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Syllabus: GS paper 3: S&T, GS paper 4: Ethics

> What are designer babies? What are the ethical concerns associated with gene editing?

What is the issue?

- There are ethical concerns over the clinical application of gene editing technique in recent times.

What is CRISPR?

- It is a gene editing technique which stands for Clustered Regularly Interspaced Short Palindromic Repeats.
- It harnesses the natural defence mechanisms of bacteria to alter an organism's genetic code.
- The bacteria are likened to a pair of molecular scissors that can cut the two DNA strands at a specific location and modify gene function.
- The cutting is done by enzymes like Cas9, guided by pre-designed RNA sequences, which ensure that the targeted section of the genome is edited out.
- CRISPR – Cas9 is the most prominent genome editing technique .

- It allows researchers to permanently modify genes in living cells and organisms.
- This can be used to correct mutations at precise locations in the human genome to treat genetic causes of diseases.
- Correcting the mutation in an embryo ensures that the child is born healthy and the defective gene is not passed on to future generations.

How does gene editing work?

- The gene editing tool has two components :

1. A single-guide RNA (sgRNA) that contains a sequence that can bind to DNA.
2. The Cas9 enzyme which acts as a molecular scissor that can cleave DNA.

- In order to selectively edit a desired sequence in DNA, the sgRNA is designed to find and bind to the target.
- The genetic sequence of the sgRNA matches the target sequence of the DNA that has to be edited.
- Upon finding its target, the Cas9 enzyme swings into an active form that cuts both strands of the target DNA.
- One of the two main DNA-repair pathways in the cell then gets activated to repair the double-stranded breaks.
- While one of the repair mechanisms result in changes to the DNA sequence, the other is more suitable for introducing specific sequences to enable tailored repair.
- In theory, the guide RNA will only bind to the target sequence and no other regions of the genome.
- But the CRISPR-Cas9 system can also recognise and cleave different regions of the genome than the one that was intended to be edited.
- These “off-target” changes are very likely to take place when the gene-editing tool binds to DNA sequences that are very similar to the target one.

- Though many studies have only found few unwanted changes suggesting that the tool is probably safe, researchers are working on safer alternatives.

Why is CRISPR- Cas9 system significant?

- Normally, if sperm from a father with one mutant copy of the gene is fertilized in vitro with normal eggs, 50% of the embryos would inherit the condition.
- However, when the gene-editing tool was used, the probability of inheriting the healthy gene increased from 50 to 72.4%. There was also no off-target snipping of the DNA.
- The edited embryos developed similarly to the control embryos indicating that editing does not block development.
- Clinical trials are under way in many countries to use this tool for treating cancer.
- It was shown in mice that it is possible to shut down HIV-1 replication and even eliminate the virus from infected cells.
- In agriculture, a new breed of crops that are gene-edited will become commercially available in a few years.
- Given all these, making gene editing possible in human reproductive cells deserves serious considerations in terms of legal, social and ethical consequences.

What are the practical applications?

- CRISPR was used successfully to repair a heart-damaging gene in human embryos.
- It marked a step towards preventing inherited diseases from being passed on to the next generation.
- It can be useful in learning how genes cause disease or influence development and what therapies might help.
- It was also found that gene editing in the brain can help decrease the repetitive behaviours, which is a symptom of autism spectrum disorders.
- The approach can also be used to treat other neurological diseases such as epilepsy and

the brain cancer glioblastoma.

- Scientists in the UK have used genome editing to study DNA function in human embryos that could help better understand the biology of our early development.
- The findings could improve IVF treatments and understand some causes of pregnancy failure in the future if key genes responsible for successful development of embryos are identified.
- Researchers also are using gene editing to hatch malaria-resistant mosquitoes, grow strains of algae that produce bio-fuels, improve crop growth, even make mushrooms that don't brown as quickly.

What are the concerns?

- Safety is a key question because gene editing has the possibility of accidentally cutting DNA that is similar to the real target.
- A study published in the journal Nature Medicine, found that therapeutic application of the genome-editing tool may increase the risk of cancer.
- It could be potentially used to edit out undesirable traits in human beings in the name of improving genetic quality of a human population, as Eugenics.
- It could also be used by governments to create a 'superior' race and by the private sector in the name of creating a perfect child for the parents.
- Altering genes in sperm, eggs or embryos through "germ line" engineering leads to concerns regarding creation of designer babies with enhanced traits.
- This leads to the argument that gene editing be reserved for serious diseases with no good alternatives and performed under rigorous oversight.

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