



"Top five" in the STI Policy 2013



Goal of placing India among the top five global scientific powers by 2020.

India's GII rank



Exam trap: India's GII rank was 38th in both 2025 and 2026; it was 39th in 2024, so "India rose in the 2026 edition" is wrong.

Sources: Source Index, Topic 167 | Coverage: section 4

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Pollutants and pathways

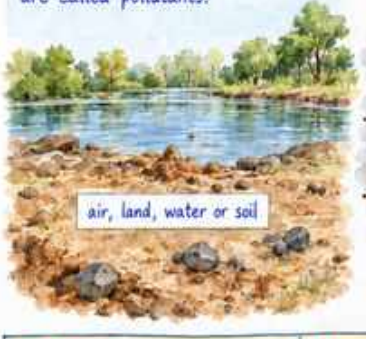
Air pollution is an undesirable change in the quality of the air caused by pollutants such as particulate matter and harmful gases. The examination asks for the main pollutants and their effects, India's National Ambient Air Quality Standards of 2009, the National Air Quality Index and the laws and programmes for clean air.

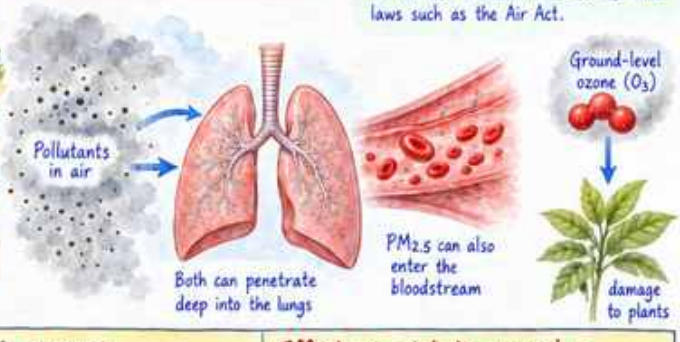


Pollution is any undesirable change in the physical, chemical or biological characteristics of air, land, water or soil. The agents that bring about such a change are called pollutants.

Air pollutants can harm living organisms. How much harm they do depends on the pollutant concentration, duration of exposure and the organism.

Links with earlier topics: Topic 96 taught the greenhouse gases; ozone in the troposphere is a greenhouse gas as well as a pollutant, and black carbon (the carbon in soot) is an aerosol. Topic 157 taught the Environment (Protection) Act, 1986, the umbrella law under which the Centre coordinates the authorities set up under laws such as the Air Act.





Pollutant	Main source	Effect or point to remember
Particulate matter: PM_{10} (10 micrometres or less across) and $PM_{2.5}$ (2.5 micrometres or less)	Exhaust from thermal power plants, among others	Fine $PM_{2.5}$ can penetrate deep into the lungs, and some particles enter the bloodstream; risk depends on exposure and susceptibility.
Sulphur dioxide (SO_2)	Burning of coal and oil, and smelting of ores that contain sulphur (WHO)	With nitrogen oxides, a main cause of acid rain; sulphur oxides also make the sulfurous (London-type) smog (Britannica).
Nitrogen oxides (NO and NO_2)	Burning of fuel in transport and industry (WHO)	A main cause of acid rain; in sunlight they react with hydrocarbons to give ozone (Britannica).
Carbon monoxide (CO)	Incomplete burning of fuel (WHO)	A catalytic converter turns it into carbon dioxide.
Ground-level ozone (O_3)	Not let out directly: formed in the lower atmosphere by sunlight acting on nitrogen oxides and hydrocarbons (Britannica).	The chief product of photochemical smog: eye irritation, breathing trouble and damage to plants (Britannica).

Sources: Day 18 Source Index | Topic 176 | 1; 2.1; 2.2

Day 18 | T176 · P01 | 80/155

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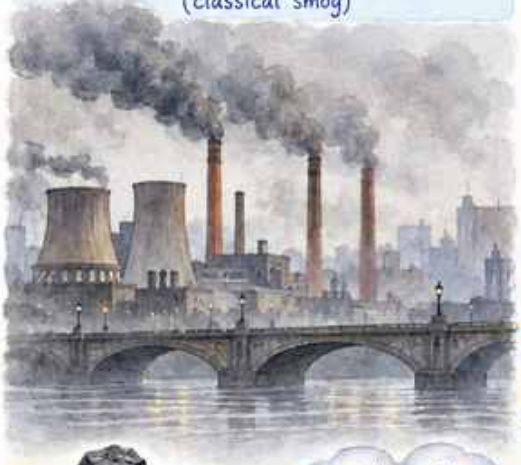
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Primary versus secondary smog

Sulfurous, London-type or classical smog: formed from sulphur oxides, mainly from burning coal.

It is a mixture of smoke, fog and sulphur dioxide that forms in a cool, humid climate and is reducing in nature.

Sulfurous or London-type smog
(classical smog)





burning coal → sulphur oxides (mainly from burning coal)

mixture of smoke, fog and sulphur dioxide



smoke + fog + sulphur dioxide



forms in a cool, humid climate and is reducing in nature

Photochemical (Los Angeles-type) smog: common in cities with many cars. It needs neither smoke nor fog: nitrogen oxides and hydrocarbons react in sunlight and produce ozone (Britannica).

It is oxidising, forming in a warm, dry, sunny climate, with peroxyacetyl nitrate (PAN) among its oxidising agents.

Photochemical (Los Angeles-type) smog





nitrogen oxides and hydrocarbons react in sunlight and produce ozone



forms in a warm, dry, sunny climate, with peroxyacetyl nitrate (PAN) among its oxidising agents.

Sources: Day 18 Source Index | Topic 176 | 2.5

Day 18 | T176 · P02 | 81/155

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NAAQS framework and units

Notification: issued by the Central Pollution Control Board (CPCB) on 18 November 2009, No. B-29016/20/90/PCI-L, with immediate effect.

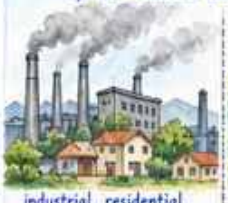
The CPCB issued it under section 16(2)(h) of the Air (Prevention and Control of Pollution) Act, 1981.

It replaced the earlier notifications of 11 April 1994 and 14 October 1998.



It sets standards for twelve pollutants, in two columns:

(a) industrial, residential, rural and other areas, and
(b) ecologically sensitive areas notified by the Central Government.



industrial, residential, rural and other areas



ecologically sensitive areas notified by the Central Government

Only two values are stricter for ecologically sensitive areas: annual SO_2 (20 against 50) and annual NO_2 (30 against 40).





Carbon monoxide is the only pollutant in the table measured in milligrams (mg/m^3). Benzo(a)pyrene, arsenic and nickel are in nanograms (ng/m^3).



Averaging periods



Annual | 24 hours | 8 hours

Unit ladder

1 mg = 1,000 µg = 1,000,000 ng.
Each concentration is per cubic metre of air (m^3).



Keep the averaging period attached to every limit.

Sources: Day 18 Source Index | Topic 176 | 2.3

Day 18 | T176 · P03 | 82/155

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NAAQS table I



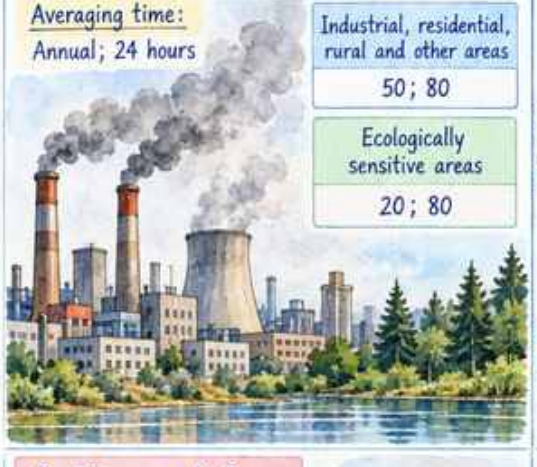
Pollutant	Averaging time	Industrial, residential, rural and other areas	Ecologically sensitive areas
1. Sulphur dioxide (SO_2), $\mu g/m^3$	Annual; 24 hours	50; 80	20; 80
2. Nitrogen dioxide (NO_2), $\mu g/m^3$	Annual; 24 hours	40; 80	30; 80
3. PM_{10}, $\mu g/m^3$	Annual; 24 hours	60; 100	60; 100
4. $PM_{2.5}$, $\mu g/m^3$	Annual; 24 hours	40; 60	40; 60

1. Sulphur dioxide (SO_2), $\mu g/m^3$

Averaging time: Annual; 24 hours

Industrial, residential, rural and other areas: 50; 80

Ecologically sensitive areas: 20; 80



2. Nitrogen dioxide (NO_2), $\mu g/m^3$

Averaging time: Annual; 24 hours

Industrial, residential, rural and other areas: 40; 80

Ecologically sensitive areas: 30; 80



3. PM_{10}, $\mu g/m^3$

Averaging time: Annual; 24 hours

Industrial, residential, rural and other areas: 60; 100

Ecologically sensitive areas: 60; 100



4. $PM_{2.5}$, $\mu g/m^3$

Averaging time: Annual; 24 hours

Industrial, residential, rural and other areas: 40; 60

Ecologically sensitive areas: 40; 60



Sources: Day 18 Source Index | Topic 176 | 2.3

Day 18 | T176 · P04 | 83/155

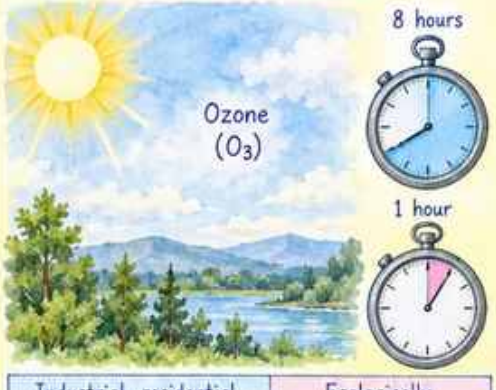
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NAAQS table II

Pollutant	Averaging time	Industrial, residential, rural and other areas	Ecologically sensitive areas
5. Ozone (O_3), $\mu g/m^3$	8 hours; 1 hour	100; 180	100; 180
6. Lead (Pb), $\mu g/m^3$	Annual; 24 hours	0.5; 1.0	0.5; 1.0
7. Carbon monoxide (CO), mg/m^3	8 hours; 1 hour	2; 4	2; 4
8. Ammonia (NH_3), $\mu g/m^3$	Annual; 24 hours	100; 400	100; 400

5. Ozone (O_3), $\mu g/m^3$



Industrial, residential, rural and other areas	Ecologically sensitive areas
100; 180	100; 180

6. Lead (Pb), $\mu g/m^3$



Industrial, residential, rural and other areas	Ecologically sensitive areas
0.5; 1.0	0.5; 1.0

7. Carbon monoxide (CO), mg/m^3



Industrial, residential, rural and other areas	Ecologically sensitive areas
2; 4	2; 4

8. Ammonia (NH_3), $\mu g/m^3$



Industrial, residential, rural and other areas	Ecologically sensitive areas
100; 400	100; 400

Sources: Day 18 Source Index | Topic 176 | 2.3

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NAAQS table III

Pollutant	Averaging time	Industrial, residential, rural and other areas	Ecologically sensitive areas
9. Benzene, µg/m³	Annual	5	5
10. Benzo(a)pyrene, particulate phase, ng/m³	Annual	1	1
11. Arsenic, ng/m³	Annual	6	6
12. Nickel, ng/m³	Annual	20	20

9. Benzene, µg/m³



Averaging time: Annual
Industrial, residential, rural and other areas: 5
Ecologically sensitive areas: 5

10. Benzo(a)pyrene, particulate phase, ng/m³



Averaging time: Annual
Industrial, residential, rural and other areas: 1
Ecologically sensitive areas: 1

11. Arsenic, ng/m³



Averaging time: Annual
Industrial, residential, rural and other areas: 6
Ecologically sensitive areas: 6

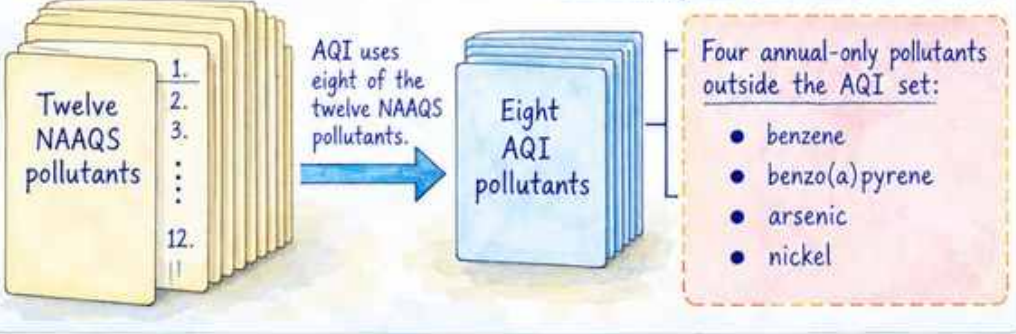
12. Nickel, ng/m³



Averaging time: Annual
Industrial, residential, rural and other areas: 20
Ecologically sensitive areas: 20

AQI uses eight of the twelve NAAQS pollutants.

The four annual-only pollutants outside the AQI set are benzene, benzo(a)pyrene, arsenic and nickel.



Sources: Day 18 Source Index | Topic 176 | 2.3

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AQI categories

Launch: 17 October 2014, by the Ministry of Environment, Forest and Climate Change (MoEFCC; the Prime Minister launched it formally on 6 April 2015, PIB; the Ministry of Environment and Forests was given this name in May 2014), under the Swachh Bharat Mission.

Its idea is "One Number-One Colour-One Description".



Eight pollutants: PM_{10}, $PM_{2.5}$, nitrogen dioxide, sulphur dioxide, carbon monoxide, ozone, ammonia and lead. These are 8 of the 12 pollutants of the NAAQS.



AQI category	Index range	Possible health impact (CPCB, in brief)
Good	0 to 50	Minimal impact
Satisfactory	51 to 100	Minor breathing discomfort to sensitive people
Moderately polluted	101 to 200	May cause breathing discomfort to people with lung disease such as asthma, and discomfort to people with heart disease, children and older adults
Poor	201 to 300	Breathing discomfort on prolonged exposure; discomfort to heart patients
Very poor	301 to 400	Respiratory illness on prolonged exposure
Severe	401 to 500	Affects even healthy people; serious impact on people with lung or heart disease



Sources: Day 18 Source Index | Topic 176 | 2.4

Day 18 | T176 · P07 | 86/155

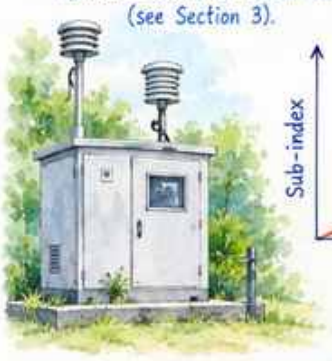
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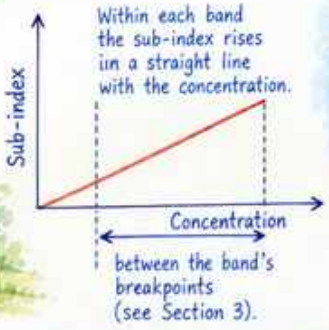
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AQI data and maximum rule

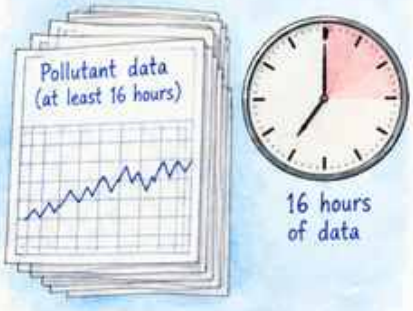
How the AQI is worked out (CPCB method):

1. For each pollutant measured, a sub-index is calculated from its concentration. Within each band the sub-index rises in a straight line with the concentration, between the band's breakpoints (see Section 3).

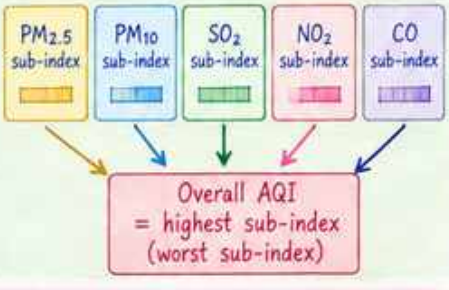




2. A sub-index needs at least 16 hours of data.

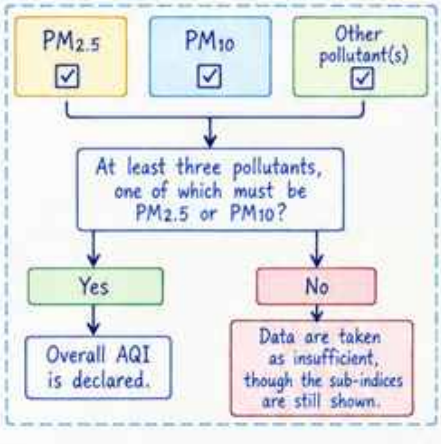


3. The overall AQI is the worst sub-index, that is, the highest one. Thus the highest eligible pollutant sub-index, calculated from the specified averaging period, sets the overall category; it is not determined by one isolated instantaneous reading.

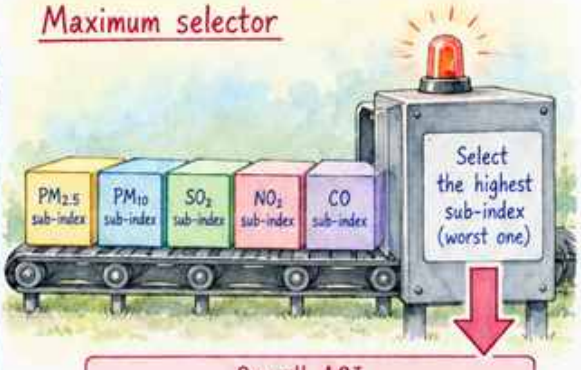


4. An overall AQI is declared only when data are available for at least three pollutants, one of which must be PM2.5 or PM10. Otherwise the data are taken as insufficient, though the sub-indices are still shown.

Data-sufficiency gate



Maximum selector



Overall AQI
= highest eligible pollutant sub-index, calculated from the specified averaging period.

Sources: Day 18 Source Index | Topic 176 | 2.4

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PM breakpoints

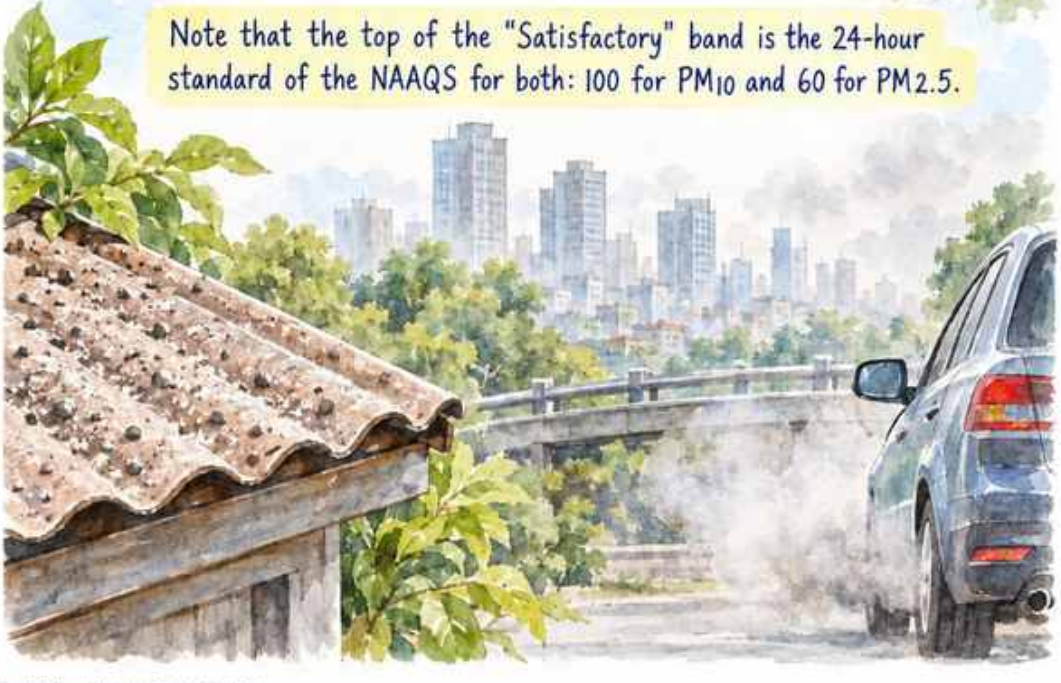
Breakpoints for the two particulates (24-hour average, $\mu g/m^3$):

AQI category	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)
Good	0 to 50	0 to 30
Satisfactory	51 to 100	31 to 60
Moderately polluted	101 to 250	61 to 90
Poor	251 to 350	91 to 120
Very poor	351 to 430	121 to 250
Severe	Above 430	Above 250





Note that the top of the "Satisfactory" band is the 24-hour standard of the NAAQS for both: 100 for PM_{10} and 60 for $PM_{2.5}$.



Sources: Day 18 Source Index | Topic 176 | 2.4

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Acid rain and inversion

Acid rain

Sulphur dioxide and nitrogen oxides can form sulphuric and nitric acids in the atmosphere. These acids reach the surface in precipitation.

Rainwater equilibrated with atmospheric carbon dioxide has a reference pH of about 5.6. Added acids lower it further.

Acid deposition can acidify lakes and streams, harm biodiversity and plants, and weather stone buildings.



Natural reference
pH about 5.6

Added acidification
pH falls below reference

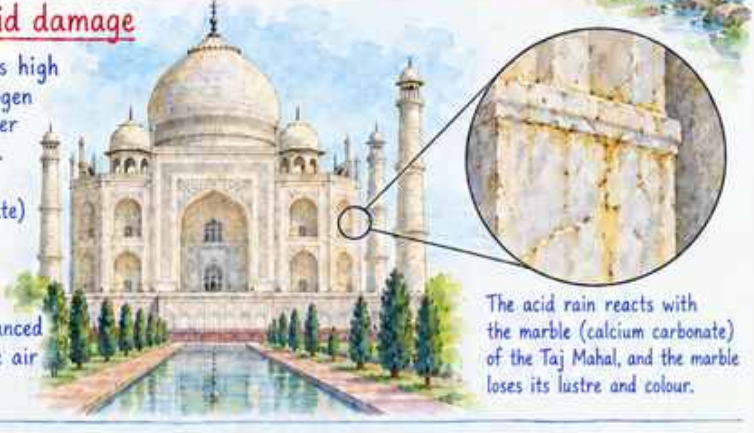
Reference point
Dissolved carbon dioxide makes rain naturally mildly acidic. A pH of about 5.6 is a reference, not a fixed value for all rain.

Convention
Below pH 5.6 is a common acid-rain convention. Actual precipitation varies.

It can lower the pH of lakes and streams, reduce biodiversity, make plants more open to disease, and wear away stone buildings (Britannica).

Taj Mahal and acid damage

The air around Agra holds high levels of sulphur and nitrogen oxides from industries, power plants and household fuels. The acid rain reacts with the marble (calcium carbonate) of the Taj Mahal, and the marble loses its lustre and colour. In 1995 the Government of India announced an action plan to clean the air of the Taj Trapezium.

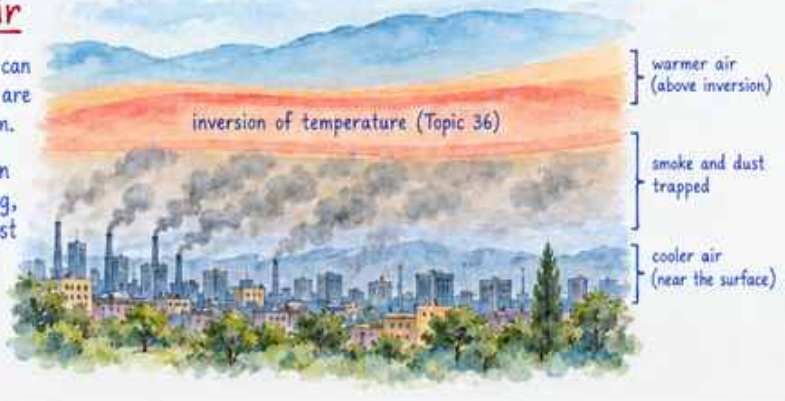


The acid rain reacts with the marble (calcium carbonate) of the Taj Mahal, and the marble loses its lustre and colour.

Still winter air

Winter particulate levels can rise when mixing heights are lower and winds are calm.

A temperature inversion restricts vertical mixing, trapping smoke and dust near the surface.



Sources: Day 18 Source Index | Topic 176 | 2.5

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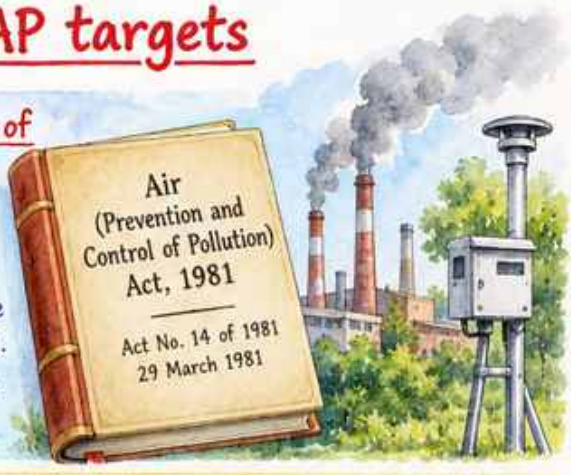
Air Act and NCAP targets

Air (Prevention and Control of Pollution) Act, 1981

Act No. 14 of 1981, enacted on 29 March 1981.

The 1987 amendment included noise in the definition of an air pollutant.

The CPCB's NAAQS of 2009 were notified under it (2.3).



National Clean Air Programme (NCAP), 2019

launched by the MoEFCC.



First target:

a tentative national target of a 20 to 30 per cent reduction in $PM_{2.5}$ and PM_{10} concentrations by 2024, with 2017 as the base year, in 102 cities whose air quality was worse than the NAAQS.

$PM_{2.5}$ — 20 to 30 per cent reduction — PM_{10}

Base year	Target year	102 cities
2017	2024	whose air quality was worse than the NAAQS

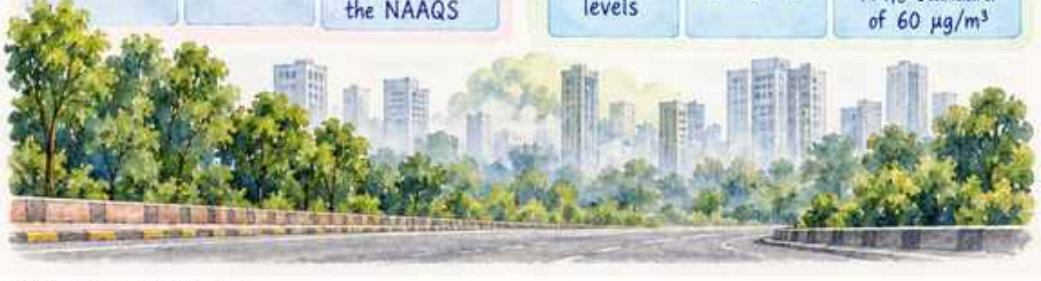
Revised target:

reduce PM_{10} concentrations by up to 40% from 2017-18 levels, or achieve the national annual PM_{10} standard of 60 µg/m³, by 2025-26 (MoEFCC/PIB).

This revised performance target specifically concerns PM_{10}.

PM_{10} — up to 40% — National annual PM_{10} standard 60 µg/m³

From	Target year	Or achieve
2017-18 levels	2025-26	the national annual PM_{10} standard of 60 µg/m³



Sources: Day 18 Source Index | Topic 176 | 2.6

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NCAP finance and GRAP

2024 snapshot

The 2024 snapshot covered 130 cities in 24 States/UTs, with reported funding of Rs 11,200 crore.

7 September 2026 snapshot

For FY 2019-20 to FY 2025-26, Rs 16,423.55 crore was provided to 130 cities; reported utilisation was Rs 11,575.54 crore (70.5%).



2024 snapshot
130 cities in 24 States/UTs
Rs 11,200 crore reported

7 September 2026 snapshot
Rs 16,423.55 crore provided to 130 cities over FY 2019-20 to FY 2025-26

Utilisation
7 September 2026 snapshot
Rs 11,575.54 crore (70.5%)

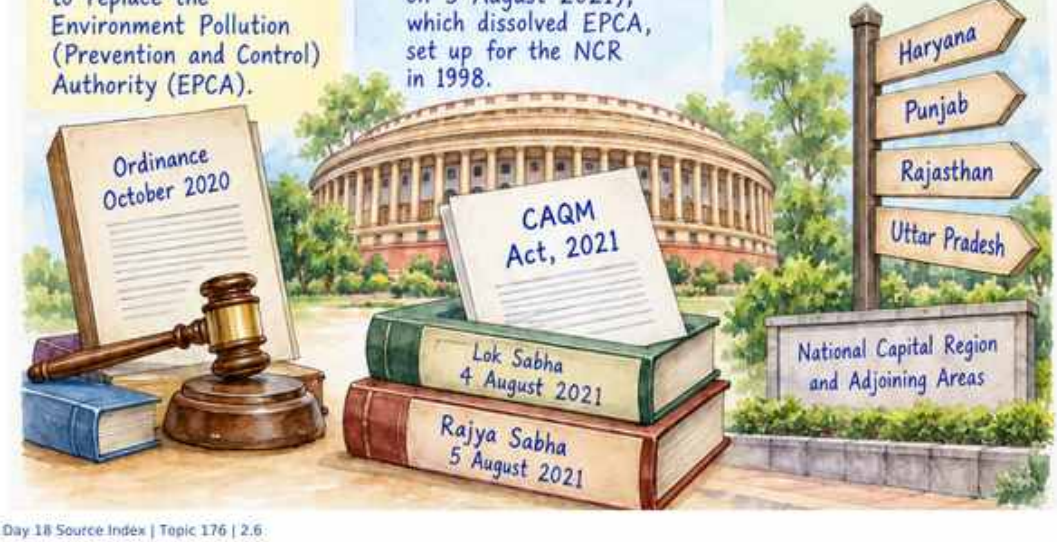
Keep the release date and funding period attached to each figure.

Commission for Air Quality Management (CAQM) in the National Capital Region and Adjoining Areas

Set up by the Union Government through an ordinance in October 2020, to replace the Environment Pollution (Prevention and Control) Authority (EPCA).

Parliament then passed the CAQM Act, 2021 (Lok Sabha on 4 August and Rajya Sabha on 5 August 2021), which dissolved EPCA, set up for the NCR in 1998.

The adjoining areas are parts of Haryana, Punjab, Rajasthan and Uttar Pradesh.



Sources: Day 18 Source Index | Topic 176 | 2.6

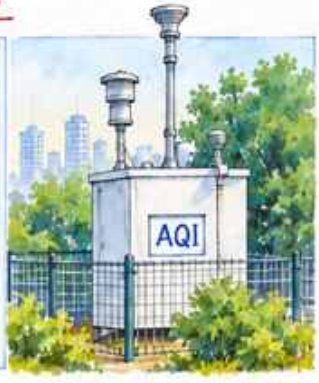
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GRAP four stages

Graded Response Action Plan (GRAP): a set of anti-pollution measures for Delhi and the National Capital Region that grow stricter as the air gets worse. The Supreme Court approved it in M.C. Mehta v. Union of India (2016). EPCA implemented it first; since 2021 the CAQM implements it. CAQM's modified GRAP schedule dated 21 November 2025, referenced by its 2026 orders, retains the following four AQI stages: Stage I for "Poor" air (201 to 300), Stage II for "Very poor" (301 to 400), Stage III for "Severe" (401 to 450), and Stage IV for "Severe+" air, above an AQI of 450.



Stage I – Poor air

AQI range: 201 to 300
Category: "Poor"

Stage II – Very poor air

AQI range: 301 to 400
Category: "Very poor"

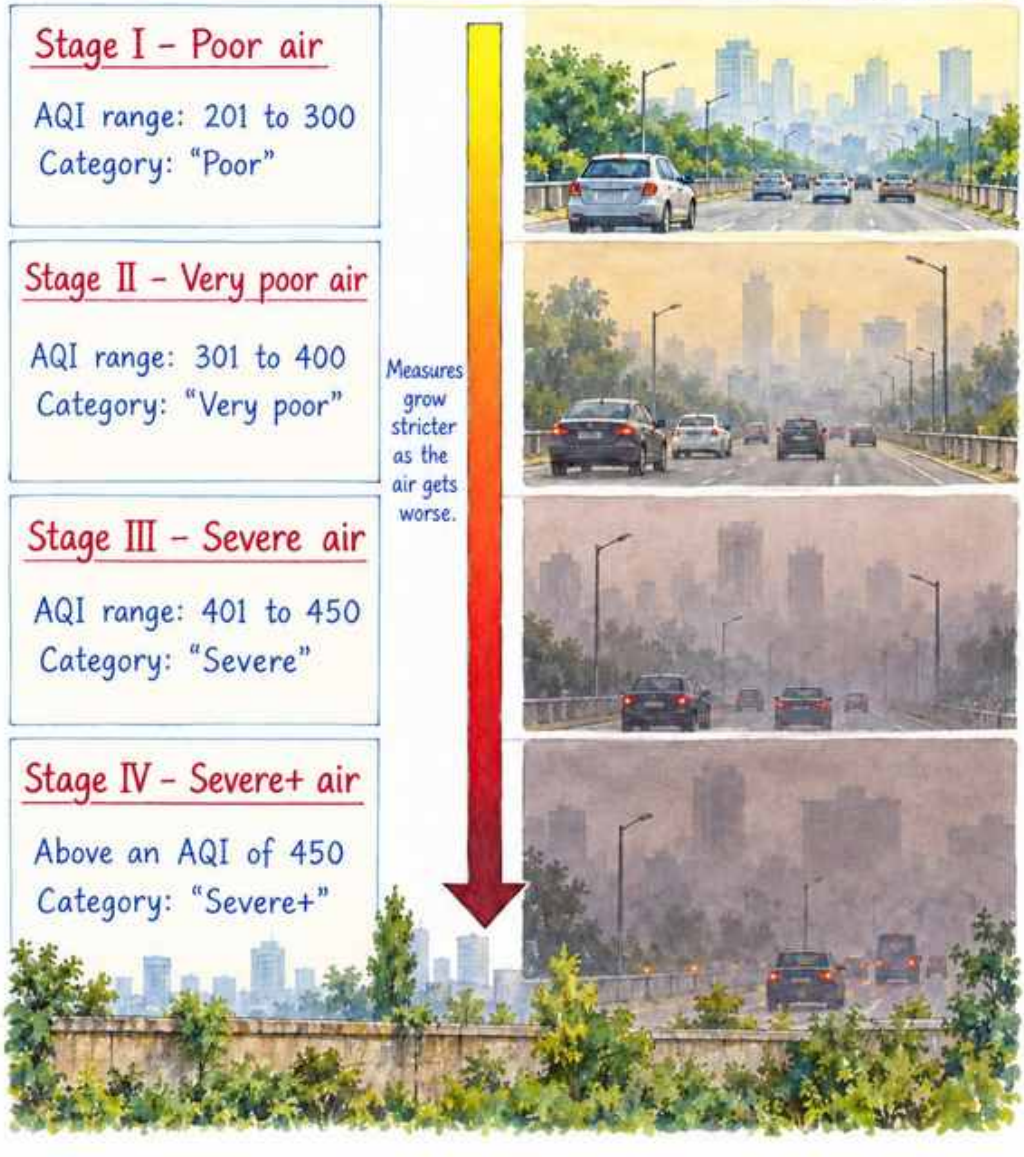
Stage III – Severe air

AQI range: 401 to 450
Category: "Severe"

Stage IV – Severe+ air

Above an AQI of 450
Category: "Severe+"

Measures grow stricter as the air gets worse.



Sources: Day 18 Source Index | Topic 176 | 2.6

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WHO versus Indian standards

Released on 22 September 2021.
They give guideline levels for six pollutants: $PM_{2.5}$, PM_{10}, ozone, nitrogen dioxide, sulphur dioxide and carbon monoxide.



India's NAAQS, 2009 (industrial, residential, rural and other areas)

$PM_{2.5}$, annual



WHO guideline, 2021	India's NAAQS, 2009
5 µg/m³ (lowered from 10 µg/m³)	40 µg/m³

$PM_{2.5}$, 24 hours



WHO guideline, 2021	India's NAAQS, 2009
15 µg/m³	60 µg/m³

PM_{10}, annual



WHO guideline, 2021	India's NAAQS, 2009
15 µg/m³	60 µg/m³

PM_{10}, 24 hours



WHO guideline, 2021	India's NAAQS, 2009
45 µg/m³	100 µg/m³



WHO guideline levels and India's legal standards are different instruments.

Sources: Day 18 Source Index | Topic 176 | 2.7

Day 18 | T176 · P14 | 93/155

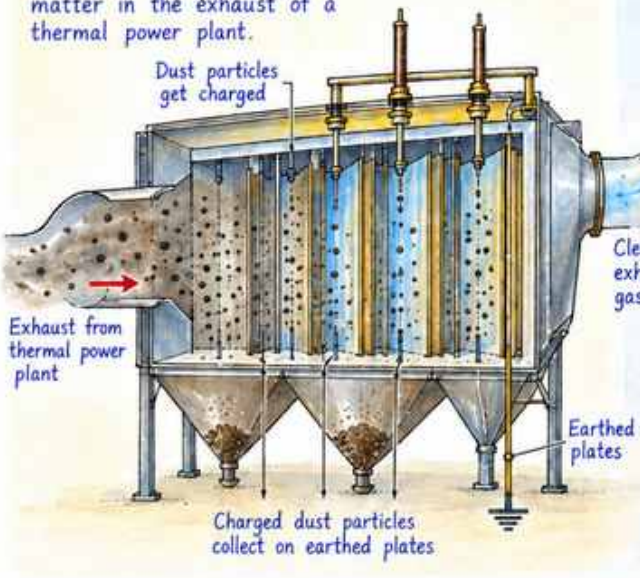
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Control devices and BS-VI

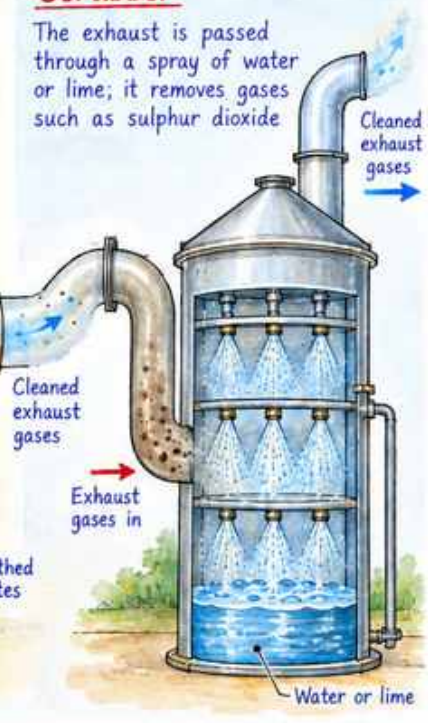
Electrostatic precipitator

It charges the dust particles and collects them on earthed plates. It can remove over 99 per cent of the particulate matter in the exhaust of a thermal power plant.



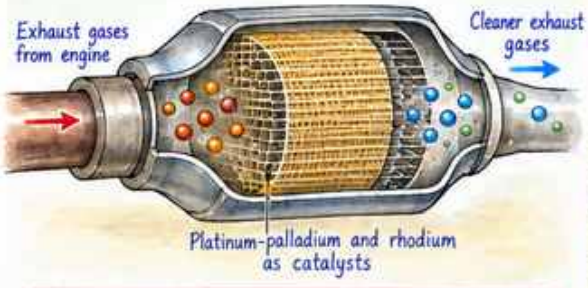
Scrubber

The exhaust is passed through a spray of water or lime; it removes gases such as sulphur dioxide



Catalytic converter

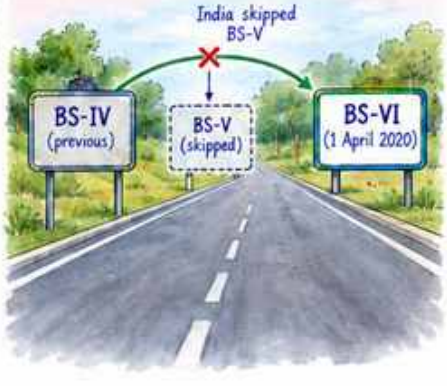
Fitted in vehicles, with platinum-palladium and rhodium as catalysts. It turns unburnt hydrocarbons into carbon dioxide and water, carbon monoxide into carbon dioxide, and nitric oxide into nitrogen gas. It needs unleaded petrol.



- Unburnt hydrocarbons → carbon dioxide and water
- Carbon monoxide → carbon dioxide
- Nitric oxide → nitrogen gas

Bharat Stage VI (BS-VI) emission norms

The nationwide transition from BS-IV to BS-VI for applicable new motor vehicles took effect on 1 April 2020. This is not a ban on zero-emission vehicles or a statement that all older vehicles became illegal. India skipped BS-V and went straight from BS-IV to BS-VI.



Sources: Day 18 Source Index | Topic 176 | 2.8

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Worked AQI: eligibility and interpolation

Suppose a station records these 24-hour averages: PM_{10} 180 µg/m³, $PM_{2.5}$ 75 µg/m³ and nitrogen dioxide 50 µg/m³.





Step 1: check that an AQI can be declared.

Three pollutants are measured, and one of them is a particulate (here both are). So an overall AQI can be declared.



Step 2: find each pollutant's band.

PM_{10} of 180 lies in 101 to 250, the "Moderately polluted" band.
$PM_{2.5}$ of 75 lies in 61 to 90, also "Moderately polluted".
Nitrogen dioxide of 50 lies in 41 to 80, the "Satisfactory" band (its breakpoints are 0 to 40, 41 to 80, 81 to 180 and so on).

PM_{10}	$PM_{2.5}$	Nitrogen dioxide
180 lies in 101 to 250 "Moderately polluted" band.	75 lies in 61 to 90 "Moderately polluted" band.	50 lies in 41 to 80 "Satisfactory" band.

Step 3: work out each sub-index.

Inside a band, the sub-index rises in a straight line from the lower index value to the upper one:

Sub-index = lower index value + (upper index value − lower index value) × (concentration − lower breakpoint) ÷ (upper breakpoint − lower breakpoint)

Pollutant	Band (concentration)	Band (index)	Working	Sub-index
PM_{10}, 180	101 to 250	101 to 200	101 + 99 × 79 ÷ 149	About 153
$PM_{2.5}$, 75	61 to 90	101 to 200	101 + 99 × 14 ÷ 29	About 149
Nitrogen dioxide, 50	41 to 80	51 to 100	51 + 49 × 9 ÷ 39	About 62

PM_{10}, 180
Band (concentration): 101 to 250
Band (index): 101 to 200
Sub-index = 101 + 99 × 79 ÷ 149 = About 153



$PM_{2.5}$, 75
Band (concentration): 61 to 90
Band (index): 101 to 200
Sub-index = 101 + 99 × 14 ÷ 29 = About 149



Nitrogen dioxide, 50
Band (concentration): 41 to 80
Band (index): 51 to 100
Sub-index = 51 + 49 × 9 ÷ 39 = About 62



The supplied 24-hour averages are assumed to satisfy CPCB data sufficiency, including at least 16 hours of data. Before rounding: $PM_{10} \approx 153.49$; $PM_{2.5} \approx 148.79$; $NO_2 \approx 62.31$. Rounded sub-indices: 153, 149 and 62.

Sources: Day 18 Source Index | Topic 176 | 3

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Worked AQI: decision and traps



Step 4: take the worst sub-index.

The highest is 153, from PM10. So the AQI is 153, in the "Moderately polluted" band (101 to 200), and PM10 is the pollutant that sets it.

The AQI is not the average of the displayed rounded sub-indices:

$(153 + 149 + 62) \div 3 = 121\frac{1}{3}$.

AQI band (relevant here)

Moderately polluted (101 to 200)



Step 5: read the health message.

For "Moderately polluted" air, people with lung disease such as asthma may feel breathing discomfort, and people with heart disease, children and older adults may feel discomfort.



Three common misconceptions

1 "Noise is not an air pollutant under Indian law."

It is.

The Air (Prevention and Control of Pollution) Act, 1981, was amended in 1987 to include noise as an air pollutant.



2 Mixing up the two NCAP targets.

The first, tentative target was a 20 to 30 per cent cut in PM2.5 and PM10 by 2024, with 2017 as the base year.

The revised target is a reduction in PM10 concentrations of up to 40 % by 2025–26 against 2017–18, or achievement of the national annual PM10 standard of 60 µg/m³.

A question that pairs 40 per cent with 2024, or 20 to 30 per cent with 2025–26, mixes the two.



3 "Smog always needs smoke and fog."

Only the sulfurous (London-type) smog comes from coal smoke with damp air.

Photochemical smog needs neither smoke nor fog: nitrogen oxides and hydrocarbons from vehicles react in sunlight and produce ozone. So it is a problem of sunny cities with heavy traffic.



Keep the counts separate. NAAQS has 12 pollutants; AQI uses 8. Keep concentrations, units and averaging periods together.



CO is in mg/m³; benzo(a)pyrene, arsenic and nickel are in ng/m³.



Sources: Day 18 Source Index | Topic 176 | 3; 4

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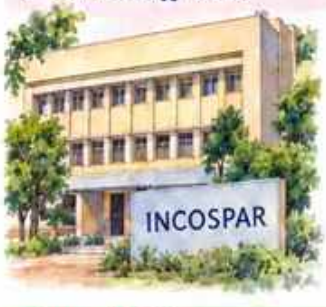
From research to ISRO

India's space programme began with a sounding rocket launched from Thumba in 1963 and has grown into a national effort with its own satellites and launch vehicles, missions to the Moon, Mars and the Sun, a human spaceflight programme and a space sector opened to private companies. The examination asks for the order and dates of its milestones, the bodies that run it, and which missions are done and which are still planned.



A sounding rocket launched from Thumba in 1963

1962: the Indian National Committee for Space Research (INCOSPAR) was set up under the Department of Atomic Energy (DAE).



Vikram Sarabhai
The founding father of the Indian space programme founded the Physical Research Laboratory (PRL), Ahmedabad, in 1947.



15 August 1969: the Indian Space Research Organisation (ISRO) was formed, in place of INCOSPAR. It was still under the DAE.



June 1972: the Government set up the Space Commission and the Department of Space (DOS). ISRO was brought under the DOS in September 1972.

On 1 April 1975 ISRO became a Government organisation.



Body	Set up	Placed under
INCOSPAR	1962	Department of Atomic Energy
ISRO	15 August 1969, in place of INCOSPAR	Department of Atomic Energy at first; Department of Space from September 1972
Space Commission and Department of Space	June 1972	The Government of India

Sources: Day 18 Source Index | Topic 177 | 1; 2.1

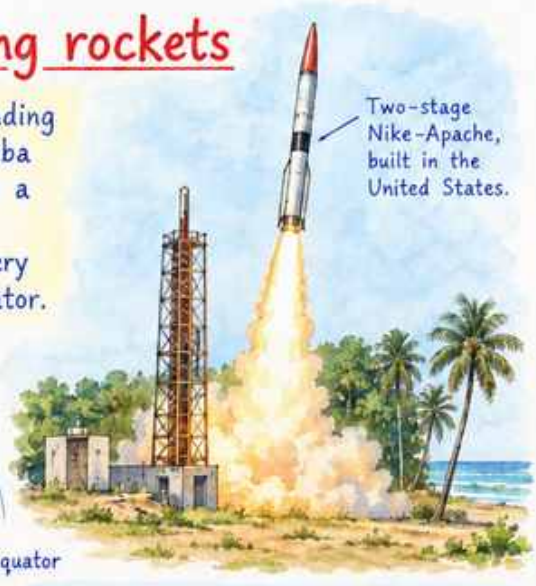
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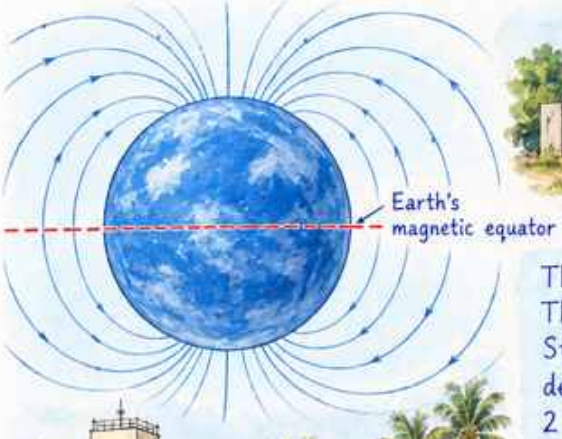
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Thumba and sounding rockets

21 November 1963: the first sounding rocket was launched, from Thumba near Thiruvananthapuram. It was a two-stage Nike-Apache, built in the United States. Thumba lies very close to the Earth's magnetic equator.





The launching station there is the Thumba Equatorial Rocket Launching Station (TERLS). It was formally dedicated to the United Nations on 2 February 1968, by Prime Minister Indira Gandhi.



After Sarabhai died on 30 December 1971, TERLS and the space establishments at Thiruvananthapuram were renamed the Vikram Sarabhai Space Centre (VSSC). TERLS is still used for sounding rockets.

Site	Where	Status as on 18 October 2026
Thumba (TERLS)	Near Thiruvananthapuram, close to the magnetic equator	India's first launch site (1963); now part of VSSC; used for sounding rockets



Sources: Day 18 Source Index | Topic 177 | 2.1; 2.6

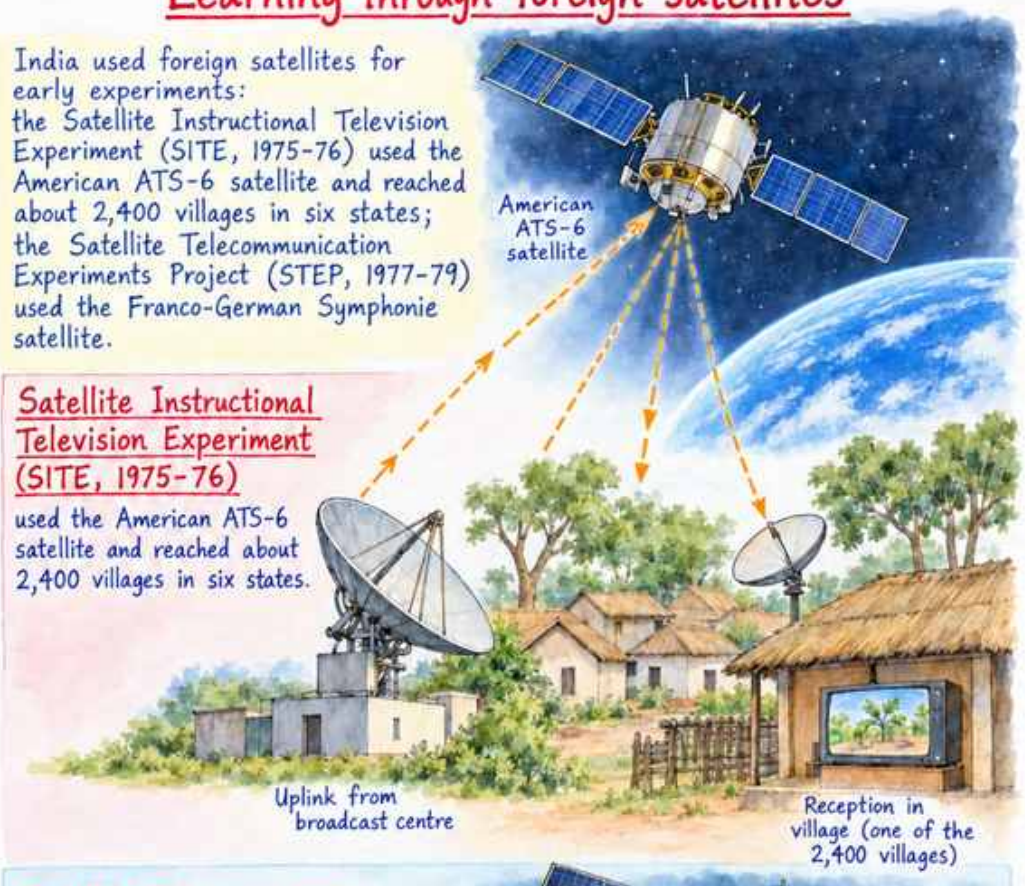
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Learning through foreign satellites

India used foreign satellites for early experiments: the Satellite Instructional Television Experiment (SITE, 1975-76) used the American ATS-6 satellite and reached about 2,400 villages in six states; the Satellite Telecommunication Experiments Project (STEP, 1977-79) used the Franco-German Symphonie satellite.



Satellite Instructional Television Experiment (SITE, 1975-76)

used the American ATS-6 satellite and reached about 2,400 villages in six states.

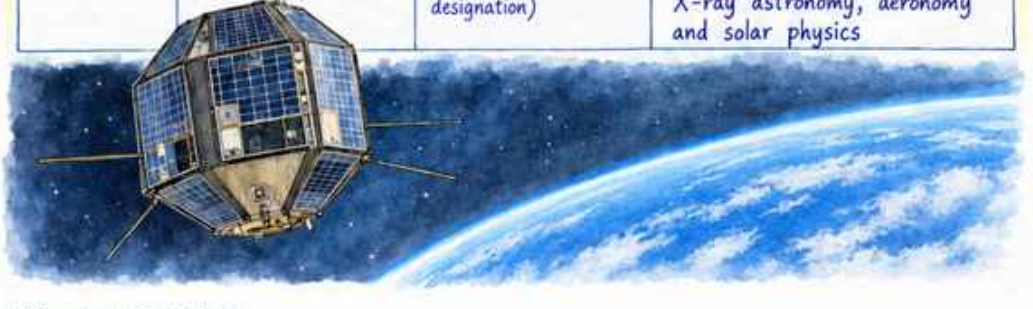
Satellite Telecommunication Experiments Project (STEP, 1977-79)

used the Franco-German Symphonie satellite.



India's first satellite

Satellite	Launched (ISRO)	Launch vehicle	What it was
Aryabhata	19 April 1975	Soviet rocket (C-1 Intercosmos designation)	India's first satellite, 360 kg, designed and built in India; X-ray astronomy, aeronomy and solar physics



Sources: Day 18 Source Index | Topic 177 | 2.2

Day 18 | T177 · P03 | 99/155

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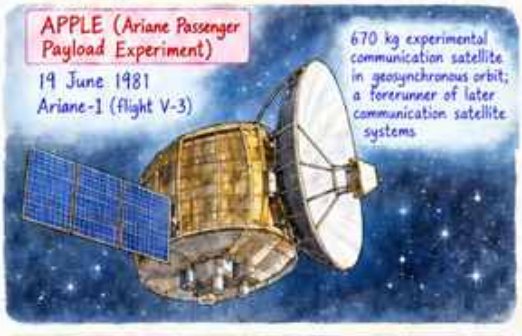
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First satellites and first indigenous orbital success

Satellite	Launch date	Launch vehicle	What it was
Bhaskara-I	7 June 1979	Soviet rocket (C-1 Intercosmos)	First of the two pioneering Bhaskara remote-sensing satellites
Rohini satellite RS-1	18 July 1980	SLV-3 (flight E2)	35 kg; placed in orbit by SLV-3, the first launch vehicle developed in India
APPLE (Ariane Passenger Payload Experiment)	19 June 1981	Ariane-1 (flight V-3)	670 kg experimental communication satellite in geosynchronous orbit; a forerunner of later communication satellite systems
Bhaskara-II	20 November 1981	Soviet rocket (C-1 Intercosmos)	The second Bhaskara remote sensing satellite













Pairs that share a year

Note the pairs that share a year: Bhaskara-I and the first SLV-3 flight both came in 1979; Bhaskara-II and APPLE were both launched in 1981.

1979	1981
Bhaskara-I and the first SLV-3 flight	Bhaskara-II and APPLE

Only one on an Indian rocket

Of the satellites in the table, only RS-1 went up on an Indian rocket.

Sources: Day 18 Source Index | Topic 177 | 2.2

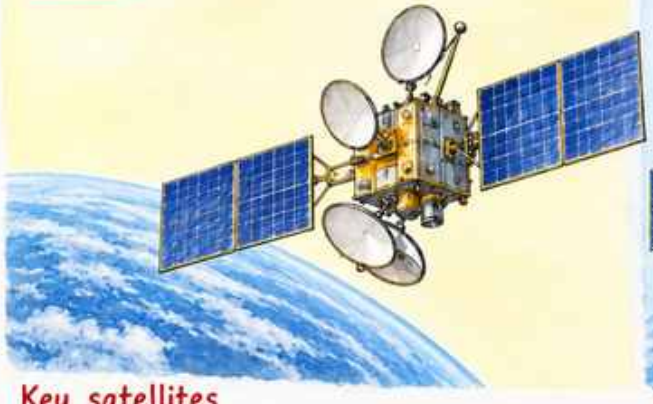
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INSAT, IRS and Sharma

INSAT



IRS



Key satellites

Satellite	Launched (ISRO)	Launch vehicle	What it was
INSAT-1A	10 April 1982	Delta (United States)	First INSAT satellite; satellite failure; deactivated on 6 September 1982.
INSAT-1B	30 August 1983	Space Shuttle (with a PAM-D stage)	Second INSAT satellite
IRS-1A	17 March 1988	Vostok (Soviet)	First Indian Remote Sensing (IRS) satellite

First Indian in space

on 2 April 1984 came the India-Soviet manned space mission (ISRO); Rakesh Sharma flew on Soyuz T-11 (PIB).



Launch vehicles

SLV-3 and ASLV (both retired), then PSLV, GSLV, LVM3 and SSLV, all taught in Topic 17.



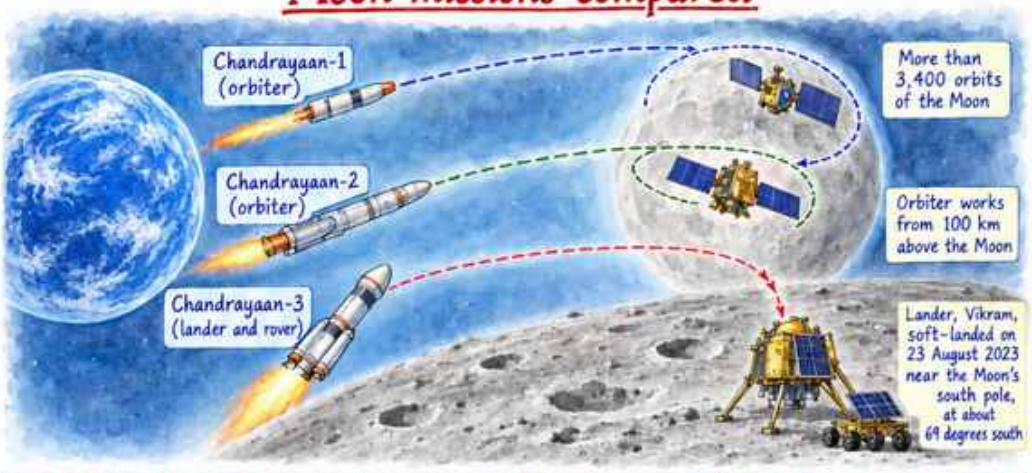
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Moon missions compared



Mission	Launch (vehicle)	Milestone	Mission status: 18 October 2026
Chandrayaan-1	22 October 2008 (PSLV-C11)	India's first mission to the Moon. It provided evidence of water molecules and hydroxyl on the Moon. It made more than 3,400 orbits of the Moon.	Not operational: contact was lost on 29 August 2009
Chandrayaan-2	22 July 2019 (GSLV Mk III-M1)	Its orbiter works from 100 km above the Moon and records details as fine as 30 cm (PIB)	Orbiter operational
Chandrayaan-3	14 July 2023 (LVM3-M4)	Its lander, Vikram, soft-landed on 23 August 2023 near the Moon's south pole, at about 69 degrees south; the rover is Pragyan. India became the first country to soft-land near the lunar south pole.	Not operational

Chandrayaan-1 (orbiter)



India's first mission to the Moon. It provided evidence of water molecules and hydroxyl on the Moon. It made more than 3,400 orbits of the Moon.

Chandrayaan-2 (orbiter)



Its orbiter works from 100 km above the Moon and records details as fine as 30 cm (PIB).

Chandrayaan-3 (lander and rover)



Its lander, Vikram, soft-landed on 23 August 2023 near the Moon's south pole, at about 69 degrees south; the rover is Pragyan. India became the first country to soft-land near the lunar south pole.

National Space Day: Prime Minister Narendra Modi declared 23 August, the day Vikram landed, National Space Day, and named the landing point Statio Shiv Shakti.



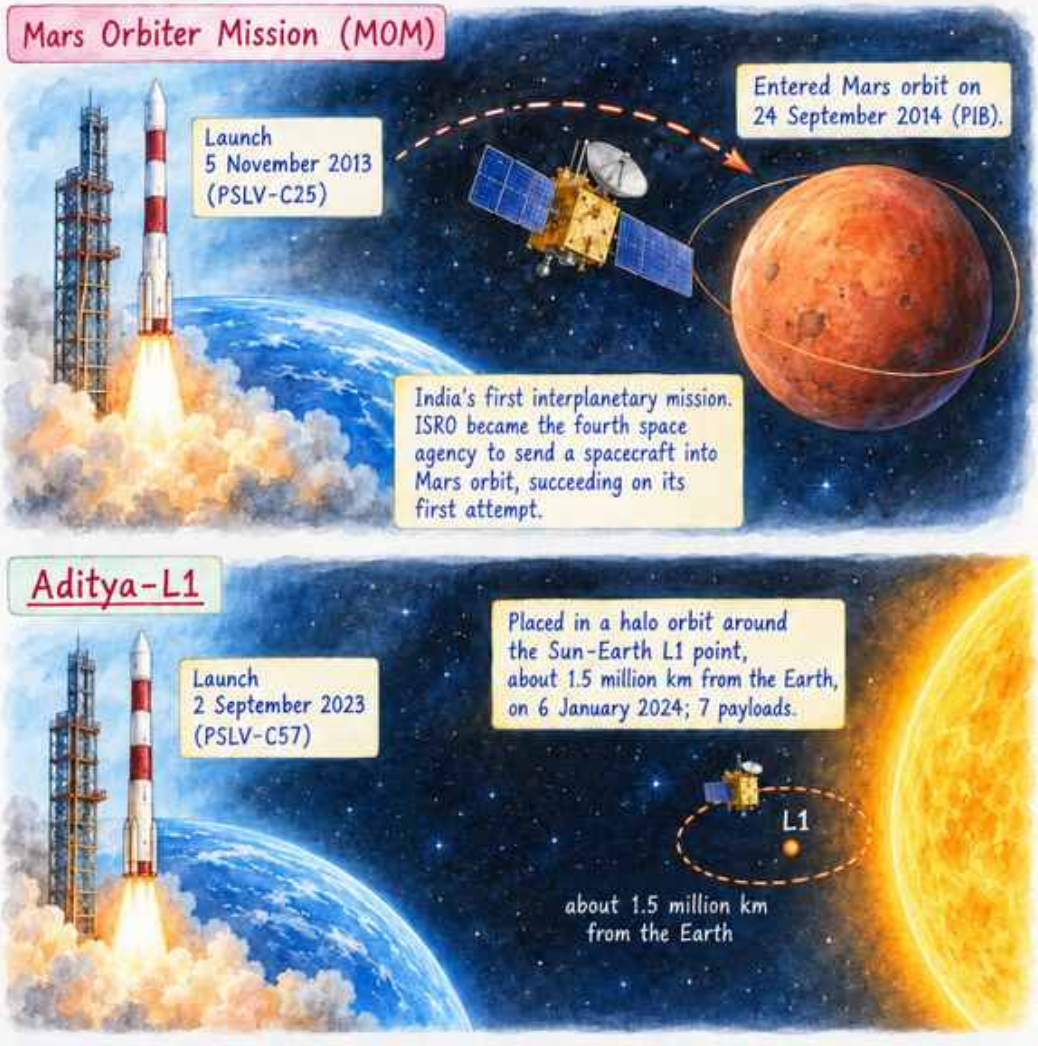
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Mars and Sun: launch versus arrival



Mission	Launch (vehicle)	Milestone	Mission status: 18 October 2026
Mars Orbiter Mission (MOM)	5 November 2013 (PSLV-C25)	Entered Mars orbit on 24 September 2014. India's first interplanetary mission. ISRO became the fourth space agency to send a spacecraft into Mars orbit, succeeding on its first attempt.	Not operational
Aditya-L1	2 September 2023 (PSLV-C57)	Placed in a halo orbit around the Sun-Earth L1 point, about 1.5 million km from the Earth, on 6 January 2024; 7 payloads.	Operational

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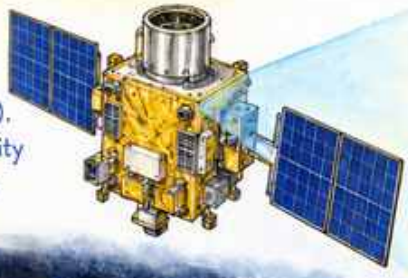
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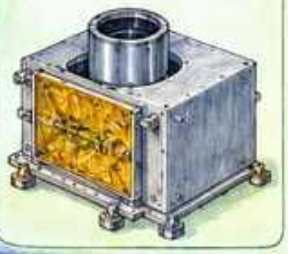
X-rays and docking

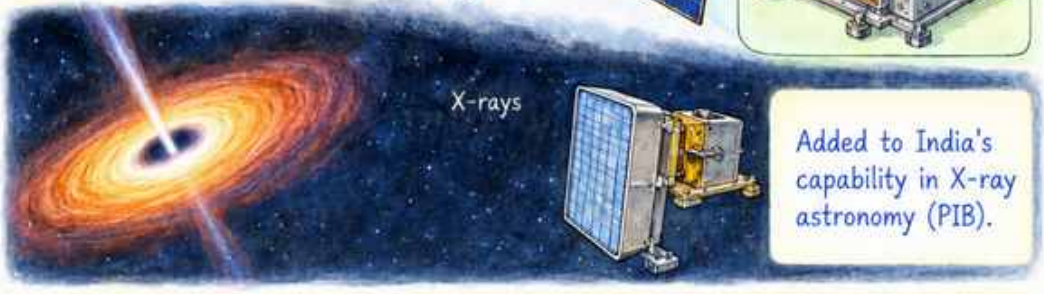
XPoSat

XPoSat was launched on 1 January 2024 (PSLV-C58). It added to India's capability in X-ray astronomy (PIB). It is operational.



X-ray astronomy (PIB)



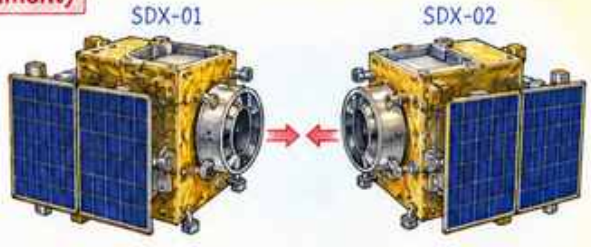


Added to India's capability in X-ray astronomy (PIB).

SpaDeX (Space Docking Experiment)

SpaDeX (Space Docking Experiment) was launched on 30 December 2024 (PSLV-C60).

Its two satellites, SDX-01 and SDX-02, docked in the early hours of 16 January 2025. India became the fourth nation to demonstrate docking in space. Operational at the 18 October 2026 snapshot.





Mission	Launch (vehicle)	Milestone	Mission status: 18 October 2026
XPoSat	1 January 2024 (PSLV-C58)	Added to India's capability in X-ray astronomy (PIB)	Operational
SpaDeX (Space Docking Experiment)	30 December 2024 (PSLV-C60)	Its two satellites, SDX-01 and SDX-02, docked in the early hours of 16 January 2025. India became the fourth nation to demonstrate docking in space.	Operational

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Gaganyaan: tests versus orbital mission

Gaganyaan aims to send up to three Indian astronauts into space (PIB). Done so far: the test flight TV-D1 on 21 October 2023 (ISRO timeline), the first Integrated Air Drop Test of the crew module's parachutes on 24 August 2025, and more than 8,000 ground tests (ISRO, January 2026).



First uncrewed orbital mission, Gaganyaan-G1:

Gaganyaan-G1 is the first planned uncrewed orbital mission. As announced by ISRO on 16 October 2026, it remained upcoming, with a 2026 launch target.

TV-D1 was an uncrewed abort-system test, not the full G1 orbital mission.

The launch campaign began on 18 December 2024 with assembly of the human-rated LVM3 at Sriharikota. Crew Module–Service Module separation tests had succeeded by the 16 October 2026 announcement.

The announced target was 2026; an exact launch date had not been specified.

Crew Module – Service Module separation tests



Test flight TV-D1

21 October 2023
(ISRO timeline)



uncrewed abort-system test

First Integrated Air Drop Test

of the crew module's parachutes
24 August 2025



More than 8,000 ground tests

(ISRO, January 2026)



Preflight:

Gaganyaan in detail comes on Day 38.

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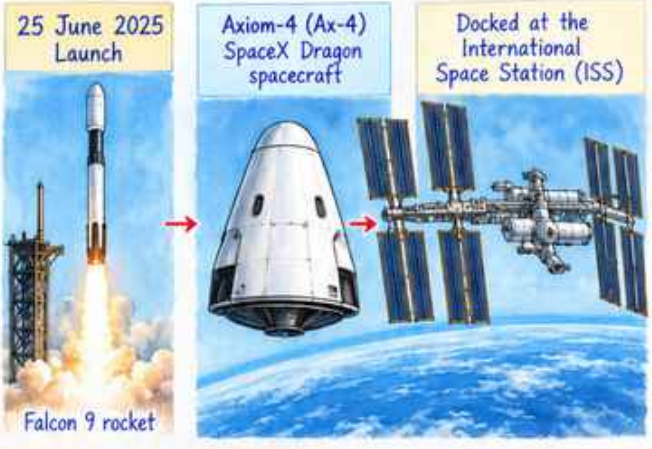
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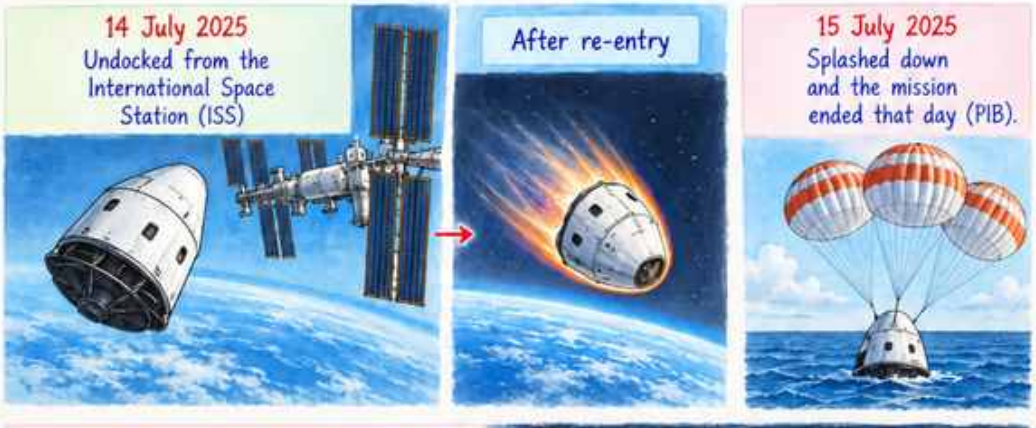
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Shukla, Ax-4 and BAS

Shubhanshu Shukla:

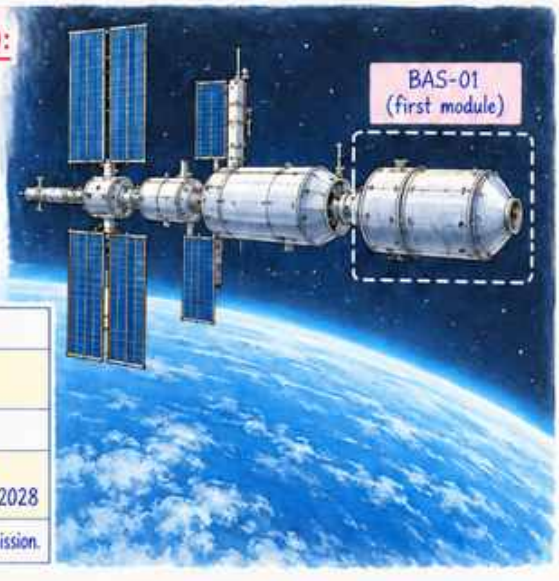
Group Captain Shubhanshu Shukla flew on Axiom-4 (Ax-4), aboard a SpaceX Dragon spacecraft launched by a Falcon 9 rocket on 25 June 2025. The Dragon undocked from the International Space Station (ISS) on 14 July 2025; after re-entry it splashed down on 15 July 2025, and the mission ended that day (PIB). Shukla became the second Indian in space and the first Indian to reach the ISS.





Bharatiya Antariksh Station (BAS):

on 18 September 2024 the Union Cabinet approved the development of the first module, BAS-01, with its launch planned by 2028 (PIB). The same decision enlarged Gaganyaan to eight missions, to be completed by December 2028. BAS-01 is a plan, not a done mission.



Approval date	18 September 2024
What was approved	Development of the first module, BAS-01
Planned launch	by 2028 (PIB)
Gaganyaan	Enlarged to eight missions, to be completed by December 2028
Status of BAS-01	BAS-01 is a plan, not a done mission.

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Private-sector institutions

NewSpace India Limited (NSIL)

Established in 2019 (PIB)



A public sector company under the Department of Space and the commercial arm of ISRO (Topic 17)

Indian National Space Promotion and Authorisation Centre (IN-SPACe)

Creation approved by the Union Cabinet on 24 June 2020 as part of opening the space sector to private participation.



An autonomous, single-window nodal agency in the Department of Space; it promotes, enables, authorises and supervises the space activities of non-governmental entities, and is their interface with ISRO

Indian Space Policy 2023

2023

Followed the opening of 2020 and enabled greater private participation across the space value chain (PIB)



Step	When	What it does
NewSpace India Limited (NSIL)	Established in 2019 (PIB)	A public sector company under the Department of Space and the commercial arm of ISRO (Topic 17)
Indian National Space Promotion and Authorisation Centre (IN-SPACe)	Creation approved by the Union Cabinet on 24 June 2020 as part of opening the space sector to private participation.	An autonomous, single-window nodal agency in the Department of Space; it promotes, enables, authorises and supervises the space activities of non-governmental entities, and is their interface with ISRO
Indian Space Policy 2023	2023	Followed the opening of 2020 and enabled greater private participation across the space value chain (PIB)

Space start-ups:

India had one registered space start-up in 2014; by February 2026 the number had crossed 400 (PIB).



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Space FDI rules

Step	When	What it does
Liberalised FDI (foreign direct investment) policy	February 2024	Up to 100 per cent FDI in selected activities. Automatic route: up to 74 per cent in satellite manufacturing and operations, satellite data products and ground and user segment services; up to 49 per cent in launch vehicles, their systems and spaceports; up to 100 per cent in making components and systems for satellites and for the ground and user segments



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Suborbital to private orbital launch

Step	When	What it does
Private launch	18 November 2022, 28 November 2022, 30 May 2024 and 18 July 2026	Skyroot Aerospace flew Vikram-S, a suborbital rocket, from Sriharikota in 2022 (ISRO). Dhanush, the first private launch pad and mission control centre in India, at Sriharikota, was inaugurated in 2022; from it AgniKul Cosmos flew Agnibaan SOrTeD on a suborbital mission in 2024. On 18 July 2026 Skyroot's Vikram-I, from Sriharikota, placed two satellites, SCOPE and Grahaa, in low Earth orbit: India's first private orbital launch (ISRO)



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Launch sites and AP link

Site	Where	Status as on 18 October 2026
Thumba (TERLS)	Near Thiruvananthapuram, close to the magnetic equator	India's first launch site (1963); now part of VSSC; used for sounding rockets
Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota	An island in Tirupati district, Andhra Pradesh	Operational since 9 October 1971, when an RH-125 sounding rocket was launched; renamed after Satish Dhawan on 5 September 2002; all of ISRO's orbital launches in Topic 17 go from here
SSLV Launch Complex, Kulasekarapattinam	Tamil Nadu	Planned second spaceport for SSLV launches. The Department of Space's January 2026 schedule targeted readiness by August 2026 and a first orbital launch by the end of 2026. These are announced targets, not completion dates.





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Space chronology: 1962–2020

1962 INCOSPAR set up under the Department of Atomic Energy (done)



1963 First sounding rocket from Thumba, 21 November (done)



1968 TERLS dedicated to the United Nations, 2 February (done)



1969 ISRO formed, 15 August (done)



1971 Sriharikota operational, 9 October (done)



1972 Space Commission and Department of Space set up, June; ISRO placed under the Department of Space, September (done)



1975 Aryabhata launched, 19 April (done)



1979 Bhaskara-I launched, 7 June; first SLV-3 flight, 10 August (done)



1980 SLV-3 places Rohini RS-1 in orbit, 18 July (done)



1981 APPLE, 19 June; Bhaskara-II, 20 November (done)



1982 INSAT-1A, 10 April (done)



1984 Rakesh Sharma on Soyuz T-11, 2 April (done)



1988 IRS-1A, 17 March (done)



2008 Chandrayaan-1 launched, 22 October (done)



2013 Mars Orbiter Mission launched, 5 November (done)



2014 Mars Orbiter Mission enters Mars orbit, 24 September (done)



2019 Chandrayaan-2 launched, 22 July; NSIL established (done)



2020 Space sector opened to private players; Union Cabinet approves the creation of IN-SPACe, 24 June (done)



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Space chronology: 2022 – 2028



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Space mission exam traps

1. "Chandrayaan-1 landed on the Moon."

Chandrayaan-1 (2008) was India's first mission to the Moon and worked from lunar orbit; it is remembered for the evidence of water molecules.

The soft landing, near the south pole, was made by Chandrayaan-3's lander Vikram in 2023.

Chandrayaan-2's orbiter remained operational in the 18 October 2026 snapshot.



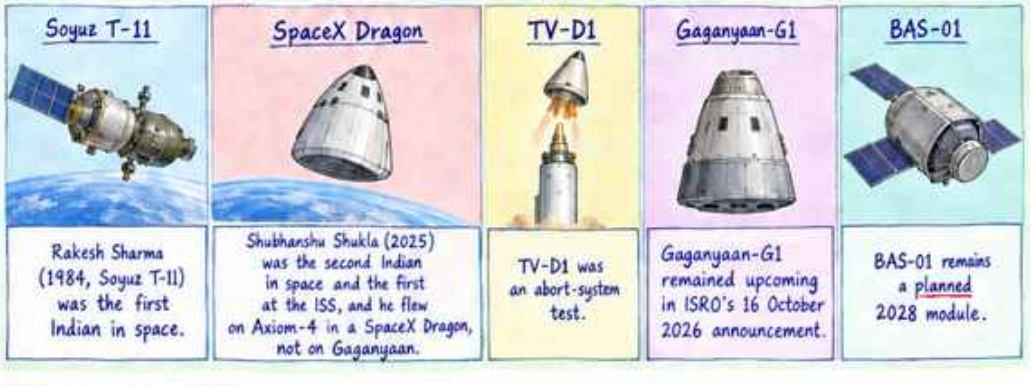
2. Mixing up the launch date and the date the goal was reached.

The Mars Orbiter Mission was launched in November 2013 but entered Mars orbit only in September 2014. SpaDeX was launched on 30 December 2024 but docked on 16 January 2025. Aditya-L1 was launched in September 2023 and reached its halo orbit on 6 January 2024. A question that asks "when did it reach" wants the second date.



3. Treating planned as done, or crediting the wrong spacecraft.

Rakesh Sharma (1984, Soyuz T-11) was the first Indian in space. Shubhanshu Shukla (2025) was the second Indian in space and the first at the ISS, and he flew on Axiom-4 in a SpaceX Dragon, not on Gaganyaan. Gaganyaan-G1 remained upcoming in ISRO's 16 October 2026 announcement; TV-D1 was an abort-system test. BAS-01 remains a planned 2028 module.



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Science: knowledge built from evidence

Science is a systematic attempt to understand natural phenomena.



Scientific knowledge uses observations, experiments and reasoning, rather than accepting authority alone.



Observation: record what happens carefully.

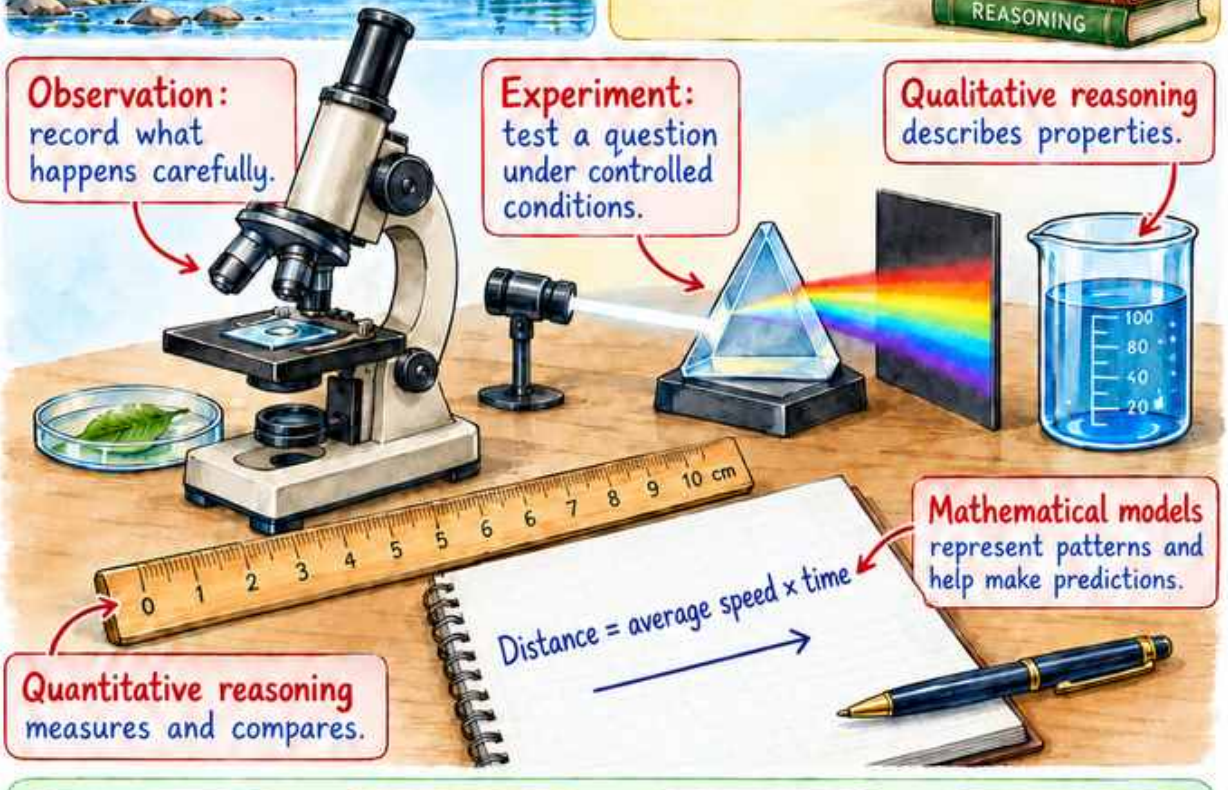
Experiment: test a question under controlled conditions.

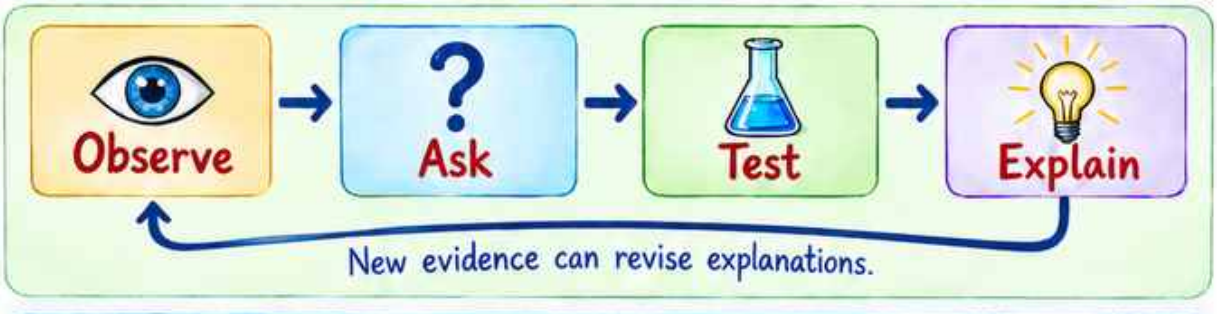
Qualitative reasoning describes properties.

Mathematical models represent patterns and help make predictions.

Quantitative reasoning measures and compares.

Distance = average speed × time





Scientific knowledge remains open to correction.

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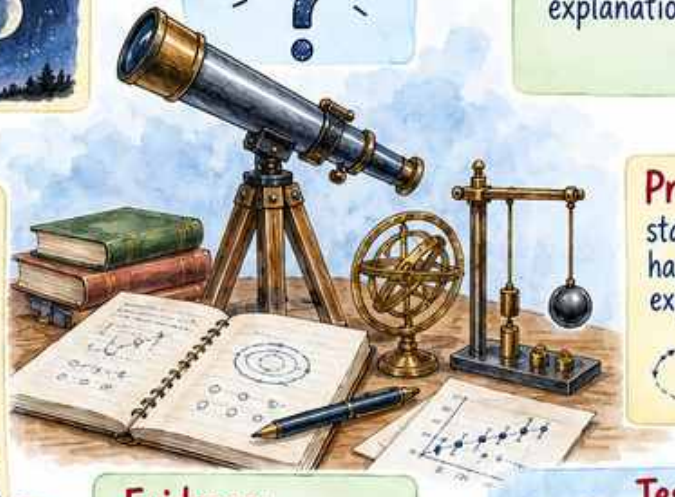
Scientific method: test, learn, revise

Observation → Question → Hypothesis → Prediction → Test → Evidence → Revise.

Observation: record a pattern carefully.

Question

Hypothesis: propose a testable explanation.



Prediction: state what should happen if the explanation is sound.

Testing: use observations or controlled experiments; compare results with the prediction.

Evidence: check measurements, uncertainty and alternative explanations.

Revision: retain, modify or reject the explanation as evidence requires.

Planetary motion: better observations challenged simple circular-orbit models. Kepler's elliptical orbits fitted the observations better.

Simple circular-orbit model (challenged by observations)

Kepler's elliptical orbits (fitted the observations better)

Science is not one rigid recipe. Steps interact; new evidence can send researchers back to an earlier question.

A successful test supports an explanation; it does not make it immune to future correction.

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Hypothesis, theory and law: different jobs

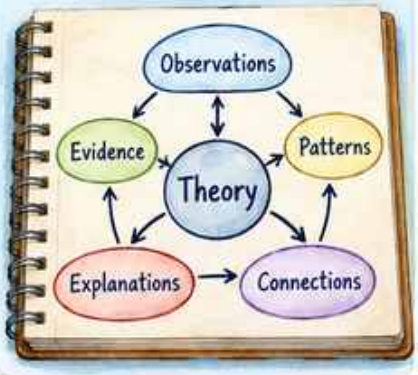
HYPOTHESIS:

a proposed explanation that can be tested.



THEORY:

a coherent explanation supported by evidence; it connects observations and explains patterns.



LAW:

a description of a regular relationship in nature, under stated conditions.

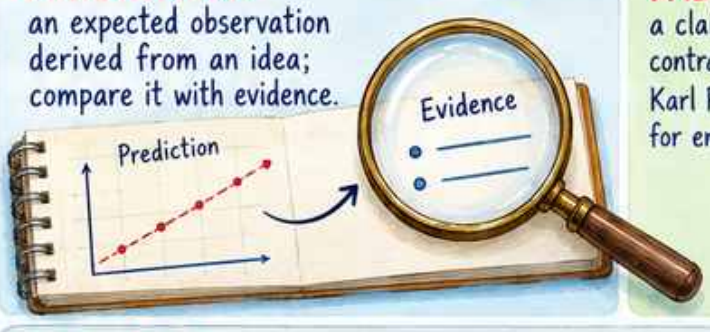


A theory does not become a law merely by collecting more evidence. Explanation and description perform different roles.



PREDICTION:

an expected observation derived from an idea; compare it with evidence.



FALSIFIABILITY:

a claim must risk being contradicted by possible evidence. Karl Popper used this as a criterion for empirical science.



Worked logic:

'All samples of this material expand when heated under these conditions.'

A reliable counterexample challenges the claim. Check the measurement and conditions before revising it.



Ask: What evidence would count against the claim?

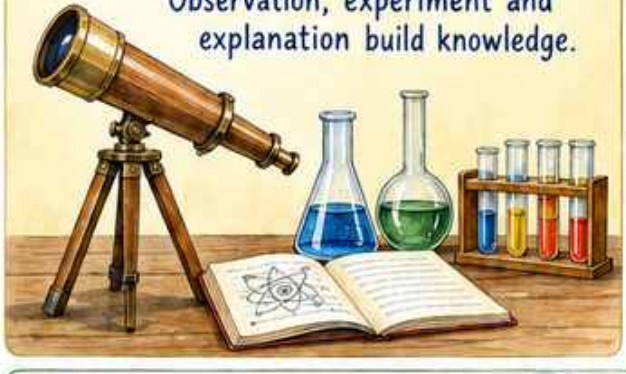
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Science ↔ technology: a two-way relationship

SCIENCE asks:
Why does nature behave this way?

Observation, experiment and explanation build knowledge.

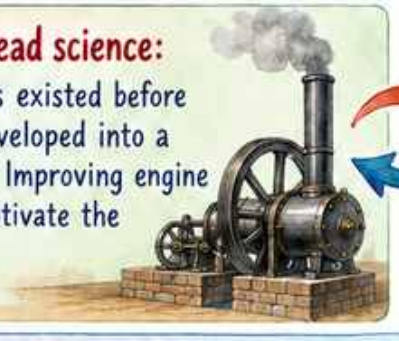


TECHNOLOGY asks:
How can we solve a practical problem?

Design, testing and improvement create useful products and processes.



Technology can lead science:
early steam engines existed before thermodynamics developed into a systematic science. Improving engine efficiency helped motivate the scientific questions.



Science can enable technology:
mathematical ideas and physical discoveries underpin modern computing.



Tools also expand discovery:
microscopes, telescopes and measuring instruments reveal observations previously unavailable.



The feedback loop:
knowledge → design → instrument → new evidence → better knowledge.



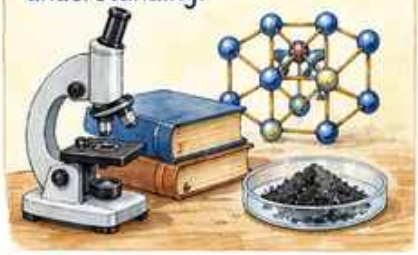
Exam trap: technology is not always a later, one-way application of science.

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Research becomes useful through several routes

BASIC RESEARCH: investigate fundamental questions and improve understanding.



APPLIED RESEARCH: investigate a specific practical aim.



EXPERIMENTAL DEVELOPMENT: use research and practical experience to produce or improve products and processes.



Example pathway:
understand a material → test it for solar conversion → build and evaluate a prototype.





R&D includes basic research, applied research and experimental development. The stages interact rather than forming an inevitable straight line.



INNOVATION: put a new or improved product or process into use. An invention alone does not guarantee successful adoption.



TECHNOLOGY TRANSFER: move knowledge and know-how from a developer to a user or producer.



INDIGENISATION: develop and produce capabilities within the country; it is not merely importing a finished system.



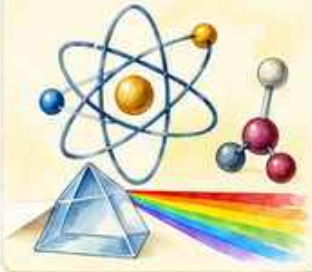


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Many sciences, connected applications

PHYSICAL SCIENCES: physics and chemistry examine matter, energy and their interactions.



EARTH SCIENCES: study Earth, its materials and processes.



LIFE SCIENCES: investigate living systems.



MATHEMATICAL AND COMPUTATIONAL SCIENCES: develop quantitative models, algorithms and tools for reasoning.



Applications cross subject boundaries:

SPACE: observation, communication and navigation.



HEALTH: diagnostics, vaccines and treatment.



AGRICULTURE: crop improvement, soil and water management.



ENERGY: generation, storage and efficient use.



ENVIRONMENT: monitoring pollution and managing resources.



DEFENCE, INFORMATION TECHNOLOGY AND BIOTECHNOLOGY: combine knowledge from several disciplines.



Example: a crop-monitoring system connects satellites, plant science, weather observations and data analysis.



Satellites provide field observations. → Weather observations give local conditions. → Data analysis identifies crop status. → Combined information supports better decisions for crop management.

Technology's value depends on the problem solved, reliability, cost and social consequences.

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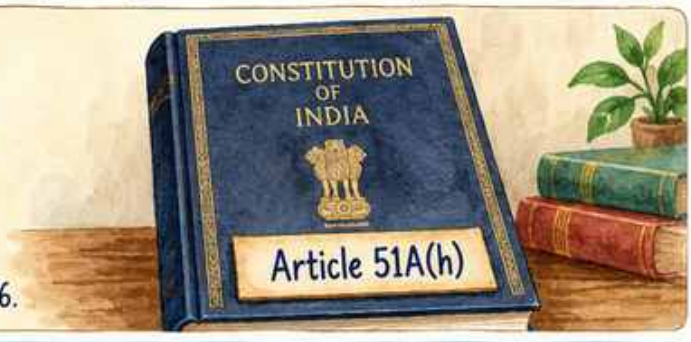
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Scientific temper: inquiry with responsibility

ARTICLE 51A(h):

develop scientific temper, humanism and the spirit of inquiry and reform.

This Fundamental Duty was added through the Forty-second Amendment, 1976.



SCIENTIFIC TEMPER IN PRACTICE:

1. Ask for evidence, not only authority.



2. Check claims and alternative explanations.



3. Revise views when reliable evidence changes.



4. Apply inquiry with humanism and concern for others.



ETHICS:

consider safety, consent, fairness, privacy and environmental effects when designing or using technology.



DUAL USE:

the same knowledge or technology may support civilian and military purposes. Examples include navigation, nuclear technology and rocketry.



A useful technology is not automatically harmless. Governance must weigh benefits, risks and safeguards.



Inquiry + evidence + responsibility → socially useful progress.

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India's science system: roles and evidence

PSA

PSA: advises the Government on science, technology and innovation.



DST

DST: supports and coordinates science and technology development.



CSIR

CSIR: multidisciplinary scientific and industrial research.





DBT

DBT: promotes biotechnology research and development.



ANRF

ANRF: supports and strengthens research and innovation under the ANRF Act, 2023.



Key evidence on research resources

GERD, 2023–24:
₹244,767.81 crore

GERD as a share of GDP, 2023–24:
0.84%

GERD means Gross Expenditure on Research and Development.

Report year vs data year



They are not measurements for 2026.

Source: Ministry of Science & Technology, PIB, 29 July 2026, citing DST Research & Development Statistics 2025–26.

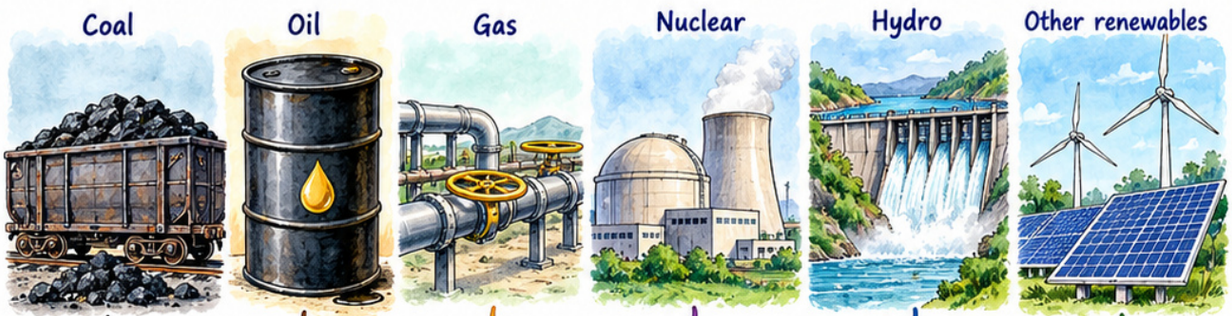
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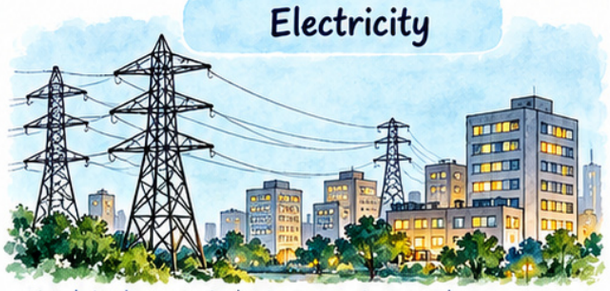
1 and 2 Energy is not just electricity

India's **energy mix** is the share that each source (coal, oil, gas, nuclear, hydro and the other renewables) holds in the energy the country uses and in its electricity. The examination asks for these shares, the electricity shortage and the dependence on imports, each with its year and its source.



India's energy mix

Electricity



Used in homes, industry, services and agriculture. Each source has a share in the electricity generated.

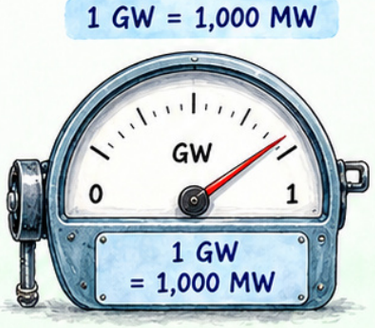
Transport, heat and other non-electric uses



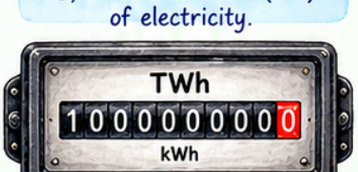
Fuels such as oil, gas, coal and modern renewables also supply energy for transport, heating and other direct uses, not just for generating electricity.

Units

1 GW = 1,000 MW



1 TWh = 1 billion units (BU) = 1,000 million units (MU) of electricity.



1 TWh
= 1 billion units (BU)
= 1,000 million units (MU)
of electricity.

KToE means thousand tonnes of oil equivalent, a common unit for adding up different fuels.



2 Revision notes

Units: 1 GW = 1,000 MW. 1 TWh = 1 billion units (BU) = 1,000 million units (MU) of electricity. KToE means thousand tonnes of oil equivalent, a common unit for adding up different fuels.

Earlier topics: Topic 47 explained fission and reactor types; Topic 76 gave India's nuclear stations (8,780 MWe in 24 units, 3.1 per cent of generation in 2024-25); Topic 97 explained solar technologies; Topic 117 gave the Solar Mission and MNRE's solar and non-fossil capacity for 30 September 2026. Their tables are not repeated here.

Concept illustrations; institutional buildings are schematic.

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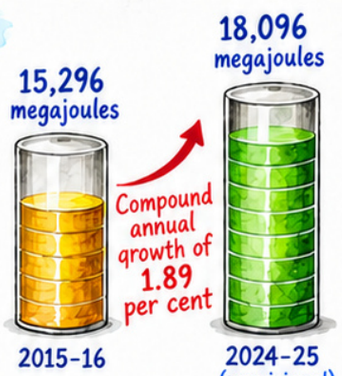
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2.1 Rising demand and final consumption

1. How much energy India needs

Per capita energy (MoSPI)

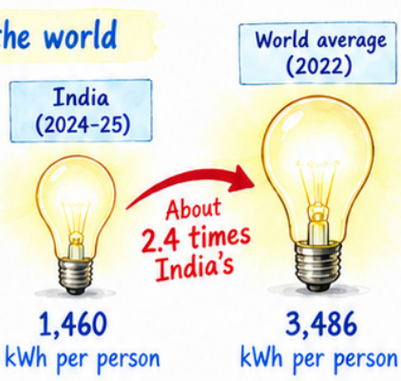
The Ministry of Statistics and Programme Implementation (MoSPI), in Energy Statistics India 2026 (33rd edition, released on 30 March 2026), puts per capita energy consumption at 18,096 megajoules in 2024-25 (provisional), up from 15,296 megajoules in 2015-16. That is a compound annual growth of 1.89 per cent.

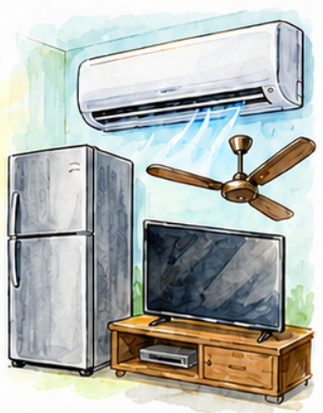




2. Per capita electricity against the world

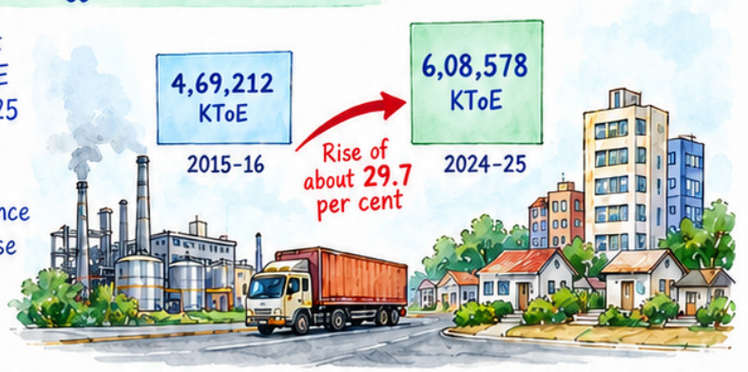
About 1,460 kWh per person in India in 2024-25, against a world average of 3,486 kWh in 2022 (Central Electricity Authority, CEA, as Wikipedia gives it). The world average is about 2.4 times India's, though the two years differ.





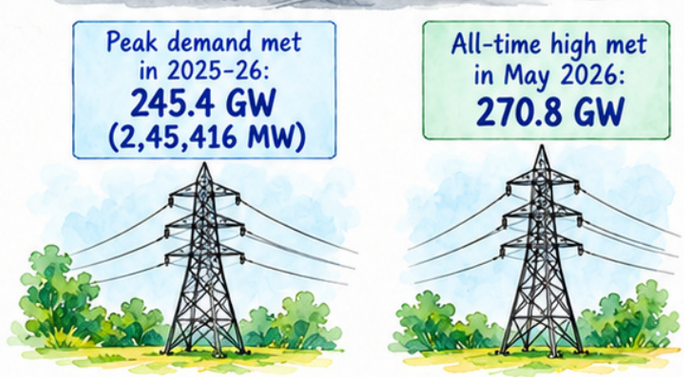
3. Total final consumption (the energy that reaches users)

Total final consumption (the energy that reaches users) rose from 4,69,212 KToE in 2015-16 to 6,08,578 KToE in 2024-25 (MoSPI), a rise of about 29.7 per cent. Both values are confirmed in the full Energy Statistics India 2026 energy-balance tables; its highlights describe the increase as around 30 per cent.



4. Peak demand for electricity

The peak demand met in 2025-26 was 2,45,416 MW, about 245.4 GW (Ministry of Power, CEA figures). The Ministry told the Lok Sabha on 23 July 2026 that an all-time high of 270.8 GW was met in May 2026.



Concept illustrations; institutional buildings are schematic.

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2.2 Reading the primary energy balance

2.2 The primary energy mix

Total primary energy supply (TPES) is all the energy that enters the economy, before it is changed into electricity or fuels.

- TPES in 2024-25: 9,32,816 KToE, 2.95 per cent more than in the year before (MoSPI).
- Coal: coal, lignite included, supplied 5,52,315 KToE in 2024-25. That is about 59 per cent of TPES.

Primary energy shares (MoSPI, 2024-25 provisional)

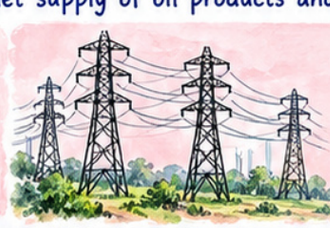


59.21 per cent	29.79 per cent	7.12 per cent	Renewable energy 3.84 per cent	1.58 per cent
Coal including lignite	Crude oil	Natural gas	Large hydro 1.37 per cent; Solar, wind and others 2.47 per cent	Nuclear energy

These five positive shares sum to 101.54 per cent: the energy balance also includes negative net supply of oil products and electricity.



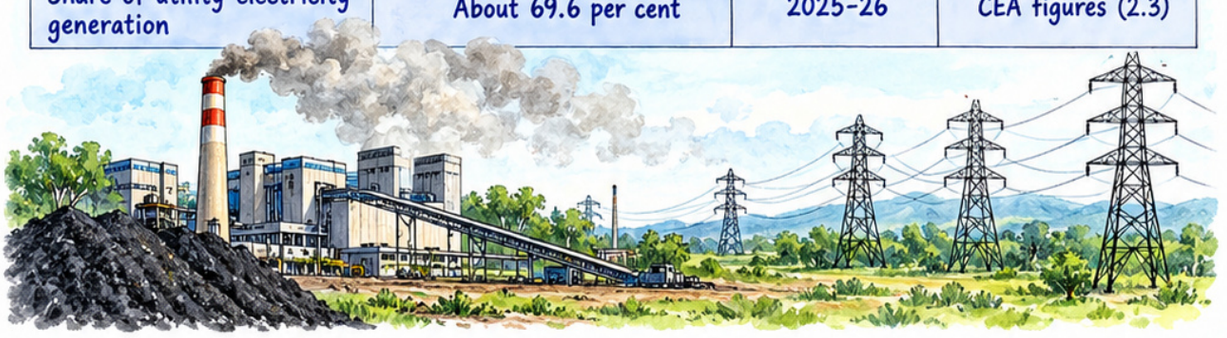
Oil products
-14,198 KToE
(negative net supply)



Electricity
-272 KToE
(negative net supply)

Two different measures of coal's share

Measure of coal's share	Figure	Year	Who gives it
Share of total primary energy supply	About 59 per cent (5,52,315 of 9,32,816 KToE)	2024-25	MoSPI, Energy Statistics India 2026
Share of utility electricity generation	About 69.6 per cent	2025-26	CEA figures (2.3)



Concept illustrations; institutional buildings are schematic.

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2.3 Capacity and actual generation

2.3 The electricity mix

Installed capacity is how much the plants can produce at full output (in GW). Generation is how much electricity they actually produced in a year (in TWh). The table uses the CEA's figures for utilities (plants that supply the grid, not captive plants built for a factory's own use): capacity as the Ministry of Power's "Power Sector at a Glance" gives it, and generation from the CEA's overview of generation for March 2026.

Installed capacity (GW)



Shows how much the plants can produce at full output.

Generation (TWh)

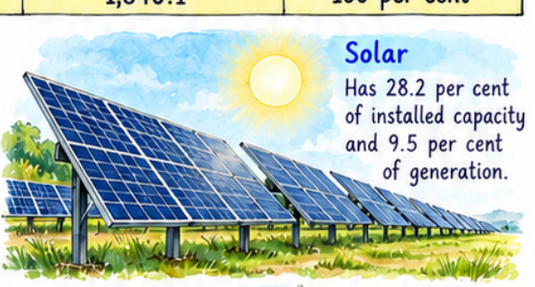


Shows how much electricity they actually produced in a year.

Source	Installed capacity, 31 March 2026 (GW)	Share of capacity	Generation, 2025-26 (TWh)	Share of generation
Coal	228.6	42.9 per cent	1,280.7	69.6 per cent
Gas	20.1	3.8 per cent	26.0	1.4 per cent
Diesel (oil)	0.6	0.1 per cent	0.4	Under 0.1 per cent
Nuclear	8.8	1.6 per cent	55.2	3.0 per cent
Large hydro	51.4	9.7 per cent	167.2	9.1 per cent
Small hydro	5.2	1.0 per cent	12.0	0.7 per cent
Solar	150.3	28.2 per cent	174.8	9.5 per cent
Wind	56.1	10.5 per cent	106.7	5.8 per cent
Biomass	10.9	2.0 per cent	14.1	0.8 per cent
Waste to power	0.9	0.2 per cent	3.0	0.2 per cent
Total	**532.7**	**100 per cent**	**1,840.1**	**100 per cent**



Coal
Largest source of generation, supplying 69.6 per cent of electricity, with 42.9 per cent of installed capacity.



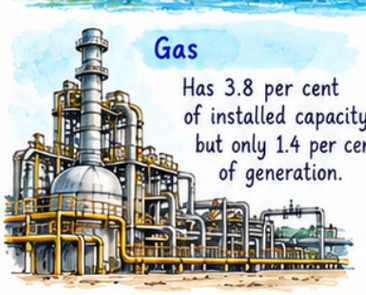
Solar
Has 28.2 per cent of installed capacity and 9.5 per cent of generation.



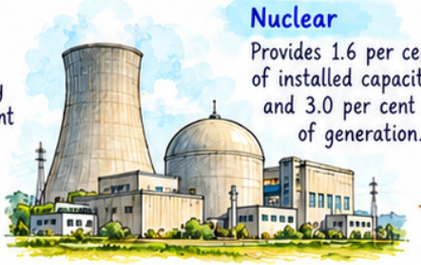
Large hydro
Accounts for 9.7 per cent of installed capacity and 9.1 per cent of generation.



Wind
Contributes 10.5 per cent of installed capacity and 5.8 per cent of generation.



Gas
Has 3.8 per cent of installed capacity but only 1.4 per cent of generation.



Nuclear
Provides 1.6 per cent of installed capacity and 3.0 per cent of generation.



Biomass and waste to power
Together account for 2.2 per cent of installed capacity and 1.0 per cent of generation (0.8 per cent from biomass and 0.2 per cent from waste to power).

Concept illustrations; institutional buildings are schematic.

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2.3 and 2.4 Non-fossil capacity is not output

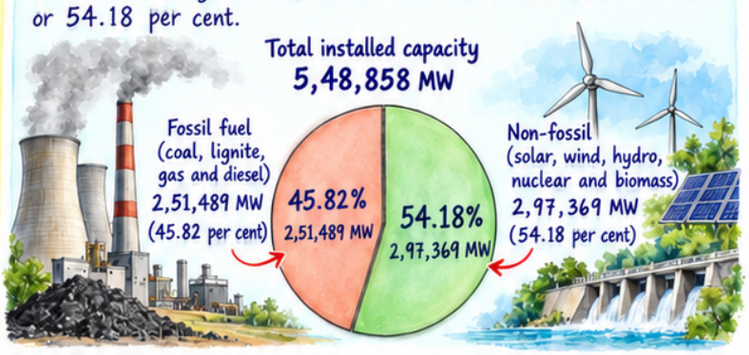
2.3 Dates scope and totals

The capacity rows add up to 532.9 GW against the total of 532.7 GW; the gap comes from rounding. Coal includes lignite (6.6 GW), and biomass includes bagasse. The shares are worked out from the unrounded MW and MU figures. The generation total leaves out 7.8 TWh imported from Bhutan.

532.9 GW ≠ 532.7 GW → The gap comes from rounding.

30 June 2026 snapshot

The Ministry of Power told the Lok Sabha on 23 July 2026 that installed capacity stood at 5,48,858 MW on 30 June 2026: fossil fuel (coal, lignite, gas and diesel) 2,51,489 MW, or 45.82 per cent, and non-fossil (solar, wind, hydro, nuclear and biomass) 2,97,369 MW, or 54.18 per cent.



Growth

Installed capacity rose from 249 GW in 2014 to about 552 GW in July 2026 (PIB, 13 August 2026).



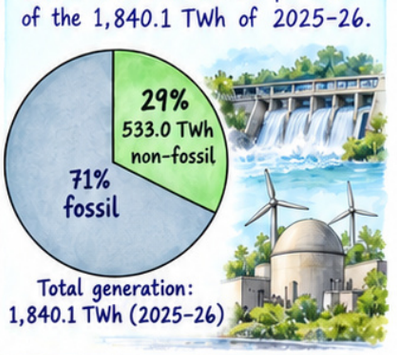
Renewables in MoSPI's count

2,29,346 MW of renewable capacity, utility and non-utility together, on 31 March 2025; renewable generation of 4,16,823 GWh in 2024-25.



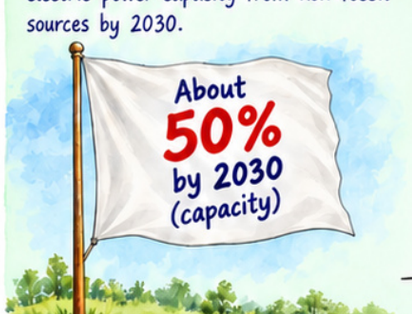
Non-fossil share of generation

Large hydro, small hydro, solar, wind, biomass, waste to power and nuclear together gave 533.0 TWh, about 29 per cent of the 1,840.1 TWh of 2025-26.

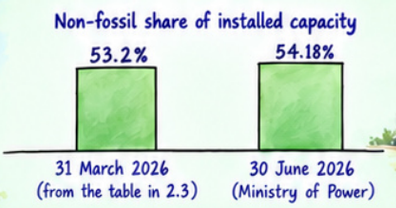


2.4 Non-fossil capacity against the 50 per cent target

India's updated nationally determined contribution (NDC) of August 2022 aims at about 50 per cent of installed electric power capacity from non-fossil sources by 2030.



That share has already been passed: 53.2 per cent on 31 March 2026 (from the table in 2.3) and 54.18 per cent on 30 June 2026 (Ministry of Power). Topic 117 gives the date on which India first crossed 50 per cent and MNRE's figures for 30 September 2026.



The target is about capacity. In generation, coal still gave about 69.6 per cent in 2025-26.



Concept illustrations; institutional buildings are schematic.

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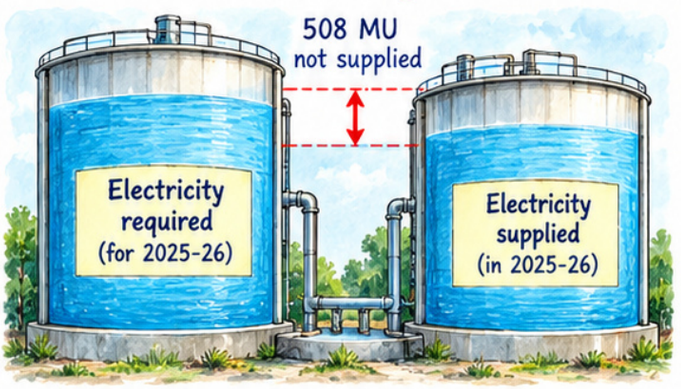
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2.5 How small is the electricity deficit

2.5 The electricity deficit

The energy shortage is the electricity that consumers required but could not be supplied, as a share of the requirement. The Ministry of Power gave these figures to the Lok Sabha on 23 July 2026.

Year	Energy not supplied	Energy shortage
2013-14	Not given in the reply	4.2 per cent
2022-23	7,583 MU	0.5 per cent
2023-24	4,112 MU	0.3 per cent
2024-25	1,590 MU	0.1 per cent
2025-26	508 MU	0.0 per cent

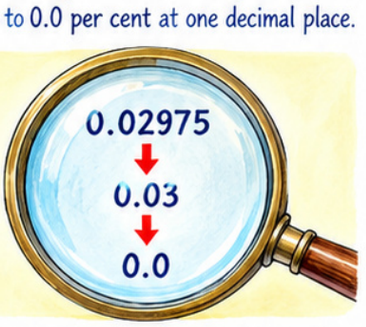


- The reply calls the 0.0 per cent of 2025-26 a sharp decline. The Ministry of Power's "Power Sector at a Glance" gives the shortage for 2025-26 as 0.03 per cent. The two agree: 508 MU is about 0.03 per cent of the year's requirement, which rounds to 0.0 per cent at one decimal place.

3 Worked example

Example 3. Why the shortage reads 0.0 and 0.03.

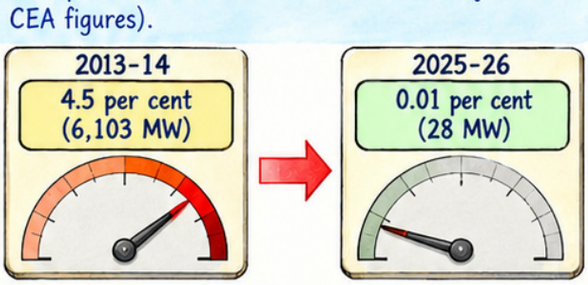
508 MU not supplied ÷ about 17,07,500 MU required = 0.0003, that is 0.03 per cent. Rounded to one decimal place it is 0.0 per cent. Both figures describe the same year.



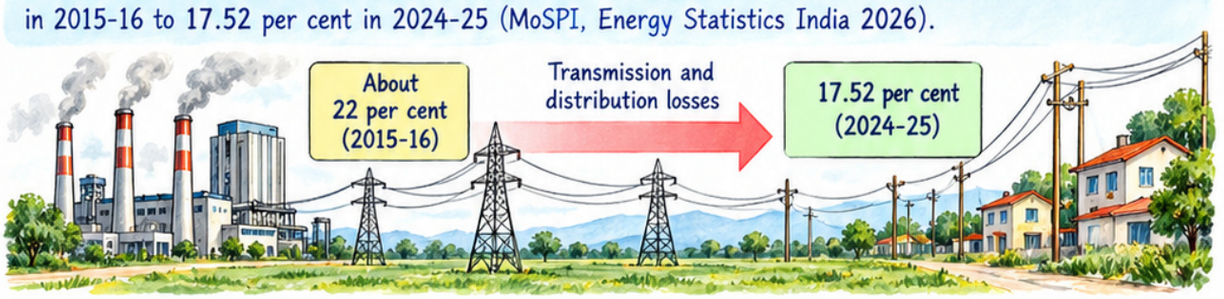
Energy supplied in 2025-26 was 1,707.0 BU (Ministry of Power, 23 July 2026).



Peak shortage (peak demand that could not be met) fell from 4.5 per cent (6,103 MW) in 2013-14 to 0.01 per cent (28 MW) in 2025-26 (Ministry of Power, CEA figures).



Transmission and distribution losses fell from about 22 per cent in 2015-16 to 17.52 per cent in 2024-25 (MoSPI, Energy Statistics India 2026).

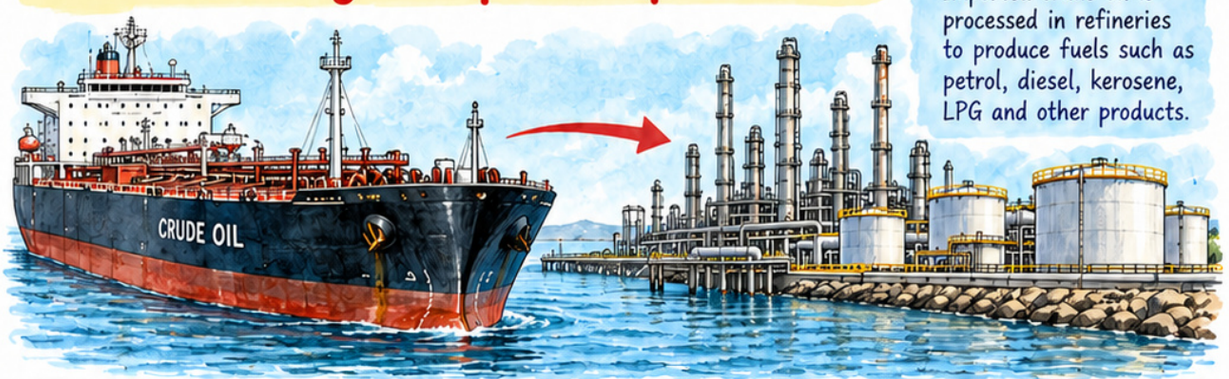


Concept illustrations; institutional buildings are schematic.

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2.6 Oil and gas import dependence



Imported crude oil is processed in refineries to produce fuels such as petrol, diesel, kerosene, LPG and other products.

Fuel	What the sources say	Year
Crude oil	Import dependence of nearly **89** per cent; imports rose from 234.26 to **243.22** million tonnes	2024-25 (Energy Statistics India 2026, as Down To Earth reported it)
Crude oil	Close to **88.5** per cent of the crude oil consumed is imported	Ministry of Petroleum and Natural Gas (PIB), July 2026
Crude oil	Import dependency on a consumption basis: **88.3** per cent for 2024-25; **88.7** per cent for 2025-26	PPAC Monthly Ready Reckoner, October 2026 (data for September 2026), p. 6
Natural gas	Import dependency: **50.1** per cent in both 2024-25 and 2025-26	Same PPAC publication, p. 28
Natural gas	Imports rose by **12.3** per cent to **35.72** billion cubic metres	2024-25 (Energy Statistics India 2026, as reported)

Crude oil import dependence

Nearly **89** per cent



2024-25 (Energy Statistics India 2026, as Down To Earth reported it)

88.5 per cent



Ministry of Petroleum and Natural Gas (PIB), July 2026

88.3 per cent | **88.7** per cent



2024-25 | 2025-26

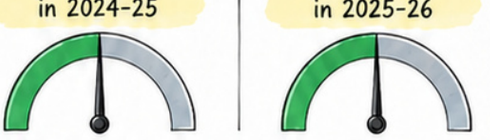
PPAC Monthly Ready Reckoner, October 2026 (data for September 2026), p. 6

Crude oil imports (million tonnes)



Natural gas import dependence

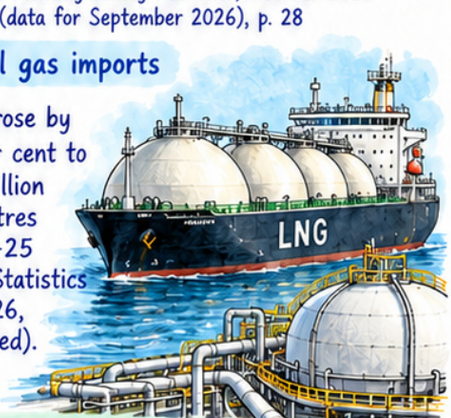
50.1 per cent in 2024-25 | **50.1** per cent in 2025-26



PPAC Monthly Ready Reckoner, October 2026 (data for September 2026), p. 28

Natural gas imports

Imports rose by **12.3** per cent to **35.72** billion cubic metres in 2024-25 (Energy Statistics India 2026, as reported).



Crude oil is the fuel on which India depends most on imports. For a question naming a source, use that source and its reference year: the older MoSPI-based description is **nearly 89 per cent** for 2024-25; PPAC's October 2026 publication reports 88.3 per cent for 2024-25 and 88.7 per cent for 2025-26.

Concept illustrations; institutional buildings are schematic.

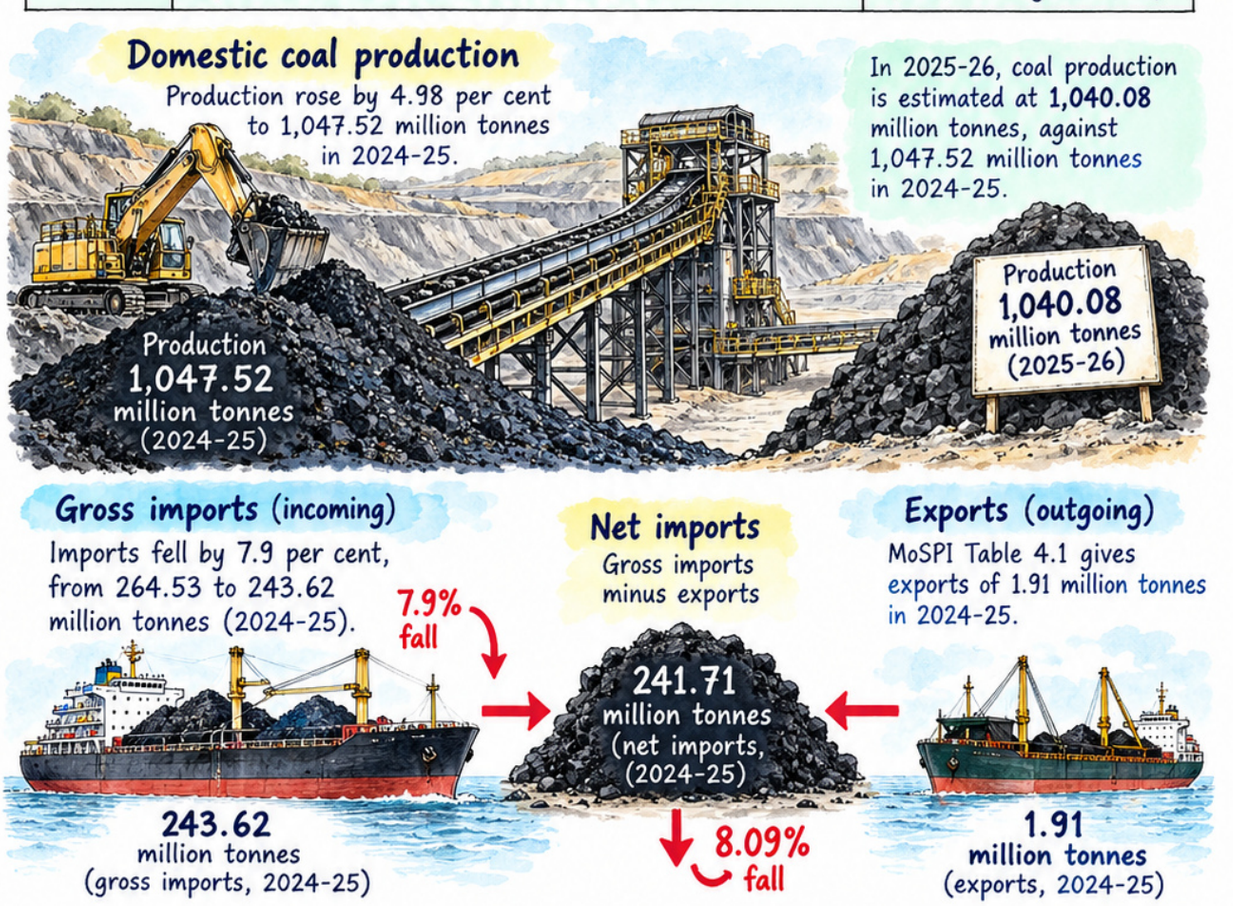
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2.6 Coal gross imports and net imports

2.6 Dependence on imports

Fuel	What the sources say	Year
Coal	Net imports (gross imports minus exports) fell by 8.09 per cent to 241.71 million tonnes; production rose by 4.98 per cent to 1,047.52 million tonnes	2024-25 provisional (MoSPI, Energy Statistics India 2026, Table 4.1 and highlights)
Coal	Imports fell by 7.9 per cent, from 264.53 to 243.62 million tonnes	2024-25 (Ministry of Coal, PIB, 27 May 2025)
Coal	Production of 1,040.08 million tonnes, against 1,047.52 million tonnes in 2024-25	2025-26 (PIB, 13 August 2026)



- Coal is the reverse case: India produces most of the coal it uses. MoSPI Table 4.1 gives gross coal imports of 243.62 million tonnes and exports of 1.91 million tonnes in 2024-25, leaving net imports of 241.71 million tonnes. Gross imports fell by 7.90 per cent; net imports fell by 8.09 per cent. The Ministry of Coal figure of 243.62 million tonnes agrees with MoSPI: these are different measures, not conflicting compilations.
- Oil and gas in detail are in Topic 826, and India's energy resources and import dependence in Topic 226.

Concept illustrations; institutional buildings are schematic.

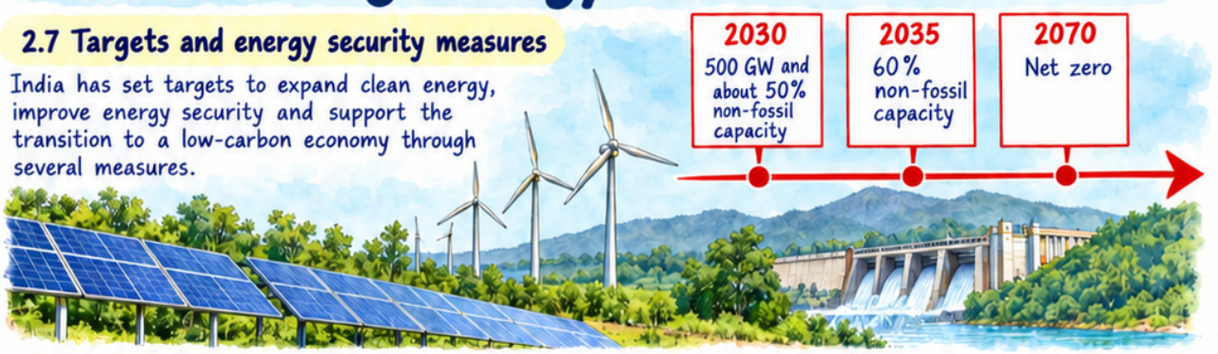
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2.7 Securing energy and the transition

2.7 Targets and energy security measures

India has set targets to expand clean energy, improve energy security and support the transition to a low-carbon economy through several measures.



500 GW target

500 GW: non-fossil capacity of 500 GW by 2030, as in Topic 117.

Updated NDC (August 2022)

About 50 per cent of installed electric power capacity from non-fossil sources by 2030 (2.4).

Later NDC (March 2026)

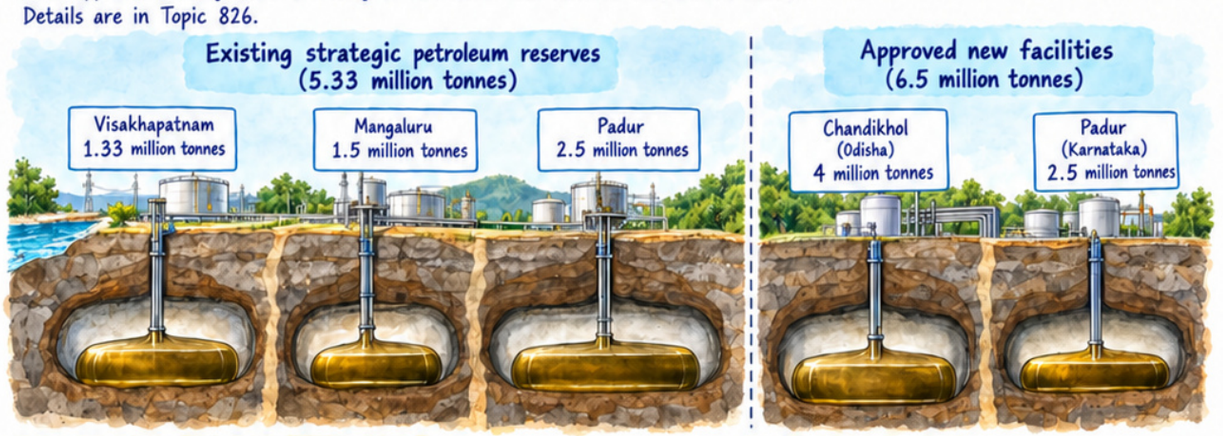
The Ministry of Power stated on 23 July 2026 that the third NDC targets 60 per cent non-fossil installed electric power capacity by 2035. This is a later target, not a replacement of the historical 2030 milestone.

Net zero

Net zero: by 2070.

Strategic Petroleum Reserves

Strategic Petroleum Reserves: reserves of crude oil held by the Government: 5.33 million tonnes at Visakhapatnam (1.33), Mangaluru (1.5) and Padur (2.5). Two more facilities of 6.5 million tonnes, at Chandikhol (Odisha, 4) and Padur (Karmataka, 2.5), were approved in July 2021 (Ministry of Petroleum and Natural Gas, March 2025). Details are in Topic 826.



National Green Hydrogen Mission

National Green Hydrogen Mission: approved in January 2023 with an outlay of ₹19,744 crore; its target is 5 million tonnes of green hydrogen production by 2030 (PIB, August 2026). Details are in Topic 487.



Outlay
₹19,744 crore (approved January 2023)

Target
5 million tonnes of green hydrogen production by 2030 (PIB, August 2026).

Ethanol blending

Ethanol blending: the target is 20 per cent ethanol in petrol (E20). It was first set for 2030 and then advanced to 2025; the Ministry of Petroleum and Natural Gas said on 8 August 2025 that it had already been achieved in the ethanol supply year then running. Details are in Topic 876.



Concept illustrations; institutional buildings are schematic.

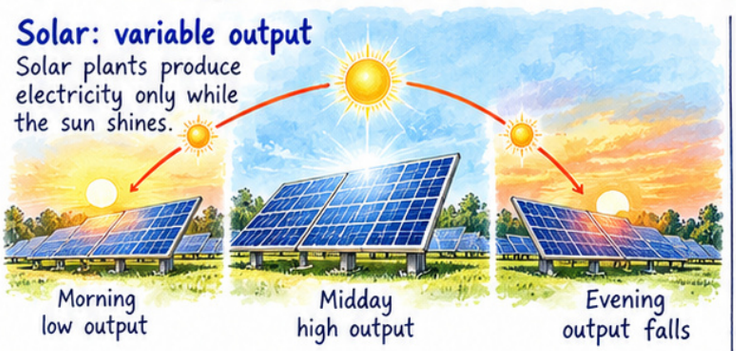
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3 Why capacity shares and output differ

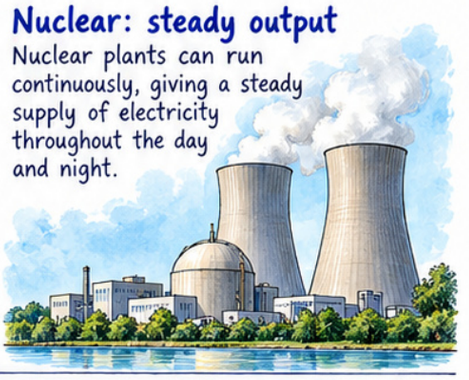
Solar: variable output

Solar plants produce electricity only while the sun shines.



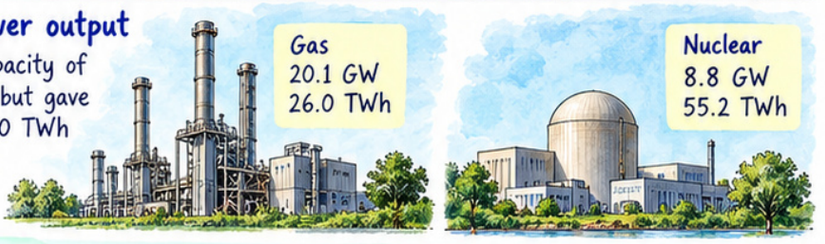
Nuclear: steady output

Nuclear plants can run continuously, giving a steady supply of electricity throughout the day and night.



Gas: higher capacity but lower output

Gas holds more than twice the capacity of nuclear (20.1 GW against 8.8 GW) but gave about half as much electricity (26.0 TWh against 55.2 TWh).



3 Worked examples

Example 1. A share from the generation figures.

Solar gave 174.8 TWh of 1,840.1 TWh in 2025-26:

174.8 ÷ 1,840.1 = 0.095, about 9.5 per cent.

Large hydro gave 167.2 TWh:

167.2 ÷ 1,840.1 = 0.091, about 9.1 per cent.

Solar is now slightly ahead of large hydro, but the two are close.



Example 2. Capacity share against generation share.

Source	Share of capacity (31 March 2026)	Share of generation (2025-26)	Generation share ÷ capacity share (from unrounded values)
Coal	42.9 per cent	69.6 per cent	1.6
Nuclear	1.6 per cent	3.0 per cent	1.8
Large hydro	9.7 per cent	9.1 per cent	0.9
Solar	28.2 per cent	9.5 per cent	0.3
Gas	3.8 per cent	1.4 per cent	0.4

- A ratio above 1 means that the source produces more than its share of capacity would suggest; below 1, less.
- Solar plants produce only while the sun shines, so solar's share of generation is about a third of its share of capacity.

Concept illustrations; institutional buildings are schematic.

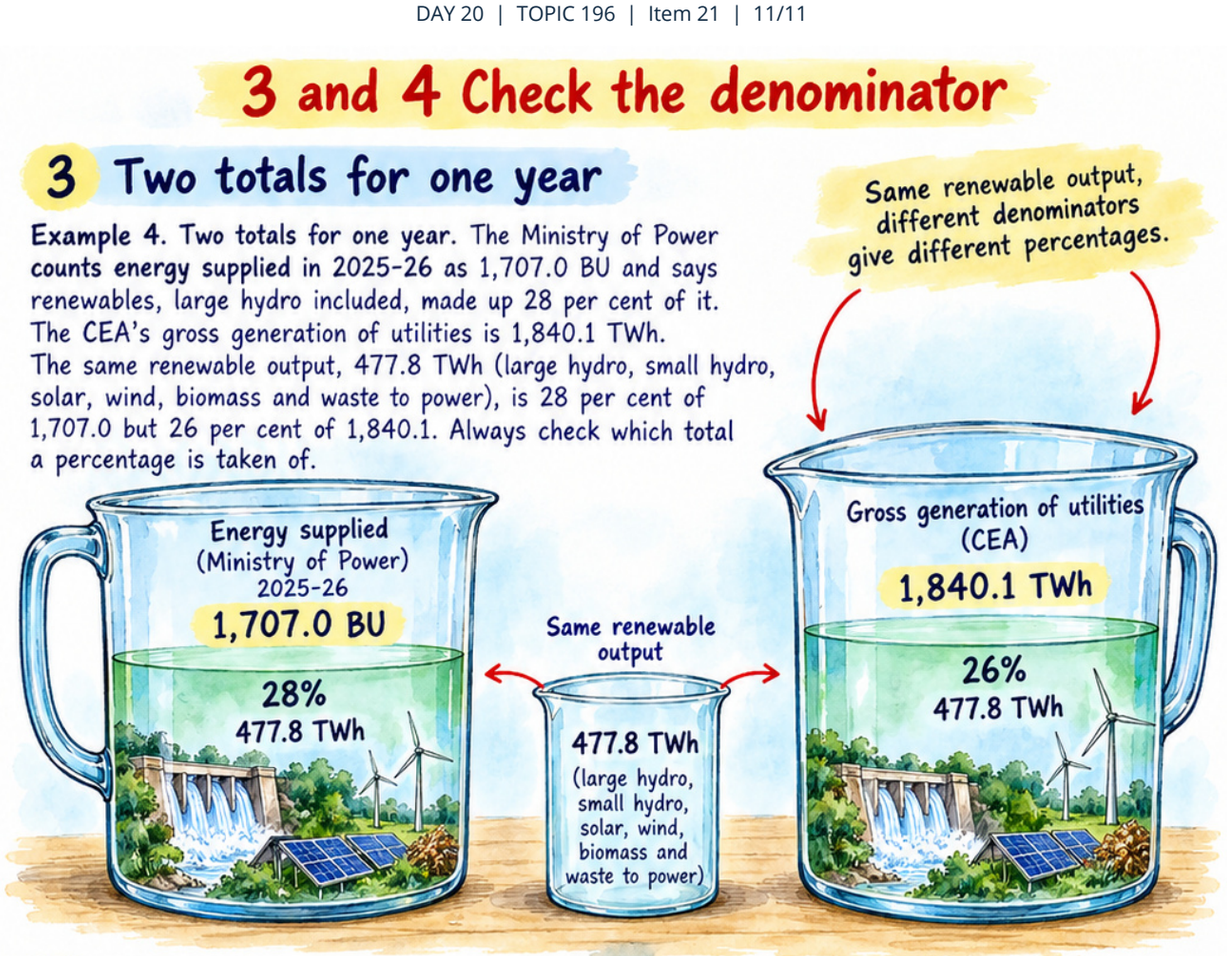
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3 and 4 Check the denominator

3 Two totals for one year

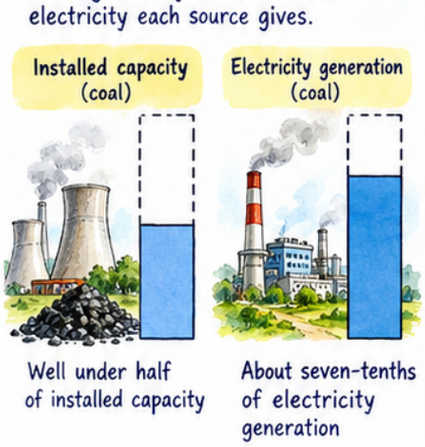
Example 4. Two totals for one year. The Ministry of Power counts energy supplied in 2025-26 as 1,707.0 BU and says renewables, large hydro included, made up 28 per cent of it. The CEA's gross generation of utilities is 1,840.1 TWh. The same renewable output, 477.8 TWh (large hydro, small hydro, solar, wind, biomass and waste to power), is 28 per cent of 1,707.0 but 26 per cent of 1,840.1. Always check which total a percentage is taken of.



4 Three common exam traps

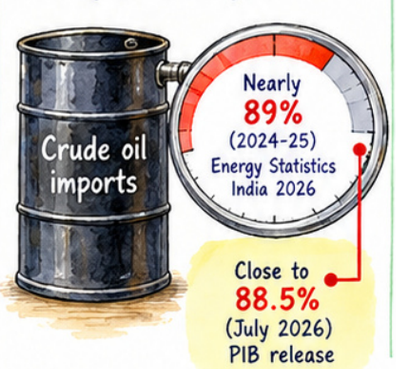
1 Taking a share of capacity for a share of generation.

Coal holds well under half of India's installed capacity but produces about seven-tenths of its electricity. A target written in capacity (the NDC's non-fossil share) says nothing directly about how much electricity each source gives.



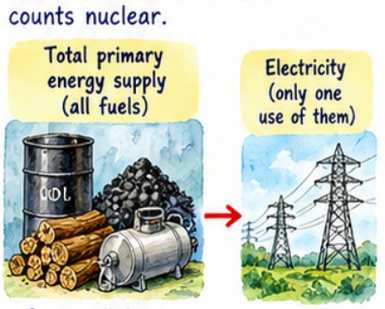
2 Using one import figure for every fuel and every year.

Crude oil is the most import-dependent fuel, while coal is mostly produced at home. For crude oil the figure changes with the source and the year (nearly 89 per cent for 2024-25 in Energy Statistics India 2026; close to 88.5 per cent in a PIB release of July 2026), so learn each figure with its year.



3 Mixing "energy" with "electricity", and one total with another.

Total primary energy supply covers all fuels; electricity is only one use of them. Even within electricity, the Ministry's 28 per cent renewable share is a share of energy supplied (1,707.0 BU), while about 29 per cent non-fossil is a share of gross generation (1,840.1 TWh), which also counts nuclear.



Concept illustrations; institutional buildings are schematic.

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Wild Life (Protection) Act: the legal framework

Day 20 | Topic 197 | Science & Technology | Item 22 | 1/9

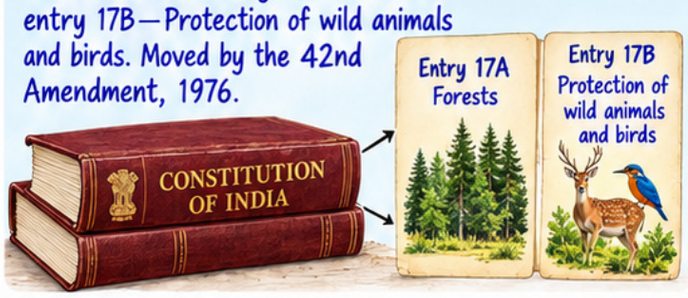
2.1 Wild Life (Protection) Act, 1972

Act No. 53 of 1972 • 9 September 1972

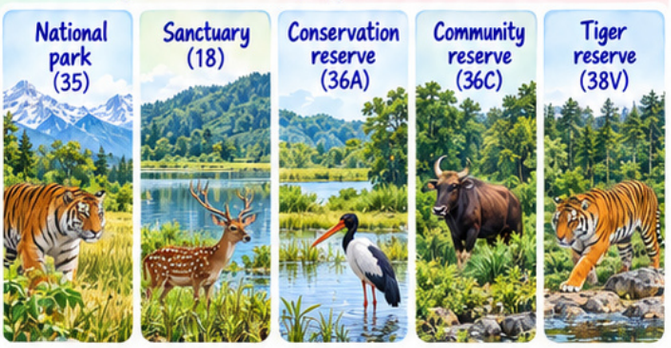
Protects wild animals, birds and plants through Schedules, authorities and protected areas.



Constitutional context: Concurrent List entry 17A—Forests; entry 17B—Protection of wild animals and birds. Moved by the 42nd Amendment, 1976.



Recall Topic 175: sanctuary—section 18; national park—35; conservation reserve—36A; community reserve—36C; tiger reserve—38V.



National park: grazing barred.
Sanctuary: grazing may be regulated, controlled or prohibited.



Topic 157: Environment (Protection) Act, 1986 is a separate umbrella law; Article 48A safeguards forests and wildlife.



Chronology: 1991 amendment—Central Zoo Authority chapter; 2006 amendment—NTCA; 2022 amendment—four Schedules and CITES chapter; effective 1 April 2023.



Read the amended Act, not the old six-Schedule structure.

Concept illustrations; institutional buildings are schematic.

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The 2022 amendment: what changed?

Day 20 | Topic 197 | Science & Technology | Item 22 | 2/9

2.2 Amendment Act 18 of 2022 → in force 1 April 2023



SCHEDULES: six → four.

Two animal lists, one plant list, one CITES specimen list.
No separate vermin Schedule.



CITES: new Chapter VB;

Management Authority—49E;
Scientific Authority—49F.



SANCTUARIES: section 33 now says control, manage and protect; management plans follow Central Government guidelines.



CONSERVATION RESERVES: the Centre can also declare them under section 38(2A), subject to the Act's conditions.



SURRENDER: section 42A; certificate holder gives seven working days' notice to Chief Wild Life Warden. No compensation; State property; certificate cancelled.



INVASIVE ALIEN SPECIES: section 62A; Centre may regulate or prohibit import, trade, possession or proliferation.



FINES increased: see section 51.



Concept illustrations; institutional buildings are schematic.

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The four Schedules: protection is not the same as trade

Day 20 | Topic 197 | Science & Technology | Item 22 | 3/9

2.3 The post-2022 Schedules, effective 1 April 2023

SCHEDULE I: wild animals with greater protection. Section 9 bars hunting, subject to sections 11 and 12. Higher penalties under section 51.



SCHEDULE II: other protected wild animals. Hunting is also barred. Section 62 vermin declarations can be made only from this Schedule.

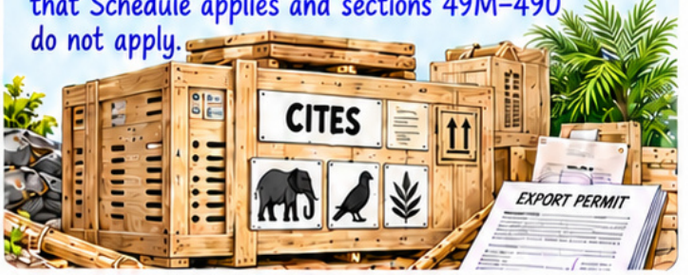


Schedule II normally attracts the general penalty, but sanctuary/national-park hunting still attracts the higher penalty.

SCHEDULE III: specified plants—section 2(27). Section 17A protects them, subject to Chapter IIIA exceptions and permits.



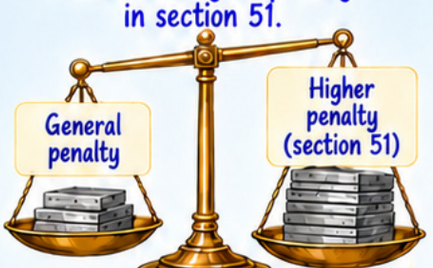
SCHEDULE IV: specimens of species listed in CITES Appendices I, II and III. Live animals fall under section 49M, subject to section 49R: if the species is also in Schedule I or II, that Schedule applies and sections 49M–490 do not apply.



CITES regulates international trade; it is not simply a list of "unprotected foreign animals".



Appendix I specimen offences attract the higher penalty in section 51.



Schedule II normally attracts the general penalty, but sanctuary/national-park hunting still attracts the higher penalty.

Vermin is NOT Schedule IV.



The Act now has four Schedules, not six.



Concept illustrations; institutional buildings are schematic.

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Central Zoo Authority: care, recognition and breeding

Day 20 | Topic 197 | Science & Technology | Item 22 | 5/9

2.4 Central Zoo Authority (CZA)

Constitution — section 38A.
Functions — section 38C.
Zoo recognition — section 38H.



1. Composition and appointment

Constituted by the Central Government; chairperson, up to ten members and a Member-Secretary, all centrally appointed.



2. Minimum standards for zoos

Minimum standards: housing, upkeep and veterinary care of zoo animals.



3. Veterinary care

Minimum standards include veterinary care of zoo animals.



4. Recognition of zoos

Recognises or derecognises zoos. No zoo may operate without CZA recognition.



5. Acquisition, exchange and loans

Coordinates acquisition, exchange and loans of animals for breeding.



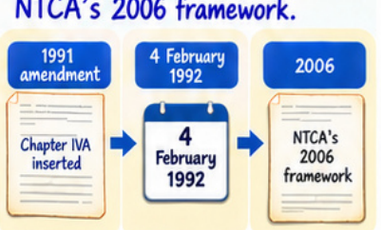
6. Stud-books and breeding

Ensures stud-books of endangered species bred in captivity are maintained. A stud-book records breeding lineage.



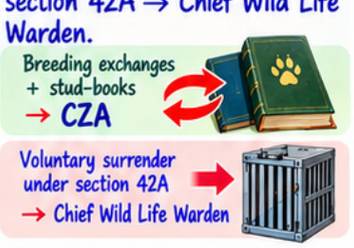
7. Chronology

Chapter IVA inserted by the 1991 amendment; in force from 4 February 1992. Older than NTCA's 2006 framework.



8. MCQ distinction

breeding exchanges + stud-books → CZA. Voluntary surrender under section 42A → Chief Wild Life Warden.



Concept illustrations; institutional buildings are schematic.

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NTCA: conserving tigers and their habitat

Day 20 | Topic 197 | Science & Technology | Item 22 | 6/9

2.4 National Tiger Conservation Authority (NTCA)

Section 38L: constituted by the Central Government under the 2006 amendment.

Section 38O: powers and functions.



Chair and Vice-chair

Chair: Minister in charge of the Ministry of Environment and Forests.

Vice-chair: Minister of State in that Ministry.



Approves the Tiger Conservation Plan prepared by the State Government.



Assesses sustainable ecology; can disallow ecologically unsustainable land use, including mining and industry, within tiger reserves.



Lays down normative standards for tourism activities and guidelines for tiger conservation.



Keep the roles distinct:

State Government prepares Tiger Conservation Plan.



NTCA approves it.



The Prime Minister chairs NBWL, not NTCA.



MCQ distinction:

tiger-reserve plans and unsustainable land use → **NTCA.**

International wildlife-crime coordination → **WCCB.**

Concept illustrations; institutional buildings are schematic.

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2.4 Wildlife Crime Control Bureau (WCCB)

Section 38Y: constituted by Central Government order in the Official Gazette.
Section 38Z: powers and functions.

- Statutory multidisciplinary body under MoEFCC. **Headquarters:** New Delhi.
- Collects and collates intelligence on organised wildlife crime; maintains a centralised wildlife crime data bank.
- Coordinates enforcement; implements India's obligations under international conventions; assists foreign authorities and international organisations.



International coordination and support



Five regional offices: Delhi, Kolkata, Mumbai, Chennai and Bhopal.



Official WCCB RTI account: three sub-regional offices—Guwahati, Amritsar, Cochin; five border units—Moreh, Nathula, Motihari, Gorakhpur, Ramanathapuram.



Do not confuse WCCB's international crime-control role with NTCA's tiger-reserve planning role.

WCCB



- Collects and collates intelligence on organised wildlife crime; maintains a centralised wildlife crime data bank.
- Coordinates enforcement; implements India's obligations under international conventions; assists foreign authorities and international organisations.

Office list: official WCCB organisation account (RTI).

NTCA



- Tiger-reserve planning role.

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CITES authorities, live animals and surrender

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2.4 CITES: Management Authority and Scientific Authority

Both designated by the Central Government.

Section 49E: Management Authority issues trade permits and certificates.

Section 49F: Scientific Authority advises on species survival and trade.

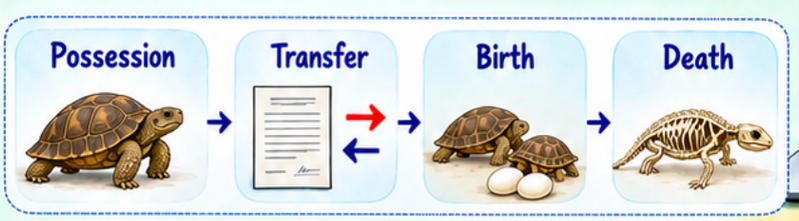


2.6 Live Schedule IV animals: section 49M

Rules notified **28 February 2024.**

Possession, transfer and births are registered; deaths are reported to the State Chief Wild Life Warden through PARIVESH 2.0.

Section 49R: if the species is also in Schedule I or II, those protections apply; sections 49M–49O do not apply.



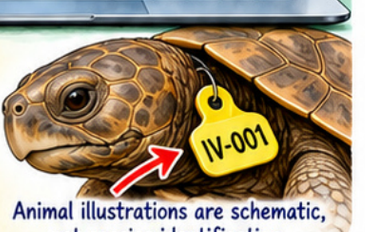


Existing holders: six months from commencement of rules.

Later possession: apply within thirty days.

These are the rule's stated deadlines, not a new grace period.

Section 49P: do not alter, deface, erase or remove identification marks.



Animal illustrations are schematic, not species identification.

2.2 Voluntary surrender: section 42A



Do not confuse a surrender under 42A with registration under 49M.

Concept illustrations; institutional buildings are schematic.

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Penalties, vermin and the final exam traps

Day 20 | Topic 197 | Science & Technology | Item 22 | 9/9

2.5 Section 51: compare the amended fines

GENERAL:
imprisonment up to **3 years OR** fine up to **₹1 lakh OR** both.
The old maximum fine was ₹25,000.



OR



OR



HIGHER-PENALTY OFFENCES:
3–7 years AND fine at least **₹25,000**; old minimum ₹10,000.



AND



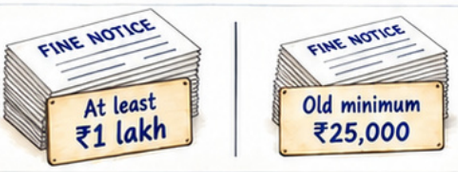
Covers Schedule I animals; hunting in or altering boundaries of a sanctuary/national park; Appendix I specimens of Schedule IV. Appendix I scope was added in 2022.



SECOND / LATER OFFENCE of this kind:
3–7 years AND fine at least **₹1 lakh**; old minimum ₹25,000.



AND



Section 62:

CENTRAL Government may notify a Schedule II animal as vermin for a specified area and period. During that notification it is treated as not in Schedule II.



Section 62A:

Centre may regulate or prohibit threatening invasive alien species.



Three checks:

Schedule III = plants



e.g. blue Vanda

Wardens = State appointments



NBWL chair = Prime Minister



Recent reference:

PIB 3 March 2025 reports the seventh NBWL meeting at Gir, chaired by the Prime Minister.



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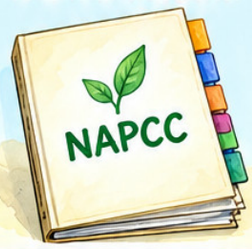
NAPCC: the plan and its governing logic

1 2.1 National Action Plan on Climate Change

13 July 2007 → first meeting of the Prime Minister's Council on Climate Change (PMCCC); it decides to prepare a national document.



30 June 2008 → Prime Minister releases NAPCC with EIGHT National Missions.



December 2008 → mission documents due to PMCCC, with objectives, strategies, timelines and monitoring criteria.



Original objectives covered the remaining 11th Plan and the 12th Plan (2012–13 to 2016–17).



PMCCC → overall oversight and periodic review.



Nodal ministries → implement their missions and publicly report annual performance.



2 2.2 Co-benefits approach

Choose measures that advance development AND address climate change.



Development benefits

Co-benefits approach



Climate change benefits



Adaptation: adjust to climate-change effects.



Mitigation: cut the emissions causing climate change.



India's per-capita pledge: its per-capita greenhouse gas emissions will at no point exceed those of developed countries.

CBDR-RC: common but differentiated responsibilities and respective capabilities.



Recall Topic 96: warming; Topic 107: UNFCCC and Paris Agreement; Topic 117: solar mission; Topic 196: energy mix.

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Seven principles: development with climate safeguards

2.2 Principles in the original NAPCC

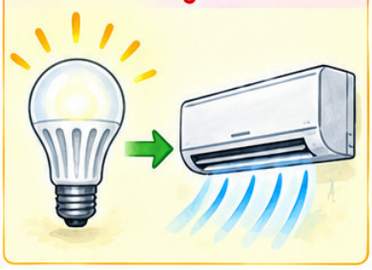
1. Protect poor and vulnerable groups through inclusive, climate-sensitive sustainable development.



2. Meet national growth objectives through a qualitative change that improves ecological sustainability.



3. Use efficient, cost-effective strategies for end-use demand-side management.



4. Deploy appropriate adaptation and mitigation technologies widely and rapidly.



5. Use innovative market, regulatory and voluntary mechanisms for sustainable development.



6. Link implementation with civil society, local government and public-private partnerships.



7. Welcome international cooperation for research, development, technology sharing and transfer, with additional funding and a supportive global intellectual-property regime.



The 2021 MoEFCC FAQ lists the first SIX only.
The seventh in the original plan is **INTERNATIONAL COOPERATION**.

Co-benefits is the plan's **APPROACH**, not an eighth principle.
Adaptation versus mitigation: different purposes can coexist.

Illustrative adaptation: rainwater storage helps manage drought impacts.



Illustrative mitigation: energy-efficient equipment reduces energy demand and associated emissions.



Do not infer that every mission belongs exclusively to just one category.

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Eight original missions: who leads what?

2.3–2.4 Original NAPCC mission–ministry matrix

1	National Solar Mission	Ministry of New and Renewable Energy (MNRE)	raise solar's share in the energy mix.
2	National Mission for Enhanced Energy Efficiency (NMEEE)	Ministry of Power, through Bureau of Energy Efficiency (BEE)	certified savings, efficient appliances and finance.
3	National Mission on Sustainable Habitat (NMSH)	Ministry of Housing and Urban Affairs (MoHUA)	buildings, waste and urban transport.
4	National Water Mission (NWM)	Ministry of Jal Shakti, Department of Water Resources, River Development and Ganga Rejuvenation	efficient water use.
5	National Mission for Sustaining the Himalayan Ecosystem (NMSHE)	Department of Science and Technology (DST)	glacier assessment, monitoring and community management.
6	National Mission for a Green India (GIM)	MoEFCC	forest/tree cover and forest quality.
7	National Mission for Sustainable Agriculture (NMSA)	Ministry of Agriculture and Farmers Welfare	climate-resilient farming.
8	National Mission on Strategic Knowledge for Climate Change (NMSKCC)	Department of Science and Technology (DST)	human and institutional climate-science capacity.










DST leads TWO missions: Himalayan ecosystem AND strategic knowledge.

MoEFCC coordinates the plan but does NOT run all eight missions.

Later human-health addition is separate from the original eight.

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Solar and energy efficiency: supply versus demand

2.3-2.5 National Solar Mission • MNRE

Goal: raise solar's share in the energy mix.

Original 2008 plan targets for 2017:

at least 1,000 MW concentrating solar power; local production of 1,000 MW of photovoltaic capacity per year.



Concentrating solar power

Photovoltaic (PV) solar cells

Later solar capacity target:

20 GW by 2022, raised in 2015 to 100 GW by 2022.

20 GW by 2022 → **100 GW by 2022**

These are dated TARGETS, not achievement claims.



NMEEE • Ministry of Power through BEE • implemented since 2011

Four initiatives:

- **PAT:** Perform, Achieve and Trade.
- **MTEE:** Market Transformation for Energy Efficiency.
- **EEFP:** Energy Efficiency Financing Platform.
- **FEEED:** Framework for Energy Efficient Economic Development.

PAT mechanism:



designated energy-intensive consumers receive targets → Target → certified energy savings → ESCerts energy saving certificates (ESCerts) → certificates can be traded.

Other NMEEE tools:



faster adoption of efficient appliances

demand-side finance from future savings

TAX

and fiscal instruments.

BEE dashboard labelled 2025:

- **1,333** energy-intensive industries
- **55%** of industrial energy use
- savings of **25.78** million tonnes of oil equivalent.

Solar adds clean energy supply; efficiency lowers energy needed for a service.
Do not equate installed capacity with electricity generation.

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Habitat and water: efficient cities and resource use

2.3–2.5 Sustainable Habitat • MoHUA

Approved by PMCCC in June 2010.

Three parts:

1. Extend Energy Conservation Building Code (ECBC) to more buildings.



2. Urban waste management, including energy from waste.



3. Better urban planning and a shift to public transport.



Works through AMRUT, Swachh Bharat Mission and Smart Cities Mission.

National Water Mission • Ministry of Jal Shakti

FIVE GOALS

1. Comprehensive public water database AND assessment of climate-change impacts on water resources.



2. Citizen and State action for conservation.



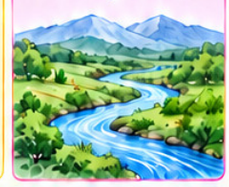
3. Attention to vulnerable areas, including over-exploited areas.



4. Increase water-use efficiency by 20%



5. Basin-level water-resource management.



State Specific Action Plan grants: ₹50 lakh for a major State. ₹30 lakh for a minor State.

20% is a mission target, not a measured achievement here.

Jal Shakti Abhiyan: Catch the Rain began in 2021, promoting rainwater harvesting.



Water conservation, information and basin management are **complementary**; no single city building represents the whole mission.



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Two DST missions: monitoring versus knowledge

2.3–2.5 Department of Science and Technology leads BOTH

1 NMSHE: National Mission for Sustaining the Himalayan Ecosystem

Assess whether, and how far, Himalayan glaciers are receding.
Build a monitoring network.
Promote community-based ecosystem management.



Monitoring network on Himalayan glaciers → Observations from the network → Assessment of whether, and how far, glaciers are receding.

2 NMSKCC: National Mission on Strategic Knowledge for Climate Change

Build human and institutional capacity in climate science and technology.
Climate Science Research Fund; university climate-research units; private innovation through venture capital.



University climate-research units → Climate Science Research Fund → Private innovation through venture capital

Original knowledge targets:

- At least 10 thematic knowledge networks.
- 50 chair professorships.
- About 200 trained professionals.
- At least 3 public-private partnerships.

Reported 30 July 2025:

DST had established 18 Centres of Excellence under NMSKCC.



Do not confuse a TARGET count with a reported institution count:
18 Centres of Excellence is not the same measure as 10 thematic networks.

Both use networks, but their purposes differ.
Matching trap: monitoring + community management → HIMALAYAN.
Thematic networks + chairs + trained professionals → STRATEGIC KNOWLEDGE.

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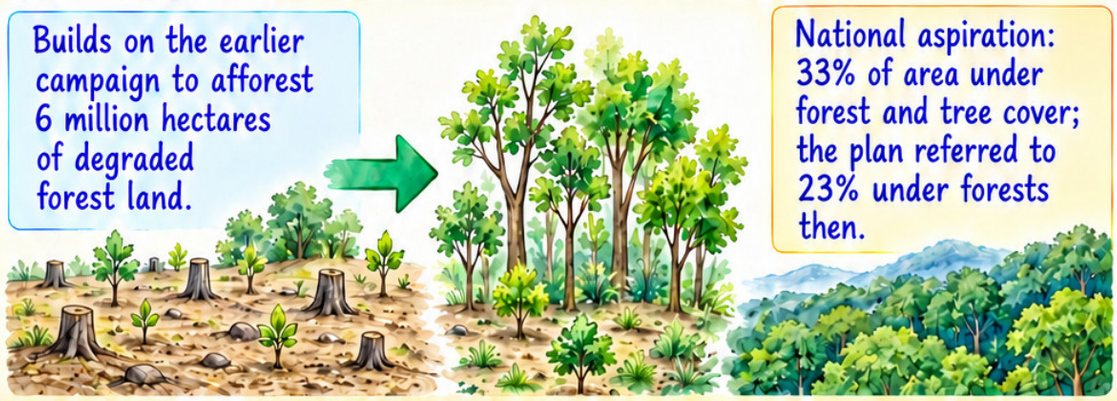
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Green India: keep three target frameworks separate

2.3–2.5 Green India Mission • MoEFCC

A Original NAPCC context (2008)

Builds on the earlier campaign to afforest 6 million hectares of degraded forest land.



National aspiration: 33% of area under forest and tree cover; the plan referred to 23% under forests then.

B Mission objectives in MoEFCC's 2021 FAQ

5 million ha: INCREASE forest/tree cover.



Another 5 million ha: IMPROVE forest quality.



Together 10 million ha, not 10 million ha of new forest.

Higher forest-based livelihood income for about 3 million households.

Annual CO_2 sequestration increase of 50–60 million tonnes by 2020: a historical TARGET, not an achievement statement.

C Revised mission document: 2021–2030

TARGET: afforestation/restoration interventions over 24 million ha through GIM and converging schemes (2021–2030).
Portal: 20–24 million ha by 2030.
NOT total national forest cover or achieved area.

Additional carbon sink target: 2.5–3 billion tonnes CO_2 equivalent by 2030.



Implementation report, 24 July 2025: ₹982.34 crore released to 17 States and one UT.



Finance released ≠ area restored ≠ carbon sink achieved.

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Agriculture, State plans and adaptation finance

2.3-2.6 Sustainable Agriculture • operational 2014-15

NMSA: Ministry of Agriculture and Farmers Welfare.

Climate-resilient crops, including heat-tolerant varieties; improved rainfed productivity; better credit and insurance.

Soil health and farm water management; Soil Health Cards issued since February 2015.

Schemes include Per Drop More Crop and Rainfed Area Development.

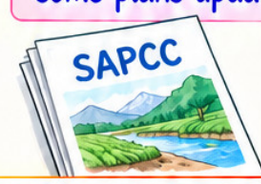


State Action Plans on Climate Change (SAPCCs)

State/UT plans align with NAPCC; they are not separate national missions.

July 2015: about 27 States + 5 UTs. → March 2022: 33 States/UTs. → 18 August 2025: 34 States/UTs; some plans updated.

Assam SAPCC 2.0 covers 2021–2030.



National Adaptation Fund on Climate Change (NAFCC)

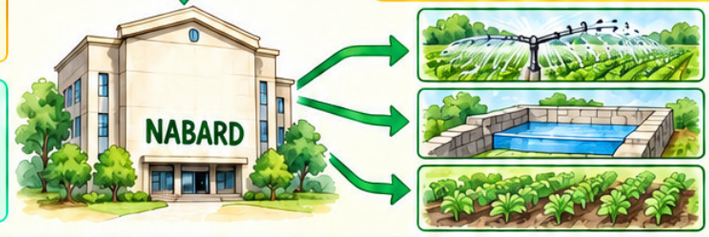
Central Sector Scheme, approved July 2015; set up 2015–16.

NABARD was appointed National Implementing Entity.

By February 2018: 23 projects sanctioned, ₹236.32 crore. Andhra Pradesh received one in 2016–17.

₹350 crore for 2015–16 and 2016–17.

Supports concrete adaptation projects in particularly vulnerable States/UTs.



These are dated scheme records, not a claim about a new 2026 allocation.

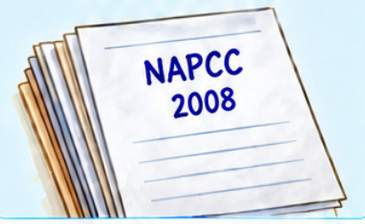
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Eight in 2008; health added in later reporting

1 2.7 The health distinction

Original NAPCC, 2008: EIGHT missions.



Official releases of 2023 and 2025: NINE areas/missions, adding human health.



National Programme on Climate Change and Human Health (NPCCHH): Ministry of Health and Family Welfare; reported in all 36 States/UTs.



2 Original eight missions (2008) and the later addition

Eight missions in the original 2008 NAPCC



Human health added in later reporting



(included in official reporting of 2023/2025)

3 Key points from official information

MoEFCC reply, 24 July 2025: six of nine focus on adaptation and climate resilience of vulnerable communities.

The reply does not name those six—do not invent a six-mission list.



2022–2023 releases describe NAPCC as an overarching framework for climate actions.

July–August 2025 replies report mission progress, without announcing a revised NAPCC.



4 Chronology checkpoints



5 Exam checks

Original 2008 plan → eight.

Later official list → nine, with health.

A revised individual mission document is not automatically a revised entire NAPCC. Do not confuse NAPCC missions with NDC target years.

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India's climate targets: two different periods

2.7 Dated NDC comparison • TARGETS, not achievements

August 2022 update — targets for 2030

GDP emissions intensity	**45%** below the 2005 level.	↓ 45% below 2005 in 2030
Non-fossil sources	About **50%** of cumulative installed electric-power capacity, supported by technology transfer and low-cost international finance, including the Green Climate Fund.	
Forest/ tree cover	An additional carbon sink of **2.5–3** billion tonnes CO_2 equivalent by 2030.	

April 2026 NDC — targets for 2035 (period 2031–2035)

GDP emissions intensity	**47%** below the 2005 level.	↓ 47% below 2005 in 2035
Non-fossil sources	About **60%** of cumulative installed electric-power capacity, supported by technology transfer and low-cost international finance.	
Forest/ tree cover	Carbon sink of **3.5–4.0** billion tonnes CO_2 equivalent relative to the 2005 baseline by 2035.	

Read the measure

- Intensity = emissions per unit of GDP, NOT an absolute emissions-cut pledge.
- Installed capacity ≠ electricity generated.
- These are **TARGETS**, not claims that each has been achieved.

Keep the August 2022 targets for 2030 separate from the April 2026 targets for 2035.

Long-term goal: net zero by 2070.
LiFE: Lifestyle for Environment.

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Heat moves in three ways

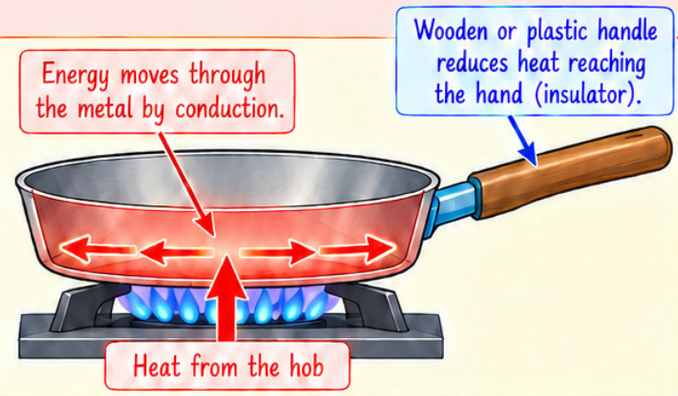
Physics at home connects a device or everyday event to a physical principle. Start by identifying what moves: energy, light, charge, matter or a wave.

1 CONDUCTION

Energy passes through material without bulk movement of the material.

A metal pan conducts heat; a wooden or suitable plastic handle reduces heat reaching the hand.

Copper spreads heat across a pot base and helps make heating more uniform.

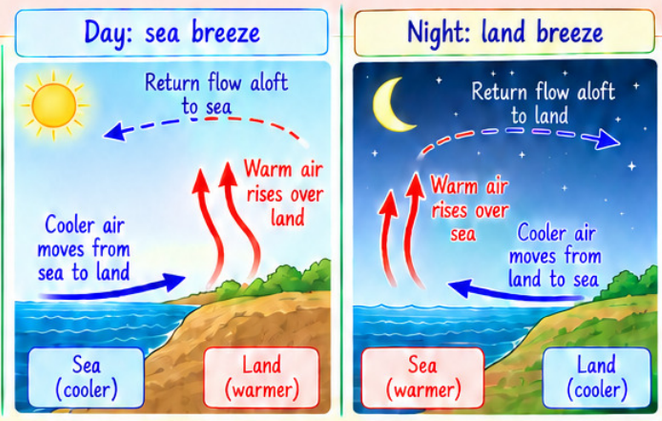


2 CONVECTION

Heat is carried by the actual motion of a liquid or gas.

By day, land heats faster than the sea. Air over land warms and rises; cooler air from the sea moves toward land: sea breeze.

At night, land cools faster; air near the warmer sea rises and cooler air flows from land to sea: land breeze.

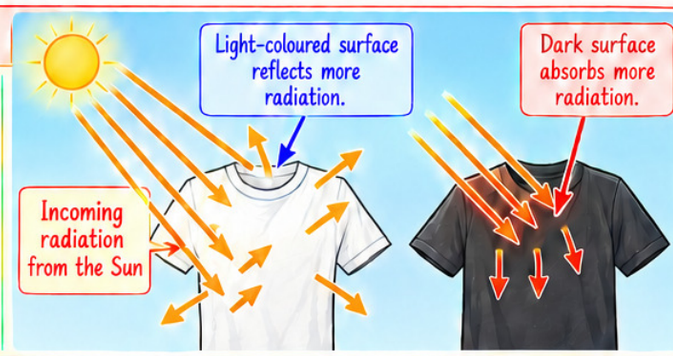


3 RADIATION

Energy can travel without a material medium.

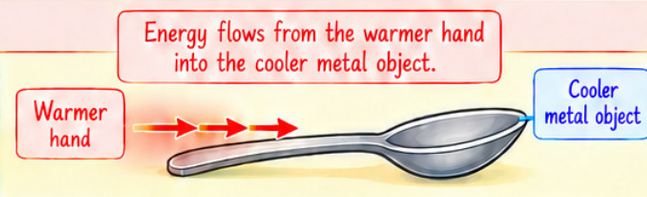
Light-coloured surfaces generally reflect more incident radiation; dark surfaces absorb more.

This explains the textbook summer-clothing comparison.



4 HEAT, NOT COLD

A cool metal object feels cold because energy flows from the warmer hand into it. There is no substance called cold flowing into the hand.



Read each example as a process, not just a memorised device name.

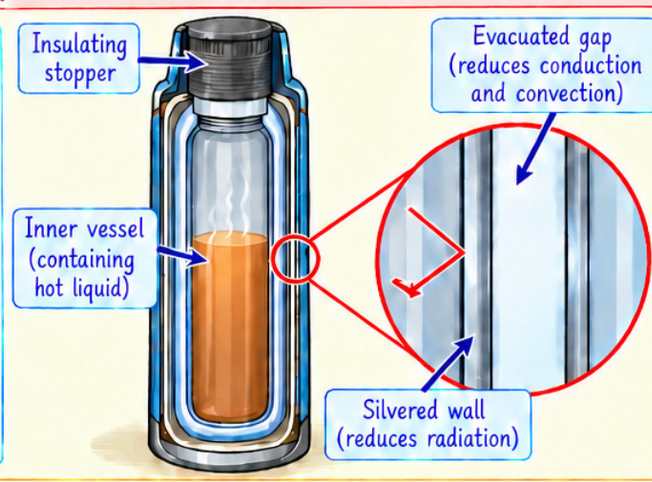
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Keeping heat in; letting heat escape

1 VACUUM FLASK

Different features reduce different modes of heat transfer. Its double wall encloses an evacuated space, reducing conduction and convection through that space. Silvered surfaces reduce transfer by radiation. The insulating stopper also limits heat transfer.
A flask slows heat exchange; it does not create heat or cold.



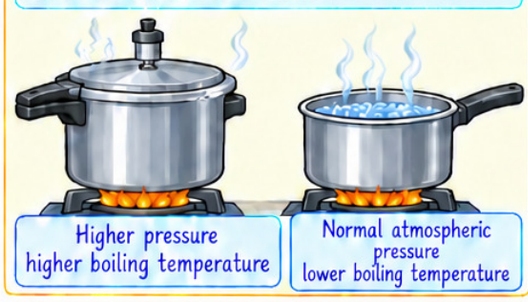
2 EARTHEN POT

Some water seeps through the pot surface and evaporates. Evaporation takes energy from the pot and remaining water, cooling the water inside. Sweating cools for the same reason. Moving air from a fan helps sweat evaporate.



3 PRESSURE COOKER

Increasing pressure raises water's boiling temperature. Food can therefore cook at a higher temperature than in an open pot at the same location. The key mechanism is the higher boiling point, not merely a thick lid or a hotter flame.



4 COOKING ON HILLS

Atmospheric pressure is lower at high altitude. Water boils at a lower temperature, so boiling food can take longer even though the water is visibly boiling.



5 COMPARE

Flask: reduce heat transfer.
Matka: encourage evaporative cooling.
Pressure cooker: increase boiling temperature by increasing pressure.

Use cookers only according to the manufacturer's instructions; this is a concept diagram, not a modification guide.

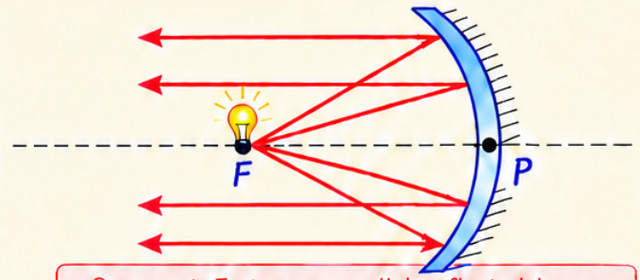
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Mirrors: match shape to function

1 Concave mirror

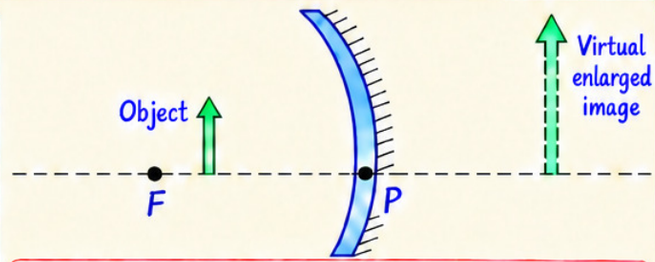
Its reflecting surface curves inward. A light source at the principal focus gives an approximately parallel reflected beam. This is the school explanation for torches, searchlights and vehicle headlights.



Source at F gives a parallel reflected beam.

2 Magnified view

A concave mirror gives a larger, erect, virtual image when the object is between its pole and focus. That condition matters for a shaving or dentist's mirror. It does not give an erect enlarged image at every object distance.

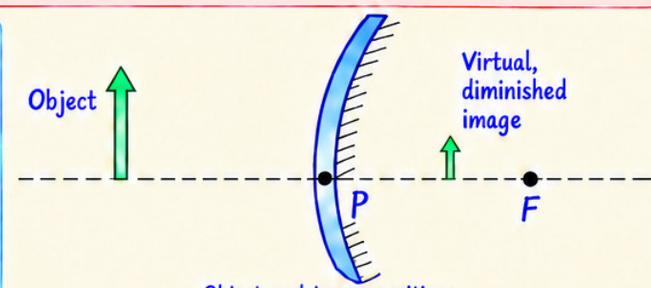


Object between P and F gives a larger, erect, virtual image.

Object and image positions

3 Convex mirror

Its reflecting surface bulges outward. It forms an erect, virtual and diminished image and provides a wider field of view. That is why the textbook uses a convex mirror as a vehicle rear-view or wing mirror.



Object and image positions

4 Do not swap

Concave: converging mirror; parallel beam when source is at focus, or magnified near-object viewing.

Convex: wider field and a smaller upright image.

5 Ray language

A solid ray is an actual light path. A dotted backward extension locates a virtual image; light does not actually travel along that extension behind the mirror.

Actual ray (solid line)

Backward extension (dotted line)

Reflection changes a ray's direction at a surface. It is not the same process as refraction through a lens.

Concept illustrations are schematic; not historical reconstructions.

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Lenses, vision and power

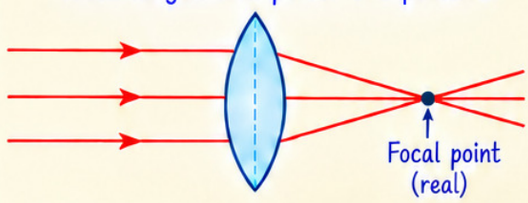
1 Lens power

$P = \frac{1}{f}$, where focal length f is in metres.
Power is measured in dioptres, symbol D.
A focal length of 1 m corresponds to a power of 1 D.

2 Convex and concave lenses

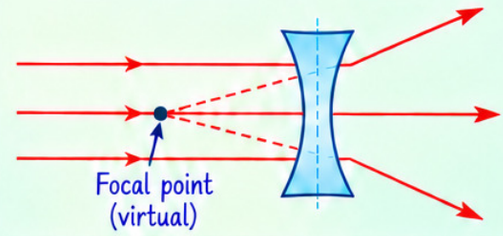
Convex lens

Thicker at its centre: converging lens.
Under the school sign convention, focal length and power are positive.



Concave lens

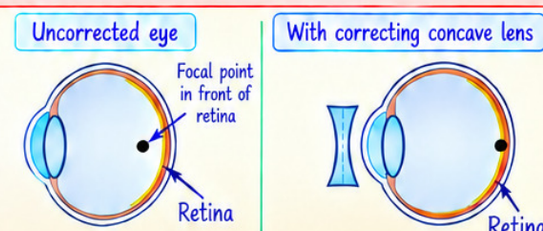
Thinner at its centre: diverging lens.
Its focal length and power are negative.



3 Myopia (short-sightedness)

A short-sighted person sees nearby objects clearly but distant objects indistinctly.

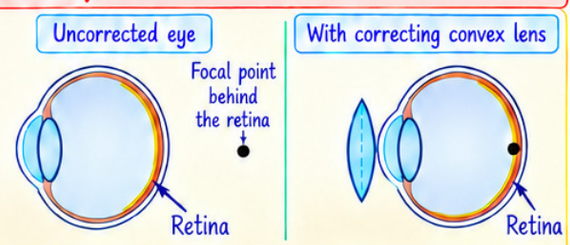
The uncorrected eye focuses distant light in front of the retina. A suitable concave lens diverges the incoming rays so that the eye focuses them on the retina. The spectacle power is negative.



4 Hypermetropia (long-sightedness)

A long-sighted person has difficulty seeing nearby objects distinctly.

A suitable convex lens helps the eye focus light from a nearby object on the retina.
The spectacle power is positive.



5 Illustrative power calculation

$f = +0.50$ m gives $P = +2$ D.

$f = -0.50$ m gives $P = -2$ D.

Metres are essential: do not substitute 50 cm as 50 in $P = 1/f$.
This is an optics lesson, not a personal spectacle prescription.

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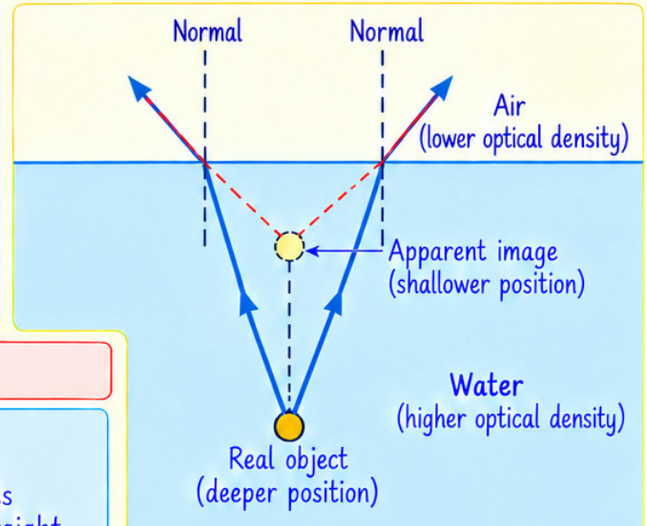
Refraction and total internal reflection

1 REFRACTION

Light changes direction when it crosses between media at an oblique angle because its speed changes.

A partly submerged pencil appears displaced at the water surface.

A pond bottom appears closer to the surface than its real position.

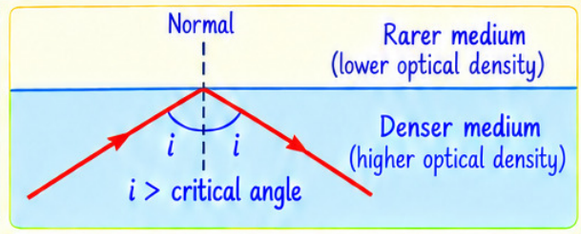


2 APPARENT DEPTH

Light from the underwater object bends away from the normal as it leaves water for air. The eye traces the emerging rays backward in straight lines, locating an apparent image above the real object.

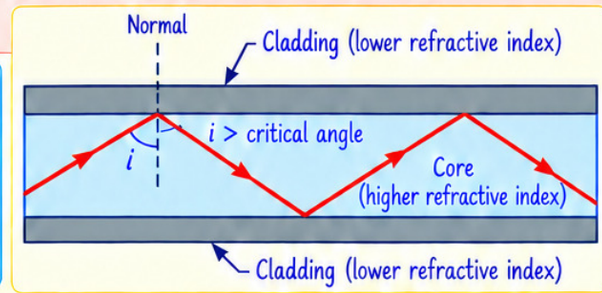
3 TOTAL INTERNAL REFLECTION

Two conditions are required: light must travel from an optically denser medium to a rarer medium, and its angle of incidence must exceed the critical angle. The angle is measured from the normal, not from the surface.



4 OPTICAL FIBRE

The core has a higher refractive index than the cladding. Rays satisfying the total-internal-reflection condition remain guided by repeated reflections at that boundary. The cladding is not a mirror coating.



5 DIAMOND

Multiple internal reflections contribute to its brilliance. Do not identify every reflection as refraction.



6 COMPARE

Refraction crosses a boundary with a transmitted ray.

Total internal reflection sends the light back into the denser medium under the stated conditions.

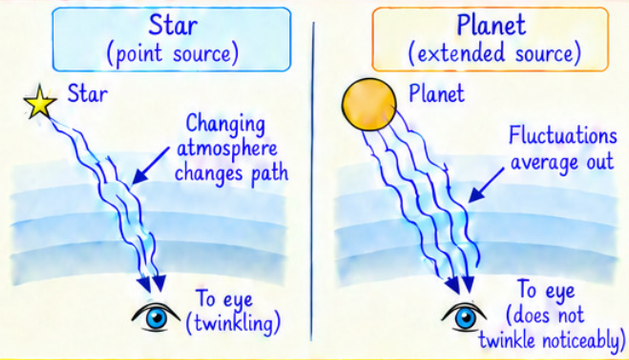
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Why sky, stars and rainbows look different

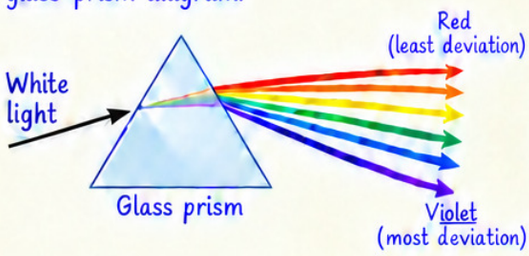
1 ATMOSPHERIC REFRACTION

A star is so distant that it behaves approximately as a point source. Changing atmospheric conditions change the path and amount of starlight reaching the eye, producing twinkling. A planet is an extended source; fluctuations from different parts tend to average out, so planets generally do not twinkle noticeably.



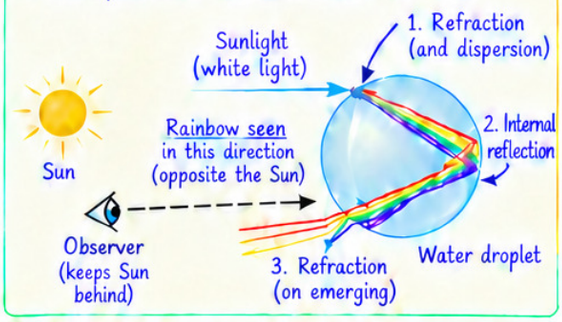
2 DISPERSION

White light contains different colours. A prism separates them because different wavelengths are refracted by different amounts. Red deviates less than violet in the usual glass-prism diagram.



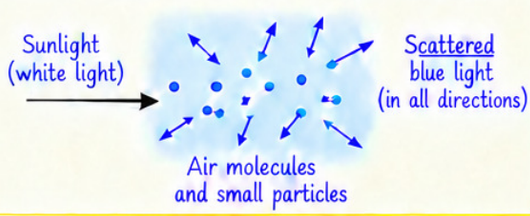
3 RAINBOW

Water droplets refract and disperse sunlight, reflect it internally and refract it again as it emerges. The rainbow is seen in the direction opposite the Sun. Keep the Sun behind the observer in the schematic; do not place the rainbow beside the Sun.



4 SCATTERING

Small particles and molecules scatter shorter-wavelength blue light more strongly than red light. Scattered light makes a clear daytime sky blue.



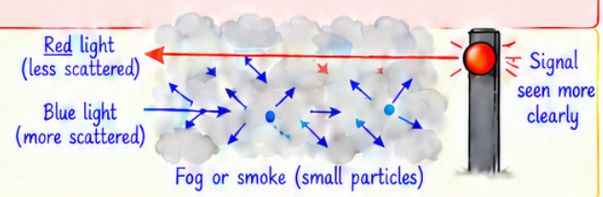
5 SUNRISE AND SUNSET

Light near the horizon travels a longer path through the atmosphere. More shorter-wavelength light is scattered away, so transmitted sunlight looks reddish.



6 RED SIGNALS

NCERT explains that red is scattered less than shorter visible wavelengths by fog or smoke. Refraction, dispersion and scattering are different processes.



Concept illustrations are schematic; not historical reconstructions.

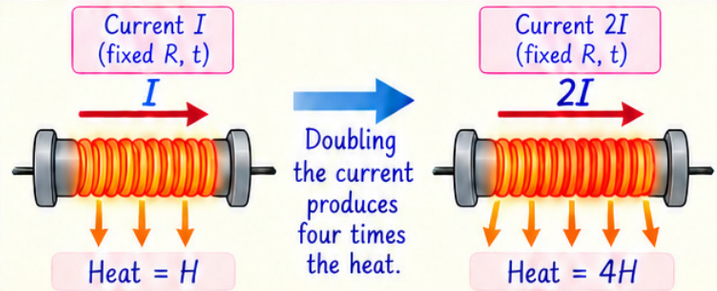
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AIM. PREPARE. ACHIEVE

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DAY 22 | TOPIC 217 | Science | Item 18 | 217.07

Current produces heat; energy earns a bill

1 JOULE HEATING | $H = I^2Rt$

Heat produced depends on the square of current I, resistance R and time t. With R and t fixed, doubling the current produces four times the heat.



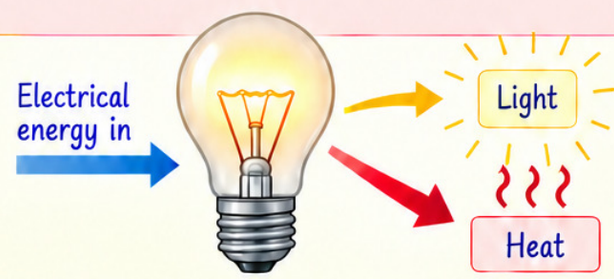
2 EVERYDAY USES

An electric iron, toaster, oven, kettle and heater use the heating effect of current. The resistance element becomes hot and transfers energy to its surroundings.



3 FILAMENT BULB

Tungsten tolerates very high temperatures; NCERT gives its melting point as 3380°C. A hot filament emits light, but much of its input energy becomes heat. Bright glow is not proof that most energy becomes visible light.



4 POWER IS A RATE

The watt and kilowatt measure power. Energy depends on both power and operating time: energy = power × time.

energy = power × time

Power (watt, kilowatt) → × Time (second, hour) → Energy (J or kWh)

W × s = J; kW × h = kWh

5 ONE ELECTRICITY UNIT

1 kilowatt hour = the energy used by a 1 kW appliance in one hour.
1 kWh = 1000 J/s × 3600 s
= 3.6 × 10^6 J.

$$1\ \text{kWh} = 1000\ \text{J/s} \times 3600\ \text{s} = 3.6 \times 10^6\ \text{J}$$

6 WORKED COMPARISON

A 2 kW heater used for half an hour consumes 1 kWh. A 100 W lamp used for ten hours also consumes 1 kWh. Equal energy does not mean equal power.



Do not call kWh a unit of power.

Concept illustrations are schematic; not historical reconstructions.

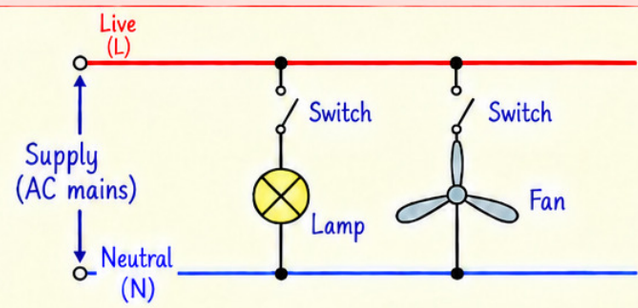
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Household circuits and three kinds of protection

1 PARALLEL CIRCUITS

Household appliances are connected in parallel so each branch receives the same potential difference and can be controlled independently. A series break would interrupt the single path through every component.

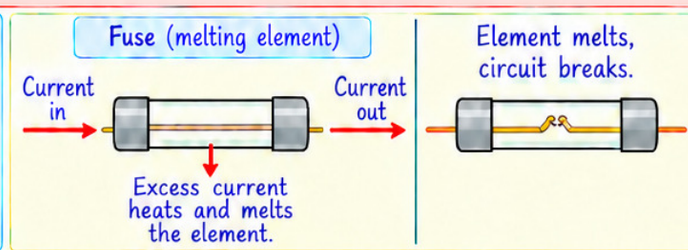


2 TEXTBOOK SUPPLY

The NCERT domestic-circuit example gives 220 V, 50 Hz, red live, black neutral and green earth; it distinguishes 5 A and 15 A circuits. These are textbook labels, not a universal present-day wiring identification guide. Actual installation standards and appliance ratings must be followed by a qualified electrician.

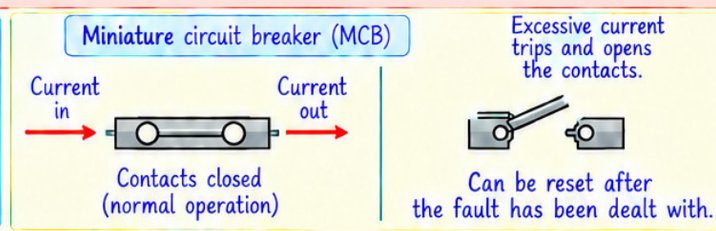
3 FUSE

A correctly rated fuse is placed in series in the protected circuit. Excess current heats and melts its element, breaking the circuit. It must be replaced with the specified type and rating, never arbitrary wire.



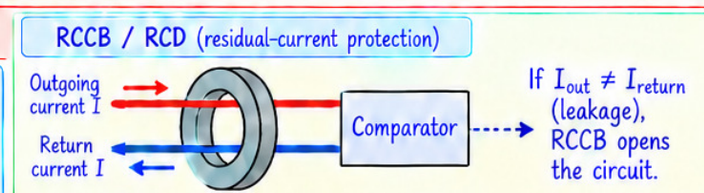
4 MCB

A miniature circuit breaker automatically opens when excessive current occurs. Unlike a melted fuse, it can be reset after the fault has been dealt with.



5 RCCB / RCD

Residual-current protection detects current imbalance that can indicate leakage. An RCCB does not itself provide overload/short-circuit protection. An RCBO combines residual-current and overcurrent protection.



RCBO (combined protection)
An RCBO combines residual-current and overcurrent protection.

6 SHORT CIRCUIT ≠ OVERLOAD



Concept illustrations are schematic; not historical reconstructions.

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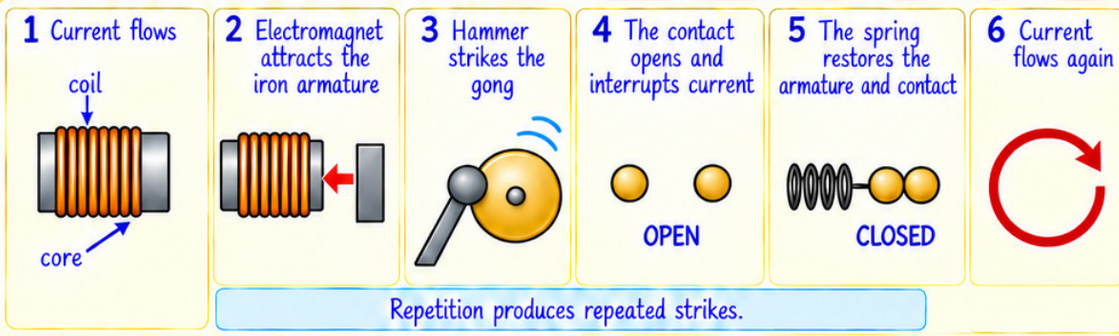
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Magnetism: a bell and an induction pan

1 ELECTROMAGNET

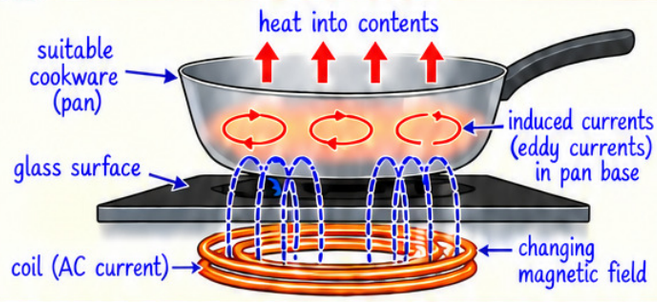
A current-carrying coil around a soft-iron core can act as a magnet. Switching the current off removes most of its magnetism, making it useful for repeated switching.

2 ELECTRIC BELL CYCLE



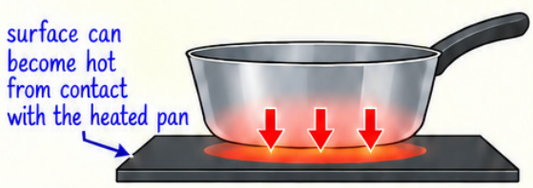
The bell uses the magnetic effect of current. Its make-and-break mechanism is essential; a permanently closed contact would not explain repeated striking.

3 INDUCTION COOKTOP



Alternating current in a coil below the cooking surface produces a changing magnetic field. This induces circulating currents in suitable cookware; electrical resistance causes heating in the cookware itself.

4 COOKWARE MATTERS



The pan must be compatible with the induction hob. Do not assume every metal pot works on every induction plate. The surface can become hot from contact with the heated pan even though the pan is heated electromagnetically.

5 COMPARE THE PROCESSES

Bell:	current	→ magnetic attraction	→ movement and contact switching.
Induction:	changing current	→ changing magnetic field	→ induced current and heating.

Both use electromagnetism, but neither is explained by simply saying that a magnet makes heat.

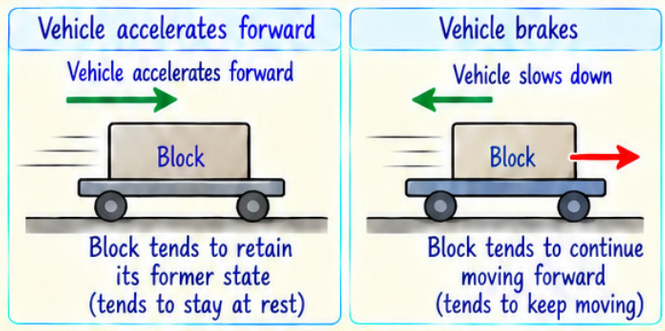
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DAY 22 | TOPIC 217 | Science | Item 18 | 217.10

Inertia, reaction and friction

1 INERTIA

Without a net external force, a body remains at rest or continues in uniform straight-line motion. Mass measures inertia. When a vehicle accelerates forward, the upper body tends to retain its former state; when it brakes, the body tends to continue moving forward.



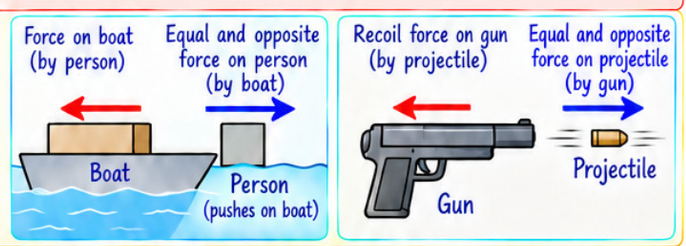
2 SEAT BELT

A belt supplies a restraining force that slows the occupant with the vehicle. It does not remove inertia.



3 ACTION-REACTION

Interacting bodies exert equal and opposite forces on each other. A boat moves backward as a person pushes it while jumping forward. A gun recoils while exerting a forward force on the projectile.



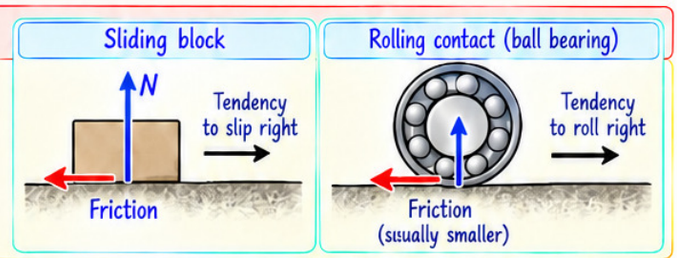
4 WHY THEY DO NOT CANCEL ON ONE BODY

The paired forces act on different bodies. Never put both arrows on the same body's force diagram and call them an action-reaction pair.

These two forces act on different bodies, not on the same body.

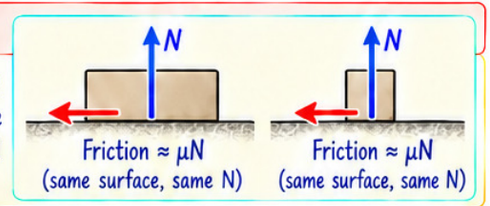
5 FRICTION

It opposes relative slipping or the tendency to slip at contact. It helps walking and braking, but can wear machine parts and dissipate energy.



6 THE AREA QUALIFIER

In the elementary dry-friction model, limiting/sliding friction is approximately independent of apparent contact area when surface properties and normal load are unchanged. This is not a universal law for every material or contact.



Lubrication and rolling contacts, such as ball bearings, can reduce friction.

IAS WITH DR RAVI
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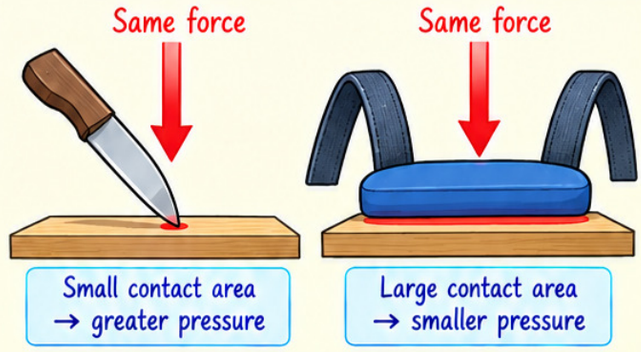
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DAY 22 | TOPIC 217 | Science | Item 18 | 217.11

Pressure, flotation and falling bodies

1 PRESSURE

Pressure = perpendicular force / area.

For the same force, a smaller contact area produces greater pressure. A sharp knife concentrates force on a narrow edge. Broad school-bag straps spread the load over a larger area and reduce pressure on the shoulder.



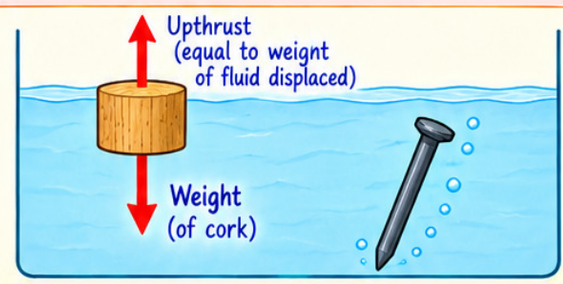
2 ATMOSPHERIC PRESSURE

Pressing a rubber suction cup against a smooth surface reduces the air beneath it. Higher external pressure helps hold it against the surface; it is not a mysterious attractive glue.



3 ARCHIMEDES' PRINCIPLE

A body immersed in fluid experiences upthrust equal to the weight of fluid displaced. Ships, submarines and lactometers use buoyancy.
A freely floating body is in balance: upthrust equals its weight.
A cork floats on water; an iron nail sinks.



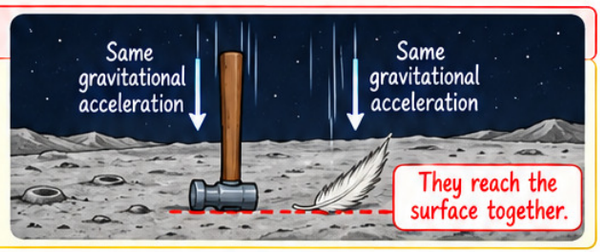
4 FREE FALL

At the same place, ignoring air resistance, bodies released together have the same gravitational acceleration regardless of mass.
Near Earth's surface, g is about 9.8 m/s².
Air resistance changes the motion in air; a falling body can approach terminal speed when drag balances weight.



5 MOON DEMONSTRATION

NASA records the Apollo 15 hammer–feather drop in 1971: they reached the lunar surface together in the near-vacuum. The equal-acceleration principle applies there; Earth's numerical g does not.



Concept illustrations are schematic; not historical reconstructions.

IAS WITH DR RAVI
AIM. PREPARE. ACHIEVE

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DAY 22 | TOPIC 217 | Science | Item 18 | 217.12

Sound, reflection and the echo distance

1 SOUND NEEDS MATTER

Sound is a mechanical wave and cannot propagate through a vacuum. The Moon's negligible atmosphere cannot carry ordinary speech from one unconnected observer to another; radio is electromagnetic communication, not sound travelling through lunar air.



Bell jar (vacuum)

Bell vibrates, but no sound is transmitted through vacuum.



The Moon's negligible atmosphere cannot carry ordinary speech from one unconnected observer to another.

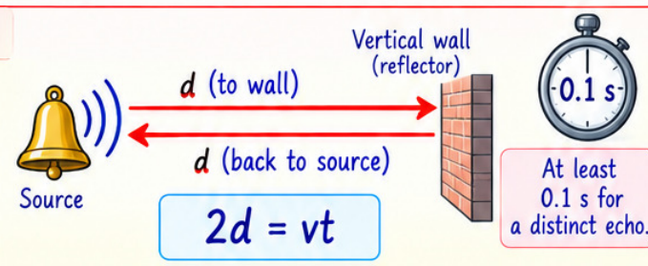
2 SPEED DEPENDS ON THE MEDIUM AND CONDITIONS

The older NCERT chapter gives air values of 331 m/s at 0°C and 344 m/s at 22°C. The source pack also lists NIOS examples of about 1520 m/s in water and 5200 m/s in steel. Do not treat one value as universal for every temperature or material.

Air 0°C	Air 22°C	Water	Steel
331 m/s	344 m/s	about 1520 m/s	about 5200 m/s

3 ECHO

A distinct echo requires a sufficient gap between the original and reflected sounds; the school model uses at least 0.1 s. Sound travels to the reflector and back, so $2d = vt$.



$2d = vt$

At least 0.1 s for a distinct echo.

4 WORKED EXAMPLE

At $v = 344$ m/s and $t = 0.1$ s:
total travel = 34.4 m;
reflector distance $d = 34.4/2 = 17.2$ m.
The 17.2 m value changes if the sound speed changes.

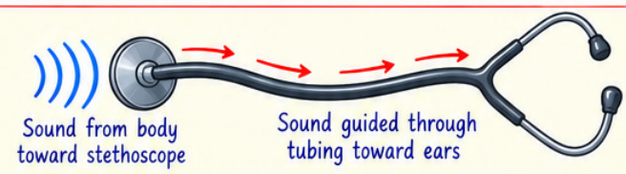
$v = 344$ m/s $\quad t = 0.1$ s

$vt = 344 \times 0.1 = 34.4$ m

$d = 34.4/2 = 17.2$ m

5 MULTIPLE REFLECTION

A stethoscope guides sound toward the ears through its tubing.



6 HEARING RANGE

The usual school range for a healthy young human is approximately 20 Hz to 20,000 Hz. Frequency is not the same quantity as speed.



Frequency is not the same quantity as speed.

Concept illustrations are schematic; not historical reconstructions.

IAS WITH DR RAVI
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DAY 22 | TOPIC 217 | Science | Item 18 | 217.13

Safe reasoning: do not swap the mechanism

HEAT

A cold object does not send cold into the hand: energy flows from warmer to cooler.

A flask reduces transfer; a matka cools by evaporation.

A pressure cooker raises the boiling temperature by raising pressure.





A flask reduces transfer.



A matka cools by evaporation.



A pressure cooker raises the boiling temperature by raising pressure.

LIGHT

A vehicle wing mirror is convex, not concave.

Myopia uses a suitable concave lens with negative power; hypermetropia uses a suitable convex lens with positive power.

Refraction, total internal reflection, dispersion and scattering are not interchangeable labels.



A vehicle wing mirror is convex, not concave.

Myopia: concave lens (negative power)



Hypermetropia: convex lens (positive power)





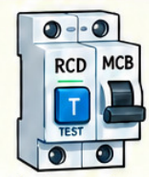
Refraction, total internal reflection, dispersion and scattering are not interchangeable labels.

ELECTRICITY

A fuse/MCB protects against excessive current.
Residual-current protection detects imbalance; a combined RCBO provides both functions.
Earthing gives fault current a protective path and supports protective-device operation; it does not make every touch safe.



A fuse/MCB protects against excessive current.



Residual-current protection detects imbalance; a combined RCBO provides both functions.



Earthing gives fault current a protective path and supports protective-device operation; it does not make every touch safe.

SAFETY

Never replace a fuse with arbitrary wire.
Do not overload sockets.
Do not operate electrical equipment with wet hands or while standing on a wet floor.
Metal-bodied appliances that require protective earthing must have it.
Follow appliance ratings and installation rules; electrical faults require a qualified person.



Never replace a fuse with arbitrary wire.



Do not overload sockets.



Do not operate electrical equipment with wet hands or while standing on a wet floor.



Metal-bodied appliances that require protective earthing must have it. Follow appliance ratings and installation rules; electrical faults require a qualified person.

MOTION

Equal and opposite action–reaction forces act on different bodies.
Air resistance, not greater mass alone, explains familiar unequal falls in air.



Equal and opposite forces act on different bodies.



Air resistance, not greater mass alone, explains familiar unequal falls in air.

UNITS

Watt or kilowatt: power.
Kilowatt hour: energy.
For numerical work, carry the units through every step and identify the quantity actually requested.

Power (kW)



kW = rate of energy transfer (how fast)

kW ≠ kWh

Energy (kWh)



kWh = total energy transferred over a time (how much)

Concept illustrations are schematic; not historical reconstructions.

Resources, reserves and potential are not the same

What do they mean?

Resource: total naturally occurring quantity that may be useful in future.

Reserve: part of the resource that is known with reasonable certainty to be economically and technically recoverable with current technology.

Potential: theoretical capacity or possibility (e.g. solar or wind) that may be harnessed in future.

Coal: geological resources

The Ministry of Coal counts coal as geological resources, in three classes by how well they have been explored: measured, indicated and inferred.

Its count covers seams 0.90 m thick and more, down to a depth of 1,200 m.

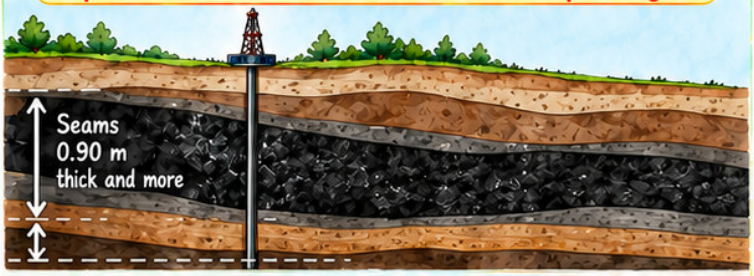
Petroleum: estimated reserves

The petroleum figures that MoSPI (the Ministry of Statistics and Programme Implementation) publishes are estimated reserves.

The Ministry of Petroleum and Natural Gas (MoPNG) sometimes speaks of "reserves and resources" together.

Coal resource classification (by level of exploration)

Exploration-confidence classes—not depth layers

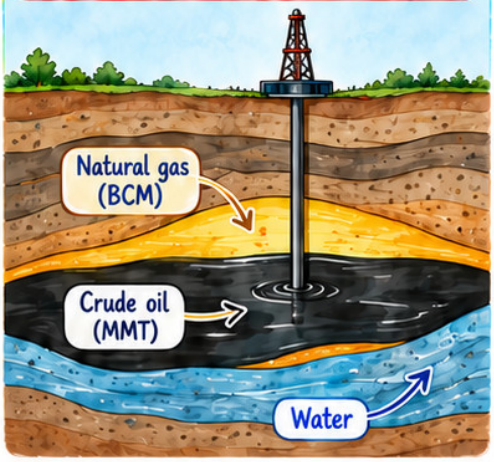


Measured
Well explored. Higher level of certainty about quantity and quality.

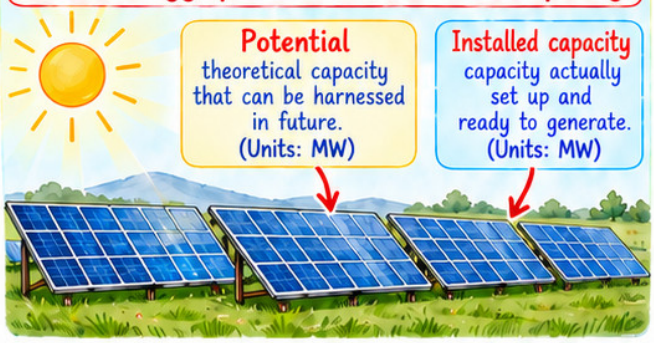
Indicated
Moderately explored. Reasonable level of certainty.

Inferred
Less explored. Lower level of certainty. May become measured or indicated with further exploration.

Petroleum: reserves in a reservoir



Solar energy: potential and installed capacity



Same term, different meanings

Aspect	Coal	Petroleum	Solar
What is reported	Geological resources	Estimated reserves (MoSPI)	Potential and installed capacity
Classes / categories	Measured, indicated, inferred	Reserves (sometimes discussed with resources by MoPNG)	Potential vs installed
Units used	MT or MMT	MMT (oil) or BCM (natural gas)	MW

So, a figure must always be read with its label, its date and the body that gives it.

Coal and lignite: read the resource label

What are coal and lignite?

Coal is a combustible geological resource formed from ancient plant remains over millions of years. Lignite is a lower-rank brown coal with lower carbon content and higher moisture than higher-rank coals.



Classification of coal resources

Coal geological resources are classified as:

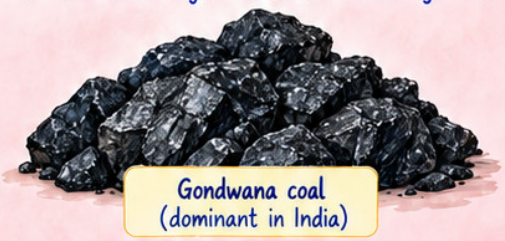
Measured	High level of geological confidence in quantity and quality.
Indicated	Moderate level of geological confidence.
Inferred	Lower level of geological confidence based on limited information.

How coal is formed?



Gondwana coal dominates

Most of India's coal resources are Gondwana coals, which form the major share of the country's coal.



Coking coal and steel making

Coking coal has special properties and is used in steel production.



State highlights



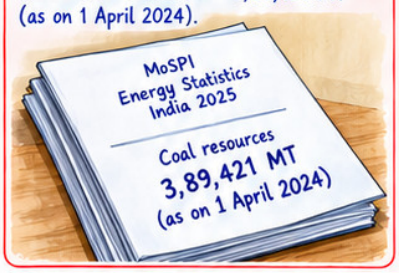
Odisha leads coal resources in India.



Tamil Nadu leads lignite resources in India.

Coal resource estimate (MoSPI)

As per MoSPI Energy Statistics India 2025, India's coal resources are 3,89,421 MT (as on 1 April 2024).



Singareni Collieries Company Limited (SCCL)

Coal in Telangana is mined by Singareni Collieries Company Limited (SCCL).



SCCL is owned by Government of Telangana (51%) and Government of India (49%).

Singareni is in Telangana, not Andhra Pradesh.

Coal and lignite: rank comparison

Feature	Coal (higher rank)	Lignite (lower rank)
Colour	Black	Brown
Carbon content	Higher	Lower
Moisture content	Lower	Higher
Energy content	Higher	Lower

From resource to power: potential vs installed capacity

Coal and lignite resources (potential) → Mining and supply → Thermal power plants (installed capacity) → Electricity supply for development

Oil and gas: offshore is a separate category

Estimated reserves of crude oil and natural gas (MoSPI, Energy Statistics India 2025, as on 1 April 2024)

Region or State	Crude oil (MMT)	Share	Natural gas (BCM)	Share
Western Offshore	213.26	31.76%	342.29	31.28%
Assam	145.41	21.66%	164.51	15.03%
Rajasthan	131.50	19.59%	63.55	5.81%
Gujarat (onshore)	118.86	17.70%	55.46	5.07%
Eastern Offshore	40.67	6.06%	263.34	24.07%
Tamil Nadu	8.54	1.27%	36.57	3.34%
Andhra Pradesh	7.69	1.15%	59.27	5.42%
Coal-bed methane (West Bengal, Madhya Pradesh, Jharkhand)	–	–	73.61	6.73%
All India	**671.40**	100%	**1,094.19**	100%

Offshore is a separate category

Offshore reserves are counted separately. Do not add them to a coastal State's onshore reserves.



Largest estimated reserves

Crude oil reserves
Western Offshore
213.26 MMT
(31.76%)

Natural gas reserves
Western Offshore
342.29 BCM
(31.28%)

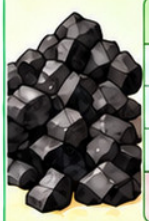
Second place differs

Crude oil second place
Assam
145.41 MMT
(21.66%)

Natural gas second place
Eastern Offshore
263.34 BCM
(24.07%)

Coal-bed methane (CBM) is listed separately

MoSPI lists CBM under three coal-bearing States. West Bengal has the largest share, about 60% of CBM.



State	Gas (BCM)	Share of CBM
West Bengal	44.37	60.3%
Madhya Pradesh	24.38	33.1%
Jharkhand	4.86	6.6%
Total (CBM)	73.61	100%

Other estimated reserves

Other crude oil reserves are in Arunachal Pradesh, Nagaland, Tripura and West Bengal.

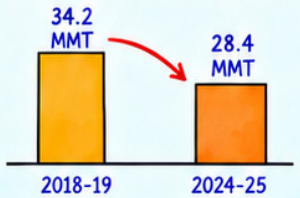
The rest of the gas is in Arunachal Pradesh, Nagaland and Tripura.

Tripura alone has 28.18 BCM of gas.

West Bengal's conventional gas row is zero; all its gas is coal-bed methane.

Falling output of crude oil

Domestic crude oil production fell from 34.2 MMT in 2018-19 to 28.4 MMT in 2024-25 (a Standing Committee of Parliament, as PRS gives it).



Uranium and monazite: Andhra Pradesh relevance

Uranium

- Uranium is a naturally occurring chemical element used in nuclear fuel.
- Atomic Minerals Directorate (AMD) had established 4,23,222 tonnes of uranium oxide (U_3O_8) in the ground, in 47 deposits, as on June 2024 (reply in the Lok Sabha, 31 July 2024).



Uranium ore



U_3O_8: resource quantity reported as uranium oxide

State-wise uranium resources (as on June 2024)

State	U_3O_8 (tonnes)	Share (worked out)
Andhra Pradesh	2,52,220	59.6 per cent
Jharkhand	98,967	23.4 per cent
Meghalaya	23,268	5.5 per cent
Telangana	18,550	4.4 per cent
Rajasthan	16,531	3.9 per cent

The YSR Tummalapalle group in Andhra Pradesh holds 2,49,459 tonnes, the largest single deposit in the list.



YSR Tummalapalle group (Andhra Pradesh)

Monazite and thorium

- Thorium is found in the mineral monazite, a mineral of the rare earths and thorium.
- The AMD has established 13.07 MT of monazite in the ground (reply in the Lok Sabha, 9 August 2023).



Monazite (sand grains)

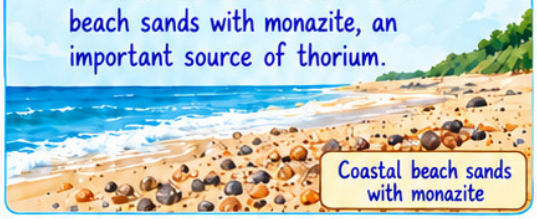
It occurs in coastal beach sands in parts of Kerala, Tamil Nadu, Odisha, Andhra Pradesh, Maharashtra and Gujarat, and inland in parts of Jharkhand, West Bengal and Tamil Nadu.



Beach sand containing monazite

Significance for Andhra Pradesh

- Andhra Pradesh has 2,52,220 tonnes of U_3O_8, about 59.6 per cent of the country's established resources.
- The YSR Tummalapalle group (2,49,459 tonnes) is the largest single uranium deposit.
- Andhra Pradesh also has coastal beach sands with monazite, an important source of thorium.



Coastal beach sands with monazite

Uranium and monazite resources: different materials and units

Uranium resources



4,23,222 tonnes of U_3O_8, as on June 2024.

Limited uranium resources underpin the rationale for India's three-stage nuclear programme.

Different materials and units—never compare these numbers as if they measure the same substance.

Monazite resources

13.07 million tonnes (MT), as reported 9 August 2023.

Monazite contains thorium; resource quantity is not the amount of thorium alone.



Potential is not installed capacity

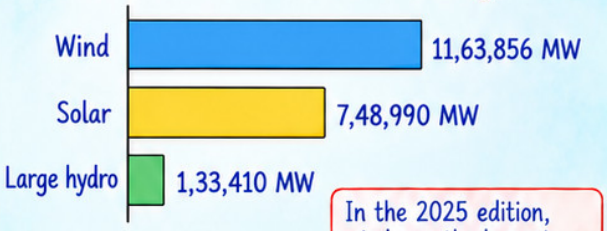
Potential means the total feasible resource estimated using studies, not the amount of power already installed or generating now.



Renewable and hydro potential (MoSPI)

Source	Potential, 31 March 2024 (Energy Statistics India 2025)	Potential, 31 March 2025 (Energy Statistics India 2026)
Solar	7,48,990 MW	33,43,378 MW
Wind, at 150 m height	11,63,856 MW	11,63,856 MW
Large hydro	1,33,410 MW	1,33,410 MW
Total, all sources	21,09,655 MW	47,04,043 MW

2025 edition: wind is the largest

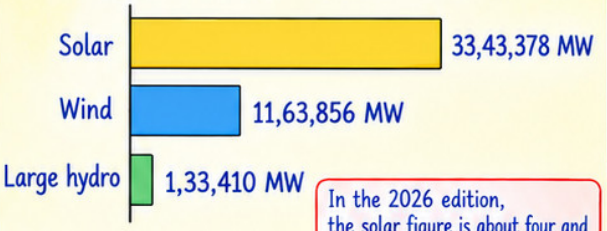


Total: 21,09,655 MW

In the 2025 edition, wind was the largest item (about 55 per cent).

Selected sources; total also includes other sources.

2026 edition: solar dominates



Total: 47,04,043 MW

In the 2026 edition, the solar figure is about four and a half times larger, and solar makes up about 71 per cent.

Selected sources; total also includes other sources.

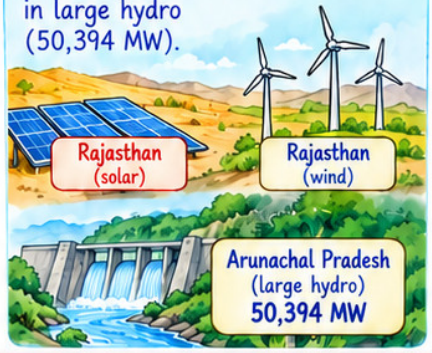
Solar potential revised by new assessment

New assessment by the National Institute of Solar Energy (NISE), an autonomous institute of the MNRE: about 3,343 GWp of ground-mounted solar potential, against the earlier estimate of 2014 of 749 GWp (PIB, 23 September 2025).



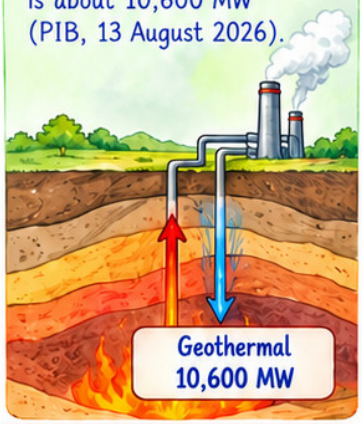
State with highest potential in 2025 edition

Rajasthan leads in both solar and wind. Arunachal Pradesh leads in large hydro (50,394 MW).



Geothermal potential

Geothermal potential is about 10,600 MW (PIB, 13 August 2026).



Potential vs installed capacity



Potential

Total feasible resource estimated through studies

e.g. 7,48,990 MW (Solar in 2024)
33,43,378 MW (Solar in 2025)
11,63,856 MW (Wind)
1,33,410 MW (Large hydro)

≠

Installed capacity

Actual installed nameplate capacity to generate electricity at a point of time. It is a part of the potential and is generally much smaller than the total potential. Actual generation depends on utilisation and conditions.

Import dependence: compare like with like

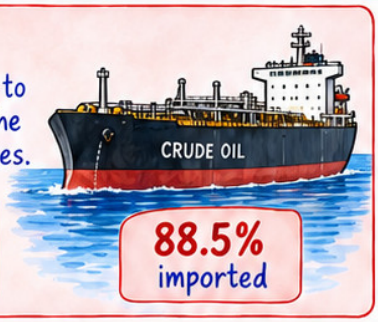
2.6 How far India depends on imports

The dependence differs across fuels. Always note the year and source along with the figure.

Crude oil

India imports close to 88.5 per cent of the crude oil it consumes.

MoPNG document on PIB, 5 July 2026 (no year stated).



88.5% imported

Natural gas

46 per cent of the gas consumed was imported, up from 28 per cent in 2011-12.

2023-24 (PPAC data, as PRS gives it).



28% 2011-12 → 46% 2023-24

Coal

Imports fell by 7.9 per cent, from 264.53 MT to 243.62 MT, while production was 1,047.52 MT.

2024-25 (Ministry of Coal, PIB, 27 May 2025; Annual Report 2025-26).



264.53 MT imports → 243.62 MT imports

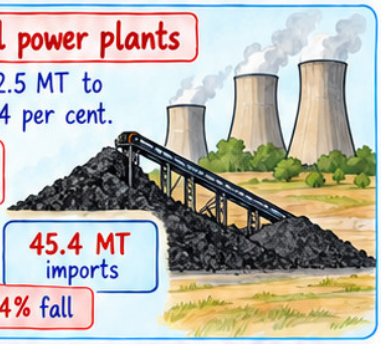
7.9% fall

1,047.52 MT production

Coal for thermal power plants

Imports fell from 62.5 MT to 45.4 MT, about 27.4 per cent.

2024-25 to 2025-26 (PIB, 13 August 2026).



62.5 MT imports → 45.4 MT imports

about 27.4% fall

Coking coal

The Ministry of Coal says coking coal and high-grade thermal coal are in short supply within the country's reserves.

Ministry of Coal, PIB, 27 May 2025.



Suppliers of crude oil

In 2023-24 the top three suppliers of oil to India were Russia, Iraq and Saudi Arabia.

Ministry of Commerce data, as PRS gives it (2023-24).



Coking coal share in resources

Coal is the opposite case to oil: most of it is mined at home, and its imports are falling. The gap is in coking coal, which is only about 9.4 per cent of the Gondwana resources.



9.4% of Gondwana resources (coking coal)

2.8 Why import dependence matters

The import bill

Crude oil makes up 85 per cent of India's petroleum imports by value.

PPAC data, as PRS gives it.



85% of India's petroleum imports (by value)

The current account

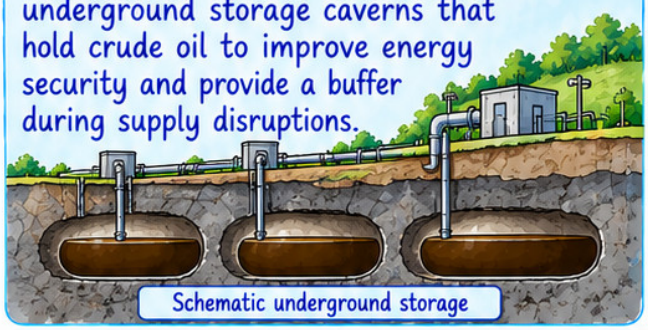
Petroleum, oil and lubricants (POL) are counted under goods in the current account. A larger oil bill widens the merchandise trade deficit and so puts pressure on the current account.

Higher oil import bill
↓
Wider merchandise trade deficit
↓
Pressure on current account

- PPAC is the Petroleum Planning and Analysis Cell of the MoPNG.
- The crude oil figures differ by period and by source. A PRS note also cites a Standing Committee report of December 2023 that put crude oil import dependence at about 85 per cent.

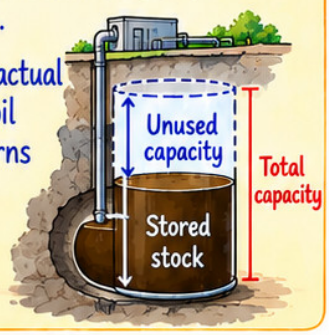
Strategic reserves: capacity is not stored stock

Strategic petroleum reserves are underground storage caverns that hold crude oil to improve energy security and provide a buffer during supply disruptions.



Capacity is the maximum amount that can be stored.

Stored stock is the actual quantity of crude oil present in the caverns at a given time.



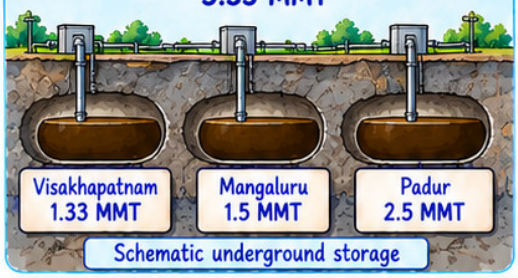
Strategic petroleum reserve facilities in India

Facility	Capacity (MMT of crude oil)	Status
Visakhapatnam	1.33	Built
Mangaluru	1.5	Built
Padur	2.5	Built
Total built	**5.33**	Built through Indian Strategic Petroleum Reserves Limited (ISPRL), a special purpose vehicle.
Chandikhol (Odisha)	4	Approved in July 2021, on the public-private partnership model.
Padur (Karnataka), second facility	2.5	Approved in July 2021, on the same model.

Built, stored and approved capacity

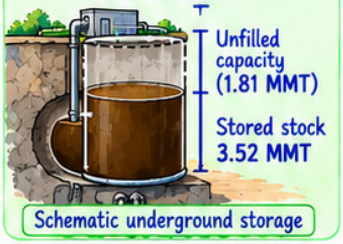
Built facilities (3)

Total capacity
5.33 MMT



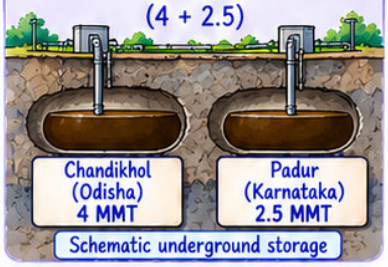
Actual stock in March 2025

Caverns held
3.52 MMT
of crude oil.



Approved additional facilities

Total approved capacity
6.5 MMT
(4 + 2.5)



Built capacity
5.33 MMT

Stored in March 2025
3.52 MMT
(less than capacity)

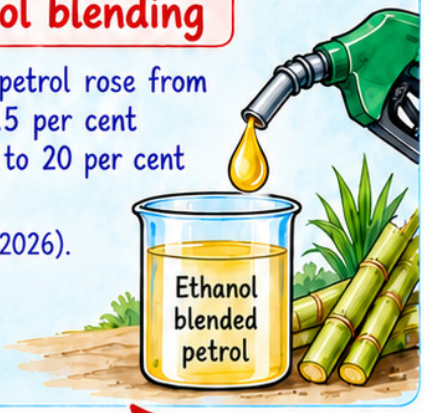
Approved additional capacity
(July 2021)
6.5 MMT

Reducing dependence needs several routes

Measures to reduce dependence

1. Ethanol blending

- Ethanol in petrol rose from less than 1.5 per cent in 2013-14 to 20 per cent in 2025-26. (PIB, 5 July 2026).



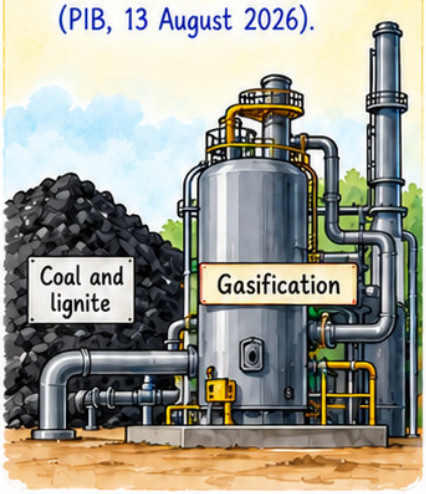
2. Compressed biogas (CBG)

- SATAT scheme (October 2018).
- GOBARdhan, the National Circular Bioenergy Scheme, approved on 6 August 2026 with ₹23,731 crore for 2026-27 to 2035-36. (PIB, 13 August 2026).



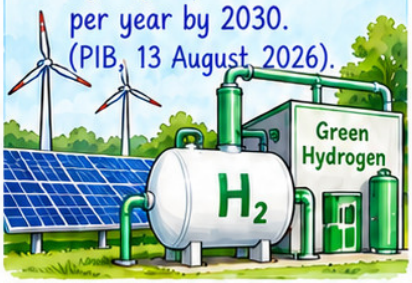
3. Coal gasification

- A target of 100 MT of coal and lignite gasified by 2030.
- A scheme of ₹37,500 crore approved in May 2026. (PIB, 13 August 2026).



4. National Green Hydrogen Mission

- ₹19,744 crore, approved in January 2023.
- Target: 5 MMT of green hydrogen production per year by 2030. (PIB, 13 August 2026).



5. More exploration at home

- "Samudra Manthan", the National Offshore Exploration Programme, approved on 31 July 2026 with ₹84,084 crore. (PIB, 13 August 2026).



Multiple routes strengthen energy security

Use renewable and alternative fuels (Ethanol, CBG, Green Hydrogen) → Convert domestic resources (Coal gasification) → Explore new sources at home (Offshore) → Broader fuel mix reduces import dependence → Stronger and more resilient energy security

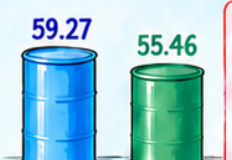
Andhra Pradesh: gas, atomic minerals and a reserve

Energy and mineral resources of Andhra Pradesh

Resource	Where	Figure and date	What to remember
Oil and gas of the KG basin 	The Krishna and Godavari river basins, onshore and offshore.	Estimated onshore reserves, 1 April 2024: **7.69 MMT of crude oil and 59.27 BCM of gas.**	The offshore part of the basin is counted in the **Eastern Offshore (263.34 BCM of gas)**, not in the Andhra Pradesh row.
KG-D6 block 	Deep water of the KG basin.	Operated by **Reliance Industries.**	Its first discoveries were **Dhirubhai-1, 2 and 3.**
Uranium 	YSR Tummalapalle group.	**2,49,459 tonnes** of U_3O_8 (June 2024).	The largest single deposit in the DAE's list; Andhra Pradesh holds **2,52,220 tonnes** in all.
Monazite (thorium) 	Coastal beach sands.	Part of India's **13.07 MT** (2023 reply).	Andhra Pradesh is one of six States with coastal monazite.
Strategic petroleum reserve 	Visakhapatnam.	Capacity: **1.33 MMT**	The smallest of the three built facilities.

Compare Andhra Pradesh's resource categories carefully

Onshore natural gas
(BCM, 1 April 2024)



Andhra Pradesh's onshore gas (59.27 BCM) is larger than Gujarat's (55.46 BCM).

Onshore crude oil
(MMT, 1 April 2024)



Andhra Pradesh's onshore crude oil (7.69 MMT) is much smaller than Gujarat's (118.86 MMT).

Coal

Singareni Collieries is in Telangana, not Andhra Pradesh.

Key points to remember



Andhra Pradesh is strong in **gas** and in **atomic minerals.**



Andhra Pradesh is **weak in coal.**



It has major atomic minerals — **uranium** (YSR Tummalapalle) and **monazite (thorium).**

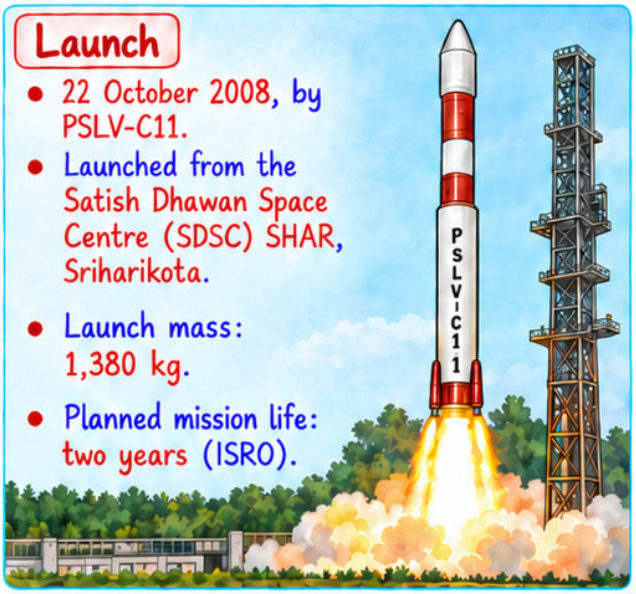


It has onshore oil and gas in the **KG basin** and a **strategic petroleum reserve** at Visakhapatnam.

Chandrayaan-1: an orbiting observatory

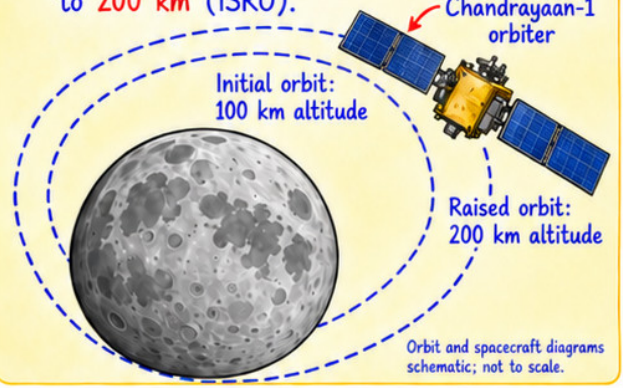
Launch

- 22 October 2008, by PSLV-C11.
- Launched from the Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota.
- Launch mass: 1,380 kg.
- Planned mission life: two years (ISRO).



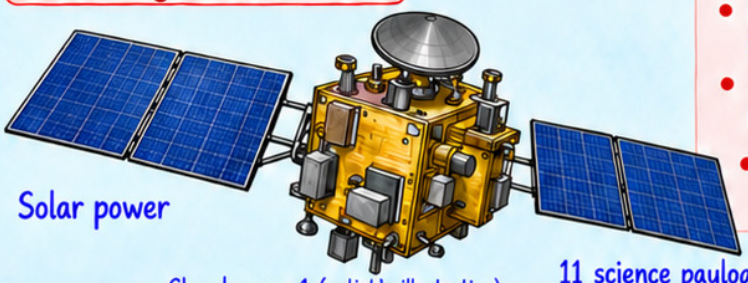
Orbit

- Chandrayaan-1 worked from an orbit 100 km above the lunar surface.
- In May 2009, the orbit was raised to 200 km (ISRO).



Orbit and spacecraft diagrams schematic; not to scale.

Chandrayaan-1 orbiter



Chandrayaan-1 (artist's illustration)

- Carried 11 scientific instruments (payloads) in total.
- Five were from India (ISRO) and six were from foreign space agencies.
- The foreign instruments came from the USA, the UK, Germany, Sweden and Bulgaria.

11 Instruments (Payloads)

Indian instruments (5)

No.	Instrument (Abbreviation)	Main purpose (name)
1	Terrain Mapping Camera (TMC)	Mapping the lunar terrain
2	Hyper Spectral Imager (HySI)	Imaging in multiple wavelengtts to study surface composition
3	Lunar Laser Ranging Instrument (LLRI)	Laser ranging studies of the Moon
4	High Energy X-ray Spectrometer (HEX)	Study of high energy X-rays from the Moon
5	Moon Impact Probe (MIP)	A probe released from the orbiter to study the lunar surface and exosphere

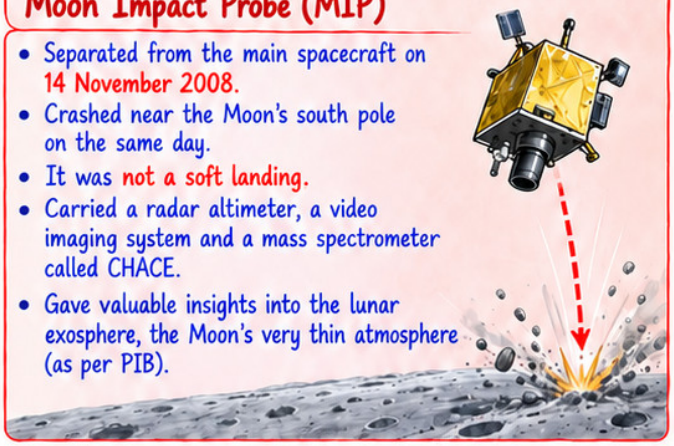
Foreign instruments (6)

No.	Instrument (Abbreviation)	Main purpose (name)
1	Chandrayaan-1 X-ray Spectrometer (CIXS)	Study of X-rays from the Moon
2	Near Infrared Spectrometer (SIR-2)	Near-infrared spectroscopy of the lunar surface
3	Sub keV Atom Reflecting Analyzer (SARA)	Study of energetic neutral atoms around the Moon
4	Miniature Synthetic Aperture Radar (Mini SAR)	Radar imaging of the lunar surface
5	Moon Mineralogy Mapper (M3)	Mapping lunar minerals (NASA instrument)
6	Radiation Dose Monitor (RADOM)	Measurement of radiation dose in lunar orbit

Impact is not a soft landing; water is not a lake

Moon Impact Probe (MIP)

- Separated from the main spacecraft on 14 November 2008.
- Crashed near the Moon's south pole on the same day.
- It was not a soft landing.
- Carried a radar altimeter, a video imaging system and a mass spectrometer called CHACE.
- Gave valuable insights into the lunar exosphere, the Moon's very thin atmosphere (as per PIB).



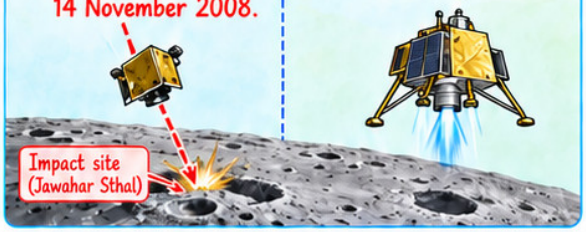
Impact vs Soft landing

MIP : Impact

- Deliberate crash.
- Not a soft landing.
- Crashed near the south pole on 14 November 2008.

Soft landing (comparison)

- Slows down gently.
- Lands intact on surface.
- Designed to operate after landing.



Instruments on MIP

Radar altimeter



Measured altitude above the surface.

Video imaging system



Captured images during the descent and impact.

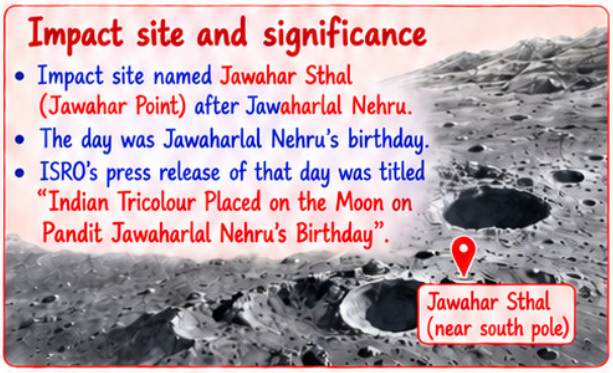
CHACE



Mass spectrometer that studied the lunar exosphere (very thin atmosphere).

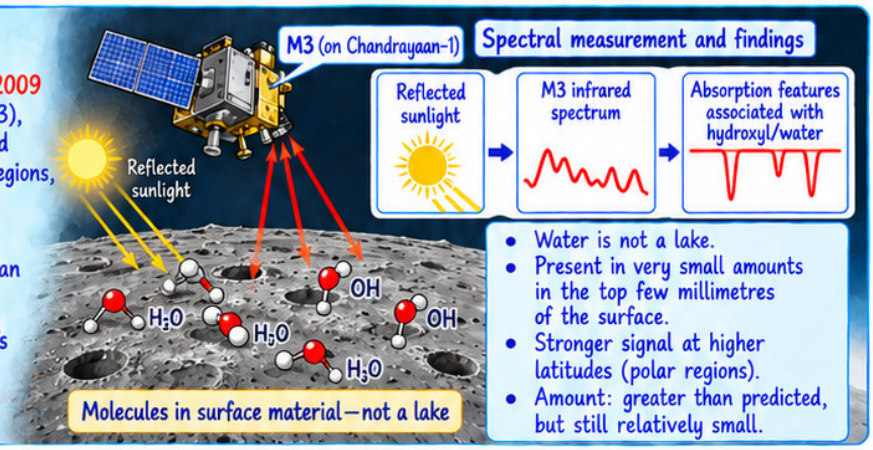
Impact site and significance

- Impact site named Jawahar Sthal (Jawahar Point) after Jawaharlal Nehru.
- The day was Jawaharlal Nehru's birthday.
- ISRO's press release of that day was titled "Indian Tricolour Placed on the Moon on Pandit Jawaharlal Nehru's Birthday".



Water on the Moon

- NASA announced on 24 September 2009 that its Moon Mineralogy Mapper (M3), carried on Chandrayaan-1, had found water molecules in the Moon's polar regions, and hydroxyl in the lunar soil.
- Water was in the top few millimetres of the surface, in amounts "greater than predicted, but still relatively small".
- The signal was stronger at the Moon's higher latitudes.



Confirmation by other missions

Cassini spacecraft



Data from Cassini's VIMS instrument agreed with M3.

EPOXI spacecraft



EPOXI confirmed the findings.

How each body words it

ISRO	Chandrayaan-1 confirmed the presence of water molecules on the Moon.
PIB	Speaks of evidence of water molecules and hydroxyl.
NASA	The instrument that made the observation was NASA's Moon Mineralogy Mapper (M3).

Mission end

- After more than 3,400 orbits, communication was lost on 29 August 2009.
- The mission ended (ISRO).

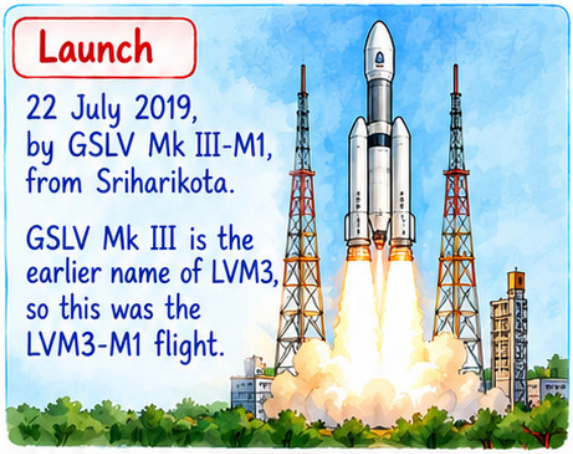


Chandrayaan-2: three parts, different outcomes

Launch

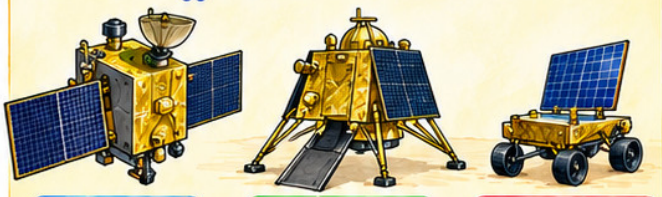
22 July 2019, by GSLV Mk III-M1, from Sriharikota.

GSLV Mk III is the earlier name of LVM3, so this was the LVM3-M1 flight.



Three parts of Chandrayaan-2

Chandrayaan-2 had an orbiter, the Vikram lander and the Pragyan rover.



Orbiter — in lunar orbit (still working)

Vikram lander — attempted landing (lost contact)

Pragyan rover — intended to roam on the Moon

Instruments on board

Orbiter - 8 instruments



1. CLASS
2. XSM
3. DFSAR
4. IIRS
5. ChACE-2
6. TMC-2
7. Dual frequency radio science experiment
8. Orbiter High Resolution Camera

Vikram lander - 4 instruments



1. ILSA
2. ChaSTE
3. RAMBHA-LP
4. Laser retroreflector array

Pragyan rover - 2 instruments

1. LIBS
2. APXS



Vikram: contact lost during descent

Contact with the Vikram lander was lost during the descent, on 7 September 2019 by Indian time (6 September by Universal Time).



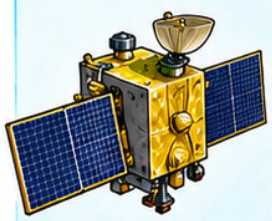
What happened to Vikram

In November 2019 the Government told the Lok Sabha that Vikram had made a hard landing within 500 m of its designated landing site, because the reduction in velocity in the second phase of descent was more than the designed value.

↓

Later estimates from satellite images put the spot about 600 m from the target.

Orbiter: still working



- The Government said in the same reply that all eight orbiter instruments were working.
- The orbiter's life had been extended to seven years, thanks to a precise launch and precise orbital manoeuvres.
- PIB (June 2026) says it works from an altitude of 100 km and has given some of the highest-resolution images of the lunar surface.

Tiranga Point

On 26 August 2023 the Prime Minister announced that the place where the Chandrayaan-2 lander crash-landed would be known as Tiranga Point, a reminder that failure is not the end.



Chandrayaan-3: the successful landing architecture

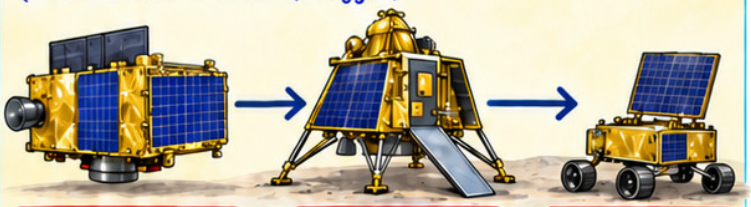
1. Launch



Date: 14 July 2023
Time: 14:35 IST
Vehicle: LVM3-M4
From: Second Launch Pad, SDSC SHAR.

2. Three parts of Chandrayaan-3

The mission has a Propulsion Module, a Lander Module (Vikram) and a rover (Pragyan).



- Propulsion Module (1 instrument)
- Lander Module (Vikram) (4 instruments)
- Rover (Pragyan) (2 instruments)

3. Scientific instruments

Lander Module (Vikram) – 4 instruments

- ChaSTE – to measure the thermal properties of the lunar surface near the south pole.
- ILSA – to measure lunar seismic activity.
- RAMBHA-LP – to study the plasma environment near the Moon.
- NASA's laser retroreflector array – for precise distance measurements between the Moon and Earth.



Rover (Pragyan) – 2 instruments

- APXS – to determine the elemental composition of lunar soil and rocks.
- LIBS – to estimate the elemental composition of lunar soil and rocks using laser-induced breakdown spectroscopy.





Propulsion Module – 1 instrument

- SHAPE – Measures spectral and polarimetric properties of Earth from lunar orbit; helps study signatures of habitable planets.



The lander and rover were designed to work for one lunar daylight, about 14 Earth days.

4. Landing on the Moon

Date: 23 August 2023
Time: about 6 p.m. IST (ISRO had announced the powered descent for about 17:45 IST).
Location: near the south pole, at about 69° south.



5. Significance

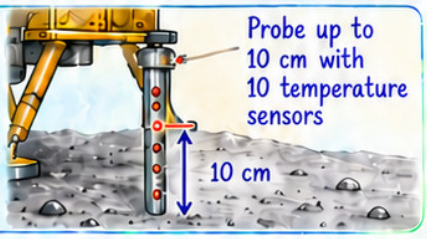
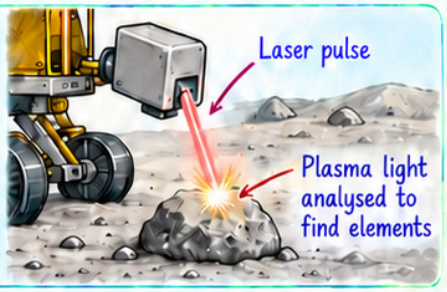
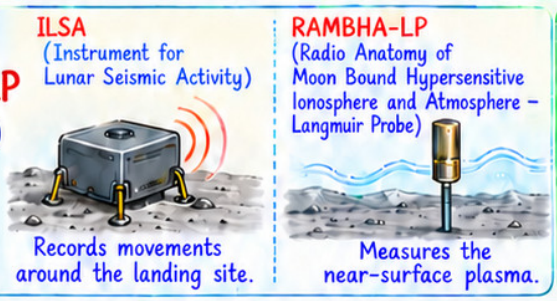
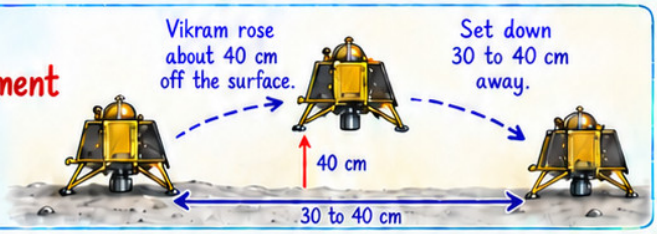
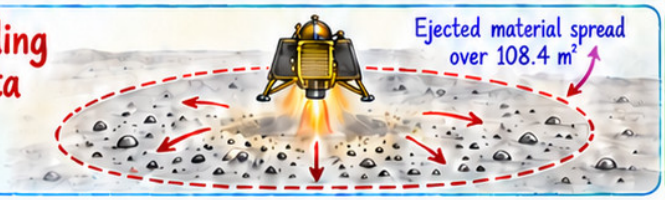
According to PIB, this made India the fourth nation, after the United States, Russia and China, to soft-land on the Moon, and the first country to soft-land near the Moon's south pole.

6. Statio Shiv Shakti

On 26 August 2023, at the ISRO Telemetry Tracking and Command Network (ISTRAC) in Bengaluru, the Prime Minister announced that the place where Vikram and Pragyan landed would be called the Shiv Shakti point (Statio Shiv Shakti), and that 23 August would be celebrated as National Space Day.



What did the instruments actually measure?

Date (2023)	Instrument or event	Finding (ISRO)
27 August	**ChaSTE** (Chandra's Surface Thermophysical Experiment) (on the lander) 	• A probe went up to 10 cm into the soil with 10 temperature sensors and gave the temperature profile of the topsoil. • ISRO calls it the first such profile for the lunar south pole.
28 August	**LIBS** (Laser-Induced Breakdown Spectroscopy) (on the rover) 	• Confirmed sulphur on the surface near the south pole through in-situ measurements, which orbiter instruments could not do. • It also found aluminium, calcium, iron, chromium and titanium, and later manganese, silicon and oxygen.
30 August	**APXS** (Alpha Particle X-ray Spectrometer) (on the rover) 	• Detected minor elements, including sulphur. • ISRO noted that LIBS on the same rover had also confirmed sulphur.
31 August	**ILSA and RAMBHA-LP** (on the lander) 	• ILSA recorded movements around the landing site. • RAMBHA-LP measured the near-surface plasma.
4 September (announced)	**Hop experiment** 	• Vikram rose about 40 cm off the surface and set down 30 to 40 cm away. • The lander and rover were then put in sleep mode.
27 October (report)	**Landing ejecta** 	• About 2.06 tonnes of lunar epiregolith were thrown up and spread over 108.4 m² (NRSC/ISRO).

The mission continued beyond the landing

After the lunar day

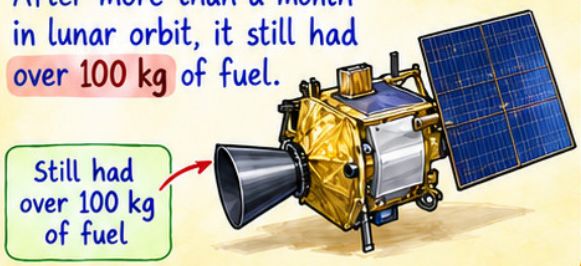
On 22 September 2023 ISRO said efforts to establish communication with the lander and the rover were under way.

In Topic 177, the mission was recorded as not operational.



The Propulsion Module came back

After more than a month in lunar orbit, it still had over 100 kg of fuel.



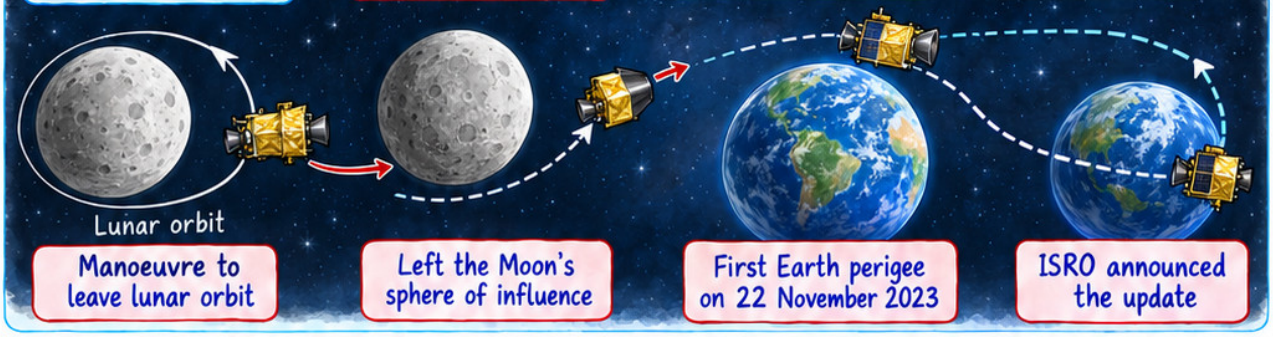
Journey after the lunar mission

13 October 2023
ISRO used the propulsion module to move it out of lunar orbit (manoeuvre).

10 November 2023
The propulsion module left the Moon's sphere of influence.

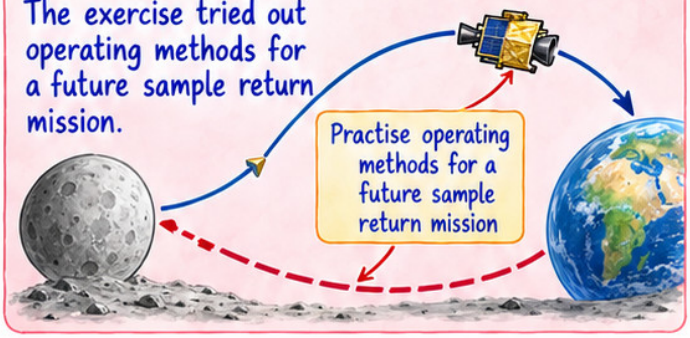
22 November 2023
It passed its first Earth perigee.

4 December 2023
ISRO announced this on 4 December 2023.



Purpose of the exercise

The exercise tried out operating methods for a future sample return mission.

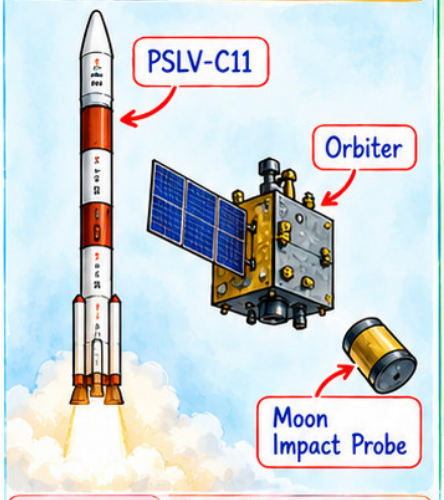
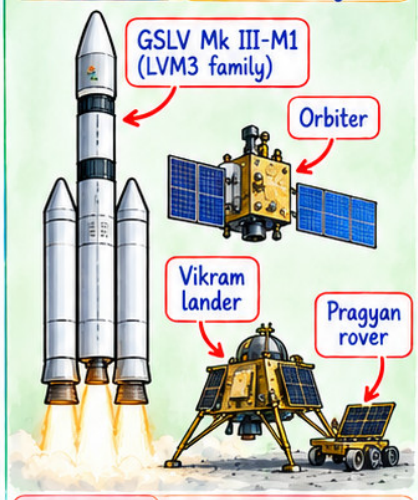
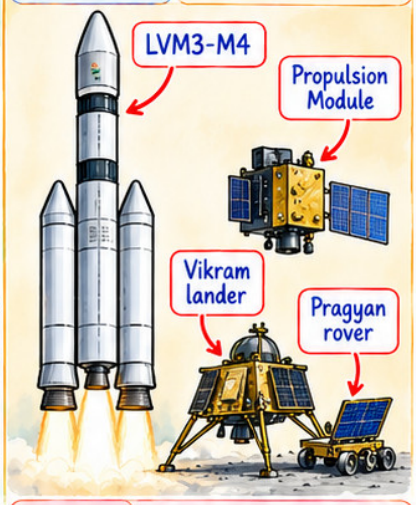
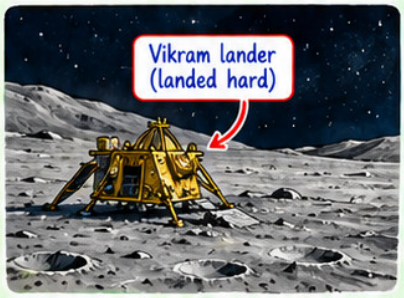
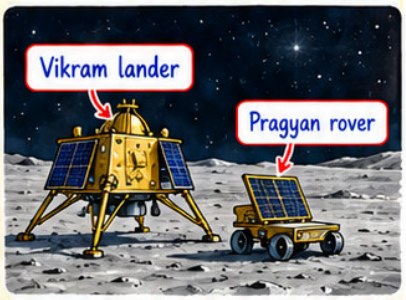


SHAPE kept observing the Earth

The SHAPE payload on the propulsion module continued to observe the Earth during its journey back.



Three missions: compare spacecraft, launcher and result

	Chandrayaan-1	Chandrayaan-2	Chandrayaan-3
Launch date and vehicle	22 October 2008 PSLV-C11	22 July 2019 GSLV Mk III-M1 (LVM3 family)	14 July 2023 LVM3-M4
			
Parts	One orbiting spacecraft, which released the Moon Impact Probe.	Orbiter, Vikram lander, Pragyan rover.	Vikram lander, Pragyan rover, Propulsion Module.
Instruments	11 (five Indian, six foreign)	Eight on the orbiter, four on the lander, two on the rover.	Four on the lander, two on the rover, one on the Propulsion Module.
			
Main result	Water molecules and hydroxyl seen by NASA's M3.	Orbiter still studying the Moon; lander's hard landing.	Soft landing near the south pole on 23 August 2023; sulphur confirmed on the surface.
Point named	Jawahar Sthal (probe's impact site).	Tiranga Point (lander's crash site).	Statio Shiv Shakti (landing site).

Chandrayaan-1 found water molecules and hydroxyl. → **Chandrayaan-2** built on the experience; orbiter continues to study. → **Chandrayaan-3** achieved a successful soft landing near the south pole.

Sample return and polar exploration are planned

What comes next

India is planning the next phase of lunar exploration. Chandrayaan-4 will focus on bringing samples back from the Moon. Chandrayaan-5 (LUPEX) will explore the Moon's polar region with India and Japan working together. These are planned missions, not completed launches.

Chandrayaan-4 (Sample return)

- **Approved:** 18 September 2024 (Union Cabinet).
- **Outlay:** Rs 2,104.06 crore.
- **Objective:** Develop and demonstrate technologies to land on the Moon, collect samples, return to Earth and analyse the samples on Earth.
- **Launch vehicles:** Cost covers two launch vehicle missions of LVM3.
- **Responsibility:** ISRO for spacecraft and the launch, with industry and academia taking part.
- **Target completion:** within 36 months of the approval (PMO release, 18 September 2024).

Timeline for Chandrayaan-4

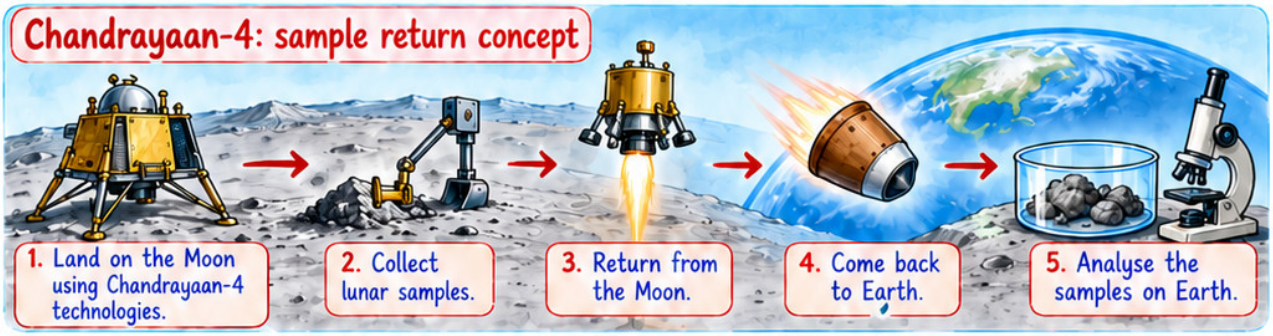
PIB backgrounder (June 2026): planned year 2027.

ISRO (April 2025): indicates 2027-28.

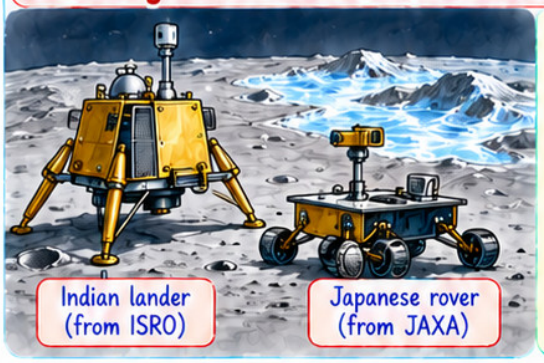
Not a firm date. Mission is planned.



Chandrayaan-4: sample return concept



Chandrayaan-5 / LUPEX (Lunar Polar Exploration)



- **Name:** Chandrayaan-5 / LUPEX (Lunar Polar Exploration) mission.
- **Partners:** India (ISRO) and Japan (JAXA).
- **Configuration:** Indian lander with a Japanese rover.
- **Objective:** Explore the Moon's polar region and search for lunar water and ice.
- **Launch vehicle:** To be launched on Japan's H3 rocket.

Timeline for Chandrayaan-5 / LUPEX

PIB backgrounder (June 2026): 2027-28.

JAXA mission page (checked 30 October 2026): launch no earlier than 2028.

This is a planned mission, not a completed launch.



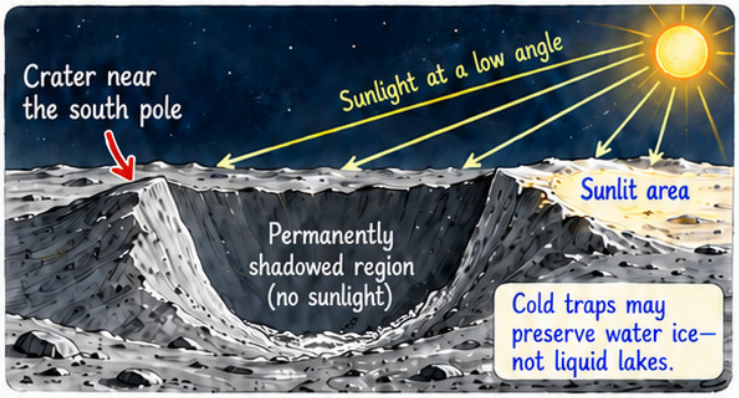
Wider vision for India's space programme

Chandrayaan-4 (sample return)	Chandrayaan-5 / LUPEX (polar exploration)	Bharatiya Antariksh Station	Indian landing on the Moon
Planned year **2027** (PIB June 2026)	No earlier than **2028** (JAXA, checked 30 October 2026)	Target year **2035** (Cabinet note)	Target year **2040** (Cabinet note)

Near the south pole is not at the pole

Why the south pole?

- PIB says LUPEX will explore water and other volatile materials in the **permanently shadowed regions near** the lunar south pole, that is, places where sunlight never falls.
- NASA's M3 had already found the water signal stronger at **higher latitudes.**



National Space Day

23 Aug 2023 — Chandrayaan-3 landed near the lunar south pole on 23 August 2023.

26 Aug 2023 — Government declared 23 August as National Space Day on 26 August 2023.

2024 — First National Space Day was observed in 2024.

2025 — ISRO describes the celebration of 2025, held in New Delhi, as the second National Space Day.



Chandrayaan-3 landed near the south pole on 23 August 2023.

Near the pole ≠ at the pole

Chandrayaan-3 landed at about **69° south latitude.**

The geographic lunar south pole is **90° south.**

Polar exploration investigates cold traps and volatile materials.

69° S — Chandrayaan-3 (about 69° S)

Near the pole (but not at the pole)

90° S — Geographic south pole (90° S)

Latitude (south)

Three common exam traps

1 "India's first landing on the Moon came with Chandrayaan-1."



- Chandrayaan-1 was an **orbiting** mission, not a landing.
- It is remembered for the **evidence of water.**
- The **first Indian soft landing** was Chandrayaan-3's, near the south pole, on 23 August 2023.
- Credit the water finding correctly: the spacecraft was ISRO's, but the instrument that saw the water was NASA's.

2 Mixing up names.

GSLV Mk III-M1 (Chandrayaan-2) and LVM3-M4 (Chandrayaan-3) are the same family of rocket, since LVM3 was earlier called GSLV Mk III.

GSLV Mk III (earlier name) Chandrayaan-2 = LVM3 (same family) Chandrayaan-3

GSLV Mk II is a different launcher.

Chandrayaan-2 and Chandrayaan-3 both had a lander named Vikram and a rover named Pragyan, so always ask "which mission?".

Vikram-S and Vikram-I are different things again: Skyroot's private rockets.

3 Treating planned as done, or an announcement as the first observance.

Chandrayaan-4 — PIB June 2026 plan: 2027 — not a firm date. Not yet launched.

Chandrayaan-5 (LUPEX): Joint mission with Japan. JAXA lists launch no earlier than2028.

23 Aug 2023 — National Space Day was declared in 2023 and first observed in 2024.

Chandrayaan-3 launched on 14 July 2023 → Chandrayaan-3 landed on 23 August 2023

A question on the landing wants the second date.

A hazard is not automatically a disaster

Day24 | Topic237 | 237.01

High exposure + fragile buildings + weak preparedness



Safer siting + stronger buildings + warning and evacuation capacity

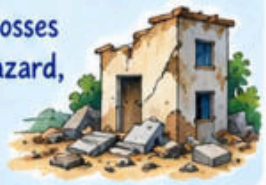


Illustrative comparison—not a prediction of a specific storm.



Hazard: a potentially harmful process, event or human activity.

Disaster risk: potential losses over a period, shaped by hazard, exposure, vulnerability and capacity.





Conceptual relationship—not a universal arithmetic formula.



A hazardous event can cause very different losses in different communities.

Under Indian disaster law, disaster involves substantial harm and a scale beyond the affected community's coping capacity.

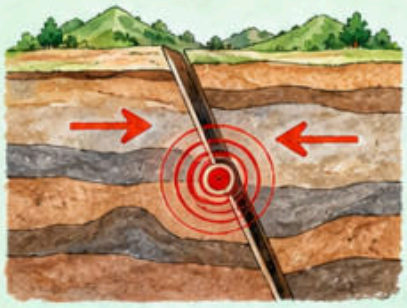


Takeaway: Risk reduction addresses exposure and vulnerability and strengthens capacity; it is not limited to relief after damage.

Sources: UNDRR terminology; suppliedDay24 notes; Disaster Management Act2005 section2(d).

Classify the origin—not just the event name

Day24 | Topic237 | 237.02



NATURAL: mainly natural processes



ANTHROPOGENIC: mainly human activities and choices



SOCIONATURAL: natural and human factors combine

Different origins can interact

Illustrative cascading sequence



Heavy rain → Slope failure → Road blockage → Delayed access

Hazards may occur singly, sequentially or together.
Their effects can cascade rather than remain isolated.

Important comparison

Aspect	Origin	Hazard type
Question answered	Why it arose	What process causes harm
What it classifies	Natural / human-induced / combined	Physical process (e.g. earthquake, flood, landslide, heatwave)
Do not	Do not collapse these two classifications.	



Revision cue:

Natural / human-induced / combined: three origins, not only two.

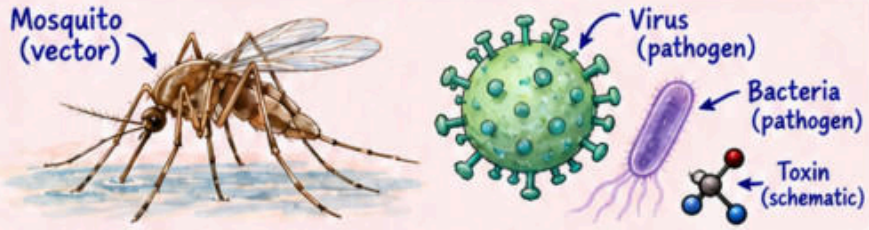
Source: UNDRR Hazard terminology (2017); supplied Day24 topic237.

Five hazard families: identify the process

Day24 | Topic237 | 237.03

BIOLOGICAL:

organisms, pathogens, toxins and biological vectors.



ENVIRONMENTAL:

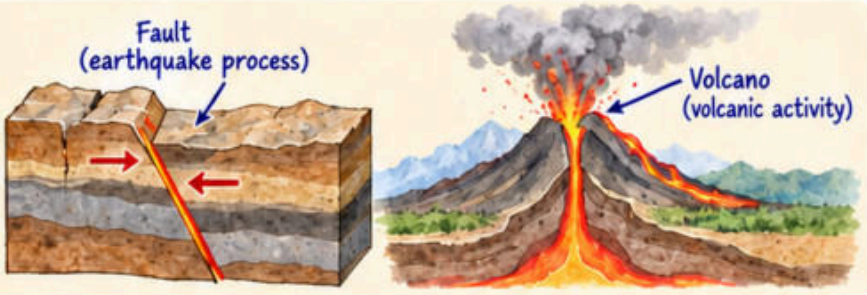
degradation and pollution can contribute to harm; some processes are risk drivers.



Context matters

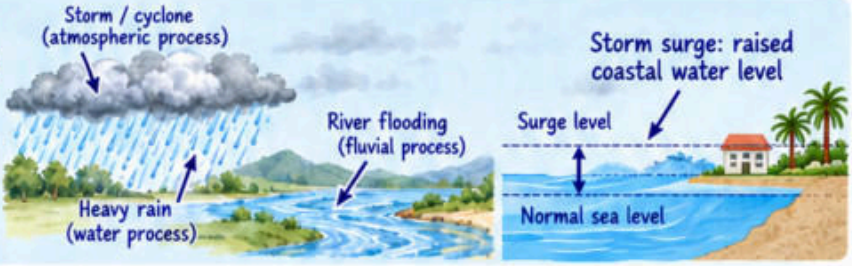
GEOLOGICAL / GEOPHYSICAL:

Earth processes such as earthquakes, volcanic activity and mass movements.



HYDROMETEOROLOGICAL:

atmospheric, water or ocean processes—cyclones, floods, drought and storm surge.



TECHNOLOGICAL:

failures or dangerous industrial conditions—chemical spills, radiation incidents, dam failures.



Categories can interact:

an earthquake can damage industrial infrastructure; a storm can trigger a landslide.

Do not assume every event fits one isolated box.



A tsunami can be geologically triggered yet become an oceanic, coastal water hazard.

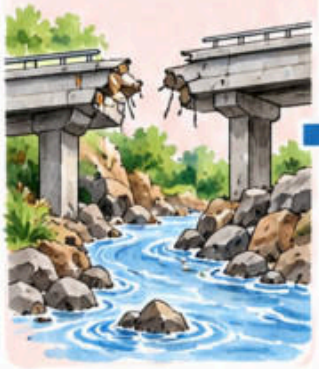
Source: UNDRR Hazard terminology; supplied Day24 topic237.

The legal test: when an event is a disaster

Day24 | Topic237 | 237.04

Disaster Management Act 2005, section 2(d): read the elements together.

1 Event: catastrophe, mishap, calamity or grave occurrence.



What happened?

2 Cause: natural or human-made, accident or negligence.



What caused it?

3 Result: substantial human suffering or loss, property damage or environmental harm.



What harm resulted?

4 Scale: beyond the affected community's coping capacity.

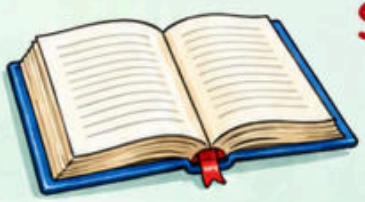


Could the community cope?



2025 clarification:

"man made causes" excludes law-and-order matters or situations, including situations arising from them.



Section 2(e):

disaster management is continuous and integrated; it includes disaster risk reduction—not just relief after an event.



Examples:

An industrial leak may qualify just as an earthquake may. Environmental harm counts: the coping-capacity threshold still matters.

Sources: Disaster Management Act 2005 as amended 2025; supplied Day24 verified source pack; District Gondia official definitions.

Mayapuri: a hazardous source enters the wrong chain

Day24 | Topic237 | 237.05

1 Unused gamma cell containing cobalt-60



2 Auctioned as scrap, February2010



3 Radiation exposure at Mayapuri, April 2010



4 Treatment and regulatory action



Fact from official reply

Rajya Sabha reply1954,12August2010:
seven people with radiation-induced symptoms were treated;
one died on26April2010.

The material posed a hazard before the event.
Improper disposal created exposure; the health consequences made the risk concrete.

Prevention chain



Source inventory



Regulatory control



Scrap-sector awareness



Detection and response

Policy lessons from the official reply—
not do-it-yourself radiation advice.

Radiological incident ≠ chemical gas leak.
Mayapuri's substance was cobalt-60.



Unused equipment is not automatically harmless.
Hazardous-source control must cover its entire life cycle.

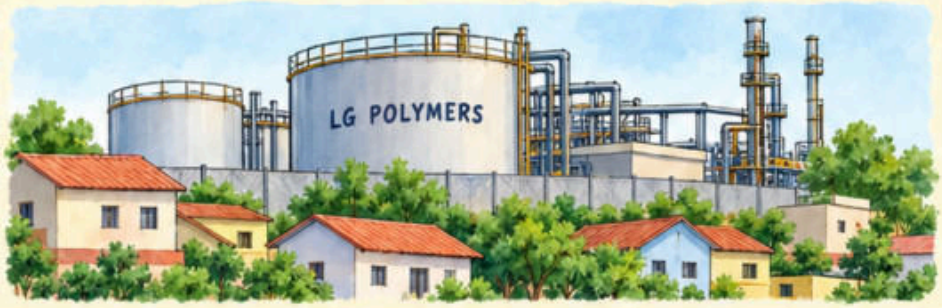
Source: Government of India, Rajya Sabha Q1954,12August2010; suppliedDay24 notes.

Visakhapatnam: separate incident, finding and order

Day 24 | Topic 237 | 237.06

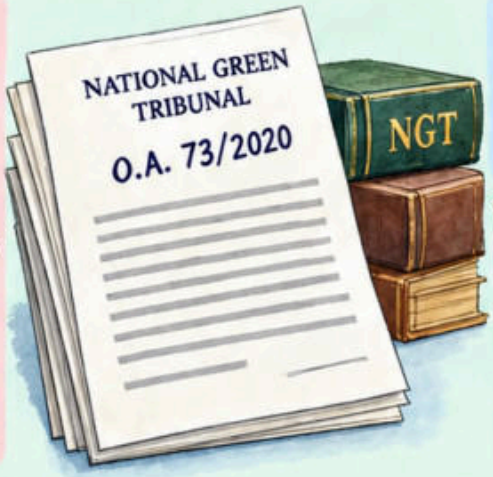
7 May 2020:

styrene leak at LG Polymers, R.R. Venkatapuram, Visakhapatnam.



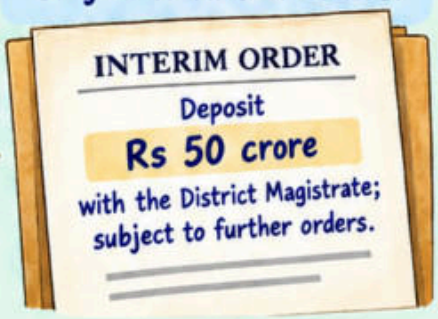
8 May 2020:

NGT took up O.A. 73/2020. Its initial order recorded media reports of 11 deaths and expressly noted that fatalities and injuries might rise.



Interim direction:

deposit Rs 50 crore with the District Magistrate; subject to further orders.



Key distinction

The 11 figure belongs to the initial 8 May 2020 record.
It is not a claim about the final casualty total.
An interim deposit is not the same as final compensation.

Prevention and emergency readiness



Hazardous chemical (styrene)

On-site planning



Risk assessment, safe operations, on-site emergency plan

Off-site planning



Community awareness, early warning, evacuation planning

Prevention and emergency readiness



Lower risk of incidents and better response if an incident occurs.



The order identified styrene as a hazardous chemical under the 1989 Rules and sought a committee report on causes, damage and remedial measures.

Source: NG T Principal Bench, O.A. 73/2020, order 8 May 2020, pp 1–4; supplied Day 24 notes.

Four incidents: match the substance and lesson

Day 24 | Topic 237 | 237.07

Event	Substance	Revision distinction
 Bhopal, 1984	Methyl isocyanate	Industrial chemical disaster
 Delhi, 1985	Oleum	Shriram industrial leak; M.C. Mehta litigation
 Mayapuri, Delhi, 2010	Cobalt-60	Radiological source in scrap chain
 Visakhapatnam, 2020	Styrene	LG Polymers chemical leak

Do not mix the two Delhi events



1985: Oleum — chemical

Industrial leak at Shriram. M.C. Mehta litigation.



2010: Cobalt-60 — radiological

Radiological source in scrap chain.



Casualty figures need a date and source

A settlement-era figure, a later government claim and a final judicial finding are not interchangeable. State whose figure you are quoting and when.



Same category does not mean same substance.

Accurate examples strengthen an answer only when event, year and hazard are correctly paired.

Source: Supplied Day 24 source pack; M.C. Mehta judgment 20 December 1986; official Mayapuri reply 12 August 2010; NGT order 8 May 2020.

Hazard percentages: check the denominator

Day 24 | Topic 237 | 237.08

Historical vulnerability profile—not a 2026 remeasurement

Earthquakes:

almost **58.6%** of landmass—moderate to very high intensity.



→ **Denominator: landmass**

Percentage of the country's landmass.

Floods and river erosion:

over **40 million** hectares, about **12%** of land.



→ **Denominator: land**

Percentage of the total land area.

Cyclones and tsunamis:

close to **5,700 km** of the older **7,516 km** coastline.



→ **Denominator: coastline**

Percentage of the 7,516 km coastline (historical baseline).

Drought:

68% of cultivable area.



→ **Denominator: cultivable area**

Percentage of the total cultivable area.

These percentages overlap and use different bases. Do not add them to obtain a total hazard percentage.

The 7,516 km coastline is the historical baseline used in this profile, not the later remeasured coastline.



Earthquake-code caution

The 2016 IS 1893 classification had **Zones II, III, IV and V**, with **V** most severe.

This is a dated textbook classification, not a certification of which edition is currently in force.

For a current-code question, check the applicable BIS edition and official notice.

Sources: Supplied Day 24 notes; NDMA/NIDM historical vulnerability profile; MHA Lok Sabha reply 3 March 2015.

Resilience: reduce risk before the emergency

Day 24 | Topic 237 | 237.09

Anticipate



Monitor hazards, assess risks and plan ahead.

Resist and absorb



Strengthen people, infrastructure and systems to withstand hazards.

Adapt



Adjust to changing risks and learn from experience.

Recover essential functions



Restore key services such as water, electricity and other lifelines.

Resilience concerns how a system or community withstands, adapts and recovers—not merely how quickly relief arrives.

Hyogo Framework for Action 2005 – 2015	Sendai Framework for Disaster Risk Reduction 2015 – 2030
Built global awareness of disaster risk reduction and provided a 10-year framework to make communities safer.	Builds on Hyogo, with a broader and people-centred approach to reduce disaster risk and build resilient communities and societies.

Sendai adopted 18 March 2015 at the Third UN World Conference in Sendai, Japan.

7 global targets

4 priorities for action

Understand risk



Identify and assess hazards, exposure and vulnerability.

Strengthen risk governance



Set policies, roles and coordination across all levels.

Invest in risk reduction



Use risk-informed planning, resilient infrastructure and ecosystem approaches.

Prepare for response and Build Back Better



Plan, practise and ensure recovery reduces future vulnerability.

Preparedness and mitigation work before loss; recovery can reduce future vulnerability.
Disaster management is a continuous process, not a relief-only activity.

Source: UNDRR Sendai Framework; UNDRR Resilience terminology; supplied Day 24 notes.

Disaster management is more than relief.

What is a disaster?

A disaster overwhelms the coping capacity of the affected community.



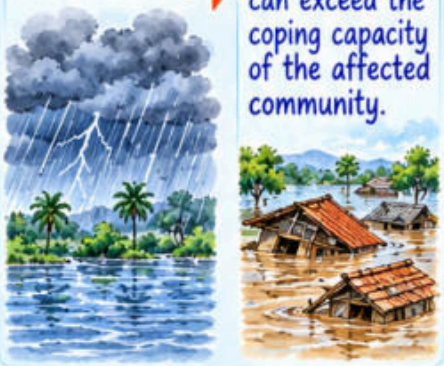
Hazard vs Disaster

Hazard

A hazardous event with the potential to cause harm.

Disaster

When a hazardous event, together with exposure and vulnerability, can exceed the coping capacity of the affected community.



Disaster Management Act 2005 (Act 53)

The Disaster Management Act 2005 (Act 53), dated 23 December 2005, provides the legal framework for disaster management in India.



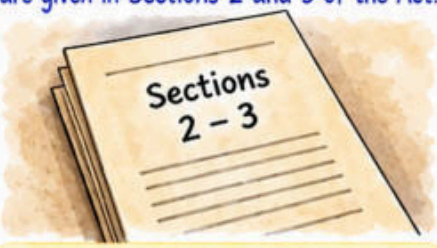
Man made causes in 2025

The 2025 explanation clarifies that law and order related situations are excluded from the expression 'man made causes'.



Key provisions (Sections 2 – 3)

Definitions and important provisions are given in Sections 2 and 3 of the Act.



Source: Ministry of Home Affairs consolidated Act as on 15 May 2026, sections 2 – 3.

More than relief

Disaster management is a continuous process that goes beyond relief to reduce future risks.



The disaster management process

Prevention and mitigation

Avoid or reduce potential risks and their impact.



Preparedness

Be ready with plans, early warning and resources.



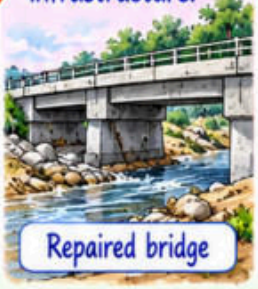
Response

Provide immediate assistance and manage the situation.



Recovery and reconstruction

Restore services, livelihoods and infrastructure.



Risk reduction

Build safer and more resilient communities to minimise future risks.



Three levels, different chairs.

Authority under the Act

NDMA, SDMA and DDMA are authorities under the Act, each with a specified chair.

Executive committee

Supports the authority in implementation. Chaired by the indicated official.

NATIONAL LEVEL

NDMA
Section 3
Chaired by the Prime Minister.



NATIONAL EXECUTIVE COMMITTEE

NEC
Chaired by the Union Home Secretary.



STATE LEVEL

SDMA
Section 14
Chaired by the Chief Minister.



STATE EXECUTIVE COMMITTEE

SEC
Chaired by the Chief Secretary.



DISTRICT LEVEL

DDMA
Section 25
Chaired by the Collector / District Magistrate / Deputy Commissioner.



DISTRICT EXECUTIVE ARRANGEMENT

The DDMA itself has a CEO.
There is not a separate district executive committee under the Act.



From policy to local implementation

NDMA
Sets overall policy and directions.

→

SDMA
Adapts and issues state level directions.

→

DDMA
Implements at the district level.

Key: Authority is not the same as executive committee.
The authority (NDMA / SDMA / DDMA) is chaired at the indicated level and empowered under the specified section, while the executive committee supports implementation.

Source:
MHA consolidated Act 15 May 2026.

NDMA sets direction; NEC coordinates action.

National Disaster Management Authority (NDMA)

- Prime Minister chairs the NDMA.
- Up to nine other members.
- Prepares and lays down policies, plans and guidelines for disaster management.
- Creates a national disaster database.



- The Vice-Chairperson performs day-to-day functions. In the Vice-Chairperson's absence, a member designated by the Chairperson or Vice-Chairperson performs these functions.

National Executive Committee (NEC)

- Union Home Secretary chairs the NEC.
- Includes the secretaries of the listed ministries and the Chief of the Integrated Defence Staff.
- Coordinates the implementation of policies, plans and guidelines.
- Monitors the implementation of the National Plan.
- Ensures preparedness and effective response for disasters.



Policies, plans and guidelines



Coordination and monitoring



Deployment of resources



National Plan for Disaster Management

- The NDMA coordinates the preparation and approval of the National Plan for Disaster Management.
- The plan is reviewed every three years.
- The plan is updated at least every five years.
- The first National Disaster Management Plan (NDMP) was released on 1 June 2016.



Source: Disaster Management Act, Sections 3, 6, 8, 10 and 11; Press Information Bureau, 1 June 2016.

Two national committees you must not confuse.

Both are under the Disaster Management Act, 2005 and have different roles.

Section 8A
NCMC – National Crisis Management Committee

Chair: Cabinet Secretary.

Purpose: Nodal body for major disasters with serious or national ramifications.



Key role:

- Overall coordination in a major disaster situation.
- Brings together different ministries and agencies.
- Focus on response and control measures for national level situations.

Section 8B
HLC – High Level Committee

Chair: Minister in charge of the Central ministry administering disaster management (Union Home Minister).

Purpose:

- Financial assistance to States under section 46.
- Approval of mitigation assistance under section 47.



Key role:

- Examines and approves financial assistance to States under section 46.
- Approves mitigation assistance under section 47.
- Focus on funding support for relief and long term risk reduction measures.

Compare at a glance:

NCMC – Emergency coordination and control board



Focus on coordinating the national response in major disaster situations.

HLC – Financial approval ledger



Focus on approval of financial assistance to States under section 46 and mitigation assistance under section 47.



National Executive Committee (NEC)

The NEC is chaired by the Union Home Secretary, not the Cabinet Secretary.

Source: Ministry of Home Affairs, Consolidated Act, 15 May 2026, page 12.

State authority and executive committee work together.

State Disaster Management Authority (SDMA)

Chief Minister chairs the SDMA.
Chief Secretary is the CEO ex officio.



State Executive Committee (SEC)

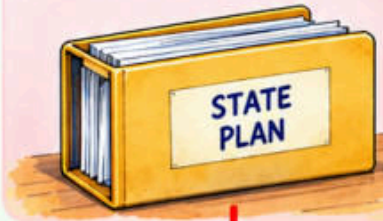
Chief Secretary chairs the SEC.
Four State Secretaries plus DGP ex officio.

DGP addition 2025.

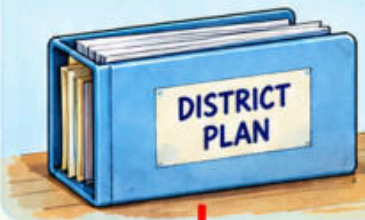


Functional preparation and approval tree

State Plan
coordinated by SDMA.



District Plan
by DDMA.



Urban Plan
by Urban Authority.





Review and update

State Plan is reviewed every 3 years and updated at least every 5 years.



Source

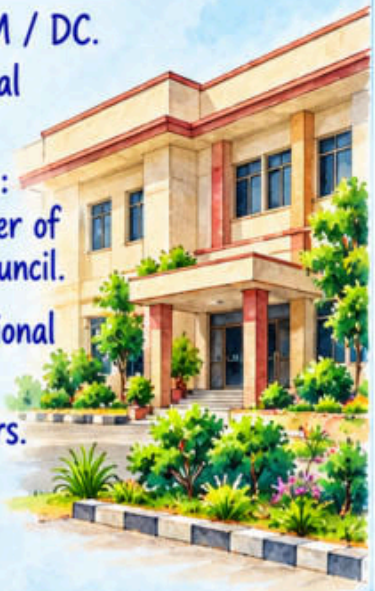
Act sections 14, 18, 20, 23, 31, 41A as on 15 May 2026.



District coordination meets local action.

DDMA composition

- Chair : Collector / DM / DC.
- Co-chair : elected local representative.
- Sixth Schedule areas : Chief Executive Member of autonomous district council.
- CEO : not below Additional Collector / equivalent.
- SP and CMO : members.



District plan and approval

- District plan prepared by DDMA after consulting local authorities.
- Approved by SDMA.
- Review and update at least every 2 years or earlier as necessary.



Functional example : generic flood preparedness

District plan → Municipal / panchayat staff training → Ready resources → Building standards → Relief / reconstruction



Role of local bodies

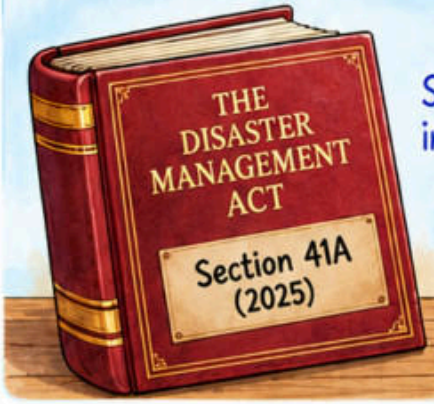
Local bodies prepare disaster management plans since 2025.



Source : Act sections 25, 31, 41.

Urban authority: enabling law, not automatic establishment.

Section 41A inserted 2025.



Section 41A inserted 2025.

State Government MAY notify

Urban Disaster Management Authority for State capitals and all cities having Municipal Corporation; Delhi and Chandigarh excluded.



Composition of Urban Authority.



Municipal Commissioner = CHAIR.



District Collector = VICE CHAIR.

Functions and process.

Urban Authority prepares Urban Plan.



SDMA approves.



Urban Authority coordinates implementation.



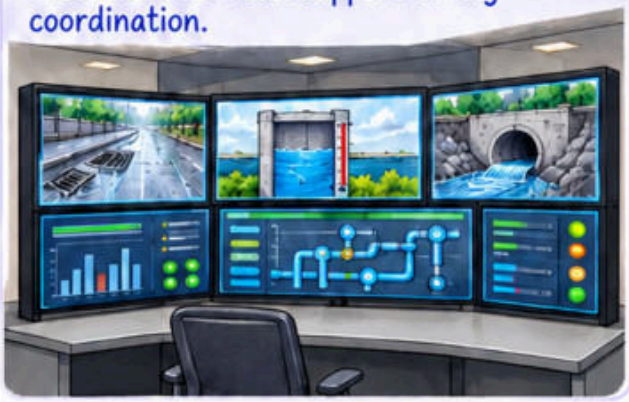
Illustrative urban risk coordination.

An Urban Plan can coordinate flood-risk measures such as drainage and pumping.



Illustrative monitoring tools.

A control room can support timely coordination.



Key comparison.



≠



Power to constitute does not prove authority already constituted in every city.

Source: MHA consolidated Act 15 May 2026, section 41A.

Force, fund and training institute are different.

National Disaster Response FORCE

Section 44
specialist response.

Section 45
NDMA general control.

Director General
command and supervision.



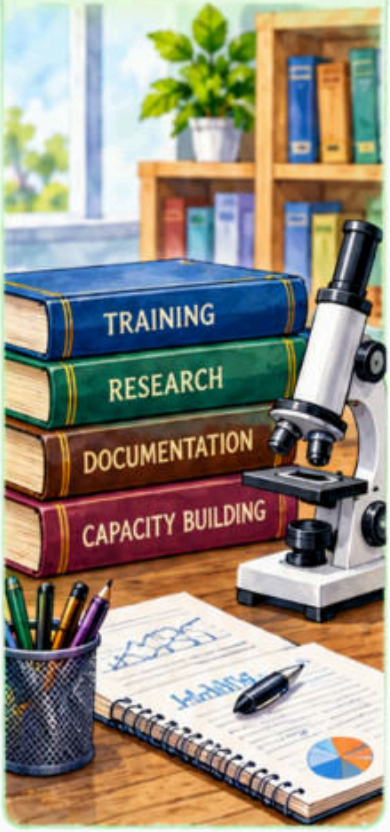
National Disaster Response FUND

Section 46
money for different aspects of disaster management.



NIDM

Section 42
training, research, documentation, capacity building.





Additional 2025 rule:

State Government MAY constitute State Disaster Response Force by notification under section 44A.

Source: MHA Act 15 May 2026.

Follow the fund to the correct institution.

State Disaster Response Fund	State Executive Committee
State Disaster Mitigation Fund	SDMA (State Disaster Management Authority)
District Response Fund and District Mitigation Fund	DDMA (District Disaster Management Authority)
National Response Fund and National Mitigation Fund	Applied under Central Government guidelines in consultation with NDMA (National Disaster Management Authority)

STATUTORY DESIGN

The Disaster Management Act provides separate response and mitigation funds at the national, state and district levels, and specifies the institutions that receive and manage these funds.

This page explains the statutory design of fund flow under Sections 46 to 48. It does not prove that each district fund is operational.

Source: Act sections 46 – 48 as on 15 May 2026.

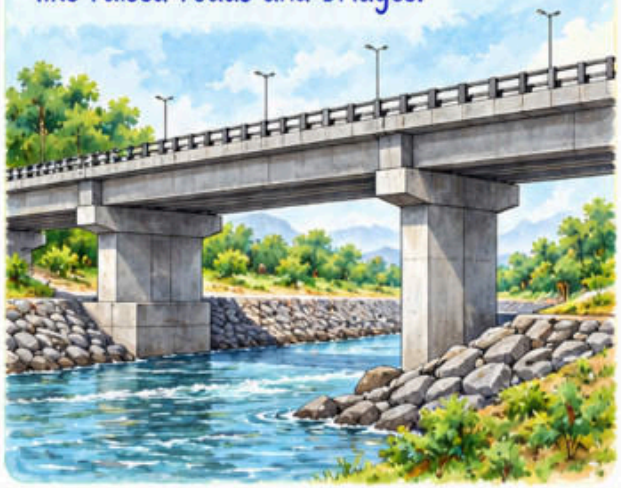
Example use: Emergency relief supplies

Response funds can be used to provide immediate relief such as food, water, shelter materials, medicines and other essential supplies during a disaster.



Example use: Disaster-resilient infrastructure

Mitigation funds can be used to reduce future risk, such as constructing or upgrading disaster-resilient infrastructure like raised roads and bridges.



Read disaster finance with its award period.

Historical FC 15, 2021 – 22 to 2025 – 26

The Fifteenth Finance Commission (FC 15) recommended disaster finance for the period 2021 – 22 to 2025 – 26.



Total risk fund: 100%

The total risk fund is divided into two parts:

- Response: 80%
- Mitigation: 20%



Response windows as SHARES OF THE WHOLE:

The 80% response component is further divided into three windows.

Relief: 40%

Immediate assistance after a disaster.



Recovery/ reconstruction: 30%

Restoring and rebuilding assets and services after a disaster.

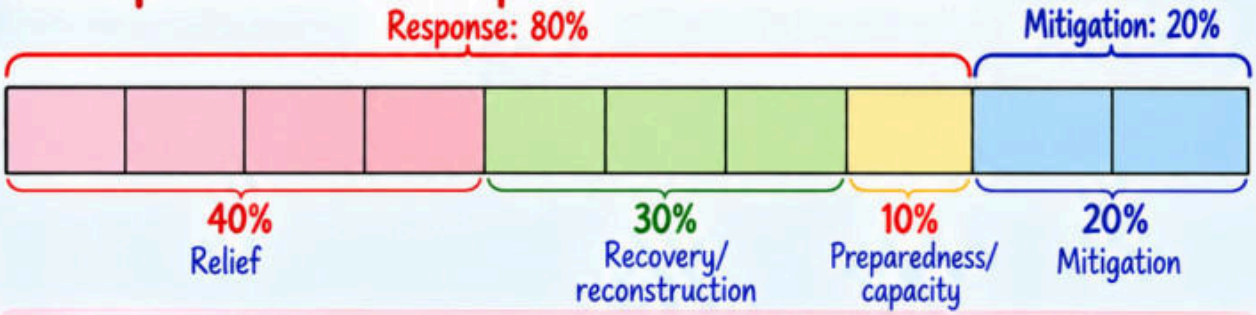


Preparedness/ capacity: 10%

Building systems, capacity and early warning for future risks.



Ten equal units: each represents 10% of the whole



- 40 + 30 + 10 = 80 (these are shares of the whole risk fund, not percentages of 80).
- Mitigation is the remaining 20% of the total risk fund.

Historical totals (recommendations)

National risk fund
Rs 68,463 crore



State risk fund
Rs 1,60,153 crore



These are recommendations/ allocations, not actual spending.

Do not carry old windows unchanged into FC 16.

FC 16 recommends different flexibility and preparendess arrangements. See the next page for its 2026-31 recommendations.



Source: FC 15 report 2021 – 26; MHA 2023.

FC16 changes the financing picture.

RECOMMENDATIONS for 2026 – 27 to 2030 – 31, not actual releases.

State funds together
Rs 2,04,401 crore.

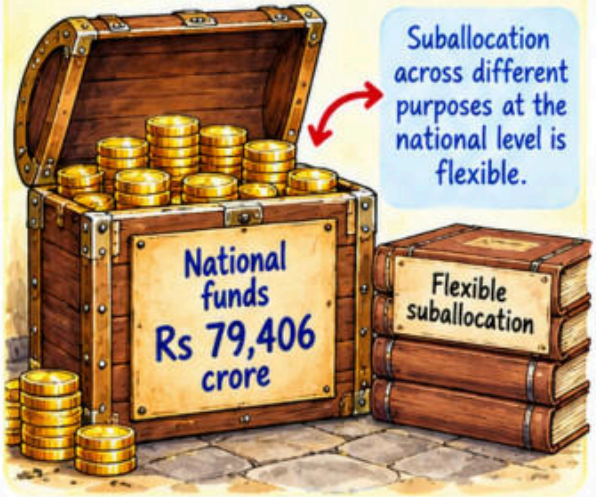
This consists of the State Disaster Response Fund (SDRF) and the State Disaster Mitigation Fund (SDMF).



80 : 20 split
between SDRF and SDMF.

National funds
Rs 79,406 crore.

The 16th Finance Commission recommends this amount for the national level.



Functional comparison

FC16 recommends flexibility between State Response / Relief and Recovery / Reconstruction, with preparedness and capacity building under Mitigation funds.

State Response / Relief
Use for immediate response and relief activities.



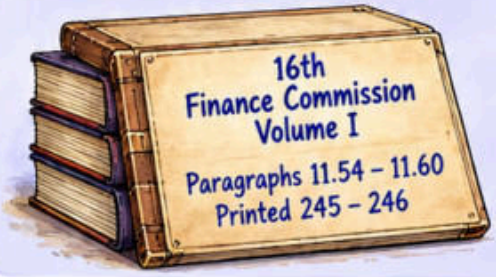
Flexibility

Recovery / Reconstruction
Use for restoring and rebuilding after a disaster.



Preparedness and Capacity Building
Under Mitigation funds.





Source:
16th Finance Commission Volume I, paragraphs 11.54 – 11.60, printed 245 – 246.

Date the law before memorising it.

KEY DATES

23 December 2005
The original Act was enacted.



9 April 2025
A major amendment came into force.



15 May 2026
Jan Vishwas changes are reflected in the official consolidation.



CURRENT SCOPE

Teaching checked against MHA consolidated text 'as on 15 May 2026', not an undated claim.



2026 EXAMPLES (SELECTED OFFENCES)

Maximum penalties, not automatic sentences.

Section 51
Obstruction or refusal under the Act, without reasonable cause.

- Up to 6 months' imprisonment or fine or both.
- If this causes loss of lives or imminent danger thereof: up to 1 year imprisonment.



Section 52
Knowing false claim.

- Up to 6 months' imprisonment AND fine.



Section 53
Misappropriation of money or materials meant for disaster relief.

- Up to 1 year' imprisonment AND fine.



TWO AMENDMENTS, DIFFERENT DATES



2025 institutional changes: effective 9 April 2025.



Selected penalty changes under Jan Vishwas 2026: effective 15 May 2026.

Do not attribute the 2026 penalty changes to April 2025.

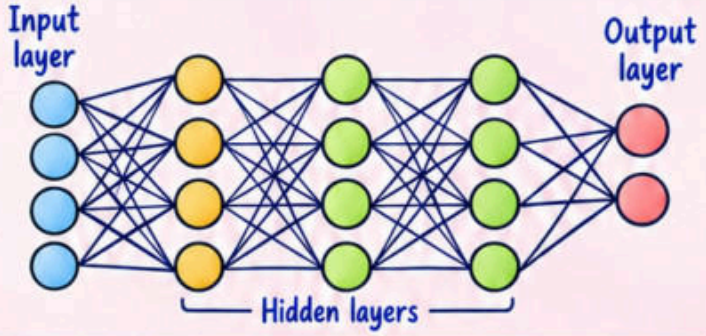
Source: MHA consolidated Act, page 31 (footnotes); Jan Vishwas Act 8 of 2026. | No legal advice.

AI is the field; learning is one route

Artificial intelligence: tasks involving intelligent behaviour.

Machine learning: patterns learned from data.

Deep learning: multi-layer neural networks.



Symbolic rules

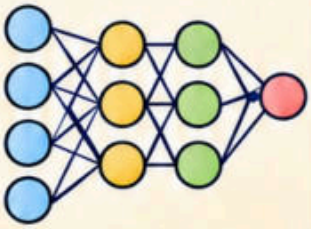


Example: identifying a crop pest (illustrative, verify before action)

Input



Model



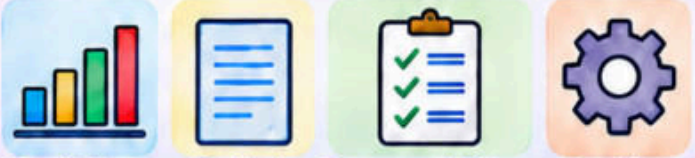
Possible pest class



Possible caterpillar class
(illustrative output)

OECD 2023

Covers explicit OR implicit objectives.
Outputs include predictions, content, recommendations and decisions.



Not every AI system learns continuously after deployment.



Source: OECD 29 Nov 2023.

A proposal is not the workshop

1950 Turing: imitation game

Alan Turing proposed the imitation game as a way to discuss whether a machine could show intelligent behaviour through conversation.



31 August 1955

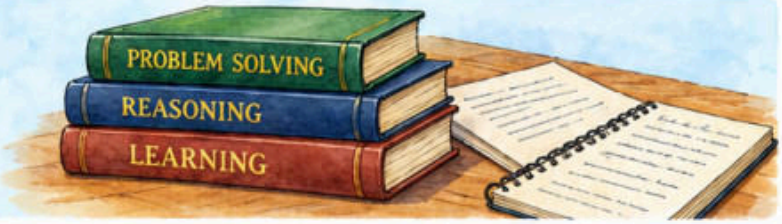
John McCarthy, Marvin Minsky, Nathaniel Rochester and Claude Shannon submitted a proposal to the Rockefeller Foundation using the term "artificial intelligence".



The proposal introduced the term "artificial intelligence" and outlined a plan for a summer research project.

Summer 1956

The Dartmouth research project took place in the summer of 1956 at Dartmouth College, bringing together a group of researchers to work on artificial intelligence.



1959 Samuel: published machine-learning checkers study

Arthur Samuel published a study showing that a checkers program could learn and improve through self-play using machine-learning techniques.



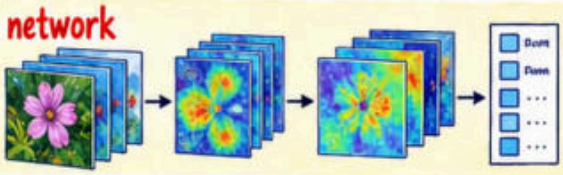
1997 Deep Blue defeats Kasparov in six-game match

IBM's Deep Blue defeated Garry Kasparov in a six-game match, a landmark result in computer chess.



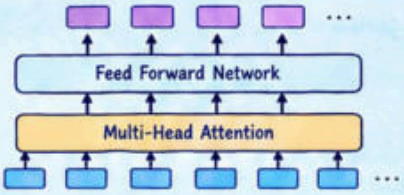
2012 AlexNet: ImageNet deep convolutional network

AlexNet used a deep convolutional network to achieve a major improvement in image recognition on the ImageNet dataset.



2017 Attention Is All You Need: Transformer

The paper "Attention Is All You Need" introduced the Transformer architecture, showing that attention mechanisms can be used for highly effective language models.



COMPARE: 1955 proposal vs 1956 workshop

1955 proposal

- Submitted on 31 August 1955.
- Used the term "artificial intelligence".
- Outlined a plan and requested funding for a summer research project.
- It was a proposal, not the event itself.



1956 workshop

- Took place in the summer of 1956 at Dartmouth College.
- Brought together a group of researchers to work on artificial intelligence.
- Was the research project described in the proposal.
- The workshop was the event, not the original proposal document.



Sources Stanford McCarthy archive; IBM; original research.

Labels teach a spam filter

What is supervised learning?

We learn a pattern from labelled examples. Each email has input features and a desired output label. The model learns from the training data and then predicts labels for new emails.

Key terms

Feature = input attribute of an email.

Label = desired output (spam or not spam).

Training fits model to find patterns in the data.

Testing checks unseen examples to estimate performance.

Worked example

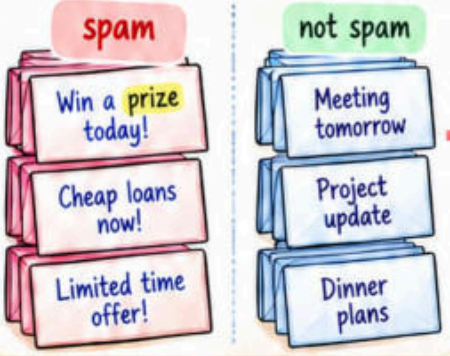
The word "prize" can be a feature. If an email contains "prize", the label might be spam. But this is not a guarantee. Some genuine emails (for example, a school prize) may also contain the word "prize".



The 7-step supervised learning pipeline

1 Collect labelled examples

Emails with known labels.



2 Convert to features

Turn each email into input attributes.

Contains word prize?	1
Contains word free?	0
Number of links	2
Number of capital letters	5
Email length	120
Sender domain type	0

3 Split the data

Keep some emails for training and a separate held-out set for testing.

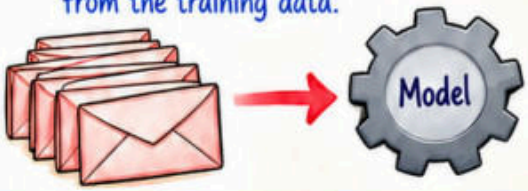


Training data
Used to fit the model.

Held-out test data
Kept separate and unseen during training.

4 Train the model

The model learns patterns from the training data.



5 Test on held-out emails

Use the trained model to predict labels for the unseen test data.



6 Inspect errors

Inspect mistakes to understand limitations. Tune using separate validation data, not the final test set.

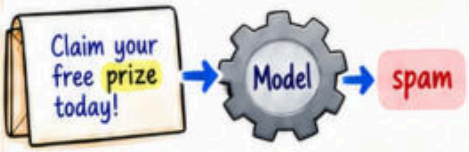


Model predicted spam but actual label is not spam

Model predicted not spam but actual label is spam

7 Predict new email

Use the trained model on unseen emails in real use.



Important

Keep the test data unseen during training. If test emails influence training, the performance can be misleadingly high and will not reflect real-world performance.

Sources

IBM supervised learning; Google ML glossary.

No labels, or rewards? Not the same

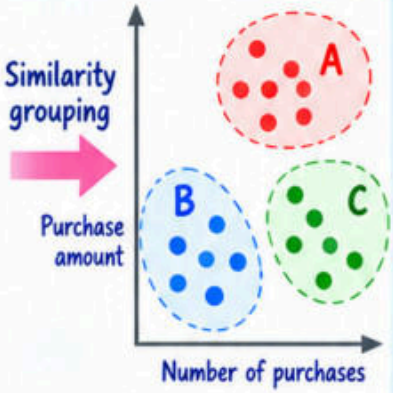
Unsupervised learning: finds structure without labels

The algorithm sees unlabelled purchasing records. It looks for patterns and groups similar customers together. The clusters reveal structure in the data, but the cluster names need human interpretation.

Unlabelled purchasing records

●	23	5	120
●	45	2	80
●	31	8	300
●	22	1	60
●	46	3	90
●	25	6	150
●	33	7	280
●	20	2	70
	...	...	...

Clusters found in the data



The algorithm discovers structure, but the cluster names such as A, B and C need to be interpreted, for example as "high value customers", "occasional buyers" or "budget customers".

Reinforcement learning: learns from rewards

The agent learns a policy through interaction with an environment. It takes action, receives a numerical reward and a new state, and over time learns to choose actions that maximise cumulative reward. This is not a table of labelled answers.



The agent improves its policy over many interactions, seeking the highest cumulative reward. It learns from feedback, not from a set of labelled examples.

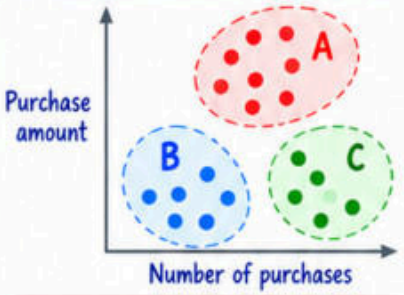
How the three learning approaches differ

Supervised learning
Learns from labelled examples

	Features (input)	Label (target)
●	Age 23, 5 purchases	Electronics
●	Age 45, 2 purchases	Groceries
●	Age 31, 8 purchases	Travel
●	Age 22, 1 purchase	Books
	...	...

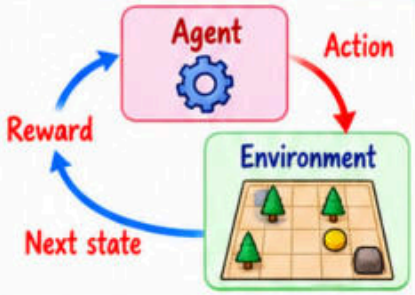
Learns a mapping from inputs to known labels to make predictions on new data.

Unsupervised learning
Finds structure without labels



Discovers natural groupings in the data. The cluster names need interpretation, for example types of customers or products.

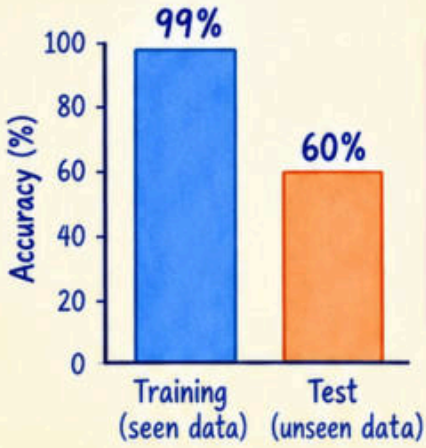
Reinforcement learning
Learns from reward feedback



Learns a policy through interaction, seeking the highest cumulative reward. This is not a set of labelled answers.

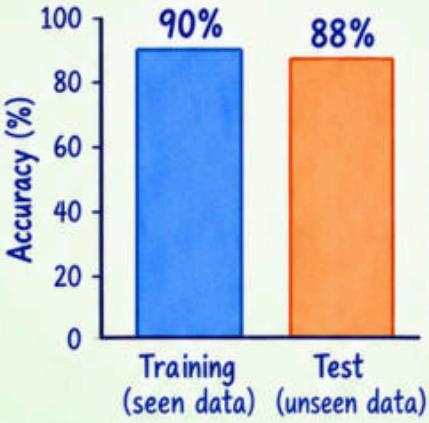
High training accuracy can mislead

Model A



Large gap between training and test accuracy suggests overfitting.

Model B

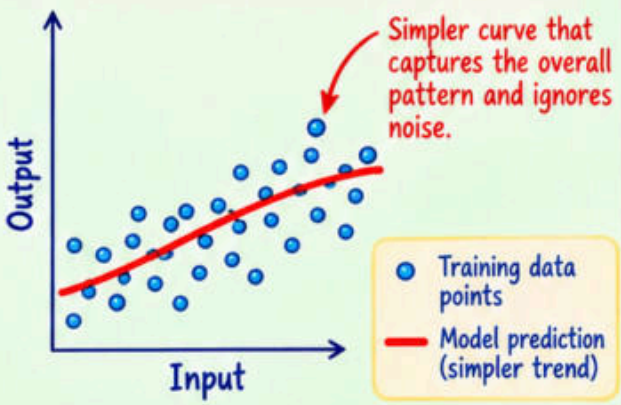


Training and test accuracy are similar, so this model generalises better in this illustration.

Model A: overfitting

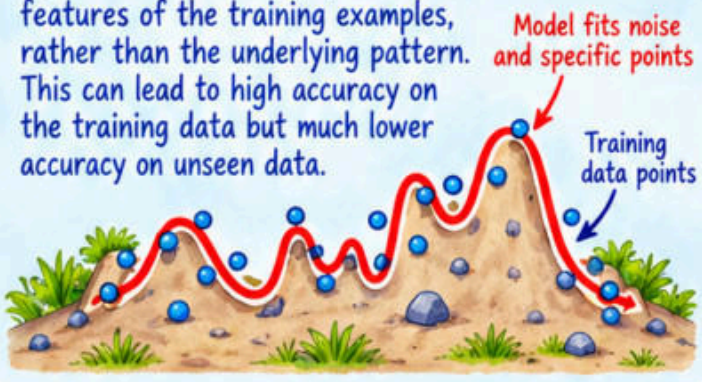


Model B: better generalisation



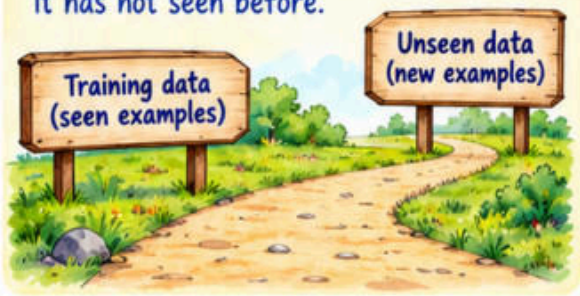
What is overfitting?

Overfitting happens when a model captures noise or very specific features of the training examples, rather than the underlying pattern. This can lead to high accuracy on the training data but much lower accuracy on unseen data.



Why testing on unseen data matters

A high training score alone is not proof of usefulness. We need to evaluate the model on unseen data (test data) to see how well it performs on new examples it has not seen before.



Source: Google Machine Learning Glossary – Overfitting. Numbers are illustrative examples, not research findings.

Deep learning is a model approach

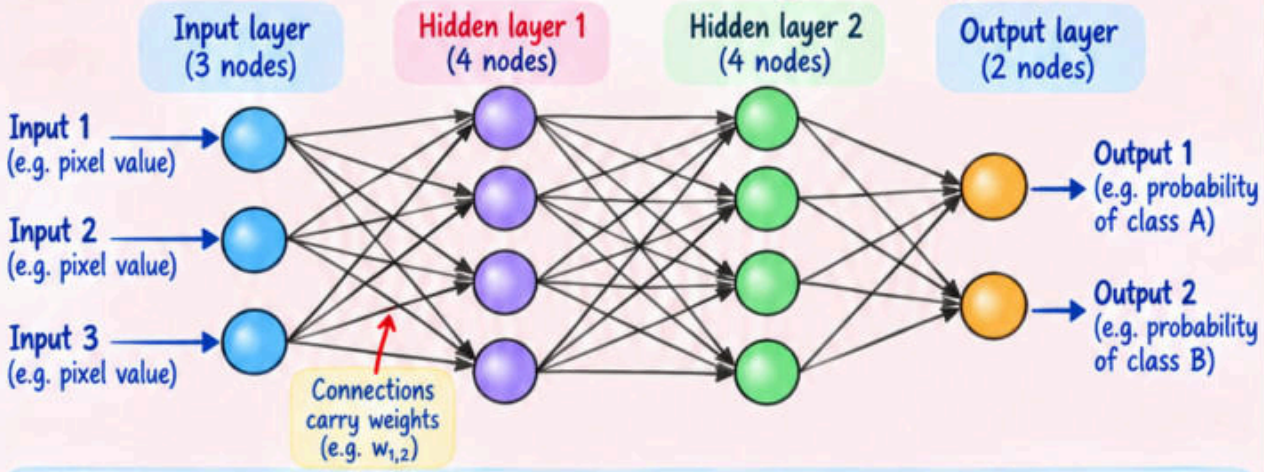
What is deep learning?

Deep learning uses multi-layer neural networks to learn patterns from data. It is a model approach that learns from examples rather than following hand-written rules.

Key idea

A neural network is a mathematical model made of simple connected units that transform inputs step by step. It is inspired by the brain, but it is not an exact model of the human brain.

A neural network for deep learning



Training adjusts the weights so that the model's outputs match the desired targets. The network is a mathematical model, not an exact model of the human brain.

Two key design choices

1. Architecture
What model?

- number of layers
- number of nodes per layer
- type of connections
- activation functions

2. Learning paradigm
What feedback?

- labelled data (supervised learning)
- self-supervised objectives
- reward-based methods (reinforcement learning)

Ways to train deep networks

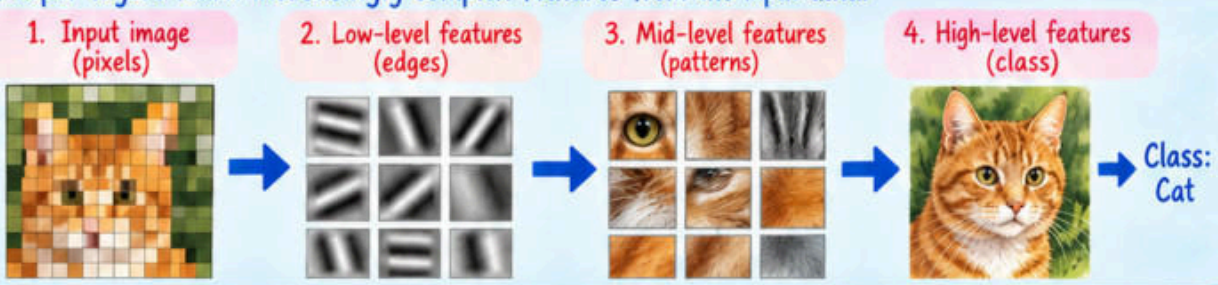
Labelled learning
Use input-output pairs and minimise the difference between predicted and true labels.

Self-supervised learning
Create a learning objective from the data itself (e.g. predict a missing or next part).

Reward-based learning
Learn from a reward signal that indicates better or worse actions or outputs.

How deep learning builds understanding

Deeper layers learn increasingly complex features from the input data.

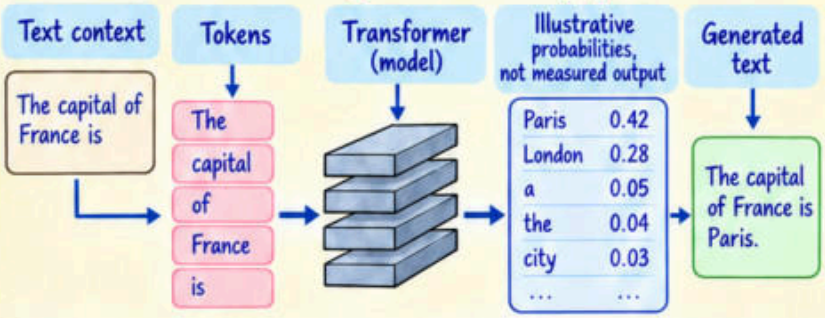


Fluent text is not verified knowledge

What is generative AI?

- Generative AI creates new content such as text, images, code or audio.
- An LLM (large language model) is a language-focused model that generates text.
- Next-token prediction alone is not real-time fact verification.

Next-token generation pipeline



A token can be part of a word, a whole word, or punctuation. It is not always one whole word (e.g. "Fran", "ce", or ".").

Training objective vs verification

Training objective (next-token prediction)

The model is trained to predict tokens that are likely to come next in large collections of text. It learns statistical patterns of language.



Prediction alone is not verification

Additional training and tools can improve reliability. Next-token prediction alone does not establish whether a claim is true or up to date. Fluent and confident text can still be incorrect or unsupported.



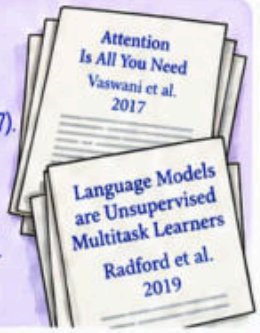
Hallucination

A hallucination is a plausible but incorrect or unsupported output. It can sound fluent and factual, but it is not based on verified evidence.



Sources

- The Transformer architecture: *Attention Is All You Need* (Vaswani et al., 2017).
- GPT models: Research on generative, pre-trained language models (e.g. Language Models are Unsupervised Multitask Learners – Radford et al., 2019).



From output to responsible use

Generated text

A generated factual claim.

Check with a primary source and date

- Look for reliable, original sources (e.g. government websites, official reports, academic publications).
- Check the publication date and whether the information is current.
- Compare claims with multiple sources.



Supported by reliable sources

- Use the information with judgement.
- Consider the context, limitations and whether the source is recent.
- It may still need interpretation.



Unsupported or contradictory

- Do not treat the claim as true.
- Reject it or investigate further.
- Look for better sources or additional evidence.



IndiaAI: capacity plus guardrails

Cabinet approval

7 March 2024 for the IndiaAI Mission.



Total outlay

Rs 10,371.92 crore over 5 years.

This is the approved outlay, not the expenditure achieved.



Implementation

IndiaAI Independent Business Division under Digital India Corporation.



Seven connected pillars

1 Compute Capacity

High performance computing infrastructure to train large AI models.



2 Innovation Centre

Develop indigenous Large Multimodal Models and domain-specific foundational models.



3 Datasets Platform

Streamline access to quality non-personal datasets for startups and researchers.



4 Application Development Initiative

Build sectoral AI applications in areas such as agriculture, health, education and governance.





5 FutureSkills

Develop AI skills and talent through training, courses and certification programmes.



6 Startup Financing

Support deep-tech AI startups with streamlined funding access.



7 Safe & Trusted AI

Ensure ethical, safe and responsible AI through standards, tools and governance mechanisms.



From resources



- Compute capacity
- Curated datassts
- Skilled talent
- Innovation ecosystem
- Startup support

To models and applications



- Foundation models
- Sectoral applications
- Tools and solutions
- Innovation and startups

To responsible deployment



- Safe
- Transparent
- Inclusive
- Trustworthy
- For public good

Applications in action (PIB, 12 October 2025)

BHASHINI



Language access tools to make digital services and information available in Indian languages.

Kisan e-Mitra



AI based scheme help for farmers, providing personalised advice and information on government schemes.

Education tools



AI based tools to support students and teachers with learning resources and personalised support.

Source: PIB 2012355 and PIB 12 October 2025 backgrounder.

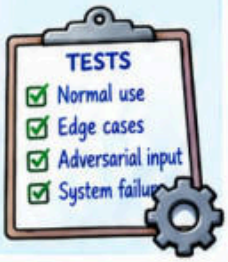
Responsible AI: principle to practice

NITI Aayog, February 2021

1 Safety & reliability

AI systems should be safe, reliable and robust in real world use.

PRACTICE: Test failure modes before deployment.



2 Equality

AI should promote fair and just outcomes for all.

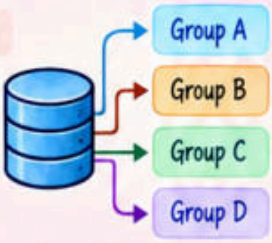
PRACTICE: Compare outcomes across different groups.



3 Inclusivity & non-discrimination

AI should be inclusive and not discriminate against any group.

PRACTICE: Check for excluded groups in data and outcomes.



4 Privacy & security

AI should respect privacy and ensure data security throughout its use.

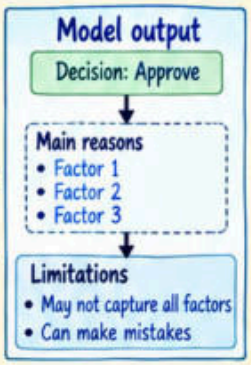
PRACTICE: Protect data with appropriate technical and organisational measures.



5 Transparency

AI systems should be transparent and explainable to relevant stakeholders.

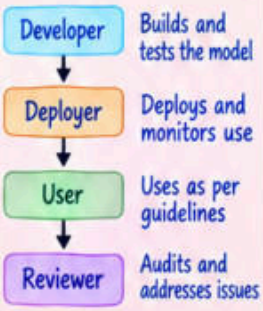
PRACTICE: Explain how the system works and its limitations.



6 Accountability

There should be accountability for the design, development, deployment and use of AI systems.

PRACTICE: Assign clear responsibility across the AI lifecycle.



7 Positive human values

AI should preserve human agency and support human well-being and social good.

PRACTICE: Preserve human agency by keeping humans in the loop.



- ✓ Informs decisions
- ✓ Allows human override
- ✓ Supports human well-being

From principle to practice: an AI system audit pipeline



Constitutional and legal foundations

Responsible AI should be consistent with India's constitutional values and applicable laws.

Ethical principles are not a substitute for verification.

Principles guide action, but must be supported by technical testing, evidence and continuous review.

Source: NITI Responsible AI Part 1, 2021.

2025 guidelines, 2026 cooperation

5 November 2025 — MeitY India AI Governance Guidelines

The Ministry of Electronics and Information Technology (MeitY), Government of India released AI Governance Guidelines to enable responsible, inclusive and trusted AI.

Seven sutras for responsible AI

1. Trust
2. People First
3. Innovation over Restraint
4. Fairness and Equity
5. Accountability
6. Understandable by Design
7. Safety, Resilience and Sustainability

Six governance pillars

- Infrastructure
- Capacity building
- Policy and regulation
- Risk mitigation
- Accountability
- Institutions

Action plan and practical guidance

- Guidelines for government, industry, researchers and users.
- Risk based approach across the AI lifecycle.
- Practical tools such as governance checklists, impact assessments and documentation.
- Enables innovation while managing risks and protecting rights.



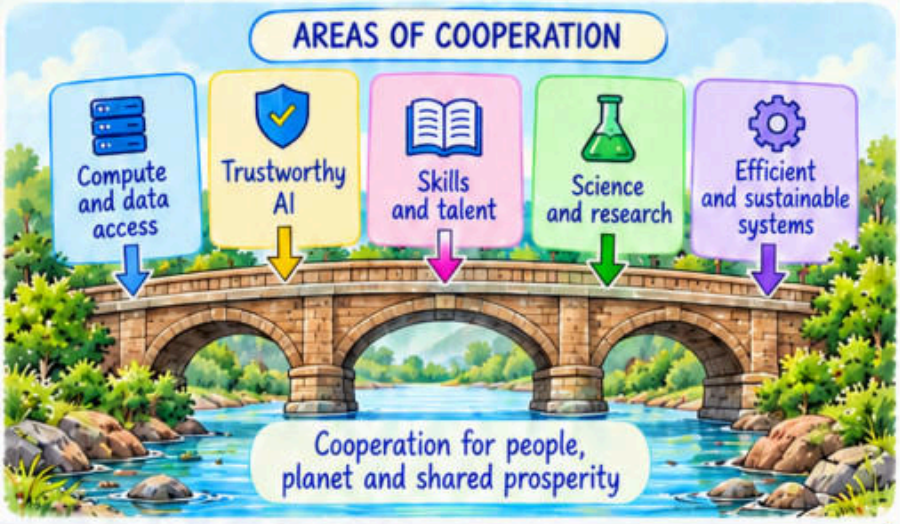
21 February 2026 — PIB reports New Delhi Declaration after AI Impact Summit 18 – 19 February 2026

The Press Information Bureau (PIB) reported that the New Delhi Declaration was adopted after the AI Impact Summit held on 18 – 19 February 2026.

Key distinction

The Declaration sets out voluntary, non-binding cooperation. It is **NOT** a global AI law.

Countries, international organisations, industry, academia and civil society agreed to work together to harness AI for people, planet and shared prosperity.



Source: PIB 2186639 / 2231208

Four legal protected-area categories

Wild Life (Protection) Act, 1972
Section 2(24A) defines
four protected-area categories.

Protected areas (Section 2(24A))

National Park

No livestock grazing.

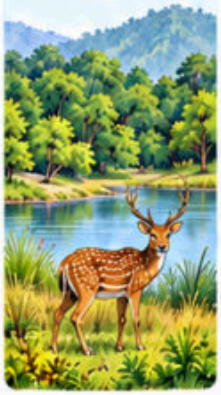
Rights must be settled before final notification.



Sanctuary

Certain existing rights may continue under law.

Grazing may be regulated, controlled or prohibited.



Conservation Reserve

Government-owned land, declared after consulting local communities.



Community Reserve

Private or community land voluntarily offered for conservation, outside national parks, sanctuaries and conservation reserves.



Tiger Reserve
(Section 38V, same Act)

- Separately provided in the Wild Life (Protection) Act, 1972.
- A landscape with a core and a buffer for long term conservation of tigers and their habitat.
- Can include one or more of the four protected-area categories.



Biosphere Reserve
(National / UNESCO MAB framework)

- Not created under the Wild Life (Protection) Act, 1972.
- A large landscape for conservation, sustainable development and research.
- Includes core, buffer and transition areas.
- Can overlap with any of the above protected areas, including tiger reserves.



Important points

- The four categories are defined in Section 2(24A) of the Wild Life (Protection) Act, 1972.
- Tiger reserve is separately provided in Section 38V of the same Act.
- Biosphere reserve is a national / UNESCO MAB framework, not created under this Act.
- The categories can overlap. Do not add or sum unlike categories.

Habitat illustrations are conceptual, not maps or exact site depictions; zoning shapes vary by site.

Sanctuary or national park?

Start with rights

Both are declared areas for wildlife protection, but the treatment of existing rights is different.

Key difference

A sanctuary may allow continuation of certain existing rights. A national park does not have this continuation provision and its final notification follows after rights vest in the State.

Wildlife sanctuary

- Collector may allow continuation of existing rights under Section 24(2)(c) with the Chief Wild Life Warden's consultation.
- Grazing and movement of livestock may be regulated, controlled or prohibited by the Chief Wild Life Warden under Section 33(d).

National park

- No provision for continuation of existing rights under Section 24(2)(c).
- Final notification is issued only after rights vest in the State under Section 35(4).
- Grazing of livestock is not allowed in a national park under Section 35(7).

Sanctuary habitat (regulated grazing)



Grazing and movement of livestock may be regulated, controlled or prohibited by the Chief Wild Life Warden under Section 33(d).

National park habitat (no grazing)



Grazing of livestock is not allowed in a national park under Section 35(7). Final notification is issued only after rights vest in the State under Section 35(4).

Habitat illustrations are conceptual, not maps or exact site depictions; zoning shapes vary by site.

Who declares – and who recommends?

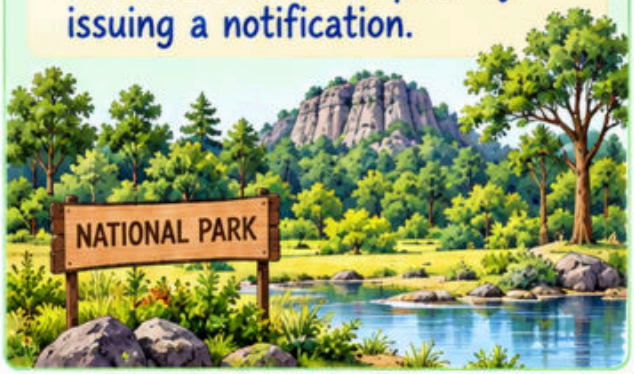
Sanctuary (Section 18 and 26A)

State Government
declares a sanctuary by issuing a notification.



National Park (Section 35)

State Government
declares a national park by issuing a notification.



Transferred or leased protected area (Section 38)

Central Government
may declare a sanctuary or a national park for an area that is transferred to, or leased by, it.



Boundary alteration (Section 26A(3) and 35(5))

The boundary of a sanctuary or a national park can be altered only on the recommendation of the National Board for Wildlife (NBWL).

A resolution of the State Legislature cannot by itself change the boundary.



Process for boundary alteration

National Board for Wildlife recommends boundary alteration. → State Government examines the recommendation. → State Government decides and issues a notification.

Declaration is not the same as management

Declaration

- Creates the legal status as a sanctuary or national park.
- Done by the appropriate government as explained above.

Management

- Day to day protection, conservation and administration.
- Carried out through the prescribed authorities and management measures after declaration.

Habitat illustrations are conceptual, not maps or exact site depictions; zoning shapes vary by site.

Conservation reserve or community reserve?

Government land

Government-owned land.



Private or community land

voluntarily offered for conservation.



Conservation reserve
Section 36A

Can be declared on government land. The State Government shall consult local communities before declaring a conservation reserve.



Community reserve
Section 36C

Declared on private or community land volunteered for conservation. Must be outside a national park, wildlife sanctuary and conservation reserve.





The Central Government can also declare a conservation reserve for transferred or leased areas under Section 38(2A), subject to Section 36A conditions. (as inserted by the 2022 amendment, effective 2023).

Management
Section 36B

A conservation committee advises the Chief Wild Life Warden on management of the conservation reserve.



Management
Section 36D

A community committee manages the community reserve and prepares a management plan.



Habitat illustrations are conceptual, not maps or exact site depictions; zoning shapes vary by site.

A tiger reserve has a core and a buffer.

Core area

- Inviolate area for tigers.
- Strict protection.
- Managed to keep critical tiger habitat inviolate, subject to statutory safeguards for rights.



Buffer area

- Surrounds the core area.
- Allows coexistence with local communities.
- Regulated use of forest resources for livelihoods.
- Supports conservation and reduces pressure on the core.



How a tiger reserve is notified

A State Government notifies a tiger reserve on the recommendation of the National Tiger Conservation Authority (NTCA) under Section 38V of the Wildlife (Protection) Act, 1972.



NTCA list of tiger reserves (as on 23 October 2026)

The National Tiger Conservation Authority (NTCA) maintains a list of 58 tiger reserves in India (as on 23 October 2026).

Total area:
Core area: 46,701.29 sq km
Buffer area: 37,786.54 sq km
Total: 84,487.83 sq km

Latest listed tiger reserve (as on 2026)

Madhav Tiger Reserve in Madhya Pradesh was the latest to be included in the list in 2025.



Nagarjunsagar Srisailam Tiger Reserve (Andhra Pradesh)

Area details:
Core area: 2,595.72 sq km
Buffer area: 700.59 sq km
Total area: 3,296.31 sq km



Habitat illustrations are conceptual, not maps or exact site depictions; zoning shapes vary by site.

A biosphere reserve connects protection with livelihoods.

A biosphere reserve, under UNESCO's Man and the Biosphere (MAB) programme, conserves biodiversity, supports sustainable development and provides opportunities for research, monitoring and education.

Zoning in a biosphere reserve

A biosphere reserve has three interlinked zones. The shape and size vary by place and are not always concentric.

CORE ZONE

- Strictly protected ecosystems.
- Conservation of biodiversity and natural processes.
- Minimal human use.

BUFFER ZONE

- Adjoins or surrounds the core.
- Compatible activities such as research, education, monitoring and sustainable resource use.
- Helps reduce pressure on the core.

TRANSITION ZONE

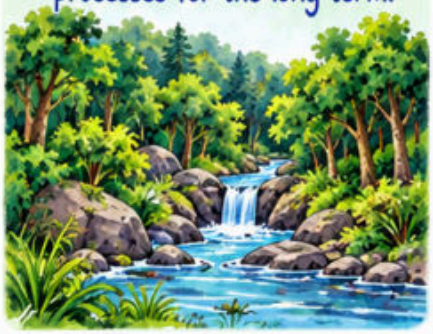
- Communities live and work here.
- Sustainable development activities such as agriculture, agroforestry and eco-friendly enterprises.
- Links conservation with livelihoods.



Three functions of a biosphere reserve

Conservation

- Protects biodiversity, ecosystems and natural processes for the long term.



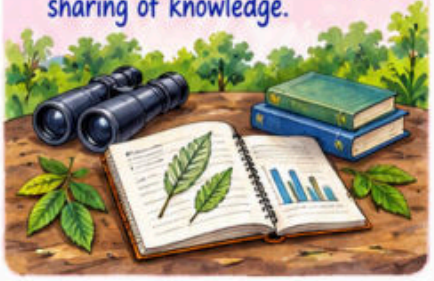
Sustainable development

- Supports nature-friendly livelihoods and responsible resource use.
- Helps people and nature thrive together.



Logistics, research, monitoring and education

- Provides a platform for long-term research and monitoring.
- Supports education, training and sharing of knowledge.



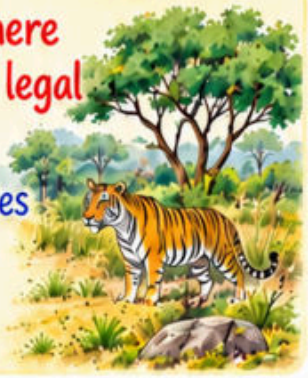
Habitat illustrations are conceptual, not maps or exact site depictions; zoning shapes vary by site.

A number without a date is a trap.

Numbers about protected areas change over time because of new notifications, revisions and reclassification. Always check the source and the date.

Tiger reserves and biosphere reserves can overlap these legal protected areas.

They are not extra categories in this four-category total. Do not add unlike counts.



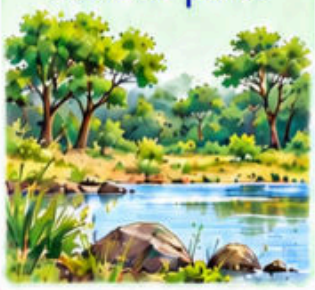
Dated snapshot: 27 November 2023 (WII)

Total protected areas in India (WII, 27 November 2023)

1,014 = 106 parks + 573 sanctuaries + 115 conservation + 220 community

Total area = 1,75,169.42 sq km (5.32%)

106
national parks



573
wildlife sanctuaries



115
conservation reserves



220
community reserves



Later official totals are different vintages.

10 February 2025 (Lok Sabha)

1,022
total protected areas

5.43% of India's area



2025 baseline, reported in New India Samachar, 1–15 June 2026

1,134
total protected areas



Key points to remember

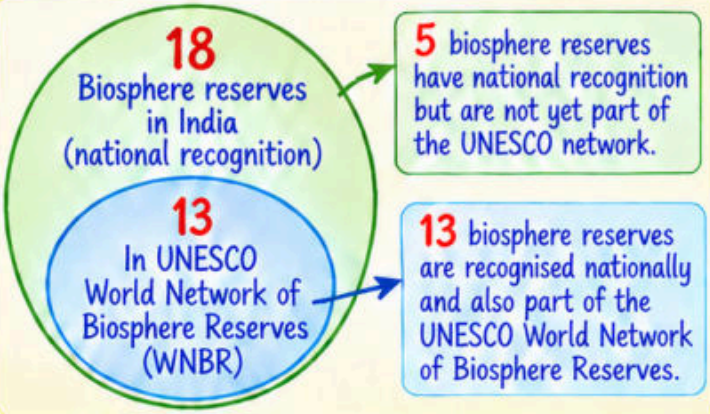
- The figures 1,014 (27 November 2023), 1,022 (10 February 2025) and 1,134 (2025 baseline, reported in New India Samachar, 1–15 June 2026) are from different sources and different dates.
- Percent of area also differs: 5.32% (27 November 2023) and 5.43% (10 February 2025).
- A number without a date can be misleading.
- Do not add tiger reserves or biosphere reserves: these designations can overlap the four categories.

Habitat illustrations are conceptual, not maps or exact site depictions; zoning shapes vary by site.

National recognition is not UNESCO recognition

India has 18 biosphere reserves recognised nationally.

Out of these, 13 are part of the UNESCO World Network of Biosphere Reserves (WNBR) as per PIB, 3 November 2025.



Cold Desert joined UNESCO network in September 2025

National recognition: 2009.
UNESCO entry: September 2025.
It became India's 13th site in the UNESCO network.



Panna (2011) – newest national designation

The Panna Biosphere Reserve was given national recognition in 2011. It is not the newest entry in the UNESCO World Network.



Smallest among all 18 (national list)

Dibru-Saikhowa
765 sq km

as per MoEFCC December 2023 list.



Smallest Indian biosphere reserve in the UNESCO network

Nokrek
820 sq km



Largest among all 18

Great Rann of Kutch
12,454 sq km



Global update – 5 June 2026

UNESCO announced that the World Network of Biosphere Reserves has 797 sites in 145 countries as on 5 June 2026.

14 new sites were added in 2026, but none are from India.



Total sites: 797
Countries: 145
New sites in 2026: 14
From India: None

Key takeaways

1. National recognition and UNESCO recognition are different.
2. India has 18 biosphere reserves, of which 13 are in the UNESCO World Network (as per PIB, 3 November 2025).
3. Cold Desert: national recognition in 2009; India's 13th UNESCO site in September 2025.
4. Panna (2011) is the newest national designation, but not the newest UNESCO entry.
5. Smallest among all 18: Dibru-Saikhowa (765 sq km).
6. Smallest Indian in UNESCO network: Nokrek (820 sq km).
7. Largest among all 18: Great Rann of Kutch (12,454 sq km).
8. UNESCO (5 June 2026): 797 sites in 145 countries. 14 new sites, none from India.

Habitat illustrations are conceptual, not maps or exact site depictions; zoning shapes vary by site.

ESZ modification did not remove the mining bar

KEY IDEA

The Supreme Court modified the Eco-Sensitive Zone (ESZ) directions on 26 April 2023. This modification did not remove the existing bar on mining inside National Parks and Sanctuaries and within 1 kilometre of their boundary.

TIMELINE

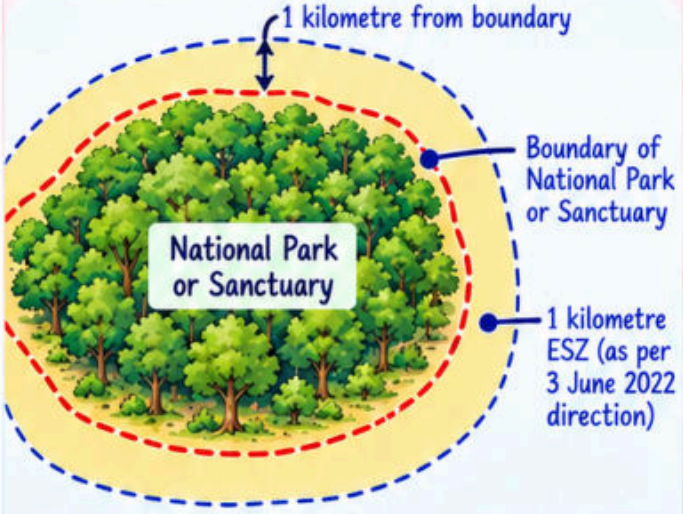
3 June 2022

Supreme Court directed a minimum 1 kilometre ESZ from the boundary of all National Parks and Sanctuaries.

26 April 2023

Supreme Court modified the 3 June 2022 direction. The minimum 1 kilometre ESZ direction does NOT apply where MoEFCC has issued draft/final notifications or received proposals, or where parks/sanctuaries are on inter-State/common boundaries.

HYPOTHETICAL FOREST BOUNDARY AND 1 km RING



This is a schematic diagram for illustration only. It does not represent an actual site or map.

PARA 65: CONTINUING MINING BAR

Mining is prohibited:

- inside a National Park or Sanctuary, and
- within 1 kilometre of the boundary of a National Park or Sanctuary.



ESZ WIDTH IS NOT UNIFORM EVERYWHERE

The actual width of the ESZ is notification-specific. It may be more or less than 1 kilometre depending on the particular notification or proposal.



WHAT CHANGED ON 26 APRIL 2023?

- The Supreme Court modified the 3 June 2022 direction.
- The minimum 1 kilometre ESZ direction does NOT apply where MoEFCC has issued draft/ final notifications or received proposals, or where parks/sanctuaries are on inter-State/ common boundaries.
- It also covers inter-State and common boundaries.
- The modification did not remove the mining prohibition inside National Parks and Sanctuaries and within 1 kilometre of their boundary (Para 65).
- Other applicable approvals and restrictions still apply beyond 1 kilometre.

Habitat illustrations are conceptual, not maps or exact site depictions; zoning shapes vary by site.

Keep three classification systems separate

Wildlife (Protection) Act legal categories

These are legal designations under Indian law to protect areas for wildlife conservation.

1. National Park

Strict protection for wildlife and habitats. Only regulated activities are allowed.



Example: Sri Venkateswara National Park

2. Wildlife Sanctuary

Protected area for wildlife with some regulated human use allowed.



Example: Coringa Sanctuary

3. Conservation Reserve

Government-owned land declared after local consultation.



4. Community Reserve

Voluntarily conserved private or community land, outside national parks, sanctuaries and conservation reserves.

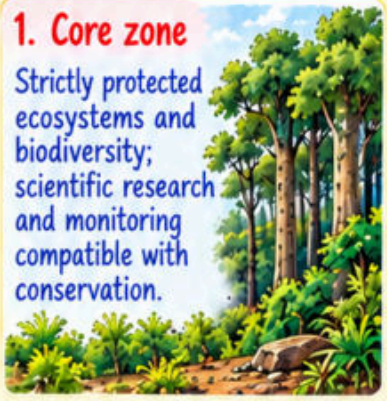


Biosphere Reserve zoning

A biosphere reserve has three zones with different levels of protection and use.

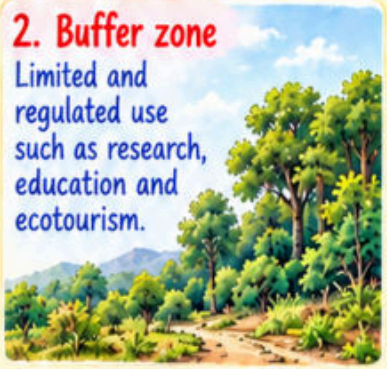
1. Core zone

Strictly protected ecosystems and biodiversity; scientific research and monitoring compatible with conservation.



2. Buffer zone

Limited and regulated use such as research, education and ecotourism.



3. Transition zone

Sustainable use with settlements, agriculture and other human activities.



Example:
Seshachalam Biosphere Reserve



IUCN management categories

These are international management categories for protected areas. They are NOT species risk categories. Each category has a different management objective.

Ia. Strict nature reserve

Strictly protected areas with tightly controlled and limited human visitation, use and impacts; scientific research and monitoring may occur.



Ib. Wilderness area

Large natural areas mostly free from human disturbance.



II. National park

Protection of ecosystems and recreation allowed in a controlled way.



III. Natural monument

Protection of specific natural features such as unique landforms, caves or old trees.



IV. Habitat/species management area

Active management to conserve specific habitats or species.



V. Protected landscape/seascape

Conservation with harmonious human use and strong cultural and natural values.



VI. Sustainable use area

Conservation of biodiversity with sustainable use of natural resources.



Habitat illustrations are conceptual, not maps or exact site depictions; zoning shapes vary by site.

267 | Micronutrients: small amounts, major roles

From food to nutrients to body functions

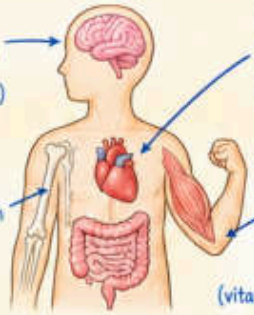


A variety of foods provide vitamins and minerals

Vitamins (13 total)

Minerals

Micronutrients in small amounts



- Support brain function, vision and immunity (vitamins A, B, C)
- Keep heart, nerves and cells working normally (B vitamins, minerals)
- Help build and maintain bones and teeth (minerals, vitamins D, K)
- Support growth, tissue repair and good health (vitamins and minerals)

Vitamins support normal body functions and health. Minerals are essential for growth and health.

Small amounts, but essential



Vitamins and minerals are needed in small quantities.

A long-term lack can cause deficiency disorders.

Protein, energy and micronutrient deficiency

Micronutrient deficiency	Protein deficiency	Lack of both protein and energy
May impair vision (impaired night vision with vitamin A) Weaker immunity (more infections) Specific deficiency disorders (e.g. rickets with vitamin D, anaemia with iron)	Can stunt growth (low height for age).	Can severely impair growth (weight and height) and lead to wasting and serious health problems.



The 13 vitamins: two groups

13 vitamins

4 fat-soluble vitamins (A, D, E, K)



Fat-soluble vitamins dissolve in oil (fat).

- A: vision, immunity and healthy skin
- D: helps calcium absorption for bones and teeth
- E: antioxidant protection for cells
- K: blood clotting and bone health

9 water-soluble vitamins (Eight B vitamins plus C)



Water-soluble vitamins dissolve in water.

- B1 (thiamine): energy release from food
- B2 (riboflavin): energy metabolism
- B3 (niacin): cells, skin and nerves
- B5 (pantothenic acid): coenzyme in many reactions
- B6 (pyridoxine): protein metabolism, nerves, red blood cells
- B7 (biotin): helps enzyme function
- B9 (folate): red blood cells, DNA synthesis
- B12 (cobalamin): red blood cells, nerves
- C (ascorbic acid): collagen formation, wound healing, immunity, helps iron absorption

Regular intake and body stores

Water-soluble vitamins



- Usually not stored in large amounts (except B12).
- Need regular intake from the diet.
- Excess is usually excreted in urine.

Vitamin B12: important storage exception (mainly liver)



Liver

- Vitamin B12 can be stored in the liver for many months or years.
- Important for red blood cells and nerve function.

Fat-soluble vitamins A and D also have body stores



Liver (stores A and D) | Body fat (stores A and D)

- Vitamins A and D can be stored in the liver and in body fat.
- These stores help maintain the body's supply between intakes.

Micronutrient deficiency is different from protein-energy malnutrition

Micronutrient deficiency	Protein-energy malnutrition (PEM)
• Due to lack of specific vitamin(s) or mineral(s). • Can occur even when overall energy and protein intake are adequate. • Causes specific deficiency disorders (e.g. vitamin A deficiency, iron deficiency anaemia, rickets).	• Due to inadequate protein, energy, or both. • Can cause wasting, stunting and impaired growth. • Affects overall body tissues and multiple functions, not just specific micronutrient deficiencies.

267 | Fat-soluble vitamins: A, D, E, K

Vitamin A

Supports healthy vision and skin



Healthy eye



Night blindness is often an early sign of deficiency.

Deficiency can cause:

- Night blindness (difficulty seeing in dim light).
- Xerophthalmia – a range of eye signs due to deficiency, including dry eyes, Bitot spots (white, foamy patches on the conjunctiva) and corneal damage.
- Severe deficiency may lead to blindness.



Bitot spot (on conjunctiva)

Vitamin D

Helps the body use calcium for strong bones and teeth





Healthy tooth

Dietary lack of vitamin D and insufficient sunlight exposure can contribute to deficiency.

Deficiency can cause soft bones:

Rickets (children)



- Soft, weak bones that may bend.
- Can lead to deformities such as bowed legs.

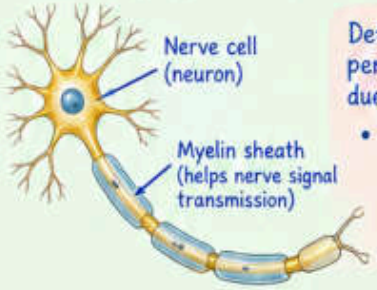
Osteomalacia (adults)



- Soft bones.
- Bone pain and tenderness.
- Muscle weakness.

Vitamin E

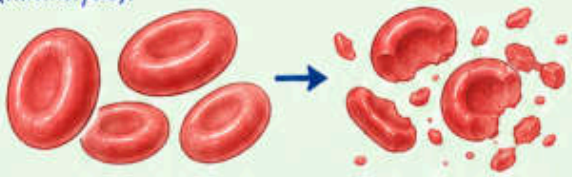
Helps protect cells from damage



Deficiency can cause peripheral neuropathy due to nerve damage.

- Numbness, tingling and weakness, often in the hands and feet.

Deficiency can also cause red-cell breakdown (haemolysis).



Normal red blood cells (carry oxygen)

Red-cell breakdown (haemolysis)

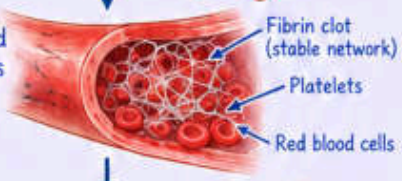
Vitamin K

Essential for normal blood clotting

Injury to a blood vessel causes bleeding.



Vitamin K is needed for clotting factors that help form a stable fibrin clot.



The clot helps stop bleeding and allows the vessel to heal.



Deficiency can impair blood clotting and can cause prolonged bleeding, such as easy bruising, nosebleeds or excessive bleeding after injury or procedures.

Key contrasts to remember



Rickets = children

Due to vitamin D deficiency. Soft, weak bones that may bend.

Osteomalacia = adults

Due to vitamin D deficiency. Soft bones, bone pain and muscle weakness.



Clotting = vitamin K

Vitamin K is needed for clotting factors. Deficiency impairs blood clotting and can cause bleeding.



267 | Water-soluble vitamins: deficiency links

1. Vitamin B1 (thiamine)



Vitamin B1 (thiamine)

Found in whole grains, legumes, nuts and pork.

Deficiency effects



- Weak muscles and low energy (fatigue).
- Nerves may be affected (tingling, numbness).
- Heart may be affected (breathlessness, heart failure).

2. Vitamin B3 (niacin)



Vitamin B3 (niacin)

Found in meat, poultry, fish, peanuts and whole grains.

Deficiency effects



Skin symptoms (rash, rough skin)



Gastrointestinal symptoms (loss of appetite, diarrhoea, abdominal discomfort)



Nervous symptoms (confusion, irritability, memory problems).

3. Vitamin B9 (folate)



Vitamin B9 (folate)

Found in leafy green vegetables, legumes, citrus fruits and fortified foods.

Deficiency effects



- Reduced red blood cell production (megaloblastic anaemia).
- Leads to tiredness, weakness and shortness of breath due to lower oxygen-carrying capacity of the blood.

4. Vitamin B12 → Anaemia and other features



Vitamin B12 (cobalamin)

Found in animal products such as meat, fish, eggs and dairy foods.

Although water-soluble, vitamin B12 is stored mainly in the liver.

Deficiency effects



Anaemia (reduced red blood cell formation).



Smooth tongue (glossitis).



Digestive disturbances (loss of appetite, constipation or diarrhoea).



Possible nervous symptoms (numbness, tingling, balance problems, memory difficulties).

5. Vitamin C → Scurvy



Vitamin C (ascorbic acid)

Found in citrus fruits, berries, peppers, broccoli and other fresh fruits and vegetables.

Deficiency effects



Bleeding gums (spongy gums that bleed easily).



Skin bleeding (easy bruising, pinpoint spots).



Joint soreness (pain and swelling).



Slow wound healing (poor tissue repair).

6. The nine water-soluble vitamins

The eight B vitamins and vitamin C together form the nine water-soluble vitamins.

The eight B vitamins	
B1	thiamine
B2	riboflavin
B3	niacin
B5	pantothenic acid
B6	pyridoxine
B7	biotin
B9	folate
B12	cobalamin

\+

Vitamin C	
C	ascorbic acid

= Nine water-soluble vitamins

267 | Minerals: deficiency versus excess

Iron (Fe)

Needed to make haemoglobin in red blood cells which carry oxygen in the body.

Deficiency → anaemia



- Less haemoglobin and fewer healthy red blood cells.
- Leads to anaemia with symptoms such as tiredness, weakness, pale skin and shortness of breath.



Normal blood (red blood cells)



Smaller, paler cells (same magnification)

Iron deficiency is the most common nutritional cause of anaemia, but it is not the only cause.

Iodine (I)

Needed to make thyroid hormones which regulate growth, brain development and metabolism.

Deficiency → goitre and developmental effects



Goitre (enlarged thyroid gland in the neck)

- Lack of iodine can cause goitre (enlarged thyroid gland in the neck).
- Severe deficiency in children can impair brain development, leading to learning difficulties.
- Deficiency during pregnancy can harm fetal development.



Severe iodine deficiency in childhood can affect brain development.



Maternal iodine deficiency can harm fetal development.

Calcium (Ca)

Needed for strong bones and teeth. Also important for muscle contraction, nerve function and blood clotting.

Deficiency → weak bones and teeth



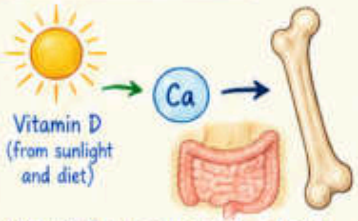
Weak and less dense bone (more likely to fracture)



Weaker teeth (more prone to decay)

- Not enough calcium can lead to weak bones, increasing the risk of fractures.
- Teeth can be weaker and more prone to decay.

Role of vitamin D



Vitamin D (from sunlight and diet)

Vitamin D helps the body absorb and use calcium effectively for strong bones and teeth.

Fluoride (F)

Helps prevent dental caries (tooth decay) by strengthening tooth enamel.

Low exposure → less protection against dental caries



Tooth more prone to dental caries (with low fluoride exposure)



Stronger enamel with adequate fluoride exposure

- Low fluoride exposure provides less protection against dental caries (tooth decay).
- Adequate fluoride strengthens tooth enamel and reduces the risk of dental caries.

Excess fluoride → fluorosis

Dental fluorosis (from prolonged excess)



Mottled enamel (discoloration and patches)

Skeletal fluorosis (from higher exposure)



Changes in bones (stiffness and pain)

Fluoride in drinking water and important points



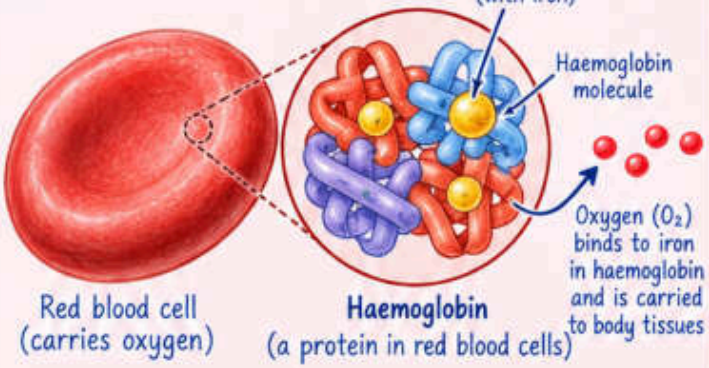
- WHO guideline: 1.5 mg/L
- BIS acceptable limit: 1.0 mg/L
- BIS permissible limit: 1.5mg/L ONLY in the absence of an alternate source.
- 1 mg/L is approximately 1 ppm in water.

- Total fluoride intake (from water, food and other sources) and duration of exposure matter.
- These guideline values are not universal safety guarantees for everyone.
- Skeletal effects have been reported with prolonged exposure to around 3–6 mg/L.

267 | Anaemia: causes and survey context

What is anaemia?

Anaemia means a lower than normal number of red blood cells or a reduced amount of haemoglobin, so the blood carries less oxygen to the body tissues.



Causes of anaemia

Main causes

- **Iron deficiency** (most common nutritional cause)



- **Deficiency of folate, vitamin B12 or vitamin A**



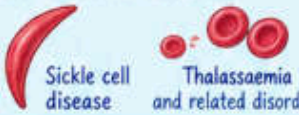
Other causes

- **Infections**



e.g. malaria, chronic infections, parasitic infections

- **Inherited blood disorders**



Common symptoms



Symptoms alone are not a diagnosis of anaemia. A blood test to measure haemoglobin is needed.

Global burden (WHO fact sheet, 10 February 2025; estimates for 2019)



Non-pregnant women 15-49 years
30%
(539 million)
(53.9 crore)
are anaemic globally (2019).



Children 6-59 months
about **40%**
(269 million)
(26.9 crore)
are anaemic globally (2019).

Survey context (National Family Health Survey – NFHS)

NFHS-4 = 2015-16
NFHS-5 = 2019-21

Historical NFHS classification of anaemia (used in these surveys)

Children 6-59 months	Non-pregnant women 15-49 years
Haemoglobin < 11.0 g/dL	Haemoglobin < 12.0 g/dL

These are survey thresholds used for classification in NFHS. They are not individualized treatment advice.

India (NFHS-5, 2019-21)



Men 15-49 years
25.0%
are anaemic in India (NFHS-5).

267 | NFHS anaemia: India and Andhra Pradesh

Group	India NFHS4 (2015-16) → NFHS5 (2019-21)	Andhra Pradesh NFHS4 (2015-16) → NFHS5 (2019-21)
Children 6-59 months	58.6 → 67.1 ↑	58.6 → 63.2 ↑
All women 15-49	53.1 → 57.0 ↑	60.0 → 58.8 ↓
Pregnant women 15-49	50.4 → 52.2 ↑	52.9 → 53.7 ↑
Girls 15-19	54.1 → 59.1 ↑	61.1 → 60.1 ↓

Children 6-59 months



Anaemia among children increased in both India and Andhra Pradesh.

India: 58.6% → 67.1% ↑

Andhra Pradesh: 58.6% → 63.2% ↑

A higher percentage of children were anaemic in NFHS5 than in NFHS4.

All women 15-49 years



Anaemia among all women increased in India, but decreased slightly in Andhra Pradesh.

India: 53.1% → 57.0% ↑

Andhra Pradesh: 60.0% → 58.8% ↓

Anaemia among women remains higher in Andhra Pradesh (58.8%) than in India (57.0%) in NFHS5.

Pregnant women 15-49 years



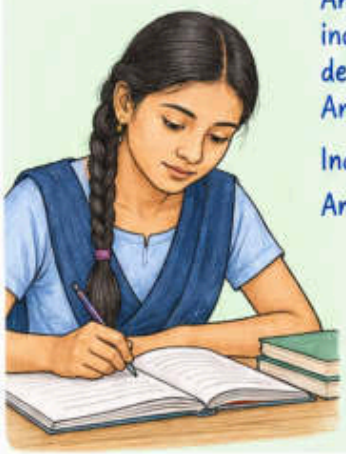
Anaemia among pregnant women increased in both India and Andhra Pradesh.

India: 50.4% → 52.2% ↑

Andhra Pradesh: 52.9% → 53.7% ↑

A higher percentage of pregnant women were anaemic in NFHS5 than in NFHS4.

Girls 15-19 years



Anaemia among girls increased in India, but decreased slightly in Andhra Pradesh.

India: 54.1% → 59.1% ↑

Andhra Pradesh: 61.1% → 60.1% ↓

A higher percentage of girls were anaemic in India in NFHS5, while Andhra Pradesh saw a small decrease.

Key takeaways



- In India, anaemia increased among children and all women from NFHS4 to NFHS5.
- In Andhra Pradesh, anaemia increased among children and pregnant women, and decreased slightly among all women and girls.
- Anaemia among all women in Andhra Pradesh (58.8%) is still higher than in India (57.0%) in NFHS5.
- These are percentages of people who are anaemic. They are not percentage-point changes. For example, an increase from 53.1% to 57.0% is a 3.9 percentage-point increase.

267 | Iodised salt and Anaemia Mukt Bharat

A. Iodised salt and National Iodine Deficiency Disorders Control Programme (NIDDCP)

1962
National Goitre Control Programme (NGCP)

→

1992
Broadened and renamed National Iodine Deficiency Disorders Control Programme (NIDDCP)

Goal
Ensure adequately iodised salt in every household, with at least 15 ppm iodine at the consumer level.



15 ppm iodine (at consumer level)

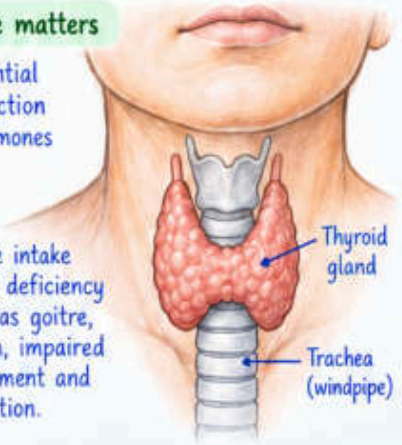
Under the Food Safety and Standards Regulations, 2011, common salt for direct human consumption must be iodised.



Why iodine matters

Iodine is essential for the production of thyroid hormones (T3 and T4).

Adequate iodine intake prevents iodine deficiency disorders such as goitre, hypothyroidism, impaired mental development and growth retardation.



B. Anaemia Mukt Bharat (AMB)

Launched in **2018** to accelerate reduction of anaemia across the life cycle.

6 × 6 × 6 Strategy
Six beneficiary groups, six interventions, six institutional mechanisms.

Six key interventions

1. Iron and folic acid supplementation as per programme guidelines.



2. Deworming.



3. Year-round behaviour-change communication and iron-rich food.



4. Testing and appropriate treatment.



5. Fortified foods.



6. Addressing non-nutritional causes, including malaria, haemoglobinopathies and fluorosis in endemic areas.



267 | Fortified rice: what is added and why

What is fortified rice?

Ordinary rice is mixed with specially prepared fortified rice kernels. These kernels contain added micronutrients. When mixed, the fortified kernels look and cook like ordinary rice, helping people get important nutrients through a commonly eaten food.



The three added nutrients and why they matter



Iron

- Needed to make haemoglobin, which helps red blood cells carry oxygen.
- Helps address iron deficiency, a major nutritional contributor to anaemia.



Folic acid (vitamin B9)

- Needed for making new cells, including red blood cells.
- Helps address folate deficiency, which can contribute to anaemia.



Vitamin B12

- Needed for healthy red blood cell formation and for normal nerve function.
- Helps address vitamin B12 deficiency, which can contribute to anaemia.

How these nutrients help



Iron, folic acid and vitamin B12 support the production of healthy red blood cells. By helping to address deficiencies in these nutrients, fortified rice can reduce nutritional contributors to anaemia in the population.

Important points to remember

- ✓ This formulation adds only iron, folic acid (B9) and vitamin B12.
- ✓ No vitamin A or iodine is added in this formulation.
- ✓ Fortification helps address nutritional contributors to anaemia.
- ✗ Fortification is not a cure for every cause of anaemia. Anaemia can also result from other causes, which need separate attention.

Standards for fortified rice kernels



The Food Safety and Standards Authority of India (FSSAI) sets standards for fortified (enriched) rice kernels. These standards specify the type and amount of micronutrients and other quality requirements to ensure safety and uniformity.

Government decision and funding (dated)

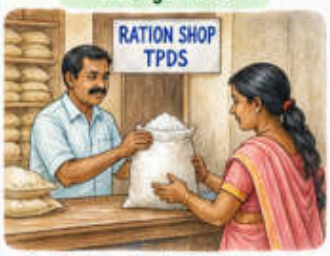


- Cabinet decision on 9 October 2024: continuation of the fortified rice programme from July 2024 to 31 December 2028.
- 100% central funding under PMGKAY (Pradhan Mantri Garib Kalyan Anna Yojana).
- Estimated cost: ₹2,565 crore per year (as stated in the October 2024 backgrounder).

How fortified rice reaches people

Fortified rice is supplied through multiple government channels so that it reaches different age groups and communities.

Through TPDS



Supplied under the Targeted Public Distribution System (TPDS) to eligible households.

Other welfare schemes



Also supplied through other welfare schemes to reach vulnerable groups.

Through ICDS



Provided through the Integrated Child Development Services (ICDS) for young children.

Through PM POSHAN



Provided through PM POSHAN (Pradhan Mantri Poshan Shakti Nirman) for school children.

267 | Rice fortification: phased rollout

1 15 August 2021

Independence Day announcement



- On 15 August 2021, the Prime Minister announced fortification of rice supplied through government welfare schemes to improve nutrition, especially among vulnerable groups.
- The rollout was planned in phases, starting with children's schemes and then expanding to wider public distribution.

2 Phase I 2021–22

ICDS and PM POSHAN



- Phase I (2021–22) began with fortified rice in the Integrated Child Development Services (ICDS) for young children in anganwadis.
- It also covered school students under PM POSHAN (mid-day meal scheme).

3 Phase II 2022–23

TPDS and other welfare schemes in 291 districts



- Phase II (2022–23) expanded fortified rice to the Targrated Public Distribution System (TPDS) and other welfare schemes in 291 districts.
- This extended coverage beyond children's schemes to other eligible population groups in these districts.

4 Phase III 2023–24

Remaining districts



- Phase III (2023–24) extended fortified rice to the remaining districts, completing the rollout across the country.

5 Universal coverage March 2024

All schemes, all districts



- By March 2024, fortified rice was supplied through all relevant schemes in all districts, as stated in the October 2024 programme account.
- This marks distribution coverage across the intended schemes and geography.

6 Continuation July 2024 – 31 December 2028

Fully Centre funded



- The fortification programme continued from July 2024 to 31 December 2028 with full funding by the Government of India (Centre).

Why start with children's schemes?



- Children in anganwadis and school meals were prioritised because they are a high-priority group for nutrition support.
- Starting with ICDS and PM POSHAN allowed a focused and manageable beginning, before expanding to the wider TPDS and other welfare schemes.

Nutrients in fortified rice



Important to note:

- Fortified rice contains iron, folic acid and vitamin B12.
- No vitamin A or iodine is added in this formulation.

267 | Vitamin A programme and key distinctions

National programme schedule—not self-medication

Vitamin A supplementation is a government public-health programme for young children. It should be given only through planned programme sessions, not as self-medication.



First dose



100,000 IU orally at 9 completed months, usually given with MR (measles-rubella) vaccine.

Second dose

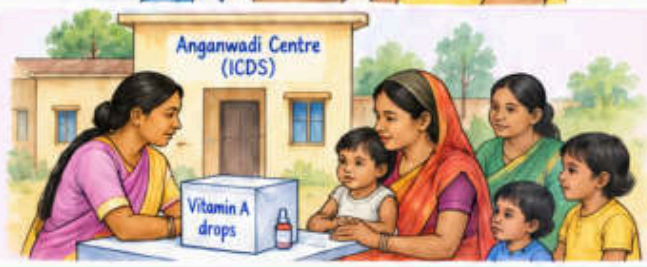


200,000 IU orally at 16–18 months.

Later doses



200,000 IU orally every 6 months up to 5 years of age (total 9 doses).



Twice-yearly Vitamin A rounds may be coordinated with the Integrated Child Development Services (ICDS) through Anganwadi centres and outreach sessions to improve coverage.

Vitamin A deficiency—key points

Early sign: night blindness



Difficulty seeing in dim light or at night is an early sign of vitamin A deficiency.

Xerophthalmia: spectrum of eye changes



Conjunctival dryness | Bitot spots (foamy patches) | Corneal dryness



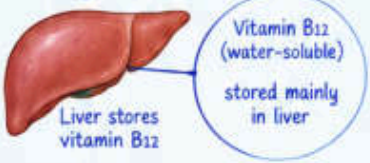
Corneal ulceration | Keratomalacia (soft, melting cornea)

Severe deficiency can lead to childhood blindness and increased risk of infections due to reduced immunity.

Vitamin B12 and Vitamin K—key distinctions

Vitamin B12

- Water-soluble vitamin.
- Despite being water-soluble, it is stored mainly in the liver (in significant amounts).
- Important for DNA synthesis, red blood cell formation and neurological function.



Vitamin K

- Fat-soluble vitamin.
- Essential for synthesis of clotting factors (II, VII, IX and X) in the liver.
- Important for normal blood coagulation and prevention of excessive bleeding.



Liver synthesises clotting factors with vitamin K | Normal blood clotting (prevents excessive bleeding)

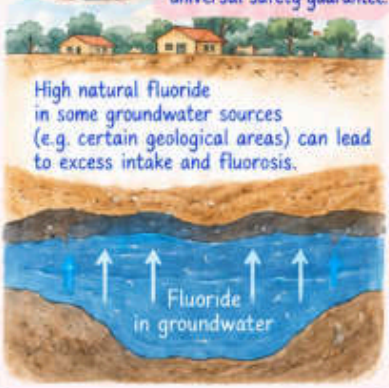
Fluorosis—key distinctions

- Fluorosis is caused by excess intake of fluoride, not by deficiency.
- Risk depends on total exposure (from drinking water, food, tea and other sources), not just the fluoride level in water alone.



Guideline values for fluoride in drinking water (require total-exposure context)

WHO guideline: 1.5 mg/L
BIS acceptable: 1.0 mg/L
BIS 1.5 mg/L permissible ONLY in absence of an alternate source. Not a universal safety guarantee.



How communication satellites work

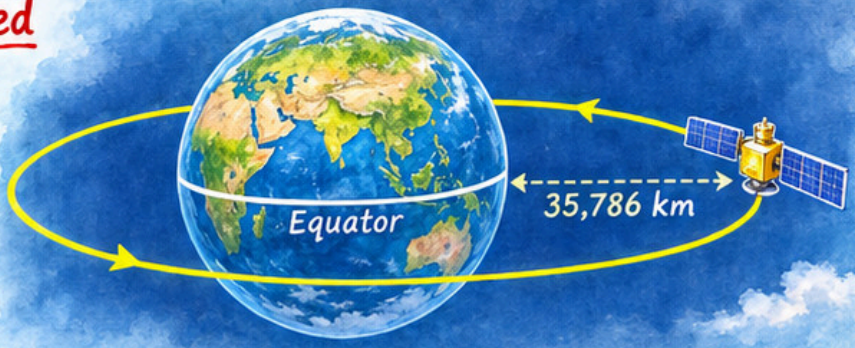
A relay above Earth

A communication satellite relays television, radio, data and telephone signals between places on Earth. India's INSAT, GSAT and CMS satellites work mainly from geostationary orbit.



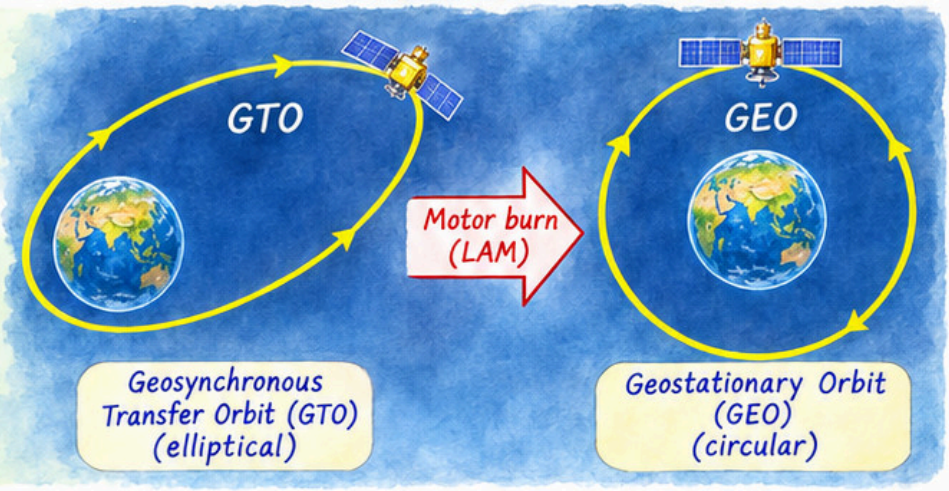
Why GEO appears fixed

GEO is 35,786 km above the equator. One revolution takes 23 hours 56 minutes 4 seconds: one sidereal day. The satellite appears fixed above one spot, so ground antennas can remain fixed.



GTO is not GEO

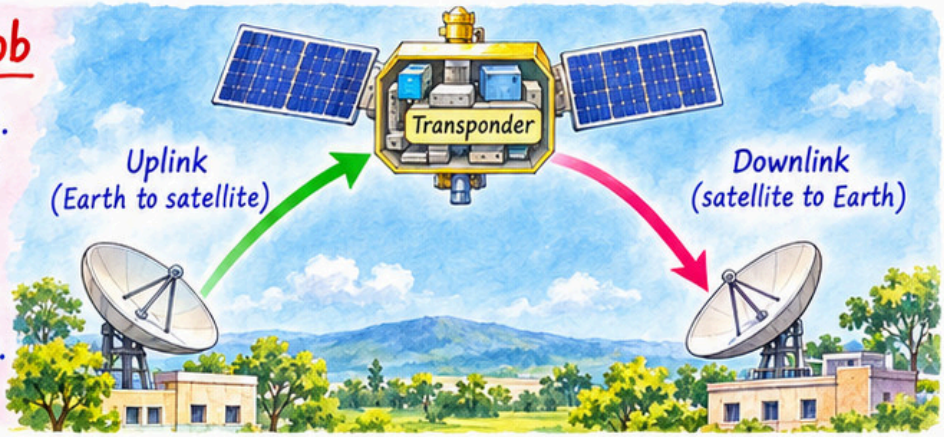
The rocket places the satellite in an elliptical Geosynchronous Transfer Orbit (GTO). For GSAT-11, the Master Control Facility at Hassan commanded the satellite's Liquid Apogee Motor to make the working orbit circular and geostationary.



The transponder's job

Uplink: Earth to satellite. The transponder receives the signal, changes its frequency, amplifies it and sends it back.

Downlink: satellite to Earth.



Sources: Day 28 Corrected Notes | Topic 276.

IAS WITH DR RAVI
AIM. PREPARE. ACHIEVE

Bands and satellite life

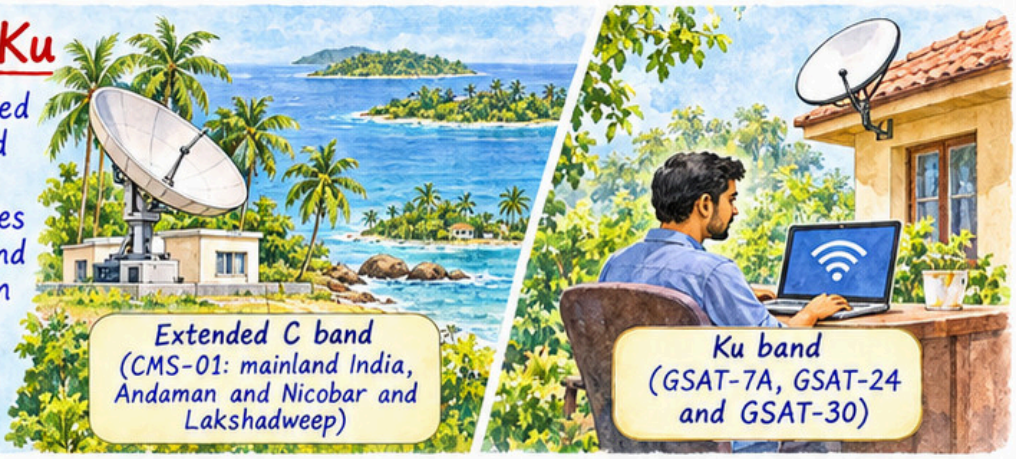
S and C bands

ISRO lists S and C among satcom bands. INSAT-2A carried 2 S-band transponders for broadcast services and 12 C-band transponders. GSAT-30's C-band coverage includes the Gulf countries, many Asian countries and Australia.



Extended C and Ku

ISRO names Upper Extended C band. INSAT-2A carried 6 extended C-band transponders. CMS-01 serves mainland India, Andaman and Nicobar and Lakshadweep in extended C. GSAT-7A, GSAT-24 and GSAT-30 use Ku band.



Ka and UHF

GSAT-20 (GSAT-N2) is a Ka-Ka band high-throughput satellite. UHF is not in ISRO's cited list of satcom bands; the Navy names it for GSAT-7, and press reports for CMS-03.



Life and retirement

ISRO's communication FAQ gives a mission life of 7 to 15 years, depending on fuel. At end of life, a geosynchronous satellite is moved about 200–250 km higher and its communication equipment is permanently switched off.



Sources: Day 28 Corrected Notes | Topic 276

The INSAT system

Meaning and beginning

INSAT means Indian National Satellite. The system was established in 1983 when INSAT-1B was commissioned. ISRO calls it one of the largest domestic communication satellite systems in the Asia-Pacific.



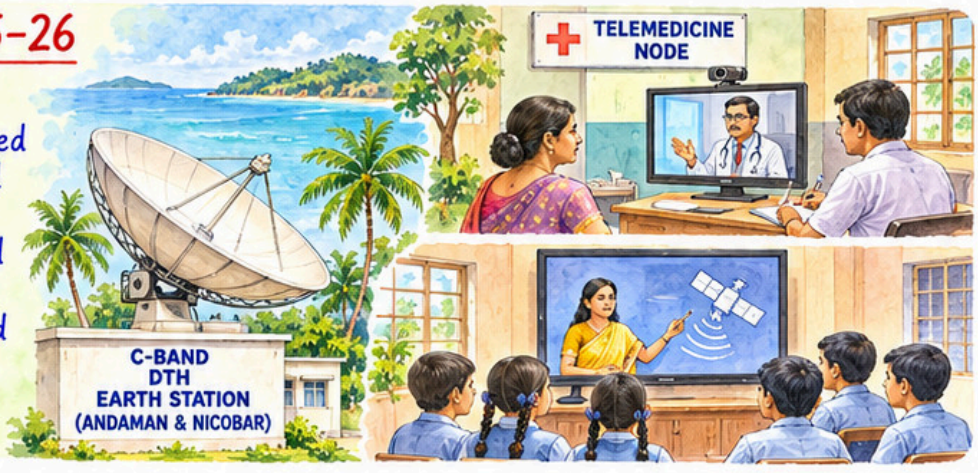
Services across India

Telecommunications, TV broadcasting, satellite newsgathering, societal applications, weather forecasting, disaster warning, and search and rescue.



Public services in 2025-26

The DOS Annual Report lists 5 DTH operators in the licensed satcom network and a C-band DTH earth station serving Andaman and Nicobar. Around 179 telemedicine nodes were operational. BISAG-N received capacity for 200 educational channels.



Who runs it

Under the Satcom Norms, Guidelines and Procedures (2000), the INSAT Coordination Committee (ICC) manages the programme and determines its policies, with technical support from its Technical Advisory Group. The ICC earmarks capacity for non-government users.

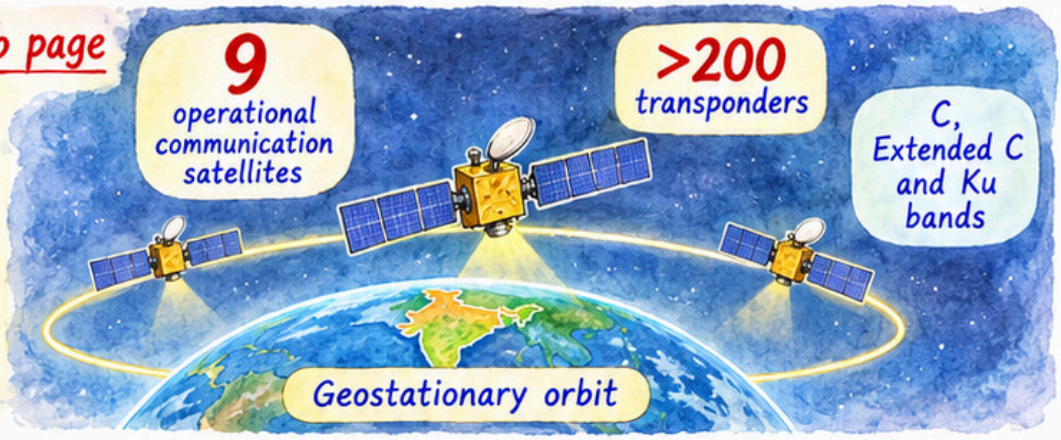


Sources: Day 28 Corrected Notes | Topic 276.

Fleet counts need a source and date

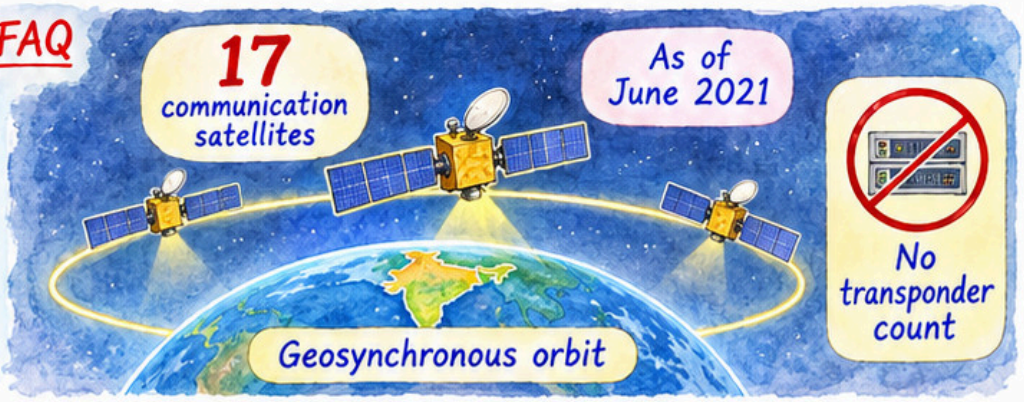
ISRO's undated web page

9 operational communication satellites in geostationary orbit, with more than 200 transponders in C, Extended C and Ku bands.



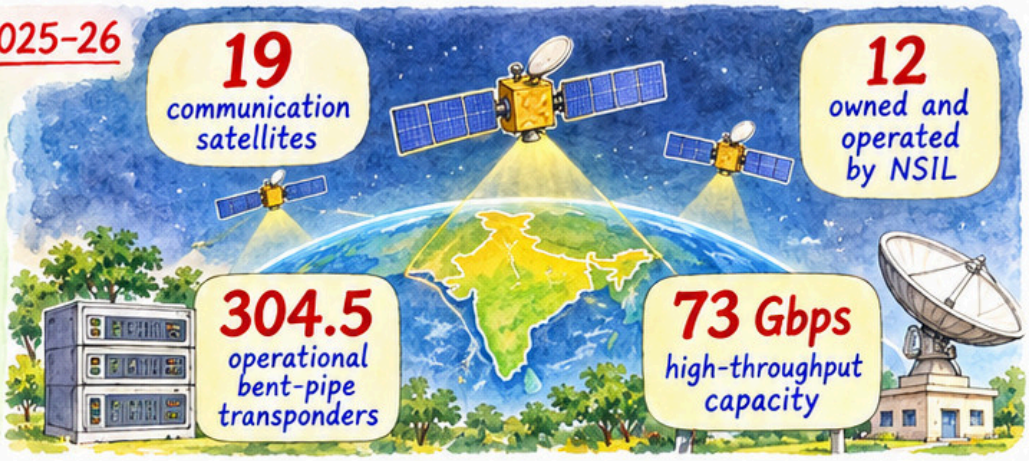
ISRO communication FAQ

17 communication satellites operated from geosynchronous orbit, as of June 2021.
The cited FAQ does not give a transponder count.



DOS Annual Report 2025-26

19 communication satellites operating over India. Of these, 12 were owned and operated by NSIL. Together: 304.5 operational bent-pipe transponders, plus 73 Gbps of high-throughput capacity.



One report, different scopes

The same report's Master Control Facility section says it handles 20 communication spacecraft. Do not treat the figures as interchangeable. For revision, quote 19 satellites and 304.5 transponders with the Annual Report 2025-26 source.



Sources: Day 28 Corrected Notes | Topic 276.

The early milestones

APPLE and the first INSAT

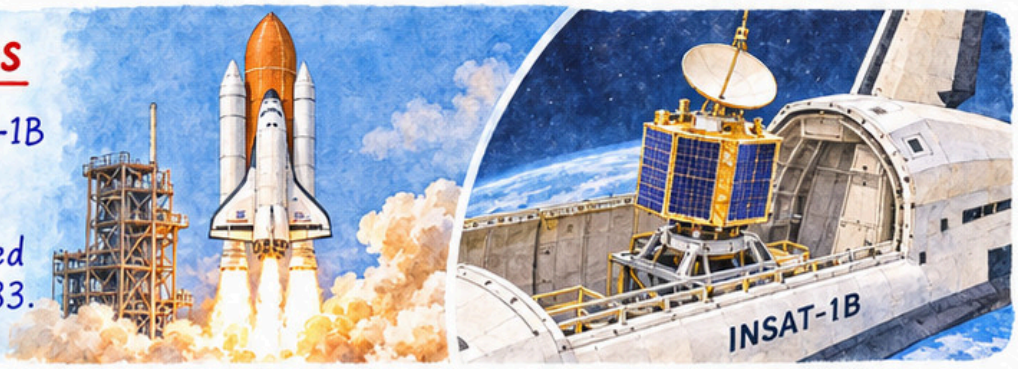
19 June 1981: APPLE flew on Ariane-1 (V-3). India's first experimental communication satellite weighed 670 kg and used geosynchronous orbit.

10 April 1982: INSAT-1A launched on a Delta rocket; ISRO records 'Failed in Orbit'.



The system begins

30 August 1983: INSAT-1B launched on the Space Shuttle (PAM-D). Its commissioning established the INSAT system in 1983.



Built in India

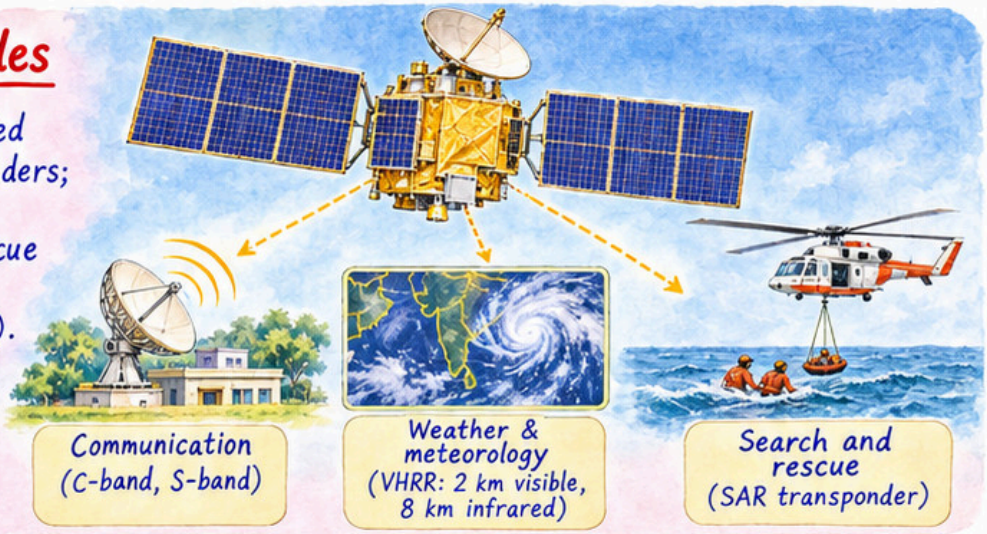
10 July 1992: INSAT-2A launched on Ariane-44L H10. ISRO calls it the 'First Multipurpose satellite built by India'. It began second-generation INSAT, was operational from August 1992 and worked at 74° E.



INSAT-2A's many roles

Payload: 12 C-band, 6 extended C-band and 2 S-band transponders; a meteorological data-relay transponder; a search-and-rescue transponder; and a Very High Resolution Radiometer (VHRR).

Weather-image resolution: 2 km visible, 8 km infrared.



Sources: Day 28 Corrected Notes | Topic 276.

GSAT begins and serves defence

GSAT and education

18 April 2001: GSAT-1 flew on GSLV-D1, GSLV's first flight. ISRO's spacecraft list records 'Launch unsuccessful'.

20 September 2004: EDUSAT (GSAT-3), for education, launched on GSLV-F01.



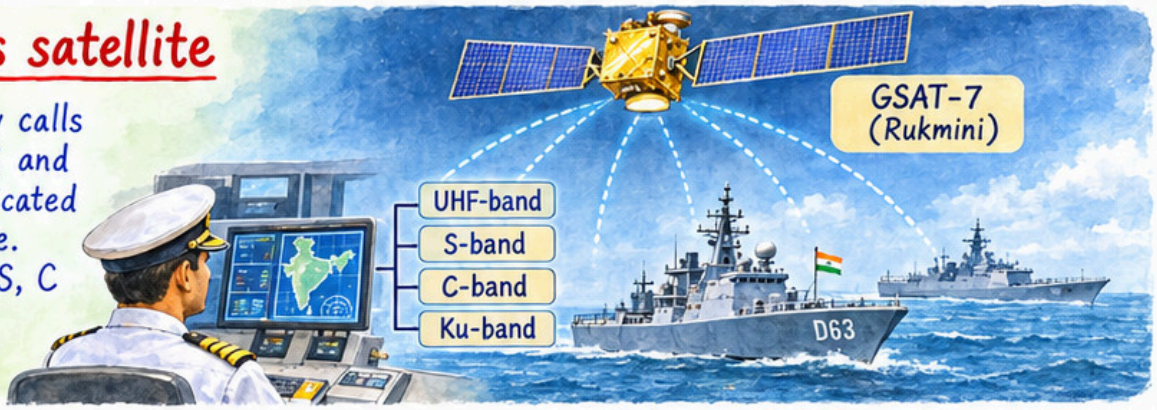
GSAT-7 or Rukmini

30 August 2013: Ariane-5 VA-215 launched GSAT-7 from Kourou, French Guiana. Mass: 2,650 kg; orbital position: 74° E. Multi-band coverage spans a wide oceanic region and the Indian landmass.



The Navy's satellite

The Indian Navy calls GSAT-7 Rukmini and India's first dedicated defence satellite. It carries UHF, S, C and Ku-band transponders.



GSAT-7A

19 December 2018: launched on GSLV-F11. Ku-band coverage over the Indian region. ISRO calls it the '35th Indian communication satellite built by ISRO'. December 2018 press reports identify the Indian Air Force as its primary user.



Sources: Day 28 Corrected Notes | Topic 276.

GSAT-11 and GSAT-30

GSAT-11

5 December 2018: launched by Ariane-5 VA-246 from Kourou, French Guiana. About 5,854 kg. ISRO describes it as the heaviest satellite built by ISRO.



Broadband from space

GSAT-11 uses multi-spot beam coverage for broadband services. Mission life: 15 years.



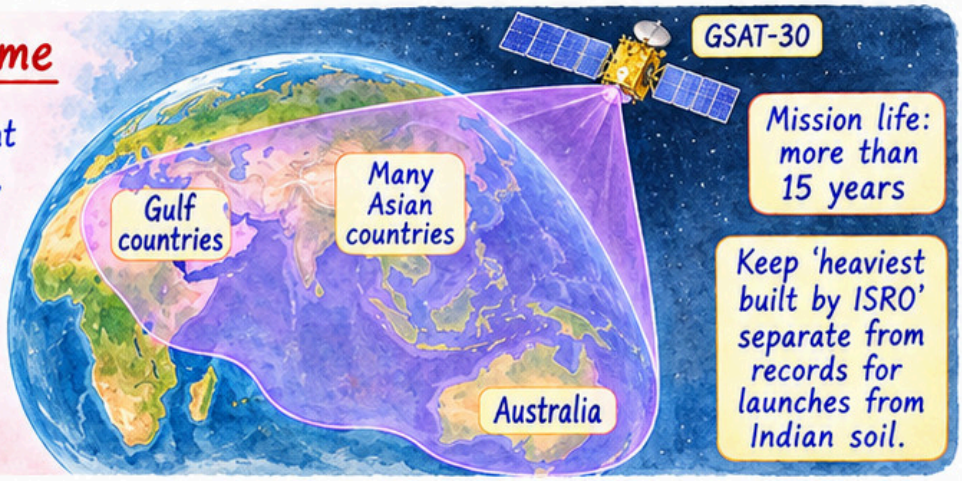
GSAT-30

17 January 2020: launched by Ariane-5 VA-251 from Kourou. Mass: 3,357 kg. It provides C and Ku-band services and replaces the services of INSAT-4A.



Coverage and lifetime

GSAT-30's C-band footprint reaches the Gulf countries, many Asian countries and Australia. Its mission life is more than 15 years. Keep 'heaviest built by ISRO' separate from records for launches from Indian soil.



Sources: Day 28 Corrected Notes | Topic 276.

CMS-01 and GSAT-24

CMS-01

17 December 2020: launched by PSLV-C50. ISRO calls it the '42nd Communication Satellite of India'. It uses extended C band. Mission life: 7 years.



Mainland and islands

CMS-01 serves mainland India, the Andaman and Nicobar Islands, and Lakshadweep. CMS is the newer naming series: CMS-01 launched in 2020 and CMS-03 in 2025.



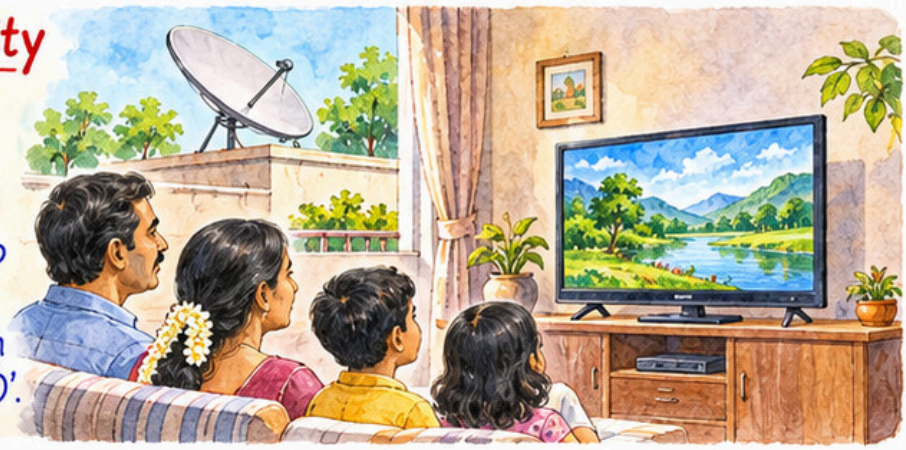
GSAT-24

23 June 2022, 03:20 IST: launched by Ariane-5 VA257 from Kourou. The local date at Kourou was still 22 June. Mass: 4,180 kg; Ku band.



Demand-driven capacity

ISRO calls GSAT-24 NSIL's first demand-driven mission after space reforms. NSIL leased its entire capacity to Tata Play. Keep CMS-01's '42nd' wording distinct from GSAT-7A's '35th built by ISRO'.



Sources: Day 28 Corrected Notes | Topic 276.

GSAT-20 also called GSAT-N2

The launch

19 November 2024 at 00:01 IST: SpaceX's Falcon 9 launched GSAT-N2 from Cape Canaveral, Florida, USA. Mass: 4,700 kg.



High-throughput design

A Ka-Ka band high-throughput satellite (HTS), with 32 spot beams and 48 Gbps capacity. NSIL gives a mission life of 14 years.



Service and reach

NSIL's second demand-driven mission supports broadband and in-flight connectivity across India. Operational services began in January 2025, according to the DOS Annual Report 2025-26.



Why a foreign launcher

News On AIR reported on 17 November 2024 that GSAT-20 was too heavy for India's own LVM3. Earlier heavy Indian communication satellites had relied on Arianespace; this mission used Falcon 9.



Sources: Day 28 Corrected Notes | Topic 276.

CMS-03 also called GSAT-7R

Launch from India

2 November 2025: LVM3-M5 launched CMS-03 from Sriharikota. About 4,400 kg. ISRO describes multi-band services across a wide oceanic region including the Indian landmass.



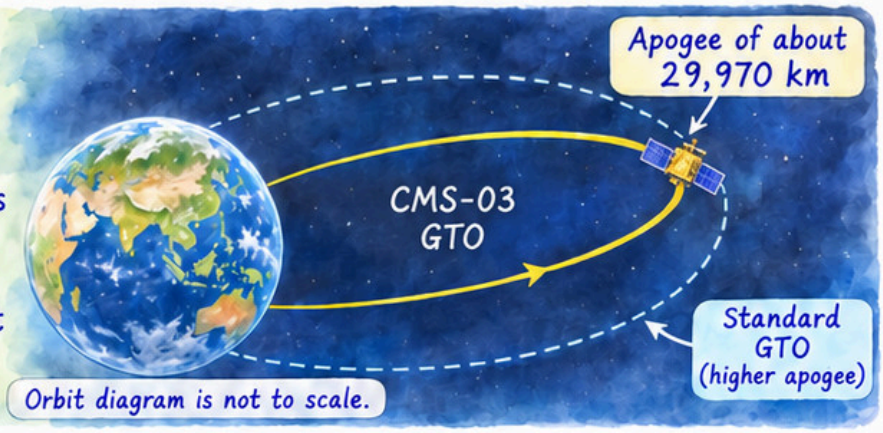
Naval communication

PIB identifies CMS-03 as a satellite for the Indian Navy. UHF is mentioned in press reports. Its transfer orbit had an apogee of about 29,970 km, lower than a standard GTO.



The exact record

ISRO: the heaviest communication satellite launched to Geosynchronous Transfer Orbit (GTO) from Indian soil. This is not the same claim as the heaviest satellite built by ISRO.



Keep both records precise

GSAT-11: about 5,854 kg, built by ISRO, launched from French Guiana. CMS-03: about 4,400 kg, launched to GTO from Indian soil. The source notes record all eight highlighted satellites as operational in ISRO's list on 31 October 2026.





Sources: Day 28 Corrected Notes | Topic 276.

NSIL and launch choices

NewSpace India Limited

NSIL is a Government of India company under the Department of Space and ISRO's commercial arm. Its mandate includes building and launching satellites as per demand.



The demand-driven model

Users ask for capacity; a satellite is built for that demand, and NSIL owns or leases out that capacity. GSAT-24 was the first post-reform mission, entirely leased to Tata Play, GSAT-N2 was the second, for broadband and in-flight connectivity.



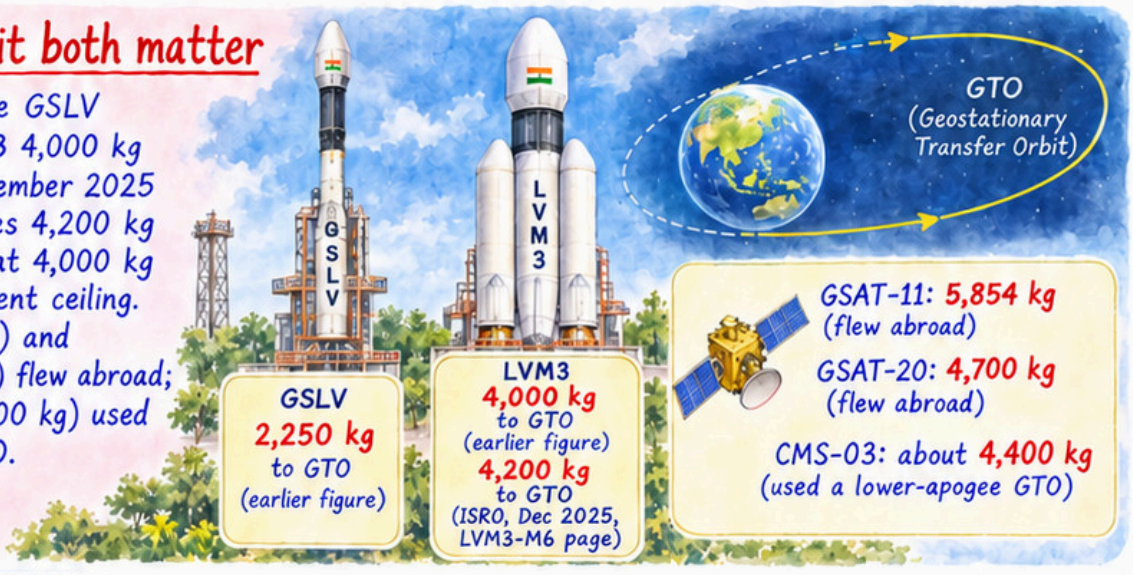
Dated fleet share

The DOS Annual Report 2025-26 says NSIL owned and operated 12 of the 19 communication satellites operating over India.



Mass and orbit both matter

Earlier figures gave GSLV 2,250 kg and LVM3 4,000 kg to GTO. ISRO's December 2025 LVM3-M6 page gives 4,200 kg to GTO. Do not treat 4,000 kg as an undated current ceiling. GSAT-11 (5,854 kg) and GSAT-20 (4,700 kg) flew abroad; CMS-03 (about 4,400 kg) used a lower-apogee GTO.



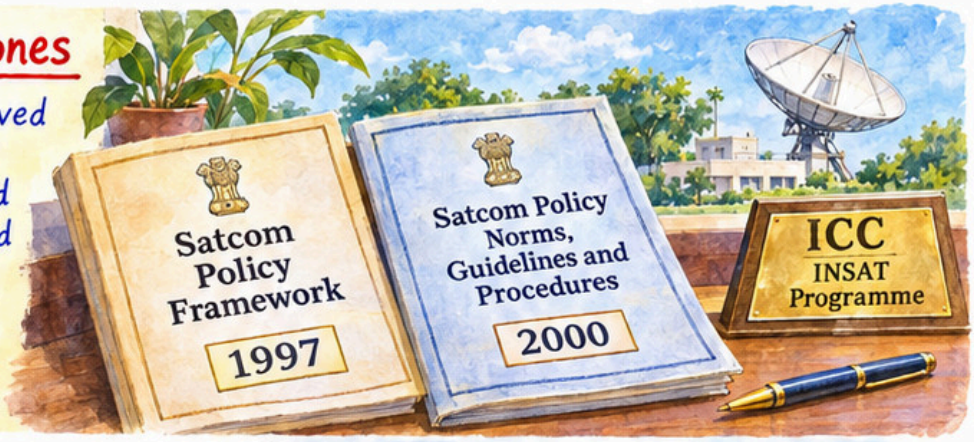
Sources: Day 28 Corrected Notes | Topic 276.

Day 28 | T276 | P11.

Policy and revision connections

Two policy milestones

The Government approved the Satcom Policy framework in 1997 and its norms, guidelines and procedures in 2000. The ICC manages the INSAT programme.



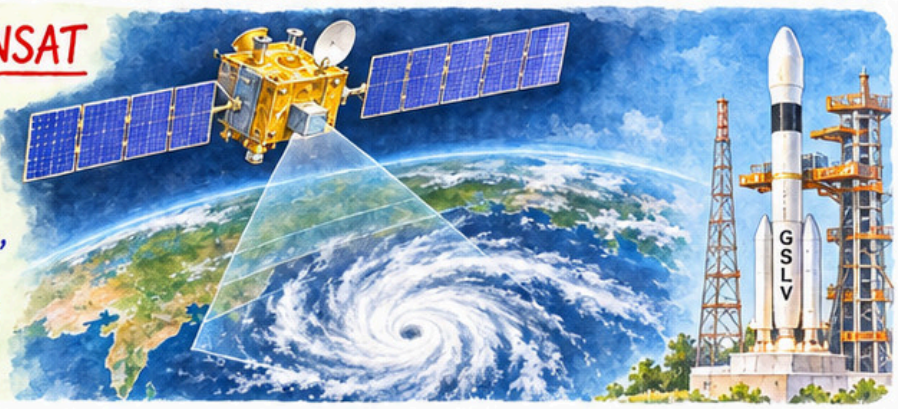
Indian Space Policy 2023

Non-government entities may offer national and international space-based communication services using their own, procured or leased satellites. IN-SPACe authorises the use of space objects for communication services to or from Indian territory.



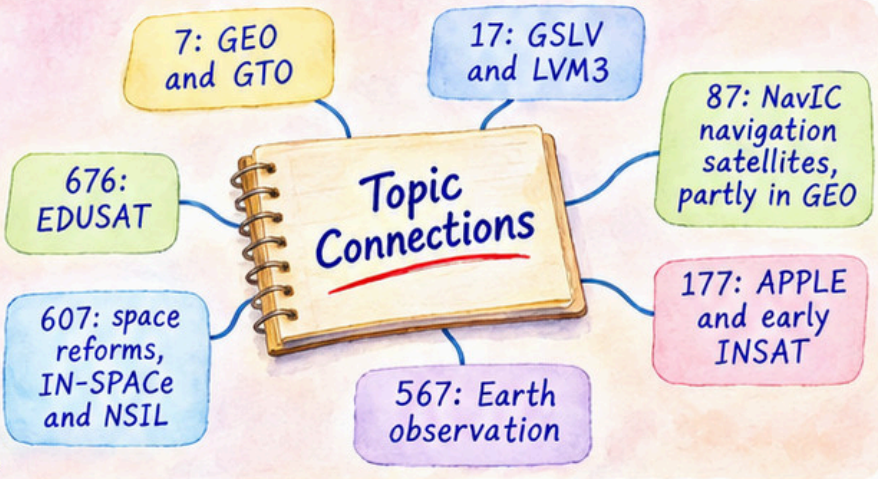
Weather members of INSAT

INSAT-3D: 26 July 2013, Ariane-5 VA-214.
INSAT-3DR: GSLV-F05, 2016.
INSAT-3DS: 17 February 2024, GSLV-F14.
These meteorological satellites are covered in Topic 817.



Connect the topics

7: GEO and GTO.
17: GSLV and LVM3.
87: NavIC navigation satellites, partly in GEO.
177: APPLE and early INSAT.
567: Earth observation.
607: space reforms, IN-SPACe and NSIL.
676: EDUSAT.
Remember: transfer orbit is not working orbit; distinct 'firsts' and dated fleet counts must not be mixed.

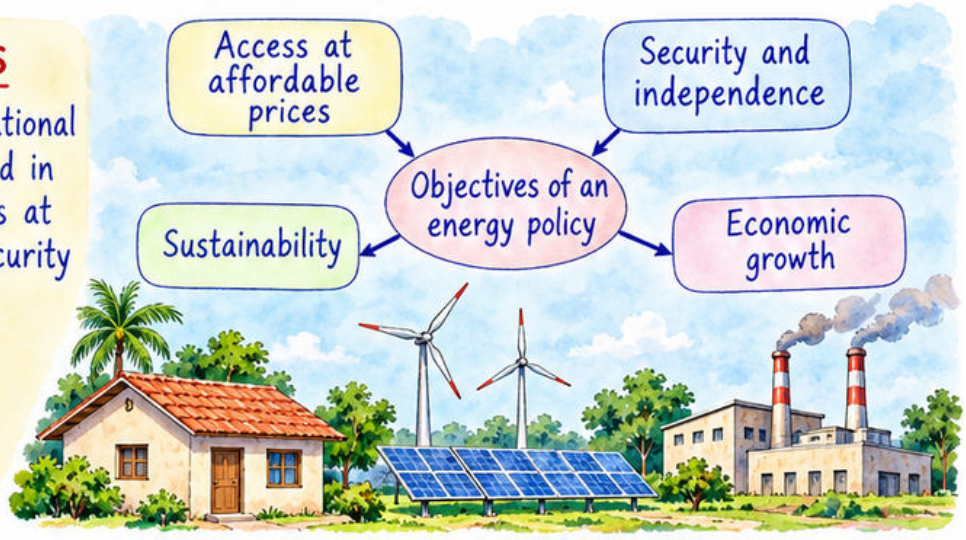


Sources: Day 28 Corrected Notes | Topic 276.

What an energy policy tries to achieve

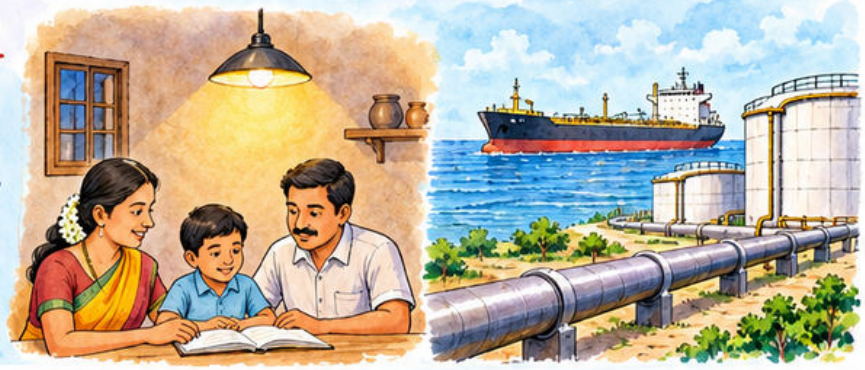
Four objectives

NITI Aayog's draft National Energy Policy, released in 2017, identifies access at affordable prices, security and independence, sustainability and economic growth.



Access and security

Households and businesses need reliable energy they can afford. Security requires less exposure to supply shocks, including dependence on imported oil and gas.



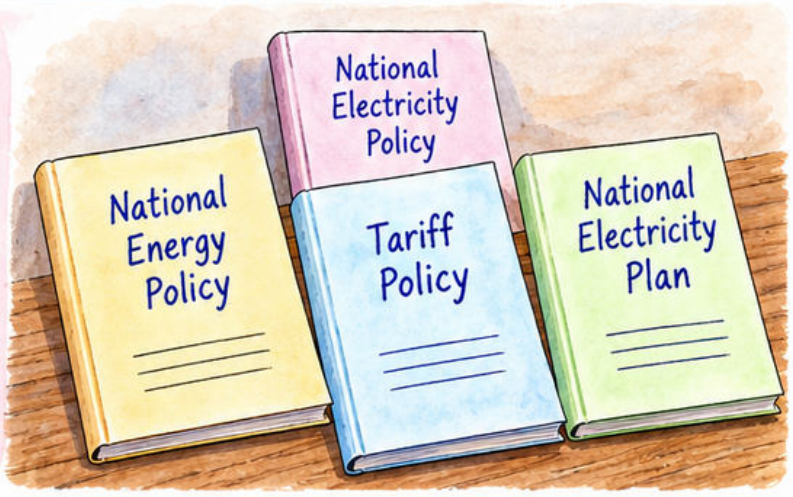
Sustainability and growth

Cleaner energy and lower emissions support sustainability. Supply must also keep pace with a growing economy. These objectives can involve trade-offs in price, reliability and environmental impact.



Three similar names

NITI Aayog prepared the draft National Energy Policy covering energy broadly. Under the Electricity Act, the Central Government prepares the National Electricity Policy and Tariff Policy; the Central Electricity Authority prepares the National Electricity Plan.



Sources: Day 28 Complete Content Pack | Topic 277

Installed capacity on 31 July 2026

The non-fossil mix

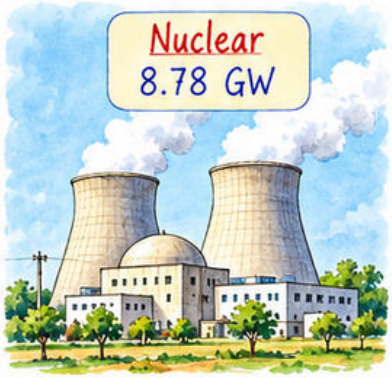
Solar: 164.59 GW.
Wind: 58.14 GW.
Large and small hydro: 57.24 GW.
Bio-power: 11.75 GW.
Nuclear: 8.78 GW.
Total non-fossil capacity: 300.50 GW.











Share and target

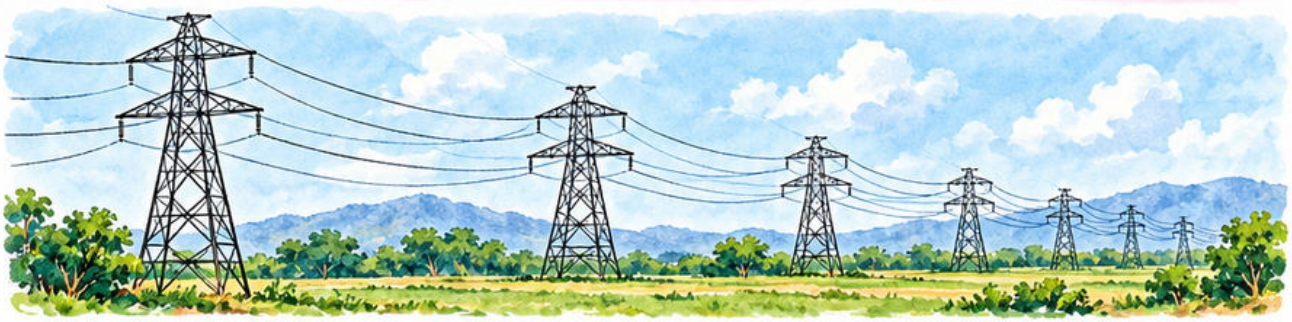
All-source capacity was about 552 GW, so non-fossil sources held over 54%. The remaining fossil capacity was approximately 251.5 GW, calculated from the rounded total. Non-fossil capacity had passed 60% of the 500 GW target for 2030.

Earlier comparison dates

Total installed capacity rose from 249 GW in 2014 to about 552 GW in July 2026. On 31 March 2026 it was 532,740 MW, with 283,468 MW non-fossil, or 53.2%.

Read the units

One GW equals 1,000 MW. Non-fossil includes nuclear and large hydro as well as other renewable sources. It is broader than renewable capacity alone.

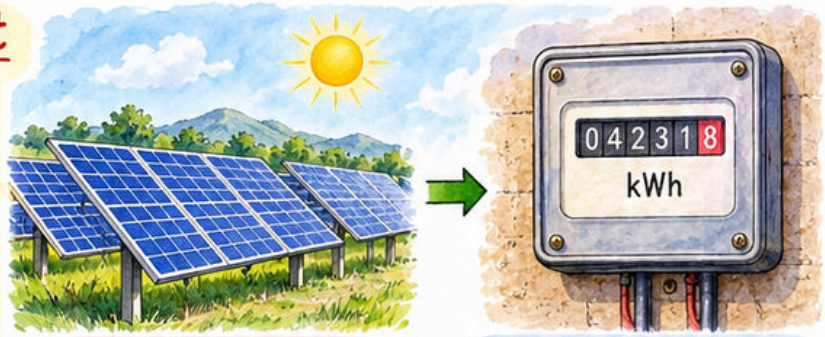


Sources: Day 28 Complete Content Pack | Topic 277

Capacity, generation and import dependence

Capacity is not output

Installed capacity measures potential generating power. Electricity generation measures energy actually produced. Solar and wind availability varies, so a capacity share is not a generation share.



Installed capacity (potential power)

Electricity generation (metered output)

Dated coal comparisons

MoSPI placed coal including lignite at about 59% of primary energy supply in 2024-25. CEA figures put coal at about 69.6% of utility generation in 2025-26. A PIB factsheet of 13 August 2026 instead used about 55% of primary needs and over 70% of generation.



MoSPI (2024-25)
Coal (incl. lignite): about 59% of primary energy supply

CEA (2025-26)
Coal: about 69.6% of utility generation

PIB factsheet (13 August 2026)
Coal: about 55% of primary needs and over 70% of generation

Coal production

Production was 1,047.52 million tonnes in 2024-25 and 1,040.08 million tonnes in 2025-26. Keep these physical-output figures separate from electricity shares.



2024-25
1,047.52 million tonnes

2025-26
1,040.08 million tonnes

Imported fuels

A July 2026 Ministry account put crude-oil import dependence near 88.5%. Imported gas supplied 46% of consumption in 2023-24. Dependence figures need their fuel and year attached.



Crude oil
Import dependence: near 88.5% (July 2026)

Imported gas
46% of consumption (2023-24)

Sources: Day 28 Complete Content Pack | Topic 277

Panchamrit at COP26

Glasgow, 1 November 2021

The Prime Minister's national statement announced five commitments called Panchamrit. They should be distinguished from the later wording of the updated NDC.



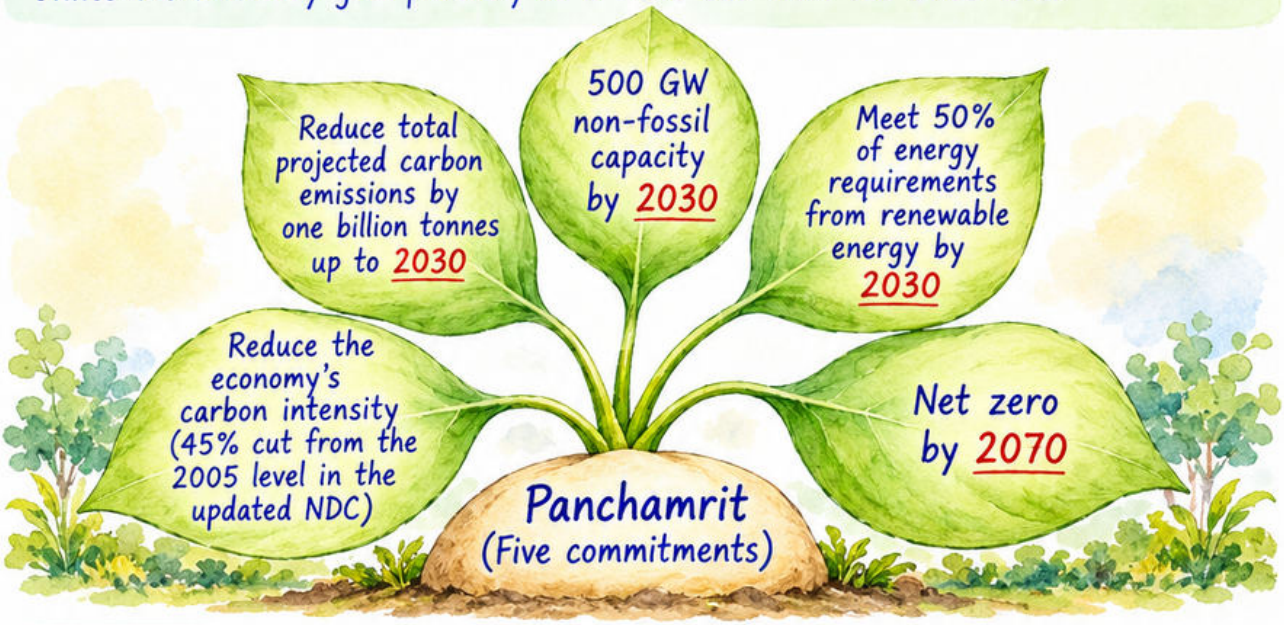
Capacity and energy

The commitments included 500 GW of non-fossil capacity by 2030 and meeting 50% of energy requirements from renewable energy by 2030.



Emissions and intensity

They also included reducing total projected carbon emissions by one billion tonnes up to 2030 and reducing the economy's carbon intensity. The later updated NDC states the intensity goal precisely as a 45% cut from the 2005 level.



Net zero

India committed to net zero by 2070. This is a different target year from 2030. Do not change a long-term net-zero commitment into a claim that all fossil energy ends in 2030.



Sources: Day 28 Complete Content Pack | Topic 277

The updated NDC of August 2022

What an NDC is

A nationally determined contribution is a country's climate pledge under the Paris Agreement, submitted to the United Nations Framework Convention on Climate Change.



Two central 2030 goals

India's updated NDC targets a 45% reduction in emissions intensity of GDP from 2005 and about 50% of cumulative installed electric-power capacity from non-fossil resources by 2030.

Emissions intensity of GDP

45% reduction

Base: 2005



Cumulative installed electric-power capacity from non-fossil resources

about 50%

By: 2030

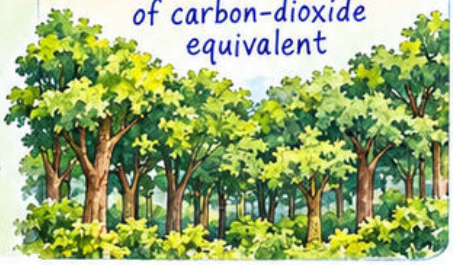


Sink and lifestyle

It also includes an additional carbon sink of 2.5–3 billion tonnes of carbon-dioxide equivalent through forest and tree cover, and a mass movement for LIFE, Lifestyle for Environment.

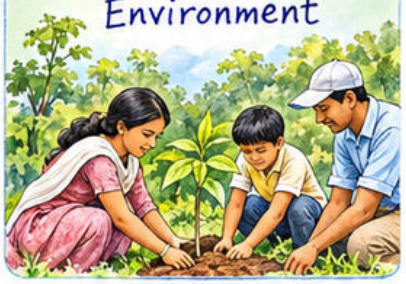
Additional carbon sink

2.5–3 billion tonnes of carbon-dioxide equivalent



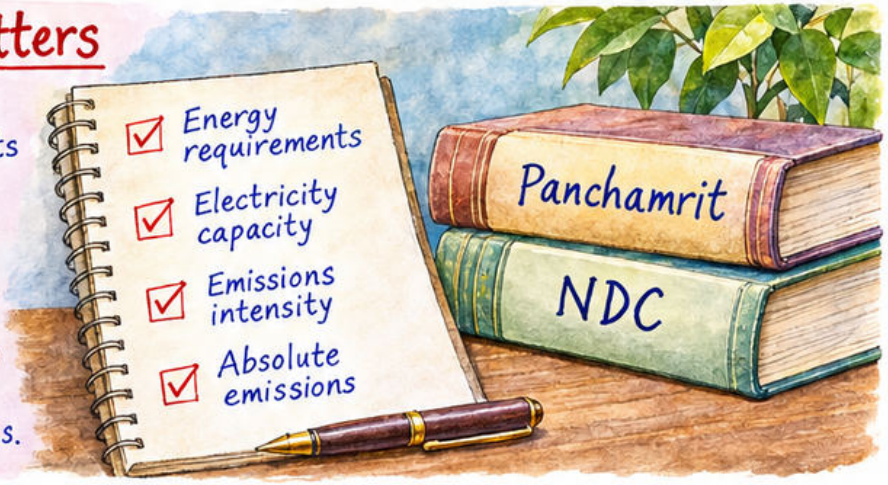
LIFE

Lifestyle for Environment



The wording matters

Panchamrit's renewable share of energy requirements and the NDC's non-fossil share of installed electric capacity are different formulations. Energy requirements, electricity capacity, emissions intensity and absolute emissions are not interchangeable measures.



Sources: Day 28 Complete Content Pack | Topic 277

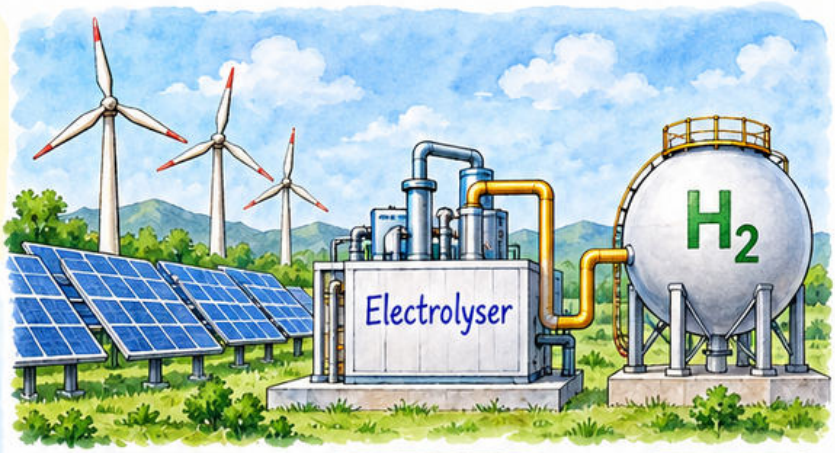
The National Green Hydrogen Mission

Approval and funding

The Union Cabinet approved the Mission on 4 January 2023 with an outlay of ₹19,744 crore.

The 2030 capacity goal

The aim is at least five million metric tonnes of green-hydrogen production capacity a year by 2030. MMT means million metric tonnes, not megawatts.

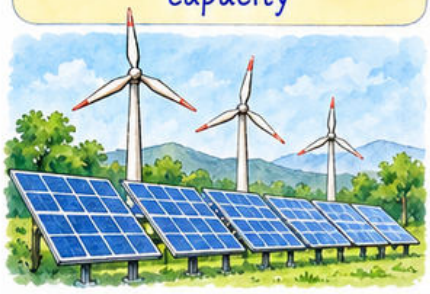


Renewable electricity (solar, wind) → Electrolyser (produces green hydrogen) → Hydrogen storage (H_2)

Associated aims

The Mission envisages about 125 GW of additional renewable capacity, avoidance of nearly 50 MMT of greenhouse-gas emissions annually and savings exceeding ₹1 lakh crore in fossil-fuel imports.

About 125 GW of additional renewable capacity



Avoidance of nearly 50 MMT of greenhouse-gas emissions annually



Savings exceeding ₹1 lakh crore in fossil-fuel imports



Dated progress

About 8,000 tonnes per year of production capacity was operational by February 2026. Keep operational progress separate from the five-MMT target and its 2030 deadline.

Operational progress

About 8,000 tonnes per year of production capacity

by February 2026

Target

At least 5 MMT per year of green-hydrogen production capacity

by 2030

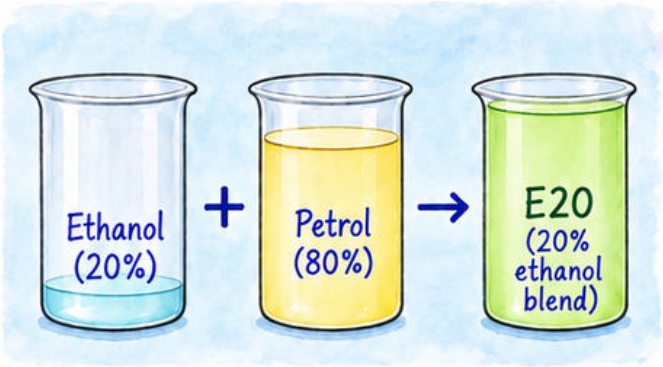
Sources: Day 28 Complete Content Pack | Topic 277

Biofuels and offshore wind

Biofuels policy

The National Policy on Biofuels dates to 2018. Cabinet amendments approved on 18 May 2022 moved the 20% ethanol-blending target from 2030 to ethanol supply year 2025–26.





Other changes and progress

The amendments widened permitted feedstocks, allowed exports in specified cases and added National Biofuel Coordination Committee members. The Petroleum Ministry stated on 8 August 2025 that the 20% blending milestone had been achieved.

Offshore wind policy

The National Offshore Wind Energy Policy was notified in 2015. On 19 June 2024, the Cabinet approved a ₹7,453 crore viability-gap-funding scheme.



Projects and ports

₹6,853 crore was allocated for one GW of projects, 500 MW each off Gujarat and Tamil Nadu. ₹600 crore was for upgrading two ports. These are approved project allocations, not a claim that all capacity is already operating.



Sources: Day 28 Complete Content Pack | Topic 277

Nuclear targets and small modular reactors

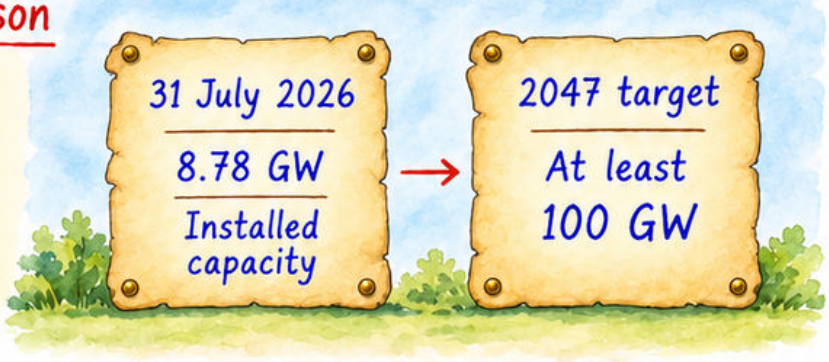
Budget 2025-26

The Nuclear Energy Mission for Viksit Bharat was announced on 1 February 2025. It seeks at least 100 GW of nuclear capacity by 2047.



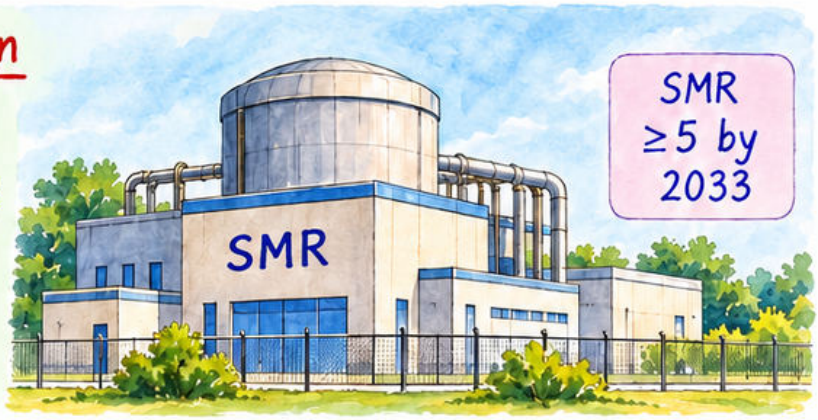
The starting comparison

Nuclear capacity stood at 8.78 GW on 31 July 2026. The 100 GW figure is a future target, not current capacity.



SMR research mission

The Budget provided an outlay of ₹20,000 crore for research and development of small modular reactors. It aims to have at least five indigenously developed SMRs operating by 2033.



Law and policy

The Budget announced changes to the Atomic Energy Act and the Civil Liability for Nuclear Damage Act. The later SHANTI Act enacted a new framework, but commencement of its provisions must be distinguished from announcement and assent.

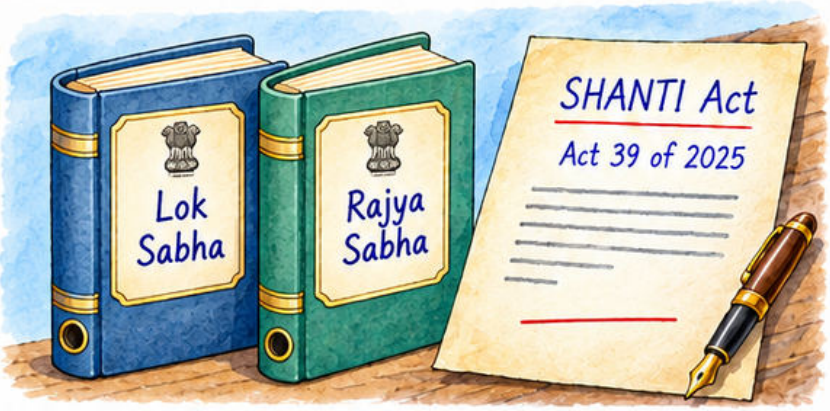


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SHANTI Act: enactment is not commencement

Name and assent

SHANTI means Sustainable Harnessing and Advancement of Nuclear Energy for Transforming India. Parliament passed it in the Winter Session of 2025; presidential assent followed on 20 December 2025 as Act 39 of 2025.



The enacted framework

It provides for licensed private-company and joint-venture participation in building, owning and operating nuclear plants, and statutory status for the Atomic Energy Regulatory Board.



Repeal provisions

The enacted text provides for repeal of the Atomic Energy Act, 1962 and the Civil Liability for Nuclear Damage Act, 2010. This describes the legislative framework, not proof that every repeal has taken effect.

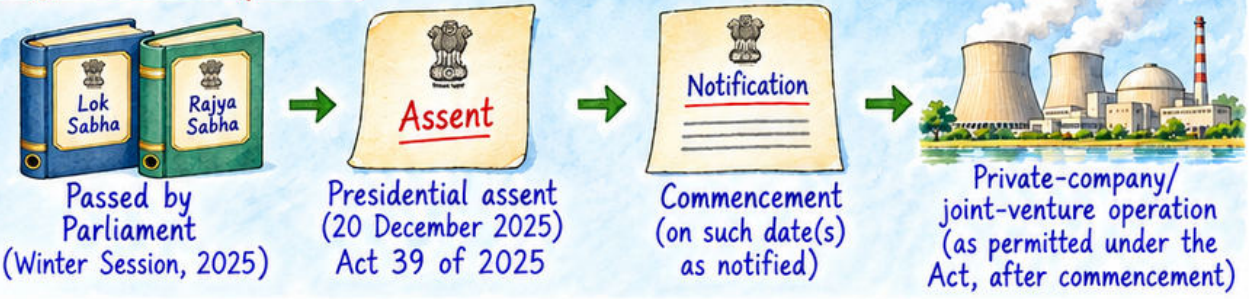


Section 1(2)

Commencement requires a notification, and different provisions may begin on different dates. Assent alone does not establish that every provision, repeal or operational permission is already in force.



Legislative sequence



Sources: Day 28 Complete Content Pack | Topic 277

Electricity law and energy efficiency

Electricity Act, 2003

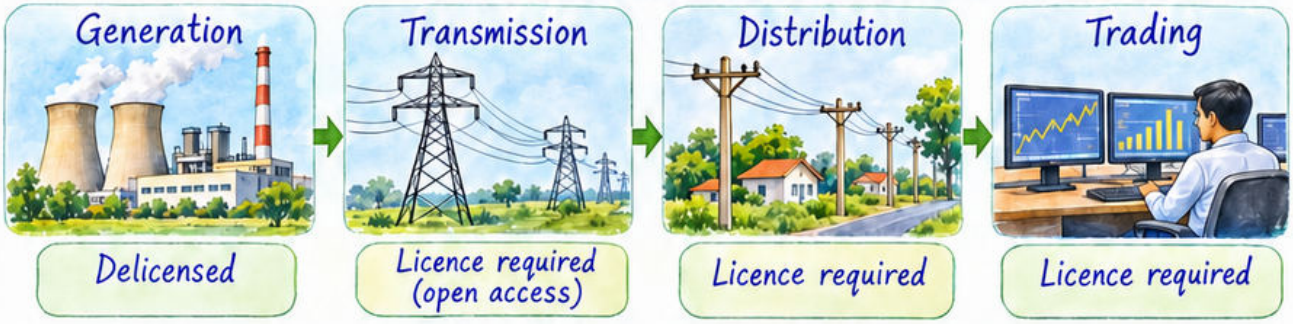
Assented to on 26 May 2003, it replaced the Indian Electricity Act, 1910, Electricity (Supply) Act, 1948 and Electricity Regulatory Commissions Act, 1998.



Licensing distinctions

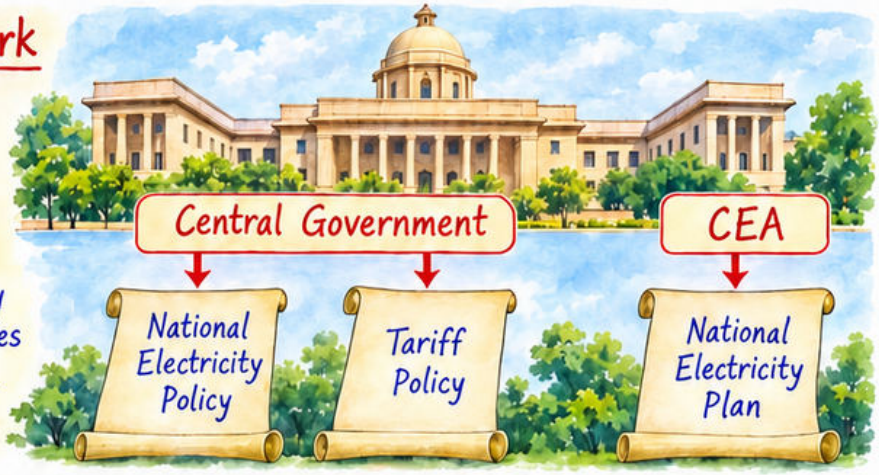
Generation is delicensed. A hydro scheme above a cost threshold set by the Central Government requires CEA concurrence. Transmission, distribution and trading require licences, and transmission permits open access.





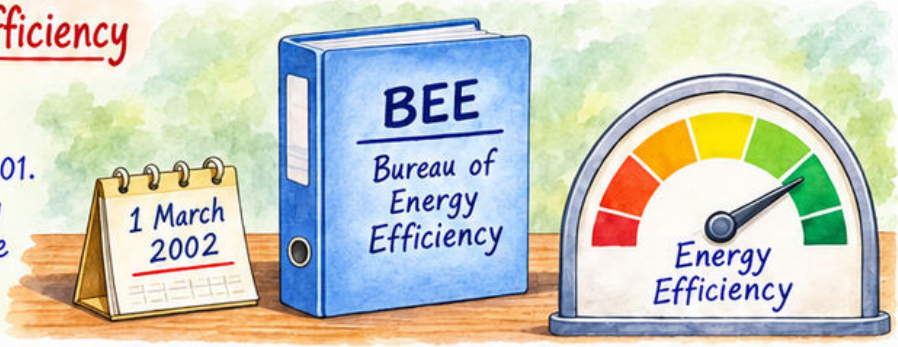
Institutional framework

State Electricity Regulatory Commissions are compulsory and State Electricity Boards are to be unbundled. The Central Government writes the National Electricity Policy and Tariff Policy; CEA prepares the National Electricity Plan.



Bureau of Energy Efficiency

BEE was set up on 1 March 2002 under the Energy Conservation Act, 2001. Its primary aim is reducing the energy intensity of the Indian economy.

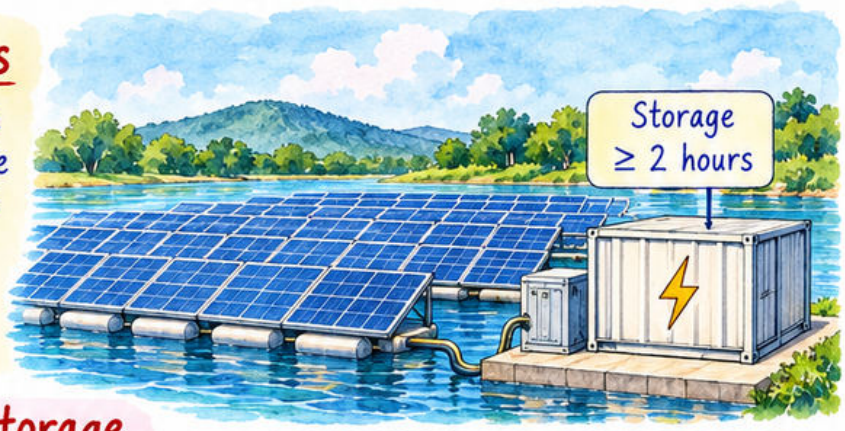


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Storage and the sequence of targets

Why storage matters

Solar output is unavailable after sunset, and renewable production varies. Storage helps align electricity supply with the timing of demand.



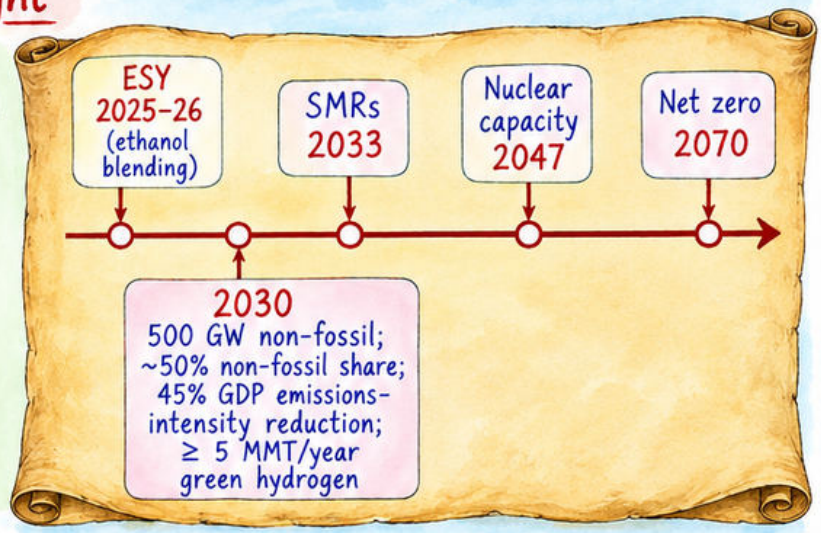
Floating solar with storage

PM Surya Sarovar Yojana was approved on 31 July 2026 with ₹5,070 crore. It aims for 5,000 MW of floating solar paired with storage lasting at least two hours. Approval is not completed installation.



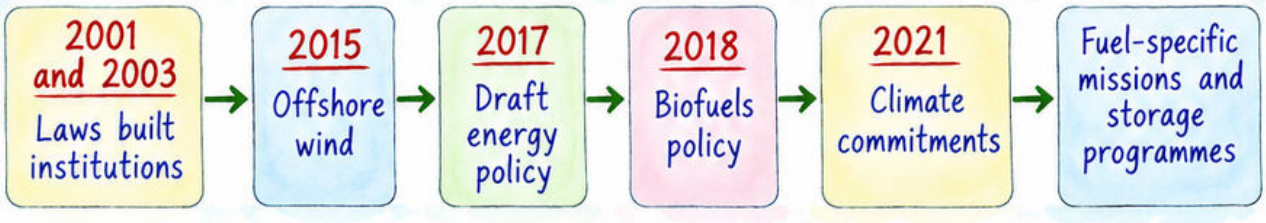
Keep the years straight

2030: 500 GW non-fossil capacity, about 50% non-fossil installed share, 45% GDP emissions-intensity reduction and at least five MMT/year green hydrogen. Ethanol blending uses ESY 2025-26; SMRs 2033; nuclear capacity 2047; net zero 2070.



The policy sequence

The 2001 and 2003 laws built institutions. Offshore wind followed in 2015, the draft energy policy in 2017 and biofuels policy in 2018. Climate commitments from 2021 were followed by fuel-specific missions and storage programmes.

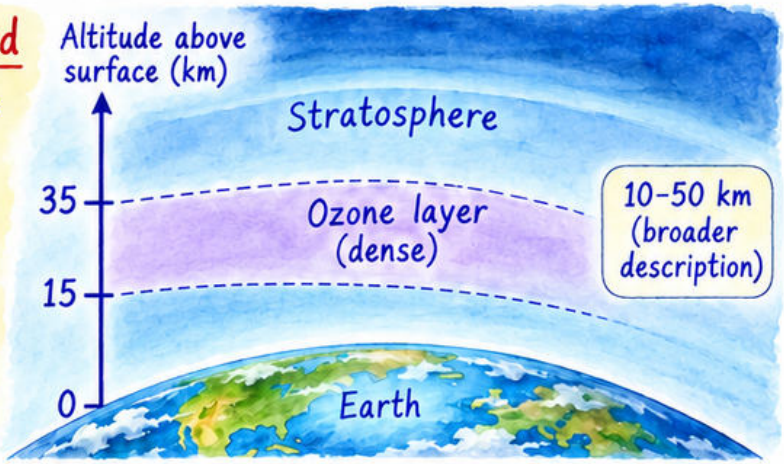


Sources: Day 28 Complete Content Pack | Topic 277

A thin shield high above Earth

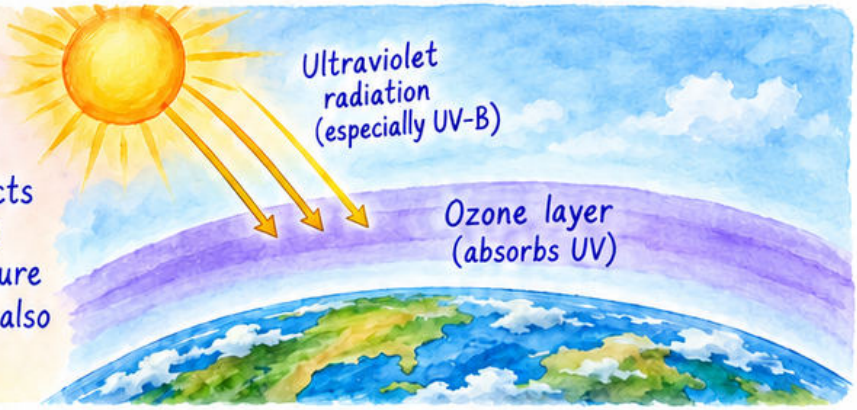
Where ozone is concentrated

About 90 per cent of atmospheric ozone lies in the stratosphere. The dense ozone layer is roughly 15–35 km high. Broader descriptions use 10–50 km or about 15–50 km because they include different portions of the ozone distribution.



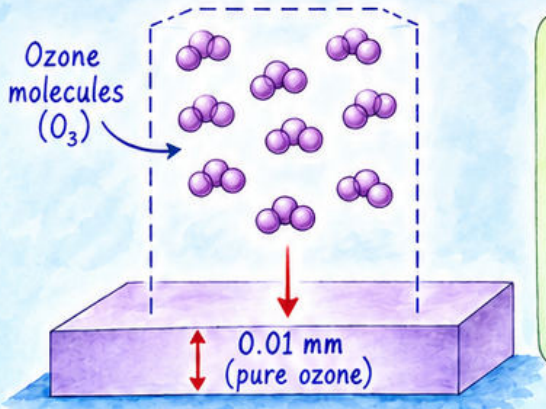
What it does

Ozone absorbs much of the Sun's ultraviolet radiation, especially UV-B. This protects life below and helps explain why stratospheric temperature rises with height. Ozone is also a greenhouse gas.



The Dobson unit

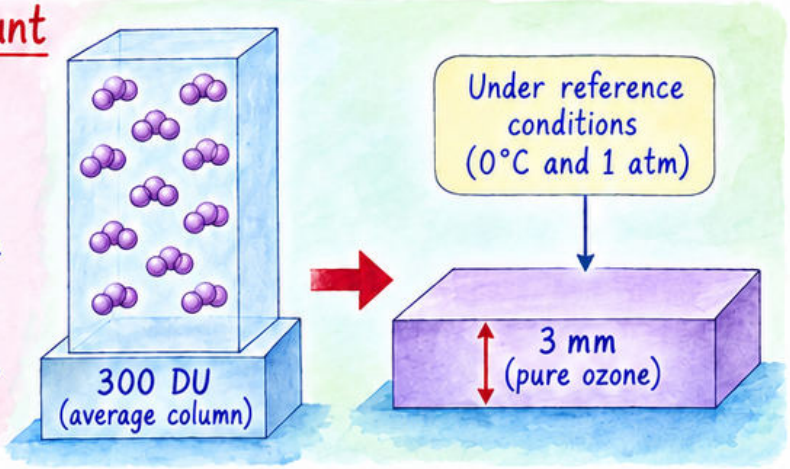
One Dobson unit, DU, is the number of ozone molecules needed to form a pure-ozone layer 0.01 mm thick at 0°C and one atmosphere pressure. This is a compressed-column measure, not the physical thickness of the stratospheric region.



One Dobson unit (DU) = number of ozone molecules needed to form 0.01 mm of pure ozone at 0°C and 1 atmosphere pressure.

A surprisingly small amount

An average column of about 300 DU would form only about 3 mm of pure ozone under those reference conditions. Keep kilometres of atmospheric altitude separate from millimetres of compressed ozone. Both describe the same shield in different ways, not contradictory estimates of its height.

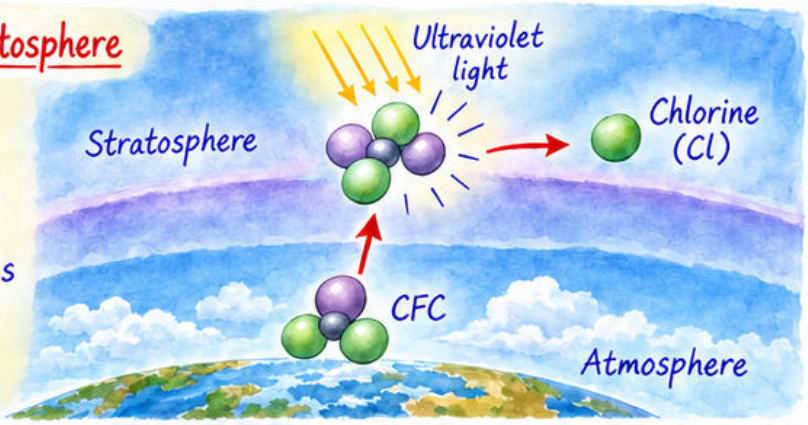


Sources: Day 29 Source Index | Topic 287

How chlorine and bromine destroy ozone

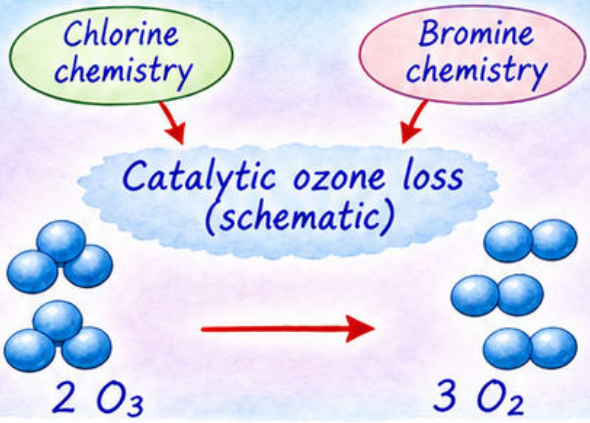
Chemicals that reach the stratosphere

CFCs are stable in the lower atmosphere and survive long enough to reach higher layers. Stratospheric ultraviolet light breaks them apart and releases chlorine, which participates in ozone-destroying reactions.



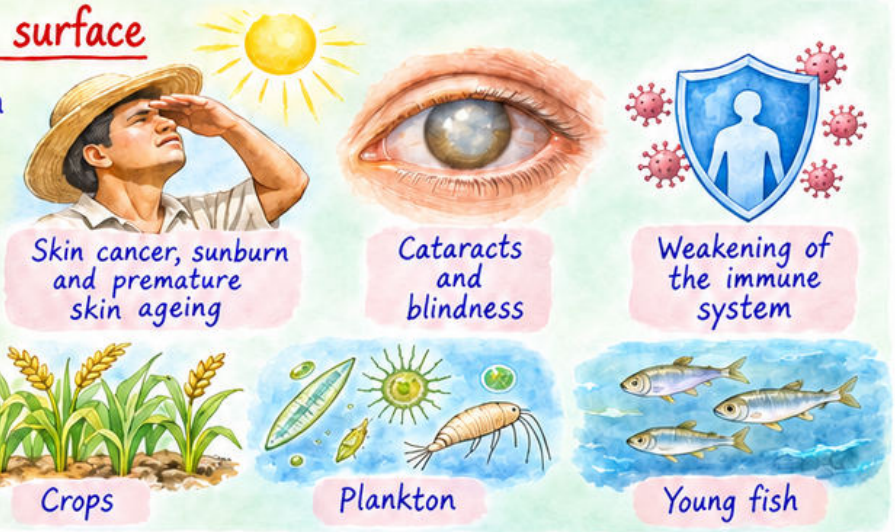
The controlled substances

Ozone-depleting substances include CFCs, halons, carbon tetrachloride, methyl chloroform, methyl bromide, HCFCs, HBFCs and bromochloromethane. Chlorine and bromine chemistry together account for a large share of ozone loss.



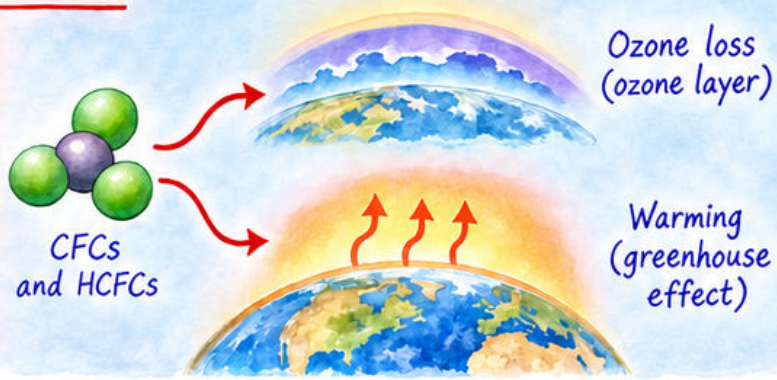
Consequences at the surface

More UV-B can cause skin cancer, sunburn and premature skin ageing; cataracts and blindness; and weakening of the immune system. Crops, plankton and young fish are also vulnerable.



Ozone and climate are connected

CFCs and HCFCs are greenhouse gases as well as ozone-depleting substances. That does not mean every greenhouse gas destroys ozone. The chemical action causing ozone loss and the warming influence of a gas are separate properties that may coexist in the same substance.

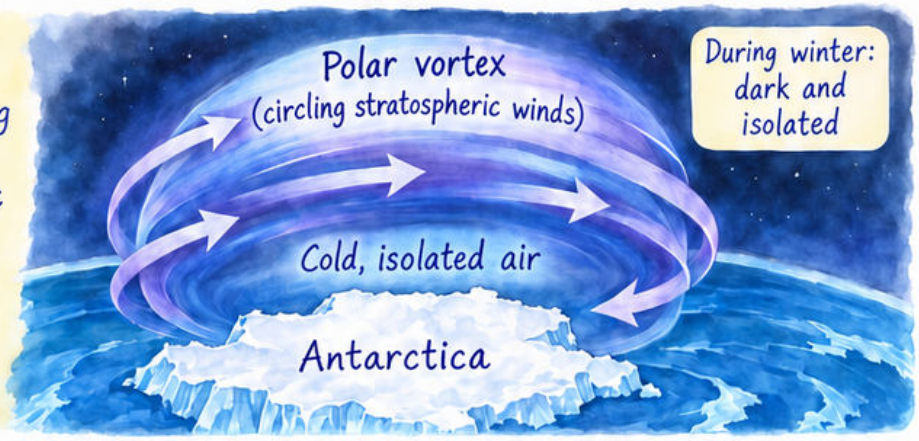


Sources: Day 29 Source Index | Topic 287

Why Antarctica develops an ozone hole

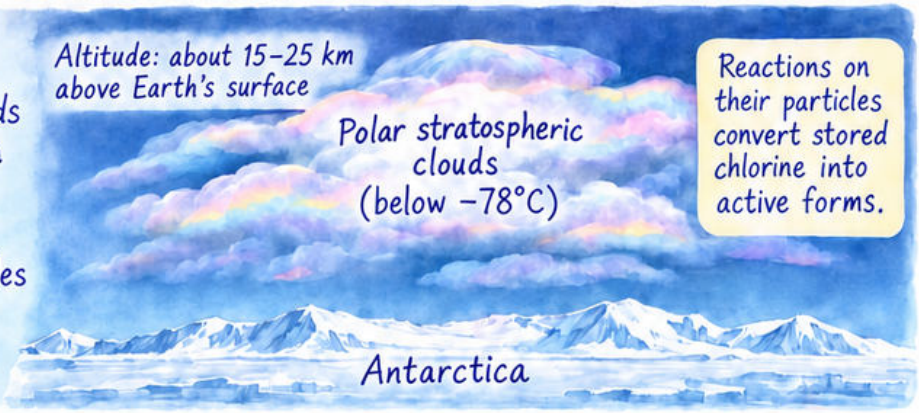
Winter isolation

A polar vortex, a circling system of stratospheric winds, isolates Antarctic air during winter. Darkness allows the trapped air to become extremely cold.



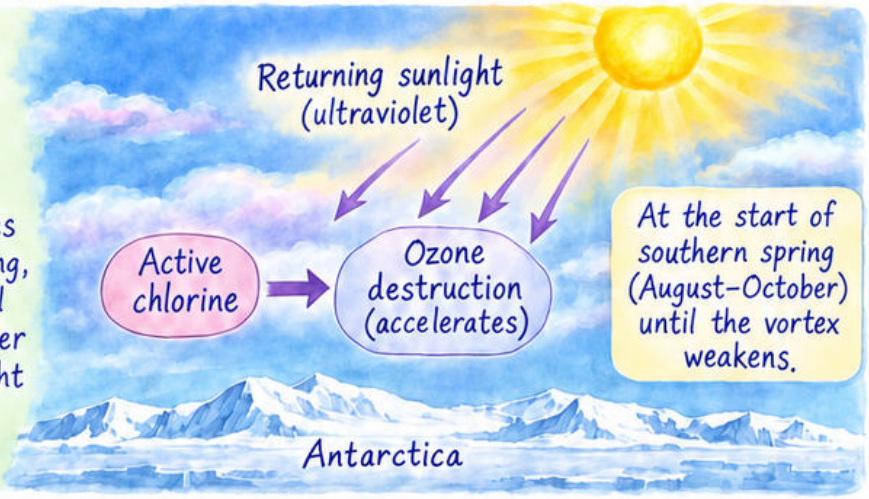
Cloud chemistry

Polar stratospheric clouds form at about 15–25 km when temperatures fall below minus 78°C. Reactions on their particles convert stored chlorine into active forms.



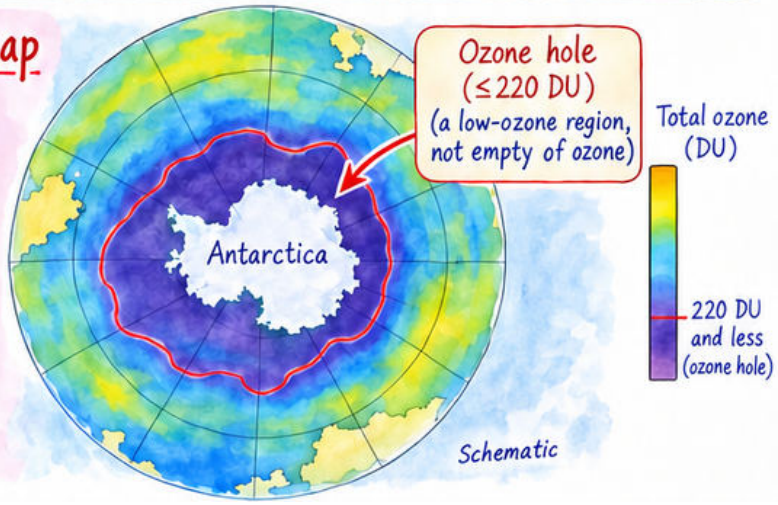
Spring destruction

Returning sunlight releases reactive chlorine through ultraviolet-driven chemistry. Ozone destruction accelerates at the start of southern spring, during August–October, until the vortex weakens. The winter preparation and spring sunlight are both necessary parts of the explanation.



A low-ozone region, not a gap

NASA Ozone Watch defines the Antarctic ozone hole as the area with total ozone of 220 DU or less. Values below 220 DU were not observed before 1979. "Hole" therefore describes severe thinning, not a region entirely empty of ozone. Its size and depth vary with stratospheric conditions.



Sources: Day 29 Source Index | Topic 287

Ground measurements revealed the loss

Halley Bay's record

The British Antarctic Survey measured ozone at Halley Bay from 1957 using a Dobson spectrophotometer. A long ground-based record made the seasonal change detectable.



The discovery paper

J.C. Farman, B.G. Gardiner and J.D. Shanklin published the first paper on Antarctic springtime ozone losses in Nature in 1985. The initial published discovery did not come from satellites.



The satellite contribution

In 1986, NASA scientists used satellite data to establish that the hole was a regional-scale Antarctic phenomenon. Ground measurements identified the loss; satellites showed its broad extent.



Satellite data (1986, NASA)

↓

Established that the hole was a regional-scale Antarctic phenomenon.

World Ozone Day

16 September commemorates the Montreal Protocol agreed in 1987. The UN General Assembly proclaimed the International Day for the Preservation of the Ozone Layer on 19 December 1994. The 2026 theme is "Global action for a cooler planet", marking ten years of the Kigali Amendment. The commemoration links ozone protection with the continuing climate benefits of action.



Sources: Day 29 Source Index | Topic 287

Vienna provides a framework Montreal adds controls

Vienna Convention

Adopted on 22 March 1985 and in force from 22 September 1988, the Convention for the Protection of the Ozone Layer promotes systematic observation, research and information exchange. It did not itself require control actions.



Montreal Protocol

Agreed on 16 September 1987 and in force from 1 January 1989, the Protocol on Substances that Deplete the Ozone Layer establishes binding controls on production and consumption of ozone-depleting substances.

Vienna: framework for observation, research and information exchange



Adoption
Vienna: 22 March 1985

Adoption
Montreal: 16 September 1987

In force
Vienna: 22 September 1988

In force
Montreal: 1 January 1989

Montreal: binding controls on production and consumption of ozone-depleting substances



Universal participation

On 16 September 2009, Vienna and Montreal became the first treaties in UN history ratified by every country. Vienna is also described as the first convention of any kind to achieve universal ratification.



Ratified by every country (16 September 2009)

Amendments and adjustments

Five amendments expanded the regime. Adjustments can accelerate agreed reductions and apply automatically to all Parties. Keep the mechanisms distinct. Also separate adoption from commencement: Vienna and Montreal were adopted two years apart, in 1985 and 1987, but entered into force one year apart, in 1988 and 1989.

Amendments (five) expand the regime

Adjustments can accelerate agreed reductions and apply automatically to all Parties

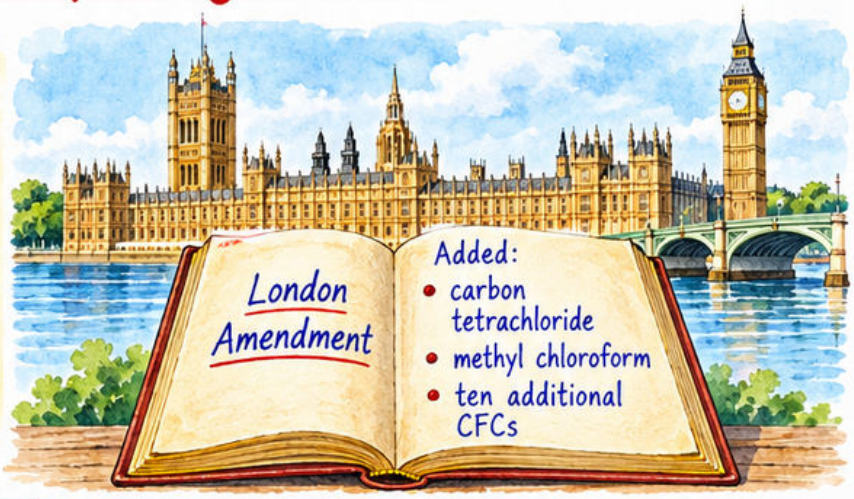


Sources: Day 29 Source Index | Topic 287

London and Copenhagen widen the controls

London, 1990

The Second Meeting of the Parties, held in London from 27–29 June 1990, agreed the London Amendment. It added carbon tetrachloride, methyl chloroform and ten additional CFCs.



Paying incremental costs

The same meeting established the Multilateral Fund. It covers the extra costs developing countries incur in complying with the controls. These countries are called Article 5 Parties, after the Protocol provision allowing them more time.



Copenhagen, 1992

The Fourth Meeting, held from 23–25 November 1992, agreed the Copenhagen Amendment. It brought methyl bromide, HBFCs and HCFCs under control.



Implementation matters

Copenhagen also agreed the non-compliance procedure and established the Implementation Committee. Adding substances, financing compliance and checking implementation are different functions of the treaty system. The years 1990 and 1992 identify the meetings that adopted these amendments; they should not be presented as unverified entry-into-force dates.



Functions of the treaty system

- Adding substances
- Financing compliance
- Checking implementation

Sources: Day 29 Source Index | Topic 287

Licences further controls and Kigali

Montreal Amendment, 1997

The Ninth Meeting of the Parties, 15–17 September 1997 in Montreal, introduced licensing for the import and export of ozone-depleting substances. It strengthened the control of trade, rather than creating the original Protocol anew.



Beijing Amendment, 1999

The Eleventh Meeting, held from 29 November to 3 December 1999, brought bromochloromethane under control and added further controls on HCFCs.



Kigali Amendment, 2016

The Twenty-Eighth Meeting was held in Kigali, Rwanda, from 10–15 October 2016. The Amendment was agreed on 15 October to phase down HFC production and consumption.



When Kigali began

Kigali entered into force on 1 January 2019. The condition of twenty ratifications had been met on 17 November 2017. The regime's five amendment names are London, Copenhagen, Montreal, Beijing and Kigali. A treaty amendment's adoption, ratification threshold and entry into force are different milestones, each with its own date.

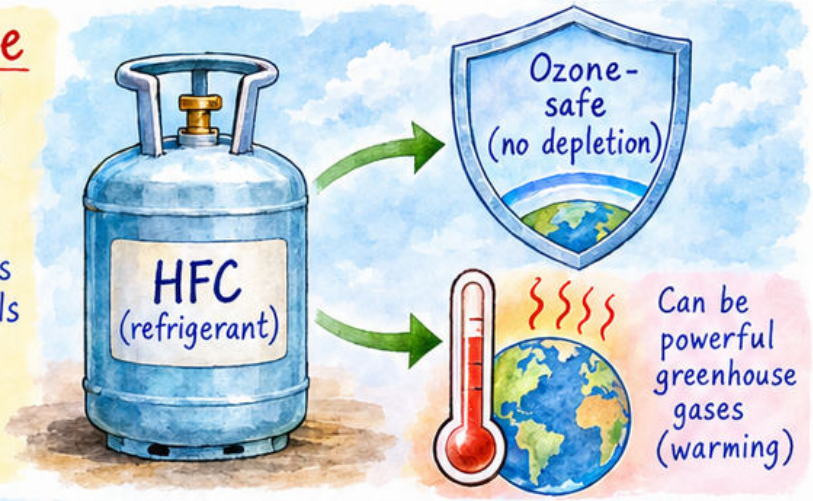


Sources: Day 29 Source Index | Topic 287

HFCs spare ozone but warm the planet

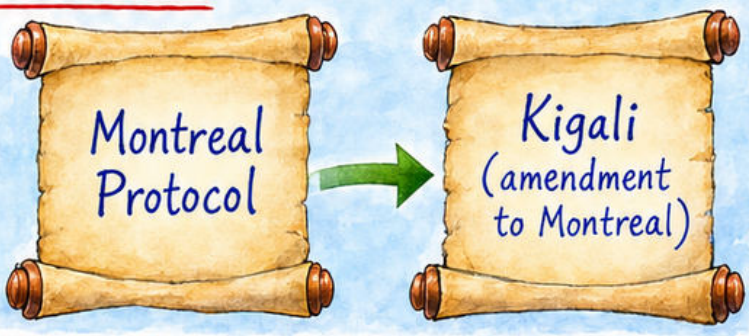
Why HFCs entered use

Hydrofluorocarbons replaced ozone-depleting substances. They do not deplete ozone, but they can be powerful greenhouse gases. UNEP gives HFC global-warming potentials ranging from about 121 to about 14,800.



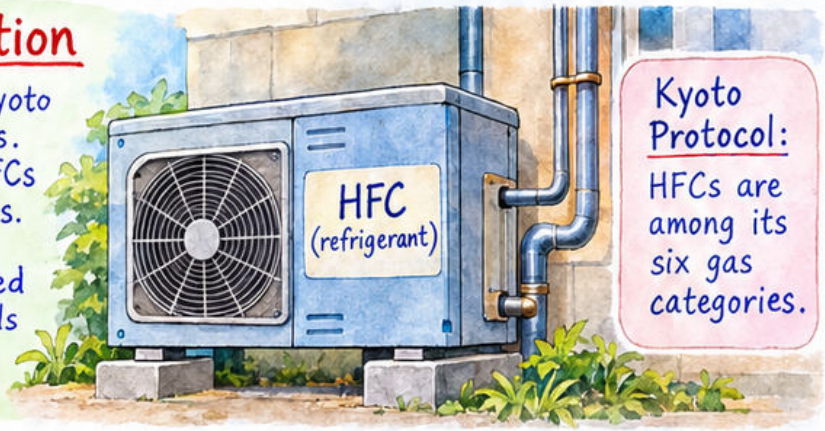
Why Montreal now controls them

Kigali brings HFC production and consumption under the Montreal Protocol. It is an amendment to Montreal, not to the Kyoto Protocol or the UN Framework Convention on Climate Change.



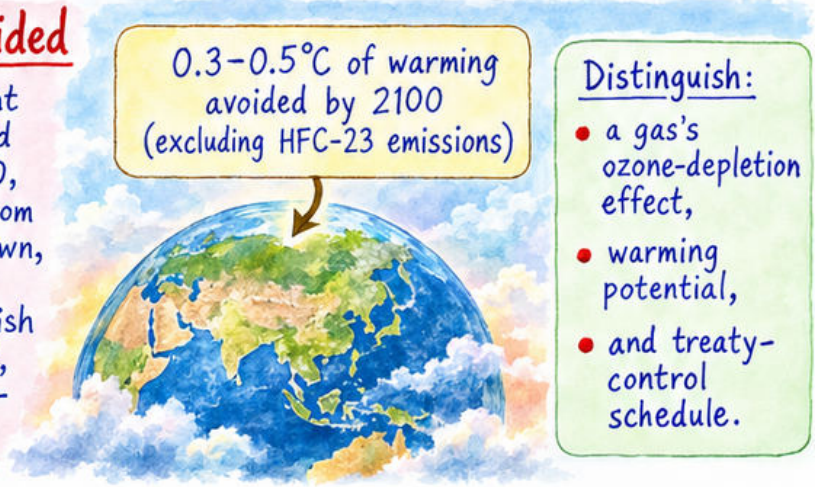
The climate connection

HFCs are also among the Kyoto Protocol's six gas categories. The overlap does not turn HFCs into ozone-depleting chemicals. Kyoto's framework concerns greenhouse gases not controlled by Montreal, while Kigali adds a specific HFC phase-down within the ozone regime.



Expected warming avoided

The 2022 scientific assessment estimates that Kigali can avoid 0.3–0.5°C of warming by 2100, excluding HFC-23 emissions from that estimate. It is a phase-down, not an assertion that HFCs immediately disappear. Distinguish a gas's ozone-depletion effect, warming potential and treaty-control schedule.



Sources: Day 29 Source Index | Topic 287

Kigali schedules differ by group

Most developed countries

For most non-Article 5 Parties, baseline years are 2011–13, with no separate freeze. Cuts below baseline are 10 per cent in 2019, 40 in 2024, 70 in 2029, 80 in 2034 and 85 in 2036.

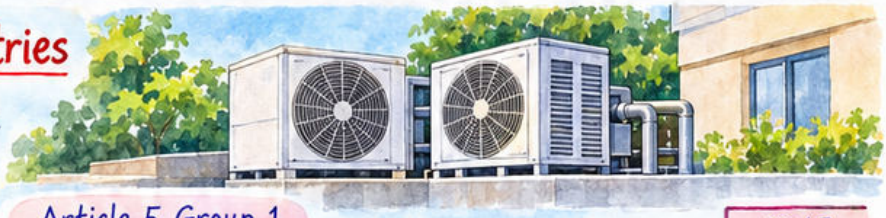


Non-Article 5 Parties (most developed)

- Baseline: 2011–13
- 2019: 10% reduction
- 2024: 40% reduction
- 2029: 70% reduction
- 2034: 80% reduction
- 2036: 85% reduction

Most developing countries

Article 5 Group 1 uses a 2020–22 baseline and a 2024 freeze. Cuts are 10 per cent in 2029, 30 in 2035, 50 in 2040 and 80 in 2045.

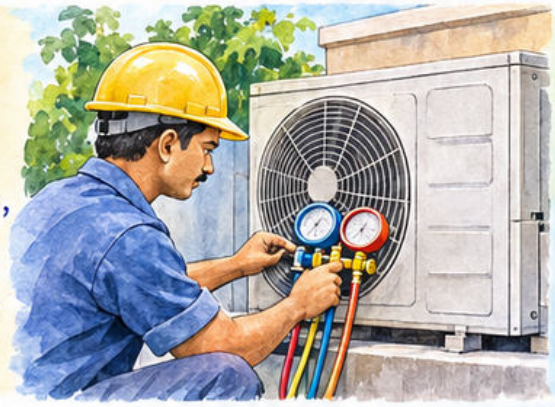


Article 5 Group 1 (most developing)

- Baseline: 2020–22
- Freeze: 2024
- 2029: 10% reduction
- 2035: 30% reduction
- 2040: 50% reduction
- 2045: 80% reduction

India's group

Article 5 Group 2 comprises India, Bahrain, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia and the United Arab Emirates. Its baseline is 2024–26 and freeze year 2028.



Article 5 Group 2 members: India, Bahrain, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia and the United Arab Emirates.

Baseline: 2024–26 | Freeze: 2028

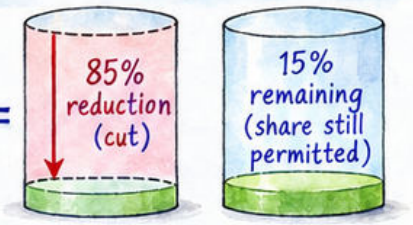
Group 2 reductions

Cuts are 10 per cent in 2032, 20 in 2037, 30 in 2042 and 85 in 2047. The treaty expresses the final limit as 15 per cent of baseline remaining, which equals an 85 per cent cut. Always label whether a number is the reduction or the share still permitted.

Article 5 Group 2 (India's group)

- Baseline: 2024–26
- Freeze: 2028
- 2032: 10% reduction
- 2037: 20% reduction
- 2042: 30% reduction
- 2047: 85% reduction

85% cut (reduction) = 15% remaining (share still permitted) =

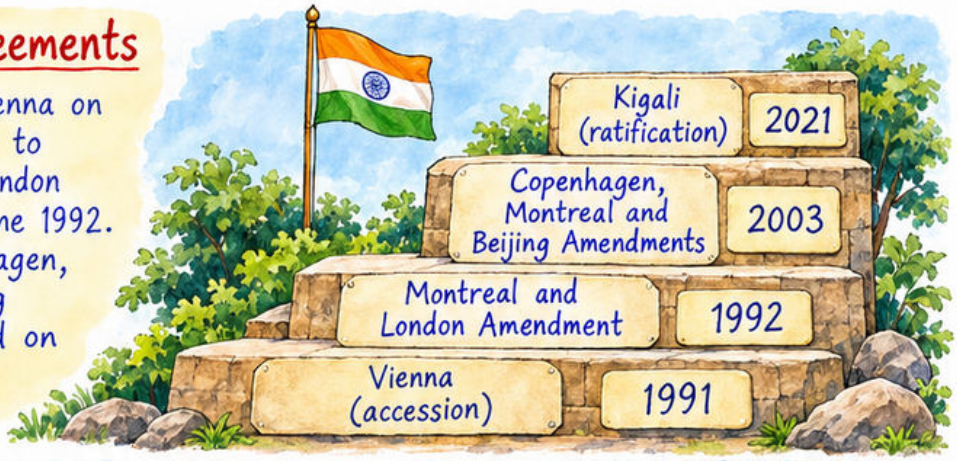


Sources: Day 29 Source Index | Topic 287

India's ratifications and domestic rules

Joining the agreements

India acceded to Vienna on 18 March 1991, and to Montreal and the London Amendment on 19 June 1992. Accession to Copenhagen, Montreal and Beijing Amendments followed on 3 March 2003.



Kigali ratification

The Cabinet approved ratification on 18 August 2021; India ratified on 27 September 2021. The 2021 Cabinet release listed an 80 per cent final cut in 2047, whereas the treaty, UNEP schedule and 30 November 2016 Cabinet release give 85 per cent. Use 85 per cent for the treaty schedule.

Treaty clarification

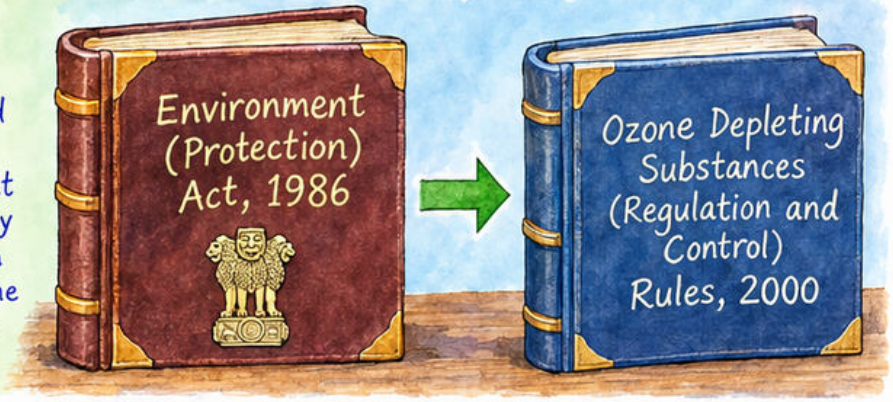
Treaty, UNEP schedule and 30 November 2016 Cabinet release: 85 per cent ✓

2021 Cabinet release: 80 per cent



Domestic controls

The Ozone Depleting Substances (Regulation and Control) Rules, 2000 were made under the Environment (Protection) Act, 1986. They banned CFCs and halons in new equipment by 2003. The 2014 and 2019 amendment rules used the same Act.



Implementation

MoEFCC's Ozone Cell handles control schedules, the HCFC Phase-out Management Plan and the India Cooling Action Plan. India phased out CFCs, carbon tetrachloride and halons for controlled uses by 2010. CFC production and consumption stopped on 1 August 2008, seventeen months ahead of schedule.





Treaty schedule (final cut): 85 per cent ✓

Sources: Day 29 Source Index | Topic 287

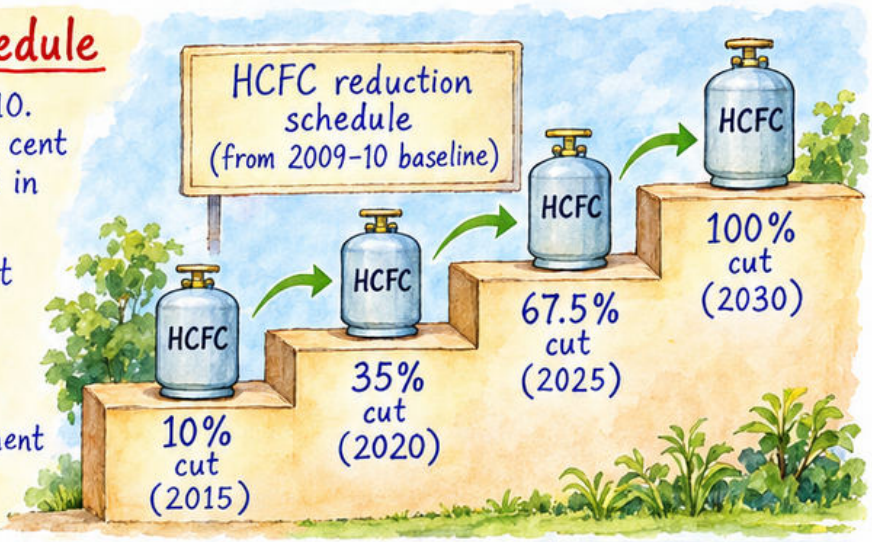
India's HCFC phase-out and cooling plan

HCFC reduction schedule

India's baseline is 2009-10. Scheduled cuts are 10 per cent in 2015, 35 in 2020, 67.5 in 2025 and 100 in 2030.

HCFC-141b was phased out in foam production from 1 January 2020.

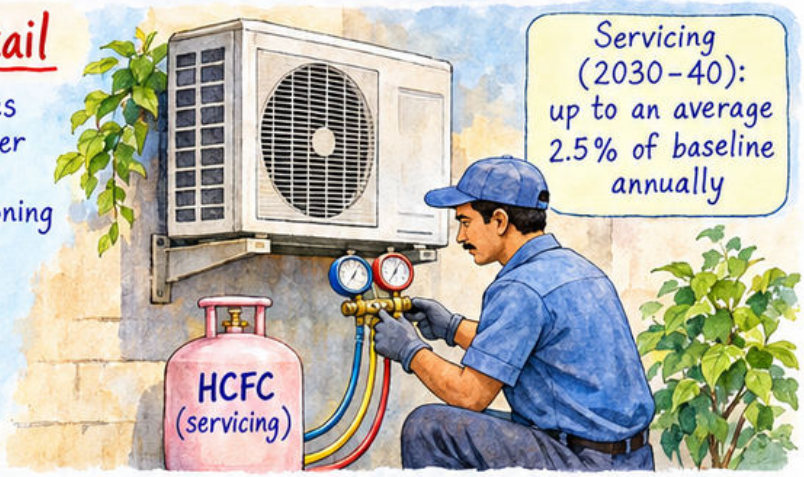
HCFCs cannot be used to manufacture any new equipment from 1 January 2025.



The narrow servicing tail

From 2030-40, Article 5 Parties may use up to an average 2.5 per cent of baseline annually for servicing refrigeration, air-conditioning and fire-protection equipment existing on 1 January 2030, plus two other narrow uses.

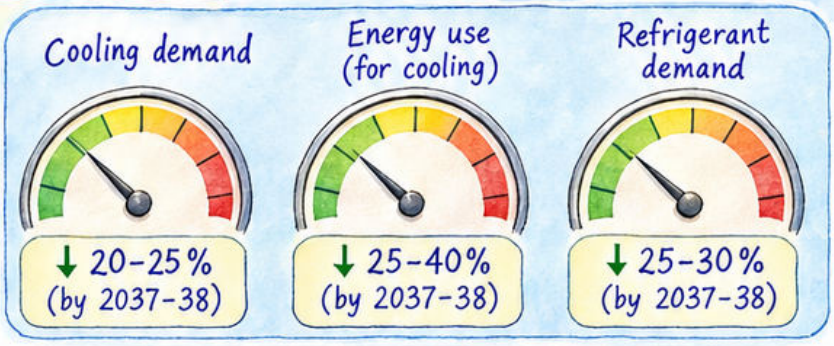
A 100 per cent scheduled cut therefore has specified limited exceptions.



India Cooling Action Plan, 2019

By 2037-38, ICAP aims to reduce cooling demand by 20-25 per cent, energy use for cooling by 25-40 per cent and refrigerant demand by 25-30 per cent.

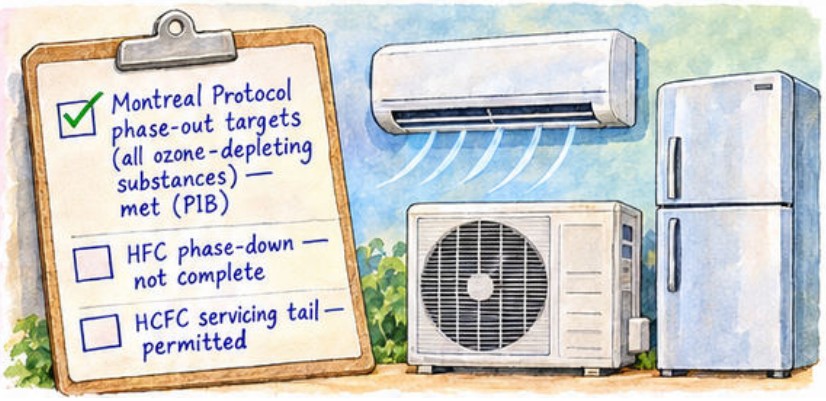
These are three different quantities and target ranges.



Progress and scope

PIB reports India has met its Montreal Protocol phase-out targets for all ozone-depleting substances.

That does not mean the later HFC phase-down is already complete, nor does it erase the permitted HCFC servicing tail.

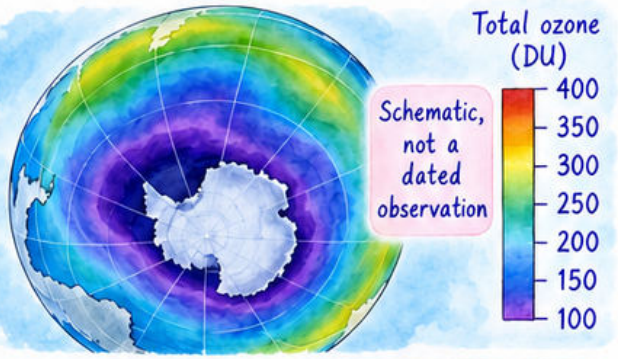


Sources: Day 29 Source Index | Topic 287

Recovery takes decades not one season

The scientific assessment

WMO/UNEP's Scientific Assessment of Ozone Depletion: 2022 was released on 9 January 2023. The Montreal Protocol's Scientific Assessment Panel prepares an assessment every four years.



Expected return to 1980 values

If current policies continue, recovery is projected around 2066 over Antarctica, 2045 over the Arctic and 2040 elsewhere. Nearly 99 per cent of banned ozone-depleting substances have been phased out. Antarctic hole area and depth have slowly improved since 2000.



Compare the same measures

In 2006, the largest daily area was 29.6 million sq km on 24 September; the 7 September–13 October mean was 26.6 million sq km; minimum daily ozone was 84 DU on 8 October.

In 2025, corresponding figures were 22.9 million sq km on 9 September, 18.7 million sq km, and 127 DU on 25 September.

	2006	2025
Largest daily area	29.6 million sq km (24 September)	22.9 million sq km (9 September)
Seasonal mean area	26.6 million sq km (7 September–13 October mean)	18.7 million sq km
Minimum daily ozone	84 DU (8 October)	127 DU (25 September)

Weather still changes each season

The 2006 season has the largest mean area in NASA's table. As of 1 November 2026, that annual table ran through 2025. Recovery must be judged across years because stratospheric weather affects individual seasons; one smaller hole does not mean complete recovery.

Two reported seasons, not an annual series

2006
seasonal mean:
26.6 million sq km

2025
seasonal mean:
18.7 million sq km

Sources: Day 29 Source Index | Topic 287

Aadhaar identity and the law

Aadhaar and UIDAI

Aadhaar is a 12-digit identity number issued by the Unique Identification Authority of India. Alongside UPI, DigiLocker and consent-based Account Aggregators, it forms the core of India Stack and India's digital public infrastructure.

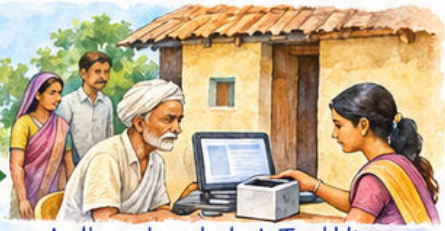


UIDAI's journey

UIDAI began on 28 January 2009 as an attached office of the Planning Commission. Aadhaar was launched on 29 September 2010 at Tembhli, Nandurbar district, Maharashtra, where the first Aadhaar was issued. UIDAI moved under MeitY in September 2015 and became a statutory authority under MeitY on 12 July 2016.



Planning Commission (28 January 2009)



Aadhaar launched at Tembhli, Nandurbar district, Maharashtra (29 September 2010)



MeitY (September 2015)



Statutory authority under MeitY (12 July 2016)

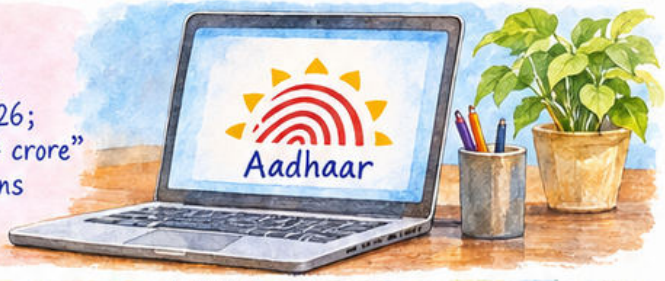
The law

The Aadhaar (Targeted Delivery of Financial and Other Subsidies, Benefits and Services) Act, 2016 was notified on 26 March 2016. The Aadhaar and Other Laws (Amendment) Act, 2019 was notified on 23 July and took effect on 25 July 2019. It added privacy safeguards and permitted voluntary Aadhaar authentication for SIM cards and bank accounts, with corresponding changes to the Indian Telegraph Act, 1885 and Prevention of Money Laundering Act, 2002.



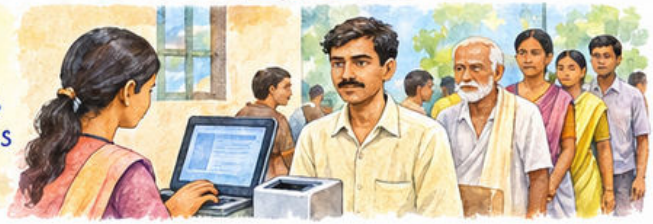
Dated scale

The enrolment dashboard showed 145.32 crore Aadhaar generated when read on 1 November 2026; its update date was 28 September 2026. "Over 144 crore" refers to March 2026. Authentication transactions exceeded 2,707 crore in 2024-25.



Identity is not citizenship

Section 9: Aadhaar or its authentication is not, by itself, proof of citizenship or domicile. It proves identity.



Sources: Day 30 Source Index | Topic 296

The 2018 Aadhaar judgment

Puttaswamy Aadhaar judgment

On 26 September 2018, a five-judge Constitution Bench upheld the scheme 4:1; Justice D.Y. Chandrachud dissented. The Aadhaar Act was held not to violate the fundamental right to privacy. Section 7, covering subsidies, benefits and services, remained valid.



Benefits and access

Enrolment is voluntary. Aadhaar is compulsory for those seeking subsidies, benefits or services funded from the Consolidated Fund of India. CBSE, UGC, NEET and JEE cannot make it mandatory for students. No deserving person may lose a benefit because authentication fails: another means of identity must be offered. A child cannot lose a section 7 benefit for lacking Aadhaar; another identity document is allowed.



Limits on use and storage

Section 57 was struck down only in part: a body corporate or person could not use Aadhaar authentication merely under a contract. Other uses to establish identity require backing by law. Regulation 27, permitting five-year archiving of authentication data, was struck down; retention beyond six months became impermissible.



PAN, banks and mobiles

Section 139AA of the Income-tax Act, 1961, linking PAN with Aadhaar, was upheld. Mandatory bank-account linkage under Rule 9 of the Prevention of Money-laundering (Maintenance of Records) Rules, 2005, as amended in 2017, was unconstitutional. So was the Department of Telecommunications circular of 23 March 2017 requiring mobile linkage.



Keep the dates separate

These are the 2018 holdings. The 2019 amendment subsequently permitted voluntary bank and SIM authentication. The general data law is the Digital Personal Data Protection Act, 2023.

Sources: Day 30 Source Index | Topic 296

India Stack and payments

A shared digital foundation

India Stack consists of open APIs and digital public goods. UIDAI provides Aadhaar and eKYC; the Controller of Certifying Authorities provides eSign; MeitY provides DigiLocker; NPCI provides UPI, the Aadhaar Payments Bridge and the Aadhaar Enabled Payments System.

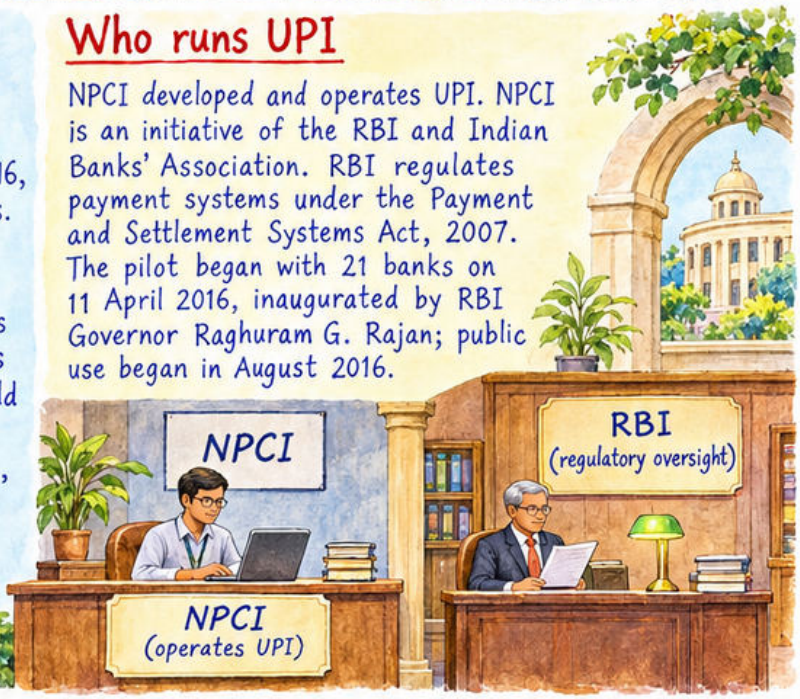


Layers and functions

Aadhaar, launched in 2010, gives a digitally verifiable identity supporting eKYC and eSign. UPI, launched in 2016, enables interoperable mobile payments. DigiLocker gathers documents from official sources. NITI Aayog's August 2020 DEPA discussion draft identifies consent as the final layer: it governs secure sharing and does not itself hold the data. A three-layer grouping combines identity, payments and data, placing DigiLocker and Account Aggregators in data; the DEPA model separates consent.

Who runs UPI

NPCI developed and operates UPI. NPCI is an initiative of the RBI and Indian Banks' Association. RBI regulates payment systems under the Payment and Settlement Systems Act, 2007. The pilot began with 21 banks on 11 April 2016, inaugurated by RBI Governor Raghuram G. Rajan; public use began in August 2016.



Dated payment figures

September 2026: 24.07 billion, or 2,407 crore, transactions worth Rs 29.37 lakh crore.

July 2026: 2,365.8 crore transactions worth Rs 29.87 lakh crore, with 741 banks live.

Documents and commerce

DigiLocker began in 2015 under MeitY as a digital document wallet with consent-based access. ONDC, the Open Network for Digital Commerce, began in 2022; over 1.16 lakh retail sellers were live by December 2025.



Sources: Day 30 Source Index | Topic 296

Account Aggregators and consent

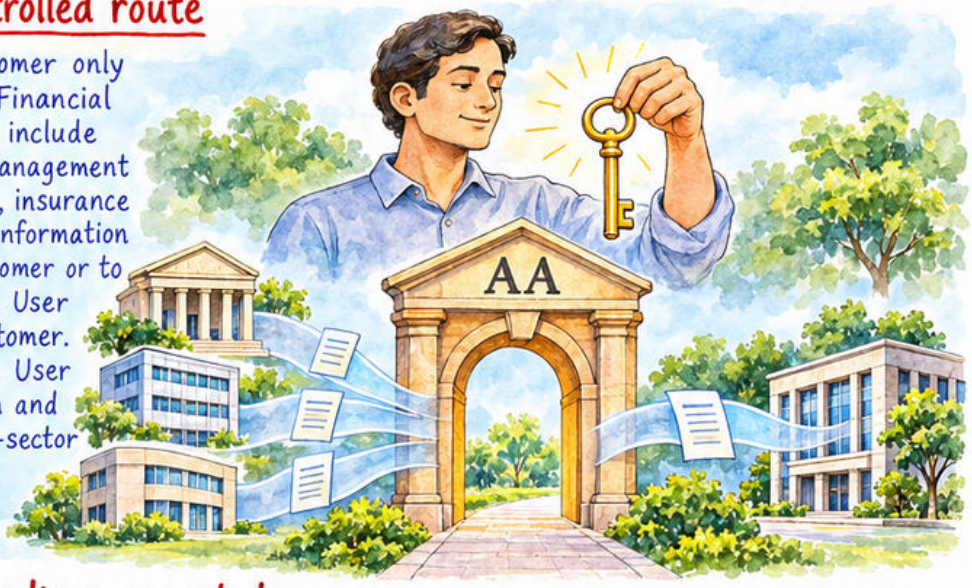
What an Account Aggregator is

An Account Aggregator, or AA, is an NBFC that enables consent-based sharing of financial information. The Non-Banking Financial Company–Account Aggregator (Reserve Bank) Directions, 2016 were issued on 2 September 2016. Only a company may undertake this business. It needs RBI registration and net owned funds of at least Rs 2 crore.



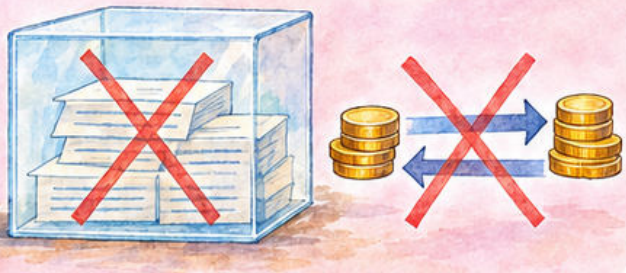
A customer-controlled route

The AA serves a customer only with explicit consent. Financial Information Providers include banks, NBFCs, asset management companies, depositories, insurance companies and GSTN. Information may go only to the customer or to a Financial Information User authorised by that customer. A Financial Information User must be registered with and regulated by a financial-sector regulator.



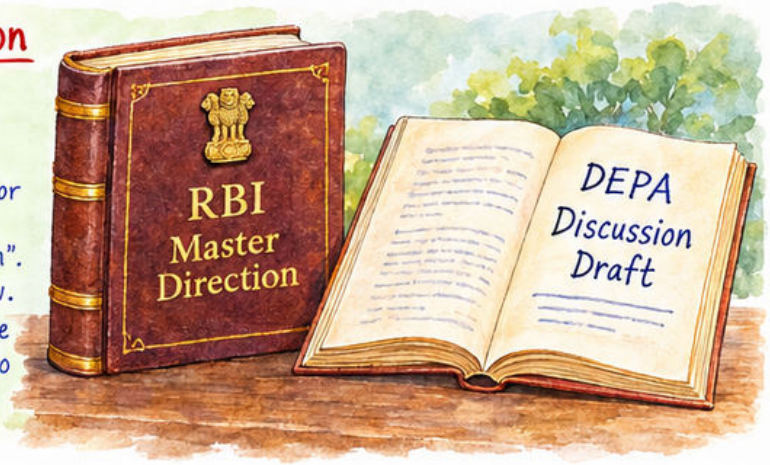
What the intermediary cannot do

An AA carries on no business other than account aggregation and does not support transactions. The customer's financial information is not the AA's property. Information received from providers must not reside with the AA. Sharing financial information is therefore different from transferring money or storing a permanent financial dossier.



DEPA and the legal distinction

DEPA means Data Empowerment and Protection Architecture. NITI Aayog's August 2020 discussion draft sets out consent-based data sharing. Financial-sector consent managers are called Account Aggregators and are "data blind by design". DEPA is a discussion framework, not a law. The RBI Master Direction is binding on the entities it covers. Do not confuse these two kinds of authority.



Sources: Day 30 Source Index | Topic 296

DPI and the G20

A global definition

The G20 New Delhi Leaders' Declaration of 9–10 September 2023 describes digital public infrastructure as an evolving concept and a set of shared digital systems. These systems rest on secure, resilient infrastructure and can use open standards and open-source software. This wording in paragraph 55 is broader than any single Indian app or identity system.



A voluntary framework

Paragraph 56 welcomes the G20 Framework for Systems of Digital Public Infrastructure as a voluntary and suggested framework. It also welcomes India's plan to build and maintain the Global Digital Public Infrastructure Repository, or GDPIR. The repository is a virtual store of DPI that countries share voluntarily; it is not a compulsory international system.



Two distinct initiatives

The One Future Alliance was India's proposed voluntary initiative for capacity building, technical help and funding for DPI in low- and middle-income countries. The Social Impact Fund aims to accelerate DPI adoption in the Global South. At the Virtual G20 Leaders' Summit on 22 November 2023, the Prime Minister announced an initial Indian contribution of US $25 million to this Fund. The Global DPI Repository was declared complete on the same date.



Development role

The Government's 6 March 2026 backgrounder characterises the Declaration as recognising DPI as a development accelerator and records that India contributed the largest number of DPI solutions to the repository. Keep that later description distinct from the Declaration's own definitions and voluntary commitments.

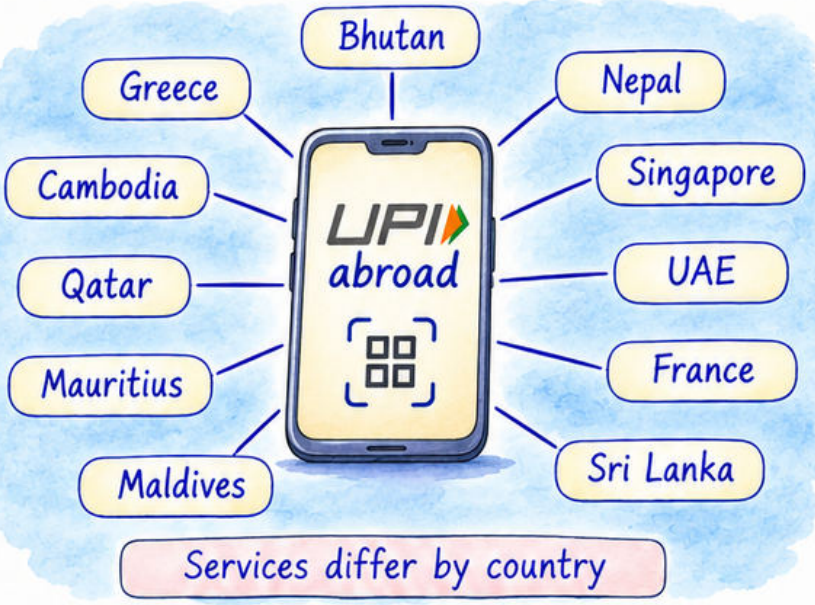


Sources: Day 30 Source Index | Topic 296

India's DPI abroad

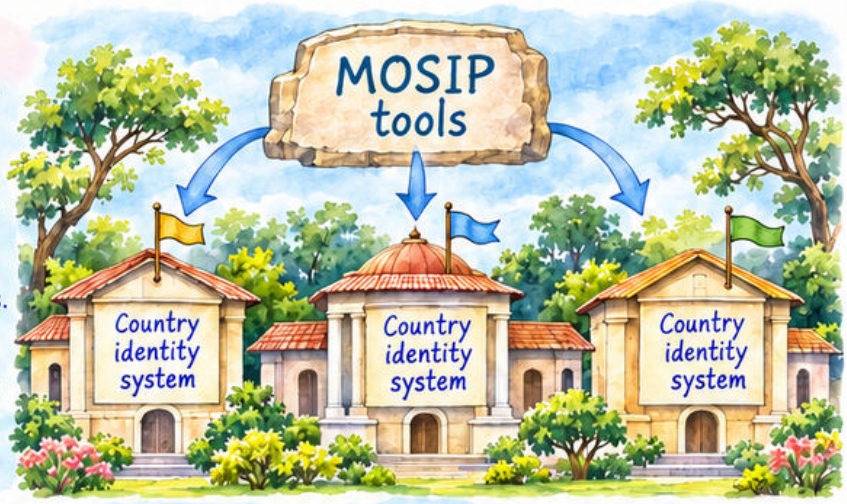
UPI beyond India

UPI abroad means merchant acceptance or cross-border remittances, partly through NPCI International Payments Limited, or NIPL. By 24 August 2026 it was live in eleven foreign countries: Bhutan, Nepal, Singapore, the UAE, France, Sri Lanka, Mauritius, Qatar, Cambodia, Greece and the Maldives, Cambodia and Greece joined in June 2026; the Maldives joined on 30 July 2026. "Live" should not be read as identical services or universal acceptance in every country.



MOSIP is a platform

The Modular Open Source Identity Platform was established in 2018 at the International Institute of Information Technology Bangalore. Its modular, open-source technology lets countries build and own their national identity systems. It is not the export of Indian Aadhaar numbers. On 1 November 2026, MOSIP's site showed 32 country engagements and 14 national rollouts. The March 2026 government description was earlier: more than 25 nations adopting or exploring it.



Agreements and adoption

India had DPI memorandums of understanding and agreements with 24 countries by February 2026, including Armenia, Sierra Leone, Trinidad and Tobago, Kenya, Brazil and Malaysia. India Stack Global showcases Indian DPI and helps partner countries adopt it.



Read the sequence

Identity institutions began in 2009–10. The law, payment launch and consent rules converged in 2016, Judicial limits followed in 2018, while international adoption developed through MOSIP, G20 cooperation and UPI links. Country engagements, completed rollouts and bilateral agreements measure different things; their counts are not interchangeable.



Sources: Day 30 Source Index | Topic 296

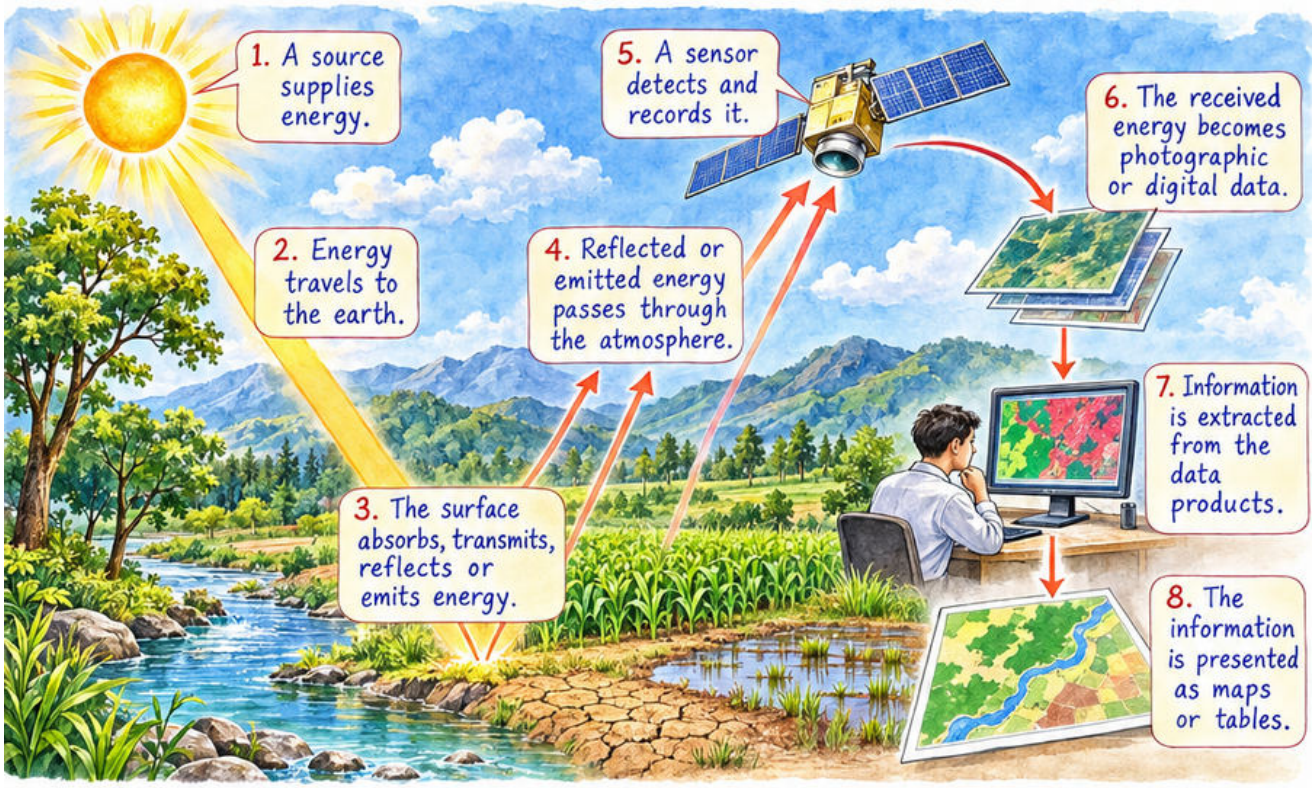
Remote sensing from energy to information

Information without contact

Remote sensing acquires and measures information about objects or phenomena with a sensor that does not physically touch them. For the earth's surface, it uses electromagnetic energy that is reflected or emitted. The Sun is the most important energy source; artificial sources include flashguns and radar beams. Objects also emit their own energy.

The eight-stage journey

1. A source supplies energy.
2. Energy travels to the earth.
3. The surface absorbs, transmits, reflects or emits energy.
4. Reflected or emitted energy passes through the atmosphere.
5. A sensor detects and records it.
6. The received energy becomes photographic or digital data.
7. Information is extracted from the data products.
8. The information is presented as maps or tables.



The sensor's job

A sensor collects electromagnetic radiation and converts it into a signal. Photographic sensors are analogue. Non-photographic sensors build an image bit by bit and are called scanners.



Surfaces leave signatures

Different surfaces reflect and absorb spectral bands in characteristic patterns. Graphs of these spectral signatures help distinguish surfaces, including one crop from another. Healthy vegetation absorbs blue and red light and strongly reflects near infrared because of its layered leaf structure. In a standard false-colour composite, near infrared is displayed in red, so healthy vegetation appears red. Fresh water is dark in red and infrared; turbid water reflects more blue and green and looks lighter. Smooth, dry surfaces reflect more than rough, moist surfaces.



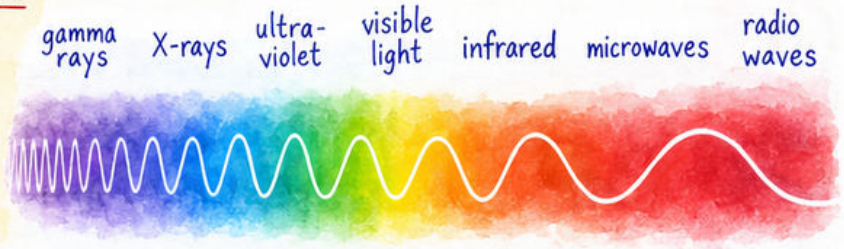
False-colour composite
Near infrared → red

Sources: Day 30 Source Index | Topic 297

Spectrum and atmospheric windows

Which wavelengths are useful

The electromagnetic spectrum runs through gamma rays, X-rays, ultraviolet, visible light, infrared, microwaves and radio waves. Visible, infrared and microwave regions are used in remote sensing.



Atmospheric windows

A window is a spectral region that can pass through the atmosphere. The three main windows are optical, infrared and radio. Transmission depends on clouds, water vapour and trace greenhouse gases, so sensors use wavelengths within suitable windows.



Visible and near infrared

Green light spans 0.5–0.6 micrometres and red 0.6–0.7 micrometres. Turbid water reflects more blue and green light. Near infrared spans 0.7–1.1 micrometres: healthy vegetation reflects strongly, while fresh water absorbs it and looks dark. A plant with more chlorophyll reflects more near-infrared energy than an unhealthy plant in the comparison used here.



Thermal infrared

The 8–15 micrometre region measures energy emitted as heat. It reveals land- and sea-surface temperature changes and distinguishes warmer from cooler clouds. Heat emission is different from reflected sunlight.



Microwave radar bands

X band: 2.4–3.8 cm.
C band: 3.8–7.5 cm.
S band: 7.5–15 cm.
L band: 15–30 cm.

Radar imagery can be acquired by day or night and through cloud, regardless of weather. A longer wavelength, such as L band around 23 cm, penetrates farther through a tree canopy. Do not mix these centimetre radar ranges with the micrometre optical and infrared ranges.



Sources: Day 30 Source Index | Topic 297

Four resolutions and two scanners

Spatial resolution

This is the ability to distinguish closely spaced surfaces, or the ground-cell size represented by one pixel. LISS-IV on Resourcesat-1 resolves 5.8 m at nadir. A smaller ground-cell figure means finer detail, not a poorer image.



Spectral resolution

This describes recording in different bands: how many bands and how narrow they are. LISS-III has four bands, including shortwave infrared at 1.55–1.70 micrometres; LISS-IV has three.



Radiometric resolution

This is sensitivity to small differences in received energy, expressed as grey levels. IRS sensors have levels 0–127: 128 levels = 2^7, or 7 bits. Landsat TM has 0–255: 256 levels = 2^8, or 8 bits. LISS-III transmits 7-bit data. More distinguishable grey levels give finer radiometric resolution.



Temporal resolution

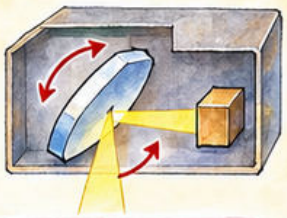
This is the interval before the same area is observed again, not one orbital period. LISS-III revisits in 24 days. AWiFS achieves a five-day revisit over 80% of its covered area.



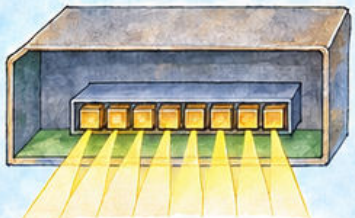
How scanners look

The Instantaneous Field of View, IFOV, describes the scanner's instantaneous view of the ground. Total Field of View, TFOV, is the whole width covered by the oscillating sensor.

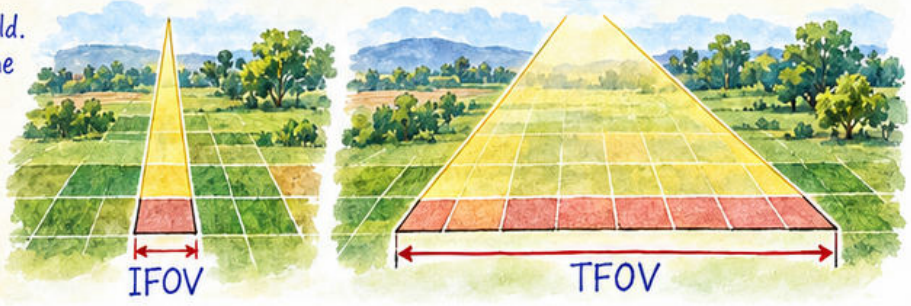
A whiskbroom scanner uses a rotating mirror and a single detector sweeping across the field. A pushbroom scanner uses a line of detectors, each gathering energy from one ground cell. Detector count equals swath width divided by spatial resolution; both distances must use the same unit.



Rotating mirror (whiskbroom)



Detector row (pushbroom)

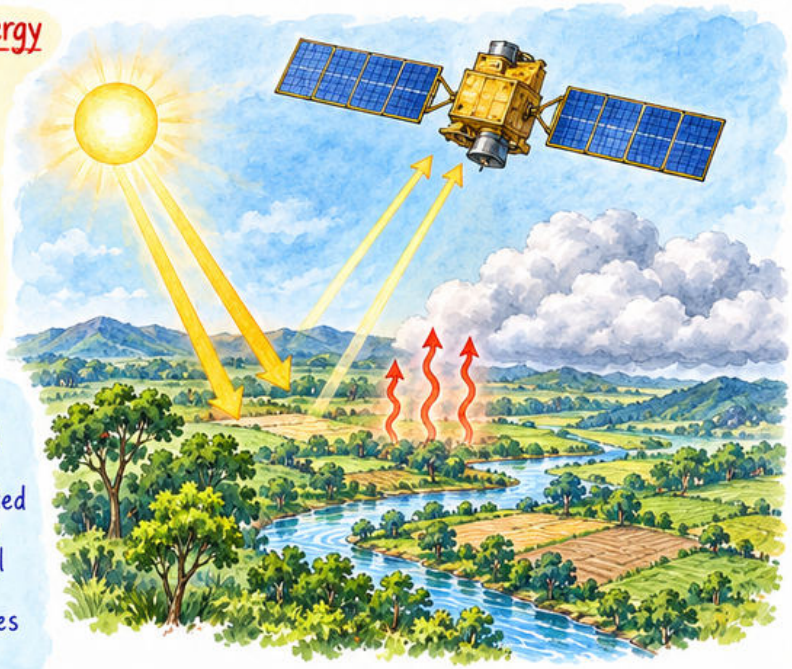


Sources: Day 30 Source Index | Topic 297

Passive and active sensing

Passive sensors receive natural energy

A passive sensor records reflected sunlight or heat emitted by the natural environment. Optical cameras and scanners such as LISS-IV, LISS-III and AWiFS are passive. INSAT-3DS also uses passive visible and infrared observations; its first images included a thermal-infrared band.

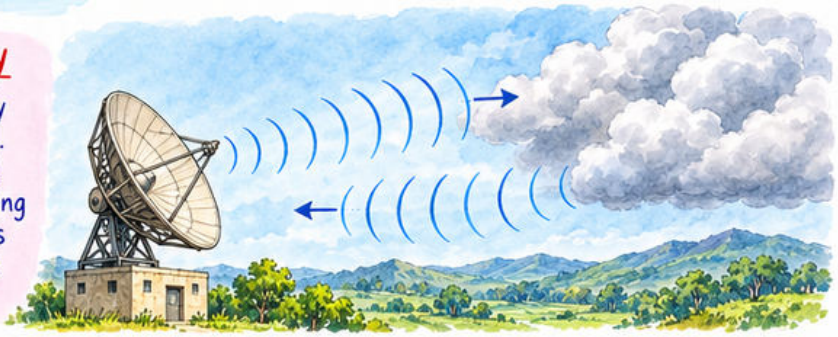


Sunlight, heat and cloud

Sensors using reflected sunlight need the Sun to illuminate the scene. Thermal-infrared sensors record emitted heat and remain passive because they send no energy of their own. Optical imagery cannot reveal land hidden beneath cloud. "Passive" therefore does not mean "every measurement is reflected sunlight".

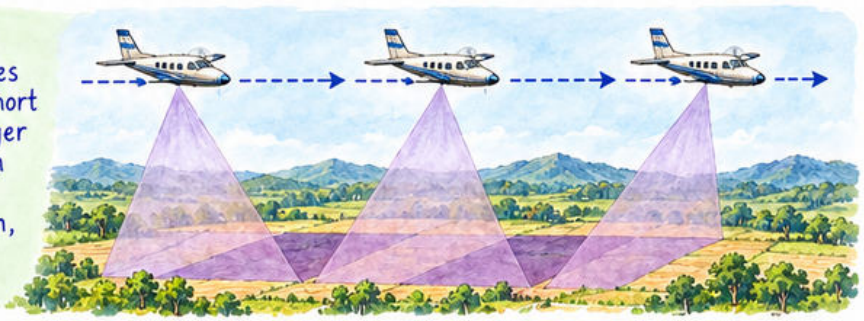
Active sensors supply energy

An active instrument emits energy and measures the returning signal. Radar uses microwave pulses and can image by day or night, including land under cloud. EOS-04 carries C-band synthetic aperture radar; NISAR uses L- and S-band SAR.



How SAR works

Synthetic aperture radar combines successive observations from a short antenna to simulate a much longer antenna. Its active classification comes from sending microwave energy and recording the return, not merely from producing detailed imagery.



How lidar works

Light Detection and Ranging measures distance using pulsed laser light. Topographic lidar typically uses near-infrared laser light for land mapping. Bathymetric lidar uses green light that eeturs water to measure seafloor and riverbed heights. Lidar and radar are both active, but they use different parts of the electromagnetic spectrum. Radar's all-weather advantage should not be transferred indiscriminately to every active sensor.

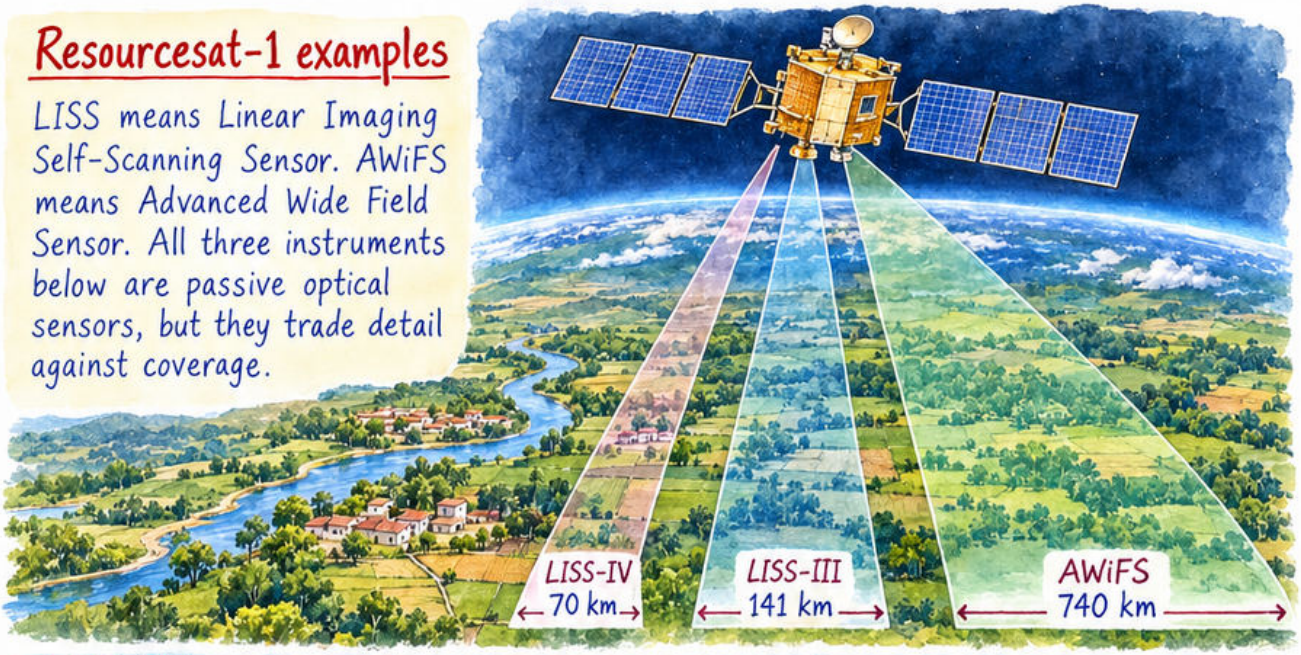


Sources: Day 30 Source Index | Topic 297

Indian optical instruments

Resourcesat-1 examples

LISS means Linear Imaging Self-Scanning Sensor. AWiFS means Advanced Wide Field Sensor. All three instruments below are passive optical sensors, but they trade detail against coverage.



LISS-IV

Spatial resolution is 5.8 m at nadir. Its bands are 0.52–0.59, 0.62–0.68 and 0.77–0.86 micrometres, corresponding to green, red and near infrared. Single-band swath is 70 km. Tilting allows a five-day revisit.



LISS-III

Resolution is 23.5 m. It records the same three bands plus shortwave infrared at 1.55–1.70 micrometres. Swath is 141 km and repeat interval is 24 days. NCERT lists IRS LISS-III as 23 m, while the NRSC Resourcesat-1 specification is 23.5 m. These are source-specific figures, not two different sensors; use 23 m when the question explicitly follows NCERT.



AWiFS

Resolution is 56 m at nadir. Its four bands match LISS-III. A 740 km swath provides a five-day revisit for 80% of the covered area. This broad coverage sacrifices the fine ground detail of LISS-IV.



Related satellites

Resourcesat-2A, launched on 7 December 2016, carries similar cameras with the same stated resolutions: 5.8 m, 23.5 m and 56 m.

INSAT-3DS operates in geostationary orbit for meteorological observation, using a six-channel Imager and nineteen-channel Sounder in the visible and infrared sensing system.



Sources: Day 30 Source Index | Topic 297

Orbits and radar examples

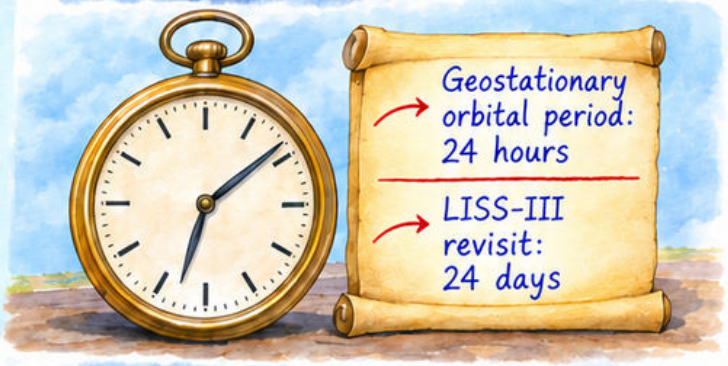
Sun-synchronous observations

The NCERT comparison places sun-synchronous satellites at 700–900 km, covering 81°N to 81°S, with about fourteen orbits daily. It gives fine resolutions from 182 m to 1 m and earth-resource applications. Fourteen daily orbits do not mean fourteen daily observations of one place: LISS-III's revisit is 24 days.



Geostationary observations

At about 36,000 km, a satellite has a 24-hour orbital period and stays over one spot. It repeatedly views roughly one-third of the globe, useful for telecommunications and weather monitoring. The comparison gives coarse resolution of 1 km × 1 km. Frequent observation does not guarantee fine detail.



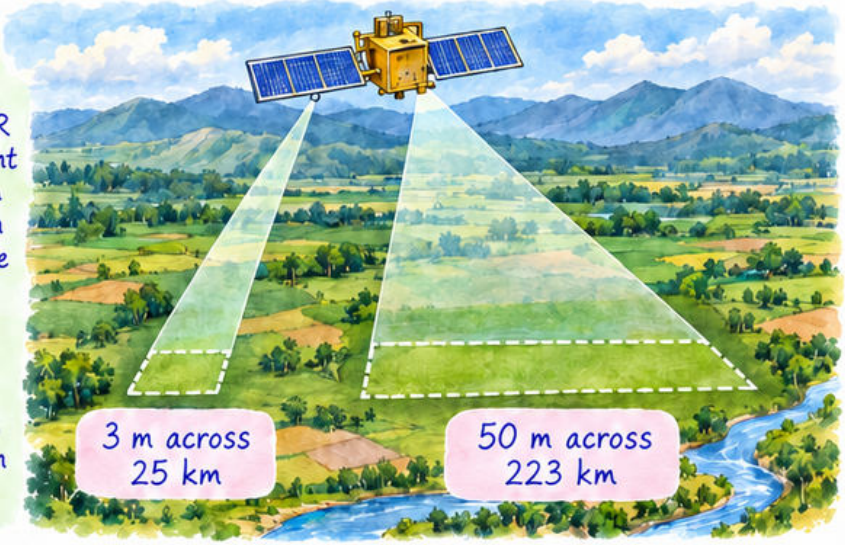
Indian examples

PSLV can carry remote-sensing payloads to sun-synchronous polar orbit: 1,750 kg to 600 km in the stated capability. NavIC provides navigation, not imagery, using geostationary and inclined geosynchronous orbits. INSAT-2A also carried a Very High Resolution Radiometer: 2 km visible and 8 km infrared resolution.



Active radar

EOS-04, also RISAT-1A, follows RISAT-1 of 2012. Its C-band SAR provides all-weather, day-and-night imaging. Modes range from 50 m resolution across a 223 km swath to 3 m across 25 km. NISAR, the NASA–ISRO Synthetic Aperture Radar mission, collects L-band and S-band SAR data. Satellite orbit, sensor type, spatial detail and revisit frequency are distinct properties; read each specification separately.

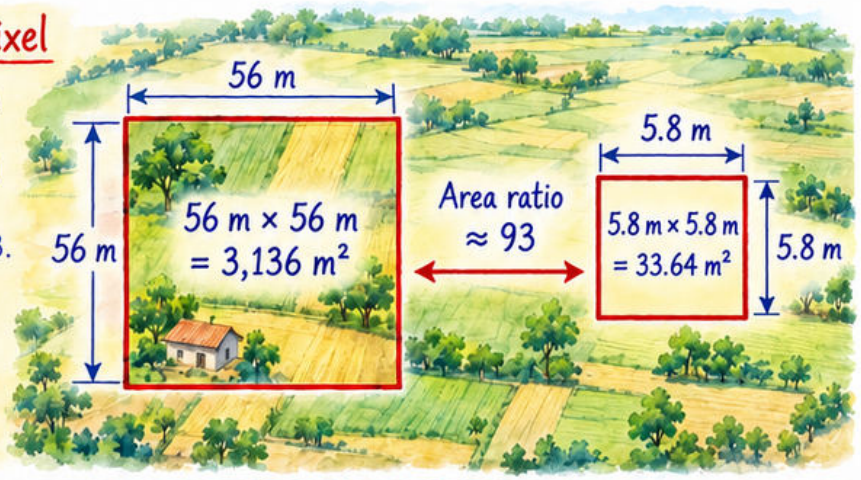


Sources: Day 30 Source Index | Topic 297

Resolution calculations that prevent errors

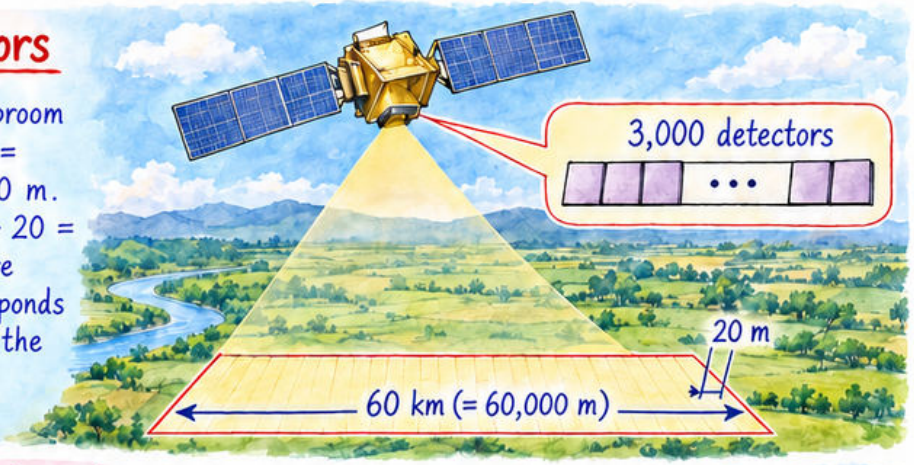
How much land is one pixel

For LISS-IV, a 5.8 m × 5.8 m pixel covers 33.64 m². For AWiFS, a 56 m × 56 m pixel covers 3,136 m². Dividing 3,136 by 33.64 gives about 93. One AWiFS pixel therefore covers roughly 93 LISS-IV pixels' worth of ground. The smaller metre value gives finer spatial detail.



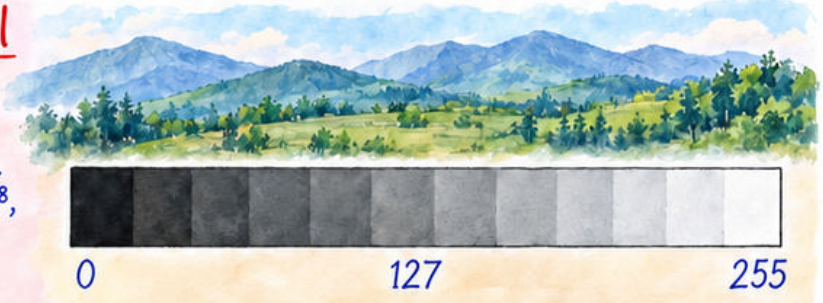
How many detectors

For the SPOT HRV-I pushbroom example, swath = 60 km = 60,000 m. Resolution = 20 m. Detector count = 60,000 ÷ 20 = 3,000. Convert units before dividing; a detector corresponds to one ground cell across the swath.



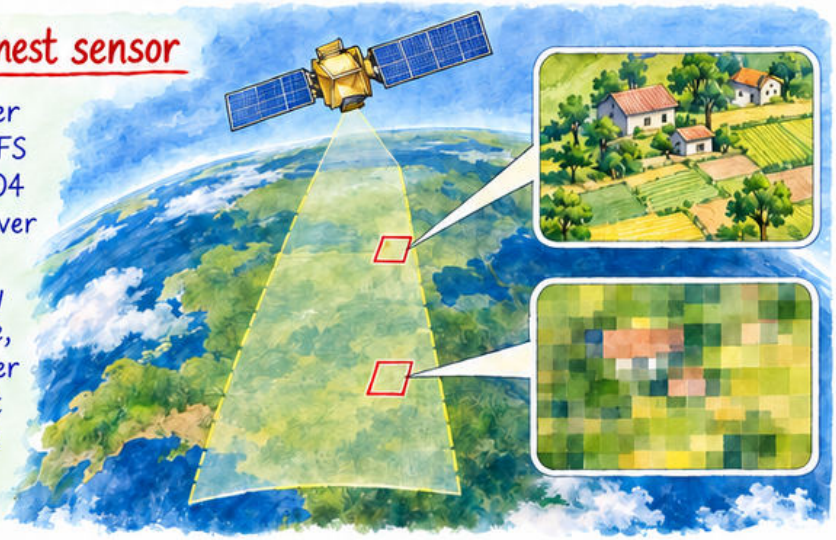
How much energy detail

Levels 0 through 127 include both endpoints, giving 128 levels, not 127. That is 2^7, or seven bits. Levels 0 through 255 give 256 = 2^8, or eight bits. This measures radiometric discrimination, not pixel dimensions.



Why not always use the finest sensor

LISS-IV offers 5.8 m detail over 70 km in single-band mode; AWiFS offers 56 m over 740 km. EOS-04 offers 3 m over 25 km or 50 m over 223 km. A wide swath supports frequent revisits but trades away detail in these examples. Likewise, SPOT HRV-II at 10 m resolves finer ground detail than Landsat TM at 30 m. Choose the resolution that answers the observation task.



Sources: Day 30 Source Index | Topic 297

India's climate commitments

What an NDC is

A nationally determined contribution, NDC, sets a country's climate targets under the Paris Agreement. India's sequence is the first NDC of 2015, its August 2022 update and the NDC for 2031–2035 submitted in April 2026.

These sit beside a long-term net-zero goal for 2070 and a mass movement for LiFE, Lifestyle for Environment.



Paris Agreement recall

The Agreement was adopted in 2015 and entered into force on 4 November 2016. Each Party communicates a new NDC every five years. The first global stocktake was in 2023, with another every five years.

Recall Topic 107.





Delivery and revision

Much of the NDC is delivered through the National Action Plan on Climate Change and its eight missions, covered in Topic 207.

Learn every target with its exact wording, base year, target year, date and officially reported progress. Later topics cover climate-change evidence and causes (586), UN climate conferences (667), and climate impacts (776).



Sources: Day 31 Source Index | Topic 307

India's NDC timeline

First NDC in 2015

India submitted its Intended Nationally Determined Contribution, INDC, to the United Nations Framework Convention on Climate Change, UNFCCC, on 2 October 2015. This became its first NDC under the Paris Agreement: eight goals, including three numerical goals for 2030.



The 2022 update

Cabinet approval came on 3 August 2022; submission to the UNFCCC followed in August. Its title is "India's Updated First Nationally Determined Contribution Under Paris Agreement (2021-2030)". It updates the first NDC; it is not a second NDC.

Only three goals carry "[UPDATED]": LIFE, emissions intensity and installed capacity. No other first-NDC change was proposed, so the carbon-sink target remained unchanged.

The update translated COP26's Panchamrit into enhanced targets.



The 2031–2035 NDC

Cabinet approval was announced on 25 March 2026. The document is dated April 2026; the UNFCCC registry records submission on 24 April 2026.

It contains eight targets: three numerical and five qualitative.



Sources: Day 31 Source Index | Topic 307

Compare the numerical targets

First NDC for 2030

Submitted on 2 October 2015: reduce emissions intensity of GDP by 33–35% from the 2005 level; attain "about 40 per cent" non-fossil fuel-based energy resources in cumulative electric power installed capacity; create an additional forest-and-tree-cover carbon sink of 2.5–3 billion tonnes of CO_2 equivalent.



Emissions intensity of GDP	Non-fossil share of installed capacity	Additional carbon sink
reduce by 33–35% from the 2005 level	about 40 per cent	2.5–3 billion tonnes of CO_2 equivalent

Updated first NDC for 2030

August 2022: emissions intensity reduction rises to 45% from 2005; the installed-capacity share becomes "about 50 percent". The additional carbon-sink target remains unchanged at 2.5–3 billion tonnes of CO_2 equivalent.



Emissions intensity of GDP	Non-fossil share of installed capacity	Additional carbon sink
reduce by 45% from the 2005 level	about 50 percent	2.5–3 billion tonnes of CO_2 equivalent

NDC for 2031–2035

April 2026, targets for 2035: emissions intensity reduction of 47% from 2005; non-fossil share of cumulative electric power installed capacity of "about 60 percent"; forest-and-tree-cover carbon sink of 3.5–4.0 billion tonnes of CO_2 equivalent compared with baseline 2005.



Emissions intensity of GDP	Non-fossil share of installed capacity	Additional carbon sink
reduce by 47% from the 2005 level	about 60 percent	3.5–4.0 billion tonnes of CO_2 equivalent compared with baseline 2005

Sources: Day 31 Source Index | Topic 307

Read the NDC wording carefully

LiFE across the NDCs

The 2015 goal of "a healthy and sustainable way of living" had no LIFE mass movement; LIFE was proposed in 2021. The 2022 update added a mass movement for LIFE, Lifestyle for Environment. The 2035 NDC retains it and names Mission LiFE.



Intensity, not absolute emissions

Emissions intensity means emissions per unit of GDP. Total emissions may still grow while the target is met.

$$\text{Emissions intensity} = \frac{\text{emissions}}{\text{GDP}}$$



Capacity, not generation

The share concerns installed capacity, not electricity generated. All three NDC texts use "about" 40, 50 and 60 per cent and link the goal to "transfer of technology and low-cost international finance".

PIB's 2022 release also uses "about 50 percent"; its 2026 release uses 60 per cent. MNRE, the Ministry of New and Renewable Energy, describes reaching 50 per cent.



Clean electricity share (installed capacity)

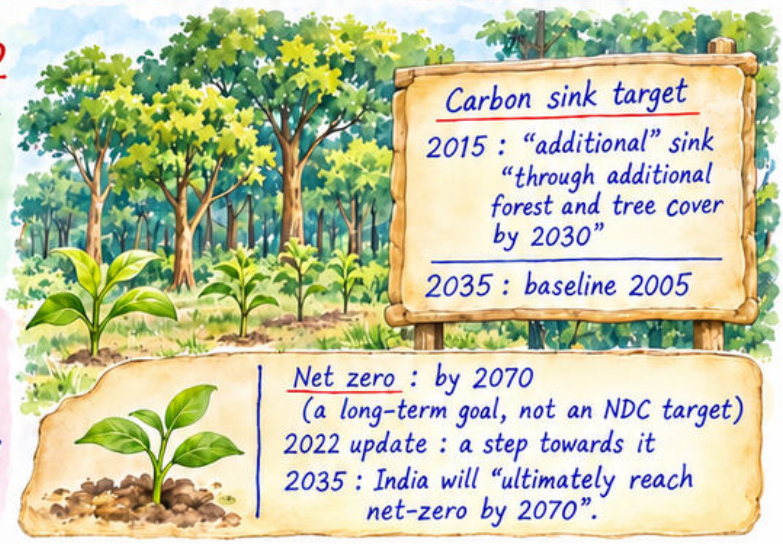
2015 NDC : about 40 per cent
2022 update : about 50 per cent
2035 NDC : about 60 per cent

} Linked to "transfer of technology and low-cost international finance".

Carbon sink and net zero

The 2015 target is an "additional" sink "through additional forest and tree cover by 2030"; the 2035 target uses baseline 2005.

Net zero by 2070 is a long-term goal, not an NDC target. The 2022 update is a step towards it; the 2035 NDC says India will "ultimately reach net-zero by 2070".



Carbon sink target

2015 : "additional" sink "through additional forest and tree cover by 2030"

2035 : baseline 2005

Net zero : by 2070 (a long-term goal, not an NDC target)
2022 update : a step towards it
2035 : India will "ultimately reach net-zero by 2070".

Sources: Day 31 Source Index | Topic 307

Panchamrit and net zero

COP26 commitments

At Glasgow on 1 November 2021, the Prime Minister's National Statement presented the five Panchamrit commitments:

1. Non-fossil energy capacity of 500 GW by 2030.
2. 50% of energy requirements from renewable energy by 2030.
3. Reduce total projected carbon emissions by one billion tonnes from then until 2030.
4. Cut the economy's carbon intensity by 2030.
5. Net zero by 2070.

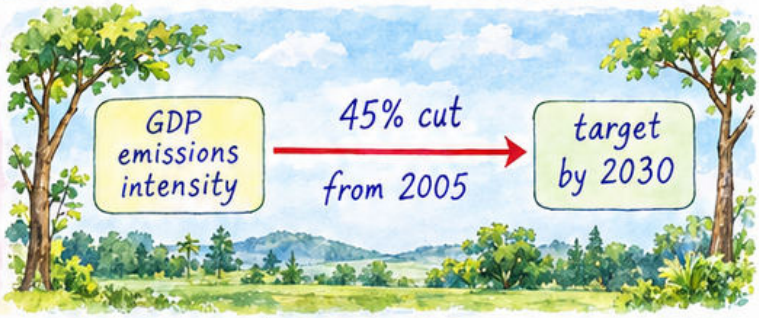


Panchamrit: targets and qualifications

Non-fossil energy capacity	500 GW by 2030
Renewable energy share	50% of energy requirements by 2030
Projected emissions	Reduce by one billion tonnes from then until 2030
Carbon intensity	Cut by 2030
Net zero	by 2070

The 45 per cent wording

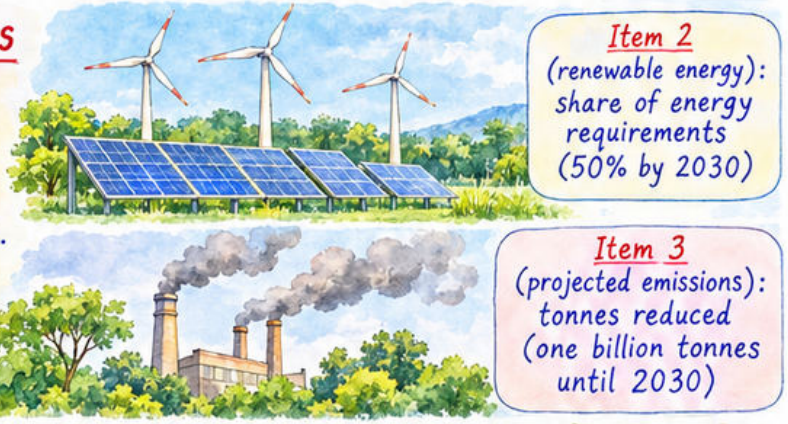
The 2022 NDC fixes item 4 as a 45% cut in GDP emissions intensity from 2005. PIB's English speech text says "by less than 45 percent"; remember the NDC's 45% cut, not "less than 45 per cent".



Do not equate the measures

Panchamrit item 2 concerns renewable energy meeting energy requirements. The NDC concerns installed electric power capacity from all non-fossil sources.

Item 3 measures tonnes reduced against projected emissions; NDC emissions targets measure intensity.



LIFE proposal

The same speech proposed LIFE, Lifestyle for Environment, described as a "One-Word Movement".



Sources: Day 31 Source Index | Topic 307

The long-term climate strategy

Paris Agreement basis

Article 4.19 asks Parties to "strive to formulate and communicate long-term low greenhouse gas emission development strategies".



India's submission

India submitted "India's Long-Term Low-Carbon Development Strategy" to the UNFCCC on 14 November 2022 during COP27. Recall Topic 107.



The document uses LT-LEDS; books expand this as Long-Term Low-Emission Development Strategy. India "will strive towards net-zero by 2070 through low carbon development in accordance with national circumstances".

Climate target
Net-zero by 2070

- Target: net-zero
- Target year: 2070
- Qualification; through low carbon development in accordance with national circumstances

Seven key transitions

Electricity systems; transport; urban design and buildings; industry; carbon dioxide removal; forest and vegetative cover; and the economic and financial side.



The strategy also has a section on Mission LiFE.



Sources: Day 31 Source Index | Topic 307

Reported climate progress

BUR-4 and the first goals

The Fourth Biennial Update Report was submitted on 30 December 2024: GDP emissions intensity fell 36% during 2005–2020. The 2035 NDC and PIB's 25 March 2026 release repeat this. The latter reports the first intensity target met 11 years early and the "about 40%" capacity target 9 years early.

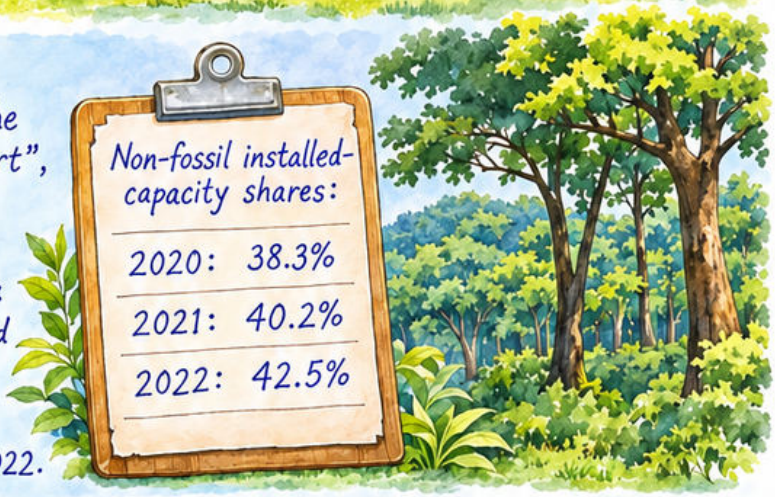


BTR1

Submitted on 30 April 2026 as the "2024 Biennial Transparency Report", BTR1 records a 37.38% intensity reduction by 2022 from 2005.

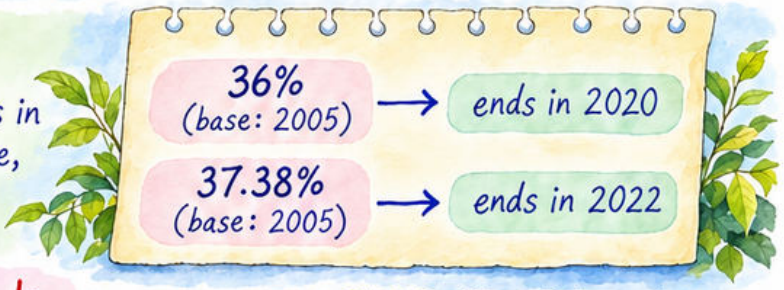
Non-fossil installed-capacity shares: 38.3% in 2020, 40.2% in 2021 and 42.5% in 2022.

Additional carbon sink: 2.44 billion tonnes CO_2 equivalent during 2005–2022.



Different end years

36% ends in 2020; 37.38% ends in 2022. Both use 2005 as the base, so they do not conflict.



Capacity and carbon sink

MNRE recorded 242.78 GW non-fossil out of 484.82 GW, or 50.08%, on 30 June 2025, five years early (release: 14 July 2025). The 2035 NDC records 52.57% on 28 February 2026.

PIB's 25 March 2026 release gives a sink of 2.29 billion tonnes by 2021; BTR1 gives 2.44 billion tonnes during 2005–2022.



Sources: Day 31 Source Index | Topic 307

Mission LiFE and green credits

Launch and idea

The Prime Minister launched Mission LiFE on 20 October 2022 at the Statue of Unity, Ekta Nagar, Kevadia, Gujarat, with UN Secretary-General António Guterres present.

Its message: "Mindful and Deliberate Utilisation, instead of Mindless and Destructive Consumption." It seeks sustainable lifestyles through P3: Pro Planet People.



Three prongs

Demand: change daily individual habits.

Supply: make industry and markets respond.

Policy: shape government and industrial policy.



Seven action themes

Save energy; save water; reject single-use plastic; adopt sustainable food systems; reduce waste; adopt healthy lifestyles; reduce e-waste.



MoEFCC, the Ministry of Environment, Forest and Climate Change, lists 75 individual actions; the list is non-exhaustive.

One portal heading says "Adapt Sustainable Life Styles", whereas its banner and MoEFCC say "Adopt Sustainable Food Systems".

Green Credit Programme

Green Credit Rules, 2023 were notified on 12 October 2023 under the Environment (Protection) Act, 1986. Their purpose is to "incentivise environmental positive actions through market-based mechanism".

Carbon markets: Topic 457.



Sources: Day 31 Source Index | Topic 307

The 2030 targets and progress

First intensity target

First NDC, 2 October 2015: reduce GDP emissions intensity 33–35% from 2005 by 2030. Met: a 36% reduction during 2005–2020, reported as 11 years early in BUR-4 (30 December 2024) and PIB (25 March 2026).



First capacity target

First NDC, 2015: "about 40%" non-fossil installed capacity by 2030. Met 9 years early; 40.2% in 2021 (BTR1; PIB, 25 March 2026).



Carbon sink

First NDC, 2015, retained August 2022: additional 2.5–3 billion tonnes CO_2 equivalent by 2030. Still below the range: 2.29 billion tonnes by 2021; 2.44 billion tonnes during 2005–2022 (PIB, 25 March 2026; BTR1).



Updated intensity target

August 2022 update: reduce intensity 45% from 2005 by 2030. In progress: 37.38% by 2022 (BTR1, 30 April 2026).



Updated capacity target

August 2022 update: "about 50%" non-fossil installed capacity by 2030. Reached: 50.08% on 30 June 2025 and 52.57% on 28 February 2026 (MNRE, 14 July 2025; 2031–2035 NDC).



Status date: 1 November 2026.

Sources: Day 31 Source Index | Topic 307

New targets for 2035

The new NDC

India submitted its NDC for 2031–2035 on 24 April 2026. These targets are newly set, with achievement due in 2035.



Emissions intensity

Cut GDP emissions intensity by 47% from the 2005 base.

The latest reported reduction is 37.38% by 2022, in BTR1. This is a progress measure, not proof that the new target has been achieved.

GDP emissions intensity (reduction from 2005 base)

Progress	Target
37.38% by 2022 (in BTR1)	47% by 2035



Non-fossil installed capacity

Attain "about 60%" non-fossil share in installed electric power capacity.

The NDC records progress of 52.57% on 28 February 2026. Status date for this comparison: 1 November 2026.

Non-fossil share in installed electric power capacity

Progress	Target
52.57% on 28 February 2026	about 60% by 2035

Status date for this comparison: 1 November 2026.



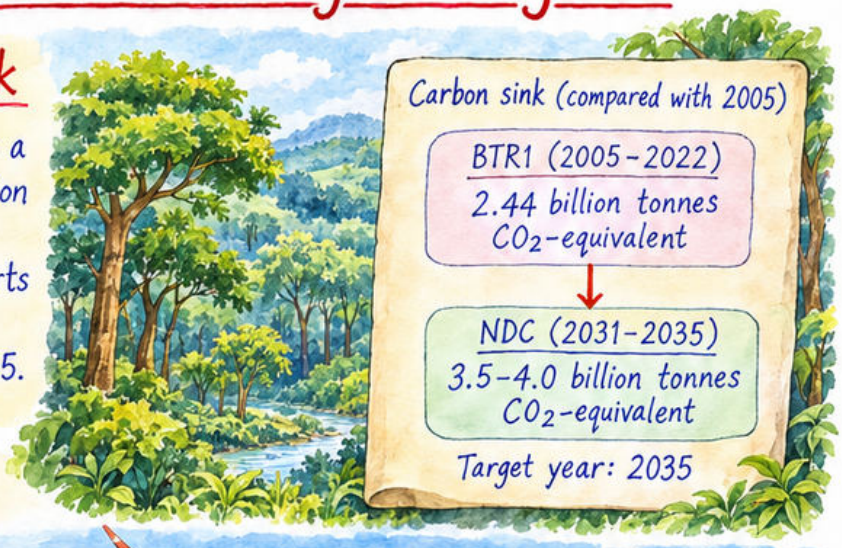


Sources: Day 31 Source Index | Topic 307

Carbon sink and long-term goals

The 2035 carbon sink

The NDC for 2031–2035 sets a newly announced 3.5–4.0 billion tonnes CO_2-equivalent sink compared with 2005. BTR1 reports 2.44 billion tonnes during 2005–2022. Target year: 2035.



Net zero in 2070

The long-term goal was in Panchamrit at COP26 on 1 November 2021, and the strategy of 14 November 2022. It is restated in the NDC for 2031–2035.



LIFE mass movement

Added in the August 2022 update, with no target year. Mission LiFE launched on 20 October 2022 and is named again in the NDC for 2031–2035.



Read the progress correctly

Status date: 1 November 2026. Every intensity target and intensity-progress figure uses 2005 as its base.

Among 2030 targets, the first NDC's intensity and capacity goals and the 2022 capacity goal are reported met. The 45% intensity cut and 2030 carbon-sink target are still being worked towards in the latest official figures.



Sources: Day 31 Source Index | Topic 307

Climate target exam traps

Intensity is not total emissions

NDC targets cut emissions per unit of GDP. Total emissions can still rise while the target is met.

The Panchamrit commitment expressed in tonnes is a cut against projected emissions, not against a past year's emissions.



$$\text{Emissions intensity} = \frac{\text{Total emissions (tonnes)}}{\text{GDP (value)}}$$

NDC target: reduce emissions per unit of GDP (intensity), not total emissions.

Panchamrit commitment

Projected emissions (tonnes) → a cut against projected emissions → Lower emissions (tonnes)

Capacity is not energy or generation

The NDC counts installed electric power capacity from all non-fossil sources, including large hydro and nuclear. Panchamrit's 50% concerns energy requirements met by renewables.

Crossing the capacity mark does not mean half of India's electricity is generated from non-fossil sources.



Capacity
Installed electric power capacity (from all non-fossil sources, including large hydro and nuclear).

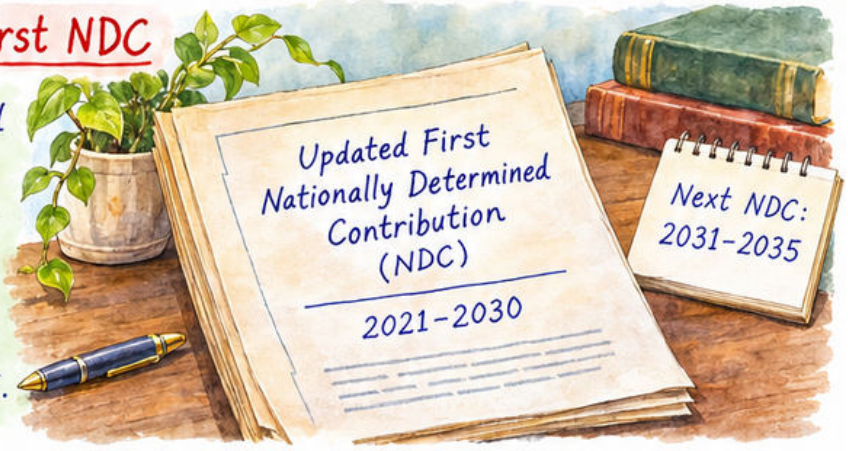
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Generation
Actual electricity generated or energy produced.

2022 is an updated first NDC

The document is the "Updated First Nationally Determined Contribution", for 2021–2030. It changes only the goals marked updated.

It is not India's second NDC; the next NDC covers 2031–2035.



Sources: Day 31 Source Index | Topic 307

CSIR: organisation and purpose

The Council of Scientific and Industrial Research (CSIR) is a registered society under the Department of Scientific and Industrial Research (DSIR), Ministry of Science and Technology. It operates a national network of research laboratories.

Key institutional details

- **Name:** Council of Scientific and Industrial Research (CSIR)
- **Legal status:** Registered society
- **Under:** Department of Scientific and Industrial Research (DSIR)
- **Ministry:** Ministry of Science and Technology
- **Network:** Runs a network of national laboratories spread across India

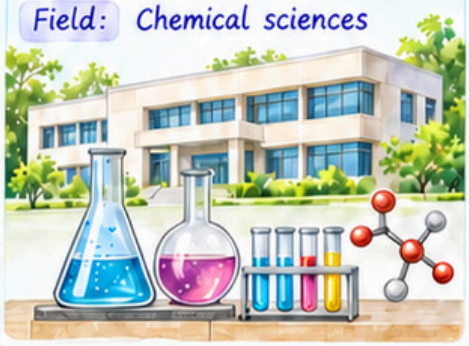


CSIR at a glance

- Origin and legal status
- Leadership
- Laboratories and cities
- Research fields
- Missions
- Awards

Network of national laboratories (illustrative)

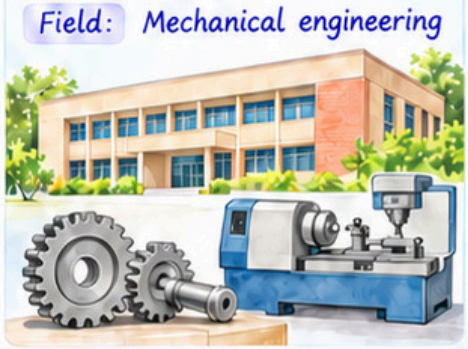
Laboratory: CSIR-NCL
City: Pune
Field: Chemical sciences



Laboratory: CSIR-IITR
City: Lucknow
Field: Toxicology



Laboratory: CSIR-CMERI
City: Durgapur
Field: Mechanical engineering



Missions



Awards



Illustrations are schematic

2.1 What CSIR is

Point	Fact (as on 7 November 2026)
Full name	Council of Scientific and Industrial Research
Origin	Registered as a society on 12 March 1942; the Government Resolution on CSIR is dated 26 September 1942
Legal status	A society registered under the Societies Registration Act (XXI of 1860)
President	The Prime Minister, ex officio (Shri Narendra Modi)
Vice-President	The Minister in charge of the ministry or department that deals with CSIR, ex officio (Dr Jitendra Singh, Minister of State for Science and Technology and Earth Sciences)
Director-General	The principal executive officer of the society; Dr (Smt) N. Kalaiselvi, Director-General, CSIR and Secretary, DSIR
Parent department	DSIR, Ministry of Science and Technology
Headquarters	Anusandhan Bhawan, 2 Rafi Ahmed Kidwai Marg, New Delhi
Network	37 national laboratories, 39 outreach centres, 1 innovation complex and 3 units with pan-India presence

- "Ex officio" means by virtue of the office: whoever holds the office holds the CSIR post.

- CSIR is under DSIR, not the Department of Science and Technology (DST).



President
(The Prime Minister)
(Shri Narendra Modi)

↓

Vice-President
(The Minister in charge of the ministry or department that deals with CSIR)
(Dr Jitendra Singh, Minister of State for Science and Technology and Earth Sciences)

↓

Director-General
(The principal executive officer of the society)
(Dr (Smt) N. Kalaiselvi)



37	39	1	3
national laboratories	outreach centres	innovation complex	units with pan-India presence

Illustrations are schematic

2.2 Origin and governance

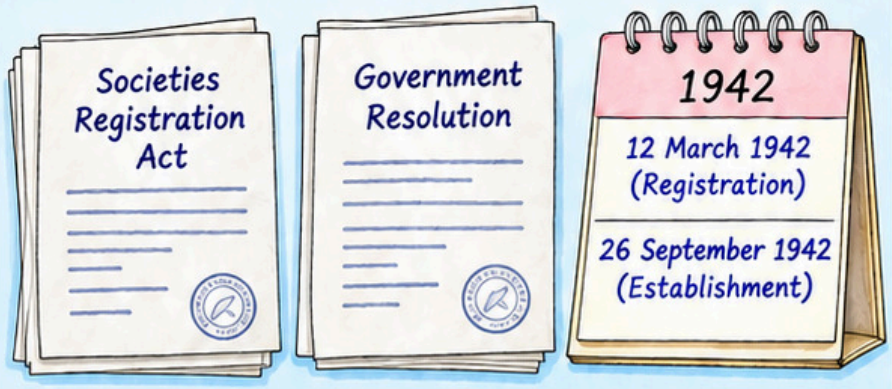
1 April 1940: Board of Scientific and Industrial Research (BSIR) created; Shanti Swarup Bhatnagar appointed Director. He became CSIR's founder Director.



12 March 1942: CSIR registered under the Societies Registration Act.

26 September 1942: Government Resolution establishing CSIR.

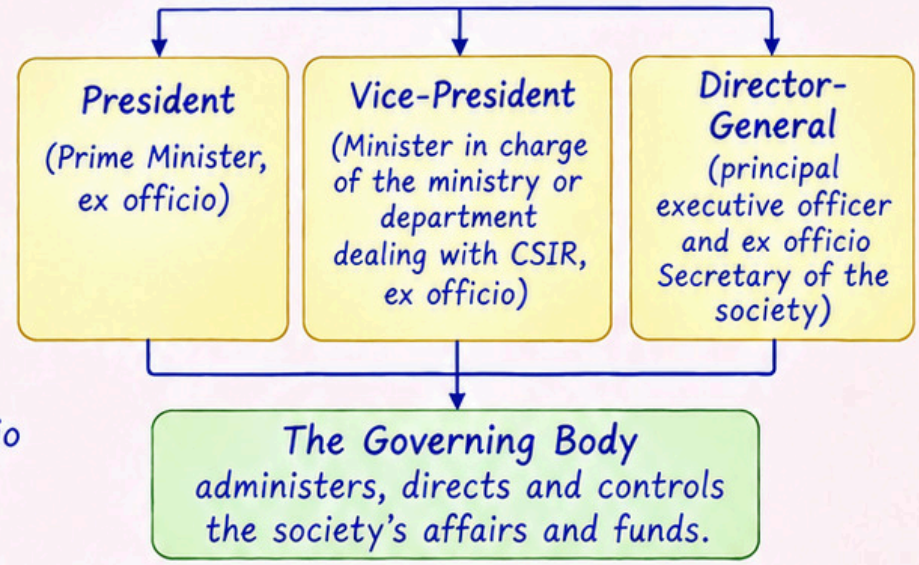
Registration and establishment are distinct dates.



President: Prime Minister, ex officio.

Vice-President: Minister in charge of the ministry or department dealing with CSIR, ex officio.

Director-General: principal executive officer and ex officio Secretary of the society.



N. Kalaiselvi became Director-General in August 2022. As on 7 November 2026, she is Director-General, CSIR and Secretary, DSIR.

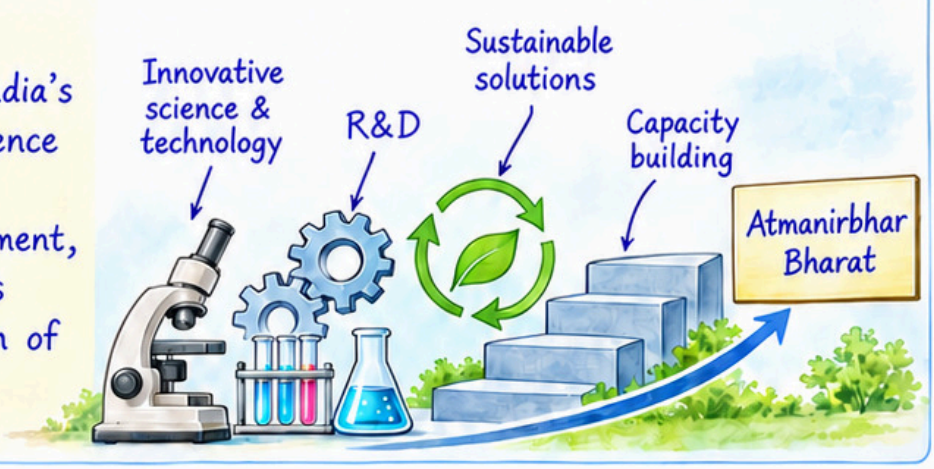


Illustrations are schematic

Vision and mission

Vision:

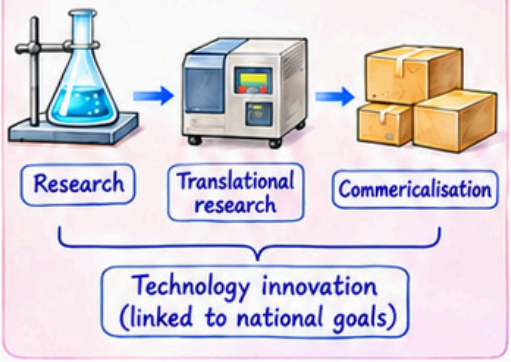
to raise the quality of life of India's citizens through innovative science and technology and globally competitive research and development, by building sustainable solutions and capacity to fulfil the dream of Atmanirbhar Bharat.



Mission:

thirteen points. Among them:

- technology innovation, translational research and commercialisation linked to national goals;



- design and development of small and medium civil aircraft;



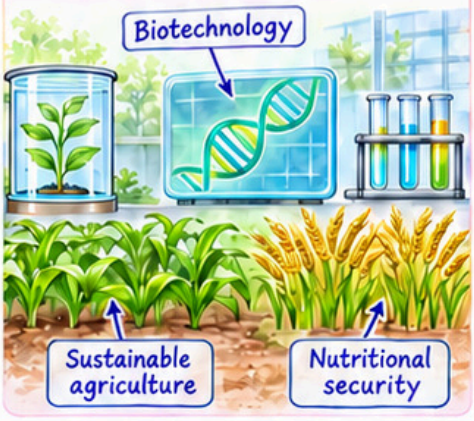
- scalable green energy technologies;



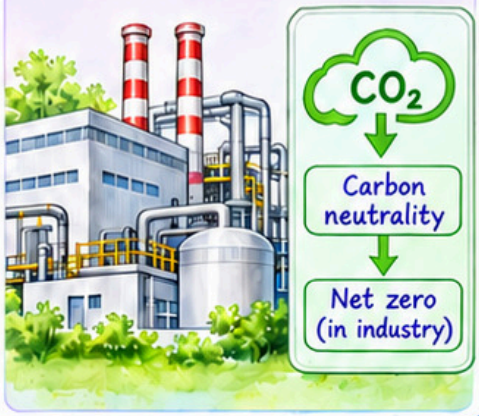
- globally benchmarked sustainable chemical processes that reduce the trade deficit;



- sustainable agriculture and nutritional security through biotechnology;



- technologies for carbon neutrality and net zero in industry.



Illustrations are schematic

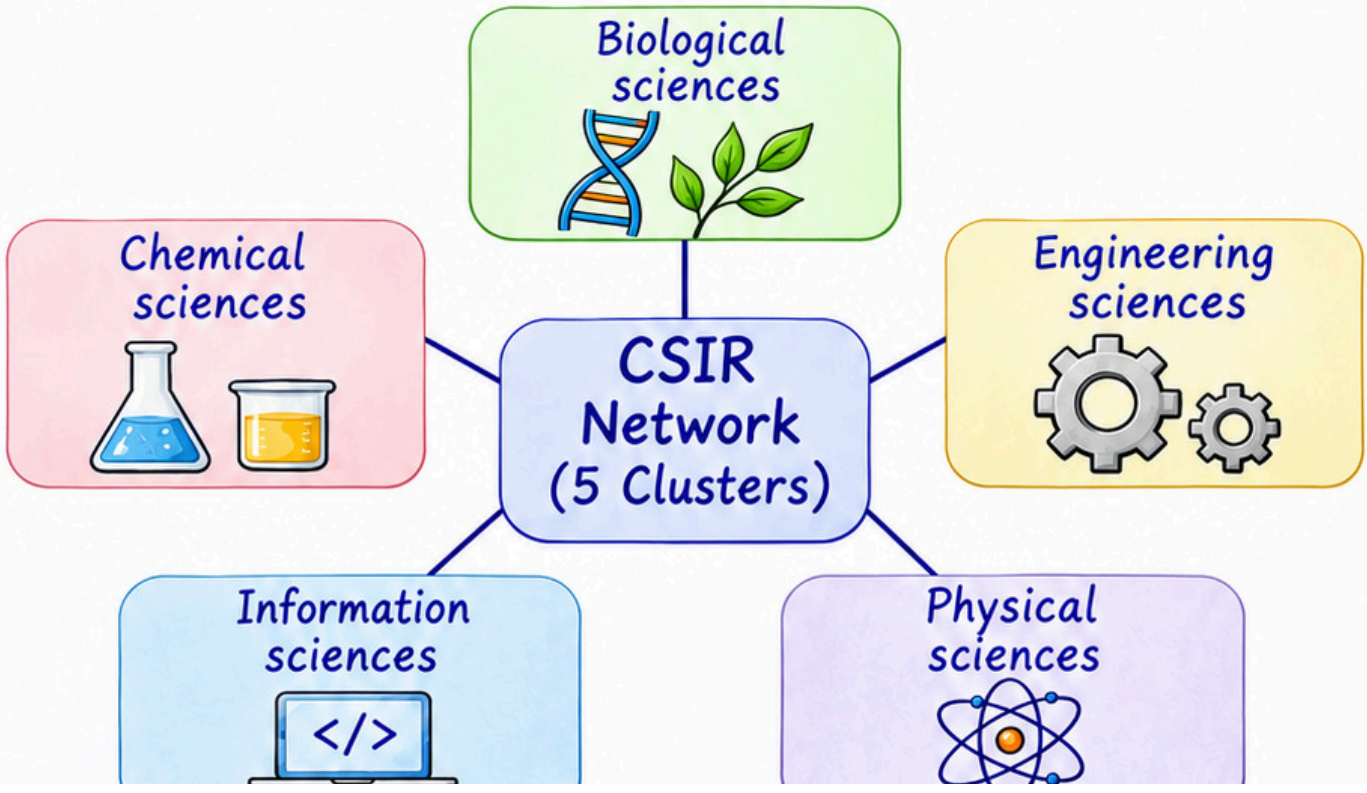
2.4 The size of the network (as on 7 November 2026)

- As on 7 November 2026: 37 national laboratories, 39 outreach centres, 1 innovation complex and 3 units.
- CSIR-Innovation Complex is in Mumbai.
- AcSIR, Ghaziabad; TKDL, New Delhi; and URDIP, Pune are other bodies/units, not members of the 37-laboratory count.



National laboratories	= 37
Outreach centres	= 39
Innovation complex	= 1
Units	= three

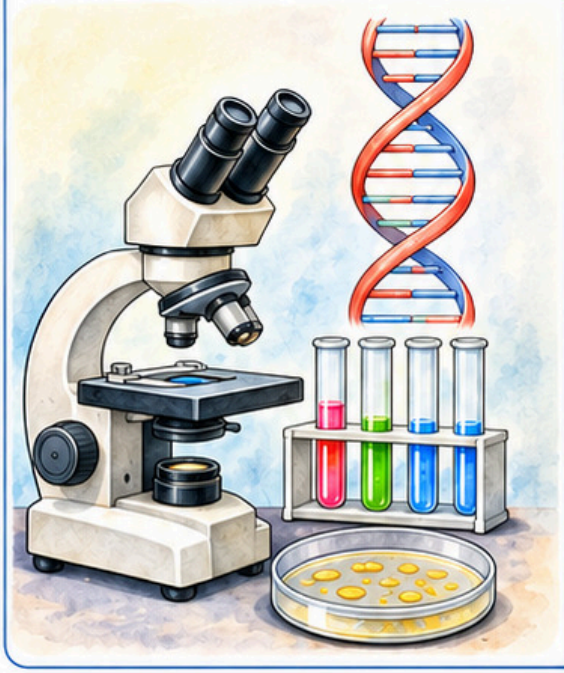
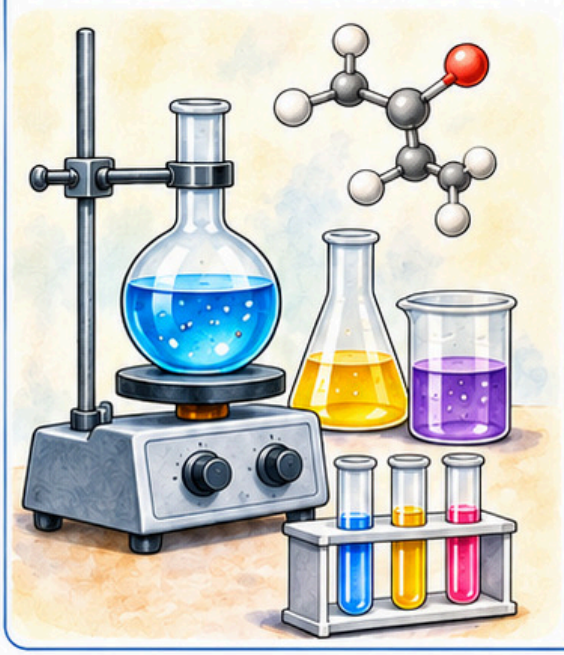
Five clusters: biological sciences, chemical sciences, engineering sciences, information sciences and physical sciences.



Illustrations are schematic

2.5 The laboratories by field

The 37 laboratories are grouped into five scientific clusters. AcSIR, TKDL and URDIP are not included in this laboratory count.

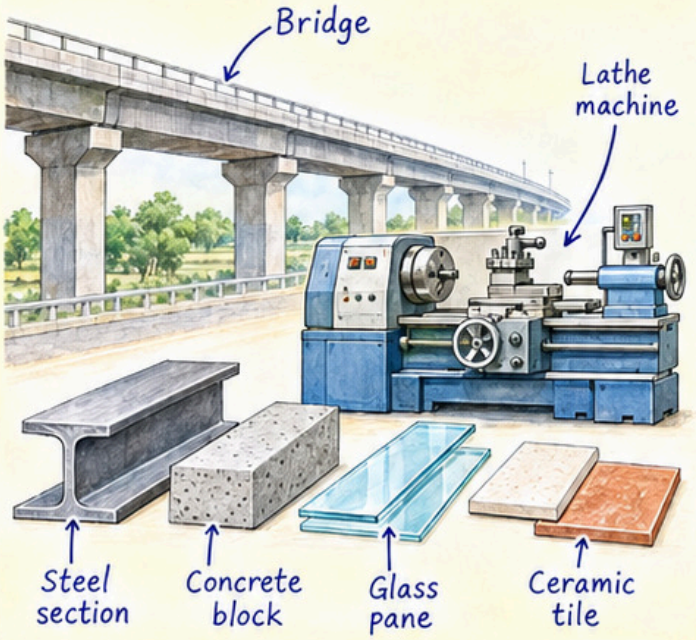
CSIR cluster (number of laboratories)	Laboratories and their cities
Biological sciences (11) 	• Centre for Cellular and Molecular Biology (CCMB), Hyderabad; • Central Drug Research Institute (CDRI), Lucknow; • Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow; • Central Food Technological Research Institute (CFTRI), Mysuru; • Institute of Genomics and Integrative Biology (IGIB), Delhi; • Institute of Himalayan Bioresource Technology (IHBT), Palampur; • Indian Institute of Chemical Biology (IICB), Kolkata; • Indian Institute of Integrative Medicine (IIIM), Jammu; • Institute of Microbial Technology (IMTECH), Chandigarh; • Indian Institute of Toxicology Research (IITR), Lucknow; • National Botanical Research Institute (NBRI), Lucknow.
Chemical sciences (9) 	• Central Electrochemical Research Institute (CECRI), Karaikudi; • Central Leather Research Institute (CLRI), Chennai; • Central Institute of Mining and Fuel Research (CIMFR), Dhanbad; • Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar; • Indian Institute of Chemical Technology (IICT), Hyderabad; • Indian Institute of Petroleum (IIP), Dehradun; • National Chemical Laboratory (NCL), Pune; • North-East Institute of Science and Technology (NEIST), Jorhat; • National Institute for Interdisciplinary Science and Technology (NIIST), Thiruvananthapuram.

Illustrations are schematic

2.5 The laboratories by field (2/2)

CSIR cluster (number of laboratories)	Laboratories and their cities

Engineering sciences (10)



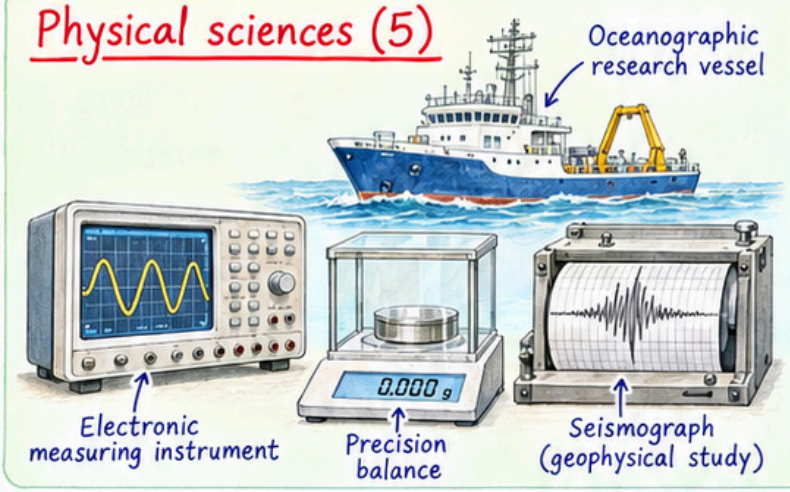
- Advanced Materials and Processes Research Institute (AMPRI), Bhopal;
- Central Building Research Institute (CBRI), Roorkee;
- Central Glass and Ceramic Research Institute (CGCRI), Kolkata;
- Central Mechanical Engineering Research Institute (CMERI), Durgapur;
- Central Road Research Institute (CRRI), New Delhi;
- Institute of Minerals and Materials Technology (IMMT), Bhubaneswar;
- National Aerospace Laboratories (NAL), Bengaluru;
- National Environmental Engineering Research Institute (NEERI), Nagpur;
- National Metallurgical Laboratory (NML), Jamshedpur;
- Structural Engineering Research Centre (SERC), Chennai

Information sciences (2)



- National Institute of Science Communication and Policy Research (NISCPR), New Delhi;
- National Institute of Data Science and Artificial Intelligence (formerly CSIR-4PI), Bengaluru

Physical sciences (5)



- Central Electronics Engineering Research Institute (CEERI), Pilani;
- Central Scientific Instruments Organisation (CSIO), Chandigarh;
- National Geophysical Research Institute (NGRI), Hyderabad;
- National Institute of Oceanography (NIO), Goa;
- National Physical Laboratory (NPL), New Delhi

Illustrations are schematic

Laboratory–city pairs

Several laboratories in one city: Hyderabad has three (CCMB, IICT, NGRI). Lucknow has four (CDRI, CIMAP, NBRI, IITR). Chandigarh has two: CSIO, the instruments laboratory, and IMTECH, the microbial technology laboratory. Chennai has two (CLRI and SERC), Kolkata two (IICB and CGCRI), and New Delhi three (NPL, CRRI and NISCPR).

Mining and mechanical engineering:

the mining and fuel laboratory (CIMFR) is at Dhanbad; the mechanical engineering laboratory (CMERI) is at Durgapur; the metallurgy laboratory (NML) is at Jamshedpur.



NPL, New Delhi:

is the National Metrology Institute (NMI) of India. Its mandate is to develop measurement and calibration standards that are internationally accepted. CSIR-NPL maintains Indian Standard Time (IST).







Illustrations are schematic

2.7 Andhra Pradesh and Hyderabad

Institutional comparison

CSIR laboratories in Hyderabad

CCMB (cellular and molecular biology)
IICT (chemical technology)
NGRI (geophysics)

Hyderabad is in Telangana.

DRDO laboratories in Hyderabad

DRDL, RCI, ASL and DMRL.

These belong to the Ministry of Defence, not to CSIR.

Andhra Pradesh

None of the 37 laboratories in the CSIR network is located in Andhra Pradesh (as on 7 November 2026).

2.8 Missions and achievements

Mission or achievement refers to a focused government or scientific initiative that aims to promote a specific activity, expand its scale and create wider benefits, such as in agriculture and aroma crops.

Key takeaways:

- Aroma Mission has been implemented in two phases.
- It promotes cultivation of aromatic plants, builds skilled human resources and supports farming families.
- Lavender in Jammu and Kashmir has expanded with planting support and distillation units.
- Bhaderwah is recognised as the Lavender capital of India.

Aroma and lavender value chain (illustration)



Mission or achievement	What it is	Status date
Aroma Mission, Phase I	Launched by the Union Ministry of Science and Technology. In Phase I, CSIR helped cultivation on 6,000 hectares, covered 46 Aspirational districts and trained more than 44,000 persons	As of 16 January 2022
Aroma Mission, Phase II	Launched after Phase I. It proposed to engage over 45,000 skilled human resources and benefit more than 75,000 farming families. CSIR-IHBT, CSIR-CIMAP, CSIR-NBRI and CSIR-NEIST take part in Phase II along with CSIR-IIIM	As of 16 January 2022
Lavender in Jammu and Kashmir	CSIR-IIIM, Jammu, introduced lavender (its variety RRL-12), gave more than 30 lakh free lavender plants and installed 50 distillation units (45 fixed and 5 mobile). More than 2,500 farmers grow lavender in Jammu and Kashmir. This is known as the "Purple Revolution"	As of 4 June 2023
Bhaderwah	Bhaderwah is known as the Lavender capital of India. Lavender oil output there rose from 300 litres in 2019 to 1,500 litres in 2022	As of 4 June 2023

Illustrations are schematic

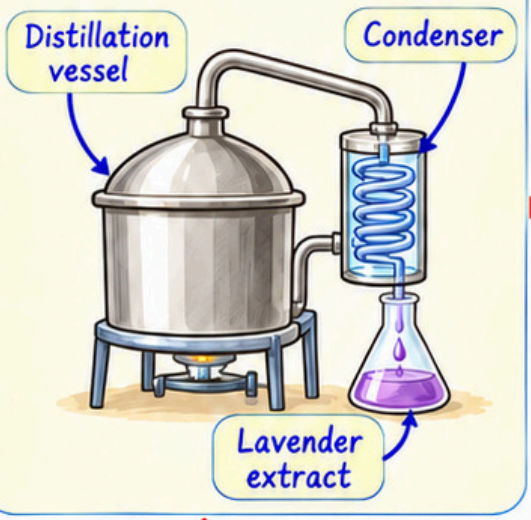
2.8 Missions and achievements

Mission or achievement	What it is	Status date
Rural development award	CSIR-IIIM received the CSIR award for S&T innovations for rural development (CAIRD-2020) for its lavender work	As of 4 June 2023

Lavender cultivation



Distillation unit



Lavender oil





Higher income for small and marginal farmers



Agriculture-based start-ups

- The Aroma Mission is a flagship project of CSIR under which lavender cultivation is promoted. Its aim is to raise the income of small and marginal farmers and to develop agriculture-based start-ups.

Illustrations are schematic

Science awards

The Shanti Swarup Bhatnagar Prize is named after CSIR's founder Director. It was first awarded in 1958 and covered seven fields of science.

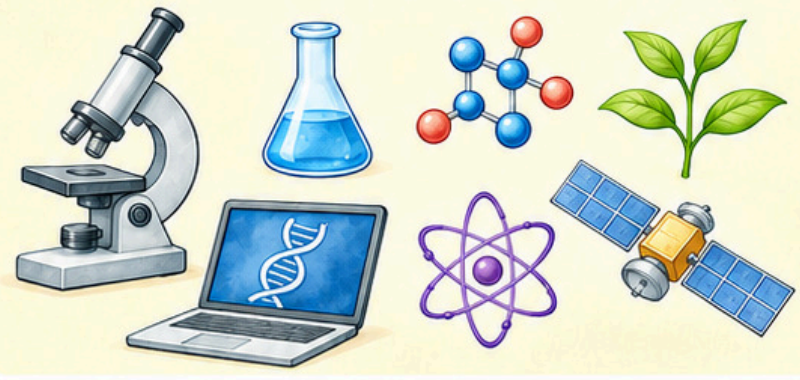
Rashtriya Vigyan Puraskar was announced on 21 September 2023.

Rashtriya Vigyan Puraskar

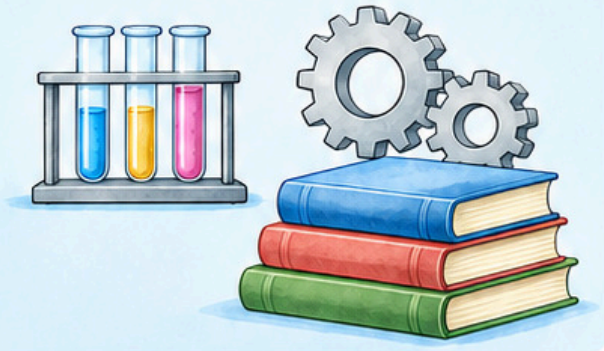
- Vigyan Ratna
- Vigyan Shri
- Vigyan Yuva-Shanti Swarup Bhatnagar (for young scientists up to 45 years
- Vigyan Team

Four categories across 13 domains.

Seven fields of science



13 domains



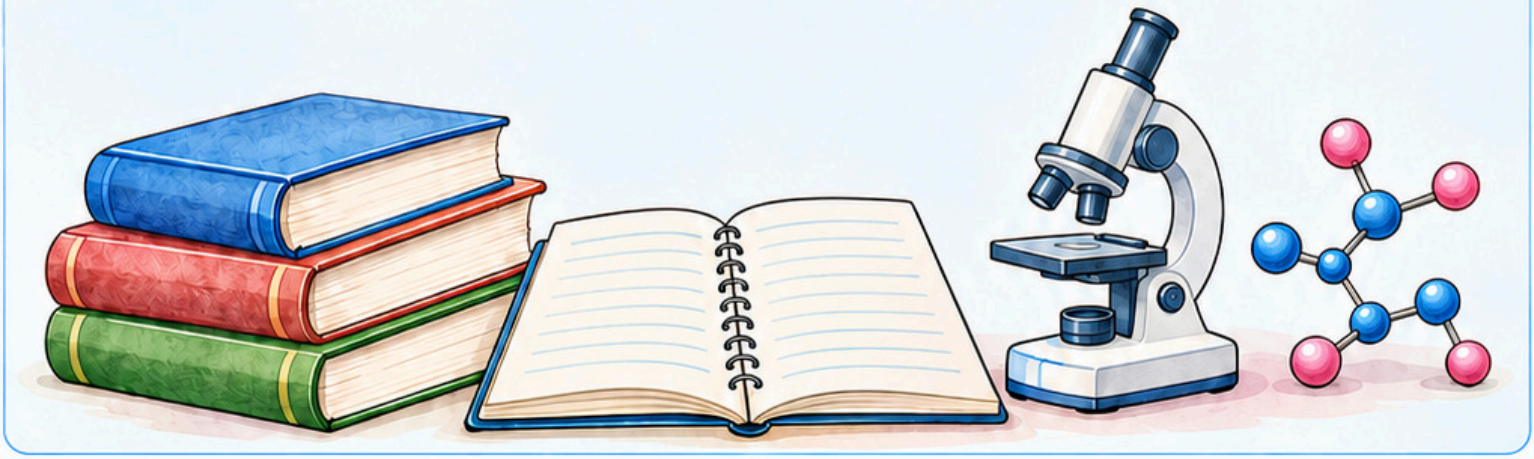
Illustrations are schematic

CSIR and other research organisations

- DRDO is the research and development wing of the Ministry of Defence, formed in 1958. As on 17 October 2026, it has around 41 laboratories and 5 Young Scientist Laboratories.
- Keep CSIR's laboratory network separate from DRDO and from research bodies such as ICAR, ICMR, DBT, IISc, IITs and the Anusandhan National Research Foundation.

Indian Research Organisations

- **CSIR** — laboratory network
- **DRDO**
- ICAR, ICMR and DBT
- IISc, the IITs and other national research institutes
- **Anusandhan** National Research Foundation

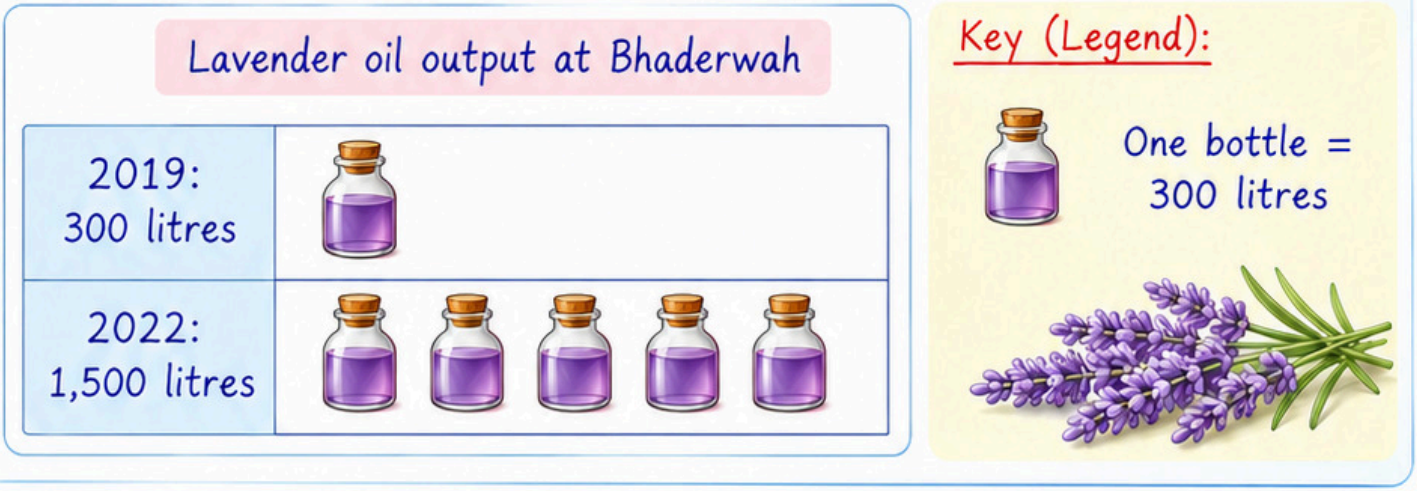


Illustrations are schematic

Extra section: CSIR in date order

Registration: 12 March 1942 → **Establishment:** 26 September 1942

Example: Pictograph (Lavender oil output at Bhaderwah)



CSIR in date order

Date	Event
1 April 1940	Board of Scientific and Industrial Research created, with Shanti Swarup Bhatnagar as Director
12 March 1942	CSIR registered as a society under the Societies Registration Act (XXI of 1860)
26 September 1942	Government Resolution on CSIR; CSIR established
1958	Shanti Swarup Bhatnagar Prize first given by CSIR
2019 to 2022	Lavender oil output at Bhaderwah rises from 300 litres to 1,500 litres
By 16 January 2022	Aroma Mission Phase I completed (6,000 hectares, 46 Aspirational districts); Phase II launched
August 2022	N. Kalaiselvi becomes Director-General of CSIR
4 June 2023	Bhaderwah called the "Lavender capital of India"
21 September 2023	Rashtriya Vigyan Puraskar announced, with a Vigyan Yuva-Shanti Swarup Bhatnagar category
7 November 2026	CSIR gives 37 national laboratories and 39 outreach centres

Key distinctions

1. Counting.

CSIR gives 37 national laboratories and 39 outreach centres (as on 7 November 2026). Do not swap the two figures.

DRDO's "around 41 laboratories" belongs to a different organisation, under the Ministry of Defence.





2. Look-alike "National" laboratories.

NAL is the aerospace laboratory at Bengaluru; NML is the metallurgy laboratory at Jamshedpur; NCL is the chemistry laboratory at Pune; NBRI is the botanical laboratory at Lucknow; NEERI is the environmental engineering laboratory at Nagpur.

One changed letter moves a laboratory to another city and another field.











3. CSIR or DRDO in Hyderabad.

CCMB, IICT and NGRI are CSIR laboratories, under DSIR in the Ministry of Science and Technology.

DRDL, RCI, ASL and DMRL are DRDO laboratories, under the Ministry of Defence.

A question that puts IICT under DRDO, or DRDL under CSIR, is wrong.





Illustrations are schematic