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DAY 15

Complete Pictograph Guide

APPSC Group 1 • Topics 141–150

110 teaching panels • 187 source-index entries • 20 MCQs with bilingual worked solutions in the separate practice file.

Topic / teaching set		Pages
141	Harappan town planning, drainage and Great Bath	2–13
142	Centre–State legislative relations and the Lists	14–27
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How to read this pack

The images carry teaching notes and diagrams. Companion notes and bilingual practice questions are provided separately.

Source IDs restart within each topic: S1 in Topic 141 is a different entry from S1 in Topic 142. The full source index follows all teaching panels.

Historical and engineering reconstructions are illustrative schematics unless a diagram explicitly carries a quantitative scale. Practice-graph data are illustrative, not official statistics.

Dates identify the reference period of changing claims. Permission scopes, measurement methods and historical uncertainty remain explicit.

Mohenjo-daro: A Planned Urban Centre

Harappan Town Planning

Harappan town planning concerns how cities were laid out and built: raised and lower areas, streets, bricks, houses, drains and water structures such as the Great Bath. Identify each feature by its archaeological site.

Important Harappan Sites (Recall from Topic 1)

The Harappan (Indus Valley) Civilisation is known through sites such as Harappa, Mohenjo-daro, Lothal, Kalibangan and Dholavira. Each is remembered for one or two finds.

Two Parts of Mohenjo-daro

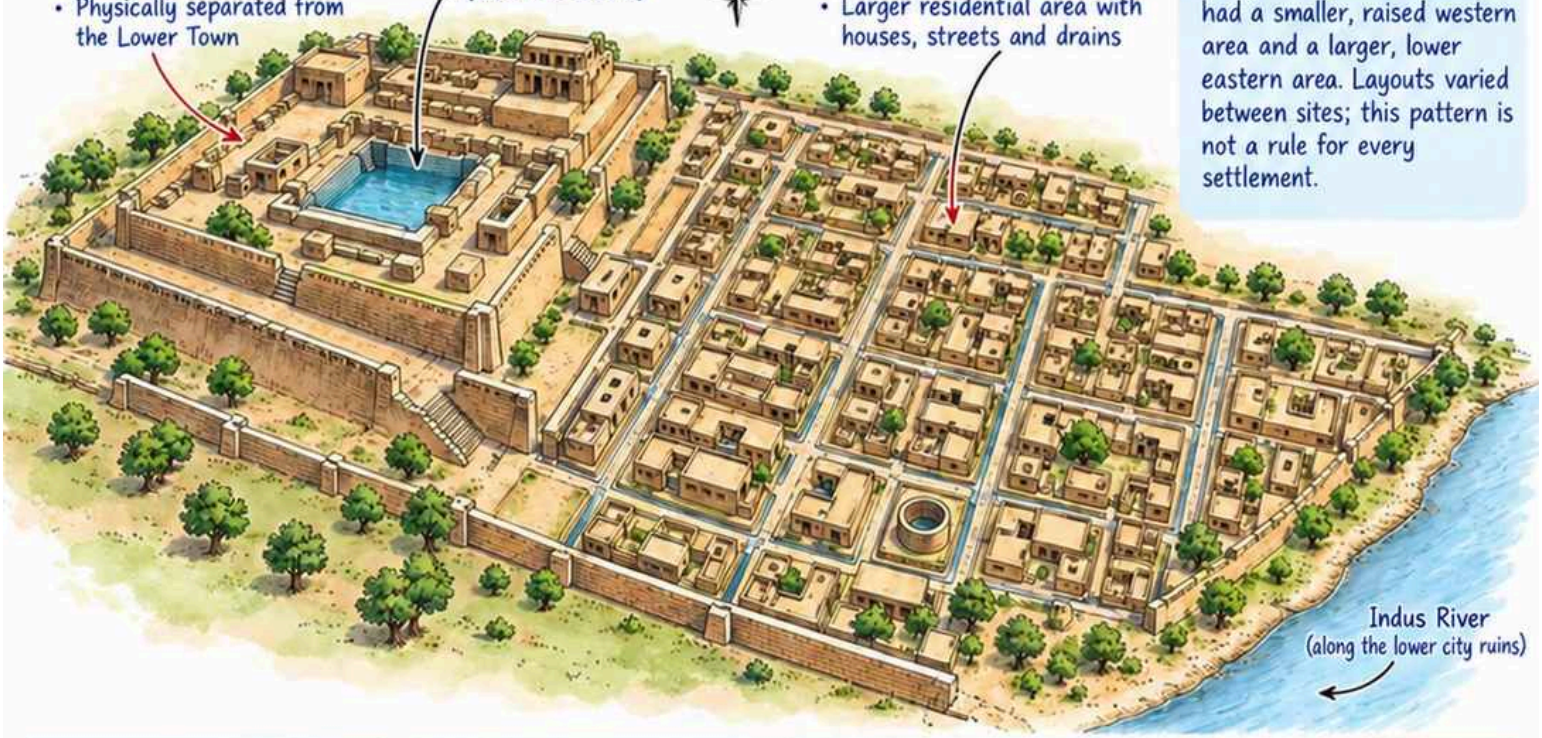
Mohenjo-daro had two principal sections: the smaller, higher Citadel and the much larger, lower Lower Town.

Citadel (western part)

- Smaller but higher
- Built on mud-brick platforms
- Walled
- Physically separated from the Lower Town

Lower Town (eastern part)

- Much larger but lower
- Larger residential area with houses, streets and drains



A Common Pattern, with Variations

Many Harappan settlements had a smaller, raised western area and a larger, lower eastern area. Layouts varied between sites; this pattern is not a rule for every settlement.

Mud-brick Platforms



The Citadel owes its height to buildings raised on mud-brick platforms.

Walled Citadel



The Citadel was walled, so it was physically separated from the Lower Town.

Streets in a Planned Layout



Streets were laid out in a planned manner.

Houses



Houses were built using bricks.

Drains



Drains were an important part of the town planning.

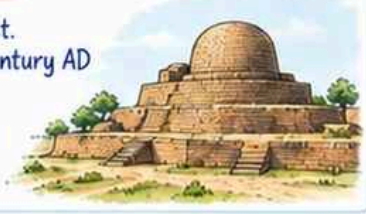
Great Bath



The Great Bath is a water structure at Mohenjo-daro.

Mohenjo-daro Across Time

- The Citadel area is in the west. A Buddhist stupa of the 2nd century AD was later built over it.
- The lower city ruins lie along the Indus.



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Harappan Town Plans: Important Variations

Site	Layout	What is different
Mohenjo-daro	Citadel and Lower Town	The standard case: a smaller, higher, walled Citadel and a larger, lower town.
Kalibangan	Citadel to the west, lower city to the east, more than 40 m apart	The citadel was in two almost equal parts, separated by a partition wall: the southern part had mud-brick platforms, some with fire altars; the northern part had houses, perhaps of the elite (B.K. Thapar, one of its excavators).
Lothal	Whole settlement fortified	The Citadel was not walled off but was built at a height.
Dholavira	Whole settlement fortified, with walls between sections	Three principal divisions: "citadel", "middle town" and "lower town" (R.S. Bisht, its excavator).

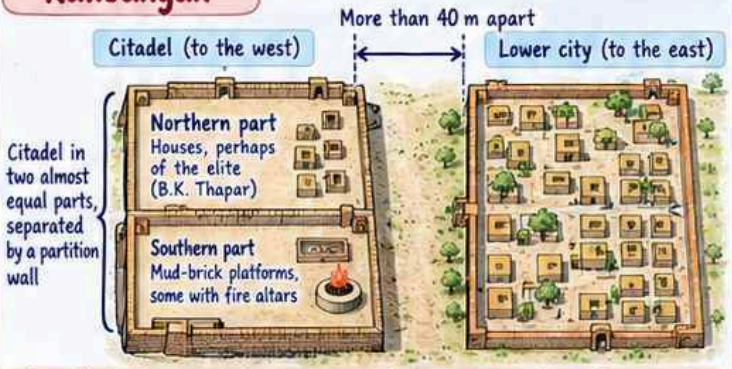
Whole-settlement fortification and a separately walled citadel are different features.
At Lothal, the whole settlement was fortified, while its raised Citadel was not separately walled.
At Dholavira, walls separated town sections.

Mohenjo-daro



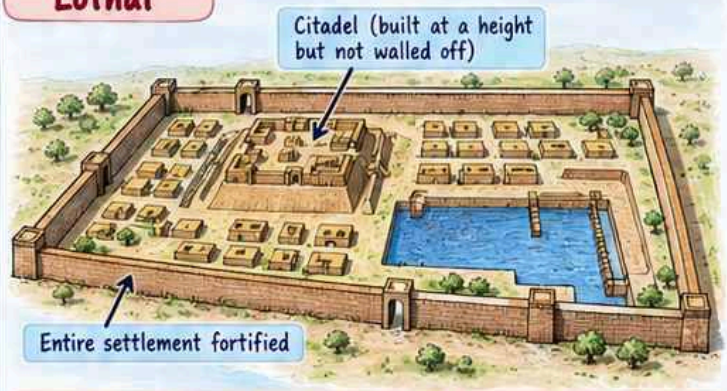
The standard case: a smaller, higher, walled Citadel and a larger, lower town.

Kalibangan



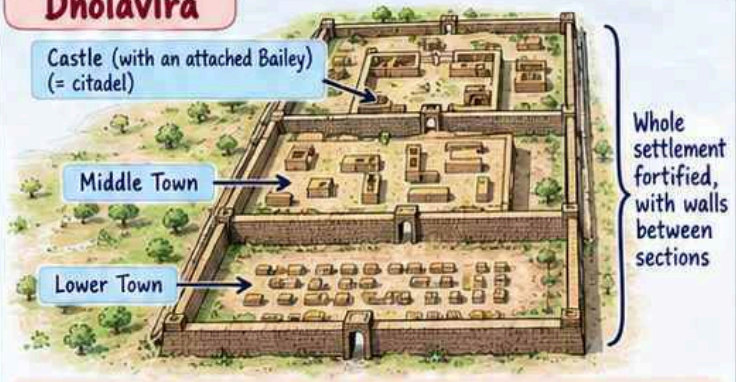
Citadel to the west, lower city to the east, more than 40 m apart. The citadel was in two almost equal parts, separated by a partition wall: the southern part had mud-brick platforms, some with fire altars; the northern part had houses, perhaps of the elite (B.K. Thapar).

Lothal



Whole settlement fortified. The Citadel was not walled off but was built at a height.

Dholavira



Three principal divisions: "citadel", "middle town" and "lower town" (R.S. Bisht).

Sources: S15, S4, S9

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Platforms, Streets and Bricks: Read the Phase

Platforms

Illustrative labour estimate: if one labourer moved roughly a cubic metre of earth a day, the foundation platforms would have required about four million person-days.



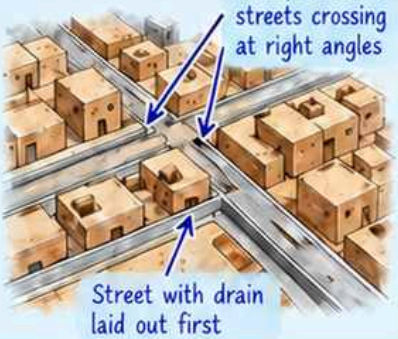
Once the platforms were in place, all building was restricted to a fixed area on them. The settlement was planned before construction.

Streets

Roads and streets were laid out along an approximate 'grid" pattern, crossing at right angles.

Streets with drains were laid out first, and houses were built along them.

Kalibangan's lower city also had a gridiron plan of streets.



Planning Sequence

1 Earth platforms



Platforms prepared as foundations (large investment of labour)

2 Streets and drains



Streets with drains laid out first

3 Houses

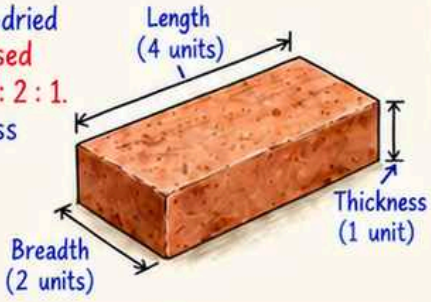


Houses built along the streets and drains, within a fixed area on the platforms

Bricks: Standardised Ratio

Mature Harappan bricks, whether sun-dried or baked, commonly used a standardised length : breadth : thickness ratio of 4 : 2 : 1. The length was four times the thickness and the breadth was twice it.

This ratio is widely associated with Mature Harappan construction.



Length : Breadth : Thickness = 4 : 2 : 1

Exact Examples at Kalibangan

At Kalibangan, Thapar measured mud bricks of 40 × 20 × 10 cm and 30 × 15 × 7.5 cm, both in the ratio 4:2:1. There, baked bricks were used mostly for drains, wells, sills and bathing platforms.



40 × 20 × 10 cm (4 : 2 : 1)

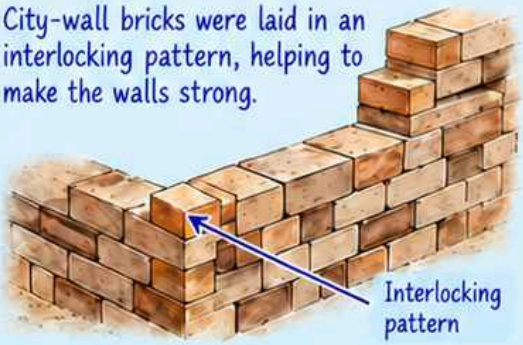


30 × 15 × 7.5 cm (4 : 2 : 1)

At Kalibangan, baked bricks were used mostly for drains, wells, sills and bathing platforms.

City Walls: Interlocking Pattern

City-wall bricks were laid in an interlocking pattern, helping to make the walls strong.



Phase Difference at Kalibangan

Thapar's Period I (pre-Harappan)



30 × 20 × 10 cm (3 : 2 : 1)

Thapar's Period II (Harappan)



40 × 20 × 10 cm (4 : 2 : 1)

Brick proportions differed by phase; the Mature Harappan ratio does not apply to every period.

House Drains at Kalibangan (Period II)

His excavated lower city had house drains discharging into soakage jars; no regular street drains had then been encountered.



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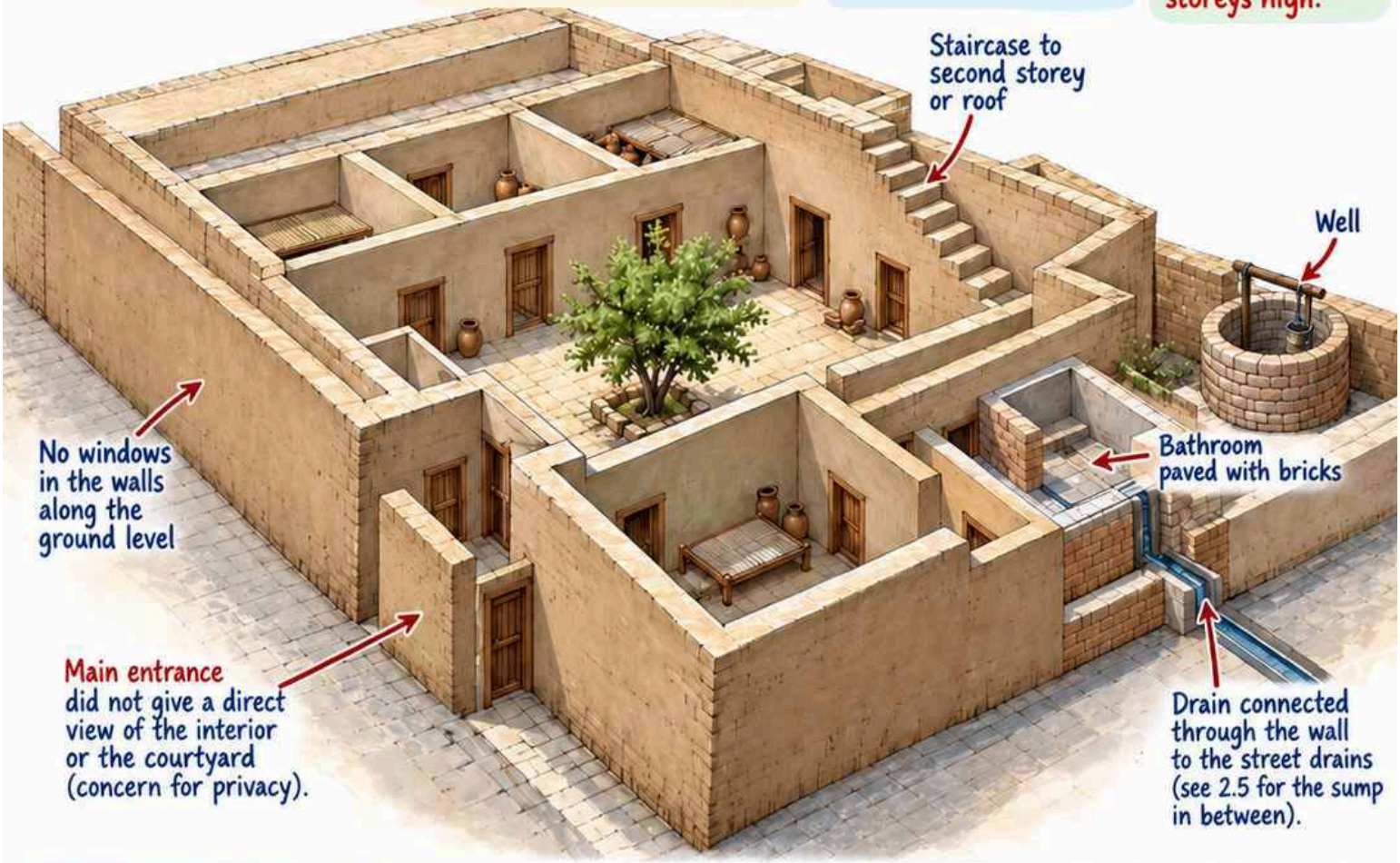
Courtyard Houses, Privacy and Wells

Many houses at Mohenjo-daro were centred on a **courtyard**, with **rooms on all sides.**

There were **no windows** in the walls along the ground level, and the **main entrance did not give a direct view** of the interior or give courtyard. **This layout is interpreted as a concern for privacy.**

Every house had its own **bathroom** paved with bricks. Its **drains** were connected through the wall to the street drains (see 2.5 for the sump in between).

Some houses have remains of staircases to a second storey or the roof. Some houses were **one or two storeys high.**



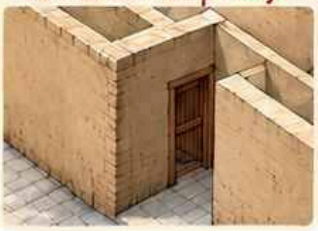
1. Courtyard and rooms

Many houses at Mohenjo-daro were centred on a courtyard, with rooms on all sides.



2. Privacy in design

There were no windows in the walls along the ground level, and the main entrance did not give a direct view of the interior or the courtyard. This layout is interpreted as a concern for privacy.



3. Bathroom and drains

Every house had its own bathroom paved with bricks. Its drains were connected through the wall to the street drains (see 2.5 for the sump in between).



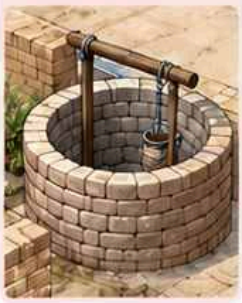
4. Staircase

Some houses have remains of staircases to a second storey or the roof. Some houses were one or two storeys high.



5. Wells

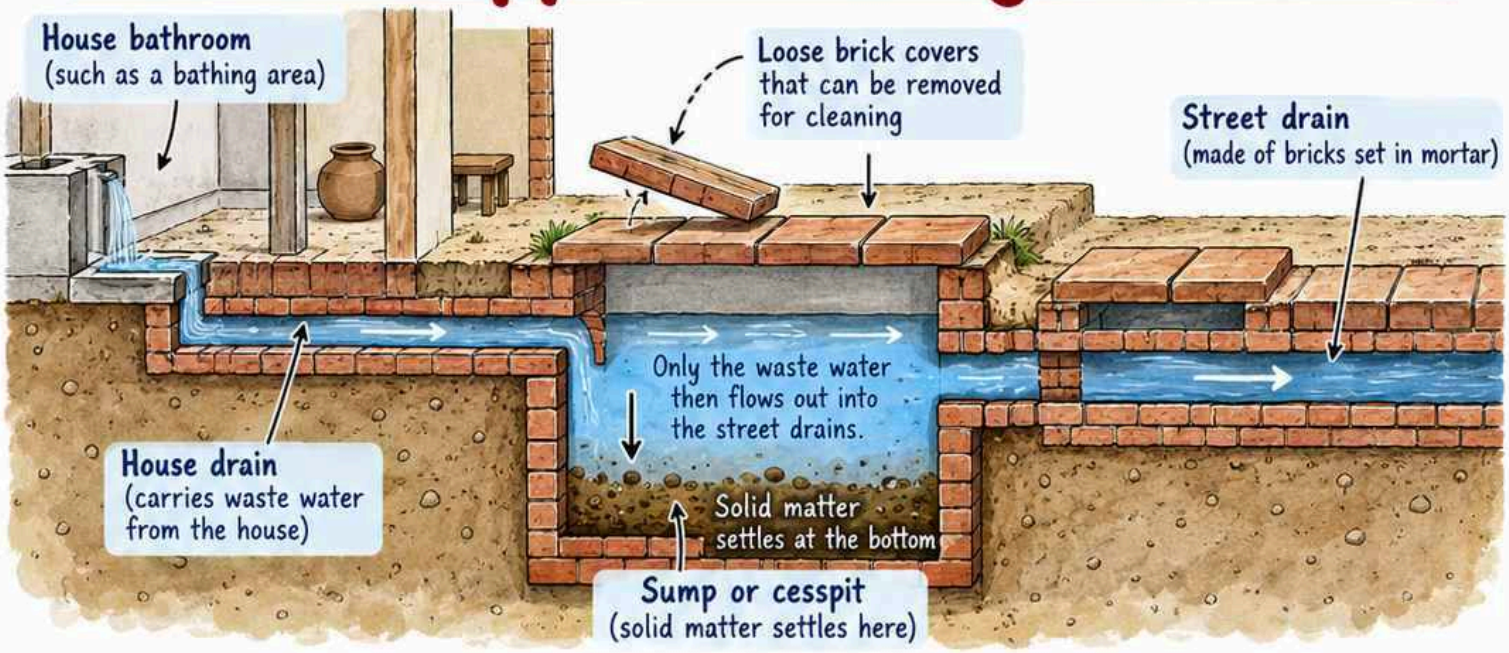
Scholars have estimated that Mohenjo-daro had **about 700 wells.**



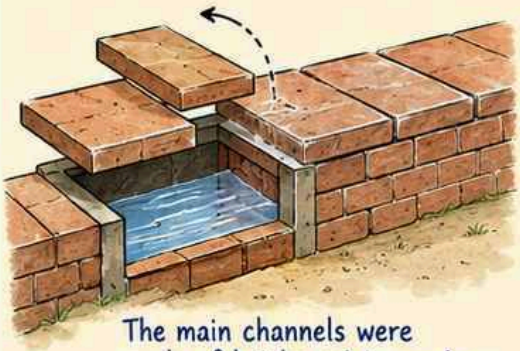
Sources: S15, S2

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How Harappan Drainage Worked



Main channels and covers



The main channels were made of bricks set in mortar. They were covered with loose bricks that could be removed for cleaning.

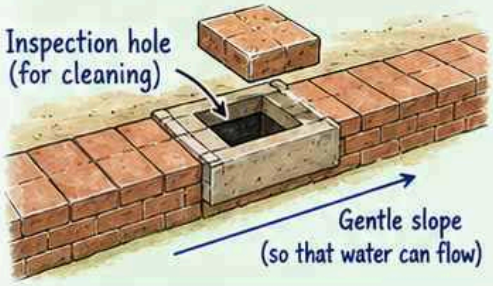
Sumps at intervals

Very long drainage channels had sumps at intervals for cleaning.



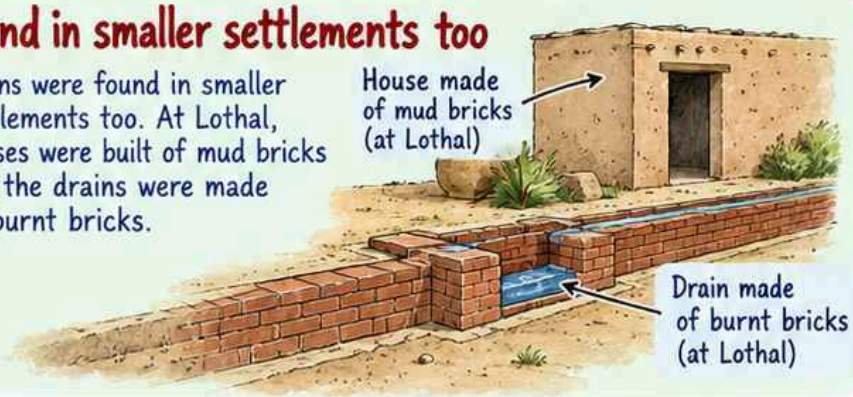
Inspection holes and slope

Many cities had covered drains, laid in straight lines. Each drain had a gentle slope so that water could flow. Inspection holes were provided at intervals to clean them



Found in smaller settlements too

Drains were found in smaller settlements too. At Lothal, houses were built of mud bricks but the drains were made of burnt bricks.



What an early excavator said

Ernest Mackay, one of the earliest excavators (Early Indus Civilisation, 1948), wrote:

> "It is certainly the most complete ancient system as yet discovered."
> – Ernest Mackay

Sources: S15, S2

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Inside the Great Bath

Where is it?

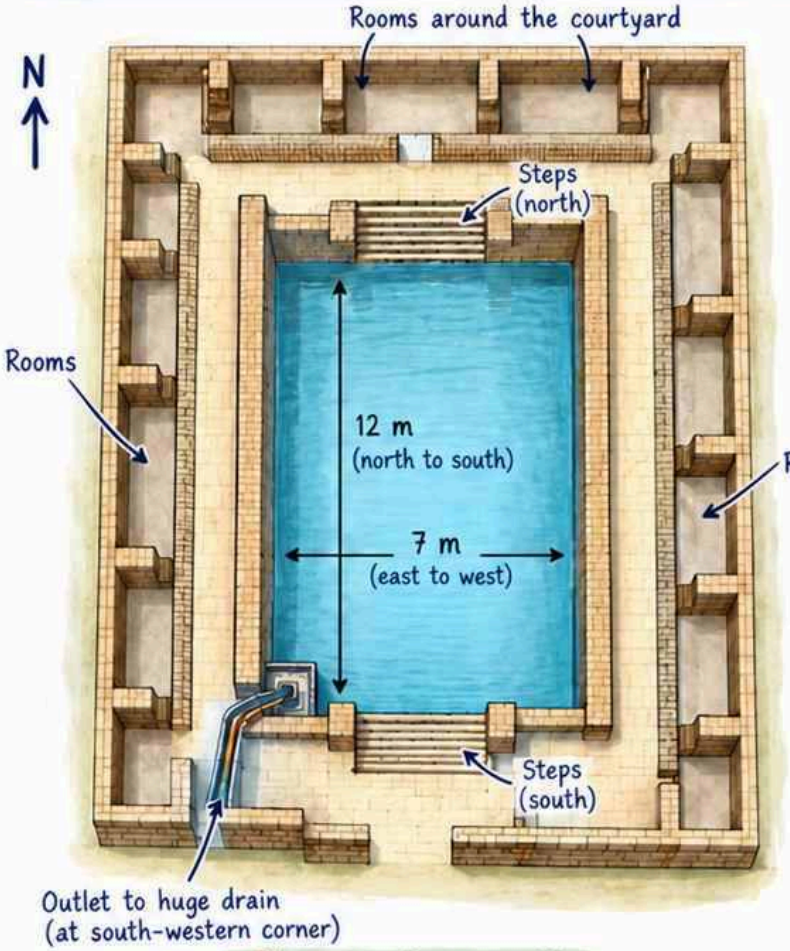
On the Citadel at Mohenjo-daro, in a courtyard with a corridor on all four sides.

Size

About 12 m from north to south, 7 m wide, and at most 2.4 m deep (Harappa.com, J. M. Kenoyer).

Steps

Two flights of steps, on the north and the south, led into the tank.



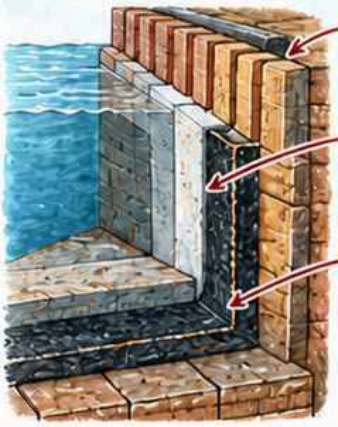
Plan view (not to scale)

Rooms on three sides, in one of which was a large well.
A corridor ran on all four sides.
Kenoyer places the rooms along the eastern edge.

View from the south



How it was made watertight

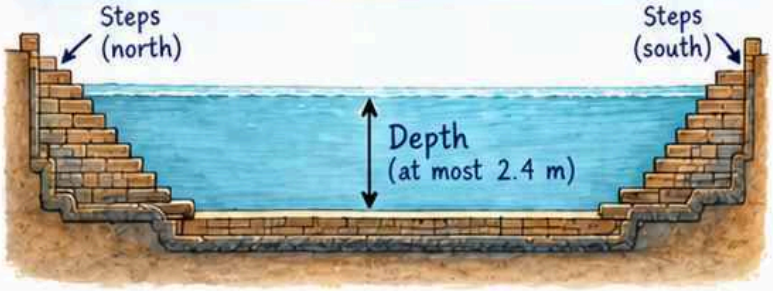


Bricks set on edge with a mortar of gypsum.

Lined with bricks, coated with plaster.

Thick layer of bitumen (natural tar) along the sides, and presumably beneath the floor (Kenoyer). This made the tank watertight.

Section from north to south (not to scale)

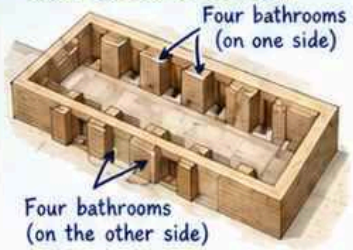


Drain

Water from the tank flowed into a huge drain (it the south-western corner of the tank (Kenoyer).

Nearby building

Across a lane to the north, a smaller building with eight bathrooms, four on each side of a corridor.

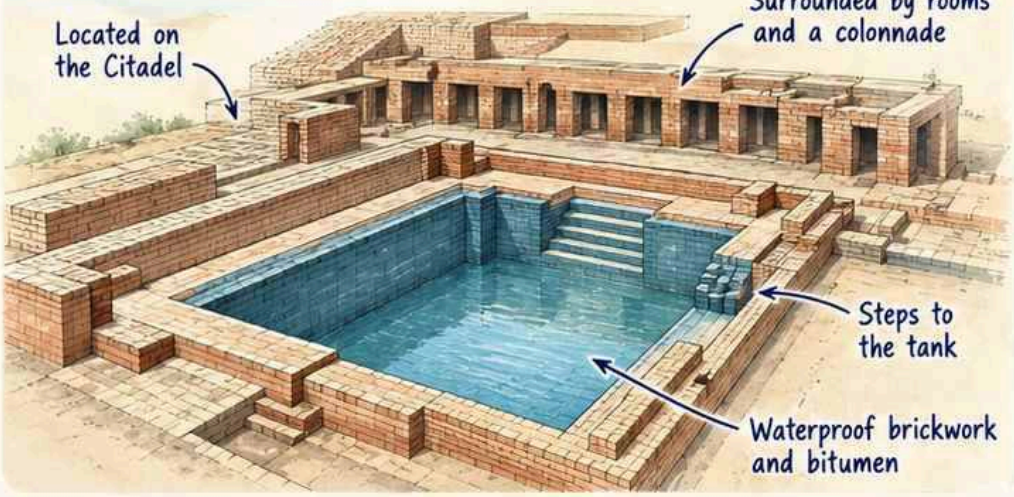


Sources: S15, S18

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Ritual Bath and Granary: Evidence or Interpretation?

The Great Bath (Mohenjo-daro)

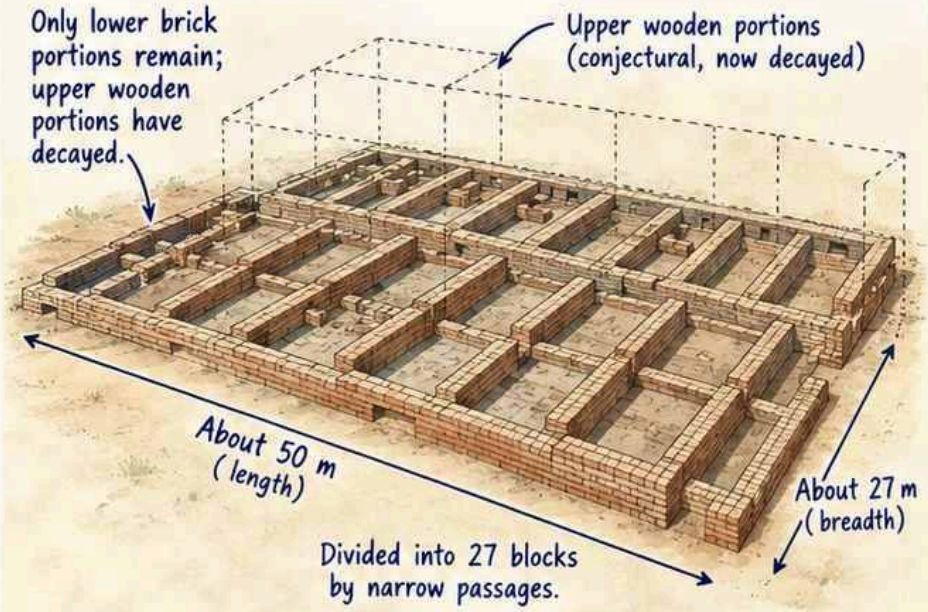


Its use

- Its uniqueness and its place on the Citadel have led scholars to suggest that it was meant for some kind of special ritual bath
- Kenoyer says most scholars think it was used for special religious functions.
- This is an interpretation, not a proven fact.

Suggested ritual use (uncertain)

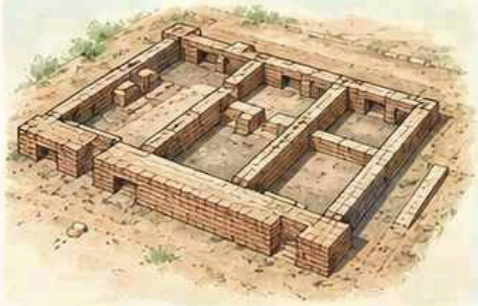
A massive building behind the Great Bath (Mohenjo-daro)



- The traditional labels "warehouse" and "granary" are interpretations; the building's exact function remains uncertain.
- Kenoyer (Harappa.com) describes its solid brick foundation, about 50 m by 27 m, divided into 27 blocks by narrow passages.
- No charred grain, storage jars or sealings were found there, and these absences "raise doubts" about calling it a granary.
- He suggests the name "great hall".

Called a "warehouse" or "a large granary", but there is no direct evidence of stored grain. The building's exact function remains uncertain.

A structure on Mound F (Harappa)



- At Harappa, a structure on Mound F is also called a "granary".
- Harappa.com calls it the "so-called granary", a puzzling structure.

"So-called granary" (a puzzling structure)

Interpretations at other sites

Large buildings at Mohenjo-daro, Harappa and Lothal have been interpreted as storehouses; function must be assessed from archaeological evidence.



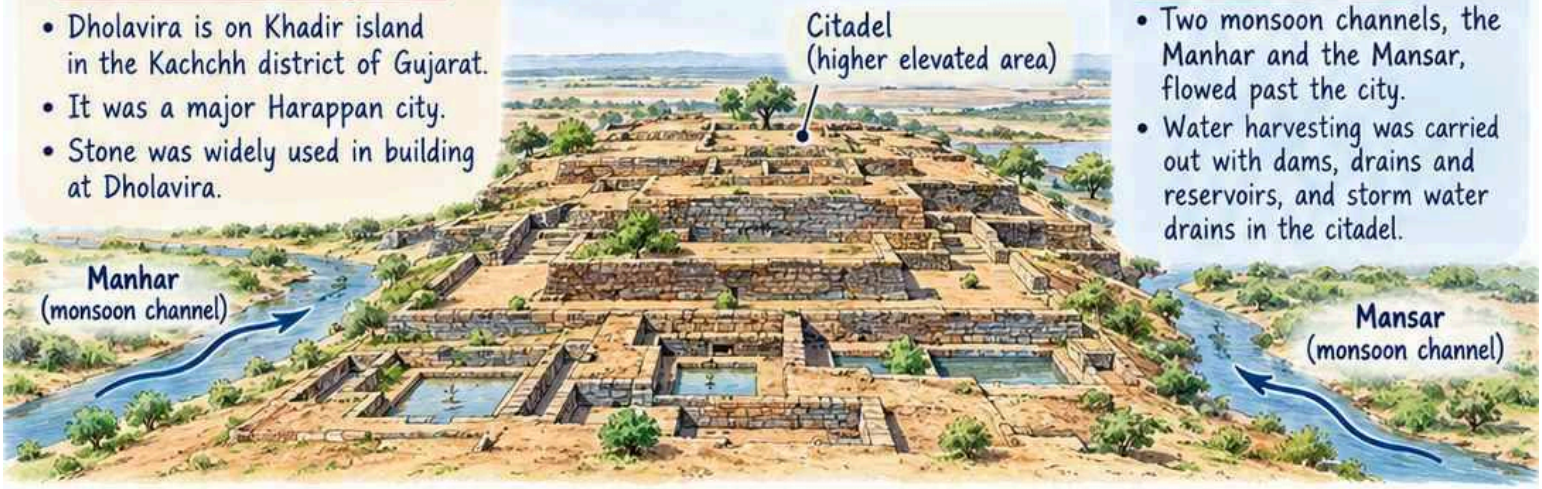
Mohenjo-daro | Harappa | Lothal

Sources: S15, S7, S18 | Day 15 | Topic 141 | 7/12 | @iaswithdrravi

Dholavira: A Connected Water System

Location and background

- Dholavira is on Khadir island in the Kachchh district of Gujarat.
- It was a major Harappan city.
- Stone was widely used in building at Dholavira.

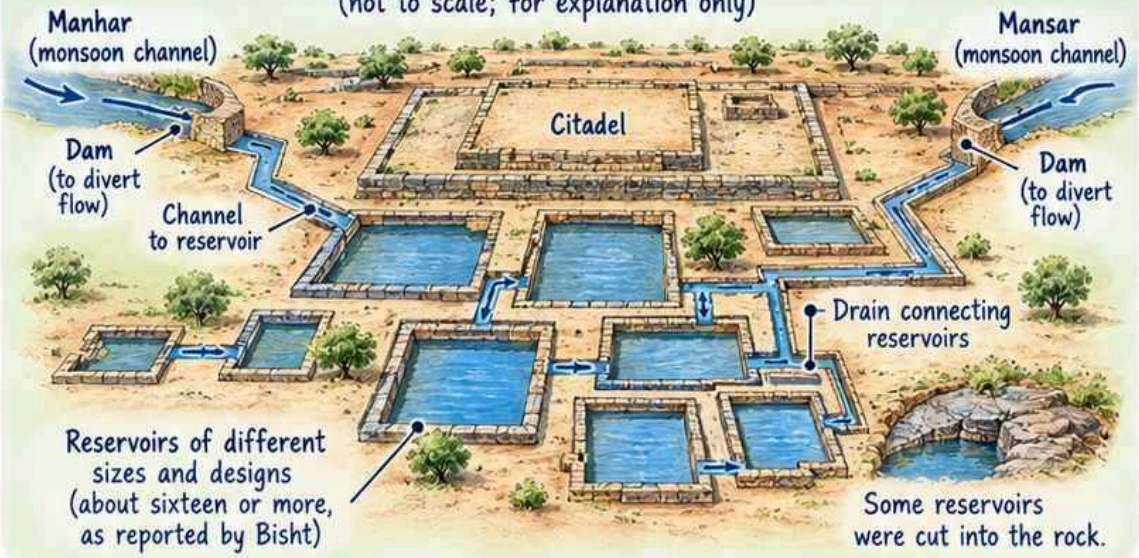


Monsoon channels

- Two monsoon channels, the Manhar and the Mansar, flowed past the city.
- Water harvesting was carried out with dams, drains and reservoirs, and storm water drains in the citadel.

Illustrative schematic: Connected water system at Dholavira

(not to scale; for explanation only)



Some reservoirs were cut into the rock.

Reservoir cut into rock

(illustrative view)



Some of the tanks at Dholavira were cut into the rock.

Key observations by Bisht

- About sixteen or more reservoirs of different sizes and designs have been reported at Dholavira.
- One reservoir lies to the east of the castle and five to its south.
- The tanks were connected to one another by a drain.
- Water harvesting involved dams, drains and reservoirs, and there were storm water drains in the citadel.

Possible use of reservoirs



The reservoirs at Dholavira may have been used to store water for agriculture.

UNESCO World Heritage status



- "Dholavira: a Harappan City" was inscribed on the UNESCO World Heritage List on 27 July 2021 (extended 44th session of the World Heritage Committee, held online and chaired from Fuzhou, China).
- It was India's 40th World Heritage site.

Sources: S4, S5, S12, S13

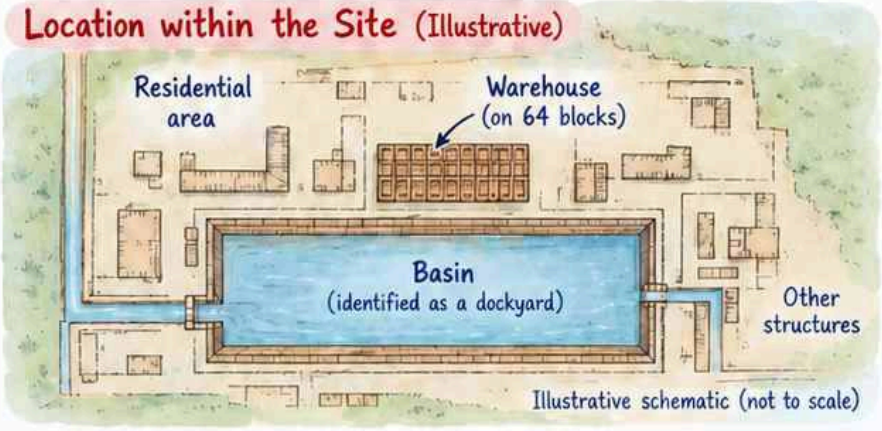
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Lothal: Basin, Warehouse and the Dockyard Debate

About Lothal

- Lothal is an important Harappan site in present-day Gujarat.
- It is known for its planned town layout, bead making, a large brick basin identified as a dockyard, and a warehouse.
- The basin and warehouse show planning and specialized activities, but their exact use and function continue to be debated by scholars.

Location within the Site (Illustrative)



Lothal Basin (Identified as a Dockyard)

- A large brick basin identified by excavator S. R. Rao as a dockyard.
- One reported measurement is 217 m by 26 m.
- Reported dimensions vary.
- Leshnik (1968) challenged the navigability of the supposed inlet and proposed an irrigation tank.
- The basin has been identified as a dockyard; its function remains debated.



Interpretations of the Basin

Archaeological structure

A large brick basin identified as a dockyard at Lothal.

Rao's Interpretation (Dockyard)

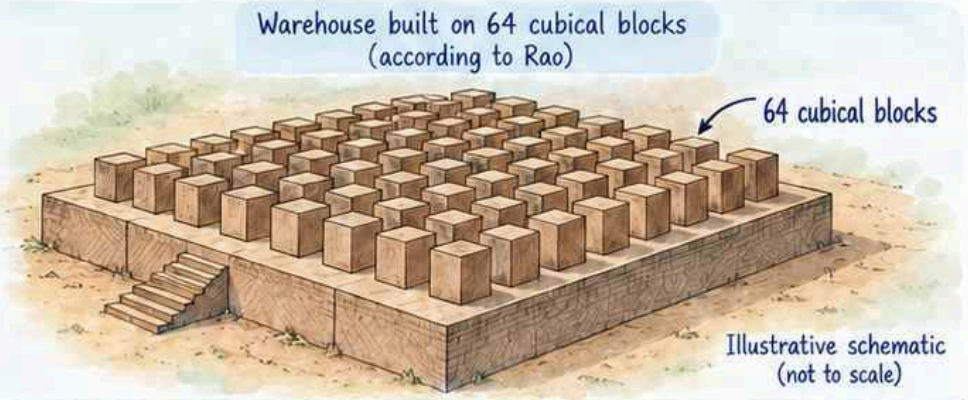
- Excavator S. R. Rao identified the basin as a dockyard.
- Suggested it was used for berthing ships and related maritime activities.

Leshnik's Interpretation (Irrigation Tank)

- Leshnik (1968) challenged the navigability of the supposed inlet.
- Proposed that the structure may have been an irrigation tank rather than a dockyard.

Lothal Warehouse

- A warehouse was present at Lothal.
- According to S. R. Rao, it was built on 64 cubical blocks.
- It is a large, raised structure with a planned layout.
- Its exact use (such as storage of specific goods) is not directly proven, but it indicates organized economic activities at the site.



Sources: S14, S16, S17

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Weights and the Excavation Timeline

Weights

- Weights were usually made of a stone called **chert** and were generally **cubical**, with **no markings**.
- The lower denominations were **binary** (1, 2, 4, 8, 16, 32 and so on); the higher ones followed the **decimal system**.
- They were **carefully** and **precisely** shaped.

Harappan Weights : Form and System



Schematic representation of Harappan weights (cubical, unmarked chert)
Schematic; sizes not to scale.

Excavation Timeline

1921 — Harappa
- Daya Ram Sahni began excavations in 1921.
- The first trench on Mound AB was opened in January 1921.

1922 — Mohenjo-daro
- R. D. Banerji found Harappa-type seals there.
- Excavations began in 1922.
- The discovery is also dated to 1922.

1924 — Announcement of a new civilisation
- In 1924 John Marshall, Director-General of the Archaeological Survey of India (ASI), announced a new civilisation.
- His article appeared on **20 September 1924**.

1955 — Lothal
- S.R. Rao began excavations in 1955.

1990 — Dholavira
- R.S. Bisht began excavations in 1990.
- His report covers fourteen field seasons from **1989 to 2005**.

Sources: S15, S7

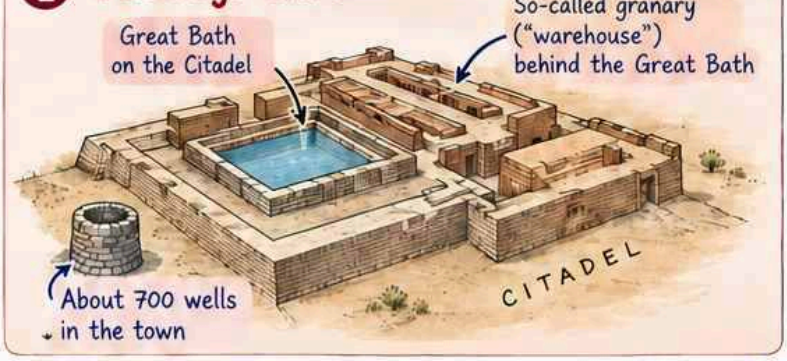
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Five Sites: Planning and Water Recall

Site	Planning or water feature to remember
Mohenjo-daro	Great Bath on the Citadel; about 700 wells; the "warehouse" or so-called granary behind the Great Bath.
Harappa	Another so-called granary, on Mound F.
Kalibangan	Citadel in two parts, divided by a wall; fire altars on mud-brick platforms in the southern part.
Lothal	Brick basin identified as a dockyard (disputed); citadel built at a height but not walled off; burnt-brick drains.
Dholavira	Three divisions with a middle town; a chain of reservoirs, some cut in rock.

How to use the table: When a question names a feature, first ask whether it is about the **plan** (how the town is divided) or about **water** (tanks, drains, reservoirs, basins). Then find the feature in the right column and read the site beside it.

1 Mohenjo-daro



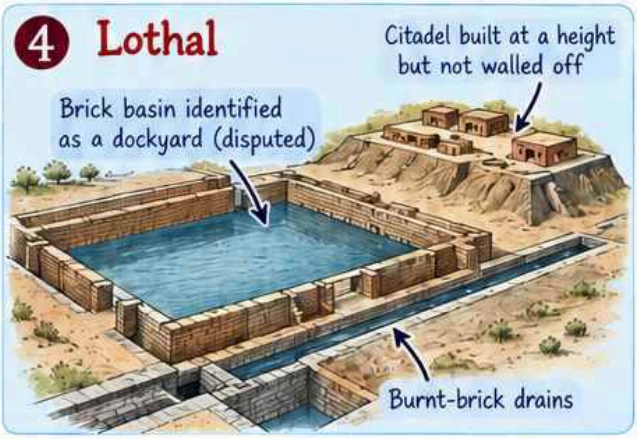
2 Harappa



3 Kalibangan



4 Lothal



5 Dholavira



All site diagrams are illustrative schematics, not surveyed plans or to scale

Sources: S15, S4, S9, S14

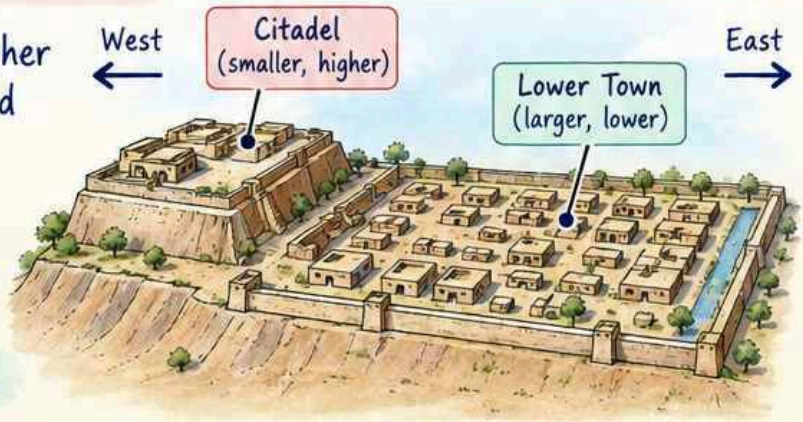
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Three Harappan Exam Traps

1 West or east, higher or lower?

- The usual pattern is a smaller, higher part to the west (the Citadel) and a larger, lower part to the east (the Lower Town).
- Questions reverse the sizes or the directions.
- The bigger part is the lower one.

Usual pattern; schematic, not to scale.



2 Name or proof?

- "Great Bath used for ritual bathing" and "granary" are labels and suggestions.
- Scholars suggest a ritual use for the Great Bath; warehouse or granary labels are interpretations.
- A statement that calls either use certain is open to challenge.

Great Bath at Mohenjo-daro



Evidence
A large, well-built water tank.

↓

Proposed interpretation
Scholars suggest it was used for ritual bathing.

"Granary" at Mohenjo-daro



Evidence
A large, multi-roomed structure.

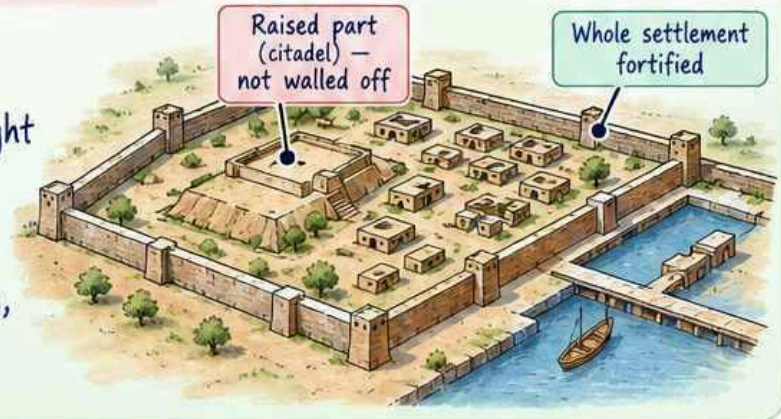
↓

Proposed interpretation
Traditionally labelled a warehouse or granary; its exact function is uncertain.

3 "Every citadel was walled off."

- Not at Lothal.
- There the citadel was raised on a height but not walled off, while the whole settlement was fortified.
- Dholavira too was fortified as a whole, with walls between its sections.

Lothal: raised part but no separate wall



Sources: S15, S7

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Legislative Relations: Territory and Special Routes

Context and Coverage

- Articles 245 to 255 and the Seventh Schedule divide law-making power between Parliament and the State Legislatures through three Lists, and settle whose law prevails when the two overlap or conflict.
- The examination asks which List a subject is in, how amendments have changed the Lists, and what the Articles on supremacy, residuary power and repugnancy say.
- This topic is Chapter I of Part XI, "Legislative Relations".
- Topic 124 covered the financial relations.



Parliament (Union Legislature)

May make laws for the whole or any part of the territory of India (Article 245(1))

Territory of India (whole or any part) Article 245(1)



State Legislature

May make laws for the whole or any part of the State (Article 245(1))

State (whole or any part) Article 245(1)

The Three Lists (Seventh Schedule)

Law-making power is divided between Parliament and the State Legislatures through three Lists in the Seventh Schedule.



- Parliament alone may make laws on the subjects in this List.



- State Legislatures may make laws on the subjects in this List.



- Both Parliament and State Legislatures may make laws on the subjects in this List.

Important Questions in the Examination



- Which List a subject is in.



- How amendments have changed the Lists.



- What the Articles on supremacy, residuary power and repugnancy say.

Article 245 – Extent of Laws

Article 245(1)

Subject to the provisions of the Constitution, Parliament may make laws for the whole or any part of the territory of India, and the Legislature of a State may make laws for the whole or any part of the State.

Article 245(2)

No law made by Parliament shall be deemed to be invalid on the ground that it would have extra-territorial operation, that is, operation outside India. The clause speaks only of Parliament.



Parliament's Four Routes into State List Matters

Topic 132 covered the federal features and the unitary bias, with Parliament's four routes into State List matters (Articles 249, 250, 252 and 253).

Article 249



If the Rajya Sabha passes a resolution by not less than two-thirds of the members present and voting, in the national interest.

Article 250



During a Proclamation of Emergency (Article 352).

Article 252



When two or more States pass resolutions for Parliament to legislate on a State List matter.

Article 253



To give effect to any international agreement, treaty or convention.

Another Route: President's Rule

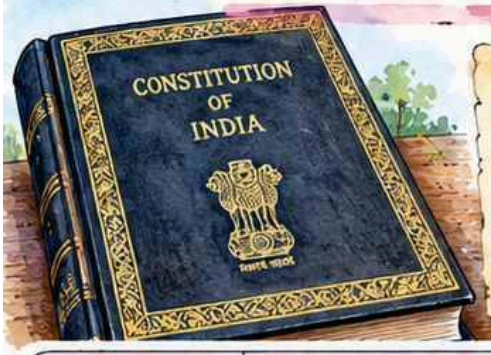
Under President's Rule the President may declare that the powers of the State Legislature shall be exercisable by or under the authority of Parliament (Article 356(1)(b)).



Sources: S1, S2, S20

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Article 246: Read the Opening Words



Article 246 deals with the distribution of legislative powers between Parliament and the Legislatures of States by reference to the three Lists in the Seventh Schedule.



The opening words of each clause of Article 246 show the order of legislative supremacy.

Clause	Who makes the law	On which List	How the clause opens
246(1)	Parliament, with exclusive power	List I, the Union List	"Notwithstanding anything in clauses (2) and (3)"
246(2)	Parliament, and, subject to clause (1), the Legislature of any State also	List III, the Concurrent List	"Notwithstanding anything in clause (3)"
246(3)	The Legislature of a State, with exclusive power, for the State or any part of it	List II, the State List	"Subject to clauses (1) and (2)"
246(4)	Parliament	Any matter, even one in the State List	For any part of the territory of India not included in a State

Key to the opening words



A clause that opens with "notwithstanding anything in ..." takes effect over the provisions it names.



A clause that opens with "subject to ..." means it is subordinate to the provisions it names.



The legal decision ladder (from the opening words)

1. **Article 246(1) Union List** — Parliament, with exclusive power "Notwithstanding anything in clauses (2) and (3)"
   → Union List power overrides both the other Lists.
2. **Article 246(2) Concurrent List** — Parliament, and, subject to clause (1), the Legislature of any State also "Notwithstanding anything in clause (3)"
   → Concurrent List power overrides the State List.
3. **Article 246(3) State List** — The Legislature of a State, with exclusive power, for the State or any part of it "Subject to clauses (1) and (2)"
   → State List power is subject to both.
4. **Article 246(4) Territories not included in a State** — Parliament: For any part of the territory of India not included in a State.



Resulting order of supremacy



The order of supremacy follows from these words. The Union List power overrides both the other Lists. The Concurrent List power overrides the State List. The State List power is subject to both. So the order is Union List, then Concurrent List, then State List.

Article 246A (2:3)

A special GST provision, which works "notwithstanding anything contained in articles 246 and 254".



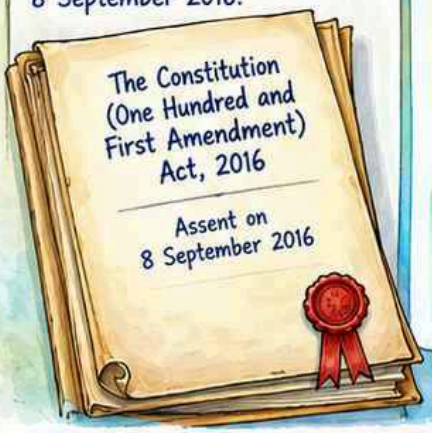
Sources: S1, S2

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GST and Residuary Legislative Power

Insertion of Article 246A

Article 246A was inserted by the Constitution (One Hundred and First Amendment) Act, 2016, which received assent on 8 September 2016.



Article 246A

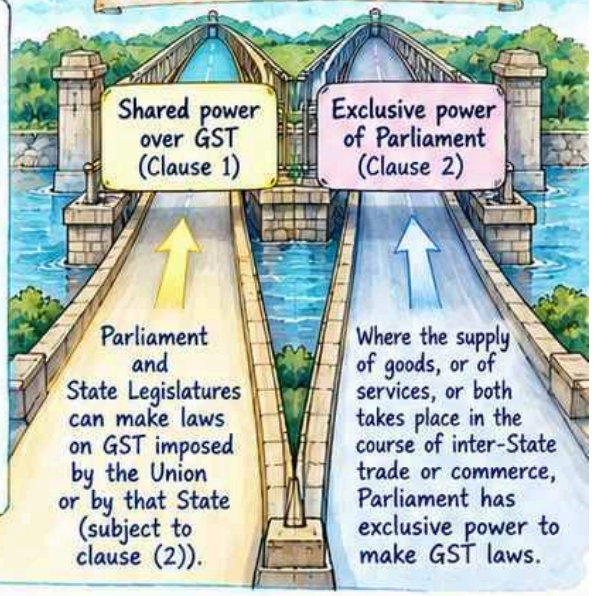
Clause (1)

"notwithstanding Articles 246 and 254, Parliament, and, subject to clause (2), the Legislature of every State, have power to make laws on goods and services tax (GST) imposed by the Union or by that State."

Clause (2)

Parliament has exclusive power to make GST laws where the supply of goods, or of services, or both takes place in the course of inter-State trade or commerce.

GST: A Two-Track Framework



Article 248

Article 248 (1)

"Subject to article 246A", Parliament has exclusive power to make any law on any matter not enumerated in the Concurrent List or the State List.

The opening words were put in by the same 101st Amendment.

Article 248 (2)

This includes the power to make a law imposing a tax not mentioned in either of those Lists.



Entry 97 of the Union List

Entry 97 of the Union List says the same in the Schedule:

"Any other matter not enumerated in List II or List III including any tax not mentioned in either of those Lists."

Union List
(Seventh Schedule)

Entry 97

Any other matter not enumerated in List II or List III including any tax not mentioned in either of those Lists.

Comparative Position on Residuary Powers

United States



The Tenth Amendment reserves to the states, or to the people, the powers not delegated to the federal government.

Australia



Section 107 of its Constitution preserves the powers of the States that are not exclusively vested in the Commonwealth.

Canada



The residual powers lie with the federal government.

India



India is like Canada: the residue goes to the Centre.

Sources: S1, S3, S18, S19

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Repugnancy and Procedural Sanctions

Article 254 : Heading

The heading of Article 254 is "Inconsistency between laws made by Parliament and laws made by the Legislatures of States".

A provision that is inconsistent in this way is called **repugnant**.



Law made by Parliament

Concurrent List matter

Potential inconsistency (repugnancy)



Law made by the Legislatures of States

Point	Article 254(1) : the rule	Article 254(2) : the exception
When it applies	A provision of a State law is repugnant to a provision of a law made by Parliament which Parliament is competent to enact, or of an existing law on a Concurrent List matter.	A State law on a Concurrent List matter is repugnant to an earlier law of Parliament, or an existing law, on that matter.
Which law prevails	The law of Parliament, whether passed before or after the State law.	The State law, in that State, if it was reserved for the consideration of the President and received his assent.
What happens to the other law	The State law is void to the extent of the repugnancy.	**Proviso:** Parliament may at any time make a law on the same matter, including one adding to, amending, varying or repealing the State law.

How Article 254 Works : Legal Flow

Subject falls in the Concurrent List

↓

Is there repugnancy between a State law and a law made by Parliament (which Parliament is competent to enact), or an existing law on that matter?

↓ Yes

Ordinarily, the law of Parliament prevails, whether passed before or after the State law (Article 254(1)).

↓

The State law is void to the extent of the repugnancy (Article 254(1)).

→

Parliament may at any time make a law on the same matter, including one adding to, amending, varying or repealing the State law (Proviso to Article 254(2)).

However, if the State law on a Concurrent List matter is reserved for the consideration of the President and receives his assent (Article 254(2))

↓

Then, the State law prevails in that State.

↓

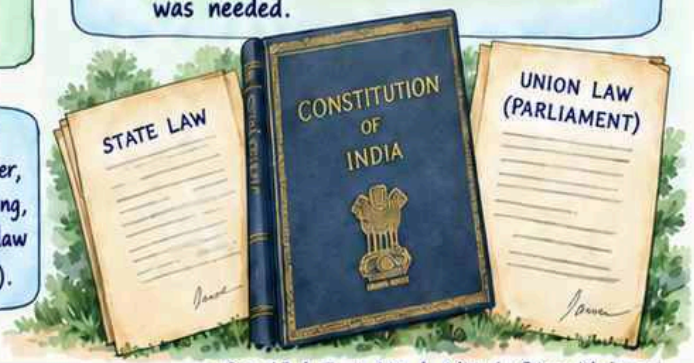
Parliament may at any time make a law on the same matter, including one adding to, amending, varying or repealing the State law (Proviso to Article 254(2)).

Article 255 : Procedural Sanctions

Article 255: recommendations and previous sanctions are "matters of procedure only".

An Act is not invalid only because a required recommendation or previous sanction was not given, if assent was given:

- by the Governor or the President where the Governor's recommendation was needed, and
- by the President where the President's recommendation or previous sanction was needed.



Sources: S1, S2

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Counting the Three Lists Correctly

At the commencement of the Constitution the Union List had **97** entries, the State List **66** and the Concurrent List **47**.



Amendments do not renumber the Lists.
A new entry gets a letter (2A, 92A, 92B and 92C in the Union List; 11A, 17A, 17B, 20A and 33A in the Concurrent List), and an omitted entry leaves its number empty.

Any change in the Lists needs, besides the special majority in Parliament, ratification by the Legislatures of not less than one-half of the States (proviso to Article 368(2), Topic 104).



Special majority in Parliament



Ratification by the Legislatures of not less than one-half of the States

→ Proviso to Article 368(2), Topic 104



	Entries at the commencement	Numbers in the text now, with letters	Entries omitted	Entries in force now
1 **Union List (List I)**	97	101 (1 to 97, with 2A, 92A, 92B, 92C)	3 ~~33, 92, 92C~~	98
2 **State List (List II)**	66	66 (1 to 66)	7 ~~11, 19, 20, 29, 36, 52, 55~~	59
3 **Concurrent List (List III)**	47	52 (1 to 47, with 11A, 17A, 17B, 20A, 33A)	None	52

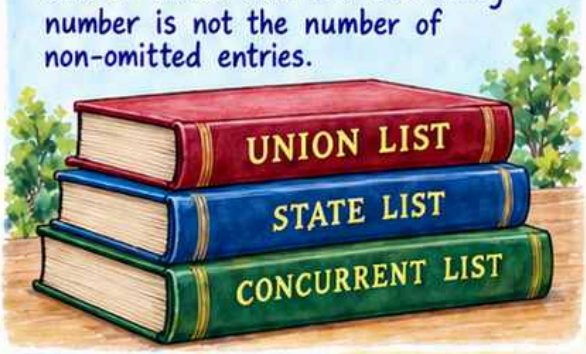
Sources: S1, S15

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Seventh Schedule: entry numbers and entry counts

Three Legislative Lists

The Union, State and Concurrent Lists distribute legislative subjects between the Union and the States. Inserted lettered entries and omitted entries mean that the last entry number is not the number of non-omitted entries.



Constitutional text: 1 MAY 2024 snapshot

The final numbered entries are 97, 66 and 47. Count each lettered entry separately, then exclude omitted entries.



Each List in the 1 MAY 2024 text

1 Union List (List I)



Original numbered entries:	97
Lettered insertions:	2A, 92A, 92B, 92C
Omitted entries:	33, 92, 92C
Non-omitted count:	97 + 4 − 3 = 98

2 State List (List II)



Original numbered entries:	66
Lettered insertions:	None
Omitted entries:	11, 19, 20, 29, 36, 52, 55
Non-omitted count:	66 − 7 = 59

3 Concurrent List (List III)



Original numbered entries:	47
Lettered insertions:	11A, 17A, 17B, 20A, 33A
Omitted entries:	None
Non-omitted count:	47 + 5 = 52

Insertion and commencement are different



- Entry 92C was enacted by the 88th Amendment but never brought into force.
- It was later omitted by the 101st Amendment in 2016.
- An enacted but uncommenced entry must not be counted as an operative power.

Reading the numbers

Description	Union List (List I)	State List (List II)	Concurrent List (List III)
Original counts	97	66	47
Final printed entry numbers	97	66	47
Non-omitted entries in this dated text	98	59	52

A legal amendment can insert, replace or omit an entry without renumbering the entire list.

Sources: S15

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List Subjects: Union and State Fields

Union List
(Matters of national importance)

Subject	Entry No.	Words of the entry (in short)
Defence	1	Defence of India and every part thereof
Atomic energy	6	Atomic energy and mineral resources necessary for its production
Foreign affairs	10	Foreign affairs; matters which bring the Union into relation with any foreign country
Railways	22	Railways
Banking	45	Banking
Census	69	Census

State List
(Matters of State and local importance)

Subject	Entry No.	Words of the entry (in short)
Public order	1	Public order, but not the use of any armed force of the Union
Police	2	Police (including railway and village police), subject to entry 2A of List I
Local government	5	Local government, that is to say, the constitution and powers of municipal corporations, improvement trusts and other local authorities
Public health	6	Public health and sanitation; hospitals and dispensaries
Agriculture	14	Agriculture, including agricultural education and research
Land	18	Land: rights in or over land, land tenures

Concurrent List
(Matters of common interest)

Subject	Entry No.	Words of the entry (in short)
Criminal law	1	Criminal law, including matters in the Indian Penal Code

Key Contrasts

Railways vs Railway Police

Railways (Union List) Entry 22	Railway police (State List) Entry 2
Railways	Police (including railway and village police), subject to entry 2A of List I

Public health vs Family planning

Public health (State List) Entry 6	Family planning (Concurrent List)
Public health and sanitation; hospitals and dispensaries	Falls under population control and family planning (Entry 20A of List III)

What do the Lists show?

- The Constitution divides legislative subjects between the Union, States and both (Concurrent).
- Each subject is identified by an entry number and described in the words of the entry.

Sources: S1, S15

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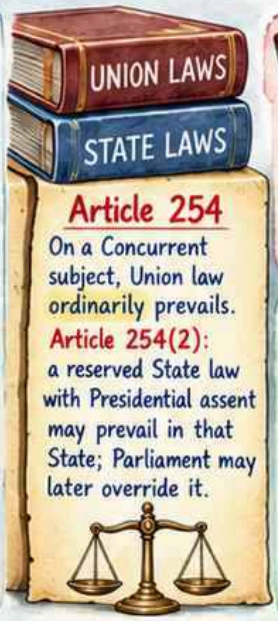
Concurrent Subjects and Common Confusions

The Concurrent List contains subjects on which both Parliament and State Legislatures can make laws.

If there is a conflict between a Union law and a State law on a Concurrent subject, the Union law ordinarily prevails (Article 254).

Selected Subjects from the Concurrent List

List	Subject	Entry No.	Subject matter (as per Seventh Schedule)
Concurrent	Marriage and divorce	5	Marriage and divorce; adoption; wills, intestacy and succession
Concurrent	Forests	17A	Forests (added by the 42nd Amendment)
Concurrent	Population control and family planning	20A	Population control and family planning (added by the 42nd Amendment)
Concurrent	Trade unions	22	Trade unions; industrial and labour disputes
Concurrent	Education	25	Education, including technical and medical education and universities (rewritten by the 42nd Amendment)
Concurrent	Electricity	38	Electricity



Article 254

On a Concurrent subject, Union law ordinarily prevails.

Article 254(2): a reserved State law with Presidential assent may prevail in that State; Parliament may later override it.

From the Commencement

Criminal law, marriage and divorce, trade unions and electricity have been in the Concurrent List since the commencement.

Added or Rewritten by the 42nd Amendment

- Forests – Entry 17A (added by the 42nd Amendment)
- Population control and family planning – Entry 20A (added by the 42nd Amendment)
- Education – Entry 25 (rewritten by the 42nd Amendment)

Three Lists: Subject Classification

Union List
(Parliament can legislate)



- Union List contains subjects of national importance.
- Parliament alone can make laws on these subjects.
- Example relevant here: Railways – Entry 22.

Concurrent List
(Both can legislate)



- Both Parliament and State Legislatures can make laws.
- If there is a conflict, the Union law ordinarily prevails (Article 254).
- Examples: marriage and divorce (5), forests (17A), population control and family planning (20A), trade unions (22), education (25) and electricity (38).

State List
(State Legislatures can legislate)



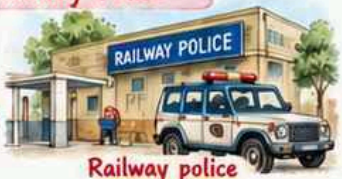
- State List contains subjects of State and local importance.
- State Legislatures alone can make laws on these subjects.
- Example relevant here: Railway police – Entry 2.

Common Confusions (With Clear Distinctions)

1 Railways vs Railway Police



Railways
Union List
Entry 22



Railway police
State List
Entry 2

- Railway police are in the State List (entry 2), though railways are in the Union List (entry 22).
- This illustrates that different aspects can fall in different lists.

2 Public Health vs Family Planning



Public health
State List

Subject of State and local importance (in the State List).



Population control and family planning
Concurrent List
Entry 20A

Population control and family planning (added by the 42nd Amendment).

Sources: S1, S15

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The 42nd Amendment: Five Subject Transfers

The Constitution (Forty-second Amendment) Act, 1976 is dated **18 December 1976.**



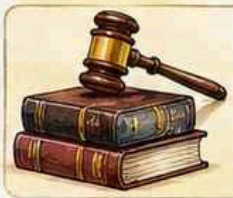
Its section 57 amended the Seventh Schedule with effect from **3 January 1977.**



It moved five subjects from the State List to the Concurrent List:



State List (Before Amendment)

 Education, including technical and medical education and universities, subject to entries 63 to 66 of List I	→	Entry 25 (rewritten)
 Forests	→	Entry 17A 
 Protection of wild animals and birds	→	Entry 17B 
 Weights and measures except establishment of standards	→	Entry 33A 
 Administration of justice; constitution and organisation of all courts, except the Supreme Court and the High Courts	→	Entry 11A 



Concurrent List (After Amendment)

Changes in the State List due to section 57

In the State List, section 57 **omitted entries 11, 19, 20 and 29** and took the words on the **administration of justice** out of entry 3.

Omitted from

Entry 11	Entry 19	Entry 20	Entry 29
✗	✗	✗	✗

Words on the administration of justice taken out of entry 3. ✗



Sources: S1, S15

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New Entries and the GST Amendment

Section 57 of the 42nd Amendment made other changes that were not transfers. It added entry 20A, "Population control and family planning", to the Concurrent List as a new subject. It added entry 2A to the Union List, on deploying the armed forces of the Union or other forces under its control in a State in aid of the civil power. It rewrote entry 2 of the State List to read "Police (including railway and village police) subject to the provisions of entry 2A of List I". Police stayed in the State List, and so did public health.

New entry in Concurrent List

Entry 20A
(to Concurrent List)
"Population control and family planning"



New entry in Union List

Entry 2A
(to Union List)
Deploying the armed forces of the Union or other forces under its control in a State in aid of the civil power.



Rewritten entry in State List

Entry 2
(to State List)
"Police (including railway and village police) subject to the provisions of entry 2A of List I".





- ✓ Police stayed in the State List.
- ✓ Public health also stayed in the State List.

Five subjects transferred from State List to Concurrent List

1. Education → Concurrent entry 25
2. Forests → Concurrent entry 17A
3. Protection of wild animals and birds → Concurrent entry 17B
4. Weights and measures except establishment of standards → Concurrent entry 33A
5. Administration of justice; constitution and organisation of all courts, except Supreme Court and High Courts → Concurrent entry 11A













State List (List II) → Transfer of five subjects (only these) → Concurrent List (List III)

These are true State-to-Concurrent transfers. Arrows show only the five moved subjects.

Entries omitted by the 101st Amendment

Union List

Entry 92
Taxes on the sale or purchase of newspapers and on advertisements published in them.



Entry 92C
Taxes on services.



State List

Entry 52
Taxes on the entry of goods into a local area for consumption, use or sale therein.



Entry 55
Taxes on advertisements other than advertisements published in newspapers.



Entries not omitted, but rewritten

Entry 62
(State List)
Not omitted; rewritten so that it now covers taxes on entertainments and amusements only to the extent levied and collected by a Panchayat, a Municipality, a Regional Council or a District Council.

Entry 84
(Union List)
Rewritten (by 101st Amendment).



Entry 54
(State List)
Rewritten (by 101st Amendment).

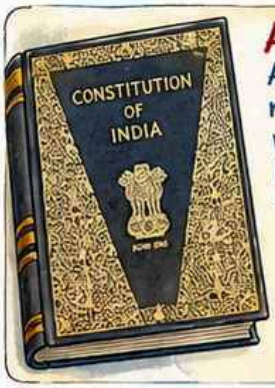




Sources: S3, S15

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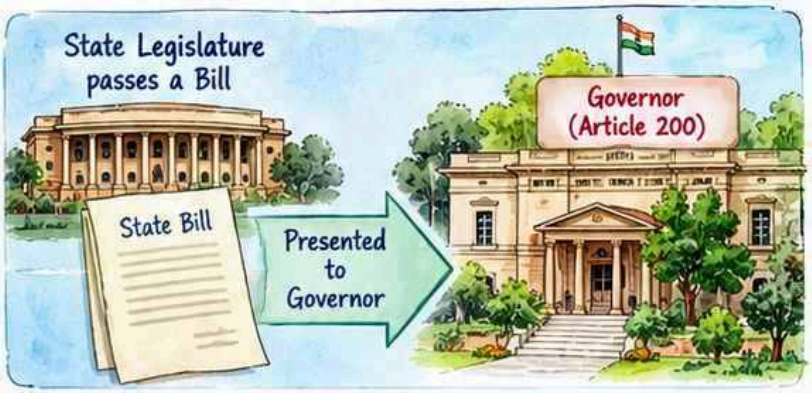
State Bills: Assent, Return and Reservation



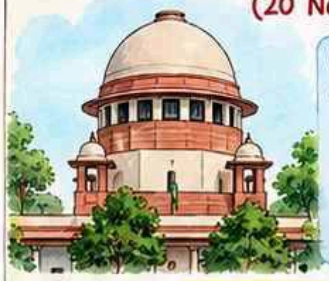
Article 200
Assent, withholding and reservation of State Bills

When a Bill is passed by the State Legislature, it shall be presented to the Governor, who may:

1. give his assent to the Bill;
2. withhold his assent to the Bill; or
3. reserve the Bill for the consideration of the President.



Supreme Court's Advisory Opinion (20 November 2025)

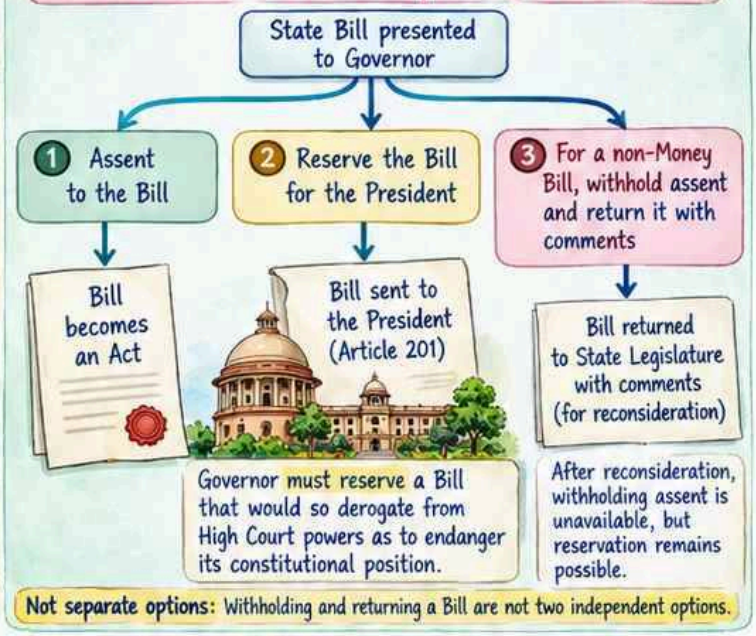


Clarifies three options for the Governor after a State Bill is presented:

1. Assent to the Bill.
2. Reserve the Bill for the President.
3. For a non-Money Bill, withhold assent and return it with comments.

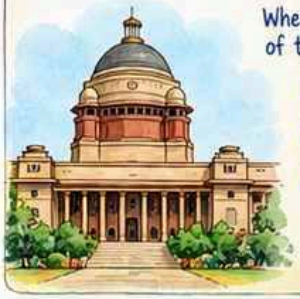
- The Governor must reserve a Bill that would so derogate from High Court powers as to endanger its constitutional position.
- After reconsideration by the State Legislature, the option of withholding assent is unavailable, but reservation remains possible.
- Withholding and returning a Bill are not two independent options.
- The opinion rejects judicially fixed general timelines and deemed assent.
- Prolonged, unexplained inaction can invite a limited direction to act.

Article 200: Governor's Options (as clarified)



Not separate options: Withholding and returning a Bill are not two independent options.

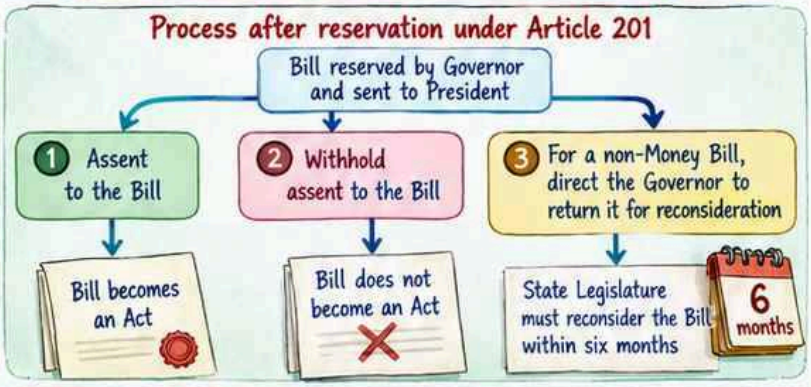
Article 201
President's powers in respect of reserved Bills



When a Bill is reserved for the consideration of the President, he may:

1. give his assent to the Bill; or
2. withhold his assent to the Bill; or
3. for a Bill that is not a Money Bill, direct the Governor to return it, and the House or Houses must reconsider it within six months.

Process after reservation under Article 201





Link with Article 254(2)

Reservation under Article 200 is how a State law gets the President's assent that Article 254(2) speaks of.

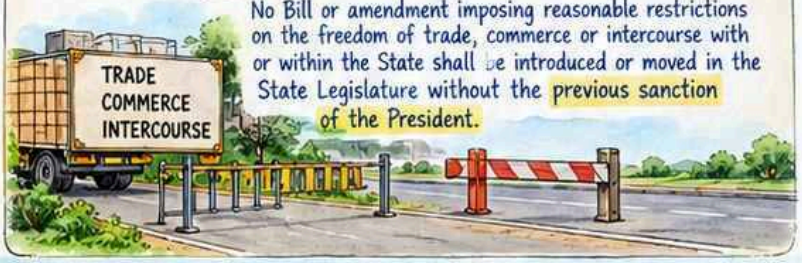


Article 255

A missing sanction under Article 304(b) does not make the Act invalid if the President later gave assent.

Article 304(b), Proviso

No Bill or amendment imposing reasonable restrictions on the freedom of trade, commerce or intercourse with or within the State shall be introduced or moved in the State Legislature without the previous sanction of the President.



Sources: S1, S6, S7, S21

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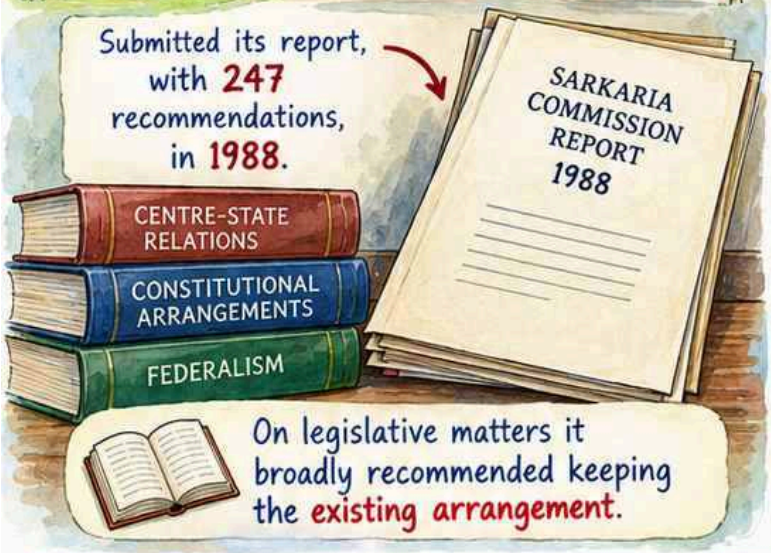
Sarkaria and Punchhi: Dates and Recommendations

Sarkaria Commission

Set up on **9 June 1983** under **Justice Ranjit Singh Sarkaria**, a retired judge of the Supreme Court.



Submitted its report, with **247** recommendations, in **1988**.



On legislative matters it broadly recommended keeping the **existing arrangement**.

Punchhi Commission

The **second Commission on Centre-State Relations**, set up on **27 April 2007** under **Justice Madan Mohan Punchhi**, a retired Chief Justice of India.



Submitted its report, with **273** recommendations, on **31 March 2010**.



Key Points at a Glance

Sarkaria Commission

- Set up on: **9 June 1983**
- Under: **Justice Ranjit Singh Sarkaria**, a retired judge of the Supreme Court.
- Report submitted in: **1988**
- Total recommendations: **247**
- On legislative matters: broadly recommended keeping the **existing arrangement**.

Punchhi Commission

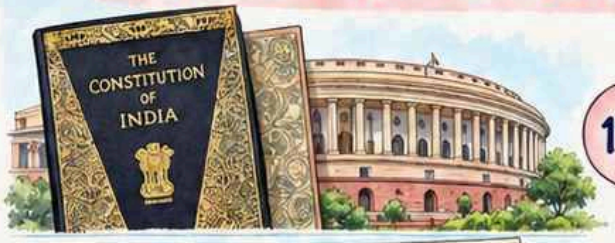
- Set up on: **27 April 2007**
- Under: **Justice Madan Mohan Punchhi**, a retired Chief Justice of India.
- Report submitted on: **31 March 2010**
- Total recommendations: **273**
- The **second Commission on Centre-State Relations**.

Both commissions, administrative relations (Topic 554) and Article 356 are taught on other days (Topic 903 for the commissions).

Sources: S16, S17

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How the Seventh Schedule Changed



1950 — The Constitution comes into force

- Union List — 97 entries
- State List — 66 entries
- Concurrent List — 47 entries

1954 — 3rd Amendment — Constitution (Third Amendment) Act, 1954

Entry 33 of the Concurrent List substituted



1956 — 6th Amendment — Constitution (Sixth Amendment) Act, 1956

Entry 92A (taxes on the sale or purchase of goods other than newspapers in the course of inter-State trade or commerce) inserted in the Union List



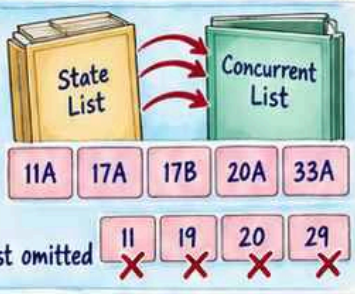
1956 — 7th Amendment — Constitution (Seventh Amendment) Act, 1956

Entry 33 of the Union List and entry 36 of the State List omitted



1976 — 42nd Amendment (in force from 3 January 1977) — Constitution (Forty-second Amendment) Act, 1976

- Five subjects moved from the State List to the Concurrent List
- entries 11A, 17A, 17B, 20A and 33A inserted and entry 25 rewritten in the Concurrent List
- entry 2A inserted in the Union List
- entries 11, 19, 20 and 29 of the State List omitted



1982 — 46th Amendment — Constitution (Forty-sixth Amendment) Act, 1982

Entry 92B (taxes on the consignment of goods) inserted in the Union List



2003 — 88th Amendment — Constitution (Eighty-eighth Amendment) Act, 2003

Entry 92C (taxes on services) inserted in the Union List; it was never brought into force



2016 — 101st Amendment — Constitution (One Hundred and First Amendment) Act, 2016

- Article 246A inserted
- entries 92 and 92C of the Union List and 52 and 55 of the State List omitted
- entries 84 (Union List), 54 and 62 (State List) rewritten



Sources: S1, S3, S15

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The Lists: Arithmetic and Exam Traps

Union List
(List I – Seventh Schedule)



Last entry number in 1950 : 97
Last entry number today : 97
Entries in force today : 98

97 + 4 − 3 = 98

Four lettered entries added since 1950

- ⊕ 2A
- ⊕ 92A
- ⊕ 92B
- ⊕ 92C

Three entries omitted since 1950

- ⊖ 33
- ⊖ 92
- ⊖ 92C

Entry 92C was never brought into force.

The Union List gained four lettered entries and lost three: 97 + 4 − 3 = 98.

State List
(List II – Seventh Schedule)



Last entry number in 1950: 66
Last entry number today : 66
Entries in force today : 59

66 − 7 = 59

Seven entries omitted since 1950

- ⊖ 11
- ⊖ 19
- ⊖ 20
- ⊖ 29
- ⊖ 36
- ⊖ 52
- ⊖ 55

No entries added

The State List has only lost entries; it has gained none.

That is why its count has fallen from 66 to 59.

Concurrent List
(List III – Seventh Schedule)



Last entry number in 1950: 47
Last entry number today : 47
Entries in force today : 52

47 + 5 = 52

Five lettered entries added (42nd Amendment)

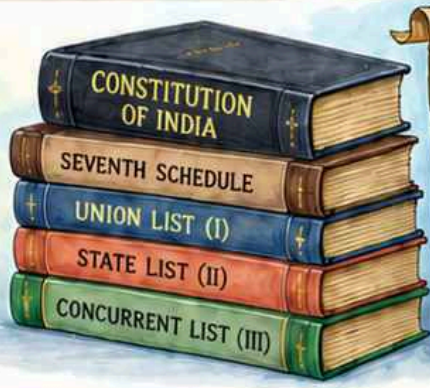
- ⊕ 11A
- ⊕ 17A
- ⊕ 17B
- ⊕ 20A
- ⊕ 33A

No entries omitted

The Concurrent List has never lost an entry; all its five lettered entries came from the 42nd Amendment.

Important Points to Remember

- Every entry that has been added is a lettered entry, so the last numbers 97, 66 and 47 have stayed the same since 1950.
- The State List has only lost entries; it has gained none. That is why its count has fallen from 66 to 59.
- The Concurrent List has never lost an entry; all its five lettered entries came from the 42nd Amendment.
- The Union List gained four lettered entries and lost three: 97 + 4 − 3 = 98.



97, 66 and 47 are the numbers at the commencement and also the last entry numbers today, not the number of entries in force. Counting what stands in the text now gives 98, 59 and 52.

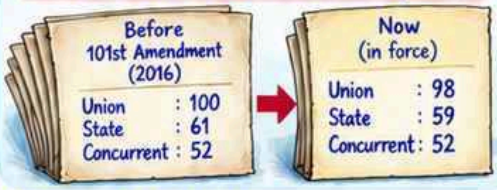
Common Exam Traps

1 Mixing the counts.

97, 66 and 47 are the numbers at the commencement and also the last entry numbers today, not the number of entries in force.

Countring what stands in the text now gives 98, 59 and 52.

The figures 100 and 61 belong to the text before the 101st Amendment (2016).



2 "Everything the 42nd Amendment put in the Concurrent List came from the State List."

Not so.

- Population control and family planning (entry 20A) was a new subject, not a transfer.
- The same section put entry 2A (deployment of the Union's forces in aid of the civil power) into the Union List and rewrote the police entry, but police stayed in the State List.



3 "Residuary power lies with the States, as in the United States."

Not so.

- In India it lies with Parliament (Article 248 and entry 97 of the Union List), as in Canada; in the United States and Australia it lies with the states.
- And since 2016 Article 248 is "Subject to article 246A", so GST is not a residuary tax: it has its own Article.



Sources: S1, S15, S18, S19

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Polavaram: identify the project

Project and Alternate Name

Polavaram Irrigation Project, also called Indira Sagar Polavaram, is a multipurpose major irrigation project on the Godavari.



Site

Site: near Ramayyapeta village, Polavaram mandal, where the river leaves the last Eastern Ghats range and enters the plains.



Location and Key Distances

The project is about 34 km upstream of the Kovvur-Rajahmundry road-cum-rail bridge and 42 km upstream of Sir Arthur Cotton Barrage.



District Snapshot (17 October 2026)

On 17 October 2026, Polavaram mandal is listed under Eluru district. West Godavari is the historical district label for this site. The project's name and its administrative district are distinct.



River and District Identity

- River: Godavari.
- Site: near Ramayyapeta village, Polavaram mandal.
- District listing (17 October 2026): Eluru.
- Historical district label: West Godavari.



Planned Benefits (Multipurpose)

The project combines new irrigation, more reliable water for existing deltas, domestic and industrial supply, hydropower and inter-basin transfer.



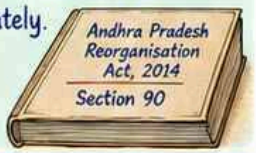
Right Canal and Basin Link

Its right canal links the Godavari to the Krishna; that does not make the dam a Krishna-river project.



Statutory Identity

Section 90 of the Andhra Pradesh Reorganisation Act, 2014 supplies its national-project status. The project's statutory identity, physical location, planned benefits and construction status must be studied separately.



Sources: S1, S2, S12

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Section 90: duties and delivery

Section 90 is in Part IX, Water Resources, of the Andhra Pradesh Reorganisation Act, 2014.

90(1)

Polavaram is declared a national project.



90(2)

the Union takes control of regulation and development of the project for irrigation in the public interest.



90(3)

the successor State of Telangana's consent is deemed to have been given.



90(4)

the Central Government must execute the project and obtain the required clearances, including environmental and forest clearances, while meeting rehabilitation and resettlement norms.



The Act received presidential assent on 1 March 2014.



The Polavaram Project Authority was constituted on 28 May 2014, with a Governing Body, to implement these provisions.



Government of India (Union)



Takes control of regulation and development of the project for irrigation in the public interest. Responsible for executing the project and obtaining the required clearances, including environmental and forest clearances, while meeting R&R norms.

Polavaram Project Authority (PPA) with a Governing Body



Constituted on 28 May 2014, to implement the provisions of Section 90.

In practice, Andhra Pradesh's Water Resources Department executes the project on behalf of the Government of India.

Andhra Pradesh's Water Resources Department (executes the project on behalf of the Government of India)



Chief Engineer handles the project.



Special Commissioner handles land acquisition and R&R.



National-project status does not erase clearance or rehabilitation duties. Also distinguish the Union's statutory responsibility from the State agency carrying out construction.



Funding of the irrigation component is a separate question.



Sources: S1, S4, S8, S13

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Seven mandals and inter-State safeguards

The 2014 amendment to Section 3 transferred areas of the former Khammam district to Andhra Pradesh for the Polavaram arrangements.

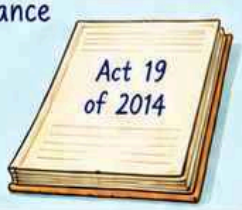


Seven mandals:

Kukunoor, Velairpadu, Bhurgampadu, Chintoor, Kunavaram, Vararamachandrapuram and Bhadrachalam.

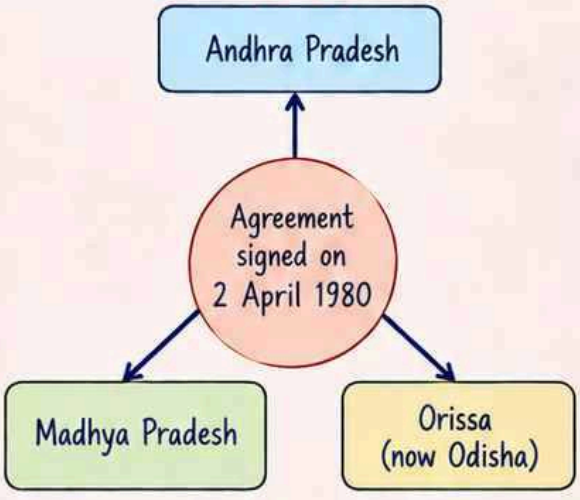
1 Kukunoor	2 Velairpadu	3 Bhurgampadu	4 Chintoor	5 Kunavaram	6 Vararamachandrapuram	7 Bhadrachalam
						
Full transfer	Full transfer	Partial transfer Twelve revenue villages of Bhurgampadu remained in Telangana.	Full transfer	Full transfer	Full transfer	Partial transfer Bhadrachalam revenue village itself remained in Telangana.

Act 19 of 2014 replaced the ordinance and operated from 29 May 2014. The 2020 NGT committee records 136 villages and 211 hamlets in the transferred areas.



The project's inter-State agreement was signed on 2 April 1980 by Andhra Pradesh, Madhya Pradesh and Orissa, now Odisha. It formed part of the Godavari Water Disputes Tribunal settlement of 1980.

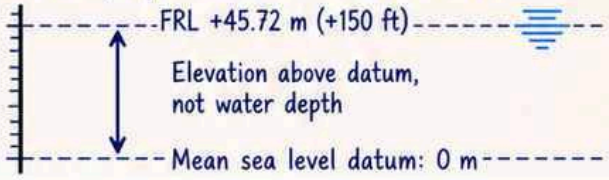
Three-signatory agreement



Formed part of the Godavari Water Disputes Tribunal settlement of 1980.

Full reservoir level

The agreed full reservoir level is 150 feet above mean sea level, equivalent to +45.72 metres.



Inter-State safeguards

Odisha and Chhattisgarh's safeguards include protective embankments with drainage arrangements along the Sabari and Sileru, or compensation. National status and inter-State safeguards are distinct legal layers.



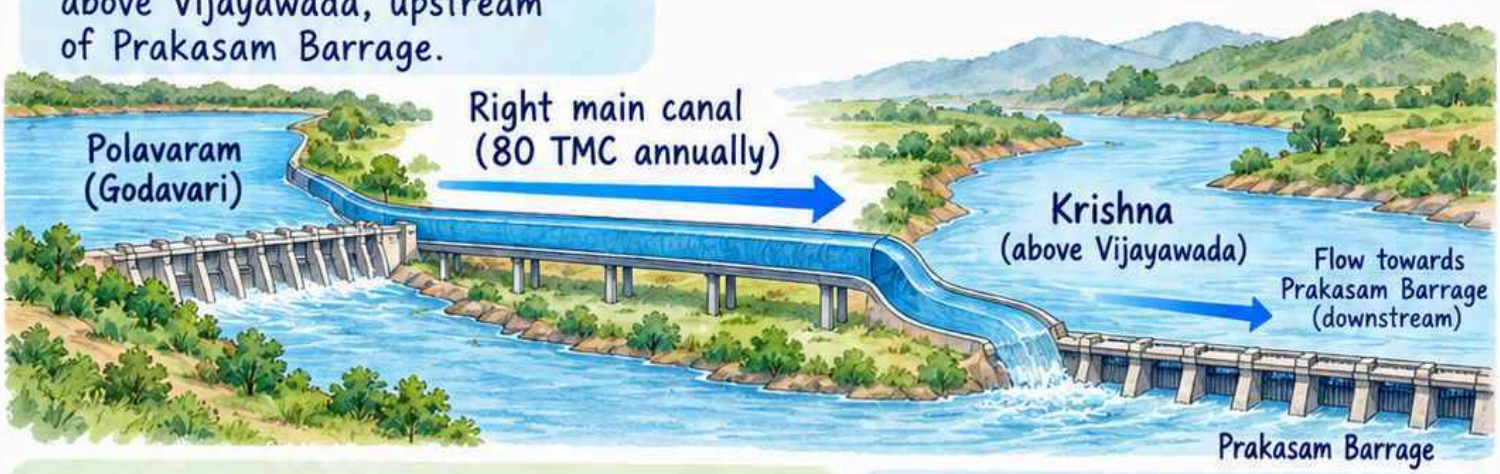
Sources: S1, S10, S17, S20

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Water allocation: flow versus entitlement

The right main canal is planned to divert **80 TMC** of Godavari water annually into the Krishna above Vijayawada, upstream of Prakasam Barrage.

TMC means thousand million cubic feet.



The 4 August 1978 agreement, incorporated in the GWDT award, concerns the additional use of Krishna water freed upstream of Nagarjunasagar by this diversion.

These upstream Krishna-use entitlements are not canals carrying Polavaram water directly to those States.

Upstream Krishna-use entitlements
(from water freed by the 80 TMC diversion)

- **45 TMC** for Andhra Pradesh
- **35 TMC** jointly for Karnataka and Maharashtra
  - **21 TMC** for Karnataka
  - **14 TMC** for Maharashtra

From the reservoir rim



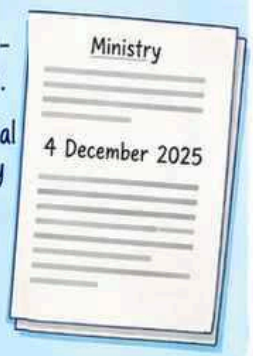
PPA allocates **23.44 TMC** for industrial supply and drinking water to Visakhapatnam together.
Do not add an unspecified extra Visakhapatnam drinking-water quantity to that figure.



23.44 TMC
(for industrial supply and drinking water to Visakhapatnam together)

The canal connection is the Godavari (Polavaram)-Krishna (Vijayawada) link.

A 4 December 2025 ministerial reply described temporary operation through lift arrangements, rather than completion of the full dam project.



Sources: S2, S9, S17

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Irrigation: land, crop seasons and stabilisation

LAND AND CANAL DESIGN:

Culturable command area is the cultivable land a canal system can serve.
The planned irrigation area is 7.2 lakh acres, approximately 2.91 lakh hectares.

CANAL DESIGN EXAMPLE: MAY 2024

Left main canal: 181.999 km; planned irrigation 4 lakh acres.

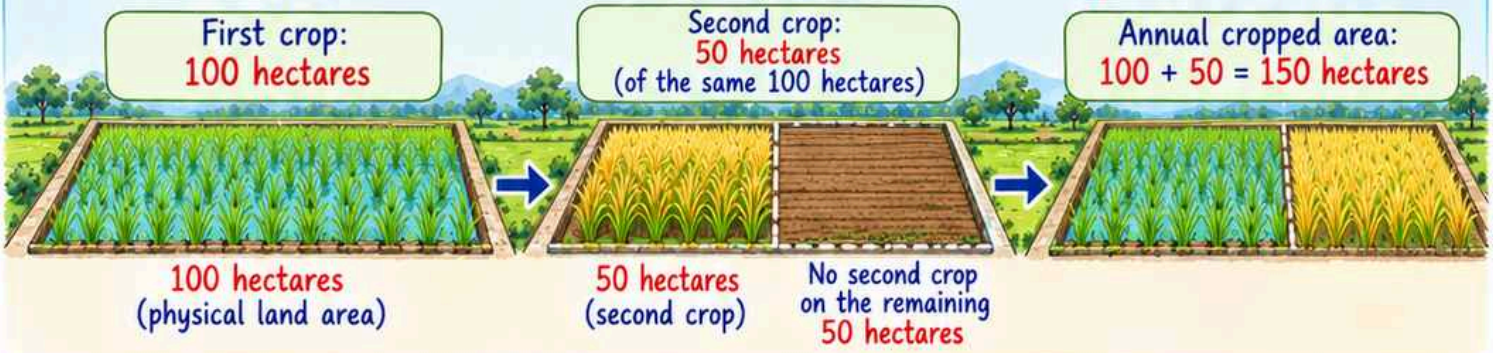
Right main canal: 178.81 km; planned irrigation 3.2 lakh acres.



The left canal is on the east bank; the right canal is on the west bank and carries the Krishna diversion.

150% IRRIGATION INTENSITY: A WORKED EXAMPLE

If 100 hectares receive one crop and 50 of those hectares receive a second crop, the annual cropped area is 150 hectares. The physical land is still 100 hectares.
On the displayed 7.2 lakh-acre base, 150% gives 10.80 lakh crop-acres over a year.



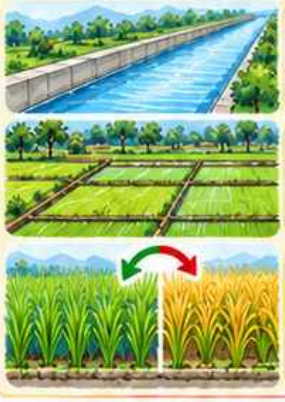
STABILISATION

Stabilisation means a more reliable supply to land that is already irrigated.
Planned delta-stabilisation areas:



These existing areas are separate from new command area.

THREE DIFFERENT MEASUREMENTS



Canal length measures a water route in kilometres.

Command area measures land in hectares or acres.

Annual irrigation counts crop seasons, so it can exceed the physical land area.

Sources: S2, S10

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Dam engineering: structures, levels and storage

Design example: MAY 2024

- Two earth-cum-rock-fill sections total 2,314 metres; the concrete section adds 153.5 metres.
- Combined dam sections: 2,467.5 metres.
- The separate spillway is 1,121.2 metres long.

How the structures work

- The dam retains water.
- A diaphragm wall in the foundation reduces seepage.
- The spillway passes floodwater downstream.
- A concepttial schematic shows functions, not a scale drawing.

Different flood questions

In the 2020 evaluation, about 50 lakh cusecs was the dam-safety design flood; 36 lakh cusecs was the backwater-study flood.

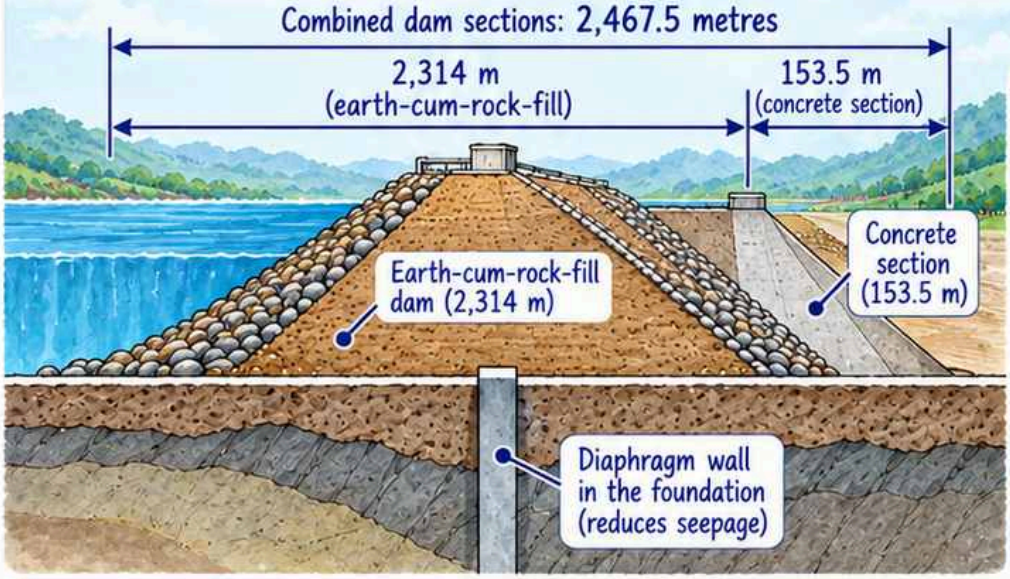
Spillway safety and upstream backwater effects are different engineering questions.

These dated study assumptions do not establish the resolution of every later environmental or interstate issue.

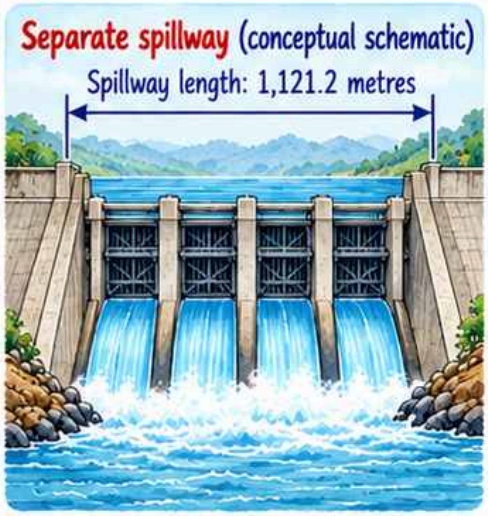
50 lakh cusecs for dam safety (2020)

36 lakh cusecs for backwater studies (2020)

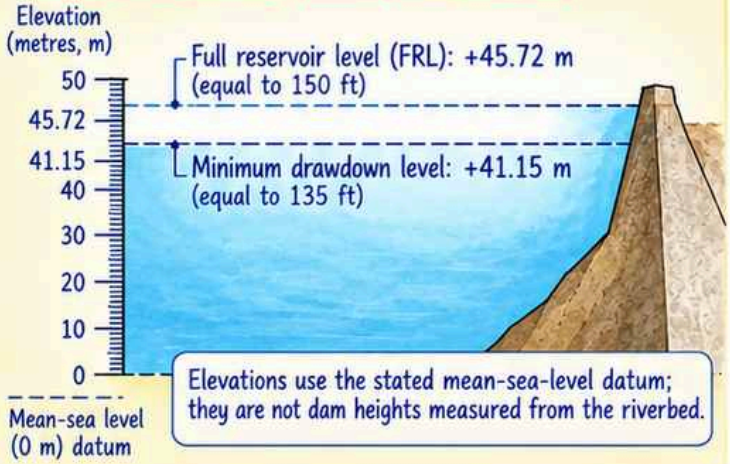
Dam and foundation (conceptual schematic)



Separate spillway (conceptual schematic)



Reservoir levels (conceptual section)



Storage in this design example

- Gross storage: 194.60 TMC.
- Live storage: 75.20 TMC.
- Dead storage: 119.40 TMC.

75.20 + 119.40 = 194.60

Live storage is the usable volume between the minimum drawdown and full reservoir levels; gross storage also includes the volume below the minimum drawdown level.

Phase I scope

10 AUGUST 2026:

Phase I approval concerned storage up to +41.15 m.

This staged storage level differs from the full reservoir level of +45.72 m.

Sources: S2, S5, S8, S10

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Benefits and rehabilitation measure different outcomes

Planned canal-route drinking water

1 August 2024: 28.5 lakh people in 540 villages along the canals were planned to receive domestic water.

This is the canal-route village component, not a count of every urban and rural beneficiary.



Planned hydropower

12 units × 80 MW = 960 MW installed capacity.

Planned capacity does not mean every unit is generating.



Water uses and people

Water benefits include irrigation, delta stabilisation, industrial supply and the Krishna diversion.

These benefits do not remove the need to rehabilitate displaced families.



Displacement snapshot

10 August 2026:

Project-displaced families in all	96,660
Families physically shifted under Phase I, up to EL +41.15 m	17,892

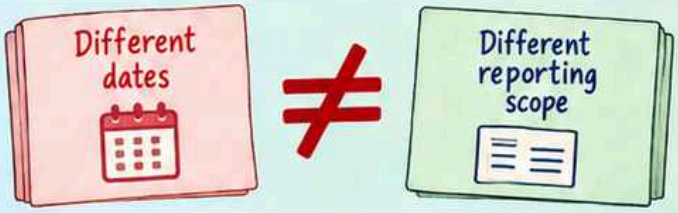
Rehabilitation snapshot

March 2023:

Total project-displaced families to be rehabilitated	1,06,006
Families recorded as rehabilitated	11,677

Match the denominator

The two snapshots differ in date and reporting scope. Physical shifting and rehabilitation are not automatically identical measures. A percentage needs the same date, population and definition in its numerator and denominator.



Three separate outcomes

A completed spillway, planned electricity capacity and completed rehabilitation are three separate claims.



A completed spillway | Planned electricity capacity | Completed rehabilitation

Sources: S2, S11, S18, S19

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Cost: keep price level and project stage together

Approved costs cannot be compared without their price year and project scope.

1. 2010-11 prices (Lok Sabha)

Price year	2010-11
Rupees crore	Rs 16,010.45 crore
Project scope	for the whole project, including Rs 12,294.40 crore for the irrigation component, as reported to Lok Sabha on 8 February 2018.

2. RCC estimates for FRL +45.72 m

Price year	2013-14
Rupees crore	Rs 29,027.95 crore
	2017-18
	Rs 47,725.74 crore
Project scope	Revised Cost Committee estimates for FRL +45.72 m.

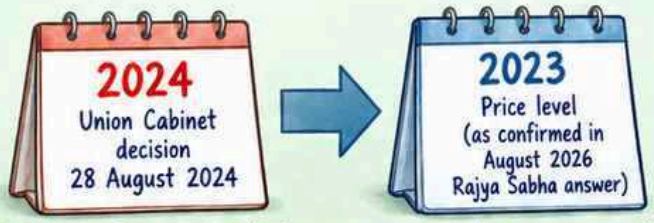
3. Union Cabinet decision

Price year	2023
Rupees crore	Rs 30,436.95 crore
Project scope	for Phase I storage up to +41.15 m.
Balance central grant	Rs 12,157.53 crore

Union Cabinet decision, 28 August 2024.

4. Rajya Sabha answer

Price level	2023
Rupees crore	—
Project scope	Confirms the 2023 price level.



"Approved in 2024" does not mean "2024 prices".



The lower first-stage figure is not a reduction of the full-FRL RCC estimate on an identical basis.

The 2016 funding arrangement covered the remaining irrigation-component cost from 1 April 2014, subject to its stated cost-date limit. It did not promise central payment for every component. The later Cabinet approval must be read separately.

Sources: S5, S6, S8, S11

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Funding decisions and unfinished works

Key funding decisions (timeline)

5 June 2023



the Department of Expenditure had no objection to Rs 10,911.15 crore for storage up to +41.15 m, plus Rs 2,000 crore for flood-damage repairs, subject to Cabinet approval.

25 July 2024



Lok Sabha was told that Phase I was targeted for March 2026.

28 August 2024



Cabinet approved the revised first-stage cost.

9 October 2024



Rs 2,348 crore was released as an advance.

4 December 2025



cumulative central assistance was reported as Rs 20,658 crore.

Construction progress (10 August 2026)

Construction snapshot: 10 August 2026.
Progress is earthwork / concrete / steel:

	Earthwork	Concrete	Steel
Spillway	96.87%	98.84%	92.95%
ECRF dam and connectivities	75.56%	81.99%	81.31%
Main canals	98.96%	88.44%	55.68%



These component measures show unfinished work. They are not an overall October 2026 completion percentage and must not be averaged.



The reply retains March 2026 with provision for a one-year extension; it does not prove an extension was granted or announce a revised completion date.

Sources: S5, S7, S8, S9, S11

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Submergence, clearances and exam distinctions

State concerns

Odisha and Chhattisgarh's concerns centre on submergence and displacement.

- Odisha's concerns include tribal land in Malkangiri;
- Chhattisgarh's concern includes border areas.

2020 NGT committee assessed affected families

The 2020 NGT committee reproduces assessed affected-family figures of 1,002 in Odisha and 2,335 in Chhattisgarh.

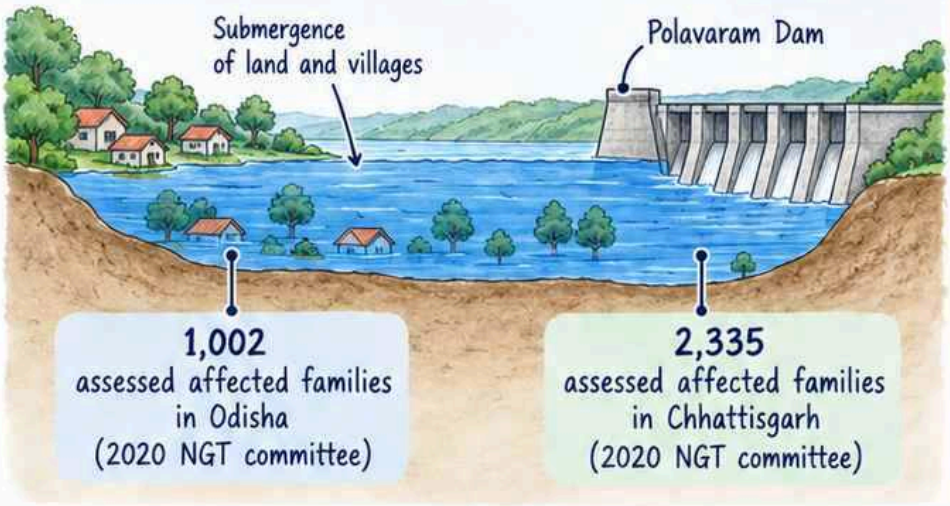
These historical assessments are not current completed-rehabilitation totals.

Legal requirement

Section 90(4) requires environmental and forest clearances and compliance with R&R norms.

A national-project declaration does not waive those duties.

Submergence and affected families



Three linked obligations



All three are required under Section 90(4), and a national-project declaration does not waive those duties.

Polavaram–Banakacherla



Keep Polavaram–Banakacherla separate: the Ministry discussed it as a proposed link in December 2025.

A proposal or litigation about that link is not automatically the same issue as the statutory Polavaram Irrigation Project.

Final distinctions

Godavari dam	↔	Krishna diversion
New command area	↔	Stabilisation of existing ayacut
Land area	↔	Annual cropped area at 150% intensity
Live storage	↔ Gross storage ↔	Yearly transfer

Full FRL +45.72 m	↔	Phase I +41.15 m
Statutory Union responsibility	↔	Construction by AP's Water Resources Department
A dated official measurement	↔	An unsupported claim of current completion

Sources: S1, S9, S10, S11

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Read the ocean floor

Ocean relief means the shape of the floor beneath the water. Tectonic movement, volcanism and sediment deposition create its mountains, plains and trenches.

Much of the ocean floor lies roughly **3–6 km** below sea level.

Mean ocean depth is about **3,682 m**; a mean is different from a depth range.

Major divisions and smaller features

Four major divisions

1. Continental shelf
2. Continental slope
3. Deep sea plain
4. Oceanic deeps or trenches

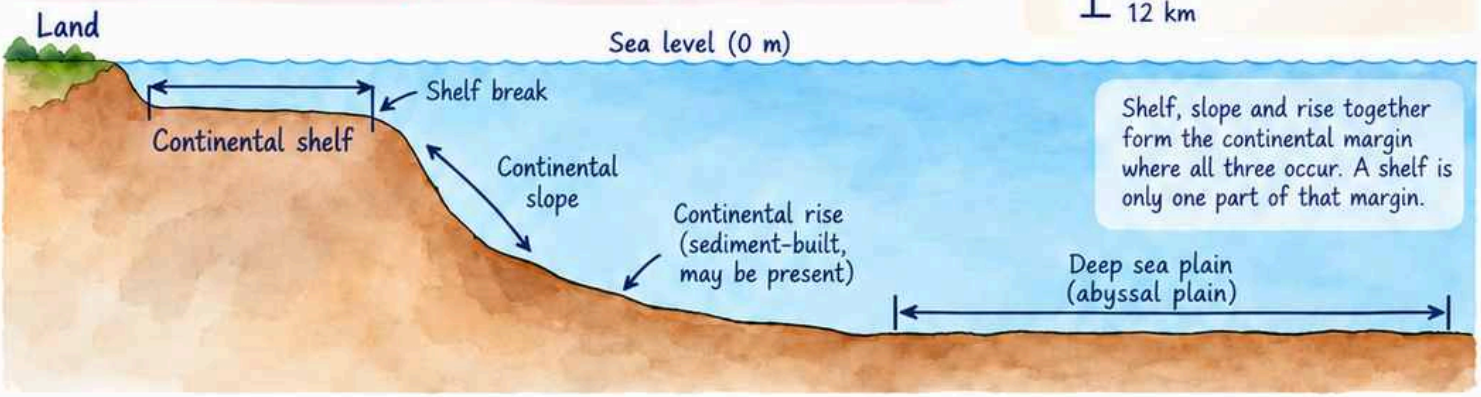
Five minor features

1. Mid-oceanic ridges
2. Seamounts
3. Submarine canyons
4. Guyots
5. Atolls

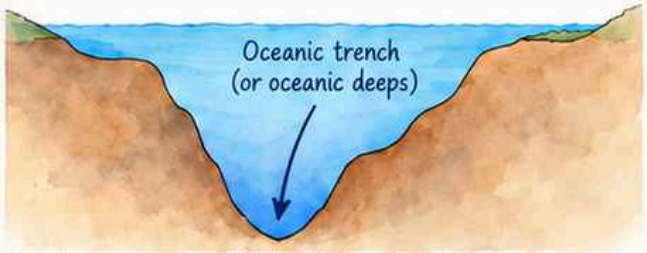
Depth guide (below sea level)



Generic ocean floor profile (schematic, not to scale)



Subduction trench (at a particular plate margin)



Trenches occur at particular plate margins; every cross-section does not contain every feature. The deep sea plain is especially flat, while trenches are deepest.

Minor features (schematic sketches, not to scale)



- **Mid-oceanic ridges**: Underwater mountain chains formed by volcanism.
- **Seamounts**: Isolated volcanic mountains rising from the seafloor (but not to sea level).
- **Submarine canyons**: Deep valleys cut into continental shelves and slopes.
- **Guyots**: Flat-topped seamounts (older, eroded volcanoes).
- **Atolls**: Ring-shaped reefs, usually formed on or around sunken volcanoes.

Reading the profile

Read the profile from land to a shelf, then a steeper slope and a deep basin. A sediment-built continental rise may lie between slope and plain. This is a schematic route, not a compulsory sequence.

Distinguish three measurements

- Depth below sea level (vertical distance downward).
- Height above the local seabed (vertical distance upward).
- Horizontal width (distance along the seafloor).

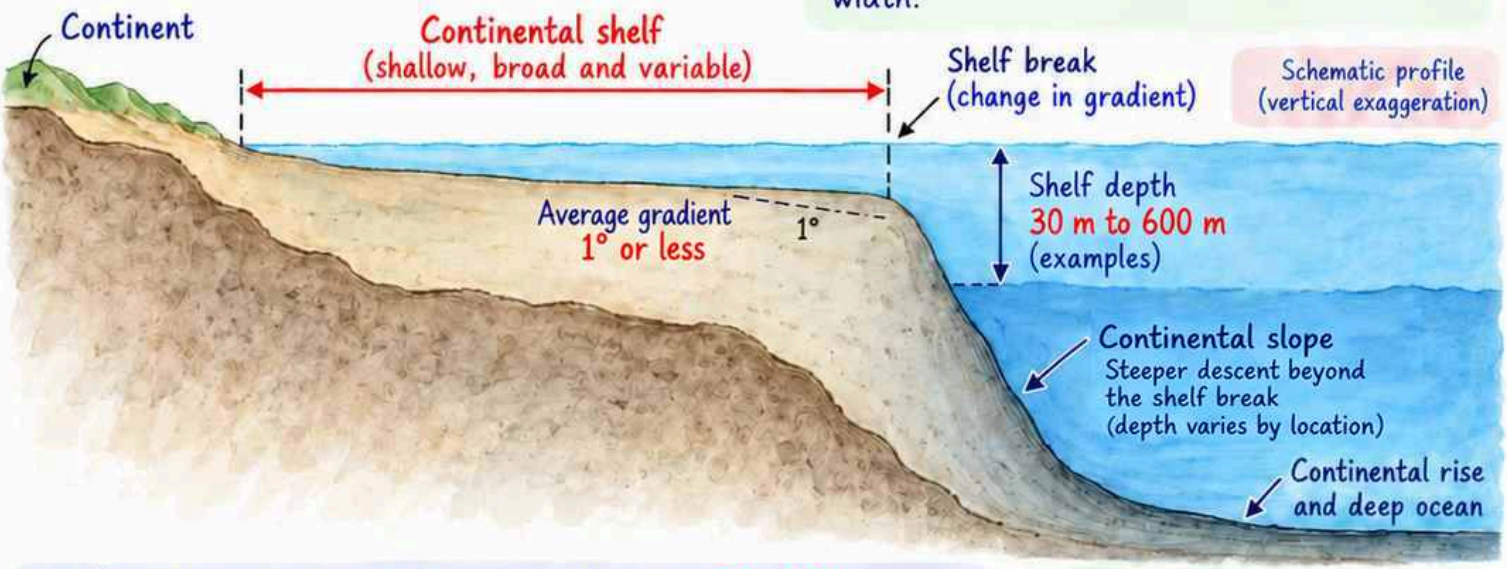
Topic link Topic 116 introduced the oceans; this topic explains their floors.

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Continental shelf: shallow, broad and variable

The **continental shelf** is the submerged extension of a continent, occupied by relatively shallow seas and gulfs. It ends where the sea floor becomes markedly steeper: the **shelf break**.

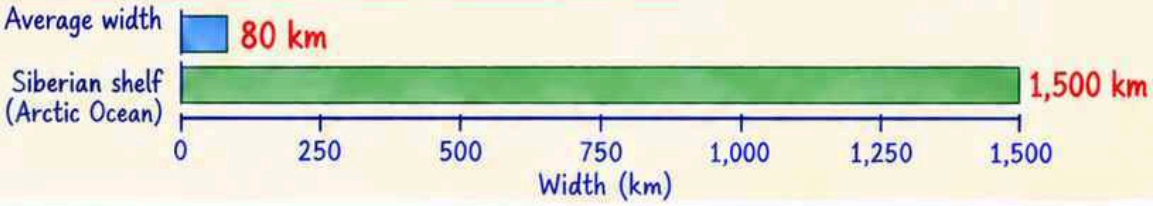
Continental shelves are gently sloping, commonly 1° or less, with an average width of about 80 km. Width varies greatly. Shelves are almost absent or very narrow along some coasts, including Chile on the Pacific coast of South America. The broad Siberian shelf in the Arctic Ocean reaches about 1,500 km in width.



Shelf depths vary: illustrative examples span 30–600 m. These values describe different locations, not a universal depth band. The shelf break is a marked change in gradient; its depth is not fixed globally at 200 m.

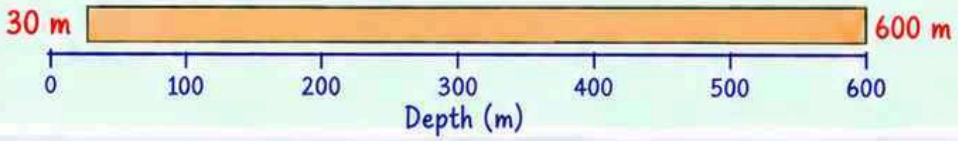
Rivers, glaciers and wind supply sediment of variable thickness. Long accumulation of sedimentary deposits helps explain offshore fossil-fuel resources.

Continental shelf width: comparison



Width varies greatly. Shelves are almost absent or very narrow along some coasts, including Chile on the Pacific coast of South America.

Illustrative shelf depths at different locations



These depths illustrate different locations, not a universal band.

Average shelf gradient (slope)

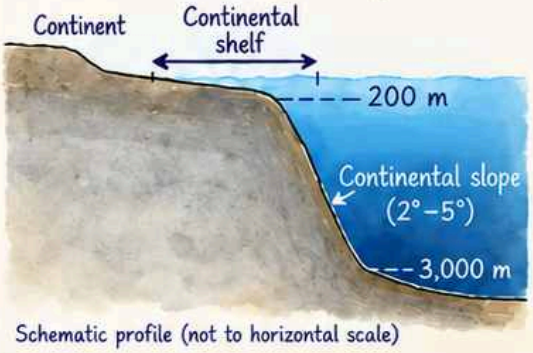


A gentle shelf gradient is commonly 1° or less.

Sources: S1

Slope, plain and trench: three different measures

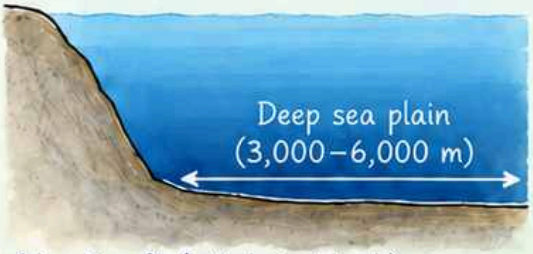
1. Continental slope



Schematic profile (not to horizontal scale)

- The continental slope connects the shelf to the ocean basin.
- An illustrative range is a gradient of 2°–5° and depths of 200–3,000 m.
- The slope forms the transition from the continental shelf towards the deep ocean basin.
- Canyons and trenches can occur in this region.

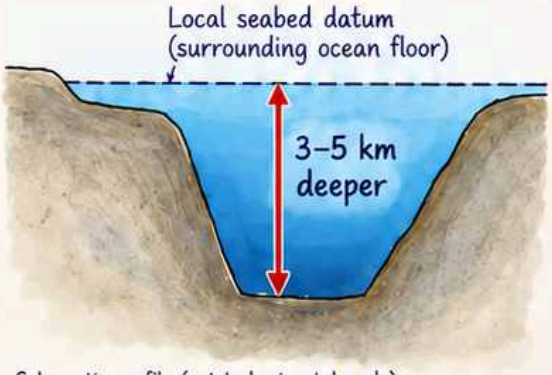
2. Deep sea plain



Schematic profile (not to horizontal scale)

- A broad depth range for deep sea plains is 3,000–6,000 m.
- Fine clay and silt cover these gently sloping, extremely flat regions.
- "Flattest" does not mean "deepest".

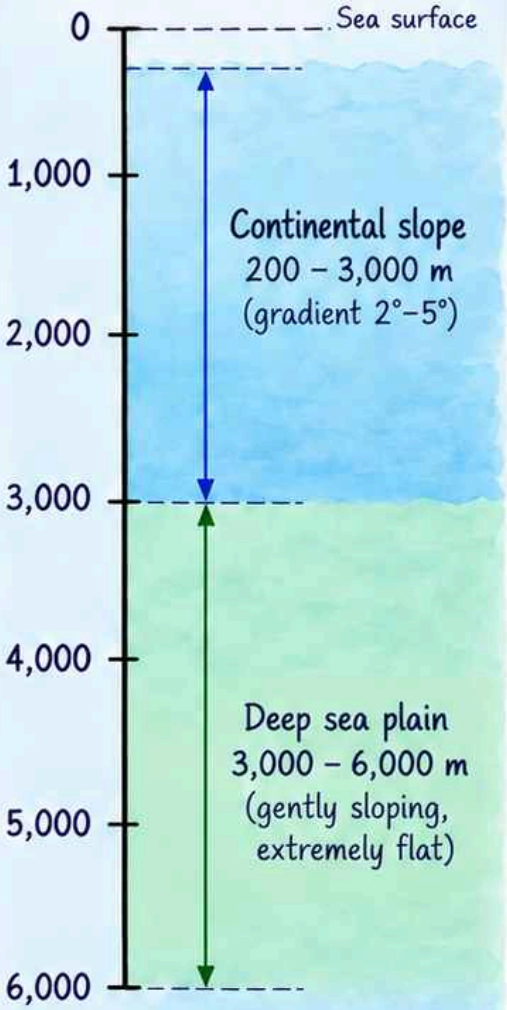
3. Oceanic deeps or trenches



Schematic profile (not to horizontal scale)

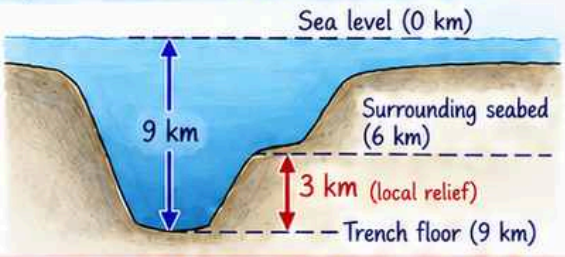
- Oceanic deeps or trenches are narrow, steep-sided basins, associated with active volcanoes and strong earthquukes.
- They occur at continental-slope bases and along island arcs.
- The 3–5 km figure shown is depth below the surrounding ocean floor. It is relative relief, not depth below sea level.
- Many trenches mark convergent boundaries where one plate descends beneath another.
- Subduction is not a required last stage of every ocean-floor profile.

Illustrative depth ranges (below sea level)



ABSOLUTE DEPTH ≠ RELATIVE RELIEF

Depth below sea level
Measured from the sea surface to the seabed.



Depth below surrounding seabed
Measured from the nearby ocean floor to the trench floor.

Illustrative example: surrounding seabed 6 km below sea level + trench relief 3 km = trench floor 9 km below sea level.

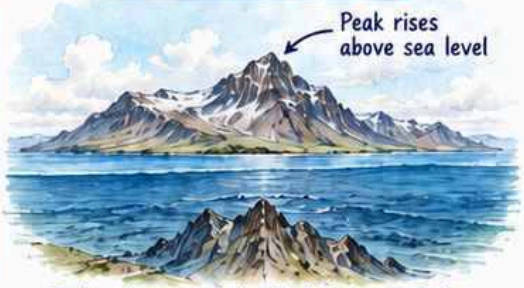
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Mid-ocean ridges: height is not water depth

Ridge relief

Mid-ocean ridges are underwater mountain systems formed where plates spread apart. Slow-spreading ridges commonly have a central rift valley. Some ridge peaks emerge above the sea. Iceland lies on the Mid-Atlantic Ridge, its example.

Iceland (emergent peak)

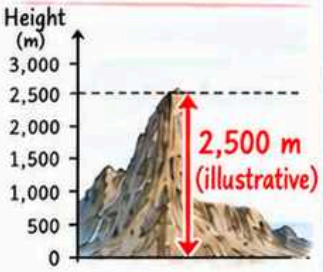


Iceland, part of the Mid-Atlantic Ridge

Water depth to the ridge top

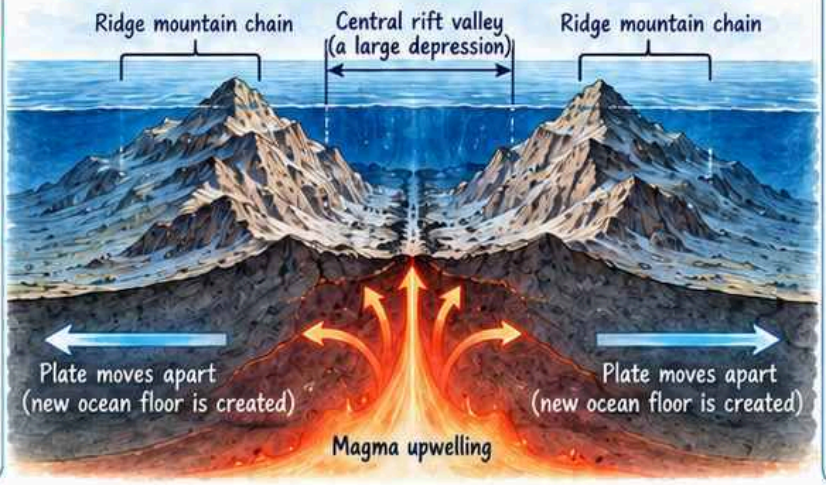
The global mid-ocean ridge system extends nearly 65,000 km, with more than 90% underwater. The average water depth to the ridge top is about 2,500 m.

Illustrative height above the local seabed

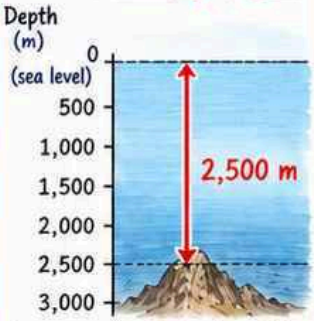


Illustrative relief: a summit 2,500 m above its local base. This example is not a universal ridge height.

Schematic cross-section of a mid-ocean ridge (not to scale)



Average water depth to the ridge top



Average depth to the ridge top is about 2,500 m below sea level.

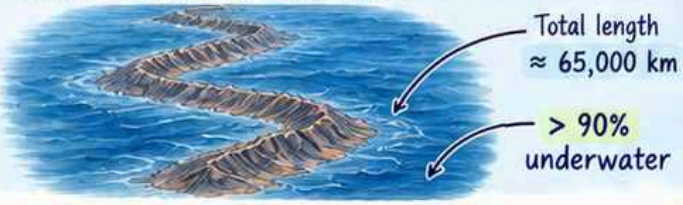
Different meanings of the same number

Height is measured upward from the local seabed.
Water depth is measured downward from sea level.

The illustrative 2,500 m height and the approximately 2,500 m average water depth use different reference levels; they need not describe one location.

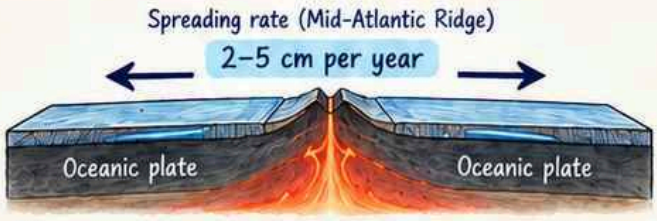
A global mid-ocean ridge system

The global ridge system is nearly 65,000 km long, with more than 90% underwater.



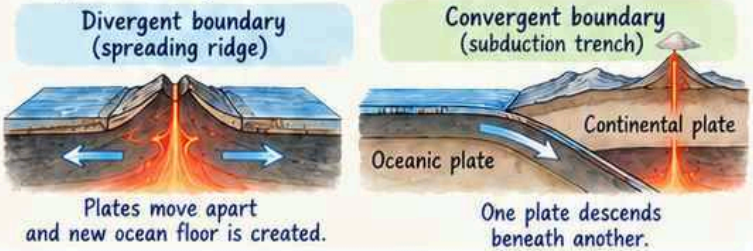
Formation at divergent boundaries

Ridges form at divergent boundaries: plates spread apart and new ocean floor is created. The Mid-Atlantic Ridge spreads slowly, about 2–5 cm per year. Its central rift valley is a deep depression between the ridge flanks.



Contrast the mechanisms

At a spreading ridge, plates move apart; at a subduction trench, one plate descends beneath another. These opposite boundary processes create different relief. Plate tectonics is revisited in Topic 286, Day 29.



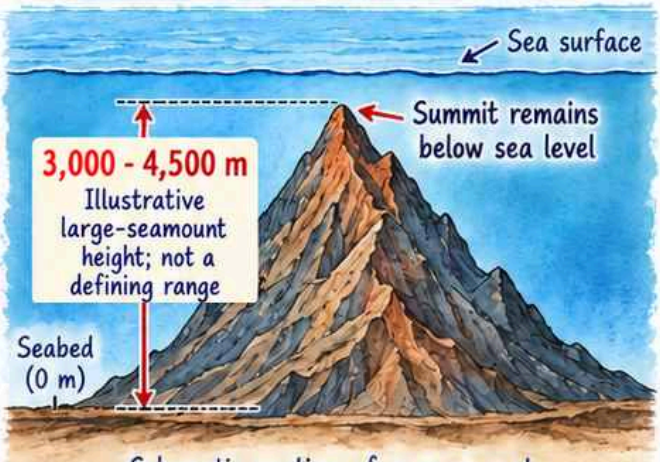
Sources: S1, S4, S18.

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Seamount, guyot and atoll

Seamount

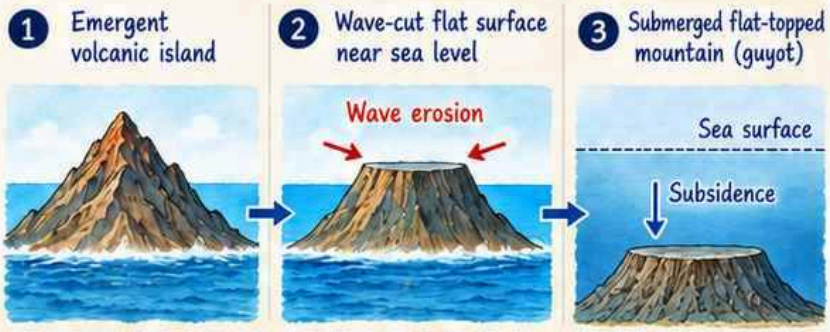
A seamount is an underwater mountain rising from the seabed. Most are volcanic; shapes and heights vary. Large examples rise several thousand metres without reathing the surface.
The Hawaiian–Emperor chain contains islands and submerged volcanic mountains in the Pacific.



Schematic section of a seamount (volcanic mountain with pointed summit)

Guyot

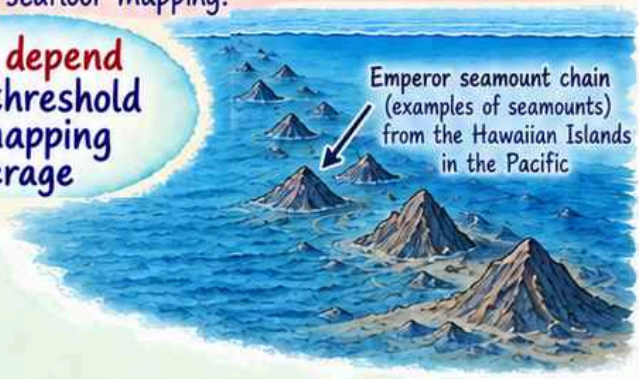
A guyot is a flat-topped type of seamount. Seamount shapes vary.
A volcanic island can be flattened by wave erosion near sea level, then subside below the surface. Subsidence alone does not cut a summit flat.



Process of guyot formation (schematic section)

Seamounts occur throughout the oceans. Their estimated number depends on the minimum height counted and the coverage of seafloor mapping.

Counts depend on size threshold and mapping coverage

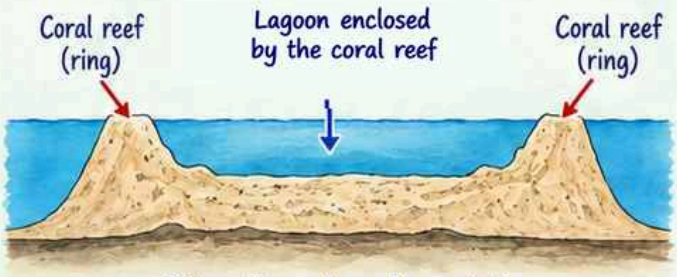


Atoll

An atoll is a ring-shaped coral reef surrounding a lagoon. Lagoon conditions vary with rainfall, evaporation and exchange with the open ocean.



Top view of an atoll (schematic)



Schematic section of an atoll

Read the forms by shape and process: pointed submerged mountain, flat-topped submerged mountain, and coral ring around central water. Atoll and guyot are different features.
Coral reefs and their types return in Topic 625, Day 63.

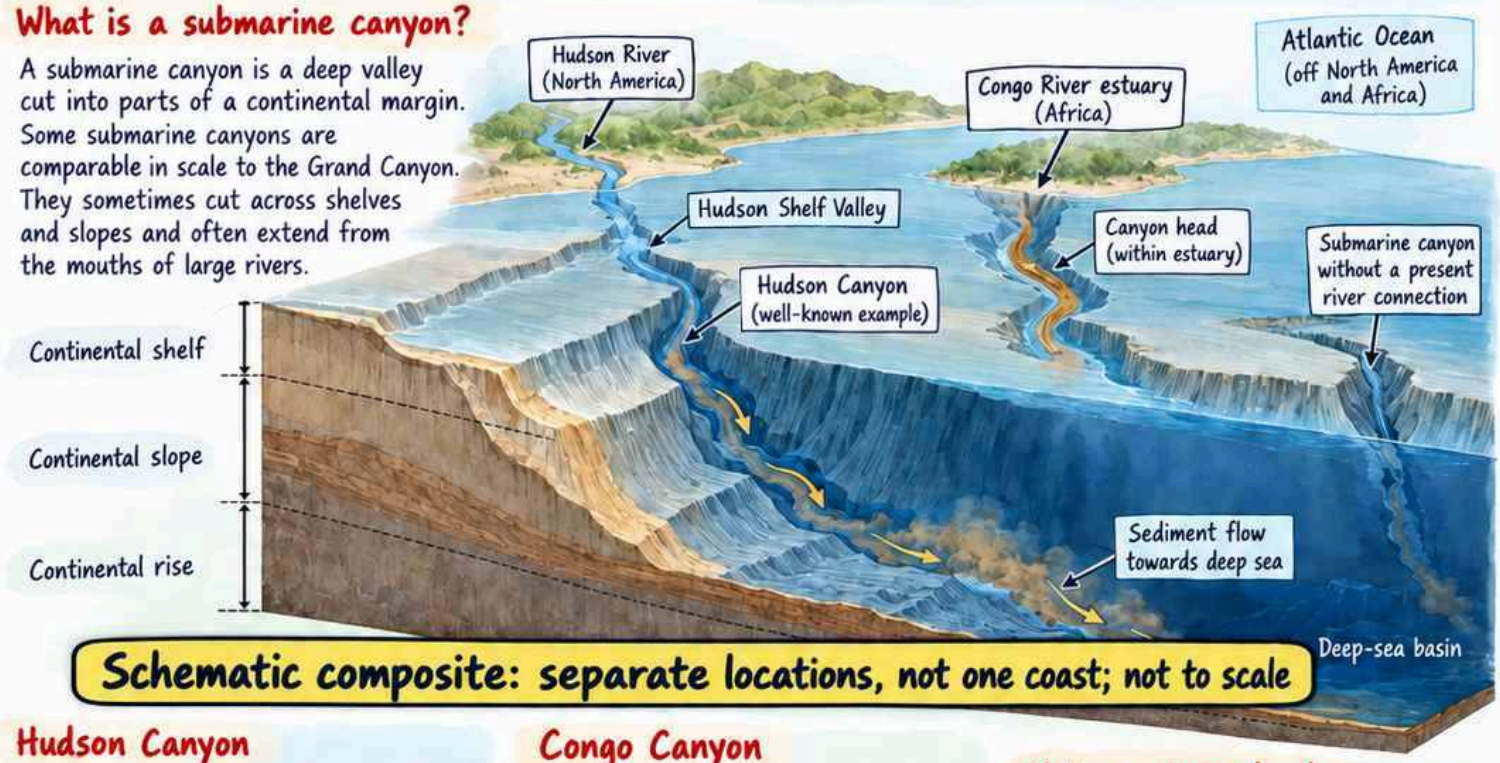
Sources: S1, S7, S8.

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Submarine canyons carry sediment downslope

What is a submarine canyon?

A submarine canyon is a deep valley cut into parts of a continental margin. Some submarine canyons are comparable in scale to the Grand Canyon. They sometimes cut across shelves and slopes and often extend from the mouths of large rivers.



Hudson Canyon

Hudson Canyon is a well-known example. It lies off the Atlantic coast of North America, seaward of the Hudson River, connected through the Hudson Shelf Valley. The canyon is connected to the river through the Hudson Shelf Valley; it is not simply the present river channel.

Congo Canyon

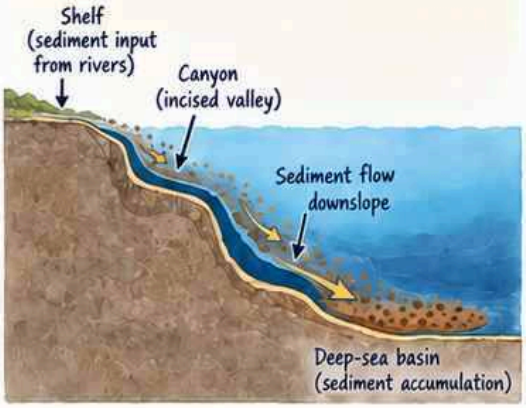
Congo Canyon lies off the Atlantic coast of Africa. Its head lies within the Congo River estuary. River-connected canyons can efficiently transfer sediment towards the deep sea.

Not a universal rule

Not every submarine canyon begins at a present-day river mouth. "Often" is important: the examples illustrate a connection, not a universal definition.

Role in sediment transfer

River-connected canyons can efficiently transfer sediment from continental shelves and slopes towards the deep sea.



Canyon vs trench

Submarine canyon



- Incised valley crossing parts of a continental margin.
- May act as a sediment pathway.
- Can cut across shelves and slopes.
- Often extend from the mouths of large rivers (but not always).

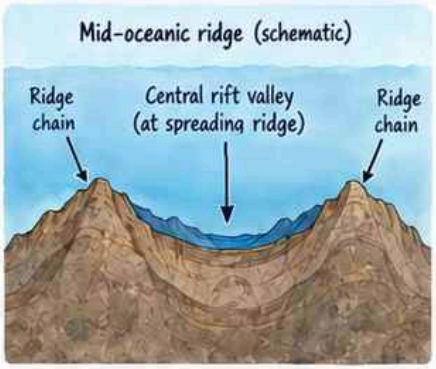
Subduction trench



- Long, narrow, exceptionally deep basin.
- Associated with particular tectonic settings.
- Different from a canyon.

Not a mid-oceanic ridge

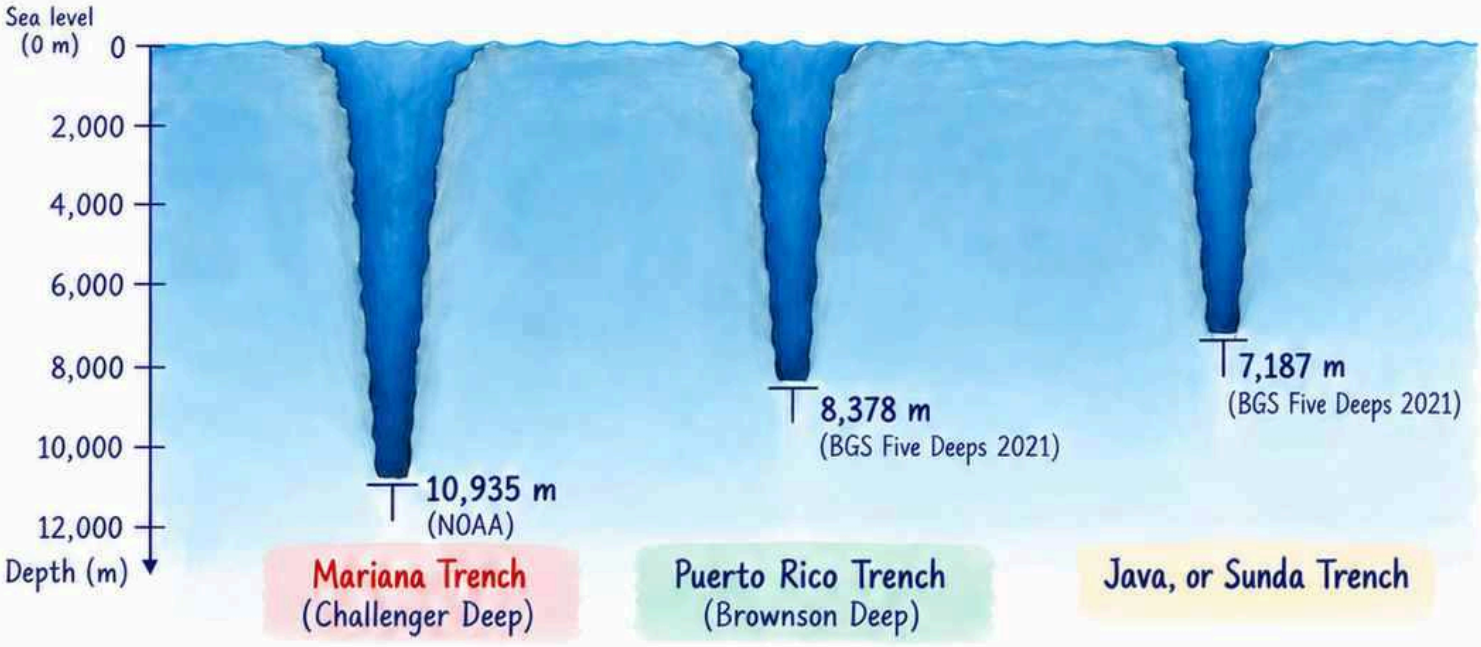
A submarine canyon differs from a central rift valley at a spreading ridge.



Sources: S1, S10, S11

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Named trenches: keep each survey beside its depth



Mariana Trench



Mariana Trench lies in the western Pacific, near the Mariana Islands and east of Guam. Challenger Deep, near its southern end, is the deepest known ocean point. The trench is an elongated landform; the deep is a specific place within it. One current reference estimate is approximately 10,935 m (35,876 feet); survey estimates differ.

Puerto Rico Trench



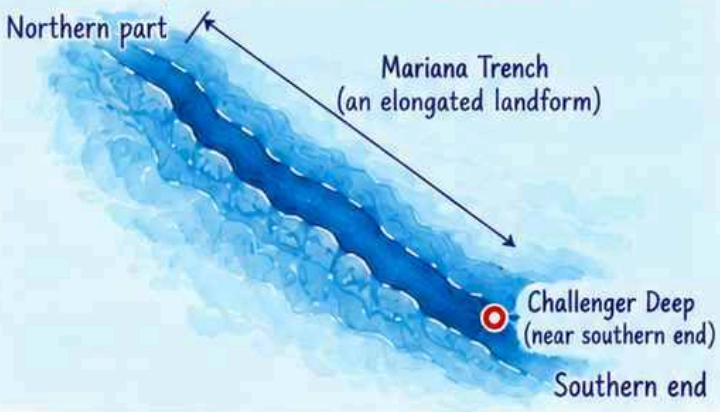
Puerto Rico Trench lies in the North Atlantic, north of Puerto Rico. Brownson Deep was measured at approximately 8,378 m in the Five Deeps survey published in 2021, identifying the Atlantic's deepest surveyed point in that dataset.

Java, or Sunda Trench



Java, or Sunda Trench lies in the eastern Indian Ocean, off Sumatra and Java. The Five Deeps survey measured the Indian Ocean's deepest point here at approximately 7,187 m; the descent took place in 2019 and the survey was published in 2021.

Schematic plan view of Mariana Trench (not to scale)



Survey note: different estimates

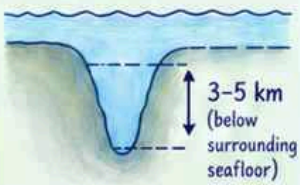
Depth estimates depend on survey and method. The 2021 Five Deeps estimate for Challenger Deep is approximately 10,924 m; another reference estimate is approximately 10,935 m. These are separate measurements, not the limits of a single official range.

BGS (2021, Challenger): 10,924 m

Alternative reference estimate: 10,935 m

Relative relief versus sea-level depth

An illustrative 3–5 km trench relief is measured below the surrounding seafloor. It is not the sea-level depth of any named trench.

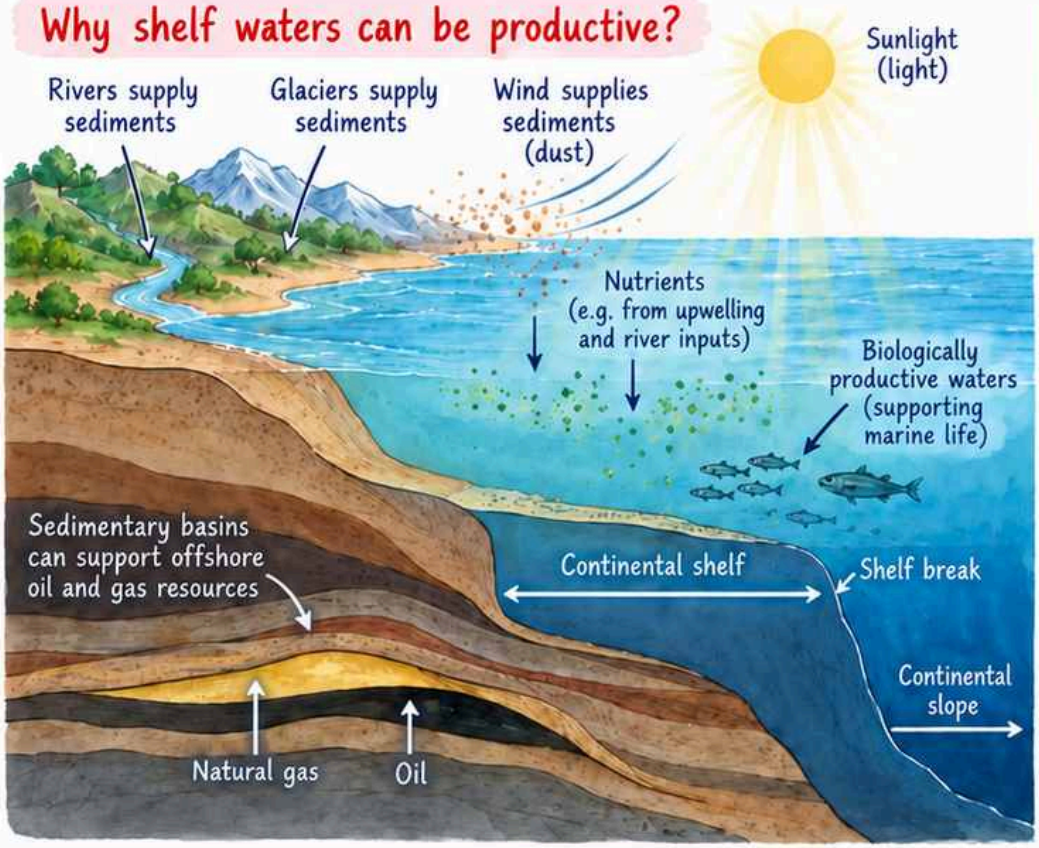


Sources: S1, S3, S5.

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India's shelf: resources, examples and limits

Why shelf waters can be productive?



Example: Mumbai High

Mumbai High is an important offshore oil and gas field in the Arabian Sea, near Mumbai, operated by ONGC.



1974 Discovered in 1974.

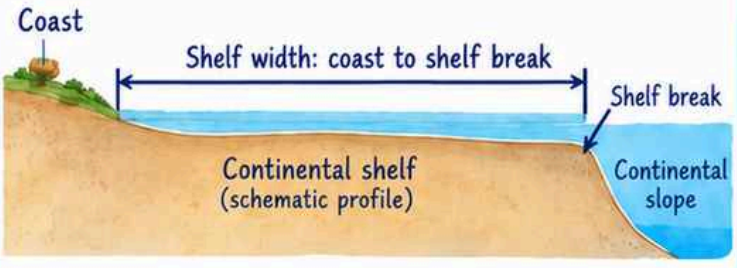
1976 Production beginning in 1976.

These dates provide a clear Indian example of offshore hydrocarbon development.

Two measurements of a continental shelf

Shelf width: horizontal distance

Shelf width is the horizontal distance from the coast to the shelf break. It varies along a continental margin; one coastal section cannot represent every coast.

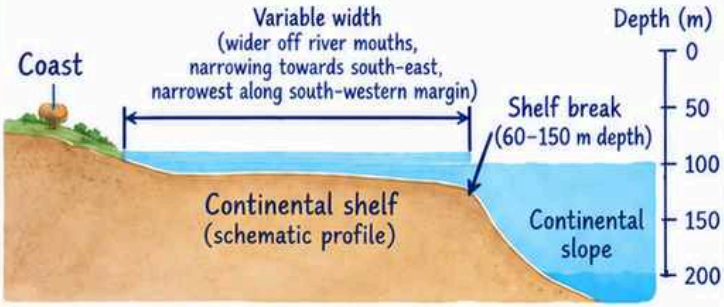


Width and depth are different measurements. Both profiles are schematic and do not share a comparative width scale.

Shelf-break depth: vertical measurement

Western Indian margin

Along the western Indian margin, the shelf is wider off river mouths, narrows towards the south-east, and is narrowest along the south-western margin. Shelf-break depths vary roughly from 60 to 150 m.



Shelf waters can support fisheries, and sedimentary basins may contain hydrocarbons. Resource occurrence varies with geology and ocean conditions.

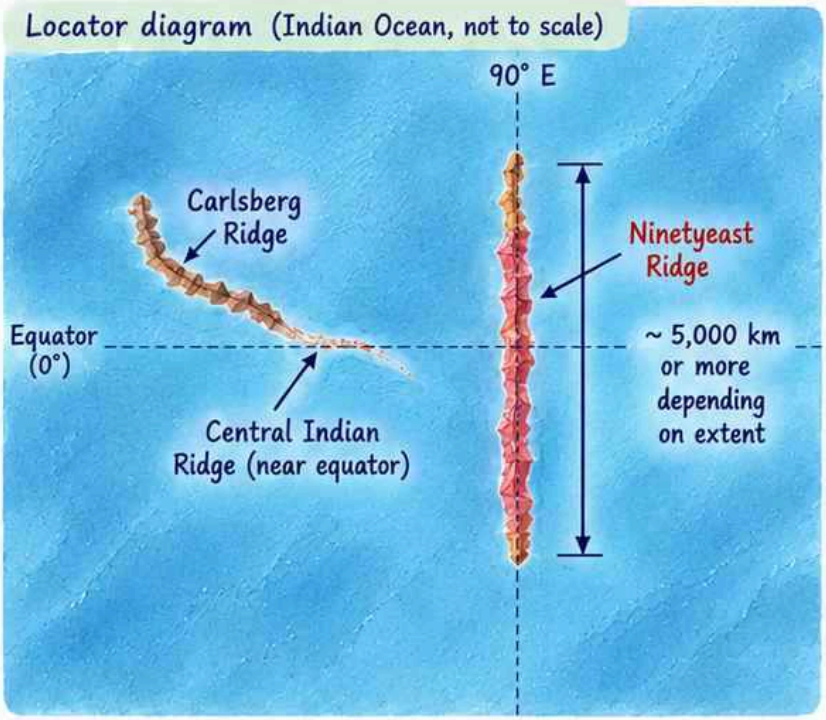
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Indian Ocean ridges: hotspot trail versus spreading boundary

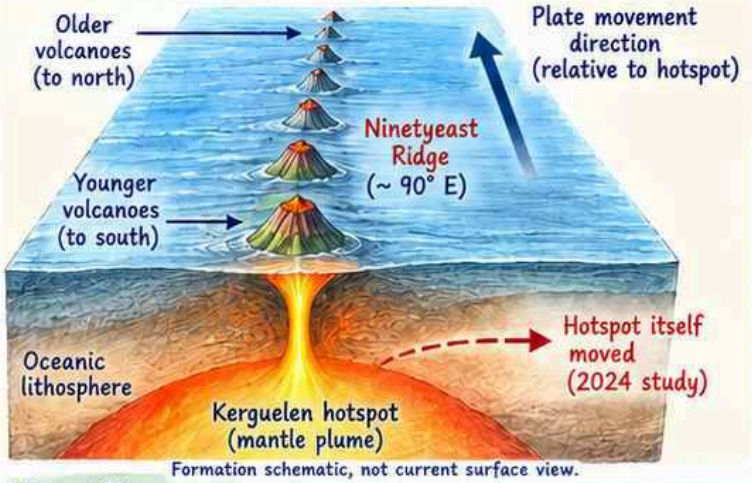
Key points

- Ninetyeast Ridge is a long volcanic ridge roughly along 90° E in the Indian Ocean. Its measured length depends on which extensions are counted; modern studies describe roughly 5,000 km or more, including buried parts.
- It records Kerguelen-hotspot volcanism and plate movement. A 2024 study shows that the hotspot itself moved. The older label "aseismic ridge" distinguisbes its origin from an active spreading ridge; it does not mean earthquakes never occur. Deformation and earthquakes occur on and around Ninetyeast Ridge.
- Carlsberg Ridge is an active, slow-spreading mid-ocean ridge in the north-western Indian Ocean and Arabian Sea region. It forms a divergent boundary between the Indian and Somali plates and joins the Central Indian Ridge system near the equator. Seismic and volcanic activity accompany spreading.
- Compare the mechanisms: Ninetyeast Ridge is a hotspor-built volcanic trail; Carlsberg Ridge is an active plate-spreading boundary between the Indian and Somali plates. They represent different formation mechanisms.
- The Andaman Sea is a marginal sea in the north-eastern Indian Ocean. The Andaman and Nicobar islands are emergent parts of submarine mountain systems. Topic 136 supplies the wider coastal and island context.

Locator diagram (Indian Ocean, not to scale)

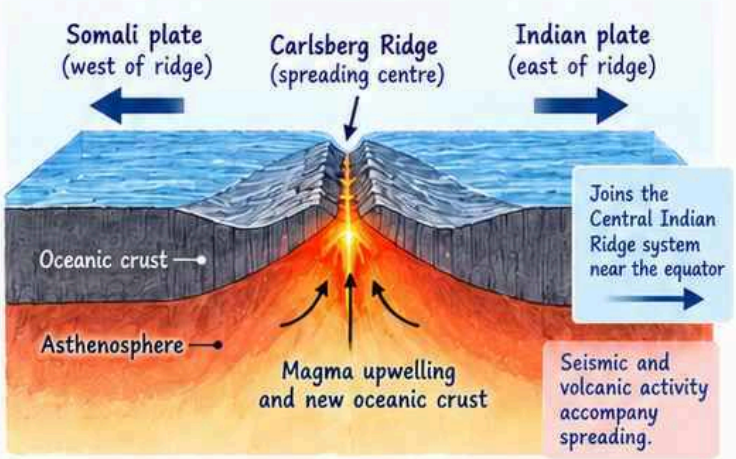


Ninetyeast Ridge – hotspot-built volcanic trail



Formation schematic, not current surface view.

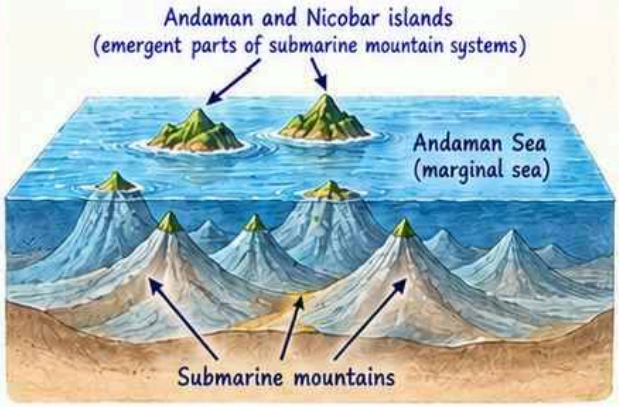
Carlsberg Ridge – active, slow-spreading mid-ocean ridge



Key differences

Aspect	Ninetyeast Ridge	Carlsberg Ridge
Origin	Hotspot-built volcanic trail (Kerguelen hotspot)	Active mid-ocean ridge (spreading boundary)
Tectonic setting	Intraplate (hotspot track)	Divergent boundary between Indian and Somali plates
Volcanic activity	Records past hotspot volcanism	Active volcanism with spreading
Seismicity	Deformation and earthquakes occur on and around the ridge ("aseismic ridge" does not mean no earthquakes)	Seismic and volcanic activity accompany spreading
Plate motion link	Records plate movement and a 2024 study shows the hotspot itself moved	Formed by seafloor spreading; joins the Central Indian Ridge near the equator
General character	Long volcanic ridge (~ 5,000 km or more)	Active, slow-spreading mid-ocean ridge

Andaman Sea – emergent parts of submarine mountain systems



Sources: S2, S14, S15, S16, S17, S18, S19.

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Census 2011: Understanding Provisional and Final Figures

Distribution tells us where people live; density measures people per unit area; growth measures change over time. ORGI, under the Ministry of Home Affairs, conducts the Census. The 2011 national count refers to 1 March 2011.

	FINAL CENSUS FIGURES	PROVISIONAL CENSUS FIGURES
Population	1,210,854,977  Schematic people icons, not to scale	1,210,193,422  Schematic people icons, not to scale
2001–11 growth	17.7%	17.64%
Density	382 persons/km²	382 persons/km²
Sex ratio	943	940 females per 1,000 males
Literacy	73.0% final	74.04% provisional

Final total = 121.09 crore = 1,210.85 million; Approximately 1,210 million.

Urban and rural shares: 2011 release status



Urban 31.16% (provisional)



Rural about 68.8% (provisional, rounded)

Final urban share: 31.14%.

India's share in the world (2011 context)



17.5% of world population

2.4% of world area

These are historical comparisons, not 2026 population shares.

Provisional totals are assembled soon after enumeration. Validation and processing can revise the totals and derived indicators.

Compare figures for the same reference year and territorial boundaries. State whether each figure is provisional or final.

YEAR + BOUNDARY + RELEASE STATUS

Sources: S1, S2, S3, S4, S10

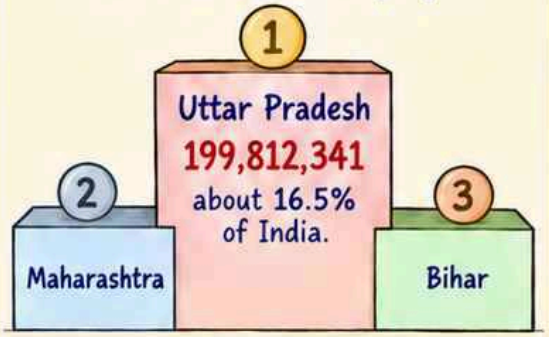
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Population Size and Density Give Different Rankings

All figures below refer to Census 2011 boundaries.

TOTAL POPULATION

State with the most people



The next three are Maharashtra, Bihar and West Bengal.

STATE DENSITY

Densest State



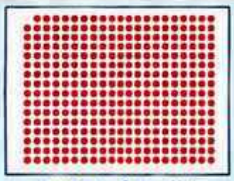


Bihar
1,106 persons/km²
(final)

ALL STATE/UT DENSITY

Densest State or Union Territory



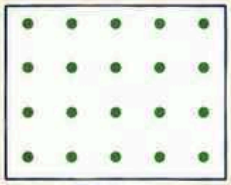


NCT of Delhi
11,320 persons/km²
(final)

Fewest People Among States

Sikkim, 610,577.

Its density is 86 persons/km²; the smallest population does not mean the lowest density.



Sikkim
86 persons/km²

Least Dense State

Arunachal Pradesh,
17 persons/km².

Its 2011 population was about 0.11% of India's total.

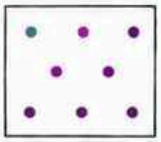


Arunachal Pradesh
17 persons/km²

Other Final Figures

Andaman and Nicobar Islands

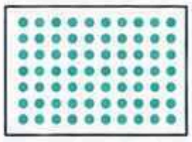
Density
46
persons/km².



46 persons/km²

Lakshadweep

Population
64,473
and density
2,149.

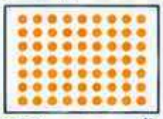


2,149 persons/km²

2011 provisional density examples

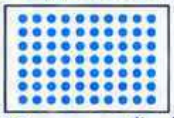
West Bengal 1,029;
Uttar Pradesh 828;
Kerala 859.
These illustrate dense northern settlement and Kerala's dense peninsular settlement.

West Bengal
1,029 (provisional)



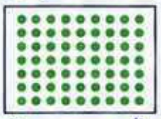
1,029 persons/km²

Uttar Pradesh
828 (provisional)



828 persons/km²

Kerala
859 (provisional)



859 persons/km²

All dot diagrams are schematic; dot counts are not proportional to Census densities.

Which State has the most people?	Which State is densest?	Which State/UT is densest?
Uttar Pradesh	Bihar	Delhi

Sources: S1, S2, S3, S4

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Undivided Andhra Pradesh and Uneven Settlement

Census 2011

Census 2011 preceded Andhra Pradesh's division in 2014. The historical State row is for **UNDIVIDED ANDHRA PRADESH:**

Population	84,580,777, about 7% of India
Density	308 persons/km²
Sex ratio	993 females per 1,000 males
2001–11 decadal growth	11.0%

2014
Andhra Pradesh's division

CHECK TERRITORIAL BASE

Do not transfer these figures to present-day Andhra Pradesh without checking the territorial base.

Present-day Andhra Pradesh

Present-State figures may differ because the territorial base has changed due to the 2014 division.

Using the provisional 2001–11 growth figures, the decline from 1991–2001 among the six most populous States was smallest in undivided Andhra Pradesh, about **3.5** percentage points, and largest in Maharashtra, about **6.7** points.

Why is population unevenly distributed?

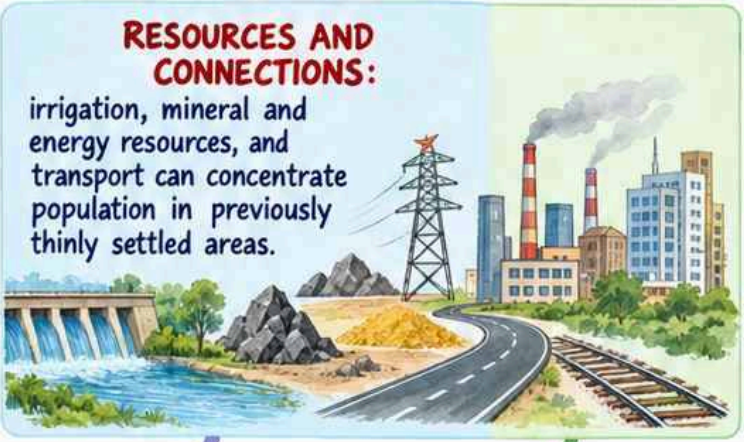
PHYSICAL:
climate, terrain and water availability.

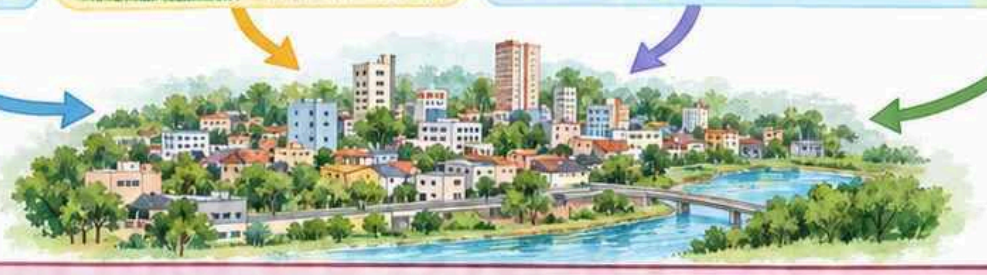


HISTORICAL AND SOCIO-ECONOMIC:
- settled agriculture and agricultural development;
- settlement patterns;
- transport networks;
- industrialisation and urbanisation.



RESOURCES AND CONNECTIONS:
irrigation, mineral and energy resources, and transport can concentrate population in previously thinly settled areas.





These factors work together; a density figure alone does not identify one cause.

Revision links: Andhra Pradesh Reorganisation Act and population ratio, Topic 14; present-State figures, Topic 275.

Sources: S1, S3, S4

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Three Density Measures: Read the Denominator

ARITHMETIC POPULATION DENSITY

Total population ÷ total area.

India's Census 2011 figure is 382 persons per square kilometre. Earlier figures were 325 in 2001 and 117 in 1951.



Total area
(e.g., 100 km²)

PHYSIOLOGICAL DENSITY

Total population ÷ net cultivated area.

This compares all people with land actually cultivated.



Net cultivated area
(e.g., 20 km²)

AGRICULTURAL DENSITY

Total agricultural population ÷ net cultivable area.

Net cultivated area and net cultivable area are different measures; the denominator changes what the ratio describes.



Net cultivable area
(e.g., 25 km²)

The two farmland-based measures must not be substituted for ordinary density. Their numerators also differ: all people versus agricultural people.

Illustrative calculation only, not an Indian Census dataset:

Total population 1,000; total area 100 km²; net cultivated area 20 km²; agricultural population 100; net cultivable area 25 km².

HYPOTHETICAL

ARITHMETIC POPULATION DENSITY	Total population 1,000 / Total area 100 km²	1,000 ÷ 100 =	10 persons/km²
PHYSIOLOGICAL DENSITY	Total population 1,000 / Net cultivated area 20 km²	1,000 ÷ 20 =	50 persons/km² of cultivated area
AGRICULTURAL DENSITY	Total agricultural population 100 / Net cultivable area 25 km²	100 ÷ 25 =	4 agricultural persons/km² of cultivable area

First identify the numerator and denominator; only then calculate or compare.

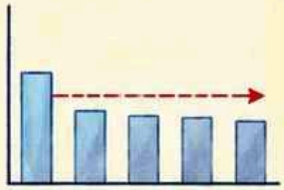
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Four Phases and the Decadal Growth Curve

FOUR BROAD HISTORICAL PHASES

I: 1901–1921
stagnant or stationary.

Growth was very low; 1911–21 was negative.



Very low growth (stagnant)

II: 1921–1951
steady growth.

Better health, sanitation, transport and communication supported growth.



III: 1951–1981
population explosion.

Mortality fell rapidly while fertility stayed high; average annual growth was about 2.2%.

Mortality fell rapidly + Fertility stayed high → **Population explosion**

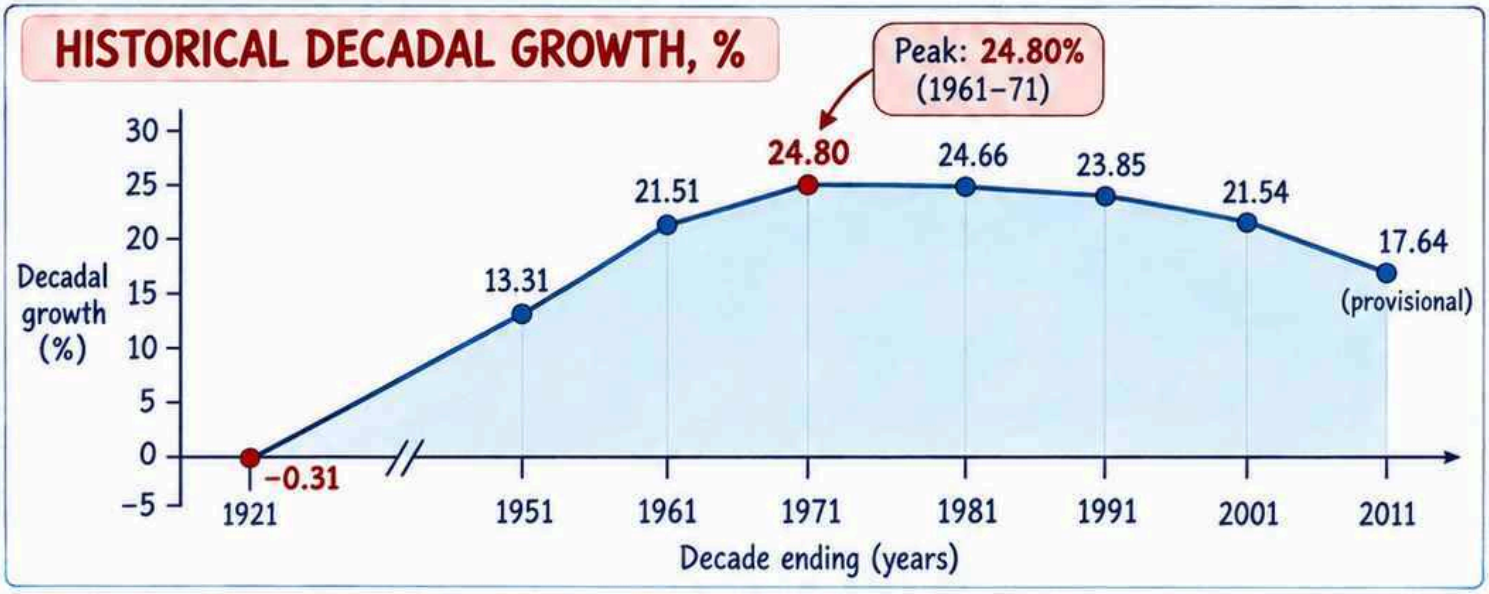
IV: after 1981
High but slowing growth.

A falling crude birth rate helps explain slower growth.



Falling crude birth rate leads to slower growth

HISTORICAL DECADAL GROWTH, %



1. Decade ending 1921: −0.31
1951: 13.31; 1961: 21.51; 1971: 24.80
1981: 24.66; 1991: 23.85; 2001: 21.54;
2011: 17.64 (provisional).

2. 1921 is the turning point in the 1901–2011 series: 1911–21 is its only negative decade. Every later decade through 2001–11 is positive.

3. The table's peak, 24.80%, belongs to 1961–71, not to the decade after 1971.

4. Population rose by over 181 million during 2001–11; average annual growth was 1.64%. Decadal growth fell about 4 percentage points from 21.54% in 1991–2001.

5. The 2011 endpoint shown is provisional. Historical growth series can differ with revisions and territorial adjustments.

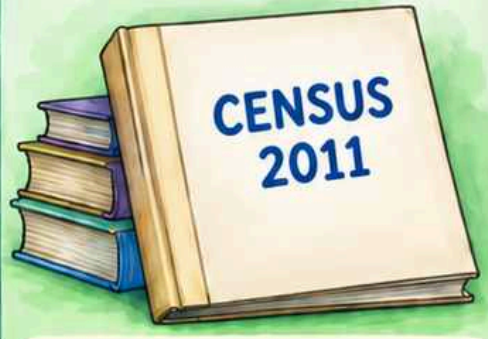
Sources: S1, S2, S5

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Census Counts and UN Projections: Different Clocks

A Census count and a United Nations estimate or projection are different kinds of evidence. Keep the reference year and publication date beside each number.

2011 POPULATION CONTEXT



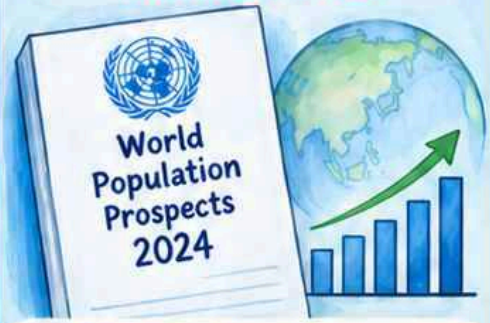
In 2011, India had the world's second-largest population, after China. This ranking describes that historical year.

24 APRIL 2023 UN ANNOUNCEMENT

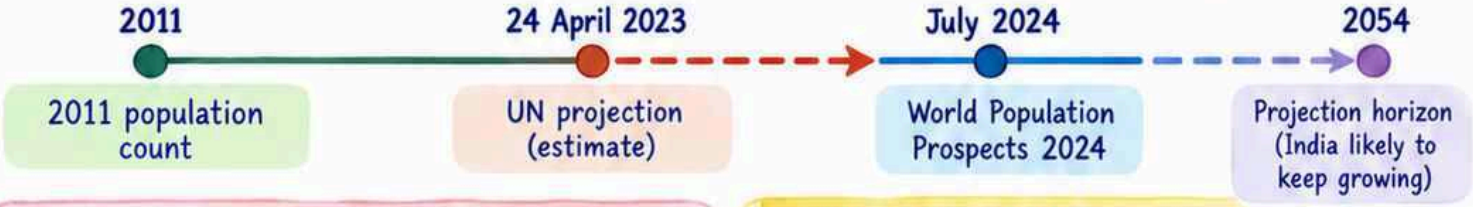


UN DESA projected India to reach 1,425,775,850 people by the end of April 2023 and surpass China as the world's most populous country. This is an estimate/projection, not a new Indian Census count.

WORLD POPULATION PROSPECTS 2024



UN DESA's Population Division prepares WPP. The July 2024 edition places world population at 8.2 billion in 2024 and India among countries whose population is likely to keep growing through 2054.



TWO DIFFERENT CLOCKS



REFERENCE YEAR

Year to which the population number actually refers.



PUBLICATION DATE

Date when the number is released, such as a census report, estimate or projection.

KEY TAKEAWAYS

- Do not present the 2011 ranking as the current ranking or relabel a projection as enumeration.
- Further study: world trends, Topic 386.
- Composition, age, sex, literacy, religion, language, child sex ratio, migration and urbanisation are covered in Topics 215, 244, 316, 325, 425 and 475.



Sources: S1, S8, S9

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Census 2027: Three Reference Dates

30 April 2025



Cabinet Committee on Political Affairs decided to include caste enumeration.

16 June 2025



Census 2027 notified in the Gazette.

12 December 2025



Cabinet approved the scheme, costing **₹11,718.24 crore.**

5 September 2026



replacement notification revised the reference-date framework.

Census 2027 is India's 16th Census and the 8th since independence.

A **reference date** is the moment to which the count refers; it is not the whole fieldwork period.

LANE 1
MOST OF INDIA



Population Enumeration scheduled for **February 2027.**

Reference: 00:00 hours, 1 March 2027.

ENUMERATION — February 2027 — 1 March 2027

LANE 2
LADAKH + SNOW-BOUND AREAS



Ladakh, and snow-bound areas of Jammu and Kashmir, Himachal Pradesh and Uttarakhand: enumeration scheduled in **September 2026.**

Reference: 00:00 hours, 1 October 2026.

ENUMERATION — September 2026 — 1 October 2026

LANE 3
FOUR EARLIER-ENUMERATION AREAS



Goa, Uttar Pradesh, Punjab and non-snow-bound Uttarakhand: enumeration **1 December 2026–4 January 2027**; revision **5–9 January 2027.**

Reference: 00:00 hours, 5 January 2027.

ENUMERATION — 1 December 2026 – 4 January 2027 | REVISION — 5 – 9 January 2027 — 9 January 2027

Do not extend the October exception to all Jammu and Kashmir.

Do not give 1 March as the reference for every area.

Schedules are plans; elapsed dates do not independently prove that fieldwork was completed.

Cutoff: 17 October 2026.

Sources: S6, S7, S11, S12, S13

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First Digital Census: Workflow and Schedule Exceptions

PHASE 1: HOUSELISTING AND HOUSING CENSUS

- The original national window was April – September 2026, with a notified 30-day period for each State or Union territory.
- This is a scheduling statement, not evidence of universal completion.

April – September 2026

Apr 2026	May 2026	Jun 2026	Jul 2026	Aug 2026	Sep 2026

Notified 30-day period for each State or Union territory.

LATER EXCEPTIONS

5 September 2026 →



Houselisting and Housing Census in Manipur was deferred until further declaration.

17 September 2026 →



Houselisting in Charaideo and Sivasagar districts of Assam received a district-specific extension.

A fieldwork extension changes the operating window. It does not establish completion of houselisting or population enumeration.

PHASE 2: POPULATION ENUMERATION

- Caste data are to be captured electronically during this phase.

Houselisting and Housing Census (Phase 1)



Homes / building checklist

Population Enumeration (Phase 2)



Data collected through mobile apps on Android and iOS.

Self-enumeration (by citizens)



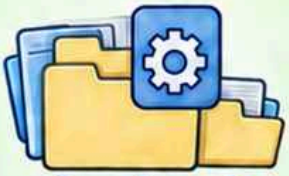
Citizens have the option of self-enumeration.

Supervised Data Pipeline



About 30 lakh field functionaries are involved: enumerators, supervisors, master trainers, charge officers and district census officers.

Census-as-a-service (CaaS)



Ministry A | Ministry B | Ministry C

Intended to supply clean, machine-readable data to ministries.

Keep four ideas separate: houselisting, population enumeration, the reference moment and a completion announcement. A digital method changes collection and data delivery; it does not remove the need for an officially notified schedule.

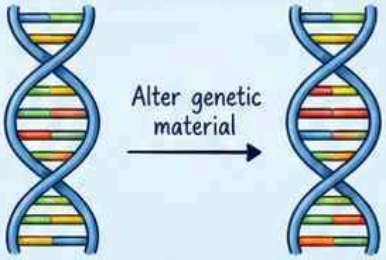
Schedule context: September 2026 notifications.

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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.

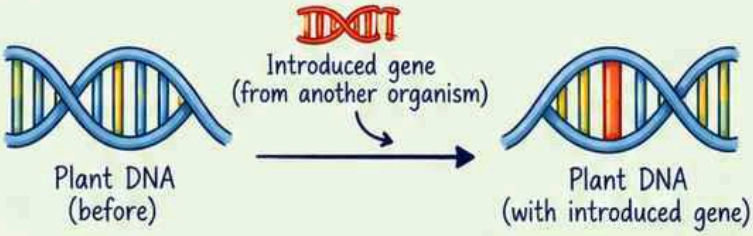

Bt cotton


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.



Conditional exemption

The exemption is conditional. Institutional Biosafety Committee oversight continues until freedom from exogenous DNA is established, with 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?

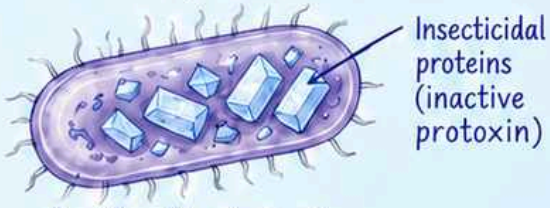
Sources: S9, S13, S27

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Bt toxin: target-specific biological action

1. Bt and its insecticidal proteins

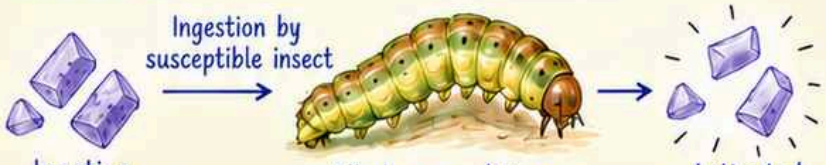
Bt stands for *Bacillus thuringiensis*, the bacterium that produces insecticidal proteins.



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.

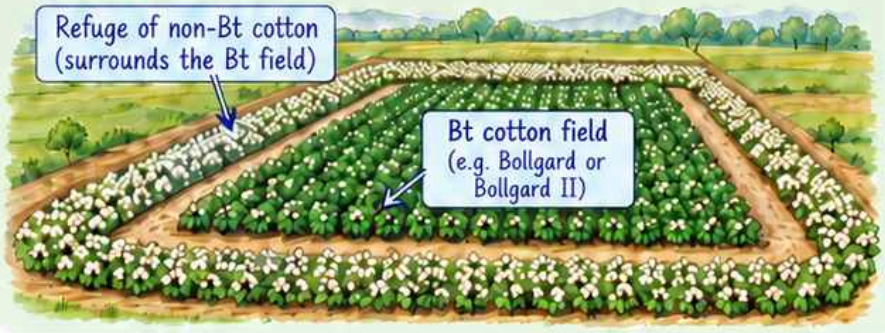
6. Regulatory approval detail

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).

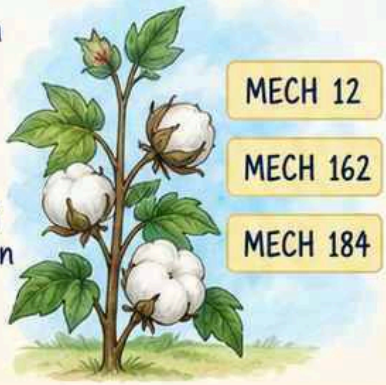
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Bt cotton: approval, adoption and resistance

1. First commercial permission (2002)

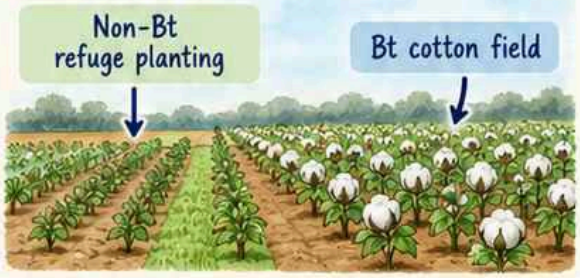
India's first commercial Bt-cotton permission covered **MECH 12**, **MECH 162** and **MECH 184**.

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

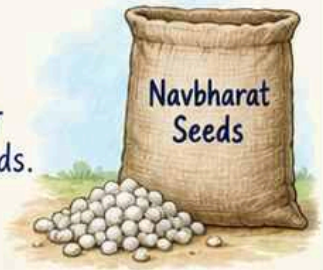
Required safeguards included non-Bt refuge planting and monitoring bollworm susceptibility.



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** — Unapproved Bt cotton sold in Gujarat in 2001.
- **March 2002** — First commercial permission for MECH 12, MECH 162 and MECH 184 (recorded in March 2002).
- **April 2002 – March 2005** — Conditional three-year cultivation period ran from April 2002 to March 2005.
- **2006** — Bollgard II introduced (2006).
- **January 2010** — Reports described pink-bollworm survival on Bollgard in Saurashtra (January 2010).
- **2014** — CICR's 2014 studies found survival on genuine Bollgard II and resistance to Cry1Ac, Cry2Ab and their combination in Amreli and Bhavnagar.
- **6 August 2024** — 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.



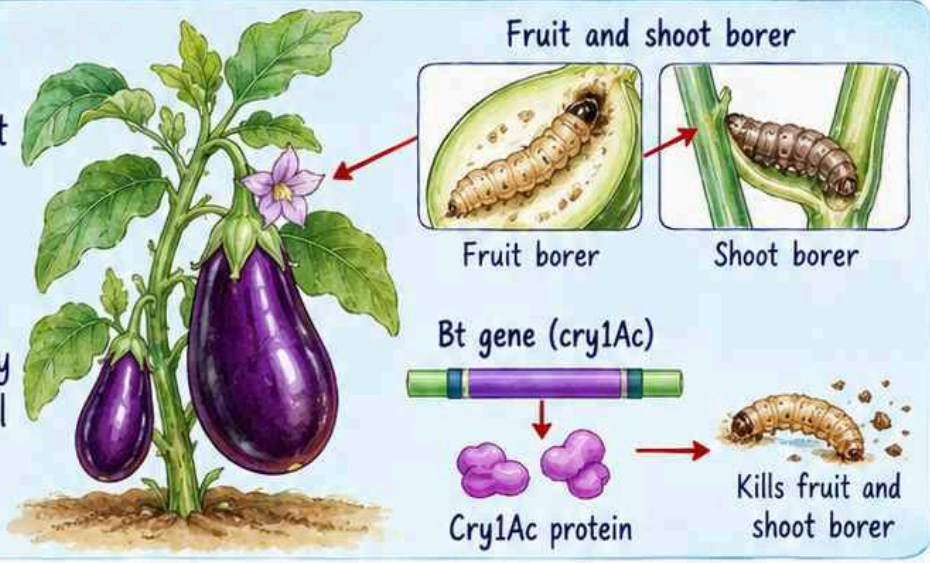
Sources: S5, S6, S7, S19, S23, S29

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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.

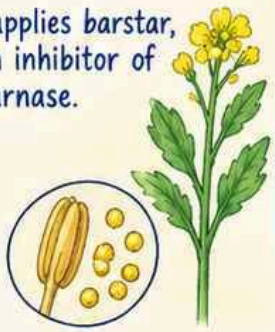


Male sterile
(no functional pollen)

×

EH-2 (male parent)

- Supplies barstar, an inhibitor of barnase.



Fertile
(produces pollen)

→

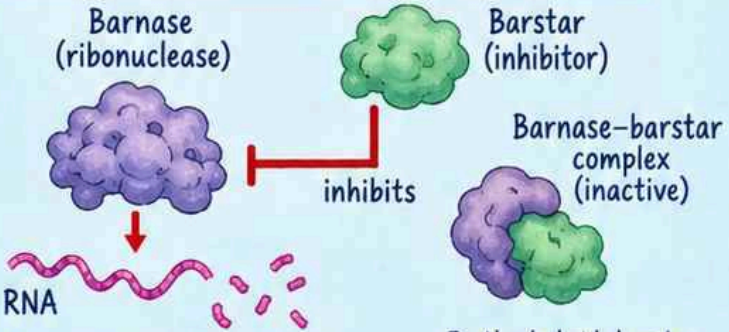
DMH-11 hybrid (fertile)

- 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.

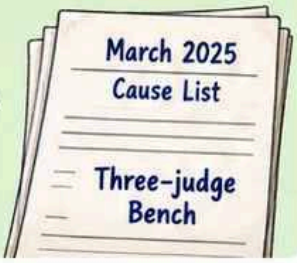
Subsequent legal developments

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.



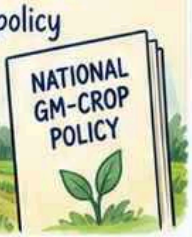
Chief Justice of India for an appropriate Bench.

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



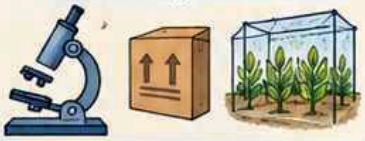
- RDAC is in DBT.
- It reviews biotechnology developments and advises on safety regulations and long-term research policy.



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

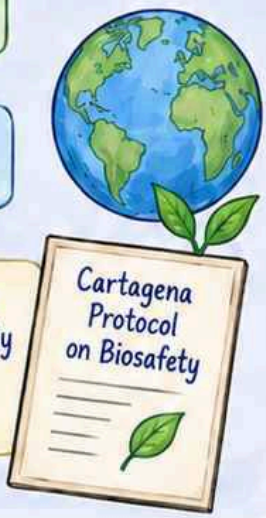


- **Section 22** restricts manufacture, distribution, sale and import of genetically modified articles of food, subject to what the Act and its regulations allow. It is not an exceptionless total ban.
- **Section 23** governs packaging and labelling; the Supreme Court's July 2024 common order applies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

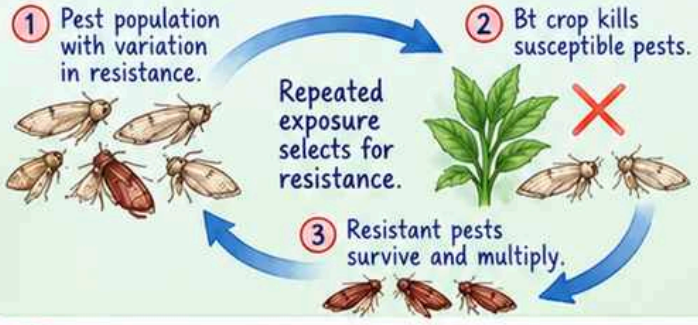
A 2012–2015 ICAR study of 2,700 farmers across 18 cotton-growing districts of Maharashtra reported higher average seed-cotton yield after Bt adoption.



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)

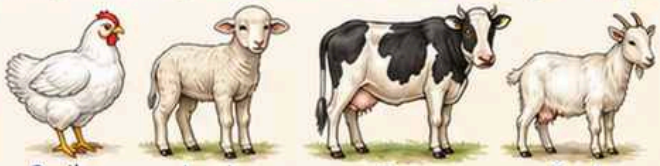


Ecological uncertainty (may affect non-target organisms)



4 Governance questions

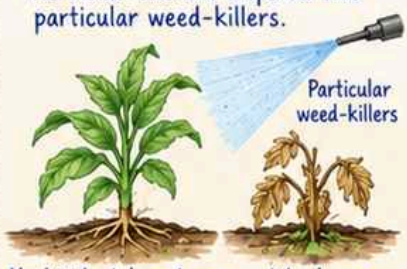
ICAR feeding studies involving broiler chickens, lambs, cows and goats found the tested feed safe. That does not prove every GM product is safe in every setting.



Broiler chickens | Lambs | Cows | Goats

Herbicide-tolerant crops

Herbicide-tolerant crops survive particular weed-killers.



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 Cyloer 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.

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

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.

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

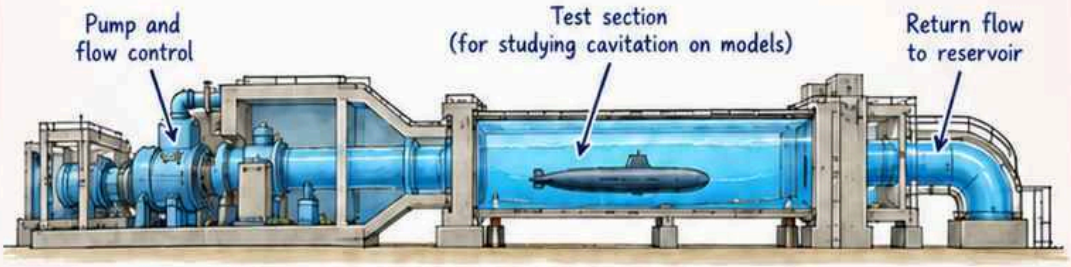
Kanpur (Uttar Pradesh)



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)



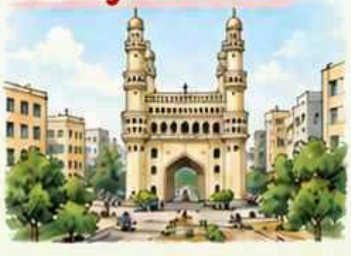
DYSL – Smart Materials
The cluster also lists DYSL–Smart Materials at Hyderabad.

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.

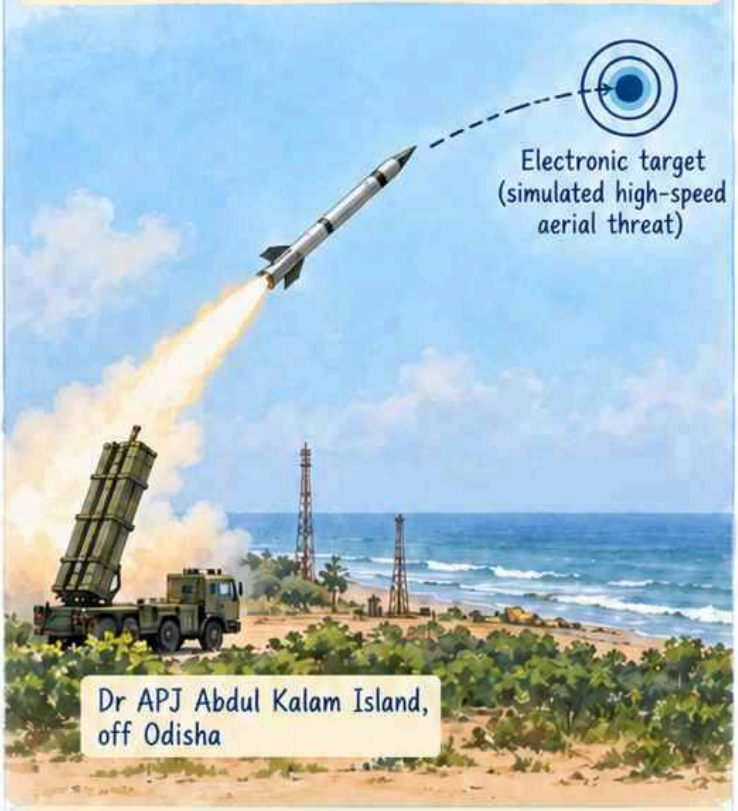
Sources: S11, S13, S22

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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.

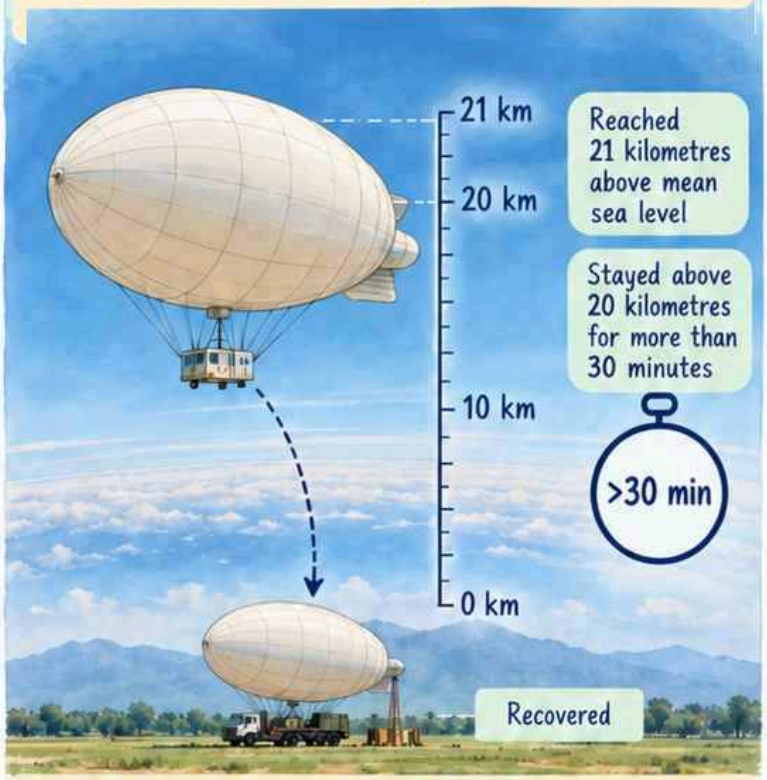


PIB describes engagement of an electronic target simulating a high-speed aerial threat.

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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Recognise the building blocks: squares 1–15

Perfect square

A perfect square is $n^2 = n \times n$.

Perfect cube

A perfect cube is $n^3 = n \times n \times n$.

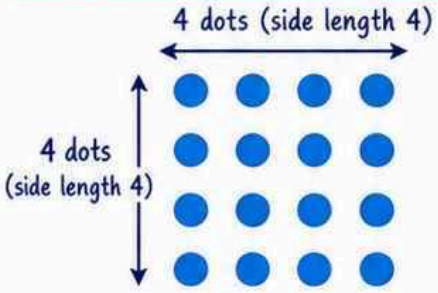
Prime number

A prime is a natural number greater than 1 with exactly two factors: 1 and itself.

Square lookup, bases 1–15:

Bases 1 – 5	Bases 6 – 10	Bases 11 – 15
$1^2 = 1$	$6^2 = 36$	$11^2 = 121$
$2^2 = 4$	$7^2 = 49$	$12^2 = 144$
$3^2 = 9$	$8^2 = 64$	$13^2 = 169$
$4^2 = 16$	$9^2 = 81$	$14^2 = 196$
$5^2 = 25$	$10^2 = 100$	$15^2 = 225$

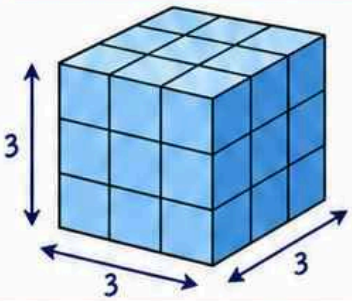
A square as an array of dots



$4^2 = 4 \times 4 = 16$

Area = 16 square units
(16 dots)

A cube as three factors



$n^3 = n \times n \times n$

For example,
$3^3 = 3 \times 3 \times 3 = 27$

How to look for a pattern in a number series

Start by reading the direction, speed and size of the steps.
Write first differences, second differences and ratios.
If these do not reveal a simple pattern, compare the terms with squares, cubes and primes.

Prime example:

7 has exactly two positive factors, 1 and 7.
Therefore 7 is prime.



About n

Here n usually means the base being squared or cubed. It need not be the position of the term: a sequence may begin at n = 3 or n = 7.

Use the lookup properly

Use the lookup as evidence, not as a guessing shortcut. A candidate rule must explain every supplied term and both neighbours of any gap.

Link to earlier learning

Topic 78 introduced the first inspection of number series.

A decision path for analysing a number series

1. Read the direction, speed and size of the steps.
2. Write first differences, second differences and ratios.
3. If these do not reveal a simple pattern, compare the terms with squares, cubes and primes.
4. Use the lookup as evidence, not as a guessing shortcut.
5. Verify that a candidate rule explains every supplied term and both neighbours of any gap.

Sources: S1, S2, S3, S4.

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Squares 16-30 and the odd-number pattern

Square lookup, bases 16–30

$16^2 = 256$	$17^2 = 289$	$18^2 = 324$
$19^2 = 361$	$20^2 = 400$	$21^2 = 441$
$22^2 = 484$	$23^2 = 529$	$24^2 = 576$
$25^2 = 625$	$26^2 = 676$	$27^2 = 729$
$28^2 = 784$	$29^2 = 841$	$30^2 = 900$

Last digit test for squares

Square endings are 0, 1, 4, 5, 6 or 9. Endings 2, 3, 7 and 8 rule out a square. The converse fails: 21 and 29 have allowed endings but are not squares.

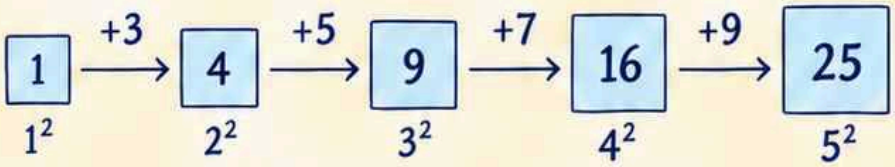
Possible last digits (can be a square)					
0	1	4	5	6	9

Impossible last digits (not a square)			
2	3	7	8

21 → allowed ending, not a square.

29 → allowed ending, not a square.

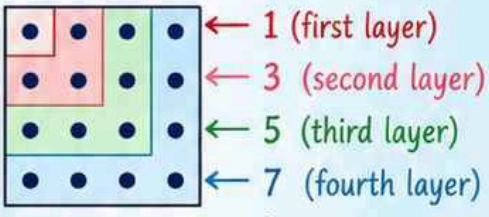
Consecutive squares differ by odd numbers



$(n+1)^2 - n^2 = 2n + 1.$

1, 4, 9, 16, 25 → differences 3, 5, 7, 9.

The first n odd numbers sum to n^2



$1 + 3 + 5 + 7 = 16 = 4^2.$

The first n odd numbers sum to n^2:

$1 + 3 + 5 + 7 = 16 = 4^2.$

Parity of squares and cubes

Even bases have even squares and cubes; odd bases have odd squares and cubes.

If n is even:
n^2 is even,
n^3 is even.

If n is odd:
n^2 is odd,
n^3 is odd.

Numbers that are both squares and cubes

Among positive integers 1–1000, exactly three are both squares and cubes: 1, $64 = 8^2 = 4^3$, and $729 = 27^2 = 9^3$.

Neighbouring terms decide which interpretation fits a series.

Sources: S1, S2, S4.

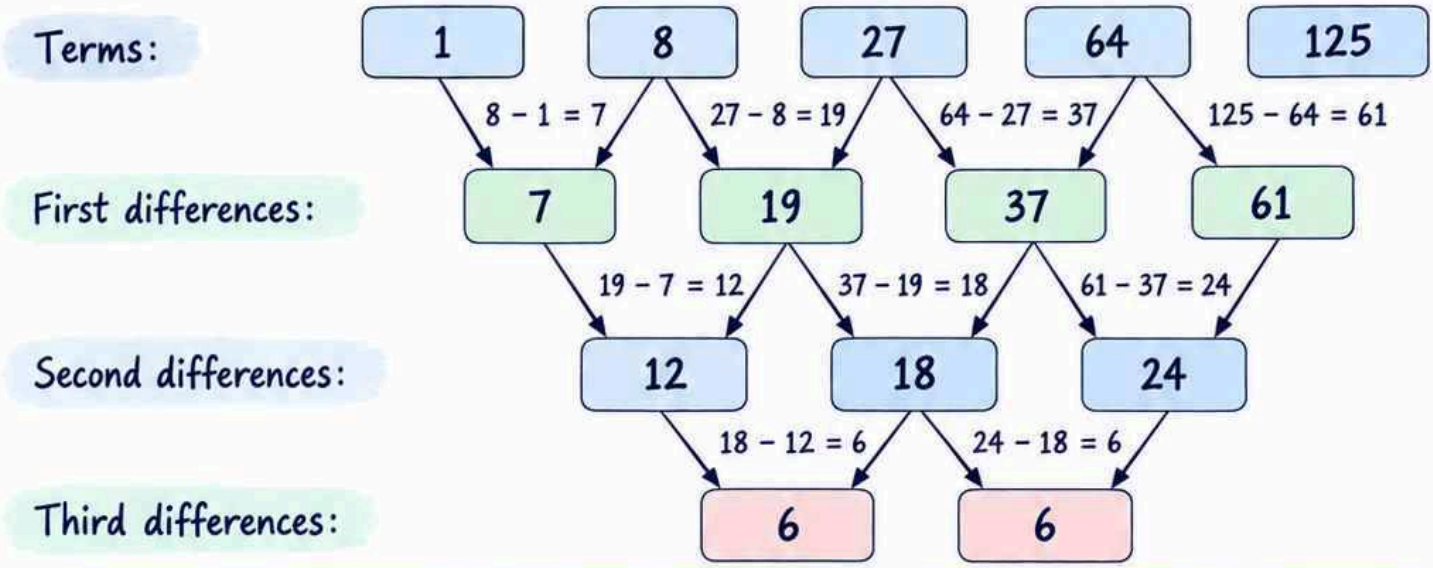
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Cubes 1–15 and three levels of differences

Cube lookup:

$1^3 = 1$	$6^3 = 216$	$11^3 = 1331$
$2^3 = 8$	$7^3 = 343$	$12^3 = 1728$
$3^3 = 27$	$8^3 = 512$	$13^3 = 2197$
$4^3 = 64$	$9^3 = 729$	$14^3 = 2744$
$5^3 = 125$	$10^3 = 1000$	$15^3 = 3375$

Difference pyramid for 1, 8, 27, 64, 125:



Unit-step bases; clue to cubic form, not proof of perfect cubes.

For consecutive integer bases, n^3 has third differences 6.
This suggests a cubic rule, but does not prove that the terms themselves are perfect cubes: $n^3 + n$ has the same third difference.

Cube last digits follow this complete map:

Base last digit	0	1	2	3	4	5	6	7	8	9
Cube last digit	0	1	8	7	4	5	6	3	2	9

Thus a cube can end in any digit. In particular, 2 and 8 exchange endings, as do 3 and 7.

Sources: S2, S4.

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Primes through 100 and the square-root test

The 25 primes up to 100

The 25 primes up to 100 are:
2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47;
53, 59, 61, 67, 71, 73, 79, 83, 89, 97.

15 primes up to 50

2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47

(15 numbers)

10 primes from 51 to 100

53, 59, 61, 67, 71, 73, 79, 83, 89, 97

(10 numbers)

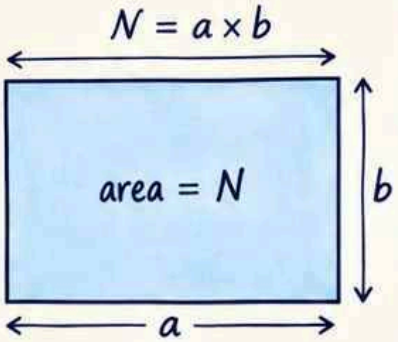
There are 15 up to 50 and 10 from 51 to 100:
$15 + 10 = 25$.

The only even prime is 2; 1 is not prime.

Square-root test

A number $N > 1$ is prime if no prime up to $\sqrt{N}$ divides it exactly.

If $N = a \times b$ is composite, at least one factor is $\leq \sqrt{N}$; that factor has a prime divisor $\leq \sqrt{N}$.



If $a > \sqrt{N}$ and $b > \sqrt{N}$, then $a \times b > \sqrt{N} \times \sqrt{N} = N$, which contradicts $N = a \times b$. So at least one factor is $\leq \sqrt{N}$.

Which primes to test (strict bounds)

Below $121 = 11^2$

test 2, 3, 5 and 7.

$N < 121 \Rightarrow$ test 2, 3, 5, 7.

Below $169 = 13^2$

also test 11.

$N < 169 \Rightarrow$ test 2, 3, 5, 7, 11.

Below $289 = 17^2$

also test 13.

$N < 289 \Rightarrow$ test 2, 3, 5, 7, 11, 13.

These bounds are strict.

Reject look-alikes (composite numbers)

$51 = 3 \times 17$ | $57 = 3 \times 19$ | $87 = 3 \times 29$ | $91 = 7 \times 13$

The first ten prime gaps

The first ten prime gaps are 1, 2, 2, 4, 2, 4, 2, 4, 6, 2.

Only the gap 2 → 3 is odd.

2 —1→ 3 —2→ 5 —2→ 7 —4→ 11 —2→ 13 —4→ 17 —2→ 19 —4→ 23 —6→ 29 —2→ 31

Small irregular gaps are clues, not a repeating rule: verify the primes themselves.

Sources: S3, S4.

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Find the matching base, then test the residual

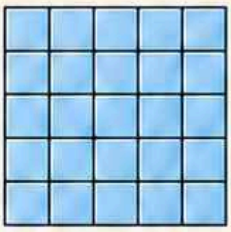
Steps to identify the pattern

1. First inspect growth and differences.
2. Next compare each term with a nearby square or cube.
3. Subtract the candidate power from the term.
4. Look for a constant residual, the base itself, or another simple rule.
5. Finally verify every term and both sides of a gap.

Square example: 26, 37, 50, 65.

Term	26	37	50	65	Next term (predict)
Base (n)	5	6	7	8	9
Square (n^2)	25	36	49	64	81
Residual (Term − n^2)	+1	+1	+1	+1	+1

$26 - 25 = 1$
$37 - 36 = 1$
$50 - 49 = 1$
65 minus 64 equals 1



The matching squares are 5^2, 6^2, 7^2, 8^2.

$5^2 = 25$ (schematic)

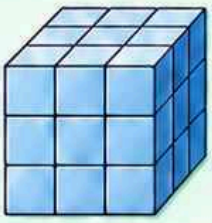
Rule: $n^2 + 1$, with bases 5–8.

Next base = 9; next term = $9^2 + 1 = 81 + 1 = 82$.

Cube example: 25, 62, 123, 214.

Term	25	62	123	214	Next term (predict)
Base (n)	3	4	5	6	7
Cube (n^3)	27	64	125	216	343
Residual (Term − n^3)	−2	−2	−2	−2	−2

$25 - 27 = -2$
$62 - 64 = -2$
$123 - 125 = -2$
$214 - 216 = -2$



The matching cubes are 3^3, 4^3, 5^3, 6^3.

$3^3 = 27$ (schematic)

Rule: $n^3 - 2$, with bases 3–6.

Next base = 7; next term = $7^3 - 2 = 343 - 2 = 341$.

If the closest power fails, try the other side. With a large offset, the mathematically matching power need not be the nearest one.

Sources: S1, S2, S4.

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Five square-based forms, fully worked

n^2

Bases 7–11: 49, 64, 81, 100, 121

15 17 19 21

Next: $12^2 = 144$.

$n^2 + 4$

Bases 4–8: 20, 29, 40, 53, 68

9 11 13 15

Next: $9^2 + 4 = 81 + 4 = 85$.

$n^2 - 2$

Bases 3–7: 7, 14, 23, 34, 47

7 9 11 13

Next: $8^2 - 2 = 64 - 2 = 62$.

$n^2 + n$

Bases 2–6: 6, 12, 20, 30, 42

6 8 10 12

Next: $7^2 + 7 = 49 + 7 = 56$.

$n^2 - n$

Bases 2–6: 2, 6, 12, 20, 30

4 6 8 10

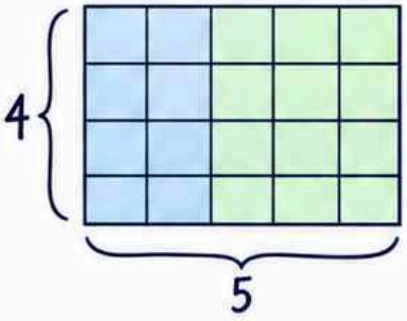
Next: $7^2 - 7 = 49 - 7 = 42$.

A fixed offset cancels when differences are taken, so $n^2 \pm k$ retains the odd-number differences.

The forms $n^2 + n = n(n+1)$ and $n^2 - n = (n-1)n$ describe the same product family at shifted bases:

$20 = 4^2 + 4 = 5^2 - 5$.

Adjacent-rectangle model for $20 = 4 \times 5$



$20 = 4 \times 5$
$= 4^2 + 4$
$= 5^2 - 5$.

Sources: S1, S4.

Four cube-based forms

Cube patterns can add a fixed number, subtract a fixed number, or use the base itself. Keep the base range visible and check every term.

Constant offsets (+1 and −1)

1. $n^3 + 1$, bases 2–6:

n:	2	3	4	5	6
$n^3 + 1$:	9	28	65	126	217
First differences:	19	37	61	91	

Next base = 7; $7^3 + 1 = 343 + 1 = 344$.

2. $n^3 - 1$, bases 2–6:

n:	2	3	4	5	6
$n^3 - 1$:	7	26	63	124	215
First differences:	19	37	61	91	

Next base = 7; $7^3 - 1 = 343 - 1 = 342$.

Identical first differences

Base offsets (+n and −n)

3. $n^3 + n$, bases 1–5:

n:	1	2	3	4	5
$n^3 + n$:	2	10	30	68	130
First differences:	8	20	38	62	

Next base = 6; $6^3 + 6 = 216 + 6 = 222$.

4. $n^3 - n$, bases 2–6:

n:	2	3	4	5	6
$n^3 - n$:	6	24	60	120	210
First differences:	18	36	60	90	

Next base = 7; $7^3 - 7 = 343 - 7 = 336$.

Why +1 and −1 give the same differences?

Adding or subtracting a constant leaves the first differences unchanged.

(b + k)
minus (a + k)
equals b minus a

Key takeaways

- Adding or subtracting a constant leaves the first differences unchanged.
- The changing offsets +n and −n alter the first differences.
- In all four forms, consecutive bases still produce third differences of 6; that identifies a cubic pattern, not necessarily a sequence of perfect cubes.

Sources: S2, S4.

Locate the pattern: terms, bases or differences

Not every series is best read with an ordinary difference table. Decide where the structure lives.

1. Square then cube of each base:

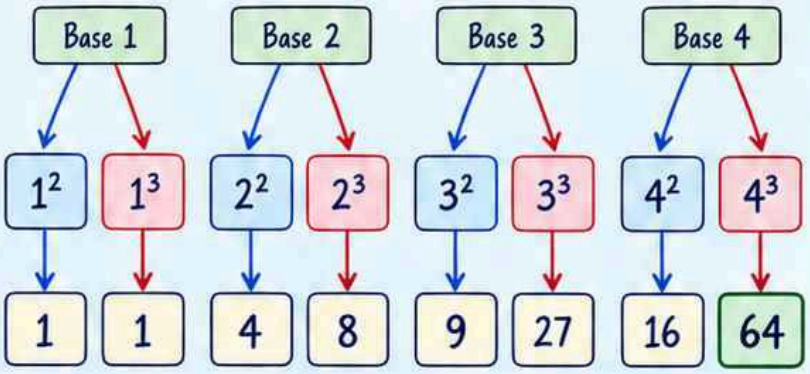
1, 1, 4, 8, 9, 27, 16, ...

Read paired bases: 1^2, 1^3; 2^2, 2^3; 3^2, 3^3; 4^2, 4^3.

The next term is $4^3 = 64$.

Splitting alternate positions gives square and cube streams with bases 1, 2, 3, 4.

Zipper view (paired bases)



2. Squares of consecutive primes:

4, 9, 25, 49, 121, ...

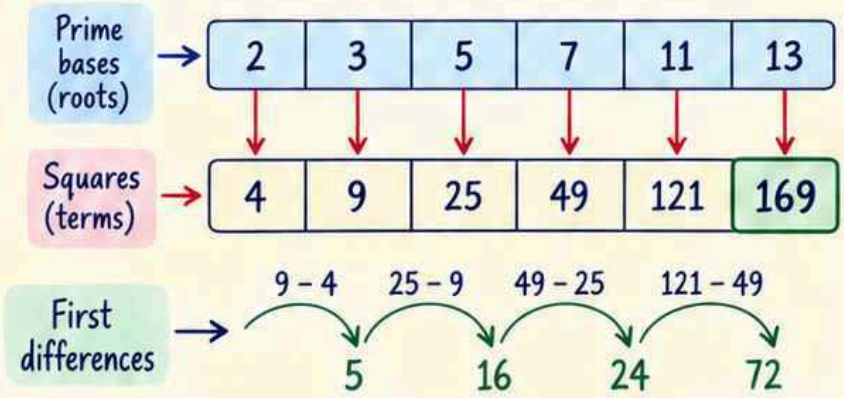
Roots: 2, 3, 5, 7, 11.

First differences: 5, 16, 24, 72.

Next prime base = 13; next term = $13^2 = 169$.

After 7^2 comes 11^2, not 8^2.

Root ladder (primes as bases)



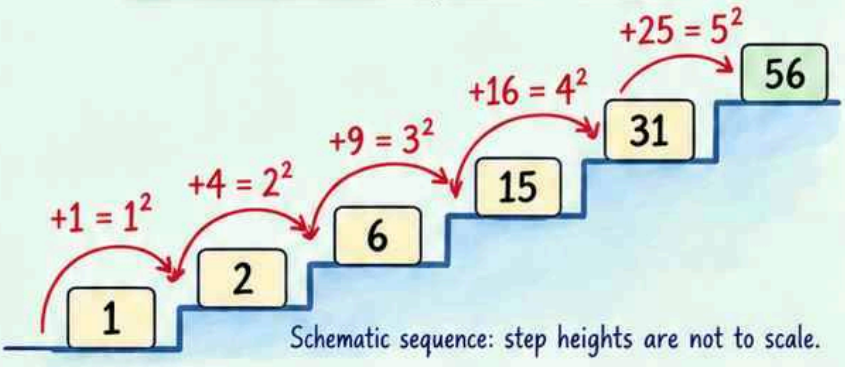
3. Squares in the differences:

1, 2, 6, 15, 31, ...

$2 - 1 = 1 = 1^2$;
$6 - 2 = 4 = 2^2$;
$15 - 6 = 9 = 3^2$;
$31 - 15 = 16 = 4^2$.

Next difference = $5^2 = 25$; next term = 31 + 25 = 56.

Staircase view (square increments)



The first pattern alternates operations, the second restricts the bases, and the third puts squares between the terms.

Sources: S1, S2, S3, S4.

Five prime-based constructions

1 Consecutive primes

Given: 23, 29, 31, 37, 41. Next: 43.

First gaps: 6, 2, 6, 4.

29 − 23 = 6	37 − 31 = 6
31 − 29 = 2	41 − 37 = 4

Verify the primes themselves:
23, 29, 31, 37, 41, 43 are all prime.

2 Prime plus 2

Term	13	15	19	21	25	31
Term minus 2	11	13	17	19	23	29

Next prime = 31; next term = 31 + 2 = 33.

Gaps: 2, 4, 2, 4, 6.

Gaps 2, 4, 2, 4, 6 defeat a repeating +2, +4 rule.

Where are the primes?

3 Products of consecutive primes

667 = 23 × 29
899 = 29 × 31
1147 = 31 × 37
1517 = 37 × 41

Next: 41 × 43 = 1763.

One term's second factor becomes the next term's first factor.

4 Sums of consecutive primes

5 = 2 + 3
8 = 3 + 5
12 = 5 + 7
18 = 7 + 11
24 = 11 + 13

Next: 13 + 17 = 30.

5 Consecutive primes as differences

4, 6, 9, 14, 21, 32

Differences:
2, 3, 5, 7, 11

6 − 4 = 2
9 − 6 = 3
14 − 9 = 5
21 − 14 = 7
32 − 21 = 11

Next difference = 13;
next term = 32 + 13 = 45.

The visible terms need not be prime. Identify whether primes supply the terms, the underlying shifted values, paired factors, paired addends or the increments.
Test the whole series before choosing a rule.

Sources: S3, S4.

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Drills 1-2: squares and adjacent products

D1: 11, 18, 27, 38, 51, ...

Term	11	18	27	38	51	66
Matching square	9	16	25	36	49	64
Residual (term − square)	2	2	2	2	2	2
Base n (for $n^2 + 2$)	3	4	5	6	7	8

$11 - 9 = 2$; $18 - 16 = 2$; $27 - 25 = 2$; $38 - 36 = 2$; $51 - 49 = 2$.

Rule: $n^2 + 2$, bases 3, 4, 5, 6, 7.

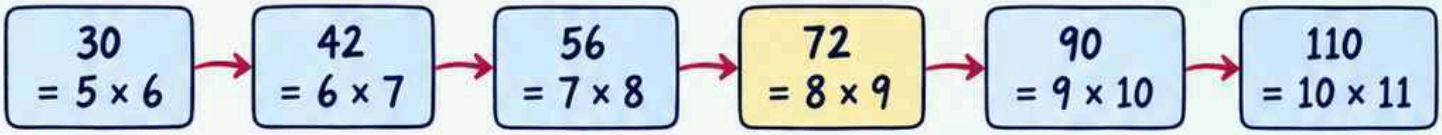
Next base = 8; $8^2 + 2 = 64 + 2 = 66$.

Difference check: 7, 9, 11, 13; next difference = 15.



$51 + 15 = 66$.

D2: 30, 42, 56, □, 90, 110.



Rule: $n^2 + n = n(n + 1)$. Missing term = $8 \times 9 = 72$.

Differences: 12, 14, 16, 18, 20.

Left check: $56 + 16 = 72$.

Right check: $72 + 18 = 90$.

Equivalent form:
$9^2 - 9 = 81 - 9 = 72$.

These standard readings agree on 72. They do not prove that no artificially constructed rule could fit the same finite list. The exam strategy is to prefer a simple standard rule that explains every given term.

Sources: S1, S4.

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Drills 3–4: cube offsets and full checks

D3: 11, 30, □, 128, 219.

Identify the rule (cubes + 3)

$11 = 2^3 + 3 = 8 + 3.$
$30 = 3^3 + 3 = 27 + 3.$
$67 = 4^3 + 3 = 64 + 3.$
$128 = 5^3 + 3 = 125 + 3.$
$219 = 6^3 + 3 = 216 + 3.$

The missing term is **67**.

Check using differences

First differences:
$30 - 11 = 19$; $67 - 30 = 37$;
$128 - 67 = 61$; $219 - 128 = 91$.

Second differences:
18, 24, 30, increasing by 6.

Difference rows (D3)

Terms:	11	30	67	128	219
First differences:		19	37	61	91
Second differences:			18	24	30

D4: 210, 336, 504, 720, ...

Identify the rule (cubes − base)

$210 = 6^3 - 6 = 216 - 6.$
$336 = 7^3 - 7 = 343 - 7.$
$504 = 8^3 - 8 = 512 - 8.$
$720 = 9^3 - 9 = 729 - 9.$

Rule: $n^3 - n$.
Next base = 10;
next term = $10^3 - 10 = 1000 - 10 =$ **990**.

Check using differences

First differences:
126, 168, 216, 270.

Second differences:
42, 48, 54, increasing by 6.

Difference rows (D4)

Terms:	210	336	504	720	990
First differences:		126	168	216	270
Second differences:			42	48	54

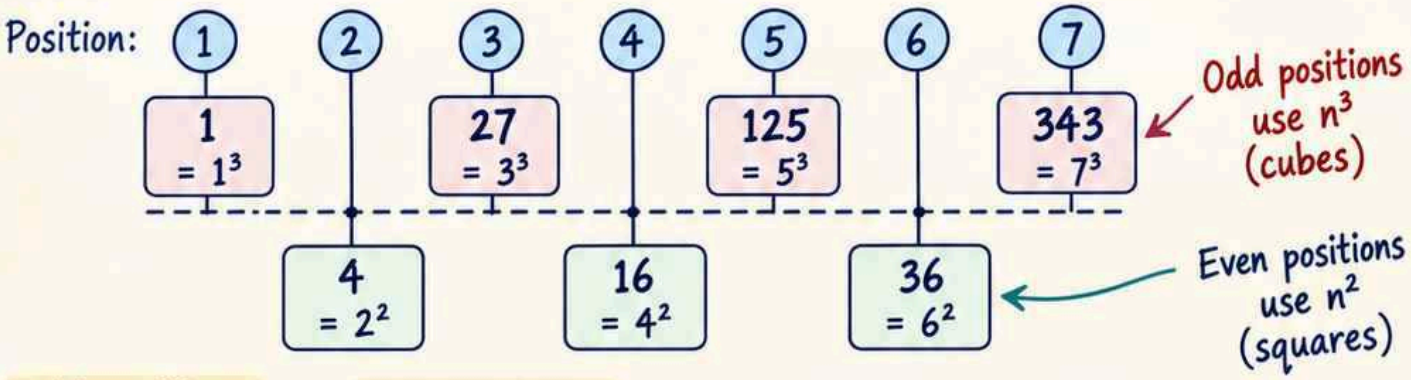
Both examples use consecutive bases and a cubic form. The offset differs: D3 adds a constant 3, while D4 subtracts the changing base. Check the complete formula, not just the rapid growth.

Sources: S2, S4.

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Drills 5–6: choose the right positions and bases

D5: 1, 4, 27, 16, 125, 36, ...



Odd positions:

$1^{st} = 1^3 = 1$

$3^{rd} = 3^3 = 27$

$5^{th} = 5^3 = 125.$

Even positions:

$2^{nd} = 2^2 = 4$

$4^{th} = 4^2 = 16$

$6^{th} = 6^2 = 36.$

Here the base n equals the position.
Odd positions use n^3; even positions use n^2.

The 7^{th} position is odd:

$7^3 = 343.$

$7^2 = 49$ would apply the wrong operation.

D6: 49, 121, □, 289, 361, 529.

Take the square roots:

Base (prime) 7	Base (prime) 11	Base (prime) 13	Base (prime) 17	Base (prime) 19	Base (prime) 23
↓	↓	↓	↓	↓	↓
$49 = 7^2$	$121 = 11^2$	$169 = 13^2$	$289 = 17^2$	$361 = 19^2$	$529 = 23^2$

$49 = 7^2$; $121 = 11^2$; $169 = 13^2$;
$289 = 17^2$; $361 = 19^2$; $529 = 23^2$.

The bases are consecutive primes: 7, 11, 13, 17, 19, 23.

The prime after 11 is 13, so the missing term is $13^2 = 169$.

$12^2 = 144$ ✗

Wrong base because 12 is not prime.

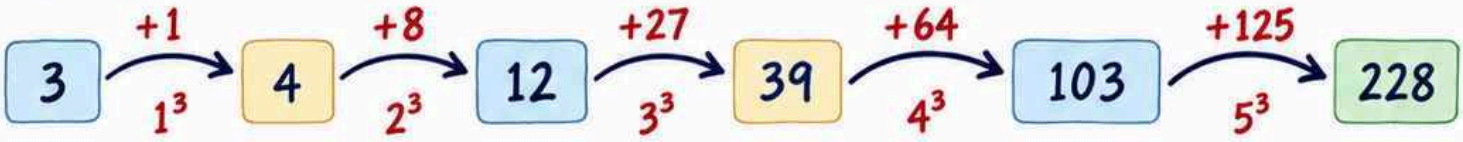
The two drills test different structures.
D5 restricts the operation by position;
D6 restricts the permitted bases.
State that structure before calculating the answer.

Sources: S1, S2, S3, S4.

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Drills 7–8: cube increments and shifted primes

D7: 3, 4, 12, 39, 103, ...



Find first differences:

$4 - 3 = 1 = 1^3$.
$12 - 4 = 8 = 2^3$.
$39 - 12 = 27 = 3^3$.
$103 - 39 = 64 = 4^3$.

The next difference is $5^3 = 125$.
Next term = 103 + 125 = 228.

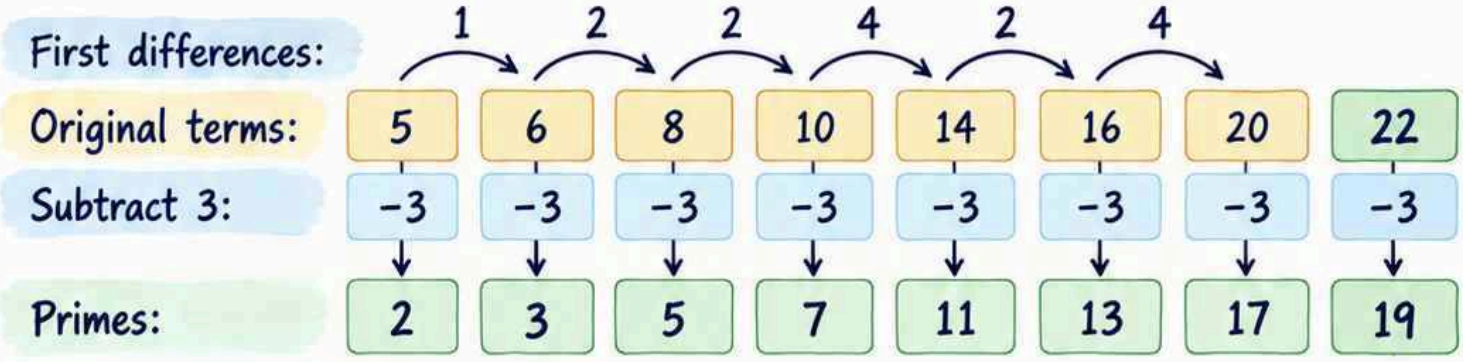
The cubes are the increments, not the visible terms themselves.

D8: 5, 6, 8, 10, 14, 16, 20, ...

First differences: 1, 2, 2, 4, 2, 4.

The initial gap 1 followed by small even gaps suggests the prime-gap pattern.

Subtract 3 from every term: $5 - 3 = 2$; $6 - 3 = 3$; $8 - 3 = 5$; $10 - 3 = 7$; $14 - 3 = 11$; $16 - 3 = 13$; $20 - 3 = 17$.
These are consecutive primes.



Rule: prime + 3.

Next prime = 19; next term = 19 + 3 = 22.

Verify the hidden structure rather than extending a short apparent alternation.
In D7, identify the next cube increment. In D8, recover and check every underlying prime.
Both methods explain all supplied terms and show exactly where the final addition comes from.

Sources: S2, S3, S4.

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Three traps: uniqueness, primes and starting bases

Trap 1: too few terms can support different rules.

For 3, 10, 29, ..., $n^3 + 2$ gives

$1^3 + 2 = 3$

$2^3 + 2 = 10$

$3^3 + 2 = 29$

then $4^3 + 2 = 66$.

But first differences 7, 19 give second difference 12.

$10 - 3 = 7$

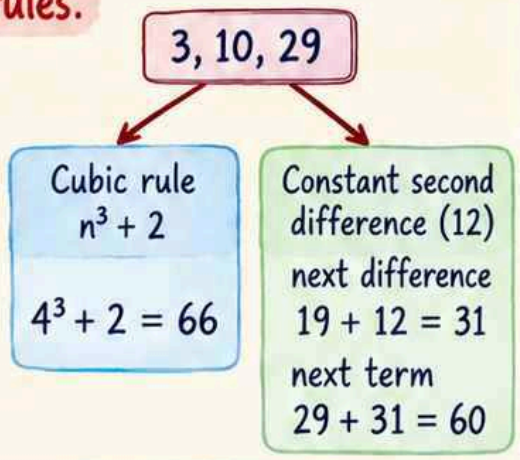
$29 - 10 = 19$

$19 - 7 = 12$.

Continuing that constant gives next difference

$19 + 12 = 31$,

then $29 + 31 = 60$.

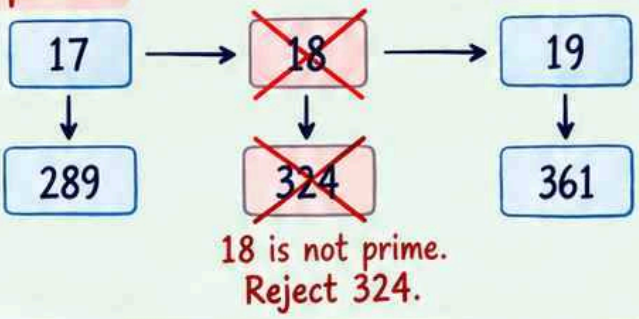


Without another restriction, both continuations are possible.
Options may suggest intention; they do not prove uniqueness.

Trap 2: the next integer is not the next prime.

After $17^2 = 289$ comes $19^2 = 361$ in a prime-square series, not $18^2 = 324$.

Reject composites:
$51 = 3 \times 17$; $57 = 3 \times 19$;
$87 = 3 \times 29$; $91 = 7 \times 13$.



Trap 3: base and position can differ.

39, 52, 67, 84 are $6^2 + 3$, $7^2 + 3$, $8^2 + 3$, $9^2 + 3$.

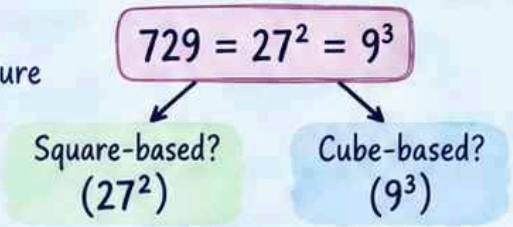
Fifth term: $10^2 + 3 = 103$.

Sixth term: $11^2 + 3 = 124$.

Using position 6 as the base gives $6^2 + 3 = 39$, merely the first term again.

Position (n)	1	2	3	4	5	6
Base (n + 5)	6	7	8	9	10	11
Value $(n+5)^2+3$	39	52	67	84	103	124

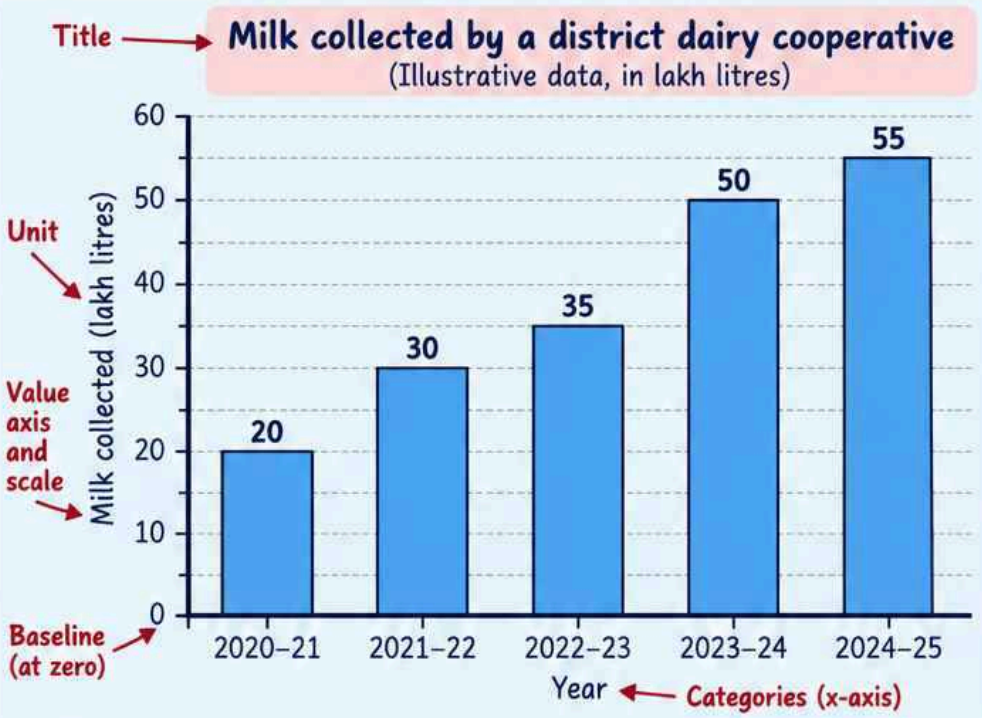
Finally, $729 = 27^2 = 9^3$.
Its neighbours decide whether the intended structure is square-based or cube-based.
A number alone cannot settle the pattern.
Test every supplied term.



Alternating/mixed series return in Topic 358, wrong-term series in Topic 498, and letter series in Topic 228.

Sources: S1, S2, S3, S4.

Read the graph before calculating



Key data (from the graph)

Year	Milk collected (lakh litres)
2020–21	20
2021–22	30
2022–23	35
2023–24	50
2024–25	55

Symbols (if one symbol represents 5 lakh litres)

2020–21: 4 symbols
2021–22: 6 symbols
2022–23: 7 symbols
2023–24: 10 symbols
2024–25: 11 symbols

What a bar graph shows

A bar graph compares separate categories using bars of equal width and equal spacing. One axis gives categories; the other gives values and units. Bars may be vertical or horizontal. A vertical bar graph is also called a column chart.

How to read a bar graph (in this order)

1. Title
2. Axes and units
3. Scale step
4. Legend
5. Baseline
6. Bar ends and gridlines

Key points

- A series is one set of figures, consistently identified by colour or shading.
- Use a zero baseline and equal value-axis intervals.
- Interpolate when a bar ends between gridlines: halfway between 20 and 30 means 25, not automatically 20 or 30.

Interpolation between gridlines



Halfway between 20 and 30 means 25, not automatically 20 or 30.

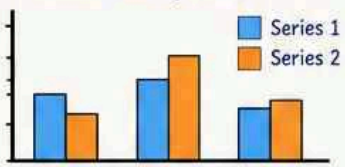
Types of bar graphs

1. Simple bar graph (one series)



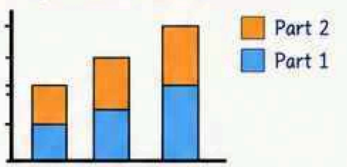
Simple bars compare one series.

2. Grouped (multiple) bar graph (series side by side)



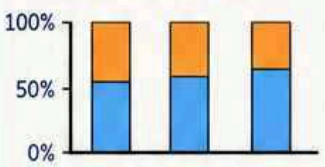
Grouped, or multiple, bars compare series side by side.

3. Stacked (component) bar graph (parts and totals)



Stacked, or component, bars show parts and totals.

4. Percentage bar graph (shares within 100%)



Percentage bars show shares within equal-height 100% totals.

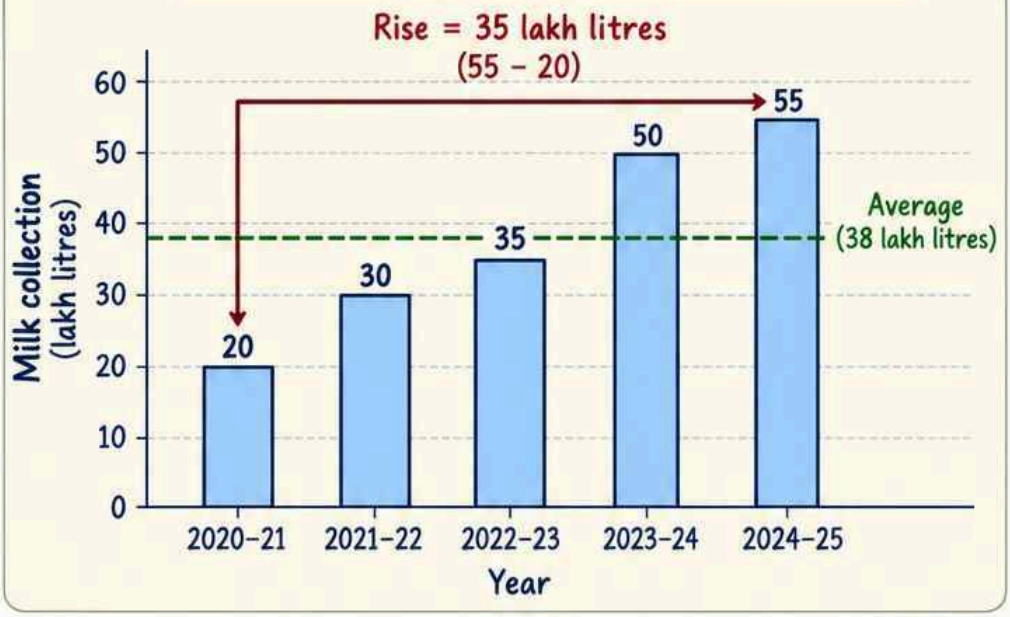
These are practice figures, not official statistics.
Line graphs return in Topic 449 and pie charts in Topic 249.

Sources: S1, S2, S4

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Graph 1: overall rise, average and ratio

Milk collection from 2020–21 to 2024–25



Key data (from graph)

Year	Milk collection (lakh litres)
2020–21	20
2021–22	30
2022–23	35
2023–24	50
2024–25	55

Milk collection rose from 20 lakh litres in 2020–21 to 55 lakh litres in 2024–25.

1. Percentage increase (from 2020–21 to 2024–25)

Increase = 55 – 20
= 35 lakh litres.

Earlier-value base
= 20 lakh litres,

Increase percentage
= 35 ÷ 20 × 100
= 175%.

The denominator is the earlier value. Percentage change is undefined when that earlier value is zero; all examples here use positive bases.

2. Multiplier check

55 ÷ 20 = 2.75 times the original value.

If the new value is k times the original, it is (k – 1) × 100% more.

(2.75 – 1) × 100
= 175% more.

Do not confuse "2.75 times as large" with "275% more".

3. Average and ratio

Average over all five years:

20 + 30 + 35 + 50 + 55
= 190 lakh litres.

Average = 190 ÷ 5
= 38 lakh litres per year.

Ratio of first to last year:

20 : 55 = (20 ÷ 5) : (55 ÷ 5)
= 4 : 11.

General rules

- share = part ÷ total × 100
- percentage change = (new – old) ÷ old × 100
- average = sum ÷ count.
- Keep units with amounts, and do not confuse "2.75 times as large" with "275% more".

Sources: S2, S4 | Day 15 | Topic 149 | 2/11 | @iaswithdrravi

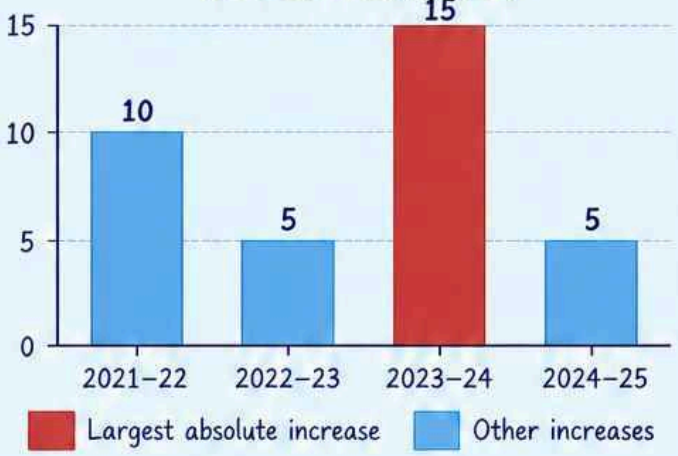
Largest increase: amount and percentage differ

Given data

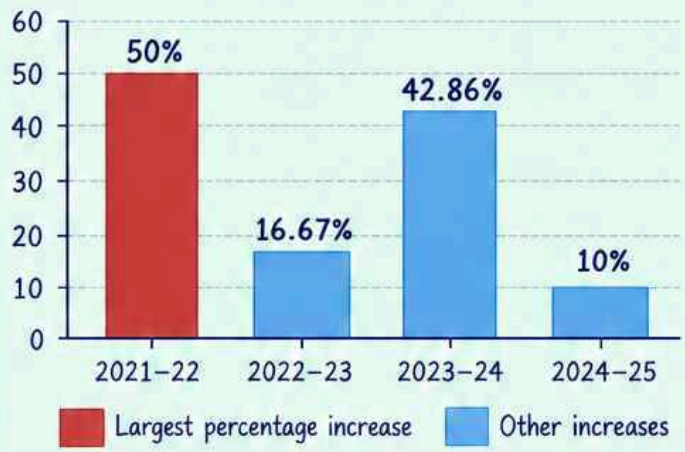
Milk collected (lakh litres):

2020–21: 20 2021–22: 30 2022–23: 35 2023–24: 50 2024–25: 55

Year-on-year increase (amount)



Year-on-year increase (percentage)



Year-on-year calculations

2021–22	2022–23	2023–24	2024–25
30 − 20 = 10	35 − 30 = 5	50 − 35 = 15	55 − 50 = 5
10 ÷ 20 × 100	5 ÷ 30 × 100	15 ÷ 35 × 100	5 ÷ 50 × 100
= 50%	≈ 16.67%	≈ 42.86%	= 10%

Key results

- **Largest absolute increase:** 15 lakh litres in 2023–24.
- **Largest percentage increase:** 50% in 2021–22.

Why the results differ?

The smaller rise of 10 is measured against 20, while the larger rise of 15 is measured against 35. Compare the full rise-to-base fractions.

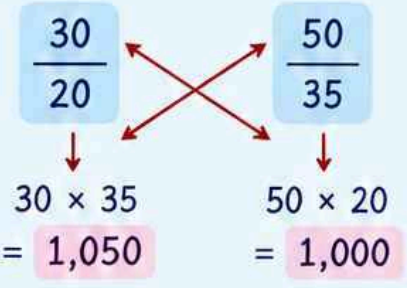
Cross-multiplication check

Compare later/earlier ratios 30/20 and 50/35.

30 × 35 = 1,050.

50 × 20 = 1,000.

Since 1,050 > 1,000, the first ratio is larger. Subtracting 1 from both preserves the ordering, so 2021–22 has the larger growth percentage.



Important point Do not choose the biggest numerical rise when the question asks for the biggest percentage rise. The base matters as well as the increase.

Sources: S2, S4

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Graph 2: grouped bars and the legend

Graph 2 shows Class 6 enrolment in three government schools.
These are **illustrative counts, not official data.**

Key ideas

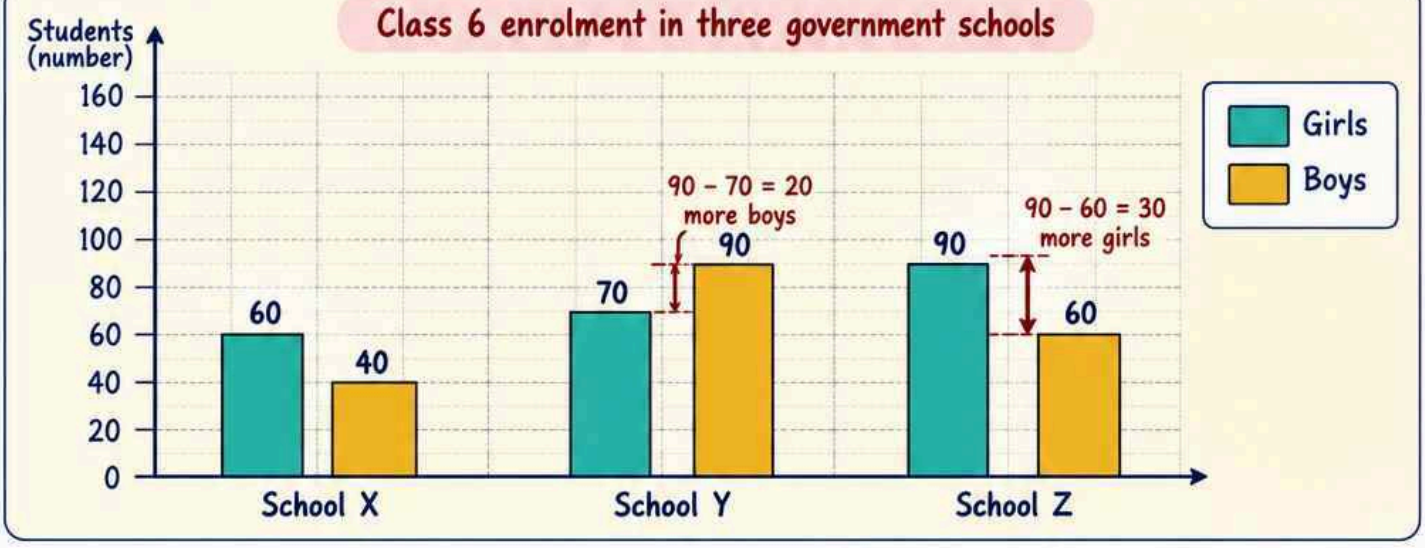
- In a grouped bar graph, each school has two bars side by side.
- Keep girls on the left and boys on the right, with the same colours throughout.
- The legend identifies the series; position alone is unsafe unless you have checked it.
- Read the bars from a number axis beginning at zero.
- The given graph uses 0–160, with gridlines every 10.
- Equal bar widths and equal spacing between school groups prevent visual distortion.

Given counts (Class 6 enrolment)

School X: 60 girls and 40 boys.

School Y: 70 girls and 90 boys.

School Z: 90 girls and 60 boys.



Data used in the graph (for easy checking)

School	Girls (number)	Boys (number)
School X	60	40
School Y	70	90
School Z	90	60

Calculations from the graph

Difference in School Z, girls minus boys: 90 – 60 = 30 more girls.

Difference in School Y, boys minus girls: 90 – 70 = 20 more boys.

Reversing the legend would wrongly turn that into "20 more girls".

Always preserve the order requested in the subtraction.

What grouped bars show

Grouped bars make within-school comparisons easy. Stacked bars will instead emphasise each school's total, while percentage bars will compare composition. The underlying six counts stay the same when the chart form changes.

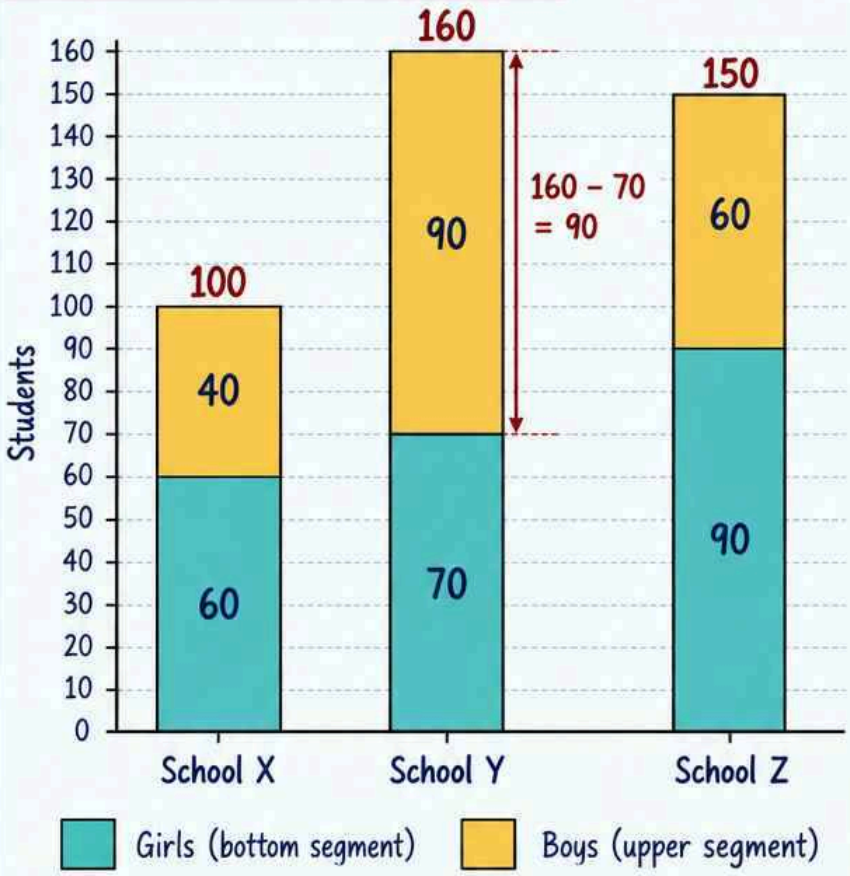
Sources: S1, S2, S4

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Graph 2: stacked bars require subtraction

A stacked bar combines non-negative parts into a total. In this graph girls form the bottom segment and boys the upper segment. Only the bottom part starts at zero.

Number of students in each school



Totals for each school

School X: girls 60; boys 40; total = 60 + 40 = 100.

School Y: girls 70; boys 90; total = 70 + 90 = 160.

School Z: girls 90; boys 60; total = 90 + 60 = 150.

School Y has the largest total.

Read each upper segment by subtraction

X boys = 100 − 60 = 40.

Y boys = 160 − 70 = 90.

Z boys = 150 − 90 = 60.

School Y boys' share

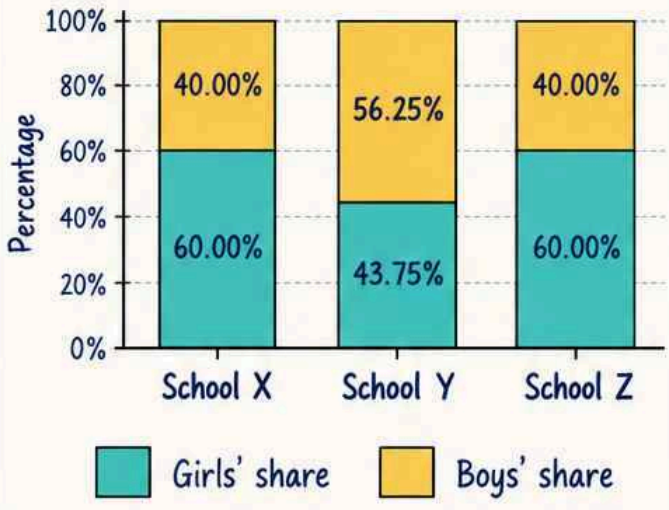
Part = upper edge − lower edge
= 160 − 70 = 90.

Share = 90 ÷ 160 × 100 = 56.25%.

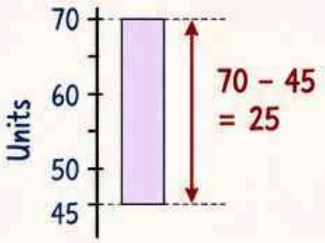
Girls' share = 70 ÷ 160 × 100 = 43.75%.

Check: 56.25% + 43.75% = 100%.

Percentage share within each school



Example of a segment that does not start at zero



A segment running from 45 to 70 represents 70 − 45 = 25 units.

Read segment thickness rather than its upper coordinate.

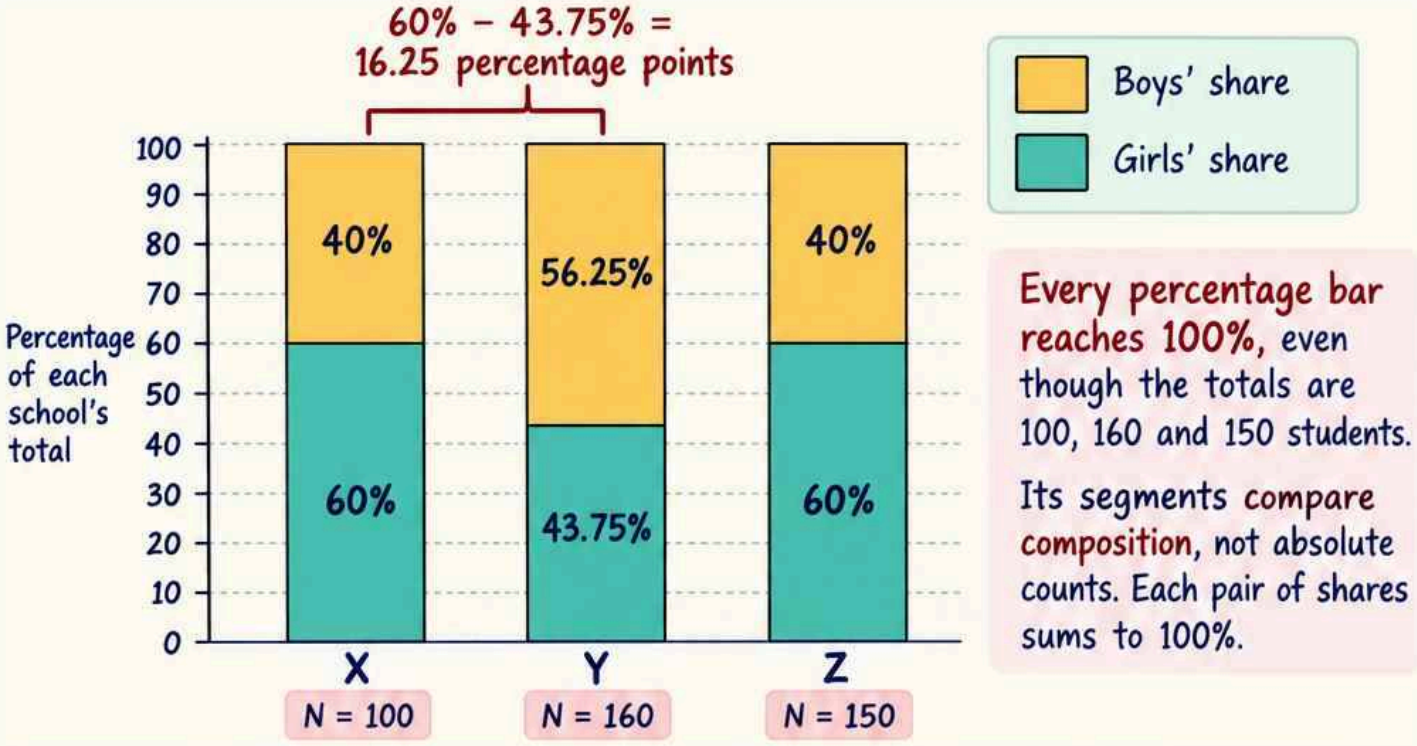
Key points

- The top of Y's bar is 160 students, not 160 boys.
- More generally, a segment running from 45 to 70 represents 70 − 45 = 25 units.
- Read segment thickness rather than its upper coordinate.

Sources: S1, S2, S3, S4

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Graph 2: percentage bars compare shares



Every percentage bar reaches 100%, even though the totals are 100, 160 and 150 students.

Its segments compare **composition**, not absolute counts. Each pair of shares sums to 100%.

Calculations: convert each count into a share of its own school's total.

School X, total 100:

Girls = $\frac{60}{100} \times 100 =$ **60%.**

Boys = $\frac{40}{100} \times 100 =$ **40%.**

School Y, total 160:

Girls = $\frac{70}{160} \times 100 =$ **43.75%.**

Boys = $\frac{90}{160} \times 100 =$ **56.25%.**

School Z, total 150:

Girls = $\frac{90}{150} \times 100 =$ **60%.**

Boys = $\frac{60}{150} \times 100 =$ **40%.**

Difference between girls' shares in X and Y:

60% − 43.75% = **16.25 percentage points.**

The answer is in **percentage points**, not a percentage change.

Count comparison and share comparison:

Y has more girls than X in count: 70 > 60.
Yet Y's girls' share is smaller:
43.75% < 60%.

The count comparison comes from the supplied totals and counts, not from percentage heights alone.

Important points:

- Without each category's total, a 100% chart cannot reveal how many people its segments represent.
- X and Z have identical shares but different counts.

Sources: S1, S2, S3, S4

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Bounds, falls and the correct denominator

- A good estimate starts with an accurate scale reading.
- Interpolate between gridlines when needed.
- Round only when a justified estimate is enough; use exact stated values when choices are close.
- A blurry graph cannot supply invented precision.

Reading a value from a scale



25 is halfway between 20 and 30.

Bound the milk increase from 35 to 50

Increase = 50 − 35 = 15.

10% of 35 = 3.5.
40% of 35 = 14.
50% of 35 = 17.5.

Since 14 < 15 < 17.5, the rise lies between 40% and 50%.

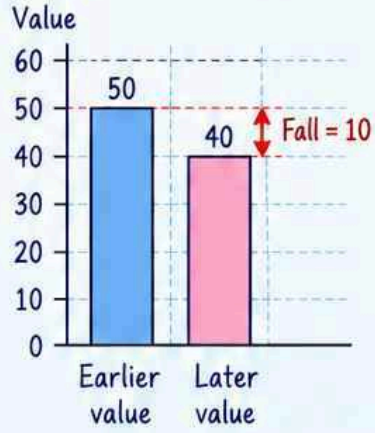
Exact working: 15/35 × 100 ≈ 42.86%.

Rise on base 35: bounds for the percentage increase

14 units = 40% of 35	<	15 units ≈ 42.86% of 35	<	17.5 units = 50% of 35

14 < 15 < 17.5, so 40% < rise percentage < 50%.

For a fall from 50 to 40



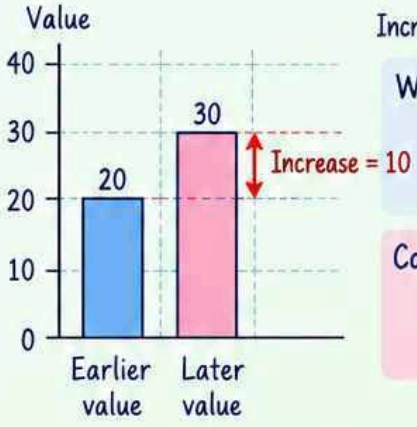
Fall = 50 − 40 = 10.

Earlier-value base = 50.

Percentage fall
= 10/50 × 100
= 20%.

The denominator remains the earlier value, even when the change is negative.

Wrong-base trap, 20 rising to 30



Increase = 30 − 20 = 10.

Wrong calculation:
10/30 × 100
= 33⅓%.

Correct calculation:
10/20 × 100
= 50%.

Keep three questions separate

1. **What changed?**
   Find the difference (e.g. increase or fall).
2. **Which value is the base?**
   Use the earlier value for both increases and falls.
3. **Is the answer an amount or a percentage?**
   Be clear whether you need the change in units or the percentage change.

A quick estimate should support the calculation, not replace reading the graph.

Sources: S2, S4

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Graph 3: decode every stacked boundary

Electricity consumption in a town, million units.
Practice data; domestic is bottom, commercial middle, agricultural top.



Key points to read the graph:

- Check the legend before reading.
- Use the top of each complete stack for the total and subtract neighbouring edges for upper parts.
- The four total heights are 240, 260, 290 and 320.
- The coordinate of an upper boundary is a cumulative total, not the segment's value.

Edge to part calculations (million units)

Year	Cumulative edges (bottom, middle, top)	Domestic (bottom)	Commercial (middle)	Agricultural (top)
2021–22	120, 160, 240	120	160 − 120 = 40	240 − 160 = 80
2022–23	130, 180, 260	130	180 − 130 = 50	260 − 180 = 80
2023–24	150, 210, 290	150	210 − 150 = 60	290 − 210 = 80
2024–25	160, 230, 320	160	230 − 160 = 70	320 − 230 = 90

Drill 1: commercial consumption in 2023–24.

Upper edge = 210; lower edge = 150.

Commercial = 210 − 150 = 60 million units.

The coordinate 210 is not the commercial segment's value.

Drill 2: domestic share in 2024–25.

Domestic = 160; total = 320.

$$\text{Share} = \frac{160}{320} \times 100 = 50\%.$$

Sources: S1, S2, S3, S4

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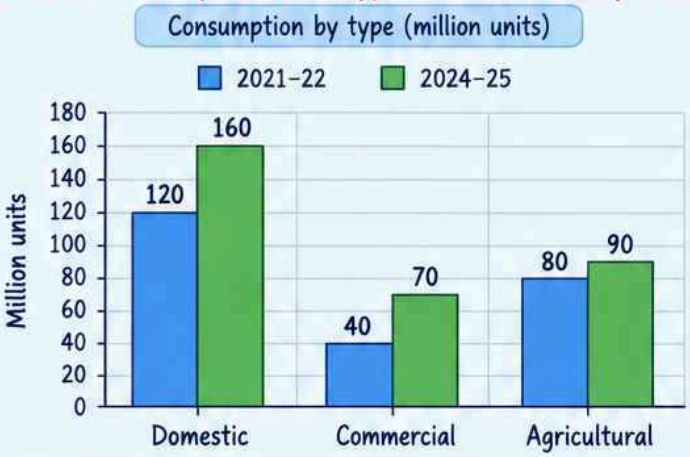
Graph 3: compare totals, categories and shares

Drill 3: total rise from 2021–22 to 2024–25.

Earlier total = 240 million units.
Later total = 320 million units.
Increase = 320 − 240 = 80.
Percentage increase = 80/240 × 100
= $\frac{1}{3}$ × 100 = 33⅓%.



Drill 4: compare each type over the same years.

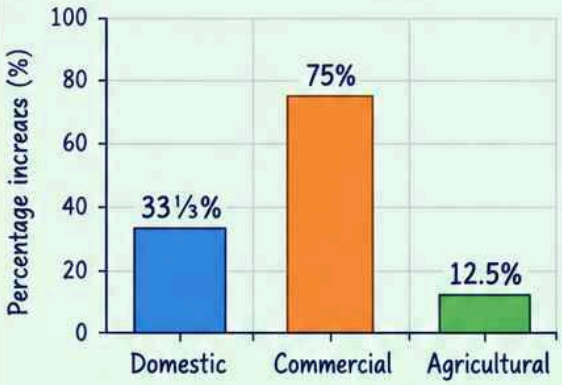


Domestic: 120 → 160
Increase = 160 − 120 = 40.
Percentage = $\frac{40}{120}$ × 100 = 33⅓%.

Commercial: 40 → 70
Increase = 70 − 40 = 30.
Percentage = $\frac{30}{40}$ × 100 = 75%.

Agricultural: 80 → 90
Increase = 90 − 80 = 10.
Percentage = $\frac{10}{80}$ × 100 = 12.5%.

Percentage growth by type

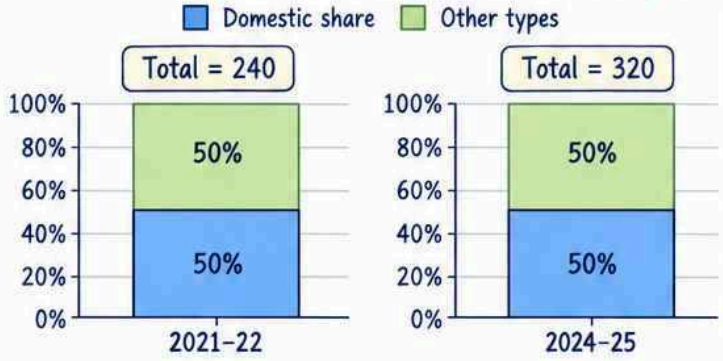


Domestic has the largest absolute increase: **40 million units.**

Commercial has the largest percentage increase: **75%.**

The reason is the largest increase-to-base ratio, $\frac{30}{40}$ A smaller base alone is not enough; the increase matters too.

Share check: domestic share in total consumption



Domestic in 2021–22 = $\frac{120}{240}$ × 100 = 50%.

Domestic in 2024–25 = $\frac{160}{320}$ × 100 = 50%.

Its share stays unchanged despite the largest numerical increase, because domestic consumption and the total both grow by 33⅓%.

Always keep the comparison years, units and denominator consistent.

Sources: S2, S3, S4

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Graph 3: average and a deceptive baseline

Drill 5: average total consumption across four years.

Totals: 240, 260, 290, 320 million units.

Sum = 240 + 260 + 290 + 320 = 1,110.

Average = 1,110 ÷ 4 = 277.5 million units per year.

Drill 6: imagine the value axis starts at 200.

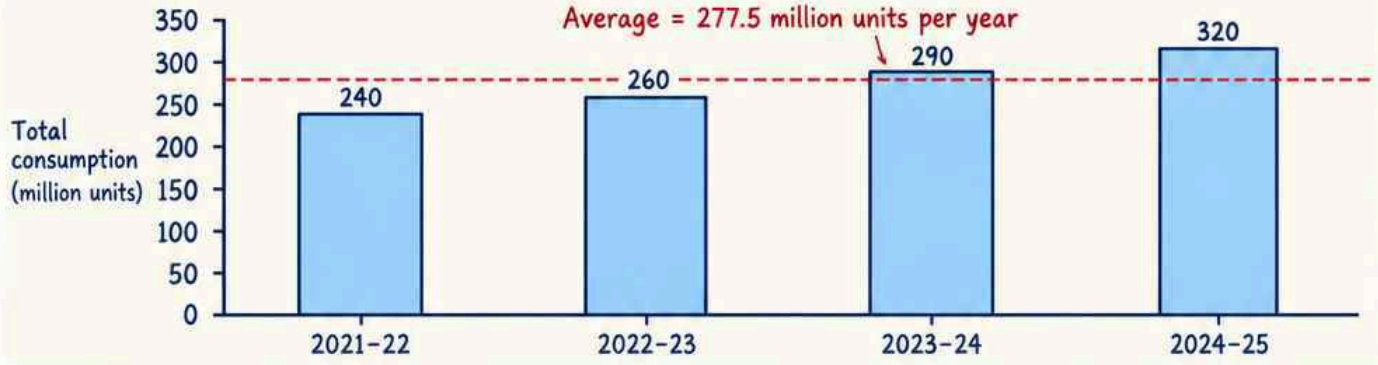
For 2021–22, the visible length would be 240 – 200 = 40.

For 2024–25, it would be 320 – 200 = 120.

Apparent length ratio = 120/40 = 3 times.

Apparent increase from those lengths = (120 – 40)/40 × 100 = 200%.

Total consumption over four years (correct zero-based axis)



Comparing 2021–22 and 2024–25: correct vs deceptive baseline

Correct comparison (axis starts at zero)



Using the actual values:

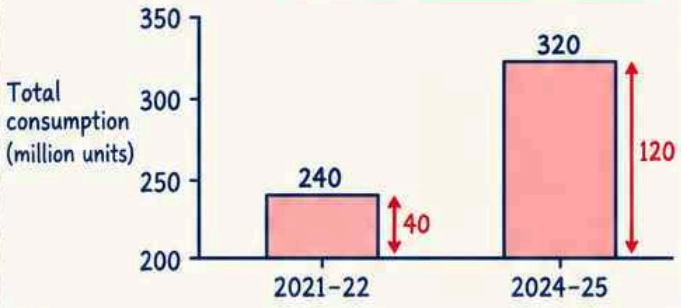
Real ratio = 320/240 = 4/3 ≈ 1.33 times.

Real increase = (320 – 240)/240 × 100

= 80/240 × 100 = 33⅓%.

Deceptive comparison (truncated baseline)

Axis starts at 200 (misleading truncated baseline)



Using the visible lengths (axis starts at 200):

For 2021–22, visible length = 240 – 200 = 40.

For 2024–25, visible length = 320 – 200 = 120.

Apparent length ratio = 120/40 = 3 times.

Apparent increase = (120 – 40)/40 × 100 = 200%.

A 33⅓% increase can look like 200% when the baseline is truncated.
The scale still gives the values, but the visible bar lengths no longer preserve their ratio.

For an honest bar comparison:

- start the quantitative axis at zero and use equal intervals.
- Each bar here represents a total. In a stacked bar, an upper segment's value is the difference between its two edges.

Sources: S2, S4

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Final graph traps: length, segment and legend

1. A truncated baseline breaks the link between bar-length ratios and value ratios.

A truncated baseline breaks the link between bar-length ratios and value ratios.

Read the scale, not the apparent length.

Calculation flow; boxes are not quantities to scale.

Milk example (values 20 and 55, baseline 15)

- Bar-end value 20 − Displayed baseline 15 → Minus (20 − 15) → Visible length = 5
- Bar-end value 55 − Displayed baseline 15 → Minus (55 − 15) → Visible length = 40
- Apparent ratio (visible lengths): 40 ÷ 5 = 8 times
- Actual ratio (values): 55 ÷ 20 = 2.75 times

Second example (values 275 and 330, baseline 220)

- Bar-end value 275 − Displayed baseline 220 → Minus (275 − 220) → Visible length = 55
- Bar-end value 330 − Displayed baseline 220 → Minus (330 − 220) → Visible length = 110
- Apparent ratio (visible lengths): 110 ÷ 55 = 2 times
- Actual ratio (values): 330 ÷ 275 = 1.2 times

2. A stacked-bar coordinate is not automatically a part.

A stacked-bar coordinate is not automatically a part.

A segment from 45 to 70 represents 70 − 45 = 25.

- Upper edge 70 − Lower edge 45 → Minus (70 − 45) → Segment value = 25

For School Y, boys = 160 − 70 = 90; 160 is the total.

- Total 160 − Girls 70 → Minus (160 − 70) → Boys = 90

3. The legend controls series identity.

The legend controls series identity.

School Y has 70 girls and 90 boys.

Boys minus girls = 90 − 70 = 20 more boys.

Reversing the legend gives the opposite, wrong claim.

- Girls (pink) 70 − Boys (blue) 90 → Minus (90 − 70) → = 20 more boys

Reversing the legend gives the opposite, wrong claim.

- Girls (blue) 90 − Boys (pink) 70 → Girls − boys (90 − 70) → = 20 more girls (wrong claim)

4. Reading checklist before any calculation.

Before any calculation, check title, years, units, scale, baseline and legend.

Then decide whether the question asks for a value, a difference, a share, a ratio or a percentage change.

Use a zero-based graph for faithful visual comparison.

Check these features in the diagram.

Title → Years → Units → Scale → Baseline → Legend

Then identify what is being asked.

Value → Difference → Share → Ratio → Percentage change

Use a zero-based graph for faithful visual comparison.

Sources: S2, S3, S4

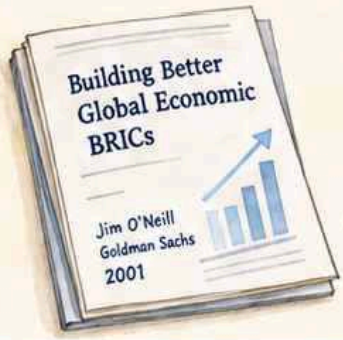
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BRIC to BRICS: Origins and Cooperation

BRICS is a grouping of emerging economies. Its history has several different starting points.

1. IDEA: BRIC (2001)

2001: Jim O'Neill of Goldman Sachs used BRIC in "Building Better Global Economic BRICs".



2. MINISTERIAL PROCESS (2006)

2006: Russia, India and China's leaders met at St. Petersburg during G8 Outreach.

The grouping was formalised at the first BRIC Foreign Ministers' meeting on the UN General Assembly sidelines in New York.



St. Petersburg (G8 Outreach)

BRIC Foreign Ministers' meeting, UNGA sidelines New York

3. LEADERS SUMMIT AND EXPANSION (2009–2011)

16 June 2009
first BRIC leaders' summit, Yekaterinburg, Russia.



Yekaterinburg, Russia

2010
South Africa's inclusion agreed at the New York Foreign Ministers' meeting.



2011
South Africa first attended a summit, the third, at Sanya, China.
Distinguish entry decision from first summit participation.



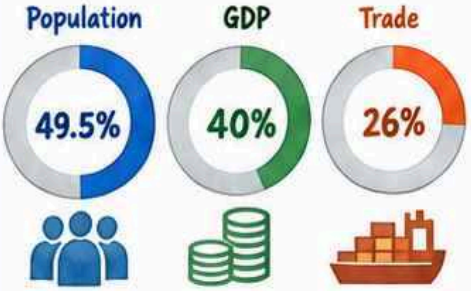
Sanya, China

THREE PILLARS



MEMBERS' GLOBAL SHARES

PIB, 10 September 2026, reports members' global shares: population 49.5%, GDP 40%, trade 26%. The valuation basis for this dated GDP estimate is unspecified; the figure cannot be identified as nominal GDP or PPP.



Source: PIB, 10 September 2026

CHAIRSHIP ROTATION

Chairmanship follows the agreed annual sequence.

Chairship runs 1 January – 31 December.

Year	Chair	Flag
2023	South Africa	
2024	Russia	
2025	Brazil	
2026	India	
2027	China	

Sources: S1, S2, S19, S32

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BRICS: membership, partnership and invitations

INDIA'S 2026 CHAIRSHIP: 11 COUNTRIES

11 countries are included in the chairship membership grouping. The Saudi Arabia status qualification below is part of this dated snapshot.

- Brazil
- Russia
- India
- China
- South Africa
- Egypt
- Ethiopia
- Iran
- United Arab Emirates
- Saudi Arabia
- Indonesia

Saudi Arabia status qualification:
Saudi Arabia is included in India's 2026 chairship membership grouping. Its delegation participated in the 12 September 2026 New Delhi summit as an invited country.

ORIGINAL FIVE AND EXPANSION

Original five: Brazil, Russia, India, China, South Africa.

- Brazil
- Russia
- India
- China
- South Africa

January 2024 expansion: Egypt, Ethiopia, Iran, United Arab Emirates.

- Egypt
- Ethiopia
- Iran
- United Arab Emirates

Saudi Arabia was invited in 2023 to join from January 2024; its status qualification is below.

Indonesia became a full member in January 2025.

TEN PARTNER COUNTRIES IN 2025

- Belarus
- Bolivia
- Kazakhstan
- Cuba
- Nigeria
- Malaysia
- Thailand
- Vietnam
- Uganda
- Uzbekistan

Partner status is a separate category from full membership.

HOW THE PARTNER CATEGORY DEVELOPED

2023 → Johannesburg: expansion decision and mandate to develop a partner category.

2024 → Kazan: partner status and criteria approved.

2026 → New Delhi: partners' contribution recognised; no new member or partner announced in the declaration.

THREE DIFFERENT RELATIONSHIPS

Member: a country admitted to the group.

Partner: a designated cooperation category.

Invited participant: a country attending a particular meeting by invitation. Attendance alone is not a membership test.

Snapshot: 17 October 2026.

Sources: S2, S3, S4, S6, S7, S20

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Summits 1–6: From Dialogue to Financial Institutions



2009, Yekaterinburg, Russia, 16 June: first BRIC Summit.
The 2008 financial crisis and a more representative financial order shaped the discussion.

2010, Brasilia, Brazil: global-governance reform.

2011, Sanya, China: South Africa participated for the first time; the five-country BRICS summit began.

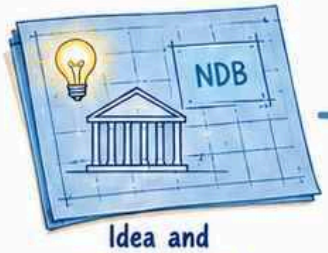
2012, New Delhi, India, 29 March: India's first chairship.
Theme: "BRICS Partnership for Global Stability, Security and Prosperity".
The Delhi Declaration and Action Plan included consideration of a new development bank.

2013, Durban, South Africa: work advanced on the development bank and a contingent reserve arrangement.

2014, Fortaleza, Brazil, 15 July: The NDB Agreement and CRA Treaty were signed.

BANK IDEA ≠ SIGNED AGREEMENT ≠ OPERATING INSTITUTION

New Delhi 2012: bank considered.



Idea and consideration

Fortaleza 2014: agreement signed.



Signed agreement

3 July 2015: NDB founding members' membership dates.



Founding members' membership dates

7 July 2015: inaugural Board of Governors meeting.



Inaugural Board of Governors meeting

The broader 2014 travel/programme range should not obscure the signing date of 15 July.

The bank and the reserve arrangement were created for different functions:

New Development Bank (NDB)



Long-term development projects.

Contingent Reserve Arrangement (CRA)



Short-term balance-of-payments liquidity support.

Sources: S1, S7, S9, S10, S13, S16

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Summits 7-12: Cooperation Broadens

7 2015, Ufa, Russia:

Strategy for BRICS Economic Partnership.



8 2016, Goa, India, 15-16 October:

India's second chairship.

Theme: "Building Responsive, Inclusive and Collective Solutions".

The leaders noted the NDB's first loans for renewable-energy projects.



9 2017, Xiamen, China:

digital-economy cooperation and global health.



10 2018, Johannesburg, South Africa:

cooperation in the context of the Fourth Industrial Revolution.



11 2019, Brasilia, Brazil:

support for the multilateral trading system represented by the World Trade Organization, WTO.



12 2020, hosted by Russia online, 17 November:

COVID-19 recovery.

Do not mistake the hosting country for an in-person summit location.



India's Chairship Chronology

2012 New Delhi → 2016 Goa (second chairship) → 2021 online → 2026 New Delhi (fourth chairship)

A summit can address many subjects; these are selected recall anchors, not an exhaustive agenda.

An annual chairship and a particular summit date are different time units. Retain both the year and city/format when matching an outcome to a summit.

Sources: S1, S2, S7

Day 15 | Topic 150 | 4/12 | @iaswithdrravi

Summits 13–17: Expansion and the Rio Declaration

13

2021, New Delhi, India, online, 9 September.

India's third chairship:

"BRICS@15: Intra BRICS Cooperation for Continuity, Consolidation and Consensus".



Over 150 events; first Digital Health Summit and first Water Ministers Meeting; Counter-Terrorism Action Plan.

- Digital Health Summit
- Water Ministers Meeting
- Counter-Terrorism Action Plan

14

2022, Beijing, China, online: food and energy security.



- Food security
- Energy security

15

2023, Johannesburg, South Africa, 22–24 August: expansion decision and mandate for foreign ministers to develop a partner-country category.





Mandate for foreign ministers to develop a partner-country category.

16

2024, Kazan, Russia, 22–24 October: partner status and criteria approved.

Theme: "Strengthening Multilateralism for Fair Global Development and Security".





17

2025, Rio de Janeiro, Brazil, 6–7 July: Rio Declaration.



RIO DECLARATION — PIB PUBLICATION 7 JULY 2025

Title: "Strengthening Global South Cooperation for a More Inclusive and Sustainable Governance".

- Welcomed Indonesia as a member and listed ten partner countries.
- Condemned the terrorist attack in Jammu and Kashmir on 22 April 2025.
- Expressed serious concern over rising unilateral tariff and non-tariff measures.

Sources: S1, S2, S6, S7

Day 15 | Topic 150 | 5/12 | @iaswithdrravi

India's Fourth Chairship: 2026 Programme

India took over from Brazil on 1 January 2026.
Its previous chairships were 2012, 2016 and 2021.

10 September

PIB, 10 September:
more than 350 meetings in 25 cities.



25 cities

Later figure includes meetings AND engagements.

12 September

New Delhi Declaration, 12 September, paragraph 6:
over 400 meetings and engagements in 30 cities.

30 cities

THEME

"Building for Resilience, Innovation, Cooperation and Sustainability".

The initial letters of Building, Resilience, Innovation, Cooperation and Sustainability spell BRICS.



SELECTED MINISTERIAL OUTCOMES

- BRICS Mission for Healthy Lifestyle: roadmap 2026–2029.
- Mental-health network coordinated by NIMHANS, National Institute of Mental Health and Neuro-Sciences.
- Digital Agriculture Network.
- Incubator network and startup innovation fund.
- Global Value Chains Action Plan 2026–2030.
- Youth Cooperation Framework 2026.

At the 12 September briefing, MEA Secretary for Economic Relations Sudhakar Dalela reported more than fifty chairship outcomes.

The programme spans the political/security, economic/financial and cultural/people-to-people pillars.
A chairship is a year-long process, not only the two summit days.

A YEAR-LONG CHAIRSHIP PROCESS

- 1 January 2026: India took over from Brazil.
- Preparatory meetings and engagements.
- 12–13 September 2026: Summit days.
- 31 December 2026: Chairship year ends.

Sources: S2, S3, S4, S5

Day 15 | Topic 150 | 6/12 | @iaswithdrravi

18th Summit: New Delhi, 12-13 September 2026

India hosted the 18th BRICS Summit at Bharat Mandapam, New Delhi, on 12–13 September 2026, chaired by Prime Minister Narendra Modi.





SELECTED PARTICIPANTS — NOT A COMPLETE ROLL

MEMBER REPRESENTATIVES

- **Russia:** President Vladimir Putin.
- **China:** President Xi Jinping.
- **Iran:** President Masoud Pezeshkian.
- **United Arab Emirates:** Sheikh Khaled bin Mohamed bin Zayed Al Nahyan, Crown Prince of Abu Dhabi.
- **South Africa:** President Cyril Ramaphosa.

PARTNER – OUTREACH – INVITED

- **Saudi Arabia:** Foreign Minister, described by Saudi Press Agency as representing an invited country.
- **Kazakhstan:** President Kassym-Jomart Tokayev; Kazakhstan is a partner country.
- **Burundi's** President participated as Chairperson of the African Union.
- The President of the Philippines also participated.

NEW DEVELOPMENT BANK

New Development Bank

New Development Bank: President Dilma Rousseff.

THE DOCUMENT



- Adopted by consensus on 12 September; 140 paragraphs.
- Do not merge summit dates with adoption date: the meeting covered two days, while the Declaration was adopted on the first day.

Attendance at a summit or outreach session is not evidence of full BRICS membership.



Bharat Mandapam also hosted the G20 New Delhi summit in September 2023; the two declarations belong to different groupings.

Sources: S2, S4, S5, S17, S20, S23, S24, S25, S26, S27, S28, S29, S30, S31

Day 15 | Topic 150 | 7/12 | @iaswithdrravi

New Delhi Declaration: What It Actually Commits To

UN REFORM – paragraph 13



China and Russia support Brazil and India's aspirations for a greater role in the UN, including its Security Council.

Do not silently turn "greater role" into an explicit promise of permanent seats.

TRADE – paragraph 21



Serious concern over rising unilateral tariff and non-tariff measures that distort trade.

TERRORISM – paragraph 40



Condemnation of the 22 April 2025 terrorist attack in Jammu and Kashmir.

PAYMENTS – paragraph 90

BRICS Payment Task Force under the Cross-Border Payments Initiative; work on payment/messaging interoperability and local-currency trade settlement and investment.



National priorities matter; there is no single approach for all members. This creates no common BRICS currency.

CRA – paragraph 97



Treaty amendments aim at greater flexibility and responsiveness.

NDB – paragraph 115



Support for expanding membership and local-currency financing.

Thanks to Russia for the bank's 11th Annual Meeting in Moscow, 14–15 May 2026.

NEXT CHAIR – paragraph 140



Support for China's chairship in 2027 and the 19th Summit in China.

CHINA 2027
19th SUMMIT



The Declaration recognises partners but announces no new member or partner.

Separate an endorsed direction, a study or proposed mechanism from a completed institutional change.

Sources: S4, S18, S29

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NDB and CRA: Two Different US$100 Billion Figures

NEW DEVELOPMENT BANK — PROJECT FINANCE

Multilateral development bank for infrastructure and sustainable development in BRICS and other emerging and developing countries.

Agreement signed at Fortaleza, 15 July 2014.

Initial authorised capital:
US$100 billion.

Initial subscribed capital:
US$50 billion across five founders.

Composition of the US$50 billion subscribed capital

Initial subscribed capital:
US$50 billion

- **US$10 billion** paid-in
- **US$40 billion** callable

10 + 40 = **50** (US$ billion)

Each founder: 100,000 shares = US$10 billion; equal founder subscriptions.

Five Founders (equal subscriptions)

Brazil	Russia	India	China	South Africa
100,000 shares = US$10 billion	100,000 shares = US$10 billion	100,000 shares = US$10 billion	100,000 shares = US$10 billion	100,000 shares = US$10 billion

The US$50 billion comprises US$10 billion paid-in and US$40 billion callable capital. Subscription is not cash already paid in.

CONTINGENT RESERVE ARRANGEMENT — SHORT-TERM LIQUIDITY

Treaty signed at Fortaleza, 15 July 2014.

Initial committed resources:
US$100 billion.

Country-wise commitments (US$ billion)

China	Brazil	India	Russia	South Africa
US$41 billion	US$18 billion	US$18 billion	US$18 billion	US$5 billion

Total: 41 + 18 + 18 + 18 + 5 = **100.**

CRA supports members facing actual or potential short-term balance-of-payments pressures through currency swaps.

It is a contingent commitment arrangement, not a paid-in common fund: countries retain resources until a supported request leads to a swap.

How a CRA currency swap works (reversible)

Member country (central bank) facing short-term balance-of-payments pressures

→ Draws currency via swap

← Repays currency (as per agreed terms)

CRA (central banks of members)

Central banks operate under an Inter-Central Bank Agreement and Standing Committee procedures.

Exam distinction: NDB finances projects; CRA supports liquidity.
Equal NDB founding subscriptions do not mean equal CRA commitments.

Sources: S8, S11, S12, S13, S16, S21

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NDB: Headquarters, Offices and Presidents

The New Development Bank's headquarters is in **SHANGHAI, CHINA.** India hosts a regional office, not the headquarters.











GIFT expands to Gujarat International Finance Tec-City.

PRESIDENTS

K.V. Kamath of India — first President, 2015. → **Marcos Prado Troyjo** — 2020. → **Dilma Rousseff** — 2023; re-elected in 2025.

FOUNDING MILESTONES

- **2012:** BRICS leaders considered the bank.
- **2013:** leaders agreed it was feasible.
- **15 July 2014:** agreement signed at Fortaleza.
- **3 July 2015:** founding members' membership dates.
- **7 July 2015:** first Board of Governors meeting.

Do not confuse the location of an annual meeting with the bank's permanent headquarters: its 11th Annual Meeting was held in Moscow on 14–15 May 2026, while headquarters remained Shanghai.

Institutional history, membership entry and the opening of an office are different events. Label each date by what happened rather than using an undifferentiated "founded" date.

Sources: S9, S10, S16, S29

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NDB Membership: Approval Is Not Accession

NDB MEMBERSHIP SNAPSHOT: 17 OCTOBER 2026

Five founders: Brazil, Russia, India, China and South Africa; membership dates 3 July 2015.



ADDITIONAL MEMBERS AND ENTRY DATES



- Bangladesh — 16 September 2021
- United Arab Emirates — 4 October 2021
- Egypt — 20 February 2023
- Algeria — 19 May 2025
- Uzbekistan — 5 June 2026

PROSPECTIVE MEMBERS

Uruguay, Colombia, Ethiopia, Angola, Zimbabwe and Belarus.





NDB MEMBERS



As of 17 October 2026, these six countries have Board approval and remain prospective members.

A country becomes a member when it deposits its instrument of accession.

Approval → accession instrument deposited → membership.

Board approval and the legally operative membership date are distinct.

THREE DISTINCT LISTS

1. BRICS full members.
2. BRICS partner countries.
3. NDB members.

STATUS OF SELECTED COUNTRIES

Country	BRICS member	BRICS partner country	NDB member (as per dated list)
Bangladesh	No	No	Yes (16 September 2021)
Algeria	No	No	Yes (19 May 2025)
Uzbekistan	No	Yes	Yes (5 June 2026)
Ethiopia	Yes	No	No (remains prospective)

- New Delhi supported further NDB expansion; that statement does not automatically confer membership on every prospective country.
- Membership status can change after this dated snapshot.

Sources: S2, S6, S9, S10, S4

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Chronology and Interpretation: Avoid the Look-Alikes

INDIA'S FOUR CHAIRSHIPS

2012 New Delhi → **2016** Goa → **2021** online → **2026** New Delhi



2026 is the fourth, not the third. China is endorsed for 2027 and the 19th Summit.

TWO CITIES, TWO GROUPINGS

Rio de Janeiro



G20 November 2024 | **BRICS** 6–7 July 2025

Bharat Mandapam, New Delhi



G20 September 2023 | **BRICS** 12–13 September 2026

Do not mix their declarations. G20 is covered in Topic 70.

REPRESENTATION AND RESULTS

India's stated aim was to turn greater representation into meaningful cooperation and tangible outcomes. New Delhi announced no new member or partner.

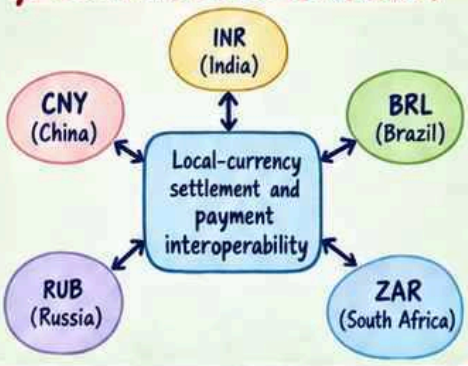
UNITY: DISTINGUISH DOCUMENT TYPES

MEA issued a Chair's Statement and Outcome Document for the Foreign Ministers' meeting on 15 May 2026. September's leaders adopted a consensus Declaration.

CHAIR'S STATEMENT
MAY 2026
Foreign Ministers' meeting
15 May 2026

CONSENSUS DECLARATION
SEPTEMBER 2026
Leaders' meeting
September 2026

PAYMENT INTEROPERABILITY ≠ COMMON BRICS CURRENCY



A chair's statement is not interchangeable with a consensus leaders' declaration. A document's title alone does not explain why countries differed.

A partner, invited participant and NDB member are not automatically a BRICS full member. Membership categories and dates must be distinguished.

Sources: S2, S3, S4, S5, S6, S20, S22, S31 | Day 15 | Topic 150 | 12/12 | @iaswithdrravi

APPSC GROUP 1 · 1,000 TOPICS IN 100 DAYS

Day 15 | English | Source Index

Source Index

187 bibliography entries, grouped by topic. Source IDs restart in each topic.

Topics in this booklet

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143	Polavaram: statutory, economic and irrigation significance
144	Ocean relief: continental shelf, slope, abyssal plain and trenches
145	Population of India: distribution, density and growth
146	Genetically modified crops in India: Bt cotton, GM mustard and regulation
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148	Number series: squares, cubes and primes
149	Data interpretation: bar graphs
150	Current affairs: BRICS and India's presidency 2026

DAY 15 · TOPIC 141

Indus Valley town planning, drainage and the Great Bath

Source references

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S2 NCERT, Our Pasts I, Class VI, chapter 3: In the Earliest Cities. Rationalised 2023–24 edition, pp. 23–26; listed reproductions. Source 1 Source 2 Source 3

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S12 UNESCO World Heritage Centre, news item of 27 July 2021, "Cultural sites in Africa, Arab Region, Asia, Europe, and Latin America inscribed on UNESCO's World Heritage List". Source

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S14 UNESCO World Heritage Centre, Tentative List, "Archaeological remains of a Harappa Port-Town, Lothal". Source

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S16 Lawrence S. Leshnik, “The Harappan Port at Lothal: Another View”, American Anthropologist 70 (1968), original paper. Source

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