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Dear Students,

In the competitive landscape of the UPSC Mains examination, the significance of integrating data, facts, and examples into your answers cannot be overstated.

These elements serve as the backbone of a compelling and persuasive response, **elevating your answer from a generic narrative to a well-substantiated argument.**

To support you, we have **distilled essential information from the VisionIAS Mains 365 resources** which are renowned for their comprehensive coverage of current affairs. This document **provides a concentrated source of high-quality data, facts, and examples.**

The layout of this document is designed for **quick reference and easy integration into your answer.**

Leveraging this distilled information will help you **craft comprehensive, informative, and compelling answers** essential for securing higher marks.

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International Year of Quantum Science and Technology

- **It marks 100 years** since Werner Heisenberg's 1925 paper that initiated the development of **quantum mechanics.**
- **Google's 'Willow' is a quantum chip** marking a milestone in quantum computing.
- **Quantum chips use qubits** that can exist in superposition, unlike classical bits (0 or 1).

Internet of Things (IoT)

- **Applications in sectors** like agriculture (e.g., Fasal), healthcare (e.g., Apple Watch), and transport (e.g., FASTag).
- **Initiatives include** Smart Cities Mission, Centre of Excellence for IoT, and NM-ICPS.
- **Challenges include** security risks, e-waste, power consumption, and lack of interoperability among devices.

Robotics Technology

- **India ranks 7th globally** in robot installations (World Robotics 2024).
- **Used in healthcare** (SSI Mantra), education (Manav), defence (Daksha), and space (Vyom Mitra).
- **Challenges include** high cost, limited R&D, and ethical concerns like job displacement.

Brain-Computer Interfaces (BCIs)

- **BCIs convert brain signals into commands** for devices, aiding communication and control.
- **Challenges include signal interference**, brain tapping risks, and ethical concerns.

Organ-on-chip (OoC) Technology

- **Organ-on-chip technology**, expected to be worth around **$1.4 billion** by 2032.
- **Organ-on-Chip devices** recreate human organs and diseases using microfluidic technology.
- **OoC allows researchers** to simulate human physiology in a lab dish using 3D culture systems.
- **It forms part of New Approach Methods (NAMs)** aimed at reducing animal testing.

Blockchain Technology

- **Applications:** Crypto (Bitcoin), Voting (Remote voting), IP protection (ResonanceIP), Health Records (EHR).
- **Key initiatives include** National Blockchain Strategy, Vishvasya Stack, and Centre of Excellence by NASSCOM.
- **Challenges include** interoperability issues, high energy consumption, and lack of skilled workforce.

Deepfakes

- **Deepfakes are AI-generated videos/images** that blur the line between real and fake content.
- **US introduced the Take It Down Act** to tackle harmful deepfake content.
- **India uses IT Act, 2000 and CERT-In advisories** but lacks specific deepfake legislation.

Big Data

- **India joined UN-CEBD** to align its big data efforts with international standards.
- **Big Data includes** structured, unstructured, and mixed datasets needing new analytics tools.
- **Applications** span healthcare, logistics, education, smart cities, and earth sciences.

Supercomputers

- **National Supercomputing Mission (NSM)** aims for a network of supercomputers with **45 PetaFlops** capacity.
- **PARAM and AIRAWAT systems** support cancer research, weather forecasting, and governance.
- **Challenges include** energy demand, cooling requirements, and foreign dependency.

4D Printing

- **India developed 4D-printed artificial blood vessels** for advanced medical grafts.
- **4D printing extends** 3D printing by allowing objects to change over time via stimuli.
- **Applications include** drug delivery, soft robotics, and adaptive aerospace parts.

Genetically Modified Organism (GMO)

- **A GMO is a plant, animal, or microbe** with an altered genome, typically modified through genetic engineering to change its trait.
- **Bt Cotton is the only GMO crop** approved for commercial cultivation in India since **2002.**
- **Challenges** include ecological risks, ethical issues, and market monopoly by IP-holding corporations.

RNA Editing

- It is a process that **modifies genetic information** on RNA sequences through insertion, deletion or substitution.
- **RNA has four building blocks**: A (Adenine), G (Guanine), U (Uracil), and C (Cytosine).
- **RNA editing** modifies mRNA without altering DNA—using ADAR enzymes to convert Adenosine to Inosine.
- **Safer and reversible compared** to DNA editing, reducing risk of permanent unintended mutations.

Mitochondrial Transplantation

- **Mitochondria transplants** restore energy function in damaged tissues such as heart, brain, and skin.
- **Challenges include short** viability (1–2 hours), immune rejection, and ethical concerns of germline modification.
- **Promising applications** in treating Parkinson's, osteoporosis, infertility, and skin disorders.

Recombinant Proteins (RPs)

- **These are modified or manipulated proteins** encoded by recombinant DNA (rDNA) for
- **RPs are used** in making insulin, monoclonal antibodies, GM crops, and bioremediation products.
- **Escherichia coli (E. coli) is also one of the organisms of choice for RP production**

Graphene

- **Graphene is a one-atom-thick sheet** of carbon.
- **Strength:** 200 times stronger than steel, 6 times lighter.
- **Transparency:** Absorbs only 2.3% of light (ideal for displays and solar cells).
- **Applications range** from quantum computing and batteries to composites and defense tech.

Axiom-4 Mission

- **It is the 4th private astronaut mission**, to the International Space Station (ISS).
- **ISRO conducted experiments** on space farming, Cyanobacteria, and Study muscle loss etc.
- **India faces technological hurdles like** life support systems, thermal protection during re-entry, and human-rated rocket reliability.

Bharatiya Antariksh Station (BAS)

- **India aims to operationalize BAS by 2035** with five modular components in LEO.
- **It will advance microgravity research**, disaster imaging, and long-duration spaceflight training.
- **Challenges include** low R&D budget, life support systems, and radiation shielding.

Space Docking Experiment (SPaDeX)

- **ISRO demonstrated autonomous in-orbit docking** of two satellites under SPaDeX.
- **The mission achieved real-time rendezvous,** formation flying, and remote operation testing.
- **Mastering docking enables ISRO** to develop space stations and crew transfer systems.

Third Launch Pad

- **ISRO's Third Launch Pad** at Sriharikota will support **Next Generation Launch Vehicles (NGLV) and Launch Vehicle Mark-3 (LVM3).**
- **To be completed in 4 years**, it is crucial for future human and lunar missions.
- **It expands launch frequency** and supports India's goal of establishing Bharatiya Antariksh Station.

Scramjet Engine

- **India conducted its first successful 120-second test** of an active-cooled Scramjet combustor.
- **A scramjet engine** means a Supersonic Combusting Ramjet engine.
- **Scramjets operate efficiently** at hypersonic speeds using supersonic combustion.
- **Challenges include** high-energy fuel needs, cooling systems, and integration with launch systems.

CE20 Cryogenic Engine

- **CE20 is ISRO's high-thrust cryogenic engine** used in LVM3 missions including Chandrayaan-3.
- **Generally liquid hydrogen liquefied** at -253° Celsius is used as fuel and **liquid oxygen liquefied** at -183° Celsius is used as oxidizer.
- **Challenges involve** extreme thermal stress, superalloy requirements, and ignition reliability.

Hyperspectral Imaging (HSI) Satellites

- **HSI analyses** a wide spectrum of light instead of just assigning primary colours (red, green, blue) to each pixel.
- **Applications** include agriculture, water quality monitoring, and pollution tracking.

Space Debris

- **Over 1.2 million** debris pieces larger **than 1 cm** are currently in orbit.
- **Risks include** Kessler syndrome, satellite damage, and re-entry dangers to life on Earth.
- **India's initiatives include** ISRO's IS4OM, NETRA, and Space Situational Awareness Control Centre.

Traditional Medicine

- **Over 80% of global population** uses some form of traditional medicine (WHO).
- **Initiatives:** TKDL, WHO Centre in Jamnagar, National Ayush Mission, Ayush Mark certification.
- **Challenges:** Lack of scientific evidence, biopiracy, standardization issues, and limited integration with allopathy.

Anti-Microbial Resistance (AMR)

- **AMR is projected to cause 10 million deaths** annually by 2050 if left unchecked.
- **Factors include misuse of antibiotics** in humans and livestock, and lack of diagnostic tools.
- **India launched** NAP-AMR and AMR Surveillance Network across 30+ labs for tracking resistance.

Non-Communicable Diseases (NCDs)

- **NCDs account** for 74% of global deaths and 63% of all deaths in India.
- **Types include** cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes.
- **India's efforts include** NPCDCS, AMRIT, etc

Tuberculosis (TB)

- **India introduced the BPaLM regimen** to treat drug-resistant TB **in 6 months.**
- **There were 25.52 lakh notified TB patients** in India in 2023 (India TB Report 2024).
- **Challenges include** comorbidities, delayed diagnosis, private sector inefficiencies, and social stigma.

Neglected Tropical Diseases (NTDs)

- **In 2022, 1.62 billion people** required interventions against NTDs, down 26% from 2010.
- **India has the world's largest burden** of at least 10 major NTDs like dengue and filariasis.
- **WHO aims to reduce NTD intervention** needs by 90% by 2030.

Rare Diseases

- **In India, 63 Rare Diseases** are listed under National Policy for Rare Disease 2021 (NPRD, 2021).
- **Diseases include** Spinal Muscular Atrophy (SMA), Gaucher disease, and Pompe disease.
- **Challenges include** diagnosis delays, lack of treatment options, and high costs.

Nuclear Energy

- **India's installed nuclear capacity** is 8.78 GW, planned to triple by 2031–32.
- **Initiatives:** Three-stage programme, Bhavni thorium plant, Kakrapar PHWRs, Nuclear Energy Mission for 100 GW by 2047.
- **Challenges:** Safety concerns, land protests, fuel import dependency, and high upfront costs.

Nuclear Fusion

- It combines **lighter nuclei** (e.g., hydrogen) to form heavier ones, releasing energy.
- **India is a partner in the ITER Project**—world's largest nuclear fusion experiment in France.
- **Fusion is safer than fission** and offers a nearly limitless clean energy source but faces technological barriers.

Battery Energy Storage System (BESS)

- **BESS stores surplus electricity for later use**, improving grid stability and integration of renewables.
- **It reduces dependence on fossil fuels** and helps manage peak electricity demand.
- **India aims to develop 47 GW BESS** capacity by 2030 to support its clean energy goals.

Sodium-Ion Battery

- **Sodium-ion batteries** are emerging as an alternative to lithium-ion batteries.
- **Advantages include** abundant raw materials, low cost, and environmental sustainability.
- **Challenges involve** lower energy density and limited commercial scale production.

Hyperloop Technology

- **Hyperloop involves** high-speed pods traveling in low-pressure tubes using magnetic levitation.
- **It aims to significantly** reduce travel time and carbon emissions for inter-city transport.
- **Challenges like** high costs, safety risks, vacuum maintenance, passenger discomfort from acceleration, and demanding infrastructure needs.

Desalination Technologies

- **Desalination helps** convert seawater into freshwater using methods like reverse osmosis and thermal distillation.
- **India faces freshwater scarcity** with only 0.06% accessible freshwater out of 3% total.
- **Innovations like** solar graphene evaporators can enhance efficiency and reduce costs.

Appendix: Indian Scientist and their Contribution

Scientist	Contribution/Key Work
Satyendra Nath Bose	➔ **He was an Indian physicist one** of the fathers of **quantum mechanics.** ➔ **He developed** theory **of Bose–Einstein Statistics** and the concept of the **Bose–Einstein Condensate.**
Prafulla Chandra Ray	➔ **Established** first Indian research school in chemistry. ➔ **He is known** as **Father of Indian Chemistry.** ➔ **Important Research:** Platinum, Iridium and Sulphides of organic substances.
Srinivasa Ramanujan	➔ **He was an exceptional Indian mathematician** renowned for his substantial contributions to various branches of mathematics. **These are:** ➔ **Mathematical concepts:** Complex analysis, number theory, infinite series, continued fractions, game theory, etc. ➔ **Ramanujan sum:** Sum of all natural numbers till infinity is -1/12. ➔ **Ramanujan number:** 1729 (It is the smallest number that could be expressed as sum of two cubes in two different ways, i.e., 10^3+9^3 and 1^3+12^3.)
C. V. Raman	➔ He was **Indian Physicist** known for discovery of the **'Raman Effect'** in 1928. o **Raman Effect** is a phenomenon when a stream of light passes through a liquid, a fraction of light scattered **by liquid is of a different colour.** ➔ **He Won Nobel Prize** in Physics in **1930 (for Raman Effect).**
Homi Jehangir Bhabha	➔ First chairman of the **Atomic Energy Commission of India** (Known as **Father of Indian Nuclear Power)** ➔ Founded and directed **Tata Institute of Fundamental Research (TIFR)** and **Atomic Energy Establishment,** Trombay, later renamed the **Bhabha Atomic Research Centre (BARC).** ➔ **Pioneered** the use of thorium to extract uranium from it rather than relying on the meagre reserves of uranium in India.
Meghnad Saha	➔ He was Indian astrophysicist noted for his development in 1920 for **thermal ionization equation.** ➔ He established the **National Academy of Sciences** in 1930.

Scientist	Contribution/Key Work
Vikram Sarabhai	➔ He was regarded as the **father of the Indian space programme.** ➔ Founded the **Physical Research Laboratory (PRL) in Ahmedabad in 1947.** ➔ Played key role in setting up **Thumba Equatorial Rocket Launching Station** in Thiruvananthapuram. ➔ Worked on India's first satellite **'Aryabhata'.** ➔ He received the **Shanti Swarup Bhatnagar Medal in 1962.**
A.P.J. Abdul Kalam	➔ Project director of India's **first Satellite Launch Vehicle (SLV-III)** which successfully deployed the **Rohini satellite.** ➔ Worked on **Integrated Guided Missile Development Programme (IGMDP) .** ➔ He led to the **weaponisation of strategic missile** systems and the **Pokhran-II nuclear tests** in collaboration with Department of Atomic Energy.
Subrahmanyan Chandrasekhar	➔ **Played an important role** in notable contribution of **'Chandrasekhar Limit' (1.4 of solar masses).** ➔ **Chandrasekhar limit** determines if a star dies as a white dwarf, or has the mass to exceed this, launching a supernova to create a black hole or neutron star. ➔ **He was awarded the Nobel Prize in Physics in 1983** for his work on the physical processes involved in the structure and evolution of stars.
Prasanta Chandra Mahalanobis	➔ Founded the **Indian Statistical Institute.** Established the **National Sample Survey** (1950) and set up **Central** ➔ **Statistical Organisation** to coordinate statistical activities. ➔ **Shaped India's second Five-year Plan (1956-61),** also called the **Mahalanobis Plan.**
C.N.R. Rao	➔ Main research interests are in **solid state and materials chemistry.** ➔ Also, worked on **metal oxides, carbon nanotubes, and other materials and two-dimensional systems,** including graphene, boron-nitrogen-carbon hybrid materials etc.
Gagandeep Kang	➔ **Known for her inter-disciplinary research** studying the transmission, development and prevention of enteric infections and their sequelae in children in India. ➔ **She has worked on the development and use of vaccines** for rotaviruses, cholera and typhoid, conducting large studies to define burden, test vaccines.

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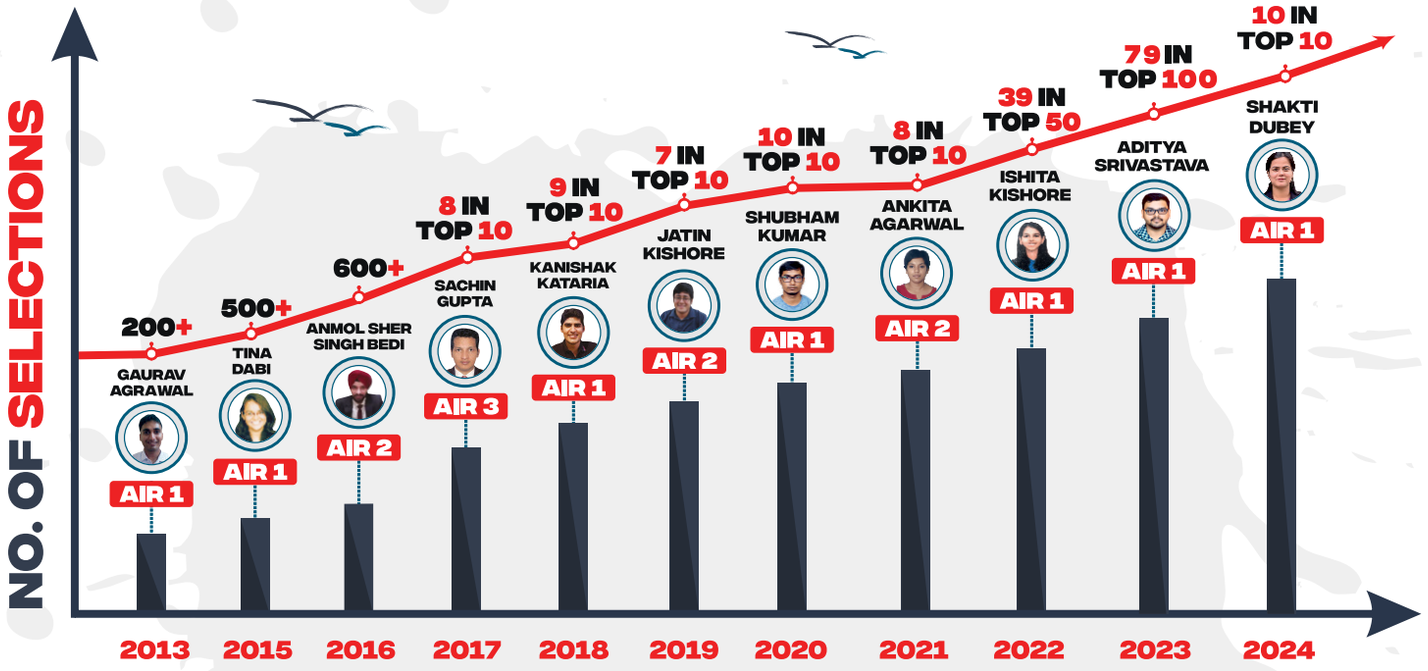

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