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CURRENT TRENDS

- Reports & Schemes
- Global Initiatives
- Science in Daily Life

UPSC Prelims Current Affairs

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MONTHLY COMPILATION



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1. JWST Maps Daily Weather Cycle on Exoplanet Wasp-94a B

NASA's James Webb Space Telescope (JWST) has mapped a daily weather cycle on an exoplanet nearly 700 light-years away, marking the first time a repeating daily cloud cycle has been observed on an alien world. The planet, WASP-94A b, is a Hot Jupiter located in the constellation Microscopium. Unlike Earth's water vapor clouds, the clouds on this planet are made of magnesium silicate (vaporized rock), iron, and magnesium sulphide. JWST detected stronger water vapor signals from the planet's relatively clear evening limb, suggesting a Jupiter-like atmospheric composition previously unrecognized. The discovery represents a landmark achievement in exoplanet atmospheric science.

1. Recent Key Findings

Atmospheric Asymmetry

1. JWST observed planet's terminator region (boundary between day and night sides)

2. **Morning limb** - Cloud-rich
3. **Evening limb** - Comparatively clearer
4. Asymmetry revealing distinct atmospheric dynamics

Clouds of Vaporized Rock

1. Unlike Earth (water vapor clouds), WASP-94A b clouds made of -
 1. Magnesium silicate (vaporized rock)
 2. Iron
 3. Magnesium sulphide
2. Extreme temperature conditions creating exotic cloud compositions

Daily Weather Cycle

1. **Nightside** - Rock-forming minerals cool down, condense into clouds
2. **Atmospheric winds** - Powerful winds push clouds from nightside to dayside
3. **Dayside** - Extreme heat ($>1,000^{\circ}\text{C}$) causes mineral clouds to evaporate or move into deeper atmospheric layers
4. **Evening limb** - Left relatively clear after cloud evaporation
5. First observed repeating daily cycle on alien world

Overcoming Cloud Obstruction

1. Pervasive clouds usually block telescope's view like frosted pane of glass distorting data
2. By observing relatively clear evening limb, JWST detected -
 1. Stronger water vapor signals
 2. Suggesting planet's atmosphere chemically closer to Jupiter-like composition than earlier understood
3. Breakthrough in exoplanet atmospheric characterization

2. About WASP-94A b (The Exoplanet)

Classification

1. "Hot Jupiter" - Massive gas giant located in constellation Microscopium
2. Named for star WASP-94A it orbits

Physical Traits

1. Almost twice as big as Jupiter in volume
2. Only half Jupiter's mass (lower density than Jupiter)
3. Gas giant composition

Orbit

1. Orbits extremely close to its star
2. Takes just four Earth days to complete one full year (extremely short orbital period)
3. Proximity to star creates extreme temperatures

Tidal Locking

1. Due to tidal locking, same side of WASP-94A b always faces its star
2. Creates - Permanent scorching dayside ($>1,000^{\circ}\text{C}$) and relatively cooler nightside
3. Similar to Moon's tidal locking with Earth (same face always visible)

3. About Exoplanets

Definition

1. Any planet orbiting a star outside our Solar System
2. More than 6,000 found so far (confirmed by NASA)

Diverse Environments

Extreme weather conditions -

1. Rain made of molten metal
2. Vaporized rock precipitation
3. Liquid glass driven by supersonic winds
4. Diamonds raining down (high-pressure carbon atmospheres)

Key Detection Methods

1. **Transit Method** - Tracking slight dimming of star's light when exoplanet passes directly in front; measures planet size relative to star
2. **Transmission Spectroscopy** - As starlight filters through edges of planet's atmosphere during transit, gases selectively absorb specific wavelengths; reading missing wavelengths identifies exact atmospheric chemicals

Significance

1. Understanding how planetary systems form, grow, differ from our Solar System
2. Searching for potentially habitable worlds
3. Advancing atmospheric science beyond Solar System
4. About James Webb Space Telescope (JWST)

Overview

1. NASA's premier space observatory launched December 25, 2021
2. Observes in infrared wavelengths (invisible to human eye; penetrates dust clouds)
3. Located at Lagrange Point 2 (L2) approximately 1.5 million km from Earth
4. Collaborative project - NASA, European Space Agency (ESA), Canadian Space Agency (CSA)

Capabilities

1. Primary mirror - 6.5 meters (gold-coated beryllium segments)
2. Infrared sensitivity enabling - Deep universe observations, exoplanet atmosphere analysis, star formation studies
3. Succeeds Hubble Space Telescope (visible/ultraviolet light)

Achievements

1. Deepest infrared image of early universe
2. Atmospheric characterization of multiple exoplanets
3. Detection of CO₂ in exoplanet atmospheres
4. Observation of stellar nurseries, galaxy formation

5. Significance of Discovery

Scientific Significance

1. First repeating daily weather cycle observed on alien world
2. Demonstrates JWST's capability to study atmospheric dynamics beyond detection
3. New understanding of Hot Jupiter atmospheric processes
4. Water vapor detection indicating complex atmospheric chemistry

Broader Implications

1. Understanding atmospheric evolution of gas giants
2. Improved models for exoplanet weather, climate
3. Potential insights into early Solar System's gas giant formation
4. Advancing search for biosignatures in exoplanet atmospheres

6. Conclusion

JWST's mapping of daily weather cycle on WASP-94A b (Hot Jupiter, 700 light-years, constellation Microscopium) marks historic first—repeating alien weather pattern observed through atmospheric asymmetry between cloud-rich morning limb and clearer evening limb. Exotic clouds of magnesium silicate-iron-magnesium sulphide (vaporized rock) form on cooler nightside, transported by atmospheric winds to scorching dayside ($>1,000^{\circ}\text{C}$) where they evaporate, leaving evening limb clear. This asymmetry enabled JWST to detect stronger water vapor signals through transmission spectroscopy revealing Jupiter-like atmospheric composition. WASP-94A b's tidal locking (same face permanently toward star), four-day orbital period, twice Jupiter's volume but half its mass created conditions supporting this exotic weather cycle. Discovery advances exoplanet atmospheric science, planetary formation understanding, and JWST's transformative capabilities in characterizing alien worlds beyond simple detection toward dynamic weather monitoring.

Source - <https://economictimes.indiatimes.com/news/international/us/on-this-planet-clouds-emerge-every-morning-and-disappear-by-night-james-webb-space-telescope-reveals-daily-cloud-cycle-on-wasp-94a-b/articleshow/131471160.cms?from=mdr>

2. Chandrayaan-2 Detects Possible Ice at Moon's South Pole

Nearly six years after its launch, Chandrayaan-2 has provided new evidence suggesting the possible presence of subsurface ice in the Moon's south polar regions. Scientists used the orbiter's DFSAR (Dual Frequency Synthetic Aperture Radar) payload for advanced radar polarimetric analysis, identifying potential ice-rich subsurface

material in doubly shadowed craters. Although Vikram lander did not achieve soft landing in 2019, Chandrayaan-2 Orbiter continues delivering valuable scientific data through high-resolution fully polarimetric L-band and S-band radar observations. Discovery is significant for In-Situ Resource Utilization (ISRU), future lunar exploration, and deep-space mission propellant production.

1. The Science Behind the Discovery

Doubly Shadowed Craters

1. Small craters located within larger Permanently Shadowed Regions (PSRs) near lunar poles
2. Receive neither direct sunlight nor significant scattered radiation
3. Remain among coldest known locations on Moon
4. Ideal long-term preservation sites for water-ice

Thermal Shielding

1. Regions remain extremely cold due to continuous shielding from sunlight, thermal radiation
2. Favorable conditions for long-term water-ice preservation
3. Temperatures among lowest in Solar System ($\sim -230^{\circ}\text{C}$)

Volatile Trap

1. Ultra-cold regions acting as cold traps
2. Water, other volatile compounds remain preserved over geological timescales
3. Similar to natural freezers preserving ancient material

2. Analytical Methodology

Radar Polarimetric Analysis

1. Scientists used advanced radar polarimetric analysis distinguishing possible ice-rich subsurface material from rough, rocky terrain
2. Both can produce similar radar echoes requiring refined criteria

Degree of Polarization (DOP)

1. Measures how much returned radar signal retains original polarization after interacting with lunar surface/subsurface
2. Lower DOP may indicate more complex internal scattering (suggestive of ice)

Radar Detection Criterion

1. Study proposed refined diagnostic criterion for volumetric scattering –
 1. **Circular Polarization Ratio (CPR) > 1.0 AND Degree of Polarization (DOP) < 0.13**
 2. CPR alone insufficient (both rough terrain and ice produce high CPR)
 3. Combining CPR with DOP improves interpretation accuracy

Morphological Support

1. ~1.1 km-wide crater within Faustini crater showed –
 1. Enhanced radar polarization
 2. Distinct lobate-rim morphology (flow-like, tongue-shaped crater rim)
2. Suggesting impact may have excavated, interacted with ice-rich subsurface layer

3. Key Terms Explained

Moon Surface and Temperature Features

1. **Permanently Shadowed Regions (PSRs)** – Dark regions near lunar poles receiving little/no direct sunlight; crater rims block solar illumination; preserve water-ice, volatiles
2. **Doubly Shadowed Craters** – Smaller craters within larger PSRs; shielded from both direct sunlight and scattered light/thermal radiation; extremely cold
3. **Volatile Trap/Cold Trap** – Ultra-cold region where volatile substances (water vapour) freeze, remain preserved for long geological periods
4. **Lobate-Rim Morphology** – Flow-like or tongue-shaped crater rim indicating possible ice-rich subsurface excavation

Radar Technology Terms

1. **DFSAR (Dual Frequency Synthetic Aperture Radar)** – Radar instrument on Chandrayaan-2 using microwave signals studying lunar surface, shallow subsurface even in dark polar regions

2. **Radar Polarimetry** – Method studying how polarization of radar waves changes after reflection; infers surface roughness, buried material, possible ice-rich deposits
3. **CPR (Circular Polarization Ratio)** – Radar parameter comparing returned circularly polarized signals; high CPR alone indicates rough terrain OR ice

4. Why is this Discovery Significant?

In-Situ Resource Utilization (ISRU)

1. Mapping possible subsurface ice deposits critical for future lunar exploration
2. Lunar ice could potentially be used to –
 1. Extract drinking water for astronauts
 2. Generate oxygen for life support
 3. Produce hydrogen-oxygen rocket propellant (electrolysis splitting water into H₂ and O₂)

Fuel for Deep-Space Missions

1. Accessible lunar water converted into propellant
2. Moon becoming strategic refuelling hub for future missions to Mars, beyond
3. Reducing cost, weight of Earth-launched missions

Chandrayaan-2's Continuing Scientific Value

1. Vikram lander did not achieve soft landing (2019) but orbiter operational
2. DFSAR payload providing high-resolution, fully polarimetric L-band, S-band radar observations
3. Demonstrating India's sustained space science capability
4. Contributing to global lunar science despite partial mission success

5. India's Lunar Exploration Programme

Chandrayaan-1 (2008)

1. Discovered hydroxyl molecules, water molecules on lunar surface through M3 (Moon Mineralogy Mapper)
2. Confirmed water ice in permanently shadowed regions

Chandrayaan-2 (2019)

1. Orbiter operational; Vikram lander crashed during soft landing attempt
2. DFSAR continuing polar ice research
3. Pragyan rover could not be deployed

Chandrayaan-3 (2023)

1. Successfully landed Vikram lander near lunar south pole (August 23, 2023)
2. India became 4th nation achieving lunar soft landing (after USA, USSR, China)
3. Pragyan rover confirmed sulphur, other elements near south pole
4. Confirmed thermal gradient between lunar surface and subsurface

6. Conclusion

Chandrayaan-2's new evidence of possible subsurface ice in Moon's south polar regions through DFSAR radar polarimetric analysis combining $CPR > 1.0$ and $DOP < 0.13$ criterion demonstrates orbiter's continuing scientific value despite 2019 lander failure. Doubly shadowed craters within Permanently Shadowed Regions acting as volatile traps preserve ancient water-ice under extreme cold conditions. Discovery is critical for ISRU enabling future lunar colonization (drinking water, oxygen, rocket propellant through electrolysis) and positioning Moon as strategic deep-space refuelling hub. Building on Chandrayaan-1's water molecule discovery (2008) and Chandrayaan-3's successful south pole landing (2023) confirming sulphur-thermal gradient, Chandrayaan-2's findings strengthen India's contribution to global lunar science advancing human understanding of Moon's resource potential for sustainable deep-space exploration.

Source - <https://www.thehindu.com/sci-tech/science/chandrayaan-2-detects-possible-presence-of-subsurface-ice-near-south-pole-of-moon/article71031903.ece>

3. Synthetic Biology

Synthetic biology now allows scientists to design artificial life forms using AI and genetic engineering, creating major opportunities in medicine and industry while

raising serious biosecurity, ethical, and environmental concerns. Recent breakthroughs demonstrate that a complete bacterial genome can be built chemically using a digital computer file — the world's first digitally created life. DNA sequencing costs have collapsed from \$3 billion and ten years (Human Genome Project) to a few hundred dollars and a few hours in a small lab, democratizing genetic engineering at unprecedented scale and speed.

1. Recent Key Findings

The Complexity Paradox

1. Genetic tests showing how complex a living creature looks does NOT depend on total gene count
2. **Single-celled bacterium**- ~4,300 genes
3. **Human being**- ~22,000 protein-coding genes
4. **Water flea (Daphnia)**- 31,000 genes — far more than humans
5. Biological complexity driven by gene regulation, NOT gene count

Cheaper and Faster Technology

1. DNA sequencing speed growing exponentially while cost collapsed completely
2. **Earlier**- International team, 10+ years, \$3 billion (Human Genome Project)
3. **Now**- Few hours, few hundred dollars, small lab
4. Democratizing genetic research globally

Computer-Made Life

1. Scientists proved complete bacterial genome can be built chemically using digital computer file
2. Man-made DNA successfully placed inside living cell with natural DNA removed
3. **Result**- World's first digitally created life
4. Landmark proving biology can be treated as programmable system

2. About Synthetic Biology

Definition

1. Field applying engineering rules to biology to design, build new biological parts, tools, systems
2. Treats living organisms as programmable machines

Two Main Methods

Top-Down Synthetic Biology (Genome Replacement)-

1. Takes existing living cell
2. Completely replaces natural DNA with human-designed, chemically made DNA chains
3. Changes how cell behaves or what it produces
4. Example- Creating first synthetic bacterial cell

Bottom-Up Synthetic Biology (Protocells)-

1. Does NOT use any pre-existing life
2. Scientists build simple cell completely from scratch using non-living chemistry
3. **Protocells-** Using fatty-acid vesicles (tiny fat bubbles) naturally forming closed walls
4. These vesicles trap RNA inside, copy genetic material under right conditions, split into two
5. Mimicking earliest stages of life's origin

3. Core Genetics vs. Biological Complexity

DNA — Basic Code of Life

1. Deoxyribonucleic acid (DNA)- Main building block of genome
2. Four-letter chemical alphabet-
 1. **A** — Adenine
 2. **T** — Thymine
 3. **G** — Guanine
 4. **C** — Cytosine
3. Sequences of these letters encoding all biological information

The Role of Transcription Factors

1. True biological complexity driven by gene control rather than total gene numbers
2. Regulatory regions of DNA acting like light switches
3. **Transcription factors**– Control proteins attaching to regulatory regions turning specific genes "on" or "off"
4. This interaction deciding–
 1. How much protein is made
 2. When protein is produced
 3. Where in the body it is expressed
 4. Duration of expression
5. Explains why humans (22,000 genes) are more complex than water fleas (31,000 genes)

4. Significance of Synthetic Biology

Improving Healthcare

1. Advanced gene design allowing scientists to build special cell factories
2. Manufacturing targeted medicines, new vaccines
3. Treatments for severe inherited conditions like Phenylketonuria (PKU – metabolic disorder)
4. Personalized medicine, cancer immunotherapy applications
5. Faster vaccine development (COVID-19 mRNA vaccine precedent)

Cleaning the Environment and Clean Energy

1. Artificial cells designed to–
 1. Trap carbon (climate change mitigation)
 2. Clean up toxic industrial chemical spills (bioremediation)
 3. Produce clean biofuels directly from non-food plants
2. Reducing dependence on fossil fuels
3. Addressing industrial pollution

Mapping the Tree of Life

1. Genome sequences acting like detailed history book of Earth

2. Showing how different animals, plants are related
3. How evolutionary branches split, how living things change through mutations
4. Filling gaps where fossils are missing
5. Understanding human origins, migration, disease evolution

Other Applications

1. **Agriculture**– Drought-resistant, pest-resistant crops; nitrogen-fixing plants reducing fertilizer dependence
2. **Materials**– Spider silk proteins, biodegradable plastics, novel biomaterials
3. **Biosensors**– Detecting pollutants, pathogens, explosives using engineered organisms
4. **Food security**– Lab-grown meat, precision fermentation, engineered food crops

6. Concerns That Need to Be Tackled

The Risk of Independent Copying

1. Unlike machines or nuclear plants, engineered biological creatures can convert digital data into self-replicating products
2. Once let into nature, they breed independently
3. Making them nearly impossible to bring back or control
4. Containment failure = permanent ecological change

The Evolution Trap

1. Artificial life forms released into nature will naturally mix with wild plants, animals
2. Over time undergo unmonitored mutations driven by natural selection
3. Can harm local wildlife, damage ecosystem balances in unpredictable ways
4. Gene drives (spreading engineered traits through wild populations) particularly concerning

Biosecurity and Dual-Use Risks

1. Gene-making becoming cheap, easy + AI power = higher risk of-
 1. Accidental lab leaks
 2. Intentional creation of highly dangerous, custom-made germs (bioweapons)

2. Dual-use dilemma- Same knowledge enabling vaccines also enabling bioweapons
3. Low-cost barrier to entry increasing non-state actor risk

Ethical Concerns

1. "Playing God" — creating, designing life forms raises profound philosophical, religious questions
2. Intellectual property over life forms
3. Access equity- Who benefits from synthetic biology breakthroughs (rich vs. poor nations)
4. Consent issues in human genetic applications
5. Long-term ecological consequences unknown

Regulatory Gaps

1. Existing biosafety laws designed for earlier era of slower, expensive biotechnology
2. Struggling to keep pace with rapid, cheap AI-driven gene design
3. International regulatory coordination insufficient

7. Way Forward

Flexible Rules and Oversight

1. Governments moving away from old, slow safety laws
2. Fast, smart safety checks keeping pace with quick breakthroughs in gene design, AI
3. Adaptive regulatory frameworks updating continuously
4. Pre-market risk assessment for synthetic organisms

International Biosecurity Agreements

1. Biological germs not respecting national borders
2. Global agreements, treaties urgently needed-
 1. Monitor commercial DNA orders
 2. Stop illegal creation of dangerous germs
 3. Strengthen Biological Weapons Convention (BWC) enforcement
 4. International synthetic biology registry

Safe Isolation Practices

1. First real-world uses strictly locked inside closed industrial tanks
2. Any artificial life meant for outside use must have-
 1. Built-in genetic kill-switches stopping breeding outside laboratory
 2. Multiple containment layers
 3. Regular monitoring, reporting requirements

Ethical Governance

1. Inclusive global dialogue involving scientists, ethicists, civil society, governments
2. Benefit-sharing mechanisms ensuring Global South access
3. Moratorium on most dangerous applications pending framework development

8. Conclusion

Synthetic biology's convergence with AI represents both transformative opportunity and existential risk requiring urgent global governance frameworks balancing innovation with biosecurity, ethics, and ecological protection.

Source- <https://www.thehindu.com/sci-tech/science/genie-synthetic-biology-out-power-and-peril/article71041355.ece>

4. Kodaikanal Solar Observatory

Scientists from the Indian Institute of Astrophysics (IIA), an autonomous institute of the Department of Science and Technology (DST), used over 100 years of archival solar observations from the Kodaikanal Solar Observatory (KSO) to uncover new clues about how the Sun's surface convection patterns respond to its 11-year activity cycle. Researchers analysed approximately 34,000 Ca II K spectroheliograms recorded between 1907 and the present, covering more than nine solar cycles. Key findings reveal that surface convection features closely follow the 11-year solar cycle, with a notable time lag of 1.25–1.5 years between changes in convection-cell widths (at solar maximum) and subsequent changes in network brightness.

1. About the Study

Study Basis

1. Analysed ~34,000 Ca II K spectroheliograms recorded between 1907 and present
2. Covering more than nine solar cycles
3. One of longest continuous solar observation datasets globally

Ca II K Spectroheliograms

1. Images of the Sun taken in the calcium-II K spectral line
2. Useful for studying magnetic activity and solar networks
3. Ca II K wavelength (~393 nm) in violet part of spectrum
4. Reveals chromospheric features including active regions, filaments, network structures

Supergranulation and EUV Network

1. Study examined large-scale convection cells (supergranules) forming the chromospheric network
2. Network extends into transition region as Extreme UltraViolet (EUV) network
3. Linking surface convection to higher atmospheric layers

2. Key Findings of the Study

Linked to Solar Activity

1. Surface convection features closely follow 11-year solar cycle
2. Especially in regions located about 11°–22° north and south of the equator
3. Demonstrating latitude-specific solar activity response

Different Latitudes Behave Differently

1. No single latitude perfectly reflects solar activity
2. Sun's surface responds differently across regions
3. Complex latitude-dependent dynamics

Time Lag Observed

1. Changes in convection-cell widths occur around solar maximum
2. Changes in network brightness appear 1.25–1.5 years later
3. Suggesting cascade of effects through solar atmosphere layers

Variable Response Across Latitudes

1. Time lag differs across latitudes
2. Suggesting complex interactions between solar magnetic fields and convection patterns

Role of Magnetic Flux

1. Supergranular properties influenced by –
 1. Local magnetic flux concentrations
 2. Changing solar activity levels
2. Magnetic field-convection interaction central to observed patterns

3. About Supergranulation

Definition

1. Large convective cells on the Sun's surface
2. **Average size** – ~30,000 km (Earth's diameter ~12,750 km for comparison)
3. **Lifetime** – ~24 hours
4. Horizontal flow cells carrying hot plasma from solar interior to surface

Magnetic Network Formation

1. Boundaries contain concentrated magnetic fields
2. Forming chromospheric network visible in Ca II K observations
3. Network traces supergranular boundaries across solar surface

Role in Magnetic Flux Transport

1. Play important role in transporting magnetic flux across solar surface
2. Horizontal flows sweeping magnetic elements to supergranular boundaries
3. Contributing to solar magnetic field evolution

Other Solar Convection Structures

1. **Granules** – Smaller convection cells (~1,000 km, lifetime ~10 minutes)
2. **Supergranules** – ~30,000 km, ~24 hours (studied here)
3. **Giant cells** – Hypothetical very large convection cells (~200,000 km)

4. About Kodaikanal Solar Observatory (KSO)

Location and Administration

1. Situated in Palani Hills of Tamil Nadu
2. Operated by Indian Institute of Astrophysics (IIA)
3. IIA – Autonomous institute under Department of Science and Technology (DST)

Establishment

1. Founded in 1899 for systematic solar observations
2. Originally established by British colonial government
3. One of world's oldest continuously operational solar observatories

Long-Term Solar Records

1. Maintains one of world's longest continuous series of solar observations
2. Spanning over 100 years
3. Invaluable for studying multi-decadal solar variability

Multi-Wavelength Observations

1. Conducts simultaneous observations in different wavelengths –
 1. **Ca II K (393 nm)** – Chromospheric magnetic activity
 2. **H-alpha** – Solar flares, prominences, filaments
 3. **White light** – Sunspot observations
2. Dataset uniquely suited for multi-wavelength solar studies

Global Research Resource

1. Century-long records providing insights into long-term solar behavior
2. Covering multiple solar cycles (11-year periodicity)
3. Freely accessible to international solar physics community

5. The 11-Year Solar Cycle

Definition

1. Approximately 11-year cycle of solar activity variation
2. Measured by sunspot number, magnetic activity, solar radiation
3. **Solar maximum** – Peak sunspot activity, intense magnetic activity
4. **Solar minimum** – Fewest sunspots, lowest activity

Solar Cycle Indicators

1. **Sunspots** – Dark, cool regions on solar surface due to strong magnetic fields
2. **Solar flares** – Intense bursts of electromagnetic radiation
3. **Coronal Mass Ejections (CMEs)** – Large plasma and magnetic field expulsions
4. **Solar wind** – Stream of charged particles from Sun varying with cycle

Impact on Earth

1. **Geomagnetic storms** – CMEs disrupting Earth's magnetic field
2. **Aurora borealis/australis** – Enhanced during solar maximum
3. **Satellite drags** – Increased upper atmosphere density during maximum
4. **Radio communication disruption** – Ionospheric changes affecting signals
5. **Power grid failures** – Geomagnetically induced currents
6. **Climate** – Solar irradiance variations affecting Earth's energy balance (studied for monsoon connections)

6. Significance of the Study

Improves Solar Cycle Understanding

1. New insights into how supergranulation, EUV network evolve during 11-year solar activity cycle
2. Revealing latitude-dependent response patterns previously unknown

Supports Solar Activity Prediction

1. Understanding correlation between supergranulation and sunspot activity
2. Improving future solar cycle forecasts
3. Critical for space weather prediction

Helps Study Solar Irradiance

1. Findings relevant for understanding variations in solar ultraviolet radiation
2. Affecting Earth's upper atmosphere, ozone layer, ionosphere
3. Implications for satellite operations, GPS accuracy

Advances Solar Physics

1. Contributes to resolving long-standing puzzle of origin, evolution of supergranulation
2. One of unsolved problems in solar physics

Value of Long-Term Data

1. Demonstrates scientific importance of century-long observations
2. Validating investment in maintaining historical observational archives
3. Encouraging preservation of other long-term datasets globally

Future Research Potential

1. **National Large Solar Telescope (NLST)** - High-resolution observations expected to further improve understanding of supergranular dynamics
2. NLST - India's planned large solar telescope (planned for Merak, Ladakh — high-altitude site for superior seeing conditions)

Conclusion

IIA scientists' analysis of 34,000 Ca II K spectroheliograms from Kodaikanal Solar Observatory (founded 1899) across nine solar cycles reveals supergranulation closely follows the 11-year solar activity cycle — with convection-cell width changes at solar maximum and network brightness responding 1.25–1.5 years later — demonstrating KSO's century-long dataset as globally irreplaceable resource advancing solar physics, space weather prediction, and solar irradiance understanding critical for Earth's atmospheric, communication, and satellite systems.

Source - [https -](https://www.pib.gov.in/PressReleasePage.aspx?PRID=2269299®=48&lang=2)

[//www.pib.gov.in/PressReleasePage.aspx?PRID=2269299®=48&lang=2](https://www.pib.gov.in/PressReleasePage.aspx?PRID=2269299®=48&lang=2)

5. SIPRI Yearbook 2026

According to the Stockholm International Peace Research Institute (SIPRI) Yearbook 2026, India is estimated to have modestly expanded its nuclear arsenal in 2025.

1. The report documents a reversal of decades-long efforts to reduce the role and number of nuclear weapons as nuclear-armed states increase reliance on nuclear deterrence.
2. Global nuclear stockpiles continue expanding with all nine nuclear-armed states pursuing modernization programmes.

1.Global Nuclear Trends

Growing Dependence on nuclear weapons

1. Nuclear-armed states are placing greater emphasis on nuclear deterrence in their security strategies marking a reversal of Cold War-era disarmament trends.
2. This shift reflects heightened geopolitical tensions and strategic competition particularly in Asia-Pacific and Eastern Europe regions.

Expansion and Modernization of Arsenals

1. All nine nuclear-armed states—United States, Russia, United Kingdom, France, China, India, Pakistan, North Korea, and Israel—continued modernization programmes in 2025.
2. Each nation deployed new nuclear-capable systems representing technological advancement in delivery mechanisms and warhead sophistication.

Global Nuclear Stockpile

1. Estimated global inventory (January 2026) - 12,187 nuclear warheads reflecting continued arsenal accumulation.
2. Russia and USA together possess around 83% of all stockpiled nuclear warheads maintaining strategic balance concerns.

Declining Arms Control and Disarmament

1. Since the end of Cold War, dismantling retired warheads generally exceeded deployment of new ones reflecting disarmament progress.
2. SIPRI warns this trend is likely to reverse as dismantlement slows and deployment of new weapons accelerates.

Weakening Arms Control Regime

1. Strategic dialogue among major nuclear powers is declining reducing communication channels preventing miscalculation.
2. Traditional arms control treaties face increasing strain with compliance and verification challenges.

Rising Escalation Risks

1. Advances in missile technology, artificial intelligence, cyber capabilities, and space-based systems complicate deterrence calculations.
2. SIPRI warns heightened geopolitical tensions increase possibility of miscalculation leading to nuclear escalation.

2.India-Specific Nuclear Observations

Arsenal Expansion

1. India's estimated nuclear arsenal increased to 190 warheads, up from 180 the previous year reflecting modest expansion consistent with strategic requirements.
2. Expansion reflects India's response to regional security challenges and evolving strategic environment.

Modernization and Capability Development

1. India continues modernizing its deterrent through developments including longer-range missiles extending strike capability.
2. MIRV technology development (Multiple Independently targetable Re-entry Vehicles) enhances penetrability against air defences.
3. Stronger sea-based nuclear capabilities provide survivability and continuous deterrent capability.

Strategic Planning Drivers

1. India's strategic planning is increasingly influenced by China's growing military capabilities reflecting broader Asian security dynamics.
2. India-Pakistan nuclear rivalry remains important consideration in strategic doctrine though focus has shifted toward China.

Military Spending

1. India retained its position as world's fifth-largest military spender in 2025 reflecting defence modernization emphasis.
2. India's military expenditure at \$92.1 billion, an increase of 8.9% over previous year demonstrating rising defence budgets.

Arms Imports

1. India remained world's second-largest importer of major arms during 2021-25 period, accounting for 8.2% of global arms imports.
2. High import dependence reflects limited domestic defence manufacturing capacity and need for advanced weaponry.

3.Nuclear Disarmament Framework

Definition and Approaches

1. Nuclear disarmament refers to act of eliminating or abolishing weapons (particularly offensive arms) either unilaterally or reciprocally.
2. May refer to reducing number of arms or eliminating entire categories of weapons.

4.Key Treaties and Agreements

Treaty on non-proliferation of nuclear weapons (NPT)

1. Signed in 1968 and entered into force in 1970, NPT aims to prevent spread of nuclear weapons and promote disarmament.
2. Divides world into nuclear-weapon states (NWS) and non-nuclear-weapon states (NNWS) with differential obligations.
3. Requires NWS to pursue disarmament negotiations in good faith though enforcement remains weak.
4. India, Israel, North Korea, and Pakistan have not signed NPT maintaining strategic autonomy.

Treaty on Prohibition of nuclear weapons (TPNW)

1. Adopted by United Nations in 2017 and opened for signature in 2018, TPNW aims to prohibit development, testing, production, stockpiling, stationing, transfer, use, and threat of use of nuclear weapons.

2. Represents significant step toward nuclear disarmament although not signed by nuclear-armed states limiting practical impact.

Comprehensive Nuclear-Test-Ban Treaty (CTBT)

1. Opened for signature in 1996, CTBT aims to ban all nuclear explosions for civilian and military purposes.
2. While signed by 185 countries and ratified by 170, has not entered into force as nuclear-armed states must ratify for operation.

Outer Space Treaty

1. Multilateral agreement entered into force in 1967 banning siting of weapons of mass destruction in space.
2. All nine states believed to have nuclear weapons are parties to this treaty.

5.India's Nuclear Weapons Policy

No First Use Doctrine

1. India has declared nuclear no-first-use policy under which will not use nuclear weapons unless first attacked by nuclear weapons.
2. This policy distinguishes India from some other nuclear powers maintaining moral authority and strategic restraint.

Non-Use Against Non-Nuclear States

1. India committed to not using nuclear weapons against non-nuclear weapon states providing negative security assurances.

Retaliation Only Doctrine

1. India's nuclear doctrine asserts nuclear weapons are solely for deterrence and will pursue policy of 'retaliation only'.
2. Emphasis is on credible minimum deterrent protecting national interests.

Multilateral Legal Arrangements

1. India is prepared to convert nuclear commitments into multilateral legal arrangements supporting disarmament frameworks.

6.Way Forward

1. **Strengthen Dialogue Channels** – Enhance strategic communication with nuclear-armed states reducing misunderstanding and miscalculation risks.
2. **Support Arms Control Treaties** – Advocate for stronger verification mechanisms and compliance frameworks in existing treaties.
3. **Promote Disarmament** – Support international disarmament initiatives while maintaining credible deterrent against identified threats.
4. **Technological Governance** – Develop international norms governing artificial intelligence and cyber capabilities in nuclear security.

Source – https://www.sipri.org/sites/default/files/2026-06/yb26_summary_en_0.pdf

6. Long Range Land Attack Cruise Missile (LRLACM)

Subject: Science & Technology | Defence Technology | Internal Security

DRDO successfully flight-tested the indigenously developed Long Range Land Attack Cruise Missile (LRLACM) from Dr. APJ Abdul Kalam Island, Odisha.

About LRLACM

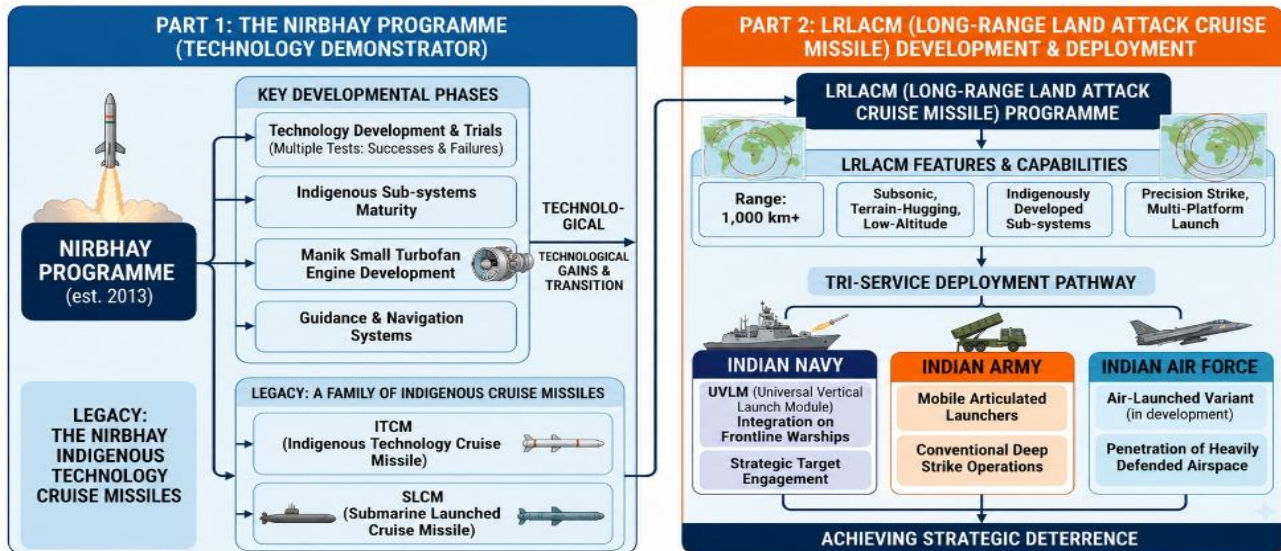
1. Indigenous long-range land-attack cruise missile developed by DRDO.
2. Designed for precision strikes against strategic land targets.
3. Estimated range: **1,000–1,500 km**.
4. Capable of **terrain-hugging flight**, making radar detection difficult.
5. Validated propulsion, guidance, navigation, control and warhead delivery systems.
6. Developed with contributions from multiple DRDO laboratories;

ADE Bengaluru serves as the nodal laboratory.

7. Derived from technologies developed under the **Nirbhay Programme**.
8. Intended for deployment across the Army, Navy and Air Force.

Cruise Missile	Ballistic Missile
Powered throughout flight	Powered only during boost phase

INDIA'S LONG-RANGE CRUISE MISSILE DEVELOPMENT: FROM NIRBHAY TO LRLACM



Source: <https://www.pib.gov.in/PressReleaseDetail.aspx?PRID=2273160®=48&lang=1>

7. India AI Mission – Indigenous AI Video Model “Varya”

GS Paper III – Science & Technology | Artificial Intelligence

Why in News?

India AI Mission-supported start up Avataar.ai has launched “Varya”, India’s indigenous AI-powered video generation model, marking a significant milestone in the country’s efforts to build sovereign Artificial Intelligence capabilities.

Background

Artificial Intelligence (AI) has emerged as a strategic technology driving economic growth, innovation and national competitiveness. Most advanced Generative AI models are currently dominated by companies in the United States and China. To strengthen India’s AI ecosystem, the Government launched the IndiaAI Mission, promoting indigenous AI research, computing infrastructure and responsible AI development.

About Varya

- Varya is an indigenous Generative AI video model developed by Avataar.ai under the IndiaAI Mission.
- It enables users to generate high-quality videos from:
 - Text prompts

ii. Images

iii. Product descriptions

3. The model is designed for sectors such as:

i. Education

ii. E-commerce

iii. Healthcare

iv. Media & Entertainment

v. Digital Marketing

vi. Manufacturing



What is the IndiaAI Mission?

The IndiaAI Mission is a flagship initiative of the Ministry of Electronics and Information Technology (MeitY) aimed at creating a robust, inclusive and globally competitive AI ecosystem.

Objectives

i. Develop indigenous AI models.

ii. Build AI computing infrastructure.

iii. Promote AI startups and innovation.

- iv. Encourage responsible and ethical AI.
- v. Create AI-skilled manpower.
- vi. Strengthen public-private partnerships.

Six Pillars of the IndiaAI Mission

- i. IndiaAI Compute – High-performance computing infrastructure.
- ii. IndiaAI Innovation Centre – Indigenous AI model development.
- iii. IndiaAI Datasets Platform – High-quality datasets for AI.
- iv. IndiaAI FutureSkills – AI education and workforce development.
- v. IndiaAI Startup Financing – Support for AI startups.
- vi. Safe & Trusted AI – Ethical, secure and responsible AI.

Significance

Technological

- i. Strengthens India's AI self-reliance.
- ii. Reduces dependence on foreign AI models.
- iii. Promotes indigenous innovation.

Economic

- i. Boosts AI startups and digital economy.
- ii. Enhances productivity across industries.
- iii. Supports the vision of a \$1 trillion digital economy.

Strategic

- i. Improves technological sovereignty.
- ii. Strengthens India's position in the global AI race.
- iii. Supports Digital Public Infrastructure (DPI).

Challenges

- i. Limited availability of high-quality datasets.
- ii. High cost of AI computing infrastructure.
- iii. Data privacy and cybersecurity concerns.
- iv. Algorithmic bias and ethical issues.

- v. Shortage of skilled AI professionals.

Way Forward

- i. Expand indigenous AI computing capacity.
- ii. Promote responsible AI governance.
- iii. Strengthen academia-industry collaboration.
- iv. Develop multilingual Indian AI models.
- v. Enhance AI research and semiconductor ecosystem

8. GRAPES-3 (Gamma Ray Astronomy Pev Energies Phase-3) Telescope

Prelims

Science & Technology, Space Technology

Mains

GS Paper III – Science & Technology, Disaster Management

Current relevance

Researchers from **Mumbai, Kochi, and Japan** used the GRAPES-3 Telescope to study -

1. Earth's upper atmosphere temperature.
2. The Sun's magnetic field.
3. Their effects on muons (subatomic particles from space).

Importance of the Research

1. GRAPES-3 can create a high-resolution map of -
 - i. Cosmic ray activity.
 - ii. Solar magnetic effects.
 - iii. Changes in the Earth's upper atmosphere.
2. The new technique allows **real-time atmospheric monitoring** with high precision.

About GRAPES-3 Telescope -

1. It is designed to investigate the origin, acceleration, and movement of **cosmic rays** by detecting extensive air showers in the Earth's atmosphere.

2. It also examines solar and atmospheric phenomena, including thunderstorms, through the observation of **cosmic-ray muons**.



Source – THE HINDU – https://www.pressreader.com/india/the-hindu-international-9bn2/20260617/281921664747624?srsIid=AfmBOorOcC44YkC4zNOy7GKA2SDDIAzIwGh7-5JwGxJmuZ2q2py4xL_5

9. National internet exchange of India (NIXI)

Prelims

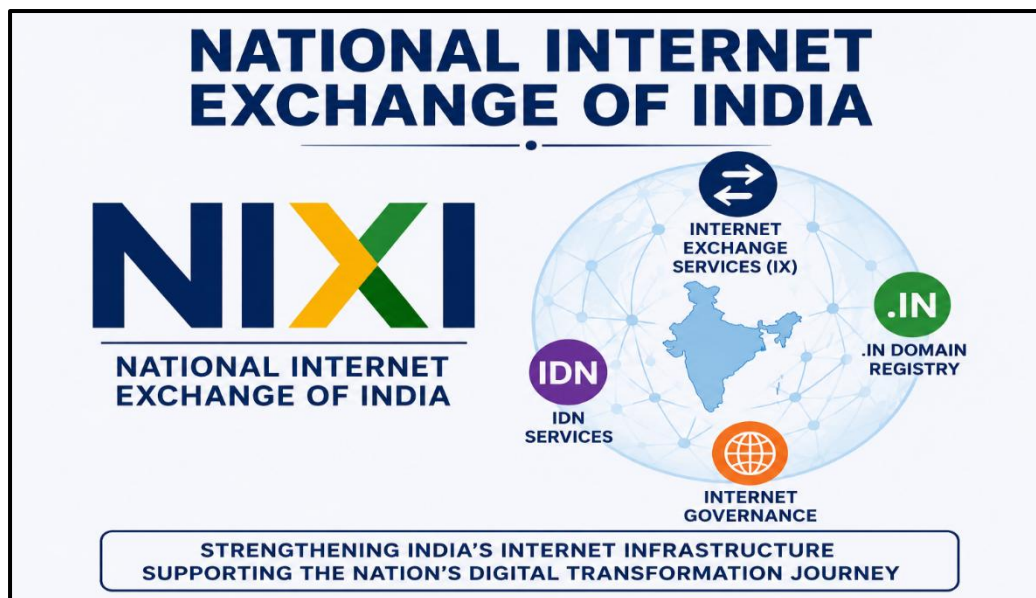
Science & Technology, Government Initiatives

Mains

GS Paper III – Science & Technology, GS Paper II – E-Governance

Current relevance

National Internet Exchange of India (NIXI) will observe its 23rd Foundation Day on 19 June 2026, it strengthening India's internet infrastructure and promoting digital transformation.



Highlights

1. The National Internet Exchange of India (NIXI) is a **not-for-profit organization** functioning under the **Ministry of Electronics and Information Technology (MeitY)**.
2. **Objective** - It is to promote internet penetration and strengthen the internet ecosystem within India and beyond.
3. **NIXI** facilitates the exchange of domestic internet traffic among **Internet Service Providers (ISPs)**, content providers, and other entities possessing **Autonomous System (AS)**.
4. Improves internet efficiency and reducing dependence on international bandwidth.

Source - PIB - [https -](https://www.pib.gov.in/PressReleasePage.aspx?PRID=2274704®=3&lang=1)

[//www.pib.gov.in/PressReleasePage.aspx?PRID=2274704®=3&lang=1](https://www.pib.gov.in/PressReleasePage.aspx?PRID=2274704®=3&lang=1)

10. Quantum 5G fixed wireless access

Prelims:

Science and Technology

Mains:

Current relevance:

BSNL has launched the **pilot version of its indigenous 5G service in Hyderabad**, becoming the **first Indian telecom operator** to offer indigenous 5G radio technology with **SIM-less authentication**.



Characteristics of Q-5G FWA:

1. **SIM-less architecture:** BSNL's **Direct-to-Device platform** enables automatic authentication of the **Customer Premises Equipment (CPE)**, eliminating the need for a physical SIM card.
2. **Fully indigenous stack:** **Core, RAN, and CPE** designed and integrated by Indian vendors under the **Atmanirbhar Bharat programme**.
3. **Gigabit-class speeds:** Achieves up to **980 Mbps Download (DL) / 140 Mbps Upload (UL)** with sub-10 ms latency—**ideal for UHD streaming, cloud gaming and remote work**.
4. **Rapid install:** The **self-install gateway** provides coverage to nearly 85% of Hyderabad households using BSNL's existing tower network, without requiring fiber deployment or trenching.

Road-map after the pilot launch:

1. **Pilot expansion cities:** Bengaluru, Pondicherry, Visakhapatnam, Pune, Gwalior and Chandigarh.

2. **Enterprise edge-cloud:** The same **5G SA (standalone) core** will support network-slicing and, **SLA (Service level agreement)**-backed connectivity for **MSMEs and smart-manufacturing clusters**.

SOURCE: PIB

<https://www.pib.gov.in/PressReleasePage.aspx?PRID=2138086®=48&lang=2>

11. Aqueous zinc -ion battery (AZIB)

Prelims:

Science & Technology, Environment

Mains:

GS Paper III – Science & Technology, Environment, Economy

Current relevance:

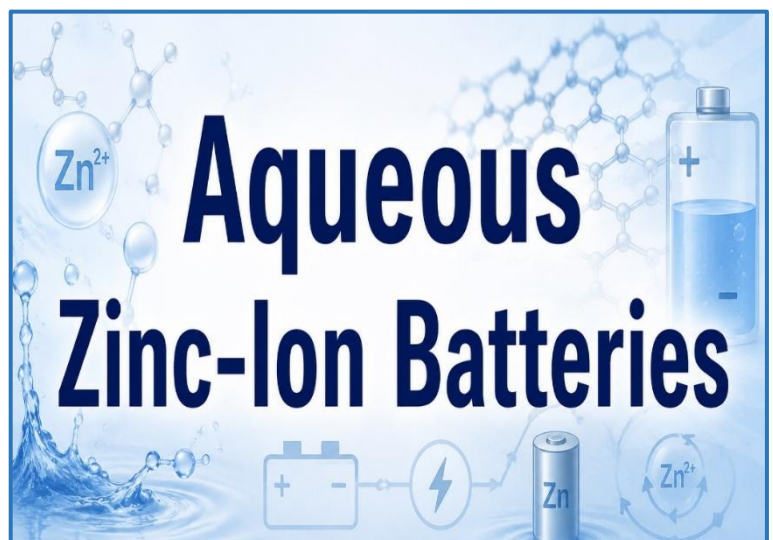
The Institute of Nano Science and Technology (INST) has developed a **new additive** that increases the safety and durability of **Aqueous Zinc-Ion Batteries (AZIBs)**.

Highlights:

1. Researchers developed **a new electrolyte additive** called **1,3-bis(1,3-dicarboxypropyl)-1H-imidazole-3-ium chloride (BDIM)** to improve the performance of **Aqueous Zinc-Ion Batteries (AZIBs)**.

Aim:

1. To develop **safer, longer-lasting, and cost-effective rechargeable zinc batteries** for large-scale energy storage.
2. It uses **electrolyte interface engineering** to enhance battery performance without redesigning battery materials.



BDIM:

- (i) It was synthesized **using glutamic acid, sodium hydroxide (NaOH), glyoxal, formaldehyde, and acetic acid.**
- (ii) It selectively adsorbs onto the **zinc metal surface.**
- (iii) Suppresses **zinc dendrite growth** and corrosion.
- (iv) Minimizes **Hydrogen Evolution Reaction (HER).**

Significance:

- (i) Promotes **safe and sustainable** battery technology.
- (ii) Extends the **operational life** of rechargeable zinc batteries.
- (iii) Enables reliable energy storage for **renewable energy integration** and power grids.
- (iv) Provides an **alternative to lithium-ion batteries** by reducing dependence on critical minerals such as lithium and cobalt.

Source: PIB

12.India's First Commercial-Scale Coal-to-Ammonium Nitrate Plant

One of the landmark announcements was the foundation stone for **India's first commercial-scale Coal-to-Ammonium Nitrate Plant** at **Lakhanpur, Jharsuguda district.**

Why is it important?

- i. Converts **domestic coal** into **Ammonium Nitrate** through coal gasification.
- ii. Reduces dependence on imported industrial chemicals.
- iii. Supports the **Atmanirbhar Bharat** initiative.
- iv. Ensures reliable availability of ammonium nitrate for:
 - Mining sector
 - Infrastructure projects
 - Industrial explosives

- v. Promotes value addition to India's abundant coal reserves instead of exporting raw resources.



Model Solar Village Initiative

Prime Minister announced **Pahadpur** as a **Model Solar Village**, with the objective of ensuring solar power access to every household.

The initiative aims to:

1. Promote decentralised renewable energy.
2. Reduce dependence on conventional electricity.
3. Improve rural energy security.
4. Support India's clean energy transition and climate commitments.

Infrastructure-led Growth Strategy

The projects reinforce the Government's focus on:

1. Industrialisation of eastern India.
2. Modern infrastructure creation.

3. Energy security.
4. Inclusive regional development.
5. Employment generation.
6. Balanced economic growth under the **Purvodaya** vision.

The emphasis on infrastructure and industrial investments aligns with India's long-term objective of becoming a developed economy (**Viksit Bharat 2047**).

Coal Gasification

1. Converts coal into **Synthesis Gas (Syngas)**.
2. Syngas is used to manufacture:
 - Ammonia
 - Methanol
 - Hydrogen
 - Synthetic fuels
3. Helps reduce crude oil and chemical imports.

Ammonium Nitrate

1. Chemical formula: **NH_4NO_3**
2. Major uses:
 - Mining explosives
 - Infrastructure blasting
 - Fertiliser production (certain formulations)

Net Zero Target

1. India aims to achieve **Net Zero emissions by 2070**.
2. Announced at **COP26 (Glasgow, 2021)**.

National Solar Mission

1. Launched in **2010** under the **National Action Plan on Climate Change (NAPCC)**.
2. Objective: Expand solar energy capacity and promote clean energy adoption.

Purvodaya Initiative

1. Focuses on accelerating industrial and infrastructure development in eastern India.

2. Covers mineral-rich states such as **Odisha, Jharkhand, Bihar, West Bengal and Chhattisgarh.**
3. Promotes manufacturing, logistics, mining and steel-based industries.

13.NETRA AEW&C System: Strengthening India's Airborne Surveillance

Prelims: DRDO | AEW&C | Indian Air Force

GS-III: Defence Technology | Indigenisation

Why in News?

The **DRDO** handed over the **Final Operational Clearance (FOC)** certificate for the indigenous **NETRA Airborne Early Warning and Control (AEW&C) system** to the Indian Air Force on 25 June 2026.



What Is an AEW&C System?

1. An AEW&C system combines an airborne platform with sensors, communication equipment and battle-management systems to detect and track airborne or surface targets from long distances.
2. Operating radar at altitude extends the surveillance horizon beyond what many ground-based radars can achieve because the sensor is less constrained by terrain and Earth's curvature.

3. NETRA's mission systems are integrated on **Embraer EMB-145 aircraft**. DRDO states that the system detects airborne and sea-surface targets as well as hostile emissions and provides information to onboard controllers and ground stations.

Operational Functions

1. **Early Warning:** Detects approaching aircraft and other aerial threats before they reach defended airspace.
2. **Airspace Surveillance:** Maintains a wider operational picture for commanders.
3. **Battle Management:** Supports coordination of fighters and other assets during air operations.
4. **Electronic Intelligence:** Detects hostile emissions relevant to situational awareness.
5. **Networked Operations:** Shares information with ground stations and other combat elements.

Final Operational Clearance

1. **FOC** signifies completion of the required operational evaluation for the approved configuration after earlier stages of development and user trials.
2. The significance of the 2026 milestone lies not merely in possession of an airborne radar platform, but in operational validation of an **indigenously developed mission system**.

Strategic Relevance

1. Modern air warfare increasingly depends upon the quality of the **sensor and information network** connecting surveillance platforms, fighters, missiles and command centres.
2. An AEW&C aircraft therefore acts as a force multiplier by improving:
 - i. Detection range
 - ii. Reaction time
 - iii. Airspace coordination
 - iv. Situational awareness
 - v. Command and control

3. NETRA also strengthens India's objective of reducing dependence on imported high-end surveillance and battle-management systems.

14. Reforms in India's Drug Import Regulations

Prelims:

Science & Technology, Governance

Mains:

GS Paper II-Government Policies and Interventions,

GS Paper III-Science & Technology

Current relevance:

The Union Health Ministry has proposed amendments to the **Drugs Rules, 1945** to simplify the import procedure for small quantities of drugs used for examination, testing, and analysis.



Highlights:

1. Regulatory Reforms in Drug Imports:

- (i) Introduces an **acknowledgement-based system** for importing small quantities of drugs.

(ii) Applicants can import eligible drugs after submitting a **prior intimation form**, without obtaining a separate import licence.

2. **Scope of the New regulation:**

(i) Applicable to **analytical and non-clinical testing** of imported drugs.

(ii) Intended to **facilitate research**, product evaluation, and quality testing.

3. **Exempted Drug Categories**

The simplified procedure **does not apply** to:

(i) Sex hormones

(ii) Cytotoxic drugs

(iii) Beta-lactam drugs

(iv) Biologics containing live microorganisms

(v) Narcotic and psychotropic substances

4. **Revised Shelf-Life Requirement:**

Proposes replacing the existing requirement of **more than 60% residual shelf life** with a **minimum residual shelf life of 12 months** at the time of import.

Source: THE HINDU – <https://www.thehindu.com/news/national/government-proposes-simplifying-procedure-for-import-of-drugs-for-examination-test-or-analysis-under-drugs-rules-1945/article71150769.ece>

15. Aarogya Setu 2.0

Prelims:

Government initiatives, Science & Technology

Mains:

GS Paper II – Government Policies and Interventions, E-Governance, Social Justice, GS

Paper III – Science & Technology

Current relevance:

AAROGYA SETU 2.0

A COMPREHENSIVE PERSONAL HEALTH RECORD APP

ONE APP. MANY HEALTH SERVICES.



DIGITAL HEALTH RECORDS



SECURE & CONSENT BASED SHARING



AI-POWERED HEALTH INSIGHTS



WEARABLE DEVICE INTEGRATION



FIND DOCTORS, HOSPITALS & HEALTH FACILITIES



AMBULANCE SERVICES



BLOOD BANKS & BLOOD AVAILABILITY



JAN AUSHADHI KENDRAS



SEARCH PM-JAY EMPANELLED HOSPITALS



AB PM-JAY WALLET



AYUSHMAN CAPF POLICY

SEAMLESS ACCESS TO PM-JAY SERVICES

BUILDING A HEALTHY INDIA WITH DIGITAL INNOVATION
Accessible. Connected. Efficient.



National Health Authority



Ayushman Bharat Digital Mission

The Union Health Minister is set to launch **Aarogya Setu 2.0** along with several digital health initiatives under the **Ayushman Bharat Digital Mission (ABDM)** to strengthen India's **Digital Public Infrastructure (DPI)**.

Highlights:

1. **Aarogya Setu 2.0:**

Revamped as a **comprehensive Personal Health Record (PHR) application**, serving as a **single digital gateway** for accessing multiple healthcare services.

2. **Citizen-Centric Digital Services:**

The application enables users to:

- (i) Create and manage **ABHA (Ayushman Bharat Health Account)**.
- (ii) Exchange health information through a **consent-based mechanism**.
- (iii) Receive **AI-powered health insights** and smart health reports.

3. **Integrates PM-JAY services**, providing easy access to empanelled hospitals, the digital wallet, Ayushman CAPF benefits, and healthcare services.

4. **Ayushman Sarathi: A WhatsApp chatbot** for PM-JAY beneficiaries, Provides scheme-related information through a conversational interface.

5. **National Health Claims Exchange (NHCX):** Establishes a **Digital Public Infrastructure** for health insurance claims.
6. **e-Sushrut Clinic:** A **plug-and-play digital clinic management platform** that streamlines healthcare operations and clinical workflows.

Source: PIB –

<https://www.pib.gov.in/PressReleaseDetail.aspx?PRID=2278390®=48&lang=1>

16. e-Sushrut@Clinic

Prelims:

Science & Technology, e-Governance, Health Sector

Mains:

GS Paper II- Health, Government Policies, E-Governance, GS Paper III-Science & Technology

Current relevance:

The Union Health Ministry is set to launch **e-Sushrut@Clinic, a Hospital Management Information System (HMIS)** developed by **C-DAC**.



The graphic is a promotional banner for e-Sushrut@Clinic. On the left, the text 'e-Sushrut@Clinic' is in large blue and green font, with the tagline 'Smart. Simple. Secure Healthcare Management' below it. A cloud icon with a hospital building inside is shown. Below this, it says 'DEVELOPED BY' followed by the C-DAC logo and 'CENTRE FOR DEVELOPMENT OF ADVANCED COMPUTING (C-DAC)'. Five circular icons represent features: Cloud-Based Access, Easy Patient Registration, Simplified Billing, Smart Reports, and Secure & Reliable. At the bottom, four icons represent additional benefits: Accessible from any device, No technical expertise required, Affordable solution for small clinics, and Maintenance & upgradation by C-DAC. On the right, there is an image of a modern outpatient clinic entrance with a sign that says 'OUTPATIENT CLINIC' and a poster that reads 'YOUR HEALTH OUR PRIORITY' and 'QUALITY CARE MADE EASY'. A man and a woman are sitting on a bench in front of the clinic.

About e-Sushrut@Clinic:

1. **A lightweight, cloud-based** Hospital Management Information System (HMIS) designed specifically for small outpatient clinics, developed by the **Centre for Development of Advanced Computing (C-DAC)**.

2. **Objective:**

To provide an **affordable, user-friendly, and government-backed digital solution** for small healthcare facilities that lack access to advanced hospital management systems.

3. **Beneficiaries:**

- (i) Small outpatient clinics
- (ii) Primary Health Centres (PHCs)
- (iii) Health Sub-Centres
- (iv) Private clinics

4. **Addressing Existing Challenges:**

- (i) Large HMIS platforms are often **expensive and technically complex** for small clinics.
- (ii) Inefficiencies caused by **manual record-keeping** and limited digital infrastructure.

Source: THE HINDU- <https://www.pressreader.com/india/the-hindu-erode-9ww6/20260628/281968909411084?srsId=AfmBOop-M7OPIMVzzLtkI9HmXwMVosB2Ccft5IYUqsZl0m4AtNfUelo>