



Ramanujan  
Machine



# GENERAL SCIENCE CAPSULE

Part -1

(June-November 2019)

**GUIDED SELF STUDY  
PROGRAMME**

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## Superconductivity

### ● Why in news?

- Researchers of IISc have recently reported that they have achieved superconductivity at room temperature.

### ● What is Superconductivity?

- Electricity is essentially free electron movement in materials such as copper.
- The passage of electrons in a conducting medium is spontaneous and haphazard in one particular direction.

- They often connect with each other and also other particles in the material and therefore causes resistance to current flow.
- **Superconductivity is a state in which there is virtually no electrical resistance in the material.**
- Superconductivity allows unimpeded movement of electrons which is only possible at extremely low temperatures, i.e in the 100 ° C range below freezing.
- Another property of a superconductor, is the Meissner effect- i.e the magnetic fields are excluded.
- John Bardeen, Leon Cooper and Robert Schrieffer modelled the absence of electrical resistivity in the form of electron mixing in the crystal grid (BCS principle).

### ● SIGNIFICANCE:

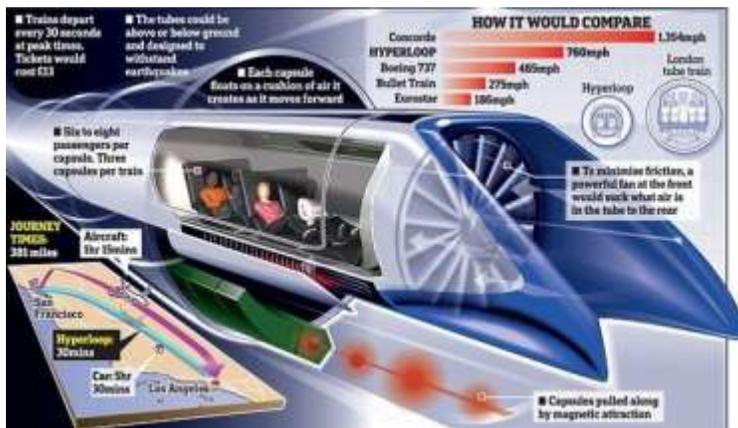
- Super-conductors built with room temperature are highly efficient in terms of both energy and cost savings.
- With the introduction of MRI devices superconductors have reduced the number of exploratory surgeries.
- The phenomenon of superconductivity, which has until now only happened at extremely low temperatures, is 100 ° C below zero.
- The researchers from the IISc recently shared a video that shows clear evidence of diamagnetism at ambient temperature and pressure.
- The team claimed to have achieved superconductivity at ambient temperature and pressure.
- Though superconductors will help build very high efficient devices leading to huge energy savings, it has not been possible to exploit it for everyday use as till now scientists had been able to achieve superconductivity only at temperatures far below 0°C.
- Hence the new discovery of IISc team, which has been able to achieve superconductivity at ambient pressure and temperature of 286 K (13°C) will be a huge breakthrough if the work stands the test of time and other groups succeed in reproducing the results.

## Hyperloop

### ● Why in news?

- Virgin Group and Maharashtra Govt have signed a new MOU to build a hyperloop between Mumbai and Pune.

● **Hyperloop**



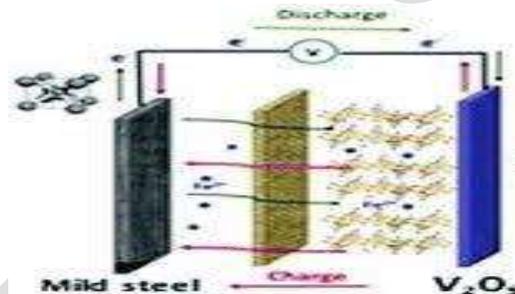
- It is a still untested mode of transport system based on the idea mooted by Elon Musk.
- It involves building a near-perfect vacuum tunnel or tube, a railway track and a vehicle that floats above the track on magnetic levitation.
- A payload- passengers or cargo, accelerates through electric propulsion and gains speed due to extremely low friction.
- Air caster skis at the bottom support the pod which sandwiches the passenger compartment between an air compressor upfront and a battery compartment at the rear.
- The skis float under high pressure on a thin layer of air, reducing the rolling resistance and allowing for high-speed travel of the tubes.
- Such capsules are designed to be driverless with projected velocities as high as 1,000 km/h.
- Linear induction motors control the velocity of the pod along the tunnel.
- Capsule speed is determined by electronically aided acceleration and braking.
- In 2018, the Maharashtra government approved Virgin Hyperloop One-led consortium’s plans to develop a high-speed line between Mumbai and Pune.
- The Pune-Mumbai line, which will be roughly 150km long, will run from the Bandra-Kurla Complex commercial centre in Mumbai to Wakad, a suburb of Pune.
- It can shrink the travel time between the two cities to under 30 minutes, instead of the 3.5-hour drive that it currently is.

**Iron Ion Battery**

● **Why in news?**

- IIT Madras has invented the world’s first rechargeable iron ion battery.

● **What is this battery?**



- The newly-developed battery by IIT-Madras is made using an anode made from low-carbon steel, along with a cathode made of vanadium pentoxide.
- Vanadium pentoxide has been selected since it has a layered composition with very wide interlayer spacing which allows iron ions to easily move in and bind to cathode interlayers, as well as easily separate themselves and move back to the anode.
- The electrolyte used is iron chlorate.

**Advantages over lithium-ion batteries:**

- The iron-ion battery is much more cost-effective and features slightly better storage capacity and stability compared to the traditional lithium-ion batteries.
- They are safer to use due to the inability of iron to produce dendrites during the charging process and therefore, prevents short-circuiting of the batteries.
- The other notable benefit is its favourable physical and chemical properties.
- It has good power retention after multiple charge cycles (It is capable of 150 cycles of charging and discharging for the time being).

**Drawback:**

- At the present stage, the energy density of the battery is able to reach around 220 Wh/kilo, which is only around 55-60 per cent of the 350 Wh/kilo of energy density for lithium-ion battery.

## Dirac Metals

### • Why in news?

- Researchers from IIT Bombay have discovered special properties in a class of materials called “semi-Dirac metals”.

### • What are Dirac Metals?

- Metals are good conductors of electricity in which energy depends on the momentum of electrons.
- Dirac metals differ from normal metals in that the energy depends linearly on the momentum of electrons.
- Semi-Dirac metals behave in one direction like Dirac metals and in perpendicular directions like regular metals (since their microscopic configuration is different in both directions). Examples of semi-Dirac metals are systems such as TiO<sub>2</sub>/V<sub>2</sub>O<sub>3</sub> nanostructures (Titanium and Vanadium oxides).
- Such materials would be transparent to light of a given frequency and polarisation when it is incident along a particular direction.
- The same material would be opaque to the same light when it falls on it from a different direction.
- The research shows very high optical conductivity of semi-Dirac materials of a specific frequency and specific polarization for electromagnetic waves[ light waves].

### • Applications

- Used for transparent film-making like the mobile touch screens.
- The material possesses interesting thermo-electric properties.
- Thermoelectricity is a clean energy system that utilizes waste heat to generate electricity usually for applications with low power.
- This technology is used in efficient cars, for keeping the lights on and to warm seats.

## Shanti Swarup Bhatnagar Memorial Prize

### • Why in news?

- The awards for the year 2019 were conferred by the PM Narendra Modi.

### • Which is the prize?

- Established in 1958, the award is named after Shanti Swarup Bhatnagar.
- It is awarded annually by the Scientific and Industrial Research Council (CSIR) with a memento and prize money of 5 lakhs.
- It is awarded for various science disciplines such as physical science, chemistry, biological science, medical science, mathematical science, computer science, earth science and planetary science.
- Every specialty will have no more than 2 award winners.
- The award winner must be an Indian resident with 45 years of research in the field.
- His work shall be made in the jurisdiction of India.

### Who is the Shanti Swarup Bhatnagar?

- He was the first director of CSIR (Scientific and Industrial Research Council) and University Grants Commission (UGC).
- In 1954 he received the Padma Bhushan award.

## Geochemical Baseline Atlas

### • Why in news?

The CSIR-National Geophysical Research Institute (NGRI) developed Geochemical Baseline Atlas of India to be used by policymakers to evaluate environmental damage.

### • What is this Atlas?

- This is an atlas of 45 metals, oxides and elements in India's upper and lower soil.
- It will be used to assess the changes in chemical composition on the surface of the earth by future generations.
- These maps help to track potential emissions from polluting industries or other structures.
- There was no way earlier to prove that polluters resisted environmental damage.
- The atlas helps policymakers to learn about high and low metal concentrations in regions. For example, Tanneries release chromium. The policymakers will

learn about regions with a high concentration by going through the map of chromium.

## Kimberley process certification scheme

### • Why in news?

- India held a plenary meeting of the Kimberly Process Certification Scheme (KPCS) from 18th-22nd November, 2019. This is an important protocol in trade of diamonds which has ensured that **99.8% of the diamonds in the world are conflict-free.**

### What is the Kimberly Process Certification Scheme?

- The Kimberley Process was established in 2008 and regulates trade in rough diamonds.
- The goal is to avoid the movement of diamonds in conflict and to protect legitimate trade in raw diamonds.
- **Conflict Diamonds** means rough diamonds used by rebel movements or their allies to finance conflict aimed at undermining legitimate governments.
- The KPCS came into effect from 1st January 2003 and evolved into an effective mechanism for stopping the trade in conflict diamonds.
- It is also described in the United Nations Security Council (UNSC) resolutions.
- The KP is not an international organization, and it has no permanent office.
- It is based on members' participation, sponsored by business and civil society experts, under the burden-sharing concept.
- It cannot be regarded as an international agreement from the legal point of view by participant nations.
- There are 55 members currently.
- India has been one of the KPCS founding members.
- More than once, India presided over KPCS.
- India is now producing about 24 billion US dollars of cut and polished diamonds to meet its export goal of 1 trillion US dollars in the coming years.
- KPCS is of immense importance to India as **more than one million people are directly employed** by the diamond industry.
- The Commerce Department is the nodal department in this regard.

## Selenium Graphene-based catalyst in Fuel Cell

### • Why in news?

- A selenium-graphene catalyst has been developed by a team of scientists from India.

### • What is this?

- Platinum and other such metals which are expensive are used as catalysts in today's fuel cells.
- However, their efficiency in many purposes is not reliable.
- Graphene modified with very low amounts of selenium atoms can work like platinum in a seen reaction by scientists.
- The "soft" catalyst for the oxygen decrease reaction in fuel cells is the graphene itself.
- The oxygen reduction reaction is a key step in the functioning of the fuel cell where Graphene by itself is a "poor" catalyst of this reaction.
- It involves the reduction of oxygen in two steps, each of which consumes two electrons.
- Neither selenium nor graphene are useful by themselves, but the combination of both works efficiently.
- The fuel cells with methanol have a poisoning effect (process where the methanol reaches the negative electrode and coats it thus making the electrode ineffective after some cycles).
- It has been found that the developed catalyst is highly poisoning-tolerant.

### What does selenium mean?

- Selenium is a non-metallic chemical element in the periodic table belonging to Group XVI.
- This behaves like arsenic and tellurium in chemical behaviour and physical properties.
- Selenium has excellent photovoltaic and photoconductive characteristics and is commonly used in electronics, including photocell, light meters, and solar panels.

### What is a Fuel Cell?

- Fuel cells are electrical systems that translate chemical energy directly from reactants into electricity and heat.

- The device consists of a pore anode and a cathode on one side of the electrolyte layer.
- Gaseous fuels are continuously fed into the anode in a typical fuel cell (negative electrode), while oxidants (air oxygen) are fed into the cathode continuously (positive electrode). In order to produce an electric current, electrochemical reactions take place on the electrodes.

## Ramanujan Machine

### ● Why in news?

- Technion researchers of Israel Institute of Technology have designed a Ramanujan Computer.

### What is this machine?

- It is a network of computers running algorithms devoted to conjecturing the continued fractions of fundamental constants.
- The machine has the purpose of producing conjectures (these are still unproven mathematical statements) that people can mathematically analyze and hopefully prove true.
- The machine is designed to inspire future generations of mathematicians.

### Srinivasa Ramanujan:

- Born on December 22nd, 1887 in Erode, Tamilnadu, the day is celebrated in his memory as the National Day of Mathematics.
- Famous British mathematician Godfrey Harold Hardy acknowledged his talent in 1913 and invited Ramanujan to Cambridge.
- Ramanujan made significant contributions and worked on elliptical functions to analytic number theories.
- He worked on the whole number division, hypergeometric series and the constant of Euler as well.
- He published his papers in English and European journals and was elected to the Royal Society of London in 1918.
- He died after a long illness on 26 April 1920, in India.

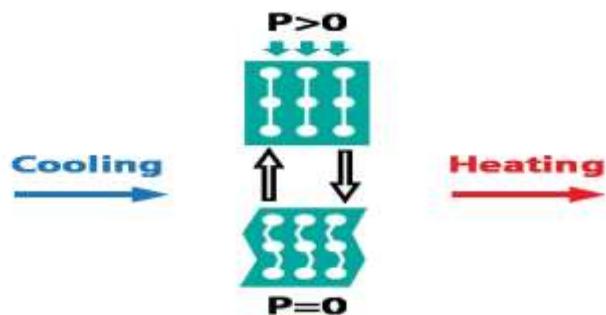
## Elastocaloric Effect

- When rubber bands are twisted and untwisted, it produces a cooling effect called the “electrocaloric” effect.

- The electrocaloric effect can be regarded as the entropy change under isothermal condition or temperature change under the adiabatic condition when mechanical stress is used or released in a given material.
- Basically, electrocaloric materials are solids capable of stress-induced reversible phase transformations during which latent heat is released or absorbed.

### ● Why in news?

- This method, according to a research paper published recently, can be used to do away with refrigerants (These are leak-prone fluids and can contribute to global warming in refrigerators and air conditioners).
- The transfer of heat in the electrocaloric effect is as effective as the expansion and compression of fluent refrigerant.



- The researchers compared the cooling capacity of rubber fibres, nylon and polyethene fishing lines and nickel-titanium wires to find out how the twisting mechanism would allow a cooling system.

## Ceramic Membrane

### ● Why in news?

- Scientific and Industrial Research Council CSIR-NEIST has developed a ceramic membrane that is able to clean toxic effluents with the aid of the potter's mixture of clay, stein dust and tea waste.
- These filters are particularly useful for petrochemical processing where organic membranes can not be used.
- It is able to remove dimethylene blue, a toxic colour and Congo red, a carcinogen, from water.



- His birth anniversary was celebrated this year on October 30.

### Who is he?

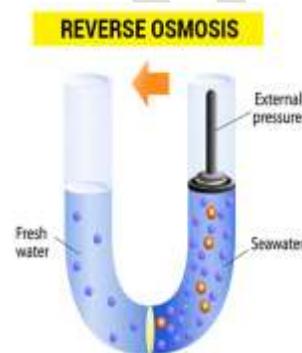
- Also known as the Father of India's nuclear programme, he helped India accomplish a variety of atomic science feats.
- He was educated at Elphinstone College, Bombay and Cambridge, United Kingdoms, and born in Mumbai to an affluent Parsi family.
- He studied mechanical engineering in line with his family's wishes and then also graduated in math.
- He received a PhD in nuclear physics in 1933. His thesis paper was titled 'The Cosmic Radiation Absorption.'
- In Oslo, he worked with Nobel laureate Niels Bohr while teaching in Cambridge.
- The scientific community greatly appreciated a paper published in 1935 on electron-positron spreading and was later renamed Bhabha spreading.
- He joined in 1939, the Department of Physics at the Indian Institute of Science.
- The Cosmic Ray Research Unit was founded at the IISC.
- He played a key role in establishing the Tata Institute of Fundamental Research in Mumbai.
- Bhabha persuaded Jawaharlal Nehru, the then Prime Minister, to start a nuclear program.
- In 1945 he founded the Tata Foundation Research Institute and in 1948 the Atomic Energy Commission and became its first chairman.
- Bhabha led IAEA India and was also Chairman of the UN Conference on the Peaceful Uses of Atomic Energy in Geneva in 1955.
- Bhabha played a key role in planning the nuclear program plan of the government.
- Instead of using meagre uranium reserves in India, he pioneered the use of thorium to remove uranium from it.
- Based on his ideas the three-stage plan for nuclear power was conceived in India.
- On 24 January 1966, on his way to Austria, Homi Bhabha died in a plane crash.
- The Bhabha Atomic Research Center (BARC), formerly referred to as the Atomic Energy Establishment was founded by him in Mumbai in 1954.
- Adams prize (1942) by Cambridge University, Padma Bhushan (1954) by the Indian government, Royal

Society Fellow, London are some of the honours bestowed on him.

### Reverse Osmosis(RO)

#### ● Why in news?

- The NGT had issued an order stating that RO purifiers to be banned if they had less than 500 mg/litre total dissolved solids (TDS) in water. The Supreme Court rejected the NGT order and requested the RO Association to approach the Center with its complaints.



#### What is reverse osmosis?

- Osmosis is the movement of solvent molecules from the region of pure solvent (area of low solute concentration) towards the solution (area of higher solute concentration) through a semipermeable membrane.
- Using the concept of osmosis and osmotic pressure, a process called reverse osmosis (RO) has been devised.
- RO is a process in which a large pressure is applied to the solution side so as to overcome the osmotic pressure.
- This pushes the pure solvent under pressure, out of the solution through the semipermeable membrane.
- This process finds a number of practical applications like purification of drinking water, removal of salt from water molecules, removal of effluents from water, etc.

### Nobel prize for Physics

#### ● Why in news?

- Nobel Prize in Physics 2019 has been awarded to **James Peebles** "for theoretical discoveries in physical cosmology" and to **Michel Mayor and Didier Queloz**

“for the discovery of an exoplanet orbiting a solar-type star”.

### Evolution of universe:

- James Peebles’ theoretical framework, developed since the mid-1960s, is the basis of our contemporary ideas about the universe.
- The importance of the cosmic radiation during birth of the Big Bang was realized by him.
- Barely 400,000 years after the Big Bang, the universe became transparent and light rays were able to travel through space.
- Using his theoretical tools and calculations, James Peebles interpreted traces from the infancy of the universe and discovered new physical processes.
- The universe in which just five per cent of its content is known constitutes stars, planets, trees and us.
- The remaining 95 per cent is unknown dark matter and dark energy.
- This dark energy helps the universe’s increasingly rapid and constant expansion.

**The unknown & an exoplanet**

Canadian-American cosmologist James Peebles and Swiss scientists Michel Mayor and Didier Queloz won the 2019 Nobel Prize for Physics for revealing the wonder of the evolution of the universe and discovering exoplanets

The universe was in a hot and dense state, and 14 billion years ago there was a “big bang” and then it started expanding and cooling down

**BIG BANG**

Four lakh years later, the “first rays” of light travelled through space. These rays still exist in the cosmos and are omnipresent

James Peebles, Michel Mayor, Didier Queloz

- Peebles interpreted the “first rays” and showed that in the universe just 5% is known matter. The rest is unknown dark matter & dark energy. His insights turned cosmology from speculation to science sparking further research
- The dark matter is the force which holds together galaxies which otherwise may get torn apart. The dark energy helps the universe’s increasingly rapid and constant expansion. Thus, one pulls and the other pushes

- Mayor and Queloz discovered “51 Pegasi b” — first-ever find of an exoplanet orbiting a solar-type star
- Surprisingly, the planet was as big as Jupiter (1,300 times Earth’s volume) but was very close to its star (takes just 4 days to orbit)
- Big planets were thought to be created far from their stars. How did “51 Pegasi b” get so close? This question led to theories that described how large gas balls formed at the edges of their solar systems, then spiralled inward

### Discovery of exoplanet:

- In October 1995, Michel Mayor and Didier Queloz announced the first discovery of a planet

outside our solar system, an exoplanet, orbiting a solar-type star in the Milky Way.

- At the Haute-Provence Observatory in Southern France, using custom-made instruments, they were able to see the planet 51 Pegasi b.
- It is a gaseous ball comparable with the solar system’s planet, Jupiter.
- With this discovery, we now know that a quarter of all stars have a planet of Earth’s size and surface temperature, with the potential of hosting liquid water and the chemistry of life on its surface.
- Over 4,000 exoplanets have since been found in the Milky Way.

## **Nobel prize for Medicine/Physiology**

### ● **Why in news?**

The Nobel Prize in Physiology or Medicine for 2019 has been **jointly awarded to William G. Kaelin, Sir Peter J. Ratcliffe, and Gregg L. Semenza, for ‘their discoveries on how cells sense and adapt to oxygen availability.’**

### What is the discovery all about?

The discovery by scientists aims to identify the molecular machinery that regulates the activity of genes in response to varying levels of oxygen and understand how underlying cells adapt to such variations in oxygen supply.

Oxygen is used by the mitochondria present in virtually all animal cells in order to convert food into useful energy. The carotid body, adjacent to large blood vessels on both sides of the neck, contains specialized cells that sense the blood’s oxygen levels.

In addition to the carotid body-controlled rapid adaptation to low oxygen levels (hypoxia), a key

physiological response to hypoxia is the rise in levels of the **hormone erythropoietin (EPO)**, which leads to increased production of red blood cells (erythropoiesis).

#### Gregg Semenza:

He is credited with identifying a set of DNA-binding proteins called hypoxia-inducible factor, or HIF, which spur the hypoxia response and activates the genes that make EPO.

HIF was found to consist of two different DNA-binding proteins, called transcription factors, now named HIF-1a and ARNT. When oxygen levels are high, cells contain very little HIF-1a. However, when oxygen levels are low, the amount of HIF-1a increases so that it can bind to and thus regulate the EPO gene.

#### William Kaelin, Jr:

His research is about a genetic syndrome, Von Hippel-Lindau's disease (VHL disease) which leads to dramatically increased risk of certain cancers in families with inherited VHL mutations. Kaelin showed that the VHL gene encodes a protein that prevents the onset of cancer.

But cancer cells lacking a functional VHL gene express abnormally high levels of hypoxia-regulated genes but that when the VHL gene was reintroduced into cancer cells, normal levels were restored. This was an important clue showing that VHL was somehow involved in controlling responses to hypoxia.

#### Sir Peter J. Ratcliffe:

Ratcliffe and his research group discovered that VHL can physically interact with HIF-1a and is required for its degradation at normal oxygen levels. This conclusively linked VHL to HIF-1a.

Oxygen sensing is central to a large number of diseases. E.g. patients with chronic renal failure often

suffer from severe anemia due to decreased EPO expression.

When oxygen levels are low in the cells, this mechanism signals the kidneys to produce more red blood cells, which carry the vital molecule throughout the body. Thus the three scientists focused on developing drugs that could treat diseases by either activating or blocking the body's oxygen-sensing machinery.

#### How is the discovery useful?

Researchers hope new advances in this field can ultimately develop treatments that help mitigate the effects of hypoxia-related illnesses, such as coronary heart disease and anemia.

People with chronic kidney disease can't make erythropoietin and therefore have hypoxic cells. Now, erythropoietin can be produced in the lab and injected into patients.



An oral treatment for anemia called roxadustat, which prevents the breakdown of HIF and subsequently makes more erythropoietin, is in the middle of a clinical trial in China. These types of treatments could even be used to treat neurodegenerative diseases or help repair the brain after a stroke.

Most chemotherapy drugs are currently designed to kill well oxygenated cells, but there's a dearth of approved

treatments that target hypoxic cancer cells. Now drugs that will inhibit HIF activity as an addition to existing cancer therapies can be developed.

## Nobel Prize for Chemistry

### • Why in news?

The 2019 Nobel Prize in Chemistry has been awarded to **John B. Goodenough, M. Stanley Whittingham and Akira Yoshino** "for the **development of lithium-ion batteries**".

### Science behind lithium ion batteries:

At the time, it was assumed that metallic lithium should serve as the anode in the batteries special focus was put on identifying matching cathode materials. Those materials with high reduction potential that were able to accommodate lithium ions at high transfer rates were of special interest.

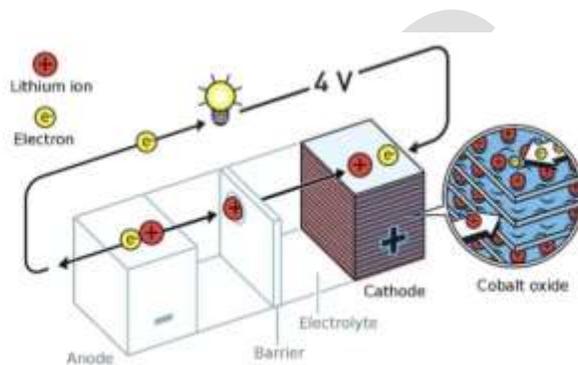
Titanium disulfide ( $\text{TiS}_2$ ) was shown to be able to host lithium ions by Walter Rüdorff in 1965. This structure was lamellar with  $\text{TiS}_2$  arranged in layers, between which lithium ions could become intercalated.

The intercalation effect was further demonstrated by M. Stanley Whittingham and his team who showed that lithium can be chemically intercalated in the  $\text{Li}_x\text{TiS}_2$  material. Hence he used extremely energy rich  $\text{TiS}_2$  to create an innovative cathode in a lithium battery.

The battery's anode was partially made from metallic lithium, which has a strong drive to release electrons. This resulted in a battery that literally had great potential, just over two volts. A working, rechargeable battery was subsequently demonstrated in 1976. However, metallic lithium is reactive and the battery was too explosive to be viable.

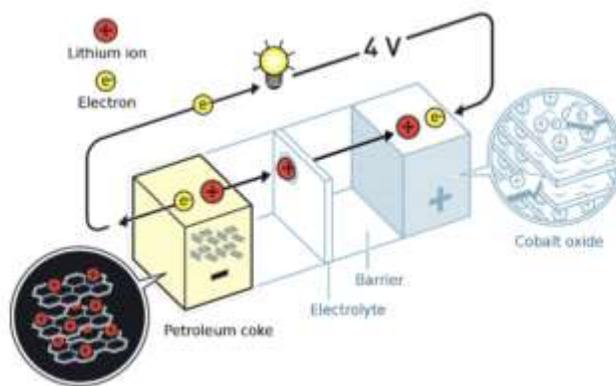
John Goodenough predicted that the cathode would have even greater potential if it was made using a metal oxide instead of a metal sulphide. In 1980 he

demonstrated that cobalt oxide ( $\text{CoO}_2$ ) with intercalated lithium ions can produce as much as four volts which would lead to much more powerful batteries.



### Lithium-based battery using $\text{Li}_x\text{CoO}_2$ as the cathode

With Goodenough's cathode as a basis, Akira Yoshino created the first commercially viable lithium-ion battery in 1985. Instead of using reactive lithium in the anode, he used petroleum coke, which like the cathode's cobalt oxide, can intercalate lithium ions.



### Ion transfer cell lithium-ion battery configuration

These discoveries and developments ultimately led to the release of a commercial lithium battery in 1991 which was a lightweight, hardwearing battery that could be charged hundreds of times before its performance deteriorated.

The advantage of lithium-ion batteries is that they are not based upon chemical reactions that break down the

electrodes, but upon lithium ions flowing back and forth between the anode and cathode.

### Chemical properties of Li:

- With atomic number 3, lithium is the lightest metal with a density of only 0.53 g/cm<sup>3</sup>.
- It also has a very low standard reduction potential, thus making it suitable for high-density, high-voltage battery cells.
- Lithium is a relatively reactive metal, which has to be protected from water and air.

### Applications:

- Power backups/UPS
- Mobile, Laptops, and other commonly used consumer electronic goods
- Electric mobility
- Surveillance systems
- Energy Storage Systems (solar, wind)
- Light and reliable marine performance

### Comparison with other batteries:

Nickel Cadmium (NiCd) - has relatively low energy density. The NiCd is used where long life, high discharge rate and economical price are important. Main applications are two-way radios, biomedical equipment, professional video cameras and power tools. The NiCd contains toxic metals and is environmentally unfriendly.

Nickel-Metal Hydride (NiMH) - has a higher energy density compared to the NiCd at the expense of reduced cycle life. NiMH contains no toxic metals. Applications include mobile phones and laptop computers.

Lead Acid - most economical for larger power applications where weight is of little concern. Used for hospital equipment, wheelchairs, emergency lighting and UPS systems.

Lithium Ion (Li-ion) - fastest growing battery system. Is used where high-energy density and lightweight is of prime importance. The technology is fragile and a protection circuit is required to assure safety.

## **Coal Bed Methane**

### • **Why in news?**

- Coal's Ministry has asked Coal India Limited (CIL) to produce 2 MMSCBs per day of coalbed methane (CBM) gas in the next two or three years.

### **What does CBM consist of?**

- CBM is an unconventional natural gas form in coal deposits and carbon seam formed during the gasification process.
- India has the fifth largest proven coal reserves in the world.
- The vast majority of the best prospective areas for CBM development are in eastern India, situated in Damodar Koel valley and Son valley.
- CBM projects exist in Raniganj South, Raniganj East and Raniganj North areas in the Raniganj coalfield, the Parbatpur block in Jharia coalfield and the East and west Bokaro coalfields.

**Applications-** Generation of power, Auto-fuel compressed gas (CNG), as nitrogen feedstock, Production of cement, methane and steel.

### **Issues -**

1. Methane is a CBM mining greenhouse gas. The global carbon mining methane emissions are estimated to account for about 8% of total global emissions of methane.
2. Disruption of drilled lands and their effect on habitats of wildlife leads to damage of ecosystems.
3. Production behaviour in CBM at an early stage of recovery is complex and difficult to predict.
4. Another issue is the possible impact on downstream water sources of water of CBM development.
5. High-salinated water to be disposed of in order to release the methane is a risk because it could have adverse effects on freshwater ecosystems.

## Fly Ash

### • Why in news?

- IIT Hyderabad scientists have converted fly ash into waterproofing material.

### Fly Ash

- Fly ash is a fine powder that is a byproduct of burning pulverized coal in electric generation power plants.
- Fly ash is a pozzolan, a substance containing aluminous and siliceous material that forms cement in the presence of water.
- When mixed with lime and water, fly ash forms a compound similar to Portland cement.
- This makes fly ash suitable as a prime material in blended cement, mosaic tiles, and hollow blocks, among other building materials.

### Problems-

- It is a pollutant and a major source of Particulate matter (PM) 2.5 in the summer.
- It contains black carbon (BC) and other heavy and toxic metals like chromium, copper and lead.
- Makes water unworthy of drinking and cause potential damage for growing crops.
- It contains more radiation than nuclear wastes.

## Coal gasification plant for Urea

### • Why in news?

- Chemicals & Fertilizers Ministry recently concluded a coal gasification plant contract in Talcher, Odisha for the urea sector.

### About the plant:

Presently urea is produced in the country using pooled natural gas, which includes domestic natural gas and imported LNG. The use of natural raw material for urea and other fertilizers in a country is therefore desirable.

- The project will enhance the independence of India in Urea and promote agriculture.
- It will promote the environmentally friendly use of highly available domestic coal.
- This shall also accelerate the use of coal for the manufacture of synthetic gas (SNG), as opposed to the

combustion of fossil fuels, in other products such as synthesizing, gasoline, methanol, petrochemicals, etc.

- It produces syngas, which is mainly composed of methane (CH<sub>4</sub>), carbon monoxide (CO) and hydrogen (H<sub>2</sub>), used primarily for the production of electricity, and for chemical feedstock production.
- The hydrogen produced by coal gasification could be used to produce ammonia, to promote a hydrogen economy for various purposes.

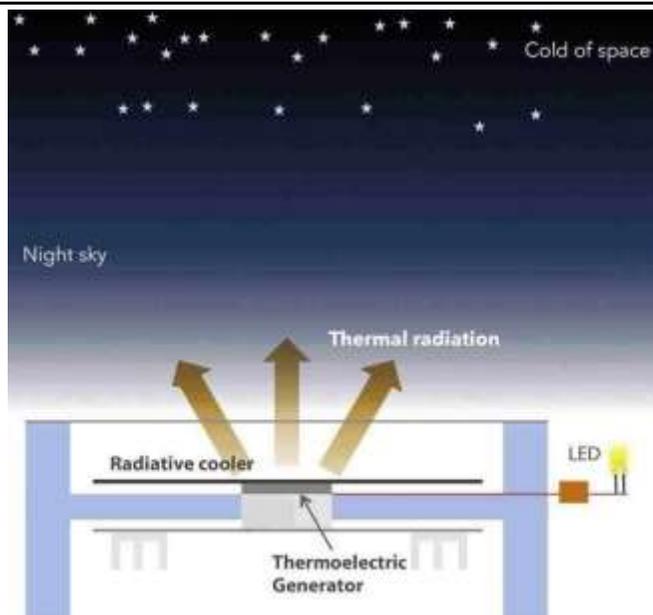
## Radiative cooling and electricity generation

### • Why in news?

A scientist of Indian-origin has demonstrated a new way to generate electricity at night.

### What is this method?

- The prototype device employs radiative cooling, in which a sky-facing surface passes its heat to the atmosphere as thermal radiation, losing some heat to space and reaching a cooler temperature than the surrounding air.
- This effect describes how frozen plants grow during freezing nights and the same theory may be used to generate renewable electricity by manipulating changes in temperature during the night when the need for illumination increases.
- This instrument releases the heat uniformly so that the cooling on the top is better than the cooling on the bottom and the difference between heat and electricity is then converted.
- The heart of the device is a generator that uses the temperature difference between the opposite sides to produce the current.
- The control could be controlled by a white LED when the system is connected to a voltage converter.
- Six thousand years ago, people in Iran and Afghanistan constructed enormous **beehive-shaped structures** called **Yakhchal**, which used this **passive cooling** effect to **create and store ice in the desert**.



### Application-

This could be a broadly enabling approach to power generation suitable for remote locations and anywhere where power generation at night is needed. As of now, the amount of electricity it generates per unit area remains relatively small, but the researchers predict it can be made twenty times more powerful with improved engineering such as by suppressing heat gain in the radiative cooling component to increase heat-exchange efficiency.

### Indigenous fuel cells

#### ● Why in news?

- The President of India launched the first Indian High-Temperature Fuel Cell System developed by CSIR.

#### What is this?

- It is a special example of Public-Private Partnership (PPP) among the CSIR-NCL, Pune, CSIR-NPL, New Delhi & CSIR-CECRI, Karaikudi (Chennai Center)] and two Indian industries; M/s Thermax Limited, Pune and M/s Reliance Industries Limited, Mumbai e Mumbai.
- The 5.0 kW fuel cell system produces green energy using methanol / bio-methane, with heat and water for further utilization as bi-products, which amount to over

70 per cent of efficiency which other energy sources may not otherwise achieve.

- The designed combustible cells are based on high-temperature HTPEM technology.
- The technology developed is world-class and its growth will put India in the league of developed nations with such a knowledge base.

### Applications:

- The development of the system is best suited to distributed fixed power systems such as small offices, commercial units, data centres, etc., where highly reliable power with simultaneous air conditioning requirements is essential.
- It also satisfies the needs of a power generator for telecom towers, remote locations and strategic applications with efficiency, cleanness and reliability.
- This would replace diesel generator sets (DGs) and help to reduce India's crude oil dependency.
- The distributed power generation systems of Fuel Cell are emerging as a viable alternative to grid power in the area of clean energy.

### Hydrothermal carbonization

#### ● Why in news?

- The method of hydrothermal carbonization (HTC) has been tailored by IIT Kharagpur research team to the Indian environment and is capable of effectively handling mixed, high humidity, urban solid waste (MSW).

#### What are hydrothermal charges?

- Presently, India has adopted a waste incineration process similar to developed countries that mainly focuses on the treatment of drier waste.
- These processes require high energy consumption for the burning of urban solid waste in India.
- Due to tropical weather, open collection systems and mixed waste, only 20-30% of organic fraction of municipal solid waste is being recycled to biofuel.
- The new technology of Hydro Thermal Carbonization (HTC) can convert wet municipal solid waste to biofuel, soil absorbents.
- The moisture in the waste is used to the advantage of the process which uses water for the reaction.
- The biofuel generated as the recovered output is comparable to lignite coal thus significantly addressing

the fossil fuel depletion issue and helping curb air pollution issues.

- The product can further be used as an absorbent to manage soil contamination which could significantly help brownfield sites or contaminated industrial sites or landfills.
- The technology can be used by the civic bodies to effectively manage solid waste.
- Once the organic waste is entered into the process, the outputs generated are all usable.

## Bayesian Inversion

### ● Context

- Scientists at ISRO have used a novel mathematical technique called Bayesian inversion and analysed satellite images to estimate the strength of North Korea's underground nuclear test of September 2017.
- It was found that the explosive yield was about 17 times that of the Hiroshima explosion.
- According to the test site analysis data, those tests are considered the most powerful thermonuclear devices to have been developed by the country.
- In the normal course, the detection and estimation of nuclear device explosions is based on the reading of earthquake monitoring sensors.
- The test site was at Mount Mantap, Punggye-ri.
- For the purpose of analysis, the images of the location of the explosion were sourced from the ALOS-2, a Japanese satellite, and Sentinel 1B, a European radar imaging satellite.

- This information is important to determine the type of bomb, and consequently, the degree of know-how the detonating country possesses.
- The uncertainties in the yield and source depth estimated using the Bayesian modelling of InSAR data were significantly less than that of seismic methods.
- InSAR refers to the interferometric synthetic aperture radar and is a radar technique used to generate maps of how a place would look after an earthquake or a detonation.
- According to ISRO, Bayesian inversion can correct for errors and uncertainties in the yield and depth data by 25-85% and 40-97% respectively.
- The estimates of a yield of 250 kilotons with the assessment held by the US scientists in June stated that the 2017 test was about 10 times more powerful than the tests first conducted by North Korea in 2016.

