Sleepy Classes
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Daily Mains Answer Discussion

(Punjab PCS)

(Day - 6)

Questions on Topics

- Herd Immunity
- Stem Cell Therapy
- Crispr - Cas9
- Hyperloop
- Nuclear Technology

Q 1. What do you understand by herd immunity? How it can be achieved? Discuss it in the light of recent COVID 19 pandemic.

What is herd immunity

- When most of a population is immune to an infectious disease, this provides indirect protection—or herd immunity to those who are not immune to the disease. For example, if 80% of a population is immune to a virus, four out of every five people who encounter someone with the disease won't get sick (and won't spread the disease any further).
- In this way, the spread of infectious diseases is kept under control. Depending how contagious an infection is, usually 50% to 90% of a population needs immunity to achieve herd immunity.
- Herd immunity makes it possible to protect the population from a disease, including those who can't be vaccinated, such as newborns or those who have compromised immune systems.

Examples

- Measles, mumps, polio, and chickenpox are examples of infectious diseases that were once very common but are now rare because vaccines helped to establish herd immunity.

How is herd immunity achieved?

- Herd immunity may be achieved either through
- infection and recovery
- vaccination

Herd Immunity and COVID – 19

- Vaccines
- A vaccine for the virus that causes COVID-19 would be an ideal approach to achieving herd immunity. Vaccines create immunity without causing illness or resulting complications.
- Challenges
- Reaching herd immunity through vaccination sometimes has drawbacks, though.
- Protection from some vaccines can wane over time, requiring revaccination.
- Sometimes people don't get all of the shots that they need to be completely protected from a disease.
- In addition, some people may object to vaccines because of religious objections, fears about the possible risks or skepticism about the benefits.
- Natural infection
- Herd immunity can also be reached when a sufficient number of people in the population have recovered from a disease and have developed antibodies against future infection.
- Challenges
    - However, there are some major problems with relying on community infection to create herd immunity to the virus that causes COVID-19.

- First, it isn't yet clear if infection with the COVID-19 virus makes a person immune to future infection.
- Even if infection with the COVID-19 virus creates longlasting immunity, a large number of people would have to become infected to reach the herd immunity threshold.
- Conclusion
- In the absence of a vaccine or drug, and without a clear understanding of the disease pathology, seeking to achieve herd immunity through infection is a dangerous strategy. Allow the disease to spread too quickly, it overwhelms the health system and causes many people to die "unnecessarily"; do it too slowly, and it takes that much longer for life to come back to "normal".
- Therefore, for almost all countries, at this juncture, it is a cruel choice between saving lives and saving livelihoods.

Q 2. 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.

Introduction

- Stem cells are undifferentiated biological cells that can differentiate into specialised cells and can divide to produce more stem cells.
- They can be thought of as primitive, "unspecialised" cells that are able to divide and become specialised cells of the body such as liver cells, muscle cells, blood cells, and other cells with specific functions.
- They are found in multicellular organisms.
- Stem cells of adult organisms and progenitor cells act as a repair system for the body and again fill the adult tissues. Treatments or therapies that use Stem Cells to prevent or treat any disease are known as stem cell therapy (SCT). For e.g. Bone Marrow transplantation

Advantages

- It is proven to dramatically improve the condition of people with degenerative diseases
- Stem cells are not foreign bodies that are introduced into the system like antibiotics. There are no cases where stem cells itself can cause side-effects
- They have the ability to repair and regenerate which makes it highly beneficial for them to heal highly damaged organs with its self-repairing qualities
- Stem cells ability to form into muscle cells can be utilized in performing transplant surgeries aimed at healing muscle cells that could potentially reverse paralysis in patients with spinal muscular injuries
- Offers an opportunity to address the symptoms and side effects of chronic, incurable disease that has dramatically affected their quality of life
- Uses or medication post the stem cell transplant surgery is fairly low, pertaining to just anti-rejection medications.
- Benefits other studies: SCT is essential to the study of particular development stages that cannot be directly studied in human embryo
- Physical health and wellbeing
    - Reverse inflammation
    - Regulate immune system

- Re-establish cell-to-cell communication
- Replace damaged cells
- Regenerate normal blood flow

Associated Risks

- Stem cells are still produced in a laboratory opens up a chance of possible infection in the cells, that could multiply into an entire infected organ or tissue that could prove fatal to the patient
- Stem cell research is still in its initial stages and the treatment methods involving stem cells are not at all clear for use and there is some experimental aspect to the treatment.
- Other challenges include those new developments such as the ability of scientists to isolate and culture embryonic stem cells, to create stem cells using somatic cell nuclear transfer and their use of techniques to create induced pluripotent stem cells. This controversy is often related to abortion politics and to human cloning.

Conclusion

- Stem cell therapy can offer lasting relief from pain and decreased mobility and with advances in the research the scope of stem cell therapy keeps growing. The major problem affecting it is the high cost that is involved in it and this poses a critical challenge to its growth.

Q 3. Define CRISPR/Cas9 system. Critically analyse its prospects and significance.

Introduction

- Recently, the Nobel Prize in Chemistry for 2020 was given to two women scientists who have pioneered the use of CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) – Cas9 (CRISPR-associated protein 9) system as a gene-editing tool.
- The technology allows scientist to manipulate the sequence of DNA in a precise manner. CRISPR-CAS9 system is a remarkable tool for greatly simplifying gene manipulation (Insertion, deletions, development of knock in and knock out of gene).
- CRISPR-Cast technology behaves like a cut-and-paste mechanism on DNA strands that contain genetic information. The specific location of the genetic codes that need to be changed, or "edited", is identified on the DNA strand, and then, using the Cas9 protein, which acts like a pair of scissors, that location is cut off from the strand. A DNA strand, when broken, has a natural tendency to repair itself. Scientists intervene during this auto-repair process, supplying the desired sequence of genetic codes that binds itself with the broken DNA strand.

Significance

- The most important advantages of CRISPR/Cas9 over other genome editing technologies is its simplicity and efficiency.
- Since it can be applied directly in embryo, CRISPR/Cas9 reduces the time required to modify target genes compared to gene targeting technologies based on the use of embryonic stem (ES) cells.
- The simplicity of CRISPR-Cas9 programming and its capacity for multiplexed target recognition have fuelled the popularity of this cost-effective and easy-to use technology.
- This technology is widely used for studying the functionality of genetic elements, creating genetic modified organisms and research for genetic disorders.
- Harnessing the CRISPR/Cas9 system for genome editing and manipulation has accelerated research and expanded researchers' ability to generate genetic models.

Prospects

- This technology could dramatically improve human life for everyone across all fields drastically in areas such as cancer immunotherapy, biofuel, pollution techniques, disease modification, and medicine production.

- These new capabilities have drastically simplified genome editing in human cell lines, which has made possible direct testing of causal genetic variations linked to human diseases. The ease of design and testing of Cas9 may also facilitate the treatment of highly rare genetic variants through personalized medicine (Hsu).
- The development of personalized drugs would cut down on patients becoming resistant to the drugs they are or at least increase the time they don't become resistant. Similarly, these comprehensive genetic screens may also identify novel disease protective mutations such as the loss-of-function mutations in CCR5 and PCSK9, which result in protection against HIV infection and hypercholesterolemia, respectively.
- Crispr goes beyond just disease and genetic immunity, but also into helping modify our food. Crispr could be used to increase the muscle mass of animals, render farmed animals less susceptible to disease, enhance nutritional content, or create hornless cattle that are easier to handle. Crispr can be used to genetic crops to be resistant to environmental deprivation or pathogenic infection. Agriculturally important plants have been genetically manipulated to make these less susceptible to disease and pests, more productive, and more resilient to changing climates.
- Crispr could open up the future to different fuel alternatives with a new and improved version of ethanol. This can be employed to analyse the interaction of genes and relationship between genetic differences and expression (phenotype).
- It can also be used to knock out gene and replaced it with another gene for diseases therapy In the future, another tantalizing application of the CRISPR/Cas9 technology is the direct treatment of deleterious genetic diseases through genome editing of somatic cells. By correcting disease-causing mutations, it may be possible to reverse disease symptoms

Shortcomings

- Many current CRISPR trials are focusing on cancers, muscular genetic mutations, such as duchenne muscular dystrophy, and HIV/AIDS. Since this technology is still very new, it should only be offered to those who have exhausted all other treatment options.

DNA-Damage Toxicity

- CRISPR-induced DSBs (double strand breaks) often trigger apoptosis rather than the intended gene edit. CRISPR-Cas9 is based on the use of nuclease enzymes. The nuclease enzymes used may not be as effective as desired and not be able to cut all copies of the target gene, or the cell may begin to divide before genome editing is completed. As a result, a condition called genetic mosaicism can occur.
- The effect of off-target can alter the function of a gene and may result in genomic instability, hindering it prospective and application in clinical procedure
- Another issue to consider about CRISPR-Cas9 is patenting.
- Patenting can considerably limit the application of such technologies. Unilateral patenting can significantly increase the profitability of biotechnology companies, which may lead to a rise of bioethical issues.

Ethical Concerns

- With most new technology it comes with an ethical dilemma, and especially since this one will be able to change the human genome for both disease and cosmetic purposes.
- The most serious debate and ethical concerns come from the ability of CRISPR to edit germ line cells, not only will those cells be passed down to future generations but also along with any genetic change that occurred. The second bioethical issue is what the fate of children born using genome editing will be. From whom or where informed consent will be obtained in the case of undesirable effects on behalf of genome-edited children and whether informed consent will give detailed information are important questions.

Immunotoxicity

- In addition to technical limitations, CRISPR/Cas9, like traditional gene therapy, still raises concerns for immunogenic toxicity Furthermore, the use of this technique needs a legal regulation in order to avoid engineering organism that may pose treats to humans, animals, plants and microbes. The potential effects of CRISPR-Cas9 in other areas should not be forgotten.
- CRISPR-Cas9 is not just about social and bioethical issues related to people. Interactions with other organisms and the environment, such as the consideration of the principle of intentional harm in risk assessment, safety measures to prevent ecological degradation, or potential use in genetic enhancement of animals and agriculture products should also be discussed

Way Forward

- Need for Guidelines/Policy for Gene Editing in India Scientific and Ethical Considerations in Gene Therapy Mechanism for Review & Oversight
    - Responsibilities of investigators/institution/sponsors/ Institutional ethics committee
    - Considerations for Chemistry, Manufacturing and Control, Quality Assurance
    - Guidelines: Infrastructure, Personnel , Clinical Trials
    - Requirements for Preclinical evaluation of investigational strategies/ products for gene therapy International Collaboration For Gene Therapy
    - Awareness and Education of Stakeholders
    - Periodic Review of Guidelines
- CRISPR Technology as a tool for gene editing has shown to be a saviour for human being's health diseases especially genetic diseases that can be pass from parents to offspring. However, before the launch of such techniques s, the necessary explanations and declarations should be made by the authorities in a transparent and clear manner in order to prevent misjudgements and questions that may occur in the public, and precautions and arrangements should be established to ensure the safety of the public. All we have to remember is that the tools themselves do not pose a threat, rather we have to make sure that CRISPR/ Cas9 technology lives up to its promise by being used responsibly and carefully.

Q 4. What do you understand by Hyperloop as fifth mode of transportation? Analyse its significance.

Introduction

- Elon Musk in 2013, in an open source paper, described Hyperloop as the fifth mode of transportation after Rail, Water, Road and Air.
- Hyperloop is a tube-based transportation system wherein a a high-speed train would use a low-pressure tube to whisk passengers back and forth. It is basically a train travelling within an airless vacuum tube. No air means no resistance and a highly efficient system.
- Hyperloop Vactrain (vacuum train) is based on three-part
- Magnetic or air levitation
- Linear motor proportion
- Vacuum based transport system
- The pods would be supported by a soft air cushion and propelled forward via magnetic induction and electromagnetic pulses, thus avoiding air resistance and friction

Significance

- It would be one only transport system that will have its own sustainable power producer system that can run the whole system.
- The system can transport goods and cargo at a very high speed (1200 kmph), almost double the speed of aircraft

and four times that of train.

- Implementation cost is cheap than other modes of highspeed transport systems.
- This transport system could be three modes of transportation like surface, underwater, underground as well. The association of all three can revolutionise the speed of shipping industry.
- A small weight of transport capsules of several tons compared to multi-tonnage railroad train allows the use of significantly simpler bridges and transitions in the construction of Hyperloop roads.
- Independence from weather conditions, no problem caused at high-speed by small solid counter particles. For Subsonic transport, this is a big problem.
- This system is much quieter than the traditional highspeed transport system.
- Another part of this technology is ecological cleanliness due to using air, electricity generated by solar batteries.
- Reliability and safety - The system is safe from all the natural obstacles like floods, earthquakes, bad weather, against birds, animals and also different vehicles, pedestrians.

Challenges

- Ensuring demonstrable human safety in passenger services
- Creating comfortable passenger environments
- Designing faster airlock systems to deliver capacity expectations
- Designing vacuum pumps that push the limits of current technology
- Accommodating the thermal expansion of the tubes while maintaining a vacuum
- Finding favorable alignments (routes that allow for minimal turns, to maintain speed)
- Expensive

Conclusion

- As this new technology is in under construction and visiualization so here has a huge opportunity to develop as new mode to transportation which could dominate the all available transportation system(High Speed transportation system, Meglev transportation system). Being a transportation system fast is not enough; it should be durable, sustainable and safer than others.

Q 5. Give an account of the growth and development of nuclear science and technology in India. What is the advantage of a fast breeder reactor programme in India?

Introduction

- Post-independence, team of physicists under Dr. Homi J. Bhabha convinced PM Nehru to invest in the development of nuclear energy and subsequently in 1948, Indian Atomic Energy Commission was created. In early stages, the nuclear program was primarily concerned with developing nuclear energy rather than weapons, but weapons were never ruled out. Bhabha outlined a threestage plan for establishing nuclear power generation in India. Recognising the limited resources of natural uranium and abundance of thorium in the country, heavy water moderated, natural uranium-fueled, Pressurised Heavy Water Reactors (PHWRs) formed the first stage. PHWRs will produce plutonium as a by-product, which in turn would be used as a fuel in fast breeder reactors, comprising the second stage. Uranium 233 produced in second-stage and natural thorium will form the fuel for fast breeder reactors in the third stage. Ultimately, thirdstage reactors would produce more fissile material than they burn while producing electricity, thus ensuring sustainability of nuclear power.

Advantages of Fast Breeder

- Concept of breeding: FBR based on Pu fuel is the best among various spectrum reactor types to derive higher fissile material production that can be used to fuel another reactor. Also, it is relatively easy to modulate the breeding ratio in the FBRs by enhancing the number of neutrons that are captured
- Economic advantages: Fast breeder reactors have higher thermodynamic efficiency and less thermal pollution
- Waste Management: Due to high level of neutron flux, it is easier in FBR to transmute trans-uranium or minor actinides, which are responsible for decay heat. Thus, there is less impact on fuel cycle and also large gains in repository space are possible. Thus, waste management burdens are reduced by about 200 times in terms of storage space
- India-specific advantages: India has limited indigenous uranium (~110 kt) and hence, FBRs are important due to its capability of efficient utilization of uranium
    - India has abundant thorium. The fast reactors also play important and essential role to exploit the thorium resources
    - Introduction of thorium without going to FBRs is extremely counterproductive, since the installed power capacity with thorium and plutonium being used together in thermal reactors will be insignificant given the India's requirements
    - Sodium cooled Fast Reactors (SFR), in particular would provide critical liquid metal technology and high temperature design inputs for fusion and high temperature reactor systems. These systems can provide electricity at competitive costs over long periods.

Challenges

- More possibility of accidents
- Electricity from the PFBR at-least about 80 percent more expensive in comparison with electricity from nuclear power plants based on the heavy water.

Conclusion

- FBRs are considered to be the most suitable and strong options for providing sustainable and environmentally acceptable energy systems. Enrico Fermi, who demonstrated the breeding principle in 1946 itself, said: 'the people who will develop Liquid Metal based FSR technology will lead the world in the future.