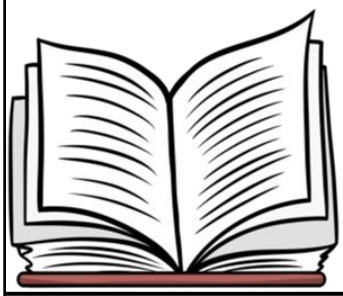
All-Inclusive Current Affairs for Prelims 2021

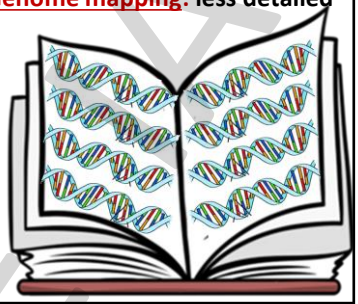
Science & Tech Class-1

Genome / DNA / RNA

Genome: complete set of DNA
Genome sequencing: studying it
Genome mapping: less detailed

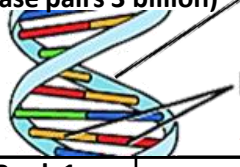


Book = Genome
23 sheets = 23 Chromosome pairs
46 pages = 46 Chromosomes
Text on a page = DNA
30k Sentences = 30k Genes
3 billion Words = 3 billion Base pairs
4 Alphabets = ATGC molecules

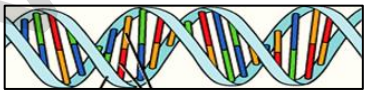


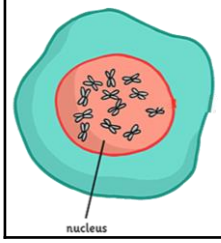
Alphabets 4 (Molecules 4)
Adenine
Thymine
Guanine
Cytosine

Words 3 billion (Base pairs 3 billion)

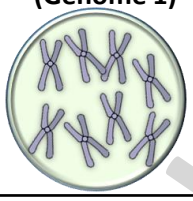


Sentences 30k (Genes 30k)

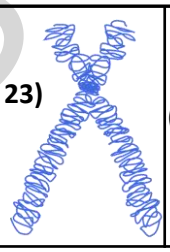




Book 1 (Genome 1)

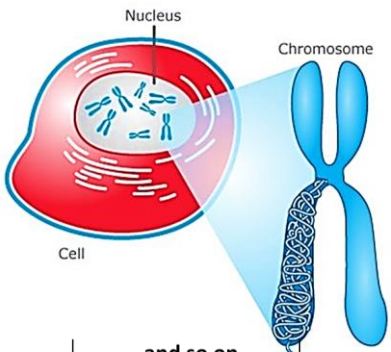


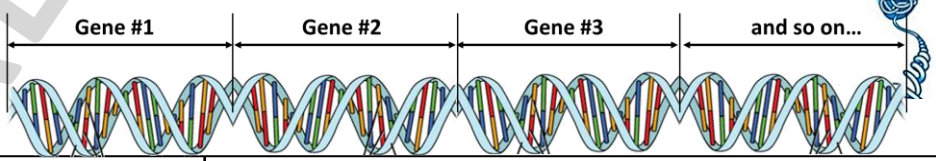
Sheets 23 (Chromosome pairs 23)



Pages 46 (DNA 46) (Chromosome 46)

- DNA is packaged into **chromosome**.
- A chromosome contains a single, long **DNA** molecule.
- Chromosomes are found in the **nucleus** of the cell.
- Different organisms have different numbers of chromosomes.
- Humans have 23 pairs of chromosomes.
- Human **Genome** is made up of 23 **chromosome** pairs, 46 **DNA** molecules, made of 30,000 **Genes**, with a total of about 3 billion DNA **base pairs.**





Prelims 2011:

At present, scientists can determine the arrangement or relative position of genes or DNA sequence on a chromosome. How does this knowledge benefit us?

1. It is possible to know the pedigree of livestock.
2. It is possible to understand the causes of all human diseases.
3. It is possible to develop disease resistant animal breeds.

Which of the statements given above is/are correct?

(a) 1 and 2 only (b) 2 only
(c) 1 and 3 only (d) 1, 2 and 3

Prelims 2017:

With reference to agriculture in India, how can the technique of `Genome Sequencing', often seen in news, be used in immediate future?

1. Genome sequencing can be used to identify genetic markers for disease resistance and drought tolerance in various crop plants
2. This technique helps in reducing the time required to develop new varieties of crop plants.
3. It can be used to decipher the host-pathogen relationships in crops.

Select the correct answer using the code given below:

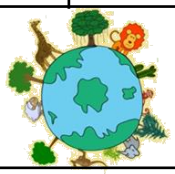
(a) 1 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Note: *Health & disease outcomes are determined by interactions between genome & environment.*

Human Genome Project:
- ❑ 1990-2003
- ❑ Genome sequencing
- ❑ US/UK/China etc

IndiGen Project:
Genome sequencing
- ❑ 1,029 Indians
- ❑ Lead by CSIR
- ❑ identified 5.6 crore nucleotide variants
- ❑ 32% of them are unique to Indians

Genome India Project:
Genome sequencing
- ❑ 10,000 Indians
- ❑ Lead by IISc etc



Earth Biogenome Project:
- ✓ Since 2018
- ✓ Target is all eukaryotic biodiversity in 10 years

Indian Initiative on Earth Biogenome Sequencing:
Part of Earth Biogenome project
- ✓ National Institute of Plant Genome Research
- ✓ Target is 1,000 species in 5 years

Some DBT programs on Genetics:
- ❑ **Unique Methods of Management of Inherited Disorders (UMMID)**
  Identify genetic disease in pregnant women and new born babies; Establishes NIDAN Kendras for this purpose.
- ❑ **Genome India:**
  Genome sequencing of 10,000 Indians
- ❑ **Human Microbiome Initiative of select endogamous populations**
  Influence of lifestyle on microbiome using genomics in tribals
- ❑ **Programme on Monogenic disorders**
  Disorders due to mutations in a single gene; for specific regions
- ❑ **National Genomics Core**
  Database & Computing facility for academia and industry

Use/benefits of DNA tech:
- ❑ Forensic investigation
- ❑ Faster justice delivery
- ❑ Chemicals for industries
- ❑ Prevent genetic defects
- ❑ Accurate diagnosis
- ❑ Treating diseases
- ❑ Pharmacogenomics (Role of genome in drug response)
- ❑ Personalized medicine
- ❑ Crops: high yield, disease resistant, drought resistant, high nutrition, etc.

National SARS-CoV-2 Genome Consortium
- ❑ by DBT, MoHFW, CSIR, ICMR
- ❑ To assess corona virus variants

National Biomedical Resource Indigenization Consortium
- ❑ PPP; by DBT
- ❑ For innovations against Covid

Biotechnology Industry Research Assistance Council (BIRAC)
- ❑ PSU under DBT
- ❑ wide role

The Indian EXPRESS

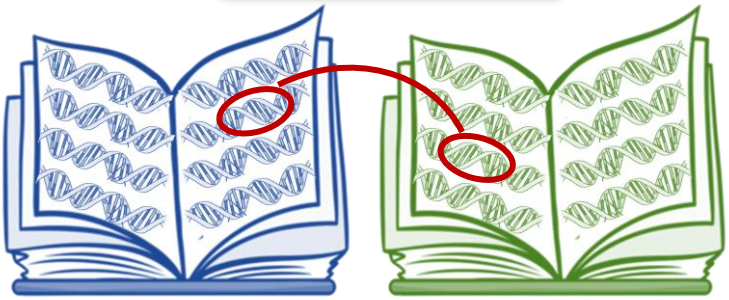
Explained: Mapping the 'Indian' genome

SOCIAL ISSUES: The question of heredity and racial purity has obsessed civilisations, and more scientific studies of genes and classifying them could reinforce stereotypes and allow for politics and history to acquire a racial twist.

In India a lot of politics is now on the lines of who are "indigenous" people and who are not. A Genome India Project could add a genetic dimension to the cauldron.

"Selective breeding" has been controversial since time immemorial, and well before the DNA was discovered. But eugenics acquired a dangerous context with the Nazis deliberating on the theme at length and its mention came up in the Nuremberg trials. Post World War-2, it has been a very touchy issue.

Genome editing



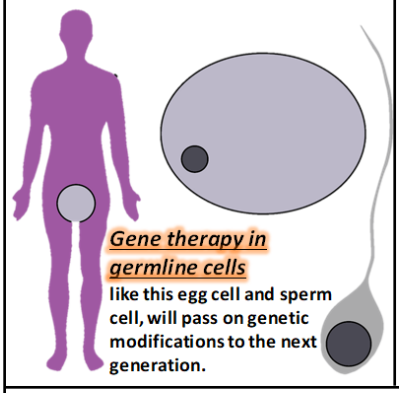
A pleiotropic gene is a single gene that controls more than one trait.

Gene editing:
- ❑ Changing an organism's DNA
- ❑ Genes can be added/removed/altered
- ❑ Many technologies to do so.
- ❑ One such technology is CRISPR-Cas9
- ❑ CRISPR guides Cas9 to particular gene, Cas9 does the cutting.

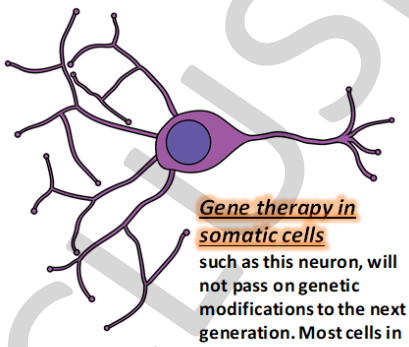
CRISPR: Clustered Regularly Interspaced Short Palindromic Repeats
CAS9: Crispr-ASsociated protein 9

Lulu and Nana: (2018)
- ❑ Gene edited twin girls
- ❑ Chinese scientist 'He Jiankui' used Crispr-Cas9
- ❑ Edit CCR5 genes in embryo to give genetic resistance to HIV.
- ❑ Fined and jailed.

Prelims 2019:
What is Cas9 protein that is often seen in news?
(a) A molecular scissors used in targeted gene editing
(b) A biosensor used in accurate detection of pathogens in patients
(c) A gene that makes plants pest-resistant
(d) A herbicidal substance synthesized in genetically modified crops



Gene therapy in germline cells like this egg cell and sperm cell, will pass on genetic modifications to the next generation.



Gene therapy in somatic cells such as this neuron, will not pass on genetic modifications to the next generation. Most cells in the body are somatic cells.

Prelims 2020:
Consider the following statements:
1. Genetic changes can be introduced in the cells that produce eggs or sperms of a prospective parent.
2. A person's genome can be edited before birth at the early embryonic stage.
3. Human induced pluripotent stem cells can be injected into the embryo of a pig.

Which of the statements given above is/are correct?
(a) 1 only (b) 2, 3 only
(c) 2 only (d) 1, 2, 3

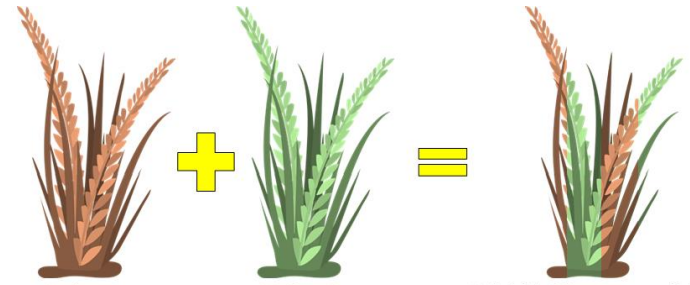
Mains 2017 Stem cell therapy is gaining popularity in India to treat a wide variety of medical conditions including Leukaemia, Thalassemia, damaged cornea and several burns. Describe briefly what stem cell therapy is and what advantages it has over other treatments?

CELL POTENCY:
- ❑ ability to differentiate into other cell types.
- ❑ Decreasing order of cell potency:
  Totipotent > Pluri p. > Multi p. > Oligo p. > Uni p.
- ❑ Induced Pluripotent stem cells:
  Genetic editing of adult cells to behave like embryonic pluripotent cell; can be used to treat diseases

STEM CELLS:
- ❑ Cells that can develop into different type of cells
- ❑ They are unspecialised, but can become specialised
- ❑ Two main types: embryonic and adult

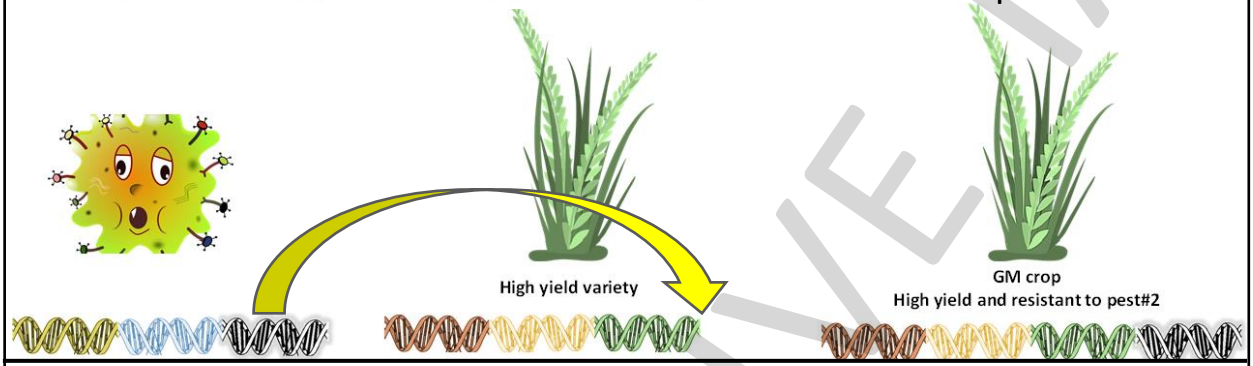
CLONED ANIMAL:
- ❑ animal with identical DNA
- ❑ Natural: bacteria, fungi, plants, etc.
- ❑ Artificial: sheep, goat, rat, etc.
- ❑ Dolly Sheep (1996-2003) was the first mammal cloned from an adult somatic cell
- ❑ Samrupa first buffalo cloned using "Hand guided cloning technique" in 2009 at National Dairy Research Institute (NDRI), Karnal (Haryana)

GM crops



Problem: none of the varieties is resistant to pest#2, say pink bollworm

Solution: a soil bacteria has some gene that is resistant to pink bollworm



Regulation of GM crops:

- ❑ EPA 1986 classifies GM crops as "Hazardous Substances"
- ❑ Cultivation needs approval from Genetic Engineering Appraisal Committee (MoEFCC, EPA 1986)
- ❑ Import needs approval under EPA 1986 and FSSAI Act 2006 (1% adventitious presence allowed)

Benefits: Less labour; less pesticides; more tolerant; more yield

Issues: Consequences; monoculture; gene flow; monopoly (sterile plants i.e. seeds don't germinate)

Cartagena Protocol on Biosafety applies to GM crops?

Yes, if it can transfer genes

Bt Brinjal

- ❑ 2009 allowed
- ❑ 2010 stopped
- ❑ By Mahyco, TNAU, ICAR

Golden Rice:

- ❑ GM rice; German Sc. 1990s
- ❑ Genes from Maize/Bacteria
- ❑ Vitamin A
- ❑ ✓ Philippines; X India

Flavr Savr

- ❑ GM Tomato;
- ❑ 1994; USA
- ❑ 1st GM food for consumption

Janak, BSS-793, Event-142

- ❑ Janak & BSS-793: Bt Brinjal varieties
- ❑ Event 142: Cry1Fa1 gene
- ❑ By Nat. Inst. for Plant Biotech (ICAR)
- ❑ GEAC has allowed field trials

Rht14 and Rht18:

- ❑ dwarfing genes in wheat
- ❑ better seedling vigour
- ❑ longer coleoptiles
- ❑ deeper sowing
- ❑ less paddy stubble burning

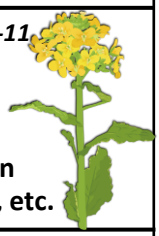
Bt Cotton:

- 2002: commercial cultivation allowed
- Today: 95% of cotton is Bt. Cotton

Ht-Bt cotton:

- Bt-cotton has two alien genes from Bacillus Thuringiensis: Cry1Ac & Cry2Ab
- These alien genes protect plant against many pests, like pink bollworm.
- Ht-Bt cotton = Bt. cotton + cp4-Epsps (brings glyphosate tolerance)

DMH-11 (2017-18): *Dhara Mustard Hybrid-11*

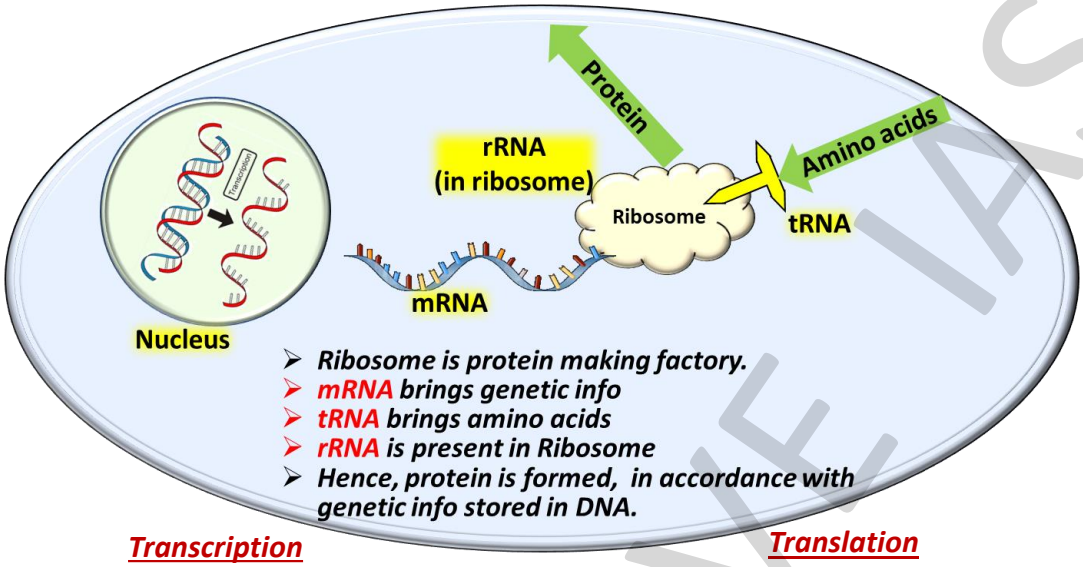


- ❑ By Delhi University
- ❑ More yield; Herbicide tolerant
- ❑ Used Bar, Barnase, Bastar gene system
- ❑ Allows cross-pollination & hybridization
- ❑ Allegations: 40% less nectar formation, etc.

Codex Alimentarius: (food code)

- ❑ Standards to ensure food is safe and can be traded
- ❑ Also used as reference in WTO trade disputes.
- ❑ C.A. Commission est. by FAO & WHO in 1963
- ❑ India member? Yes, since 1964

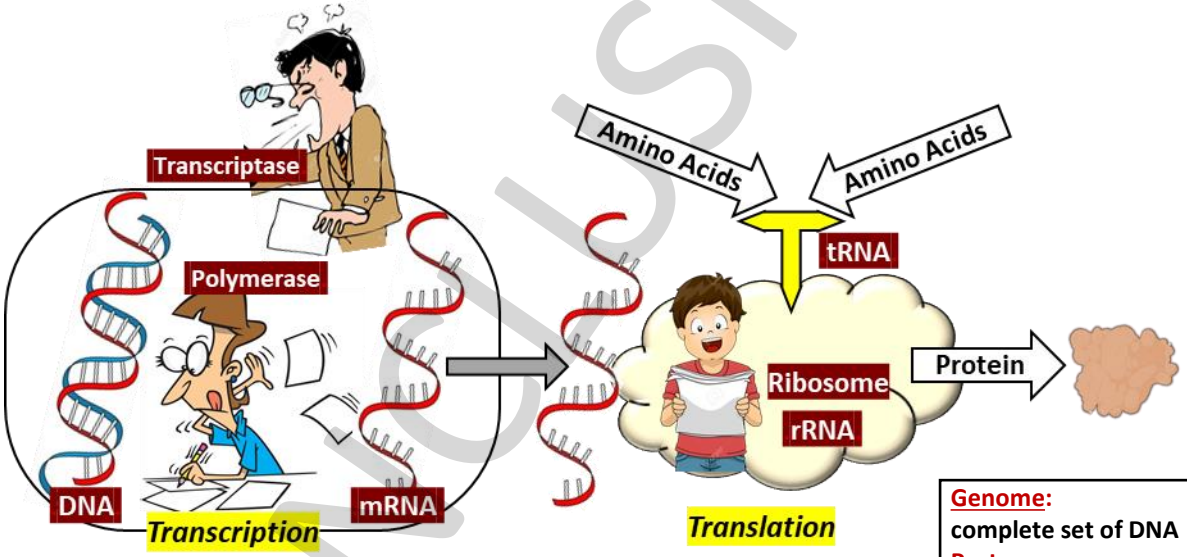
DNA vs RNA



- Ribosome is protein making factory.
- mRNA brings genetic info
- tRNA brings amino acids
- rRNA is present in Ribosome
- Hence, protein is formed, in accordance with genetic info stored in DNA.

Transcription
process by which DNA info is copied to RNA

Translation
process by which RNA is used to produce proteins



Genome: complete set of DNA
Proteome: complete set of protein

Transcription Translation
DNA → mRNA → Protein

Gene expression: process by which DNA info is converted to protein

DNA is Book RNA is Transcript
Transcriptome is set of all Transcripts

Transcription is process DNA → RNA
RNA Polymerase is enzyme that does the process
Transcriptase is enzyme that catalyses the process

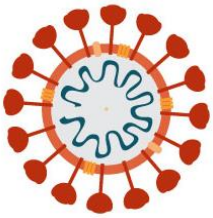
Reverse Transcription is process RNA → DNA
DNA Polymerase is enzyme that does process
Reverse Transcriptase is enzyme that catalyses RT

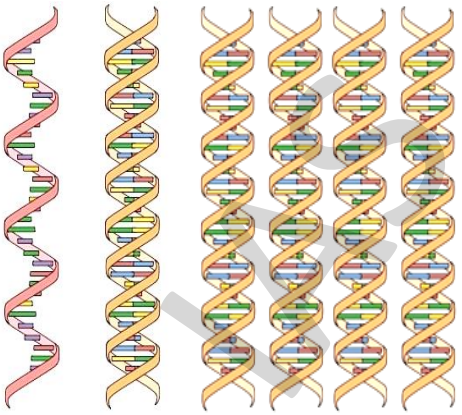
Prelims 2016:
In the context of the developments in Bioinformatics, the term 'transcriptome', sometimes seen in news, refers to
(a) a range of enzymes used in genome editing
(b) full range of mRNA molecules expressed by an organism
(c) description of the mechanism of gene expression
(d) a mechanism of genetic mutations taking place in cells

Polymerase: enzyme that makes long chain of nucleic acids
RNA Polymerase: enzyme that makes RNA
DNA Polymerase: enzyme that makes DNA

Reverse Transcription - Polymerase Chain Reaction (RT-PCR Test):

- ❑ **Reverse Transcription** RNA fragment converted to DNA fragment.
- ❑ '**Polymerase Chain reaction**' creates billions of copies of DNA fragment.
- ❑ PCR test invented in 1983; Inventor got **1993** Nobel Prize in **Chemistry**.





RNA fragment *DNA fragment* *Billions of copies for easy detection*

Next Generation Sequencing (NGS tests):

- ✓ Uses modified NGS machines (for genome sequencing)
- ✓ RT-PCR analyses only small section of virus.
- ✓ NGS analyses entire genome of virus.
- ✓ It can even track **mutations** in the virus.

GISAID *Global Initiative on Sharing All Influenza Data*

- Launched in **2008**; HQ: Munich, **Germany**; Managed by Germany; EpiFlu is name of its database
- It provides open-access to **genomic data** of influenza viruses and SARS-CoV-2

Prelims 2007:

What is the broad area in which Nobel Prize winners for 2006 in Physiology/Medicine, worked to get the Prize?

(a) Prevention of weakening due to ageing
(b) Flow of genetic info
(c) Immunology and disease resistance
(d) Adult stem cell research

Prelims 2019:

'RNA interference (RNAi)' technology has gained popularity in the last few years. Why?

1. It is used in developing **gene silencing** therapies.
2. It can be used in developing therapies for the **treatment of cancer**.
3. It can be used to develop **hormone replacement** therapies.
4. It can be used to produce crop plants that are **resistant to viral pathogens**

Select the correct answer using the code given below.

(a) 1, 2 and 4 (b) 2 and 3
(c) 1 and 3 (d) 1 and 4 only

	DNA	RNA
Structure	Helix; Double-stranded; Long chain of nucleotides; Guanine , Cytosine, Adenine, Thymine	Helix; Single-stranded; Short chain of nucleotides; Guanine , Cytosine, Adenine, Uracil
Function	Stores genetic info	Transfers genetic info
Propagation	Self-replicating	Synthesized from DNA
Location	Nucleus, Mitochondria	Nucleus, Cytoplasm, Ribosome
Stability	More stable, less reactive	Less stable, more reactive
UV	Vulnerable to damage	Resistant to damage

3-Parent baby

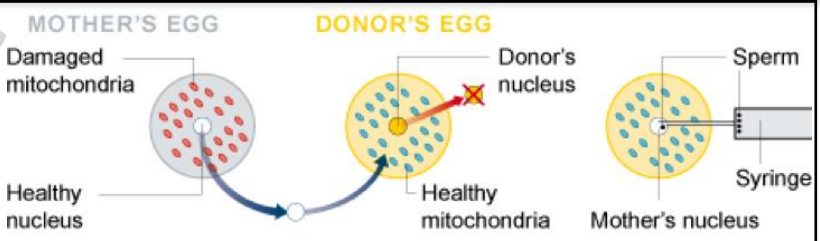
Prelims 2001:

Which organelle in the cell, other than nucleus contains DNA?

(a) Centriole
(b) Golgi apparatus
(c) Lysosome
(d) Mitochondria

Mitochondrial DNA

circular, inherited from mother



Spinal Muscular Atrophy: loss of motor neurons; progressive muscle wasting; due to mutation in SMN1 gene; treated by Zolgensma

Virus

Prelims 2016:

Which of the following statements is/are correct? Virus can infect:
1. Bacteria 2. Fungi 3. Plants

Select the correct answer.
(a) 1, 2 (b) 3 (c) 1, 3 (d) 1,2,3

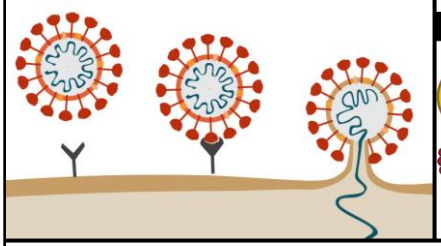
Prelims 1997:

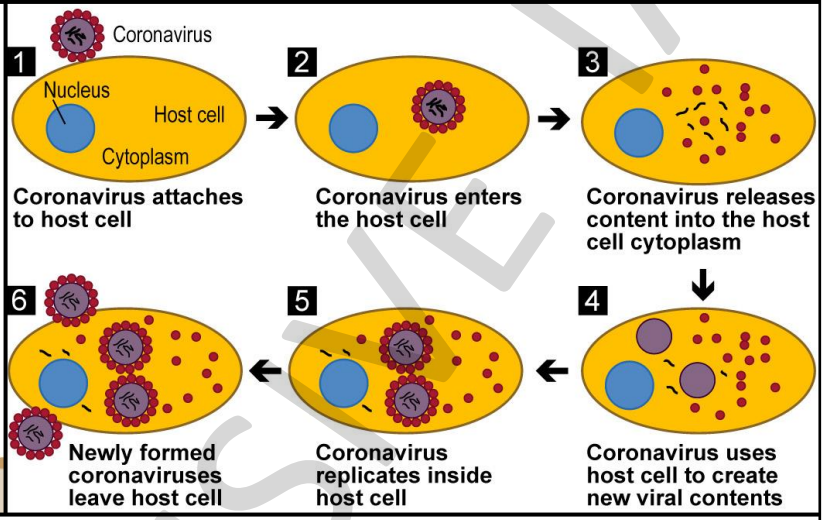
Antigen is a substance which
(a) Lowers body temperatures
(b) Destroys harmful bacteria
(c) Triggers immune system
(d) Is used as antidote to poison

SARS-CoV-2

- Shape: spherical
- Size: 50-200 nm (not mm)
- Genetic material: RNA
- RBD is on spike of virus
- ACE-2 is on host cell

RBD: Receptor Binding Domain





Diagnostic test:

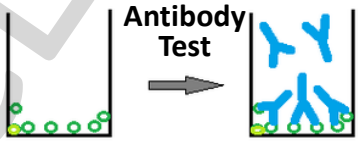
- ✓ Tells if person is currently infected.
- ✓ Rapid Antigen, RT-PCR, NGS

Rapid Antigen Tests:

- ✓ detects virus in minutes.
- ✓ Misses many positive cases.
- ✓ Negative cases need confirmation by RT-PCR or NGS test

Antibody tests:

- ✓ Tells if person was infected in past.
- ✓ Rapid Antibody, ELISA, IgM, IgG, Sero-survey



- ✓ IgM, IgG are antibodies.
- ✓ IgM forms first, does not stay for long.
- ✓ IgG forms later, remains longer.

IMMUNITY:

Immunity is of two types:

1. **Innate immunity:**
   - ❑ non-specific type of defence, present at time of birth
   - ❑ skin, acid in stomach, saliva, tears, interferons
2. **Acquired immunity:**
   - ❑ pathogen specific, characterised by memory.
   - ❑ Low intensity primary response, then high intensity secondary response.
   - ❑ By two special types of lymphocytes present in our blood, B-cells and T-cells

Blood:

- ❑ RBC carry oxygen
- ❑ WBC fight infection
  - → Macrophages: eat
  - → B-cells: make antibodies
  - → T-cells: kill, help, regulate

Active immunity:

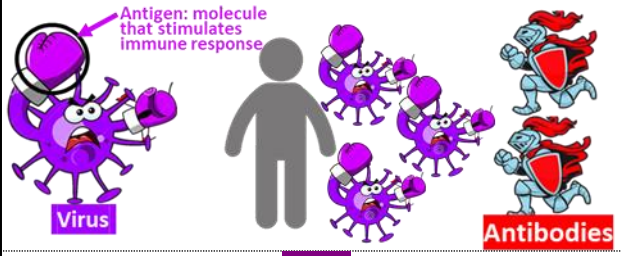
- ✓ Your body produces antibodies.
- ✓ Vaccine or actual disease
- ✓ Long lasting

Passive immunity:

- ✓ you get antibodies from someone.
- ✓ Mother to child, Plasma therapy, etc.
- ✓ Short lived

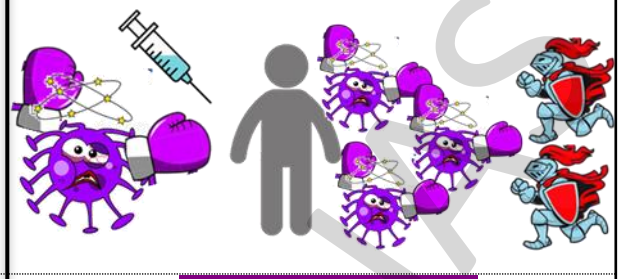
Cytokine storm, Septic shock, sepsis: *body's over-reaction to infection. Can cause organ failure / death*

Types of Vaccines



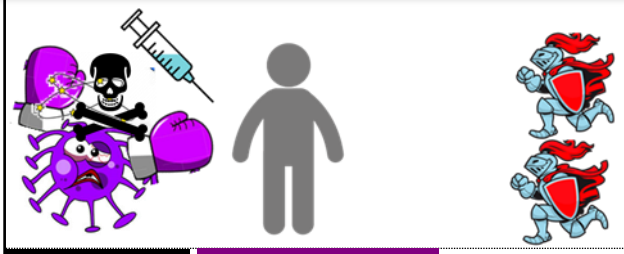
Virus

Too few:
Virus kills us
Too many:
Army kills us
Cytokine storm



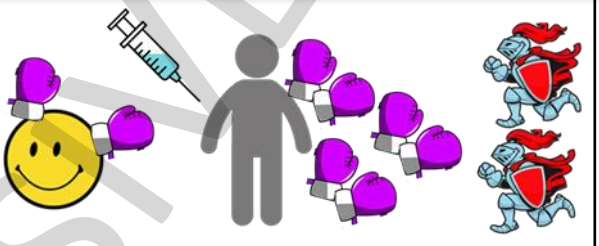
Live Attenuated vaccine Measles

- ❑ Inserts weakened virus into our body
- ❑ Strong and long-lasting response
- ❑ Shouldn't be given to people with weak immunity



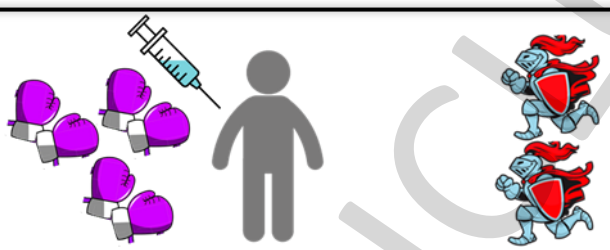
Covaxin, Sinovac **Inactivated vaccine** Hepatitis A, Polio

- ❑ Inserts killed virus into our body
- ❑ Not very strong response from body
- ❑ Needs several booster shots



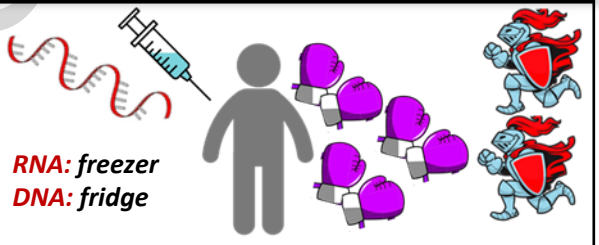
Covishield, Sputnik **Viral vector vaccine** Ebola, Covid

- ❑ Inserts a different harmless modified virus
- ❑ Has genetic instructions to create specific antigen
- ❑ Cannot give us Covid



Novavax **Subunit vaccine** Hepatitis B

- ❑ Inserts antigens, instead of the whole virus
- ❑ May use protein, sugar, capsid
- ❑ May need booster shots

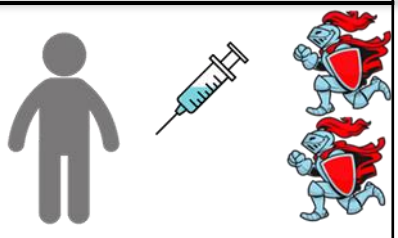


Pfizer, Moderna **Nucleic Acid vaccine** Covid

- ❑ Inserts genetic instructions to create antigens
- ❑ Doesn't enter Nucleus; doesn't affect our DNA
- ❑ Cell kills mRNA after use
- ❑ Cannot give us Covid
- ❑ Faster than traditional methods

Toxoid vaccine Tetanus, Diphtheria

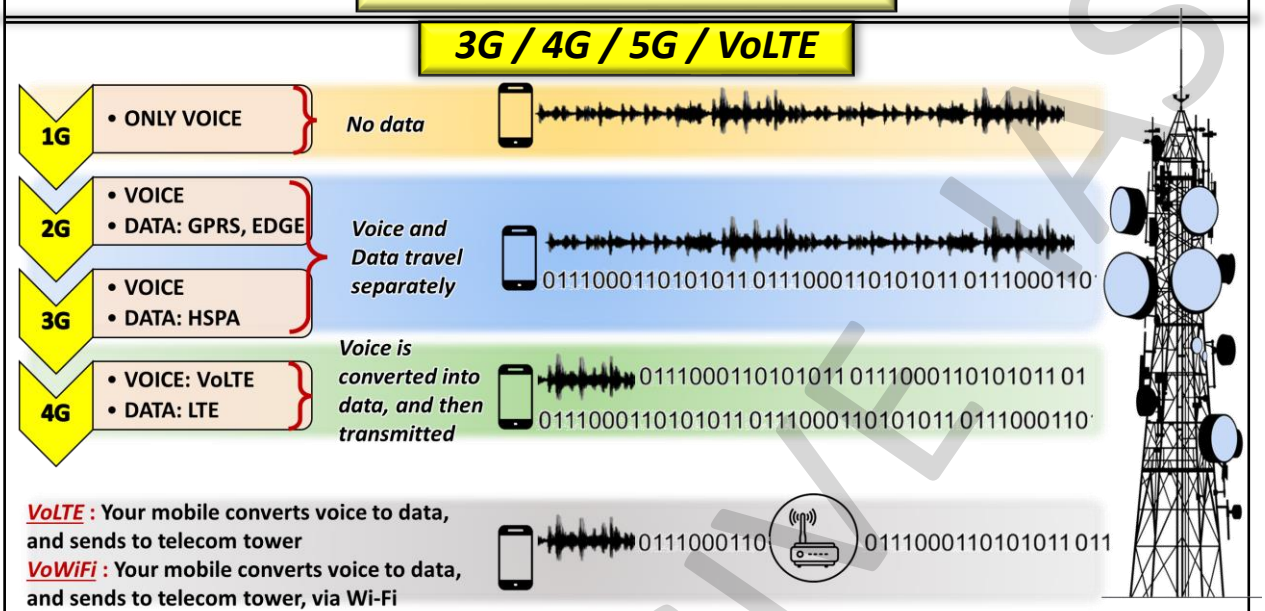
- ❑ Inserts Toxins created by the virus



Antibodies

- ❑ Plasma therapy
- ❑ Monoclonal antibodies

3G / 4G / 5G / VoLTE



	4G	5G
Users/km²	1 lakh	10 lakh
Peak speed	1 Gbps	20 Gbps
Latency	50 ms	1 ms
Encrypted?	Yes	Yes*

All values approximate

- 5G test bed to test 5G techs by universities and companies
- 5G hackathon by DoT to develop various 5G applications
- D-10 club UK initiative; 10 democracies; G7 + India/Australia/S.K.
- MIMO Multiple Input Multiple Output; more capacity in 3G/4G/5G
- vRAN Virtualized Radio Access Network; some hardware functions done by software on Cloud

Prelims 2019:

With reference to communications technologies, what is/are the difference/differences between LTE (Long-Term Evolution) and VoLTE (Voice over Long-Term Evolution)?

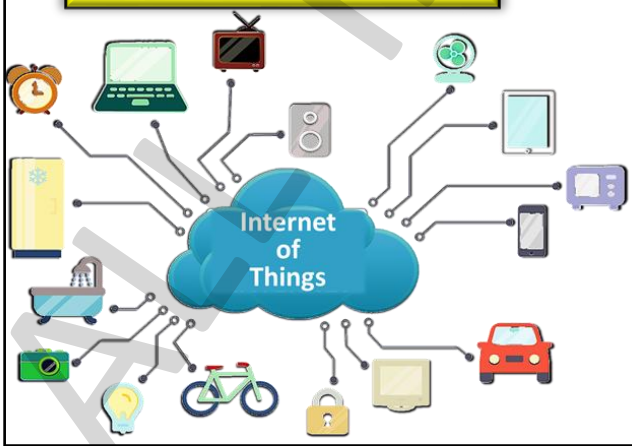
1. **LTE is commonly marketed as 3G and VoLTE is commonly marketed as advanced 3G.**
2. **LTE is data-only technology and VoLTE is voice-only technology.**

Select the correct answer using the code given below.

(a) 1 only (b) 2 only (c) Both 1 and 2 (d) Neither 1 nor 2

Internet of Things

Note: **In IoT, connection to "Internet" is not necessary**



Narrow band IoT:

- Low Power WAN tech developed by 3GPP
- Can use existing telecom networks or work independently; needs just 200 kHz
- Competing technologies: SigFox, LoRaWAN

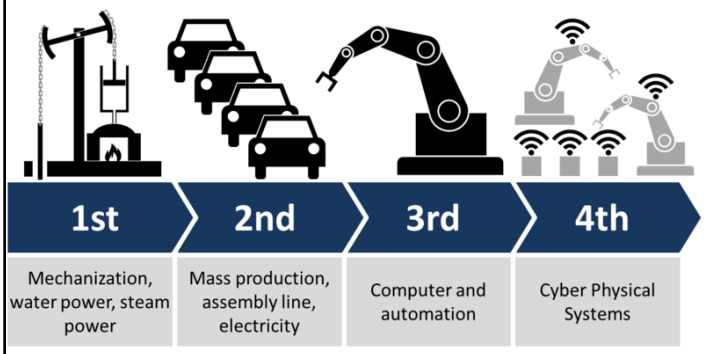
Features:

✓ Wide area; ✓ Underground;
✓ low processing power;
✓ low battery consumption;
✓ low data speed (200kbps)

It will bring broadband to rural areas? No

Cyber Physical Systems

Cyber *[computer, network]* + **Physical** *[machines]* = **Cyber Physical System** *[integration of cyber & physical elements]*



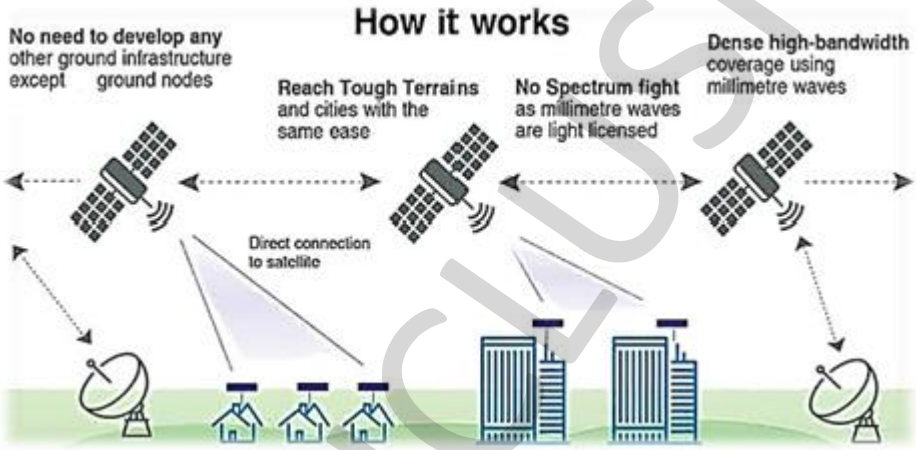
- Computer based system that does work in real world.
- e.g. self-driving cars; autonomous weapons; smart lighting; robots; traffic control systems; smart health sensors.

National Mission on Interdisciplinary Cyber-Physical Systems:

- 5-year mission launched in 2019
- by Department of Science & Tech

Space Based Internet

- Earlier by few GEO satellites, now with thousands in LEO
- Example: Starlink of SpaceX; Kuiper of Amazon



Problem:

- Kessler syndrome: domino effect of satellite collisions
- Astronomy: obstruct sight of land based space observatories

Related info:	***Project Loon:***	***White Space Internet:*** (Microsoft/Google)
	❑ balloons in Stratosphere (20km) ❑ Earlier under Google; now shut	❑ Uses gaps in existing (TV) spectrum ❑ For internet connectivity to rural areas

PM-WANI

PCO : Public Call Office
PDO : Public Data Office

- By DoT (Ministry of Communication) (not Meity)
- To increase access to high speed internet
- PDOA will provide WiFi hotspots through PDO
- PDO can be anyone (shop, tea stall, etc.)
- There will be no Licence fee
- Other initiatives for public WiFi: Google Station; Express WiFi by FB

Li-Fi vs Wi-Fi

	Li-Fi	Wi-Fi
Waves	Light waves	Radio waves
Range	10 metres	100 metres
Pass walls?	No	Yes

Prelims 2016:

With reference to 'LiFi', which of the following statements is/are correct?

1. It uses light as the medium for high-speed data transmission.
2. It is a wireless technology and is several times faster than 'WiFi'.

Select the correct answer

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

Prelims 2020:

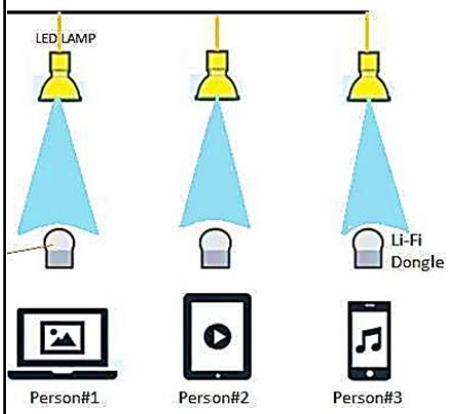
With reference to Visible Light Communication (VLC) technology, which of the following statements are correct?

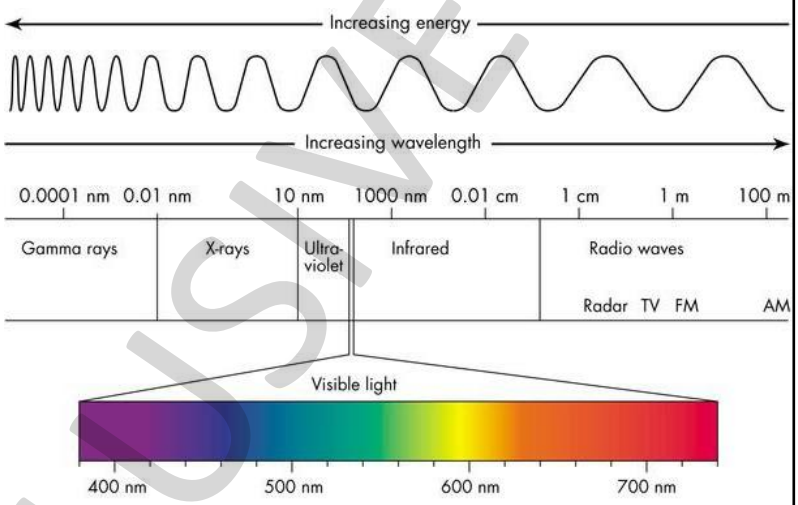
1. VLC uses electromagnetic spectrum wavelengths 375 to 780 nm
2. VLC is known as long-range optical wireless communication
3. VLC can transmit large amounts of data faster than Bluetooth
4. VLC has no electromagnetic interference

Select the correct answer using the code given below:

(a) 1, 2 and 3 only (b) 1, 2 and 4 only

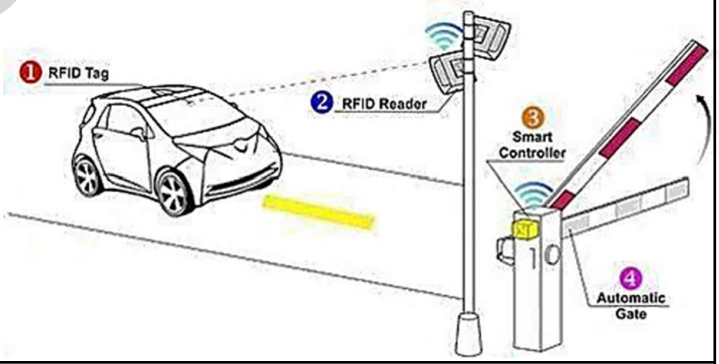
(c) 1, 3 and 4 only (d) 2, 3 and 4 only





NFC / Bluetooth / RFID

	NFC	Bluetooth	RFID
Waves	Radio waves		
Range	10 cm	10 metres	100 metres
Main use	Secure Payments	Wireless Headsets	Inventory control



Prelims 2015:

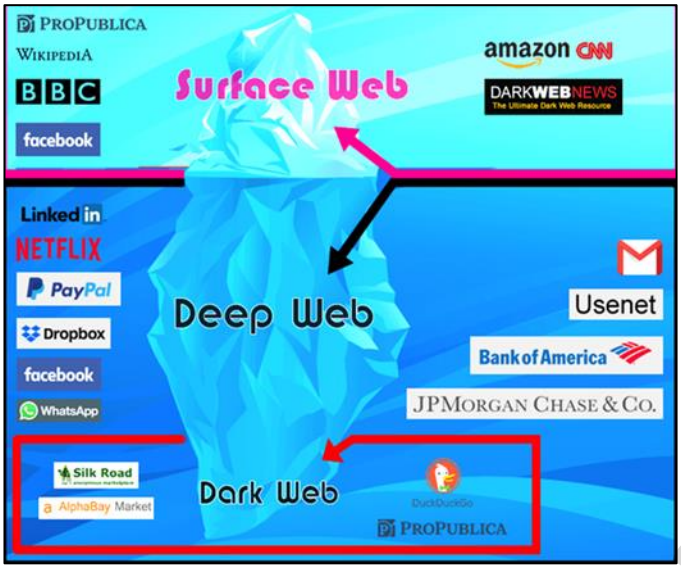
With reference to 'Near Field Communication', which of the following statements are correct?

1. It is a contactless communication technology that uses electromagnetic radio fields.
2. NFC is designed for use by devices which can be at a distance of even a metre from each other.
3. NFC can use encryption when sending sensitive information.

Select the correct answer using the code given below:

(a) 1 and 2 only (b) 3 only (c) 1 and 3 only (d) 1, 2 and 3

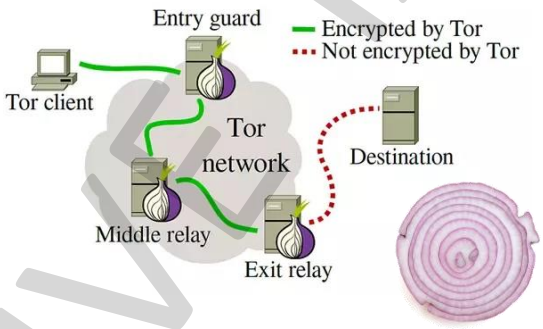
Dark Web



Surface web:
- ❑ Open for all, only 5%

Deep web:
- ❑ Needs login
- ❑ Email, net banking

Dark web:
- ❑ Totally anonymous
- ❑ By special software like DuckDuckGo, TOR, Freenet



Supercomputer

- ❑ 1987: India requested Cray X-MP; USA denied; India started our own mission; CDAC formed
- ❑ 1991: PARAM 8000 (PARAllel Machine; also Supreme); 28 times faster than Cray; Exported
- ❑ What are Pratyush, Mihir and Param (8000… Shivay, Shakti, Brahma…)? Supercomputers
- ❑ Fastest: PARAM Siddhi-AI (210 AI PetaFlops / 5.3 Pflops / 4.5 Pflops) (completely indigenous? No)

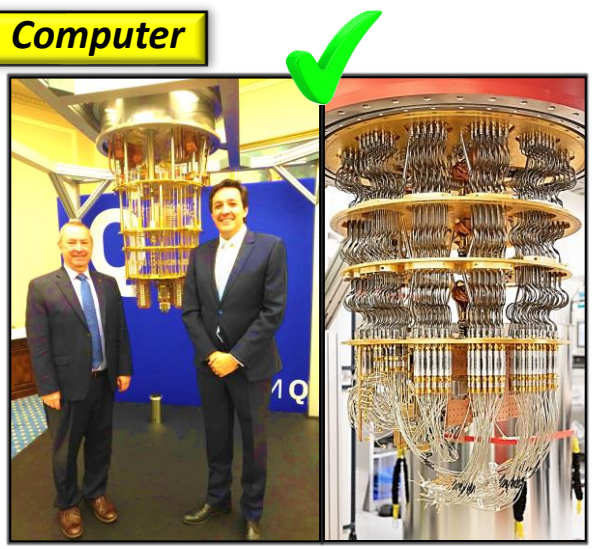
FLOPS = Floating Operations Per Second (K:1000; M:million ; G:billion ; T:trillion ; P: 1000T)

National Supercomputing Mission:
- ❑ 2015; MoS&T / Meity; implemented by CDAC
- ❑ Create a network of 70 high performance computing facilities (Supercomputing grid)
- ❑ Link to National Knowledge Network

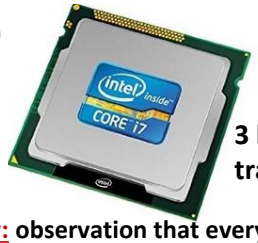
C-DAC:
- ❑ 1987 / MEITY
- ❑ Centre for Development of Advanced Computing

NKN: (2010) inter-connect all research institutions in India through a high bandwidth network

Quantum Computer

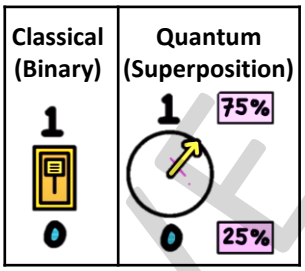


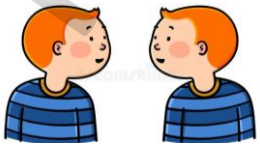
	Classical Computers	Quantum Computers
Based on	Classical physics	Quantum physics (physics at atomic/subatomic level)
Uses	Transistors	Photons and electrons
Basic unit of info	Bit State of transistor at any instant	Qubit State of photon/electron at any instant
Basic principle	At a time, Bit can take single value from either of the two values: either 0 or 1 (like a tube light). 	At a time, Qubit can take multiple values, i.e. at a time a qubit can be both 0 and 1 (like a fan with regulator) (Superposition) 



3 billion transistors

Moore's law: observation that every two years transistors on chip doubles but cost becomes half





Entanglement

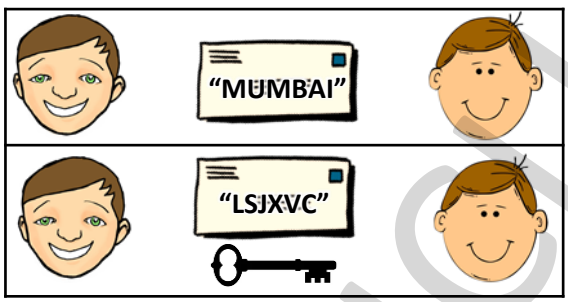
Einstein: spooky action at a distance

Quantum Metrology: Using Quantum theory to take highly sensitive measurements.

Quantum Cryptography: Using Quantum theory for secure communication.

Quantum supremacy:

- ❑ QC solving a problem that Classical Computer cannot in feasible amount of time.
- ❑ Google's Sycamore solved a problem in 200 seconds that fastest SC will take 10,000 years.



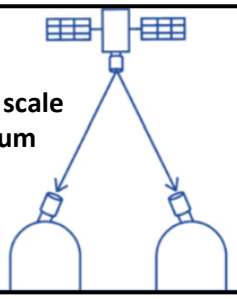
	Traditional Cryptography	Quantum Cryptography
Based on	Mathematics	Quantum physics
Secured by	Code	Quantum state of particle
Safety	Code can be deciphered by powerful computers	if one attempts to read the encoded data, the quantum state will be changed

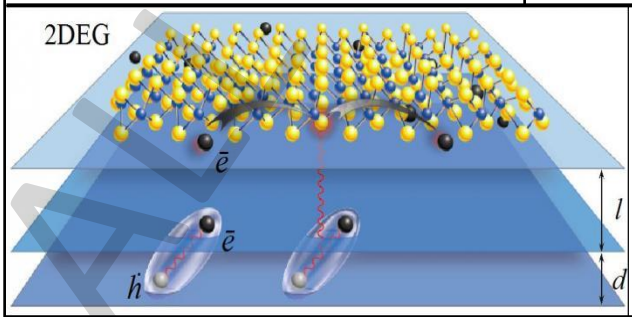
National Mission on Quantum Technologies and Applications:

- ❑ Launched in 2020
- ❑ Budget: ₹ 8,000 crore for five years
- ❑ Dept. of Science & Technology

QUESS *(China)*

- ❑ Quantum Experiments at Space scale
- ❑ Made 'Micius' world's 1st quantum comm. satellite.
- ❑ Uses Quantum Key Distribution



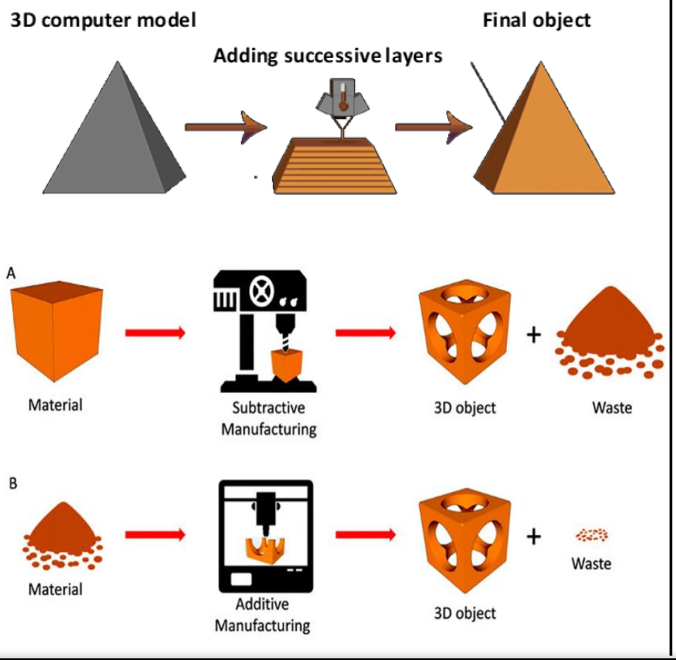


2DEG: *Two-Dimensional Electron Gas*

- ❑ Ultra-high mobility 2-D electron gas
- ❑ Produced at INST, Mohali, Punjab (D.o.S&T)
  INST = Institute of Nano Science & Technology
- ❑ Use in Quantum devices (speed, storage, etc.)

Spintronics: (spin-electronics)

- ❑ Application in modern electronic devices
- ❑ Manipulating spin degree of freedom of electron
- ❑ Uses Rashba effect (splitting of spin-bands)



3D Printing

What it is?

- Manufacturing by adding successive layers (just like buildings are made!!!)

Benefits?

- Direct CAD model to manufacturing
- Totally automated
- Negligible material wastage
- High customization possible

Applications?

- Almost anything that's made in factories
- Also, biological organs, tissues, implants (knee, hip), etc

Data Protection

Prelims 2019:

The Reserve Bank of India's recent directives relating to 'Storage of Payment System Data', popularly known as data diktat, command the payment system providers that

1. they shall ensure that entire data relating to payment systems operated by them are stored in a system only in India.
2. they shall ensure that the systems are owned and operated by public sector enterprises.
3. they shall submit consolidated system audit report to CAG by the end of the calendar year

Which of the above statements is/are correct?

(a) 1 only (b) 1 and 2 only
(c) 3 only (d) 1, 2 and 3

Osaka declaration on digital economy:

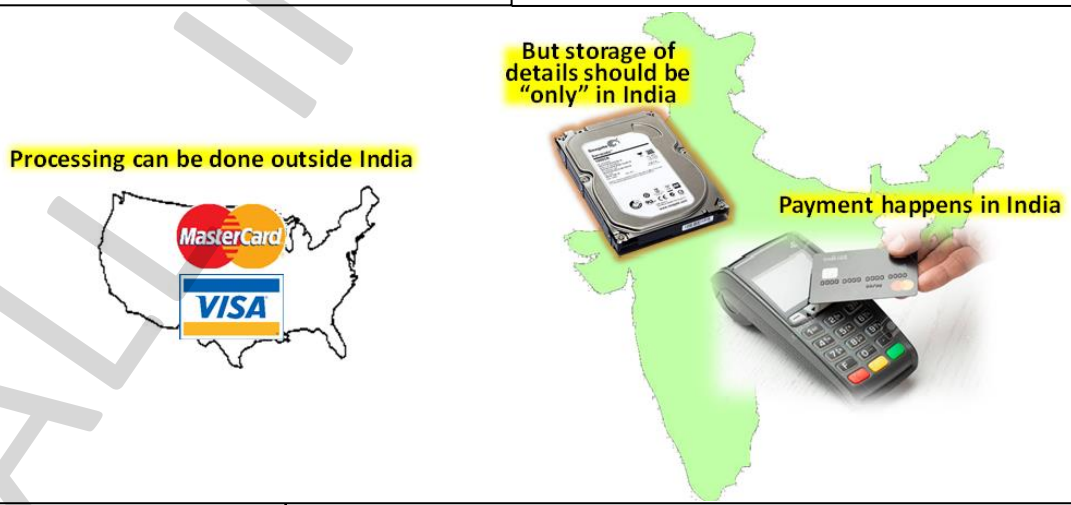
- Signed in 2019 at G-20 meet in Japan
- For free flow of data across borders
- India did not sign

Prelims 2019:

Which of the following adopted a law on data protection and privacy for its citizens known as 'General Data Protection Regulation' in April 2016 and started implementation of its from 25th May, 2018?

(a) Australia (b) Canada
(c) European Union (d) USA

GDPR : Europe
CLOUD : USA



Nanotech

Centre has released guidelines for evaluation of Nano-based Agri-input and food products in India

Guidelines? Not for exam.
Applications and **concerns**? All correct

Nanometre? **one-billionth** of a metre
milli > micro > nano > pico
10^{-3} > 10^{-6} > 10^{-9} > 10^{-12}

Nanomaterial?
at least one dimension is 1-100 nm

Phytotoxic: toxic to **plant**
Cytotoxic: toxic to living **cells**
Genotoxic: toxic to **genetic** material

Use of all nanoparticles is controlled by the **govt**.? No
Are all nanoparticles **manmade**? No
Do nanoparticles also occur **naturally**? Yes, for example,
- **Coronavirus** has average diameter of 120 nm.
- **Fly ash** has nano-particles of several heavy metals.

- **National Nano mission**: since 2007; Dept. of S&T
- **ICONSAT**? biennial conference by DST (International Conference on Nano Science and Tech)
- ICONSAT should not be confused with **ICON satellite** of NASA launched in 2019 to study Ionosphere.

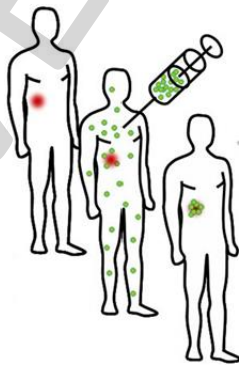
Prelims 2015:

With reference to the use of **nano technology in health sector**, which of the following statements is/are correct ?

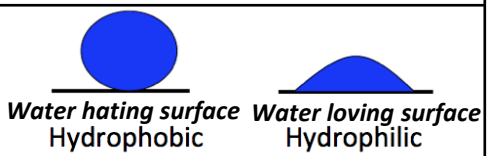
1. **Targeted drug delivery** is made possible by nanotechnology.
2. Nanotechnology can largely contribute to **gene therapy**.

Select the correct answer using the codes given below.

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2



Nanomicelles: type of nanoparticles
- Have hydrophilic outer shell and hydrophobic interior
- Effective in targeted drug delivery, cancer treatment, etc.



Ministry of Earth Science

Eco-friendly Synthesis of Gold Nanoparticles from Antarctic Bacteria for Therapeutic Use

These GNPs can be used as a composite therapeutic agent clinical trials, especially in anti-cancer, anti-viral, anti-diabetic, and cholesterol-lowering drugs

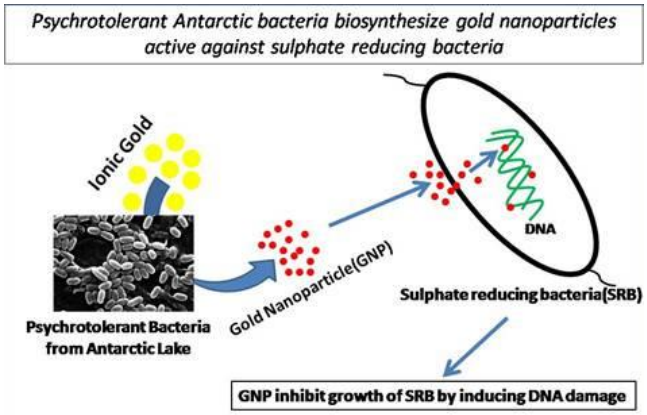
Posted On: 29 JUN 2020 12:47PM by PIB Delhi

---By:MohammadFaiyaz Anwar

The National Centre for Polar and Ocean Research (NCPOR) and the Goa University (GU) have successfully synthesized gold nanoparticles (GNPs) using psychrotolerant Antarctic bacteria through a non-toxic,

Gold Nano Particles:
- They have genotoxic effect on sulphate reducing bacteria
- They melt at less temperature (300 °C) than gold (1064 °C)
- They change colour in different settings.
- They are stable, non-toxic and have various applications.

NOMFET: Nanoparticle Organic Memory Field-Effect Transistor
- Can mimic human synapse (neural junction)

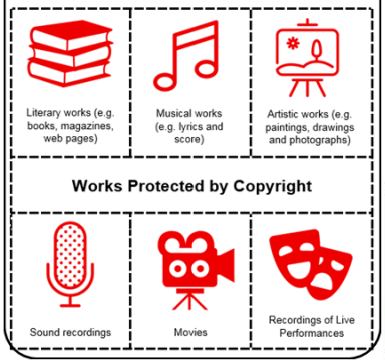


IPR

20 years PATENT:
for new invention, like a new drug

10 years GEOGRAPHICAL INDICATION:
To distinguish products of a region from that of other regions

60 years COPYRIGHT:
To protect original piece of work



10 years TRADEMARK:
To distinguish a company's products from others

DESIGN: 15 years
To protect new shape, configuration, etc.

Intellect : mental powers
Intellectual Property : creation of mind, e.g. artistic work
Intellectual Property Rights : right of creator on own creations

KAPILA program: Ministry of Education.
- ❑ Kalam Program for IP Literacy & Awareness
- ❑ FOR IPR awareness in college students

Office of Controller General of Patents, Designs & Trademarks:
- ❑ also known as Indian Patent Office.
- ❑ It administers laws on patent, design, trademark & geographical indication.
- ❑ Comes under DPIIT under MoC&I
- ❑ Its HQ is in Mumbai.

Compulsory licensing and Patent Pool:
- ❑ Economy class-3 page 38 on YouTube
- ❑ Hindi video from 41:35
- ❑ English video from 35:11

Evergreening of Patent:
- ❑ Renewing patent by making minor changes
- ❑ Prohibited by Section 3(d) of Patent Act 1970

Patent Law Treaty, 2000
- ❑ Simplifies patent application procedures.
- ❑ Does not interfere with domestic patent laws
- ❑ Signed and ratified by around 40 countries (USA? Yes. India? No)
- ❑ It is administered by WIPO.

Singapore Treaty on Law of Trademarks, 2006
→ Like Patent law Treaty, but for Trademarks

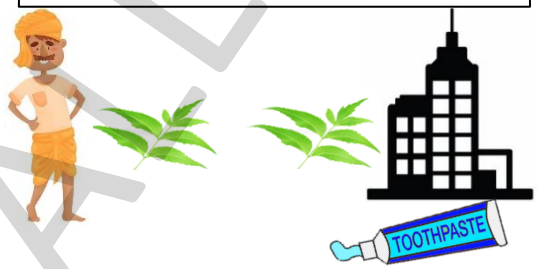
Q. Berne Convention 1886 is related to?
→ Copyright protection

Q. WIPO Copyright Treaty 1996 is related to?
→ Copyright in digital environment

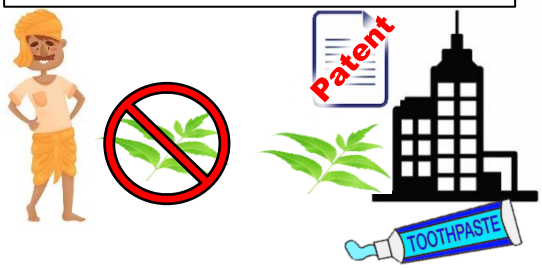
Traditional Knowledge Digital Library

- ❑ Database of traditional knowledge about Ayurveda, Unani, Siddha, Yoga
- ❑ Created in 2001 by CSIR and Min. of Ayush; Inspiration: Turmeric, Basmati patents in USA
- ❑ access is available to 13 foreign Patent Offices, but only for search purpose, not to be shared.

Bioprospecting: exploring biodiversity for commercially valuable properties.



Biopiracy: commercial use of biodiversity with monopoly control.



C. V. Raman

Raman Effect:

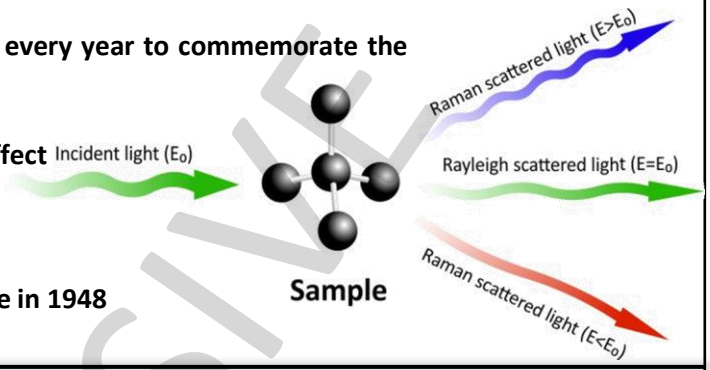
- When light passes through a transparent medium, some of the deflected light changes wavelength.
- Change in wavelength varies with the molecules.
- So it can be used in spectroscopic analysis.
- It forms the basis of Raman Spectroscopy.
- It helps non-destructive chemical analysis of most materials.
- It gave further proof of 'quantum nature of light'.
- It explains the color of sky. Sunlight passing through atmosphere scatters blue light the most, giving sky its color.
- National Science Day on 28 February of every year to commemorate the discovery of the Raman effect in 1928.

Awards:

- Nobel Prize in Physics 1930 for Raman effect
- Bharat Ratna in 1954

Institutes founded:

- Indian Academy of Sciences in 1933
- Raman Institute of Research at Bangalore in 1948



Vikram Sarabhai

- Father of India's space program.
- 1962: est. INCOSPAR, later renamed ISRO
- 1966: Succeeded Homi Jehangir Bhabha as chairman of Atomic Energy Commission of India

Founder of:

- 1947: Ahmedabad Textile Industry's Research Association
- 1949: Darpana Academy of Performing Arts
- 1961: Operations Research Group, 1st market research org in India
- 1965: Nehru Foundation for Development

Srinivasa Ramanujan

- 1987: Born in Madras; poverty; lacked formal education
- 1913: famous British mathematician GH Hardy recognized his talent and invited him to England.
- 1918: elected Fellow of Royal Society
- 1920: died in India, age 32

Contributed more than 3,900 identities and equations
e.g. Ramanujan prime, Ramanujan theta function.

Ramanujan machine: made in 2019 by Israeli scientists

Lithium

- Lightest metal ; doesn't sink in water (Lithium, Sodium, Potassium)
- Highly flammable (so stored in mineral oil)

Lithium uses:

- Electronics; batteries, etc.
- Li-Ion battery better than most other types; but are expensive
- Makers got 2019 Nobel Prize in Chemistry

Lithium reserves:

- Largest reserves: Chile; Largest producer: Australia
- India currently imports all its lithium needs.
- In 2020, some lithium reserves were found in Mandya in Karnataka

Lithium Triangle:

- Region in Argentina, Bolivia, Chile; has 2/3rd of global reserves
- It has Lithium brine deposits with high concentration, making its exploitation extremely profitable.
- KABIL signed agreement with Argentina for Lithium.

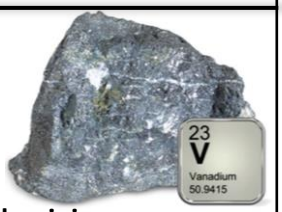
KABIL Khanij Bidesh India Ltd:

- JV of three PSUs of Ministry of Mines.
  National Aluminium Company Ltd. (NALCO),
  Hindustan Copper Ltd.(HCL)
  Mineral Exploration Company Ltd. (MECL).
- Purpose is to ensure supply of strategic minerals from overseas to Indian domestic market.

Graphene

- 2-D carbon allotrope
- One atom thick layer of Graphite
- 2010 Nobel Prize in Physics
- High electrical conductivity
- Applications: many
- Can be used for touchscreen

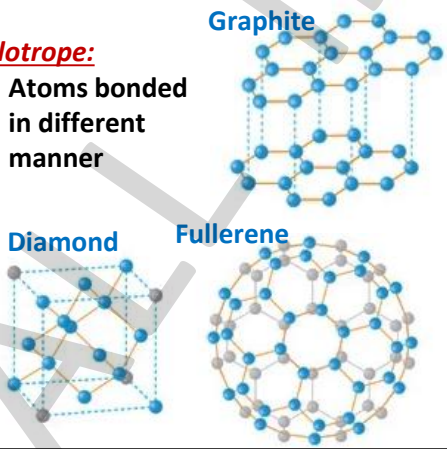
Vanadium



- silvery grey metal;
- Used in medicines, batteries, etc.
- Used as alloying element in steel, aluminium
- Applications in nuclear reactors, aerospace, etc.
- Found in Karnataka, Maharashtra, Odisha, Arunachal, etc.

Allotrope:

- Atoms bonded in different manner



Prelims 2012:

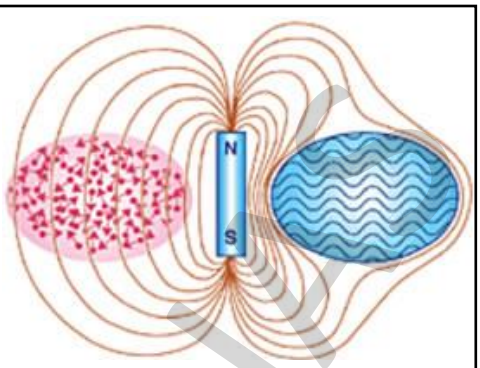
Graphene is frequently in news. What is its importance?

1. It is a two-dimensional material and has good electrical conductivity.
2. It is one of the thinnest but strongest materials tested so far.
3. It is entirely made of silicon & has high optical transparency.
4. It can be used as 'conducting electrodes' required for touch screens, LCD's, organic LED's

Which of the statements given above are correct?

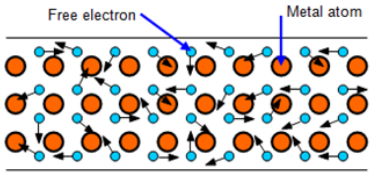
a) 1, 2 b) 3, 4 **c) 1, 2, 4** d) 1, 2, 3, 4

Superconductivity

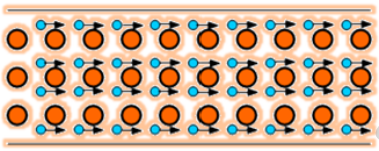


Meissner effect:

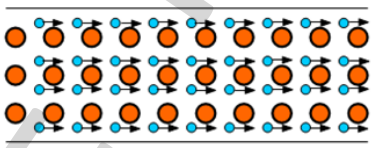
- ❑ expulsion of a magnetic field from a superconductor during its transition to the superconducting state when it is cooled below the critical temperature.
- ❑ This expulsion will repel a nearby magnet.



- Normally, electrons move randomly.
- Hence, no current.



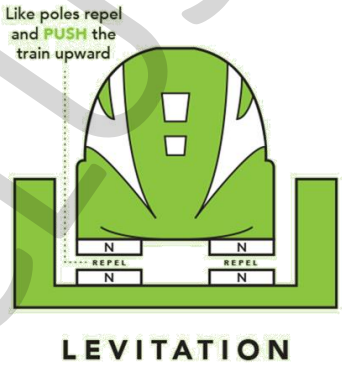
- When electric field is applied, free electrons move in almost same direction.
- Hence, generating current.
- Movement of electrons faces resistance, hence energy loss.
- This is evident from heating of wire.



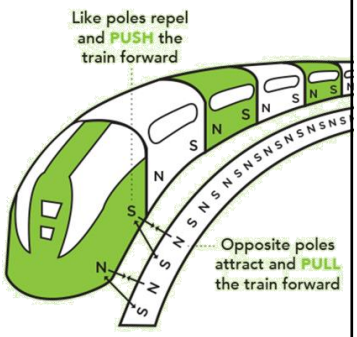
- If electrons face no resistance, then it is called as superconductivity.
- But this happens only at extremely low temperatures.
- This happening at room temperature is a breakthrough.
- Applications? Wherever electric or magnetic field is there.

Hyperloop

like a short maglev train in vacuum tube

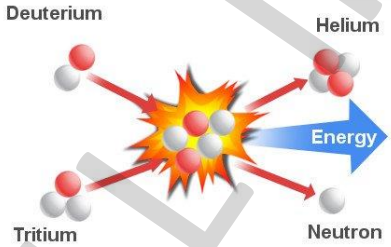


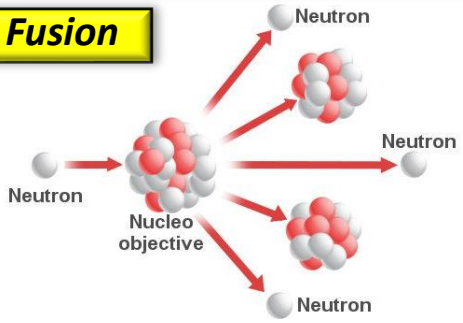
LEVITATION



PROPULSION

Nuclear Fission vs Fusion





Nuclear Fusion	Nuclear Fission
Two light nuclei combine together	Heavy nucleus splits into lighter nuclei
Mostly Deuterium and Tritium are used	Mostly uranium and plutonium are used
Energy produced is more than that in fission	Energy produced is less than that in fusion
No long-lived radioactive waste produced	Long lived radio-active waste is produced
No chain reaction; plasma cools if disturbed	Chain reaction; can go uncontrolled

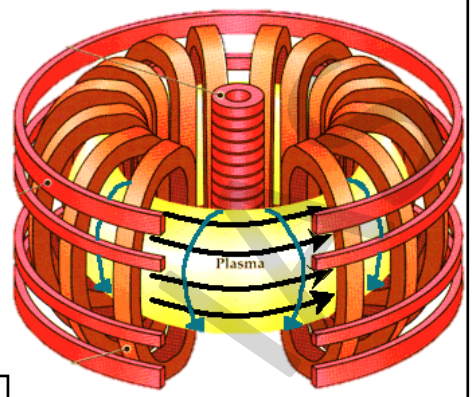
Nuclear Fusion - ITER

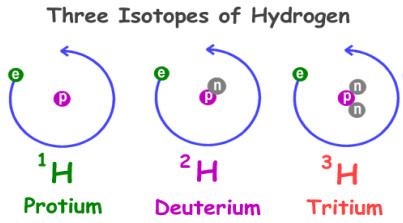
International Thermonuclear Experimental Reactor:

- ✓ for nuclear Fusion (not fission)
- ✓ World's largest tokamak, under construction in France
- ✓ Members: USA, Russia, EU, India, China, Japan, Korea

ITER-India:

- ✓ Project under Institute of Plasma research, Gandhinagar
- ✓ It is to deliver India's in-kind contribution to ITER.
- ✓ India became full member of ITER in December 2005





Isotope:

- ❖ Same number of protons, but different no. of neutrons
- ❖ Remember: Elements are identified by number of protons

Tokamak:

- ✓ Doughnut shaped device that uses powerful magnetic field to confine hot plasma
- ✓ It is one way to achieve make a fusion reactor.

Prelims 2008:

In which of the following locations is the ITER project to be built?

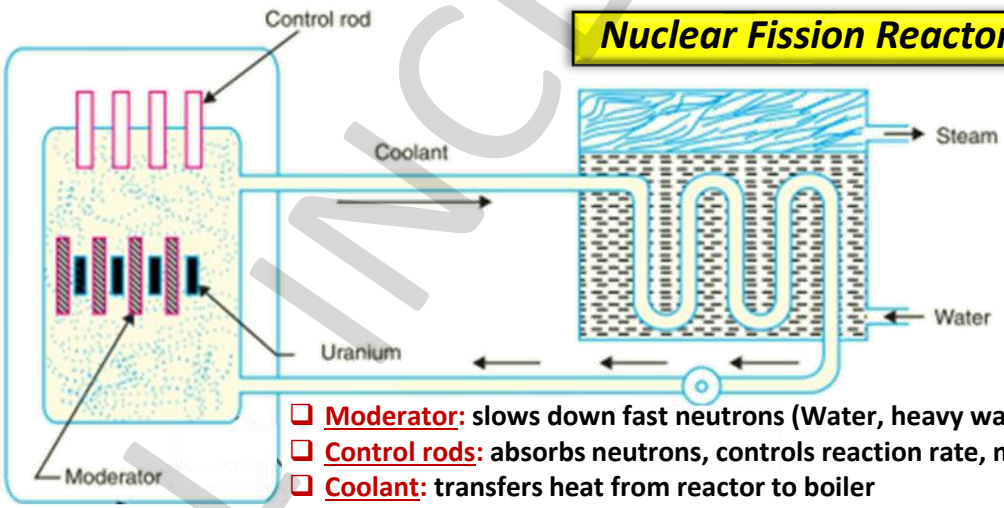
(a) Northern Spain
(b) Southern France
(c) Eastern Germany
(d) Southern Italy

Prelims 2016:

India is an important member of the ITER. If this experiment succeeds, what is the immediate advantage for India?

(a) It can use thorium in place of uranium for power generation
(b) It attain a global role in satellite-navigation
(c) It can drastically improve efficiency of its fission reactors in power generation
(d) It can build fusion reactors for power generation

Nuclear Fission Reactor



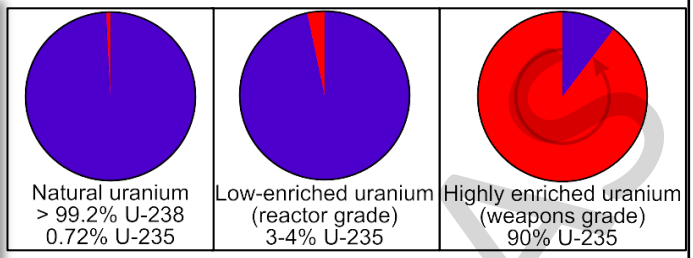
- ❑ Moderator: slows down fast neutrons (Water, heavy water, D_2O Graphite)
- ❑ Control rods: absorbs neutrons, controls reaction rate, made of Cadmium
- ❑ Coolant: transfers heat from reactor to boiler

Uses of Depleted Uranium:

- ✓ Nuclear weapons;
- ✓ Radiation shield in medical equipment.
- ✓ Tank armour; Armour piercing ammunition
- ✓ Counter-weights in aircrafts, etc.

Manhattan Project:

- ❑ US project for nuclear weapons
- ❑ 16 July 1945 Trinity test: 1st detonation of a nuclear weapon
- ❑ 06 August 1945 Little Boy in Hiroshima
- ❑ 09 August 1945 Fat Man in Nagasaki



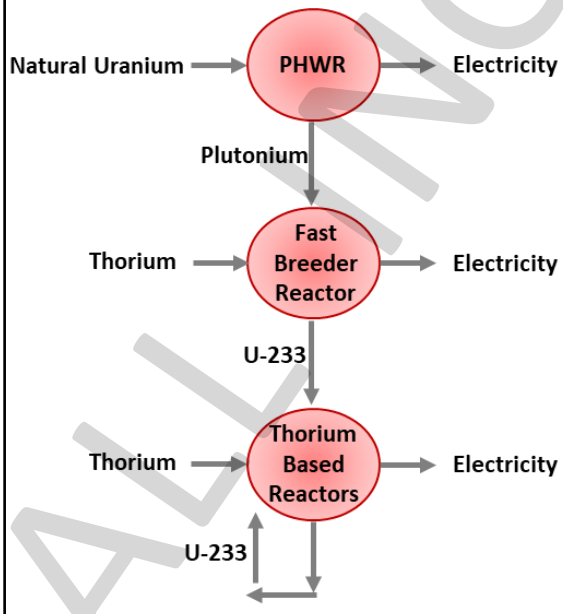
- **Haryana**: Gorakhpur
- **UP**: Narora
- **Rajasthan**: Rawatbhata, Banswara
- **MP**: Chutka
- **Gujarat**: Kakrapar
- **Maharashtra**: Tarapur (1st), Mumbai, Jaitapur
- **Karnataka**: Kaiga
- **TN**: Kudamkulam, Kalpakkam
- **Andhra**: Kovvada

1969 Tarapur Atomic Power Station was first commercial nuclear power station built in India.

India's three-stage nuclear power programme:

- Formulated by Homi Jehangir Bhabha in 1950s.
- Need? India has just 1-2% of global uranium reserves, but 25% of thorium reserves (Monazite sands, most in Andhra)
- But reactor with Thorium alone is not possible.
- It has to be converted into U-233; so 3-stages.

- Breeder reactor: generates more fissile material than it consumes
- Fast Breeder Reactor: Breeder reactor that uses fast neutrons (no moderator)
- India: 500 MW prototype under construction at Kalpakkam (TN); uses Sodium as coolant. (Earlier 13 MW Test reactor made in 1985)



Prelims 2012:

To meet its rapidly growing energy demand, some opine that India should pursue R&D on Thorium as the future fuel of nuclear energy. In this context, what advantage does Thorium hold over uranium?

1. Thorium is far more abundant in nature than Uranium
2. On the basis of per unit mass of mined mineral, Thorium can generate more energy compared to natural Uranium.
3. Thorium produces less harmful waste in comparison to Uranium.

Which of the above statements is/are correct?

(a) 1 only (b) 2 & 3 only
(c) 1 & 3 only (d) 1,2 & 3

Prelims 2018:

In the Indian context, what is the implication of ratifying the 'Additional Protocol' with the 'International Atomic Energy Agency (IAEA)'?

(a) The civilian nuclear reactors come under IAEA safeguards.
(b) The military nuclear installations come under the inspection of IAEA.
(c) The country will have the privilege to buy uranium from the Nuclear Suppliers Group (NSG).
(d) The country automatically becomes a member of the NSG.

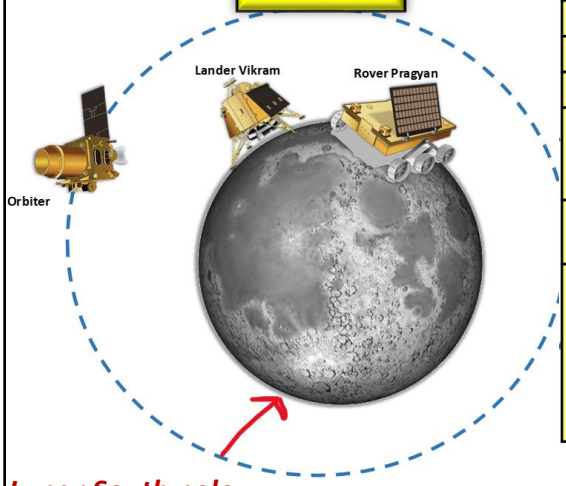
Prelims 2020:

In India, why are some nuclear reactors kept under "IAEA Safeguards" while others are not?

(a) Some use uranium and others use thorium
(b) Some use imported uranium and others use domestic supplies.
(c) Some are operated by foreign enterprises and others are operated by domestic enterprises
(d) Some are State-owned and others are privately-owned

- **2005:** India-US agree on civil nuclear deal
- **2005-2008:**
  - US amended its Atomic Energy Act 1954
  - India separated civil and military nuclear facilities
  - US convinced NSG to make exception for India.
- **2008:** finally deal was signed (aka 123 agreement) (UPA govt. was about to fall, still we signed)
- **Significance?** India became the **only** non-NPT nuclear state that can do nuclear commerce.
- Later, in next few years, India signed deals for fuel, reactors, etc. with **multiple countries**.

Moon



	Chandrayaan -1	Chandrayaan -2
Year	2008	2019
Launch vehicle	PSLV-XL	GSLV Mk-III
Orbiter	Yes	Yes
Lander	Yes; Planned crash landing	Yes (Vikram); Planned soft landing, but crashed
Rover	No	Yes (Pragyan); failed due to lander's crash
Major achievements	❑ Moon impact probe stuck South Pole; ❑ India 4th country to have flag on Moon; ❑ Confirmed lunar ice (water)	

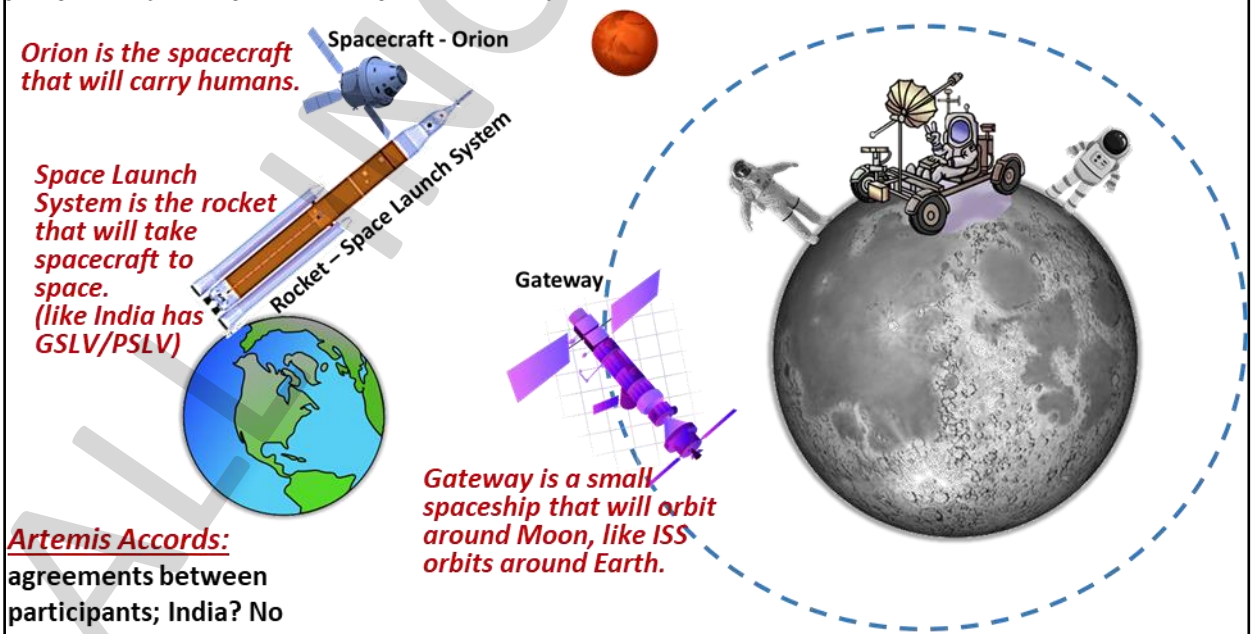
Lunar South pole:
- ❑ Mountains permanently sunlit (energy)
- ❑ Craters permanently shaded (water)
- ❑ Rich in minerals

Lunar Polar Exploration Mission (Lupex):
- ❑ By ISRO (India) and JAXA (Japan)
- ❑ To explore lunar south pole.
- ❑ After 2023, not much finalised yet.

Moon landings:
- ❑ First: 1959, Russia, Luna 2
- ❑ Soft: USA, Russia, China
- ❑ Far side: only Chang'e 4
- ❑ Humans: only USA

- ❑ Total 12 men have landed on moon.
  First - Neil Armstrong; Last - Gene Cernan.
- ❑ 1st mission - Apollo 11: 20 July 1969 (Tranquility base)
- ❑ Last mission - Apollo 17: 14 December 1972
- ❑ Apollo 11: Neil Armstrong & Buzz Aldrin walked.
  Michael Collins in orbit.

Artemis : NASA mission to again send humans to Moon by 2024, but this time with long term perspective, to help in future space missions, like for Mars manned missions.



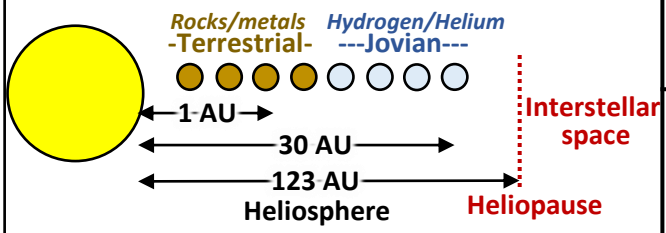
Artemis Accords:
agreements between participants; India? No

Planets

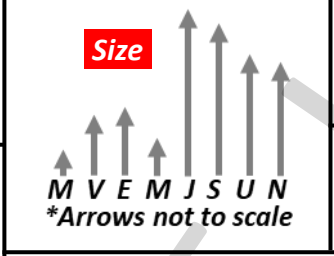
Revolution and Rotation:
All 8 planets revolve around Sun in direction of Sun's rotation? Yes
All 8 planets rotate in same direction? No. On Venus Sun rises in West.

Time to orbit around Sun?
(in earth days)
Mercury → Neptune

Why are inner planets rocky? (NCERT)
- ✓ Too hot for gases to condense
- ✓ Intense Solar wind blew off gases
- ✓ Low gravity could not hold gases



Astronomical Unit 15 crore or 150 million km



Density:
- ❑ Max Earth
- ❑ Min Saturn

Rings:
- X Terrestrial
- ✓ Jovian

Prelims 2003:
Among following, which planet takes maximum time for one revolution around Sun?
(a) Earth (b) Jupiter (c) Mars (d) Venus

Great conjunction:
Jupiter & Saturn appear closest together in sky

Opposition event:
- ❑ Sun, Earth, some outer planet in same line
- ❑ Planet appears bigger as its closest to Earth

Mars

Martian blueberries:
- ❑ Made of hematite (iron oxide)
- ❑ Needs water/oxygen to form
- ❑ Similar to Jhurans in Gujarat

Mangalyaan:
- ❑ Launched using PSLV-C25? Yes!
- ❑ Unmanned; No lander/rover
- ❑ Travel: November 2013 - Sept. 2014.
- ❑ India's 1st interplanetary mission;
- ❑ India became 4th country to reach Mars; 1st from Asia; 1st in maiden attempt
- ❑ Note with Mangalyaan's pic? Rs 2,000

Mars 2020: NASA mission. July 2020. Jezero crater. Perseverance rover. Ingenuity helicopter drone. MOXIE will make oxygen from CO_2 (95% of Mars).

Some NASA missions:
Viking (1975), Spirit (2003), Opportunity (2003), Pathfinder (1997), Curiosity (2011), InSight (2018)

- ❑ Stickney, Shklovsky, Roche, Grildrig ? Craters on Phobos
- ❑ Phobos & Deimos? Moons of Mars
- ❑ Moons: Mercury & Venus zero. Saturn most.

Some other Mars missions:
Mars Express: Europe
ExoMars: Europe + Russia; search for life on Mars
Tianwen-1: China's mission to Mars
Emirates Mars Mission: by UAE; Hope orbiter (first Mars mission by any Arab country)

Prelims 1997:
Which one of the following conditions is most relevant for the presence of life on Mars?
(a) Atmospheric composition
(b) Thermal conditions
(c) Occurrence of ice caps and frozen water
(d) Occurrence of ozone

Prelims 2006:
Assertion (A): To orbit around the Sun, Mars takes lesser time than the time taken by earth.
Reason (R): The diameter of Mars is less than that of earth.
(a) Both A & R are true and R is the correct explanation of A
(b) Both A & R are true but R is NOT a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Venus

Prelims 2005:

Assertion (A): Existence of human life on Venus is highly improbable.

Reason (R): Venus has extremely high level of carbon dioxide in its atmosphere.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT a correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

- Brightest object in night, after moon.
- Atmosphere:
  - → Highly reflective Sulphuric acid clouds;
  - → 96% CO_2 in air; Hottest planet (500^{O}C)
  - → Rotates 60 times faster than land
- On Venus, a day is longer than a year.
- The only planet on which Sun rises in West.
- First planet to be explored by a spacecraft (1962, NASA, Mariner 2)
- First planet to be landed on by a spacecraft (1970, USSR, Venera 7)
- Shukrayaan-1: ISRO's proposed mission

Saturn

- Tilted 26.7^{O} (Earth is 23.5^{O})
- It is 2nd biggest planet
- Has 2nd biggest moon (Titan)
- Ganymede of Jupiter is biggest

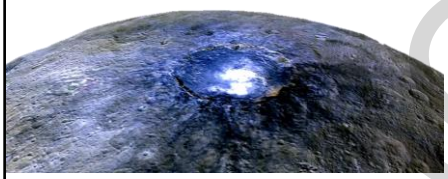
Pioneer 11: (1973-1995)
First to reach Saturn (1979)

Voyager program: (1977, NASA)
- To study Jupiter and Saturn; but continued
- Entered interstellar space: 2012 V1 ; 2018 V2
- Found increase in density outside solar system

Cassini–Huygens (1997 – 2017):
- Saturn Mission of NASA, ESA, Italy
- Cassini orbited Saturn
- Huygens landed on its largest moon Titan

Dwarf planet

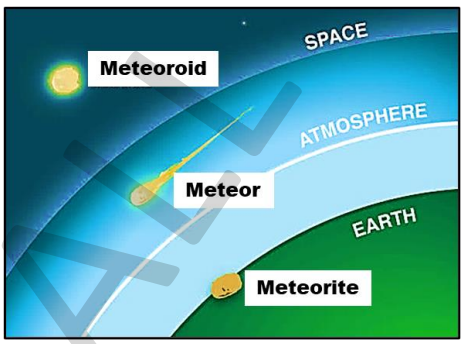
Ceres:
- Largest asteroid (940 km).
- Salty water discovered, hence called Ocean World.



- By International Astronomical Union (1919, Paris, NGO)
- How many? Five (Pluto, Eris, Makemake, Haumea, Ceres).
- Hygiea, an asteroid, may soon be labelled as Dwarf planet.
- Criteria used by IAU to identify Dwarf planets:
  - → It orbits Sun, but is not a moon (natural satellite)
  - → It has not cleared the neighborhood around its orbit.
  - → It is roughly spherical due to its strong gravity.

Note: Not to be confused with *Planetesimals* (dust particles came together, developed into planets)

Comet / Asteroid / etc



- Comet: made of ice, rock, dust; leaves a tail of gas and ice as it travels near the Sun.
- Asteroid: rocky body, larger than 10 meters, orbiting the Sun. Mostly between Mars & Jupiter.
- Meteoroid: rocky body, smaller than 10 meters.
- Meteor: a meteoroid that enters earth's atmosphere and vaporizes.
- Meteorite: A meteor that hits earth's surface.

Note:
- Asteroid belt: between Mars Jupiter
- Kuiper belt: beyond Neptune
- Hailey's comet: seen every 76 years
- Comet Shoemaker–Levy 9 crashed into Jupiter in 1994

Prelims 1998:

Consider the following statements regarding asteroids:

1. Asteroids are rocky debris of varying size orbiting the sun
2. Most of the asteroids are small but some have diameter as large and 1000 km
3. The orbit of asteroids lies between the orbits of Jupiter and Saturn

Which of the above statements are correct:

(a) 1, 2, 3 (b) 2 and 3
(c) 1 and 2 (d) 1 and 3

Prelims 2011:

What is difference between asteroids and comets?

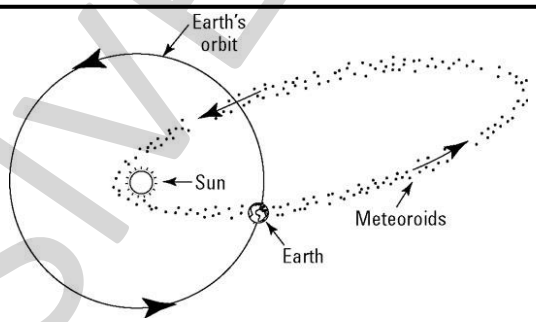
1. Asteroids are small rocky planetoids, while comets are formed of frozen gases held together by rocky and metallic material.
2. Asteroids are found mostly between the orbits of Jupiter and Mars, while comets are found mostly between Venus and Mercury.
3. Comets show a perceptible glowing tail, while asteroids do not.

Which of the above statements are correct:

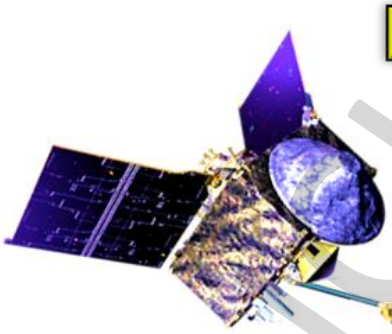
(a) 1 and 2 only (b) 1 and 3 only
(c) 3 only (d) 1,2 and 3

Meteor Shower

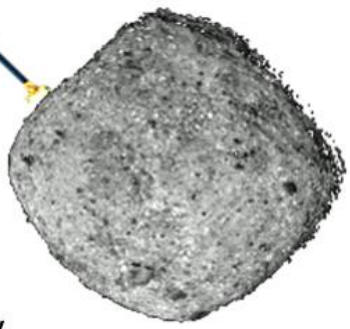
- number of meteors observed in night.
- when earth passes through path of a comet.
- due to debris of comet from its tail.
- size no more than grain of sand.



Osiris -Rex



1. It is a NASA mission.
2. It left earth in 2016.
3. It aims to bring a sample from Asteroid Bennu.
4. It is expected to return with its sample to Earth in September 2023.



Bennu:

1. It is a near earth Asteroid.
2. Its orbit lies mostly between Earth and Mars.
3. It was discovered in 1999.
4. It is just 500 metres wide.
5. It is an active asteroid, sporadically emitting plumes of dust and rocks

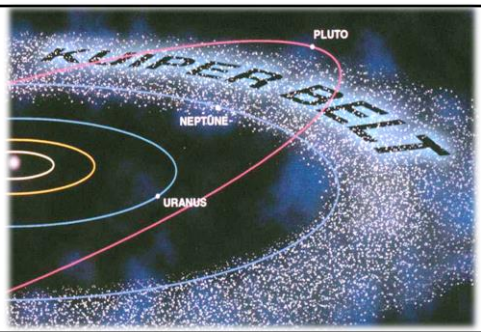
16 Psyche:

- metal asteroid; iron & nickel
- NASA Psyche mission 2022-26

Asteroid Impact and Deflection Assessment (AIDA) mission:

To test if we can deflect asteroids. Two components:

- DART: NASA; impact in 2022
- HERA: Europe; reach in 2027

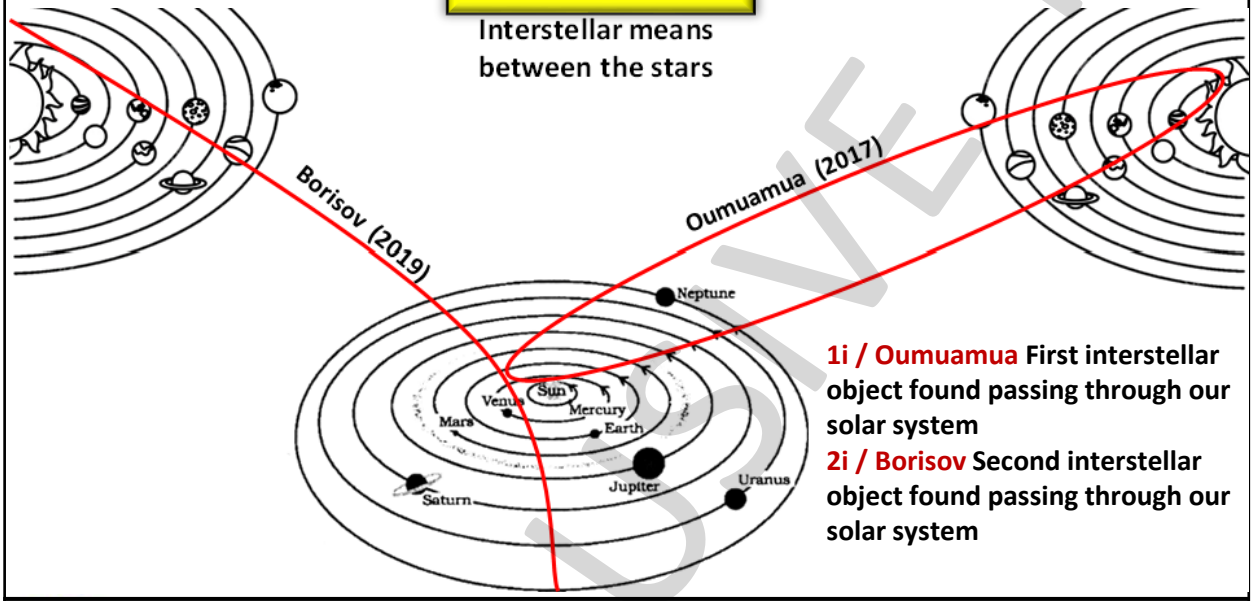


Arrokoth

- New name of 'Ultima Thule'.
- It is a Kuiper belt object.
- It is a contact-binary.
- It was discovered by NASA's Hubble Space Telescope in 2014.

Interstellar

Interstellar means between the stars

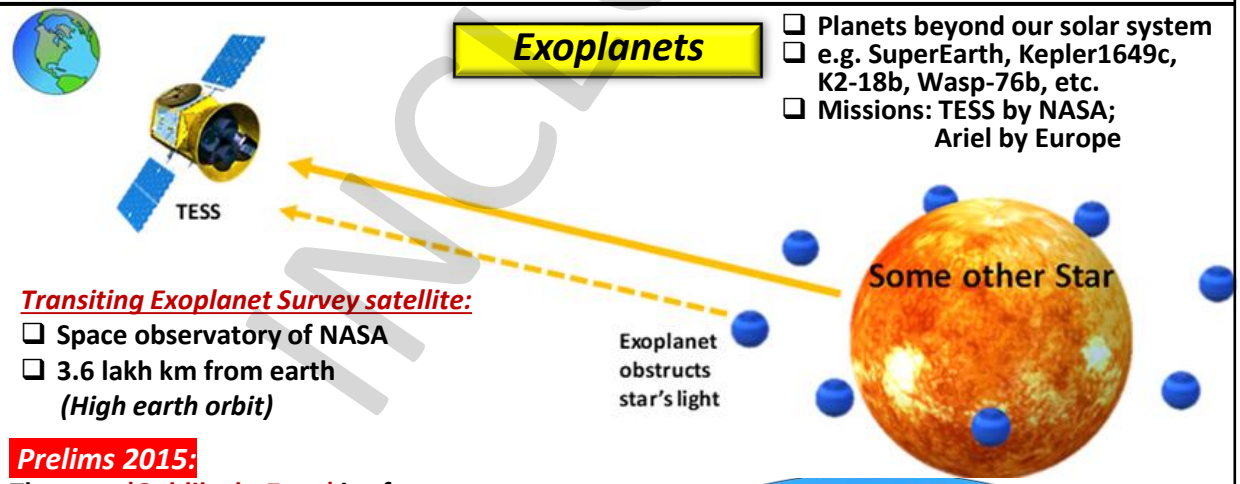


1i / Oumuamua First interstellar object found passing through our solar system

2i / Borisov Second interstellar object found passing through our solar system

Exoplanets

- Planets beyond our solar system
- e.g. SuperEarth, Kepler1649c, K2-18b, Wasp-76b, etc.
- Missions: TESS by NASA; Ariel by Europe



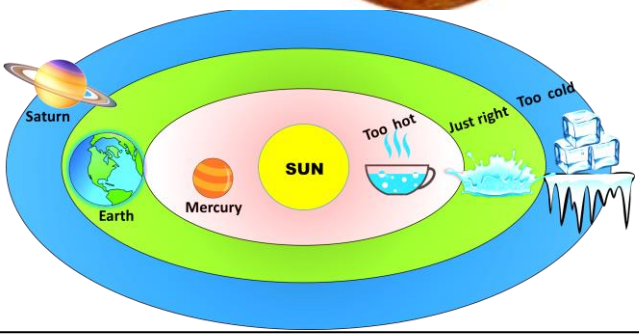
Transiting Exoplanet Survey satellite:

- Space observatory of NASA
- 3.6 lakh km from earth *(High earth orbit)*

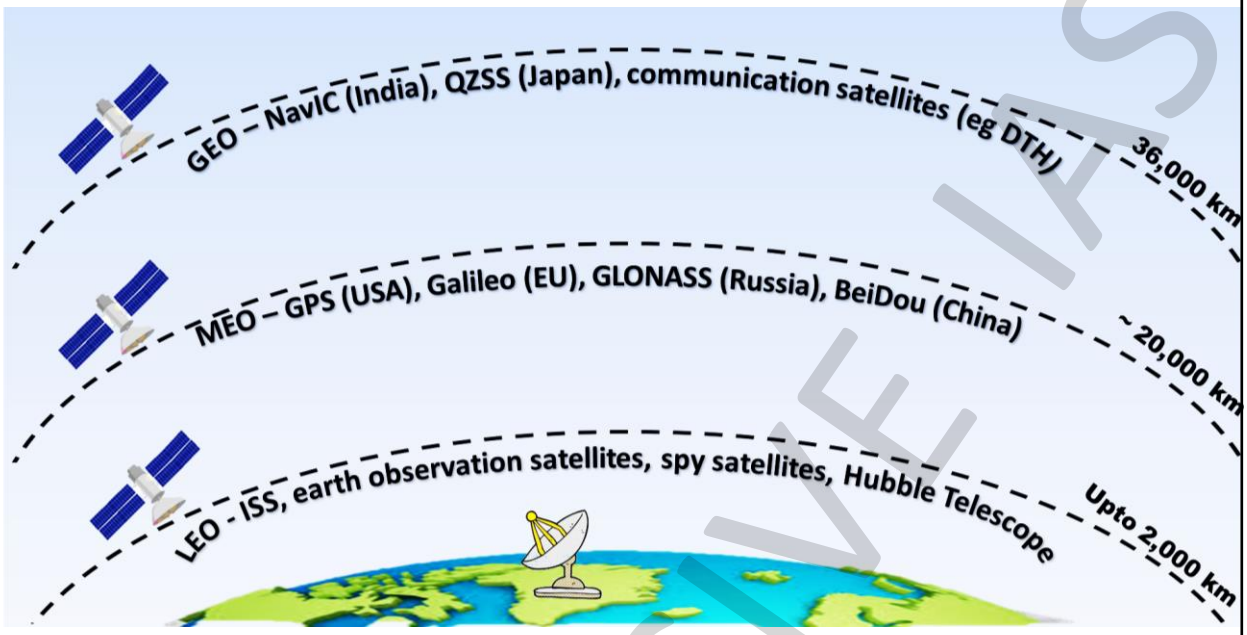
Prelims 2015:

The term 'Goldilocks Zone' is often seen in the news in the context of

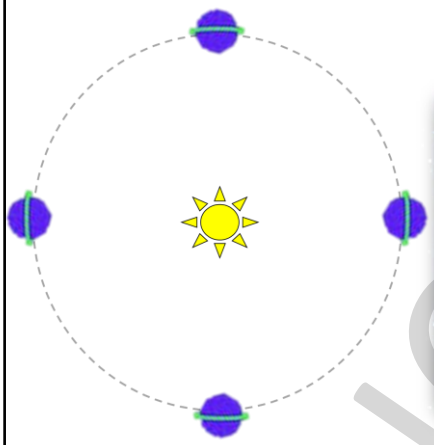
(a) limits of habitable zone above the surface of the Earth
(b) regions inside the Earth where shale gas is available
(c) search for the Earth-like planets in outer space
(d) search for meteorites containing precious metals



Orbits

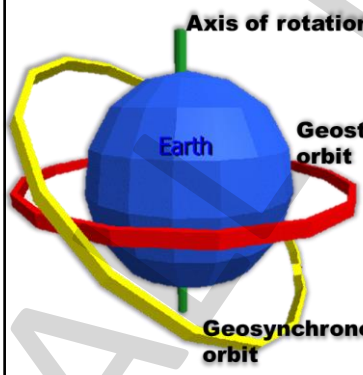


Sun-synchronous polar orbit



- *600–800 km in altitude*
- *Passes through poles*
- *satellite passes over any given point of the planet's surface at the same local mean solar time*
- *Rotates approximately one degree eastward each day to keep pace with the Earth's movement around the Sun.*

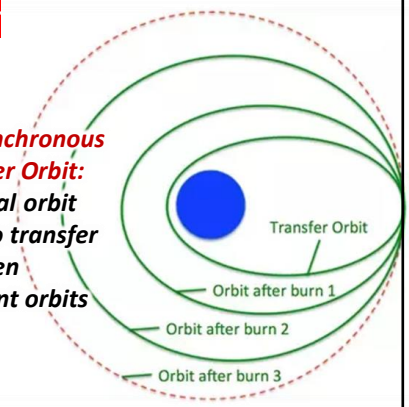
Geosynchronous orbit



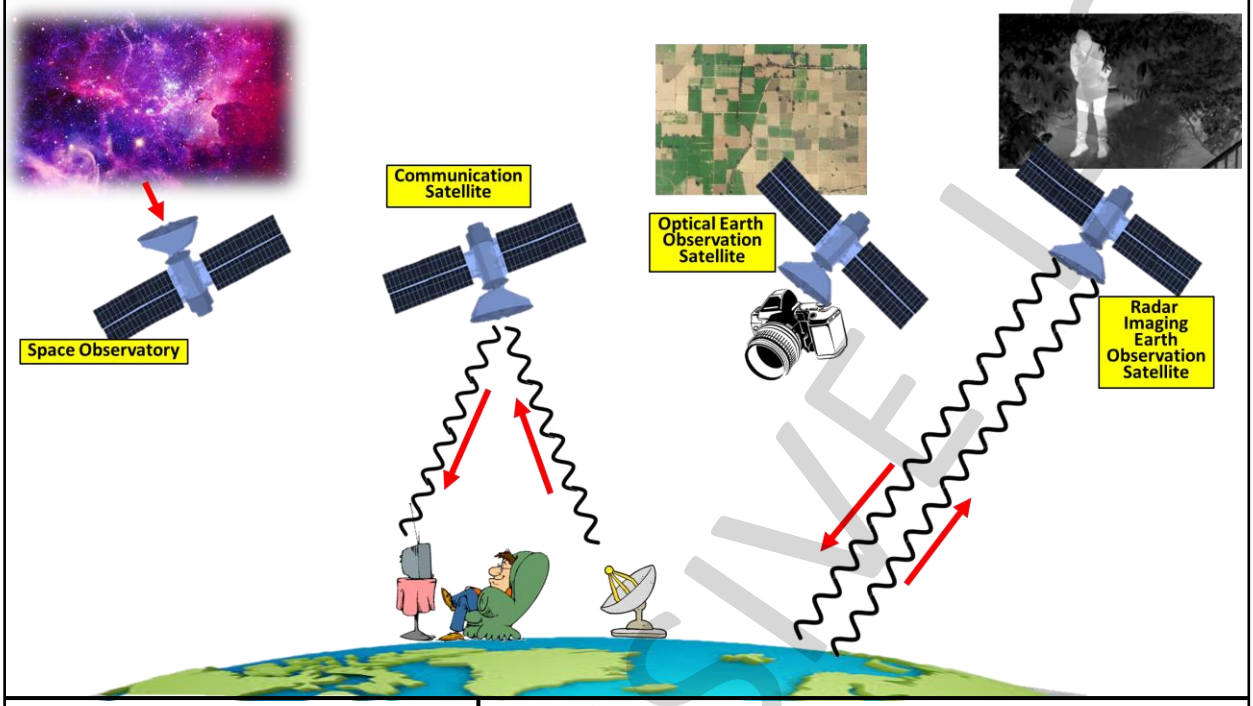
- *It's Geosynchronous orbit over equator*
- *Satellite seems fixed in sky*

- *36,000 km altitude*
- *Orbital period matches Earth's rotation*

Geosynchronous Transfer Orbit: *Elliptical orbit used to transfer between different orbits*



Satellites



EOS-1

EOS-01:
→ not 1st earth observation satellite

CMS-01:
→ not 1st communication satellite

The Indian EXPRESS

Explained: EOS-01, India's latest earth observation satellite that was launched today

EOS-01 is nothing but another Radar Imaging Satellite (RISAT) that will work together with RISAT-2B and RISAT-2BR1 launched last year.

With EOS-01, ISRO is moving to a new naming system for its earth observation satellites which till now have been named thematically, according to the purpose they are meant for. For example, the Cartosat series of satellites were meant to provide data for land topography and mapping, while the Oceansat satellites were meant for observations over sea.

RISAT

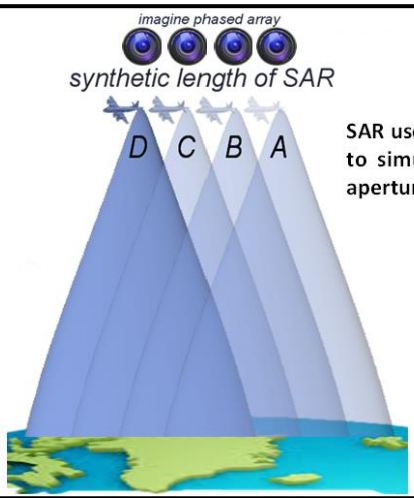
Satellite	Year
RISAT-2	2009
RISAT-1	2012
RISAT-2B	2019
RISAT-2BR1	2019
EOS-1	2020

- All-weather earth observation satellites.
- Launched in LEO, by PSLV.
- 2008 Mumbai attacks → 2 before 1
- Uses Synthetic Aperture Radar.

Q. Earth Observation Satellites need clear view of earth. They cannot work under cloudy conditions. True/False?

A. Radar can penetrate clouds. That is the whole purpose of making RISAT satellites!

Aperture means the opening in a lens through which light passes to enter the camera.



SAR uses flight path to simulate a large aperture.

Japan : QZSS
Europe : Galileo
Russia : GLONASS
China : BeiDou

IRNSS / NavIC

Indian Regional Navigation Satellite System
Navigation with Indian Constellation

Orbit: 4 Geosynchronous; 3 Geostationary
Launch: 9 launches (7 Sats) in 2013-2018
Range: up to 1,500 km beyond borders
Variants: Standard (Civil) and Restricted (Military)
Accuracy: 20 metre

Recognized by:
IMO for World Wide Radio Navigation System
USA as Allied navigational satellite system

Prelims 2018:
In which of the following areas can GPS technology be used?
1. Mobile phone operations
2. Banking operations
3. Controlling the power grids

Select the correct answer using the code given below:
(a) 1 only (b) 2, 3 only
(c) 1, 3 only (d) 1, 2, 3

Prelims 2018:
With reference to the Indian Regional Navigation Satellite System (IRNSS), consider the following statements:
1. IRNSS has three satellites in geostationary and four satellites in geosynchronous orbits.
2. IRNSS covers entire India & 5500 sq. km beyond its borders.
3. India will have its own satellite navigation system with full global coverage by the middle of 2019.

Which of the statements given above is/are correct?
(a) 1 only (b) 1 and 2 only (c) 2 and 3 only (d) None

IRNSS (NavIC) is designed to provide accurate real-time positioning and timing services to users in India as well as region extending up to 1,500 km from its boundary

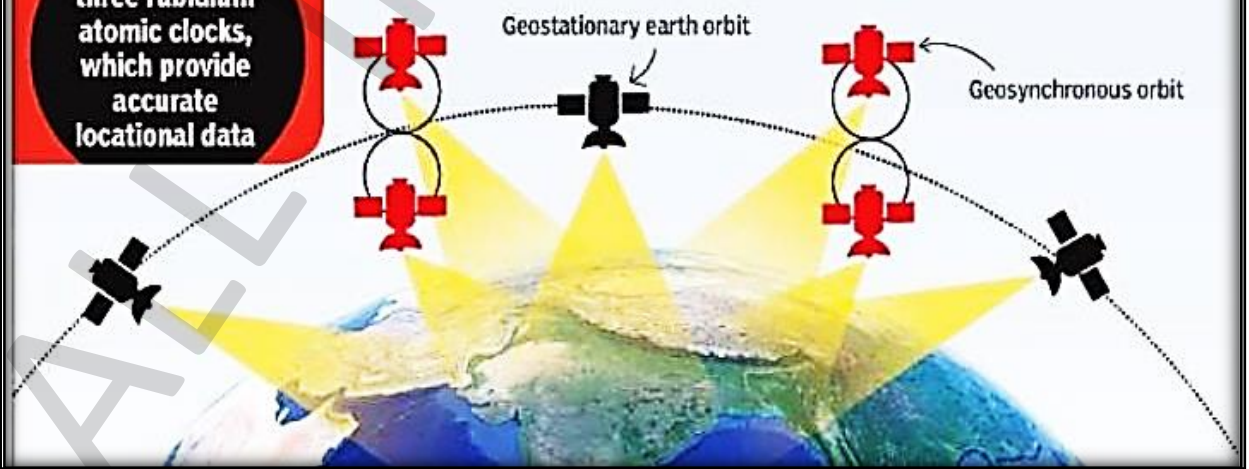
NAVIGATION CONSTELLATION CONSISTS OF SEVEN SATELLITES
3 in geostationary earth orbit (GEO) and 4 in geosynchronous orbit (GSO) inclined at 29 degrees to equator

Each sat has three rubidium atomic clocks, which provide accurate locational data

IT WILL PROVIDE TWO TYPES OF SERVICES
1 **Standard positioning service** | Meant for all users
2 **Restricted service** | Encrypted service provided only to authorised users (military and security agencies)

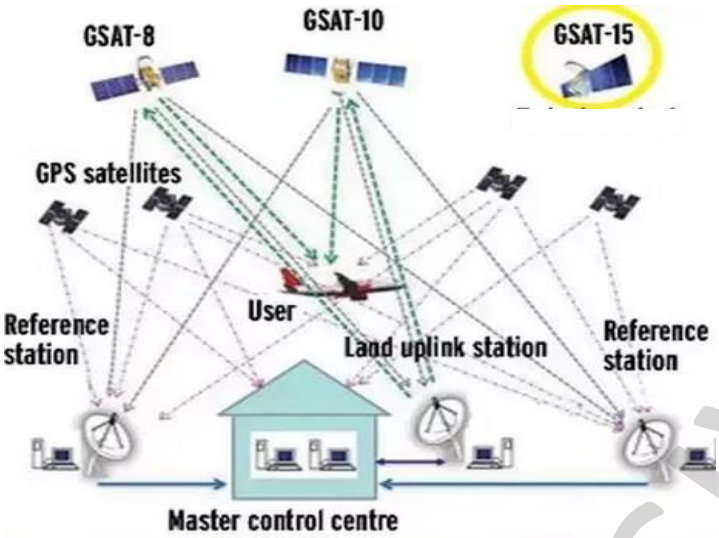
Applications of IRNSS are:
Terrestrial, aerial and marine navigation; disaster management; vehicle tracking and fleet management; precise timing mapping and geodetic data capture; terrestrial navigation aid for hikers and travellers; visual and voice navigation for drivers

While **American GPS** has **24 satellites** in orbit, the number of sats visible to ground receiver is limited. In **IRNSS, four satellites** are always in geosynchronous orbits, hence always visible to a receiver in a region **1,500 km** around India



GAGAN

GPS Aided GEO Augmented Navigation



Satellite Based Augmentation System:
Uses ground stations to improve accuracy of GPS signals.

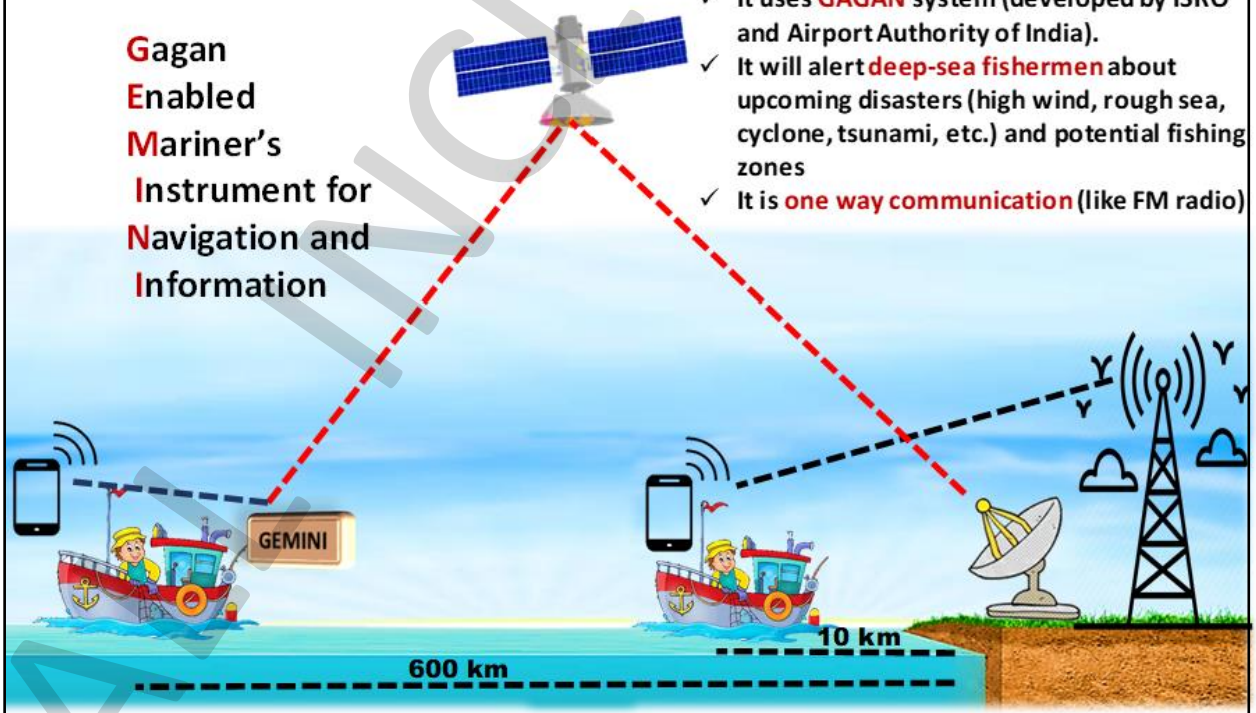
GAGAN:

- Made by ISRO and AAI.
- Covers Africa to Australia.
- Inter-operable with other international SBAS systems.
- First SBAS system in the world to serve the equatorial region.
- Primarily meant for aviation, but has other applications also, like railways.
- Other SBAS:
  - US - WAAS
  - Europe - EGNOS
  - Japan - MSAS

GEMINI

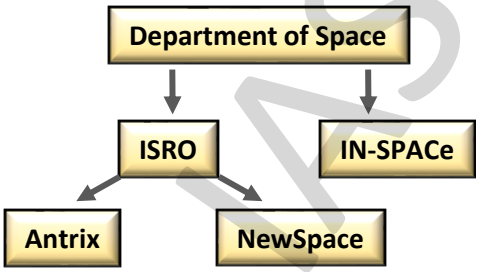
Gagan Enabled Mariner's Instrument for Navigation and Information

- ✓ It uses GAGAN system (developed by ISRO and Airport Authority of India).
- ✓ It will alert deep-sea fishermen about upcoming disasters (high wind, rough sea, cyclone, tsunami, etc.) and potential fishing zones
- ✓ It is one way communication (like FM radio)



NewSpace vs In-Space

- 1992 ANTRIX focusses on selling ISRO's products and services like satellite launch.
- 2019 NEWSPACE also focusses on increasing private industry participation in space programmes.
- 2020 INSPACe is currently stated to promote private industry in space program, but in future, it will become regulator of space activities in India.
- INSPACe is not a commercial arm of ISRO.
- Antrix & NewSpace are both commercial arms of ISRO.



Space Debris

- Kessler syndrome: domino effect of satellite collisions in LEO
- Law: no explicit on space debris removal
- ISRO's NETRA: NEtwork for space object TRacking and Analysis
- Digantara: Private company to track debris.
- Some other initiatives:
  - → Europe's Clearspace-1;
  - → China's Neo-01; Japan's Elsa-d

Space Law

Outer Space Treaty, 1967

- 110 members; India ratified it in 1982
- Launching country liable for damage
- Bans WMDs, not other weapons
- no nation can lay claim on any celestial body
- Administered by a UN committee
  - → COPUS: Committee on Peaceful Uses of Outer Space (1959; HQ Austria)

Astrosat (2015)

- India's first dedicated multi wavelength space observatory.
- It enables the simultaneous multi-wavelength (optical, UV, X-Ray) observations of various astronomical objects with a single satellite.

Prelims 2016:

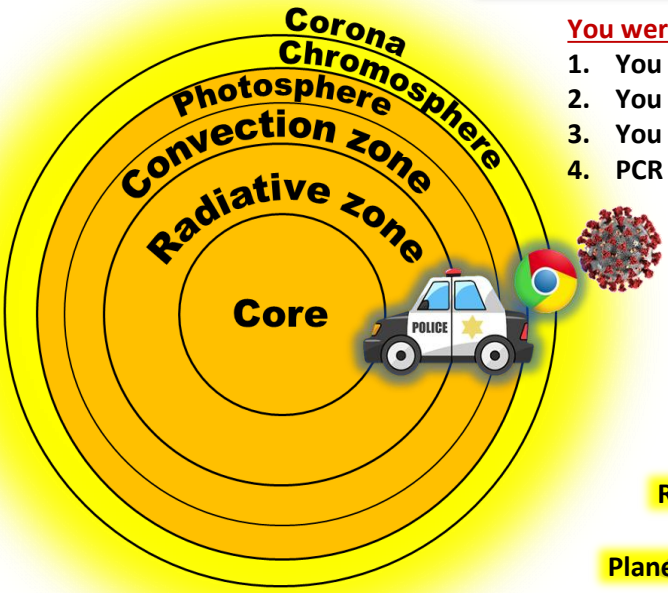
With reference to 'Astrosat',' the astronomical observatory launched by India, which of the following statements is/are correct?

1. Other than USA and Russia, India is the only country to have launched a similar observatory into space.
2. Astrosat is a 2000 kg satellite placed in an orbit at 1650 km above the surface of Earth.

Select the correct answer using the code given below.

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Sun



You were trying to go to core of the sun:

1. You encounter **CORONA**virus
2. You search on **CHROME** how to tackle corona
3. You find that calling **PCR** is the best way
4. PCR transports you to the **CORE**

Temperature: Core 15 million K; Photosphere 6,000 K; Corona 1 million K

Star life Cycle

Nebula → Protostar → Main Sequence star

- Red Giant → Planetary Nebula → White dwarf
- Red Supergiant → Supernova → Neutron star or Black hole

Stellar nucleosynthesis:

- ❑ Universe is made of matter & energy.
- ❑ Hydrogen is the most abundant element in the universe.
- ❑ In stars, fusion causes hydrogen to combine to form Helium.
- ❑ Fusion continues to form other elements also, mainly till iron.

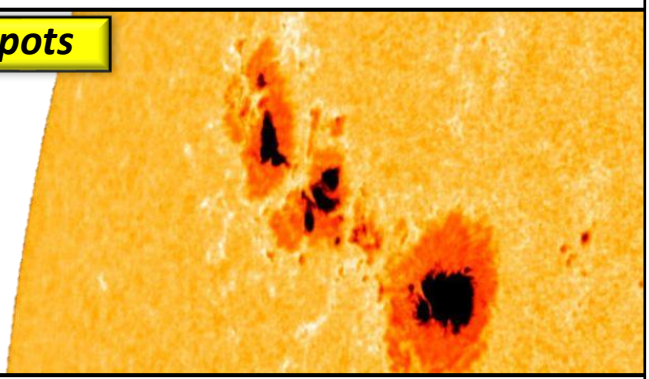
Chandrasekhar limit is the maximum mass of a stable white dwarf star. It is about 1.4 times solar mass.

Sun is in main-sequence stage; will become white dwarf.

Helium Flash

- ❑ nuclear fusion of Helium into carbon in Red Giants
- ❑ Like a chain reaction; lasts only few minutes
- ❑ Also produces Lithium; so some stars have more lithium than their planets

Sunspots



- ❑ They are dark spots on Sun
- ❑ They have less temperature
- ❑ They are caused by strong magnetic field
- ❑ They usually follow 11 year solar cycle

Solar maxima:

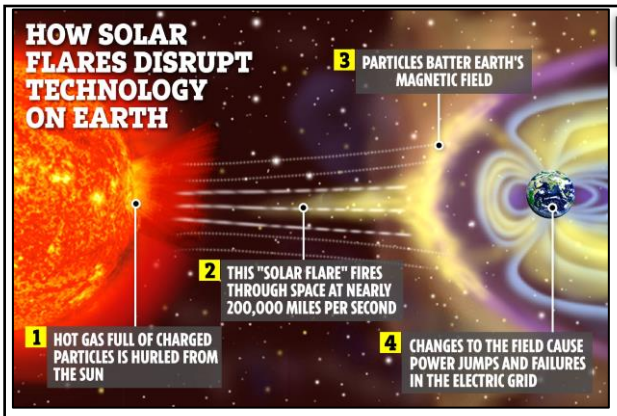
- ❑ period of greatest sun activity
- ❑ Large number of sunspots appear.
- ❑ Large solar flares appear.

Solar maxima → more sunspots → more solar flares in surroundings → more heat on earth

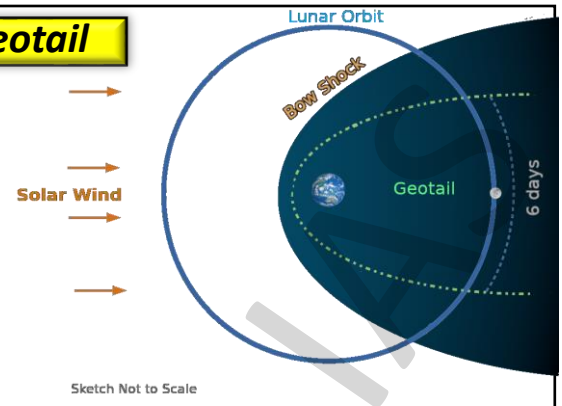
Solar minima → less sunspots → less solar flares in surroundings → less heat on earth

Note:

- ❑ Solar flares are sometimes accompanied by Coronal Mass Ejections
- ❑ Solar wind / Solar flares/ Coronal Mass Ejections all contain plasma/charged particles, and can disturb electronic equipment on earth.

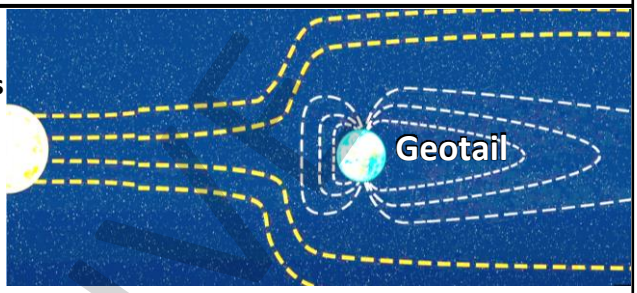


Geotail



Magnetosphere:

- Region where earth's magnetic field dominates
- Its shape is influenced by Solar wind
- 6-10 times of earth's radius on sun side
- 1000 times of earth's radius on night side
- Magnetopause: outer boundary of earth's magnetosphere



Auroras:

Formed at poles due to disturbances in earth's magnetosphere caused by solar wind.

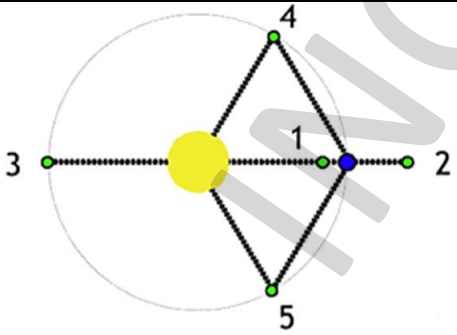
Polar lights (aurora polaris)
Northern lights (aurora borealis)
Southern lights (aurora australis)

Some Solar missions:

- NASA: Parker; EZIE
- Europe: Solar Orbiter
- ISRO: Aditya L-1
- Japan: Solar-C_EUVST

Alfven waves:

- occur in plasma, need magnetic field to exist
- travel in direction of magnetic field



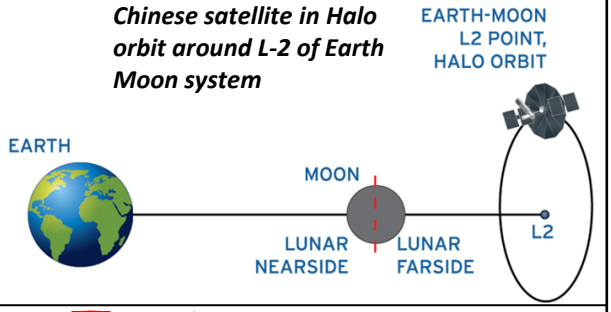
Aditya L-1

- 1,500 kg; 2022 launch
- First Indian mission to study the Sun.
- It will be inserted in a halo orbit around the L-1, at 15 lakh km from Earth.
- Reason: L-1 gives continuous view of the Sun, without any obstruction or eclipse.

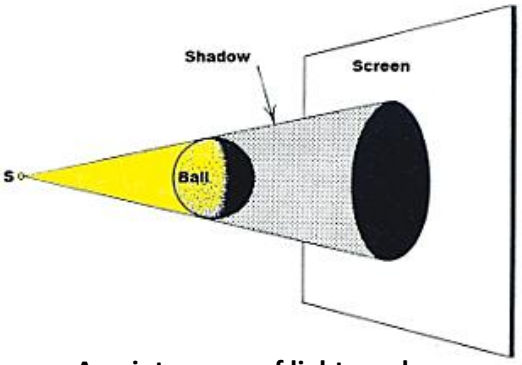
What are Lagrangian points?

- These are positions in space where a small object will maintain its position relative to the large orbiting bodies.
- For a two body system, there are five Lagrangian points.
- Although a Lagrange point is just a point in empty space, its peculiar characteristic is that it can be orbited.

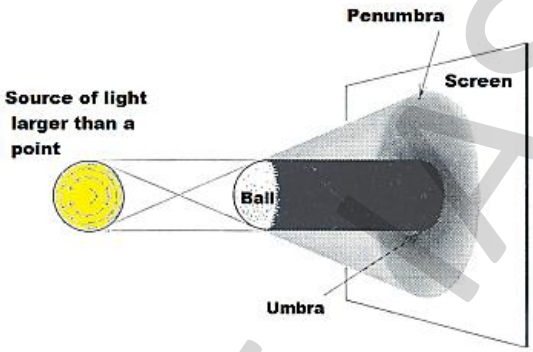
Chinese satellite in Halo orbit around L-2 of Earth Moon system



Solar / Lunar Eclipse

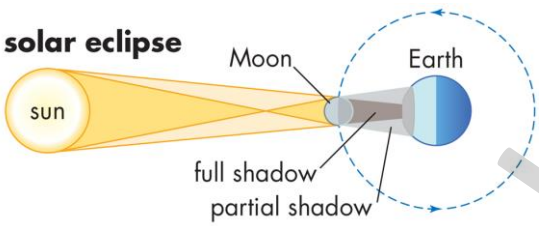


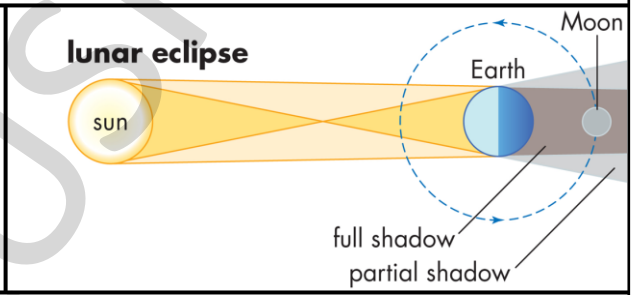
A point source of light produces a single well-defined shadow.



A bigger source of light produces shadows like umbra and penumbra.

Umbra	*Penumbra*
(1) It is the darkest part of shadow. (2) No light reaches to this region. (3) It is central part of shadow.	(1) It is less dark part of shadow. (2) Light from some parts of the source reaches. (3) It is outerpart of a shadow.





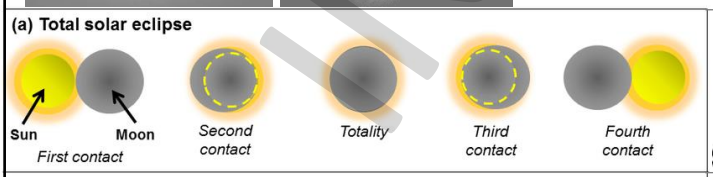
Diamond Ring

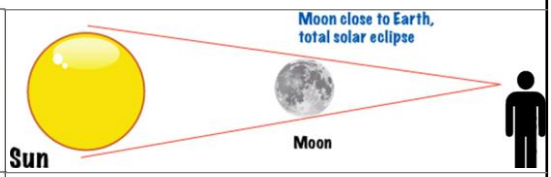
Bailey's beads

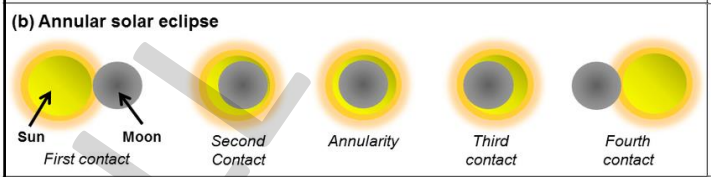
Prelims 1996:

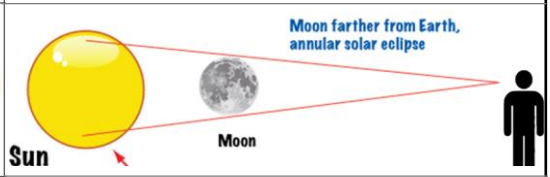
Diamond ring is a phenomenon observed:

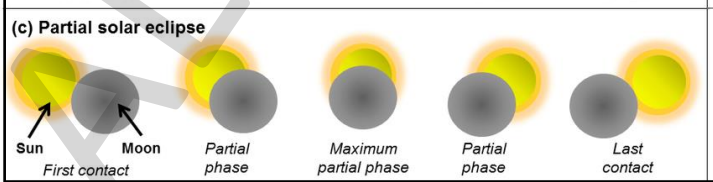
(a) at the start of a total solar eclipse
(b) at the end of a total solar eclipse
(c) only along the peripheral regions of the totality trail
(d) only in the central regions of the totality trail





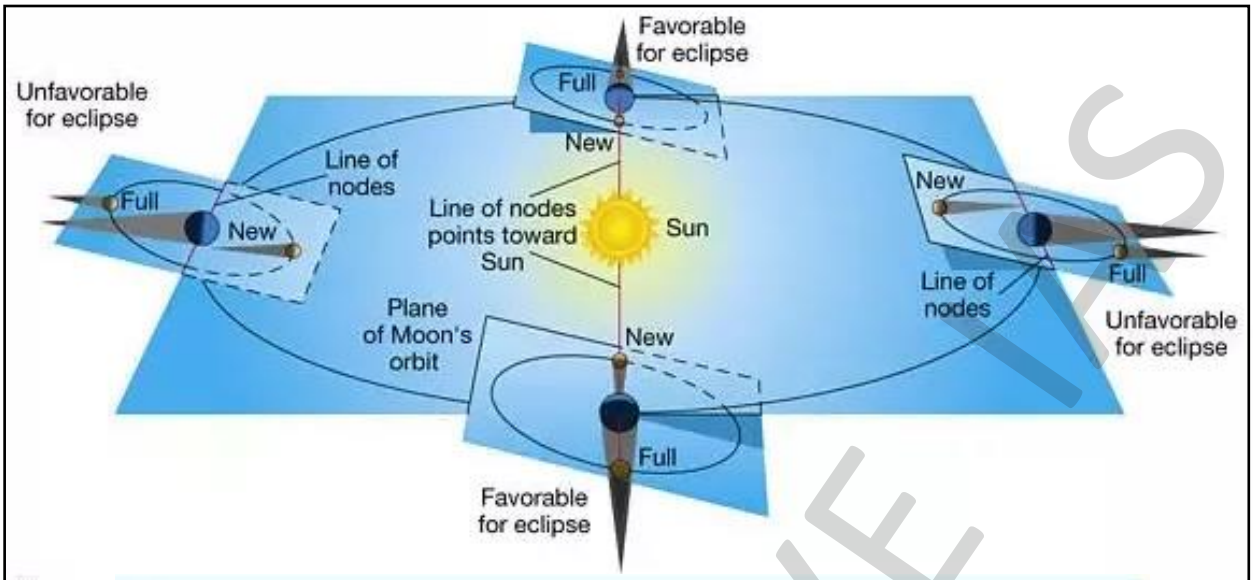


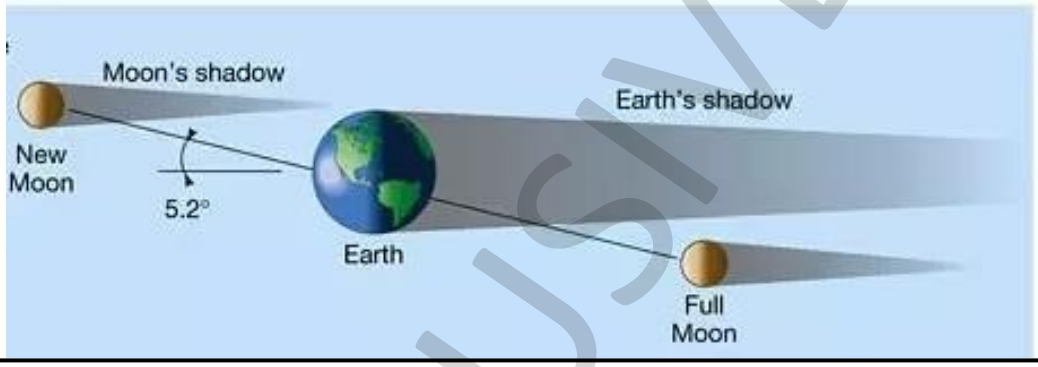




Moon's orbit is inclined, else every month two eclipses would occur:

- ❑ **Solar eclipse (new moon)**
- ❑ **Lunar eclipse (full moon)**





Trans fats

Prelims 2003:

Assertion (A): Unsaturated fats are more reactive compared to saturated fats.

Reason (R): Unsaturated fats have only single bonds in their structure.

(a) Both A & R are individually true and R is the correct explanation of A

(b) Both A & R are individually true but R is not the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

Prelims 2011:

A company marketing food products advertises that its items do not contain trans-fats. What does this campaign signify to the customers?

1. The food products are not made out of hydrogenated oils.
2. The food products are not made out of animal fats / oils.
3. The oils used are not likely to damage the cardiovascular health of the consumers.

Which of the above statements are correct?

(a) 1 only (b) 2 & 3 only (c) 1 & 3 only (d) 1, 2, 3

Prelims 2004:

Assertion (A): Fatty acids should be a part of the balanced human diet.

Reason (R): The cells of the human body cannot synthesize any fatty acids.

(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and Rare individually true but R is not the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

Prelims 2008:

Assertion (A): In human body, liver has important role in fat digestion.

Reason (R): Liver produces two important fat-digesting enzymes.

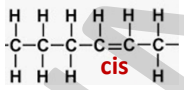
(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and Rare individually true but R is not the correct explanation of A

(c) A is true but R is false

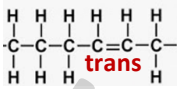
(d) A is false but R is true

Unsaturated fats
Liquid



- Mono Unsaturated Fatty Acids (One double bond)
  Found in olive oil, canola oil, avocados, nuts, etc.
  Lowers bad cholesterol (LDL); raises good cholesterol (HDL)
- Poly Unsaturated Fatty Acids (2 or more double bonds)
  Found in Sunflower oil, soybean oil, fish (Omega-3), walnut, etc.
  Lowers both good and bad cholestrol

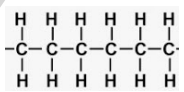
Trans fats
Semi-solid



- Natural: cow, sheep, dairy
- Artificial: by hydrogenation (heat vegetable oil in presence of hydrogen)

→ aka Partially hydrogenated oils; most common Vanaspati
→ Longer shelf life, more stable to withstand repeated heating
→ Lowers good (HDL) cholesterol; Raises bad (LDL) cholesterol
→ Humans don't need Transfats

Saturated fats
Solid



- Mainly in animal foods like meat, cheese, etc. B
- But also in some plant foods like coconut oil & palm oil

FSSAI	**Limit on Trans fats in food:** ❑ 3% of total oil/fats (2% from 2022) ❑ Excludes natural (dairy, meat, fish)	**Heart-attack rewind:** Educate people about dangers of Transfats	TRANS FAT FREE If TFA < 0.2g/100g
WHO	❑ Transfats must be < 1% of daily energy intake ❑ REPLACE initiative to eliminate transfats by 2023		

Food safety

FSSAI:
- ❑ est in 2011
- ❑ under FSS Act 2006
- ❑ under MoH&FW

Eat-right movement:
- ❑ Educate people about healthy eating, reduce intake of oil, salt, sugar, etc.
- ❑ Encourage Places of Worship to maintain hygiene

Repurpose Used Cooking Oil:
- ❑ In cooking oil, Total Polar Compounds must be < 25%
- ❑ Else, stop re-using cooking oil
- ❑ Use it to make bio-diesel

State Food Safety Index:
- ❑ by FSSAI
- ❑ ranks states on food safety
- ❑ Based on testing facilities, consumer empowerment, etc.

Food Hygiene Rating Scheme:
- ❑ by QCI and FSSAI
- ❑ Voluntary, not compulsory.
- ❑ For Food Business Owners
- ❑ Public can see the ratings

Quality Council of India:
- ❑ 1997; Delhi
- ❑ Set up by MoC&I and industry associations (Assocham, FICCI, CII)

Prelims 2018:

Consider the following statements
1. The Food Safety and Standards Act, 2006 replaced the Prevention of Food Adulteration Act, 1954.
2. The Food Safety and Standards Authority of India (FSSAI) is under the charge of Director General of Health Services in the Union Ministry of Health and Family Welfare.

Which of the above statements are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Prelims 2016:

With reference to pre-packaged items in India, it is mandatory to the manufacturer to put which of the following information on the main label, as per the Food Safety and Standards (Packaging and Labelling) Regulations, 2011?
1. List of ingredients including additives
2. Nutrition information
3. Recommendation, if any, made by the medical profession about possibility of any allergic reaction
4. Vegetarian/non-vegetarian

Select the correct answer using the code given below.
(a) 1, 2, 3 (b) 2, 3, 4 (c) 1, 2, 4 (d) 1, 4

Honey Adulteration

Prelims 2017:

Consider the following pairs:
Commonly used materials and the unwanted chemicals likely to be found in them:
1. Lipstick – Lead
2. Soft drinks – Brominated vegetable oils
3. Chinese fast food – Monosodium glutamate

Which of the above pairs are correctly matched?
(a) 1 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3


ThePrint

'Chinese sugar' found in Indian honey, Dabur, Patanjali call CSE report 'bid to malign' brands

Brands have denied the allegations of selling adulterated honey but CSE research team says sugar syrups are designed to pass India's food regulatory standards.

MOHANA BASU
3 December, 2020 8:52 am IST

Honey:

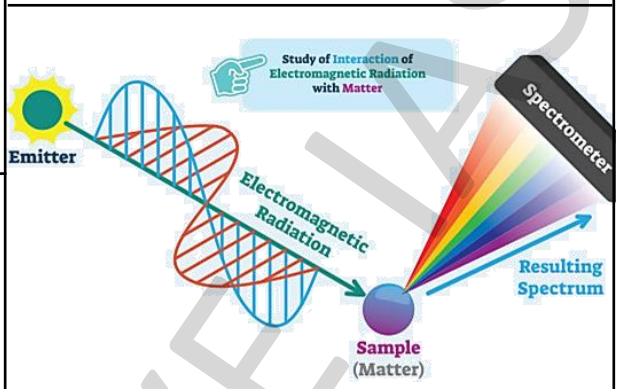
- 82% carbohydrates; 17% water
- Fructose (40-50%) > Glucose (30-40%)
- Adulterants:
  - sugar, golden syrup, rice syrup, water
- Crystals in honey don't indicate adulteration
- Purity Tests:
  - NMR test; Trace Marker for Rice test
  - C3-C4 tests; Oligosaccharides sugar test

NMR spectroscopy:

- Nuclear Magnetic Resonance spectroscopy
- observes local magnetic fields around nuclei
- NMR test is compulsory for honey exports, but not for sale in India.

Prelims 1997:

The major component of honey is
(a) glucose (30%) (b) sucrose
(c) maltose (d) fructose (40%)



Apiculture:

- rearing honeybees for honey, wax

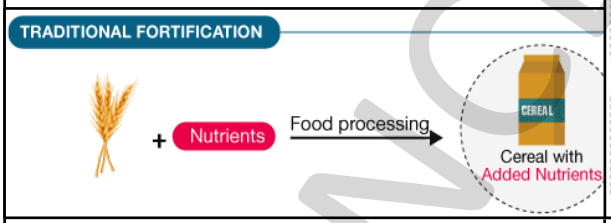
National Beekeeping & Honey Mission:

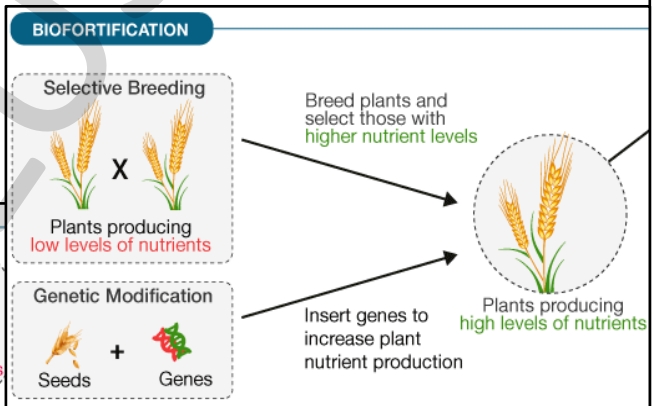
- Launched in 2020, for 3 years
- Central sector scheme; MoA&FW
- To promote beekeeping, Sweet Revolution

Fortification

Deliberate addition of micronutrients to food

Helps fight hidden hunger (micronutrient deficiency)





FORTIFIED
SAMPOORNA POSHAN SWASTH JEEVAN
➔ by FSSAI, for fortified foods

Some FF in India (https://ffrc.fssai.gov.in/)	
Wheat flour	Iron, Folic acid, Vitamin B12
Rice	
Milk	Vitamins A and D
Edible Oil	
Salt	Iron, Iodine

FSSAI plans to make some food fortification mandatory:

- Will help address micronutrient deficiency
- Small food processors will close down
- Side effects like gut inflammation
- Its no solution to monotonous cereal diet, less veggies, less protein

Disease

Bacteria → Tetanus, Leprosy, TB
Virus → Influenza, Smallpox, Rabies, AIDS, Polio
Fungi → Athlete's foot, Yeast infections, Mucormycosis
Protozoa → Malaria, Kala Azar

Tuberculosis

- 1 crore cases in 2019; 24 lakh from India
- Elimination target: Global 2030, India 2025

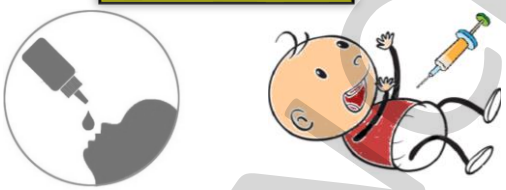
Bacteria	Mycobacterium tuberculosis; Spreads by cough, sneeze, spit
Impacts	Lungs: Pulmonary TB Other organs: Extra-Pulmonary TB
Tests	Sputum smear microscopy, Chest X -ray, CB-NAAT, Truenat, Ziehl–Neelsen
Medicine	Vaccine: BCG vaccine, given to infants Treatment: at 4.5 lakh DOTS centres Directly Observed Treatment Short course

Nikshay	web portal to monitor TB cases Ni=End, Kshay=TB क्षय रोग
TB sample transport network	by India Post, for sample transport to lab
END TB Strategy	By WHO
Stop TB Partnership	2001; Geneva Govt, NGOs, private sector

Multi Drug Resistant TB	Does not respond to rifampicin and isoniazid (1st line drugs)
EXtensively Drug Resistant TB	Also resistant to fluroquinolones and some 2nd line drugs
Totally Drug Resistant TB	Resistant to all 1st and 2nd line drugs

Prelims 1995:
Which one of the following antimicrobial drugs, is suitable for treatment of both tuberculosis and leprosy?
(a) Isoniazid (b) P-aminosalicylic acid
(c) Streptomycin (d) Rifampicin

Polio



- Oral Polio Vaccine
- Weakened virus
- Can spread virus
- Inactivate Polio Vaccine
- Killed virus
- Cannot spread virus

There is no cure for polio, it can only be prevented.

Vaccine derived:
- Still occurs in some countries in children with low immunity

Wild:
- Type-1: only in Pak and Afghan
- Type-2: declared eliminated in 2015
- Type-3: declared eliminated in 2019

Remember:
- 2014: India declared polio free
- Now endemic only to Pakistan, Afghanistan

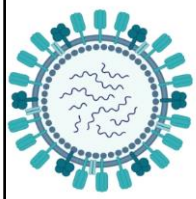
Prelims 2014:
Consider the following diseases:
1. Diphtheria
2. Chickenpox
3. Smallpox

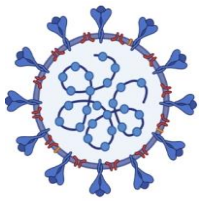
Yaws; Guinea worm; Polio; Smallpox; Maternal & neonatal tetanus

Which of the above diseases have been eradicated in India?
(a) 1, 2 (b) 3
(c) 1, 2, 3 (d) None

Acute flaccid myelitis:
- Like Polio it is a neurological disease that weakens the limbs.
- 1.5 lakh people in India are affected by it.

Two viral diseases eradicated globally:
- 1980: Small pox → in Humans
- 2011: Rinderpest → in cattle, buffalo, etc.


Influenza virus


SARS-CoV-2

Influenza

Types of Influenza viruses:
- ❑ Only A have caused Pandemics
- ❑ A, B causes seasonal epidemics
- ❑ C causes only mild illness
- ❑ D mainly affects cattle

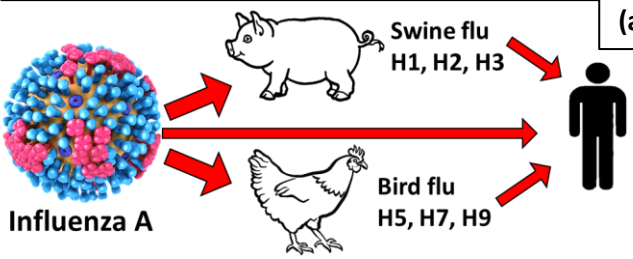
Some past pandemics:
H1N1 : 1918 : Spanish flu
H2N2 : 1958 : Asian flu
H3N2 : 1968 : Hong Kong flu
H1N1 : 2009 : Swine flu

Current pandemics:
HIV/AIDS: since 1981
Covid-19: since 2019

Influenza viruses:
- ❑ segmented RNA (single-stranded)
- ❑ Vaccines: inactivated & live attenuated
- ❑ Mutates frequently; so does vaccine

G4 virus: H1N1 like virus, found in pigs in China

Prelims 2015:
H1N1 virus is sometimes mentioned in news with reference to which one of the following diseases?
(a) AIDS (b) Bird flu (c) Dengue (d) Swine flu



- ❑ Mark H1, H2, H3 as swine flu
- ❑ Mark H5, H7, H9, H10 as bird/avian flu
- ❑ All of these are "Influenza-A" virus

If still you get confused in exam hall,
Then just recall: Swine is NOT nine.

HIV / AIDS

HIV: Human Immunodeficiency Virus
AIDS: Acquired Immunodeficiency Syndrome

Corona:
- ❑ virus identified in 2019
- ❑ causes a disease Covid

HIV:
- ❑ virus identified in 1983
- ❑ causes a disease AIDS

- ❑ HIV spreads through body fluids.
- ❑ HIV attacks body's immune system.
- ❑ If untreated, HIV can lead to AIDS
- ❑ Cure? No
- ❑ Medicine? Yes. AntiRetroviral Therapy
  It reduces the amount of HIV in body
  It does not prevent transmission.
- ❑ Tests: ELISA, Western blot, CD4 count…

Prelims 1996:
Consider the following statements
AIDS is transmitted by
1. By sexual intercourse
2. By blood transfusion
3. By mosquitoes & other blood sucking insects
4. Across the placenta

Which of the above statements are correct?
(a) 1, 2, 3 (b) 1, 2, 4
(c) 1, 3, 4 (d) 1, 3

Q. Does our body create anti-bodies to fight HIV? Yes

ELISA test:
- ❑ Enzyme Linked ImmunoSorbent Assay
- ❑ Test to detect anti-bodies in blood.
- ❑ For many diseases: HIV, rotavirus, etc.

90–90–90:
- ❑ UN target for countries to control AIDS. By 2020,
  90% PLHIV will know their status
  90% detected cases will receive ART
  90% of those getting ART will have viral suppression
- ❑ Status: progress made, but targets not achieved

India's and SDG target: by 2030

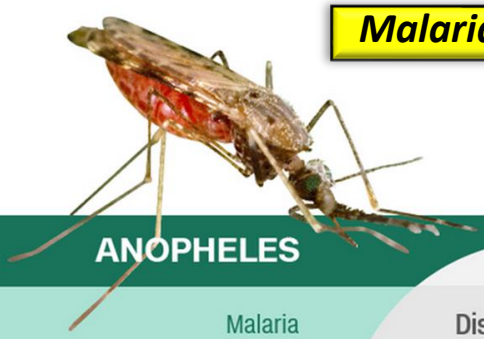
National AIDS Control Organisation:
1992; under MoH&FW; NACP also in 1992

Project Ahana: by Plan India (NGO)
to stop mother-to-child HIV transmission

Global HIV Prevention Coalition: (2017, by UNAIDS)
25 highest HIV burden countries, NGOs, donors, etc.
reduce new infections by 75% by 2020, end by 2030

Red Ribbon Express 2007: train for AIDS awareness
Project Sunrise 2016: focus on North-east
Mission Sampark 2017: for PLHIV who left treatment

Malaria, Dengue, etc



ANOPHELES	Diseases spread	AEDES MOSQUITO
Malaria		Dengue, Yellow Fever, Chikungunya, Lymphatic filariasis
Pregnant females	Which mosquitoes bite?	Pregnant females
Night	When do they bite?	Day
With abdomen sticking upwards	Resting position	Lies parallel to resting surface
Predominantly rural	Location	Predominantly urban
Bodies of water	Breeding ground	Shallow water surfaces

Prelims 2010:

Widespread resistance of malarial parasite to drugs like chloroquine has prompted attempts to develop vaccine to combat malaria. Why is it difficult to develop an effective malaria vaccine?

(a) Malaria is caused by several species of Plasmodium *True & correct reason*
(b) Man doesn't develop immunity to malaria during natural infection. *Immunity develops, but it is partial and short lived*
(c) Vaccines can be developed only against bacteria. *Wrong*
(d) Man is only an intermediate host and not the definitive host. *True but not the reason*

Malaria:
- ❑ by plasmodium parasite
- ❑ > 90% cases in Africa
- ❑ Vaccines: RTS,S R21/Matrix-M
- ❑ Medicine: yes

National Framework for Malaria Elimination:
- ❑ 2016-2030
- ❑ Eliminate by 2030

WHO:
- ❑ E-2025; Reaching Zero; High Burden to High Impact
- ❑ 38 countries malaria-free

Prelims 2005:

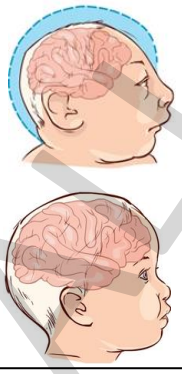
Consider the following statements:
1. **Dengue is a protozoan disease transmitted by mosquitoes.**
2. **Retro-orbital pain is not a symptom of dengue.**
3. **Skin rash and bleeding from nose and gums are some of the symptoms of dengue.**

Which of the above statements are correct?
(a) 1 & 2 (b) 3 only (c) 2 only (d) 1 & 3

Prelims 2017:

Consider the following statements:
1. **In tropical regions, Zika virus disease is transmitted by the same mosquito that transmits dengue.**
2. **Sexual transmission of Zika virus disease is possible.**

Which of the above statements are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2



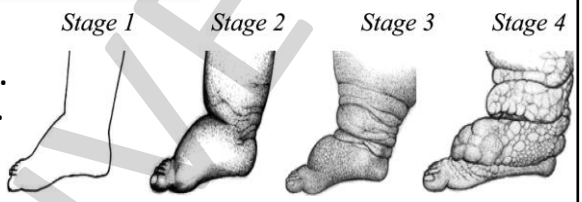
Zika virus	Dengue virus	Chikungunya virus	Yellow fever virus
Aedes aegypti	Aedes aegypti	Aedes aegypti	Aedes aegypti
Vaccine: no Medicine: no	Vaccine: Dengvaxia Medicine: no	Vaccine: no Medicine: no	Vaccine: yes Medicine: no
❑ 1947 Uganda, monkeys ❑ 1952 Uganda, humans ❑ 2015 infection during pregnancy can cause microcephaly in infants ❑ 2017 India (Gujarat)	❑ Serotypes 1,2,3,4 (5) ❑ Lifelong immunity against that serotype ❑ But can get infected by other serotypes	Fever and Joint pain	❑ Africa & S. America ❑ It was the 1st human virus to be isolated (1927)

Kala Azar

- aka visceral leishmaniasis, Black fever or Dum Dum Fever.
- 2nd biggest parasitic killer in the world after Malaria.
- Caused by protozoa parasite Leishmania
- Transmitted by female sand-fly
- 95% fatality if not treated
- Some recovered patients can transmit it for years
- Half the global cases are in India
- Endemic to UP, Bihar, Jharkhand, WB
  UP, WB achieved elimination target in 2020, need to maintain this status for three years (<1 in 10,000)

Lymphatic filariasis

- aka elephantiasis or Hathi Paon
- abnormal enlargement of body parts.
- Due to filarial parasites transmitted by mosquitoes.
- These worms only live in the human lymph system.
  (maintains body's fluid balance & fights infections)
- Hathipaon Mukt Bharat: launched by govt in 2015
- 2nd most common long-term disability after mental illness.



Neglected Tropical Diseases

- Mostly in poor countries of tropical areas
- Don't receive much research and funding attention.
- Due to various virus, bacteria, protozoa, worms.
- e.g. Dengue, Chikungunya, Kala azar, Leprosy, Lymphatic filariasis, rabies, etc.
- END7: international campaign launched in 2012 to eliminate seven NTDs by 2020. Not by UN etc.

National Vector Borne Disease Control Programme:

- under DGHS (MoH&FW)
- for six vector borne diseases
- Malaria, Dengue, Filaria, Chikungunya, Kala Azar, Japanese Encephalitis

Hepatitis

Hepatitis is inflammation of the liver.
Causes: Genetic, alcohol, virus, etc.

Prelims 2019:

Which of the following statements is not correct?

(a) Hepatitis B virus is transmitted much like HIV.
(b) Hepatitis B, unlike Hepatitis C, does not have a vaccine.
(c) Globally, the number of people infected with Hepatitis B and C viruses are several times more than those infected with HIV.
(d) Some of those infected with Hepatitis B and C viruses do not show the symptoms for many years.

Virus	Main source	Vaccine
A	Contaminated food, water	Yes
B	Body fluids	Yes
C	Body fluids	No
D	Only if B	Same as B
E	Contaminated food, water	Yes

Prelims 2010:

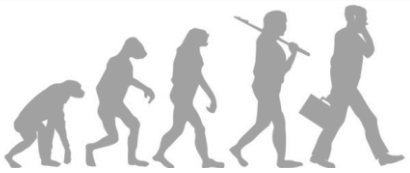
Consider the following statements:

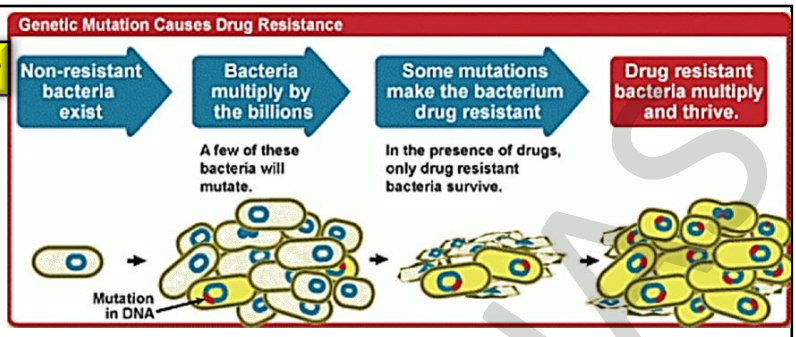
1. Hepatitis B is several times more infectious than HIV/ AIDS
2. Hepatitis B can cause liver cancer

Which of the above statements are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Anti Microbial Resistance





Antimicrobials:
medicines for infections e.g. antibiotics, antivirals, antifungals and antiparasitics

Antimicrobial Resistance:
Bacteria, viruses, fungi, parasites change over time and no longer respond to medicines

Superbugs:
multi- and pan-resistant bacteria that are not treatable with existing medicines.

Twin challenge before India?
- ❑ Antibiotics are cheap & effective. They help poor people quickly overcome illness at low cost.
- ❑ But, more use of antibiotics means more AMR.

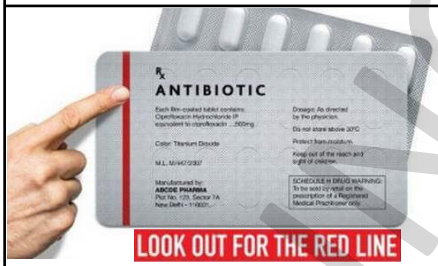
New Delhi metallo-beta-lactamase 1 (NDM-1)
- ❑ A superbug, first found in New Delhi in 2009 in a Swedish national
- ❑ Origin: unknown (it may not be Delhi)

Prelims 2019:
Which of the following are reasons for occurrence of multi-drug resistance in microbial pathogens in India?
1. Genetic predisposition of some people
2. Taking incorrect doses of antibiotics to cure diseases
3. Using antibiotics in livestock farming
4. Multiple chronic diseases in some people

Select the correct answer using codes given below
(a) 1, 2 **(b) 2, 3** (c) 1, 3, 4 (d) 2, 3, 4

Also, waste water from pharma factories and hospitals

Reasons: (as per WHO website)
- ❑ Misuse/overuse of antimicrobials
- ❑ Lack of clean water and hygiene
- ❑ Poor disease prevention
- ❑ Poor access to quality, affordable medicines, vaccines and diagnostics
- ❑ Lack of awareness and knowledge
- ❑ Lack of enforcement of legislation



Awareness campaign: don't use medicines marked with red line, without a doctor's prescription.

H & H1 are schedules of Drugs & Cosmetics Rules, 1945

Schedule H Drugs?
- ❑ Sold only on doctor's prescription

Schedule H1 drugs?
- ❑ Chemist needs to record in a separate register: doctor, patient, drug, quantity.
- ❑ Since 2013; to control AMR due to antibiotics overuse
- ❑ These are 3rd & 4th generation antibiotics, anti-tuberculosis drugs and certain habit-forming drugs like psychotropic drugs.

Fixed Dose Combination:
Medicines with two or more drugs in single dose

AWaRe tool:
- ❑ Access, Watch, Reserve
- ❑ portal by WHO to guide govts & doctors on AMR

Global AMR R&D Hub:
- ❑ 2018; Berlin, Germany
- ❑ India recently joined it

Interagency Coordination group on AMR:
- ❑ By UN in 2017
- ❑ for coordination

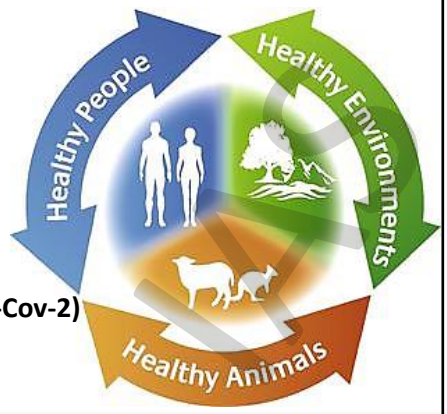
Global Leaders Group on AMR:
- ❑ formed by WHO, FAO, WOAH
- ❑ on recomm. of ICG on AMR

World Organisation for Animal Health: 1924; Paris
- ❑ Inter-govt org; not UN body
- ❑ 182 members (India also)

One Health

One Health:

- Health of humans, Animals, Environment are interdependent.
- Manhattan principles 2004 and Berlin principles 2019 are related to it.



Zoonotic diseases:

- caused by pathogen that jumped from animals to humans.
- e.g. Plague, Rabies, Ebola, Corona viruses (SARS, MERS, SARS-Cov-2)
- Can be bacteria, virus, parasite, fungus, etc.
- Reason: many (natural also)

Alternate System of Medicine

Ayurveda, Yoga, Naturopathy, Unani, Siddha, Sowa-Rigpa, Homoeopathy

- 1995: Department of Indian System of Medicine & Homoeopathy under MoH&FW
- 2003: renamed to Department of AYUSH
- 2014: upgraded into Ministry

National Commission for Indian System of Medicine Act, 2020	National Commission for Homoeopathy Act, 2020:	Institute of Teaching and Research in Ayurveda (ITRA) Act, 2020:
Repeals Indian Medicine Central Council Act, 1970	Repeals Homoeopathy Central Council Act, 1973	Est. ITRA by merging four ayurvedic institutes
NCISM; Advisory Council; Uniform entrance/exit exam for UG/PG	NCH; Advisory Council; Uniform entrance/exit exam for UG/PG	Made Institution of National Importance, first in AYUSH Sector

Ayurveda:

- Jaipur: National Institute of Ayurveda
- Delhi: All India Institute of Ayurveda
- Jamnagar: ITRA

WHO to est. centre for traditional medicine in India

Institution of National Importance:

- by an act of Parliament;
- more autonomy, funding
- IITs, IIMs, etc. Currently 159

Assisted Reproductive Technology

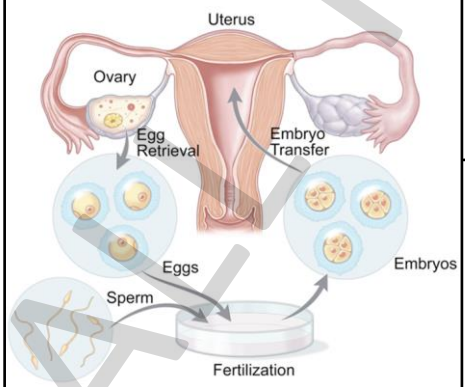
techniques that obtain pregnancy by handling sperm or egg outside human body

Prelims 2007:

In human beings, in which of the following parts, does the sperm fertilize the ovum?

(a) Cervix (b) Fallopian tube

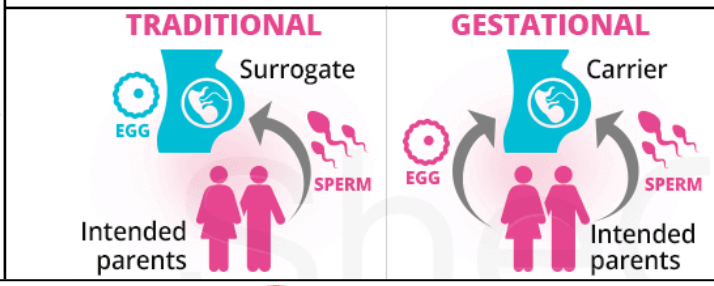
(c) Lower part of uterus (d) Upper part of uterus



IVF: egg fertilized with sperm in lab. Embryo planted in uterus.

Artificial insemination: sperm inserted into uterus

Gamete intrafallopian transfer: Eggs are removed from ovaries, and placed in one of the Fallopian tubes, along with sperm.



Defence

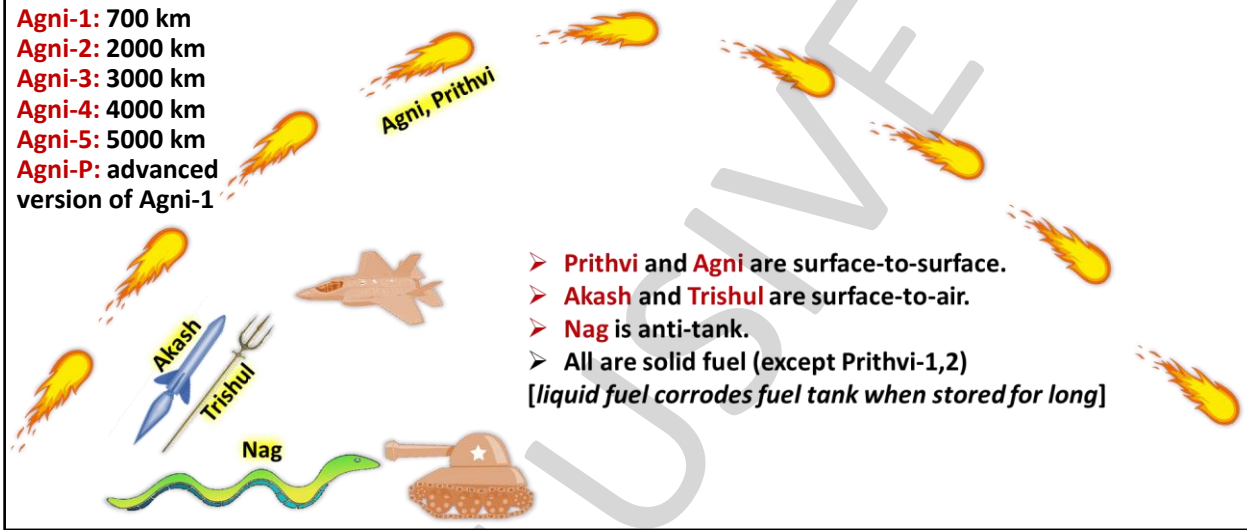
Integrated Guided Missile Development Plan (1982-2008)

	Purpose	Range	Fuel	Nuclear	
Prithvi	Surface-to-surface	100, 350	1,2 Liquid 3 solid	✓	3 is Dhanush (Navy)
Akash	Surface-to-Air	30, 70	Solid	X	
Trishul	Surface-to-Air	9	Solid	X	
Nag	Anti-Tank	20	Solid	X	Namika, Helina, Sant, Dhruvastra
Agni	Surface-to-surface	700-5000	Solid	✓	

Prelims 2014:
With reference to Agni-IV missile, which of the following statements are correct?
1. It is surface-to surface missile.
2. It is fuelled by liquid propellant only
3. It can deliver one-tonne nuclear warheads about 7500 km away.

Select the correct answer
(a) 1 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Agni-1: 700 km
Agni-2: 2000 km
Agni-3: 3000 km
Agni-4: 4000 km
Agni-5: 5000 km
Agni-P: advanced version of Agni-1

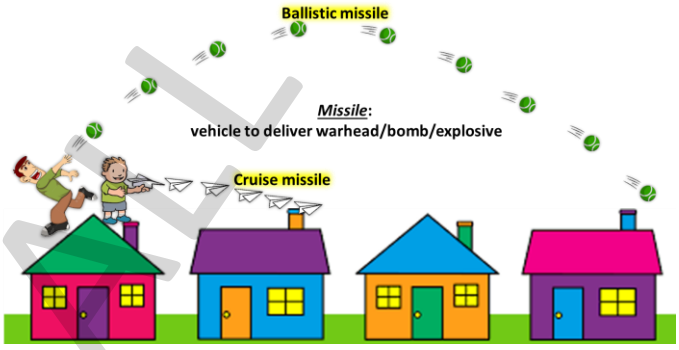


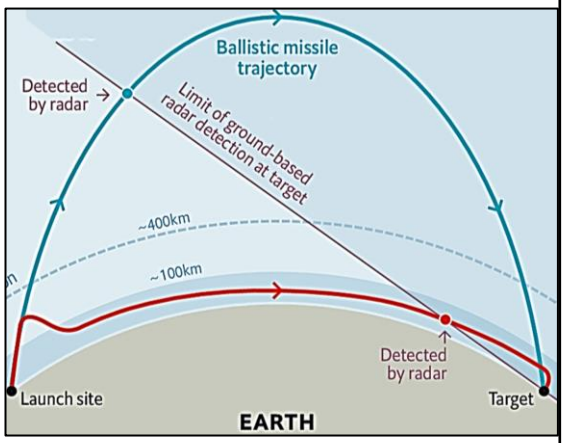
- Prithvi and Agni are surface-to-surface.
- Akash and Trishul are surface-to-air.
- Nag is anti-tank.
- All are solid fuel (except Prithvi-1,2)

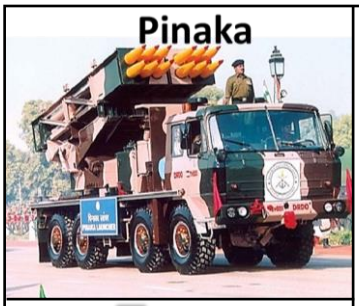
[*liquid fuel corrodes fuel tank when stored for long*]

Indian Ballistic Missile Defence Programme:

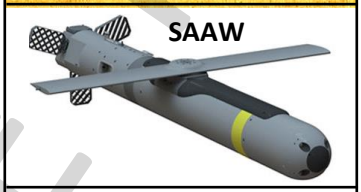
- ❑ Two tiered defence.
- ❑ For endo-atmospheric defence- Ashwin (Advanced Air defence)
- ❑ For exo-atmospheric defence- Pradyumna (Prithvi Air Defence)
- ❑ They were first tested in 2007 and improved continuously.
- ❑ Latest version can shoot down targets moving at 10 km/s in orbits as high as 1200 km.
- ❑ Used in 27 March, 2019 Mission Shakti.





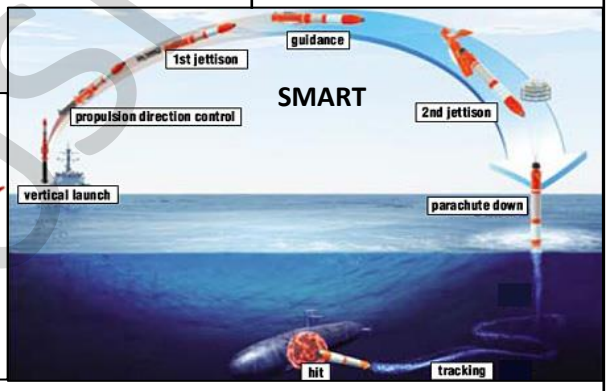


- **Pinaka:** Indigenous multi barrel rocket launch system; range 40 km
- **Ulka, Fluffy, Abhyas:** aerial targets for practicing anti-missile systems
- **Saras:** indigenous passenger aircraft
- **Apache:** fighter helicopter of USA, purchased by India
- **Chinook:** helicopter of USA; has two horizontal rotors; purchased by India
- **C-17, C-130, C-295:** military transport aircrafts
- **Derby and Python-5:** Air-to-Air Missiles
- **Netra:** Airborne Early Warning And Control made by ISRO. Radar on airplane
- **Smart Anti-Airfield Weapon:** glide bomb; for ground targets; range 100 km
- **Arjun:** Main Battle Tank
- **Dhanush:** artillery gun
- **Supersonic Missile Assisted Release of Torpedo:** for anti-submarine ops; range 600 km

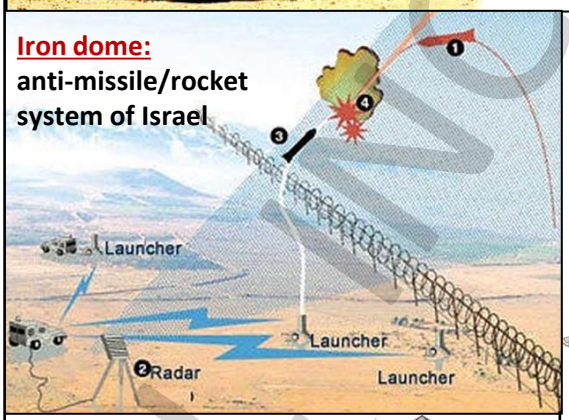


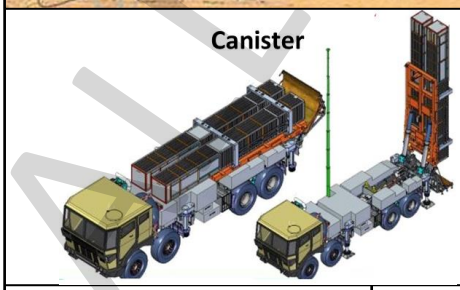
Fighter jets:

France: Rafale, Mirage 2000
Russia : Sukhoi-30, MiG-29
India : Tejas
None is 5th generation



Iron dome:
anti-missile/rocket system of Israel





Aircraft carriers:

- 1961-1997: INS Vikrant (from UK)
- 1987-2017: INS Viraat (from UK)
- 2013- : INS Vikramaditya (from Russia)
- 2022- : INS Vikrant (IAC-1)

Rudram: (Range 200 km)

- 1st indigenous anti-radiation missile
- against electronic surveillance
- Can be launched from fighter jets
- DRDO; started in 2012; 2016 first flight
- Many tests; induction in IAF by 2022

BrahMos:

- by India and Russia
- 300-500 km; Mach 3
- world's fastest cruise missile
- Fuel: 1st stage Solid, 2nd stage Liquid
- can be launched from any platform
- Hypersonic version being developed

- Supersonic: > Mach 1
- Hypersonic: > Mach 5

QRSAM:

- by DRDO
- 30 km; Mach 4
- For moving army

Barak 8:

- LRSAM, MRSAM
- by India and Israel
- SAM; 150 km; Mach 3

S-400:

- Russian SAM
- 400 km; Mach 6
- China, India, etc.

Shaurya missile:

- by DRDO
- Surface-to-Surface
- 2000 km; Mach 7
- Nuclear capable

Prelims 2016:

Which one of the following is the best description of 'INS Astradharini', that was in the news recently?

(a) Amphibious warfare ship
(b) Nuclear-powered submarine
(c) Torpedo launch and recovery vessel
(d) Nuclear-powered aircraft carrier

Prelims 2018:

What is "Terminal High Altitude Area Defence" (THAAD), sometimes seen in the news?

(a) An Israeli radar system
(b) India's indigenous anti-missile Programme
(c) An American anti missile system
(d) A defence collaboration between Japan and South Korea

Nuclear submarines:

- (Russian) INS Chakra-I : 1987-1990
- (Russian) INS Chakra-II : 2012-2021
- (Russian) INS Chakra-III : 2025 (expected)
- (Indian) INS Arihant : 2009
- (Indian) INS Arighat : under trials
- Advanced Technology Vessel Project: launched in 1984; to build nuclear submarines

Varunastra:

- indigenous anti-submarine torpedo like underwater cruise missile; 40 km

Nuclear triad:

- ability to launch nuclear missile by land, air, submarine.
- India has nuclear triad? Yes (2016 Arihant commissioned)

Nanosniffer:

- Indigenous; by IITs (not DRDO)
- Gives result in seconds.
- Can detect nano-gram quantity of explosives
- world's first Explosive Trace Detector using microsensor technology

Coastal Radar Stations:

- Sri Lanka, Mauritius, Seychelles; plan for more

Navy's centres to monitor traffic in IOR:

- Info Management & Analysis Centre (after 26/11)
- Info Fusion Centre for Indian Ocean Region
- Both in Gurugram

Project-75:

- Six scorpene submarines built in India with French help.
- Kalvari (2015), Khanderi (2017), Karanj (2018), Vela (2019), Vagir (2020), Vagsheer.
- Diesel powered, not nuclear. Air Independent Propulsion enables 21 days underwater stay.

Project-75i:

- similar to Project-75
- Subs may be bigger

Project-17A, 18, 28:

- frigates

Innovations For Defence Excellence (iDEX)

- Promote innovation, involve private
- initiative launched in 2018

BL

FSSAI clarifies food crop importers will need to declare non-GMO status from March 1

Meenakshi Verma Ambwani | New Delhi | Updated on February 08, 2021

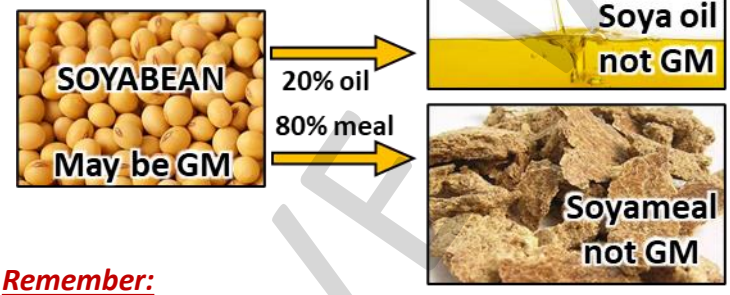
The Indian EXPRESS

In a first, India set to import 15 lakh tonnes of genetically modified soyameal

Written by Parthasarathi Biswas , Harikishan Sharma | New Delhi, Pune |
August 13, 2021 8:43:23 am

GM Crops

Already covered on page-6



Remember:

Bt cotton is the only GM crop allowed for commercial cultivation in India

Genome mapping

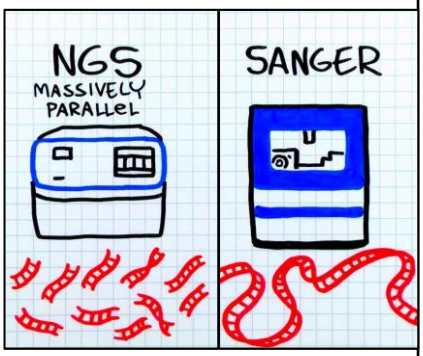
see page-1

National Institute of Oceanography:

Under MoS&T (CSIR)

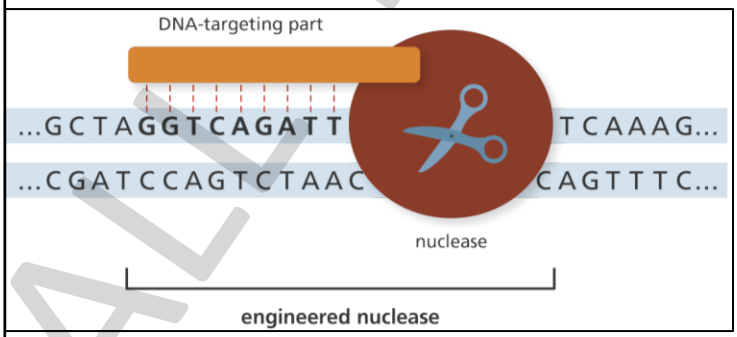
TraceBioMe project:

- ❑ Do genome & proteome mapping of microbes in IOR; use NGS (page-6) and Sanger sequencing (single DNA fragment at a time)
- ❑ Study impact of metals and minerals
- ❑ Help in medicines, industry, etc.



Gene editing

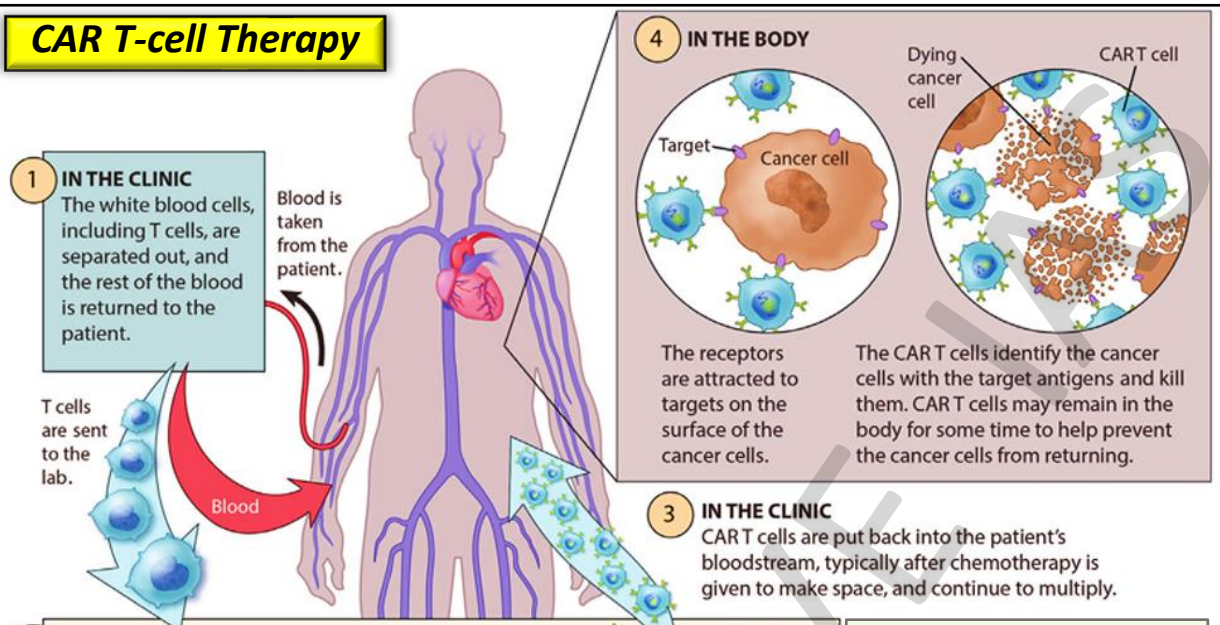
Already covered on page-3



Engineered Nuclease:

- ❑ Enzyme used in gene editing. Types:
  - → RNA based: uses RNA
    e.g. Crispr-Cas9
  - → Protein based: uses protein
    e.g. TALENS, Zinc Finger Nuclease
- ❑ Has two parts: guide and scissors
  e.g. Crispr is guide, Cas9 is scissor

CAR T-cell Therapy



CAR T-cell therapy:

Chimeric **A**ntigen **R**eceptor

- ❑ Type of immunotherapy
- ❑ Take T-cells from patient (or donor)
- ❑ Genetically modify in lab
- ❑ Multiply to millions
- ❑ Insert into patient
- ❑ Will attack cancer cells
- ❑ Its like a Living Drug
- ❑ Examples: Yescarta, Kymriah, Tecartus, etc.

RNA interference

PYQs explained on page-6

RNA interference pathway:

- ❑ dsRNA → siRNA → two ssRNA
- ❑ Dicer enzyme splits dsRNA to siRNA
- ❑ Through RISC, ssRNA binds to mRNA
- ❑ A portion of mRNA get silenced

dsRNA: double stranded RNA
siRNA: small interfering RNA
ssRNA: single stranded RNA
RISC: RNA-induced silencing complex

Pest Resistant Plants: Several nematodes parasitise a wide variety of plants and animals including human beings. A nematode *Meloidegyne incognitia* infects the roots of tobacco plants and causes a great reduction in yield. A novel strategy was adopted to prevent this infestation which was based on the process of **RNA interference** (RNAi). RNAi takes place in all eukaryotic organisms as a method of cellular defense. This method involves silencing of a specific mRNA due to a complementary dsRNA molecule that binds to and prevents translation of the mRNA (silencing). The source of this complementary RNA could be from an infection by viruses having RNA genomes or mobile genetic elements (transposons) that replicate via an RNA intermediate. ***NCERT class-12***

RNA interference:

- ❑ It is a natural process for gene silencing.
- ❑ It is part of immune response to foreign genetic material (e.g. by virus)
- ❑ It prevents manufacture of specific proteins.

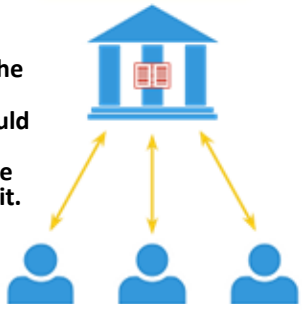
RNAi pesticides:

- ❑ Identify protein necessary for pest
- ❑ Create dsRNA to interfere in is formation
- ❑ Deliver it to pest through crops.

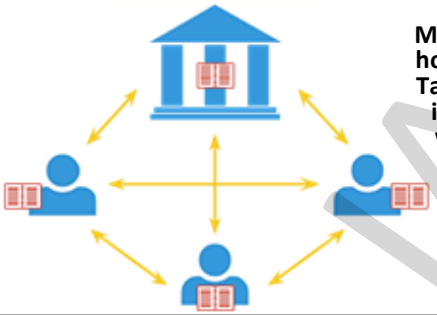
Blockchain

Centralized ledger

Everyone is dependent on the central party. Central party could tamper data without anyone knowing about it.

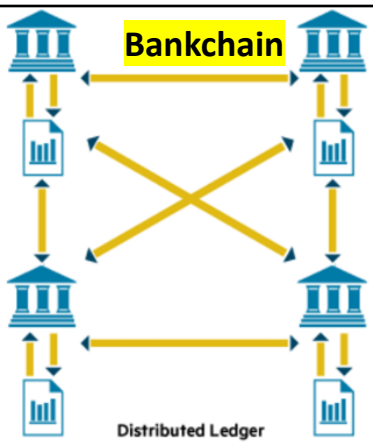


Distributed ledger



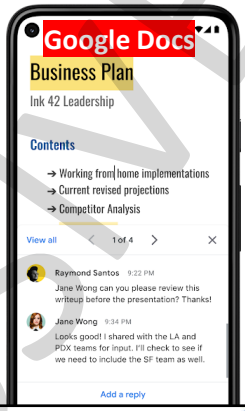
Multiple parties hold the ledger. Tampering data in one ledger will be of no use.

Bankchain

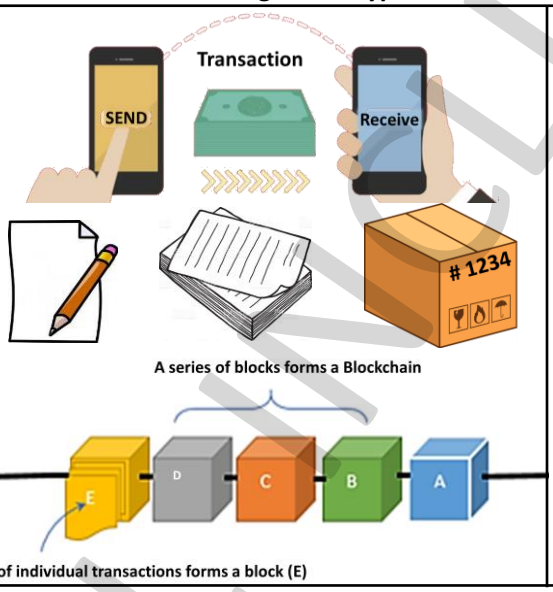


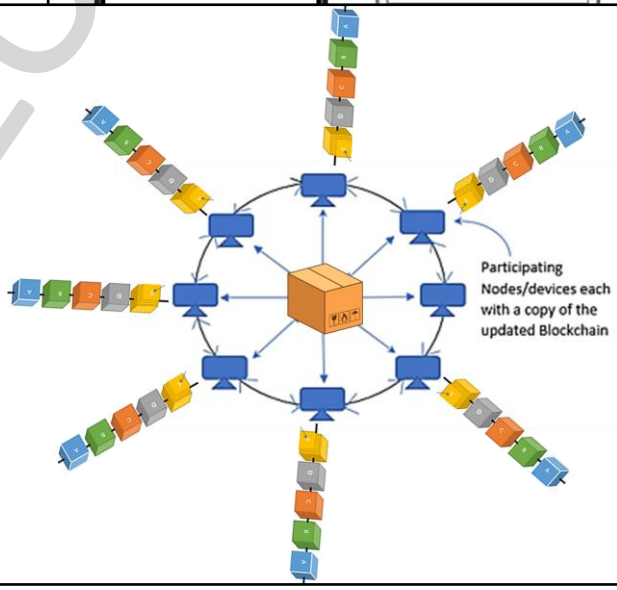
- By SBI in 2017, includes many private banks
- KYC, consortium lending, asset hypothecation, etc.

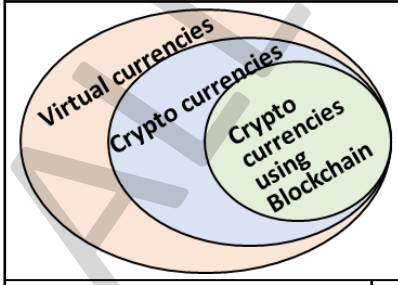
Digital Ledger Distributed Ledger Editable



Digital Ledger Distributed Ledger Non-Editable







Cryptocurrency

- Usually not issued by Central bank of country
- Anyone with computer can mine.
- Same value across the world
- Problems: anonymity, electricity, volatile value, money supply
- Examples: Bitcoin, Ethereum, Ripple, Litecoin, Tether

Prelims 2016:

With reference to 'Bitcoins', sometimes seen in the news, which of the following statements is/are correct?

1. Bitcoins are tracked by the Central Banks of the countries.
2. Anyone with a Bitcoin address can send and receive Bitcoins from anyone else with a Bitcoin address.
3. Online payments can be sent without either side knowing identity of the other.

Select the correct answer:

(a) 1 and 2 only (b) 2 and 3 only
(c) 3 only (d) 1, 2 and 3

Prelims 2020:

With reference to "Blockchain Technology" consider the following statements:

1. It is a public ledger that everyone can inspect, but which no single user controls.
2. The structure and design of blockchain is such that all the data in it are about cryptocurrency only
3. Applications that depend on basic features of blockchain can be developed without anybody's permission.

Which of the above statements are correct?

(a) 1 only (b) 1 and 2 only
(c) 2 only (d) 1 and 3 only

Smart Contracts

Contract is written as code into a blockchain

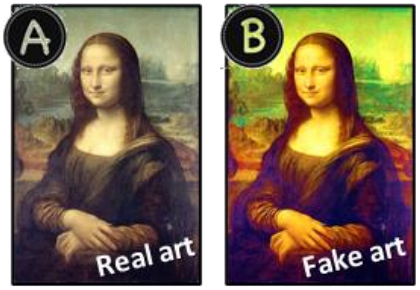
Contract is part of public blockchain

Parties involved in the contact are anonymous

Contract executes itself when the conditions are met

Regulators use Blockchain to keep an eye on contracts

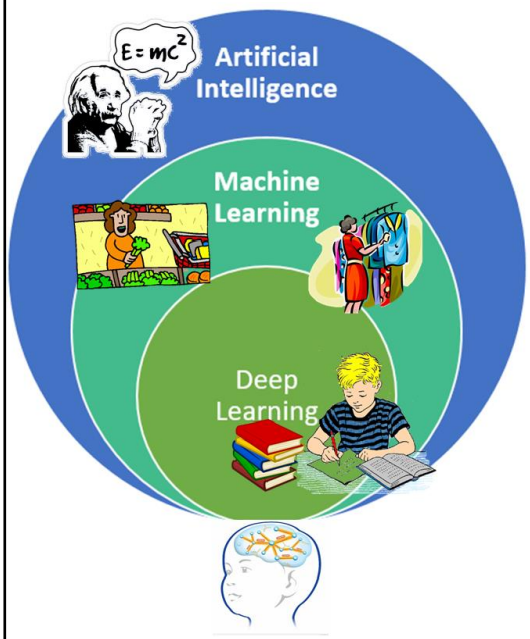
Non-Fungible Token

Concept of fungibility (replaceability)	
Money	Art
A  B 	
There are many real notes. All are replaceable.	There is only one real. Fakes are many and readily available.

Problem: how to differentiate between real and fake.
Solution: give a certificate of authenticity to the real one.
Problem: someone can create fake certificates.
Solution: use blockchain technology to certify authenticity.
NFT: unit of data that certifies a digital asset to be unique.

Fungible:
→ replaceable by another identical item
Non-fungible:
→ not replaceable by another identical item
Non-fungible token:
→ proof that the digital product is original

Artificial Intelligence



Artificial intelligence:
Machine mimics human intelligence

Machine learning:
Machine improves with experience, by itself

Deep Learning:
Machine learns from vast amount of data

Neural network:
create code that mimics human brain

Turing Test:
Test of a machine's ability to exhibit behaviour indistinguishable from that of a human.

Microsoft Tay:
- ❑ AI chatbot released on Twitter by Microsoft in 2016
- ❑ Quickly learnt hate existing on Twitter. Example: Justified fascism; said minorities must be put in camps.
- ❑ Removed by Microsoft within 16 hours.

INDIAai:
- ❑ national AI portal
- ❑ all about AI in India
- ❑ by Meity & Nasscom

AIRAWAT:
- ❑ AI Research, Analytics and knoWledge Assimilation PlaTform
- ❑ a platform to assist in R&D of new technologies
- ❑ proposed by NITI Aayog

IP address

IP Address	MAC address
Internet Protocol	Media Access Control
Identifies connection	Identifies device
Given by Internet Service Provider	Given by manufacturer


14:A7:2B:3E:42:6F Mr Sharma *MAC*
192.168.1.200 2nd Floor *Local IP*


14:A3:4B:3E:42:5F Mr Verma *MAC*
192.168.1.100 1st Floor *Local IP*

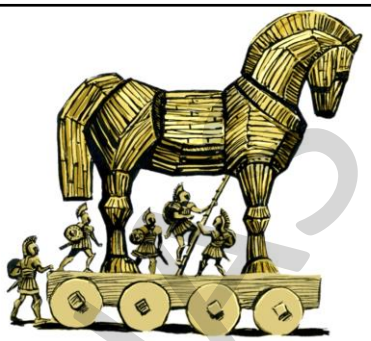
airtel ➡ 
23.24.35.63 House no. 21, ABC lane, XYZ vihar
IP address

IPv4	IPv6
32 bits (4 bytes)	128 bits (16 bytes)
Deployed in 1981	Deployed in 1998
4.3 billion addresses Reused & masked	7.9×10^{28} addresses Unique for every device
Dot decimal 23.24.35.63	Alphanumeric Hexadecimal 50b2:6400::6c3a:b17d:0:10a9

Indian Registry for Internet Names & Numbers:
- ❑ aka National Internet Registry
- ❑ Coordinates IP address allocation
- ❑ Part of NIXI:
  - → National Internet Exchange of India
  - → 2003; not for profit company
  - → connects ISPs; manages .in registry

Cyber Security

Malware: malicious software,
- ❑ Software made to harm devices
- ❑ spyware, trojans, virus, etc.
- ❑ Virus needs host file, worms don't.



Trojan horse
- ❑ misleads you of its true intent
- ❑ Greeks used it to enter Troy

RANSOMware:
- ❑ It will lock your files; ask for money
- ❑ Payment by cryptocurrencies
- ❑ e.g. DearCry, WannaCry, etc.

SPYware:
you won't know its there, it will spy on you
e.g. Pegasus

Phishing:
Attacker will trick you to reveal sensitive info

Prelims 2017:

In India, it is legally mandatory for which of the following to report on cyber security incidents?
1. Service providers
2. Data centres
3. Body corporate

Select the correct answer using the code given below:
(a) 1 only (b) 1 & 2 only (c) 3 only **(d) 1, 2 and 3**

Prelims 2018:

The terms 'Wanna Cry, Petya and Eternal Blue' sometimes mentioned in the news recently are related to
(a) Exo-planets
(b) Crypto-currency
(c) Cyber attacks
(d) Mini satellites

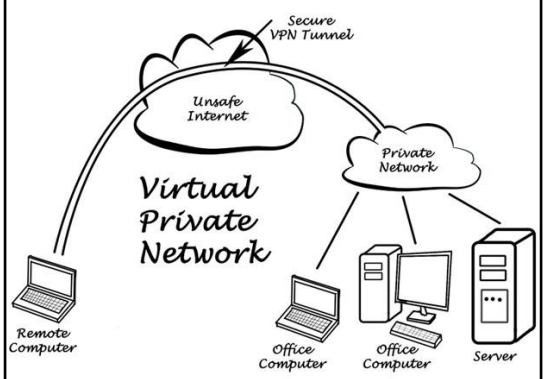
Prelims 2020:

In India, under cyber insurance for individuals, which of the following benefits are generally covered, in addition to payment for the loss of funds and other benefits?
1. Cost of restoration of computer system in case of malware disrupting access to one's computer
2. Cost of a new computer if some miscreant wilfully damages it, if proved so
3. Cost of hiring a specialized consultant to minimize the loss in case of cyber extortion
4. Cost of defence in court of law if any third party files a suit

Select the correct answer using the code given below:
(a) 1, 2 and 4 only **(b) 1, 3 and 4 only** (c) 2 and 3 only (d) 1, 2, 3 and 4

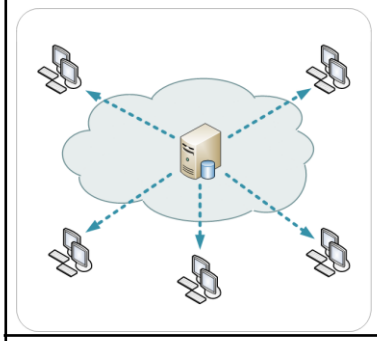
Prelims 2011:

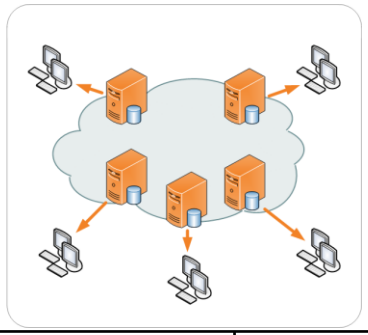
What is "Virtual Private Network"?
(a) It is a private computer network of an organization where the remote users can transmit encrypted information through the server of the organization.
(b) It is a computer network across a public internet that provides users access to their organization's network while maintaining the security of the information transmitted.
(c) It is a computer network in which users can access a shared pool of computing resources through a service provider
(d) None of the statements (a), (b) and (c) given above is a correct description of Virtual Private Network



Organization	Ministry
Indian Computer Emergency Response Team (CERT-IN)	Meity
National Cyber Coordination Centre	MHA
Indian Cybercrime Coordination Centre (I4C)	MHA
National Critical Information Infrastructure Protection Centre	NTRO* < NSA < PMO

National Technical Research Organization





Content Delivery Network (CDN):

Geographically distributed servers to speed up delivery of web content by bringing it closer to users.

Clean Network:

→ US initiative for safe web (against China)

Global Initiative on Data Security:

→ Chinese initiative for safe web (against US)

Sandes:

- ❑ Government Instant Messaging System
- ❑ owned by GoI (NIC under Meity made it)
- ❑ earlier it was only for govt employees

Supercomputers:

- ❑ Worlds fastest SC? Fugaku of Japan
- ❑ Country with most SCs? China 188 (USA 122)

Frontier technologies:

- ❑ New technologies with big impact
- ❑ Like AI, 3D printing, robotics, IoT, etc.

Digiboxx:

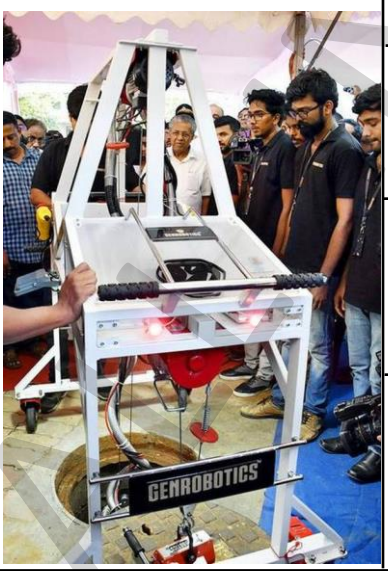
- ❑ Made by ~~NITI Aayog~~ a private Indian company
- ❑ Just like google drive

Global Cybersecurity Index:

- ❑ 1 - USA; 10 - India
- ❑ by International Telecommunication Union:
  → specialized agency of UN; 1865; Geneva

Bandicoot:

- ❑ sewer cleaning machine
- ❑ By a private Indian company



- ❑ BlackRock, Xeres, LokiBot, EventBot? Android malwares
- ❑ Super app: multiple services in one app. Example: Paytm for recharge, bills, movie, bus, train, flight, shopping, etc.

El Salvador:

- ❑ first country to adopt Bitcoin as legal tender
- ❑ Note: Bitcoins in Japan are legal property, not legal tender

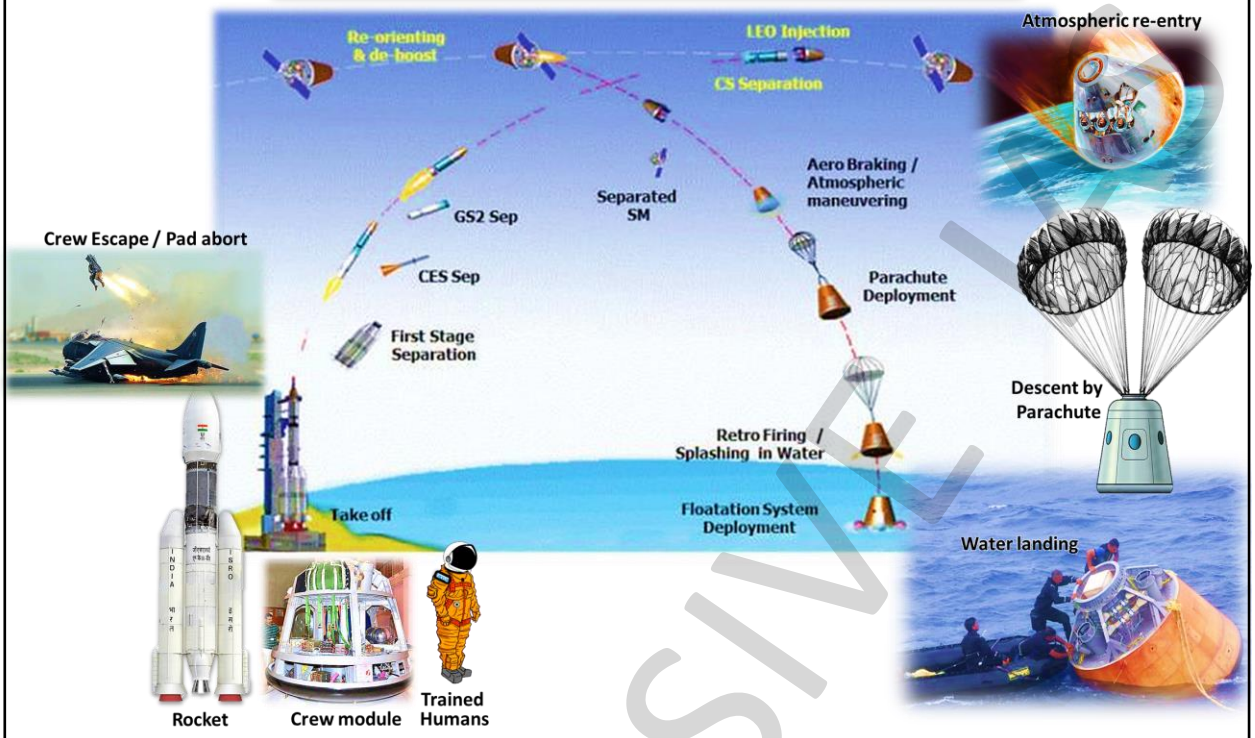
Indo-US Science & Tech Forum:

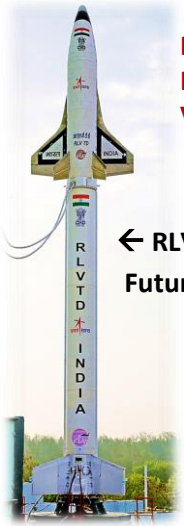
- ❑ Formed in 2000
- ❑ To promote S&T through govt, academia, industry interactions.
- ❑ Recently launched US India Artificial Intelligence Initiative

UN Conference on Trade & Development:

- ❑ 1964; Geneva; Important reports:
  - World Investment Report
  - Trade & Development Report
  - Least Developed Countries Report

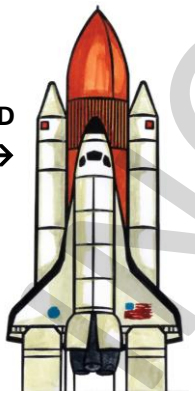
Indian Human Spaceflight Programme





Reusable
Launch
Vehicle

← RLV-TD
Future →



Timeline of Indian Human Space flight Programme:

	2001	2011	2021
	2002	2012	2022
	2003	2013	2023 Target
ISRO recommends manned space mission	2004	2014	❑ GSLV Mk-III ❑ Crew module Atmospheric Re-entry Experiment
	2005	2015	
work starts under name "Orbital vehicle"	2006	2016	RLV-TD (looks like space shuttle, not for present Gaganyaan mission)
Space Capsule Recovery Experiment	2007	2017	
	2008	2018	❑ Pad Abort Test ❑ Gaganyaan announced
Biggest challenge was launch vehicle. Developed by 2014	2009	2019	
	2010	2020	

Gaganyaan programme:

- ❑ two unmanned missions
- ❑ one manned mission
- ❑ three Indians;
- ❑ in LEO (400km);
- ❑ for 7 days
- ❑ by GSLV Mk-III

Rakesh Sharma:

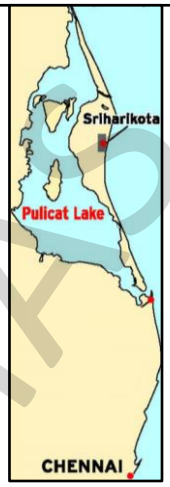
- ❑ the only Indian citizen in space
- ❑ 3 April 1984 in Soyuz T-11

Manned mission to space:

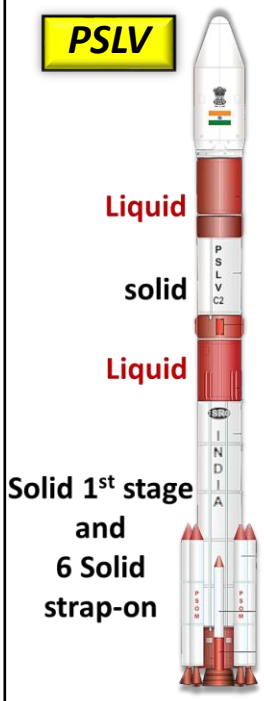
USSR, USA, China

April 12, 1961	1st man in space	Yuri Gagarin
1963	1st woman in space	Valentina Tereshkova
1965	1st space walk	Alexei Leonov
July 20, 1969	1st man on moon	Neil Armstrong

Speciality	Institute	Place
Design and development of launch vehicle technology	Vikram Sarabhai Space Centre	Thiruvananthapuram (Kerala)
Design, development and integration of satellites	U R Rao Satellite Centre	Bengaluru (Karnataka)
Spaceport of India, provides Launch Base Infra	Satish Dhawan Space Centre	Sriharikota (Andhra Pradesh)
Manned missions	Human Space Flight Centre	Challakere (Karnataka)
Remote Sensing Satellite data processing	National Remote Sensing Centre	Hyderabad (Telangana)
Space University (Asia's first, 2007)	Indian Institute of Space Science and Technology	Thiruvananthapuram (Kerala)



PSLV



- 1980: Satellite Launch Vehicle-3. Capacity 40 kg satellite in LEO.
- 1987: Augmented Satellite Launch Vehicle. Capacity 150 kg satellite in LEO. Used new technologies like strap-on.
- 1993: PSLV. First vehicle with liquid stages. Workhorse of ISRO.
  - ✓ After 39 consecutively successful missions since 1994, had a unsuccessful launch in August 2017.
  - ✓ Unmatched reliability; called as 'Workhorse of ISRO'; used to launch various satellites into GTO like satellites from the IRNSS constellation.
- 2014: GSLV Mk-III

PSLV	GSLV Mk-III
1993	2014
Four stages	Three stages
No cryogenic	3rd stage is Cryogenic
LEO: 1,750 kg	LEO: 8,000 kg
GTO: 1,425 kg	GTO: 4,000 kg
Prominent missions: ➢ Chandrayaan-1 in 2008 ➢ Mangalyaan in 2013 ➢ IRNSS/NavIC	Prominent missions: ➢ Chandrayaan-2 in 2019

Cryogenic engine:
- Uses Liquid Oxygen and Hydrogen.
- Benefits: More power to weight ratio
- Drawback: technically very complex

GSLV

SSLV

Small Satellite Launch Vehicle; Under development; for small satellites.

- ❑ NSIL will get it made with private players
- ❑ Will have 3 stages, all will use solid fuel
- ❑ 500 kg satellite mass into 500 km LEO

Prelims 2007:

Consider the following statements:
1. In the year 2006, India successfully tested a full fledged cryogenic stage in rocketry.
2. After USA, Russia and China, India is the only country to have acquired the capability for use of cryogenic stage in rocketry.

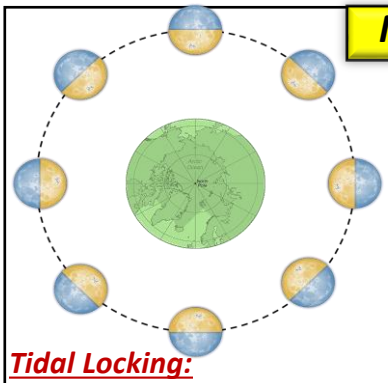
Which of the above statements are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Prelims 2018:

With reference to India's satellite launch vehicles, consider the following statements:
1. PSLVs launch the satellite useful for Earth resources monitoring whereas GSLVs are designed mainly to launch communication satellites.
2. Satellites launched by PSLV appear to remain permanently fixed in same position in the sky, as viewed from a particular location in Earth.
3. GSLV Mk III is a four-staged launch vehicle with the first and third stages using solid rocket motors; and the second and fourth stages using liquid rocket engines.

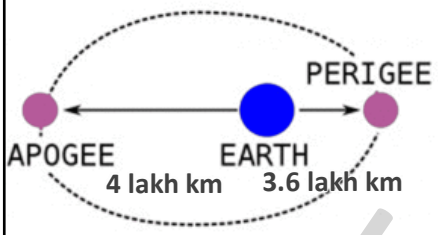
Which of the above statements are correct?
(a) 1 only (b) 2 and 3 (c) 1 and 2 (d) 3 only

Moon



Tidal Locking:
Moon is tidally locked to Earth.
It always has same face towards Earth
So, far side of Moon has more craters

Blood Moon	red; during total lunar eclipse
Pink Moon	full moon of April
Blue Moon	second full moon in calendar month
Super Moon	perigean full moon; looks bigger
Micro Moon	apogee full moon; looks smaller



Aphelion: (4th July)
→ Earth farthest from Sun;

Perihelion: (3rd January)
→ Earth nearest to Sun;

Prelims 2005:
Assertion (A): The same face of the moon is always presented to the earth.
Reason (R): The moon rotates about its own axis in 23 and half days which is about the same time that it takes to orbit the earth.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Lunar maria: dark, basaltic plains on Earth's Moon; mostly on near side

Giant impact / Big splat / Ocean Magma hypo:
Mars sized object collided with earth → Part of earth blasted into space → molten due to heat → later cooled → formed moon

Some features of Moon:
- Sea of Serenity; South Pole-Aitken Basin;
- Craters (~9000): Von Kármán, Clavius, Tycho, Sarabhai, Copernicus, etc.

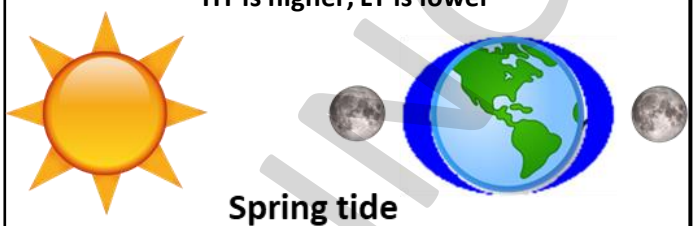
Space bricks: Lunar soil + urine + etc; by ISRO

Tides

7-day interval between spring and neap
Moon's attraction is twice that of sun

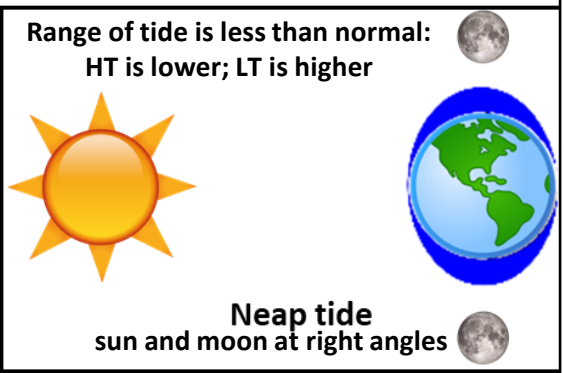
Flow: water rises; LT → HT
Ebb: water falls; HT → LT

Range of tide is more than normal:
HT is higher; LT is lower



Spring tide
sun, moon, earth in straight line

Range of tide is less than normal:
HT is lower; LT is higher

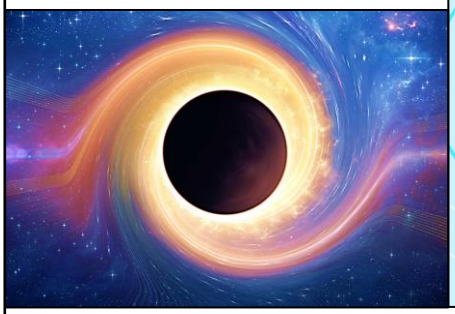


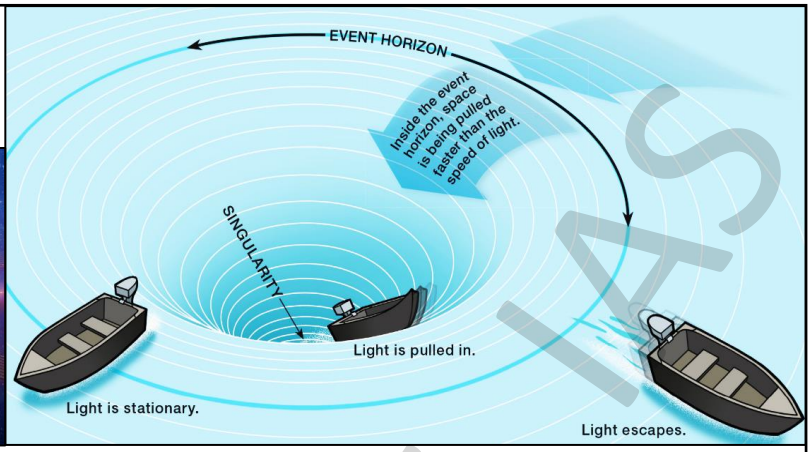
Neap tide
sun and moon at right angles

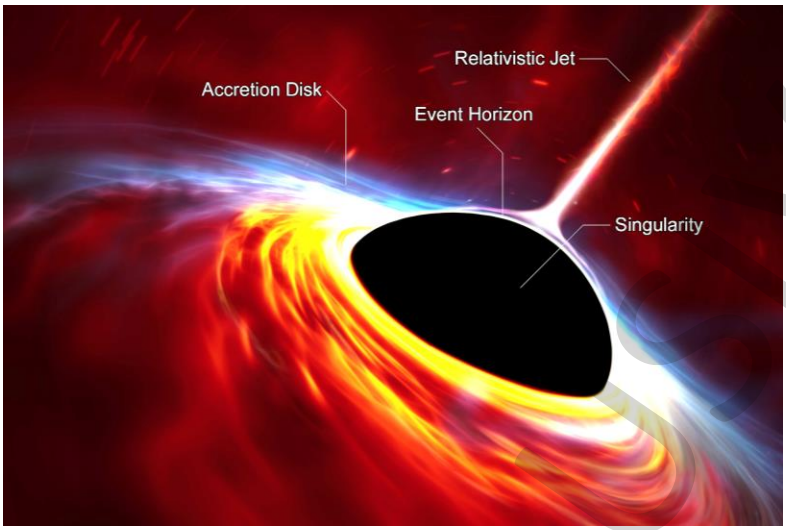
Prelims 2015:
Tides occur in the oceans and seas due to which of the following?
1. Gravitational force of the Sun
2. Gravitational force of the Moon
3. Centrifugal force of the Earth
Select the correct answer
(a) 1 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Prelims 2001:
Assertion (A): During neap tides, the high tide is lower and the low tide is higher than usual.
Reason (R): The neap tide, unlike the spring tide, occurs on the new moon, instead of on the full moon.
(a) Both A & R are true and R is the correct explanation of A
(b) Both A & R are true but R is NOT a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Black hole







Accretion disc:
matter revolving around BH

Photon sphere:
just outside event horizon

Relativistic jets:
matter that didn't fall into BH

Event Horizon:
point of no return

Singularity:
at centre of BH; infinite density

Black Hole theorem:
given by Stephen Hawking in 1971
area of Event Horizon cannot shrink

Black hole: a place in space so dense that nothing (not even light) can escape it.
Einstein's theory of ~~Special~~ **General relativity** predicted black holes. (*Hint: too much gravity!*)

Hawking Radiation: electromagnetic radiation that escapes black hole (theory, not proven).

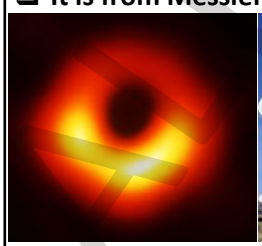
How can they form?

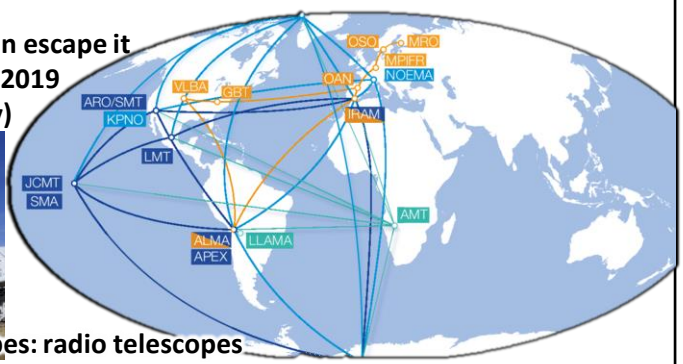
1. **Big Bang:** some black holes formed soon after the Big Bang (Primordial black hole)
2. **Stars:** Gravitational collapse of massive stars can cause supernova explosion and form black hole
3. High energy **collisions** (not yet proven)

Unicorn:

- ❑ recently discovered
- ❑ probably **smallest** BH in Milky way
- ❑ 3 times the mass of our Sun
- ❑ **nearest** BH to our solar system
- ❑ 1,500 light years from earth.

- ❑ We **can't see** black hole because no light can escape it
- ❑ **1st Photo** of Black hole was published April 2019
- ❑ It is from Messier 87 galaxy (not Milky Way)

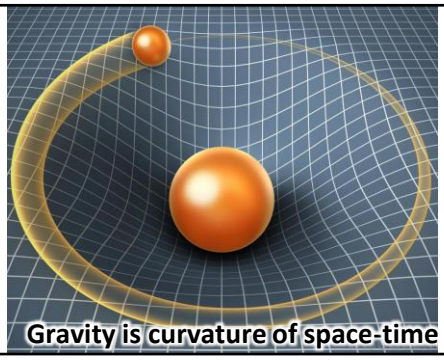




Event Horizon Telescopes: radio telescopes

Relativity: According to **Einstein**, time is relative. He gave two **theories of relativity**:

- 1905: **Special theory**: time is affected by **S**peed. (Time **slows** down when **speed is increased**).
- 1915: **General theory**: time is affected by **G**ravity. (Time **slows** down **around heavy objects**).



Gravity is curvature of space-time

Prelims 2018:

Consider the following statements:

1. Light is affected by gravity.
2. The Universe is constantly expanding.
3. Matter warps its surrounding space-time.

Which of the above are predictions of Albert Einstein's **General Theory of Relativity**, often discussed in media?

(a) 1 and 2 only (b) 3 only
(c) 1 and 3 only **(d) 1, 2 and 3**

Gravitational waves

➔ Distortions of space-time moving at speed of light

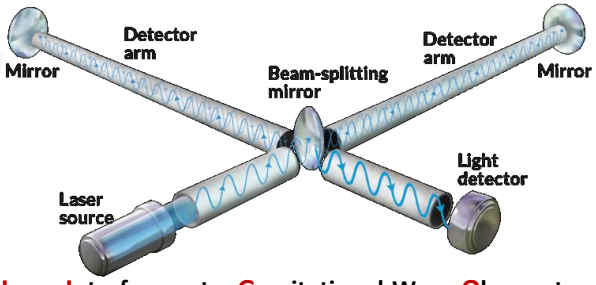
Prelims 2019:

Recently, scientists observed **merger of giant 'blackholes'** billions of light-years away from earth. What is significance of this observation?

(a) 'Higgs boson particles' were detected.
(b) 'Gravitational waves' were detected.
(c) Possibility of inter-galactic space travel through 'wormhole' was confirmed.
(d) It enabled the scientists to understand 'singularity'.

- Space-time = surface of a still pond.
- Waves in pond = gravitational waves.
- Created when: heavy objects move, etc.
- 1905: proposed by Henri Poincaré
- 1915: GTOR by Albert Einstein
- 2015: first direct observation (LIGO USA)
- 2017: Nobel Prize in Physics for detection

LIGO: **Virgo** in Italy, **GEO600** in Germany and **Kagra** in Japan



Laser **I**nterferometer **G**ravitational-Wave **O**bservatory

- LIGO in USA (detected GW in 2015)
- **INDIGO** in India (Hingoli Maharashtra)
- **eLISA** in space by EU in 2034

Prelims 2017:

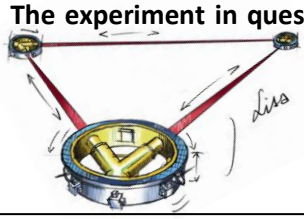
What is the purpose of 'evolved Laser Interferometer Space Antenna (**eLISA**)' project?

(a) To detect neutrinos
(b) To detect gravitational waves
(c) To detect the effectiveness of missile defence system
(d) To study the effect of solar flares on our communication systems

Prelims 2020:

The experiment will employ a trio of spacecraft flying in formation in the shape of an equilateral triangle that has sides one million kilometers long, with lasers shining between the craft. The experiment in question refers to

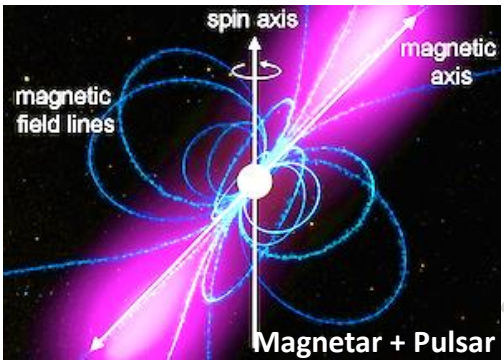
(a) Voyager-2
(b) New Horizons
(c) LISA Pathfinder
(d) Evolved LISA



A galaxy with Quasar at its center

Quasar

- Super massive Black Hole at centre of galaxy
- Billion times mass than our Sun
- Actively feeding on material
- Brightest objects in Universe
- They outshine the galaxy they are in.
- Millions of quasars have been found
- Nearest is 60 crore light-years away.
- Our Milky way also has a super massive BH at its centre, but its not a quasar currently.
- Some scientists say our Milky way once had Quasar, some say it will have Quasar in future.

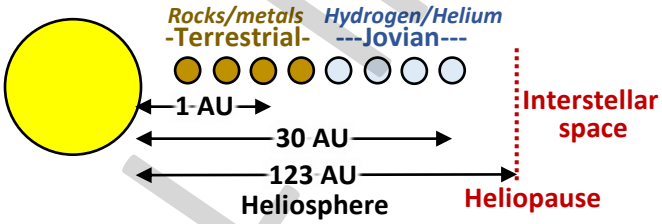


Neutron star

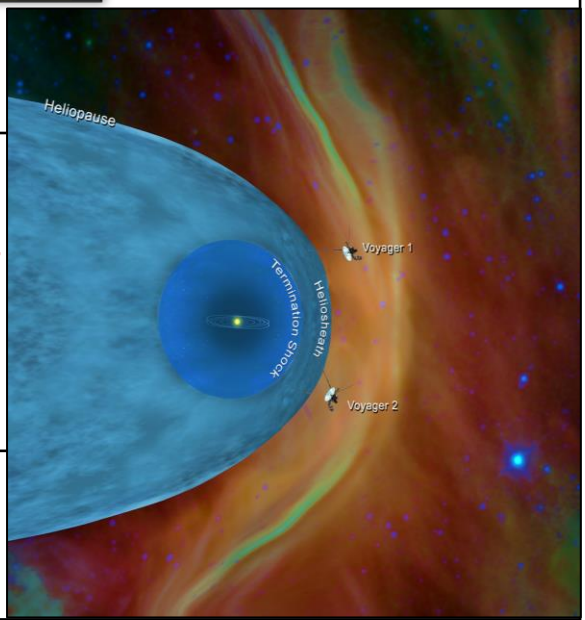
- Forms when star runs out of fuel and collapses.
- Forms if mass is up to 3 solar mass, else BH.
- Dense core left behind after supernova
- Extremely dense object (only BH is more dense)
- Three main types:
  1. Magnetar: has very strong magnetic field
  2. Pulsar: two beams from poles (seems on off)
  3. Magnetar + Pulsar: both

Heliosphere

Outermost atmospheric layer of Sun
120 AU in interstellar wind side
More than 350 AU in opposite direction



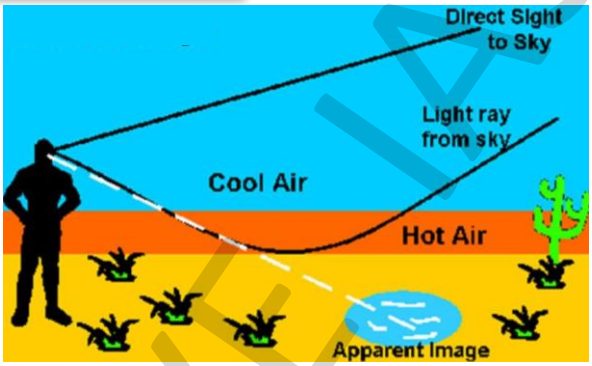
Astronomical Unit 15 crore or 150 million km

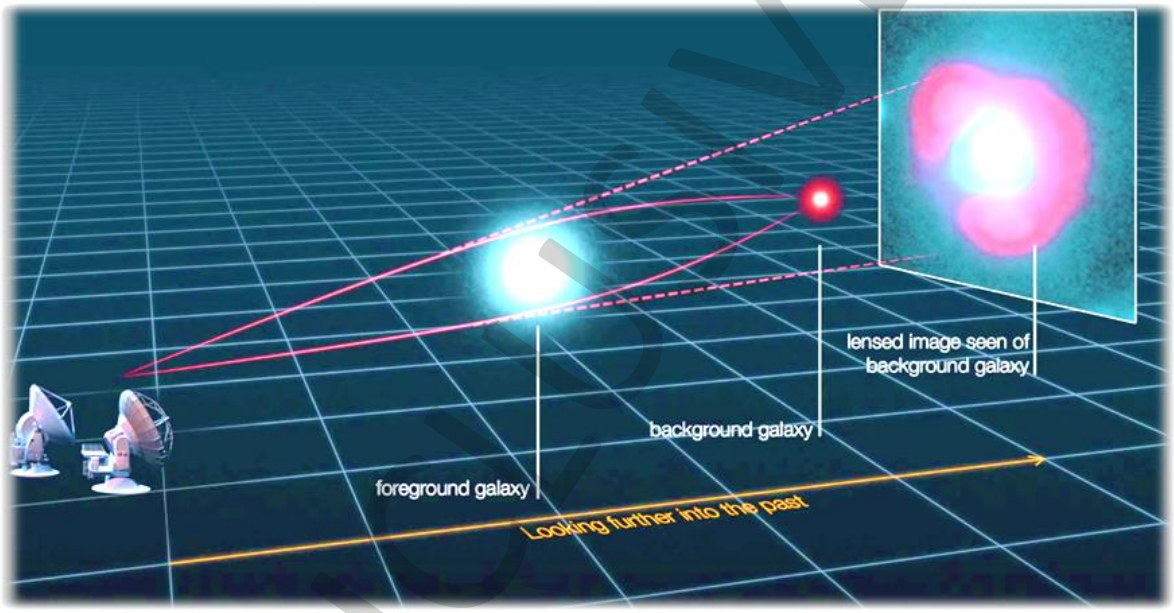


Voyager program: (1977, NASA) (page-25)

- To study Jupiter and Saturn; but continued
- Entered interstellar space: 2012 V1 ; 2018 V2
- Found increase in density outside solar system

Gravitational lensing

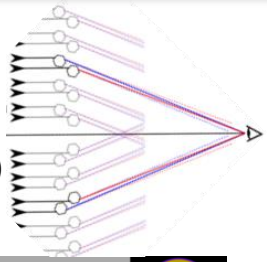


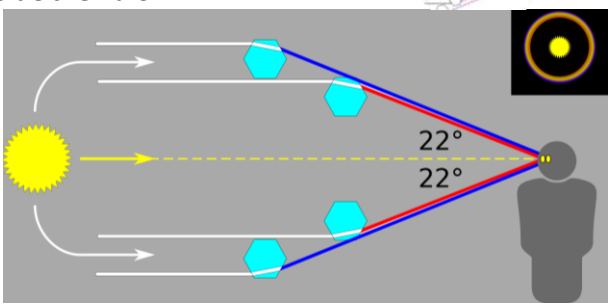


22^{o} Halo

Sun halo / Moon Halo:

- type of ice-crystal halo
- looks like a ring around Sun (or Moon)
- light is refracted by ice crystals in atmosphere
- Usually by cirrus clouds (or few days before storm)
- As no light is refracted at angles smaller than 22°, the sky is darker inside the halo.





Universe

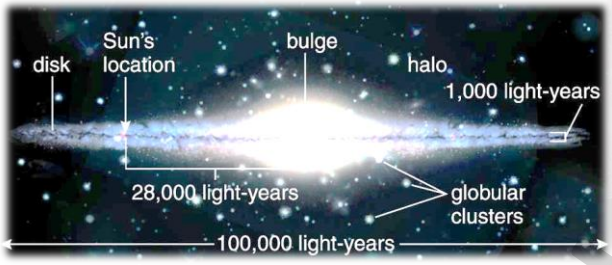
11th class Geography NCERT:	
13.7 billion	Big Bang
5.0 billion	Sun formed
4.7 billion	Earth formed
4.4 billion	Moon formed
3.8 billion	Life began

Galaxy: group of stars/gas/dust bound together by gravity

Types of Galaxies

Milky way: (spiral galaxy)

- ❑ It appears as a milky band of light in the sky when seen in a really dark area.
- ❑ All the stars we see in the night sky (without telescope) are in Milky Way Galaxy.



Proxima Centauri	nearest star to Sun; 4 light years away;	Red dwarf; Not visible by eye

Globular cluster:
It is a spherical collection of stars.

Galaxy nearest to our Milky way?

- ❑ Andromeda (25 lakh light years from us) is the nearest major galaxy to our Milky Way.
- ❑ Canis Major Dwarf is the nearest galaxy to Milky way (it is a satellite galaxy of Milky way)

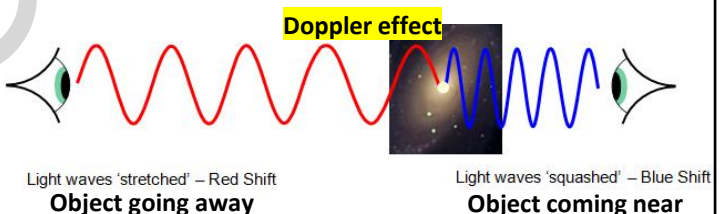
Prelims 2012:

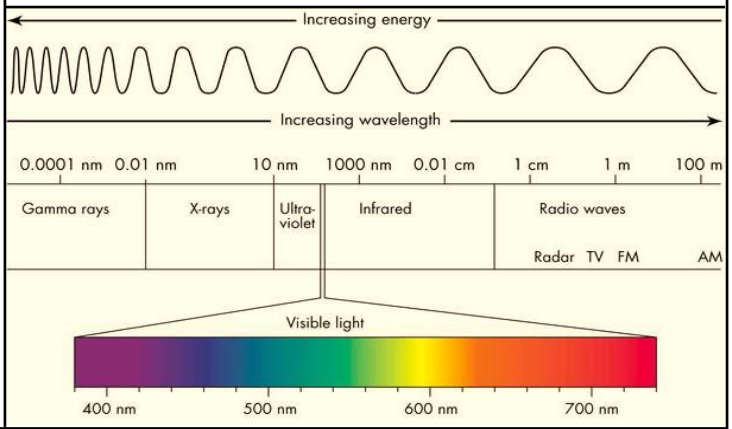
Which of the following are cited by the scientists as evidence for the continued expansion of universe?

1. Detection of microwaves in space
2. Observation of redshift phenomenon in space
3. Movement of asteroids in space
4. Occurrence of supernova explosions in space

Select the correct answer:

(a) 1 and 2
(b) 2 only
(c) 1, 3 and 4
(d) None of the above can be cited as evidence





Dark energy, Dark matter

Dark Energy:

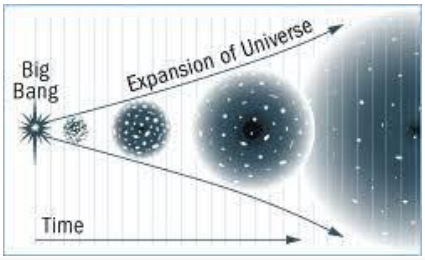
1) Big bang
2) Universe started expanding
3) But there is so much matter
4) Gravity must slow down expansion
5) But speed of expansion is increasing
6) Reason: dark energy

Dark matter:

- ❑ It is not in the form of stars and planets that we see.
- ❑ It is not in the form of dark clouds of normal matter, (matter made up of particles called baryons.)
- ❑ It is not antimatter, because we do not see the unique gamma rays that are produced when antimatter annihilates with matter.
- ❑ It is not large galaxy-sized black hole, because there are not many gravitational lensing events.
- ❑ It does not interact (absorb, reflect, emit) with electromagnetic waves.
- ❑ Existence inferred by gravity and maths

Universe = 68% dark energy + 27% dark matter + 5% normal matter

Dark energy is responsible for accelerated expansion of Universe



Dark matter is responsible for holding together galaxies

Cake is Milky way
Gems are Stars

Anti-matter

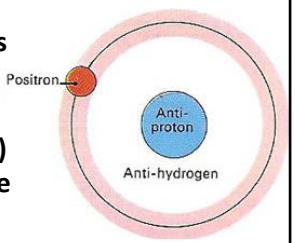
Ministry of Science & Technology

Cosmic rays propagating through Milky Way interact with matter producing excess antimatter counterpart of electron

Posted On: 30 APR 2021 6:02PM by PIB Delhi

High energy particles are generally lower in number in the cosmic universe. But the excess number of high energy particles of the antimatter counterpart of the electrons, called positrons have intrigued scientists for long. Now they have found an explanation for this mystery.

- ❑ Antimatter is made of antiparticles
- ❑ Same mass but opposite charge
- ❑ Proton → antiproton
- ❑ Electron → antielectron (positron)
- ❑ every basic particle has antiparticle



Baryon asymmetry:

Universe doesn't have equal amount of matter & anti-matter

How is it made?

- ❑ Big bang, cosmic rays, radioactive decays, etc
- ❑ In particle accelerators, also, but extremely less.

When matter and antimatter come into contact, they annihilate, disappearing in a flash of energy.

Positron excess:

- ❑ excess number of positrons between 10-300GeV energy found in space.
- ❑ Reason? cosmic rays in space interact with matter to produce electrons and positrons.

Prelims 2012:

A team of scientists at Brookhaven National Laboratory including those from India created the heaviest anti-matter (anti-helium nucleus). What are the implications of the creation of anti-matter?

1. It will make mineral prospecting and oil exploration easier and cheaper.
2. It will help probe the possibility of the existence of stars and galaxies made of anti-matter.
3. It will help understand the evolution of the universe.

Select the correct answer:

(a) 1 only (b) 2 and 3 only (c) 3 only (d) 1, 2 and 3

New rocket launch pad

Hindustan Times E-Paper

ISRO calls private entities to set up new launch sites

Currently, the Satish Dhawan Space Centre at Sriharikota is the country's only spaceport operated by the Indian Space Research Organisation. Another spaceport is under development at Tamil Nadu's Toothukudi.

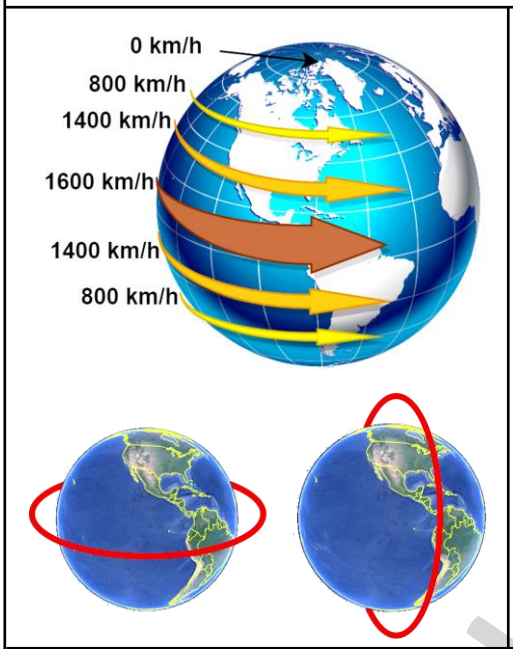
By Anonna Dutt, Hindustan Times, New Delhi
PUBLISHED ON JUN 27, 2021 06:11 AM IST

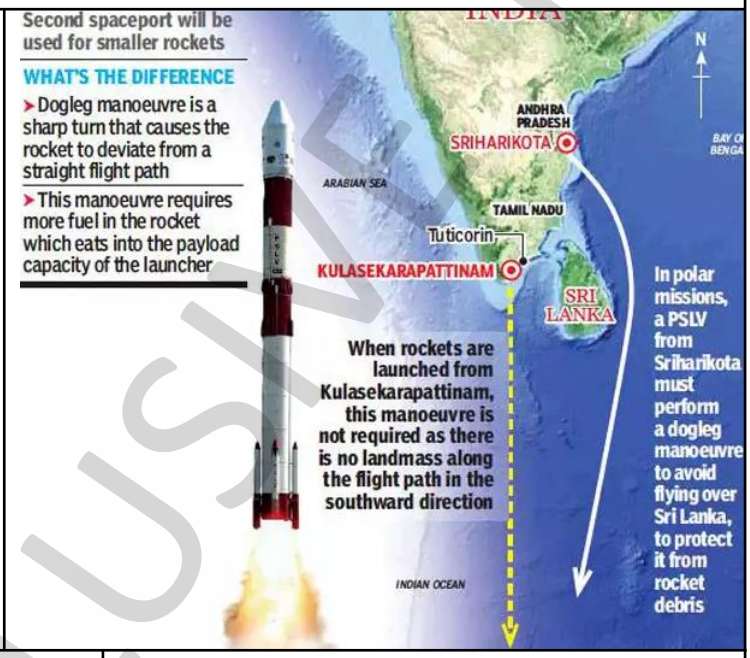
Launch pad on east coast because:

- ❑ Debris will fall in sea, not land

Launch pad near equator because:

- ❑ Earth rotates towards east.
- ❑ Surface velocity reduces towards poles.
- ❑ Launching near equator gives initial boost.
- ❑ True for GEO sats, not for polar sats.





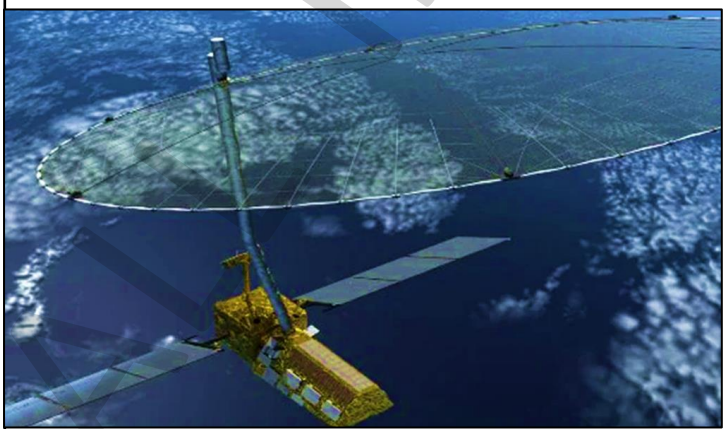
Thumba Equatorial Rocket Launch Station:

- ❑ 1963; Kerala; close to magnetic equator
- ❑ Used for launching sounding rockets

Sounding Rockets:

- ❑ aka research rockets
- ❑ measurements/experiments at 50-150 km.
- ❑ ISRO uses Rohini series of sounding rockets.

NASA-ISRO SAR satellite



NISAR:

- ❑ NASA-ISRO Synthetic Aperture Radar
- ❑ 2023; by GSLV; from India
- ❑ It will be the first radar imaging satellite to use dual frequencies.
- ❑ Purpose: To better understand natural processes on earth like ice-sheet collapse, volcanoes, etc.
- ❑ It will use two bands:
  - → S band by ISRO
  - → L band by NASA

Some telescopes

Indian Astronomical Observatory:
- ❑ 2001; at Hanle in Ladakh
- ❑ remotely operated by Indian Institute of Astrophysics, Bangalore
- ❑ 2-m Himalayan Chandra Telescope

Subrahmanyan Chandrasekhar:
- ❑ Indian-American astrophysicist
- ❑ 1983 Physics Nobel Prize
- ❑ for studying evolution of Stars
- ❑ Chandrasekhar limit (1.4 M_O)
- ❑ max mass of stable white dwarf

Thirty Meter Telescope:
- ❑ Being made on Mauna Kea
- ❑ Members: USA, India, China....

James Webb Space Telescope
- ❑ December 2021;
- ❑ by NASA, EU, Canada
- ❑ will succeed Hubble (1990)
- ❑ But will be in Sun-Earth L_2

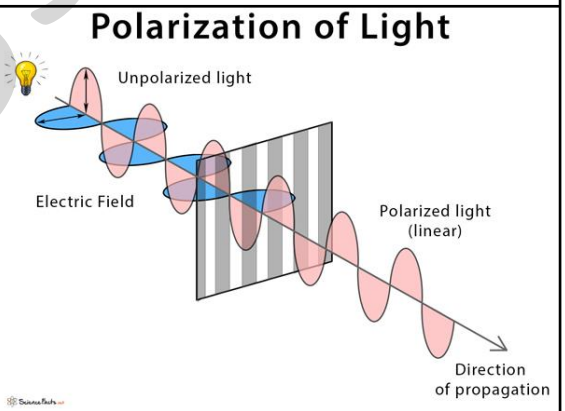
Square Kilometre Array
- ❑ radio (not optical) telescopes So, can detect invisible objects
- ❑ in South Africa & Australia
- ❑ in Southern Hemisphere
- ❑ UK, India, China, etc.
- ❑ may operate from 2027

ASTHROS: (by NASA)
- ❑ Astrophysics Stratospheric Telescope for High Spectral Resolution Observations at Submillimeter-wavelengths
- ❑ Space observatory in Helium balloon on Antarctica

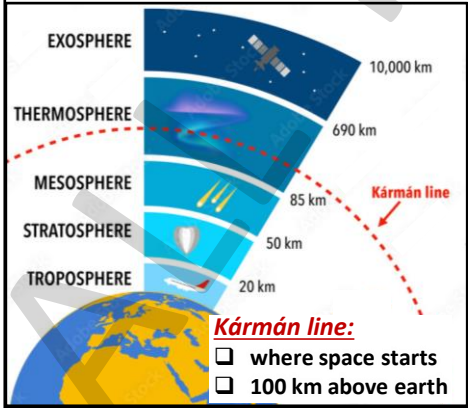
Devasthal Optical Telescope:
- ❑ 3.6 m, largest single telescope in Asia
- ❑ At Devasthal, Nainital (Uttarakhand)

Asthros will look into the SPACE for far-infrared light.
ANITA will look at the radio pulses emitted by their interactions with the Antarctic ice sheet.

Pasiphae:
- ❑ Polar-Areas Stellar-Imaging in Polarisation High Accuracy Experiment
- ❑ It is not a satellite. WALOP instrument will be used with some existing large telescopes on earth (outside India).
- ❑ Will help in research on Big bang, cosmic microwave background, etc.
- ❑ It will study polarisation of light from Space.
- ❑ Polarization is a property of light that represents the direction that the light wave oscillates.



Miscellaneous



Kármán line:
- ❑ where space starts
- ❑ 100 km above earth

International Space Station:
- → Since 1998; in LEO (400km)
- → It can be seen by naked eye
- → USA, Russia, EU, Japan, Canada
- → Tiangong: like ISS, by China

VIPER:
- → lunar rover by NASA for 2023
- → To map resources for Artemis

Extreme helium star (EHe):
- → Star with almost no hydrogen
- → 21 detected in Milky way

Hayabusa2: (Japan)
Brought sample from Asteroid Ryugu

Venus missions:
- → NASA: Veritas & Davinci+
- → EU: EnVision

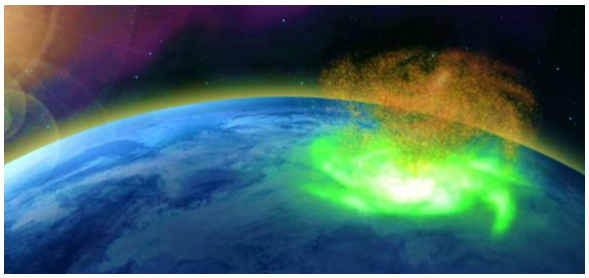
BepiColombo: EU Japan mission to Mercury

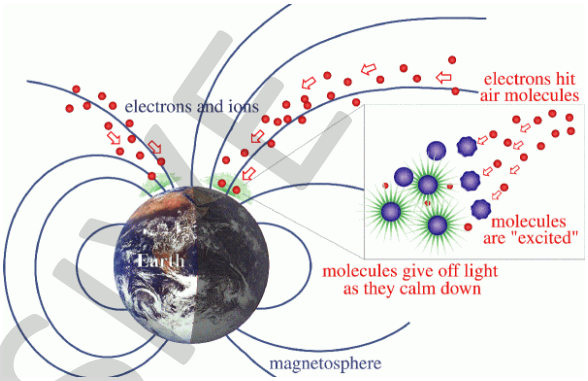
Sonic boom

- **Speed of sound:** 343 m/s
  approx. 3 seconds for 1 km
- **Sonic boom:** sound of shock waves when something travels faster than sound
- Mach < 1 Subsonic
- Mach > 1 Supersonic
- Mach > 5 Hypersonic

Space Hurricane

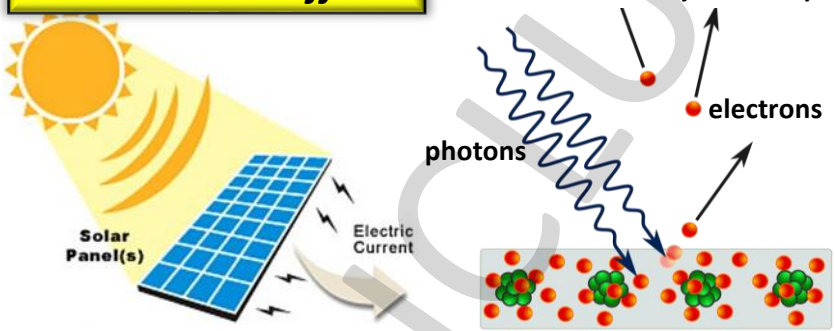
Aurora (page-34) shaped like hurricane





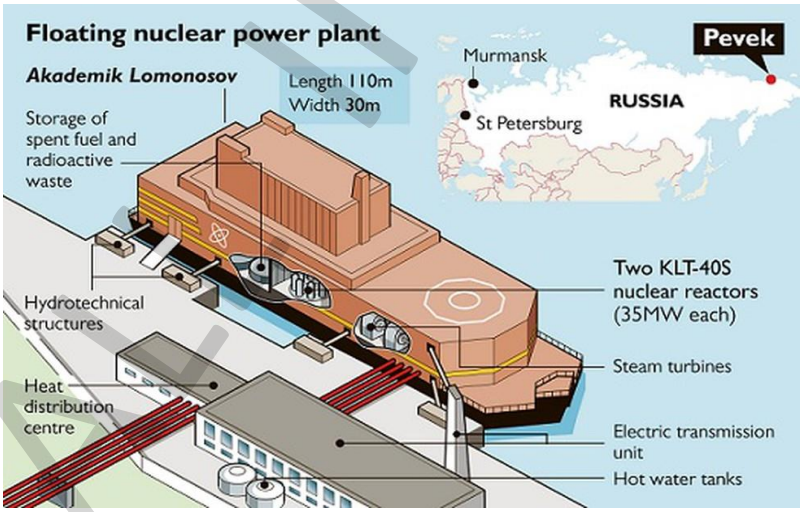
Photoelectric effect

discovered in 1887 by German physicist Heinrich Rudolf Hertz



Photoelectric effect:
emission of electrons when electromagnetic radiation, such as light, hits a material.

Albert Einstein:
He got Nobel Prize in Physics 1921 for theory of ~~relativity~~ photoelectric effect.



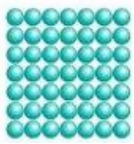
Arktika

Arktika:
- Russian ice breaker **ship**
- Nuclear powered

Arktika-M:
- Russian **satellite**
- To study Arctic climate

Akademic Lomonosov:
- world's 1st floating nuclear power plant
- In Russian far-east

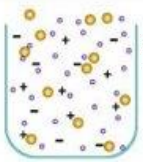
Fifth state of Matter



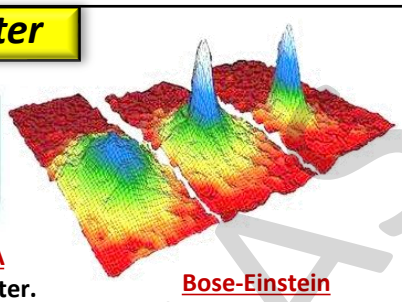
SOLID
Particles in fixed position

LIQUID
Particles flow around each other

GAS
Particles flow freely with high energy



PLASMA
4th state of matter.
Superheated matter.
Electrons ripped away.
Equal +ve and -ve
99% of visible universe



Bose-Einstein condensate
5th state of matter.

Four natural states of matter: Solid, liquid, gas, plasma.
Fifth state of matter: Bose-Einstein condensate

- Predicted by Einstein in 1924 based on paper by S.N. Bose but was made for the first time only in 1995.
- At near zero kelvin, molecular motion almost stops.
- There is almost no kinetic energy.
- Atoms clump to form just one 'super atom'.
- They are extremely sensitive. Smallest disturbance increases the temperature and ends the BEC state.
- Recently also made in Cold Atom Lab in ISS

Boson:

- discovered by Satyendra Nath Bose
- follows Bose–Einstein statistics
- e.g. Photons, Higgs Bosons (God particle)

Prelims 2013:

The efforts to detect existence of Higgs boson particle have become frequent news in recent past. What is the importance of discovering this particle?

1. It will enable us to understand as to why elementary particles have mass.
2. It will enable us in near future to develop technology of transferring matter from one point to another without traversing the physical space between them.
3. It will enable us to create better fuels for nuclear fission.

Select the correct answer
(a) 1 (b) 2,3 (c) 1,3 (d) 1, 2, 3

Neutrinos

Neutrinos are second most abundant particles in the universe, after Photons

Experiments related to neutrinos:

- IceCube: thousands of sensors below Antarctic ice (2.5km)
- ANITA: ANtarctic Impulsive Transient Antenna Radio telescope in Helium balloon over Antarctica
- INO: Indian Neutrino Observatory (Bodi West hills, Theni, TN)

Prelims 2010:

India-based Neutrino Observatory is included by the Planning Commission as a mega science project under the 11th Five-Year Plan. In this context, consider the following statements:

1. Neutrinos are chargeless elementary particles that travel close to the speed of light.
2. Neutrinos are created in nuclear reactions of beta decay.
3. Neutrinos have a negligible, but non-zero mass
4. Trillions of neutrinos pass through human body every second.

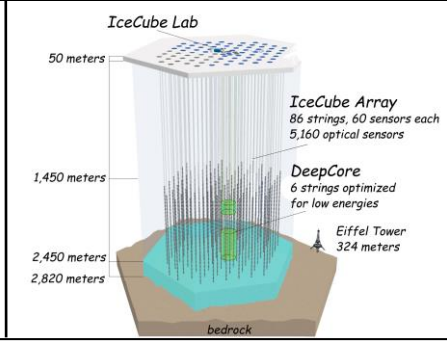
Which of the statements given above are correct?
(a) 1 and 3 only (b) 1, 2 and 3 only (c) 2, 3 and 4 (d) 1, 2, 3 and 4

Prelims 2015:

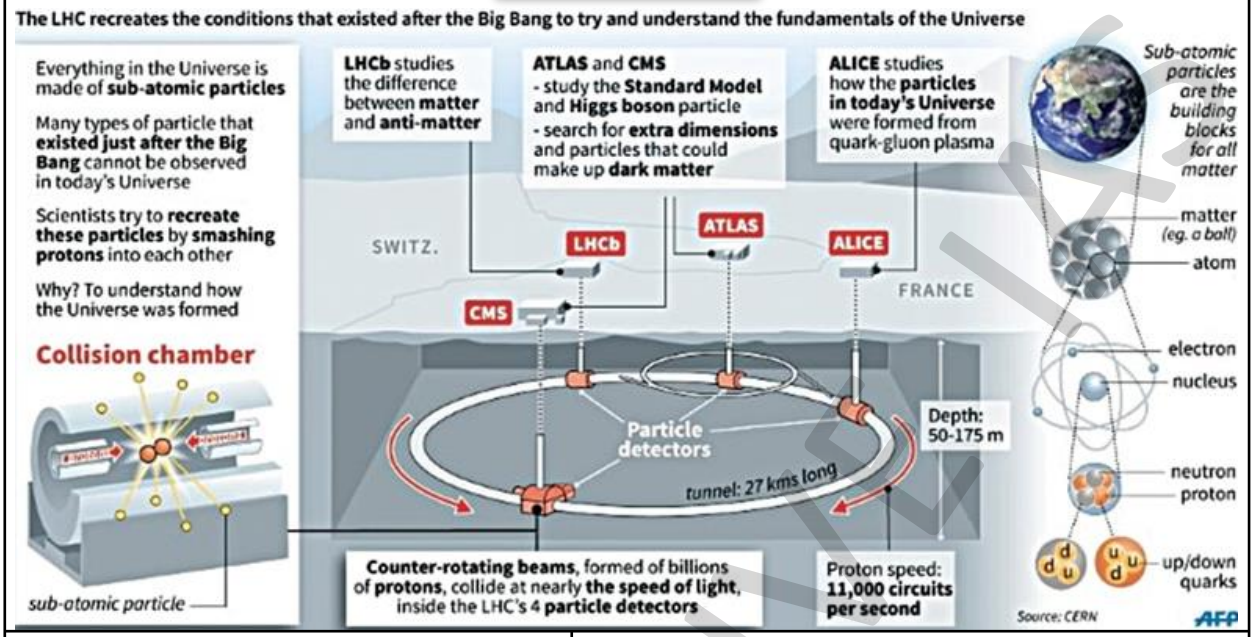
In the context of modern scientific research, consider the following statements about 'IceCube', a particle detector located at South Pole, which was recently in the news:

1. It is the world's largest neutrino detector, encompassing a cubic kilometre of ice.
2. It is a powerful telescope to search for dark matter.
3. It is buried deep in the ice.

Which of the statements given above is/are correct?
(a) 1 (b) 2,3 (c) 1,3 (d) 1, 2 and 3



LHC



CERN:

- ❑ European Organization for Nuclear Research
- ❑ 1954; HQ in Switzerland
- ❑ India: associate member
- ❑ Israel: the only non-European full member.
- ❑ 27 km long accelerator; 4 detectors

Large Hadron Collider:

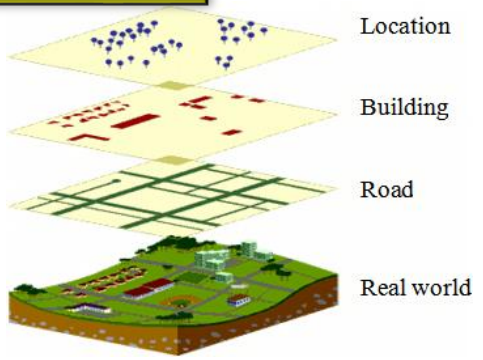
- ❑ World's largest & highest-energy particle collider.
- ❑ Has 27 km long ring of superconducting magnets.
- ❑ High energy particle beams made to collide at near speed of light.
- ❑ Built by CERN
- ❑ France–Switzerland border near Geneva.

Hydrogen Fuel

- ❑ See Environment class-4 on YouTube.
- ❑ National Hydrogen Mission launched by Ministry of New and Renewable Energy
- ❑ MoRTH notifies 18% blend of Hydrogen with CNG (HCNG) as an automotive fuel

Geospatial

geography + mapping



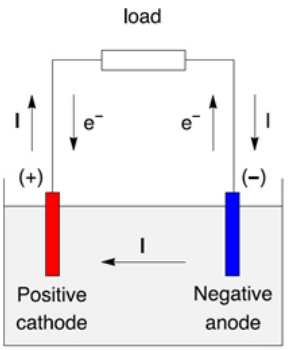
Aluminum-Air battery

Aluminium–air battery:

- ❑ Produces electricity from reaction of aluminium with oxygen (from air).
- ❑ Need to put new aluminium anodes.
- ❑ It is a primary cell

Primary battery (cannot be recharged)

Secondary battery (can be recharged)



NEWS SERVICES DIVISION
ALL INDIA RADIO

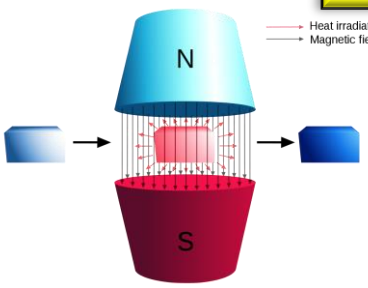
Jun 07, 2020, 10:04PM

Scientists at ARCI develop a rare-earth-based material that can be effectively used for cancer treatment

Scientists at the International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI) have developed a rare-earth-based material that can be effectively used for cancer treatment.

The rare earth based material is being tested at Sree Chitra Tirunal Institute for Medical Sciences & Technology. The newly developed composition is said to be magnetocaloric in nature which can become warmer or cooler due to magnetic field.

Magnetocaloric effect



magnetocaloric
Magnetic field Heat or energy

Magnetocaloric effect:

- Magnetic field causing temperature change in certain (magnetocaloric) materials.
- It is the basis of magnetic refrigeration:
  - → More efficient than conventional refrigeration (not used due to very strong magnetic field)
  - → Can also give extremely low temperatures (even 0.3K)

Rare-earth materials: (aka lanthanides)

- 17 silvery-white soft heavy metals.
- They are plentiful in Earth's crust
  e.g. Cerium is more abundant than copper
- But they are dispersed; ores are rare.
- Application: everywhere, especially electronics
- China: Most reserves and most production

Ministry of Health and Family Welfare

Liquid Medical Oxygen: Explainer

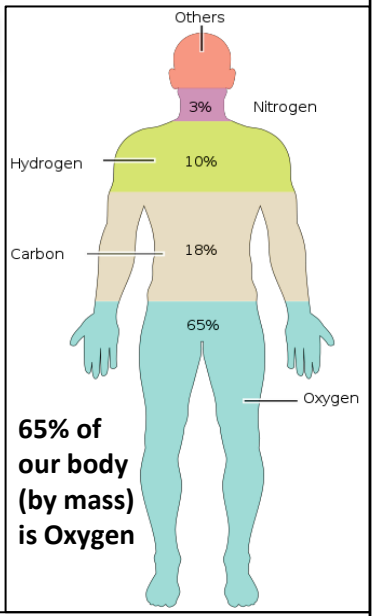
Posted On: 06 MAY 2021 11:00AM by PIB Mumbai

Mumbai, May 6, 2021

We know 65% of human body is oxygen. Yes, oxygen is vital for respiration, the process that transfers energy from glucose to cells. In fact, every cell in our body requires oxygen. When we breathe air in, oxygen molecules enter the lungs and pass through lung walls into our blood.

Medical Oxygen

Air
V
Liquid Oxygen
V
Transport
V
Gas
V
Cylinder



65% of our body (by mass) is Oxygen

AIR 78% - Nitrogen 0.93% - Argon
21% - Oxygen 0.04% - CO_2

Liquid Medical Oxygen:

- Fractional Distillation in Air Separation Units
  - → Air cooled to -181°C
  - → Oxygen (& some Argon) liquify, extracted.
  - → Nitrogen remains gas (boiling point -196°C)
- Transported by cryogenic containers.
- Liquid converted to Gas, filled into cylinders

Why Liquid? more quantity, easy transportation
Cryogenic? liquid with boiling point below –90°C

Pressure Swing Adsorption and Oxygen concentrators:

- Concept: at high pressure gases are attracted to solid surfaces
- Zeolite attracts Nitrogen more strongly than Oxygen

Rare disease

Orphan disease
Orphan drugs

Examples: Haemophilia, Thalassemia, Sickle-cell Anaemia, Muscular dystrophy (7,000 world; 450 India)

National Policy for rare disease 2021:

- Awareness, screening, registry, crowd funding, etc.
- Financial support through Rashtriya Arogya Nidhi and PM-JAY
- Not just for BPL; covers 40% population;
- up to Rs 20 lakh under RAN (not PM-JAY)

- No universal definition
- WHO: disease affecting < 1 in 1000 people.
- Around 6-8% people suffer from rare disease
- Most of them are genetic in nature.
- Why treating them is difficult?
  Less market, so less infra (tests, docs, R&D…)

Rashtriya Arogya Nidhi:

- since 1997 for financial assistance to BPL patients of major life threatening disease.
- Money given to Medical Superintendent of the Hospital, not patient.
- In 2019, scheme was closed and again opened

Immunization

Immunization Agenda 2030:

- By WHO, GAVI, etc.
- For everyone to benefit from vaccines
- Zero-dose children by 50%
- 90% coverage for essential vaccines
- 2011-20: Global Vaccine Action Plan
- 2021-30: Immunization Agenda 2030
- Caution: This is not just about Covid

Vaccine hesitancy:

- Refusal to get vaccinated, despite being available & affordable.
- In USA, vaccines are absolutely free and easily available. Still only 53% are fully vaccinated. (August 2021)

Intensified Mission Indradhanush

- 1.0 in 2017; 2.0 in 2019;
- 3.0 in 2021 for children and pregnant women who missed routine immunisation due to covid

UIP free vaccines for 12 diseases:

To all children across the country free of cost to protect them against:

Tuberculosis, Diphtheria, Pertussis, Tetanus, Polio, Hepatitis B, Pneumonia and Meningitis due to Haemophilus Influenzae type b (Hib), Measles, Rubella, Japanese Encephalitis (JE) and Rotavirus diarrhoea.

(Rubella, JE and Rotavirus vaccine in select states and districts)

1978: Expanded Programme of Immunization
1985: Universal Immunization Programme
2014: Mission Indradhanush

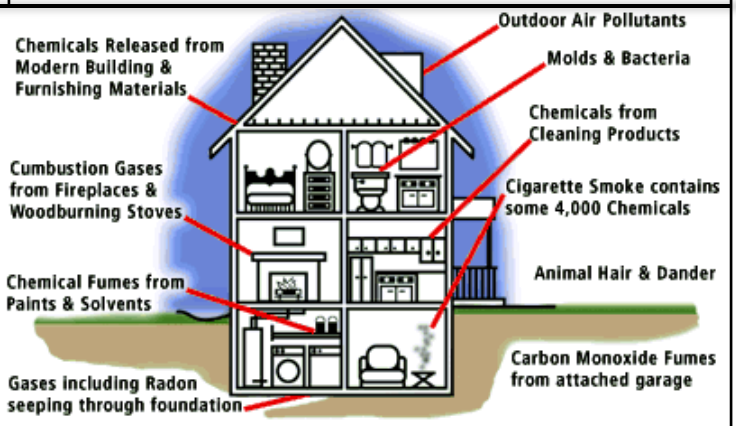
Prelims 2016:

'Mission Indradhanush' launched by the Government of India pertains to

(a) immunization of children and pregnant women
(b) construction of smart cities across the country
(c) India's own search for Earth-like planets in outer space
(d) New Educational Policy

Sick building syndrome

- A building's occupants usually feel sick, but can't identify any specific cause.
- Usually can be prevented by proper ventilation.



Miscellaneous

Integrated Health Information Platform:
- ❑ It is a disease surveillance platform
- ❑ Revised Integrated Disease Surveillance Program
- ❑ Tracks 33 diseases, earlier 18.

Trachoma:
- ❑ Bacterial infection; affects eyes
- ❑ Neglected tropical diseases
- ❑ India declared free in 2017
- ❑ WHO Global target 2030

Anemia:
- ❑ number of red blood cells or their oxygen carrying capacity is insufficient
- ❑ Mostly due to deficiency of iron or folic acid

Haemoglobin:
- ❑ a protein in red blood cells
- ❑ carries oxygen; gives red color to blood.

Anemia Mukt Bharat targets:
reduce prevalence of anemia by 3 percentage points per year among children, adolescents and women in the reproductive age group (15–49 years), between the year 2018 and 2022.

Drugs used to treat cattle:
- ❑ Diclofenac and ketoprofen: unsafe for vultures
- ❑ Meloxicam and tolfenamic: safe for vultures
- ❑ India banned veterinary use of diclofenac in 2006

Acute Encephalitis Syndrome
- ❑ sudden fever and change in mental status
- ❑ Mostly in children; considerable mortality
- ❑ Cause: mostly virus, but bacteria, etc also

Dried blood spot test:
- ❑ Used by WADA at Tokyo Olympics
- ❑ World Anti-Doping Agency:
  - → est. 1999; HQ: Montreal Canada
  - → not a UN agency

Human growth hormone:
- ❑ Naturally produced by pituitary gland at base of brain
- ❑ Helps in our growth and repair
- ❑ Synthetic used in some medicines
- ❑ Misused, banned in sports

Sophisticated Analytical & Technical Help Institutes scheme
- ❑ By Department of Science & Technology
- ❑ SATHI centres will have high end instruments
- ❑ Will be useful for industry, universities, etc.

Autoimmune disease:
A disease in which the body's immune system attacks healthy cells.

Tubarial salivary gland:
- ❑ new organ in human body
- ❑ between the nasal cavity and throat.
- ❑ recently discovered by Dutch scientists

Cancer Atlas:
- ❑ Cancer Genome Atlas:
  - → US program, started in 2006; study genetic mutations that cause cancer
- ❑ Indian Cancer Genome Atlas:
  - → India starting similar initiative

Photosynthesis vs chemosynthesis:
- ❑ Processes by which organisms produce food
- ❑ Photosynthesis is powered by sunlight.
- ❑ Chemosynthesis by chemical energy.

MRI scan	CT scan
Magnetic Resonance Imaging	Computed Tomography
uses magnets and radio waves	uses X-rays
Metals can create problem	Metals don't create problem
15-30 minutes	5 minutes

Mucormycosis

Black fungus

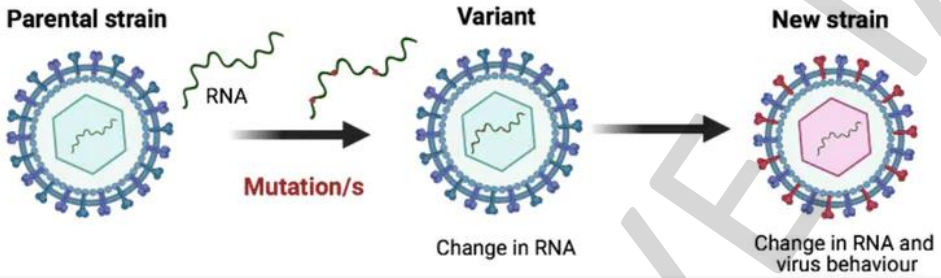
- ❑ rare fungal infection caused by a group of molds called mucormycetes
- ❑ naturally present in environment
- ❑ affects immunosuppressed people (weak immune system)
- ❑ It is not contagious (doesn't spread between people)
- ❑ Medicines: amphotericin B, posaconazole, isavuconazole

(early use of steroids → weak immunity → black fungus)

Variant vs Strain

Change in RNA → New Variant

Change in RNA and change in behavior → New Strain



RT-PCR vs RT-LAMP

RT-PCR test	RT-LAMP test
Needs 10 hours	Needs 30 minutes, and is more accurate
Needs different temperatures (56-92^{O}C)	Done at constant temperature (65^{O}C)
Needs expensive lab equipment	Less expensive lab

2-deoxy-D-glucose (2-DG)

~~Vaccine~~ Anti-Covid drug by DRDO

- ❑ The drug accumulates in virus-infected cells and prevents viral synthesis.
- ❑ Result: faster recovery, less oxygen dependence

Covid related terms *(not much important)*

- ❑ Covid Kavach Elisa: anti-body test developed by ICMR & NIV Pune
- ❑ Covirap: diagnostic machine by IIT-Kharagpur; portable, quick result
- ❑ eCovSens: diagnostic machine; uses biosensor (living orgnasim detecting presence of something)
- ❑ Druvs: uses UV rays to kill corona on surfaces
- ❑ Atulya: uses microwaves rays to kill corona on surfaces
- ❑ Mission Covid Suraksha: speed up vaccine development, approval, etc.
- ❑ Cawach: Dept of Science initiative to support innovations to fight Covid
- ❑ India Covid Emergency Response and Health Systems: World Bank helping India
- ❑ WHO solidarity trials: WHO initiative to find covid treatment
- ❑ Team Halo: UN initiative to increase people's confidence in vaccines
- ❑ Biorepository: storing biological samples for future scientific study
- ❑ Latent viral infection: virus in the body is dormant and does not replicate within the host.
- ❑ Feluda: FNCAS9 Editor-Limited Uniform Detection Assay.
  - → Uses CRISPR-Cas technology to detect corona
  - → TataMD CHECK: paper strip based Feluda test
- ❑ Methanol & 1-propanol: types of alcohol; toxic; found in some sanitizers

Covax

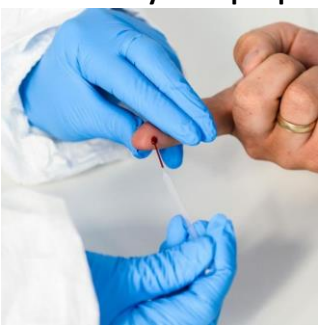
COVAX	GAVI	CEPI
❑ April 2020 ❑ Global initiative for equitable access to vaccines. ❑ By WHO, CEPI, GAVI	❑ 2000; Geneva ❑ Global Alliance for Vaccines and Immunization ❑ increase access to vaccines in poor countries	❑ 2017; Oslo Norway ❑ Coalition for Epidemic Preparedness Innovations ❑ India also founding member; ❑ fund R&D projects for vaccines against emerging infectious diseases

World Health Org.	Structure	Source of Funds
❑ specialized agency of UN; ❑ est. 1948; ❑ HQ Geneva	❑ World Health Assembly: member states; supreme decision making body ❑ Executive Board: technical experts; oversee implementation of programs ❑ Secretariat: headed by Director General; implements the programs	❑ Assessed contributions: paid by member states based on GNP and population. ❑ Voluntary contributions: paid by members states, organizations, individuals, etc.

Sero-survey

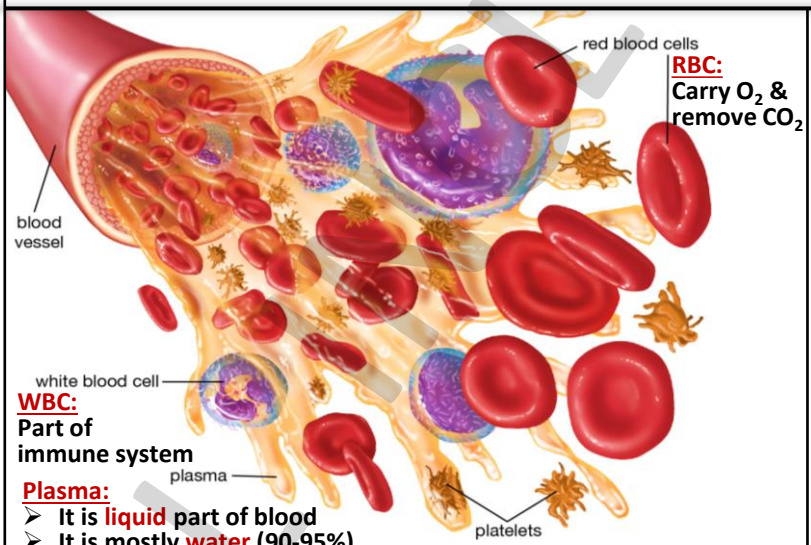
Official covid cases 3 crore

Sero-survey: 67% people



Sero-survey:

- ❑ ICMR July sero-survey: 67% of population i.e. 67% people have covid antibodies
- ❑ But it may not give herd immunity:
  - anti-bodies may not last for long time
  - anti-bodies may not be enough to fight again
  - new variants may emerge



RBC: Carry O_2 & remove CO_2

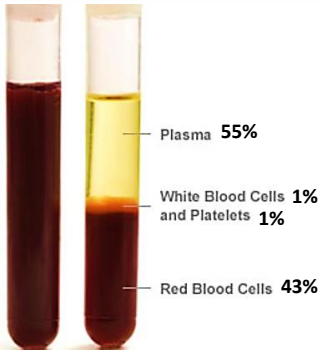
WBC: Part of immune system

Plasma:

- ➢ It is liquid part of blood
- ➢ It is mostly water (90-95%)
- ➢ Yellow in colour (not red)
- ➢ largest part of blood (55%)
- ➢ It contains antibodies, minerals, proteins, hormones, etc.

Platelets: Form clots to stop bleeding

Plasma Therapy



Blood fractionation: process of separating blood into constituents

Apheresis machine: separates blood into its constituents

Antiserum: blood serum containing antibodies against specific antigen.

Horses given inactivated corona virus → antibodies develop in horse → extracted, given to humans

This is not the first time; method used earlier for other diseases also.

Vaccines

please see page-8

Prelims 2020:

What is the importance of using Pneumococcal Conjugate Vaccines in India?

1. **These vaccines are effective against pneumonia as well as meningitis and sepsis.**
2. **Dependence on antibiotics that are not effective against drug-resistant bacteria can be reduced.**
3. **These vaccines have no side effects and cause no allergic reactions.**

Select the correct answer using the code given below:

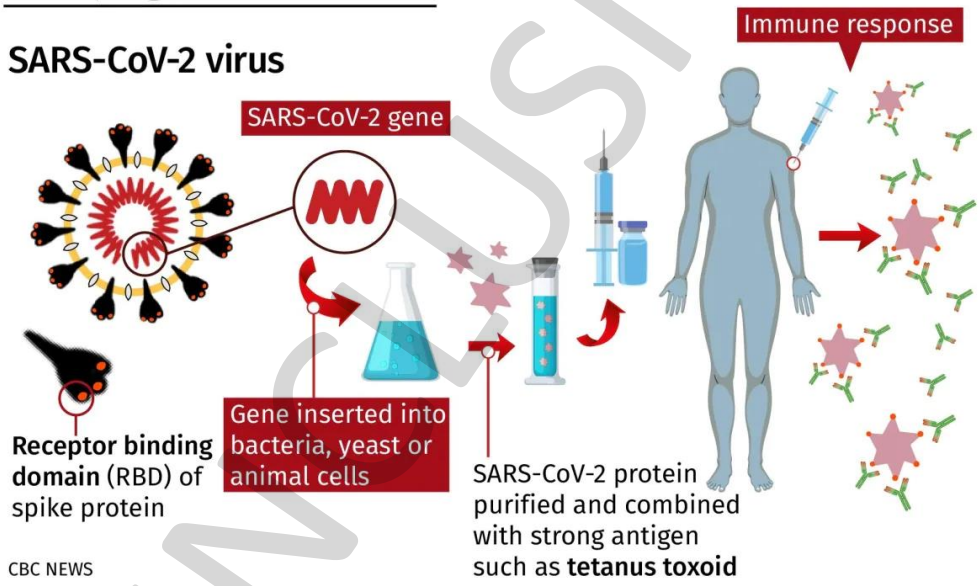
(a) 1 only (b) 1 and 2 only (c) 3 only (d) 1, 2 and 3

Pneumococcal disease:

- infection by bacteria Streptococcus pneumoniae
- example: pneumonia, meningitis, sepsis
- significant contributor under-five mortality
- Pneumococcal Vaccine: vaccine against it.
- Pneumosil: India's first indigenously developed pneumococcal conjugate vaccine; by Serum Institute of India

Conjugate vaccine

- combines a weak antigen with a strong antigen as a carrier so that the immune system has a stronger response to the weak antigen.
- Soberana 2: world's first conjugate vaccine for COVID-19; by Cuba



mRNA vaccines:

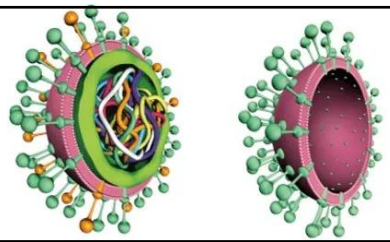
- Vaccines by Pfizer and Moderna were the first mRNA vaccines to be licensed for use.
- Before that no mRNA vaccine or drug has ever won approval.

ZyCoV-D:

- three-dose;
- by Cadila Healthcare (Indian)
- world's first DNA vaccine
- approved by India in Augut 2021

Plant based vaccines:

- Some antigens inserted into plants
- Plants produce Virus like particles (VLPs)
- VLPs extracted, and inserted into humans
- VLP is like virus, but has no viral genetic material



Corrections

Prelims 2011: **page-2**

At present, scientists can determine the arrangement or relative position of genes or DNA sequence on a chromosome. How does this knowledge benefit us?

1. It is possible to know the pedigree of livestock.
2. It is possible to understand the causes of all human diseases.
3. It is possible to develop disease resistant animal breeds.

Which of the statements given above is/are correct?

(a) 1 and 2 only (b) 2 only
(c) 1 and 3 only (d) 1, 2 and 3

UPSC official answer key says (c) is the right answer.

However, as per two websites of US government, statement (2) should also be correct.

- https://public.ornl.gov/site/gallery/detail.cfm?id=383&restsection=HGPArchive All diseases have a genetic component, whether inherited or resulting from the body's response to environmental stresses like viruses or toxins. The successes of the Human Genome Project (HGP) have even enabled researchers to pinpoint errors in genes--the smallest units of heredity--that cause or contribute to disease. The ultimate goal is to use this information to develop new ways to treat, cure, or even prevent the thousands of diseases that afflict humankind.
- https://www.ncbi.nlm.nih.gov/books/NBK132142/ All diseases have a genetic component. However, the extent to which genes contribute to disease varies and much remains to be learned.

Prelims 2008: **page-37**

Assertion (A): In human body, liver has important role in fat digestion.

Reason (R): Liver produces two important fat-digesting enzymes.

(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and Rare individually true but R is not the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Correct answer is (c)

- *Liver secretes bile (a digestive fluid)*
- *But bile is not "enzyme"*
- *Enzymes are proteins that act as biological catalysts.*

NETRA: **page-32 & 47**

DRDO's Netra:

AWACS to improve Air Force's Surveillance capabilities

ISRO's NETRA:

- NEtwork for space object TRacking & Analysis.
- Early warning system to detect space debris and other hazards to Indian satellites.

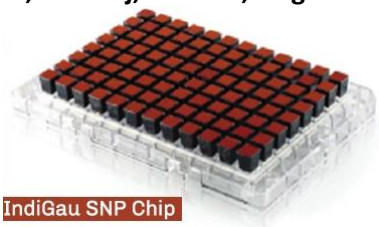
Note:

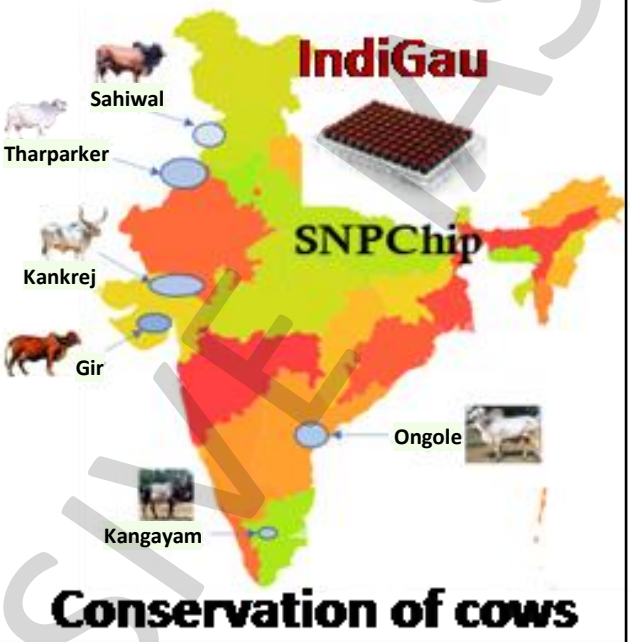
- At the end of Class-5B, it was announced that there will be class-5C.
- There is no class 5C as we have replaced it by classes 6A and 6B.
- In classes 1-6 we have finished May 2020 to June 2021.
- There will be one more short class, in September end, covering July-August.

IndiGau

IndiGau:

- by National Institute of Animal Biotechnology (NAIB), Hyderabad (DBT, MoS&T)
- India's first Cattle Genomic Chip; world's largest, has 11,496 markers
- It will help in identifying pure Indian cattle breeds
- Their milk is high in fat and SNF content (vitamins, minerals, casein, lactose)
- e.g. Gir, Kankrej, Sahiwal, Ongole etc.


IndiGau SNP Chip



Biotech Kisan:

- launched in 2017, by DBT (MoS&T)
- connect science labs with farmers to find innovative solutions to their problems

Dairy sector:

- 1965: National Dairy Development Board in Anand Gujarat
- 1970: Operation Flood launched
- 1998: India became largest producer of milk
- Today India has largest bovine population
- Only 36% milk goes to organized sector.

- National Animal Disease Control Programme to vaccinate 60 crore livestock against Foot & Mouth disease.
- Dairy Processing and Infra Development Fund to increase milk processing facilities.
- Rashtriya Gokul Mission for bovine breeding and dairy development
- Pashu Sanjivani to give health cards to milch animals
- E-Pashu haat portal to link farmers and breeders of indigenous breed

Biotech-PRIDE

- Promotion of Research and Innovation through Data Exchange
- guidelines released by DBT (MoS&T) to create Bio-grid (linking multiple bio data sets)
- will be implemented by IBDC
  - Indian Biologicla Data Centre
  - national repository of biotech related data

Virus

Monkey B virus:

- recent case reported in China
- First identified in 1932, only 50 human infections
- Obviously no vaccine

Marburg virus:

- from same family as Ebola; high fatality 88%
- Two outbreaks in 1967: Germany and Serbia
- Humans infected from bats in caves
- Can transmit human-to-human

91. In the context of digital technologies for entertainment, consider the following statements :

1. In Augmented Reality (AR), a simulated environment is created and the physical world is completely shut out.
2. In Virtual Reality (VR), images generated from a computer are projected onto real-life objects or surroundings.
3. AR allows individuals to be present in the world and improves the experience using the camera of smart-phone or PC.
4. VR closes the world, and transposes an individual, providing complete immersion experience.

Which of the statements given above is/are correct?

(a) 1 and 2 only
(b) 3 and 4
(c) 1, 2 and 3
(d) 4 only

Prelims 2019

Metaverse

- **Metaverse**: a virtual universe (in future) (like an advanced version of Second life)
- **Related techs**: Augmented reality, Virtual reality
- **Not to be confused Multiverse** (hypothetical group of multiple universes)

Virtual reality: Everything is fake (virtual), like a video game.

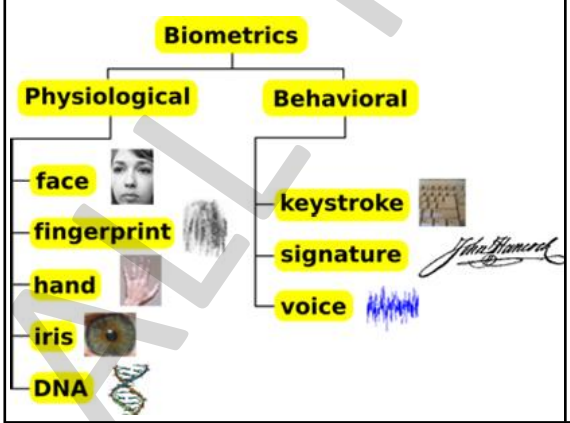
Fake (virtual) environment of roads and buildings

Fake (virtual) environment of garden, plants, Pokemons

Augmented reality: Fake images are overlaid on real things

Real environment of roads and buildings augmented by images of green lines and speedometer

Real environment of road and Trees augmented by images of Pokemon



NAFRS

National Automated Facial Recognition System:
- initiative of **NCRB**
- use database to identify people on CCTV videos, etc
- example of use of AI for surveillance, dead bodies, etc.

National Crime Records Bureau:
- 1986; **MHA**; initiatives like CCTNS 2009, ICJS 2019, etc

Crimes and criminal Tracking Network System:
- national **database** of crimes and criminals
- **connects** databases, police stations, etc.

Inter-operable Criminal Justice System (ICJS)
- integrating CCTNS with e-Courts, e-prisons, etc.

Unmanned Aerial Vehicles

Indrajaal: autonomous anti-drone system; by pvt. co.

- ‘Digital sky platform’ → Portal to register drones, and get permission to fly it.
- ‘No permission, No take-off’ policy → Take permission each time you want to fly a drone
- Counter Drone Guidelines 2019, Drone Rules 2021 by? Ministry of Civil Aviation
  - It is mandatory to get drones registered, except Nano drones (< 250 grams)
  - If weight > 500 kg, Aircraft Rules 1937 shall apply
  - Airspace has been partitioned into Red Zone (flying not permitted), Yellow Zone (controlled airspace), and Green Zone (automatic permission)
- Applications: mark all correct with common sense

Methods to control drones:

- Sky fence: disrupt signals to prevent drone from entering an area
- Drone gun: jam signals to bring it down to the ground.
- Laser: damage drone by high energy laser beam
- Net: throw a net around drone with a gun
- Bigger drone: use a bigger drone with net to catch smaller drone

Some drones: Israel → Heron, SkyStriker; USA → Sea Guardian, Reaper, Predator
DRDO → Rustom, Ghatak, Bharat, Lakshya, Nishant, etc.

Cyber security

see page-54

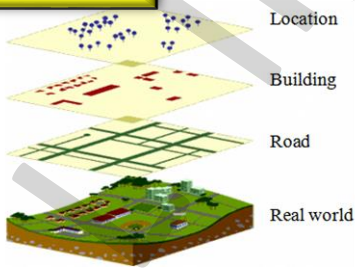
Pegasus:
Spyware by NSO group of Israel; sold only to governments.

Laws used for Communication surveillance:

- Telegraph Act, 1885 → mainly for calls
- Information Technology Act, 2000 → for all electronic

Geospatial

geography + mapping



Three new geospatial data portal:

1) SOI GEO Spatial Data Dissemination Portal
2) SOI SARTHI: WEB GIS application
3) NATMO: Manchitran Enterprise Geoportal

SOI: Survey of India
National Atlas & Thematic Mapping Organisation

Survey of India	1767	Dehradun	Ministry of Science & Tech
Geological Survey of India	1851	Kolkata	Ministry of Mines
Archaeological Survey of India	1861	Delhi	Ministry of Culture

bhuvan Beta
INDIAN EARTH OBSERVATION VISUALISATION

- since 2009; by ISRO
- Just like Google Earth
- India specific; Lots of information to help govt. in e-governance

Miscellaneous

***Mosquirix*: trade name of RTS,S (malaria vaccine, page-42)**

SATNAV 2021: draft policy for satellite-based navigation prepared by ISRO (also see pages-30,31)

Ministry of Electronics & IT

India to host the first Internet Governance Forum in the country

The Forum will act as the platform for various stakeholders to discuss public policy issues related to the Internet

Posted On: 09 AUG 2021 2:22PM by PIB Delhi

Internet Governance Forum:

- started in 2006 by UN; India hosted it in 2008
- Govt, companies, etc. to discuss internet related policies
- India Internet Governance Forum launched recently.

Private companies in space race:

- Blue Origin (Jeff Bezos),
- Virgin Galactic (Richard Branson)
- SpaceX (Elon Musk)

World's first space tourist:

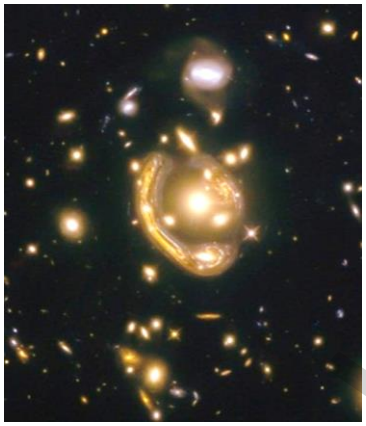
Dennis Tito in 2001 (went to ISS in Russian Soyuz rocket)

Indian origin women in space:

1) Kalpana Chawla
2) Sunita Williams
3) Sirisha Bandla

Einstein ring / Chwolson ring:

- due to gravitational lensing
- because gravity bends light



Eutelsat Quantum satellite:

- Uses Quantum technology? No (see Micius page-13)
- communication satellite by ESA; in geostationary orbit
- reprogrammable: change coverage zone, bandwidth, etc.

GISAT-1 aka EOS-3 satellite:

- launched by GSLV-F10; failed
- issue with cryogenic stage (page57)

Nauka:

- lab module for Russia for ISS (pg-66)

Ganymede:

- largest moon in Solar system; (of Jupiter)
- evidence of water found recently using data from Hubble
- Galileo: 1st spacecraft to orbit Jupiter (1995-2003)
- Juno: 2nd spacecraft to orbit Jupiter (2016-)