Prelims Exam Topics

ANDROMEDA GALAXY

Context

Astronomers have used data from the **Hubble Space Telescope** to create the **most detailed map of star formation across** the **Andromeda Galaxy** over the past **500 million years**.

About Andromeda Galaxy

- **Nature:** The **Andromeda Galaxy (M31)** is the **nearest major spiral galaxy** to the **Milky Way** and its largest neighbouring galaxy.
- **Location:** Situated about **2.5 million light-years** from Earth in the **Andromeda constellation**.
- **Future Evolution:** It is about **2–2.5 times wider than the Milky Way**, with both galaxies having a significant probability of **colliding within the next 10 billion years**.

Key Findings

- **Star Formation:** The study found that **star formation has been steadily declining**, particularly over the **last 40 million years**, with recent star formation concentrated in the galaxy's **ring structures**.
- **Dead Zone:** Researchers identified a **'dead zone'** near the satellite galaxy **M32**, where star formation has nearly ceased, likely due to a recent interaction between **M32** and Andromeda's **stellar disc**.
- **Evolutionary Stage:** The findings suggest that **Andromeda is transitioning from an active star-forming galaxy to a more quiescent ('middle-aged') galaxy**, providing insights into the evolution of massive galaxies.

MALVI CAMEL

Context

The **National Research Centre on Camel (NRCC)** has launched a **breeding and conservation programme** for the **Malvi camel**, following a sharp decline in its population.

About Malvi Camel

- **Nature:** The **Malvi camel** is one of the **nine recognised camel breeds** in India.
- **Distribution:** Native to the **Malwa region of Madhya Pradesh** and adjoining parts of **Rajasthan**.

- **Status:** Classified as **endangered**, with only **102 animals remaining**; camel breeds with **fewer than 300 breeding females** are considered at risk.
- **Physical Characteristics:** Distinguished by its **white coat**, it is the **smallest recognised camel breed**.
- **Utility:** Reared for **milk production** and valued for its **strength and endurance** in transportation and agricultural operations.
- IUCN: Critically Endangered

SHETA2 THERAPY

Context

A new **oral therapy, SHetA2**, has shown promise in preventing **Human Papillomavirus (HPV)** infections from progressing to **cervical cancer**.

About SHetA2 Therapy

- **Nature: SHetA2** is an **oral small-molecule therapy** designed to prevent **HPV-induced cervical cancer** by targeting viral cancer-causing mechanisms.
- **Development:** Developed by the **Stephenson Cancer Center, University of Oklahoma**, with **ICMR–National Institute of Cancer Prevention and Research (ICMR-NICPR)**.
- **Target Group:** Intended for patients with **high-grade cervical intraepithelial neoplasia (CIN)** and potentially **early-stage cervical cancer**, subject to successful clinical trials.
- **Mechanism of Action:** Targets host proteins **Mortalin, Heat Shock Cognate 70 (Hsc70), and Glucose-Regulated Protein 78 (Grp78)**, disrupting the interaction between the **HPV E7 oncoprotein** and host cells, leading to the destruction of the viral protein while sparing normal cells.

About Human Papillomavirus (HPV)

- **Nature: Human Papillomavirus (HPV)** is the **most common sexually transmitted infection (STI)**, comprising **more than 100 virus types**.
- **Disease Association:** While many HPV infections are harmless, some types cause **genital warts**, and **high-risk strains** can lead to **cervical and other anogenital and oropharyngeal cancers**.
- **Transmission:** Spreads primarily through **skin-to-skin contact**, including **sexual contact**.
- **Prevention: No specific cure** exists for HPV infection; **HPV vaccination** is the most effective method to prevent **HPV-related cancers**.

KIKAI CALDERA

Context

Scientists have found evidence that the **magma reservoir beneath Japan's Kikai Caldera is replenishing**.

About Kikai Caldera

- **Nature: Kikai Caldera** is a **large submarine volcanic caldera** with **three small islands** representing parts of its rim above sea level.
- **Location:** Situated in the **East China Sea**, just south of **Kyushu, Japan**.

PITHORA PAINTING

Context

Pithora Painting has been awarded the **Geographical Indication (GI) Tag**.

About Pithora Painting

- **Nature: Pithora Painting** is a **ritualistic tribal wall painting** traditionally practised by the **Rathwa, Bhil, and Bhilala** communities.
- **Origin:** It originated in the tribal regions of **Panchmahal** and **Chhota Udaipur** districts of **Gujarat**.
- **History:** The art form dates back to around the **13th century** and is named after **Pithora De**, the tribal deity associated with **prosperity, marriage, and community well-being**.
- **Traditional Practice:** Created on the **walls of houses** during occasions such as **marriages, childbirth, festivals, or fulfilment of vows**, and traditionally painted by **Lakharas (ritual painters)** under the guidance of a **Badwa (priest)**.
- **Materials & Technique:** Walls are coated with a **mixture of cow dung and clay**, while colours are prepared from **natural pigments**; artists use **bamboo sticks, cotton, and wooden stencils** to create the paintings.
- **Themes:** Depicts **Pithora De**, other **tribal and Hindu deities**, **horses, animals**, and scenes of **farming, hunting, dancing, and everyday tribal life**; today, the art is also produced on **paper and canvas** for commercial purposes.

SOLIGA TRIBE

Context

A recent study has highlighted the **Soliga tribe of Karnataka** as an example of **community-based conservation**, arguing that their traditional forest management practices offer an alternative to the **'fortress conservation'**approach.

About Soliga Tribe

- **Distribution:** The Soligas are a Scheduled Tribe (ST) primarily inhabiting the **Biligiri Ranganathaswamy Temple (BRT) Tiger Reserve** and adjoining forests of Karnataka.
- **Livelihood:** Their economy is largely based on the **sustainable collection of Non-Timber Forest Produce (NTFP)**, small-scale agriculture, and traditional forest-based livelihoods.
- **Community Governance:** Local institutions such as **Podu Sanghas** and **Taluka Sanghas** facilitate collective decision-making on forest management, customary practices, and community welfare.
- **Language:** The **Sholaga** language, belonging to the **Dravidian family**, is the tribe's native language.
- **Housing:** They traditionally live in **single-room huts** constructed using **bamboo and mud**.
- **Culture:** The Soligas practise a **nature-centric lifestyle**, crafting eco-friendly products such as the **'Jottai'**, a cup made from leaves.

POLYMER BANKNOTES

Context

The **Union Government** has approved the **Reserve Bank of India (RBI)** to conduct **field trials** of **polymer banknotes** in **₹10 and ₹20 denominations**.

About Polymer Banknotes

- **Nature:** Polymer banknotes are currency notes printed on an **opacified synthetic polymer substrate** instead of the conventional **cotton-paper** substrate.
- **Implementation:** The pilot project is being undertaken by the **Reserve Bank of India (RBI)** in collaboration with **Bharatiya Reserve Bank Note Mudran Pvt. Ltd. (BRBNMPL)**.
- **Objective:** To improve the **durability** of frequently used low-denomination notes, reduce replacement costs, and minimise environmental impact.

- **Material:** Printed on a **non-porous, moisture- and dirt-resistant polymer film**, making the notes more durable than traditional cotton-based notes.
- **Lifespan:** Polymer notes typically last **2–6 times longer** than paper notes, reducing the frequency of printing, transportation, and destruction of soiled currency.
- **Circulation & Sustainability:** Polymer notes will **circulate alongside existing paper notes** and can be **recycled** at the end of their lifecycle, lowering environmental impacts.
- Currency Issuance: Under Section 22 of the Reserve Bank of India Act, 1934, the RBI has the exclusive authority to issue banknotes in India, except the ₹1 note, which is issued by the Ministry of Finance.

Mains Exam Topics

ETHANOL BLENDING

Context

Although India has rapidly expanded ethanol blending to strengthen energy security and reduce emissions, consumer concerns over mileage, engine compatibility and fuel costs continue to shape public acceptance. In contrast, Brazil's long experience with flex-fuel vehicles and stable ethanol markets highlights that successful energy transitions depend not only on technology and policy but also on sustained consumer confidence.

How has ethanol blending transformed energy transition into an arena of cooperative federalism?

- **Fiscal Partnership:** The Union's blending targets depended on state-level feedstock production, making financial incentives a subject of Centre–State negotiation rather than unilateral policymaking.
    - **e.g.** States such as Uttar Pradesh and Maharashtra provided tax concessions and investment incentives alongside the Centre's Interest Subvention Scheme to expand ethanol production.
- **Regulatory Coordination:** As fiscal incentives expanded production, aligning ethanol supply required harmonising regulations, since the Centre procures ethanol while States administer sugarcane, molasses and excise laws.
    - **e.g.** State governments periodically revise molasses reservation and release policies to align with the Centre's ethanol procurement programme.
- **Constitutional Balancing:** As regulatory coordination accelerated production, implementation increasingly depended on State List subjects, requiring national energy objectives to accommodate state control over agriculture, land use and irrigation.
    - **e.g.** Maharashtra's restrictions on sugarcane cultivation in drought-prone Marathwada influenced the pace of ethanol expansion despite national blending targets.
- **Resource Facilitation:** As constitutional constraints determined where expansion was feasible, scaling ethanol capacity required States to facilitate industrial resources through land for distilleries, power connectivity and local infrastructure in partnership with the Centre.
    - **e.g.** Grain-based distilleries in Madhya Pradesh and Chhattisgarh were established through central interest subvention complemented by state-level land allocation and utility support.

- **Institutional Federalism:** As developmental collaboration multiplied Centre–State implementation partnerships across states, sustained coordination required permanent intergovernmental institutions rather than ad hoc negotiations.
    - **e.g.** The National Biofuel Coordination Committee provides a platform for coordinating Centre–State decisions on feedstock availability, blending targets and implementation issues.

How does the ethanol blending programme demonstrate that sustainability transitions are fundamentally systems transitions rather than fuel transitions?

- **Agricultural System Reconfiguration:** The blending mandate first transformed fuel demand into agricultural demand, making sugarcane and maize cultivation increasingly respond to ethanol procurement prices rather than food markets.
    - **e.g.** Maize prices surged in 2023–24 as ethanol distilleries competed directly with the poultry-feed industry for the same grain.
- **Industrial System Transformation:** As agricultural output shifted towards ethanol feedstock, absorbing this expanding supply required dedicated processing capacity, transforming distilleries from flexible alcohol producers into capital-intensive ethanol manufacturers.
    - **e.g.** The Interest Subvention Scheme financed standalone grain-based ethanol plants designed exclusively for blending supply.
- **Energy Logistics Modernisation:** As dedicated industrial capacity scaled ethanol production, the existing petroleum logistics network became the binding constraint, requiring storage, transport and dispensing systems to be redesigned for ethanol handling.
    - **e.g.** Oil Marketing Companies upgraded storage tanks, pipelines and depot infrastructure before the E20 rollout.
- **Mobility Technology Adaptation:** Even after supply chains became blending-ready, sustainability transition remained incomplete because the vehicle fleet itself was not, necessitating engine redesign and flex-fuel technologies.
    - **e.g.** Flex-Fuel Vehicles required modified fuel systems, while older vehicles faced compatibility and warranty concerns.
- **Natural Resource Reallocation:** As vehicle adaptation locked in sustained long-term ethanol demand, maintaining this supply required continued feedstock expansion, intensifying competition for land and water between food and fuel production.

- **e.g.** Sugarcane-based ethanol expansion in drought-prone Marathwada increased pressure on already stressed groundwater resources.

- **Institutional Coordination Challenge:** These cumulative agricultural, industrial, technological and environmental interdependencies exposed the limits of fragmented governance, requiring coordinated regulation across multiple sectors rather than isolated fuel policy.
    - **e.g.** Although the National Biofuel Coordination Committee sets blending targets, water-use regulation remains fragmented across ministries and states.

Why has Brazil been able to integrate higher ethanol blends into its transport sector with relatively fewer consumer concerns than India?

- **Fleet Design Legacy:** Brazil introduced flex-fuel vehicles with engines designed for variable ethanol–petrol blends from the outset, eliminating compatibility concerns for consumers. India, by contrast, relied on petrol-optimised vehicles, making higher ethanol blends a retrofit challenge rather than a native design feature.
    - **e.g.** Brazilian FFVs operate seamlessly on any blend from E20 to E100, whereas many pre-2023 Indian vehicles carried manufacturer warranty limitations beyond E10.
- **Consumer Market Choice: Once vehicles became blend-neutral, ethanol adoption shifted from a technical constraint to a consumer choice**, making transparent fuel pricing and competition central to public acceptance.
    - **e.g.** Brazilian fuel stations display both hydrous ethanol (E100) and petrol prices, enabling drivers to choose the more economical fuel in real time.
- **Competitive Production Economics: For consumers to consistently prefer ethanol, market choice had to be supported by structurally competitive production costs**, which Brazil achieved through its highly efficient sugarcane-based ethanol industry.
    - **e.g.** Brazil's sugarcane produces significantly higher ethanol yields per hectare than India's mixed sugarcane–grain feedstock system, enabling lower retail prices.
- **Policy Credibility: Even competitive production economics was insufficient without confidence that government support would endure market disruptions**, prompting Brazil to sustain its ethanol programme despite supply crises rather than reversing course.
    - **e.g.** Following the 1989–90 ethanol shortage, Brazil strengthened the Proálcool programme through policy continuity instead of abandoning ethanol blending.

- **Institutional Trust Accumulation: Sustained policy credibility gradually transformed ethanol from an alternative fuel into a trusted default**, reducing consumer concerns over fuel availability, quality and long-term government commitment.
    - **e.g.** After nearly five decades of Proálcool, Brazilian consumers generally regard ethanol as a dependable transport fuel, whereas India's accelerated post-2014 expansion has had less time to build comparable trust.

Way Forward

- **Accelerate Fleet Readiness:** Higher ethanol blends can gain public acceptance when vehicles are designed for blend flexibility rather than retrofitted after deployment. India should fast-track universal Flex-Fuel Vehicle (FFV) compatibility across new vehicle segments.
    - **e.g.** Time-bound FFV adoption standards and uniform E20 warranty coverage across automobile manufacturers would reduce consumer uncertainty.
- **Strengthen Consumer Price Competitiveness: Once vehicles become blend-compatible, consumers need a clear economic incentive to prefer ethanol**, requiring competitive pricing through improved production efficiency and transparent pricing mechanisms.
    - **e.g.** Improving ethanol productivity and displaying ethanol-equivalent fuel costs at retail outlets can encourage informed consumer choice.
- **Enhance Production Competitiveness: Sustaining price competitiveness requires lowering production costs**, making feedstock diversification and commercial-scale second-generation (2G) ethanol essential for reducing dependence on food-based ethanol.
    - **e.g.** Scaling up agricultural residue-based ethanol under the Pradhan Mantri JI-VAN Yojana can improve long-term supply without intensifying food–fuel competition.
- **Ensure Policy Credibility: Even competitive ethanol markets cannot sustain consumer confidence without predictable policy support**, requiring stable blending targets and consistent long-term incentives.
    - **e.g.** Maintaining a transparent roadmap for E20 and future blending milestones, with stable procurement policies, would reduce policy uncertainty for consumers and industry.
- **Build Institutional Trust: Sustained policy credibility should culminate in long-term public trust**, requiring integrated governance, quality assurance and continuous consumer engagement.
    - **e.g.** A statutory **National Biofuel Authority**, supported by nationwide fuel-quality certification and public awareness campaigns, **can strengthen confidence in ethanol as a reliable transport fuel.**