DEFENCE TECHNOLOGY

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1. Missile Systems and Strategic Weapons-Ballistic missiles, cruise missiles, anti-ballistic missiles

Anti-Ballistic Missile (ABM) Systems: Layered Defence and Interception Principles

- **Anti-Ballistic Missile (ABM) Systems**

  Designed to intercept and destroy incoming ballistic missiles.

- **Terminal High Altitude Area Defense (THAAD)**
  - An American anti-missile system.
  - Intercepts ballistic missiles at high altitudes during their terminal phase.
- **S-400 Triumf**
  - Russian-made long-range air defense missile system (Surface-to-Air Missile - SAM).
  - India procured 5 systems/squadrons from Russia.
  - Upgraded version of the S-300 family of SAM systems.
- **Iron Dome**
  - Israeli air defense missile system.
  - Operates in all weather conditions.
  - Designed to intercept short-range rockets, artillery shells, and mortars.
  - Uses radar to track threats and differentiate between those likely to hit built-up areas.
  - Developed by Israel (Rafael Advanced Defense Systems) with significant US financial support.
- **Arrow-4**
  - New Ballistic Missile Shield developed by Israel in collaboration with the USA.
- **Mission Shakti**
  - DRDO (India) mission.
  - Demonstrated India's Anti-Satellite (ASAT) missile capability, allowing a rocket to destroy an orbiting satellite.
- **Phase-II Ballistic Missile Defence (BMD) interceptor AD-1 missile**
  - Tested by DRDO (India).

Ballistic Missiles: Trajectory, Stages, and Variants (SRBM, MRBM, ICBM, SLBM)

- Ballistic missiles are rocket-powered only during their initial flight phase (boost phase).
- They follow a ballistic trajectory: after boost, they are unpowered, primarily influenced by gravity and air resistance.
- Ballistic missiles typically travel outside Earth's atmosphere and re-enter to strike a target.
- Guidance systems are active during the initial launch phase and sometimes during the terminal (re-entry) phase to fine-tune impact.
- Unlike cruise missiles, which are jet-propelled, guided throughout, remain within the atmosphere, and fly parallel to the Earth's surface. BrahMos is a cruise missile, not ballistic.
- **Trajectory Stages**
  - **Boost Phase**

    Rocket engines fire, missile gains altitude and velocity, guided.
  - **Mid-course Phase**

    Engines shut off, missile coasts in space along a sub-orbital or orbital path, largely unguided.
  - **Terminal Phase**

    Missile re-enters atmosphere, descends towards target, re-entry vehicle may perform maneuvers.
- **Fractional Orbital Bombardment System (FOBS)**

  A missile is put into a stable orbit around Earth and then deorbits over a target.
- **Ballistic Missile Variants by Range**
  - **SRBM (Short-Range Ballistic Missile)**

    Range less than 1,000 km.
    - E.g., India's Prithvi series, Pakistan's Hatf IX (Nasr) (surface-to-surface, multi-tube).
  - **MRBM (Medium-Range Ballistic Missile)**

    Range 1,000 – 3,000 km.
    - E.g., India's Agni-P (1,000-2,000 km), India's Agni-II (~2,000 km), Pakistan's Shaheen-III (medium-range, surface-to-surface).
  - **IRBM (Intermediate-Range Ballistic Missile)**

    Range 1,000 – 5,500 km (often considered 3,000-5,500 km for distinction from MRBM).
    - E.g., India's Agni-IV (4,000-5,000 km).
  - **ICBM (Intercontinental Ballistic Missile)**

    Range greater than 5,500 km.
    - E.g., India's Agni-V (>5,000 km).
  - **SLBM (Submarine-Launched Ballistic Missile)**

    Launched from submarines.
    - E.g., India's K-15 (Sagarika), Dhanush (naval variant of Prithvi).
- **Indian Ballistic Missiles**
  - **Agni-P**

    Surface-to-surface MRBM, range 1,000-2,000 km.
  - **Agni-II**

    Surface-to-surface MRBM/IRBM, range around 2,000 km.
  - **Agni-IV**

    Surface-to-surface IRBM, range 4,000-5,000 km. Features two-stage solid propellant. Can deliver 1-tonne nuclear warheads.
  - **Agni-V**

    Surface-to-surface ICBM, nuclear-capable, range more than 5,000 km. Features Ring Laser Gyro-based Inertial Navigation System (RINS) and Micro Navigation System (MINS). It is solid-fuelled. Launched from Dr. APJ Abdul Kalam Island (formerly Wheeler Is-

land). India joined US, Russia, France, China in the elite ICBM club with Agni-V.

- **Prithvi series**

  Surface-to-surface SRBM. Prithvi-II is a ballistic missile.

- **Dhanush**

  Naval variant of the Prithvi missile; an SLBM/SSM.

- **K-15 (Sagarika)**

  Submarine-Launched Ballistic Missile (SLBM).

- **Mission Divyastra (DRDO)**

  Refers to India's Multiple Independently Targetable Re-Entry Vehicle (MIRV) technology, associated with advanced ballistic missiles.

Cruise Missiles: Guidance, Propulsion, and Terrain-Following Capabilities

- BrahMos: Short-range, supersonic cruise missile.
- BrahMos: Joint venture between India (Brahmaputra) and Russia (Moskva).
- BrahMos: Achieves speed of Mach 2.8 to 3.0.
- BrahMos: Original flight range up to 290 km; extended versions exceed 400 km (e.g., 450 km, 500 km+).
- BrahMos: Cruising altitude typically very low, including sea-skimming, up to 15 km, not 30 km.
- Nirbhay: India's indigenously developed subsonic cruise missile (by DRDO).
- Cruise Missile Propulsion: Generally uses jet engines (turbojet or turbofan) for sustained flight; ramjets for supersonic speeds (e.g., BrahMos).
- Cruise Missile Guidance: Utilizes Inertial Navigation System (INS), Global Positioning System (GPS), and advanced systems like Terrain Contour Matching (TERCOM) or Digital Scene Matching Area Correlation (DSMAC).
- Cruise Missile Terrain-Following: Capability to fly at extremely low altitudes, following the contours of the terrain to avoid radar detection and air defenses.

Emerging Technologies in Missile Warfare: AI, Swarm Missiles, and Directed Energy Defences

- **Mission Shakti:** India's Anti-Satellite (ASAT) missile test.
- Developed and conducted by Defence Research and Development Organisation (DRDO).
- Demonstrates India's capability to intercept and destroy satellites in low earth orbit, thereby enhancing strategic deterrence.
- **DURGA-II (DRDO):** Stands for Directed-Energy Urja for Ranging & Abatement - II.
- It is a Directed Energy Weapon (DEW) developed by DRDO.
- DEWs are emerging technologies that use highly focused energy (e.g., laser, microwave beams) to damage, disable, or destroy targets.
- DEWs have applications in missile defence, counter-drone operations, and other strategic warfare scenarios.

Hypersonic Missiles: Technology, Capabilities, and Strategic Implications

- **Shorya Missile**

  India's canister-launched, surface-to-surface strategic missile.

- **Speed**

  Hypersonic, capable of reaching speeds up to Mach 7.5.

- **Range**

  Operational range is 700-1900 km; initial versions commonly cited around 750 km.

- **Key Test**

  Successfully test-fired on 24 September 2011 from Chandipur, Odisha.

India's Indigenous Missile Development Programs (e.g., Agni, Prithvi, BrahMos, Akash)

- **Integrated Guided Missile Development Program (IGMDP)**

  Launched in 1983 under Dr. A.P.J. Abdul Kalam. Developed five missile systems: Prithvi, Agni, Trishul, Akash, Nag.

- **Dr. A.P.J. Abdul Kalam**

  Popularly known as the 'Missile Man of India'. Flew Sukhoi-30 MKI fighter.

- **Missile Technology Control Regime (MTCR)**

  India became a member in 2016. China is not a member.

- **Organizations**
  - **Defence Research and Development Organisation (DRDO)**

    R&D wing of the Ministry of Defence (formed 1958). Developed most indigenous missile systems (Agni, Prithvi series, Pinaka, Akash).

  - **Bharat Dynamics Limited (BDL)**

    Produces missiles developed by DRDO (e.g., Akash).

  - **Bharat Electronics Limited (BEL)**

    Engaged in components for air defence systems (e.g., Akashier).

  - **Ordnance Factory Board (OFB)**

    Engaged in projects like 'Dhanush' (howitzer).

- **Ballistic Missiles (Surface-to-Surface)**
  - **Prithvi**

    India's first indigenous surface-to-surface missile. Test fired from Chandipur, Odisha.

  - **Dhanush**

    Naval variant of Prithvi III. Short Range Ballistic Missile (SRBM), can carry conventional/nuclear warheads, range ~350-600 km.

  - **Agni Series**

    Surface-to-surface ballistic missiles, nuclear-capable, developed by DRDO.

    - **Agni-I**

      Single-stage, solid-fuel, range 700-1200 km.

    - **Agni-P (Prime)**

      Canisterised, two-stage solid propellant, range up to 2000 km. Canisterisation reduces launch time, improves storage/handling.

    - **Agni-V**

      India's longest-range Intercontinental Ballistic Missile (ICBM) (5000+ km). Three-stage solid-fuelled engine. Canister-launched. Nuclear-capable (more than one tonne warhead). Uses Multiple Independently Targetable Re-entry Vehicle (MIRV) technology (associated with Mission Divyastra). Indigenously developed by DRDO.

  - **Prahaar**

    Short-range (150-200 km) surface-to-surface missile. Single stage, solid propellants. Can fire multiple missiles in one salvo.

  - **Pralay**

    Conventional Short-Range Ballistic Missile (SRBM). Surface-to-surface.

  - **Shaurya**

    Surface-to-surface strategic missile (canister-launched), land variant of K-15 SLBM, known for high maneuverability and potentially hypersonic capabilities.

  - **K-4**

    Submarine-Launched Ballistic Missile (SLBM), fitted to Arihant-class submarines.

- **Cruise Missiles**
  - **BrahMos**

    Indo-Russian (DRDO + NPO Mashinostroyeniya) supersonic cruise missile. Name from Brahmaputra (India) & Moskva (Russia) rivers. Multi-platform capable (submarine, ship, air, land). World's fastest supersonic cruise missile. Initial range 290 km, extended to 600 km post-MTCR. Integrated with Sukhoi-30 MKI fighter. Test site: Chandipur. India delivered BrahMos to the Philippines (April 2024).

- **Nirbhay**

  India's first indigenous long-range subsonic cruise missile. Multi-platform capable.

- **Air Defence Missiles (Surface-to-Air)**
  - **Akash**

    Medium Range Surface-to-Air Missile (MRSAM) system, uses radar. Developed by DRDO, produced by Bharat Dynamics Limited (BDL).

  - **Akash-NG (New Generation)**

    Surface-to-air missile, strike range ~80km, high indigenous content (~96%), developed for the Indian Air Force.

  - **Trishul**

    Short-range (around 9 km) supersonic surface-to-air missile.

  - **Quick Reaction Surface-to-Air Missile (QRSAM)**

    DRDO-developed, solid fuel propellant, range 25-30 km. Equipped with electronic countermeasures (ECM).

  - **Barak-8 (LRSAM)**

    Long Range Surface-to-Air Missile, jointly developed by India and Israel. Naval version attached to frigates/destroyers, range ~70-100 km.

  - **VSHORADS (Very Short Range Air Defence System)**

    DRDO-developed Man-Portable Air Defence System (MANPADS) to neutralize aerial threats.

  - **Igla Missile**

    Russian-origin Short-Range Man-Portable Infrared Homing Surface-to-Air Missile (MANPADS).

  - **S-400 'Triumf'**

    Russian-developed long-range Surface-to-Air Missile (SAM) system (India procures). Max speed up to Mach 14. Designed for quick deployment.

  - **NASAMS II**

    Advanced air defence system India plans to procure from the United States.

- **Air-to-Air Missiles**
  - **Astra**

    India's first indigenous Beyond-Visual-Range (BVR) Air-to-Air Missile. Developed by DRDO. Range ~90 km. Successfully test-fired from LCA Tejas.

- **Anti-Tank Guided Missiles (ATGMs)**
  - **Nag**

    "Fire and forget" ATGM. Uses IR imaging for guidance. Test fired at Pokhran.

  - **Helina (HELINA) / Dhruvastra**

    Helicopter-launched versions of Nag ATGM. Indigenously developed by DRDO. Range ~7-8 km. Test fired from Advanced Light Helicopter (ALH).

- **Anti-Radiation/Air-to-Surface Missiles**
  - **Rudram-1 (earlier known as NGARM)**

    India's first indigenous anti-radiation missile. Air-to-surface missile. Test fired from Sukhoi 30 MKI.

  - **RudraM-II**

    Air-to-Surface missile.

- **Anti-Satellite (ASAT) Missile**
  - **Mission Shakti**

    India's first Anti-Satellite Missile program (tested in 2019).

- **Other Weapon Systems / Platforms**
  - **Pinaka**

    Multi-Barrel Rocket Launcher (MBRL) system. Developed by DRDO. Test fired from Pokhran range.

  - **Smart Anti Airfield Weapon (SAAW)**

    Indigenously developed precision strike glide bomb. ~120 kg class, range ~100 km. Launched from Hawk-i air-

craft. Targets enemy assets like radars, bunkers, runways.

- **GAURAV**

  500 kg class glide bomb.

- **Tejas**

  India's first indigenous Light Combat Aircraft (LCA).

- **Sukhoi-30 MKI**

  Fighter aircraft (not manufactured by DRDO).

- **Dhanush (Howitzer)**

  Indigenously upgraded 155-mm Bofors Howitzer by Ordnance Factory Board (OFB).

- **Lakshya-2**

  DRDO-developed pilotless aircraft (UAV).

- **MIG-27**

  Indian Air Force retired this fighter aircraft in Dec 2019.

- **M777 Howitzer**

  Procured from the USA.

- **INS Trishul (Warship)**

  Built by Russia.

- **INS Vikrant (IAC-I)**

  India's first Indigenous Aircraft Carrier.

- **INS Imphal**

  Warship armed with BrahMos surface-to-surface missile.

- **Tatra**

  Vehicle/truck manufacturer (not a missile system).

- **Key Events/Concepts**
  - **Pokhran I (Smiling Buddha)**

    India's first nuclear test, conducted on May 18, 1974.

  - **Mission Divyastra**

    Related to MIRV technology (specifically for Agni-V).

  - **Project Arrow**

    Initiative by the Department of Posts to restructure core operations.

- **Foreign Missile Systems**
  - **Fath-360 Missile**

    Developed by Iran.

Missile Classification: Types and Operational Ranges

- **Missile Classification**
  - **Ballistic Missiles**

    Follow a ballistic trajectory; primarily initial propulsion. Eg: Agni-I, Dhanush (naval variant of Prithvi series).

  - **Cruise Missiles**

    Fly at a relatively constant altitude; use jet engines; guided throughout flight. Eg: BrahMos (supersonic cruise missile).

  - **MANPADS (Man-Portable Air-Defense Systems)**

    Surface-to-Air Missiles (SAMs), shoulder-fired.

- **Aircraft & Helicopters**
  - **Rafale**

    Fighter aircraft manufactured by Dassault Aviation (France).

  - **Eurofighter Typhoon**

    Multi-role fighter aircraft developed by Eurofighter GmbH (a European consortium).

  - **Jaguar**

    Twin-engine, single-seater, deep penetration strike aircraft of Anglo-French origin (max speed approx. 1700 km/hr).

  - **Rudra**

    Attack helicopter (Advanced Light Helicopter - Weapon System Integrated, ALH-WSI); features turret gun, rocket system, and air-to-air missiles.

  - **Cheetah/Chetak**

    Light utility helicopters; not equipped with integrated attack helicopter armament like turret guns, rocket systems, or air-to-air missiles.

Missile Defence Architectures: Integrated Air and Missile Defence (IAMD)

- **Integrated Air and Missile Defence (IAMD)**
  Comprehensive, layered defence architecture combining systems to counter various aerial threats (aircraft, drones, cruise missiles, ballistic missiles).
- **S-400 Triumf (Russia)**
  Long-range Surface-to-Air Missile (SAM) system.
- **S-400 Capabilities**
  Engages aircraft, Unmanned Aerial Vehicles (UAVs), cruise missiles, and ballistic missiles.
- **S-400 Recipients**
  China was the first country to receive S-400 missiles from Russia. India is also a recipient.
- **C-Dome Air Defence System**
  Developed by Israel.

Propulsion Systems in Missiles: Solid, Liquid, Ramjet, Scramjet Engines

- **Propulsion Systems in Missiles**
  Mechanisms generating thrust to propel missiles, primarily using chemical reactions to expel high-velocity gases.
- **Solid Rocket Motors (SRM)**
  - **Propellant**
    Solid mixture of fuel (e.g., HTPB, Polyurethane) and oxidizer (e.g., Ammonium Perchlorate).
  - **Characteristics**
    Simple design, high reliability, long storage life, instant high thrust. Cannot be throttled, stopped, or restarted once ignited.
  - **Application**
    Ballistic missiles (e.g., Agni, Prithvi boosters), boosters for space launch vehicles, tactical missiles.
- **Liquid Rocket Engines (LRE)**
  - **Propellant**
    Liquid fuel and oxidizer stored separately in tanks, mixed in a combustion chamber.
  - **Characteristics**
    More complex (pumps, valves), allows for throttling, multiple restarts, and higher specific impulse (efficiency).
  - **Propellant Types (relevant to MCQ 2)**
    - **Cryogenic**
      Requires extremely low temperatures. Common combination: Liquid Oxygen (O_2) as oxidizer, Liquid Hydrogen (H_2) as fuel.
    - **Hypergolic**
      Ignite spontaneously on contact. Common combination: Hydrazine (N_2H_4) as fuel, Nitrogen Tetroxide (N_2O_4) as oxidizer. Storable at room temperature.
    - **Non-hypergolic**
      Requires an external ignition source.
  - **Application**
    Upper stages of launch vehicles, cruise missile maneuvering, orbital insertion.
- **Ramjet Engines (relevant to MCQ 1)**
  - **Definition**
    An air-breathing jet engine that uses the vehicle's forward motion to compress incoming air, eliminating the need for a mechanical compressor.
  - **Operation**
    Air enters at supersonic speed, is slowed to subsonic for combustion, fuel is injected and ignited, and hot exhaust gases provide thrust.
  - **Speed Range**
    Efficient at supersonic speeds (typically Mach 3-6). Cannot operate from a

standstill; requires a booster (e.g., solid rocket) to reach operating speed.

- **Application**

  Supersonic cruise missiles (e.g., BrahMos).

- **Scramjet Engines (Supersonic Combustion Ramjet)**
  - **Definition**

    An advanced ramjet where combustion of fuel with incoming air occurs at supersonic speeds throughout the engine.

  - **Operation**

    Airflow remains supersonic through the entire engine, allowing operation at very high speeds.

  - **Speed Range**

    Operates at hypersonic speeds (typically Mach 5+).

  - **Complexity**

    Extremely high due to challenges in fuel injection and combustion within supersonic airflow.

  - **Application**

    Experimental for hypersonic cruise missiles and future space access vehicles.

Strategic Deterrence, Arms Control, and Missile Proliferation Challenges

- Missile Technology Control Regime (MTCR): An informal and voluntary export control regime initially formed among G-7 countries.
- MTCR objective: Prevent the proliferation of missile and unmanned aerial vehicle (UAV) systems capable of carrying above 500 kg payload for more than 300 km.
- China applied to join the MTCR but was not granted membership.
- MTCR establishes international norms for missile and UAV technology control; while membership is voluntary, its guidelines influence international trade and proliferation efforts, meaning non-members may still be impacted or adhere to its rules.
- India's Strategic Forces Command (SFC): Established in 2003, it is a tri-service command responsible for the management and administration of India's tactical and strategic nuclear weapons stockpile.
- The Commander-in-Chief of the Strategic Forces Command (SFC) is entrusted to manage and administer all strategic forces of India.

Warhead Technologies: Conventional Precision-Strike and Nuclear Payloads

- Fuses: Devices designed to initiate an explosive train in munitions.
- Fuses function as a switch, activating an explosive device.
- Primary types of fuses include:
  - **Time Delay Fuses**

    Detonate after a predetermined period. Example: Chemical pencils.

  - **Physical Action Fuses**

    Activated by physical stimuli like impact, pressure, pull, or vibration.

  - **Environmental Fuses**

    Triggered by changes in ambient conditions such as altitude, proximity (radar/laser), magnetic fields, or temperature.
- "Little Boy": Code name for the atomic bomb dropped on Hiroshima, Japan (August 6, 1945).
- "Little Boy" was a **Uranium-235 (U-bomb)** implosion-type nuclear device.
- "Fat Man": Code name for the atomic bomb dropped on Nagasaki, Japan (August 9, 1945), a Plutonium-239 (Pu-bomb) implosion-type device.

2. Nuclear, Biological, and Chemical Defence Technologies

Biological Agent Identification and Detection Systems

- Non-Linear Junction Detector (NLJD), Threat Containment Vehicle (TCV), and Bomb Blanket are Bomb Detection/Disposal Equipment.
- A Buried Cable is not a Bomb Detection/Disposal Equipment; it's typically for electrical or communication purposes.
- Through the X-BIS (X-ray Baggage Inspection System) Screen, explosives are typically seen in orange colour.
- A Non-Linear Junction Detector (NLJD) is capable of detecting devices containing semiconductors, which are components of many Improvised Explosive Devices (IEDs).
- According to prescribed specifications, an NLJD should be capable of detecting an ABCD circuit buried under dry soil up to a depth of at least 12 inches.
- The dog squad of CISF (Central Industrial Security Force) is trained to sniff and identify narcotics and Improvised Explosive Devices (IEDs).

Chemical Warfare Agent Sensors and Monitors

- Sarin is a highly toxic Nerve Agent.
- Sarin was used in the 2013 chemical attack in Syria.
- Napalm bombs are typically made of gasoline thickened with gelling agents like aluminum salts of naphthenic and palmitic acids; petroleum jelly is a simplified component that aids in thickening.

Collective Protection Systems (CPS)

- Collective Protection Systems (CPS): Designed to protect personnel and equipment from Nuclear, Biological, and Chemical (NBC) threats.
- Mechanism: Creates an over-pressured, filtered, and sealed internal environment (e.g., shelters, vehicles, command posts) to prevent contaminants from entering.
- Components typically include: NBC filters (particulate and gas), blowers to maintain positive pressure, airlocks, and monitoring systems.
- National Disaster Response Force (NDRF): Specialized force for disaster management, including Chemical, Biological, Radiological, and Nuclear (CBRN) incidents.
- NDRF Academy: Established in Nagpur in 2018 to provide training for disaster response personnel, including those managing CBRN threats.

Decontamination Technologies for NBC Agents

- RDX stands for Research Department Explosive.
- An Improvised Explosive Device (IED) typically requires a Detonator, Explosive, and a Battery (or other power source).
- During a fire outbreak, immediate actions include stopping spread, rescuing persons, and deploying equipment/manpower; waiting for external authorities (e.g., police) without taking immediate action is incorrect.
- **Indian Navy Training Institutes**
  - Anti-Submarine Warfare School: INS Venduruthy, Kochi
  - NBCD (Nuclear, Biological, Chemical Defence & Damage Control) School: INS Shivaji, Lonavala
  - Music Training School: INS Kunjali, Mumbai
  - Provost and Physical Training School: INS Mandovi, Goa
- **Class 'B' Fires (Flammable liquids like oil, petrol)**
  - CO_2 extinguishers are effective.
  - Special dry chemical extinguishers are effective.
  - Foam extinguishers are highly effective (not less effective) for 'B' type fires as they smother the fire and cool the fuel.
  - Water (including steam) should be used with caution, or avoided, as it can spread 'B' type fires due to flammable liquids floating on water.

Forensic Analysis of NBC Materials

- **Improvised Explosive Device (IED) Essential Components**

  Explosive (main charge), Detonator/Initiator, Power Source (for electronic components), and a Switch/Fuzing System (e.g., timer, command, victim-operated).
- A mechanical timer/clock is a specific type of switch/fuzing system; not all IEDs utilize this specific mechanism (e.g., command-detonated, victim-operated switches).
- **High Explosives**

  Undergo detonation, producing a supersonic shockwave and shattering effect. Examples include TNT, RDX, PETN, and plastic explosives (e.g., C4).
- **Low Explosives**

  Undergo deflagration (rapid burning), producing a subsonic pressure wave and a propelling effect. Examples include Black Powder (gunpowder) and smokeless powder.
- Black gunpowder is classified as a low explosive.
- TNT, RDX, and plastic explosives are classified as high explosives.

Medical Countermeasures and Therapeutics for NBC Exposure

- DRDO developed 'Lukoskin' for the treatment of Leukoderma (Leucoderma).
- DRDO's developed polyherbal products include 'Amtooth' and 'Eczit'.
- DRDO, in collaboration with Dr. Reddy's Laboratories (DRL), developed the anti-COVID drug "2-DG".

Next-generation NBC Defence Research and Development

- HMX: High Melting Explosive.
- Atom bomb working principle: Nuclear fission (e.g., uranium).
- Hydrogen bomb working principle: Nuclear fusion (e.g., deuterium).
- Hydrogen bomb (thermonuclear weapon) is significantly more powerful than an atom bomb (fission weapon) of the same capacity/power.
- Neutron bomb (Enhanced Radiation Weapon): Designed to maximize radiation yield, minimize blast/heat; causes less structural damage but more human casualties.
- Hydrogen bomb developer: Edward Teller.
- Fast Breeder Reactor (FBTR) at Kalpakkam coolant: Liquid sodium.
- India's first nuclear reactor: Apsara.
- Pokhran-I (1974) official code name: 'Smiling Buddha'.
- Pokhran-II: Conducted on May 11-13, 1998.
- National Technology Day (May 11): Commemorates the successful Pokhran-II nuclear tests.
- Multi Influence Ground Mine (MIGM) development: Collaborated by Centre for Fire Explosive and Environment Safety (CFEES), Delhi, and Defence Laboratory (DL), Jodhpur.
- Nuclear Non-Proliferation Treaty (NPT): Accepted by the UN General Assembly in June 1968.
- SEBEX 2: An explosive device based on melting explosive technology, developed by High Energy Materials Research Laboratory (HEMRL), Pune.

Nuclear Hardening and Shielding Technologies

- Heavy-water plants in India include Hazira, Thal, Tuticorin, and Manuguru. Kalpakkam is a nuclear power plant, not primarily a heavy-water plant.
- The Subterranean Nuclear Explosion Project (SNEP) was approved by Prime Minister Indira Gandhi.
- The first Pokhran nuclear test (1974) was code-named ‘Smiling Buddha’. The Indian Ministry of External Affairs described it as a Peaceful Nuclear Explosion (PNE).
- India's Nuclear Doctrine comprises No First Use (NFU), Unilateral Moratorium (on nuclear testing), and Minimum Credible Deterrence (MCD).
- Minimum Credible Deterrence (MCD) refers to the necessity of nuclear weapons for a country facing a clear nuclear threat. India