CURRENT AFFAIRS PROGRAM
PRE CUM MAINS 2024
DEC 2023: BOOKLET-5

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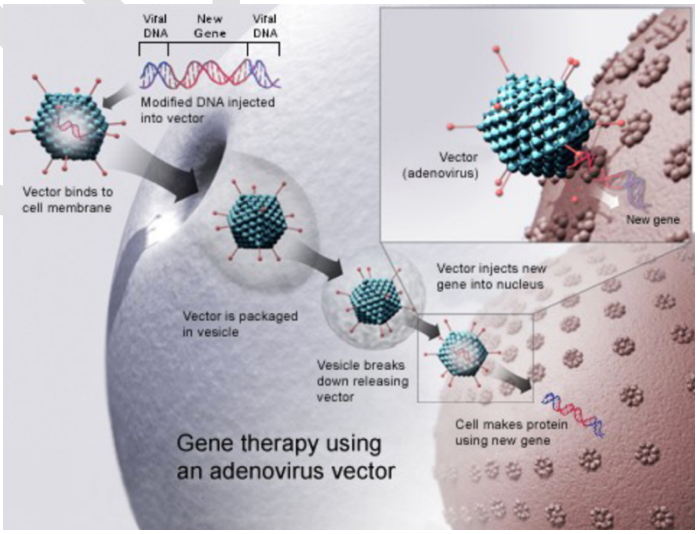
1. GENERAL STUDIES – 3: S&T UPDATES

1) GENE THERAPY

- **Example Questions**

  » Gene therapy is gaining popularity in developed countries to treat various types of rare genetic disorders. Describe briefly what gene therapy is and what advantages it has over other treatments? How are National Guidelines for Gene Therapy Product development and Clinical Trials, 2019 going to contribute to the gene therapy development in the country. [250 words, 15 marks]

- **Introduction**
  - **Gene therapy** refers to the process of introduction, removal or change in the content of an individual's genetic material with the goal of treating the disease and a possibility of achieving long term cure.
    - For e.g. UK recently approved **Casgevy**, a gene therapy production which genetically replaces the defective genes which are responsible for causing sickle cell anaemia.
  - **Gene Therapy Products (GTPs)** include the mechanisms to deliver nucleic acid components by various means for therapeutic benefit to patients. They include entities that are used for things like gene augmentation, gene editing, gene silencing, synthetic or chimeric gene augmentation etc.



- **Advantages of promoting gene therapy**
  - **Permanent result may be a possibility**: Once the faulty genetics are replaced by the correct genes, the positive impact may be long lasting, sometimes permanent too.
  - Gene therapy is the only option for the treatment of several genetic diseases.
  - **High burden of rare genetic diseases in India:** Around 7 core of India's population suffers from rare genetic diseases. Gene therapy can prove to be a turning point in treatment of such genetic diseases.
  - **Worldwide market for the gene therapy products** is expected to go to $250 billion by 2025.

- **Steps taken by India:**
  - » **National Guidelines for Gene Therapy Product Development and Clinical Trials – Released by ICMR in Dec 2019**
    - Aims to ensure that **gene therapies are introduced in India** and **clinical trials for gene therapy can be performed in an ethical, scientific and safe manner.**
    - Provides for general principles for developing gene therapy products (GTPs) for any human ailment.
    - Provides a **framework for all areas of GT**P production including pre-clinical testing, clinical administration, human clinical trials, as well as long term follow ups.
    - They **apply to all stakeholders** involved in the field of gene therapy including researchers, clinicians, oversight/regulatory committees, industry, patient support groups and any other involved in GTP development or their application in humans and their derivatives.
    - The guidelines will serve as a **roadmap** for those in the field trying to develop gene and cell therapies and will thus **contribute to accelerating the development** of advanced therapeutic options
  - » **ICMR** has also proposed setting up of task force to promote gene technology research in the country.

- **Concerns/Limitations/ Challenges associated with Gene Therapy**:
  - » **Technical Challenges:**
    - Unwanted immune response; gene therapy targeting wrong cells; the delivery viruses may mutate and become harmful.
  - » **Affordability issues:**
    - Gene therapy products are very expensive (for e.g. gene therapy for sickle cell anaemia recently approved in UK costs approx. $2 million)
    - **Absence of local manufacturing capacity** leads to most GTPs needing to go to another country for processing which also increases the cost.
  - » **Ethical Challenges**
    - For e.g. creation of GM babies using germline gene editing by a Chinese scientist attracted global criticism and fueled debate on ethical concerns regarding applications of gene therapy technologies.
    - **Playing God** debate.

- **Way Forward:**
  - » **Policy Interventions** are needed to improve infrastructure of biotechnology research in the country.
  - » **Promoting PPP** in the gene therapy sector can increase the amount of required investments.

» **Capacity building of healthcare professionals** to deliver gene therapy products once developed.
» **International Collaboration** for tech-transfer, knowledge sharing etc.
» **Awareness Generation**: Here community engagement will be crucial to promote screening for genetic disease.
» **Continue to explore and promote alternatives,** such stem cell transplant wherever possible to develop complementary alternatives.

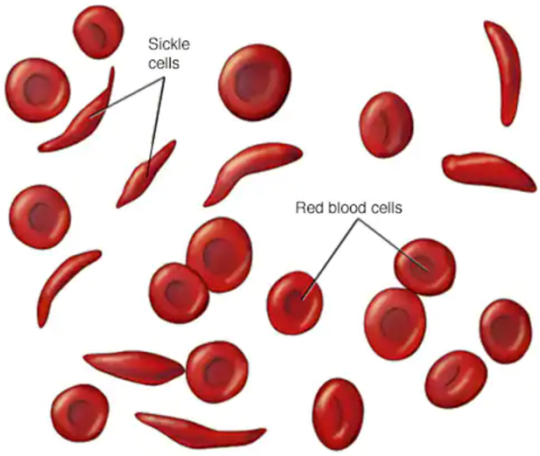
- **Conclusion:**
  » Gene therapy acts as a beacon of hope for crores of patients in India suffering from rare genetic diseases. Therefore, it is important that through various policy intervention and international collaboration more R&D in the field is promoted and gene therapy products which are not only of very high quality but also affordable.

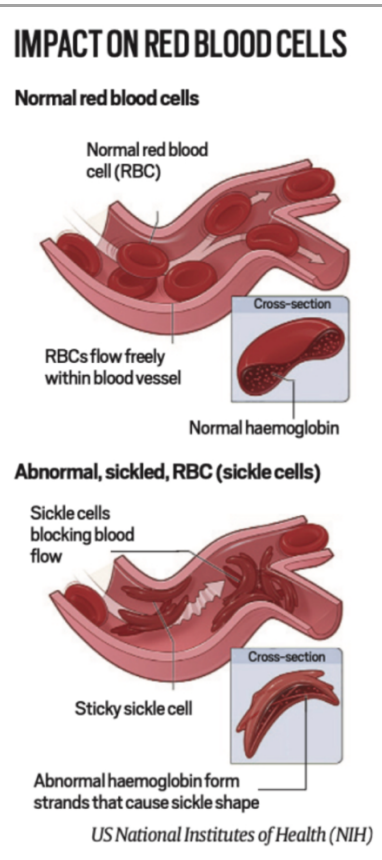
2) SICKLE CELL ANAEMIA

- **Why in news?**
  » The first therapy based on gene editing technology Crispr-Cas9 for Sickle cell disease and thalassemia has been approved in UK (Nov 2023)

About Sickle Cell Anaemia:
It is one of a group of inherited disorders known as Sickle Cell Diseases. It affects shape of the red blood cells which carry oxygen to all parts of the body.

RBCs are usually round and flexible so that they move easily through the blood vessels. But, in sickle cell Anaemia, some of the RBCs are shaped like sickle and also become rigid and sticky. This slows or blocks blood flow.





Note: Both Sickle Cell Anaemia and thalassemia are caused by **errors in the gene for haemoglobin**, a protein in the red blood cells that carry oxygen to organs and tissues. **Symptoms**: Anaemia -> fatigue; Episodes of extreme pain called pain crises; Swelling of hands and feet; delayed growth and puberty; Vision problems etc.	

- **Treatment:**
  - No cure (except bone marrow transplant)
  - UK has recently approved a gene therapy for the treatment of sickle cell anaemia.

- **The UK Drug** Regulator, in a landmark breakthrough, in Nov 2023 approved a gene therapy for the cure of **sickle cell disease** and **thalassemia**.
  - This therapy is called **Casgevy**. It is the first licensed therapy in the world based on gene editing technology CRISPR-CAS9. This therapy edits the faulty gene that leads to these blood disorder, potentially curing person for life.

- **How does the therapy work?**
  - The therapy uses the patient's own blood stem cells, which are precisely edited using Crispr-Cas9. A gene called BCL11A, which is crucial for switching from foetal to adult is targeted in the therapy.
  - Foetal haemoglobin, which is naturally present in everyone at birth, doesn't carry the same abnormalities as adult haemoglobin. The therapy uses the body's own mechanisms to start producing more of this foetal haemoglobin, alleviating the symptoms of the two conditions.

- **How is the therapy prepared and given**:
  - **Casgevy** is one time treatment for which the doctor has to first collect blood stem cells from the bone marrow using a process called apheresis - used to filter out the blood for different components. The cells are then sent to the manufacturing site where it takes about six months for them to be edited and tested.
  - **Then the edited cells are then transplanted**. Before this doctor gives a conditioning medicine for a few days to clear the bone marrow of other cells that will be replaced by modified cells.
  - **The patient has to stay in hospital for at least one month** so that the edited cells take up the residence in bone marrow and start making RBCs with normal haemoglobin.
- **Side effects** from the treatment are similar to those associated with autologous stem cell transplants, including nausea, fatigue, fever and increased risk of infection.

- **Key challenges of the treatment:**
  - » **Very Costly**: it is estimated that the therapy will cause around $2 million per patient, which is in line with other gene therapies.
  - » **Absence of local manufacturing technology**: This means that the harvested blood stem cells have to be sent across countries.
  - » **Preventing the misuse of CRISPR-CAS9**:

- **Situation in India**:
  - An estimated 30,000 - 40,000 children in India are born with this disorder every year. Thus, India has one of the highest burdens of sickle cell anaemia in the world.
- **Steps taken by India:**
  - In Budget 2023-24, a **Mission to Eliminate Sickle Cell Anaemia by 2047** was announced. It entails awareness creation, universal screening of 7 crore people in the age group of 0-40 years in affected tribal areas, and counselling through collaborative efforts.

- **Way Forward:**
  - **Identify people suffering from Sickle Cell Anaemia**: Awareness creation; universal screening of people in the age group of 0-40 years in affected tribal areas; counselling through collaborative efforts.
  - **Replicate the success of this therapy in India** while keeping the cost affordable.
  - **Create an environment for development** of various gene therapy productions using CRISPR CAS9
    - More funds to various research institutions
    - Improving infrastructure of research labs etc.
  - **Strengthen regulatory framework** of Gene Therapy Products (GTP) in India to prevent its misuse.

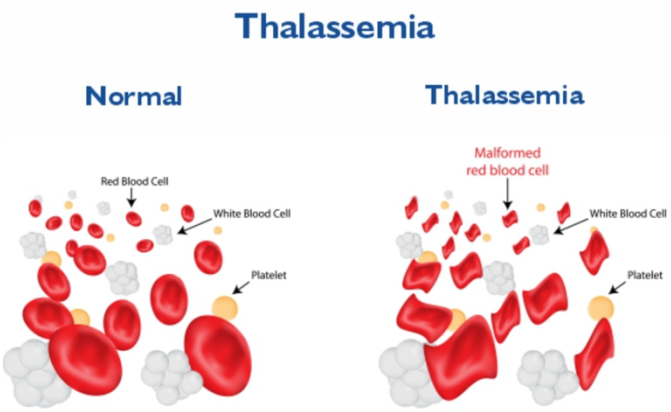
- **Conclusion:**
  - Gene Therapy can play a very important role in achieving India's mission of eliminating Sickle Cell Anaemia by 2047.

A) THALLASEMIA

- Thalassemia is an inherited blood disorder in which the body makes an **abnormal form of hemoglobin**.

- If both of your parents are carriers of thalassemia, you have a greater chance of inheriting a more serious form of disease.

- The disorder results in excessive destruction of RBCs, which leads to anemia.



- **Treatment Option**
  - » Blood Transfusion
  - » Bone Marrow transplantation
  - » Medication and supplements
  - » Possible surgery to remove spleen or gallbladder.

- **Situation in India**

» India is the **thalassemia capital of the world with 40 million carriers** (highest in the world) and over 1,00,000 patients (Majors) under blood transfusion every month. It is the most common genetic blood disorder that is prevalent in India.
» People suffering form the disease are unknowingly transferring on this genetic disorder to their children.
  - Around 10,000 births of Thalassemia major are taking place every year.
» Most of the thalassemia treatment takes place in private sector with out-of-pocket expenses.
» The 2021 policy and associated benefits haven't been operationalized yet.

- **World Thalassemia Day**
  - It is observed on May 8 every year to commemorate Thalassemia victims and to encourage those who struggle to live with the disease.
    - The day was created by Thalassemia International Federation (TIF) in 1994.
  - **Theme for 2023**: "Strengthening Education to Bridge the Thalassemia Care gap"

3) RARE DISEASES

- **Introduction**
  » A rare disease is a **health condition of low prevalence that affects a small number of people** compared with other prevalent diseases in general population.
    - They generally include **genetic diseases**, rare cancers, infectious tropical diseases, degenerative diseases etc.

  » The **most common rare diseases recorded in India** are Haemophilia, Thalassemia, sickle cell anaemia, primary immuno-deficiency in children, auto-immune diseases, Lysosomal storage disorders such as Pompe disease, Hirschsprung disease, Gacher's disease, Cystic fibrosis etc. These diseases may be impacting around 70 million people from India, 50% of which are children.

- **Why special focus is needed for Rare diseases / Need of a separate policy on Rare Diseases**
  » **High cost of treatment** or no treatment> not affordable for most of the citizens -> health insurance generally excludes rare diseases.
    - Available are primarily expensive because pharma companies are not interested in R&D as the number of patients for each disease is very less (**Orphan Drugs)**
    - **As per WHO**, only 5% of the identified rare diseases have treatment.
  » **Difficult to diagnose**.
  » **Early screening generally doesn't happe**n because of lack of awareness among primary care physicians, lack of adequate screening and diagnostic facilities etc. There are very few medical professionals who can deal with these diseases
  » Currently there is **inadequate insurance cover** and treating practitioners are lacking **management practices.**

- **National Policy for Rare Diseases, 2021**
  » MoH&FW came up with the policy in March 2021.

- It aims to **lower the high cost of treatment** for rare diseases with **increased focus on indigenous research** with the help of a **National Consortium** to be set up by Department of Health Research, MoH&FW as convenor.

- It envisages creation of a **national hospital based registry of rare diseases** so that adequate data is available for definition of rare diseases and for R&D.

- It focuses on **early screening and prevention** through primary and secondary healthcare infrastructure such as H&W Centres and District Early Intervention Centres (DEICs) and through counselling of high risk parents.
  - Screening will also be supported by NIDAN Kendras set up by the DBT.

- The policy aims to strengthen **tertiary health care facilities for prevention and treatment of rare disease**s through designating 8 health facilities as **Centre of Excellence** and these CoEs will also be provided **one-time financial support of upto Rs 5 crores for upgradation of diagnostic facilities**.

- **Provision for financial support:** The policy was amended in May 2022. It now provides a financial assistance of upto Rs 50 lakh for treatment of rare diseases of all categories.
  - In the original policy, a financial support of upto Rs 20 Lakhs was provided under the Umbrella Scheme of Rashtriya Arogya Nidhi for treatment of those rare diseases that require a one time treatment (disease listed under Group 1 in the rare diseases policy)
- The policy also envisages a **crowd funding mechanism** in which corporates and individuals will be encouraged to extend financial support through a robust IT platform for treatment of rare diseases.
  - Funds so collected will be utilized by CoEs for treatment of **all three categories of rare diseases a**s first charge and then the balance financial research could also be used for research.

- **Performance of the policy** (Critical Analysis) (Jan 2023)
  - LS MP Varun Gandhi have written to Union Health Minister and have said that more than 4,00 identified patients of rare diseases - mostly children - **are yet to receive the Rs 50 lakh financial assistance for treatment guaranteed by the Union Government** under the National Policy for Rare diseases, 2021.
    - More than 10 children who were awaiting treatment have already lost their lives.
  - The **10 CoEs constituted under the policy are yet to seek financial assistance** (crowdfunding) for patients with rare diseases.

- **Key Issues:**
  - Implementation challenges.
  - Cost Effectiveness of interventions for rare disease vis a vis other health priorities
  - the sharing of expenditure between central and state governments.
  - **Other issues** (about gene therapy - already discussed)

4) ANTI-MICROBIAL RESISTANCE

- **Why in news?**
  - » **Genes fuel antibiotic resistance in Yemen Cholera Epidemic** (Sep 2023)
    - The Cholera outbreak in Yemen, which began in 2016, is the largest in modern history and anti-biotic resistance has become widespread among *V. cholerae* bacteria since 2018.
    - A study has found the **presence of a new plasmid** - a small, circular DNA molecule - in V. *cholerae* from late 2018 to the bacterial strain behind the epidemic. This plasmid introduced genes encoding resistance to multiple clinically used antibiotics, including macrolides (such as azithromycin).

- **Example Questions:**
  - » Antimicrobial resistance is a multi-driven problem and only a multi-pronged approach can be helpful in tackling the scourge. Elaborate [10 marks, 150 words]

- **Introduction:**
  - » Antibiotic resistance occurs when an antibiotic has lost its ability to effectively control or kill bacterial growth; in other words, the bacteria becomes "resistant" and continue to multiply in the presence of therapeutic levels of antibiotic.

- Why do bacteria become resistant to antibiotic?
  - » **Natural Phenomena**: **Evolution** - Selective pressure for the survival of resistant strains of bacteria.
  - » **Human Action:** Current higher levels of antibiotic resistant bacteria are attributed to the **overuse and abuse of antibiotics**.

- **How do bacteria become resistant?**
  - » Some bacteria are naturally resistant to certain type of antibiotics.
  - » However, bacteria may also become resistant in two ways :
    - By Genetic Mutation
    - By acquiring resistance from another bacterium.

- **Why India is vulnerable to Anti-biotic resistance?**
  - » **India is the largest consumer of anti-microbials globally** and the use of **last resort anti-microbials** like **cephalosporins** is soaring.
    - **Easy availability and overuse** of anti-biotics is the most important factor: Over the Counter Availability; Irrational Use; over-prescription by doctors
      - For e.g. Children often receive multiple courses of antibiotic every year since the viral infections are recurrent. This makes them more vulnerable to anti-microbial resistance.
  - » **Poor Health Sector** -> improper treatment -> Development of anti-biotic resistance
    - Further, exposure to subtherapeutic levels of anti-microbials or non-adherence to prescribed medications has also been cited as a driver of AMR
    - E.g.: in case of TB

- » Increasing and completely unregulated use of antibiotic **in Agriculture, live stocks and Poultry** sector.
  - Amount of antibiotics used in the farm animal and food industry is three to four times more than those used by humans.
  - For instance, Colistin is extensively used in veterinary practices as a growth promoter. This leads to generation of colistin-resistant bacteria in poultry and fresh water fish.
- » **Poor Sanitation conditions ->** More diseases -> More use of medicines -> More AMR development
- » Unchecked **discharge of effluents by the pharmaceutical industrie**s -> high concentration of pharmaceutical substances are found in surface and ground water systems near production facilities -> anti-biotics cause development of anti-microbial resistance in environment.

- **Impact of increasing anti-microbial resistance**
  - » **Damage to Public Health:**
    - In 2019, drug-resistant superbugs killed about **1.27 million people** globally - a toll more than HIV/AIDs or malaria - and according to the UN estimates, the number could reach 10 million by 2050.
    - Demands **complicated treatment pattern, with longer stay in hospital**s -> increase in cost of treatment.
    - Stronger antibiotics which are used after the first line of drugs fail generally have toxic side effects
    - Resistance also emerging for second line of drugs (e.g. XDR-TB emerging)
    - Without functional anti-microbials to treat bacterial and fungal infections, even the most common surgical procedures, as well as cancer chemotherapy, will become fraught with the risk of untreatable infections.
    - All this is compounded by the fact that **no new class of anti-biotics have made it to the market** in the last three decades, largely on account of inadequate incentives for their development and production.
  - » **Economic damages** due to AMR can be equivalent to what 2008-09 economic shocks resulted into: UN Report
  - » **Environmental Damages**
    - Extensive amount of anti-biotics lead to development of AMR in some micro-organisms. It impacts the microbial biodiversity and thus the environmental balance needed.

- **Steps that government has taken and Steps that we further need to take**
  - **National Policy** for Containment of Antimicrobial Resistance, 2011
  - Guidelines for appropriate antibiotic usage which have revised Schedule H drugs to make over-the-counter availability of certain antibiotics nearly impossible
  - Programs such as Red Line Campaign
  - Sanitation campaigns such as Swatch Bharat Mission etc.
  - National Surveillance system for AMR (April 2017)
  - **National Action Plan on Antimicrobial Resistance (April 2017):** Focused on enhancing awareness, strengthening surveillance, improving rational use, promoting research and supporting neighboring countries.

- **What more could be done**
  - **Strengthen healthcare services** -> early detection; high quality medicines, complete treatment.
  - **Strengthening infection prevention and control in health care facilities and farm**
  - **Proper Implementation** of National AMR resistance action plan should get high priority, towards tackling drug resistance.
    - » Efficient utilization -> Following WHO's '**Access, Watch and Reserve**' strategy.
    - » Strict implementation of various drugs control regulation and increasing the fine for over the counter sale of drugs.
    - » Import and Export policies of food and feed should strictly regulate the anti-biotic use.
  - **Proper regulation of livestock sector** to reduce the use of anti-biotics there.
    - » **Improve biosecurity** and ensure that harmful pathogenic organisms are not present at the farm.
    - » Promote vaccination over drugs
    - » **Developing and Using Alternatives**
      - **Botanical products with anti-microbial properties:** Extracts from turmeric, ginger, pepper and garlic are effective anti-microbial and can be added to the feed to control bacteria.
      - Use of **Probiotics and Prebiotics**
      - Using Seaweed extracts for improvement of immunity and additional physiological performance among aquaculture animals.
      - **Using enzymes** instead of antibiotics as growth enhancers. For e.g. enzymes like proteases, amylases, cellulase, esterase, lipase etc. are intended to enhance the availability of nutrients and help nutrient absorption in the digestive system.
      - **Phage therapy** (i.e. using Bacteriophages in aquaculture)
      - **Irradiation of food crops**
    - » DAHD should develop standard treatment guidelines to reduce misuse of anti-biotics.
    - » Bring a **law to regulate manufacturing and sale of poultry feed** laced with anti-biotics.
  - **Regulating pharmaceutical industry effluents** -> strengthening BWM rules and improving its strict implementation.
  - **Tackling AMR in Environment**
    - » Come up with a technical guidance to contain AMR from waste and environment.
    - » Shift to safer manufacturing practices for pharma to ensure reduced wastage and discharge in environment.
  - **More Research** in the field of Anti-biotic resistance and coming up with safe mechanism to treat these AMR diseases
    - » **A multi-sectoral $1 billion AMR Action Fund** was launched in 2020 to support the development of new anti-biotics. Similar steps to allocate more resources for AMR research would be required.
  - **International Collaboration** should increase.
    - » All UN member states should phase out the use of anti-microbial on the WHO's highest priority list as growth promotion agents.
    - » Trade of anti-biotics must be regularized for therapeutic purpose only with strict legalized medical prescription and supervision.
  - **Increased focus on awareness** generation among common people against the need of excessive use of anti-biotics.
  - **Develop new varieties of anti-biotics:**

» Since developing new anti-biotics is expensive and requires a few years at least, a developing country like India needs to jump tart in-house development of new anti-biotics through PPP. Government agencies like ICMR and CSIR, long with DBT, DST can also work with global partners like Global Antibiotic Research Development Partnership (GARDP) etc.

- **Conclusion**
  - » The world can't contain anti-microbial resistance unless stakeholders from all sectors such as human and animal health, environment, crops, food and drug come forward to act. **One-Health action** is must to slow down AMR chronic.

5) NUCLEAR ENERGY

- **PYQ:** With growing energy needs should India keep on extending its nuclear energy program? Discuss the facts and fears associated with nuclear energy

- **Introduction:**
  - » Energy security means consistent availability of sufficient energy in various forms at affordable prices. When a country moves ahead on the path of development, it is necessary to utilize every energy resource available in the country.

  - » Currently, nuclear energy makes up about 3% of India's energy sources

- **Advantages of Nuclear Energy:**

  a) **Least carbon footprint** (lesser than renewable energy)

  - The threat of climate change and environmental pollution are likely to constraint the use of fossil fuels

  b) **Cost of nuclear power**

  - The cost of nuclear power plants is pretty competitive to other fossil versions

  c) **Quantity of waste generated** is also very less

  d) **Potential of self sufficiency**

  - India has huge reserves of thorium which if properly utilized will reduce the dependency of India on foreign country

  e) **Depleting fossil fuels and import dependency**: India is currently drawing around 63% of its total energy from thermal sources. A significant part of this is imported.

  f) **Limitations of Renewable Energy**

  - Renewable energy are subject to vagaries of weather; they are land intensive; dependence on import technology; energy storage handicaps;

- Renewable energy is inevitable and nuclear option should be retained as insurance.

» **Limitations**

a) Safety concerns in light of recent disasters

b) Nuclear waste disposal is a big concern

- India still doesn't have a credible waste disposal policy.

c) Potential of developing nuclear weapons

d) Security concerns

- Nuclear power plants can be favorite targets for terrorist organizations. If this happens it may cause irreversible damage to people living in the region and the ecosystem.

e) India is dependent on other countries both for raw material and technology

- Our future potentially depends on third stage of nuclear program.

f) Ecological concerns

- Nuclear plants are generally set near the coast as it requires a lot of water.
- It is going to put pressure on coastline as India's western coastline is home to fragile ecology of western Ghats.

g) Long gestation period

- Till now only more than 20 plants are operational. There are long gestation periods which increases the cost of plants significantly.

h) More safeguards -> more costly

- Post Fukushima disaster, the cost of per unit energy has gone up. This has led to concerns regarding the cost viability of nuclear power plants.

» **Way Forward**

- **Adopt National Policies that advance the deployment of nuclear reactor technologies:** As we know that India's total energy demand is expected to cross 800 GW by 2032, it is very important to utilize all possible options available and nuclear energy is one of the most important of those options.
- We need to **develop a fledging domestic nuclear industry** which will reduce our dependence as well as help us in reducing the gestation period of the plants.

- In light of the limitation's association with nuclear energy, stress should be laid on **cautious development, safety precautions in operation and disposal of wastes.** But development of nuclear energy can't be stonewalled in the light of such concerns.
- **Establish a harmonized international regulatory system coordinated by the IAEA.**
- **Encourage multinational Cooperation on permanent disposal of spent fuel**