



IAS PARLIAMENT

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A Shankar IAS Academy Initiative

TARGET 2019

SCIENCE & TECHNOLOGY

Shankar IAS Academy

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INDEX

1. Space Technology.....6	1.38 Juno Spacecraft20
1.1 Types of Orbits..... 6	1.39 OSIRIS-REx.....20
1.2 Types of Satellites..... 7	1.40 Orion Spacecraft.....21
1.3 Launch Vehicles 7	1.41 Voyager 1 & Voyager 221
Indian Missions10	1.42 Dawn Mission.....21
1.4 PSLV C-44/Kalamsat 10	1.43 Europa Clipper Mission.....22
1.5 PSLV C-43/HysIS..... 10	1.44 Lucy and Psyche22
1.6 HySIS..... 11	1.45 Magnetospheric Multiscale (MMS) Mission.....22
1.7 PSLV C-42..... 11	1.46 CubeSat.....23
1.8 PSLV C-41/IRNSS-1I..... 11	1.47 NICER23
1.9 PSLV-C40/Cartosat-2 11	1.48 GOLD & ICON.....23
1.10 Cartosat Series Satellite 12	1.49 IMAP23
1.11 Other Notable missions of PSLV..... 12	1.50 VISIONS – 2.....24
1.12 GSAT – 31..... 12	1.51 Kilopower Project.....24
1.13 GSAT – 11..... 12	1.52 Asteroid Impact and Deflection Assessment Mission.24
1.14 GSLV MK-III D2 / GSAT 29..... 13	1.53 TESS24
1.15 Other Developmental & Experimental Flights of GSLV MK-III..... 13	1.54 TDRS-M.....24
1.16 GSLV F-11/GSAT -7A..... 13	1.55 EcAMSat Mission24
1.17 GSLV-F08/GSAT-6A 13	1.56 ICESat-2 and GRACE.....25
1.18 GSLV-F09 / GSAT-9..... 13	1.57 GRACE FO.....25
1.19 INSAT-3DR..... 14	1.58 OCO-3 Mission.....25
1.20 ExseedSAT – 1..... 14	1.59 SUBSEA.....25
Other Notable Missions14	1.60 Cyclone Global Navigation Satellite System.....25
1.21 Gaganyaan..... 14	1.61 Joint Polar Satellite System26
1.22 Mission Venus 15	1.62 Cassini Space Craft26
1.23 Aditya-L1 Mission 15	1.63 Rosetta.....26
1.24 AstroSat..... 16	Other Space Agencies26
1.25 Mars Orbiter Mission..... 16	1.64 Gaia mission.....26
1.26 Chandrayaan..... 16	1.65 Belle II.....27
1.27 Chandrayaan-2 17	1.66 Aeolus Satellite27
1.28 NISAR..... 17	1.67 Galileo27
Global Missions17	1.68 BepiColombo mission27
NASA.....17	1.69 ExoMars27
1.29 NASA Solar Probe..... 17	1.70 SENTINEL-5P28
1.30 FOXSI Mission..... 18	1.71 Tiangong-128
1.31 Insight Mission..... 18	1.72 Queqiao28
1.32 Curiosity..... 18	1.73 Chang'e 429
1.33 Opportunity Rover..... 19	1.74 HY-1C satellite29
1.34 ASPIRE 19	1.75 Cargo Spacecraft and Lunar Palace29
1.35 MAVEN 19	1.76 Quasi-Zenith Satellite System29
1.36 New Frontiers program..... 19	1.77 MINERVA-III30
1.37 New Horizons..... 20	1.78 Ibuki – 2.....30
	1.79 Kirameki -2.....30
	1.80 Hope Mission.....30



1.81	Israel Spacecraft	30	3.6	James Webb Telescope	42
1.82	Venus Satellite.....	30	3.7	Kepler Telescope	42
1.83	Remove Debris Mission.....	31	3.8	SPHEREx.....	42
1.84	Falcon Heavy.....	31	3.9	Giant Magellan Telescope.....	42
2.	Planetary Systems	31	3.10	SPARCS telescope	42
2.1	Sun's Atmosphere.....	31	3.11	Very Large Telescope	43
2.2	Solar Cycles and Sun spots	32	3.12	Giant Metrewave Radio Telescope	43
2.3	Presence of Water in the Moon	32	3.13	ARIES Telescope.....	43
2.4	Super Blood Wolf Moon.....	32	3.14	X-Calibur Telescope.....	43
2.5	Super Blood Blue Moon	33	3.15	INO Project	43
2.6	Pink Moon.....	33	2.36	Green Propellants.....	44
2.7	Longest Lunar Eclipse of the Century	33	2.37	Indo-UN Small Satellites Programme.....	45
2.8	Kordylewski Clouds.....	33	3.16	Excitonium.....	45
2.9	Liquid Water Lake in Mars	34	4. Defense	45	
2.10	Definition of a Planet.....	34	Artillery	45	
2.11	Graveyard Orbits	34	4.1	Pinaka Mark I.....	45
2.12	Rogue Planet.....	35	4.2	Dhanush Artillery Gun	45
2.13	Ganymede.....	35	4.3	K9 Vajra-T Gun.....	45
2.14	Asteroid & Comet.....	35	4.4	Advanced Towed Artillery Gun System.....	46
2.15	Ultima Thule	35	4.5	Smart Anti-Airfield Weapon.....	46
2.16	Farout	35	4.6	Smerch Multiple Barrel Rocket Launchers.....	46
2.17	Ryugu Asteroid.....	36	Missiles.....	46	
2.18	Oumuamua.....	36	4.7	HELINA.....	46
2.19	Habitable exoplanet next to Earth.....	36	4.8	Akash Missile.....	47
2.20	TRAPPIST-1.....	37	4.9	Astra Missile.....	47
2.21	MAMMOTH-1.....	37	4.10	Prahar Missile	47
2.22	Northwest Africa 7635	37	4.11	Igla-S missile	47
2.23	Pluto Mountains.....	37	4.12	Agni V.....	47
2.24	Super Earth.....	37	4.13	Brahmos.....	48
2.25	Mapping of the Universe with Quasar position.....	38	4.14	Pralay.....	48
2.26	Radio Galaxy Spotted.....	38	4.15	Hypersonic Missile	48
2.27	Proxima Centauri.....	38	4.16	Nirbhay.....	48
2.28	Kepler 90i.....	38	4.17	Quick Reaction Surface to Air Missile	48
2.29	Rare and Isolated Neutron Star.....	39	4.18	Barak-8.....	49
2.30	Sagittarius A*.....	39	4.19	AGNI- V.....	49
2.31	Saraswati - Supercluster of Galaxies	39	4.20	Prithvi-II.....	49
2.32	Farthest galaxy.....	39	4.21	Ballistic Missile Defence Programme.....	49
2.33	Kuiper Belt.....	39	4.22	K-4 Missile.....	49
2.34	Ancient Spiral Galaxy	39	4.23	Interceptor Missile Test	50
2.35	Tabby's star.....	40	4.24	Man-Portable Anti-Tank Guided Missile.....	50
3.	Telescopes & Observatories	40	4.25	National Advanced Surface-to-Air Missile System	50
3.1	SOFIA	40	4.26	Advanced Air Defence systems in India.....	50
3.2	Gravitational Wave Observatory	40	4.27	Advanced Area Defence.....	50
3.3	Ngari observatory	41	Aircrafts.....	51	
3.4	Chandra X-ray Observatory.....	41	4.28	Advanced Medium Combat Aircraft	51
3.5	Hubble Space Telescope.....	41	4.29	MiG-21 Fighter Jets	51



4.30	Tejas.....	51	5.6	Diphtheria.....	62
4.31	Apache Helicopters.....	52	5.7	Japanese Encephalitis.....	62
4.32	Sukhoi Su-30MKI.....	52	5.8	Lymphatic filariasis.....	62
4.33	Mid-Air Refuelling.....	52	5.9	Leprosy.....	62
4.34	Biojet fuel for Aircraft.....	52	5.10	Hepatitis C.....	63
4.35	Feihong-98.....	52	5.11	Typhoid.....	63
4.36	Kamov Ka-226T.....	53	5.12	Scrub Typhus.....	63
Warning Systems.....		53	5.13	Influenza.....	64
4.37	NETRA.....	53	5.14	Spanish Flu.....	64
4.38	Swathi.....	53	5.15	Severe Acute Respiratory Syndrome.....	64
4.39	Recce Vehicle.....	53	5.16	Swine Flu.....	65
Programs.....		53	5.17	Avian Influenza A(H7N9).....	65
4.40	Mission Raksha Gyan Shakti.....	53	5.18	Malaria.....	65
4.41	Digital Sky Platform.....	54	5.19	Chikungunya.....	66
4.42	Strategic Partnership Model.....	54	5.20	Diabetes.....	66
Submarines.....		54	5.21	TB Vaccine for Diabetes.....	66
4.43	Submarines.....	54	5.22	Trachoma.....	66
4.44	Scorpene-class submarine.....	55	5.24	Crimean-Congo Haemorrhagic Fever.....	67
4.45	Project 28.....	55	5.25	Kyasanur Forest Disease.....	67
4.46	Project-15B.....	55	5.26	Leptospirosis.....	67
4.47	INS Chakra.....	55	5.27	Fluorosis.....	68
4.48	INS Arihant.....	56	5.28	Hunter's Syndrome.....	68
4.49	Deep Submergence Rescue Vehicle.....	56	5.29	Haemoglobinopathies.....	68
4.50	INS Kiltan.....	56	5.30	Haemophiliacs.....	68
Other Naval Ships.....		57	5.31	West Nile Virus.....	69
4.51	INS Vikramaditya.....	57	5.32	Zika Virus.....	69
4.52	INS Vishal.....	57	5.33	Nipah Virus.....	69
4.53	INS Sahyadri.....	57	5.34	Human Papilloma Virus.....	70
4.54	INS Tarangini.....	57	5.35	Hantaviruses.....	70
4.55	INS Trikand.....	58	5.36	Coronavirus.....	70
4.56	INSV Tarini Team.....	58	5.37	Wolbachia.....	70
4.57	Sagar Kanya.....	58	5.38	Noro Virus.....	71
4.58	Operation 'Madad'.....	58	5.39	Usutu Virus.....	71
4.59	Shaurya.....	58	5.40	Antimicrobial Resistance.....	71
4.60	Indian Coast Guard Ship Vijaya.....	58	5.41	Deworming.....	72
4.61	Rani Rashmoni.....	59	5.42	Typbar TCV.....	72
4.62	Navika Sagar Parikrama.....	59	5.43	New Delhi metallo-beta-lactamase-1.....	72
4.63	INS Tarasa.....	59	5.44	Rotavac.....	73
4.64	INS Kohassa.....	59	5.45	Measles-Rubella Vaccination Campaign.....	73
5. Health.....		59	5.46	Vaccine for Multiple Pathogens.....	74
5.1	Universal Immunization Programme.....	59	5.47	Phthalates.....	74
5.2	Polio.....	60	5.48	Marijuana.....	74
5.3	Pulse Polio Campaign.....	60	5.49	Gaming- A Mental Health Condition.....	75
5.4	Tuberculosis.....	61	5.50	e-Cigarettes.....	75
5.5	Latent Tuberculosis Infection.....	61	5.52	Global Syndemic.....	76
			5.53	Ban on FDC Drugs.....	76



5.54	Formalin.....	77	8.4	Memristors & AI.....	92
5.55	Oxytocin Ban.....	77	8.5	Quantum Computing.....	93
5.56	WHO - Antibiotics Protocol.....	77	8.6	Quantum Dots.....	93
5.57	Global Classification of Diseases.....	78	8.7	Quantum Mechanics.....	93
5.58	RUCO initiative.....	78	8.8	Virtual Reality.....	93
5.59	Bombay Blood Group.....	79	8.9	Microsoft HoloLens-Augmented Reality.....	94
5.60	India Health Fund.....	79	8.10	Bitcoins.....	94
5.61	Sohum.....	79	8.11	Block Chain Technology.....	94
5.62	Iodine Bindi.....	79	8.12	Free Space Optical Communications.....	95
5.63	Child Friendly HIV drug.....	79	8.13	Fiber Optics.....	95
5.64	MTCT of HIV.....	80	8.14	Triboelectric Nanogenerators - Wireless Transmission of Electrical Energy.....	95
6.	Bio-Technology.....	80	8.15	High Nitrogen Steel.....	96
6.1	Stem Cells.....	80	8.16	India's first indigenous Lithium Ion Battery project..	96
6.2	Draft Guidelines for Stem Cell Research.....	81	8.17	Lithium-ion Battery.....	96
6.3	Oesophageal Organoids.....	81	8.18	Thermal Battery Plant.....	97
6.4	Miniature Eyes.....	82	8.19	Helium.....	97
6.5	Earth BioGenome Project.....	82	8.20	5G technology.....	98
6.6	Gene Editing.....	82	8.21	4D Printing.....	98
6.7	Gene Silencing.....	83	8.22	Li-Fi.....	98
6.8	Three Parent Baby.....	83	8.23	Raman Effect.....	99
6.9	Genetically Modified Mosquitoes.....	84	8.24	Humanoid Robot-Sophia.....	99
6.10	Gene Therapy for Cancer.....	85	8.25	Largest Prime Number.....	99
6.11	Human Antibodies in Lab.....	86	8.26	VdW Materials.....	99
6.12	Embryo Transfer Technology.....	86	8.27	Change in the definition of 'Kilogram'.....	100
6.13	Bio film.....	87	9.	Intellectual Property Rights.....	100
6.16	Biomarker s.....	88	9.1	Different Categories of IPR.....	100
6.17	Artificial Leaf.....	88	9.2	Stone Sculptures of Mamallapuram.....	102
6.18	Chlorophyll - f.....	88	9.3	Rasgulla.....	102
6.19	Speed Breeding Technique - Wheat Production.....	88	9.4	Etikoppaka Toys.....	102
6.20	Flink.....	89	9.5	Shahi Litchi.....	103
6.21	Plants that can glow.....	89	9.6	Alphonso Mango.....	103
6.22	Molecular Robot.....	89	9.7	Some of the registered GIs- State Wise.....	103
6.23	BIO International Convention.....	89	10.	Technological Interventions.....	103
6.24	Major Programmes Undertaken by the Department of Biotechnology.....	90	10.1	Project Dhoop.....	103
7.	Nuclear technology.....	90	10.2	Space Activities Bill.....	104
7.1	Koyvada.....	90	10.3	Surya Joyti.....	105
7.2	Pressurized Heavy Water Reactor.....	90	10.4	Project Brainwave.....	105
7.3	Nuclear Command Authority.....	90	10.5	Food Irradiation Centers.....	105
7.4	Nuclear Recycle Board.....	90	10.6	JIGYASA.....	105
7.5	Nuclear Plant in M.P.....	91	10.7	Open Gov Data Hack.....	106
7.6	Kaiga Nuclear Power Plant.....	91	10.8	Scheme for IPR Awareness.....	106
8.	Innovations.....	91	10.9	Technology and Innovation Support Centre.....	106
8.1	Pratyush.....	91	10.10	Traditional Knowledge Digital Library.....	106
8.2	Mihir.....	92	10.11	First Hyperloop Transport System.....	107
8.3	National Supercomputing Mission.....	92			

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SCIENCE & TECHNOLOGY (UP TO FEBRUARY 2019)

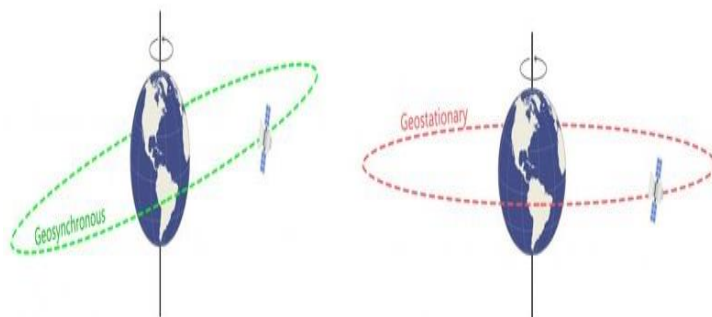
1. SPACE TECHNOLOGY

1.1 Types of Orbits

- There are many different satellite orbits that can be used depending upon satellite's functions and area it is to serve.
- The lower the satellites orbit the Earth, the stronger the gravitational pull, and this means that the satellite must travel faster to counteract this pull. Further away the gravitational field is less and the satellite velocities are correspondingly less.
- A satellites orbit the Earth in one of two basic types of orbit such as **Circular and Elliptical satellite orbit**.
- For a circular orbit, the distance from the Earth remains the same at all times whereas the elliptical orbit changes the distance to the Earth.

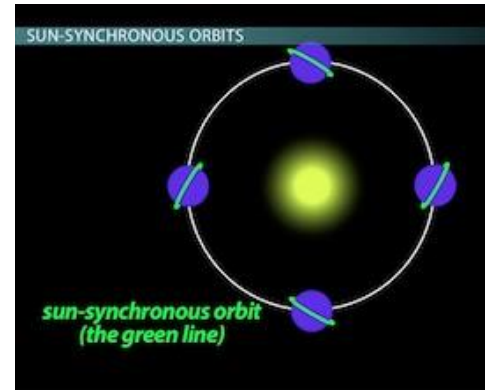
SATELLITE ORBIT DEFINITIONS			
ORBIT NAME	ORBIT INITIALS	ORBIT ALTITUDE (KM ABOVE EARTH'S SURFACE)	DETAILS / COMMENTS
Low Earth Orbit	LEO	200 - 1200	
Medium Earth Orbit	MEO	1200 - 35790	
Geosynchronous Orbit	GSO	35790	Orbits once a day, but not necessarily in the same direction as the rotation of the Earth - not necessarily stationary
Geostationary Orbit	GEO	35790	Orbits once a day and moves in the same direction as the Earth and therefore appears stationary above the same point on the Earth's surface. Can only be above the Equator.
High Earth Orbit	HEO	Above 35790	

- Circular orbits are classified into Low Earth Orbit, Medium Earth Orbit, Geosynchronous orbit etc.
- Most satellites, the International Space Station, the Space Shuttle, and the Hubble Space Telescope are all in Low Earth Orbit.
- LEO is convenient for installing new instruments, fixing things that are broken, and inspecting damage.
- A **geosynchronous orbit**, located at 35,790 km has the same orbital period as the sidereal rotation period of the Earth.
- It allows satellites to synchronize with the rotation of the Earth (only in time and not in direction).
- This makes geosynchronous satellites particularly useful for **telecommunications** and other **remote sensing** applications.
- One particular form of geosynchronous orbit is known as a **geostationary orbit**, in which the satellite rotates in the same direction as the rotation of the Earth and has an approximate 24 hour period.
- The satellite placed in geostationary orbit remains in the same position relative to the Earth.
- It is used by many applications including **direct broadcast** as well as **communications** or relay systems.
- While geosynchronous satellites can have any inclination, geostationary orbit lie on the same plane as the equator.
- **Polar Orbit** –Satellites placed in polar orbits have an inclination of about 90 degrees to the equator and travels north-south over the poles at lower altitudes.
- A satellite in the polar orbit approx. takes 90 minutes for a full rotation. As a result, a satellite can observe the entire surface in the time span of 24 hours.





- They are often used for applications such as **monitoring crops, forests and even global security.**
- **Sun Synchronous Orbit** –It is a special case of Polar Orbit moving from pole to pole allowing satellite to pass over any given point of the planet's surface at roughly the same local time each day.
- Since there are 365 days in a year and 360 degrees in a circle, it means that the satellite has to shift its orbit by approximately one degree per day.
- These orbits are used for satellites that need a constant amount of sunlight and are useful for imaging, spy, and weather satellites.



1.2 Types of Satellites

- **Communication Satellites** provides services to telecommunications, television broadcasting, satellite newsgathering, societal applications, weather forecasting, disaster warning and Search and Rescue operations.
- The Indian National Satellite (INSAT) series of satellites in **Geostationary Orbit** (INSAT-3A, 3C, 4A, 4B, 4CR) are used for communication purposes.
- GSAT series also joins the constellation of INSAT system in providing communication services.
- **Earth Observation Satellites** are used for several applications covering agriculture, water resources, urban planning, rural development, mineral prospecting, environment, forestry, ocean resources and disaster management.
- Indian Remote Sensing (IRS) series of satellites in Sun-synchronous polar orbit are Earth observation satellites.
- Currently, 13 operational satellites are in **Sun-synchronous orbit** – RESOURCESAT-1, 2, 2A CARTOSAT-1, 2, 2A, 2B, RISAT-1 and 2, OCEANSAT-2, Megha-Tropiques, SARAL and SCATSAT-1.
- There are 4 satellites in **Geostationary orbit** - INSAT-3D, Kalpana & INSAT 3A, INSAT -3DR which is also used for resource mapping.
- **Navigation Satellites** are used to meet the emerging demand of positioning, navigation and timing and also civil aviation requirements. GAGAN and IRNSS (NAVIC) are navigation satellite system in use.
- **GPS Aided GEO Augmented Navigation (GAGAN)**, is implemented jointly by ISRO and Airport Authority of India (AAI).
- The main objectives of GAGAN are to provide Satellite-based Navigation services with accuracy and integrity required for civil aviation applications and to provide better Air Traffic Management over Indian Airspace.
- The GAGAN Signal-In-Space (SIS) is available through GSAT-8 and GSAT-10.
- **Indian Regional Navigation Satellite System (IRNSS), NavIC** is an independent regional navigation satellite system to provide accurate position information service.
- **Space Science and Exploration Satellites** encompasses research in areas like astronomy, astrophysics, planetary and earth sciences, atmospheric sciences and theoretical physics.
- **Eg** – Mars Orbiter Mission, AstroSat, Chandrayaan -1,2.

1.3 Launch Vehicles

- Launch Vehicles are used to carry spacecraft to space.
- Following are the various launch vehicles used by ISRO
- **Historic launchers** - Satellite Launch Vehicle - 3 (SLV-3) and Augmented Satellite Launch Vehicle (ASLV).
- SLV was India's first experimental satellite launch vehicle with solid engines in all 4 stages. ASLV has 3 times augmented capacity of SLV-3.
- **Operational launchers** - Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV) and Sounding Rockets.
- **Future launchers** – GSLV MK-III, Reusable Launch Vehicle (RLV-TD), Scramjet Engine – TD.



PSLV

- It is the **3rd generation launch vehicle** and first Indian launch vehicle to be equipped with liquid stages.
- PSLV emerged as the reliable and versatile workhorse launch vehicle of India with consecutively successful missions.
- It successfully launched two spacecraft such as Chandrayaan-1 in 2008 and Mars Orbiter Spacecraft in 2013.
- 3 variations in PSLV - PSLV-G (General), PSLV-XL variants and PSLV-CA (Core Alone).
- It has 4 stages in its operation to provide thrust in launching spacecraft to different orbits.
- **Stage I:** It uses **solid rocket motor** that is augmented by 6 solid strap-on boosters. Strap on boosters are used only in G and XL variation.
- **Stage II:** It uses an Earth storable **liquid rocket engine**, known as the Vikas engine.
- **Stage III:** It uses **solid rocket motor** that provides high thrust after the atmospheric phase of the launch.
- **Stage IV:** It comprises two Earth storable **liquid engines**.
- **Capacity** - 1,750 kg of payload to Sun-Synchronous Polar Orbits of 600 km altitude and to 1,425 kg of payload to Geosynchronous and Geostationary orbits, like satellites from the IRNSS constellation.
- **PSLV launches in 2018/2019**—PSLV - C44/Microsat, Kalamsat ; PSLV – C43/ Hysis ; PSLV – C42/foreign satellites; PSLV – C41/IRNSS-1I ; PSLV - C40/Cartosat-2 series.

GSLV

- It is the **4th generation** launch vehicle, a three-stage vehicle with four liquid strap-on boosters.
- GSLV Mk II is the largest launch vehicle developed by India, which is currently in operation.
 1. **Stage I:** It uses **solid rocket** motor with 4 liquid strap-ons.
 2. **Stage II:** It uses **liquid rocket** engine (similar to vikas engine of PSLV stage II).
 3. **Stage III:** It uses India's **first cryogenic engine** (CE-7.5) in the upper stage. It enabled the launching of 2000 kg of communication satellites.
- **Capacity** - It can take up to 5000 kg of pay load to Low Earth Orbits, 2500 kg of payload to Geosynchronous Transfer Orbit (GTO) which are primarily INSAT class of communication satellites.
- **GSLV Launches in 2018/19** – GSLV – F11/GSAT-7A and GSLV – Fo8/GSAT – 6A mission.
- The next variant of GSLV is GSLV Mk III, with indigenous high thrust cryogenic engine.

GSLV MK III

- GSLV Mk III is a three-stage heavy lift launch vehicle which has two solid strap-ons, a core liquid booster and a cryogenic upper stage.
- The cryogenic upper stage C25 is powered by CE-20 which is India's largest cryogenic engine.
- It is designed to carry 4000 kg classes of satellites into Geosynchronous Transfer Orbit (GTO) or about 8000 kg classes to Low Earth Orbit (LEO), which is about twice the capability of GSLV Mk II.
- **Recent Launches** - GSLV Mk III-D2 / GSAT-29, GSLV MK III D1/GSAT – 19 and LVM-3 /CARE (Crew module Atmospheric Re-entry Experiment) mission.
- It is the designated launch vehicle for India's upcoming second moon mission and the first human space flight scheduled for 2022.

Cryogenic Engine

- Cryogenics is the science that addresses the production and effects of very low temperatures.
- A cryogenic rocket engine uses a cryogenic fuel or oxidizer, which are gases liquefied and stored at very low temperatures.
- Notably, these engines were one of the main factors of NASA's success in reaching the Moon.
- Amongst all rocket fuels, hydrogen is known to provide the maximum thrust.



- But hydrogen, in its natural gaseous form, is difficult to handle, and, therefore, not used in normal engines in rockets like PSLV. However, hydrogen can be used in liquid form.
- The problem is hydrogen liquefies at very low temperature, nearly 250 degrees Celsius below zero.
- To burn this fuel, oxygen also needs to be in liquid form, and that happens at about 90 degrees Celsius below zero.
- Creating such a low-temperature atmosphere in the rocket is a difficult proposition, because it creates problems for other material used in the rocket.

RLV-TD

- Reusable Launch Vehicle – Technology Demonstrator (RLV-TD) is a fully reusable launch vehicle to enable low cost access to space.
- The configuration of RLV-TD is similar to that of an aircraft and combines the complexity of both launch vehicles and aircraft.
- The winged RLV-TD has been configured to act as a flying test bed to evaluate various technologies, namely, hypersonic flight, autonomous landing and powered cruise flight.
- In future, this vehicle will be scaled up to become the first stage of India's reusable two stage orbital launch vehicle.
- **Objectives of RLV-TD** - Hypersonic aero thermodynamic characterisation of wing body, Evaluation of autonomous Navigation, Guidance and Control (NGC) schemes, Integrated flight management and Thermal Protection System Evaluation
- It was successfully flight tested in 2016 from Sriharikota.

Scramjet Engine - TD

- Usually, launch vehicles carry oxidiser along with the fuel for combustion to produce thrust to launch satellites into orbit.
- Nearly, 70% of the propellant (fuel – oxidiser) by weight consists of oxidiser which makes it to carry only 2-4% of their lift-off mass to orbit.
- Therefore, air-breathing propulsion system which can utilise the atmospheric oxygen during their flight and reduce the total propellant required to place a satellite in orbit is being developed by various space agencies.
- Ramjet, Scramjet and Dual Mode Ramjet (DMRJ) are the three concepts of air-breathing engines.
- A **ramjet** is a form of air-breathing jet engine that uses the vehicle's forward motion to compress incoming air for combustion without a rotating compressor.
- Fuel is injected in the combustion chamber where it mixes with the hot compressed air and ignites.
- It works most efficiently at supersonic speeds around Mach 3 (three times the speed of sound) and can operate up to speeds of Mach 6.
- However, the ramjet efficiency starts to drop when the vehicle reaches hypersonic speeds.
- A **scramjet** engine is an improvement over the ramjet engine as it efficiently operates at hypersonic speeds and allows supersonic combustion. Thus, it is known as Supersonic Combustion Ramjet, or Scramjet.
- A **dual mode ramjet** (DMRJ) is a type of jet engine where a ramjet transforms into scramjet over Mach 4-8 range, which means it can efficiently operate both in subsonic and supersonic combustor modes.
- ISRO's Advanced Technology Vehicle (ATV), which is an advanced sounding rocket, was the solid rocket booster used for test of Scramjet engines at supersonic conditions.
- ATV is a two- stage solid launch vehicle capable of carrying Scramjet engines weighed 3277 kg at lift-off.
- India is the fourth country (after USA, Russia and European Space Agency) to demonstrate the flight testing of a Scramjet Engine.

Small Satellite Launch Vehicle

- ISRO has completed the design of baby rocket "Small Satellite Launch Vehicle (SSLV)".
- SSLV can place a 500 kg payload at a height of 500 km in the Low Earth Orbit (LEO).

- It has three solid motor stages with a lift off mass of 120 tonnes.
- It is shorter in length than the PSLV and GSLV.
- It can accommodate multiple satellites like the PSLV and GSLV, albeit smaller ones.
- Unlike the PSLV and GSLV, the SSLV can be assembled both vertically and horizontally.

Vikas Engine

- Vikas is a family of liquid fuelled rocket engines that powers India's launch vehicles PSLV and GSLV.
- It is aimed at improving the payload capability of PSLV, GSLV and GSLV Mk-III launch vehicles.
- It is used in second stage of PSLV which consists of four stages in its operation (Solid-Liquid-Solid-Liquid) and in second stage and four strap-on stages of GSLV.
- GSLV is a three-stage vehicle (Solid-Liquid-Cryogenic Engine) with four liquid strap-on boosters.
- ISRO has recently improved the thrust of the Vikas engine which is expected to boost the rocket engine.
- The main beneficiary of the high-thrust Vikas engine is GSLV-Mark III launcher, which is expected to lift 4,000-kg satellites to space.
- GSLV-Mark III uses twin engine core liquid stage (L110).
- GSLV – Mark III with upgraded Vikas engine would be the third Mk-III and the first working one to be designated MkIII Mission-1 or M1.

Indian Missions

1.4 PSLV C-44/Kalamsat

- PSLV C-44 has successfully injected Microsat-R and Kalamsat-V2 satellites into their designated orbits from Sriharikota.
- It is a new variant of PSLV called PSLV-DL (D standing for demonstration).
- In its normal configuration, the rocket will have six strap-on motors in the first stage.
- However, PSLV-DL will have just two strap-on motors for the first time.
- In a normal launch vehicle, each stage falls off after fuel completes burn-off.
- However, stage four, after releasing the payload, wanders around in space as junk.
- PSLV-DL will follow the same pattern, except that the fourth stage (PS4) won't fall off.
- It will serve as a platform for the satellite like deploying solar panels or other tools to aid the satellite.
- **Kalamsat** is the first satellite to use PS4 as an orbital platform, thus reducing space debris.
- It is a 10cm cube communication nano-satellite weighing about 1.2kg designed by students.
- Its life span is about two months and its cost is about Rs. 12 lakh.
- A 64-gram version of the Kalamsat nicknamed "gulab jamun" was launched by NASA in 2017. But it never reached orbit.
- Microsat-R is a 130-kg military imaging satellite. It was put together by a handful of DRDO laboratories.

1.5 PSLV C-43/HysIS

- It has successfully launched India's first Hyper spectral Imaging Satellite (HysIS) and 30 international co-passenger satellites.
- PSLV-C43 is the Core Alone version of PSLV, without the six strap-ons.
- **HysIS** is an earth observation satellite, weighing about 380 kg and configured around ISRO's Mini Satellite-2 (IMS-2) bus.
- The goal is to study the earth's surface in the visible, near infrared and shortwave infrared regions of the electromagnetic spectrum.
- It has a mission life of about 5 years.

- A hyperspectral imaging camera in space can provide well-defined images that can help to identify objects on Earth far more clearly than regular optical or remote sensing cameras.
- The technology will be an added advantage of watching over India from space for a variety of purposes such as defense, agriculture, land use, minerals and so on.

1.6 HySIS

- Hyperspectral Imaging Satellite (HySIS) is a full-fledged earth observation satellite, going to be launched by ISRO.
- Hyperspectral or Hypspec imaging enables distinct identification of objects on earth by reading the spectrum for each pixel of a scene from space.
- The satellite has the Hyperspectral imager which can identify 55 spectral or colour bands from 630 km above ground.
- It can be used for monitoring of environment, finding oil and minerals apart from military surveillance.
- Hypspec was first tried out in Chandrayaan-1 mission which mapped the lunar mineral resources.

1.7 PSLV C-42

- It has launched two foreign satellites - NovaSAR and S1-4 of United Kingdom.
- PSLV C-42 is also a Core Alone version of PSLV, without the six strap-ons.
- Both satellites are earth observation systems and injected in Sun Synchronous Orbit.
- NovaSAR is a S-Band Synthetic Aperture Radar satellite intended for forest mapping, land use & ice cover monitoring, flood & disaster monitoring.
- S1-4 is a high-resolution Optical Earth Observation Satellite, used for surveying resources, environment monitoring, urban management and for the disaster monitoring.

1.8 PSLV C-41/IRNSS-1I

- It has launched IRNSS - 1I, which is the 8th satellite to join the NavIC navigation satellite constellation.
- IRNSS are constellation of satellites, meant for giving precise information of position, navigation and time of objects or people.
- The satellites will form the fleets of NavIC (Navigation with Indian Constellation), India's own GPS.
- It serves users in primary and extended service area.
 - Primary Service Area - Users in India as well as the region extending up to 1500 km from its boundary.
 - Extended Service Area - lies between primary service area and area enclosed by the rectangle from Latitude 30 deg South to 50 deg North, Longitude 30 deg East to 130 deg East.
- IRNSS will provide two types of services, namely, Standard Positioning Service (SPS) which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorised users.
- The system was planned to consist of 7 satellites (A,B,C,D,E,F,G) with 2 substitutes (H and I).
- Out of 7 satellites A, B, F, G will be in geosynchronous and C, D, E will be in geostationary orbit.
- IRNSS 1H by PSLV C-39 was unsuccessful as the satellite did not come out of its heat shield.
- While IRNSS 1I will replace IRNSS 1A as its three imported rubidium atomic clocks failed while in orbit.
- **Some applications of IRNSS** - Terrestrial, Aerial and Marine Navigation, Disaster Management, Vehicle tracking and fleet management, Integration with mobile phones, Precise Timing, Mapping and Geodetic data capture, Terrestrial navigation aid for hikers and travellers and Visual and voice navigation for drivers.

1.9 PSLV-C40/Cartosat-2

- It has successfully launched Cartosat series satellite (India's 100th satellite) along with 30 Co-passenger satellites.
- Co-passenger satellites include one micro and nano satellite from India and 25 Nanosatellites from 6 countries, namely, Canada, Finland, France, Republic of Korea, UK and USA



- The satellites are launched in two orbits, which makes the mission a unique one. Cartosat in Sun Synchronous orbit and nano-satellites in different orbits.
- It launched the third satellite in the Cartosat series with the primary objective of providing high resolution scene specific spot imageries.

1.10 Cartosat Series Satellite

- Cartosat is a series of Earth Observation Satellites placed in Polar Sun Synchronous Orbit (PSSO) with liftoff mass of 710kg.
- The series of satellites were carried by PSLV-C37, PSLV-C38 and PSLV-C40.
- The objective is to provide high-resolution scene specific spot imagery.
- The imageries from Cartosat-2 series satellite will be useful for cartographic applications, urban and rural applications, coastal land use and regulation, utility management like road network monitoring, water distribution, creation of land use maps.
- It will also be useful in various other Land Information System (LIS) and Geographical Information System (GIS) applications.

PSLV-C37

- ISRO has launched Cartosat-2 series and 103 co-passenger satellites in a single mission using PSLV-C37.
- The co-passenger satellites comprised of 101 nano satellites from Kazakhstan, Israel, The Netherlands, Switzerland, UAE and USA, as well as two Nano satellites (INS-1A and INS-1B) from India.
- The 101 International customer Nano satellites were launched as part of the commercial arrangements between Antrix Corporation Limited (Antrix), a Government of India company under Department of Space (DOS), the commercial arm of ISRO and the International customers.

1.11 Other Notable missions of PSLV

- RESOURCESAT-2A is a **Remote Sensing satellite in Sun Synchronous Polar orbit** intended for resource monitoring and carried by PSLV-C36.
- It is intended to continue the remote sensing data services provided by RESOURCESAT-1 and RESOURCESAT-2, launched in 2003 and 2011 respectively.
- SCATSAT-1 is a continuity mission for Oceansat-2 Scatterometer launched by PSLV-C35 in sun synchronous polar orbit.
- Its application is in the field of **Climate & Environment**. It will provide data products for weather forecasting, cyclone detection and tracking services to the users.

1.12 GSAT – 31

- It was 40th communication satellite of India, launched by launch vehicle **Ariane-5 VA-247** from French Guiana base.
- It was initially placed in Geosynchronous Transfer Orbit and will subsequently be placed in Geostationary Orbit.
- It operates in Ku band and provide continuity to operational services on some of the in-orbit satellites.
- It will provide communication services to Indian mainland and islands.
- The mission life is about 15 years.
- The Ariane-5 vehicle also carried Saudi Geostationary Satellite 1/Hellas Sat 4 along with GSAT-31.

1.13 GSAT – 11

- It is India's next generation high throughput communication satellite launched by **Ariane-5 VA-246** launch vehicle from French Guiana base.
- It is the heaviest satellite built by ISRO, weighing 5854 kg.



- It is the fore-runner in the series of advanced communication satellites with multi-spot beam antenna coverage over Indian mainland and Islands.
- It was launched into a Geosynchronous Transfer Orbit and subsequently placed to Geostationary orbit.
- The mission life is about 15 years.
- It will boost the broadband connectivity to rural and inaccessible Gram Panchayats in the country coming under the Bharat Net Project, which is part of Digital India Programme.

1.14 **GSLV MK-III D2 / GSAT 29**

- GSLV MkIII-D2, the second developmental flight of GSLV MkIII has successfully launched GSAT-29.
- It is a 3,500 kg multi-beam, multibank communication satellite for providing high quality internet services.
- It is the heaviest satellite launched from India.
- It carries Ka/Ku-band high throughput communication transponders which will focus on connectivity to the users in Hilly and geographically inaccessible areas (especially in J&K and North Eastern region).
- For the first time, an optical communication payload will be utilised for data transmission at a very high rate.
- It is one of the planned Indian HTS (High Throughput Satellites) quartet. HTS are sent out to provide improved and faster internet connectivity
- The lifespan of the satellite is 10 years and will be in Geostationary orbit.

1.15 **Other Developmental & Experimental Flights of GSLV MK-III**

- GSLV MK-III D1, the first developmental flight launched GSAT 19, a 3136 kg communication satellite.
- It carries Ka/Ku-band high through transponders for communication purpose.
- It also carries Geostationary Radiation Spectrometer (GRASP) to monitor and study the nature of charged particles and the influence of space radiation on satellites and their electronic components.
- Crew module Atmospheric Reentry Experiment (CARE) was the first experimental flight of GSLV MK -III.

1.16 **GSLV F-11/GSAT -7A**

- GSLV F-11 has launched ISRO's 39th communication satellite GSAT-7A with a lift off mass of 2250 kg in Geostationary orbit.
- It is the heaviest satellite launched by GSLV Mk-II.
- It will service communication needs primarily for network-centric operations of the Indian Air Force and 30% for the military.
- It is the second in the family of military satellite Gsat – 7, which is for Indian Navy and monitors 2,000 nautical miles of Indian Ocean Region and sends real time inputs to warships, submarines and aircrafts.
- It will be the **first satellite built primarily for the IAF** to qualitatively unify its assets and improve combined, common intelligence during operations.
- It carried communication transponders in Ku band which will enable superior real time aircraft-to-aircraft communication; and between planes that are in flight and their commanders on the ground.

1.17 **GSLV-Fo8/GSAT-6A**

- GSAT – 6A is a military communication satellite launched in Geostationary orbit.
- It aims to provide mobile communication services through multi beam coverage. For this, it is equipped with S and C band transponders.
- The mission life is about 10 years.

1.18 **GSLV-Fo9 / GSAT-9**

- **South Asia Satellite** GSAT-9 is a Geostationary Communication satellite launched by **GSLV-Fo9** with a lift off mass of 2230 kg.
- The primary objective of GSAT-9 is to provide various communication applications in Ku-band with coverage over South Asian countries.

- It is launched for the South Asian Association for Regional Cooperation (SAARC) region.
- This idea was mooted by India in 18th SAARC summit.
- Afghanistan, Bangladesh, Bhutan, Nepal, Maldives and Sri Lanka are the users of the multi-dimensional facilities provided by the satellite.
- The benefits the countries would receive in communication, telemedicine, meteorological forecasting and broadcasting.
- Its mission life is 12 years.

1.19 INSAT-3DR

- INSAT-3DR similar to INSAT-3D is an advanced meteorological satellite of India.
- Its application is in the field of **Climate and Environment, Disaster Management System**.
- It will provide service continuity to earlier meteorological missions of ISRO and further augment the capability to provide various meteorological as well as search and rescue services.
- It was carried by **GSLV-F05** and placed in Geosynchronous Transfer Orbit.
- It carried about 1255 kg of propellant which is mainly required to raise the satellite from the Geosynchronous Transfer Orbit (GTO) to its final Geostationary Orbit.

1.20 ExseedSAT – 1

- It is a CubeSat mission by the Indian private space company Exseed Space.
- It was launched by SpaceX, a private aerospace company, from California satellite launch pad.
- It was the first Indian Private entity satellite launched by SpaceX, in its Falcon9 rocket.
- The satellite with a communication payload, will provide a major boost to ham radio operators in the country.
- It was placed in a sun-synchronous low-earth orbit.
- It is expected to have a life of 2 years, depending up on how long the battery lasts and when the satellite de-orbits naturally.

Other Notable Missions

1.21 Gaganyaan

- It is India's ambitious manned spaceflight mission.
- It aims to send a three-member crew to space for a period of five to seven days.
- It will be launched by ISRO by 2022.
- It will make India the fourth nation in the world to launch a Human Spaceflight Mission after USA, Russia and China.
- ISRO has developed some critical technologies through demonstrations like Space Capsule Recovery Experiment (SRE-2007), Crew module Atmospheric Reentry Experiment (CARE-2014) and Pad Abort Test (2018).
- The spacecraft will be placed in a low earth orbit of 300-400km.
- GSLV Mk-III launch vehicle will be used to for the mission. It has the payload capacity of 4000 kg satellites in Geosynchronous Transfer Orbit (GTO) and 8000 kg payload to Low Earth Orbit.
- The crew will be selected by Indian Air Force (IAF) and ISRO jointly after which they will undergo training for two-three years.
- **Re-entry & Recovery tech** - ISRO has already tested the GSLV Mk-III with experimental crew module.
- It came back to Earth after being taken to an altitude of 126 km into space. This this known as Crew module Atmospheric Re-entry Experiment (CARE).
- **Crew Escape System** – It is an emergency escape measure to quickly pull the astronaut crew out to a safe distance from launch vehicle during a launch abort.

- Pad Abort test was conducted earlier to demonstrate this to ascertain the efficiency of crew escape system.
- **Life support** -The Environmental Control & Life Support System (ECLSS) is meant for humans inside to live comfortably.
- It ensures that conditions inside the crew module are suitable for living.
- The ECLSS -
 - i. maintains a steady cabin pressure and air composition
 - ii. removes carbon dioxide and other harmful gases
 - iii. controls temperature and humidity
 - iv. manages parameters like fire detection and suppression, emergency support
 - v. takes care of food and water management

1.22 Mission Venus

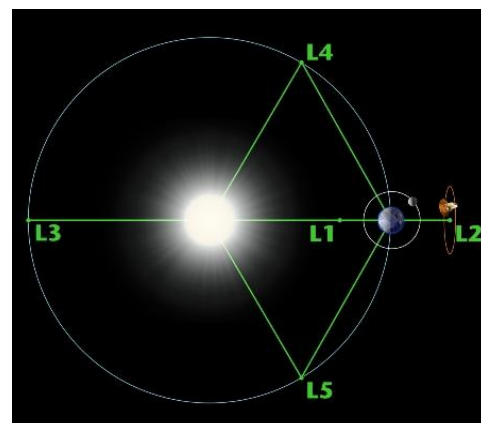
- ISRO has opened for its “Mission Venus” seeking experiment ideas from space agencies, universities and researchers.
- It is planned to be launched in Mid-2023.
- It plans to study the planet from an elliptical orbit that is closest to Venus at 500 km and 60,000 km at the farthest end.
- It is currently being handled by the Space Science Programme Office.
- If the project is approved would be ISRO’s third interplanetary mission after Chandrayaan – 1 and Mars Orbiter Mission.

1.23 Aditya-L1 Mission

- It is the first Indian mission to study the Sun.
- It is expected to be launched in 2019 by the launch vehicle PSLV-XL with six payloads from Sriharikota.
- The main aim of the solar mission is to do coronal and near UV studies.
- It was meant to observe only the solar corona but with additional experiments, it can provide observations of Sun's Photosphere (soft and hard X-ray), Chromosphere (UV) and corona (Visible and NIR).
- The outer layers of the Sun, extending to thousands of km above the disc (photosphere) is termed as the corona. It has a temperature of more than a million degree Kelvin which is much higher than the solar disc temperature of around 6000K.
- It will be launched into the halo orbit around the Lagrangian point 1 (L1) of the Sun-Earth system.
- This orbit has the advantage of allowing continuous monitoring of the sun.

Lagrange Points

- A Lagrange point is a location in space where the combined gravitational forces of two large bodies, such as Earth and the sun or Earth and the moon, equal the centrifugal force felt by a much smaller third body.
- The interaction of the forces creates a point of equilibrium where a spacecraft may be "parked" to make observations.
- The first point, L1, lies between Earth and the sun and gets an uninterrupted view of the sun and free from the occurrence of eclipses.
- L2 with the Earth, moon and sun behind it, a spacecraft can get a clear view of deep space and it has a protection for radiation field from sun.
- The James Webb Space Telescope will move into L2 point in 2018.
- The third Lagrange point, L3, lies behind the sun, opposite Earth's orbit. For now, science has not found a use for this spot.



- Points L4 and L5 are stable and lie along Earth's orbit at 60 degrees ahead of and behind Earth and dust and asteroids tend to accumulate in these regions due to its stability.
- Asteroids that surround the L4 and L5 points are called Trojans and Earth's only known Trojan asteroid, 2010 TK7 is found in the region.

1.24 AstroSat

- It is a space observatory launched by ISRO in 2015.
- It was launched with a lift-off mass of about 1500 kg by PSLV-C30.
- It is India's first dedicated multi wavelength space observatory.
- Most other scientific satellites can observe only a narrow range of wavelength band.
- But AstroSat enables the simultaneous multi-wavelength observations of various astronomical objects with a single satellite.
- It observes universe in the optical, Ultraviolet, low and high energy X-ray regions of the electromagnetic spectrum.
- The scientific objectives of ASTROSAT mission are:
 1. To understand high energy processes in binary star systems containing neutron stars and black holes
 2. Estimate magnetic fields of neutron stars
 3. Study star birth regions and high energy processes in star systems lying beyond our galaxy
 4. Detect new briefly bright X-ray sources in the sky
 5. Perform a limited deep field survey of the Universe in the Ultraviolet region
- The minimum useful life of the AstroSat mission is expected to be 5 years.

1.25 Mars Orbiter Mission

- It is ISRO's first interplanetary mission to planet Mars with an orbiter craft designed to orbit Mars in an elliptical orbit of 372 km by 80,000 km.
- It has been configured to carry out observation of physical features of Mars and carry out limited study of Martian atmosphere with following five payloads:
 - Mars Colour Camera (MCC)
 - Thermal Infrared Imaging Spectrometer (TIS)
 - Methane Sensor for Mars (MSM)
 - Mars Exospheric Neutral Composition Analyser (MENCA)
 - Lyman Alpha Photometer (LAP)
- It was launched by **PSLV – C25** with lift off mass of 1337 Kg in Martian Orbit.

1.26 Chandrayaan

- Chandrayaan -1 is India's first mission to Moon launched in 2008 by PSLV-C11.
- The spacecraft was orbiting around the Moon at a height of 100 km from the lunar surface for chemical, mineralogical and photo-geologic mapping of the Moon.
- India was the captain and carrying the payloads built in UK, USA, Bulgaria Germany and Sweden.
- The mission comprised an orbiter and an impactor launched by ISRO's workhorse PSLV.
- Chandrayaan-1's greatest discovery was the widespread presence of water molecules in the lunar soil and a related molecule "hydroxyl", which consists of one atom each of hydrogen and oxygen.
- Scientists have recently created the first map of water trapped in the uppermost layer of the moon's soil using data from Chandrayaan-1.
- The data reveals that the amount of water increases toward the poles and does not show significant difference among distinct compositional terrains and it likely comes from moon's mantle.



- Water in the lunar soil could be attributed to solar wind.

1.27 Chandrayaan-2

- It will be an advanced version of the previous Chandrayaan-1 mission to Moon.
- It is configured as a two-module system comprising of an Orbiter Craft module (OC) and a Lander Craft module (LC) carrying the Rover developed by ISRO.
- It is the first time India attempts to land a rover on the moon's South Pole.
- Only USA Russia and China were able to soft land successfully on the lunar surface and these landings were near the lunar equator.
- The purpose of the mission is to collect data on the lunar topography, mineralogy, elemental abundance, lunar exposure and signatures of water-ice.
- **Recent Developments** - A crucial test before the launch called "Lander Sensor Performance Test (LSPT)" was conducted by ISRO over an artificial lunar site setup at Challakere, Karnataka.
- It is to test how the sensor will guide the lander when it starts descending on the lunar terrain.
- As the plane descends over the artificial terrain, the sensors must show how they will guide the soft landing of the lunar craft at the right spot, speed and position.
- **Role of Sensor in the Lander** – It helps assess height from the landing spot, decides speed of the lander and helps lander navigate boulder or uneven surfaces.

1.28 NISAR

- NASA-ISRO Synthetic Aperture Radar satellite (NISAR) is the world's most expensive earth imaging satellite.
- It will be launched by 2020 and it will be the first satellite mission to use two different radar frequencies (L-band and S-band).
- The S-band is being built by ISRO and L-band by NASA.
- It is expected that the NISAR satellite will be launched in 2021 from India using GSLV.
- One of the main purposes of the mission is to observe Earth and establish a general pathway for future joint missions for Mars exploration.
- It will take weekly snapshots of earth that will provide time lapse images of the motion of tectonic plates, ice sheets and changes in vegetation over land in agriculture and forests and natural hazards.

Global Missions

NASA

1.29 NASA Solar Probe

- Parker Solar Probe named as "Eugene Parker", is the first robotic spacecraft to the Sun, which will travel directly into the sun's atmosphere about 4 million miles from the star's surface.
- The mission is to study why the surface of the Sun, called the photosphere, is not as hot as its atmosphere, called the corona.
- It will perform the closest-ever observations of the Sun's outer atmosphere Corona.
- The surface temperature of the Sun is only about 5,500°C but the atmosphere above it is an over two million degrees Celsius.
- The mission may also ascertain why the Sun occasionally emits high-energy particles that are a danger to unprotected astronauts and spacecraft.
- It has three detailed science objectives:
 1. Trace the flow of energy that heats and accelerates the solar corona and solar wind.
 2. Determine the structure and dynamics of the plasma and magnetic fields at the sources of the solar wind.
 3. Explore mechanisms that accelerate and transport energetic particles.
- **Recent Development**–It has beamed back the first-light data from each of its four instrument suites.

- It has recently got its revolutionary **heat shield** permanently attached to the spacecraft.
- The shield is made of superheated carbon composite material sprayed with a specifically formulated white coating on the sun facing side to reflect the sun's energy away from the spacecraft.
- As the spacecraft approach the sun, temperatures on the heat shield will reach nearly 1,300°C but the spacecraft will be kept at about 30°C.
- The shield will help the spacecraft remain safe as it collects data about the inner workings of the corona.

1.30 FOXSI Mission

- Focusing Optics X-ray Solar Imager (FOXSI) is a sounding rocket mission by NASA.
- It aims at directly focus at Sun and search for nanoflares using its X-ray vision.
- FOXSI rockets travel above the Earth's atmosphere for a peek at space before falling back to the ground.
- It is the first instrument built specially to image high-energy X-rays from the Sun by directly focusing them.

Nanoflares

- Nanoflares are miniature explosions invisible to the naked eye.
- They are born when magnetic field lines in the Sun's atmosphere tangle up and stretch until they break like a rubber band.
- Consequence - The energy they release accelerates particles to near light speed and heats the solar atmosphere to its searing million-degree Fahrenheit temperature.

1.31 Insight Mission

- Interior Exploration using Seismic Investigations, Geodesy & Heat Transport, is a Mars lander, launched in 2018.
- It is the first outer space **robotic explorer** to study in-depth the "inner space" of Mars - its crust, mantle, and core.
- It also measures tectonic activity and meteorite impacts on Mars.
- The lander carries a robotic arm and set of instruments to study the makeup and dimensions of the planet's core, mantle and crust.
- The landing site is Elysium Planitia, a featureless, and hopefully quiet, landscape is well-suited for the mission, to map the interior of the planet.
- Along with the spacecraft, a pair of mini satellites known as Mars Cube One, or MarCO also reached Mars.
- It will be a first test of miniaturized **CubeSat technology** at another planet, which researchers hope can offer new capabilities to future missions.
- This mission is part of **NASA's Discovery Program** for highly focused science missions that ask critical questions in solar system science.
- It is similar in design and will rely on proven technologies used on NASA's **Mars Phoenix mission**, and will send a lander to the Martian surface to spend two years to investigate interiors of Mars.
- Previous missions to Mars have investigated the surface history of the Red Planet by examining features like canyons, volcanoes, rocks and soil.

MarCO Mission

- MarCO stands for Mars Cube One which has twin low-cost cube sats – MarCO A and MarCO B, boarded in Insights lander to Mars.
- The objective of the mission is to find out whether CubeSats could survive the journey to deep space.
- By verifying cubesat as a viable technology for interplanetary mission, it could lead to many other applications to explore and study our solar system.
- It has recently beamed back an image of Mars, visible as a tiny red dot against the dark sky.

1.32 Curiosity

- It is a rover deployed by NASA in its **Mars Exploration Program**, 2011 to assess whether Mars ever had an environment able to support small life forms called microbes.
- The rover will analyze samples scooped from the soil and drilled from rocks in order to detect chemical building blocks of life (e.g., forms of carbon) on Mars and will assess what the martian environment was like in the past.
- The rover captured **mesas and buttes** on mars geological layer called as Murray formation, which is formed from the lakebed mud deposits.

- Butte otherwise called as Murray Butte is an isolated hill with steep, flat top side and with often vertical sides.
- Mesa is an elevated area that has wider top than its height, while Butte has a top that is narrower than its height.
- The rover has recently successfully collected the first rock samples on the red planet in over a year, using a new way to drill rocks and extract powder from the target called “Duluth”.

1.33 Opportunity Rover

- It was launched in 2003 to land in Mars. It landed in 2004 and began traversing the planet in search of signs of past life.
- It was the first rover to find solid evidence of water on Mars.
- It is still actively exploring the Martian terrain.
- It was originally planned for 90-day mission. But it has far outlasted its planned mission by 55 times longer than originally planned.
- Mars is prone to dust storms due to its thin atmosphere and deserts conditions.
- Recently, it witnessed an immense dust storm which led to the impenetrable, perpetual night in the planet.
- Since, opportunity rover is a solar powered, the amount of light the spacecraft receives has dropped to less than 1 percent of normal levels.
- Before the storm began, it had been rolling down a channel called Perseverance Valley, which scientists think may have been carved by water billions of years ago.

1.34 ASPIRE

- Under **Advanced Supersonic Parachute Inflation Research Experiment (ASPIRE)**, a supersonic parachute was launched into the sky that will help missions to land on Mars.
- The test was meant to mimic the conditions that a spacecraft would experience during a Red Planet entry, descent and landing (EDL).
- The Mars rover which is scheduled to launch in two years (2020), on a mission to hunt for signs of ancient life on the Red Planet and will study rocks on site and cache samples for return to earth.
- It will rely on a special parachute to slow the spacecraft down as it enters the Martian atmosphere.

1.35 MAVEN

- The Mars Atmosphere and Volatile Evolution (MAVEN) mission is part of NASA's Mars Scout program, launched in 2013.
- The mission will explore MARS's upper atmosphere, ionosphere and interactions with the sun and solar wind.
- An important aspect of the MAVEN mission is studying how early Mars lost much of its atmosphere.
- This atmospheric loss may have been partially responsible for Mars' transition from a planet capable of supporting liquid surface water to the dry, desert world we know today.
- It has avoided its head-on collision with Phobos, the natural satellite of Mars in 2018.

Phobos

- Phobos is one of the smallest moons in the solar system orbiting around the Mars.
- It is the only natural satellite in the solar system that encircles its planet in a time shorter than the parent planet's day.
- Mars has another natural satellite Deimos.
- Phobos is the innermost and largest of the two.
- Recently, NASA's Hubble Space Telescope has beamed back images of the moon Phobos in its orbital trek around the red planet.

1.36 New Frontiers program

- The New Frontiers program is a series of space exploration missions being conducted by NASA with the purpose of researching several of the Solar System bodies, including the dwarf planet Pluto.
- There are currently three New Frontiers missions in progress.
- **New Horizons**, which was launched in 2006 and reached Pluto in 2015.
- **Juno** was launched in 2011 and entered Jupiter orbit in 2016.

- **OSIRIS-REx**, launched in September 2016 towards asteroid Bennu for detailed studies from 2018 to 2021 and a sample return to Earth in 2023.

1.37 New Horizons

- It is the first mission to the Pluto system and Kuiper Belt and fastest spacecraft ever launched.
- It was launched in 2006 to explore Pluto and its **largest moon, Charon**, which are known as "ice dwarfs."
- The mission seeks to understand where Pluto and its moons "fit in" with the other objects in the solar system, such as the inner rocky planets (Earth, Mars, Venus and Mercury) and the outer gas giants (Jupiter, Saturn, Uranus and Neptune).
- **Recent developments** - Recently it is reported that the spacecraft will reach icy object nicknamed Ultima Thule (TOO-lee).
- Ultima Thule will be the farthest world ever explored by humankind, no spacecraft has visited anything so primitive.
- Pluto is barely in the Kuiper Belt, the so-called Twilight Zone stretching beyond Neptune, Ultima Thule is in the Twilight Zone's heart.
- The color of Ultima Thule is expected to be darker than coal, burned by eons of cosmic rays, with a reddish hue.

Kuiper Belt - It is a ring of objects between Neptune and the edge of the solar system full of dwarf planets, hundreds of thousands of icy rocks and comets.

Penitentes on Pluto

- Penitentes are snow and ice features formed by erosion and characterized by bowl-shaped depressions.
- Scientist has found the evidence of penitentes on Pluto using the images from the **New Horizons spacecraft** in 2015.
- Until now, Earth is the only planet in the solar system to have Penitentes.
- Unlike in Earth, Penitentes in Pluto are mainly made from methane and nitrogen due to its different environment i.e. thinner air, dimmer sun and much colder conditions. They are much larger than earth's counterparts.

1.38 Juno Spacecraft

- Its mission is to measure Jupiter's composition, gravity field, magnetic field, and polar magnetosphere.
- The objectives of the mission are
 1. Determine how much water is in Jupiter's atmosphere
 2. Look deep into Jupiter's atmosphere to measure composition, temperature, cloud motions and other properties
 3. Map Jupiter's magnetic and gravity fields, revealing the planet's deep structure
 4. Explore and study Jupiter's magnetosphere near the planet's poles, especially the auroras – Jupiter's northern and southern lights.
- It has sent new images of volcanic plume on Jupiter's moon Io.
- Jovian moon Io is the most volcanic body in our solar system.
- The images can lead to new insights into the gas giant's interactions with its five moons.
- Recently, the spacecraft reached "Perijove", the point at which an orbit comes closest to Jupiter's centre and completed a close flyby of Jupiter's Great Red Spot (GRS).
- GRS is a 16,000-km wide storm monitored since 1830 and possibly existing for more than 350 years.
- It has also beamed back an image of a long, brown oval known as a "brown barge".
- Brown barge is an elusive atmospheric feature in Jupiter's South Equatorial Belt.

1.39 OSIRIS-REx

- The Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx) spacecraft will travel to a near-Earth asteroid, called **Bennu**.
- It will bring sample back to Earth for study and help scientists investigate how planets formed and how life began, as well as improve our understanding of asteroids that could impact Earth.
- The aim of the mission is to collect a sample of regolith- the loose, soil-like material which covers the surface of the asteroid.
- It was launched in 2016 and it will return a sample to Earth in 2023.

1.40 Orion Spacecraft

- Orion spacecraft is being designed by NASA to take humans deeper into space than ever before.
- It is the next-generation vehicle that the US is developing to carry astronauts to the Moon and on to Mars.
- It is scheduled to be launched in 2020.
- It is known as Exploration Mission-1 (EM-1).
- European industry has recently handed over a key part of the spaceship infrastructure to NASA.
- The European Service Module (ESM) is essentially Orion's back end. This is the first time America has gone outside its shores for such an important piece of human spaceflight hardware.
- ESM will provide propulsion, an electricity supply, thermal control, and all the gases and water needed to sustain any humans riding inside the capsule.

1.41 Voyager 1 & Voyager 2

- It was launched to explore **Jupiter and Saturn** and later extended to other solar bodies.
- The twin voyager probes are the NASA's longest running missions.
- Voyager 1 made the historic entry into interstellar space, the region between stars, filled with material ejected by the death of nearby stars millions of years ago.
- Voyager 2 went on to explore Uranus and Neptune, and is still the only spacecraft to have visited those outer planets.
- The current mission objective of the Voyager Interstellar Mission (VIM) is to explore beyond the neighborhood of the outer planets to the outer limits of the Sun's sphere of influence i.e Sun's magnetic field and outward flow of the solar wind.
- Voyager probes are the first spacecraft to date that humans have sent to this boundary, called the heliopause.
- **Recent developments** - NASA has recently reported that Voyager 2 is nearing heliosphere (Sun's outer border) and could soon enter interstellar space.
- **Heliopause** - The place where the sun's constant flow of material and magnetic field stops affecting its surroundings.
- Heliopause marks the end of a region created by our sun that is called the heliosphere.
- The sun creates **heliosphere** by sending a constant flow of particles and a magnetic field out into space at over 670,000 miles per hour. This stream is called the 'solar wind.'
- **Interstellar Space** is the part of space that exists between stars with cold particles around it.
- Inside the heliosphere, the solar particles are hot but less concentrated. Outside of the bubble, they are very much colder but more concentrated.
- Once an object arrives in interstellar space, there would be an increase of "cold" particles around it.

1.42 Dawn Mission

- It was launched to study the asteroid Vesta and dwarf planet Ceres, which are celestial bodies believed to have accreted early in the history of the solar system.
- It is the only mission ever to orbit two extraterrestrial targets and will characterize the early solar system and the processes that dominated its formation.

- Dawn orbited giant asteroid Vesta for 14 months from 2011 to 2012, then continued on to Ceres, where it has been in orbit since March 2015.
- NASA has recently authorized a second extension of the Dawn mission at Ceres, during which the spacecraft will descend to lower altitudes than ever before at the dwarf planet.

Ceres and Vesta

- Ceres is the earliest known and smallest of the dwarf planet.
- It is also the largest object in the asteroid belt between Mars and Jupiter.
- Thus Ceres is both dwarf planet and asteroid.
- Vesta is the second most massive body in the asteroid belt, surpassed only by Ceres.
- It is known as the brightest asteroid and the first asteroid to be visited by a spacecraft.
- The International Astronomical Union defines three criteria to classify any object as a “planet”
 - i. It needs to be in orbit around a any fully fledged star.
 - ii. It needs to have enough gravity to pull itself into a spherical shape.
 - iii. It has cleared the neighbourhood around its orbit
- This last criterion is the point at which planets and **dwarf planets** differ. Dwarf planets have other objects in its orbit around its star.
- IAU recognizes five named dwarf planets: Ceres, Pluto, Eris, Haumea, and Makemake. Except Ceres, other dwarf planets are also known as “Plutoids”.
- **Asteroids**, or minor planets, are small and often irregularly shaped celestial bodies.
- The known majority of them orbit the Sun in the so-called main asteroid belt, between the orbits of the planets Mars and Jupiter.
- An asteroid is coined a **Near Earth Asteroid (NEA)** when its trajectory brings it within 1.3 Astronomical Units (AU) from the Sun and hence within 0.3 AU of the Earth's orbit.
- The largest known NEA is Ganymed. NEA's are also known Potentially Hazardous Asteroid.

1.43 Europa Clipper Mission

- It will launch a spacecraft in 2022, which conduct detailed investigation of **Jupiter's moon Europa**.
- Europa holds strong evidence for an ocean of liquid water beneath its icy crust and which could host conditions favorable for life.

1.44 Lucy and Psyche

- Lucy and Psyche are two robotic missions to **explore asteroids**.
- The Psyche mission, to be launched in 2023, will explore 16 Psyche, a giant metal asteroid in the asteroid belt between Mars and Jupiter.
- The Lucy Mission will explore the environment of **Jupiter's Trojan asteroids**. Trojans are bodies that are present in Lagrange points.
- Lucy will be the first space mission to study the Trojans and it will be launched in 2021.

1.45 Magnetospheric Multiscale (MMS) Mission

- MMS, launched in 2015, consists of 4 identical spacecraft that orbit around Earth to study a little-understood phenomenon called “**Magnetic Reconnection**”.
- MMS will travel directly through areas near Earth known to be magnetic reconnection sites.

Ralph

- It is a space instrument launched by NASA to explore outer solar system.
- It was first launched aboard the New Horizons spacecraft in 2006.
- It revealed images of Jupiter and its moons and Pluto.
- In 2021, Ralph is set to journey with the Lucy mission to Jupiter's Trojan asteroids.
- It will study this diverse group of bodies and will detect trojan asteroid's chemical footprints.
- It allows scientists to interpret data provided by the Sun's reflected light that are the fingerprints of different elements and compounds.

- Reconnection occurs when magnetic field lines of sun and Earth cross and release a gigantic burst of energy.
- On the sun-side of Earth, reconnection can link the sun's magnetic field lines to Earth's magnetic field lines, allowing material and energy from the sun to funnel into Earth's magnetic environment.
- On the night side of Earth, reconnection is believed to help trigger aurora, also known as the northern and southern lights.

1.46 CubeSat

- CubeSats are a class of research spacecraft called nanosatellites, which can serve purposes such as Earth observation or amateur radio.
- They are used to demonstrate spacecraft technologies that are targeted for use in small satellites.
- They are built to standard dimensions of 10 cm x 10 cm x 11 cm unit and typically weigh less than 1.33 kg/unit.
- They require Micropropulsion devices which use **ultra-purified water as propulsive agent**.
- It uses Film-Evaporation MEMS Tunable Array (FEMTA) thrusters which uses capillaries small enough to harness the microscopic properties of water.
- The thrusters deliver precise low-thrust for scientific, commercial and military space applications.
- It can be manoeuvred in space with tiny bursts of water vapour to perform tasks like high-resolution imaging and internet services to disaster response, environmental monitoring and military surveillance.

1.47 NICER

- Neutron star Interior Composition Explorer (NICER) is the world's first mission devoted to studying rapidly spinning **neutron stars**.
- It was launched in 2017 and a part of International space station payload.
- Neutron stars are the **remnants of massive stars** that, after exhausting their nuclear fuel, exploded and collapsed into super-dense spheres about the size of New York City.
- Although neutron stars **emit radiation across the spectrum**, observing them in the energetic X-ray band offers the greatest insights into their structure and the high-energy phenomena that they host, including starquakes, thermonuclear explosions, and the most powerful magnetic fields known in the cosmos.

1.48 GOLD & ICON

- NASA has announced two missions to explore the little-understood area of 96 km above Earth's surface.
- Global-scale Observations of the Limb and Disk (GOLD) and Ionospheric Connection Explorer (ICON) are launched to explore the ionosphere, 96 km above Earth's surface.
- ICON will be in low-Earth orbit, at 560 km above Earth, like a close-up camera while GOLD will be in a geostationary orbit over the Western Hemisphere, about 35,398 km above the planet's surface.
- It will help in full-disk view of the ionosphere and the upper atmosphere beneath it every half hour.

1.49 IMAP

- NASA's Interstellar Mapping and Acceleration Probe (IMAP) mission will help researchers better understand the boundary of the heliosphere.
- NASA is targeting 2024 for the launch of a new mission to learn more about the generation of cosmic rays in the heliosphere.
- Heliosphere is the region where the constant flow of particles from our Sun, called the solar wind, collides with material from the rest of the galaxy.
- Cosmic rays created locally and from the galaxy and beyond affect human explorers in space and can harm technological systems, and likely play a role in the presence of life itself in the universe.
- The spacecraft will be positioned about 1.5 million kilometres away from Earth towards the Sun at what is called the first Lagrange point or L1.

1.50 VISIONS – 2

- The VISIONS-2 mission, short for Visualizing Ion Outflow via Neutral Atom Sensing-2, is a sounding rocket going to be launched by NASA.
- It aims to explore how the Earth's atmosphere is slowly leaking in to space.
- Sounding rockets are unique among scientific spacecraft for their superior dexterity.
- The current mission's precursor, VISIONS – 1 was launched from Alaska in 2013.
- It studied oxygen outflow from aurora that forms on Earth's night side, the part of the planet that is temporarily pointed away from the Sun.

1.51 Kilopower Project

- Under the project, a new generation of small nuclear reactors are being built up, which intends to power missions to deep space and even future astronaut bases on the moon and mars.
- It aims to provide a safe, effective, and powerful nuclear power reactor that can power spacecraft for years.
- It can generate a reliable power supply by using uranium-235 reactor core.
- NASA already uses small nuclear devices called radiothermal gradients (RTG) on board deep space missions and the Mars Curiosity rover, which runs on watts of power. But, Kilopower project will be able to achieve kilowatts of power.

1.52 Asteroid Impact and Deflection Assessment Mission

- AIDA is a dual-mission concept, involving two independent spacecraft NASA's Double Asteroid Redirection Test (DART), and European Space Agency's Asteroid Impact Mission (AIM).
- It will be the first demonstration of the kinetic impact technique to change the motion of an asteroid in space.
- Kinetic Impact technique is one of the technologies for preventing the Earth from a hazardous asteroid.
- AIDA's primary objective is to demonstrate, and to measure the effects of, a kinetic impact on a small asteroid.
- It targets binary near-Earth asteroid Didymos, which pose a hazard to earth.
- DART spacecraft will cause deliberately crashing itself into the asteroid at a speed of approximately 6 km/s.
- The collision will change the speed of the asteroid in its orbit around the main body by a fraction of one percent, enough to be measured using telescopes on Earth.

1.53 TESS

- Transiting Exoplanet Survey Satellite (TESS) is a planet hunter mission. It deploys a space telescope to search for exoplanets (planets outside of our solar system) that could support life.
- The spacecraft will be looking for a phenomenon known as a transit, where a planet passes in front of its star, causing a periodic and regular dip in the star's brightness.
- The principal goal is to detect small planets with bright host stars in the solar neighborhood.
- It will survey 200,000 of the brightest stars near the sun to search for transiting exoplanets.
- It will do an all-sky survey from an orbit between the Earth and the moon

1.54 TDRS-M

- Tracking and Data Relay Satellite-M (TDRS-M) is a next generation communication satellite .
- The research found that the moon formed only about 60 million years after the birth of solar system.
- The moon was formed by a violent, head-on collision between the early Earth and a **planetary embryo called "Theia"**.
- The Earth's collision with Theia created a liquefied moon, which then solidified and most of the moon's surface was covered with magma right after its formation.

1.55 EcAMSat Mission

- EcAMSat – E.coli Anti-Microbial Satellite Mission was launched to International space station to investigate spaceflight effects on bacterial antibiotic resistance and its genetic basis.

- E.Coli is a common bacterial pathogen linked to urinary tract infections and foodborne illnesses.
- It aims to determine the lowest dose of antibiotic needed to inhibit the growth of E.coli.
- It will help to determine the appropriate dosages of antibiotics to protect astronaut health during long-duration human space flight and how antibiotic effectiveness may change as a function of stress on Earth.

1.56 ICESat-2 and GRACE

- ICESat-2, improves upon ICESAT, is a laser-armed satellite which measures changes in the glaciers, icesheets and sea ice.
- It will measure the average annual elevation change of land ice covering Greenland and Antarctica to within the width of a pencil, capturing 60,000 measurements per second.
- Its Advanced Topographic Laser Altimeter System (ATLAS) measures height by timing how long it takes individual light photons to travel from the spacecraft to Earth and back.
- NASA started the ICESAT mission in the year 2003 and continued in 2009 with NASA's Operation IceBridge.
- ICESat-2 will also measure the height of ocean and land surfaces, including forests.

1.57 GRACE FO

- It is follow-on to the prior, 15-year mission known as the Gravity Recovery and Climate Experiment (GRACE), which measures the amount of ice greenland was losing.
- GRACE Follow on (FO) mission will keep track changes in mass distribution around the planet, including the massive polar ice sheets, sea level rise and aquifers level.
- The two satellites, will circle the Earth at a distance of 220 km from each other and flying about 490 km above the Earth for the next five years.

1.58 OCO-3 Mission

- The Orbiting Carbon Observatory 3, or OCO-3, is a space instrument designed to investigate important questions about the distribution of carbon dioxide on Earth.
- The Carbon Monitoring System (CMS) tracked sources and sinks for carbon and made high-resolution models of the planet's flows of carbon.

1.59 SUBSEA

- Systematic Underwater Biogeochemical Science and Exploration Analog (SUBSEA) is the space and ocean exploration research program, proposed by NASA in the year 2017.
- It focuses on ocean worlds in our Solar System such as Saturn's moons Enceladus and Titan and Jupiter's moon Europa.
- Scientist will apply the knowledge on our deep ocean in Earth to interplanetary worlds and how ocean explorers can help NASA test instruments and systems destined for outer space in the deep ocean.
- Under this programme, under water remotely based vehicles or robots are operated by ship-based human operators, who inturn receive guidance from remote science team in space.
- The target of SUBSEA 2018 is Loihi seamount, an underwater volcano off Hawaii Island.
- The submarine will analyse the warm springs emanating from Loihi.
- The purpose behind this is to predict conditions in other ocean worlds such as moons of Saturn (Enceladus) and Jupiter (Europa).
- It will also help mission design teams to develop methods for doing operations in deep space environments such as Mars.

1.60 Cyclone Global Navigation Satellite System

- It will use 8 micro-satellites to measure wind speeds over Earth's oceans, increasing the ability of scientists to **understand and predict hurricanes**.
- Each satellite will take information based on the signals from 4 GPS satellites.
- CYGNSS orbit is designed to measure only in the tropics, where hurricanes are most often found.

- The CYGNSS satellites themselves will not broadcast. It will use the GPS satellites deployed to receive & transmit signals to Earth.

1.61 Joint Polar Satellite System

- Joint Polar Satellite System-1 (JPSS-1), a next-generation satellite to monitor weather around the world and help improve forecasts.
- It is a joint venture between the US space agency and the National Oceanic and Atmospheric Administration (NOAA), US scientific agency.
- It will orbit the Earth 14 times each day from one pole to the other at 512 miles above the planet.
- It is the first in NOAA's series of 4 next-generation operational environmental satellites used for severe weather prediction and environmental monitoring.
- Four smaller satellites called CubeSats, part of NASA's educational nano-satellite program, are to be released on the same mission.

1.62 Cassini Space Craft

- It is a joint project of NASA, European space agency mission and Italian space agency launched to probe **Saturn**.
- It was launched in 1997 and it arrived in Saturn in 2004.
- It is the fourth space probe to visit Saturn (after pioneer 11, Voyager 1, Voyager 2) and the first to enter orbit.
- Its design includes a Saturn Orbiter and a Lander called "Huygens" for the **moon Titan** (landed in 2005).
- The data collected by lander suggest the possibility of hosting life in Saturn's **moon Enceladus**.
- This was the first landing ever accomplished in the outer solar system.
- After 20 years in Space, NASA's Cassini Spacecraft has made its final death plunge in Saturn recently.
- It is a well planned demise to prevent any damage to Saturn's ocean bearing moons Titan and Enceladus.

Titan

- Titan is the largest moon of Saturn.
- Scientists recently identified negatively charged molecules called 'carbon chain anions' in the atmosphere of Titan using the data collected by Cassini Spacecraft.
- Those carbon chains may have acted as the basis for the earliest forms of life on Earth.

Enceladus

- Enceladus is a small moon with an ocean of liquid water beneath its icy crust.
- Clouds of gas erupting out of Enceladus contain hydrogen.

1.63 Rosetta

- The mission was launched in 2004 to land a probe on a comet.
- It arrived in the Comet 67P/Churyumov-Gerasimenko in 2014.
- It is the first spacecraft to accompany a comet as it enters the inner solar system, as well as the first to attempt landing on a comet.
- The mission included the Philae lander, which made the first touchdown on the comet but it did not stay down.
- In 2016, it made a planned final plunge into its comet, ending its mission.

Comet 67P—It makes regular visits to the inner solar system, as it orbits the sun every 6.5 years between the orbits of Earth and Jupiter.

Other Space Agencies

1.64 Gaia mission

- Global Astrometric Interferometer for Astrophysics (Gaia) It is a European Space Agency's mission, to chart a 3-D map of the home galaxy, revealing in the process its composition, formation and evolution.
- It will provide unprecedented positional measurements for about one billion stars – about 1 per cent of the Galactic stellar population – in our Galaxy and Local Group.
- It has recently produced 2nd latest data containing information about million stars. The first data was released in 2016.

1.65 Belle II

- It is an experiment carried out by **The High Energy Accelerator Research Organisation (KEK), Japan** to study violations of the standard model and dark matter.
- It has a six layer highly sensitive particle detector which indirectly probe new physics using intense electron-positron beams unlike direct search experiments being carried out in Large Hadron Collider.
- The experiment has a significant Indian participation. The particle detector at the heart of Belle –II has been built by an Indian Scientists Tariq Aziz and Gagan Mohanty from Tata Institute of Fundamental Research
- Recently, the experiment has been rolled out. It has a grand collaboration of 700 Scientist from 23 countries.

1.66 Aeolus Satellite

- Aeolus is a European wind survey satellite launched by Arianespace, world's leading satellite launch company.
- It is part of the **Copernicus project**, a joint initiative of the European Union and the European Space Agency (ESA) to track environmental damage and aid disaster relief operations.
- It is the fifth of the ESA's planned Earth Explorer missions and Arianespace's 50th launch for ESA.
- It was recently launched from French Guiana using Vega rocket.
- It will use advanced laser technology to track global winds and improve weather forecasts.
- The satellite is equipped with Doppler wind lidar, an advanced laser system designed to accurately measure global wind patterns from space.
- It will probe the lowermost 30 kilometres of the atmosphere in measuring winds around the Earth.
- It is the world's first space mission to gather information on Earth's wind on a global scale.

1.67 Galileo

- Galileo is a navigation satellite program being developed by the European Union as a rival to the U.S. Global Positioning System.
- It was commissioned in 2003 and is due for completion by 2020.
- It is a project of the European Commission and European space agency.
- It consists of 24 satellites in which 22 are currently in orbit and it is likely to reach 30 in 2021.
- It promises eventual real-time positioning to accuracy of one metre or less.

1.68 BepiColombo mission

- It is a first mission of its kind by European Space Agency to Mercury.
- A UK-built spacecraft will determine if the nearest planet to the Sun contains water.
- The mission will send two orbiters to explore the fiery world where the surface temperatures reach about 450°C.
- Till now, only 2 spacecraft have been to Mercury, NASA's Mariner 10 and Messenger.

1.69 ExoMars

- ExoMars is a joint space venture between European Space Agency and Russian space agency Roscosmos to Mars.
- The ExoMars programme comprises 2 missions.
- The first mission was launched in 2016 and consists of the Trace Gas Orbiter (TGO) and Schiaparelli, an entry, descent and landing demonstrator module.
- The second mission is planned to be launched in 2020 and comprises a rover and surface science platform.
- The rover that will carry a drill and a suite of instruments dedicated to search for possible existence of life beyond earth and geochemistry research.
- It is likely to land on Mars' equator called Oxia Planum, which had housed a massive pool of water in the prehistoric era.



1.70 SENTINEL-5P

- **European satellite** Sentinel-5P sends images of global air pollution
- The Sentinel-5P satellite is designed to make daily global maps of the gases and particles that pollute the air.
- Sentinel-5P is the latest spacecraft in a fleet of Earth observers being commissioned by the European Union and the European Space Agency.
- It was launched into an 824 kilometre high orbit by a Russian rocket on October 13 this year.
- It carries an instrument called Tropomi – a spectrometer that observes the reflected sunlight coming up off the Earth, analysing its many different colours.
- This helps detect the presence of trace gases such as nitrogen dioxide, ozone, sulphur dioxide, methane, and carbon monoxide in the atmosphere.
- **ISRO satellite** - The Next Generation Earth Monitoring and Observation and Aerosol Monitoring (NEMO-AM) satellite will monitor air pollutants

1.71 Tiangong-1

- It is China's space station launched in 2011. China is only the third country, after Russia and the US, to launch its own crewed missions.
- The Chinese used it to demonstrate spacecraft docking capabilities.
- Six astronauts visited Tiangong-1 in 2012 and 2013 in two crews. It included China's first woman astronaut, Liu Yang and Wang Yaping.
- Chinese lost control of the station in 2016.
- After losing control, China notified the United Nations Office for Outer Space Affairs and the Inter-Agency Space Debris Coordination Committee.
- Much of Tiangong burnt up in the atmosphere, until it finally splashed into the ocean.
- Weighing 8.5 tonnes, it dropped out of orbit and splashed into the South Pacific Ocean, just northwest of Tahiti.
- Tiangong-2 continues to be operational.
- This lab was launched the same year the Chinese lost control of the now-downed space station.

International Space Station

- The International Space Station is a collaboration between the U.S., Russia, Canada, Europe and Japan.
- It has been in operation since 1998 and due to be retired in 2024.
- China will have the only space station in orbit after ISS expires in 2024.
- Tiangong will be much smaller than the ISS which weighs 400 tonnes.
- It weighs 60 tonnes and will have the lifespan of around 10 years.
- China has announced that the lab would be open to "all countries" to conduct science experiments.

1.72 Queqiao

- China successfully launched a relay satellite to set up a communication link between the Earth and a planned Chinese lunar exploration mission to explore the Moon's mysterious far side.
- It is named as Queqiao (Magpie Bridge) which is a 400-kg satellite with a designed life of three years.
- It was carried by a Long March-4C rocket.
- Queqiao is expected to enter a halo orbit around the second Lagrangian (L2) point of the Earth-Moon system, about 455,000 kms from the Earth.
- It will be the world's first communication satellite operating in that orbit.
- The Queqiao satellite will form a communication bridge between controllers on the Earth and the far side of the Moon where the Chang'e-4 lunar probe is expected to touch down.
- Tidal forces of the Earth have slowed the Moon's rotation to the point where the same side always faces the Earth, a phenomenon called tidal locking.
- The other face, most of which is never visible from the Earth, is the far side or dark side of the Moon, not because it's dark, but because most of it remains unknown.

1.73 Chang'e 4

- Chang'e 4 is a Chinese lunar exploration mission, which will incorporate an orbiter, a robotic lander and rover
- It is the world's mission to land on the dark side of the moon.
- The moon is tidally locked Earth, rotating at the same rate that it orbits our planet, so the far side (Dark side) is never visible from the Earth.
- It will reach the far side of the Moon, not visible from the Earth, a feat no country has ever achieved.
- It will explore the lunar surface in the south pole – Aitken basin, which is one of the largest known impact craters in the solar system.
- The probe has recently entered a planned orbit to prepare for the first ever soft landing on the far side of the moon.
- Chang'e-4 will follow China's successful Chang'e-3 mission which soft-landed on the visible side of the Moon in 2013.
- The vehicle is similar to **Yutu, China's first lunar rover** launched in 2013 along with Chang'e 3.

1.74 HY-1C satellite

- It is a marine satellite launched by China recently.
- It was launched by Long March-2C rocket from the Taiyuan Satellite Launch Centre in Shanxi province.
- HY-1A was launched in 2002 and HY-1B satellite was launched in 2007.
- It was launched to help improve understanding of maritime waters and climate change.
- HY-1C can detect chlorophyll and suspended sediment concentrations and dissolved organic matter, which can affect ocean colour, as well as temperatures on the sea surface.
- The data will help survey fishery and aquaculture resources and environments, offering a scientific basis for reasonable exploitation and utilization of marine resources.
- Scientists will also use the data to study global environmental changes, the role of the oceans in the global carbon cycle and the El Nino phenomenon.

1.75 Cargo Spacecraft and Lunar Palace

- **Tianzhou-1** is the china's first cargo spacecraft launched by Long March Rocket form Hainan province.
- Chinese students will live in a laboratory simulating a lunar-like environment for up to 200 days as Beijing prepares for its long-term goal of putting humans on the moon.
- The volunteers will live in the sealed lab (dubbed the "**Yuegong-1**", or "Lunar Palace") to simulate a long-term, self-contained space mission with no input from the outside world.
- Human waste will be treated with a bio-fermentation process, and experimental crops and vegetables grown with the help of food and waste byproducts.
- The Lunar Palace is the **world's third bioregenerative life-support base**, and the first developed in China.

1.76 Quasi-Zenith Satellite System

- Quasi-Zenith is a regional terrestrial positioning network system launched by **Japan**.
- The satellite system consists of 4 satellites which will operate at an altitude of between 33,000 and 39,000 km above the earth in **geosynchronous orbit**.
- Its function is to improve GPS data accuracy for smartphones and vehicle navigation systems and complementary use of GPS.
- Japan recently launched its fourth and final quasi-zenith satellite into orbit.
- These satellites will be to establish communications during a malfunction of traditional networks due to a natural disaster.



1.77 **MINERVA-II1**

- Micro Nano Experimental Robot Vehicle for Asteroid (MINERVA) is the second-generation rover developed by Japanese Space Agency.
- It is the world's first man-made object to explore movement on an asteroid surface.
- It recently landed on Asteroid Ryugu and the world's first rover to land on the surface of an Asteroid.
- This is also the first time for autonomous movement and picture capture on an asteroid surface.
- It will collect a sample of the primitive world during its stay at Ryugu, to bring to Earth for laboratory analysis.

1.78 **Ibuki – 2**

- The Japan Aerospace Exploration Agency (JAXA) has successfully launched Ibuki-2 greenhouse gas observation satellite.
- Ibuki-2 is the successor to Ibuki, which was launched in 2009 as the world's first satellite dedicated to monitoring greenhouse gases.
- It is officially named Greenhouse Gases Observing Satellite, or Gosat.
- The satellite is designed to gather data on the densities of carbon dioxide and methane at 56,000 locations in the Earth's atmosphere to help international efforts to fight global warming.
- The data will be used to see how countries are doing in terms of fulfilling their commitments to reduce greenhouse gases under the 2015 Paris agreement.

1.79 **Kirameki -2**

- The Kirameki-2 satellite is the first military communication satellite launched by H-2A rocket from the Tanegashima Space Center in southern Japan.
- It is the first of three satellites that will replace three civilian ones currently used by Japan's military.
- The new satellites will allow military units to communicate on a high-speed and high-capacity network.

1.80 **Hope Mission**

- It is a Space mission by UAE which planned to send an unmanned probe to orbit Mars by 2021.
- It has become the first Arab Country to do so.
- The hope spacecraft will be a compact, hexagonal section spacecraft weighing approx. 1500 kg.
- The launching of the spacecraft is going to be coincided with the 50th anniversary of the founding of the UAE.

1.81 **Israel Spacecraft**

- Israel is set to launch the country's first spacecraft to the moon.
- If it becomes successful, it will be the first private spacecraft to be launched by Israel and would be the 4th country to land on the moon.
- The spacecraft, called Beresheet, or Genesis in Hebrew, weighing 585 kg.
- It will be sent via a Falcon 9 rocket from SpaceX firm.
- It will take around a month to arrive in the moon.

1.82 **Venus Satellite**

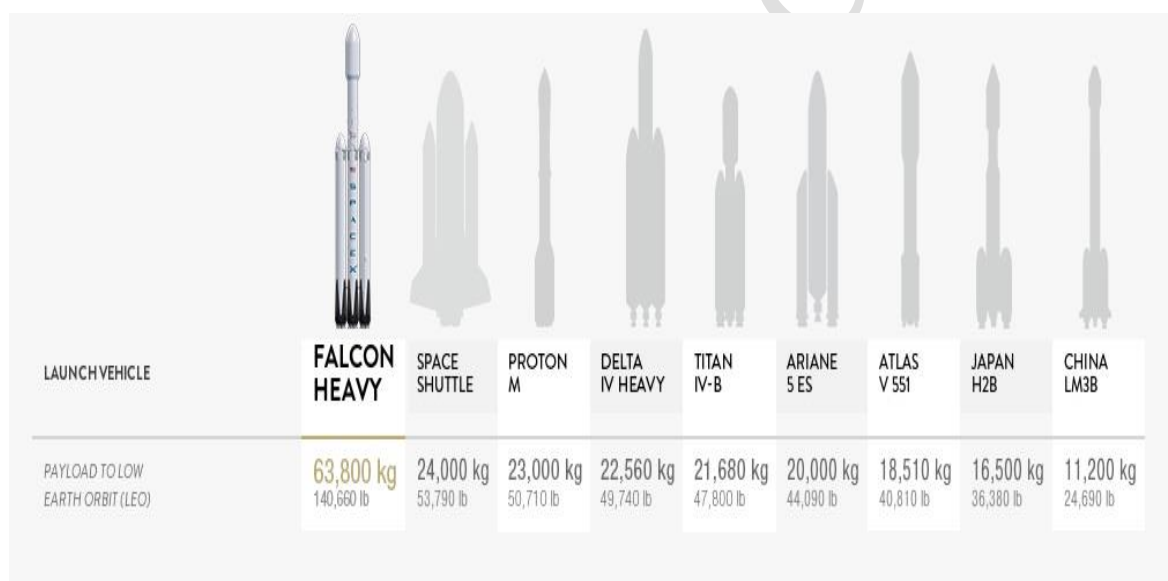
- The Venus satellite (Vegetation and Environment Monitoring New Micro-Satellite) is an earth-observation micro-satellite.
- It is designed jointly by **Israel's** agency and **France's** National Centre for Space Studies (CNES).
- The scientific mission will monitor Earth's vegetation using a camera capable of recording 12 narrow spectral bands.
- The microsatellite will send high-resolution photos to track climate change and aid efforts to tackle desertification, erosion, and pollution.

1.83 Remove Debris Mission

- The RemoveDEBRIS mission, scheduled to be launched later this year, is being led by the Surrey Space Centre (SSC) at the University of Surrey, **UK**.
- It is co-funded by the European Commission and other partners, including prominent European space companies and institutions.
- The mission started five years ago, aims to be a forerunner of missions to start removing some of the largest objects in space.
- It is expected to be launched to the International Space Station (ISS) in a capsule on board a SpaceX rocket.

1.84 Falcon Heavy

- Falcon Heavy is a reusable super heavy-lift launch vehicle designed and manufactured by SpaceX, a private American aerospace manufacturer.
- Its first test flight carrying a red sports car was successfully launched from florida pad used by NASA.
- It is the most powerful operational rocket in the world.
- It can lift about twice the payload at one third of the cost by Delta 4 rocket which was the most powerful rocket till now.
- This lift capacity allows launching heavier satellites into low Earth orbit, or reaching higher geostationary orbits to keep station over the same part of Earth.
- Its three first-stage boosters are designed to be reusable.



2. PLANETARY SYSTEMS

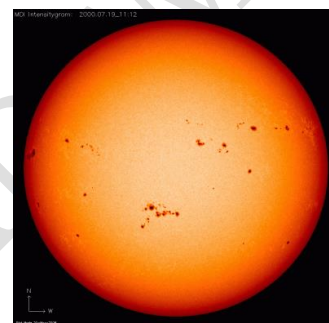
2.1 Sun's Atmosphere

- The sun's atmosphere corona is much hotter than its visible surface Photosphere.
- Normally, the layer closest to a source of heat, the Sun's surface, in this case, would have a higher temperature than the more distant atmosphere.
- But the reason for the high temperature is the constant eruption of tiny solar flares in the solar atmosphere.
- The solar flares produce hard X-rays, whose wavelengths are much shorter than the light humans can see and it is a signature of extremely hot solar material.
- **Lyrid meteor shower**
- The annual Lyrid meteor shower is set to reach a peak.
- The Lyrid meteor shower is one of the oldest known meteor showers

- They are caused by the Earth's annual trip through a cloud of dust and debris left behind by the comet C/1861 G1 Thatcher.
- It is classified as a medium-strength shower.
- A meteor shower happens when Earth passes through the path of a comet.
- When this happens, the bits of comet debris create streaks of light in the night sky as they burn up in Earth's atmosphere.
- Bits of debris which enter Earth's atmosphere are called meteors.
- A meteorite is a solid piece of debris from an object, such as a comet, asteroid, or meteoroid which survives its passage through the atmosphere to reach the surface of a planet or moon.

2.2 Solar Cycles and Sun spots

- The amount of magnetic flux that rises up to the Sun's surface varies with time in a cycle called the solar cycle, which lasts 11 years on average.
- This cycle is sometimes referred to as the sunspot cycle.
- Sunspots are regions where the solar magnetic field is very strong.
- In visible light, sunspots appear darker than their surroundings because they are a few thousand degrees cooler than their surroundings.
- They are usually concentrated in two bands, about 15 - 20 degrees wide in latitude, that go around the Sun on either side of the solar equator.



2.3 Presence of Water in the Moon

- Scientists have found frozen water deposits in the Moon's polar region using data from the Chandrayaan-1 spacecraft.
- The ice deposited on the surface would possibly acts as a resource for future expeditions to explore Moon.
- Scientists used NASA's Moon Mineralogy Mapper (M3) instrument aboard Chandrayaan-1 spacecraft to confirm the presence of solid ice using specific signatures.
- This is not the first time that evidence of water has been found on the Moon.
- In 2009, observations of NASA's EPOXI spacecraft showed the evidence of presence of water across the lunar surface.
- After 2009, the data from ISRO's hyperspectral imager aboard Chandrayaan-1, supplemented the evidence.
- The recent finding shows that water ice lies in the shadows of craters in the Moon's polar region, where the warmest temperatures never reach above -250°F.

Chandrayaan-1

- Chandrayaan-1 is India's first mission to Moon launched in 2008 by PSLV-C11.
- The spacecraft is orbiting around the Moon at a height of 100 km from the lunar surface for chemical, mineralogical and photo-geologic mapping of the Moon.
- It also carried the payloads built in UK, USA, Bulgaria Germany and Sweden.
- The mission comprised an orbiter and an impactor launched by ISRO's workhorse PSLV.

2.4 Super Blood Wolf Moon

- It is a phenomenon wherein the Moon appears particularly large and bright with a reddish glow.
- A supermoon happens when the full moon coincides with the moon's closest approach to Earth in its orbit (perigee).
- It makes the moon appear a little brighter and closer than normal.
- Blood during a total lunar eclipse when the Earth passes in between the Sun and the Moon.
- Earth blocks the Sun's light from falling directly on the Moon so the only light the moon gets is reflected off of Earth.
- Earth's atmosphere scatters blue so only the red light gets reflected onto the Moon's surface and makes it look red.
- Wolf Moon is the name given by Native Americans to a full moon that appears in January.

- So Super Blood Wolf Moon = Full Moon + Perigee + Lunar Eclipse + January
- A lunar eclipse only takes place when there is a full Moon.

2.5 Super Blood Blue Moon

- Super Blood Blue Moon = Super moon + Blue moon + Total Lunar Eclipse
- **Super moon** – It occurs when the full moon coincides with the Moon's closest orbit point (perigee) to Earth.
- During a super moon, the moon appears 14% larger and 30% brighter.
- The farthest distance between the moon and the Earth is termed 'apogee', while the perigee is the nearest point.
- **Lunar Eclipse** – It occurs when the Sun, the Earth and the Moon are so aligned that the full moon passes through the shadow of Earth.
- The moon gliding into Earth's shadow will gradually turn in to orange or red.
- This is because the sunlight passing through the Earth's atmosphere break down and red part gets scattered by the atmosphere and falls on the Moon's surface.
- For this reason, a totally eclipsed moon is called a "Blood Moon".
- **Blue Moon** - It refers to the second full moon (or second lunar eclipse) in a month.
- The Moon does not turn blue but historically the second full Moon of an English calendar month is termed as a Blue Moon.
- Typically, it happens every two years and eight months.
- The world is going to witness this event on Jan 31st in parts of western North America, Asia, the Middle East, Russia and Australia

2.6 Pink Moon

- The full moon in April is called the 'pink moon' in North America.
- It is to represent ground phlox, which are ground-cover flowering plants and usually bloom around springtime.
- The April moon is also known as the Sprouting Grass moon, the Egg Moon and the Fish Moon.
- These names are all Native American names for the phenomenon.
- Every month's full moons are named by the tribes.
- As the early Native American tribes did not record time using either the Julian or the Gregorian calendars, they used the moons to keep track of seasons.

2.7 Longest Lunar Eclipse of the Century

- A total lunar eclipse will occur on July 27-28, 2018 with a totality duration of 1 hour 43 minutes which makes it the **longest total lunar eclipse** of this century (2001 AD to 2100 AD).
- In this eclipse, the Moon will pass through the central part of the Earth's umbral shadow.
- **Longer eclipse** – The moon will be at apogee, means at farthest from the Earth in its orbit and will be moving at a slower speed in its orbit.
- This slower moving full Moon will take longer time and greater distance of Earth's umbral shadow cone to travel, making it the longest duration of total eclipse of this century.
- **Brighter Moon** - On July 27, the red planet Mars, will also be at opposition, meaning that the Sun and Mars will lie opposite to each other, keeping the Earth in the middle.
- This will result in Mars coming close to the Earth, causing it to appear brighter than normal.

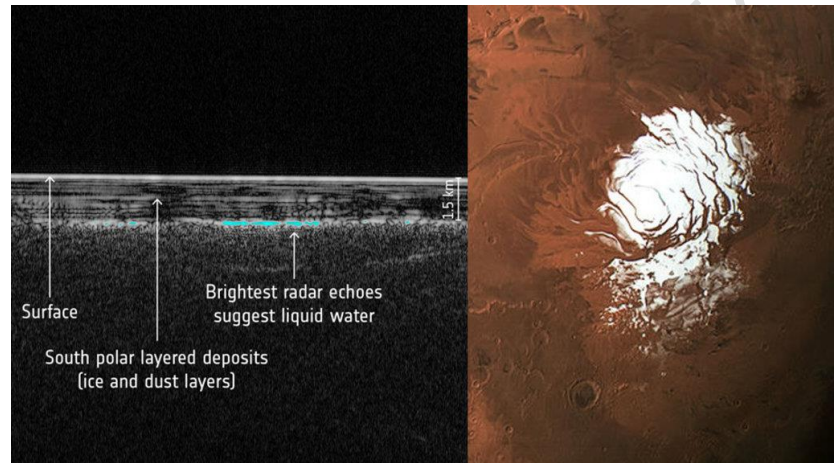
2.8 Kordylewski Clouds

- The Kordylewski clouds are two mysterious swarms of dust trapped between the competing gravitational fields of Earth and the Moon.
- These clouds occupy positions that are called Lagrange points.

- In 1961, Polish astronomer Kazimierz Kordylewski became the first scientist to claim photographic evidence of this dust accumulation phenomenon.
- Recently, team of scientists captured evidence of these clouds at Lagrange point L5.
- They identified it using a technique called sequential imaging polarimetry to detect the extreme faintness of the particles.

2.9 Liquid Water Lake in Mars

- Scientists have recently discovered a liquid water 'lake' in Mars stretching for 20-km.
- It is found 1.5 km under the southern polar ice cap of Mars.
- Despite temperatures at about -68°C , the water remains in a liquid form.
- The radar profile of the lake closely matches those of subglacial lakes on Earth, beneath the ice sheets of Greenland and Antarctica.
- Atmospheric pressure on the Martian surface is almost a hundred times less than on Earth.
- This ensures that water would not be in liquid form, but rather, as ice or vapour.
- So the presence of water in liquid form could be due to the heavy presence of sodium, magnesium and calcium salts.
- This may reduce the temperature and help it retain liquid form.
- This, along with the immense pressure of the ice from above, lowers the freezing point.



2.10 Definition of a Planet

- There is a recent debate among the astronomical community to reclassify Pluto as a planet.
- International Astronomical Union (IAU), a group of experts, is the authorised body to define the criteria for any object to be designated as a planet.
- In 2006, IAU defines three criteria to classify any object as a planet
- It needs to be in orbit around any fully-fledged star.
- It needs to have enough gravity to pull itself into a spherical shape.
- It has cleared the neighbourhood around its orbit
- This last criterion is the point at which planets and dwarf planets differ. Dwarf planets have other objects in their orbit around their star.
- In accordance with this, IAU decided to demote Pluto as a dwarf planet.
- IAU recognizes five named dwarf planets - Ceres, Pluto, Eris, Haumea, and Makemake.
- Except Ceres, other dwarf planets are also known as Plutoids.

2.11 Graveyard Orbits

- It is a higher orbit where the satellites are transferred to after they reach the end of their mission.
- It is mostly used for the disposal of geostationary satellites that orbit directly above Earth's equator at a height of 35,786 kilometers.
- It usually lies 300km above the geostationary orbit.
- When a geostationary satellite nears the end of its lifetime (10 to 15 years), it is programmed to use its remaining fuel to propel itself into the graveyard orbit.

- This is done to prevent collisions with other operational satellites and also to make space for new satellites in the geostationary orbit.

2.12 Rogue Planet

- A rogue planet or starless planet is a planetary-mass object that orbits the galaxy directly.
- They have either been ejected from the planetary system in which they formed or have never been gravitationally bound to any star or brown dwarf.

2.13 Ganymede

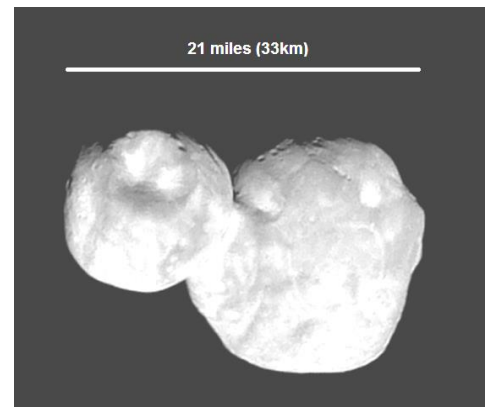
- The data from NASA's Galileo spacecraft shows that the Jupiter's moon Ganymede has a magnetic field unlike any other.
- Ganymede is a unique solar-system body because it's the only moon with an internally generated magnetosphere.
- This magnetic-field region surrounds Ganymede like a bubble and shelters it from cosmic radiation.
- Just like on Earth, the magnetosphere causes auroras near this moon's poles.
- Galileo mission was the first to enter orbit around the planet.
- Galileo data allowed the creation of the first detailed maps of Jupiter's major moons.

2.14 Asteroid & Comet

- An asteroid is a small, naturally occurring, solar system body that orbits the sun. Asteroids are typically composed of rock-forming minerals, most commonly olivine and pyroxene.
- However, they often contain metal (iron and nickel), sulfides (chemical mixtures of metals and sulfur), clays, and organic compounds. The structure and composition of asteroids vary from object to object.
- Most asteroids in our solar system reside in the region between Mars and Jupiter known as the Asteroid Belt.
- A **comet** is a small body composed mostly of dusty material embedded with icy volatiles, such as water and carbon dioxide that formed in the **cold outer solar system**.

2.15 Ultima Thule

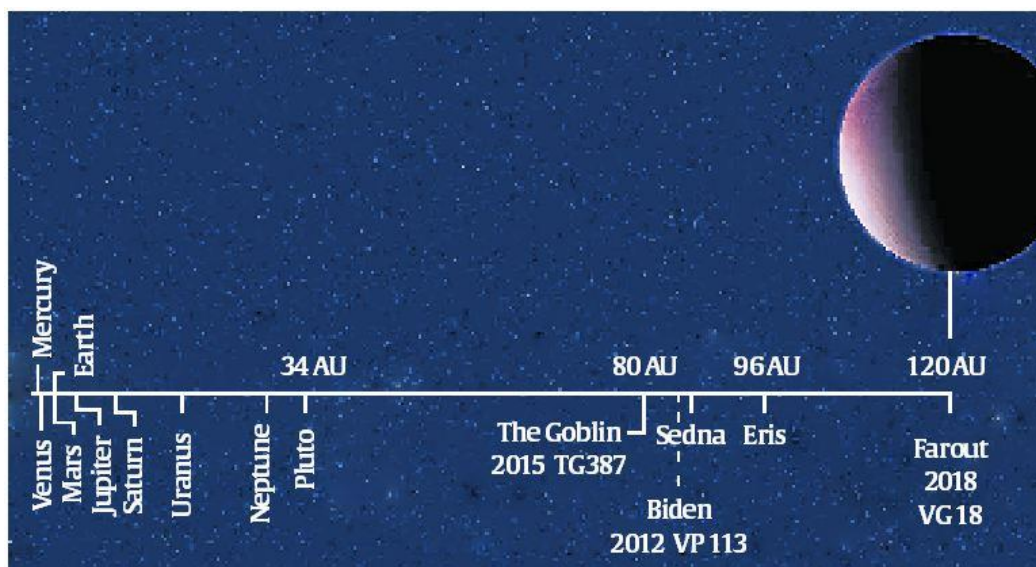
- Officially called, MU₆₉, is a contact binary composed of two joined bodies 19 km and 14 km across that are nicknamed "Ultima" and "Thule", respectively.
- When two asteroids collide and get stuck together it is known as a contact binary.
- It is named after a mythical island in medieval literature.
- Ultima Thule means 'beyond Thule', beyond the borders of the known world, symbolizing the exploration of the distant Kuiper Belt and Kuiper Belt objects.
- It was discovered in 2014 with the help of the Hubble Space Telescope.
- Scientists are not sure whether it is round or oblong or even if it is a single object or a cluster.
- It is the farthest and quite possibly the oldest, cosmic body ever photographed by humankind.
- Scientists decided to study it with New Horizons launched in 2006 after the spaceship completed its main mission of flying by Pluto in 2015 and returning the detailed images of the dwarf planet.



2.16 Farout

- Astronomers have reported the discovery of the most distant body ever observed in the Solar System, at 120 astronomical units (AU) from the Sun.
- This has led to the nickname "Farout" for the object, provisionally titled 2018 VG18.
- Farout is also the first known Solar System object that has been detected at a distance that is more than 100 times farther than Earth is from the Sun.

- For context, the second-most distant observed Solar System object is Eris, at about 96 AU. Pluto is currently at about 34 AU.
- 1 AU is defined as the distance between the Earth and the Sun.



2.17 Ryugu Asteroid

- A Japanese Probe “Hayabusa2” has recently reached “Ryugu”, an asteroid 300 million km away from Earth.
- Japan Aerospace Exploration Agency, JAXA has launched the probe in 2014.
- The aim of the mission is to collect information about the birth of the solar system and the origin of life.
- It identify suitable sites to take samples from once the probe touches down on the asteroid.
- It will deploy a small lander and three rovers.
- It will then blast an artificial crater to analyze material below the asteroid's surface. After that, the probe will head back to Earth, arriving near the end of 2020 with samples in tow.

2.18 Oumuamua

- Oumuamua is the first interstellar object known to enter our solar system.
- It accelerated faster away from the sun than expected. This has created the notion that some kind of artificial sail (force of radiation pressure that runs on sunlight) may have pushed it.
- This artificial sunlight known as “Light sail” may be responsible for the excess acceleration of the object.



2.19 Habitable exoplanet next to Earth

- The exoplanets are planets that exist outside Earth's solar system.
- The term “habitable zones” refers to a planet where water could exist in a liquid state on a planet’s surface if there's sufficient atmospheric pressure.
- Astronomers have located the habitable zone “**The Wolf 1061**”, a planetary system that is 14 light years away from the Earth.
- One of the planets in the wolf planetary system, **Wolf 1061c**, is entirely within the habitable zone which has an atmosphere more similar to Venus.
- But the climate of Wolf 1061c is quite chaotic compared to earth, since the orbit around its star changes at a much faster rate than earth. The earth also experiences climate change due to change in its orbit around the sun which resulted in ice age previously.

2.20 TRAPPIST-1

- It is a system of seven Earth-size planets orbiting an ultra-cool dwarf star about 40 light-years away.
- This is by far the largest collection of Earth-like planets in the habitable '**Goldilocks**' zone of a star.
- **Goldilocks** represents a zone which is neither too close nor too far from a star, which raises the possibility of liquid water being present on the surface.
- Unlike earlier discoveries of exoplanets, all seven planets could possibly have liquid water.
- Three of the planets have the greatest chance.
- Since the initial discovery of three planets was made using the Chile-based Transiting Planets and Planetesimals Small Telescope, the exoplanet system is called TRAPPIST-1.
- The TRAPPIST-1 planets have lower densities than Earth.
- In a new study, researchers found that the TRAPPIST-1 star is quite old: between 5.4 and 9.8 billion years.
- Recent evidence from NASA's Hubble space telescope revealed that earth sized exoplanets in the Trappist-1 system may contain water.

2.21 MAMMOTH-1

- A nebula is an interstellar cloud of dust, hydrogen, helium and other ionized gases.
- Astronomers have spotted an enormous, glowing blob of gas i.e Enormous Lyman-Alpha Nebula (ELAN) named Mammoth-1.
- It is in the middle of a region with an extraordinary concentration of galaxies called a "protocluster,".
- It has no obvious source of power for the light it is emitting.
- It is the brightest and among the largest of these rare objects.

2.22 Northwest Africa 7635

- It is a meteorite discovered in Algeria, Africa in 2012.
- It has given insight into volcanic activity on Mars.
- The largest Volcano in the solar system, Olympus Mons, is found on Mars.
- But by analysing the chemical composition NA7635, scientists learnt that Mars had a single volcano that continuously erupted for 2 billion years.
- Martian volcanoes can grow to such enormous proportions because unlike Earth, Mars doesn't have plate tectonics that constantly shuffle the surface.
- So the magma for the volcano in Mars gets hot magma from its interiors for billions of years continuously.

2.23 Pluto Mountains

- Two mountain ranges on Pluto have been named after Tenzing Norgay and Edmund Hillary respectively by the International Astronomical Union (IAU).
- These are the first geological features on the planet to be named following the close flyby by the New Horizons spacecraft in July 2015.
- IAU has officially approved the naming of 14 features on the dwarf planet for the first time.
- IAU is the internationally recognised authority for naming celestial bodies and their surface features.
- Tenzing Norgay and Sir Edmund Hillary were the first to reach the summit of Mount Everest and return safely.

2.24 Super Earth

- Scientists have discovered a new Earth-like planet, Super Earth, orbiting a red dwarf star "**LHS 1140**" about 40 light-years away.
- The astronomers estimate the age of the planet to be at least five billion years.



- The red dwarf star LHS 1140 is much smaller and cooler than the sun and the super Earth LHS 1140b is ten times closer to its star than the Earth.
- The super Earth has a mass around 7 times greater than the Earth and receives about half as much sunlight from its star as the Earth and lies in the middle of the habitable zone.
- The greater mass and higher density of the super Earth implies that the exoplanet is probably made of rock with a dense iron core.

2.25 Mapping of the Universe with Quasar position

- Astronomers have created the first map of the large-scale structure of the universe based entirely on the positions of quasars.
- Quasars are the incredibly bright and distant points of light powered by super-massive black holes.
- The amazing brightness of quasars is due to the supermassive black holes found at their centres.
- As matter and energy fall into a quasar's black hole, they heat up to incredible temperatures and begin to glow.
- To make their map, scientists used the Sloan Foundation Telescope to observe an unprecedented number of quasars.

2.26 Radio Galaxy Spotted

- Radio galaxy are colossal galaxies with a **super massive black hole** in their centre that actively accretes gas and dust from its surroundings.
- They are very rare objects in the universe.
- Most distant radio galaxy ever known, located at a distance of 12 billion light-years was discovered by Indian Telescope.
- It was found using the Giant Metrewave Radio Telescope (GMRT) in Pune, operated by the National Centre for Radio Astrophysics.
- The distance to this galaxy was determined using the Gemini North telescope in Hawaii and the Large Binocular Telescope in Arizona.
- This discovery is important for understanding of the formation and evolution of galaxies.

2.27 Proxima Centauri

- It is the closest star to Sun.
- It is a faint red dwarf lying four light years away in the southern constellation of Centaurus.
- It is orbited by the Earth-sized Proxima b which is the closest exoplanet to the solar system.
- Scientists have recently detected dust belts around Proxima Centauri, by the Atacama Large Millimeter Array (ALMA) Observatory in Chile.
- The presence of dust belts indicates the presence of an elaborate planetary system hosted by it.

2.28 Kepler 90i

- NASA has recently announced that it found another solar system with 8 planets.
- The historic discovery was made by new scientific analysis of data obtained by the Kepler space telescope.
- Kepler 90 is the first star to host as many planets as our own solar system.
- The new planet "Kepler 90i" is a small rocky planet, but very close to the sun which is hotter than Earth
- It is located 2,500 light years from Earth and it orbits its home star every 14 days and is about 30% bigger than Earth.
- The planets in the Kepler 90 system orbit much closer to their host star than Earth is to the sun.
- It is similar to the seven planets in the TRAPPIST-1 system, previously thought to be the next biggest solar system.



2.29 Rare and Isolated Neutron Star

- The NASA scientists have discovered a special kind of neutron star for the first time outside of the Milky Way galaxy.
- Neutron stars are the ultra dense cores of massive stars that collapse and undergo a supernova explosion.
- The newly identified neutron star was discovered by using data from NASA's Chandra X-ray Observatory and the European Southern Observatory's Very Large Telescope (VLT) in Chile.
- It is a rare variety that has both a low magnetic field and no stellar companion.
- Oxygen-rich supernova remnants of neutron stars E0102 are important for understanding how massive stars fuse lighter elements into heavier ones before they explode.

2.30 Sagittarius A*

- It is believed to be a super massive black hole in the Milky Way Galaxy.
- It is 4 million times heavier than sun.
- The gravity produced by it is so intense that stars many times more massive than our sun orbit around it at incredible speeds.
- One of the stars, called S2, recently passed by the black hole at a speed of nearly 3% of the speed of light.
- The passerby of the S2 was observed by Very Large Telescope of European Space Agency.
- It proved Albert Einstein's general theory of relativity is correct.
- Einstein predicted that when light (such as the light emitted from S2) passed so close to such a powerful source of gravity, it would lose some of its energy.
- In a way, the light has to struggle to move through the field of intense gravity.
- The light from S2 star has shown that it does lose some of its energy during its passage around the Black Hole.

2.31 Saraswati - Supercluster of Galaxies

- A team of Indian scientists has reported the discovery of a 'supercluster' of galaxies and named it Saraswati.
- It is located four billion light years away from the earth.
- Galaxies are themselves made of billions of stars and planets, and a cluster typically contains several hundreds of these galaxies.
- Superclusters, a group of clusters of galaxies, are the largest structures of stars, planets and other heavenly bodies in the Universe.
- The Milky Way galaxy, of which the Earth is a very small member, is part of the Laniakea supercluster, which was identified only in 2014.

2.32 Farthest galaxy

- NASA has spotted the farthest known galaxy, a primitive cluster of stars just 500 million years old.
- The galaxy was named SPT0615-JD.

2.33 Kuiper Belt

- The Kuiper Belt is a region of the Solar System that exists beyond the eight major planets.
- It is similar to the asteroid belt, in that it contains many small bodies, all remnants from the Solar System's formation.
- But unlike the Asteroid Belt, it is much larger – 20 times as wide and 20 to 200 times as massive.

2.34 Ancient Spiral Galaxy

- Scientists have discovered the most ancient spiral galaxy in the universe that existed 11 billion years ago.
- The galaxy, known as A1689B11, existed just 2.6 billion years after the Big Bang.
- Researchers used the Gemini North telescope in Hawai'i to verify the vintage and spiral nature of the galaxy.
- Spiral galaxies are exceptionally rare in the early universe.

- In spiral galaxy, the stars and gas clouds are concentrated mainly in one or more spiral arms.

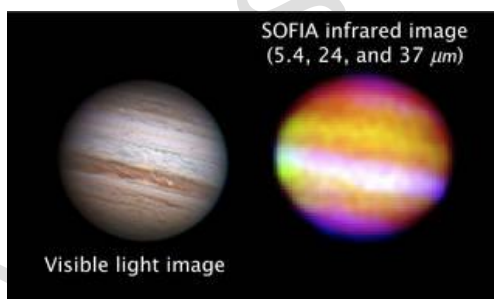
2.35 Tabby's star

- Tabby's star is the "most mysterious star in the universe" as it kept dimming and brightening irregularly, following no pattern.
- Officially called KIC 8462852, the star is 1,000 light years away from the Earth and 1,000 degrees hotter than the Sun.
- There was a 20% decrease in brightness and the dip lasted from five to 80 days.
- A recent report showed that the dimming is caused by ordinary dust particles, the majority of them at a size less than one micrometre.

3. TELESCOPES & OBSERVATORIES

3.1 SOFIA

- SOFIA, the Stratospheric Observatory for Infrared Astronomy, is the largest airborne observatory in the world.
- It consists of an extensively modified Boeing aircraft carrying a reflecting telescope with an effective diameter of 2.5 meters.
- The observatory is based at NASA's Armstrong Flight Research Center in Palmdale, California.
- The project is implemented by NASA and German Aerospace Center (DLR).
- Many objects in space emit almost all their energy at infrared wavelengths. Often, they are invisible when observed in ordinary visible light.
- Thus SOFIA observes universe in infrared wavelengths to get the expanded views.
- It is preparing for its 2018 campaign for observing Saturn's giant moon Titan.



Jupiter in Visible and Infrared Image

3.2 Gravitational Wave Observatory

- A gravitational wave (GW) is a concept, predicted by Einstein through his theory of general relativity which states that mass distorts both space and time.
- When an object accelerates, it creates ripples in space-time, just like a boat causes ripples in a pond. These space-time ripples are gravitational waves.
- GWs are caused by cataclysmic events that result in high-energy explosions, such as collision of black holes or neutron stars.
- GWs are extremely weak and so are very difficult to detect.
- Strength of the wave depends on the mass of the object and requires extremely sensitive detectors to sense them.
- Missions like **LIGO (Laser Interferometer Gravitational-wave Observatory) in U.S** helps to spot gravitation waves, detecting small changes in the distances between objects at set distances.
- **LIGO:** It is a large-scale physics experiment and observatory with the mission to **directly observe gravitational waves of cosmic origin.**
- A fourth gravitational wave has been detected with help from **Italy-based equipment Virgo detector.**

- The Virgo detector is an underground L-shaped instrument that tracks gravitational waves using the physics of laser light and space.
- The underground stations are known as interferometers, do not rely on light in the sky, but instead sense vibrations in space created by a gravitational wave.
- The Japanese **KAGRA detector** is set to go online in 2019 and LIGO India set to join by 2024.
- Previously, gravitational waves have been found using two U.S.-based detectors known as the Laser Interferometer Gravitational-Wave Observatory (LIGO).
- **LIGO-India**, or INDIGO, is a planned collaborative project between the LIGO Laboratory and the **Indian Initiative in Gravitational-wave Observations (IndIGO)** to create a world-class gravitational-wave detector in India.
- A site in the Hingoli district (Maharashtra) has been selected.
- **Noble Prize for Physics** - Rainer Weiss, Barry C. Barish's and Kip Thorne's were jointly awarded the Nobel Prize for physics for their contribution to the LIGO-VIRGO project and its detection of gravitational waves.

3.3 Ngari observatory

- China is working to set up the world's highest altitude gravitational wave telescope "Ngari No.1" in **Tibet Autonomous Region**.
- It is to detect the faintest echoes resonating from the universe, which may reveal more about the Big Bang.
- The telescope, located 5,250 meters above sea level, will detect and gather precise data on **primordial gravitational waves in the Northern Hemisphere**, which have never been detected.
- The primordial gravitational waves were created about 13.8 billion years ago by the Big Bang explosion.
- The observatory is expected to be operational by 2021.
- Tibet is considered as the best location in the northern hemisphere to detect the G-waves due to thin air and its dry climate, which reduces the influences of moisture on the primordial sub millimeter G-waves.
- Ngari observatory will be among the world's top primordial gravitational wave observation bases, alongside the South Pole Telescope and the facility in Chile's Atacama Desert.
- China has also announced setting up of **FAST**, a 500-meter aperture spherical radio telescope in southwest China's Guizhou Province.

3.4 Chandra X-ray Observatory

- NASA's Chandra X-ray Observatory is a telescope specially designed to detect X-ray emission from very hot regions of the Universe such as exploded stars, clusters of galaxies, and matter around black holes.
- It is a space based telescope. Since the Earth's atmosphere absorbs the vast majority of X-rays, they are not detectable from Earth-based telescopes
- Chandra is an Earth satellite in a 64-hour orbit, being operated in space since 1999.
- Chandra is one of the Great Observatories, along with the Hubble Space Telescope, Compton Gamma Ray Observatory (1991–2000), and the Spitzer Space Telescope.

3.5 Hubble Space Telescope

- It is the world's first large, space-based optical telescope, named in honor of astronomer Edwin Hubble.
- The Hubble is a joint project between NASA and the European Space Agency.
- Sun is the energy source of this space based telescope.
- Hubble Telescope has tracked the Neptune's Mysterious Shrinking Storm.
- Some of the interesting Hubble Discoveries are
 1. Creating a 3-D map of mysterious dark matter.
 2. Discovering Nix and Hydra, two moons of Pluto.
 3. Helping determine the rate of the universe's expansion.

4. Discovering that nearly every major galaxy is anchored by a black hole.
5. Helping refine the age of the universe.

3.6 James Webb Telescope

- NASA's James Webb Telescope is the world's **premier infrared space observatory** of the next decade.
- It is developed in coordination among NASA, the European Space Agency, and the Canadian Space Agency.
- It is the most sophisticated and expensive space observatory ever designed.
- It is scheduled for launch in 2019 aboard a European Ariane 5 rocket from French Guiana and to orbit at Earth's second Lagrange point (L2).
- It will study every phase in the history of our universe, ranging from the first luminous glows after the Big Bang, to the formation of solar systems capable of supporting life on planets like Earth, to the evolution of our own Solar System.
- It was formerly known as the "Next Generation Space Telescope".

3.7 Kepler Telescope

- It is an observatory in space dedicated to finding planets outside our solar system.
- It was originally launched in 2009 as part of NASA's Discovery Program.
- It recently ran out of fuel and was retired nearly after 9-year mission.
- It was approved far beyond its original mission length and was operating well until May 2013, when a second of its four reaction wheels or gyroscopes failed.
- It targets particularly alien planets that are around the same size as Earth in the "habitable" regions of their parent star.
- Since 2009, it has discovered extra-solar planets in the range between the size of Earth and Neptune.
- It was the first telescope to find a planet (Kepler-69c) approximately the size of Earth in the habitable region of a star.
- It examined the TRAPPIST-1 system which likely has multiple Earth-sized planets in it between December 2016 and March 2017.

3.8 SPHEREx

- NASA will launch a new space telescope in 2023 called SPHEREx.
- It would provide a glimpse of the first moments in the history of the universe, and explore how common are the ingredients for life in our galaxy's planetary system.
- SPHEREx is the Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer.
- NASA plans it as a two-year mission.
- It will survey the sky in optical as well as near-infrared light which serves as a powerful tool for answering cosmic questions.

3.9 Giant Magellan Telescope

- The telescope will be one member of the next class of **giant ground-based telescopes**.
- It is going to be commissioned in 2023.
- It is proposed to be located in Chile's Atacama Desert, one of the highest and driest locations on earth.
- It will have a resolving power 10 times greater than the Hubble Space Telescope.

3.10 SPARCS telescope

- Star-Planet Activity Research CubeSat, or SPARCS, is a new NASA-funded space telescope and will be launched in 2021.
- It will be launched into the Earth's orbit that will monitor the flares and sunspots of small stars using ultraviolet light to assess how habitable the environment is for planets orbiting them.

- It will study the habitability and high-energy environment around stars called “M dwarfs”.
- M dwarf is the smallest kind of star with masses ranging from about 50 percent of the Sun’s mass down to about 8 percent of the Sun’s mass.

3.11 Very Large Telescope

- It is the world's most advanced visible-light astronomical observatory.
- It is located on the mountain Cerro Paranal in **Chile** and consisting of four telescopes with mirrors.
- These telescopes can operate individually or together as an interferometer.
- The large telescopes are named Antu, Kueyen, Melipal, and Yepun, which are the names for the Sun, the Moon, the Southern Cross, and Venus in the language of the Mapuche people.
- It successfully integrated the light from all four of its 8.2-meter (27 feet) unit telescopes into a new instrument.

3.12 Giant Metrewave Radio Telescope

- GMRT serves as a unique facility for radio astronomical research using the metrewavelengths range of the radio spectrum.
- It is located at a site about 80 km north of **Pune**.
- It is an array of thirty fully steerable parabolic radio telescopes of 45 metre diameter, observing at metre wavelengths
- The metre wavelength part of the radio spectrum has been particularly chosen for study with GMRT because man-made radio interference is considerably lower in this part of the spectrum in India.

3.13 ARIES Telescope

- ARIES telescope is a joint collaboration between Indian, Russian, and Belgian scientists
- The telescope is located at **Devasthal, Nainital** at a height of 2,500 metres
- The telescope will be used in the study and exploration of planets, starts, magnetic field and astronomical debris.
- The high end technology incorporated in the telescope enables it to be operated with the help of remote control from anywhere in the world.

3.14 X-Calibur Telescope

- It is a telescope that has been successfully launched recently by US scientists from the McMurdo Station in Antarctica.
- It was launched on a helium balloon intended to reach an altitude of 130,000 feet i.e at nearly four times the cruising altitude of commercial airliners, and above 99 per cent of the Earth’s atmosphere.
- It will analyse X-rays arriving from distant neutron stars, black holes and other exotic celestial bodies.
- The prime observation target will be Vela X-1, a neutron star in binary orbit with a supergiant star.
- Neutron stars are objects of very small radius (typically 30 km) and very high density, composed predominantly of closely packed neutrons.
- Neutron stars are thought to be formed by the gravitational collapse of the remnant of a massive star after a supernova explosion.
- It is the same process by which black holes are formed except that here the star is not massive enough to produce a black hole.
- Supergiant stars are the largest stars in the universe. They can be thousands of times bigger than our Sun and have a mass up to 100 times greater.
- The largest known supergiant star, **VY Canis Majoris**, is up to 2,100 times the size of the Sun.
- Binary stars are two stars orbiting a common center of mass.

3.15 INO Project

- The neutrino observatory is the most ambitious scientific research facility that India is trying to build.
- Neutrinos are tiny particles, almost massless, that travel at near light speeds.
- They are born from violent astrophysical events like exploding stars, nuclear fusion in the sun and gamma ray bursts.
- Detected for the first time in 1959, though their existence was predicted almost three decades earlier, in 1931, neutrinos were later found to be **omnipresent**.
- They are the **second most abundant particles in the world**, after photons and can move easily through matter.
- These high-energy particles are **produced in natural radioactive decays** and all sorts of nuclear reactions happening in nuclear power reactors, particle accelerators or nuclear bombs.

- But the most **common source** of neutrinos are celestial phenomena i.e., the birth and death of stars, collisions and explosions happening in space.

- **The core of the Sun is an important source of neutrinos.**

- A large number of the neutrinos were produced at the time of the Big Bang, making them good candidates to extract more **information from about the origins of the universe.**

- But because they are **electrically neutral and almost massless**, these neutrinos have an extremely low tendency to interact with other objects.

- This is the reason why scientists have to go deep underground to set up special detectors in a bid to catch the faint signals of neutrinos in an environment that is relatively free from 'noise' and disturbance.

- The proposed INO project primarily aims to study atmospheric neutrinos in a 1,300-m deep cavern in the Bodi West Hills in Theni district, Tamil Nadu.

- If completed, it would house the largest magnet in the world.

2.36 Green Propellants

- ISRO is developing green propellants for use in future rocket & satellite propulsion systems.
- It has made a beginning by developing an eco-friendly solid propellant to eliminate the emission of chlorinated exhaust products from rocket.
- The propellants are based on Glycidyl Azide Polymer (GAP) as fuel and Ammonium Di-Nitramide (ADN) as oxidizer.
- ISRO is also carrying out various technology demonstration projects involving green propellant combinations such as Hydrogen Peroxide (H₂O₂), Kerosene, Liquid Oxygen (LOX), Liquid Methane etc.
- It has successfully developed **ISROSENE**, which is a rocket grade version of kerosene as an alternative to conventional hydrazine rocket fuel.
- It has already used Liquid oxygen and liquid hydrogen combination in cryogenic upper stage of GSLV MK-III.

NEUTRINOS

ARE THE second most abundant subatomic particles after photons, and one of the several fundamental particles the universe is built of. They have no charge, but are thought to have a small, as-yet-undetermined, mass. They are everywhere, but are extremely difficult to detect because they interact poorly with other objects, passing through the human body without a trace.

NEUTRINOS are thought to have been produced just after the Big Bang that created the universe. The neutrino density of the universe is 330 per cubic centimetre.

100 TRILLION neutrinos are believed to pass through the human body every second.

50,000 TONNES of magnets will make up the iron calorimeter detector.

23 INSTITUTIONS are part of the project, involving over 100 engineers and physicists.

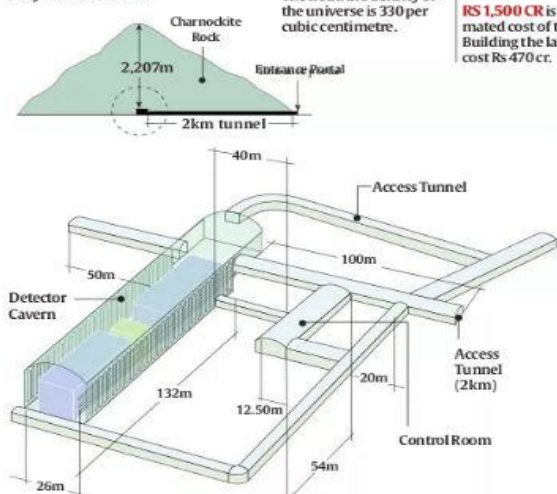
RS 1,500 CR is the estimated cost of the project. Building the lab is likely to cost Rs 470 cr.

PROJECTS ELSEWHERE

CHINA: Jiangmen Underground Neutrino Observatory in Kaiping, Jiangmen, aims to determine mass hierarchy of the three types of neutrinos and their oscillation properties, using a 20,000-tonne liquid scintillator detector.

JAPAN: Hyper-Kamiokande detector at the Kamioka Observatory in Hida aims to determine mass hierarchy and study cosmic neutrinos, using 2 cylindrical tanks filled with 1 million metric tonnes of ultrapure water as detector.

EUROPE: The Large Apparatus studying Grand Unification and Neutrino Astrophysics, or LAGUNA, is a European project aimed at building a next-generation neutrino observatory.



2.37 Indo-UN Small Satellites Programme

- UNSSP is launched by ISRO to train 90 qualifying engineers from various countries to build and test three small satellites each year.
- ISRO's Bengaluru-based U.R. Rao Satellite Centre (URSC) until recently known as ISAC will train the overseas students.
- Students will be hosted in Bengaluru for two months each year and work in three annual batches of 30.
- This capacity-building programme is in response to a request that the UN Office for Outer Space Affairs had made to space-faring nations last year.
- **UNISPACE+50** - It is an event marking the 50th year of the first UN Conference on the Exploration and Peaceful Uses of Outer Space.

3.16 Excitonium

- Scientists have proven the existence of new form of matter called excitonium.
- There are five known phases, or states, of matter: solids, liquids, gases, plasma and Bose-Einstein condensates.
- The main difference in the structures of each state is in the densities of the particles.
- Excitonium is a condensate.
- It is made up of particles known as excitons, which are made from an escaped electron.
- It exhibits phenomena like a superconductor.

4. DEFENSE

Artillery

4.1 Pinaka Mark I

- It is an indigenous multi-barrel unguided rocket launch system developed by DRDO for firing of multiple warheads.
- It was used in the 1999 Kargil conflict. Range - 40 km.
- It was later transformed in to a short-range precision guided missile and thus renamed as Guided Pinaka – Mark II.
- It has high accuracy and equipped with a navigation, guidance and control system with a range of 70 to 80 km.
- The missile is currently undergoing trials and expected to be delivered to the Army in 2 years.
- A Multiple rocket launcher is a type of rocket artillery system with multiple warheads and it was launched simultaneously by an unguided system.
- Guided Missile is a self propelled and launched by a precision guided system and it has 4 components such as targeting/missile guidance, flight system, engine and warhead.



4.2 Dhanush Artillery Gun

- It is an indigenously developed gun and upgraded version of the Swedish Bofors gun procured by India.
- It is a 155 mm ammunition system with a range of 36 km.
- It is compatible with all NATO 155mm ammunition systems.
- It has successfully completed final trials and is ready for induction into the Army.

4.3 K9 Vajra-T Gun

- It is an artillery gun produced by South Korea.

- Artillery is a class of heavy weapons built to fire far beyond the range and power of infantry's small arms.
- Self-propelled artillery is equipped with its own propulsion system to move towards its target.
- They superficially resemble tanks, but they are generally lightly armoured.
- However, they protect their crews against shrapnel and small arms and are therefore usually included as armoured fighting vehicles.

- India procured these guns and it will be the first induction of heavy artillery since the Swedish Bofors guns imported in the 1980s.
- It is a 155-mm, 52-calibre self-propelled artillery gun with a maximum range of 40 km, customized from the original K9 Thunder gun.
- The fire control system has also been customized for desert conditions.
- India is also planning to procure **M777 ultra-light howitzers** from the **U.S.**



- It is a 155-mm, 39-calibre towed artillery gun and weighs just four tonnes, making it transportable under slung from helicopters.

4.4 Advanced Towed Artillery Gun System

- It is a 155mm, 52 calibre gun being developed by the DRDO.
- Indian Army has recently begun finalising the Preliminary Specifications Qualitative Requirements (PSQR) for the gun system.
- The gun is currently weighing about 18 tonnes while the ideal weight is 14-15 tonnes.
- Significant features of the gun system - All-electric drive, high mobility, quick deployability, auxiliary power mode, advanced communications system, automated command and control system.

4.5 Smart Anti-Airfield Weapon

- It is an indigenously developed light weight glide bomb, capable of targeting large enemy infrastructure, like airfields.
- It was recently flight tested from Indian Air Force's Jaguar aircraft successfully.
- It is an accurate bomb and is termed a precision-guided munition (PGM).
- It has "Inertial navigation system" which guides it precisely to its target, typically an enemy airfield up to 100 km away.
- This precisely guided one bomb is more economical than traditional free fall bombs which are less accurate.
- It has another advantage that it can release the bomb at a safer distance to enemy airfield and return without exposing itself to enemy anti-aircraft defences.

4.6 Smerch Multiple Barrel Rocket Launchers

- It is designed to defeat soft and hard-skinned targets, artillery and missile systems.
- It features an automatic rocket preparing and launching system and range of up to 90km.
- It was developed by Russia in the early 1980s and entered service with the Russian Army in 1988.
- In December 2005, India placed an order for an initial 38 systems and deliveries began in May 2007.
- A tender for mobility vehicles to carry this Smerch system and missiles developed by DRDO, was opened by the Indian government earlier in 2015.
- For the first time, an Indian vehicle manufacturer (Ashok Leyland) has acquired the tender and it will deliver heavy duty, high mobility vehicles for the above stated purpose.

Missiles

4.7 HELINA

- It is an acronym for "Helicopter Launched Nag" missile.
- Nag is a third generation Anti-Tank guided missile indigenously developed under "**Integrated Guided Missile Development Programme (IGMDP)**" of DRDO.
- Anti-Tank Guided Missiles are primarily designed to hit and destroy heavily armored military vehicles.



- Helina is the helicopter launch variant of Nag, that can be fired from Dhruv advanced light helicopter and HAL Rudra attack helicopter.
- It is a heavier and longer-range version of the vehicle mounted Nag missile with a 7-km range.
- Typically, a land version of Nag missile has a range of only 4 km.
- The missile is guided by “infrared imaging seeker”, that homes in on the target’s heat signature.
- IGMDP involves the development of Agni, Akash, Trishul, Prithvi and Nag missiles.

4.8 Akash Missile

- It is an indigenously developed short-range surface-to-air missile (SRSAM) system
- DRDO developed Akash as part of the Integrated Guided Missile Development Programme initiated in 1984.
- It can target aircraft up to 30 km away, at altitudes up to 18,000 m.
- It consists of Rohini radar that detects incoming aircraft with a range of 120 km.
- It can intercept fighter jets, cruise missiles as well as ballistic missiles.
- It soon will get an upgraded variant and Defence Acquisition Council (DAC) gave its procedural approval to the variant.
- Recently, it was test fired with an indigenous radio frequency seeker.
- This is the first surface-to-air missile with indigenous seeker that has been test fired.
- With this success, India has achieved the capability of making any type of surface-to-air missile.

4.9 Astra Missile

- It is the indigenously developed Beyond Visual Range Air-to-Air Missile (BVRAAM).
- It was successfully test fired from Su-30 aircraft.
- It comprises a launcher and a missile and it is designed as a BVR missile with a long range of 110 km and short range of 20 km.

4.10 Prahar Missile

- It is the surface-to-surface tactical missile developed by Defence Research and Development Organisation (DRDO).
- It is a contemporary weapon system capable of carrying multiple types of warheads and neutralizing a wide variety of targets.

4.11 Igla-S missile

- It is a Russian man-portable Surface to Air missile.
- Russia has recently bagged the contract of Indian Army’s bid for air defence missile.
- Igla-S system has been confirmed as the lowest bidder for the mega deal.

4.12 Agni V

- It was successfully test fired from a canister on a road mobile launcher from Dr. Abdul Kalam Island, off the coast of Odisha.
- It is India’s longest-range ballistic missile which will be inducted into the nuclear arsenal soon.
- It is an Inter-Continental Ballistic Missile (ICBM) with a range of over 5,000 km and can reach most parts of China.
- It is powered by three stage solid fuelled missiles.
- It can carry a payload of 1.5 tonnes.
- It is a part of Integrated Guided Missile Development Program (IGMDP).
- Earlier variants of the Agni family of long-range missiles have already been deployed.



4.13 Brahmos

- It is a medium-range supersonic cruise missile that can be launched from submarine, ships, aircraft, or land.
- The missile has been jointly developed by India's Defence Research and Development Organisation (DRDO) and Russia's NPOM. The name Brahmos has been taken as a combination of the two rivers Brahmaputra and Moskva.
- It is the fastest supersonic cruise missile in the world.
- Its range was initially capped at 290 km as per obligations of the Missile Technology Control Regime (MTCR). Since India's entry into MTCR, the range has been extended to 450 km and the plan is to increase it to 600km.
- It also provides a much desired capability to strike from large stand-off ranges with pinpoint accuracy by day or night and in all weather conditions.

4.14 Pralay

- It is a newly developed surface-to-surface tactical missile.
- The trial of the missile was recently deferred by the Defence Research and Development Organisation (DRDO) due to the cyclone Phethai.
- It is a derivative of Prithvi Defence Vehicle (PDV) exo-atmospheric interceptor which can destroy enemy weapons at high altitudes.
- It has a payload of 1 tonne and it has the capacity to strike targets 350 km away.
- It can travel up to 500 km if the payload is halved.
- It is propelled by solid-fuel rocket.
- It can fly faster than the conventional missiles in its class and can evade ballistic missile defence system.
- It will be launched from its own canister-based transport erector launcher.

4.15 Hypersonic Missile

- Avangard, Hypersonic missile system in Russia, was recently test fired successfully.
- It is Intercontinental missile system and considered as a strategic weapon.
- It could fly at 20 times the speed of sound and manoeuvre up and down, meaning that it could breach defence systems.
- The final test of the missile comes after US announced its withdrawal from Intermediate-Range Nuclear Forces Treaty.

4.16 Nirbhay

- It is India's first **indigenously** designed and developed Long Range Sub-Sonic Cruise Missile.
- It can be deployed from multiple platforms.
- It was successfully test fired from the Integrated Test Range (ITR), Chandipur, Odisha.
- The missile has the capability to loiter and cruise at 0.7 Mach, at altitudes as low as 100 m.
- The Mach number is defined as the ratio of the speed of the aircraft to the speed of sound i.e Mach 1 means the velocity is equal to the speed of sound.
- When the velocity exceeds the speed of sound is called supersonic and if it is less than the speed of sound it is called subsonic.

4.17 Quick Reaction Surface to Air Missile

- QR-SAM is an indigenously developed short range surface to air missile.
- The missile has a strike range of 25 to 30 kms.
- It has an all- weather weapon system capable of tracking and firing, and it is the second developmental trial of the state-of-the-art missile with an aerial target.
- Recently, it was successfully test-fired from a test range from the launch pad Chandipur, along the Odisha coast.



4.18 Barak-8

- It is a missile system jointly developed by DRDO India and M/s Israel Aerospace Industry (IAI).
- It includes Long Range Surface-to-Air Missile (LR-SAM) and Medium Range Surface-to-Air Missile (MR-SAM).
- LR-SAM is the Ship Launch Version and Project MR-SAM is the Land Launch Version of Barak-08 Missile system.
- MR-SAM detects incoming enemy aircraft while they are well over 100 km away and destroys them at range upto 70 km.
- LR-SAM has got long range engagement capability to penetrate in deep water/land to intercept all types of aerial targets (like Subsonic & Supersonic Missiles, Fighter Aircraft, Maritime Patrolling Aircraft (MPA), Helicopter and Sea Skimming Missiles).

4.19 AGNI- V

- Recently India test-fired Agni-V, an Inter-Continental Ballistic Missile in its final operational configuration.
- Agni V is a nuclear capable missile, which can reach the northern-most parts of China with its strike range of over 5,000-km.
- The missile is over 50-tonne and designed to carry a 1.5-tonne nuclear warhead.
- It is considered to be a credible strategic deterrent against India's aggressive foes.
- It is part of the Agni series surface to surface missiles indigenously developed by DRDO under the Integrated Guided Missile Development Program (IGMDP).

4.20 Prithvi-II

- India successfully test-fired its indigenously developed nuclear capable Prithvi-II missile from a test range in Odisha.
- The surface to surface missile has strike range of 350 km.
- It is capable of carrying 500-1,000 kilogram of warheads and is thrust by liquid propulsion twin engines.
- The state-of-the-art missile uses advanced inertial guidance system with manoeuvring trajectory to hit its target.

4.21 Ballistic Missile Defence Programme

- India's Ballistic Missile Defence (BMD) system is concentrated on tracking and destroying incoming hostile missiles both inside (endo) and outside (exo) the earth's atmosphere.
- The BMD program includes a two-tiered system consisting of two interceptor missiles, namely Prithvi Air Defence (PAD)/ Pradyumna for high altitude interception (50-80 km) and Advanced Air Defence (AAD)/ Ashwin Ballistic Missile Interceptor for lower altitude interception (15-30 km).
- The Prithvi Defence Vehicle (PDV) is being developed by DRDO which is set to replace the existing PAD.
- Terminal High Altitude Area Defense (THAAD) is the name of an American anti-ballistic missile defense system designed to shoot down short-, medium-, and intermediate-range ballistic missiles.

4.22 K-4 Missile

- The entire K family of missiles is a series of submarine-launched ballistic missiles (SLBM) developed by India to boost its second-strike capabilities.
- The missile has a range of up to 3,500 km and is capable of carrying a nuclear/conventional payload of more than 2 tonnes.
- It is powered by solid rocket propellants.
- It has been designed to be fired from a depth of 50 meters.
- It uses a Ring Laser Gyro Inertial navigation system.
- It is capable of cruising at hypersonic speed.
- It also features a system of weaving in three dimensions during flight as it approaches its target.

- Indian scientists claim that the missile is highly accurate with a near zero circular error probability.
- India announced the test launch of K-4 intermediate-range nuclear-capable ballistic missile from INS Arihant, following Pakistan's first-ever test of a nuclear capable Babur-3 submarine-launched cruise missile (SLCM).

4.23 Interceptor Missile Test

- India's Ballistic Missile Defence (BMD) system is concentrated on tracking and destroying incoming hostile missiles both inside (endo) and outside (exo) the earth's atmosphere.
- The BMD program includes a two-tiered system consisting of two interceptor missiles, namely Prithvi Air Defence (PAD)/ Pradyumna and Advanced Air Defence (AAD)/Ashwin Ballistic Missile Interceptor.
- India successfully conducted an interceptor missile (Prithvi Defence Vehicle) test off the Abdul Kalam Island in Odisha Coast.
- The Prithvi Defence Vehicle (PDV) is being developed by DRDO which is set to replace the existing PAD.
- PDV mission is for engaging the targets in the exo-atmosphere region at an altitude above 50 km of the earth's atmosphere.
- PDV is guided by high-accuracy Inertial Navigation System (INS).
- AAD mission is for engaging the targets in the endo-atmosphere at a lower altitude of 15-30 km.

4.24 Man-Portable Anti-Tank Guided Missile

- DRDO has recently successfully man-portable anti-tank guided missile from Ahmednagar range.
- It is the third - generation Anti-tank Missile which will be used by Indian Army.
- It has been developed by DRDO with private sector partnership.
- It is low weight missile with a range of 2500 metres.

4.25 National Advanced Surface-to-Air Missile System

- India is planning to procure National Advanced Surface-to-Air Missile System (NASAM-II) from U.S.
- It is an advanced air defence system.
- It has the ability to quickly identify and destroy enemy aircraft, UAV or emerging cruise missile threats.
- NASAMS-II is an upgraded version of the NASAMS and features new 3D mobile surveillance radars and 12 missile launchers for quicker reaction.
- It is proposed to be deployed to protect national capital region.
- It will help in preventing 9/11-type attacks in Delhi.

4.26 Advanced Air Defence systems in India

- India is deploying a multi-tiered air defence network to fully secure its airspace from incoming fighter aircraft, missiles and UAV.
- An indigenous two tiered defence shield known as "Ballistic Missile Defence (BMD)", to destroy enemy ballistic missiles is being developed.
- The BMD consists of two interceptor missiles,
 - i. The Prithvi Defence Vehicle (PDV) for exo-atmospheric (high) altitudes of 50–80 km and
 - ii. The Advanced Area Defence (AAD) missile for endo-atmosphere (low) altitudes of 15-30 kilometers.
- India is also in an advanced stage of talks with Russia for the procurement of very long range S-400 air defence systems.

4.27 Advanced Area Defence

- DRDO has recently conducted the successful test of Ballistic missile interceptor - AAD from Abdul Kalam Island, Odisha.
- Ballistic Missile Defence (BMD) is a two tiered defence shield which aims to destroy enemy ballistic missiles.

- The BMD consists of two interceptor missiles, the Prithvi Defence Vehicle (PDV) and the Advanced Area Defence (AAD) missile.
- PDV/Pradyumna Ballistic Missile Interceptor is capable of destroying missiles at exo-atmospheric (high) altitudes of 50–80 km.
- PDV is a two stage supersonic missile fuelled by solid motor in 1st stage and liquid fuelled in 2nd stage.
- AAD/Ashvin Advanced Defense interceptor is capable of destroying missiles at endo-atmosphere (low) altitudes of 15-30 kilometers.
- AAD is a single-stage supersonic solid fuelled interceptor missile.
- BMD shield is expected to be achieved by 2022.

Aircrafts

4.28 Advanced Medium Combat Aircraft

- It is India's next indigenous fighter and expected to make its first flight by 2032.
- It is built under India's only **fifth generation aircraft** programme.
- The aircraft will feature geometric stealth which is different from material stealth feature.
- In **material stealth**, radar-absorbing materials are used to **absorb** the radio waves thus reducing the radar footprint.
- Whereas, in **geometric stealth**, the aircraft is designed at such angles to **deflect** away maximum radar waves to minimise radar cross section.
- Thus, the fighter will have low radar cross section, making it difficult for the enemy to spot it.

4.29 MiG-21 Fighter Jets

- MiG is a product of Soviet Union which entered in to the service in 1959.
- It is the first supersonic fighter aircraft of the Indian Air Force.
- India inducted the MiG-21 in 1963 and got full technology transfer and rights to license-build the aircraft in the country.
- Russia stopped producing the aircraft in 1985, while India continued operating the upgraded variants.
- In the upcoming India-Russia Bilateral summit, India is likely to gift 3 MiG fighter jets to Russia.
- MiG-21 fighter jets will be phased out of service by 2021-22.
- Tejas, an indigeneous fighter aircraft will replace the ageing MiG-21.

4.30 Tejas

- It is an indigenous fighter aircraft inducted in to Indian Airforce in the year 2016.
- It has recently commenced its operation.
- It is designed by the Aeronautical Development Agency (ADA) and Hindustan Aeronautics Limited (HAL).
- It is a single-seat, single-jet engine, multirole light fighter.
- It is the smallest and lightest multi-role supersonic fighter aircraft in its class.
- It can fire Air to Air Missiles, carry bombs and Precision Guided ammunition.
- It has its root in the Light Combat Aircraft (LCA) programme, which began in the 1980s to replace the ageing MiG-21 fighters.
- MiG-21 fighters are purchased from Russia in 1961.



4.31 Apache Helicopters

- They are developed by USA which belongs to heavy helicopter weighing more than 5 tonnes.
- India signed procurement plan of Apache helicopters with USA in 2015.
- Recently, the U.S. State Department approved the sale of six additional AH-64 Apache attack helicopters to India for the Army.
- Currently, the Army operates only smaller Cheetah and ALH (Advanced Light Helicopters) that weigh less than 5 tonnes.
- All bigger helicopters, including the Mi-35 attack helicopters, and fixed-wing aircraft are operated by the Indian Air Force (IAF).
- Under the present procurement plan, the IAF will operate 22 Apache attack helicopters, while the Army will have 6 of them.



4.32 Sukhoi Su-30MKI

- Sukhoi Aircraft was developed by Russia. The license for building it was given to Indian Air Force in the past 2 decades.
- It is twin-finned, twin-jet multi-role aircraft capable of attaining speeds of Mach 2 at high altitudes.
- It can carry guns, missiles, bombs, rockets and other weaponry.
- The first indigenously **overhauled** Sukhoi Su-30MKI supersonic aircraft was recently handed over to the Indian Air Force.
- During the overhaul, the aircraft was stripped completely and rebuilt from scratch, replacing certain worn out parts/components.

4.33 Mid-Air Refuelling

- Tejas is an indigenously developed light combat aircraft.
- It is a single-seat, single-jet engine, multirole light fighter.
- It is the smallest and lightest multi-role supersonic fighter aircraft in its class.
- It can fire Air to Air Missiles, carry bombs and Precision Guided ammunition.
- The Indian Air Force has successfully carried out the first ever mid-air refuelling of Tejas.
- A Russian-built IL-78 MKI tanker transferred fuel to a Tejas MK I aircraft.
- It is considered as a major milestone in its development cycle.
- The ability to carry out air-to-air refuelling is one of the critical requirements for Tejas to achieve final operational clearance.
- Earlier, Tejas has successfully fired an air-to-air beyond visual (BVR) range missile.

4.34 Biojet fuel for Aircraft

- IAF flew an An-32 aircraft in 'vic' formation, whose lead plane used a mix of Aviation Turbine Fuel blended with 10% biofuel.
- The biofuel has been extracted from Jatropha plant seeds using a technology patented by the CSIR and the Indian Institute of Petroleum, Dehradun.
- Following the clearance given by the Centre for Military Airworthiness and Certification IAF is expected to use biofuel for its transport fleet and helicopters.
- The 'vic' formation comprises 3 or more aircraft flying in close formation with the leader at the apex and the rest to left and right, the whole resembling the letter 'V'.

4.35 Feihong-98

- It is a world's largest unmanned transport aircraft which can carry payload of 1.5 tonnes.

- It was successfully tested by China recently.
- It has a cruising speed of 180 km/hour and a maximum range of 1,200 km.

4.36 Kamov Ka-226T

- Russia plans to deliver 10 Kamov Ka-226T military helicopters to India in a first tranche as part of a \$1-billion deal, signed in Indo-Russia Summit in Moscow, 2015.
- The Kamov 226T is a light weight, twin-engine multi-role chopper offers services for both military and civilian purposes.
- It will replace India's ageing fleet of Cheetah and Chetak.
- The military version is capable of working in extreme and difficult weather conditions such as hot climate, marine areas and high mountains.
- The helicopter has a maximum speed of 250 km/hour and maximum takeoff weight is 3,600 kg.

Warning Systems

4.37 NETRA

- It is the first indigenously built Airborne Early Warning and Control System (AEW&CS) developed by DRDO.
- It is light-weight autonomous UAV for long range surveillance and reconnaissance operations.
- This radar system is also mounted on Embraer aircraft which gives 240-degree coverage of airspace.
- It helps to detect and track aircraft, missiles, ships and vehicles.
- The other countries which have developed AEW&C are United States, Russia and Israel.
- For the first time, an IL-78 refueller aircraft has recently carried out air-to-air refuelling of the Embraer aircraft.
- Air-to-air refuelling allows the aircraft to stay airborne much beyond their limits, allowing better exploitation of capabilities.

4.38 Swathi

- It is a Weapon Locating Radar, developed by DRDO's Electronics & Radar Development Establishment.
- It provides fast, automatic and accurate location of all enemy weapons like mortars, shells and rockets firing within in its effective zone of coverage.
- It simultaneously handles multiples projectiles fired from different weapons at different locations.
- The system is capable of adjusting the fire of our own artillery weapon too.
- Thus WLR has two roles to perform i.e. Weapon Location Mode for enemy Artillery and Direction of Own artillery Fire (DOOAF) Mode for our own Artillery.



4.39 Recce Vehicle

- The NBC Recce Vehicle Mk-I, is developed by Vehicles Research & Development Establishment.
- It is designed for carrying out post event reconnaissance (recce) of Nuclear, Biological and Chemical Contaminated areas.
- It is capable of collecting solid and liquid samples of biologically contaminated areas, mark the nuclear and chemical contamination zone and transfer the recce data speedily to support formations.

Programs

4.40 Mission Raksha Gyan Shakti

- It was recently launched with an aim to educate scientists and technologists in defence public sector undertakings and ordnance factories OFs to create more patents.

- A target has been set to train approximately 10,000 persons of OFs and DPSUs on IPR in the financial year 2018-19 under the mission.

4.41 Digital Sky Platform

- The DGCA announced the Civil Aviation Regulations to enable safe flying of Remotely Piloted Aerial Systems (RPAS) popularly referred to as drones in India.
- It specified the obligations of operators, remote pilots/ users and manufacturers/ OEM for safe operations of RPAS and co-operative use of airspace.
- It also announced Digital Sky Platform, a first of its kind that implements 'no permission, no take-off' (NPNT) – a novel system of software based self-enforcement to minimize deviations from the CAR.
- The Digital Sky Platform will register and monitor the drones, pilots, and operators for online permission before the take-off.
- This platform is built to evolve with the needs of the rapidly changing industry with Digital Sky Service Providers (DSPs) by extending the functionality of the platform through Application Program Interfaces (APIs).

4.42 Strategic Partnership Model

- The Defence Ministry has recently approved key guidelines for implementation of Strategic Partnership model.
- The guidelines were approved by the Defence Acquisition Council (DAC), the ministry's highest decision making body.
- Under this model, select private firms will be roped in to build military platforms like submarines and fighter jets in India in partnership with foreign entities.
- It aims to create a vibrant defence manufacturing ecosystem in the country through joint ventures between Indian corporates and global defence majors.
- All procurements under the SP Model would be executed by specially constituted Empowered Project Committees (EPC).
- It is to provide focused attention and ensure timely execution.

Submarines

4.43 Submarines

Class	Type	Boats
Arihant	Ballistic missile submarine (SSBN)	INS Arihant INS Arighat
Chakra (Akula II)	Attack Submarine (SSN)	INS Chakra
Sindhughosh	Attack Submarine	INS Sindhughosh INS Sindhudhvaj INS Sindhuraj INS Sindhuvir INS Sindhuratna INS Sindhukesari INS Sindhukirti INS Sindhuvijay INS Sindhurashtra
Shishumar	Attack Submarine	INS Shishumar INS Shankush

		INS Shalki INS Shankul
Kalvari	Attack Submarine	INS Kalvari INS Khanderi INS Karanj

*INS Chakra and INS Arihant are Nuclear Powered, whereas the rest are Diesel Powered.

4.44 Scorpene-class submarine

- The Indian Navy has launched INS Karanj, 3rd of the 6 Scorpene class submarines that are being built under '**Project 75I**' of the Indian Navy.
- The submarines of Kalvari class of Project 75 are actually Scorpene class submarines i.e submarines that are propelled by diesel-electric engines and Torpedo is mounted as a primary weapon.
- It will have both anti-surface and anti-submarine warfare.
- The Project 75I-class submarine is a follow-on of the Project 75.
- Under this project, the Indian Navy intends to acquire 6 diesel-electric submarines, which will also feature advanced **Air Independent Propulsion (AIP) systems** to enable them to stay submerged for longer duration and substantially increase their operational range.
- Conventional diesel-electric submarines have to surface every few days to get oxygen to recharge their batteries. With AIP systems, they can stay submerged for much longer periods.

4.45 Project 28

- It is a class of anti-submarine warfare corvettes currently in service with the Indian Navy.
- They are the first anti-submarine warfare stealth corvettes to be built in India.
- Three of the four corvettes, INS Kamorta and INS Kadmat, INS Kiltan were commissioned in 2014, 2016 and 2017 respectively.
- INS Kavaratti is expected to be commissioned by May 2019.

4.46 Project-15B

- The Project 15B/ Visakhapatnam Class destroyer is a class of guided missile destroyers.
- It comprises of four ships - Visakhapatnam, Mormugao, Paradip and Porbandar all of which are being built by the Mazagon Dock Limited (MDL), for the Indian Navy.
- Visakhapatnam and Mormugao are already launched.
- Project 15B is an improved variant of the Kolkata-class destroyers (Project 15A), with enhanced stealth characteristics and a high degree of automation.
- Project 15A includes INS Kolkata, INS Kochi and INS Chennai.
- Similarly Project 15A is a follow-on of the Project 15 i.e Delhi-class destroyers, which include INS Delhi, INS Mumbai and INS Mysore.

4.47 INS Chakra

- It belongs to Akula-class nuclear powered Submarine.
- It was taken from Russia on a 10 year lease period.
- Though it is a nuclear powered submarine, it carries only conventional weapons and not nuclear tipped missiles.
- It is based at INS Virbahu, the submarine base in Visakhapatnam.
- It is the second nuclear submarine after the indigenously built INS Arihant.
- INS Arihant is capable of launching nuclear-tipped submarine ballistic missiles.

4.48 INS Arihant

- It is an indigenously-built nuclear-propelled submarine.
- It is a Strategic Strike Nuclear Submarine (SSBN), is capable of carrying 12 K-15 submarine-launched ballistic missiles having a range of over 700 km.
- It can dive to 300 metres and is powered with a 83 MW nuclear power reactor.
- It is its most dependable platform for a second-strike as the other options i.e land-based and air-launched, are easier to detect.

• There here are plans to induct INS Arighat (Aridhaman), the second SSBN.

• INS Arihant and other nuclear launch platforms are operationally handled by the Strategic Forces Command.

• They report to the Nuclear Command Authority chaired by the Prime Minister.

• However, over 100 nuclear warheads are not mated with missiles or bombs and remain in civilian custody of the Atomic Energy Department and the DRDO.

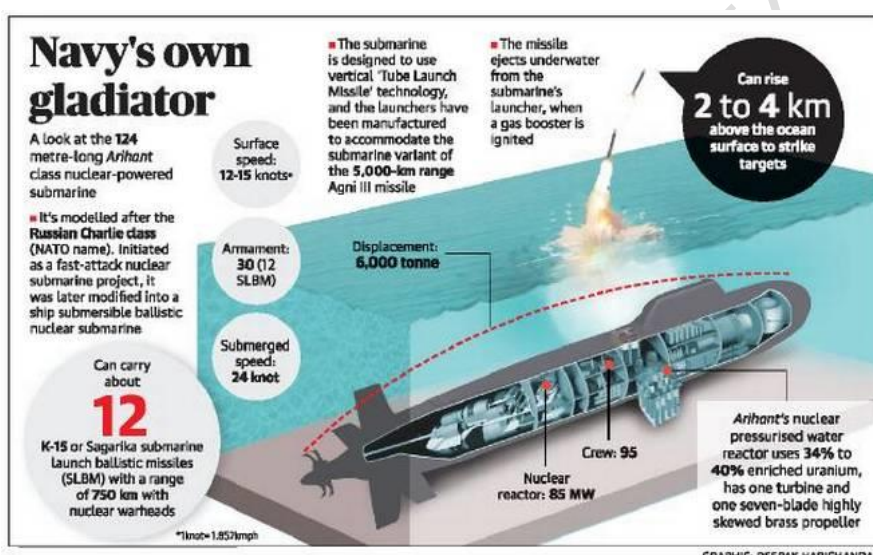
• INS Arihant was inducted into service in 2016.

• It made India the only country apart from the five permanent members of the UN Security Council to operate a homemade nuclear U-boat.

• Nuclear submarines are those that are powered by onboard nuclear reactors whereas conventional submarines generate energy by burning diesel, which requires air.

• Its induction also marked the completion of India's nuclear triad.

• A nuclear triad refers to the nuclear weapons delivery via land, air and sea i.e. land-based intercontinental ballistic missiles (ICBMs), strategic bombers, and submarine-launched ballistic missiles (SLBMs).



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4.49 Deep Submergence Rescue Vehicle

• Indian Navy has recently inducted deep submergence rescue vehicle which will be operational from April, 2019.

• Currently India operates conventional submarines of the Sindhughosh, Shishumar, Kalvari classes as well as nuclear powered submarines.

• The traditional methods of search and rescue by these conventional submarines during an eventuality exposes them to high degree of risk.

• To overcome this gap, India has acquired a 3rd generation, advanced submarine rescue system considering of a Non-tethered Deep Submergence Rescue Vehicle (DSRV) and its associated equipment.

• It is capable of undertaking rescue from a disabled submarine up to 650 metres depth.

• The DSRV, operated by a crew of three, can rescue 14 personnel from a disabled submarine at a time.

• The vehicles are developed by Scotland-based JFD.

• With this, India joins a select league of navies with the sovereign capability to search, locate and rescue crew from a disabled submarine.

4.50 INS Kiltan

• It is the indigenously-built **anti-submarine warfare stealth corvette**.

- It has been recently inducted into the Indian Navy.
- It is the latest indigenous warship after Shivalik Class, Kolkata Class and sister ships INS Kamorta and INS Kadmat.
- It is India's first major warship to have a superstructure of carbon fibre composite material resulting in improved stealth features.
- The ship derives its name from one of the islands in Aminidivi group of the Lakshadweep and Minicoy group of islands.

Other Naval Ships

4.51 INS Vikramaditya

- US team members of joint working group on aircraft carrier cooperation have been allowed to visit and operate Russian built Aircraft INS Vikramaditya.
- INS Vikramaditya is a Kiev class aircraft carrier which was commissioned by Russian Navy in 1987 under the name Baku.
- It was later renamed as Admiral Gorshkov and later offered to India in 2004.
- It is the biggest and heaviest ship to be operated by the Indian Navy.

4.52 INS Vishal

- It is a follow up of INS Vikrant class air craft carriers.
- It is currently being built by Cochin Shipyard limited for the Indian Navy.
- It is intended to be the first supercarrier to be built in India.
- It would be a 65,000-70,000 tonne, nuclear-powered vessel that launched aircraft with an "electro-magnetic aircraft launch system (EMALS)".
- EMALS uses electro-magnetic energy to catapult aircraft to launch speed.
- India's selection of EMALS would allow the US a place in the design of the ship.

4.53 INS Sahyadri

- It is an indigenously built stealth frigate.
- It participated in trilateral Malabar war games with Japan and the U.S. off the Coast of Guam.
- It recently participated in RIMPAC and has been adjudged **runner-up in an innovation competition**.
- INS Sahyadri presented the 'idea of integrating yoga into our daily life as technology for well-being during extended deployments for ships'.
- The idea was appreciated by representatives of participating countries.

4.54 INS Tarangini

- It is part of the first Training Squadron based at Kochi, under the Southern Naval Command of the Indian Navy.
- The word Tarangini means 'the one that rides the waves'.
- It is the first ship of the Indian Navy to have circumnavigated the globe in the year 2003-04.
- It commenced 'Lokayan-18' from Kochi, to cover a distance of over 20,000 nautical miles to display the Indian flag at 15 ports across 13 countries.

Aircraft Carriers of Indian Navy

- **INS Vikrant** - Initially laid down as HMS Hercules for the British Navy, but construction was put on hold. India purchased the incomplete carrier in 1957, and construction was completed in 1961 and inducted as first aircraft carrier of India.
- Decommissioned in 1997, Scrapped in 2014.
- **INS Viraat** - A Centaur-class aircraft carrier commissioned in 1959 as the British Navy's HMS Hermes and later sold to India in 1987.
- Decommissioned in 2017.
- **INS Vikramaditya** - Originally built as Baku for Soviet Navy
- Entered into Indian Navy in 2013.
- **INS Vikrant (2013)** - First domestically built aircraft carrier expected to join service by 2020.

- During its Lokayan voyage, it will participate in the prestigious 'tall ship races - 2018' at Sunderland Port in the UK.
- It has already participated in tall ship races conducted around the world in 2007, 2011 and 2015.

4.55 **INS Trikand**

- It is a state-of-the-art warship of the Indian Navy equipped with a versatile range of weapons and sensors capable.
- It can address threats in all three dimensions - air, surface and sub-surface.
- It recently visited Sri Lanka in a goodwill visit.

4.56 **INSV Tarini Team**

- Minister for Women and Child Development presented the prestigious Nari Shakti Puraskar 2017 to the members of the INSV Tarini team.
- The crew of the Indian Navy Sailing Vessel 'Tarini' is a part of the Indian Navy's unique project 'NavikaSagarParikrama'.
- It is an all-women team circumnavigating the globe, promoting ocean sailing activities in the Navy and depicting Government of India's commitment towards women empowerment.
- The Project aims to demonstrate the thrust of Nari Shakti on the world platform.
- The voyage also showcased the 'Make in India's initiative by sailing on-board the indigenously built INSV Tarini.
- All six members of the crew were trained for over three years under Captain DilipDonde, who is also the first Indian to successfully carry out solo-circumnavigation of the globe between 2009 and 2010.

4.57 **Sagar Kanya**

- It is a ocean research vessel.
- The vessel is a versatile ocean observing platform equipped with technologically advanced scientific equipment and related facilities.
- It is owned and operated by National Centre for Antarctic and Ocean Research.
- The ship has helped in India's studies of the Arabian Sea, the Bay of Bengal, and the Indian Ocean.
- In 1983, under Indo-German collaboration, this multidisciplinary research vessel was built in Germany and delivered in India to Ministry of Earth Sciences (then Department of Ocean Development).

4.58 **Operation 'Madad'**

- It has been launched by the Southern naval command at Kochi.
- It is for assisting the state administration of Kerala and undertaking disaster relief operations due to the unprecedented flooding experienced in many parts.
- Flooding in many parts is due to incessant rainfall and release of excess water from Idukki and other dams.
- **INHS Sanjivani** has been deployed for rendering medical assistance.

4.59 **Shaurya**

- Shaurya is an Indian Coast Guard ship, recently commissioned in Goa.
- It is the fifth in the series of six 105-metre offshore patrol vessels (OPVs).
- It features integrated bridge system, integrated machinery control system, power management system and high-power external fire fighting system.

4.60 **Indian Coast Guard Ship Vijaya**

- ICGS Vijaya, the second in the series of 98-metre offshore patrol vessels was commissioned recently.
- Ministry of Defence has initiated a project for building 7 offshore patrol vessels with private sector partnership.
- In 2017, the first in the series ICGS Vikram was commissioned.

- It is fitted with advanced technology, navigation and communication equipment, sensor and machinery
- The ship will be based at Paradip, Odisha.
- It will be deployed extensively for Exclusive Economic Zone surveillance and other duties
- It is designed to carry one twin-engine helicopter and four high speed boats.

4.61 Rani Rashmoni

- It is a fast patrol vessel, indigenously built by Hindustan Shipyard.
- It is built under the Fast Patrol Vessel (FPV) project of Indian Coast Guard.
- Under the first phase of the project, 5 FPV's has been built.
- The first four such ships are ICGS Rani Abbakka, ICGS Rani Avanti Bai, ICGS Rani Durgavati and ICGS Rani Gaidinliu.
- They have been commissioned and are in active service at various locations on the eastern seaboard.
- Rani Rashmoni is the last in the first phase and recently commissioned into the ICG.
- It will be based in Visakhapatnam.

4.62 Navika Sagar Parikrama

- It is a project wherein a team of women officers of the Indian Navy would circumnavigate the globe on an Indian-built sail boat INSV Tarini.
- This is the first ever Indian circumnavigation of the globe by an all-women crew.
- The project is considered essential towards promoting Ocean Sailing activities in the Navy.

4.63 INS Tarasa

- INS Tarasa, a Water Jet Fast Attack Craft was commissioned into the Indian Navy.
- It is primarily designed for extended coastal and offshore surveillance and patrolling.

4.64 INS Kohassa

- Naval Air Station (NAS) Shibpur was established in 2001 in Shibpur of North Andaman.
- It has a 1,000 feet-long airfield that permitted short-range maritime reconnaissance (SRMR) aircrafts.
- Many Indian aircrafts, which participated in the abortive search for the missing Flight 370, operated from NAS Shibpur.
- It is now commissioned as INS Kohassa, a full-fledged naval base.
- It is the fourth military airfield in the Andaman & Nicobar archipelago.
- It has been named after a White-Bellied Sea Eagle, which is a large bird of prey endemic to A&N Islands.
- It is set up as a Forward Operating Air Base (FOAB) for surveillance in North Andaman.
- The station will function as a base for joint operation of both military and civil aircraft in keeping with the UDAN scheme of the government.

5. HEALTH

5.1 Universal Immunization Programme

- Universal Immunization Programme was launched in 1985.
- The program now consists of vaccination for 12 diseases:
 - 1) Tuberculosis
 - 2) Diphtheria
 - 3) Pertussis (whooping cough)
 - 4) Tetanus

- 5) Poliomyelitis
- 6) Measles
- 7) Hepatitis b
- 8) Diarrhoea
- 9) Japanese encephalitis
- 10) Rubella
- 11) Pneumonia(Heamophilus Influenza Type B)
- 12) Pneumococcal diseases (Pneumococcal Pneumonia and Meningitis)

- The Indradhanush mission, launched in 2014, is to fast track the universal immunization programme.
- The mission aims at increasing the immunisation coverage to 90% by 2018.

5.2 Polio

- Polio is a highly infectious disease caused by a virus.
- It invades the nervous system and can cause total paralysis (Acute flaccid Paralysis) in a matter of hours.
- The virus is transmitted by person-to-person spread mainly through the faecal-oral route or, less frequently, by a common vehicle (for example, contaminated water or food) and multiplies in the intestine.
- Initial symptoms are fever, fatigue, headache, vomiting, stiffness of the neck and pain in the limbs.
- There is no cure for polio, it can only be prevented.
- Polio mainly affects children under 5 years of age. Polio vaccine, given multiple times, can protect a child for life.
- There are 3 strains of wild poliovirus (type 1, type 2, and type 3).
- P2 was **eradicated** globally in 1999. The last case due to type-2 wild poliovirus globally was reported from Aligarh in India in 1999.
- India attained a polio-free status in 2014 after successfully eliminating the wild P1 and P3 strains.
- India **eliminated** the type-2 strain in 2016, and the type-2 containing poliovirus vaccine (ToPV) was phased out in April 2016.
- Thus, Children born after April 2016 in India have no immunity to type-2 polio virus.
- Recently, Traces of polio type-2 virus were found in some batches of oral polio vaccine (OPV) manufactured by a Ghaziabad-based pharmaceutical company.
- No case of type 3 has been found since the last reported case in Nigeria in November 2012.
- Today, only 3 countries in the world have never stopped transmission of polio (Pakistan, Afghanistan and Nigeria).
- The vaccine used by the World Health Organisation (WHO) in the global eradication effort is a trivalent preparation comprising all three serotypes.

Elimination and Eradication

- Elimination means stopping the transmission of a disease in a specific geographic area or country, but not worldwide.
- Disease eradication is the permanent reduction of a disease to zero cases through deliberate measures such as vaccines.
- Once a disease has been eradicated, intervention measures are no longer needed.

5.3 Pulse Polio Campaign

- It is an immunisation campaign established by the GoI to eliminate poliomyelitis in India by vaccinating (Oral Polio Vaccine) all children under the age of five years.
- Vellore (Tamil Nadu) was the first Indian town to become polio-free through the pulse strategy, and rest of India adopted the strategy in 1995.
- **Oral Polio Vaccine (OPV)** contains weakened but live polio virus, which can cause paralytic polio.
- OPV reduced the outbreak caused by wild polio virus by 99.9% since 1988.
- The vaccine-virus is excreted by immunized children, it can move from one person to another.

- On the one hand, a vaccinated person protects unvaccinated people she comes in contact with by spreading immunity through faeces.
- But on the other, such circulation allows the virus to stick around and mutate to a more virulent form, raising the spectre of vaccine-derived poliovirus (VDPV).
- This makes OPV a double-edged sword.
- Vaccine Derived Polio Virus (VDPV), like imported wild polio, can cause outbreaks in under-immunised population.
- According to The Lancet, vaccination (using OPV) has become the main source of polio paralysis in the world.
- It is for this reason that the eradication of polio worldwide requires OPV to be stopped and replaced with the **Inactivated Polio Vaccine (IPV)**.
- It consists of killed poliovirus strains of all three poliovirus types and it produces antibodies in the blood to all three types of poliovirus.
- In the event of infection, these antibodies prevent the spread of the virus to the central nervous system and protect against paralysis.
- It is administered alone or in combination with other vaccines including the OPV (oral polio vaccine).
- IPV does not cause VDPV but protects children equally well against polio.
- The two remaining viruses that are circulating in Pakistan and Afghanistan are WPV-1 and WPV-3.
- Once we stop these two viruses in their tracks, OPV will be phased out and replaced globally with IPV.

5.4 Tuberculosis

- TB is caused by bacteria (*Mycobacterium tuberculosis*) that most often affect the lungs.
- It is curable and preventable.
- It is spread from person to person through the air.
- About 1/4th of the world's population has latent TB, which means people have been infected by TB bacteria but are not (yet) ill with the disease and cannot transmit the disease.
- It mostly affects adults in their most productive years. However, all age groups are at risk.
- People who are infected with HIV are 20 to 30 times more likely to develop active TB
- 8 countries accounted for two thirds of the new TB cases: India, China, Indonesia, the Philippines, Pakistan, Nigeria, Bangladesh and South Africa.
- Multidrug-resistant tuberculosis (MDR-TB) is a form of TB caused by bacteria that do not respond to the most powerful first-line anti-TB drugs (isoniazid and rifampicin).
- MDR-TB is treatable and curable by using second-line drugs (bedaquiline and delamanid).
- According to the WHO guidelines, all injectables are to be replaced with a fully oral regimen with Bedaquiline to treat MDR-TB patients.
- South Africa was the first country to scale up access to bedaquiline. It would replace the injectables for treating all MDR-TB patients.
- Extensively drug-resistant TB (XDR-TB) is a more serious form of MDR-TB caused by bacteria that do not respond to the most effective second-line anti-TB drugs, often leaving patients without any further treatment options.
- Worldwide, only 55% of MDR-TB patients are currently successfully treated.

5.5 Latent Tuberculosis Infection

- Persons with LTBI are those who harbor the TB-causing bacteria within, where it can lie dormant.
- In other words, it is a state of persistent immune response to stimulation by *Mycobacterium tuberculosis* antigens without evidence of clinically manifested active TB.
- The WHO lays emphasis on a specific strategy to tackle latent TB but only in high- and upper middle-income countries with a low incidence of the disease.

- According to a WHO report, approximately 10% of people with LTBI will develop TB, with the majority of them getting it within the first five years of infection.
- LTBI can often be tackled by maintaining good health and observing coughing and sneezing etiquette.

5.6 Diphtheria

- Diphtheria is a highly contagious respiratory disease caused by the **bacterium** *Corynebacterium diphtheria*.
- It primarily infects the throat and upper airways and produces a toxin affecting other organs.
- The toxin causes a membrane of dead tissue to build up over the throat and tonsils, making breathing and swallowing difficult.
- The disease is spread through direct physical contact or from breathing in the coughs or sneezes of infected individuals.
- It can be fatal if left untreated but has become increasingly rare in recent decades due to high rates of vaccination.
- Government hospitals in Delhi has reported a dozen diphtheria deaths in children over two weeks.

5.7 Japanese Encephalitis

- It is a mosquito-borne viral infection of the brain.
- Japanese encephalitis virus (JEV) is a flavivirus related to dengue, yellow fever and West Nile viruses, and is spread by mosquitoes.
- There is no cure for the disease. Treatment is focused on relieving severe clinical signs and supporting the patient to overcome the infection.
- JEV is transmitted to humans through bites from infected mosquitoes of the *Culex* species.
- The virus exists in a transmission cycle between mosquitoes, pigs and/or water birds (enzootic cycle).
- Safe and effective JE vaccines are available to prevent disease and it is one of the vaccines given under Universal Immunisation Programme of India.
- India has confirmed recent cases of JE in Assam, Kerala, Madhya Pradesh, and Maharashtra.

5.8 Lymphatic filariasis

- Lymphatic filariasis is commonly known as elephantiasis.
- It is caused by infection with parasites classified as nematodes (roundworms), which are transmitted to humans through mosquitoes.
- Mosquitoes are infected with microfilariae by ingesting blood when biting an infected host.
- Infection is usually acquired in childhood causing hidden damage to the lymphatic system.
- Its visible manifestations may occur later in life, causing temporary or permanent disability.

5.9 Leprosy

- Leprosy, also known as Hansen's disease, is a bacterial disease.
- It affects skin and nerves which can lead to physical deformity and disability if left untreated.
- It is not hereditary and completely curable, as opposite to general public views on leprosy.
- It is only mildly infectious (i.e) more than 85% of cases are non-infectious and over 95% of the population has a natural immunity to the disease.
- Leprosy colonies in the country still faces stigma and government's attention towards it is also going down.
- This is mainly because of WHO declaration of the elimination of leprosy as a public-health concern in India in 2005.
- This has diluted the international funding and reduced attention and made life difficult for the people living in the colonies.



5.10 Hepatitis C

- WHO has listed viral hepatitis as a major public health problem throughout the world and particularly in India
- Hepatitis is an inflammation of the liver caused by blood borne Hepatitis Virus.
- There are 5 main hepatitis viruses, referred to as types A, B, C, D and E.
- It has the same mode of transmission as HIV, spreading through blood, injecting drugs, blood transfusion and sexual activity, and from mother to child during pregnancy.
- Hepatitis A is closely associated with unsafe water or food, inadequate sanitation and poor personal hygiene.
- Unlike hepatitis B and C, hepatitis A infection does not cause chronic liver disease and is rarely fatal.
- Hepatitis C virus (HCV) is mostly transmitted through exposure to infective blood and it can cause both acute and chronic hepatitis.
- Acute HCV infection is usually asymptomatic (persons do not exhibit symptoms) and is only very rarely associated with life-threatening disease.
- HCV can also be transmitted sexually and can be passed from an infected mother to her baby, but it is not spread through breast milk, food, water or by casual contact.
- Hepatitis A & E virus are responsible for sporadic infections and the epidemics of acute viral hepatitis.
- Hepatitis B & C virus predominantly spread through the parental route and are notorious for causing chronic hepatitis.
- According to WHO Hepatitis is preventable and treatable but remains an acute public health challenge globally and in the Southeast Asia region.
- Currently, there is no vaccine for hepatitis C; except Hepatitis C, all other hepatitis viruses have safe and effective vaccination to prevent them.
- **Note:** Hepatitis B is included in India's Universal Immunisation Programme (UIP).
- HCV is an important public health issue in India.
- In Uttar Pradesh, Bijnor district, Pahuli village has emerged as a hotspot of hepatitis C infection.
- Union Health Ministry's National Programme for Control of Viral Hepatitis for 2018-19, for the next three years, hopes to screen the vulnerable population and provide free treatment where needed.
- The National Hepatitis Policy will translate into better surveillance and detection of water and blood-borne hepatitis viral infections in various regions.

5.11 Typhoid

- Typhoid is an infection caused by the **bacterium** *Salmonella typhimurium* (*S. typhi*).
- The bacterium lives in the intestines and bloodstream of humans.
- *S. typhi* enters through the mouth and spends 1 to 3 weeks in the intestine. After this, it makes its way through the intestinal wall and into the bloodstream and finally spreads into other tissues and organs.
- It spreads between individuals by direct contact with the feces of an infected person.
- It infects humans due to contaminated food and beverages.
- Transmission is always human to human as no animal carry this disease.
- Increasing resistance to antibiotic treatment is increasingly making it easier for typhoid to spread.
- Overcrowded populations in cities and inadequate and/or flooded water and sanitation systems add to the cause

5.12 Scrub Typhus

- It is an acute illness in humans caused by a bacterium.
- It is transmitted by the bite of infected mite larva present in the soil.
- Gorakhpur in U.P is treated as a hub of Acute Encephalitis Syndrome (AES).

- Number of patients affected by AES admitted in the Hospital has increased during Monsoon period.
- To find out the reason behind this, researchers has identified the role of scrub typhus.
- Almost, 65% of the AES patients got infected by Scrub Typhus.
- This finding is important, given that scrub typhus can be treated easily if detected early.
- The increase in infestation of rodents by mites during August-October explains why scrub typhus incidence peaks during monsoon.

5.13 Influenza

- Influenza is an **acute viral infection** of the respiratory tract, that is known to cause the flu.
- It is caused by three types of **RNA viruses** called influenza types A, B and C.
- It attacks mainly the upper respiratory tract such as the nose, throat and bronchi and rarely also the lungs.
- The different types of influenza include A, B and C.
- The serotypes of influenza A virus like the H1N1, H5N1, H3N2, etc., have caused pandemics in humans.
- Influenza type A viruses are known to infect people, birds, pigs, horses, whales, seals and other animals, but wild birds represent the natural hosts for these viruses. Thus it is called as **bird flu virus** (Avian Influenza).
- H5N8 and H5N1 are subtypes of the Influenza A virus and are considered as highly pathogenic.
- H5N1 virus is transmitted from infected birds to animal species including mammals through their saliva, blood, feces. etc.

5.14 Spanish Flu

- The outbreak of Spanish Flu in 1918 is the history's worst known infectious disease.
- It is considered to be one of the global pandemics that causes death of 40 millions in 1918-1919 across the world.
- H1N1 is the strain that caused Spanish outbreak which acquired the ability to infect humans and then to become transmissible among humans.
- The virus is easily passed from person to person through the air by droplets and small particles excreted when infected individuals cough or sneeze.
- The influenza virus enters the body through the nose or throat and takes between 1 to 4 days for the person to develop symptoms.
- Disease spreads very quickly among the population especially in crowded circumstances.
- Cold and dry weather enables the virus to survive longer outside the body than in other conditions and, as a consequence, seasonal epidemics in temperate areas appear in winter.

5.15 Severe Acute Respiratory Syndrome

- It is a viral respiratory disease of zoonotic origin caused by the SARS coronavirus.
- It leads to shortness of breath and/or pneumonia.
- The only symptom common to all patients appears to be a fever above 38 °C (100 °F).
- There is no vaccine for SARS and no cases have been reported worldwide since 2004.
- Droplets from coughing and sneezing and close human contact likely transmit the SARS virus.
- The respiratory droplets are probably absorbed into the body through the mucous membranes of the mouth, nose, and eyes.
- According to WHO, SARS affected regions include China, Hong Kong, Singapore and Canada.
- Recently, Chinese virologists have found the origins of the SARS outbreak in 2003.
- A single population of horseshoe bats in a cave in Yunnan province in China caused the outbreak.



5.16 Swine Flu

- Swine flu is a respiratory disease caused by influenza viruses H1N1 and H3N2.
- They infect the respiratory tract of pigs.
- Swine flu viruses may mutate which makes them easily transmissible among humans.
- They could spread -
 - by airborne respiratory droplets (coughs or sneezes)
 - by saliva
 - by touching a contaminated surface
 - by skin-to-skin contact
- Symptoms of swine flu in humans are similar to most influenza infections.
- These include fever (100 F or greater), cough, nasal secretions, fatigue, and headache.
- The incubation period for the disease is about 1 to 4 days.
- Swine flu is contagious about one day before symptoms develop to about 5 to 7 days after symptoms develop.
- Some patients may be contagious even for a longer time span.
- The most serious complication of the flu is pneumonia.

5.17 Avian Influenza A(H7N9)

- This particular A(H7N9) virus was first found in March 2013 in China. Since then, infections in both humans and birds have been observed.
- The disease is of concern because most patients have become severely ill.
- Most of the cases of human infection with this avian H7N9 virus have reported recent exposure to live poultry or potentially contaminated environments.
- This virus does not appear to transmit easily from person to person, and sustained human-to-human transmission has not been reported.
- However, Lab experiments on a new strain of the H7N9 bird flu suggest the virus can transmit easily among animals and can cause lethal disease.
- This raise alarm that the virus has the potential to trigger a global human pandemic.

5.18 Malaria

- **Malaria** is a life-threatening disease caused by Plasmodium parasites.
- It is transmitted to people through the bites of infected female Anopheles mosquitoes.
- The mosquito transmits the parasite in to bloodstream and after it gets matured it begin to infect red blood cells.
- There are 5 parasite species that cause malaria in humans, and 2 of these species P. falciparum and P. vivax pose the greatest threat.
- It is preventable and curable.
- An infected mother can also pass the disease to her baby at birth. This is known as congenital malaria.
- Malaria is transmitted by blood, so it can also be transmitted through:
 1. an organ transplant
 2. a transfusion
 3. use of shared needles or syringes
- **Recent developments** - WHO in its recent report has revealed that global efforts to fight Malaria stalled.
- The number of cases of the disease climbed by 2 million to 219 million in 2017.
- The international funding to fight the disease has declined in the recent years.

5.19 Chikungunya

- It is a **viral disease** transmitted to humans by infected mosquitoes.
- It causes fever and severe joint pain. Other symptoms include muscle pain, headache, nausea, fatigue and rash.
- The disease shares some clinical signs with dengue and zika, and can be misdiagnosed in areas where they are common.
- There is **no cure for the disease**. Treatment is focused on relieving the symptoms.
- The proximity of mosquito breeding sites to human habitation is a significant risk factor for chikungunya.
- The disease mostly occurs in Africa, Asia and the Indian subcontinent. However a major outbreak in 2015 affected several countries of the Region of the Americas.

5.20 Diabetes

- Diabetes mellitus (DM) - Commonly referred to as diabetes, is a group of metabolic disorders in which there are high blood sugar levels over a prolonged period.
- Most common types of Diabetes Mellitus are as follows
- **Type 2 diabetes** - A chronic condition that affects the way the body processes blood sugar (glucose).
- **Type 1 diabetes** - A chronic condition in which the pancreas produces little or no insulin.
- **Prediabetes** - A condition in which blood sugar is high, but not high enough to be type 2 diabetes.
- **Gestational diabetes** - A form of high blood sugar affecting pregnant women.
- **Diabetes insipidus** - It occurs when the body can't regulate how it handles fluids.
- The condition is caused by a hormonal abnormality and isn't related to diabetes.
- In addition to extreme thirst and heavy urination, other symptoms may include getting up at night to urinate, or bed-wetting.
- Depending on the form of the disorder, treatments might include hormone therapy, a low-salt diet and drinking more water.

5.21 TB Vaccine for Diabetes

- A recent study has revealed that the tuberculosis vaccine called BCG (Bacillus Calmette–Guérin) might lower blood sugar in diabetes (Type 1) patients several years after they get the shot.
- **Type 1 diabetes** arises when the body's immune system kills the insulin-producing beta cells. Without insulin, cells cannot absorb sugar (glucose), which they need to produce energy.
- There is no patent for BCG, thus it promises a safe and inexpensive treatment for type-1 diabetes.
- BCG also protects against leprosy, sepsis among babies, and leishmaniasis.
- It is also the first approved immunotherapy against bladder cancer.
- **Open Insulin Project** - It is a California based initiative trying to develop an open-source protocol for manufacturing off-patent insulin.
- It aims to make and refine synthetic insulin from E.Coli bacteria and document their process, so that generic pharmaceutical company can use to make affordable insulin for patients all over the world.

5.22 Trachoma

- Trachoma is a chronic disease of the eye caused by infection with the bacterium Chlamydia trachomatis.
- It causes blindness or visual impairment. It is the cause for about 1.4% of all blindness worldwide.
- Blindness from trachoma is irreversible.
- It is caused by poor environmental and personal hygiene and inadequate access to water and sanitation.
- According to the National Trachoma Survey Report (2014-17), **India has become free from Trachoma** with an overall prevalence found to be only 0.7%, much below the criteria set by WHO.



- According to WHO, active trachoma is considered eliminated if the prevalence of active infection among children below 10 years is less than 5%.
- Trachoma is no longer a public health problem in India.
- The disease is found to be affecting the population in certain pockets of north Indian states like Gujarat, Rajasthan, Punjab, Haryana, Uttar Pradesh and the Nicobar Islands.

5.23 Mycetoma

- Recently group of experts from WHO called for a combined action to address Mycetoma disease.
- It is a disease characterized by disabling deformities and associated with severe morbidity.
- It is an inflammatory disease of the skin, connective tissue, muscle and bone, results from infection caused by more than 70 bacterial or fungal microorganisms.
- The tropical disease is known to affect rural populations, particularly those who walk barefoot, like agricultural laborers and herdsmen.

5.24 Crimean-Congo Haemorrhagic Fever

- It is a widespread disease caused by a tick-borne virus called *Nairovirus*.
- CCHF virus causes severe viral haemorrhagic fever outbreaks.
- Such outbreaks have a case fatality rate of up to 40%.
- The virus is primarily transmitted to people from ticks and livestock animals.
- Human-to-human transmission can occur resulting from close contact with the blood, secretions, organs or other bodily fluids of infected persons.
- CCHF is endemic in Africa, the Balkans, the Middle East and Asia, in countries south of the 50th parallel north.
- There is no vaccine available for either people or animals

5.25 Kyasanur Forest Disease

- Kyasanur Forest disease (KFD) or Monkey Fever is a re-emerging zoonotic disease caused by virus.
- The KFD virus belongs to the family Flaviviridae, which also includes yellow fever and dengue fever.
- It was first identified in 1957 from Kyasanur forest area in Shivamogga district of Karnataka.
- It causes viral hemorrhagic fever i.e the overall vascular system is damaged, and the body's ability to regulate itself is impaired.
- Hard ticks (*Hemaphysalis spinigera*) are the carriers of KFD virus and are known to thrive in western ghats.
- Rodents, shrews, and monkeys are common hosts for KFDV after being bitten by an infected tick.
- It has high fatality in primates.
- The symptoms of the disease include a high fever with frontal headaches, followed by haemorrhagic symptoms, such as bleeding from the nasal cavity, throat, and gums, as well as gastrointestinal bleeding.
- It is a re-emerging zoonotic disease endemic in Karnataka.
- It has been detected in monkeys in parts of Bandipur National Park, Karnataka and re-emerging source has been found in cashew plantations in Goa.

5.26 Leptospirosis

- It is a zoonotic disease, caused by bacteria of the genus *Leptospira*.
- It is an emerging tropical infectious disease.
- It affects animals and humans and can be transmitted via exposure to contaminated water or soil or direct contact with reservoirs hosts like wild or domestic animal.
- The infection in man is contracted through skin abrasions and the mucosa of the nose, mouth and eyes. Human-to-human transmission is rare.

- In most of the cases, leptospirosis only causes mild flu-like symptoms, such as headache, chills and muscle pain.
- Without treatment, it can lead to kidney damage, meningitis (inflammation of the membrane around the brain and spinal cord), liver failure, respiratory distress, and even death.
- Currently there is no preventive vaccine for humans that are available in the market.
- Severe form of leptospirosis is known as **Weil's disease**.

5.27 Fluorosis

- It is a slow, progressive, crippling disease which affects every organ, tissue and cell in the body.
- According to WHO, the fluoride concentration in drinking water should not exceed 1.5mg/l.
- Thus, fluorosis is caused by excessive exposure to fluoride, beyond a concentration of 1.5 mg/l.
- It adversely affects the foetal cerebral function and neurotransmitters. Reduced intelligence in children is associated with exposure to high fluoride levels.
- Dental fluorosis is a defect in the tooth enamel caused by excessive fluoride consumption, is not treatable and the stains are permanent.
- Skeletal fluorosis is developed by the disturbance of calcium metabolism in the formation of bones in the body. It results in the softening and weakening of bones, resulting in deformities.
- The main sources of fluoride in groundwater are the rocks such as charnockite, quartzite, pegmatite, laterite etc.

5.28 Hunter's Syndrome

- Researchers have recently successfully attempted gene editing inside the human body to correct a defect in the DNA that causes Hunter's syndrome.
- It is a disorder where the body can't break down sugar that builds bones, skin, tendons and other tissue.
- These sugars can build up and damage the body.
- It appears in children as young as 18 months. It mainly occurs in boys, although very rarely it has been observed in girls.
- There's no cure for Hunter syndrome.

5.29 Haemoglobinopathies

- It is a kind of genetic defect that results in abnormal structure of one of the globin chains of the hemoglobin molecule.
- Common hemoglobinopathies include sickle-cell disease and Thalassemia, and other variant anaemia.
- Thalassemia usually results in underproduction of normal globin proteins, often through mutations in regulatory genes.
- Despite Public Health being a State subject, union Ministry of Health and Family Welfare has recently issued comprehensive guidelines for Haemoglobinopathies.
- The guidelines provide for screening of every pregnant woman during ANC, pre-marital counselling at the college level and onetime screening for variant anaemia for all children in class VIII.

5.30 Haemophiliacs

- Haemophilia is a genetic and life-threatening bleeding disorder that affects the blood's ability to clot due to the absence of clotting proteins called factors.
- It is one of the few new diseases included under the Rights of Persons with Disabilities Act 2016.
- The erstwhile Right of Persons with Disabilities Act 1995 considered only seven categories, namely blindness, low vision, locomotive disability, hearing impairment, mental retardation, mental illness and leprosy, but not haemophilia.
- According to a study conducted by the World Federation of Haemophilia in 2016, almost half of the world's haemophilia population lives in India.

- The country lags severely in providing the facility of free “clotting factor concentrates”, which helps in stopping the bleeding and is the first step in treatment of patients with severe haemophilia.

5.31 West Nile Virus

- They are typically spread by culexmosquitoes and can cause neurological disease and death in people.
- It is a member of the flavivirus genus and belongs to the same family of Japanese encephalitis - Flaviviridae.
- Its transmission cycle, by nature, revolves between birds and mosquitoes. Humans, horses and other mammals can be infected.
- Mosquitoes become infected when they feed on infected birds, which circulate the virus in their blood for a few days.
- Human infection is most often the result of bites from infected mosquitoes.
- Unlike other mosquito-borne diseases, it does not cause symptoms in everybody that contracts the virus.
- To date, no human-to-human transmission of WNV through casual contact has been documented.
- It may be transmitted through contact with other infected animals, their blood or other tissues.
- No vaccine is available for humans.
- It is commonly found in Africa, Europe, the Middle East, North America and West Asia.
- It was first isolated in a woman in the West Nile district of Uganda in 1937. In India, it was first noticed in 1956 and it had its presence in Kerala in 1973.
- It has been recently reported in Kerala from Kozhikode district.

5.32 Zika Virus

- Indian Council of Medical Research (ICMR) surveillance system has recently detected cases of Zika Virus in Jaipur.
- Zika virus is a member of the virus family Flaviviridae.
- It is a mosquito-borne disease transmitted by Aedes mosquitoes.
- It can be passed from a pregnant woman to her fetus. Infection during pregnancy can cause certain birth defects.
- Zika infection during pregnancy can cause a birth defect of the brain called **microcephaly** and other severe brain defects.
- It is also linked to other problems, such as miscarriage, stillbirth, and other birth defects.
- There is no vaccine or medicine for Zika.
- The disease is currently being reported by 86 countries worldwide.
- Symptoms of Zika virus disease are similar to other viral infections such as dengue, which include fever, skin rashes, conjunctivitis, muscle and joint pain and headache.
- In India, the first outbreak was reported in Ahmedabad in January-February 2017 and 2nd outbreak in Krishnagiri district in Tamil Nadu.
- Both were successfully contained through intensive surveillance and vector management.
- According to WHO, Zika is no longer a public health emergency of international concern.

5.33 Nipah Virus

- It is a zoonotic virus (transmitted from animals to humans) that causes severe disease in both animals and humans.
- The natural host of the virus is fruit bats of the Pteropodidae Family, Pteropus genus.
- It can be transmitted to humans from animals (such as bats or pigs), or contaminated foods and can also be transmitted directly from human-to-human.
- It spreads mainly through bad dropping or bodily remains and then spreads laterally within a species.

- In infected people, it causes a range of illnesses from asymptomatic infection to acute respiratory illness and fatal encephalitis.
- It was first identified during an outbreak of disease that took place in Kampung Sungai Nipah, Malaysia in 1998.
- The classical symptom is acute and rapidly progressive encephalitis (brain inflammation and pain) with or without respiratory involvement.
- It is also capable of causing disease in pigs and other domestic animals.
- There is no vaccine for either humans or animals.
- There is no effective specific treatment for the infection and hospitalisation is only to support our bodily immune systems.
- Recently, the presence of Nipah virus was confirmed in Kerala.

5.34 Human Papilloma Virus

- The National Technical Advisory Group on Immunization (NTAGI) has recommended the introduction of HPV vaccine in the UIP.
- NTAGI is an advisory body that recommends vaccines for India's Universal Immunization Programmed (UIP).
- Human Papilloma Virus (HPV) is a group of more than 150 viruses. It is usually harmless and goes away by itself.
- However, some types cause papilloma or warts in parts of the body.
- HPV spreads by skin-to-skin contact and is the most common sexually transmitted infection.
- HPV is commonly associated with cervical cancer.
- India has one of the world's highest burdens of HPV-related cancer and around 67,000 women die from this disease each year.
- HPV vaccines offered by private firms face clinical trial issues in India on concerns of side-effects.

5.35 Hantaviruses

- Hantaviruses are a group of viruses that may be carried by some rodents.
- It was first identified in the year 1993.
- It can cause severe and sometimes fatal respiratory infections and are known to infect lung cells.
- It can cause a rare but deadly disease called Hantavirus Pulmonary Syndrome (HPS).
- It is transmitted to humans who inhale the virus from the urine, faeces, or saliva of infected rodents.
- No treatments or vaccines are available.
- Infections caused by them are expected to increase in the coming decades as temperatures across the globe rise due to climate change.

5.36 Coronavirus

- A coronavirus is a common form of virus that typically causes upper-respiratory tract illnesses
- Six different kinds of coronavirus are known to infect humans.
- Four of these are common, and most people will experience at least one of them at some time in their life.
- The two other types cause SARS and Middle East Respiratory Syndrome (MERS). These are less common but far more deadly.
- Before SARS appeared, coronaviruses had not been particularly dangerous to humans, but they had been known to cause severe diseases in animals

5.37 Wolbachia

- It is a tiny bacterium that is present in 60% of all species of insects, including several mosquito species.

- But the bacterium is not usually in the *Aedes aegypti* mosquito, which is primarily responsible for transmitting dengue, chikungunya and Zika.
- It is one of the world's most common parasitic microbes and the most common reproductive parasite in the biosphere.
- If this bacterium is introduced in mosquitoes, it could stop disease-spreading viruses from replicating, growing and spreading the diseases.
- India and several countries are carrying out experiments to look in to the possibility of breeding *Wolbachia* in *Aedes aegypti*.
- The experiment has proved remarkably effective in a small town in Australia, preventing fresh outbreaks of dengue.
- At present, large-scale trials are under way in Brazil, Colombia and Indonesia.

5.38 Noro Virus

- The 23rd Olympic Winter Games at the South Korean city of Pyeongchang, has been hit by an extraordinary outbreak of disease caused by Norovirus.
- Noro virus is similar to rota virus that induces diahorrea.
- It infects people across all age groups and is highly contagious.
- It is primarily transmitted through oral-faecal, also through contaminated food, water and surface.
- The symptoms are Sudden onset of vomiting and/or diarrhea, Nausea and abdominal pain headaches, Body aches and fever. In Extreme cases, loss of fluids could lead to dehydration.
- At present, vaccines are not available.

5.39 Usutu Virus

- It belongs to "flavivirus" family along with tick-borne encephalitis, West Nile, and Dengue virus.
- The virus is an African origin and it was first detected in Austria in 2001.
- It caused a severe bird die-off, mainly of blackbirds and songbirds.
- Besides wild birds, humans can also be infected with the virus through mosquito bites.
- This year, already the virus is detected in songbirds in Austrian region.

5.40 Antimicrobial Resistance

- Antimicrobial resistance (AMR) is the ability of a microbe to resist the effects of medication previously used to treat them.
- The term includes the more specific "antibiotic resistance", which applies only to bacteria becoming resistant to antibiotics.
- Resistant microbes are more difficult to treat, requiring alternative medications or higher doses, both of which may be more expensive or more toxic.
- Microbes resistant to multiple antimicrobials are called multidrug resistant (MDR); or sometimes superbugs.
- AMR has emerged as a global public health concern as rampant usage of antibiotics for human and veterinary purposes has resulted in the development of antibiotic-resistant bacteria (ARB) in the guts of humans and animals, which are subsequently released in to the environment.
- India and China are the largest producers of antibiotics and contributes for 80 per cent of total antibiotics production globally.
- Due to the rising global concern UN also declared Nov 13-19 as **World Antibiotic Resistance Week**.

AMR Scenario in India

- According to the **Scoping report on Antimicrobial Resistance in India** commissioned by the Department of Biotechnology,
- In 2014, India was the highest consumer of antibiotics, followed by China and the United States.

- However, the per capita consumption of antibiotics in India is much lower than in several other high income countries.
- In India high antibiotic resistance rates were reported among bacteria that commonly cause infections in the community and healthcare facilities.
- The resistance to carbapenem class of antibiotics (one of the last-resort antibiotics to treat serious bacterial infections in humans) among various bacteria was extremely high.
- Antibiotic-resistant bacterial infections are also increasingly reported among neonates.
- Factors such as high consumption of a broad spectrum of antibiotics, antibiotic fixed-dose combinations and antibiotic consumption in animal food contribute to AMR.
- In India, effluents generated from these industries are treated as per the pharmaceutical wastewater discharge guidelines prescribed by the Central Pollution Control Board.
- Unfortunately, the current standards do not include antibiotic residues, and they are not monitored in the pharmaceutical industry effluents.
- The health ministry has identified AMR as one of the top 10 priorities for the ministry's collaborative work with WHO, which is highlighted in the National Health Policy 2017.

5.41 Deworming

- Ministry of Health and Family Welfare (MoHFW) conducts deworming drive twice a year.
- Deworming is a process to kill worms commonly tape, round and hook worm, that infest bodies of children below 18 years of age.
- As per the guidelines, children aged below two years are given 200 gm of Albendazole tablet, a drug to treat parasitic worm infestation, and school-going children are administered 400 mg tablets.
- The Albendazole tablet paralyzes the muscles of these worms, the worm loses its grip of intestinal tract and is flushed out of the human body.
- A worm takes six months to mature and start sucking, therefore the exercise is carried out biannually.
- Deworming has no serious side effects, but it can cause nausea and vomiting if a child has worms.
- The medicine disrupts the worms which leads to uneasiness in the stomach.
- **Significance** - Parasitic worms and their larvae are generally found in contaminated food and water.
- In slums children walk bare feet and they frequently contract worms.
- The worm first enters the blood circulation system and its larvae land up in the larynx, from where it finally reaches the gastrointestinal tract.
- The hook, round and tapeworm grow by sucking blood from its host in this case the human body.
- Loss of blood leads to a drop-in haemoglobin level and causes anaemia, thus deworming kills these worms and helps prevent anaemia.
- The National Family Health Survey-3 data suggests anaemia is widely prevalent in all age groups.
- Its prevalence is 56% among adolescent girls (aged 15-19) and 70 per cent among children below five years.

5.42 Typbar TCV

- Typbar TCV (Typhoid conjugate vaccines) is Bharat Biotech's typhoid vaccine and it is the first typhoid vaccine, clinically proven to be administered to children from 6 months of age to adults.
- Typbar TCV has recently received pre-qualification from the World Health Organisation (WHO).
- Typhoid conjugate vaccines (TCVs) are innovative products that have longer-lasting immunity than older vaccines and require only fewer doses.
- Also, it can be given to young children through routine childhood immunization programs and reportedly confers long term protection against typhoid fever.

5.43 New Delhi metallo-beta-lactamase-1

- A new study has found traces of antibiotic resistance (AR) genes in the High Arctic region (Svalbard).

- It includes the ‘superbug’ or the **New Delhi metallo-beta-lactamase-1** protein (coded by blaNDM-1 gene), which was first detected in urban India in 2008.
- The detection reinforces how rapidly AR can globalize.
- Bacteria with the NDM-1 gene are part of a larger group of superbug bacteria that are extremely hard to treat and can spread easily in hospitals.
- Most NDM-1 strains are resistant to all commonly used antibiotics.

5.44 Rotavac

- Bharat Biotech’s diarrhea vaccine ROTAVAC gets WHO pre-qualification
- The WHO pre-qualification paves the way for health and humanitarian organizations such as UNICEF to procure it for public health vaccination programs across the world.
- Rotavirus is the most common cause of severe diarrhea and kills more than 200,000 children every year.
- ROTAVAC is also included in the Universal Immunization Program

WHO's pre-qualification

- A WHO pre-qualification enables better procurement and supplies of this vaccine.
- The vaccine could now be supplied to UNICEF, Pan-American Health Organisation (PAHO) and GAVI supported countries (Global Alliance for Vaccines and Immunization).
- The WHO prequalification marks an important milestone in the global effort to rid the world of typhoid fever.
- It can pave the way for countries to introduce the vaccine into their immunisation programmes.
- This will help reduce the burden of typhoid disease, especially among the vulnerable populations.

5.45 Measles-Rubella Vaccination Campaign

- Central Government has completed the phase I of Measles-Rubella vaccination campaign and phase II has been rolled out.
- Under the vaccination campaign, all children in the age group of 9 months to 15 years will be vaccinated against measles-rubella.
- Following the campaign, MR vaccine will become a part of routine immunization and will replace measles vaccine, currently given at 9-12 months and 16-24 months of age of child.
- India, along with ten other WHO South East Asia Region member countries, has resolved to **eliminate measles and control rubella**/congenital rubella syndrome (CRS) by 2020.
- Measles is a highly contagious infection and one of the major childhood killer diseases, caused by the measles virus that spreads through air.
- Complications include diarrhea, blindness, inflammation of the brain, and pneumonia among others.
- Unlike measles, rubella is a mild viral infection that mainly occurs in children.
- But infection during early pregnancy may result in a child born with congenital rubella syndrome (CRS) or miscarriage.
- **Recent developments** - Delhi High Court recently put on hold the Delhi government’s plan for a measles rubella (MR) vaccination campaign in schools.
- The court said the decision did not have the consent of parents, introducing the question of consent in vaccination.
- The vaccine being given in the MR campaign is produced in India and is WHO prequalified.
- MR vaccine is safe and effective, and in use for over 40 years across 150 countries.
- It is being given in the routine immunisation programme of India and in neighbouring countries like Bangladesh, Sri Lanka, Nepal and Myanmar.
- Private practitioners in India have been giving measles-rubella (MR) or measles-mumps-rubella (MMR) vaccine to children for many years.



5.46 Vaccine for Multiple Pathogens

- A global coalition set up to develop a synthetic vaccine system that could be tailor-made to fight multiple pathogens such as flu, Ebola, Marburg and Rabies.
- Coalition for Epidemic Preparedness Innovations (CEPI) and Britain scientists is developing a “vaccine platform” to fight disease epidemics.
- Vaccine platform is using synthetic self-amplifying RNA (saRNA) approach.
- SaRNA aims to harness the body’s own cell machinery to make an antigen rather than injecting the antigen itself directly into the body.
- It can be adapted to immunize against different diseases by inserting new genetic sequences.
- The other advantage of this approach is that it’s very rapid to manufacture.
- **Antigen** – A foreign substance which induces an immune response in the body.
- **Antibodies** - also called immunoglobulins, are proteins manufactured by the body that help fight against foreign substances called antigens.
- **CEPI**, set up in 2017, aims to dramatically speed up the development of vaccines against new and unknown diseases, collectively known as “Disease X”.

5.47 Phthalates

- They are a group of chemicals used in food packaging and processing materials.
- They are used to soften and improve the flexibility and durability of plastics.
- They are known to disrupt hormones in humans and their exposure linked to breast cancer, developmental issues, decreased fertility, obesity and asthma.
- Pregnant women, children and teens are more vulnerable to the toxic effects of hormone-disrupting chemicals.
- Dining out more at restaurants, cafeterias and fast-food outlets may boost total levels of “phthalates” in the body.
- Adolescents who were high consumers of fast food and other food purchased outside the home had 55 per cent higher levels of phthalates compared to those who only consumed food at home.

5.48 Marijuana

- Canada has become the second country after Uruguay to legalise possession and use of recreational cannabis.
- It paves the way for **recreational cannabis** to be legally bought and sold within the next two or three months
- It is the first industrialised nation to do so.
- Medical marijuana has been legal in the country since 2001.
- Marijuana is a psychoactive drug from the Cannabis plant used for medical, recreational & religious purposes.
- Cannabis can be used by smoking, vaporization, within food, or as an extract.
- It creates mental and physical effects, such as a "high" or "stoned" feeling, a general change in perception, and an increase in appetite.
- Short term side effects may include a decrease in short-term memory, dry mouth, impaired motor skills, red eyes, and feelings of paranoia or anxiety.
- Long term side effects may include addiction, decreased mental ability and behavioural problems in children whose mothers used cannabis during pregnancy.
- In India recreational use of cannabis is prohibited under the Narcotic Drugs and Psychotropic Substances Act, 1985.
- The bar does not apply to an edible preparation called bhang, which is allowed in some States.

- Cannabis-based drugs have the potential to meet the unmet needs of terminally-ill cancer patients and of those suffering from epilepsy and sickle cell anemia (a hereditary disease that afflicts nearly two crore tribal living mainly in central States).

5.49 Gaming- A Mental Health Condition

- WHO has announced a plan to include “gaming disorder” as a mental health condition.
- The reclassification of gaming is a part of the WHO’s 11th revision of the International Classification of Diseases.
- The “disorder” was included in a draft of the ICD-11 released recently.
- While the classification is intended to act as a set of guidelines, ICD-11 influences many countries in determining healthcare policies, diagnoses and treatment options.
- In the ICD-11 draft, gaming disorder is defined gaming a pattern of gaming behaviour characterized by impaired control over gaming, increasing priority given to gaming over other activities to the extent that gaming takes precedence over other interests and daily activities.
- There is also concern that addiction to gaming could be a symptom of a deeper issue such as depression.
- There are potential examples around the world such as China, which has been known to conduct Internet de-addiction camps, and South Korea, which bans those under 16 from gaming after midnight.
- While addiction to gaming is widely recognised, recently reported incidents include a man being found dead in a cafe after three days of continuous gaming, and a couple neglecting their child due to gaming.
- Both the WHO and critics of the idea agree on one thing that addiction to gaming, to the point where it becomes a hindrance to a normal routine, needs more research.
- The WHO believes that formalising the disorder will help experts across the world to conduct more research, while critics believe that research should precede any attempt at formalisation.

5.50 e-Cigarettes

- The Central government has directed all states and Union Territories to not allow the manufacture, sale and advertisement of e-cigarettes and other Electronic Nicotine Delivery Systems (ENDS).
- Electronic cigarettes or e-cigarettes, are devices that do not burn or use tobacco leaves but instead vaporise a solution, which a user then inhales.
- The main constituents of the solution, in addition to nicotine, are propylene glycol (with or without glycerol and flavouring agents).
- ENDS are devices that heat a solution to create an aerosol, which also frequently contains flavours, usually dissolved into propylene glycol and glycerin.
- A number of metals, including lead, chromium and nickel, and chemicals like formaldehyde have been found in aerosols of some ENDS.
- ENDS are not approved as NRTs (nicotine-replacement therapies) under the Drugs and Cosmetics Act and rules made thereunder.
- According to Global Tobacco Epidemic 2017 report by the WHO, the governments of 30 countries like Mauritius, Australia, Singapore etc have already banned ENDS.

5.51 Extent and Pattern of Substance Use in India

- The National Survey on Extent and Pattern of Substance Use in India found that 2.06% of the population use opioids.
- Opioids is used in any one of the following form
 1. opium
 2. heroin
 3. pharmaceutical opioids (which includes a variety of medications)
- The most commonly used is heroin is (1.14%), followed by pharmaceutical opioids (0.96%) and opium (0.52%).

- Of an estimated 77 lakh problem opioid users (dependent or harmful use), more than half are concentrated in just a few states.
- Uttar Pradesh, Punjab, Haryana, Delhi, Maharashtra, Rajasthan, Andhra Pradesh and Gujarat account for the highest number of people with opioid use problems.

THE STATES: PREVALENCE OF OPIOID USE %

Mizoram	6.9
Nagaland	6.5
Arunachal	5.7
Sikkim	5.1
Manipur	4.0
Punjab	2.8
Daman & Diu	2.5
Haryana	2.5
NCT of Delhi	2.3
Meghalaya	2.0

Source: Ministry of Social Justice and Empowerment

5-52 Global Syndemic

- A syndemic is defined as “the presence of two or more disease states that adversely interact with each other”.
- A Lancet Report states that the pandemics of obesity, under nutrition, and climate change are interlinked.
- It terms it as “global syndemic”.
- They represent as the paramount challenge for humans, the environment and our planet that presses the need for urgent action.
- Until now, undernutrition and obesity have been seen as polar opposites.
- But the report states that they are both driven by the same unhealthy, inequitable food systems, underpinned by the same political economy that is focused on economic growth.
- Few instances are-
 - i. Climate change > extreme weather events > increased food insecurity > under nutrition
 - ii. Climate change > increased prices of fruit and vegetables > increasing consumption of processed foods > obesity
 - iii. Foetal and infant under nutrition > risk of adult obesity.
- Not a single country has reversed the obesity epidemic across the world.

5-53 Ban on FDC Drugs

- The Drug Technical Advisory Board has recommended banning 343 “irrational” fixed-dose combination (FDC) drugs
- An FDC drug is one that contains two or more active ingredients combined in a fixed dose to form a single drug.
- Several cough syrups, painkillers and dermatological drugs in India are FDCs.
- Some are marketed with licenses approved only by state regulatory agencies instead of the Drug Controller General of India.
- These FDCs could be irrational and unsafe for consumption, with potential health risks.
- Rampant use of FDCs has allowed antibiotic resistance to assume threatening proportions in India.
- However, not all FDCs are unsafe as some are crucial to treat chronic illnesses like diabetes and HIV.
- **Ban** - In 2016, the Ministry of Health and Family Welfare had implemented a ban on 349 FDCs.
- It included popular brands like Saridon, Corex, D Cold Total, and Vicks Action 500 Extra, etc.
- The government says there are enough single drug alternatives that are safer and effective.
- **Committee** - The ban was based on recommendations of the Chandrakant Kokate committee.
- It said FDCs are "unsafe" and "irrational" for consumption, posing health risks.
- **Court** - On pharma companies challenging the ban, the matter was taken to the Supreme Court.

Drugs Technical Advisory Board

- DTAB is the apex body to decide on technical matters related to drugs in the country.
- It is constituted as per the Drugs and Cosmetics Act, 1940.
- It functions as part of the Central Drugs Standard Control Organization (CDSCO) in the Ministry of Health and Family Welfare.

- Drug makers argued that the statutory bodies on drug regulations were not consulted before the ban.
- Eventually, the Supreme Court referred the matter to the Drug Technical Advisory Board (DTAB).
- It directed the DTAB to make a fresh review of the issue with fixed-dose combination drugs.

5-54 Formalin

- It is a form of hydrated formaldehyde, which is used as a preservative in museums to ensure the specimens doesn't decompose.
- It is also used to harden human tissue for post mortem examinations.
- It can cause gastric irritation and it also speculated to be carcinogenic, and thereby not fit for human consumption even in minimalistic proportions.
- Notably, even in laboratories, only diluted formalin is said to be used.
- Some amount of formalin is naturally formed while fish is transported with ice, but these are usually bound with tissues and not a risk.
- Contrastingly, if fish is laced externally with formalin (to prolong shelf-life), it remains free and can cause serious health issue.
- Due to fears of alleged formalin contamination, officials of the Food and Drug Administration (FDA) inspected fish markets in Goa.
- **Origin of Formalin contamination** - Andhra Pradesh has around 4,000 hectares of aqua-culture farms, whose output peaks during the monsoon season (when coastal fishing is banned).
- To meet the market demand, cultured fish from Andhra is to be transported widely, with sufficient quantity of ice for retarding degradation.
- But as distances are large, the fish nonetheless tends to get spoilt in transport.
- This has led Andhra fish suppliers to lace fish with formalin, which retards degradation to more than 10 times its natural rate.
- Notably, even a state as far as Assam found that formalin laced fish from Andhra was reaching its market (Assam has also banned outside fish now).

5-55 Oxytocin Ban

- Oxytocin is a hormone secreted by the pituitary gland in human also called as Love Hormone.
- It plays a role in reproduction, child birth and lactation, apart from social interaction in humans.
- It also has physical and psychological effects, including influencing social behavior and emotion.
- Oxytocin is used both for humans and animals, to accelerate normal labour.
- Worryingly, it is also used in illegal and unsafe abortions to induce labour.
- It is being misused in the livestock industry to stimulate the mammary gland and induce milk production in farm animals.
- The drug's abuse in animals shortens their lives and makes them barren sooner.
- Vegetables and fruit, too, are injected with Oxytocin, to increase their sizes.
- The Ministry of Health and Family Welfare has restricted the manufacture of Oxytocin formulations for domestic use to public sector only from 1st July 2018.
- It has also banned the import of Oxytocin and its formulations.
- From 1st July 2018, no private manufacturer will be allowed to manufacture the drug for domestic use.
- Karnataka Antibiotics & Pharmaceuticals Ltd (KAPL) is the only public sector company, authorised for manufacturing this drug for domestic use.

5-56 WHO - Antibiotics Protocol

- World Health Organisation has recently revised the antibiotics classes in its list of essential medicines to fight against antimicrobial resistance.

- Antimicrobial resistance is the phenomenon of bacteria becoming resistant even to the most potent drugs.
- This is the biggest revision of the antibiotics section in the 40-year history of the essential medicines list (EML).
- WHO has divided the drugs into three categories such as “Access, Watch and Reserve”.
- Different categories specify which are to be used for common ailments and which are to be kept for complicated diseases.
 - i. **First-line ‘access’** group of antibiotics to be available at all times,
 - ii. Other drugs are placed under a **‘watch’ category** as second choice,
 - iii. **‘Reserve’ category** drugs have to be deployed as a last resort.
- First-line access group includes **amoxicillin**, a widely-used antibiotic to treat infections such as pneumonia.
- Watch category drugs should be dramatically reduced to avoid further development of resistance. Eg. **Ciprofloxacin**, used to treat urinary tract infection.
- The third group, ‘reserve’, includes antibiotics such as **colistin** and some cephalosporins that should be considered last-resort options.

5.57 Global Classification of Diseases

- The World Health Organization (WHO) has released its new International Classification of Diseases (ICD-11).
- ICD is a unique code for diseases, injuries that helps health professionals to share health information across the globe.
- It is also used by national health programme managers, health insurers whose reimbursements depend on ICD coding.
- The latest edition ICD – 11 provides significant improvements on previous versions in coding structure and electronic tooling.
- This will allow health care professionals to more easily and completely record conditions.
- ICD-11 will be presented at the World Health Assembly in May 2019 for adoption by Member States.
- It will come into effect on 1 January 2022.
- **New Additions in ICD-11** – It includes new separate chapters including traditional medicine and sexual health which was previously categorized in mental health conditions.
- Gaming disorder has been added to the section on addictive disorders
- The codes relating to antimicrobial resistance are more closely in line with the Global Antimicrobial Resistance Surveillance System (GLASS).

5.58 RUCO initiative

- Repurpose Used Cooking Oil (RUCO) is an initiative launched by The Food Safety and Standards Authority of India (FSSAI).
- It will enable collection and conversion of used cooking oil to bio-diesel.
- FSSAI is also working in partnership with Biodiesel Association of India and the food industry to ensure effective compliance of used cooking oil regulations.
- The cooking oil regulation mandates that the maximum permissible limits for Total Polar Compounds (TPC) have been set at 25 per cent, beyond which the cooking oil is unsafe for consumption.
- TPC is one of the reliable variable to keep track of the changes in quality of oil during frying process.
- The repeated use of oil at high temperatures result in oxidative, polymerization and thermal degradation reactions.
- These reactions will lead to changes in their physical, chemical, nutritional and sensory properties which increases the TPC of oil.



5.59 Bombay Blood Group

- The general types of blood group are A, B, AB and O, matching of the blood types of the donor and the recipient is vital, else it could lead to serious life-threatening complications.
- Apart from the general blood group types like O, A, B, or AB, there is a special type called (hh)-, a rare one first discovered in Bombay in 1952, and hence christened as Bombay Blood.
- People who carry this rare blood type, about 1 in 10, 000 Indians, can accept blood only from another Bombay Blood type individual, and not from anyone who is O, A, B or AB type.

5.60 India Health Fund

- It is an initiative led by Tata Trusts, in collaboration with The Global Fund.
- It endeavours to leverage the power of collective impact to eradicate tuberculosis (TB) by 2025 and malaria by 2030 from India.
- It supplements the government's efforts to fight the epidemics.
- Tata Trusts is a section 8 company registered under the Companies Act, 2013.
- The Global Fund is an international financing organisation which is headquartered in Geneva, Switzerland.
- It focuses on accelerating the additional resources to end the epidemics of HIV/AIDS, TB and Malaria.
- India contributes to 27 per cent of the global TB burden and 68 per cent of all malaria cases in the Southeast Asia region.
- **Recent development** – India Health Fund has recently announced that it has chosen 4 innovators to effectively tackle eradicate the diseases.

5.61 Sohum

- Sohum is the **indigenously developed newborn hearing screening device**.
- The aim is to screen two percent of hospital-born babies to check for hearing response in the first year.
- This innovative medical device has been developed under the School of International Biodesign (SIB) programme of Department of Biotechnology (DBT).
- SIB is a flagship Programme aimed to develop innovative and affordable medical devices as per clinical needs of India and to train the next generation of medical technology innovators in India.
- This Programme is implemented jointly by AIIMS and IIT Delhi in collaboration with International partners.

5.62 Iodine Bindi

- Life Saving Dot-Jeevan Bindi was conceived and incubated in Singapore. It was implemented in the state of Maharashtra by NGOs.
- Under the project, an iodine patch, designed like a regular bindi (a decorative dot worn in the forehead) is distributed free to tribal women in Maharashtra.
- The tribals in Nashik, Ahmednagar don't consume iodized salt and they are usually deficient in this nutrient.
- The bindi when stuck on the forehead delivers the daily required amount of iodine (100-150 micro grams) to the body by absorption through the skin.
- Iodine deficiency causes a host of disorders like goitre, impaired mental development and thyroid issues, which, in turn, have been linked to breast cancer and fibroids.
- Iodine supplementation is targeted more at women of child-bearing age, because during gestation, pregnancy and lactation women need twice the amount of iodine they usually require.
- Children born to mothers deficient in this nutrient are low in IQ and also suffer from cretinism, a neurological condition.

5.63 Child Friendly HIV drug

- **Lopinavir syrup** is a child-friendly HIV drug produced by Cipla, which is the sole manufacturer of the drug.
- It stopped production consequent to non-payment by the Health Ministry.

- The drug's adult version has to be swallowed whole and thus cannot be administered to infants and young children.
- Recently, The Central Drugs Standard Control Organisation (CDSCO) has registered the child-friendly HIV drug in oral pellet form which opened up the crucial supplies from Cipla to National AIDS Control Programme.

5.64 MTCT of HIV

- A recent study shows complete elimination of mother-to-child transmission of HIV is possible.
- Mother-to-child transmission MTCT is the primary route of transmission of HIV among children.
- Babies are infected during pregnancy, labour, delivery or while breastfeeding.
- **Multidrug Therapy** - India is following the World Health Organisation (WHO) recommended 'multidrug therapy', which is a combination of three drugs — tenofovir, lamivudine and efavirenz (TLE).
- Affected women need to take it all their lives and nevirapine syrup for six weeks only for their babies.
- Multidrug therapy is usually adequate to drastically reduce a mother's viral load.
- **Caesarean** - During a baby's journey through the vaginal passage, contact with abrasions, secretions and blood, which contain the virus, increases the risk of transmission.
- Elective caesarean section and no breastfeeding will limit the transmission.

Status of MTCT

- Currently 5% of babies born to those who are HIV-positive get infected, if transmission rate is below 2% it is considered as elimination.
- According to NACO, only about 52.7% of pregnant mothers seek skilled care out of an estimated 27 million pregnancies in a year.
- An estimated 35,200 pregnancies occur in HIV-positive women and more than 10,300 infected babies are born annually, without any intervention.

6. BIO-TECHNOLOGY

6.1 Stem Cells

- Stem cells differ from other kinds of cells in the body.
- They have the remarkable potential to develop into different cell types in the body during early life and growth.
- They have three unique properties.
 1. They are capable of dividing and renewing themselves for long periods;
 2. They are unspecialized; and
 3. They can give rise to specialized cell types.
- Commonly, stem cells come from **two main sources**:
 1. **Embryonic Stem Cell** - Embryos formed during the blastocyst phase of embryological development.
 2. **Adult stem cells** – Exist throughout the body after embryonic development and are found inside of different types of tissue such as the brain, bone marrow, blood, blood vessels, skeletal muscles, skin, and the liver
- The capacity to differentiate into specialized cell types and be able to give rise to any mature cell type is referred to as potency.
- When a stem cell divides, each new cell has the potential either to remain a stem cell or become another type of cell with a more specialized function, such as a muscle cell, a red blood cell, or a brain cell.
- **Totipotent stem cells** can differentiate into embryonic and extra embryonic cell types. These cells are produced from the fusion of an egg and sperm cell and can construct a complete, viable organism.
- The only totipotent cells are the fertilized egg and the cells produced by the first few divisions of the fertilized egg are also totipotent.

- **Pluripotent stem cells** are the descendants of totipotent cells and can differentiate into nearly all cells, i.e. cells derived from any of the three germ layers.
- These are true stem cells, with the potential to make any differentiated cell in the body. **Embryonic Stem Cells** come under this category.
- **Multipotent stem cells** can differentiate into a number of cells, but only those of a closely related family of cells (i.e) it can only differentiate into a limited number of types.
- Eg. The bone marrow contains multipotent stem cells that give rise to all the cells of the blood but not to other types of cells.
- **Oligopotent stem cells** can differentiate into only a few cells, such as lymphoid or myeloid stem cells.
- **Unipotent cells** can produce only one cell type, their own, but have the property of self-renewal, which distinguishes them from non-stem cells.
- Such Unipotent cells include muscle stem cells.

6.2 Draft Guidelines for Stem Cell Research

- Indian Council of Medical Research (ICMR) has recently issued the revised draft National Guidelines for Stem Cell Research, in association with the Department of Biotechnology (DBT).
- The guidelines seek to ensure standards on various processes related to stem cell treatment.
- It stated that commercial banking of all biological materials, **other than Umbilical Cord Blood (UCB)**, is prohibited until further notification.
- ICMR quoted that at present there is no scientific evidence to substantiate clinical benefits with the use of stem cells other than UCB. Yet its procurement and banking has become a commercial activity.
- Thus the banking of stem cells derived from cord tissue, placenta, tooth extract, adipose tissue, dental pulp, menstrual blood and olfactory ensheathing cells is not permitted.
- ICMR has approved the stem-cell treatment for 30 odd categories of diseases mostly cancer.
- It listed 20 types of indications (diseases) for adults and another 13 categories of indications for children below 18 years, where stem cell treatments are permitted.
- The guidelines also mention that every other therapeutic use of stem cells shall be treated as investigational and conducted only in the form of a clinical trial after obtaining necessary regulatory approvals.
- These guidelines are applicable to all stakeholders including individual researchers, organizations, sponsors, oversight/regulatory committees and all others associated with both basic and clinical research involving any kind of human stem cells and their derivatives.
- It does not apply to research using non-human stem cells or tissues.
- Intellectual Property Rights (IPRs) associated with the outcome of research on stem cells may have commercial value.
- The option of sharing such IPRs should be indicated in the informed consent form which must be procured before the commencement of the research.

6.3 Oesophageal Organoids

- Scientists have successfully grown world's first oesophageal organoids using stem cells.
- Oesophageal organoids are miniature, functional versions of the human food pipe.
- The oesophagus is a muscular tube that actively passes food from the mouth to the stomach.
- The organ can be affected by congenital diseases called oesophageal atresia - a narrowing or malformation of the oesophagus caused by genetic mutations.
- The production of organoids using stem cells paves new ways to study and test drugs against gut disorders.

- It was grown entirely from pluripotent stem cells (PSCs), which can form any tissue type in the body.

6.4 Miniature Eyes

- Researchers from Hyderabad have successfully grown miniature eye-like organs that closely resemble the developing eyes of an early-stage embryo.
- The miniature eyes were produced using **induced pluripotent stem (iPS) cells**.
- iPS are a type of pluripotent stem cell that can be generated directly from adult cells through **epigenetic reprogramming**.
- The iPS cells are produced by genetically manipulating human skin cells to produce embryonic-like stem cells that are capable of forming any cell types of the body.

6.5 Earth BioGenome Project

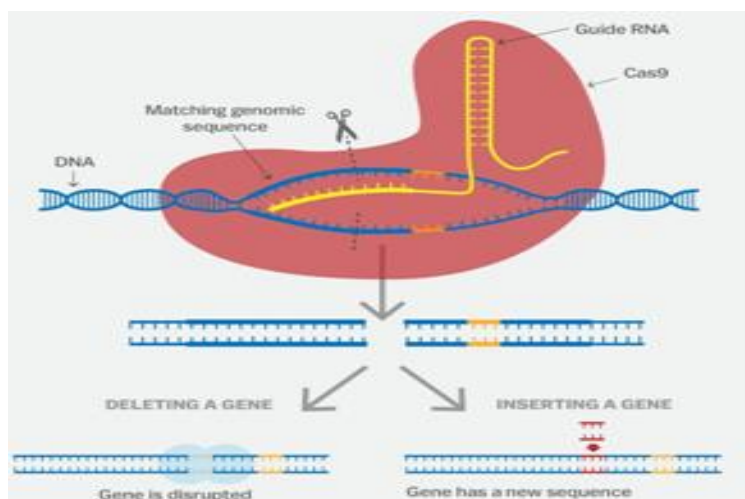
- The Earth BioGenome Project aims to sequence the genomes of the roughly 1.5 million known animal, plant, protozoan and fungal species collectively known as eukaryotes.
- The project will characterize the genomes of all of Earth's eukaryotic biodiversity over a period of 10 years.
- It was officially launched in London with an estimated cost of US\$4.7 billion.
- The last project of a similar scale and importance was the 13-year Human Genome Project which was completed in 2003.
- **Eukaryotes** - The branch of complex life consisting of organisms with cells that have a nucleus inside a membrane—lag far behind the bacteria and archaea.

6.6 Gene Editing

- Genetic modification involves the introduction of foreign DNA into an organism. On the other hand, gene editing involves editing of the organism's native genome.
- CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) is a gene editing technology.
- It allows researchers to permanently modify genes in living cells and organisms by targeting specific stretches of genetic code to edit DNA at precise locations.
- This is done by introducing a protein (Cas9) containing the code of a defective gene.
- The protein then seeks out parts of the defective DNA that match this code.
- It then attaches itself to it, cuts it out, and then the DNA is allowed to repair itself by getting rid of the defect.
- It can be used to target multiple genes simultaneously and can also activate gene expression instead of cutting the DNA.
- This can be used to correct mutations at precise locations in the human genome to treat genetic causes of diseases.
- Correcting the mutation in an embryo ensures that the child is born healthy and the defective gene is not passed on to future generations.
- Apart from being used as a gene-editing tool, CRISPR CAS-9 can also function as a diagnostic tool.
- It can recognise target DNA very quickly and identify viruses such as Zika and dengue very efficiently.
- When an alien bacteria or virus invades the body, CRISPR is "programmed" to recognise the alien material. It then uses CAS-9, an enzyme produced by the CRISPR system to bond with the alien DNA and excise it.

Genome

- A genome is an organism's complete set of DNA, including all of its genes.
- Each genome contains all of the information needed to build and maintain that organism.
- In humans, a copy of the entire genome more than 3 billion DNA base pairs is contained in all cells that have a nucleus.
- **Kinome** is the complete set of protein kinases that make up the genome of an organism.
- A protein kinase is an enzyme that modifies other proteins by chemically adding phosphate groups to them.
- It constitutes 2% of all human genes and 30% of all human proteins are modified by kinase activity.



Recent Developments

- The European Court of Justice recently ruled that organisms obtained by mutagenesis are also GMOs within the meaning of the GMO Directive.
- The ruling says that the guidelines on genetically modified organisms (GMOs) will apply to plants bred using gene editing technology (mutagenesis).
- The techniques of mutagenesis should alter the genetic material of an organism in a way that does not occur naturally.
- These organisms will come, in principle, within the scope of the GMO Directive.
- They are subject to the obligations laid down by that directive.
- The ruling, however, leaves out other mutagenesis techniques like irradiation. It's because these have a proven track record and need not be considered under the same bracket.
- In another development in the field, a Chinese scientist has claimed that he had created the world's first babies genetically edited with CRISPR. But he was later condemned for violating State law.
- For the first time, scientists in the US have successfully used gene-editing tools on human embryos to correct defective DNA that cause inherited diseases.

6.7 Gene Silencing

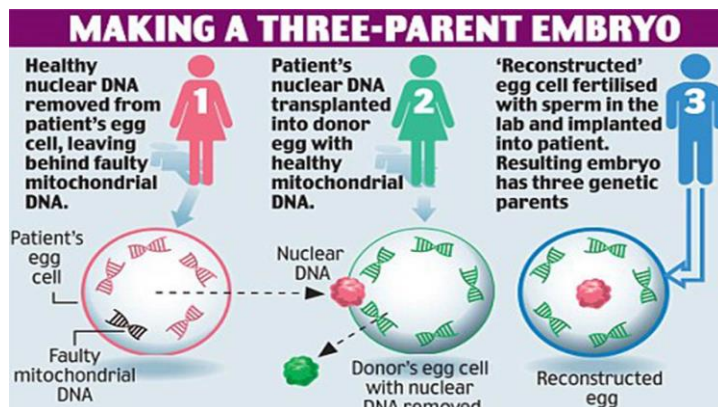
- It is a technique that aims to reduce or eliminate the production of a protein from its corresponding gene.
- It generally describes the "switching off" of a gene by a mechanism other than genetic modification.
- It occurs when RNA is unable to make a protein during translation (gene expression).
- Researchers at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Hyderabad have used the gene silencing technique to keep groundnuts free of **aflatoxin** contamination.
- Aflatoxin is a toxin produced by the fungi *Aspergillus flavus* and *Aspergillus parasiticus*.
- Researchers deployed two strategies to prevent groundnuts being infected by the fungus.
- One is inserting two alfalfa (flowering plant of pea family) genes to enhance immunity against fungal infection and growth.
- Another is preventing aflatoxin production even in case of any infection through a plant-induced **gene silencing technique**.
- The researchers designed two small RNA molecules that silence the fungal genes which produce aflatoxin.
- When the fungus and plant come in contact with each other the small RNA molecules from the plant enter the fungus and prevent it from producing aflatoxin (protein) by its corresponding gene.

6.8 Three Parent Baby

- Authorities in the UK have permitted doctors to create the country's first 'three-parent' babies.

- A child could inherit from the mother, neurodegenerative disorder, which causes problems with movement or mental functioning.
- The three Parent Baby technique will thus use mitochondrial donation therapy for the women.
- By taking the mitochondrial DNA from a healthy donor "mother", the genetic conditions will not be passed on to the child.

- **Procedure** - To perform MRT (mitochondrial replacement therapy) doctors fertilise an egg from the affected woman with her partner's sperm using normal IVF techniques.
- IVF (In Vitro Fertilization) is the process of fertilization by extracting eggs, retrieving a sperm sample, and then manually combining an egg and sperm in a laboratory dish.
- In MRT, instead of letting the egg that develop into an embryo, the chromosomes are taken out and dropped into a healthy donor egg that has had its own chromosomes removed.



- The resulting embryo now has DNA from both parents, as usual, plus mitochondrial DNA from the donor.
- **Concerns** - The procedure has been seen as controversial because any offspring from such a procedure will then have DNA from three parents.
- However, mitochondrial DNA is separate from core DNA in cells. Thus, there will be no impact on the personality or looks of the offspring from the third DNA set.
- This comes as a move to prevent passage of incurable genetic diseases from mothers to offsprings.
- There are concerns on the other hand that parents would misuse the technique to get "genetically modified" babies.

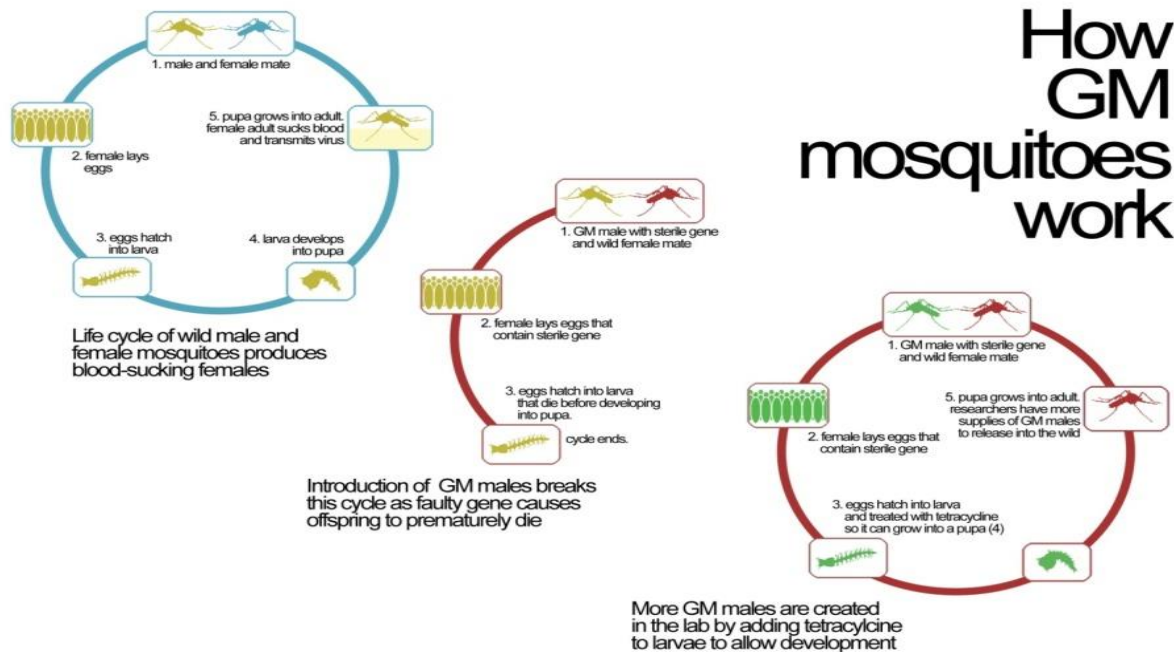
6.9 Genetically Modified Mosquitoes

- A new initiative aims at reducing the population of *Aedes aegypti* mosquito by introducing genetically modified version of mosquitoes.
- *Aedes aegypti* mosquito is the carrier of diseases such as Zika, dengue and chikungunya.
- These diseases are transmitted when an infected, pregnant female mosquito bites somebody.
- Males do not bite and are, therefore, harmless.
- Genetically modified mosquitoes involve producing *transgenic male Aedes aegypti* mosquito, which carries a new gene fatal only to female mosquitoes.
- GM male mosquitoes will then breed with normal females in the wild.
- In the next generation, only the males would survive, and these would breed again, with normal females.
- After a few generations, the female population will be drastically reduced.
- Eventually this cycle will result in a reduction of the entire mosquito population.
- Transgenic males do not bite and the modified genes are said to be harmless to humans.

Status of GM Mosquitoes in India

- The Department of Biotechnology (DBT) is hesitant to permit field trials to release GM mosquitoes to tackle certain diseases.
- The so-called "Friendly Aedes" project launched "closed cage" trials at the Oxitec facility in Maharashtra.
- But, DBT scientists fear that there may be unknown hazards associated with large scale trials.
- It is thus feared that it could result in harmful consequences to the environment or ecology.
- Notably, the *Aedes aegypti* is part of the food chain.

- During its life cycle, it is consumed by fishes.



- Also, during its early aquatic phase, it is consumed by frogs and then by birds, lizards and spiders.
- A drastic reduction in the mosquito population could thus impact prey species.
- This could also potentially result in ecological collapse.
- There is also a possibility that the engineered genes could directly harm the species that consume mosquitoes.
- More research may be required to ensure that there are no unforeseen consequences.

6.10 Gene Therapy for Cancer

- US has recently approved the first gene therapy to fight childhood leukaemia.

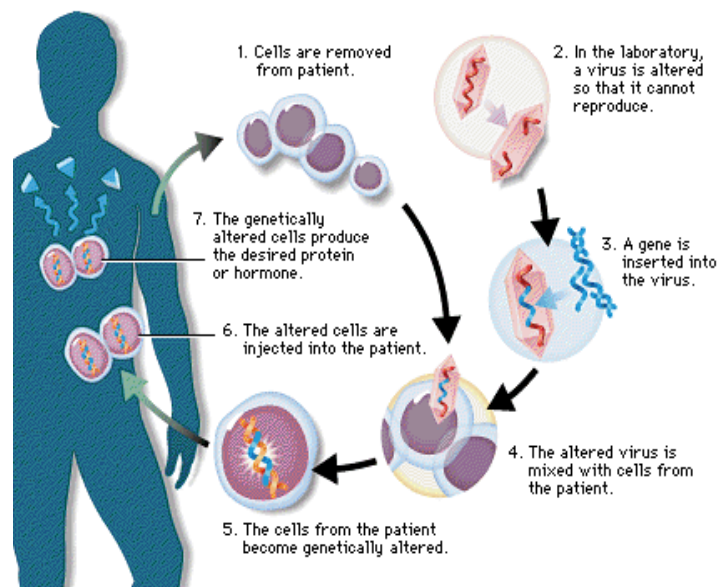
Gene Therapy is a treatment that uses a patient's own immune cells called T-cells along with white blood cells to fight against diseases.

These cells are removed from a patient, sent to a lab, and encoded with a viral vector, reprogrammed, and returned to the patient.

It is called as CAR-T cell therapies and the treatments are called **Yescarta** and **kymriah**.

Gene therapy also involves replacing mutated gene with functional gene and introducing new gene into body to help fight a disease.

- There are two types of gene therapy such as Somatic cell Gene therapy and Germ line therapy.



Leukaemia

- Leukemia is cancer of the blood cells. Most blood cells form in the bone marrow.
- In leukemia, immature blood cells become cancer.

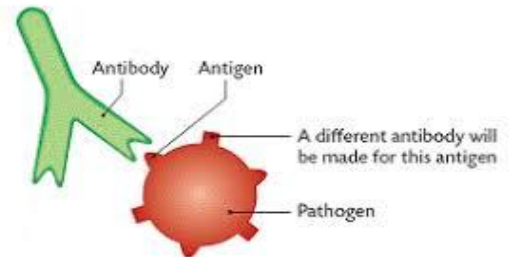
- These cells do not work the way they should and they crowd out the healthy blood cells in the bone marrow.
- It occurs most often in persons older than 55 years, but it is also the most common cancer in children younger than 15 years.
- Different types of leukemia depend on the type of blood cell that becomes cancer.

SOMATIC CELL GENE THERAPY	GERM LINE GENE THERAPY
<ul style="list-style-type: none"> • Therapeutic genes transferred into the somatic cells. • Eg. Introduction of genes into bone marrow cells, blood cells, skin cells etc. • Will not be inherited later generations. • At present all researches directed to correct genetic defects in somatic cells. 	<ul style="list-style-type: none"> • Therapeutic genes transferred into the germ cells. • Eg. Genes introduced into eggs and sperms. • It is heritable and passed on to later generations. • For safety, ethical and technical reasons, it is not being attempted at present.

- For example, lymphoblastic leukemia is a cancer of the lymphoblasts (white blood cells, which fight infection). White blood cells are the most common type of blood cell to become cancer.

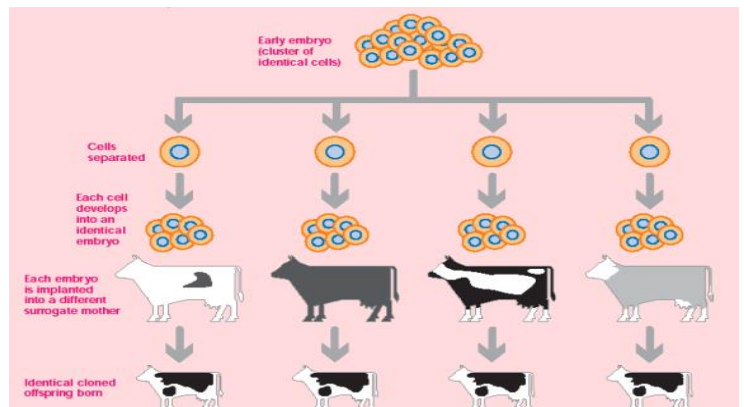
6.11 Human Antibodies in Lab

- Scientists have recently produced human antibodies in the laboratory for the first time. It could usher the rapid development of new vaccines to treat a wide range of infectious diseases.
- **Antibodies**, also called immunoglobulins, are proteins manufactured by the body that help fight against foreign substances called **antigens**.
- When an antigen enters the body, it stimulates the immune system to produce antibodies which attach, or bind themselves to the antigen and inactivate it.
- Antigens can be bacteria, viruses, or fungi that cause infection and disease. They can also be substances, called allergens that bring an allergic reaction.
- Antibody molecules are typically Y-shaped, with a binding site on each arm of the Y.
- It is produced by plasma cells (B-cells).
- When an individual B cell recognises a specific pathogen-derived "antigen" molecule, it can proliferate and develop into plasma cells that secrete large amounts of antibody capable of binding to the antigen and fending off the infection.
- There are five classes of antibodies, each having a different function. They are IgG, IgA, IgM, IgD, and IgE.
- The region of the antigen that interacts with the antibodies is called **epitopes**.
- The variable region of the antibody that specially binds to an epitope is called **paratope**.



6.12 Embryo Transfer Technology

- Government has undertaken a Mass Embryo Transfer programme in Indigenous Breeds under National Mission on Bovine Productivity.
- Embryo transfer refers to a step in the process of assisted reproduction in which embryos are placed into the uterus of a female with the intent to establish a pregnancy.
- It is implemented with the objective of conservation and development of indigenous breeds under Rashtriya Gokul Mission.
- Under this programme, embryos of higher genetic merit indigenous bovines are being transferred in to surrogate cows.



- Embryos of Indigenous breeds such as Sahiwal, Gir, Red Sindhi, Ongole, Deoni and Vechur have been proposed to be transferred under this programme.

6.13 Bio film

- Bio films are communities of microorganisms that attach to each other and to surfaces.
- They are able to act as barriers to antibiotics.
- During times of hostile conditions, such as increased temperature and presence of antibiotics, bacteria tend to come together and form a bio film to protect them.
- The stress response pathway is crucial for bacteria to survive during hostile conditions.
- Scientists have recently found two new molecules capable of destroying bio film forming bacteria.
- When the molecules combined with antibiotics, it showed efficacy in treating infections caused by multi-drug resistant pathogens.

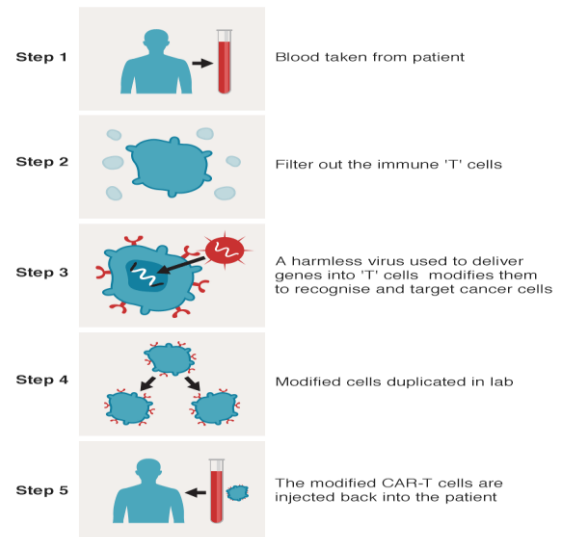
6.14 Microbial Fuel Cell (MFC)

- A microbial fuel cell (MFC) is a bio-electrochemical device that harnesses the power of respiring microbes to convert organic substrates directly into electrical energy.
- At its core, the MFC is a fuel cell, which transforms chemical energy into electricity using oxidation reduction reactions.
- The bacteria are made to act upon the organic substrates or waste water.
- These bacteria are isolated from the very wastewater they are meant to degrade.
- They feed on the organic material in the water and break it down under anaerobic (without oxygen) conditions, releasing electrons in the process.
- The electrons are collected at the anode which results in a current in the circuit.

6.15 CAR-T

- An 11-year-old has become the first patient to receive CAR-T therapy (immunotherapy) that uses the body's own cells to fight cancer.
- CAR-T is a personalized form of cancer treatment.
- It involves removing immune cells and modifying them in a laboratory so they can recognize cancer cells.
- Immunotherapy is treatment that uses your body's own immune system to help fight cancer
- First, the patient has blood removed and the white blood cells are separated out, with the rest of the blood being returned to the patient.
- A harmless virus is used to insert genes into t-cells, a special type of immune cell.
- These genes cause the t-cells to add a hook on to their surface, known as a chimeric antigen receptor (car).
- These engineered car-t cells - programmed to recognize and destroy the patient's cancer cells - are multiplied in huge numbers and then infused back into the patient.

How CAR-T therapy works



Source: BBC research

BBC

- Mycetoma**

- Recently group of experts from WHO called for a combined action to address Mycetoma disease.
- Mycetoma is a disease characterized by disabling deformities and associated with severe morbidity.
- It is an inflammatory disease of the skin, connective tissue, muscle and bone, results from infection caused by more than 70 bacterial or fungal microorganisms.

- The tropical disease is known to affect rural populations, particularly those who walk barefoot, like agricultural laborers and herdsmen.
- If not detected and managed early, this disease can cause limb deformity and, in advanced cases, lead to amputation and death.

6.16 Biomarkers

- Researchers have recently identified a peptide that could lead to the early detection of Alzheimer's disease.
- Biomarkers are indicators that help in determining the presence or severity of a disease.
- The idea is to establish molecular signatures for complicated cases.
- It is used to have a sound knowledge of the disease progression in different individuals suffering from the disease.
- Alzheimer's is the most common form of dementia, a general term for memory loss.
- It is a progressive disease, where dementia symptoms gradually worsen over a number of years.

6.17 Artificial Leaf

- CSIR Scientists have developed an artificial leaf that absorbs sunlight to generate hydrogen fuel from water.
- It may provide clean energy for powering eco-friendly cars in the future.
- The artificial leaf is produced through ultra-thin wireless device which mimics plant leaves to produce energy using water and sunlight.
- The device consists of semiconductors stacked in a manner to simulate the natural leaf system.
- When visible light strikes the semiconductors, electrons move in one direction, producing electric current.
- The current almost instantaneously splits water into hydrogen, one of the cleanest forms of fuel.
- When exposed to sunlight for 25 hours, the device retained its efficiency.
- The cell does not need any external voltage and performs better than existing solar cells.
- At present, hydrogen is produced from fossil fuels by steam reforming and in this process emits a large amount of GHG carbon dioxide (CO₂).

6.18 Chlorophyll – f

- It is a type of chlorophyll that uses near-infrared light from the sun for photosynthesis.
- It is found in a wide range of cyanobacteria (blue-green algae) when they grow in near-infrared light.
- It is also found in shaded conditions such as bacterial mats and beach rocks.
- It also occurs in a cupboard fitted with infrared LEDs.
- These insights could be useful for researchers to develop crops to perform photosynthesis using wider range of light.
- Usually, plants use chlorophyll-a for photosynthesis that is sensitive to visible red light from the sun.

6.19 Speed Breeding Technique - Wheat Production

- Recent NASA experiments used continuous light on wheat, triggering early reproduction to grow wheat in space.
- Inspired by this, Australian scientists have developed the new "DS Faraday" wheat variety with speed breeding" technique.
- Speed breeding is an artificial method to produce healthy crops at a faster pace.
- The plants are placed in a simulated growth environment, a specially modified glasshouse.
- It uses enhanced LED lights in simulated conditions to boost crop production. Here, LED lights are optimised for photosynthesis.
- The light induces growth in them 22 hours a day.

- Plants are thus grown under controlled climate and extended daylight conditions.
- The Australian team has achieved wheat generation from seed to seed in just 8 weeks.
- It was thus possible to grow as many as 6 generations of wheat every year which is a threefold increase from the current two or three generations grown in a regular glasshouse or a single generation in the field.
- The quality and yield of the plants grown in modified glasshouses was as good, or sometimes better, than those grown in regular glasshouses.
- The new technology could also have some applications in future vertical farming systems, and some horticultural crops.

6.20 Flink

- Functional Living Ink (Flink) is a new printing material developed by scientists from Switzerland.
- Flink contains different bacteria as ink which makes it possible to print objects with biochemical properties.
- It allows printing using different inks containing different species of bacteria at different concentrations in order to produce objects exhibiting several properties.
- The ink is composed of a biocompatible hydrogel along with bacteria to give it a structure.
- The culture medium for the bacteria is mixed into the ink so that the bacteria have all the prerequisites for life.

6.21 Plants that can glow

- Scientists have recently found a way to induce plants to give off dim light by embedding specialised nanoparticles into their leaves.
- It is considered as a major step towards using plants to illuminate the workspace, providing low-intensity indoor lighting or transforming trees into self-powered streetlights.
- Scientists embed 3 components in to a different type of nanoparticle carrier.
- It includes luciferase, luciferin and co-enzyme A.
- Luciferase is an enzyme. It is used by the fireflies that give their glow.
- Luciferase acts on a molecule called luciferin, causing it to emit light.
- Co-enzyme A molecule helps the process along by removing a reaction byproduct that can inhibit luciferase activity.

6.22 Molecular Robot

- Recently scientists have created the world's first 'molecular robot' millionth of a millimetre in size.
- To put that size into context, a billion of these robots piled on top of each other would still only be the same size as a single grain of salt.
- These tiny robots can be programmed to move and build molecular cargo using a tiny robotic arm.
- It can be used to build molecules and may help discover novel drugs.

6.23 BIO International Convention

- The BIO International Convention is hosted by the Biotechnology Innovation Organization (BIO).
- Recently, BIO 2017 was held in San Diego and India is represented by Minister of State for Science and Technology and Earth Sciences.
- The key benefits of attending the BIO International Convention are access to global biotech and pharma leaders via BIO One-on-One Partnering, exposure to industry though-leaders and networking opportunities.
- BIO is the largest trade organization in the world that represents the biotechnology industry.
- The organization was found in 1993 and its members include companies that make Pharmaceutical drugs, biofuels, industrial enzymes, and genetically modified crops.
- The Biotechnology Heritage Award presented annually at the Biotechnology Innovation Organization (BIO).
- The award recognizes individuals who have made significant contributions to the development of biotechnology through discovery, innovation, and public understanding.



6.24 Major Programmes Undertaken by the Department of Biotechnology

Health and Medicine

- **National Biopharma Mission** - was launched by DBT in a bid to create a globally competitive biopharmaceutical industry.
- This brings together industry and academia to promote entrepreneurship and indigenous manufacturing in the bio-pharmaceutical sector.
- This flagship program is run in collaboration with the **World Bank** and will be implemented by the Biotechnology Industry Research Assistance Council (BIRAC), a Public-Sector Enterprise set up by DBT.

7. NUCLEAR TECHNOLOGY

7.1 Kovvada

- Kovvada is a new nuclear plant to be set up in the State of **Andhra Pradesh**.
- It is a proposed light water nuclear reactor in Srikakulam District.
- Recently, the land acquired for the construction of the nuclear power plant was handed over to Nuclear Power Corporation of India Limited (NPCIL).

7.2 Pressurized Heavy Water Reactor

- Government of India has accorded approval for the construction of 10 indigenous Pressurized Heavy Water Reactors (PHWRs).
- The reactors are planned at Kaiga in Karnataka, Gorakhpur in Haryana, Chutka in M.P, and MahiBanswara in Rajasthan.
- A PHWR is a nuclear power reactor commonly using un-enriched natural Uranium as its fuel, and heavy water (deuterium oxide, D₂O) as its coolant and moderator.
- Indian PHWRs: Tarapur (Maharashtra), Rawatbhata (Rajasthan), Kalpakkam (T.N), Narora (U.P), Kakrapar (Gujarat) and Kaiga (Karnataka).

7.3 Nuclear Command Authority

- It is responsible for command, control and operational decisions regarding India's nuclear weapons programme.
- Organisational structure of NCA includes Political Council and Executive Council.
- Executive Council is headed by National Security Advisor and Political Council is headed by Prime Minister.
- The Executive Council gives its opinion to the Political Council, which authorises a nuclear attack when deemed necessary.
- This kind of organisational structure is created to prevent the accidental or unauthorised use of nuclear weapons.
- Strategic Forces Command is a part of Nuclear Command Authority, responsible to operationalize the directives of NCA and for the management and administration of the country's tactical and strategic nuclear weapons stockpile.
- SFC is headed by Commander-in-chief of the rank of Air Marshal.
- It will have the sole responsibility of initiating the process of delivering nuclear weapons and warheads, after acquiring explicit approval from the NCA.

7.4 Nuclear Recycle Board

- Nuclear Recycle Board functions as an entity within Bhabha Atomic Research Centre (BARC) and operates under the purview of BARC Safety Council.
- Nuclear Recycle Board is responsible for the design, construction and construction and operation of nuclear recycle plants involving reprocessing and waste management.
- The operation and maintenance of nuclear recycle facilities in the back end of Pressurized Heavy Water Reactor (PHWR) fuel cycle is under the purview of Nuclear Recycle Board.

Nuclear Power Plants	Types of Nuclear Reactor
Rawatbhata, Rajasthan	Pressurized Heavy Water Reactor (PHWR)
Kaiga, Karnataka	PHWR
Kakrapar, Gujarat	PHWR
Narora, UP	PHWR
Kalpakkam, TN	PHWR & Pressurized Fast Breeder Reactor
Tarapur, Maharashtra	PHWR & Boiling Water Reactor (BWR)
Kudankulam, TN	Water-Water Energetic Reactor (VVER)

7.5 Nuclear Plant in M.P

- Activist and villagers in Madhya Pradesh raised their concerns over the proposed nuclear plant in Chutka.
- In 2009, Nuclear Power Corporation of India Ltd. (NPCIL) has decided to set up the atomic station in Mandla district of Madhya Pradesh to generate 1,400 MW power.
- At present, there are 9 nuclear power reactors at various stages of construction.
- Kakrapar (2 reactors) in Gujarat, Rawatbhata (2 reactors) in Rajasthan, Kudankulam (2 reactors) and Kalpakkam (1 reactor) in Tamil Nadu and Gorakhpur (1 reactor) in Haryana.
- There are few nuclear power reactors accorded administrative approval and financial sanction. Each site has 2 reactors.
- Gorakhpur in Haryana, Mahi-Banswara in Rajasthan, Kaiga in Karnataka, Chutka in Madhya pradesh, Kudankulam in Tamil Nadu.
- **Kakrapur Atomic Power Station**
- Two units of Pressurised heavy water reactors in Kakrapur Atomic Power station recently attained 'criticality'.
- The term 'criticality' denotes initiation of self-sustaining nuclear fission chain reaction in the reactor.
- Two years before, the units were shut due to leak of heavy water coolant, leaving both units non-functional.

7.6 Kaiga Nuclear Power Plant

- Kaiga plant in Karnataka has recently created a world record for the longest uninterrupted operation for 941 days.
- It breaks the earlier record of 940 days by the Heysham – 2 reactor of United Kingdom.
- Kaiga is an indigenously built Pressurised Heavy Water Reactor (PHWR) run by domestic fuel (Uranium).
- It began commercial operation in 2016.
- While Kaiga is a PHWR and Heysham-2 Unit-8 is an Advanced Gas Cooled Reactor (AGR).

8. INNOVATIONS

8.1 Pratyush

- Pratyush is an array of computers recently unveiled in India.
- It can deliver a peak power of 6.8 petaflops.
- One petaflop is a million billion floating point operations per second and is a reflection of the computing capacity of a system.

- The machines will be installed at two government institutes: 4.0 petaflops HPC facility at Indian Institute of Tropical Meteorology (IITM), Pune & 2.8 petaflops facility at the National Centre for Medium Range Weather Forecast, Noida
- Pratyush is also the fourth fastest supercomputer in the world dedicated for weather and climate research.
- It follows machines in Japan, USA and the United Kingdom.
- A key function of the machine's computing power would be monsoon forecasting using a dynamical model.
- With the new system, it would be possible to map regions in India at a resolution of 3 km and the globe at 12 km.

Rank	Site	Rpeak (TFlop/s)	Power (kW)
1	National Supercomputing Center in Wuxi, China	1,25,435.9	15,371
2	National Super Computer Centre in Guangzhou, China	54,902.4	17,808
3	Swiss National Supercomputing Centre, Switzerland	25,326.3	2,272
4	Japan Agency for Marine Earth Science and Technology, Japan	28,192	1,350
5	DOE/SC/Oak Ridge National Laboratory, United States	27,112.5	8,209

8.2 Mihir

- Mihir' (meaning 'Sun') a High Performance Computer (HPC) System has been installed at the National Centre for Medium Range Weather Forecasting (NCMRWF).
- This HPC facility will be India's largest HPC facility in terms of peak capacity and performance.
- The new HPC facility is expected to improve the following services:
 1. Weather forecasts for predicting extreme weather events.
 2. High resolution seasonal/extended range forecasts of active/break spells of Monsoon.
 3. Very high resolution prediction of cyclones with more accuracy and lead time.
 4. Ocean state forecasts like marine water quality forecasts and Tsunami forecasts.
 5. Air quality forecasts for various cities.

8.3 National Supercomputing Mission

- India has recently granted contract to French technology firm to build 70 supercomputers under the National Supercomputing Mission.
- The mission aims to connect national academic and R&D institutions with a supercomputing grid of over 70 high-performance computing facilities.
- Supercomputers will be installed across the country and will be networked on the National Supercomputing grid over the National Knowledge Network (NKN).
- It will be implemented by the Department of Science and Technology and Department of Electronics and Information Technology (DeitY) through Centre for Development of Advanced Computing (C-DAC) and IISc, Bangalore.
- The Mission also includes development of highly professional High Performance Computing (HPC) aware human resource for meeting challenges of development of these applications.
- The NKN is another programme of the government which connects academic institutions and R&D labs over a high speed network.

8.4 Memristors & AI

- Artificial neural networks (ANNs) are computing systems that can learn and progressively improve performance on tasks by considering examples.
- Researchers have recently developed a new type of neural network chip that can dramatically improve the efficiency of teaching machines to think like humans.
- It improves a typical neural network's capacity and reduces the required training time.
- They have been created in the past with larger optical components.
- Now the researchers have created their system using memristors.

- Memristors are a special type of resistive device that can both perform logic and store data.
- This contrasts with typical computer systems, where processors perform logic separate from memory modules.
- Hence they require less space and can be integrated more easily into silicon-based electronics.

8.5 Quantum Computing

- A quantum computer, still largely a theoretical entity, employs the principles of quantum mechanics to store information in 'qubits' instead of the typical 'bits' of 1 and 0.
- Qubits work faster because of the way such circuits are designed, and their promise is that they can do intensive number-crunching tasks much more efficiently than the fastest comparable computers.
- The existing systems use principles of quantum computing to solve very limited problems.
- Internationally, Canada's D-Wave Systems, is a pioneer in developing quantum computers.
- India has joined the Quantum Computing race by funding development of quantum machines by Department of Science and Technology.

8.6 Quantum Dots

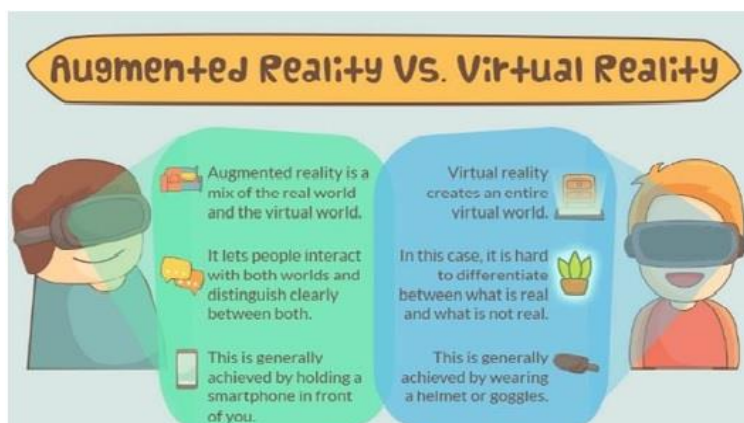
- Quantum dots are tiny particles or nanocrystals of a semiconducting material with diameters in the range of 2-10 nanometres.
- Quantum dots display unique electronic properties, intermediate between those of bulk semiconductors and discrete molecules.
- They can be made to emit or absorb specific wavelengths of light by controlling their size.
- It can lead to a new generation of high definition technology.
- It can be used as a display platform in televisions, for enhanced medical imaging as well as in solar cells.
- The Science Advances journal says, when quantum dots are clustered together they are more fluorescent, providing a wide variety of colours.
- It will pave the way for brighter, lighter and more energy efficient TVs and smart devices.

8.7 Quantum Mechanics

- Quantum mechanics deals with the behaviour of matter and light on the atomic and subatomic scale.
- It attempts to describe and account for the properties of molecules and atoms and their constituents such as electrons, protons, neutrons.
- It is considered as the dark arts of physics since it deals with the invisible world of subatomic particles.
- Through quantum mechanics, subatomic particles can be manipulated for purposes that benefit the visible world such as making integrated circuit chips and fibre-optic lines for global, instantaneous communication.
- Recently, China has combined satellite technology and quantum mechanics to demonstrate how secret information can be transmitted over a thousand kilometres.
- It has transmitted the information with the guarantee that any unauthorised attempt to decipher it would be immediately discernible.

8.8 Virtual Reality

- The school children in United States experience exotic field trips through the virtual reality headsets.
- The definition of 'virtual' is near and reality is what we experience as human beings. So the term 'virtual reality' basically means 'near-reality'.
- Virtual reality is the term used to describe a three-dimensional, computer generated



environment which can be explored and interacted with by a person.

8.9 Microsoft HoloLens-Augmented Reality

- Augmented reality headsets -HoloLens can help doctors 'see through' organs and tissues in the operating theatre.
- The advancement improves the outcome of reconstructive surgery for patients.
- The approach can help surgeons locate and reconnect key blood vessels during reconstructive surgery, which could improve outcomes for patients
- Augmented reality (AR) is a live direct or indirect view of a physical, real-world environment whose elements are "augmented" by computer-generated perceptual information.
- Other Fields of applications are: Archaeology, Architecture, Education, commerce.

8.10 Bitcoins

- Crypto-currency is a digital currency that allows transacting parties to remain anonymous while confirming the transaction is valid.
- Bitcoins are cryptocurrencies introduced in 2008.
- It is the most commonly used crypto currency across the globe.
- It does not belong to any nation, so that there is no regulatory authority for bitcoins.
- It is underpinned by a peer-to-peer computer network made up of its users' machines called block chain.
- Bitcoins are mathematically generated as the computers in this network solve various mathematical tasks.
- This procedure is known as **Bitcoin "mining"**.
- The mathematics of the Bitcoin system is set up in such a way that it becomes progressively more difficult to "mine" Bitcoins over time.
- The total number that can ever be mined is limited to around 21 million.
- When more people accept bitcoin or other cryptocurrencies for goods and services, their value increases.
- There is therefore no way for a central bank to issue a flood of new Bitcoins and devalue those already in circulation.
- Bitcoin transactions done globally can be completed in a few seconds with minimal costs compared to traditional financial systems.
- It can be bought from various international exchanges using credit cards or other electronic means.
- The provision of anonymity is widely misused especially in making cross-border transactions and used as a means for money-laundering, terror funding and drug trafficking, and other illegal activities.
- **Status of Bitcoins** - Since 2014, the American tax authorities have treated cryptocurrencies as 'property' subject to appropriate capital gains tax rate.
- Japan and Australia deemed bitcoin as a legitimate payment method in 2017.
- Chinese authorities have aggressively stepped in to ensure cryptocurrency exchanges function well.
- Indian Finance Ministry and the RBI had issued warning against investing in crypto-currencies (CC) and have likened them to 'Ponzi schemes'.

8.11 Block Chain Technology

- Blockchain is the basis of bitcoins, it is a digital public ledger that records every transaction.
- Once a transaction is entered in the blockchain, it cannot be erased or modified.
- Blockchain removes the need for using a trusted third party such as a bank to make a transaction by directly connecting the customers and suppliers.
- Each transaction is recorded to the ledger after verification by the network participants, mainly a chain of computers, called nodes.
- Bitcoin is just one of the applications for the technology, whose use is being tested across industries.

- It is an advantage, when there is a lot of data that is shared across multiple parties with no trust mechanism among the participants.
- Non-financial players like retail, travel, health care, telecom and public sector industries are also working on this technology.

Other Cryptocurrencies

- **Ripple** is a technology that acts as both a cryptocurrency and a digital payment network for financial transactions.
- It was released in 2012 and its coin is labeled as XRP.
- Ripple operates on an open source and peer-to-peer decentralized platform that allows for a seamless transfer of money in any form, whether USD, Yen, litecoin, or bitcoin.
- It is the fourth-largest cryptocurrency in the world by market capital, which now stands at around \$43 billion.
- **Petro** is a cryptocurrency launched by Venezuela backed by oil reserves.
- It is mainly to shore the collapsed oil economy.
- Venezuela's real currency "**Bolivar**" is in freefall, and the country is sorely lacking in basic needs like food and medicine.

8.12 Free Space Optical Communications

- AP and Telangana government is keen to use Free Space Optical Communications (FSOC) technology by GoogleX to provide internet access to people in parts of the state.
- FSOC technology uses beams of light to deliver high-speed, high-capacity connectivity over long distances.
- Most frequently, laser beams are used, although non-lasing sources such as light-emitting diodes (LEDs) or IR-emitting diodes (IREDs) will serve the purpose.
- The theory of FSO is essentially the same as that for fiber optic transmission.
- The difference is that the energy beam is sent through clear air or space from the source to the destination, rather than guided through an optical fiber.
- As long as there is a clear line of sight between the source and the destination, communication is theoretically possible.
- Even if there is no direct line of sight, strategically positioned mirrors can be used to reflect the energy.

8.13 Fiber Optics

- Fiber optics is the science of transmitting data, voice, and images by the passage of light through thin, transparent fibres.
- The basic medium of fibre optics is a hair-thin fibre that is most often made up of glass and sometimes plastics.
- Through a process known as **total internal reflection**, light rays beamed into the fibre can propagate within the core for great distances with remarkably little attenuation, or reduction in intensity.
- In telecommunications, fibre optic technology has virtually replaced copper wire in long-distance telephone lines, and it is used to link computers within local area networks.

8.14 Triboelectric Nanogenerators - Wireless Transmission of Electrical Energy

- For the first time wireless transmission of electrical energy has been achieved using triboelectric nanogenerator.
- Also, for the first, a triboelectric nanogenerator has been directly 3D printed from biodegradable materials.
- A nanogenerator in simple terms is a small electronic chip that harvests mechanical energy and converts it into electrical energy.
- The key components inside a nanogenerator are nanowires.
- Notably, hundreds of nanowires can be packed side by side in a space less than the width of a human hair.

- Given this scale and the flexibility of the nanogenerator's components, even the slightest movement can generate current.
- Triboelectric nanogenerator is one of the 3 types of nanogenerators.
- The other two are piezoelectric and pyroelectric.
- Piezoelectric and triboelectric nanogenerators convert mechanical energy into electricity.
- On the other hand, pyroelectric nanogenerators harvest thermal energy from a time-dependent temperature fluctuation.
- The **triboelectric effect** is a type of **contact electrification**.
- It is where certain materials become electrically charged after coming into frictional contact with another different material.

Applications

- Nanogenerators can be used to light up homes, control doors and even set burglar alarms.
- It can be installed at airports, sidewalks and battery can be placed on the nearby walls to store the energy.
- The electric field can also be made use as an actuated remote.
- E.g. Tapping the W-TENG and using its electric field as a „button“ to open a door or activate a security system, all without a battery.
- There are no wires involved and thus there is no need of power outlets.
- The wireless feature extends its application into resource-limited settings such as in outer space, in middle of the ocean, etc.

8.15 High Nitrogen Steel

- High nitrogen steel (HNS) is corrosion-resistant material, it has better holistic capabilities and mechanical properties than rolled homogenous armor steel and imported metals.
- The potential applications of HNS include combat platforms like futuristic infantry combat vehicles, mine-protected vehicles, army bridges and army corridors.
- In India Mishra Dhatu Nigam (MIDHANI), Hyderabad is having production capacity to manufacture high-nitrogen steel (HNS) for armor applications.
- This steel is will be produced in commercial scale as part of transfer of technology from Defense Metallurgical Research Laboratory (DMRL).

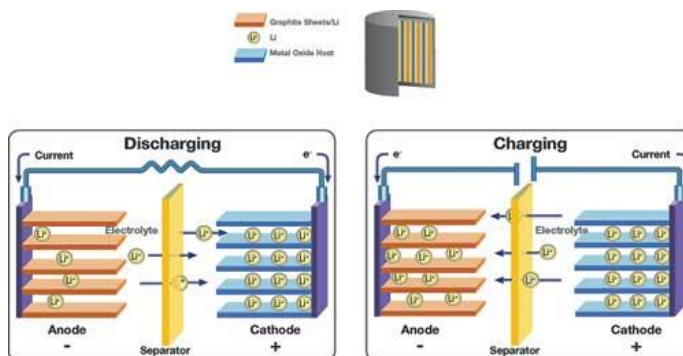
8.16 India's first indigenous Lithium Ion Battery project

- Central Electro Chemical Research Institute (CECRI), Karaikudi, Tamil Nadu and RAASI Solar Power Pvt Ltd have signed a Memorandum of Agreement for transfer of technology for India's first Lithium Ion (Li-ion) Battery project.
- CECRI is under Central Science and Industrial Research (CSIR).
- CSIR-CECRI has set up a demo facility in Chennai to manufacture prototype Lithium-Ion cells.
- It has secured global IPRs with potential to enable cost reduction, coupled with appropriate supply chain and manufacturing technology for mass production.
- Currently, Indian manufacturers source Lithium Ion Battery from China, Japan and South Korea among some other countries.

8.17 Lithium-ion Battery

- ISRO has approved commercial use of lithium-ion battery technology and the battery makers will be required to pay Rs 1 crore as a one-time technology transfer fee to ISRO for every e-vehicle.
- It is expected to save 10-15 per cent of the cost of e-vehicles.
- The process of remodelling the battery made by ISRO to be used in e-vehicles, will take time to scale up production.

- At present, lithium-ion batteries are not manufactured in India and therefore the country has to depend on imports from Japan or China.
- But there is a concern about the property of flammability of lithium-ion battery.
- Lithium-ion batteries are all about the movement of lithium ions.
- The ions move one way when the battery charges (when it's absorbing power); they move the opposite way when the battery discharges (when it's supplying power).
- Lithium ion batteries are more reliable than older technologies such as nickel-cadmium.
- Nickel batteries appear to become harder to charge unless they're discharged fully first, it is not the case with lithium ion batteries.
- Lithium-ion batteries don't contain cadmium, a toxic, heavy metal.
- It has high energy density i.e. it store more energy per unit of weight when compare to other kind of batteries.
- But it still stores a hundred times less energy dense than gasoline (which contains 12,700 Wh/kg by mass or 8760 Wh/L volume).
- It has a much lower energy density i.e it store less energy per unit of weight.
- It is used in every modern cellphone, laptop, tablet, and most other rechargeable gadgets.



8.18 Thermal Battery Plant

- World's first-ever thermal battery plant was recently inaugurated in Andhra Pradesh.
- It aims to create a new energy storage form with commercial applications, maintaining a low carbon footprint and less dependent on external factors like weather.
- Conventional battery technology is based on the system of charging/discharging cycles that are driven by electricity. Eg. Lithium ion battery used in electronic devices.
- Thermal batteries use thermal energy to operate, i.e. the energy created by temperature differences.
- The energy transfer in thermal batteries helps store heat when heat travels from one part of the battery setup to the other.
- **Working of Thermal Battery** - It consists of two parts such as a cool zone known as sink, and a hot source called source.
- When the sink of a thermal battery receives heat, it transforms physically or chemically, thereby storing energy, while the source cools down.
- During operation, the sink is cooled down, so it releases the stored energy, while the source heats up.
- **Applications** - Electric vehicles, Telecom infrastructures, Power intensive industries.

8.19 Helium

- It is the second most abundant element in the Universe, after Hydrogen.
- Its abundance is due to the very high nuclear binding energy (per nucleon) of helium.
- In its gaseous form, it is so light, and it escape from the Earth easily.
- In one of the places, it is found is in volcanic lava plumes, such as seen in Iceland and Hawaii, originating from the Earth's mantle.
- This is ancient helium from when the Earth was formed.
- It is believed to be trapped in compounds deep within the earth.
- A team of researchers has come up with the possibility that the mantle helium must exist as the compound FeO_2He .

- The compound is stable and solid under the pressure and temperature conditions prevailing at those depths.
- Researchers are using a crystal search algorithm to look at possible compounds containing helium.
- It will solve the long-standing problem of where ancient helium is stored in the Earth.

8.20 5G technology

- Union telecom ministry had announced 5G technology will be rolled out from 2020.
- This would entail accelerating the BharatNet programme for deploying connectivity infrastructures
- 5G is the fifth generation wireless network which promises ultra-reliable, very fast speeds and high bandwidth mobile connectivity and supports massive interconnected devices spread across wide areas like Internet of things (IoT).
- It made the worldwide debut in the winter Olympics at Pyeongchang, South Korea.
- Previous generations like 3G were a breakthrough in communications. 3G receives a signal from the nearest phone tower and is used for phone calls, messaging and data.
- 4G works the same as 3G but with a faster internet connection and a lower latency (the time between cause and effect).
- 5G provides peak speeds of 20 times, compared with 4G.
- To qualify for a 5G a connection should meet most of these eight criteria:
 1. **1 to 10Gbps** connections to end points in the field
 2. 1 millisecond end-to-end round trip delay
 3. 1000x bandwidth per unit area
 4. 10 to 100x number of connected devices
 5. (Perception of) 99.999 percent availability
 6. (Perception of) 100 percent coverage
 7. 90 percent reduction in network energy usage
 8. Up to **ten-year battery life** for low power, machine-type devices

8.21 4D Printing

- Scientists have successfully developed the world's first 4D printing for ceramics.
- It can be used to create complex, shape-changing objects.
- 4D printing is conventional 3D printing combined with the additional element of **time as the 4th dimension**.
- The 4D printed objects can re-shape or self-assemble themselves over time with external stimuli, such as mechanical force, temperature, or a magnetic field.
- The existing 3D-printed ceramic productions are usually difficult to deform and hinder the production of ceramics with complex shapes.
- A novel ceramic ink was developed to stretch the ceramic products beyond its initial length and allow complex shapes with heat treatment.

8.22 Li-Fi

- Light-fidelity (LiFi) is a technology used for free-space communication using visible and near-visible light.
- It is similar to Wireless Fidelity (WiFi), a technology for wireless local area network communication using microwaves.
- Microwaves can pass through walls while transmitting signals whereas visible and near-visible light cannot pass through walls.
- Microwaves are used in WiFi technology to transmit signals which can pass through walls.
- Li-Fi, on the other hand, uses visible and near-visible light that carry the LiFi signal. Hence it cannot pass through walls.



- Thus it makes LiFi signal network more secure.
- Scientists have recently added a new layer of security to LiFi.
- Light bounces off from walls and falls on the receiver.
- So wall boundaries can be used effectively for reflecting signals so that communication is maintained even without line-of-sight communication between the signal source and receiver.
- Receiving detectors can receive both direct and reflected signals.
- Walls painted with fluorescent and phosphorescent paints absorb and then emit light with marginal loss.
- The paints continue to emit light even several hours after the original source of light has been switched off.
- This makes the communication signal more effective and secure.

Parameter	Li-Fi	Wi-Fi
Medium through which data transfer	Light medium	Radio waves
Privacy	In Li-Fi, light is blocked by the walls and hence will provide more secure data transfer	In Wi-Fi, RF signal can not be blocked by the walls and hence need to employ techniques to achieve secure data transfer.
Data Transfer Speed	About 1Gbps	150Mbps
Frequency of operation	100THz	2.4GHz, 4.9GHz and 5GHz
Coverage distance	About 10 meters	About 32 meters (WLAN 802.11b/11g), vary based on transmit power and antenna type

8.23 Raman Effect

- Raman Effect deals with the change in the wavelength of light that occurs when a light beam is deflected by molecules.
- The method can provide key information easily and quickly by characterizing the chemical composition and structure of a sample.
- Raman Effect has a wide range of application in fields such as geology, material science, forensic science, nuclear science and pharmacology.
- The effect is named after the Indian Physicist Sir C.V.Raman who observed the same.
- He was awarded Nobel Prize in Physics in 1930.
- To mark the discovery of Raman Effect, February 28 is celebrated as the National Science Day in the country.

8.24 Humanoid Robot-Sophia

- Sophia is the world's first AI powered humanoid robot
- It was a part of the World Congress on Information Technology (WCIT), 2018, held in Telegana, India.
- A Humanoid may be defined as something that resembles or looks like a human and having their characteristics like opposing thumb etc,
- A Humanoid robot is fully automated as it can adapt to its surroundings and continue with its goals, as the case with Sophia.
- Sophia with her incredible human likeness and expressiveness is an evolving genius machine.
- Sophia, with a perfect skin and soft facial muscles, can give as many as 66 facial expressions.

8.25 Largest Prime Number

- A very big number over 23 million digits long has discovered to be the "largest known prime number".
- This number was discovered using software called GIMPS.
- A prime number is a number that can only be divided by itself and by 1. For example: 2, 3, 5, 7, 11, and so on.
- Prime number are used in Cryptography (the study of secret messaging, involves sharing information via secret codes), credit cards, cell phones, all depend on cryptography.

8.26 VdW Materials

- VdW materials are made of piles of ultra-thin layers that are held together by van der Waals bonds.
- Van der Waals bonds are weak forces exist between molecules of same substance and arise when atoms are in close proximity.

- VdW materials have the potential to replace the current hard drive assemblies in computers and become the key to quantum computing.
- Controlling magnetism is typical of VdW materials.
- The layers in the material can be changed, added or removed in order to introduce magnetism and other new physical properties in the material.

8.27 Change in the definition of 'Kilogram'

- The Definition of the Kilogram is about to change by redefining the International system of units (SI).
- There are seven fundamental units and every other unit of measurement can be derived from one or more of these seven units.
- Three of the seven fundamental units are already based on unchanging properties of nature.

UNIT	QUANTITY	HOW IT IS/WILL BE DEFINED
Meter*	Distance	Based on speed of light
Kilogram**	Mass	To be based on Planck constant
Second*	Time	Based on radiation of caesium-133 atom
Ampere**	Current	To be based on an electron's charge
Kelvin**	Temperature	To be based on Boltzmann constant
Mole**	Amount of substance	To be based on Avogadro constant
Candela*	Luminous intensity	From efficacy of light of specific frequency

* Current definition stands ** Being redefined

- These are the second (time), the metre (distance), and the candela (luminous intensity, a measure for light's brightness).
- The first kilogram was by the measure of mass of one cubic decimetre of distilled water at 4°C (the temperature at which water has its highest density under standard conditions).
- This had the advantage in that most properly equipped labs would be able to reproduce this standard.
- These variable measurements were finally replaced with the international prototype kilogram (IPK), used today, which is a **metal** cast from a mixture of platinum and iridium to make it very hard and prevent it reacting with oxygen.
- Although this metal is stored in a highly controlled environment, its weight can change by tiny amounts as wear and tear causes it to lose mass and dirt causes it to increase.
- Hence, even the modern IPK to measure the kilogram can gradually change in mass.
- To address this problem, scientists decided that instead of measuring the kilogram against a block stored in a vault, it should be based on precise values of constants of nature.
- Thus the kilogram's definition is set to change and the new definition of the kilogram uses a measurement from another fixed value from nature, Planck's constant (h).
- Planck's constant will be defined as $6.62607015 \times 10^{-34}$ joule seconds and can be found by dividing the electromagnetic frequency of a particle of light or "photon" by the amount of energy it carries.
- The constant is usually measured in joule seconds but this can also be expressed as **kilogram square metres per second**.
- Since 1967, the second has been defined as the time it takes for a certain amount of energy to be released as radiation from atoms of Caesium-133.
- This became the basis of all measures of time, and is used in atomic clocks.
- The SI unit of the metre is also based on another universal constant, namely the speed of light.
- The metre is defined as the distance travelled by light in vacuum in $1/299,792,458$ of a second (which is already defined).
- Thus, since definition of a second and a metre have already adjusted to universal constants, by adding these measurements, along with an exact knowledge of Planck's constant, a very precise definition of the kilogram can be reached easily.

9. INTELLECTUAL PROPERTY RIGHTS

9.1 Different Categories of IPR

PATENT

- An exclusive statutory right granted for an invention – a **product or process** that provides a new way of doing something or that offer a new technical solution to a problem.

- There are 2 types of patent – product and process patent.
- Patent gives Monopoly right for a limited period of time.
- 3 conditions should be satisfied before applying for patent. They are,
 - Utility for the society (USEFULNESS)
 - Must have an element of 'NOVELTY'
 - NON-OBVIOUSNESS
- Legal Basis – It is protected under Indian patent law 1970 and its amendments.
- Valid Time Period - generally 20 years.

TRADE MARK

- Trade Mark is a distinctive sign that identifies certain goods or services produced or provided by an individual or a company.
- Trade Mark is allocated to a visual symbol such as name, label, numerals, combination of colours, logo etc.
- Legal Basis –It is protected under Trade marks act 1999.
- Time period – renew indefinitely with payment of fees for every 10 years.

INDUSTRIAL DESIGN

- It refers to the ornamental or aesthetic aspects of an article – 3D features such as shape or 2D features like patterns, lines colours and technical features are not protected
- Industrial Design must be new or original
- Legal basis – It is protected under Design act 2000
- Time period – generally 5 yrs + maximum renewal to 15 years

COPYRIGHT

- Copyright is given to authors of literary and artistic works for their artistic creations such as books and other writings, musical composition, paintings, sculptures, films, computer programmes.
- It is protected under Copyright act 1957
- Time period
 - Literary, dramatic, musical and other artistic works – lifetime of author + 60 years
 - Government work, sound records, photography.. – 60 years
- Copyright does not cover - Names, titles or short phrases, Ideas, Facts and works lacking originality.

TRADE SECRET

- Trade secret covers any confidential business information that provides a competitive edge to an enterprise.
- It includes Manufacturing or industrial secrets or commercial secrets
- It is being protected without registration
- Time period – unlimited
- There is no specific law to deal with this but cases for violation can be filed under contract act 1872.

GEOGRAPHICAL INDICATORS (GI)

- A name or sign used on goods that have a specific geographical origin and posses qualities or a reputation due to that place of origin.
- Its purpose is to create unique identification to customers and thereby creating more demand for products.
- It is given to both man-made and natural products.
- However, it is a community right rather than individual or company.
- It is protected under Geographical indications of goods (registration and protection) act, 1999.



- It is managed by Cell for IPR promotion and Management (CIPAM) under the Department for Promotion of Industry and Internal Trade (DPII), Ministry of Commerce and Industry.
- At the International level, GI is governed by World Trade Organisation's (WTO's) Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS).
- TIME PERIOD – 10 years + renewed for any time
- The first product in India to be accorded with GI tag was Darjeeling tea in the year 2004-05.
- Some of the examples of registered Indian GIs are Tirupathi Laddu, Kangra Paintings, Nagpur Orange, Kashmir Pashmina etc.

Recent developments

- The Cell for IPR Promotions & Management (CIPAM) has launched the second edition of 'IPrism'.
- It is launched in collaboration with ASSOCHAM and ERICSSON India.
- It is an Intellectual Property (IP) competition for students of schools, polytechnic institutes, colleges and universities in India.
- It aims to foster a culture of innovation and creativity in the younger generation.
- This year, the competition is held under 2 categories - film making and comic book making.

9.2 Stone Sculptures of Mamallapuram

- The **hand-crafted stone sculptures of Mamallapuram** have been recently granted the Geographical Indications (GI) tag.
- The exquisite rock-sculpting techniques exhibited in Mamallapuram date back to early 7th century CE.
- The Pallava dynasty, which ruled the area between 6 and 9th centuries A.D., is responsible for the development of port town as a centre of art and architecture.
- Mahendravarman (AD 580-630), his son Narasimhavarman I Mamalla (AD 630-668), Paramesvaravarman (A.D. 672-700) and Narasimhavarman II Rajasimha (A.D. 700-728) had contributed the most of sculptures.
- Mamallapuram was named after the king Narasimhavarma Pallava, who was also known as Mamallan (great wrestler).
- Sculptors use blue metal for stone sculptors instead of granite which has high density and very costly.
- **Tamil Nadu has the maximum the number of GI tags** among the states, while UP comes second.
- Tamil Nadu has submitted 50 products of which 24 have been approved by the registry.
- Coimbatore wet grinder, artisans of Vadasery in Nagercoil who make dazzling jewellery of a unique kind for temples, Tanjavur Dancing Doll are some of the products that have obtained the GI certificate.
- Darjeeling Tea was the first Indian product to get a Geographic Indication in the early 2000s.

9.3 Rasgulla

- West Bengal state has recently won the GI tag for Rasgulla.
- West Bengal and Odisha have been engaged in a legal battle over the origin of the syrupy Rasgulla since June 2015.

9.4 Etikoppaka Toys

1. **Etikoppaka Toys** are made from the soft wood of Ankudi Karra (Wrightia tinctoria) tree and they are painted with natural dyes, which is prepared from seed, lacquer, bark, roots and leaves.
 - The dyes are non-toxic.
 - The art of making such toys is known as turned wood Lacquer craft
 - With this, Etikoppaka toys join elite products from Andhra Pradesh such as Kondapalli toys, Tirupati laddu, Bobbili Veena, Srikalahasthi Kalamkari, Uppada Jamdani sarees and Shadow puppets.
 - The other products that have received this tag this year include
 - i. Pochampally Ikat of Telangana;

- ii. Gobindobhog Rice of West Bengal;
- iii. Durgi Stone Carvings and
- iv. Chakshesang Shawl of Nagaland

9.5 Shahi Litchi

- Shahi Litchi is mostly grown in Muzaffarpur and neighbouring districts in Bihar.
- It has recently got Geographical Indication Tag.
- It is known for its sweet, juicy, unique flavour and aroma.
- Other known GI from Bihar - Katrani rice, Jardalu mango and Magahi paan (betel vine).

9.6 Alphonso Mango

- The government has recently granted Geographical Indication (GI) tag to the Alphonso Mango from Ratnagiri, Sindhudurg and other adjoining areas in Maharashtra.
- Alphonso, the king of Mangoes, better known as 'Hapus' in Maharashtra, is in demand in domestic and international markets for its taste, pleasant fragrance and vibrant colour.

Other Recently Granted GIs

- **Thirubuvanam silk saree** from Tamil Nadu for its unique style of silk sarees weigh around 450-1250 gm in which the silk alone weighs around 400 gm and the rest of the weight comprises of zari.
- **Erode Manjal (Turmeric)** from Tamil Nadu has been granted GI tag after 8 years of process.
- **Rajkot Patola Sarees** from the District of Rajkot, Gujarat for its pure single silk fabric produced using vegetable dyes with equal intensity of color and design on both sides.
- **Boka Chaul (soft-rice) from Assam** is a native variety of rice and is unique because it requires no fuel to cook and can be eaten by just soaking it in water at room temperature.

9.7 Some of the registered GIs- State Wise

- **Jammu & Kashmir** – Pashmina Hand-Knotted Carpet, Papier Mache, Walnut Wood Carving
- **Himachal Pradesh** - Kangra Paintings, Kullu Shawl, ChambaRumal
- **Sikkim** - Large Cardamom
- **Nagaland** - Chakshesang Shawl.
- **Assam** - Muga Silk, Joha Rice, Tezpur Litchi.
- **Manipur** - ShapheeLanphee, WangkheiPhee, MoirangPhee and Kachai Lemon.
- **Tripura**- Tripura Queen Pineapple.
- **Meghalaya** - Khasi Mandarin, Memong Narang
- **Bihar** - Madhubani Paintings, Bhagalpur Silk, Sikki Grass Work
- **Rajasthan** - Blue Pottery of Jaipur, Kathputlis, Sanganeri Hand-Block Printing
- **Maharashtra** - PuneriPagadi, Nashik Valley Wine, Mahabaleshwar Strawberry, Warli Painting
- **Telangana** - Silver Filigree of Karimnagar, Hyderabad Haleem, Narayanpet Handloom Sarees.
- **Karnataka** - Channapatna Toys & Dolls
- **Puducherry** - Villianur Terracotta Works
- **Kerala** - AranmulaKannadi, Palakkadan Matta Rice, Balaramapuram Saris and Fine Cotton Fabrics.

10. TECHNOLOGICAL INTERVENTIONS

10.1 Project Dhoop

- The 'Project Dhoop' is launched by the Food Safety and Standards Authority (FSSAI) along with National Council of Educational Research and Training (NCERT), New Delhi Municipal Council (NDMC) as well as North MCD Schools.

- It is a unique initiative to encourage schools to shift their morning assembly to around noon-time to ensure maximum absorption of Vitamin D in students through natural sunlight.
- The move comes in the backdrop of rising incidence of Vitamin D deficiency in the country.
- Over 90 per cent of boys and girls in various Indian cities are deficient in Vitamin D despite most part of India receiving abundant sunshine all the year through.
- Vitamin D deficiency occurs due to overuse of sunscreen, wearing clothes that cover most of the skin, working all day in an air-conditioned atmosphere, and other factors.
- Vitamin D deficiency may also cause several problems including:
 1. Osteomalacia
 2. Osteoporosis
 3. Rickets
 4. Periodontitis

10.2 Space Activities Bill

- The Department of Space has released a draft Space Activities Bill, 2017.
- Currently, space activities are regulated by policies such as the Satellite Communication Policy, 1997 and Remote Sensing Data Policy, 2011.
- The proposed Bill addresses the need for a legal environment for orderly performance and growth of the space sector.
- It aims at encouraging both the public and private sectors to participate in the space programme.
- The Bill specifically facilitates for the participation of non-governmental/private sector agencies in space activities in India.

Key Provisions

- The provisions of the legislation shall apply to every citizen of India.
- And also to all sectors engaged in any space activity in India or outside India.
- Regulatory mechanism - The central government is responsible for setting mechanisms and promoting space activity.
- This includes exploration and use of outer space, and development of the sector.
- The central government can:
 1. grant, transfer, or terminate licenses to any person for commercial space activities
 2. provide professional and technical support, and authorisation to launch or operate space objects
 3. regulate the procedures for conduct and operation of space activity by monitoring the conformity with international space agreements to which India is a party
 4. ensure safety requirements and investigate any incident or accident in connection with the operation of a space activity
- Licences - A non-transferable licence shall be provided by the Central Government to any person carrying out commercial space activity.
- A license granted by the central government includes -
 - permission for the central government to inspect any space activity and documents related to space activity
 - obligation on the licensee to insure himself/herself against any liability incurred due to any activity authorised by the license
- Liabilities - A licensee should compensate the central government against claims brought against the government.
- This would be regarding damages arising out of commercial space activities covered under the license.
- Penalties - The draft Bill provides for penalties in case of:

1. unauthorised commercial space activity
 2. furnishing false information or documents
 3. causing environmental damage
 4. entry into prohibited areas
 5. disclosure of restricted information
- Protection of action taken by the central government i.e. no legal proceedings can lie against the central government with respect to anything done in good faith in pursuance of space activity.
 - IPR - Intellectual property rights developed during the course of space activity will be protected under the law.
 - Further, any intellectual property right developed onboard a space object in outer space will be deemed to be the property of the central government.

10.3 Surya Joyti

- Surya Joyti is a low cost and energy efficient Photo Voltaic (PV) intergrated Micro Solar Dome (MSD).
- It started as a pilot project to stream diffused sunlight into poorly-lit rooms through the roof in thatched, tiled or tin-roofed houses in the Sundarbans in West Bengal and in Tripura.
- The Department of Science & Technology along with Ministry of New and Renewable Energy (MNRE) has taken it up for larger distribution in bigger areas.
- The Science and Technology Ministry estimates that 'Surya Jyoti' can help some 10 million households.
- These are off-grid, and can supply urban and rural areas without reliable access to electricity.
- The domes provide light equivalent to a 60W bulb.
- It has been included as a product for off grid solar lighting applications by Ministry of New and Renewable Energy.

10.4 Project Brainwave

- It is launched by Microsoft, a deep learning platform for real-time artificial intelligence (AI) and capable of processing requests as fast as it receives it.
- Artificial intelligence (AI) is areas of computer sciences that emphasizes the creation of intelligent machines that work and react like humans.
- Some of the activities computers with artificial intelligence are designed for include Speech recognition, Learning, Planning, Problem solving.

10.5 Food Irradiation Centers

- Under the integrated cold chain scheme, to tide over shortages, post-harvest losses, price rise and to preserve fruits and vegetables, four irradiation projects have been approved in U.P, Haryana, Karnataka and Rajasthan recently.
- Irradiation is a process in which food products are subjected to a low dosage of radiation to treat them for germs and insects, increasing their longevity and shelf life.
- Food can be irradiated only in a food irradiation plant authorised by the Atomic Energy Regulatory Board and licensed by the competent Government Authority.
- The irradiation doses are recommended by the International Atomic Energy Agency.
- Unique advantages of radiation processing of products (including fruits, vegetables, cereals, pulses, spices, sea foods and meat products) are:
 1. Cold (no temperature increase) and clean process (no chemical residue)
 2. Effective elimination of harmful bacteria and insects/pests
 3. Treatment after final packaging to avoid recontamination
 4. Significant increase in shelf life.

10.6 JIGYASA

- It is a student- scientist connect programme by Ministry of HRD and Ministry of Science and Technology.
- It focuses on connecting school students and scientists so as to extend student's classroom learning to research laboratory based learning by visiting CSIR laboratories and by participating in mini-science projects.
- CSIR and Kendriya Vidyalaya Sangathan (KVS) are collaborating to implement this programme.

10.7 Open Gov Data Hack

- Ministry for Electronics and Information Technology has recently launched a nationwide hackathon 'Open Gov Data Hack'.
- It was conducted by the National Informatics Centre (NIC) and the Internet and Mobile Association of India (IAMAI) in 7 cities.
- The seven cities are Surat, Patna, Jaipur, Chennai, Bhubaneswar, Hyderabad and Noida.
- It aims to enable participants develop their ideas into apps/infographics primarily by the use of open government data.
- The sectors selected for the Hackathon are Drinking Water & Sanitation, Transport, Education, Crime and Health.
- The Open Government Data (OGD) Platform India has been set up by the National Informatics Centre (NIC) in compliance with National Data Sharing and Accessibility Policy (NDSAP) 2012.
- The objective of the policy is to provide proactive access to government owned sharable data along with its usage information.

10.8 Scheme for IPR Awareness

- 'Scheme for IPR Awareness – **Creative India; Innovative India**' has been launched by Cell for IPR Promotion and Management (CIPAM) under the aegis of the Department of Industrial Policy and Promotion.
- It aims to conduct IPR awareness workshops in academic institutions (schools and colleges) and the industry including MSMEs and Startups, as also IP training and sensitization programmes for enforcement agencies and the judiciary.
- Workshops will cover all vital IP topics including international filing procedures, promotion of Geographical Indications and highlighting the ill effects of piracy and counterfeiting.

10.9 Technology and Innovation Support Centre

- Department of Industrial Policy and Promotion (DIPP) under Ministry of Commerce is establishing TISC under the World Intellectual Property Organizations (WIPO) TISC program.
- DIPP has recently signed an Institutional agreement with Anna University, Chennai to establish India's second TISC.
- TISC in Punjab is the India's first TISC.
- It provides innovators in developing countries with access to locally based, high quality technology information and related services.
- It will help the innovators to exploit their innovative potential and to create, protect, and manage their Intellectual Property Rights (IPRs).
- The objective is to foster creativity and innovation, thereby promoting entrepreneurship and enhancing social, economic and cultural development.

10.10 Traditional Knowledge Digital Library

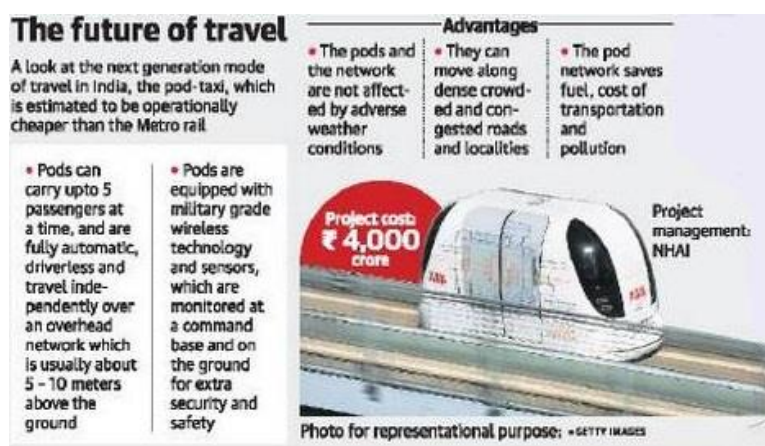
- TKDL is an Indian initiative to prevent exploitation and to protect Indian traditional knowledge from wrongful patents mainly at International Patent Offices.
- TKDL contains **Indian traditional medicine knowledge** in a digitized format and is available in five international languages (English, French, German, Spanish and Japanese).
- Indian traditional medicine knowledge in TKDL pertains to traditional books related to Ayurveda, Unani and Siddha.
- **CSIR** is the implementing agency for TKDL. Funds under the scheme are provided only to CSIR and no funds have been allocated to any state.

10.11 First Hyperloop Transport System

- Hyperloop Transportation Technologies (HTT) has signed an agreement with the Andhra Pradesh government to set up first Hyperloop transport system in India.
- The system will connect the city centres of **Amravati and Vijayawada**.
- The technology uses a high-speed train that promises travel at twice the speed of a commercial aircraft.
- Hyperloop consists of a low pressure tube with capsules that are transported at both low and high speeds throughout the length of the tube.

10.12 Pod Taxi Project

- A high-level panel has recommended inviting fresh bids for India's first pod taxi project.
- PRT is an advanced public transport using automated electric pod cars to provide a taxi-like demand responsive feeder and shuttle services.
- It is for small groups of travellers and is a green mode of uninterrupted journey.



METRINO: fully automatic, driverless small pods travel independently suspended over an overhead network

POD TAXIS: small automated vehicles – cable cars or pod cars – equipped to carry a small group of passengers

HYPERLOOP: a pod-like vehicle is propelled through a near-vacuum tube connecting cities at speeds matching that of an aircraft

10.13 Jatan & Darshak

- Centre for Development for Advanced Computing (C-DAC), has developed software named “Jatan” that is set to revolutionize museum experience.
- The latest technology will help online visitors get a 3-Dimensional (3D) view of hundreds of artifacts displayed at the museums.
- The software will enable virtual tours to museums.
- The group has developed “Darshak”, a mobile-based application, aimed at improving the museum visit experience among the differently-abled.
- It allows real-time museum visitors gather all details about objects or artifacts simply by scanning a QR code placed near the object.
- C-DAC is the premier R&D organization of the Ministry of Electronics and Information Technology (MeitY) for carrying out R&D in IT, Electronics and associated areas.