



## Genetic Engineering: Promises & Perils

This article is based on [“The dangers of genetic engineering”](#) which was published in The Hindustan Times on 23/09/2020. It talks about the promises and perils associated with Genetic engineering.

Genetic engineering may be one of the greatest breakthroughs in recent history alongside the discovery of the atom and space flight. However, there are many disadvantages and plausible risks associated with it.

Although a research **report in Nature Medicine** contradicts the likelihood of intentional engineering of [Sars-CoV-2](#), genetic engineering could well be the cause of the next pandemic.

Covid-19 have demonstrated how biological pathogens can be as destructive as nuclear missiles. Hence, the world should be cautious of the potential of genetic engineering to develop viruses that can be used for [Bio-terrorism](#).

However, the technological advancement through Genetic engineering can also provide its cure and a strong defense against it. Thus, there should be efforts globally in developing bio-defences.

### What is Genetic Engineering?

- Through genetic engineering, scientists are able to move desirable genes from one plant or animal to another or from a plant to an animal or vice versa.
- In essence, genetic engineering is a technology wherein a specific gene can be selected and implanted into the recipient organism.
- The process of genetic engineering involves splicing an area of a chromosome, a gene, that controls a certain characteristic of the body. For example:
  - This gene may be reprogrammed to produce an antiviral protein.
  - The enzyme endonuclease is used to split a DNA sequence as well as split the gene from the rest of the chromosome.
  - This gene is removed and can be placed into a bacterial cell where it can be sealed into the DNA chain using ligase.
  - When the chromosome is once again sealed the bacterial cell is now effectively re-programmed to replicate this new antiviral protein.
  - The bacterium can continue to live a healthy life while genetic engineering by human intervention has manipulated it to produce the protein.

### Advantages of Genetic Engineering

- **Genetically Modified (GM) Crops:** Genetic engineering made it possible to create crop varieties regarded as “more beneficial” terms of coming up with crops with the desired traits.
  - Examples of genetically-engineered plants ([Bt Cotton](#)) with more desirable traits are drought-resistant plants, disease-resistant crops, plants that grow faster, and plants fortified with more nutrients.

- **Treatment of Genetic Disorders and Other Diseases:** Through genetic engineering, genetic disorders may also be fixed by replacing the faulty gene with a functional gene.
  - Disease-carrying insects, such as mosquitoes, may be engineered into becoming sterile insects.
  - This will help in curbing the spread of certain diseases, e.g. malaria and dengue fever.
- **Therapeutic Cloning:** It is a process whereby embryonic cells are cloned to obtain biological organs for transplantation.

## Challenges of Genetic Engineering

While genetic engineering is beneficial in many ways, it is also implicated in certain eventualities deemed as “unpleasant” or disadvantageous.

- **Irreversible Changes:** Nature is an extremely complex interrelated chain. Some scientists believe that introducing genetically-modified genes may have an irreversible effect with consequences yet unknown.
  - GMO that can cause harmful genetic effects, and genes moving from one species to another that is not genetically engineered.
  - It has been shown that GMO crop plants can pass the beneficial gene along to a wild population which may affect the biodiversity in the region. An example is the sunflowers genetically-engineered to fend off certain insects.
- **Health Issues Related with GMO Crops:** There are concerns over the inadvertent effects, such as the creation of food that can cause an allergic reaction.
- **Bioethics:** Genetic engineering borderlines on many moral and ethical issues. One of the major questions raised is if humans have the right to manipulate the laws and course of nature.

## Dangers Associated With Genetic Engineering

- **Rapid Growth of Technology:** Clustered Regularly Interspaced Short Palindromic Repeats ([CRISPR gene editing](#)), developed only a few years ago, deploys the same natural mechanism that bacteria use to trim pieces of genetic information from one genome and insert it into another.
  - This mechanism, which bacteria developed over millennia to defend themselves from viruses, has been turned into a cheap, simple, quick way to edit the DNA of any organism in the lab.
  - CRISPR isn't the only genetic technology we need to worry about. A broader field, “synthetic biology”, is making the tools for genetic engineering widely available.
- **Democratisation of Biotechnology:** As CRISPR is cheap and easy to use, thousands of scientists all over the world are experimenting with CRISPR-based gene editing projects with very little of this research being limited by regulations.
  - The technologies have democratised to such a degree that any country can engineer viruses.
  - Further, the danger comes not only from governments: Non-state actors, rogue scientists and bio-hackers have access to the same tools.
  - Also, researchers have demonstrated that they can recreate deadly viruses such as that of smallpox, which took humanity decades to eradicate

## Way Forward

As there have been no checks or balances, and it is too late to stop the global spread of these technologies. The only solution, now, is to accelerate the good side of these technologies and build defences. In this context:

- **Leveraging Artificial Intelligence & Big Data:** With [Artificial Intelligence \(AI\)](#) and genomic data, scientists will decipher the complex relationships between DNA and biological processes and

find treatments for diseases.

- **Deploying 3D Printing:** 3-D printing can help develop at home medicines, tissues, and bacteria custom-designed to suit our DNA and keep us healthy.
- **Gathering of Genomic Data:** There is a need to develop genomic blueprints of human and other species, this information can help immensely to defend and develop vaccines against pandemics like Covid-19.

## Conclusion

Technologies such as genomics, synthetic biology, sensors, 3D printing, and AI should be leveraged by India to analyse data and develop treatments. Through this, India can lead the world in research and innovation in genetic engineering and lay the foundation for a trillion-dollar medical industry.

# genetic engineering

## new horizons in medicine

Since genetic engineering (also known as **recombinant DNA technology** or **genetic modification**) was first developed in the 1970s, scientists have discovered more and more ways in which the technology can be used in human medicine. Now techniques, including the gene editing tool known as CRISPR-Cas9, are opening up even more possibilities for us to change the DNA in the cells of bacteria, animals and plants – and potentially change medicine for ever.

### Pharming

Microorganisms, animals and plants can be genetically modified to produce medically useful products. These transgenic organisms are already used regularly to produce substances such as human insulin, human growth hormone and blood clotting factors for haemophiliacs.

### CRISPR-Cas9 technology

CRISPR-Cas9 is a genome editing tool which is changing the world of genetic engineering fast. It enables scientists to directly remove, add or change sections of the DNA sequence in a living cell. CRISPR-Cas9 is much faster, much cheaper and much more accurate than the traditional ways of editing DNA. Scientists think it has great potential for treating any diseases which involve the genome, including cancers, heart disease and even the high cholesterol levels which are a risk factor for heart disease.

### Gene therapy

Gene therapy is still in its very early stages. It involves modifying human DNA either to repair or replace a faulty gene. The idea of gene therapy is to overcome the effects of a mutation which cause a genetic disease or tendency to a disease. Progress so far has been relatively slow, although there are early signs of success in treating some childhood leukaemias, HIV/AIDS and muscular dystrophy. The speed and precision of CRISPR-Cas9 gene editing technology gives scientists hope for the future.

### Vaccines

Some vaccines are very dangerous to make using conventional methods. Genetically engineered microbes can be used to produce the antigens needed in a safe and controllable way. The use of genetically modified yeast cells to produce a vaccine against the hepatitis B virus has been a major success story.

### Xenotransplantation

The DNA of pigs has been modified using recombinant DNA technology so their cells develop without certain genes which trigger the human immune response. Other genes can be added which express human antigens. Work in this area has been slow, partly due to ethical and safety concerns, but interest is growing. Recent successes include German scientists using CRISPR-Cas9 to deliver multiple gene modifications in pigs, greatly reducing the human immune response to the pig cells.

### The basic steps in traditional genetic engineering of a bacterium

The required gene is EITHER cut from the DNA of an organism using enzymes called restriction endonucleases which leave the gene with overlapping sections called sticky ends... OR ...synthesised specifically

Required gene → Gene with sticky ends

Gene with sticky ends → Bacterial plasmid

Marker gene

A vector molecule (often a bacterial plasmid, a small circular strand of DNA sometimes found in bacteria) is opened up, also using restriction enzymes and leaving sticky ends.

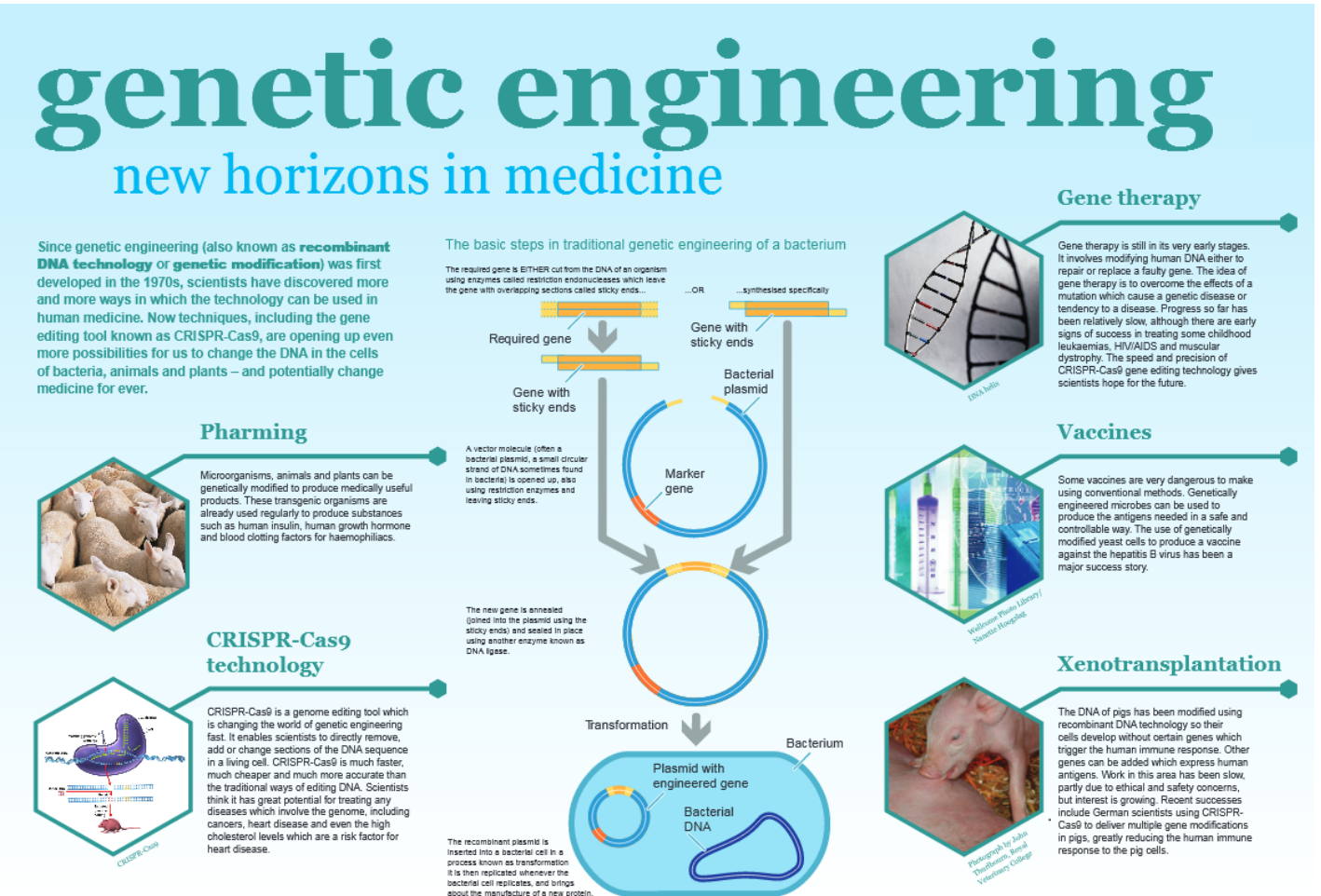
The new gene is annealed (joined into the plasmid using the sticky ends) and sealed in place using another enzyme known as DNA ligase.

Transformation → Bacterium

Plasmid with engineered gene

Bacterial DNA

The recombinant plasmid is inserted into a bacterial cell in a process known as transformation. It is then replicated whenever the bacterial cell replicates, and brings about the manufacture of a new protein.



### Drishti Mains Question

Genetic engineering may be one of the greatest breakthroughs in recent human evolution, but there are many plausible risks associated with it. Discuss.

This editorial is based on **“The vaccine protocol”** which was published in The Hindustan Times on September 21<sup>st</sup>, 2020. Now watch this on our Youtube channel.

