World Journal of Pharmaceutical and Life Sciences
WJPLS
www.wjpls.org
SJIF Impact Factor: 6.129

GMOs: THE WONDER OF 21ST CENTURY

***[1]Kushal Nandi, [1]Saroni Saha, [1]Dr. Dhrubo Jyoti Sen and [2]Dr. Dhananjoy Saha**

[1]Department of Pharmaceutical Chemistry, School of Pharmacy, Techno India University, Salt Lake City, Sector-V, EM-4, Kolkata-700091, West Bengal, India.
[2]Deputy Director, Directorate of Technical Education, Bikash Bhavan, Salt Lake City, Kolkata–700091, West Bengal, India.

Corresponding Author: Kushal Nandi
Department of Pharmaceutical Chemistry, School of Pharmacy, Techno India University, Salt Lake City, Sector-V, EM-4, Kolkata-700091, West Bengal, India.

Article Received on 11/02/2021 **Article Revised on 01/02/2021** **Article Accepted on 21/03/2021**

ABSTRACT

A genetically modified organism (GMO) is any organism whose genetic material has been altered using genetic engineering techniques. The exact definition of a genetically modified organism and what constitutes genetic engineering varies, with the most common being an organism altered in a way that "does not occur naturally by mating and/or natural recombination". A wide variety of organisms have been genetically modified (GM), from animals to plants and microorganisms. Genes have been transferred within the same species, across species (creating transgenic organisms), and even across kingdoms. New genes can be introduced, or endogenous genes can be enhanced, altered, or knocked out. Many objections have been raised over the development of GMOs, particularly their commercialization. Many of these involve GM crops and whether food produced from them is safe and what impact growing them will have on the environment. Other concerns are the objectivity and rigor of regulatory authorities, contamination of non-genetically modified food, control of the food supply, patenting of life and the use of intellectual property rights. Although there is a scientific consensus that currently available food derived from GM crops poses no greater risk to human health than conventional food, GM food safety is a leading issue with critics. Gene flow, impact on non-target organisms, and escape are the major environmental concerns. Countries have adopted regulatory measures to deal with these concerns. There are differences in the regulation for the release of GMOs between countries, with some of the most marked differences occurring between the US and Europe. Key issues concerning regulators include whether GM food should be labeled and the status of gene-edited organisms.

KEYWORDS: Genetics, Organisms, DNA, Chromosomes, Bacteria, Virus, Fungi.

INTRODUCTION

What constitutes a genetically modified organism (GMO) is not always clear and can vary widely. At its broadest it can include anything that has had its genes altered, including by nature. Taking a less broad view it can encompass every organism that has had its genes altered by humans, which would include all crops and livestock. In 1993 the Encyclopedia Britannica defined genetic engineering as "any of a wide range of techniques among them artificial insemination, in vitro fertilization (e.g., "test-tube" babies), sperm banks, cloning, and gene manipulation." The European Union (EU) included a similarly broad definition in early reviews, specifically mentioning GMOs being produced by "selective breeding and other means of artificial selection." They later excluded traditional breeding, in vitro fertilization, induction of polyploidy, mutagenesis and cell fusion techniques that do not use recombinant nucleic acids or a genetically modified organism in the process.[1]

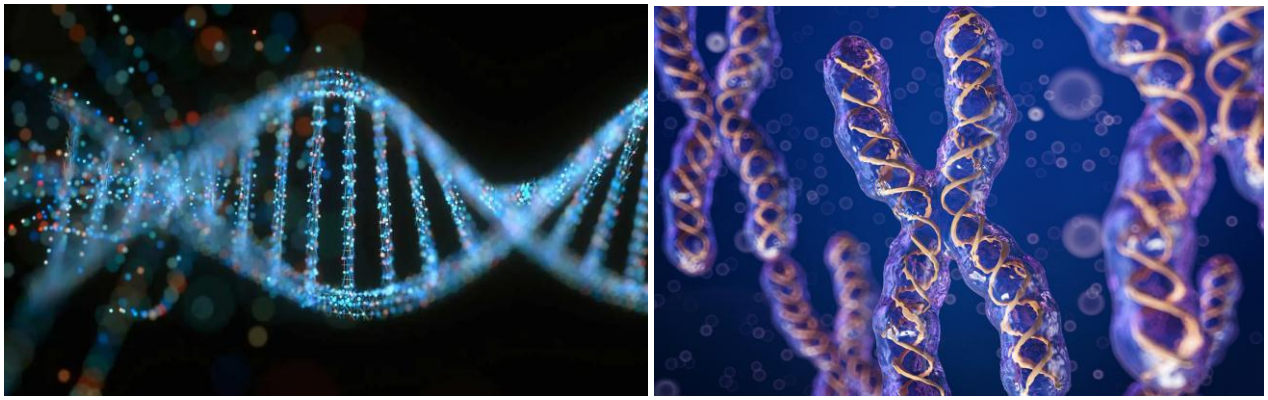

Figure-1: Two basics of GMO ; DNA and Chromosome.

Humans have domesticated plants and animals since around 12,000 BCE, using selective breeding or artificial selection (as contrasted with natural selection). The process of selective breeding, in which organisms with desired traits (and thus with the desired genes) are used to breed the next generation and organisms lacking the trait are not bred, is a precursor to the modern concept of genetic modification. Various advancements in genetics allowed humans to directly alter the DNA and therefore genes of organisms. In 1972 Paul Berg created the first recombinant DNA molecule when he combined DNA from a monkey virus with that of the lambda virus.

Herbert Boyer and Stanley Cohen made the first genetically modified organism in 1973. They took a gene from a bacterium that provided resistance to the antibiotic kanamycin, inserted it into a plasmid and then induced other bacteria to incorporate the plasmid. The bacteria that had successfully incorporated the plasmid were then able to survive in the presence of kanamycin. Boyer and Cohen expressed other genes in bacteria. This included genes from the toad *Xenopus laevis* in 1974, creating the first GMO expressing a gene from an organism of a different kingdom.

Traditionally the new genetic material was inserted randomly within the host genome. Gene targeting techniques, which creates double-stranded breaks and takes advantage on the cells natural homologous recombination repair systems, have been developed to target insertion to exact locations. Genome editing uses artificially engineered nucleases that create breaks at specific points. There are four families of engineered nucleases: mega nucleases, zinc finger nucleases, transcription activator-like effector nucleases (TALENs), and the Cas9-guideRNA system (adapted from CRISPR). TALEN and CRISPR are the two most commonly used and each have its own advantages. TALENs have greater target specificity, while CRISPR is easier to design and more efficient.

- **BACTERIA:** Bacteria were the first organisms to be genetically modified in the laboratory, due to the relative ease of modifying their chromosomes. This ease made them important tools for the creation of other GMOs. Genes and other genetic information from a wide range of organisms can be added to a plasmid and inserted into bacteria for storage and modification. Bacteria are cheap, easy to grow, clone, multiply quickly and can be stored at −80 °C almost indefinitely. Once a gene is isolated it can be stored inside the bacteria, providing an unlimited supply for research. A large number of custom plasmids make manipulating DNA extracted from bacteria relatively easy.[2]

Figure-2: *Escherichia coli.*

Their ease of use has made them great tools for scientists looking to study gene function and evolution. The simplest model organisms come from bacteria, with most of our early understanding of molecular biology coming from studying *Escherichia coli*. Scientists can easily manipulate and combine genes within the bacteria to

create novel or disrupted proteins and observe the effect this has on various molecular systems. Researchers have combined the genes from bacteria and Achaea, leading to insights on how these two diverged in the past. In the field of synthetic biology, they have been used to test various synthetic approaches, from synthesizing genomes to creating novel nucleotides.

- **VIRUSES:** Viruses are often modified so they can be used as vectors for inserting genetic information into other organisms. This process is called transduction and if successful the recipient of the introduced DNA becomes a GMO. Different viruses have different efficiencies and capabilities. Researchers can use this to control for various factors; including the target location, insert size, and duration of gene expression. Any dangerous sequences inherent in the virus must be removed, while those that allow the gene to be delivered effectively are retained.

While viral vectors can be used to insert DNA into almost any organism it is especially relevant for its potential in treating human disease. Although primarily still at trial stages, there has been some successes using gene therapy to replace defective genes. This is most evident in curing patients with severe combined immunodeficiency rising from adenosine delaminate deficiency (ADA-SCID), although the development of leukemia in some ADA-SCID patients along with the death of Jesse Gelsinger in a 1999 trial set back the development of this approach for many years. In 2009 another breakthrough was achieved when an eight-year-old boy with Leber's congenital amaurosis regained normal eyesight and in 2016 GlaxoSmithKline gained approval to commercialize a gene therapy treatment for ADA-SCID. As of 2018, there are a substantial number of clinical trials underway, including treatments for hemophilia, glioblastoma, chronic granulomatous disease, cystic fibrosis and various cancers.

- **FUNGI:** Fungi can be used for many of the same processes as bacteria. For industrial applications, yeasts combine the bacterial advantages of being a single-celled organism that is easy to manipulate and grow with the advanced protein modifications found in eukaryotes. They can be used to produce large complex molecules for use in food, pharmaceuticals, hormones, and steroids. Yeast is important for wine production and as of 2016 two genetically modified yeasts involved in the fermentation of wine have been commercialized in the United States and Canada. One has increased malolactic fermentation efficiency, while the other prevents the production of dangerous ethyl carbonate compounds during fermentation. There have also been advances in the production of biofuel from genetically modified fungi. Fungi, being the most common pathogens of insects, make attractive biopesticides. Unlike bacteria and viruses, they have the advantage of infecting the insects by contact alone, although they are out competed in efficiency by chemical pesticides. Genetic engineering can improve virulence, usually by adding more virulent proteins, increasing infection rate or enhancing spore persistence. Many of the disease carrying vectors are susceptible to entomopathogenic fungi. An attractive target for biological control are mosquitoes, vectors for a range of deadly diseases, including malaria, yellow fever and dengue fever. Mosquitoes can evolve quickly so it becomes a balancing act of killing them before the *Plasmodium* they carry becomes the infectious disease, but not so fast that they become resistant to the fungi. By genetically engineering fungi like *Metarhizium anisopliae* and *Beauveria bassiana* to delay the development of mosquito infectiousness the selection pressure to evolve resistance is reduced. Another strategy is to add proteins to the fungi that block transmission of malaria or remove the *Plasmodium* altogether.
- **PLANTS & CROPS:** Plants have been engineered for scientific research, to display new flower colors, deliver vaccines, and to create enhanced crops. Many plants are pluripotent, meaning that a single cell from a mature plant can be harvested and under the right conditions can develop into a new plant. This ability can be taken advantage of by genetic engineers; by selecting for cells that have been successfully transformed in an adult plant a new plant can then be grown that contains the transgene in every cell through a process known as tissue culture.[3]

Figure-3: Genetically Modified Crops and Brinjal.

Genetically modified crops are genetically modified plants that are used in agriculture. The first crops developed were used for animal or human food and provide resistance to certain pests, diseases, environmental conditions, spoilage or chemical treatments (e.g. resistance to an herbicide). The second generation of crops aimed to improve the quality, often by altering the nutrient profile. Third generation genetically modified crops could be used for non-food purposes, including the production of pharmaceutical agents, biofuel, and other industrially useful goods, as well as for bioremediation.

- **ANIMALS (MAMMALS, HUMANS, FISH, INSECTS):** The vast majority of genetically modified animals are at the research stage with the number close to entering the market remaining small. As of 2018 only three genetically modified animals have been approved, all in the USA. A goat and a chicken have been engineered to produce medicines and a salmon has increased its own growth. Despite the differences and difficulties in modifying them, the end aims are much the same as for plants. GM animals are created for research purposes, production of industrial or therapeutic products, agricultural uses, or improving their health. There is also a market for creating genetically modified pets.

1. **MAMMALS:** The process of genetically engineering mammals is slow, tedious, and expensive. However, new technologies are making genetic modifications easier and more precise. The first transgenic mammals were produced by injecting viral DNA into embryos and then implanting the embryos in females. The embryo would develop and it would be hoped that some of the genetic material would be incorporated into the reproductive cells. Then researchers would have to wait until the animal reached breeding age and then offspring would be screened for the presence of the gene in every cell. The development of the CRISPR-Cas9 gene editing system as a cheap and fast way of directly modifying germ cells, effectively halving the amount of time needed to develop genetically modified mammals.
2. **HUMANS:** Gene therapy uses genetically modified viruses to deliver genes which can cure disease in humans. Although gene therapy is still relatively new, it has had some successes. It has been used to treat genetic disorders such as severe combined immunodeficiency, and Leber's congenital amaurosis. Treatments are also being developed for a range of other currently incurable diseases, such as cystic fibrosis, sickle cell anemia, Parkinson's disease, cancer, diabetes, heart disease and muscular dystrophy. These treatments only affect somatic cells, meaning any changes would not be inheritable. Germ line gene therapy results in any change being inheritable, which has raised concerns within the scientific community.
3. **FISH:** Genetically modified fish are used for scientific research, as pets and as a food source. Aquaculture is a growing industry, currently providing over half the consumed fish worldwide. Through genetic engineering it is possible to increase growth rates, reduce food intake, remove allergenic properties, increase cold tolerance and provide disease resistance. Fish can also be used to detect aquatic pollution or function as bioreactors.[4]

Figure-4: Genetically Modified Fish.

1. **INSECTS:** In biological research, transgenic fruit flies (*Drosophila melanogaster*) are model organisms used to study the effects of genetic changes on development. Fruit flies are often preferred over other animals due to their short life cycle and low maintenance requirements. They also have a relatively simple genome compared to many vertebrates, with typically only one copy of each gene, making phenotypic analysis easy. *Drosophila* has been used to study genetics and inheritance, embryonic development, learning, behavior, and aging.[258] The discovery of transposons, in particular the p-element, in *Drosophila* provided an early method to add transgenes to their genome, although this has been taken over by more modern gene-editing techniques.

Techniques

- **Simple Selection:** a natural or artificial process that results or tends to result in the survival and propagation of some individuals or organisms but not of others with the result that the inherited traits of the survivors are perpetuated — compare Darwinism, natural **selection**.
- **Crossing over: Crossing** over is the swapping of genetic material that occurs in the germ line. During the formation of egg and sperm cells, also known as meiosis, paired chromosomes from each parent align so that similar DNA sequences from the paired chromosomes **cross** over one another.[5]

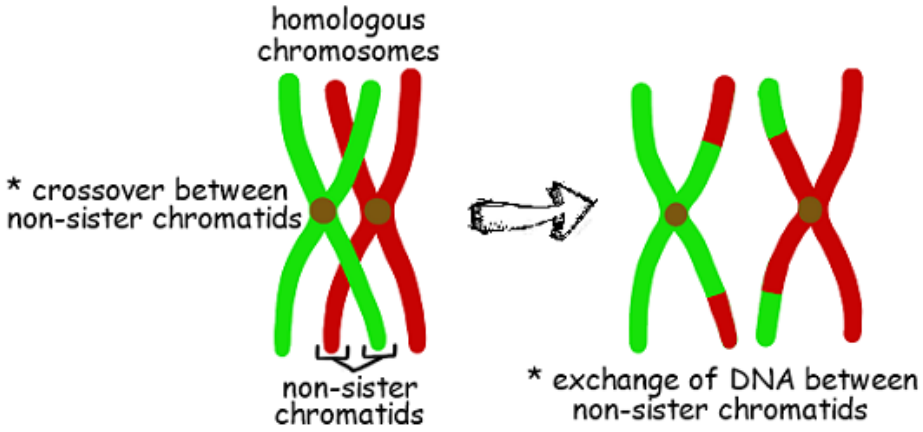

Figure-5: Crossing Over.

- **INTERSPECIFIC CROSSING:** An **interspecific** hybrid is a **cross** between plants in two different species. Many times, they will be from the same genus, but not always. In animals, hybridization often results in sterility or low fertility, but this is less often the case with plants.

Figure-6: Result of Interspecific Crossing (Pink colour flower).

- **Embryo rescue: Embryo rescue** is one of the earliest and successful forms of *in-vitro* culture techniques that is used to assist in the development of plant **embryos** that might not survive to become viable plants.
- **Somatic Hybridization: Somatic hybridization** is a technique which allows the manipulation of cellular genomes by protoplast fusion. Its major contribution to plant breeding is in overcoming common crossing barriers among plant species and in organelle genetics and breeding.

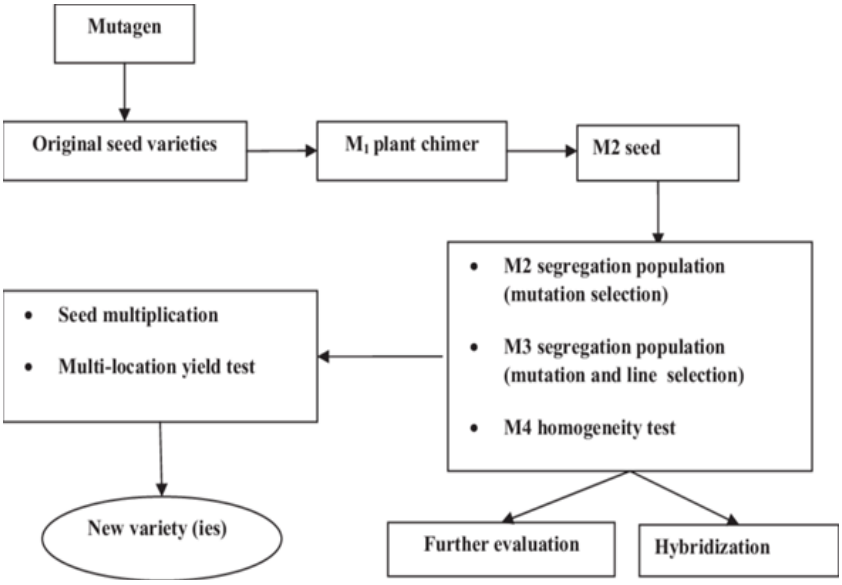

Figure-7: Methods of Mutation Breeding.

- **Soma clonal Variation: Soma clonal variation** is **defined** as genetic **variation** observed among progeny of plants regenerated from somatic cells cultured in vitro. Although theoretically all plants regenerated from somatic cells should be clones, a number of observations have indicated that this is not the case.
- **Mutation breeding: Mutation breeding**, sometimes referred to as "variation **breeding**", is the process of exposing seeds to chemicals or radiation in order to generate **mutants** with desirable traits to be **bred** with other cultivars. Plants created using mutagenesis are sometimes called mutagenic plants or mutagenic seeds.
- **Cell Reselection: Cell Reselection** is a kind of mechanism to change **cell** after UE is camped on a **cell** and stay in IDLE mode. This is to let UE get connected to **cell** which has the best condition among all the **cells** to which the UE is allowed to camp on.[6]

Procedures

Production of GMOs is a multistage process which can be summarized as follows:

- Identification of the gene interest;
- Isolation of the gene of interest;
- Amplifying the gene to produce many copies;
- Associating the gene with an appropriate promoter and poly A sequence and insertion into plasmids;. multiplying the plasmid in bacteria and recovering the cloned construct for injection;
- Transference of the construct into the recipient tissue, usually fertilized eggs;
- Integration of gene into recipient genome;
- Expression of gene in recipient genome; and
- Inheritance of gene through further generations.

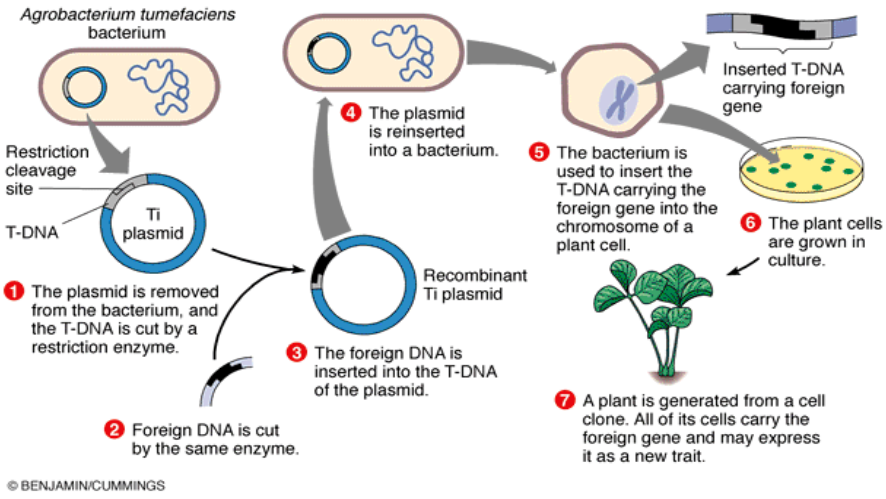

Figure-8: Procedures of making GMO.

1. **Choice of target genes:** Cold water temperatures are often a major problem in aquaculture in temperate climates when an unusually cold winter can severely damage both production and brood fish stocks of fish. Some marine teleports have high levels of serum anti-freeze proteins (AFP) or glycoproteins (AFGP) which reduce the freezing temperature by preventing ice-crystal growth. Fletcher, Hew and Davies (2001) have shown that there is one class of AFGP and four classes of AFP. Most are expressed primarily in the liver and some show clear seasonal changes (Me lamed *et al*., 2002). Work has particularly focussed on the production of AFP from the winter flounder (*Pleuronectes americanus*), and the gene has been successfully introduced into the genome of Atlantic salmon, integrated into the germ line and passed on to F3 offspring where it was expressed in the liver. However, a number of Ala, Pro-specific endopeptidases are required for production of mature proteins and these are not present in Atlantic salmon. Furthermore, the AFP gene in winter flounder, and possibly other Arctic species, exists in many copies (see Section 7). Thus, much further work is required in order to develop effective antifreeze activity in Atlantic salmon (Hew *et al*., 1999). Work on AFP has also been conducted in goldfish (Wang *et al*., 1995) and milkfish (Wu *et al*., 1998).
2. Genetic manipulation has also been undertaken in order to increase the resistance of fish to pathogens. This is currently being addressed by the use of DNA vaccines (encoding part of the pathogen genome) and antimicrobial agents such as lysozyme (Demers and Bayne 1997). An example is the injection of Atlantic salmon with a DNA sequence encoding infectious hematopoeitic echovirus (IHNV) glycoprotein under the control of the cytomegalovirus promoter (pCMV). Challenge with the virus eight weeks later revealed that a significant degree of resistance had been achieved. The fish were still resistant and were shown to have generated antibodies three months later (Traxler *et al*., 1999). Similar studies have been undertaken for other fish diseases eg. Haemorrhagic septicaemia virus (VHS) (Lorenzen, Olesen and Koch, 1999) and work of this kind appears to have great potential value for fish farms (Me lamed *et al*., 2002). We would also draw attention to the work using a cecropin B gene from the moth *Hyaloplova cecropin*. When channel catfish transgenic for this gene were challenged with *Flavobacterium columnare* and *Edwardsiella ictaluri* survival was better for transgenics than controls (Dunham *et al*., 2002).
3. **Isolation of the gene of interest:** Usually the gene of interest will already be available as an element of a "library" of short sections of the total genome of the donor strain or species. If this is the case the procedure followed is to multiply the gene using the PCR reaction. If, however, the gene is to be taken from a genome not previously investigated, a more complex procedure will need to be followed. The use of the technique of the Polymerase Chain Reaction (PCR) enables the gene in both the cases noted above to be multiplied to the level of several million copies needed for the generation of the construct.
4. **Cloning the gene of interest:** When many copies of the target gene have been generated, the gene is placed in a "construct". Once the gene of interest has been ligated enzymatically into the construct, this whole complex is ligated into bacterial plasmids, which act as "production vectors" and enable the gene to be replicated many times within the bacterial cells. The bacteria are then plated out. It is possible to tell from reporter genes (see below) whether the vector has been taken up by the bacterial cells. This usually involves some colour change in the colonies containing inserted DNA. The many times amplified DNA construct is then enzymatically cut out of the plasmids (after these have been removed from the bacterial cells) and it is ready to be used for insertion into eggs of the host species.
5. **The construct:** A construct is a piece of DNA which functions as the vehicle or vector carrying the target gene into the recipient organism. It has several different regions. There is a promoter region which controls the activity of the target gene, a region where the target DNA is inserted, usually some type of reporter gene to enable one to ascertain whether the target has combined successfully with the construct and a termination sequence.
6. **Techniques for inducing transgenics:** Transgenic fish have largely been produced through microinjection into fertilized eggs or early embryos. Electroporation of sperm has been shown to be successful in some species eg. Zebra fish (Khoo *et al*., 1992) Chinook salmon (Sin *et al*., 1994) and Loach (Tsai, Tseng and Liao, 1995). Liposomes have also been utilized as vectors (Khoo 1995). Ballistic methods using micro projectiles have been investigated in *Artemia* with a view to their use in generating transgenic crustacean (Gendreau *et al*., 1995) and also in seaweed species (Qin *et al*., 1994). "Baekonisation", an electric, flat field type of Electroporation was utilized to transfer DNA into Zebra fish embryos (Zhao, Zhang and Wong, 1993), this method appeared to be successful but has not been taken up in the same way as other forms of Electroporation and microinjection methods.
7. **Integration sites:** The factors determining sites of integration are still poorly understood though research in this direction is increasing. It is particularly important to gain greater accuracy in controlled site of integration because of the unpredictable effects of uncontrolled integration on resident genes. Caldovic and Hackett (1995) tested the ability of special sequences called transposable border elements from other species to confer

position-independent expression of transgenes or enhance integration of transgenic constructs into fish chromosomes. Early results indicate that such elements from some species do not act as enhancers and do not improve integration frequencies. However, both avian and insect border elements were found to confer position-independent expression as judged from expression of CAT genes in F_1 fish. Hackett *et al.*, (1994) showed that co-transfer of retroviral integrate protein with transgenic DNA can accelerate and enhance the rate of integration. More studies of this type are needed to improve the success and controlled positioning of integration of transgenes in the future.

8. **Expression of gene:** The uptake and integration of a transgene does not guarantee that the gene will express itself in the new genetic environment. Tests must be carried out to determine whether there is expression and if there is expression, at what level this takes place. Clearly, in commercial aquaculture only those transgenics expressing the target gene at a sufficiently high level will be of interest.
9. **Inheritance of gene:** A fish which expresses the target gene at an acceptable level may not be able to transmit the gene to progeny. This is because many transgenics are mosaic individuals and unless the gonads are included in the tissues possessing the transgene the transgenic animals will not breed true. Appropriate breeding tests must, therefore, be carried out. The high proportion of mosaic individuals is one reason why the proportions of progenies of different genotypes resulting from parents that are putatively homozygous for a transgene do not necessarily conform to Mendelian expectations. Another reason is the integration of two or more copies of the transgene at different sites in the recipient genome. Further breeding tests will be required in order to establish a pure breeding line of transgenic fish.

Risks and Precautions of Genetically Modified Organisms

Commercial potential of biotechnology is immense since the scope of its activity covers the entire spectrum of human life. The most potent biotechnological approach is the transfer of specifically constructed gene assemblies through various techniques. However, this deliberate modification and the resulting entities thereof have become the bone of contention all over the world. Benefits aside, genetically modified organisms (GMOs) have always been considered a threat to environment and human health. In view of this, it has been considered necessary by biosafety regulations of individual countries to test the feasibility of GMOs in contained and controlled environments for any potential risks they may pose.

Modern biotechnology has allowed the movement of genetic material across unrelated species, something impossible with the traditional breeding methods. This intentional transfer of genetic material has in turn brought biotechnology out from the laboratory to the field. Genetically modified organisms (GMOs) are organisms whose genetic material has been artificially modified to change their characteristics in some way or another.

Environmental applications of microorganisms are wide and varied, ranging from bioremediation, biopesticides, nitrogen fixation, plant growth promoter, to biocontrol of plant diseases, and other such agricultural practices. The sensible application of recombinant DNA techniques has shown the potential for genetically improved microorganisms to be used as soil or seed inoculants. Each gene may control several different traits in a single organism. Even the insertion of a single gene can impact the entire genome of the host resulting in unintended side effects, all of which may not be recognizable at the same time. It is difficult to predict this type of risk.[7]

Genetic Contamination/Interbreeding: Introduced GMOs may interbreed with the wild-type or sexually compatible relatives. The novel trait may disappear in wild types unless it confers a selective advantage to the recipient. However, tolerance abilities of wild types may also develop, thus altering the native species' ecological relationship and behavior.

Competition with Natural Species: Faster growth of GMOs can enable them to have a competitive advantage over the native organisms. This may allow them to become invasive, to spread into new habitats, and cause ecological and economic damage.

Increased Selection Pressure on Target and No target Organisms: Pressure may increase on target and no target species to adapt to the introduced changes as if to a geological change or a natural selection pressure causing them to evolve distinct resistant populations.

Ecosystem Impacts: The effects of changes in a single species may extend well beyond to the ecosystem. Single impacts are always joined by the risk of ecosystem damage and destruction.

Impossibility of Follow-up: Once the GMOs have been introduced into the environment and some problems arise, it is impossible to eliminate them. Many of these risks are identical to those incurred with regards to the introduction of naturally or conventionally bred species. But still, this does not suggest that GMOs are safe or beneficial, nor that they should be less scrutinized.

Horizontal Transfer of Recombinant Genes to Other Microorganisms: One risk of particular concern relating to GMOs is the risk of horizontal gene transfer (HGT). HGT is the acquisition of foreign genes (via transformation, transduction, and conjugation) by organisms in a variety of environmental situations. It occurs especially in response to changing environments

and provides organisms, especially prokaryotes, with access to genes other than those that can be inherited.

Some of the important potential impacts of HGT from GMOs include the following: -

Adverse Effects on the Health of People or the Environment: These include enhanced pathogen city, emergence of a new disease, pest or weed, increased disease burden if the recipient organism is a pathogenic microorganism or virus, increased weed or pest burden if the recipient organism is a plant or invertebrate, and adverse effects on species, communities, or ecosystems.

Unpredictable and Unintended Effects: HGT may transfer the introduced genes from a GMO to potential pests or pathogens and many yet to be identified organisms. This may alter the ecological niche or ecological potential of the recipient organism and even bring about unexpected changes in structure or function. Furthermore, the gene transferred may insert at variable sites of the recipient gene, not only introducing a novel gene but also disrupting an endogenous gene, causing unpredictable and unintended effects.

Loss of Management Control Measures: Regulatory approvals for field trials of GMOs often require measures to limit and control the release in space and time. With the spread of the introduced gene(s) to another species by HGT, a new GMO is created. This new GMO may give rise to adverse effects which are not controlled by management measures imposed by the original license or permit.

Risk Assessment: Risk is ubiquitous and unavoidable. To a great extent, therefore, our *modus operandi* involves assessment and management of risk. Directly observable risks are assessed and managed through heuristic processes. This direct observation may sometimes be insufficient to establish the nature and extent of risk. In such cases, we rely on other institutions, especially reputation and the rule of law. Biosafety issues pertaining to the marketing of GMOs have received increasing attention by national and international agencies and regulatory bodies worldwide. These are based on a common set of principles built on the accumulation of experience and scientific knowledge over the past decades. Risk assessment intends to quantify risks and evaluate the probabilities of possible outcomes on the basis of scientific data. It is a fundamental part of improving quality, being the quality of products or the quality of life, and plays a central role in the innovation required to maximize benefits. A critical step in risk assessment is identification of circumstances that may give rise to an adverse effect(s) (risk identification or "what could go wrong'' step).[8]

1. The potential to harmonize national regulatory frameworks thus ensures appropriate biosafety decision making based on scientific risk assessment. If properly implemented, the protocol has the potential to encourage innovation, development, technology transfer, and capacity building in relation to biotechnology, while also achieving the goals of conservation, sustainable agriculture, and equitable sharing of the technology's benefits.
2. To realize its potential, however, decisions concerning protocol implementation must be carefully considered and should not place undue burdens on a technology that possesses such great potential to contribute positively to sustainable agriculture and development throughout the world.
3. A first-things-first approach where initial efforts focus on bringing all parties to the protocol into compliance with it as quickly as possible. Developing further requirements or fine-tuning obligations at this stage only worsens the degree of noncompliance already in existence.
4. Therefore, capacity building should remain the primary area of focus under the Biosafety Protocol to ensure the safe adoption of this technology. In this regard, material exists to help national governments.
5. The users and developers of agricultural biotechnology embrace their share of the duty in the protocol implementation process and will continue to campaign for fair, science-based regulations and assist with and contribute to effective capacity building.

Ways to Manage Risks

- The potential for survival and persistence in the receiving environment and any selective advantage that may be offered: in case of selective advantage, its nature should be identified along with any potential for negative effects;
- The potential for gene transfer,
- The potential for negative effects or consequences based on interactions with indigenous microorganisms;
- Possible effects on humans, animals, and plants;
- Possible effects or (nonreversible) perturbations on biogeochemical processes.

CONCLUSION

The use of genetically modified organisms is important in order to meet increasing demands and improve existing conditions prevalent in our environment. We are at an anxious juncture where, on one hand, we are faced with unprecedented threats to human health and environment, while on the other hand we have opportunities to change the way things are done. Regulations concerning use of GMOs need a broader basis for decision. Post release impacts of GMOs can follow preventive and precautionary measures based on risk assessment and management. Monitoring and detection methods are vital for risk assessment and management to control the negative environmental and health impacts. The international biosafety regulatory frameworks are sufficiently stringent in order to protect against genuine ascertainable risks, as well as the ability of decision makers to discern the appropriateness of data necessary to adequately conduct a risk assessment, which

all have considerable consequences. Consideration of social, economic, and ethical issues needs to be taken care of. Application of the precautionary approach provides avenues for future development and use of genetic engineering.

Future Prospective of GMO: Regulation of GMO deals with a trans scientific problem, that is, the resolution of the problems is beyond the competence of the scientific system. Public perception and acceptance are dependent on trust and whether the products or processes benefit them as citizens and consumers. To take proper accounts of uncertainties and public concern would help to capture the benefits, minimize the risk, and provide goals for future development and use of genetic engineering. Judgment about risks should not be based on the method modification (classical or modern) but on the quality of the final product. What does the GMO contain, is it safe, and not how was the GMO made? Encouragement of new monitoring and detection methods and tools is therefore vital for assessment, control of environmental, and health impacts as well as collection of ecological knowledge of relevance to future releases.

ACKNOWLEDGEMENT




Kushal Nandi (Sem-VI) and **Saroni Saha (**Sem-IV) the two B.Pharm students are thankful to their project guide Dr. **Dhrubo Jyoti Sen** for getting inspiration to frame the article on Genetically Modified Organisms (GMO) supported by Deputy Director, Directorate of Technical Education [**Dr. Dhananjoy Saha**] Bikash Bhavan, Salt Lake City, Kolkata. This article describes the GMO type, process of making Genetically Modified Organism, their uses, Risks and precaution about GMO and how to overcome that risks.

REFERENCE

1. Oliver MJ "Why we need GMO crops in agriculture". Missouri Medicine, 2014; 111(6): 492–507.
2. Center for Food Safety and Applied Nutrition. "Food from Genetically Engineered Plants - Consumer Info About Food from Genetically Engineered Plants". www.fda.gov.
3. "What Is the Difference Between Genetically Modified Organisms and Genetically Engineered Organisms?" agbiotech.ces.ncsu.edu.
4. "Agricultural Biotechnology Glossary | USDA". www.usda.gov.
5. Zhang, Chen; Wohlhueter, Robert; Zhang, Han (September). "Genetically modified foods: A critical review of their promise and problems". Food Science and Human Wellness, 2016; 5(3): 116–123.
6. Tonelli, Fernanda M.P.; Lacerda, Samyra M.S.N.; Tonelli, Flávia C.P.; Costa, Guilherme M.J.; Renato de França, Luiz; Resende, Rodrigo R. (1 November). "Progress and biotechnological prospects in fish transgenesis". Biotechnology Advances, 2017; 35(6): 832–844.
7. Nebert DW, Stuart GW, Solis WA, Carvan MJ (January). "Use of reporter genes and vertebrate DNA motifs in transgenic zebrafish as sentinels for assessing aquatic pollution". Environmental Health Perspectives, 2002; 110(1): A15.
8. Mattingly CJ, McLachlan JA, Toscano WA (August). "Green fluorescent protein (GFP) as a marker of aryl hydrocarbon receptor (AhR) function in developing zebrafish (Danio rerio)". Environmental Health Perspectives, 2001; 109(8): 845–849.