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SECTION 1

AI, Digital & Cybersecurity

01 Egocentric Data

How wearable cameras are helping train the next generation of AI robots [The Indian Express](#)

PRELIMS POINTERS

Egocentric data is **first-person video and sensor data** recorded from the point of view of a person doing a task. Cameras worn on the **head, chest or wrist** capture what the worker sees and does, giving AI systems real-world data on human actions.

- **Training humanoid robots** to assemble, pick, grip and move through spaces.
- **Vision-Language-Action (VLA) models:** Link what a robot sees, what it is told and how it acts.
- **Real-world learning:** Captures clutter, changing light and interruptions that lab datasets miss.
- **Fine motor skills:** Hand coordination, grip pressure and timing.
- **Embodied AI:** Data for AI that must act in the physical world.
- **India as a data hub:** A large workforce and low labour costs make India a major collection site.

MAINS POINTERS

Concerns

- 1 **Worker surveillance:** Continuous recording of workers and workplaces.
- 2 **Consent and privacy** of co-workers and bystanders caught on camera.
- 3 **Data protection:** Collection must comply with the **Digital Personal Data Protection Act, 2023**.
- 4 **Fair value:** Low-paid workers generate high-value training data.
- 5 **Automation risk:** The same data may train robots that replace these jobs.

02 Information Agents

Google's new information agents are a privacy and web infrastructure problem [The Hindu](#)

PRELIMS POINTERS

Information agents are AI agents that **keep monitoring the web on a user's behalf** and report back when relevant information appears or changes. Unlike conventional search, where the user types each query, the agent understands the goal, searches repeatedly and acts proactively. Google introduced them as part of its AI-powered Search.

How they work: The user sets a goal; the agent learns preferences, monitors many websites, filters what matters and alerts the user. For example, it can track house listings by location, budget, commute and timeline.

MAINS POINTERS

Concerns

- 1 **Privacy:** Agents need detailed, continuing knowledge of a user's needs and habits.
- 2 **Web infrastructure:** Constant automated crawling raises server load, while users stop visiting the sites that produce the content.
- 3 **Publishers lose traffic and revenue**, which threatens the open web.

4 **Accountability** for wrong or biased results delivered without a human check.

03 Varya AI Model

India AI Mission launches indigenous Varya, a video story generating AI model [PIB](#)

PRELIMS POINTERS

Varya is an indigenous **distilled video-generation AI model** developed by **Avataar.ai** with support from the **IndiaAI Mission**. It creates video from text prompts and images, with an emphasis on Indian cultural and visual contexts.

- **Distillation:** Compresses a large model's capability into a smaller, efficient one.
- **50 steps to 4:** Cuts video-generation steps from about 50 to 4, saving computing power.
- **Low cost:** About **₹0.48 per second** of video by the company's own benchmarks, claimed to be up to 10 times cheaper than leading global models.
- **Indian context:** Trained to understand Indian regions, festivals, food, clothing and everyday life.
- **Multimodal input:** Text or image.
- **IndiaAI Mission:** Approved in **2024** with **₹10,371.92 crore** for compute, datasets, foundation models and skilling.

04 World Artificial Intelligence Conference 2026

Artificial intelligence collaboration: Xi's WAICO and Shanghai AI projects for developing countries [India Today](#)

PRELIMS POINTERS

The **World Artificial Intelligence Conference (WAIC)** is held annually in **Shanghai, China**. The 2026 edition, with a High-Level Meeting on Global AI Governance, was held from **17 to 20 July 2026** on the theme "**AI Partnership for a Brighter Future**", with participants from over 100 countries and organisations.

Outcomes

- **World AI Cooperation Organization (WAICO):** Its founding agreement was signed, with **29** founding members.
- **Capacity building:** China offered **5,000** AI training places to developing countries over five years.
- **Cooperation centres** proposed with ASEAN, the Arab League, the African Union, CELAC, the SCO and BRICS.
- **Governance:** Common approaches to AI safety, ethics and standards.

MAINS POINTERS

Significance

- 1 **Competing governance models:** China offers a multilateral, state-led track alongside Western-led processes.
- 2 **Global South outreach** through training and infrastructure.
- 3 **For India:** A reminder to shape AI governance through its own platforms and partnerships with the Global South.

05 5G Network Slicing and Net Neutrality

What is network slicing and does Airtel's new preferential 5G plan violate net neutrality? [The Indian Express](#)

PRELIMS POINTERS

- **Network slicing:** A 5G feature that divides one physical network into several **virtual networks ("slices")**, each tuned for speed, latency, reliability or capacity.
- **Technologies: Software-Defined Networking (SDN) and Network Function Virtualisation (NFV)** allocate resources dynamically.
- **Flow:** Physical 5G network, then virtual slices, then different quality-of-service levels for different users and applications.
- **Net neutrality:** All internet traffic must be treated equally, with no blocking, throttling or paid prioritisation.

India's rules

- **2016:** TRAI's **Prohibition of Discriminatory Tariffs for Data Services Regulations** ended zero-rating plans such as Free Basics.
- **2017:** TRAI recommended strong net neutrality principles.
- **2018:** DoT adopted them through licence conditions, but exempted "**specialised services**" (for example remote surgery, autonomous cars) and some IoT services, provided they do not degrade ordinary internet access.

MAINS POINTERS

The debate

- 1 **For operators:** Slicing enables premium, guaranteed-quality services and new revenue.
- 2 **Against:** Selling faster lanes to paying consumers could create a two-tier internet.
- 3 **Key question:** Whether a consumer plan with priority access counts as a permitted specialised service or breaches non-discrimination.
- 4 **Way forward:** Clear TRAI rules defining specialised services and transparency obligations.

06 Wi-Fi 7

India enters Wi-Fi 7 era as TP-Link begins local manufacturing [DD News](#)

PRELIMS POINTERS

Wi-Fi 7 (IEEE 802.11be) is the newest Wi-Fi standard, offering higher speeds, lower latency and better performance in crowded networks. TP-Link has begun making Wi-Fi 7 equipment in India.

- **320 MHz channels:** Twice as wide as Wi-Fi 6, for much higher throughput.
- **4096-QAM:** Packs more data into each signal.
- **Multi-Link Operation (MLO):** A device uses several bands at once for speed and reliability.
- **Bands:** 2.4 GHz, 5 GHz and **6 GHz**. India opened the **lower 6 GHz band** for licence-free indoor use in **2025**, which Wi-Fi 6E and 7 need.
- **High-density performance** where many devices connect at once.

Applications

- **AI, cloud and data-heavy work.**

- AR/VR and cloud gaming.
- Smart classrooms, hospitals and campuses with many users.
- Industrial IoT and smart factories.
- Smart homes with many connected devices.

07 Drunix

NPCI unveils Drunix to support blockchain and tokenisation ecosystems [Business Standard](#)

PRELIMS POINTERS

- **What it is:** An **open-source, enterprise-grade blockchain platform** launched by the **National Payments Corporation of India (NPCI)** in June 2026.
- **Base:** An enhanced fork of **Hyperledger Fabric**, a permissioned distributed-ledger framework.
- **Purpose:** Help institutions build **tokenisation** platforms, digital-asset systems and multi-organisation blockchain networks.
- **Tokenisation:** Representing real-world or digital assets (bonds, deposits, property) as blockchain tokens.
- **Open source:** Developers can inspect, modify and contribute to the code.
- **Significance:** Extends India's **digital public infrastructure** approach (UPI, Aadhaar) to blockchain.

08 Regulating Cyber Warfare

Cyber warfare is outpacing global legal accountability [The Hindu](#)

PRELIMS POINTERS

International frameworks

Framework	Relevance
UN Charter, Article 2(4)	Prohibits the use of force; whether cyber operations count is contested
UN Charter, Article 51	Right of self-defence against an armed attack
UN GGE / OEWG norms	Eleven voluntary norms of responsible State behaviour in cyberspace (2015)
Budapest Convention (2001)	Council of Europe cybercrime treaty; India is not a party
UN Convention against Cybercrime	Adopted in 2024; opened for signature in Hanoi in 2025
Tallinn Manual 2.0 (2017)	Non-binding expert study on how international law applies to cyber operations

MAINS POINTERS

Why cyber warfare is hard to regulate

- 1 **Attribution:** Proxies, hijacked servers and many jurisdictions hide the attacker.
- 2 **Unclear threshold:** When does a cyberattack become a prohibited **use of force**?
- 3 **Non-physical damage:** Power grids, banks and data can be disrupted without visible destruction.
- 4 **Evidence:** Technical and classified intelligence may not meet judicial standards.
- 5 **Sovereign immunity** limits suits against foreign States in domestic courts.
- 6 **Politics:** States prefer quiet diplomacy to avoid escalation or exposing intelligence.

Way forward

- 1 **Binding norms** on attacks against critical civilian infrastructure.
- 2 **Shared attribution mechanisms** and technical forensics.
- 3 **Stronger national cyber defence** and CERT cooperation.

09 Project Nimbus

What is Google's Project Nimbus and why are students protesting against it? [The Hindu](#)

PRELIMS POINTERS

- **What it is:** A multi-year **cloud-computing and digital-transformation** contract of the **Israeli government**, awarded in **2021** to **Google Cloud and Amazon Web Services**, worth about **\$1.2 billion**.
- **Scope:** Public-cloud infrastructure, data management, migration of government systems and access to cloud-based AI.
- **Google's position:** It says the contract covers government workloads, not highly sensitive military or weapons work.
- **Why protests:** Students and tech workers argue the services may support military and surveillance operations against Palestinians; Google dismissed protesting employees in 2024.

MAINS POINTERS

Issues

- 1 **Dual use of cloud and AI** in conflict.
- 2 **Corporate accountability** and transparency in defence-linked contracts.
- 3 **Employee activism** and the ethics of technology work.

SECTION 2

Quantum & Emerging Technologies

01 India's Quantum-Safe Roadmap

Quantum-safe thinking: on the new DST task force report [The Hindu](#)

PRELIMS POINTERS

A **quantum-safe ecosystem** is security infrastructure that will stay secure even against future **fault-tolerant quantum computers**, which could break today's public-key encryption used in banking, digital identity, government and the internet. A **DST task force** under the **National Quantum Mission (NQM)** released a national roadmap for quantum-resilient cybersecurity in **May 2026**.

- **National Quantum Mission:** Approved in **2023**, **₹6,003.65 crore** for 2023-24 to 2030-31, run by the **Department of Science & Technology**.
- **The threat:** Quantum algorithms could break **RSA** and **elliptic-curve cryptography (ECC)**.
- **"Harvest now, decrypt later":** Adversaries can store encrypted data today and decrypt it once quantum computers mature, which is why sensitive data needs protection now.
- **Global standards:** The US **NIST** published its first post-quantum standards in **2024** (ML-KEM, ML-DSA, SLH-DSA).

Key elements of the roadmap

- **Post-Quantum Cryptography (PQC):** Algorithms that resist quantum attacks.
- **Hybrid cryptography:** Classical and PQC used together during the transition.
- **Crypto-agility:** Systems designed so algorithms can be swapped quickly.
- **Quantum-safe PKI:** Public Key Infrastructure built on quantum-resistant algorithms.
- **National PQC Testing and Certification Programme.**
- **PQC with Quantum Key Distribution (QKD)** testbeds.

MAINS POINTERS

Why act now

- 1 **Critical infrastructure** (banking, telecom, power, health) depends on cryptography.
- 2 **Digital identity and signatures** could be forged.
- 3 **National security data** must stay secret for decades.
- 4 **Migration takes years** across a vast digital ecosystem.

02 C-SAFE Recognition

India's first quantum-safe algorithm gets certified; Fortytwo Labs earns C-SAFE recognition from DSCI [The Economic Times](#)

PRELIMS POINTERS

- **C-SAFE: Cryptographic Security Assessment & Functional Evaluation**, an independent framework of the **Data Security Council of India (DSCI)** to evaluate indigenous post-quantum algorithms and products.
- **Tests:** Mathematical soundness, resistance to quantum attacks and secure implementation.
- **First recognition (2026): Fortytwo Labs** for its **Ci2** quantum-safe key-exchange algorithm.

- **Basis of Ci2: Ring Learning With Errors (Ring-LWE)**, a lattice problem hard for both classical and quantum computers.

MAINS POINTERS

Significance

- 1 **Digital sovereignty** in a strategic security layer.
- 2 **Protection of critical infrastructure** and digital public infrastructure.
- 3 **Trust**: Independent evaluation instead of self-declared claims.
- 4 **Less dependence** on foreign cryptographic standards.

03 White Rabbit Time Synchronisation

Union Minister Pralhad Joshi inaugurates 'White Rabbit Technology' based network demonstration in Jakkur, Bengaluru [PIB](#)

PRELIMS POINTERS

White Rabbit (WR) is an open-source, Ethernet-based **precision time-synchronisation** technology developed at **CERN**. Using optical fibre and constant correction for signal delay, it achieves **sub-nanosecond** accuracy. India is using it to build an indigenous **Indian Standard Time (IST) dissemination network** under "One Nation, One Time". A demonstration network was opened in **July 2026** at the **Regional Reference Standards Laboratory (RRSL), Jakkur, Bengaluru**, under the Department of Consumer Affairs.

- **Precision Time Protocol (PTP)**: WR builds on PTP rather than the less precise NTP.
- **Delay compensation** along fibre links.
- **Resilience**: A terrestrial alternative to relying on satellite (GNSS) timing.
- **Timekeeper**: **CSIR-National Physical Laboratory** maintains IST.

MAINS POINTERS

Applications

- 1 **Financial markets**: Time-stamping of high-frequency trades.
- 2 **Digital payments**: Correct sequencing of transactions.
- 3 **Power grids**: Synchronised monitoring and protection.
- 4 **Telecom**: 5G and 6G need precise timing.
- 5 **Defence**: A trusted timing reference for networked systems.
- 6 **Digital governance**: One common, trusted IST across government systems.

04 Cyborg Botany

Cyborg botany: how scientists are turning plants into circuit boards [The Hindu](#)

PRELIMS POINTERS

Cyborg botany combines plant biology, electronics and robotics to **integrate electronic systems with living plants**. It uses plants' natural ability to sense their surroundings, produce electrical signals and grow. The idea was developed at the **MIT Media Lab**.

Applications

- **Environmental monitoring**: Plants as living sensors for light, moisture and pollutants.

- **Smart agriculture:** Plant signals reveal stress, water need or disease.
- **Urban sensing** through networks of plants.
- **Robotics:** Plant signals can steer robots, as in the plant-robot hybrid **Elowan**.
- **Living electronics** that mix biological and electronic parts.

SECTION 3

Semiconductors & Electronics

01 India Semiconductor Mission: The Chip Plants

India semiconductor mission: 12 chip plants, display fab - where are they and what do they make? [The Indian Express](#)

PRELIMS POINTERS

The **India Semiconductor Mission (ISM)**, launched in **2021** with a **₹76,000 crore** incentive package, aims to build a full chip ecosystem: design, fabrication, assembly, testing, packaging, materials and equipment. Under **ISM 1.0**, **12 projects** worth about **₹1.64 lakh crore** have been approved. **Gujarat** (Dholera and Sanand) leads with over **₹1.24 lakh crore** of investment.

Major approved projects

Project	Location	Type
Tata Electronics with PSMC (Taiwan)	Dholera, Gujarat	India's first commercial fab
Micron Technology	Sanand, Gujarat	Assembly and test (ATMP)
CG Power with Renesas	Sanand, Gujarat	OSAT
Kaynes Semicon	Sanand, Gujarat	OSAT
Tata Semiconductor Assembly and Test	Jagiroad, Assam	OSAT
HCL-Foxconn	Jewar, Uttar Pradesh	Display driver chips
SiCSem	Bhubaneswar, Odisha	Silicon carbide compound semiconductors
3D Glass Solutions	Bhubaneswar, Odisha	Glass-core substrates and advanced packaging

MAINS POINTERS

Challenges

- 1 **Capital intensity:** Clean rooms, equipment and ultra-pure utilities.
- 2 **Technology dependence** on foreign firms for processes and tools.
- 3 **Thin supplier base** for chemicals, gases and wafers.
- 4 **Water and power:** Large volumes of ultra-pure water and stable power.
- 5 **Skills gap** in process engineering and equipment maintenance.
- 6 **Competition** from Taiwan, South Korea, Japan, the US and China.

Way forward

- 1 **Clusters** linking fabs, OSATs, suppliers and design firms.
- 2 **Domestic chemicals, gases, wafers and equipment.**
- 3 **R&D and technology partnerships** with global firms.
- 4 **Semiconductor courses** in IITs and training institutes.

02 NITI Aayog's Semiconductor Roadmap

NITI Aayog Frontier Tech Hub unveils 10-year roadmap for India's semiconductor industry [PIB](#)

PRELIMS POINTERS

In **May 2026**, NITI Aayog's **Frontier Tech Hub** released "**Future of India's Semiconductor Industry**", India's first comprehensive **10-year semiconductor roadmap**. It aims to turn India from a large chip consumer into an indispensable global player, with a **US\$120-150 billion** value chain by **2035**.

Five pillars (5Ps)

- 1 **Pioneering:** Frontier R&D and design, with **100+ advanced design IPs**.
- 2 **Policy & Investment:** Long-term capital for a long-gestation industry.
- 3 **Production:** A global hub for **advanced packaging and OSAT**, plus compound and wide-bandgap semiconductors.
- 4 **People:** The full talent pyramid, from design to clean-room operations.
- 5 **Partnership:** Trusted countries, global firms, academia and start-ups.

03 Glass-Core Substrates

MoU signed to bring substrate manufacturing technology to India [AIR News](#)

PRELIMS POINTERS

- **Substrates:** Specialised layers in **chip packaging** that support the chip and connect it electrically to the circuit board.
- **The MoU:** Signed by the **Government of Odisha, Intel and 3D Glass Solutions (3DGS, USA)** for an estimated **\$3.3 billion** glass-core substrate facility in the **Bhubaneswar-Khurda** region, to be built in phases over **5-6 years**.
- **Why glass:** Compared with organic cores, glass offers dimensional stability, low warpage and very fine interconnects.
- **Uses:** AI chips, high-performance computing, data centres, 5G/6G, automotive, defence and photonics.

MAINS POINTERS

Significance

- 1 **Beyond fabs:** Packaging, substrates and testing are equally vital links in the chain.
- 2 **Advanced packaging capability** and lower imports.
- 3 **High-skilled jobs** and global investment.
- 4 **Fits the ISM** goal of an end-to-end ecosystem.

SECTION 4

Defence & Security

01 Make in India in Defence

Make in India in defence: Challenges and solutions [The Indian Express](#)

PRELIMS POINTERS

Make in India in defence aims to build an indigenous defence-industrial base covering **design, R&D, manufacturing, maintenance and exports**, moving from assembling imported platforms to designing and producing them at home. The wars in Ukraine and West Asia have underlined the value of secure domestic supply chains.

- **Output:** Defence production reached a record of about **₹1.5 lakh crore** and exports about **₹23,622 crore** in FY 2024-25.

Major initiatives

- **Buy (Indian-IDDM):** Top priority for indigenously designed, developed and manufactured equipment under **DAP 2020**.
- **Positive Indigenisation Lists:** Items that can only be bought from Indian sources.
- **Strategic Partnership Model:** Indian firms with foreign OEMs for submarines, helicopters and fighters.
- **FDI:** 74% through the automatic route since **2020**.
- **MAKE procedure:** MAKE-I, MAKE-II and MAKE-III.
- **Defence Industrial Corridors** in **Uttar Pradesh and Tamil Nadu**.
- **iDEX:** Links the forces with start-ups and MSMEs.

MAINS POINTERS

Why self-reliance matters

- 1 **Strategic autonomy** in crises.
- 2 **Supply security** for ammunition and spares in long wars.
- 3 **Technological sovereignty** in UAVs, missiles, sensors and engines.
- 4 **Jobs and industrial clusters**.
- 5 **Exports** and strategic partnerships.

Challenges

- 1 **Critical gaps:** Aero-engines, advanced electronics and materials.
- 2 **Long procurement cycles** and delays.
- 3 **Low private R&D**.
- 4 **Dependence on imported sub-systems** even in "indigenous" platforms.

02 INS Mahendragiri

Indigenous stealth frigate Mahendragiri, endowed with potent weapon system, delivered to Navy [The Hindu](#)

PRELIMS POINTERS

- **What it is:** A **Project 17A (Nilgiri-class) stealth frigate**, designed by the Navy's **Warship Design Bureau** and built by **Mazagon Dock Shipbuilders Ltd (MDL), Mumbai**.
- **Timeline:** Delivered in **April 2026**; commissioned on **11 July 2026**.
- **Place in the class:** The **sixth** of seven P17A frigates.
- **Indigenous content:** About **75%**.
- **Sister ships:** Nilgiri, Udaygiri and Taragiri (MDL); Himgiri, Dunagiri and Vindhyagiri (GRSE, Kolkata).
- **Significance:** Shows India's capability to design and build advanced warships at home.

03 Agni Missile with MIRV

India successfully tests advanced Agni missile with MIRV capability from Odisha [AIR News](#)

PRELIMS POINTERS

MIRV (Multiple Independently Targetable Re-entry Vehicle) technology lets one ballistic missile carry several warheads, each aimed at a **different target**. After the boost phase, a **post-boost vehicle** releases the re-entry vehicles on separate paths.

- **Latest test:** An advanced **Agni** missile with MIRV was flight-tested from Odisha in **May 2026**.
- **Earlier milestone:** **Mission Divyastra**, the first MIRV test of **Agni-5**, in **March 2024**.
- **Club:** MIRV technology is held by the **US, Russia, China, the UK, France and India**.

MAINS POINTERS

Strategic value

- 1 **Several targets with one missile.**
- 2 **Defeats missile defences** by saturating them.
- 3 **Force multiplication.**
- 4 **Credible deterrence:** Strengthens a survivable second-strike capability under India's **No First Use** doctrine.
- 5 **Counter-force potential** against hardened targets, depending on doctrine.

04 Long-Range Land Attack Cruise Missile

DRDO conducts successful flight-test of Long Range Land Attack Cruise Missile [PIB](#)

PRELIMS POINTERS

- **What it is:** An indigenous **long-range, precision land-attack cruise missile**.
- **Developer:** **DRDO**, with the **Aeronautical Development Establishment (ADE), Bengaluru** as nodal lab, and Indian industry.
- **Lineage:** Built on technology from **Nirbhay** and the **Indigenous Technology Cruise Missile (ITCM)**.
- **Users:** Configured for the **Navy and Air Force**.
- **Features:** **Low-altitude flight** to evade radar; **waypoint navigation**; mid-course manoeuvres.

- **Engine:** The indigenous **Small Turbo Fan Engine (Manik)**.

05 RudraM-II Missile

India successfully flight-tests indigenous RudraM-II Air-to-Surface Missile [AIR News](#)

PRELIMS POINTERS

- **What it is:** An indigenous **solid-propelled, air-launched air-to-surface missile**.
- **Developer:** DRDO, with **Research Centre Imarat (RCI), Hyderabad** as nodal lab, and industry partners.
- **Role:** **Suppression and destruction of enemy air defences (SEAD/DEAD)**, and precision strikes on ground targets.
- **Platform:** Tested from the **Su-30MKI**.
- **Family:** RudraM-I is an anti-radiation missile; RudraM-II and III extend range and target types.

06 Pinaka Long Range Guided Rocket

Pinaka Long Range Guided Rocket [PIB](#)

PRELIMS POINTERS

- **What it is:** A **guided, long-range variant** of the indigenous **Pinaka multi-barrel rocket launcher**.
- **Latest test:** **10 July 2026** at the **Integrated Test Range, Chandipur (Odisha)**, with accurate hits from **60 to 120 km**, including steep manoeuvres at minimum range.
- **Developers:** **Armament Research and Development Establishment (ARDE), Pune** with **HEMRL**, supported by DRDL and RCI.
- **Launcher:** Fired from the in-service truck-mounted Pinaka launcher, so one launcher handles several variants.
- **Future:** Longer-range versions (about **300 km and 450 km**) are planned.
- **Significance:** Precision long-range fires with less reliance on imported rocket artillery.

07 Netra AEW&C

IAF gets Final Operational Clearance of indigenous Airborne Early Warning & Control system 'Netra' [PIB](#)

PRELIMS POINTERS

- **What it is:** An indigenous **Airborne Early Warning and Control (AEW&C)** system developed by **DRDO** with the IAF and industry.
- **News:** The IAF received **Final Operational Clearance** in 2026.
- **Platform:** **Embraer ERJ-145** aircraft.
- **Sensors:** **AESA radar**, secondary surveillance radar, electronic and communication countermeasures, data links and self-protection.
- **Roles:** Early warning, airspace surveillance, battle management, fighter direction, air-defence coordination and network-centric warfare.

08 Fibre-Optic Drones

Israel-Hezbollah-Lebanon: Fibre-optic drones [The Indian Express](#)

PRELIMS POINTERS

Fibre-optic drones are UAVs controlled through a **physical fibre-optic cable** instead of radio signals. A spool on the drone unwinds a thin cable that carries commands and live video. With no radio link, they are almost **immune to jamming, spoofing and radio detection**. They have been used widely in the **Russia-Ukraine war** and, recently, by Hezbollah.

Uses

- **Precision strikes** with first-person-view (FPV) video.
- **Electronic-warfare zones** where radio drones fail.
- **Low-cost anti-armour** attacks on tanks and fortified posts.
- **Surveillance and urban warfare**.

MAINS POINTERS

Implications

- 1 **Limits of electronic defences:** Jammers do not stop them.
- 2 **Need for physical counter-measures:** Nets, guns, lasers and detection by radar or acoustics.
- 3 **Lesson for India:** Invest in counter-drone systems and indigenous FPV capability.

09 Project UDAYAK

BRO celebrates 37th Raising Day of Project UDAYAK at Doomdooa, Assam [PIB](#)

PRELIMS POINTERS

- **What it is:** A **Border Roads Organisation (BRO)** project, raised on **1 June 1989** at **Doomdooa, Assam**.
- **Name:** "Udayak" means **rising sun**; its area receives the first rays of the sun in India.
- **Area:** Over **1,457 km** of roads in eastern **Arunachal Pradesh** (Anjaw, Lohit, Dibang Valley, Longding, Tirap, Changlang) and parts of Assam.
- **Roles:** Strategic roads, bridges and last-mile links towards the **LAC** and the **India-Myanmar border**.
- **Significance:** Military mobility and development of remote frontier areas.

10 Shadow Fleet Ships

What are shadow fleet ships? Explained [The Indian Express](#)

PRELIMS POINTERS

A **shadow fleet** is a network of ships that use **deceptive practices, opaque ownership and irregular registration** to move **sanctioned cargo**, mainly oil from **Russia, Iran and Venezuela**. Estimates put it at over **3,000** vessels.

Tactics

- **AIS manipulation:** Switching off or faking the **Automatic Identification System**.
- **GNSS spoofing:** Fake satellite signals make the ship appear far away.
- **Ship-to-ship transfers** at sea to hide the cargo's origin.
- **Shell companies** that hide the real owner.

- **Flag and name changes**, sometimes with fraudulent flags.

MAINS POINTERS

Concerns

- 1 **Sanctions evasion.**
- 2 **Maritime safety:** Old, poorly insured tankers risk spills and collisions.
- 3 **Weak liability** for environmental damage.
- 4 **For India:** Balancing energy security with sanctions risk and maritime safety in its waters.

11 Kamikaze Dolphins

'Kamikaze dolphins': 5 things to know as US reacts to Iran waters report [Hindustan Times](#)

PRELIMS POINTERS

- **Meaning:** The reported idea of using **military-trained dolphins** to carry explosives or mines to enemy ships or submarines.
- **News:** In **May 2026** reports claimed Iran might use mine-carrying dolphins against US forces in the **Strait of Hormuz**; US Secretary of War **Pete Hegseth** dismissed the claim of an operational capability.
- **Background:** Navies have trained marine mammals for decades, for example the **US Navy Marine Mammal Program** (mine detection) and Russian dolphins at Sevastopol.
- **Issues:** Animal welfare and the ethics of using animals in war.

SECTION 5

Health & Biotechnology

01 CAR-T Therapy for Solid Tumours

Enhanced CAR-T therapy clears solid tumours by finding faint targets [The Hindu](#)

PRELIMS POINTERS

Chimeric Antigen Receptor T-cell (CAR-T) therapy is a cell-based immunotherapy. A patient's **T-cells** are genetically engineered to carry an artificial receptor (**CAR**) that recognises a specific antigen on cancer cells, then returned to the body to destroy those cells.

- **Success so far:** Mainly in **blood cancers** such as leukaemia and lymphoma.
- **The problem with solid tumours:** Target antigens are faint or uneven, and the tumour environment suppresses T-cells.
- **New advance:** Enhanced CAR-T cells that detect **low levels of target antigen** cleared solid tumours in studies.
- **India:** **NexCAR19**, India's first indigenous CAR-T therapy, developed by **IIT Bombay, Tata Memorial Centre and ImmunoACT**, was approved in **2023** at a fraction of the cost abroad.

MAINS POINTERS

Challenges

- 1 **High cost** and complex manufacturing.
- 2 **Side effects** such as cytokine release syndrome.
- 3 **Access** limited to specialised centres.

02 Synthetic Biology

Genie out: synthetic biology's power and peril [The Hindu](#)

PRELIMS POINTERS

Synthetic biology combines biology, genetics, engineering and computing to **design, redesign or build biological systems** with new functions. It goes beyond editing existing organisms: scientists design genetic parts, circuits and metabolic pathways that make cells perform specific tasks.

Applications

- **Medicine:** Therapeutic proteins, vaccines and diagnostics.
- **Drug production** in engineered microbes.
- **Agriculture:** Stress-tolerant and more nutritious crops.
- **Biomanufacturing:** Chemicals, polymers and fuels.
- **Environment:** Bioremediation and waste treatment.
- **Food:** Alternative proteins and enzymes.

MAINS POINTERS

Perils

- 1 **Biosecurity:** Dual-use risk of creating dangerous pathogens, made easier by AI.

- 2 **Biosafety:** Accidental release of engineered organisms.
- 3 **Ethics and equity** in access and benefit-sharing.
- 4 **Governance:** Regulation lags the science; the **Cartagena Protocol on Biosafety** and national biosafety rules need updating.

03 SpudCell: A Synthetic Cell

New synthetic cell can eat, grow, divide [The Hindu](#)

PRELIMS POINTERS

SpudCell is a lab-built **synthetic cell-like system** made from non-living chemical parts by researchers at the **University of Minnesota**. It can **take in resources, grow, copy its genome and divide**, several core cell functions working together.

Significance

- **Origin of life:** How chemistry could become coordinated cells.
- **Bottom-up synthetic biology:** Building cells from purified parts rather than modifying organisms.
- **Minimal-cell research:** Which components life really needs.
- **Future biomanufacturing** of medicines and chemicals.
- **Evolution studies:** A platform to observe selection among cell variants.

04 Leucine and Cellular Energy

How the amino acid leucine helps our cells produce energy [The Hindu](#)

PRELIMS POINTERS

- **What it is:** An **essential branched-chain amino acid (BCAA)**; the body cannot make it. The other BCAAs are **isoleucine and valine**.
- **Sources:** Meat, fish, dairy, eggs, soy and legumes.
- **Reaches tissues directly:** BCAAs largely bypass breakdown in the gut and liver.
- **Growth signal:** Leucine activates **mTORC1**, the master switch for **protein synthesis** and cell growth.
- **Ketogenic:** Leucine is purely ketogenic; its carbon skeleton becomes acetyl-CoA and acetoacetate for energy.

How it is broken down

- 1 **Transamination** by branched-chain aminotransferase (BCAT) forms a keto acid.
- 2 **Oxidative decarboxylation** by the **BCKDH** complex.
- 3 Products feed the **citric acid cycle** and ketone production.

A defect in BCKDH causes **maple syrup urine disease**.

05 India's Bioeconomy

India's bio-economy projected to grow to \$1 trillion by 2047: Union Minister Jitendra Singh [AIR News](#)

PRELIMS POINTERS

- **Meaning:** Economic activity based on biological resources and processes: biopharma, vaccines, biofuels, bioplastics, bio-based chemicals, agriculture and bioinformatics.

- **Growth:** From about **\$10 billion (2014)** to **\$165 billion (2024)** and about **\$195 billion (2025)**, nearly **4.8% of GDP**.
- **Targets:** **\$300 billion by 2030** and **\$1 trillion by 2047** (India BioEconomy Report). NITI Aayog's 2026 roadmap sets a higher **\$2.6 trillion by 2047** target.
- **BioE3 Policy (2024): Biotechnology for Economy, Environment and Employment**, promoting high-performance biomanufacturing.

MAINS POINTERS

Challenges

- 1 **High R&D costs** and the **scale-up gap**.
- 2 **Regulation** of GM organisms, gene editing and synthetic biology.
- 3 **Biosecurity** risks from AI-enabled biological design.
- 4 **Limited private R&D** and **shortage of biofoundries and skills**.

Way forward

- 1 **Regional biomanufacturing hubs** and biofoundries.
- 2 **AI-biology convergence** for drug discovery and protein design.
- 3 **Science-based regulation** with strong biosafety and ethics.

SECTION 6

Energy & Materials

01 India's First Hydrogen Train

India's first hydrogen train explained: How it works [The Indian Express](#)

PRELIMS POINTERS

India's first indigenous **hydrogen fuel-cell train** began running on the **Jind-Sonipat** section (Haryana) of Northern Railway in **July 2026**. The **10-coach** train has **two hydrogen driving power cars** and eight passenger coaches, a total output of **2,400 kW**, runs at up to **75 km/h** on an **89-km** route, and was built at the **Integral Coach Factory, Chennai**.

How it works

- Compressed hydrogen is fed to a **Proton Exchange Membrane Fuel Cell (PEMFC)**, where it reacts with oxygen to produce **electricity**.
- Electricity drives the traction motors; **water vapour and heat** are the only by-products.
- **Lithium Iron Phosphate (LFP) batteries** add power during acceleration and store energy from **regenerative braking**.
- **Hydrogen for Heritage**: Railways plans hydrogen trains on heritage and hill routes.

MAINS POINTERS

Benefits

- 1 **Zero tailpipe emissions** on diesel routes.
- 2 **Alternative to costly electrification** on low-traffic lines.
- 3 **Energy diversification** and demand for **green hydrogen**.
- 4 **Indigenous capability** in fuel cells and propulsion.

Challenges

- 1 **Costly green hydrogen**.
- 2 **Storage**: Low volumetric density needs high-pressure tanks.
- 3 **Few refuelling stations**.
- 4 **Grey hydrogen** from fossil fuels erodes climate gains.
- 5 **High upfront investment** and unproven long-term economics.

Way forward

- 1 **Link to green hydrogen** from renewable electrolysis.
- 2 **Hydrogen corridors** with production and refuelling hubs.
- 3 **Evaluate the pilot** on cost, reliability and safety before scaling.
- 4 **Indigenise** fuel cells, tanks and compressors.

02 Membrane Cell Technology

New rule requires fish survival test for caustic soda industry wastewater [Down To Earth](#)

PRELIMS POINTERS

Membrane cell technology is the modern way the **chlor-alkali industry** makes **caustic soda (NaOH)**, **chlorine (Cl₂)** and **hydrogen (H₂)** by electrolysing purified brine. An **ion-exchange membrane** separates the anode and cathode, letting mainly **sodium ions** pass, so chlorine and hydroxide do not mix.

- **Why in news:** New effluent standards for caustic soda units require a **bioassay (fish survival) test**: fish must survive in the treated wastewater.
- **Mercury-free:** Replaces the older **mercury cell** process; the **Minamata Convention** (India ratified in 2018) requires mercury-cell chlor-alkali plants to be phased out.
- **Lower energy use** than older processes.
- **High-purity** caustic soda.
- **By-product hydrogen** can be used as fuel or feedstock.

03 Rutile Oxides and Altermagnets

IIT Delhi: Ruthenium dioxide, Klemens model, Raman scattering, altermagnet [The Hindu](#)

PRELIMS POINTERS

- **Rutile oxides:** Oxides with the crystal structure of the mineral **rutile (TiO₂)**.
- **Ruthenium dioxide (RuO₂)**: Combines **metallic conductivity** with magnetism and is studied as a possible **altermagnet**.
- **Altermagnets:** A recently identified **third class of magnetism**. Like antiferromagnets they have **no net magnetisation**, but their electron bands are **spin-split** like ferromagnets, which is promising for **spintronics**.
- **IIT Delhi study:** Used **Raman scattering** (light interacting with lattice vibrations) to study RuO₂.
- **Klemens model:** Explains how high-energy **phonons** (quantised lattice vibrations) decay into lower-energy ones, which explains how Raman peaks change with temperature.

SECTION 7

Space & Astronomy

01 Private Participation in India's Space Economy

India's space ecosystem expands as private investment crosses \$600 million [DD News](#)

PRELIMS POINTERS

Private investment in India's space sector has crossed **\$600 million** since the **2020 reforms** opened the sector to non-government entities.

Reform milestones

- **IN-SPACe (2020)**: Authorises and promotes private space activity.
- **NewSpace India Ltd (NSIL)**: ISRO's commercial arm.
- **Indian Space Policy, 2023**: Defines roles of ISRO, IN-SPACe, NSIL and private firms.
- **FDI (2024)**: Up to **74%** automatic for satellites, **49%** for launch vehicles and **100%** for components.
- **Target**: Grow the space economy from about **\$8.4 billion** to **\$44 billion by 2033**.

MAINS POINTERS

Why private participation

- 1 **More capital** and faster growth.
- 2 **Innovation** in reusable launchers, small satellites and services.
- 3 **Frees ISRO** for science and strategic missions.
- 4 **Skilled jobs** and a deeper supply chain.
- 5 **Global market share** in launches and satellite services.

Challenges

- 1 **High capital needs** and long gestation.
- 2 **Imported components** and materials.
- 3 **Access to test and launch infrastructure**.
- 4 **Regulatory gaps**: No comprehensive space law yet on licensing and liability.
- 5 **Space debris** and security risks.

Way forward

- 1 **Strengthen IN-SPACe** with predictable approvals.
- 2 **A national space activities law**.
- 3 **Patient capital** for deep-tech space start-ups.
- 4 **Shared ISRO facilities** and technology transfer.

02 Vikram-1: India's First Private Orbital Rocket

Vikram-1: India's first privately developed orbital-class rocket [The Hindu](#)

PRELIMS POINTERS

- **What it is:** A small-satellite launch vehicle built by **Skyroot Aerospace**, Hyderabad, named after **Vikram Sarabhai**.
- **Milestone:** On **18 July 2026**, launched from **Satish Dhawan Space Centre, Sriharikota**, it became the **first privately developed Indian rocket to reach orbit**, placing payloads in **low Earth orbit at about 450 km**.
- **Design:** **Four stages**, with an **all-carbon-composite** structure and a **3D-printed liquid** upper-stage engine.
- **Payloads:** Six test payloads from Indian and foreign firms.
- **Earlier:** Skyroot's **Vikram-S** made India's first private **sub-orbital** flight in **2022**.
- **Next:** **Vikram-II**, with a cryogenic upper stage.

MAINS POINTERS

Significance

- 1 **Private launch capability** for India's growing small-satellite market.
- 2 **Proof of the 2020 reforms** and IN-SPACe's facilitation.
- 3 **Commercial competitiveness** in on-demand launches.

03 Mission Drishti

GalaxEye launches Mission Drishti, India's largest privately developed Earth observation satellite [The Hindu](#)

PRELIMS POINTERS

- **What it is:** The first satellite of Bengaluru-based start-up **GalaxEye**, launched on **3 May 2026** aboard a **SpaceX Falcon 9** from California.
- **Size:** About **190 kg**, India's largest privately built Earth-observation satellite.
- **OptoSAR:** Combines **optical imaging** with **Synthetic Aperture Radar (SAR)** on one satellite.
- **Why it matters:** Optical sensors need sunlight and clear skies; SAR sends its own radar pulses, so it sees **through clouds, day and night**.

Applications

- Disaster management
- Crop monitoring
- Defence and maritime surveillance
- Urban and infrastructure planning
- Environmental monitoring

04 TRISHNA Satellite

India and France to launch TRISHNA satellite in 2027 [DD News](#)

PRELIMS POINTERS

- **Full form:** **Thermal infraRed Imaging Satellite for High-resolution Natural resource Assessment**.

- **Partners:** ISRO and CNES (France); launch planned for 2027.
- **Measures:** High-resolution **land surface temperature** and **evapotranspiration**.
- **Uses:** Water stress in crops, irrigation efficiency, droughts, **urban heat islands**, glaciers, forests and wetlands.
- **Significance:** Better water management and climate adaptation.

05 SMILE Mission

SMILE mission: How the joint ESA-China mission will study Earth's magnetosphere and solar storms [The Indian Express](#)

PRELIMS POINTERS

SMILE (Solar wind Magnetosphere Ionosphere Link Explorer) is a joint mission of the **European Space Agency** and the **Chinese Academy of Sciences**, launched on **19 May 2026** on a **Vega-C** rocket from French Guiana. It studies how the **solar wind** interacts with Earth's **magnetosphere**.

- **Magnetosphere:** The region dominated by Earth's magnetic field, which shields us from charged particles in the solar wind.
- **First:** It will take the **first X-ray images** of the magnetosphere, while watching **auroras in ultraviolet**.
- **Orbit:** Highly elliptical, reaching about **121,000 km** above the North Pole.
- **Instruments:** Soft X-ray Imager, Ultraviolet Aurora Imager, Light Ion Analyser and Magnetometer.
- **Cooperation:** The first mission jointly selected, built, launched and operated by ESA and China.

MAINS POINTERS

Significance

- 1 **Space-weather forecasting.**
- 2 **Protecting satellites, GPS, communications and power grids** from geomagnetic storms.
- 3 **A global view** of Sun-Earth interaction.

06 NASA's Swift Boost Mission

NASA's Swift Boost mission begins as Link spacecraft sets out to save observatory [The Indian Express](#)

PRELIMS POINTERS

- **Swift Observatory:** NASA's **Neil Gehrels Swift Observatory** (launched **2004**) studies **gamma-ray bursts**, the most powerful explosions in the universe, along with X-ray and ultraviolet sources.
- **Problem:** Atmospheric drag is pulling it into a lower orbit.
- **Mission:** The **Link** servicing spacecraft, built by **Katalyst Space Technologies**, will dock with Swift and **boost its orbit**, extending its life.
- **Significance:** An early example of **in-orbit servicing** of a science satellite.

07 Zwan-Wolf Effect at Mars

What is the Zwan-Wolf effect at Mars? [The Hindu](#)

PRELIMS POINTERS

- **What it is:** A **plasma effect** in which charged particles are squeezed and redistributed along **magnetic flux tubes**. At Earth it helps deflect the solar wind around the planet. It was first described in **1976**.
- **Detection:** NASA's **MAVEN** spacecraft found it in the **Martian ionosphere**, below about **200 km**, especially during a **coronal mass ejection in December 2023**.
- **Why surprising:** Mars has **no global magnetic field**; it has only an **induced magnetosphere** formed by the solar wind meeting its ionosphere.
- **Significance:** Such plasma processes can occur even at unmagnetised planets, which helps explain how Mars lost its atmosphere.

08 Fast X-ray Transients

Astronomers uncover clues behind powerful cosmic X-ray flashes [DD News](#)

PRELIMS POINTERS

- **What they are:** Brief, intense, **non-repeating flashes of X-rays** from violent cosmic events.
- **Duration:** Minutes to a few hours, then they fade fast.
- **Energy range:** Mostly **soft X-rays (about 0.3-10 keV)**.
- **Why a puzzle:** Their short life made their origin hard to pin down; new wide-field X-ray telescopes now catch them as they happen.
- **Proposed sources:** Collapsing massive stars, neutron-star mergers and stars torn apart by black holes.

09 Extragalactic Jets

Extragalactic Jets [PIB](#)

PRELIMS POINTERS

Extragalactic jets are narrow, powerful streams of **plasma** launched from around **supermassive black holes** at the centres of distant galaxies. They travel thousands of light-years at **near light speed** and emit everything from **radio waves to gamma rays**.

Type	Appearance (Fanaroff-Riley, 1974)
FR I	Core-brightened: brightest near the black hole, becoming diffuse outwards
FR II	Edge-brightened: stay narrow over long distances and end in bright hotspots

- **Indian study:** Scientists from **ARIES (Nainital)**, Presidency University and others used simulations to suggest FR I and FR II may be **stages of one evolving process** rather than separate classes.
- **Significance:** How black holes shape galaxies, relativistic plasma physics and galaxy evolution.

10 Quasars

Oldest quasars ever found deepen perplexing space mystery [The Hindu](#)

PRELIMS POINTERS

- **What they are:** Quasi-stellar objects, extremely bright **active galactic nuclei** powered by gas falling into a **supermassive black hole** through a hot **accretion disc**.
- **Brightness:** They can outshine their entire host galaxy and are visible across the universe.
- **First identified:** 3C 273, in 1963.
- **The mystery:** The oldest quasars existed when the universe was **under a billion years old**, so how did their black holes grow so big so fast?
- **Uses:** Their light probes the **intergalactic medium** and the early universe.

11 A Planet around a Young Star

New planet revealed around a young star after a decade in hiding [The Hindu](#)

PRELIMS POINTERS

- **Young star:** A star recently formed from a collapsing region of a **molecular cloud**, usually surrounded by a **protoplanetary disc** of gas and dust.
- **Why study them:** The disc holds the raw material for planets and asteroids.
- **Activity:** Intense radiation and stellar winds shape forming planets and their atmospheres.
- **Significance:** A planet found around a young star shows **planet formation in action**.

SECTION 8

Science Policy & Innovation

01 India's Innovation Ecosystem

Innovate or be eaten: On India and an innovative ecosystem [The Hindu](#) [The Indian Express](#)

PRELIMS POINTERS

- **Bharat Innovates 2026:** A platform to showcase Indian deep-tech to global investors and industry. The first edition was held in **Nice, France (14-16 June 2026)** under the **India-France Year of Innovation**, with **120** deep-tech innovators, **15+** institutions and **500+** global stakeholders.
- **Spending: Gross Expenditure on R&D (GERD)** has stayed at about **0.6-0.7% of GDP** for over a decade; it is now about **0.64%**.
- **Recent support:** The **Anusandhan National Research Foundation (ANRF)** and the **₹1 lakh crore Research, Development and Innovation (RDI) Scheme**.
- **The shift needed:** From **technology adoption**, where India excels at scale, to **technology origination**: owning IP, standards and manufacturing in critical technologies.

MAINS POINTERS

Challenges

- 1 **Low R&D intensity** and **weak private R&D**.
- 2 **Bureaucratic rigidity** in grants, procurement and approvals.
- 3 **Lab-to-market gap** due to weak technology transfer.
- 4 **Talent:** Low researcher density and few postdoctoral paths.
- 5 **Risk-averse culture** and lack of patient capital for deep tech.
- 6 **Import dependence** in chips, equipment and strategic technologies.

Way forward

- 1 **Raise GERD towards 2% of GDP**, with industry contributing about half.
- 2 **Prioritise strategic technologies:** AI, semiconductors, quantum, biotech, clean energy and defence.
- 3 **Ease research administration** and give institutions autonomy.
- 4 **Stronger industry-academia links:** Technology Transfer Offices, incubators and research parks.
- 5 **Government as first customer** through mission-oriented procurement.
- 6 **Shared infrastructure:** Labs, fabs, high-performance computing and testing facilities.

02 India's Research Integrity Crisis

India needs an autonomous research integrity office [The Indian Express](#)

PRELIMS POINTERS

Research integrity means honesty, transparency and accountability across the research process: data collection, authorship, peer review, publication and funding. Violations include **plagiarism, fabrication, falsification, duplicate publication, image manipulation and improper authorship**.

MAINS POINTERS**Key issues**

- 1 **Publication pressure** that rewards quantity over quality.
- 2 **Misconduct** that damages the credibility of Indian research.
- 3 **Conflict of interest:** Institutions are reluctant to investigate senior faculty.
- 4 **Predatory journals** that publish for payment without real peer review.
- 5 **No autonomous national body** to handle integrity cases.
- 6 **Authorship disputes:** Gift and ghost authorship.
- 7 **Poor reproducibility** from weak data sharing.
- 8 **Little ethics training.**

Way forward

- 1 **An autonomous national Office of Research Integrity**, on the lines of the US ORI.
- 2 **Assessment by quality and impact**, not paper counts.
- 3 **Mandatory ethics training** and data-sharing norms.
- 4 **Protection for whistle-blowers.**

03 Jharkhand's New GI-Tagged Products

Jharkhand: Bhagaiya Silk, Kuchai Silk, Munda Jewellery, Bamboo Craft get GI tag [The Economic Times](#)

PRELIMS POINTERS

Four traditional products of **Jharkhand** received **Geographical Indication (GI)** tags in **2026**.

- **Bhagaiya Silk:** A traditional silk from Jharkhand's sericulture tradition.
- **Kuchai Silk:** Silk sarees and fabrics from the **Kuchai** region; registered as "Kuchai Silk Saree and Fabrics".
- **Munda Jewellery:** Traditional jewellery of the **Munda** tribal community, with distinctive motifs.
- **Bamboo Crafts of Jharkhand:** Utility and decorative bamboo products.
- **Significance:** Protects authenticity, improves market access and supports tribal and rural livelihoods.



GALLANT IAS ACADEMY

TRIVANDRUM

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