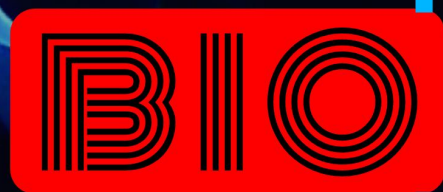


**GEMS**



**VISION**

**VOLUME 1 • ISSUE 1 • JUNE 2020**

**GENETICALLY  
MODIFIED  
ORGANISMS**

**PUBLISHED BY GEMS SOCIETY  
DEPARTMENT OF BIOTECHNOLOGY  
IMS ENGINEERING COLLEGE  
GHAZIABAD**





## FROM THE EDITOR

**DR. SANTOSH K MISHRA**  
**EDITOR-IN-CHIEF**

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Human imagination towards science is the key drive for the development of new, innovative and novel technologies. This has also become true in the field of biological sciences after the discovery of double helical DNA model. Integration of biology with science and technology leads to the development of tools with astonishing power and precision for the possible manipulation and editing of DNA. DNA (Genetic) engineering is now becoming faster, cheaper and simpler as software engineering.

Genetic engineering techniques emerged in the early 21<sup>st</sup> century focuses on desirable gene editing. With more advancement in cloning and expression of genes, large number of genetically modified organisms (GMOs) has been developed and is now available in public domain such as insulin, Bt cotton, BT brinjal, golden rice, flavr savr tomato etc.

Latest techniques of genome editing such as CRISPR-Cas has allowed researchers to customize a genetic sequence of living organism by making specific changes to its DNA. Gene editing has a diversified applications and being used for the genetic modification of crop plants and livestock. These advancements in the area of genetic engineering are useful for the production of novel therapeutic agents, development of new diagnosis and treatment of genetic disorders.

In this first issue of **BIOVISION**, we have tried to highlight the role of genetic engineering tools and techniques and subsequently its impact on the development of GMOs and its impact on the humans, society and environment.



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# ABOUT BIOTECHNOLOGY DEPARTMENT

The Department of Biotechnology was established in the year 2002 with a clear vision of educating students with latest technology in the growing field of Biotechnology as an undergraduate course. Now the department is NBA accredited and also offers postgraduate program (M.Tech). Since its inception, the Department has continuously grown and taken initiatives to impart quality education and inculcate research aptitude in Biotechnology students. The department is actively engaged in research activities in various areas of Biotechnology and related fields. It is also an authorized research center for Ph.D. program through AKTU, Lucknow. The department has consciously taken a decision to strengthen research activity in various areas of Biotechnology with a view to develop practical solutions to problems faced by industries. The department is unique in having established expertise across a broad range of scientific disciplines, thereby encouraging innovative approaches to teaching and research.

Our expert faculties in various disciplines also provide research consultancy in Environmental Biotechnology with a view to develop practical solutions to environmental problems faced by industries and the municipalities. Major Departmental Highlights include-

- Highly qualified faculties with extensive experience in industry, research and teaching
- 10 State-of-the art laboratories including Genetic Engineering, Fermentation Technology, Bioprocess and Computational Biology etc
- International internship at University of Louisville, KY, USA
- Advanced R&D in areas of Cancer Biology, Recombinant DNA Technology, Drug Discovery and Herbal Product Formulation
- Average 20 research papers published annually in peer-review journals by Faculty and Students
- Consistent 90% placement record in Core Biotechnology companies

## VISION OF DEPARTMENT

**To be a Centre of Excellence in field of Biotechnology education, research, training and entrepreneurship guided by sound scientific principles, quality teaching and thrust for improvement.**

## MISSION OF DEPARTMENT

- 1. To develop a strong Biotechnology Engineering program based on quality education, research and training.**
- 2. To impart quality education to the students and enhance their skills which will make them globally competitive.**
- 3. To develop trained biotechnology professionals who can contribute to the continuous improvement of biotechnological services and products.**
- 4. To develop scientific and/or technical resources as per biotechnology industry demands.**



## ABOUT GEMS SOCIETY

GEMS (Genetic Engineers and Molecular Scientists), the professional society of Biotechnology department was established in the year 2008. The aim of this society is to encourage students for various professional as well as social activities. These activities of this society provide students a platform where they can excel their talent in the area of science and technology with better understanding of their professional & social responsibilities. It also helps students to show leadership skills well as team work culture in among students. Faculties of department constantly providing guidance necessary support students for organizing various activities of societies. GEMS Society is constantly working to organize various techno-cultural events for overall development of students. Every semester this society organizes events like Guest lecture from experts, Seminars, Innovative idea presentation, Biofiesta (Annual techno-cultural event), Plantation of herbal plants etc. Expert from industry and research institutes like CDRI, BICOL, Dabur Research foundation, Sun Pharmaceutical Industries, Codon Biotech, Envirotech etc. delivered invited talk in the various activities organized by GEMS society. The structure of this society is as follows:-

<b>President</b>	: Prof. Rashmi Chandra (HoD, BT)
<b>Coordinator</b>	: Dr. Santosh Kr. Mishra (Assistant Professor, BT)
<b>Vice President</b>	: Mr. Nishant Veer Vikram Singh (Student of BT 4 <sup>th</sup> Year)
<b>Secretary</b>	: Ms. Saumya Mishra (Student of BT 3 <sup>rd</sup> Year)
<b>Joint Secretary</b>	: Mr. Garvit Gupta (Student of BT 2 <sup>nd</sup> Year)
<b>Treasurer</b>	: Dr. Narendra Kumar (Associate Professor, BT)
<b>Members of GEMS</b>	: All students and Faculty members of Biotechnology Department



# ACTIVITIES OF GEMS SOCIETY

The Professional society, GEMS (Genetic Engineers and Molecular Scientists) was established in the department in the year 2008. The aim of this society is to encourage students for various professional as well as social activities. These activities of this society provide students a platform where they can excel their talent in the area of science and technology with better understanding of their professional & social responsibilities. It also helps students to show leadership skills well as team work culture in among students. Faculties of department constantly providing guidance necessary support students for organizing various activities of societies. GEMS Society is constantly working to organize various techno-cultural events for overall development of students. Every semester this society organizes events like Guest lecture from experts, Seminars, Innovative idea presentation, **Biofiesta** (Annual techno-cultural event), Plantation of herbal plants etc. Experts from industry and research institute like CDRI, BIBCOL, Dabur Research foundation, Sun Pharmaceutical Industries, Codon Biotech, Envirotech etc. delivered invited talk in the various activities organized by GEMS society.

## Plantation Drive



## BIOFIESTA



## BIOBREEZE





# MILESTONES IN GENETICALLY MODIFIED ORGANISMS

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**DEPARTMENT OF BIOTECHNOLOGY**

**IMS ENGINEERING COLLEGE, GHAZIABAD**



Genetically Modified Organisms (GMOs) are the organisms with altered genetic material (i.e. deoxyribonucleic acid). The alteration is carried out by genetic engineering techniques. GMOs exist in wide ranges from microscopic (like micro-organisms) to macroscopic creatures (like plants, animals). Creation of GMOs is not a single step process, but a multistep process. The GMOS can be produced by many genetic engineering techniques but the most recent technique CRISPR, which stands for clustered regularly interspaced short palindromic repeats, is highly acceptable by scientists. It is a genome editing tool which makes GMO pigs that glow in dark (insertion of jellyfish bioluminescence genetic code into pig DNA). First commercialized genetically modified food was

FLAVR SAVR TOMATO in the year 1994. The first genetically modified animal to be approved for food was salmon in the year 2015. The foods obtained from GMOs have following advantages-

- Less nutritious food converted to highly nutritious food.
- Taste of food gets better.
- Minimal use of pesticide.
- Production of food increase with the reduced cost and longer preservative life.
- More desirable traits now food possesses like GM POTATOES that produce less of a cancer-causing substance before fried.



## DISCOVERIES

FIRST GENETICALLY MODIFIED ORGANISM		
Organism	Year	Discovered by
Bacteria	1973	Herbert Boyer and Stanley Cohen
Mouse	1974	Rudolf Jaenisch
Tobacco Plant	1983	Michael W. Bevan, Richard B. Flavell and Mary-Dell Chilton

GM foods before supplying to humans, animals, plants and to the environment must pass through US Food and Drug Administration (FDA), Environment Protection Agency (EPA) and US Department of Agriculture (USDA). There are some researchers which believe that eating GM foods is harmful and they can result into the development of cancer. They say this because cancer is caused by mutations in DNA so it is dangerous to introduce new genes into the body. The American Cancer Society (ACS) rejects this concept by saying due to absence of evidence and suggests more research work is required to draw any conclusion.

## DISCOVERY OF THE YEAR 2019



New ideas are tried and examined in many different laboratories throughout the world until the appurtenant facts are crystallized and comprehended. Did you know that virtually all tissues in our bodies have oxygen sensing mechanism and the way they adopt the available oxygen are different? This puzzle was solved by three remarkable scientists Sir William G. Kaelin Jr, Sir Peter J. Ratcliffe and Gregg L. Semenza. They have been jointly awarded Nobel Prize in physiology/medicine, 2019 for their discoveries of "how cells sense and adapt to oxygen availability". They identified molecular machinery that regulates the activity of genes in response to varying levels of oxygen. Their discovery is a milestone in the field of medicine and also paved the way for promising new strategies and techniques to fight towards numerous disorders and diseases such as anemia, cancer etc.



## **CURRENT STATUS OF GMOs IN INDIA**

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**IMS ENGINEERING COLLEGE, GHAZIABAD**



Genetically modified organisms (GMOs) are those living organisms including plants, animals and microorganisms developed by genetic manipulation techniques to improve their varieties and they are considered as advanced biotechnological application today. The genetically modified (GM) crops are the best out of them which is used for the production of food and feed. The common food based on GM crops includes corn, rice, soy, beets, zucchini, potatoes, wheat, papaya, and squash. Other than these common foods, the ingredients which are commonly added in food also obtained from genetically modified organisms such as aspartame, high fructose corn syrup, vitamin C, sucrose and artificial flavorings. Agricultural crops are genetically manipulated for many reasons as they allow

them to be genetically superior as well as be able to withstand with various environmental adverse conditions. These crops are also protected from various microbial diseases as well as from insect pests and increase the productivity. Genetically modified (GM) crops are one of the improved crops which are adopted by the agro-biotech industry. This helps to provide sustainable basis for food supply for growing global population. GM crop contains various novel genes which helps in the improvement of quality traits of plants like nutrient enrichment and herbicide tolerance. These GM crops revolutionized agricultural crops by introducing trait specific genes from different sources to produce more productive crops.

The BT cotton was the first GM plant which is



officially introduced in India in the year 2002. The BT cotton is genetically manipulated crop developed by inserting genes from the bacterium *Bacillus thuringiensis*. BT cotton is resistant insect pest and increases the productivity. The BT cotton was considered as rapidly adopting technology by the farmers and grown in an area of 3.8 million hectares in 2006-2007 to 10 million hectares in 2009-2010. As per the report released by Government of India in January 2017 “Status Paper of Indian Cotton of January 2017”, there is increased in BT cotton area to 93.14% between a period of 13 years (2002-03 to 2014-15).

Some researchers claimed that the BT cotton has no adverse effects on human and environment but increased the production by protecting from bollworms when it was compared with non-BT cotton. India has the world's fourth largest GM crop acreage as compared to China and other countries as per the International Service for the Acquisition of Agri-Biotech Applications (ISAAA) based on BT Cotton. In 2014, farmers in India planted a total 11.6 mH under transgenics, most of which (about 96%) is now covered by BT hybrids, hence we can say that the BT cotton wholly

dominates India's GM crop. In India the Consortium of Indian Farmers Associations (CIFA) is willing to welcome the crops based on GMOs, but with cautious approach, they all were introduced only after a strong independent monitoring body is established. This body should monitor and control the issues related to safeguard the biodiversity of India as well as balance the interests of Indian farmers.

## LEVERAGING FACTS

**GENE TARGETING'  
IS A TECHNIQUE  
USED TO INTRODUCE  
NEW DNA INTO  
SELECTED REGIONS  
OF A GENOME  
THROUGH A PROCESS  
CALLED HOMOLOGOUS  
RECOMBINATION?.**



# GMOs IN AGRICULTURE

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**IMS ENGINEERING COLLEGE, GHAZIABAD**

## WHAT ARE THEY?

Manipulation of genetic make-up of plants is being done by countless generations. The traditional method of such manipulation included cross-breeding of selective plants showing important traits like high yield, good quality fruit etc. However, in this modern era, this manipulation

is done by alterations in the genomic DNA of plant by using genetic engineering. Genetic engineering is becoming a preferred choice as it provides a quicker, effective and precise result in just one generation.

Genetically modified crops (GM Crops) are engineered to have desired traits like enhanced nutrients, longer shelf life, herbicide resistance,

disease and stress tolerance etc. The gene of desired trait is identified in the DNA of other organism, spliced out and reinserted in the genome of the crop. The gene of interest may be taken from a diverse set of biological organisms, completely different from the test crop and may include bacteria, plant, animal, fungi, algae etc.

## Gene Insertion Methods

Two methods are primarily used in order to insert the gene of interest in the target crop:-  
Gene Gun: The fragment of gene of interest are coated on very small gold or tungsten particles and shot into plant cells at a very high velocity. Few gene-coated particles make their way into the cells and release the DNA fragments. These



DNA fragment may get incorporated into the genome of the target crop and result in expression of the trait. *Agrobacterium tumefaciens* mediated transfer:

*Agrobacterium tumefaciens* is a tumor causing bacterium that transfers its DNA into the plant cell while infecting it. This property of the bacterium is manipulated by plant biotechnologists for inserting the gene of interest into the plant cell. This method introduces the gene of interest in a more efficient and controlled manner

### **Commercially Available GM Crops**

China, in early 1990s introduced virus-resistant tobacco as the first genetically modified crop. Later a virus-resistant tomato was also introduced. In continuation to the research on GM crops. Cal gene introduced FlavrSavr tomato, the delayed ripening tomato, commercially in US. It has been few years that GM Crops are commercially available for usage and the market is rapidly expanding.

### **Current Status and Global Impact**

Fortune Business Insights, a pioneer in market data analysis, published a report entitled

‘Genetically Modified Seeds Market: Global Market Analysis, Insights and Forecast, 2019-2026’ that states that the GM seed market is going to develop enormously in the upcoming years. It states that the global market in 2018 stood at 20.7 Billion USD. It is expected to reach 30.24 Billion USD by 2026. In addition, the Compound Annual Growth Rate (CAGR) witnessed an increase of 3.6% during the period of 2010 to 2017 and it is projected to witness a growth to 5.7% by 2026.

The giant industry players for the GM seed market like Monsanto, DuPont, Syngenta and BASF are putting significant efforts in bringing new seed varieties with improved traits and investing into research and development. The GM industry is growing fast and offers enormous opportunities in the near future.

### **Benefits and Applications**

The GMO crops offer many potential benefits as listed below:

- **Enhanced Quality Traits:** These GM crops offer higher nutrient content, e.g., ‘Golden rice’ is fortified with Vitamin A. Other biofortified crops such as corn, banana, sorghum etc. are also available in the market. Delayed ripening



and enhancement of flavor has been incorporated in tomatoes.

- **Stress Tolerance:** The crops are designed so as to have a higher resistance towards extreme environments like high and low temperatures and other adversities like drought, flood, salinity etc.

- **Disease Resistance:** GM crops show high resistance towards many diseases e.g., oranges resistant to citrus greening disease or American Chestnut resistant to fungal blight disease have been developed.

### GM Crops and Major Concerns

- **Allergenicity or toxicity:** A big concern for general public is that a GM food may accidentally introduce allergic or toxic reactions in the person consuming it. However, sufficient literature to prove this is not present
- **Ecological Imbalance:** The horizontal transfer of genes to non-target organisms has a very low chance, yet it cannot be ignored. Any such transfer e.g., antibiotic resistance gene transfer to bacteria, pesticide resistance gene

transfer to pest etc. can cause significant ecological imbalances.

- **Ethical Concerns:** There is an ongoing debate in engineering designer crops and 'playing God'.
- **Socio-economic Issues:** Most of the GM crops are patented by the companies producing them and that makes them costly.

### Conclusion

GM crops hold a lot of potential in terms of improvement of quality traits. The market of GM crops is growing everyday owing to the need of producing good quality food. Much literature is not present to confirm the effect of these crops on the health of organisms and environment. More research is required to provide an insight into their sustainability and long term effects on the ecosystem.



# TRANSGENIC ORGANISMS: CASE STUDIES

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GM: Genetically Modification is a technology which involves insertion of DNA into the genome of a given organism. The genetic makeup of an organism is its genome, which in all plants and animals is made of DNA. Here are the some genetic modified crops:-

## 1) ***BT* Brinjal**

*BT* brinjal is transgenic brinjal created by inserting a gene (cryIAC) from the soil bacteria *Bacillus thuringiensis*. This gives brinjal plant resistance against Lepidopteran insects like *Leucinodes orbonalis* (the brinjal fruit and shoot borer) and *Helicoverpa armigera* (fruit borer). When the insect injects the *BT* toxin, there is a disruption of digestive process resulting in the death of insects.

The project, *BT* brinjal started in 2000 has been developed in India by the collaboration of Maharashtra hybrid seed company Mahyco, and Monsanto. It's biosafety assessments includes pollen flow test, test for acute oral toxicity, allergenicity etc. all these test were performed in 2002. After two years of greenhouse evaluation in 2004, field trials were conducted at 11 locations with five hybrids of brinjal. Under strict evaluation, field trials were conducted.

When the transgenic *BT* brinjal was created it had both positive and negative view from different group of people. Positive views included the report that the average shoot damage in *BT* brinjal was less than the non-*BT*



brinjal, the percentage of damaged fruit was more in non-*BT* brinjal, no substantial difference was noted between *BT* brinjal and non-*BT* brinjal on the test for toxicity and allergenicity, which was helpful for the marginal farmers which otherwise would use to use 25-80 spray of pesticide that too were ineffective, the price used would also be cost-effective for all farmers. It was confirmed that farmers will be able to save and reuse their seeds. The views of opposing groups were that *BT* crops and GM crops have created many health problems as shown by several studies on bioengineered food. GM-fed animals showed various health problems regarding growth, organ development, immune response. Itching, eruption in body, swollen faces were reported on exposure to high levels of *BT* toxins, in Philippines people living next to or nearby *BT* corn field showed some strange allergies, *BT* toxin had caused slow immune response and abnormal cell growth in mice, Cry protein in *BT* crop have amino acid sequence similar to known allergens.

There were many controversies surrounding *BT* Brinjal which has generated much debate in scale farmers as it shows insect resistance, increased yield, more cost-effective and have minimum environmental impact. On the other hand, there are concerns that *BT* Brinjal relate to adverse impact on human and animal health,

biosafety and biodiversity. Ministry of Environment and Forest (MoEF) has a governing body (GEAC) which has recommended the environmental release of *BT* Brinjal in India which was based on the recommendations of (RCGM). But Ministry of State for Environment and Forest responded strongly both in favour and against the introduction of the *BT* Brinjal and has left the final decision on public after consultations across the country.



## 2) *BT* Cotton

Biosafety study was conducted on *BT* cotton expressing the cry1Ac gene. Various studies on risk assessment were done on gene flow, aggressiveness, effect on target and nontarget organism, effect on soil microflora, agronomic advantage. Further studies were conducted on toxicity of *BT* cotton seed on goats, bird, fish, allergenicity in rats, food and feed safety studies in cows and buffaloes. In all the studies and evaluation conducted on *BT* cotton, it found to be safe and very much similar to non-



*BT* cotton. As on date, 62 *BT* cotton hybrids have been approved for commercial cultivation in India. Till now the only approach to engineer crop for insect tolerance has been the addition of *BT* toxin from soil bacteria. These toxins have no effect on the non-target species and are environment-friendly. *BT* cotton is the only crop commercialized in India. Three hybrids containing cry1Ac gene were approved in 2002. Various biosafety studies were done on environmental safety, food safety, and all risk assessments. As the pollen was very sticky, its travel was confined, there was no weediness and aggressiveness found when compared to the non-*BT* counterparts. There was no toxic effect on non-target species and it was also found that this toxin was degraded in the soil as no traces of toxins were found in the soil.

Thus, all the studies conducted reveals that there is no change in composition in *BT* and non-*BT* plants with respect to proteins, oil, carbohydrates, and calories, etc., no change in endogenous allergens of *BT* seeds compared to non-*BT* seeds. No significant differences were found in animals fed with *BT* and non-*BT* seeds. Moreover, *BT* cottonseed meal was nutritionally wholesome and safe.



### 3) **GOLDEN RICE**

The development of golden rice faced technological challenges and ethical issues. The rice has been modified to contain the precursor of vitamin A, a vital constituent missing in the diet of millions of impoverished people in various developing countries. In July 2000, the magazine 'Science' announced Golden Rice to be the solution to vitamin A deficiency. This announcement created the global controversy. Various anti-GM protesters campaigned against it. Golden rice has been researched under all biosafety norms and regulations. Many tests were performed pertaining to its biosynthetic pathway and bioconversions, gene expression profiling, allergenicity potential, taste analysis, and feeding trials with human adults in China were also carried out to measure the effect of fat in diet on bioavailability and bioconversions.





All the risk assessments evaluated were documented and submitted to the approving authority in the receiving country according to the Cartagena Protocol on Biosafety. The entire risk assessment included the evaluations and documentation regarding the identification of GMOs, assessment of Risk level category, information on the recipient or parental organization, information about coding and non-coding sequences of donor organisms. Description of the modification of the introduced DNA, vector and technique used, intended use of GMO or derived product in order to allow the evaluation and compare the agronomic fitness, good lab practices followed or not in terms of safe handling, storage, transport, its use, labelling, disposal, etc., regulatory status within the country, possibly immediate or the delayed effect on environment resulting from the direct and indirect interactions between genetically modified higher plants (GMHP) and non-target

organisms were seen. It also included the effect on competition, herbivore, etc. All the possible immediate or the delayed effect on human health resulting from potential direct or indirect interaction with GMHP. Immediate and delayed effect on animal health and consequences for the food and feed chain resulting from the consumption of the GMO were also seen. Other assessments that were done during the evaluation of golden rice were regarding its specific composition and distribution, environmental safety considerations that include weediness and out crossing potential, food and feed safety it includes presence of anti-nutrients in rice, allergen assessment evaluation on the possibility of any kind of known and unknown allergen. After the assessments of all the well possible risks, all the details of all the data are documented and monitored with all the competent authorities before submitted it to approval for commercializing. In 2018, Canada and United States approved Golden rice for cultivation with 'Health Canada' and 'FDA' respectively. In 2019, it was approved for direct human and animal consumption in Philippines.



## NEWS

### 1. "LETTUCE in SPACE STATION"

Researchers have observed that the red lettuce, grown in International Space Station, is as nutritious as those grown on earth. The study was published in the journal 'Frontiers in Plant Science' claims that the lettuce grown in space is free from all sort of microbes and is secure to devour our astronauts. This remarkable work could permit astronauts to grow fresh and safe food during space missions.

### 2. "COVID-19 OUTBREAK"

Corona viruses are a large family of viruses that are known to cause illness ranging from the common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS). The most recent one was first reported in Wuhan, China. This is a unique and novel virus responsible for Covid-19 disease. The number of positive cases is gradually increasing globally. Now, declared as pandemic, is the cause of about 360 thousand of people worldwide. All the scientist communities worldwide are working hard to develop vaccines against the disease. By far, USA is the most affected nation.

## MAN OF SCIENCE: DR. PAUL BERG

During 1960-70s, nations were engaged in disputes over gene splicing and its development. They thought that this is a dangerous technique which can generate new varieties of disease causing microbes-viruses; alter human evolution etc, thus too dangerous to be allowed to continue. But between these debates, the scientists were continuously working on this technology to develop transgenic plants and animals. Several scientists, biochemists and biologists have gradual advancement in the field of biotechnology, however Sir PAUL BERG, in 1972, was the first scientist to develop a recombinant product and opened the door to the intervention on Recombinant DNA Technology (RDT).



Dr. Berg received his doctorate at Case Western Reserve University, Cleveland and then he worked with Sir Arthur Kornberg in St. Louis, Missouri. He made his Nobel Prize-awarded discovery at Stanford University. He successfully inserted a bacterium gene into tumor virus SV40. Thus creating the first ever DNA molecule made of parts from different organisms. This type of molecule became known as "hybrid DNA" or "recombinant DNA". The Paul Berg's method opened the way to creating bacteria that produce substances used in medicines.





# GENETICALLY MODIFIED ANIMALS

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The animals that have been modified genetically for the production of drugs and the purpose of research to develop new products are called Genetically Modified Organisms (GMOs).

## **Brief methodology**

Varieties of techniques/methods are available for inserting a gene into the host DNA. Microinjection method is preferred method for creating transgenic animals or through the use of viral vectors. New technologies like gene targeting and genome editing have made genetic modifications easier and more precise. CRISPR and TALEN are among recent development that will help in creating transgenic animals without hassles.

Glo-Fish, a genetically modified Zebra fish with glowing body in the dark (fluorescent gene

added in the DNA of fish) was the first commercialized, genetically modified animal, ultraviolet light. It was released to the US market in 2003.

## **Animals Produced through Genetic Modifications**

Animal are also modified for fighting diseases.

- Scientists have developed genetically modified (GM) mosquitoes to combat various deadly diseases. For almost a decade, the biotechnology firm Oxitec has been testing whether the GM mosquitoes can suppress populations of disease causing mosquitos, which carry devastating viruses such like Zika and dengue. The company has genetically changed the mosquitoes with a gene that is lethal to females but not



to males, which do not bite or transmit disease. Thousands of these transgenic mosquitoes are released in natural habitat, have shown promising result in controlling mosquito population. Oxitec has conducted releases in the Grand Caymans, Malaysia, Brazil and Florida with successful results.



A genetically modified mosquito emerges from its pupa

- Rosita ISA, a genetically modified cow is a research work of Argentine biotechnologists. If this experiment become successful this breed will produce “humanized” milk that will help in saving life of thousands of infants and newborns who die every year due to unavailability of human milk. Rosita cow’s DNA contains two genes of human origin, coding for two milk proteins, lactoferrin and lysozyme. Both proteins have antibacterial properties and protect the infant against infectious diseases. Lactoferrin stimulates the infant’s immune system and lysozyme, destroys harmful bacteria.



Rosita ISA, a cow genetically modified to produce human-like milk.

- Aqua Advantage Salmon, a GM salmon fish species developed growth hormone gene from Ocean pout. The continuous expression of the inserted gene allows the fish to grow year-round instead specific seasons. This GM fish is the first animal to be approved for food consumption in year 2015. The purpose of this genetic modification is to increase the speed of fish grows without affecting its ultimate size or other qualities.



One of Aqua Bounty's genetically engineered salmon behind a regular salmon of the same age.

- Selective fish breeding of rohu species, a commonly consumed fish in our country



has been initiated for the first time in India, in collaboration with scientist from Norway to genetically improve rohu for higher growth rate, through rigorous selection method and breeding was performed. Size gain of 18% was witnessed. Modified rohu was tested in different climatic conditions of India. These GM rohu exhibited higher growth efficiency over native rohu breed and local hatchery stocks. The improved rohu is named as “Jayanti”.



A genetically modified Rohu (top) alongside the normal, average-sized version.

### Successful Start-up, BT Alumni, IMSEC



Greenway Technologies commenced in the year 2007 jointly by Mr. Varun Arora and Mr. Neeraj Tyagi, alumni of Biotechnology Department, IMS Engineering College, Ghaziabad. This company has competent, qualified, and well experienced team of professionals to handle large projects for **waste water treatment** for industrial, municipal, institutional etc. Dedicated team of this company provides best services to clients with innovative, effective solutions to a wide range of environmental problems and issues i.e. Sewage treatment, industrial/institutional waste cleaning, sustainable agriculture, aquaculture and effluent treatment. Greenway Technologies is committed to deliver high quality products, improved technology based solution on turnkey basis with devoted services and our un-beaten competitiveness ensures customer satisfaction. Company delivers services with advancing technologies by offering selected strains of microbes, automation and controls that allow water treatment plants to use less energy in their operations and plant audits that identified energy saving opportunities.



# IMPACT OF GENETICALLY MODIFIED ORGANISMS

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The term ‘genetic modification’ uproots differently in diverse group of peoples- life scientists imagine it as desired genetic alteration to fulfill the essential condition while lawmakers and citizens consider it as a curse to the ecological balance. The advancement in genetic modification techniques resulted into increase in the number of GMOs resulting into the debate over its impact on agriculture, environment, food safety and ecological balance between these two communities. These arguments sometimes develop misconception related to the GMOs and spread entire negative information. This impartiality is required to be resolve and all the effects of GMOs must be presented to the people to face the reality.

## How genetic modifications initiated?

The theory of natural selection describes that the survival of organisms totally depends on their adaptation of changes in environment. These changes can be observed in the genetic makeup of different filial generations. The concepts of genetic modifications were adopted by the scientists to alter the genes using different tools/techniques in the laboratory, resulting into the development of ‘Genetically Modified Organisms’. The first GMO was accidentally discovered in bacteria by Frederick Griffith in *Streptococcus pneumonia* strains during 1920s. His experiments developed the concept that the bacteria can acclimatize foreign genes in its genome through a process



called as 'transformation'. In 1970s, the scientists developed techniques using plasmids to modify the genetic makeup of bacterial strains, which is now known as 'recombinant plasmids' method to insert any foreign gene in the host organism. This technique was first

reported by Stephen Norman Cohen and Herbert Boyer in 1973 in an article entitled, "Construction of Biologically Functional Bacterial Plasmids *In Vitro*". Thereafter, the encroachment of gene transfer started and the knowledge of living system at molecular level triggered with maximum pace. Now, the genetic modification has been introduced in various fields to obtain the molecular level information and data to apply for the benefits of human beings. The presence of GMOs in environment are affecting in different aspects, these impacts are summarized here.

### **Impact of GMOs in Medicine**

The entry of GMOs in the field of biomedical research opened the door to understand the molecular basis of any disease and develop the therapy or medicine accordingly. The GM animal model of human diseases allows the

scientists to learn the life cycle of causative agent of disease with its chronic effects on the hosts. This critical analysis of diseases reveals the process to generate the possible therapy to target the disease causing agent. The use of GM microbes and animals in pharmaceutical industries resulted in the presence of safer and cheaper therapeutics/vaccines in the market. Some examples are recombinant hepatitis B vaccine produced by GM *Saccharomyces cerevisiae*; insulin produced by GM *Escherichia coli*; tissue plasminogen activator produced by GM mammalian cells, novel DNA vaccines against HIV/AIDS, tuberculosis etc. The plants based edible vaccines are also produced within edible parts by genetic modifications. The insects are also modified genetically to reduce the parasitic diseases, such as SM1 Protein is developed from GM mosquitoes to block the entrance of malaria parasite; the sterile insect technique used in male *Aedes aegypti* kills mosquitoes before their sexual maturation. The method of gene therapy, recombinant DNA combined with stem cells technology, has emerged as a treatment option for the rare diseases such as metabolic disorders, cancer, anaemia etc.



## Impact of GMOs in Environment

Currently the environment is facing the problem of over population, global warming and continuous loss in biodiversity, which is leading to the result in the gap between existing food webs and food scarcity. These problems are currently trying to be resolved from the introduction of GMOs inside the environment. The entrance of any new biological entity into the environment takes years to adopt and results into either genetic or ecological impacts (unplanned) including-

- Variations in population dynamics resulting into changes in food chains/web
- Disparities in biogeochemistry
- Difficulties in farming practices
- Changes in environmental microbial populations

In agriculture, insecticides, pesticides, drought and virus resistant crops are developed. The use of insecticides, pesticides and virus resistant crop has decreased the use of chemical fertilizers, which are harmful to the humans and soil too. The widely used GM crops are

soybean, Bt cotton, maize. However some negative effects on the environment from GMOs are a big concern for scientists and the public. These restrictions are required to be monitored at every level by the scientists. These crops are thoroughly evaluated for their environmental effects before entering the marketplace. Since, there can be enormous number of variables which determine impact on the environment. All crops bred, whether obtained through “traditional” breeding techniques or through GM technology, can have an impact on the environment.

In conclusion, science cannot declare any of its technology completely risk free. Genetically engineered crops can reduce some environmental risks associated with conventional agriculture, but will also introduce new challenges that must be addressed. Society will have to decide when and where genetic engineering is safe enough. The term ‘genetic modification’ uproots differently in diverse group of peoples- life scientists imagine it as desired genetic alteration to fulfil the essential condition while lawmakers and citizens consider it as a curse to the ecological balance.



The advancement in genetic modification techniques resulted into increase in the number of GMOs resulting into the debate over its impact on agriculture, environment, food safety and ecological balance between these two communities. These arguments sometimes develop misconception related to the GMOs and spread entire negative information. This impartiality is required to be resolve and all the effects of GMOs must be presented to the people to face the reality.

## LEVERAGING FACTS

GMOs have never been detected in milk, meat or eggs derived from animals feed GM feed.

There are only 10 genetically modified crops commercially available in the United States today: alfalfa, apples, canola, corn (field and sweet), cotton, papaya, potatoes, soybeans, squash and sugar beets.

While some people may think 'GMO cancer' exists, but in more than the twenty years in the market, GMOs have not caused or contributed to a single illness or death.

## TEST YOURSELF- 1

1. The controversy regarding the use of the BT cotton is \_\_\_\_

(A) Is potentially harmful to monarch butterflies

(B) Is a potential allergic to human

(C) Both a and c

(D) Can contaminate groundwater

2. Starch content of potatoes can be increased by using a bacterial gene, known as \_\_\_\_

(A) Sucrose phosphate synthase gene

(B) ADP glucose pyrophosphatase gene

(C) Polygalacturonase gene

(D) None of the above

3. Which tropical fruit crop has been successfully engineered to be protected against a lethal virus \_\_\_\_

(A) Passion Fruit

(B) Papaya

(C) Mango

(D) Lychee

4. Which of the following metabolites are implicated in stress tolerance \_\_\_\_

(A) proline

(B) betaines

(C) both a and b

(D) citrates



5. Which of the agricultural challenges below cannot be solved with transgenic techniques \_\_\_\_

(A) Crops are damaged by frost

(B) Crops are killed by A virus

(C) Public concern about safety of synthetic pesticides

(D) Public preference for organic vegetables

6. Plants containing genes encoding cytokines and blood clotting factors are used in \_\_\_\_

(A) Nutrition improvement

(B) Pharmaceutical production

(C) Vaccine production

(D) Textile production

7. The first transgenic plants expressing engineered foreign genes were tobacco plants produced by the use of \_\_\_\_

(A) *Agrobacterium tumefaciens*

(B) *Arabidopsis thaliana*

(C) *Bacillus thuringiensis*

(D) *Streptomyces hygroscopicus*

8. If the goal were to create a plant resistant to an insecticide, which cell based plant technology would be most effective \_\_\_\_

(A) Clonal propagation

(B) Cybridisation

(C) Protoplast fusion

(D) Mutant selection

9. Which of the following self-pollinating plants tend to be homozygous \_\_\_\_

(A) Peas

(B) Tomato

(C) Peach

(D) All of these

10. Which of the following dies from Ti plasmid infection \_\_\_\_

(A) Rice

(B) Corn

(C) Sorghum

(D) All of these

11. The delayed ripening tomatoes was created by \_\_\_\_ a gene

(A) Altered

(B) Silenced

(C) Replaced

(D) Relocated

12. Sugar content of the fermentation medium for the citric acid is maintained at \_\_\_\_

(A) 10-15%

(B) 15-20%

(C) 20-25%

(D) 25-30%





## **ETHICAL ISSUES REGARDING GENETICALLY MODIFIED ORGANISMS**

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Modern techniques in Biotechnology have made the impossible, possible and have opened the whole world for Biotechnologists. Genetic modifications in the innate organisms is one such modern technology that has improved the quality of life and raised the standard of living of human beings through improved health and better quality products. As it is the deliberate introduction of beneficial genetic material from one species into the existing system of another species, it resulted in creating the population of genetically modified organisms of various kinds. This deliberate manipulation in the genome of species and along with its benefits has moved Biotechnology from small laboratories to the big fields.

But, keeping the benefits aside, there are many predicted and unpredicted risks also which are associated with the release of these genetically modified organisms in the environment. The applications of Biotechnology offer innumerate benefits to human needs and environment. Advanced biotechnology has generated a series of potential application in agriculture, animal husbandry, medical application, environmental management, and industrial products but have many concerns that are not necessarily scientific. There are numerous ethical, legal and social implications of biotechnology and other biosciences. There has been strong pressure to regulate the technology to address these concerns.



## Ethics and Morals Associated with Transgenic Animals

Many groups of people and many organizations carry strong opinions on topics like transgenic animals. Some think that the world biomass might shift following the release of transgenic animals and plants while others debate on the ethics of harming animals for research. There are debates on the ethical, spiritual and cultural impact of this science. Xenotransplantation offers treatment for people with organ failure which is a burning problem for people who are living in this era Industrialization. For example, xenotransplant pig whose cells are being genetically altered to block the expression of any specific glycoprotein residue on its surface which can be viewed as foreign by the human immune system. Such type of animals are called **knockout transgenic** animals because genetic modification is done to delete the expression of its own gene instead of expressing immune response against foreign gene, which is a normal defense system of any living organism. The ethical issue here is that the animals have to sacrifice their life to provide its organ to save human life. In a similar way, Harvard mouse is also an ethical concern as it induces the disease in mouse which is unethical, but at the same time, this is the only means to measure and find cure for

many important human diseases. In summary, the following ethical concerns exist in working on transgenic animals

Violation of animal rights – their treatment as a human property rather than beings in their own right

- Dangers that transgenic animals may pose to human health
- Poor quality of life for genetically engineered animals e.g. fast-growing pigs have discomfort in their heart when they are too active

## Other Major Bioethical Issues

### A. Socio-Legal Issues related to GMOs

- As the science of biotechnology is product-oriented, it is important to have supervisions, regulations and legal boundaries in place. The release of GMOs in the environment, farm trials, etc. must be adequately monitored because lack of supervision and regulation can lead to illegal practices around the same.
- Erosion of public accountability due to the transfer of novel technology from public to the private sector.
- No legal binding from the FDA for mandatory labeling of GM food



- Genetic engineering is being used for creation of biological warfare through the development of dreadful virus and bacteria which can cause an epidemic and initiate a genetic arms race. There has to be legal ban to stop such kind of inhumane applications of biotechnology.

### **B. Socio-Economic Issues raised by the Use of Biotechnology-**

There are certain following questions that have aroused in the minds of people regarding the use of biotech.

Will the benefits of genetic engineering and molecular biotechnology be available only to rich people or will it be universal?

With the advancement in research in the area of agriculture, will these new techniques overlook the conventional farming practices? Will it be the case in future that medicinal therapies which are based on molecular biotechnology will surpass the equally potential and effective conventional treatments? Finance to such advanced areas of biotechnology will cause hindrance to funding of important and useful technologies in other areas. More money today is being spent on rare genetic disorders than on more prevalent diseases like malaria.

### **C. Environmental Issues**

As biotic components are directly linked to the abiotic components in the environment, any change or manipulation of any biotic component may create environmental issues. A summary of environmental issues related to bioethics is given below-

- Careless release of genetically engineered micro-organisms can cause damage to the ecology. Different organizations under biosafety have made it mandatory to the release of GMO under proper regulations.
- GM products are live entities. They pose danger to the environment because they can reproduce, mutate, migrate and spread.
- Introduction of novel types into foreign habitats may disturb the natural equilibrium. Carp, salmon, etc have been transformed with number of genes from human, cattle, and rats to increase their growth and reproduction. If released into the environment the novel mutant fish can mate with the native species, mixing and polluting the gene pool of native species.
- Unforeseen and undesirable characteristics can occur in novel species through genetic engineering.



- Unacceptable transmission of gene as genetic material to other hosts.
- The production of genetically engineered organisms in large scale will reduce natural genetic diversity.

Genetic diversity found in animal breeds and plant breeds is the foundation of on-going continuous evolution and selection of stocks by farmers and breeders will inhibit this natural evolution process.

#### **D. Health and Safety Issues**

Apart from many beneficial products, Genetic engineering has proved to be unsafe in some of the projects which have been abandoned due to negative results. Some of them are Bovine growth hormone has resulted in the increased occurrence of diseases like mastitis in cows, there are reports of users of genetically engineered insulin collapsing to unconsciousness, use of synthetic tryptophan resulted in various symptoms like severe muscle pain. It was banned later but this has questioned the risks of bioengineered products, use of recombinant human growth hormone in children has been linked to incidence of leukemia and melanoma, use of BT endotoxin gene for pest resistance in crops has been linked to stunted growth in plants, possibility of antibiotic marker gene and known allergens getting passed to the human food chain

#### **E. Bioethics and Consumer Acceptance**

Bioethics is about moral choices arising from the assessment of risks and benefits related to human progress in biotechnology. Bioethics is also about a range of social and ethical factors and concerns related to the consumption and development of genetically engineered food and products. Different people have different perceptions related to this area of research. One group of people that supports the well-being of animals, do not want animals to be experimented because these techniques and manipulations inflict suffering on them, it brings loss of biodiversity and man trying to play God, vegetarians are debating on the transfer of animal genes to plants. While the other group of people advocates GM crops as they are needed to feed the growing population of the world with enhanced nutritive and therapeutic value, genetic research can find cure to diseases, xeno transplants can reduce human organ shortages saving large number of lives. Transgenic technology and genetic engineering present intriguing and difficult challenges for 21st-century scientists and ethicists. Something unethical for one group of people may not be unethical to the other group and this disparity opens up a difficult challenge to the regulatory authorities to frame guidelines for the use and development of GM food.



For public acceptance, it is very important to have the right understanding and awareness on all aspects of biotechnology. Failure to do so will surely result in lower degree of public acceptance of GMOs and agricultural products. It is also important to consider that public may not be interested in the fine technicalities involved in the development of the GMO but in the more relevant direct outcome - how GM food is going to benefit an individual, what potential it holds as a whole, what impact will it have on human health and the protection of the environment and freedom of choice to the consumer. Besides this, all queries related to moral actions need to be answered to individual satisfaction. At this point, scientific and non-scientific organizations are needed to guide the consumer to make the right choices. Labeling is under discussion in the European Union. Labeling GE products is consistent with bioethics as long as it represents the truth in full details - what all is present in the product - which will enable the consumer to choose according to their own ethical principle. This freedom of choice has an implication for national policy in technology assessment, education and other information campaigns and openness about where and what decision are taken. The scientific community, government, industry, and the media are together responsible

for providing all the relevant information in the public interest. We cannot abandon scientific research and advancements in biotechnology. At the same time, we need to make sure that ethics and morals pertaining to the commercial use of this research are observed and there is public acceptance at large scale for the use of this technology for the betterment of life on the planet.

## TEST YOURSELF-2

### 1. Alegar is a type of vinegar produced from \_\_\_\_\_

(A) Fruit Juices

(B) Malted Grain

(C) Ethanol

(D) Ale

### 2. Recombinant vaccine for hepatitis-B virus has been synthesized against antigen \_\_\_\_\_

(A) Viral core antigen (HBcAg)

(B) Viral surface antigen (HBsAg)

(C) E antigen (HBeAg)

(D) All of the above

### 3. What effect does eating genetically modified foods have on your genes \_\_\_\_\_

(A) It could cause your genes to mutate

(B) It could cause your own genes to absorb the excess genes

(C) It has no effect on your genes

(D) The effect on human genetics aren't known



4. Which of the following microbes is widely used in the removal of industrial wastes\_\_\_\_\_

(A) *Trichoderma* sp.

(B) *Aspergillus niger*

(C) *Pseudomonas putida*

(D) All of the above

5. The technique electrophoresis , for the separation of charged molecules was developed by\_\_\_\_\_

(A) Tswett

(B) Svedberg

(C) Tiselius

(D) Sanger

6. A genetically engineered micro-organism used successfully in bioremediation of oil spills is a species of \_\_\_\_\_

(A) *Trichoderma*

(B) *Bacillus*

(C) *Xanthomonas*

(D) *Pseudomonas*

7. ELISA is based on\_\_\_\_\_

(A) Antigen-antibody interaction

(B) Antigen-protein interaction

(C) Lectin-antibody interaction

(D) All of the above

8. Which one is a true statement regarding DNA polymerase used in PCR?

(A) It is isolated from a virus

(B) It remains active at high temperature

(C) It is used to ligate introduced DNA in recipient cells

(D) It serves as a selectable marker

9. First artificial gene was synthesized by-

(A) Nirenberg

(B) Mendel

(C) Morgan

(D) Khorana

10. Dolly, the first cloned mammal, was produced by

(A) Parthenogenesis

(B) Artificial fertilization

(C) Replacement of zygote nucleus by somatic nucleus

(D) in vitro fertilization



# Tools & Techniques Used in Genetic Engineering

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The science and techniques used to manipulate and improve the biological processes in living organisms and further utilized for benefits of human beings is called as 'biotechnology'. Genetic engineering, is a sub-field of biotechnology, manipulates the genome of any organism by altering the genes by heritable and non-heritable recombinant DNA constructs. The technology used to construct the new recombinant DNA is known as recombinant DNA technology. The recombinant DNA constructs can also be inserted in the different species, thus producing transgenic variety. Today, genetic engineering is playing a crucial role in developing transgenic microbes, animals and plants to produce valuable products.

The development of recombinant DNA technology based product involves following steps-

1. Isolation of the desired gene from the source genome (DNA Preparation).
2. Insertion of the isolated gene fragment into the selected vector (Vector Preparation and Ligation).
3. Transfer of the recombinant vector into the host cell and allow them to divide (Transformation).
4. Screening of recombinant DNA containing host cells. The gene carried by the recombinant molecule is now being called as 'cloned'.



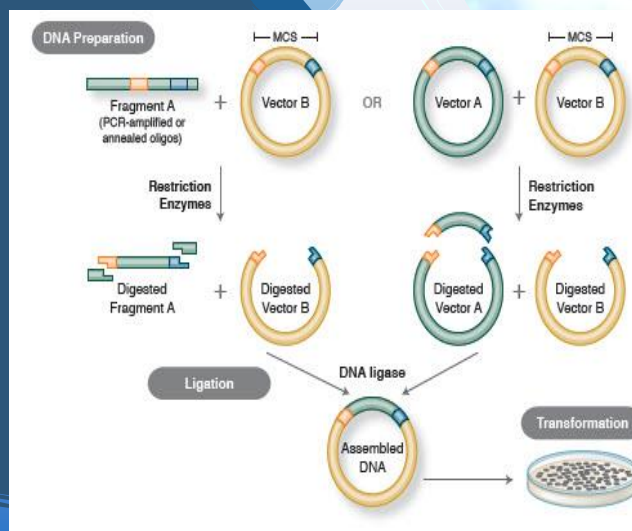


Figure: Basic Steps of gene cloning. (Image adopted from <https://international.neb.com/tools-and-resources/feature-articles/foundations-of-molecular-cloning-past-present-and-future>).

These basic steps of gene cloning are time consuming process. With the advancements in the field of genetic engineering, the rapid and efficient methods for cloning were required. The Polymerase Chain Reaction (PCR) is the technique developed by Kary Mullis allowed the cloning easier to the molecular biologists. Now, the genetic engineers are using various tools for quick and accurate amplicons (gene copies) generation.

The different tools and techniques used in Genetic Engineering are:

## I. Enzymes

- Enzymes play a key role in all biochemical reactions. The recombinant DNA technology is also based on various enzymes- restriction endonucleases, alkaline phosphatases, reverse transcriptase, kinase, DNA ligase, nucleases, terminal deoxynucleotidyl transferases and DNA polymerase.

- Restriction Endonucleases- also known as molecular scissors, recognizes and cuts at specific restriction sites of dsDNA. There are three types of restriction endonucleases identified based on its structure and the DNA cuts they produce- Type I restriction enzymes, Type II restriction enzymes, and Type III restriction enzymes.
- The restriction endonucleases are used in plasmid gene insertion, protein expression profiling, gene alleles identification, SNP analysis and restriction fragment length polymorphism (RFLP) analysis.

The function of other enzymes used in recombinant DNA technology are-



Enzyme	Function
DNA Polymerase	Fills the gap in duplexes by stepwise addition of nucleotides to 3' ends
Reverse Transcriptase	Makes a copy of an RNA molecule
Polynucleotide Kinase	Adds a phosphate to label it or permit ligation
Terminal Transferase	Adds homopolymer tails to the 3'-OH ends of a linear duplex
Alkaline Phosphatase	Removes terminal phosphates from either 5' or 3' end (or both)

## II. Vectors

- Vector is a carrier molecule which transfers recombinant DNA into host organisms. If the vector has ability to replicate in two different species, it is known as shuttle vector and if the gene of interest present in vector, is expressed as protein, the vector is known as expression vector. The various vectors used in gene cloning are- plasmid, bacteriophage, cosmid, bacterial artificial chromosome and yeast artificial chromosome.

• Vector System	• Host Cell	Insert Capacity (kb)
Plasmid	<i>Escherichia coli</i>	0.1 – 10
Bacteriophage	<i>Escherichia coli</i>	10 – 20
Cosmid	<i>Escherichia coli</i>	35 – 45
Bacteriophage P1	<i>Escherichia coli</i>	80 – 100
Bacterial Artificial Chromosome	<i>Escherichia coli</i>	50 – 300
P1 Bacteriophage-derived AC	<i>Escherichia coli</i>	100 – 300
Yeast Artificial Chromosome	Yeast	100 – 2000
Human AC	Cultured Human Cell	>2000

## III. Gel Electrophoresis

- Gel electrophoresis is a separation technique based on the size and migration of DNA fragments in an electric field. Since, DNA is



negatively charged molecule; it migrates towards the positive electrode when exposed in an electric field. A gel matrix restricts the migration of larger molecules comparatively to the smaller molecules, thus separating them into different 'bands'. The resolving power of gel electrophoresis is very high. The polyacrylamide gels are used to separate about 2000 nucleotides while molecules between 500 to 20 kb are separated by agarose gel.

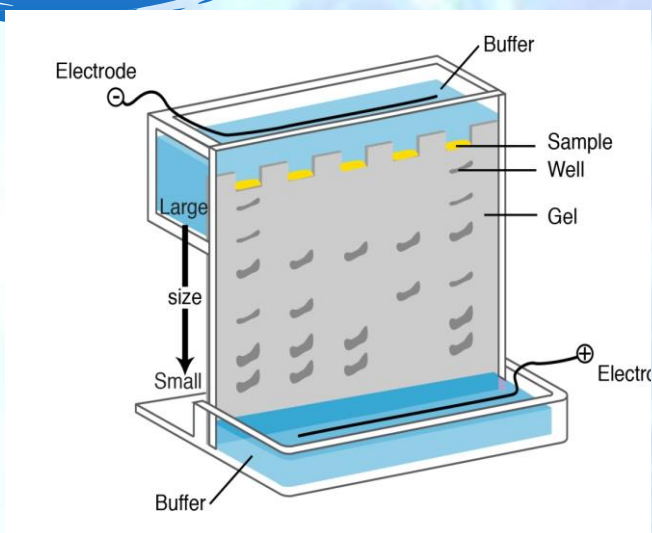


Image Source: <https://www.genome.gov/genetics-glossary/Electrophoresis>

#### IV. Polymerase Chain Reaction (PCR)

The PCR technique is based on the ability of DNA polymerases to synthesize new DNA strands complementary to the given DNA

template. The process is carried out in a single test tube simply by mixing DNA with a set of reagents and allowing the templates to amplify in a thermocycler at a series of temperatures.

The basic steps of a cycle in the PCR experiment are:

1. Denaturation: The DNA template and the PCR reagents are mixed and heated to 95°C resulting into breaking of double-stranded DNA molecule.
2. Annealing: This step allows the present primers (oligonucleotides) to anneal the DNA templates at specific positions, during cooling down the components to 55 °C.

Extension: The new DNA strands begin to synthesize at 72°C by Taq polymerase

The cycles are repeated to generate the amplicons exponentially. Usually, 20-30 standard PCR cycles are carried out to produce about  $10^6$  to  $10^9$  DNA fragments by the two primers. The PCR amplification takes place as-



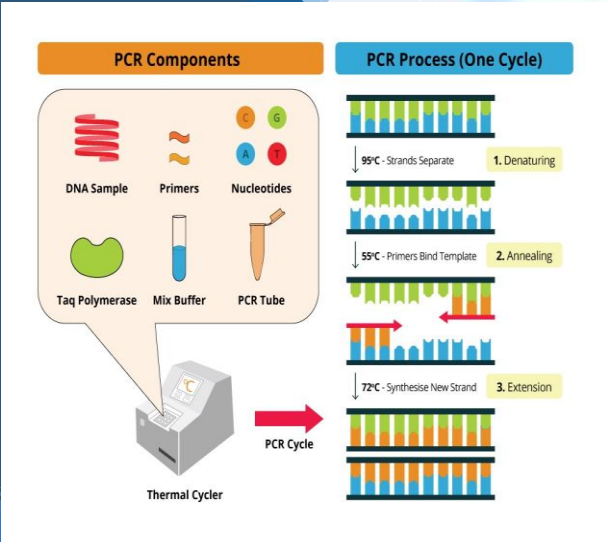


Figure: Polymerase Chain Reaction- Components and Process. (Source:<https://www.bosterbio.com/protocol-and-troubleshooting/molecular-biology-principle-pcr>).

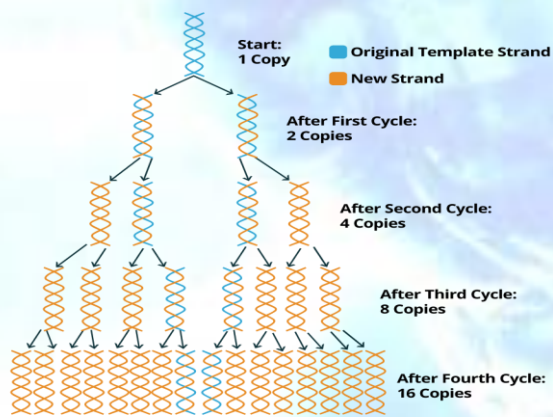


Figure Source:<https://www.bosterbio.com/protocol-and-troubleshooting/molecular-biology-principle-pcr>.

The PCR techniques are widely used in the DNA sequencing based methods such as diagnosis of genetic and infectious diseases,

genetic fingerprinting, gene mutagenesis, amplification of ancient DNA for archaeological studies etc. PCR methods involves the prior knowledge of target gene, which limits its processing for unknown samples.

### LEVERAGING FACTS

About 99.9% of human DNA is the same. It is the other 0.1% that codes for all of the differences that make each person unique.

Humans shares about 98% of their genes with chimpanzees, 92% with mice, 76% with zebrafish, 51% with fruit flies, and 18% with *E. coli* bacteria.

Each cell in your body contains about two meters of DNA. If laid end-to-end, it would measure 200 billion kilometers. That’s long enough to stretch from Earth to the sun 1,333 times. To put that in perspective, it would take 7.4 days for sunlight to travel the same distance.



# VARIOUS PROSPECTS OF GENETIC ENGINEERING

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Generally in our regular life routine, we hear some words like Herbicides, Hybrid breeds of animals, Drought resistance plant varieties, Insulin, Diagnosis of birth defects or disorders, Genetically modified organisms etc. All these things are possible only because of the new and novel techniques in genetic engineering.

## **Genetic Engineering**

Firstly, the term Genetic engineering was taken by "Jack Williamson" in a science fiction Novel- 'Dragons Island'. It is a process of adding a new or modified DNA to the Genome of a living organism. It is method to alter or remove the gene from one organism and place

it in another organism for providing the ability to express the nature of that gene. It assists to improve the traits of organism.

"Paul Berg" is the father of genetic engineering, who invented a method of joining a DNA from two different organisms in 1973. Organisms created using genetic engineering is called Genetically Modified Organisms.

## **Genetic Engineering in Human health**

In 1980s, Engineers developed a genetically modified insulin for diabetics patients, and also manufactured the genetically manufactured clot-busters to stop heart attacks. Along with this, some major inventions are antibodies and



some proteins to fight cancer, hormones to halt anemia, vaccines for hepatitis B and antibodies for the prevention of organ rejections in case of organ transplantation in humans. Genetic engineers also work on the harmful viruses or bacteria (microorganisms) into messengers that are capable to carry therapeutic drugs to specific tissues in the human body. There were too many inherited conditions incurable till 2012, but with the research carried by genetic engineers, new methods have been found to fix these conditions. In the absence of treatments, reports from genetic engineers help patients using the result of genetic testing and prepare them for diagnosis and better treatment.

### **Genetic Engineering in Agriculture**

To enhance the resistance capacity of plants against diseases and pests, changes in the genetic sequence of fruits or vegetables are introduced. For the improvement of crop yield, investigation of the plant genes and identification of DNA that aids growth are required. Genes that make crops herbicide-resistant are inserted in plant genome, so farmers could get better crop yield.

### **Genetic Engineering in Animal Sciences**

Genetic engineers also focus on boosting production of food for animals. They develop synthetic, genetically engineered vaccines that avoid the potential side effects of live vaccines against infectious diseases. They have created antibodies that make some live vaccines less dangerous.

#### **GENE THERAPY- VECTOR INJECTIONS TO CURE RENAL DISEASE**



Mastering the targeted delivery of therapeutic genes to the desired location within the body is the first necessary step towards implementing gene therapy to treat renal diseases. One way to do so is by the means of genetically modified viruses that act as vectors for the therapeutic gene. In a novel approach devised by a group of scientists from the Mayo clinic, three different gene delivery vectors were injected intravenously and directly into the kidneys of mice.

(Source: <http://timesofindia.indiatimes.com/>)



**National Conference on "CRISPR-Cas Technique" organized at  
IMS Engineering College, Ghaziabad**

Biotechnology Department of IMS Engineering College, Ghaziabad organized one-day national conference on the topic "**CRISPR-Cas as an Emerging Tool for Genome Editing**" on February 22<sup>nd</sup>, 2020. The CRISPR-Cas genome editing technique can very effectively make precise changes to the desired site in an organism's genome, and thus has the potential to correct many genetic disorders.

The conference was inaugurated by the **Shanti Swarup Bhatnagar Award winner, eminent scientist Prof. Deepak Gaur**, School of Biotechnology, JNU, New Delhi and Prof. (Dr.) Sraban Mukherjee, Director, IMS Engineering College jointly. In his welcome address, the Director said that this conference is **the first of its kind event in India**, where eminent scientists of the country came together to discuss the applications of this powerful technology.

The keynote speaker of the conference Prof. Deepak Gaur highlighted genome editing techniques using CRISPR-Cas and its various applications. He described it as a revolutionary technology in the field of biotechnology and explained its use for the treatment of many genetic disorders as well as congratulated the conference organizers.

Prof. Rita Sharma, School of Computational and Integrative Sciences, JNU, New Delhi discussed about the implementation of CRISPR-Cas for crop improvement. She also explained the technology involved in this. Dr. Vijai Singh, Indrashil University, Gujarat also explained in detail the mechanism and functioning of the CRISPR-Cas gene editing system. Dr. Lokesh, NBPGR, New Delhi emphasized the need for more active research in this field by various research institutes of our country.

This one day national conference was attended by more than a hundred participants including faculty members, research scientists, postgraduate and graduate students from various organizations like Delhi University, Jamia University, JNU, Institute of Pharmacopoeia etc.

Conference organizing secretary Prof. Meghna Singh encouraged the participants of the conference to do more active research on this subject. The conference was concluded with a vote of thanks by Prof. Rashmi Chandra, Head, Biotechnology Department.

## क्रिस्पर-कैस तकनीक पर राष्ट्रीय सम्मेलन



आइएमएस कॉलेज में आयोजित कार्यक्रम में भाग लेते लोग ● सौजन्य- कॉलेज जास, गाजियाबाद : आइएमएस जीनीनिशियल कॉलेज में शनिवार को डिपार्टमेंट ऑफ बायोटेक्नोलॉजी के क्रिस्पर-कैस विषय पर एक दिवसीय राष्ट्रीय सम्मेलन का आयोजन किया गया। सम्मेलन में बताया कि क्रिस्पर-कैस जीनोम एडिटिंग तकनीक बहुत प्रभावी ढंग से किसी जीन के जीनोम में वांछित स्थल पर सटीक परिवर्तन कर सकती है। इसमें कई अनुवांशिक विकारों को दूर करने की क्षमता है। सम्मेलन का उद्घाटन शांति स्वरूप भटनागर पुरस्कार प्राप्त प्रख्यात वैज्ञानिक डॉ. दीपक गीर, और आइएमएस के निदेशक डॉ. श्रवण मुखर्जी ने संयुक्त रूप से किया। डॉ. श्रवण मुखर्जी बताया कि भारत में इस तरह का यह पहला कार्यक्रम है, जहां देश के प्रख्यात वैज्ञानिक इस शक्तिशाली उपकरण के अनुप्रयोगों पर चर्चा करने के लिए एक साथ आए। सम्मेलन के मुख्य वक्ता डॉ. दीपक गीर ने क्रिस्पर-कैस और इसके विभिन्न अनुप्रयोगों का उपयोग करते हुए जीनोम संपादन तकनीक पर प्रकाश डाला। इस मौके पर डॉ. रीत शर्मा, डॉ. विजई सिंह, डॉ. लोकेश, सविंद डॉ. मेघना सिंह के साथ छात्रों ने भाग लिया।

आईएमएस इंजीनियरिंग कॉलेज में  
राष्ट्रीय सम्मेलन का हुआ आयोजन



गाजियाबाद (करंट क्राइम)।

[illegible]

के लिए एक साथ आए। सम्मेलन के मुख्य वाक्ता प्रोग दीपक शौर ने क्रियर केस और इसके विभिन्न अनुयोगों का उपयोग करते हुए जीनोम संयोजन तकनीक पर प्रकाश डाला। उन्होंने इसे बायोटेक्नोलॉजी के क्षेत्र में एक क्रान्तिकारी तकनीक बताया एवं इसके कई अनुयोगों के विकास के इलाज के लिए उपयोग को समझा और सम्मेलन के आभोजकों को बायार्ड टी। प्रो ग्रेस शर्माएं स्कूल ऑफ कम्यूनिटील एंड इंटीग्रेटिव साइंसजेशन जेएनएनएच नई दिल्ली ने



फसल को बेहतरी के लिए किसान कैस के कार्यक्रमन चरन को भरो में थी उन्होंने। जॉन विजय सिंह इंदरल विजयविद्यालय गुजरात में वेतन और कार्यक्रम को भी दिखार के बताता। 'हैं लोकपाल परचोणी जीन सोड दिल्ली ने हमारे देश के विभिन्न सोड संस्थाओं द्वारा इस क्षेत्र में अधिक संलग्न सोच को आलसकता पर चर्चा दिया। एक दिवसीय सम्मेलन में विभिन्न संस्थानों जैसे दिल्ली



यूनिवर्सिटीए जामिआ यूनिवर्सिटीए जेनेरल एडिटिंग इन्स्टीट्यूट ऑफ फार्माकोजीया इत्यादि के सकाये सार्वभौम अनुसंधान वैज्ञानिकोंके स्वागतकार और स्वागत छहौं खतित सी से अधिक प्रतिभागीयों ने भाग लिया। सम्मेलन के आयोजन संघ प्रो. मेघना सिंह ने सम्मेलन के प्रतिभागीओं को इस विषय में अधिक सोच करने के लिए प्रेरित किया। सम्मेलन का सम्पन्न जैव प्रौद्योगिकी विभागा के प्रमुख डॉ. रश्मि चंदा द्वारा धन्यवाद ज्ञापन के साथ किया गया।





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