Genetically Modified Organism (Transgenic Organism)

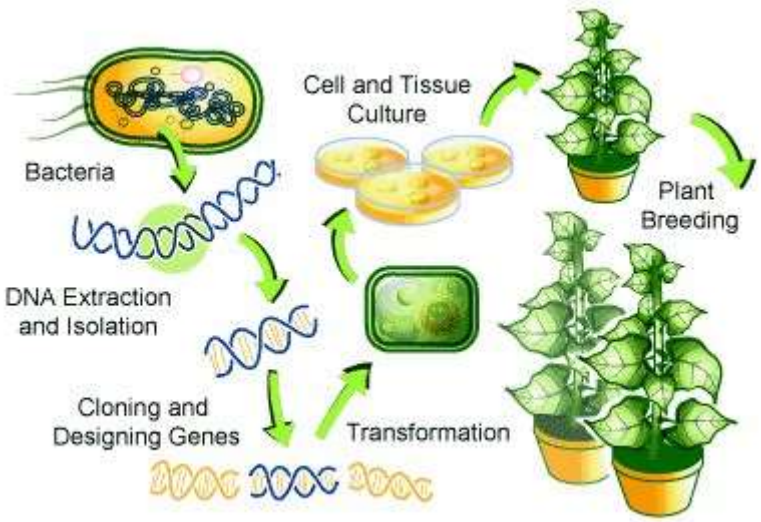
- In GMO, **genetic material (DNA) is altered or artificially introduced** using genetic engineering techniques.
- Genetic modification involves the **mutation, insertion, or deletion of genes.**
- Inserted genes usually come from a different organism (e.g. In Bt cotton, Bt genes from bacterium **Bacillus thuringiensis** are induced).
- Genetic modification is done to induce a desirable **new trait** which does not occur naturally in the species.

GM techniques are used in:

- Biological and medical research,
- Production of pharmaceutical drugs,
- Experimental medicine (e.g. gene therapy),
- Agriculture (e.g. **golden rice,** Bt cotton etc.),
- Genetically modified bacteria to produce the **protein insulin**,
- To produce biofuels from some GM bacteria, etc.

Genetically modified crops (GM Crops or Biotech Crops)

- They are the plants used in agriculture, whose DNA has been modified to induce a desired **new trait**.
- A New trait might help in
  - ✓ Controlling certain pests, diseases, or environmental conditions,
  - ✓ reduction of spoilage,
  - ✓ inducing resistance to chemical treatments (e.g. resistance to an herbicide),
  - ✓ **improving the nutrient profile** of the crop,
  - ✓ atmospheric nitrogen fixation by cereal crops,
  - ✓ inducing tolerance to high salt soils and to flooding in crops,
  - ✓ inducing drought resistance in crops,
  - ✓ prolonging shelf life and commercial value of fruits and vegetables.



Major GM Crops

Bt Cotton

- Bt cotton is **insect-resistant** cotton variety.
- Strains of the **bacterium Bacillus thuringiensis** produce different **Bt toxins**.
- Bt toxins are insecticidal to the larvae of moths, bollworms, etc. but are harmless to other forms of life.
- In 2002, a joint venture between **Monsanto** and **Mahyco** introduced Bt cotton to India.

Advantages

- Increases yield of cotton due to effective control of **three types of bollworms.**
- Reduction in insecticide use in the cultivation of Bt cotton in which bollworms are major pests.
- Potential reduction in the cost of cultivation (depending on seed cost versus insecticide costs).

Problems with Bt Cotton

- High cost of Bt cotton seeds as compared to non Bt cotton seeds.
- Ineffective against sucking pests **like whitefly.**
- Whitefly attack has become rampant in Punjab, Haryana and elsewhere.
- The costs of Bt seed and insecticide increase the risk of farmer bankruptcy in low-yield rain-fed settings.

Bt Brinjal

- Brinjal is India's second most consumed vegetable after potatoes.
- Bt brinjal is created by inserting a crystal protein gene from the soil bacterium **Bacillus thuringiensis.**
- **Mahyco** has developed the Bt brinjal variety.
- Insecticide requirement for Bt brinjal is far less than its non-Bt counterpart for the control of FSB.
- The Genetic Engineering Appraisal Committee (GEAC) cleared Bt brinjal for commercialization in 2009.
- Following concerns raised by some scientists and anti-GMO activists, the GOI has imposed a moratorium on its commercial use (not a permanent ban).
- Mahyco's Bt brinjal is commercially grown in Bangladesh.

Golden rice

- Golden rice is a variety of rice **(Oryza sativa)** produced to biosynthesize **beta-carotene**, a precursor of **Vitamin A**, in the edible parts of rice.
- It is mostly consumed in areas with a shortage of dietary vitamin A.

Benefits of GMO

Crops

- Enhanced taste and quality.
- Reduced maturation time.
- Increased nutrients, yields, and stress tolerance.
- Improved resistance to disease, pests, and herbicides.
- New products and growing techniques.

Animals

- Increased resistance, productivity, hardness, and feed efficiency.
- Better yields of meat, eggs, and milk.
- Improved animal health and diagnostic methods.

Environment

- “Friendly” bioherbicides and bioinsecticides.
- Conservation of soil, water and energy.
- Bioprocessing for forestry products.
- Better natural waste management.

Society

- Increased food security for growing population.

Issues Surrounding GMO

Safety

- The adverse impacts of genetically modified food are not evident immediately.
- Potential human health impact: allergens, transfer of antibiotic resistance markers, unknown effects.
- Potential environmental impact: unintended transfer of transgenes through crosspollination, unknown effects on other organisms (e.g., soil microbes) and loss of flora and fauna biodiversity.
- **Criticism against Anti-GM lobby:** Instead of evaluating the risks, costs and benefits of hybrids on a case-by-case basis, they propose a blanket ban on genetic modification.

Access and intellectual property

- Domination of world food production by a few companies.
- Increasing dependence on industrialized nations by developing countries.
- **Biopiracy** — foreign exploitation of natural resources.

Ethics

- Violation of natural organisms' intrinsic values.
- Tampering with nature by mixing genes among species.
- Objections to transferring animal genes in plants and vice versa.

Labelling

- Not mandatory in some countries (e.g. United States).
- Mixing GM crops with non-GM confounds labelling attempts.

Research

- The **objectivity and authenticity** of scientific research and publication.

Effectiveness

- The ineffectiveness of BT cotton against whitefly attack in Punjab and Haryana has raised more questions.

Issues with banning GM crops

- The ban on GM crops is also promoting an illegal market to flourish in India.
- Bangladesh is reaping the benefits of Bt Brinjal while its cultivation is banned in India.

GMO have already entered the food chain

- Cotton seed oil extracted from Bt cotton plants is being consumed in Gujarat and Maharashtra.
- Soybean oil is extracted from imported seeds, which are produced from GM crops abroad.

Illegal cultivation (Farmer's rights vs. Government Regulation)

- A farmers' group in Maharashtra, marked its protest against the government ban on genetically modified (GM) crops by planting Bt brinjal and HT cotton.
- There is a grave danger of illegal genetically modified brinjal cultivation proliferating.

- The **International Rice Research Institute (IRRI)** and its partners, the Philippines Rice Research Institute and the Bangladesh Rice Research Institute, have successfully cultivated **Golden Rice** in a controlled environment on IRRI campus.
- The safety evaluations have shown that Golden Rice is as safe and nutritious as conventional rice but comes with the added benefit of increased beta-carotene content in the grain.
- This is aimed at covering a vast rice-eating population in the world with high prevalence of deficiencies.

Golden Rice

- Golden Rice is a new type of rice that contains **beta-carotene (provitamin A), which is converted into vitamin A**, as needed by the body and gives the grain its **golden color**.
- It is **developed through genetic engineering** and produces two new enzymes that complete the beta-carotene expression in the rice grain.
- Research has indicated that one cup of Golden Rice can provide up to 50% of the daily requirement of an adult for **vitamin A.**
- But presently, it has a **low shelf life of not more than 3 months** as it may lose its nutrients after that.
- Golden Rice can be grown just like ordinary rice and varieties **containing the GR2E Golden Rice trait** have the same yield and agronomic performance as their conventional counterparts.
- It is intended to complement current strategies in the **fight against vitamin A deficiency (VAD)** and is intended to supply up to 30-50 percent of the estimated average requirement for vitamin A for preschool age children and pregnant or lactating mothers.

Vitamin A Deficiency (VAD)

- Vitamin A is a **fat-soluble vitamin** that is good for healthy vision, skin, bones and other tissues in the body.
- **Source:** There are two types of vitamin A.
    - **Preformed vitamin A,** also called **retinol,** is found in animal products. Good sources are fortified milk, eggs, meat, cheese, liver, halibut fish oil, cream and kidneys.
    - **Pro-vitamin A** is found in plant-based foods such as fruits and vegetables. The most common type of pro-vitamin A is **beta-carotene,** a carotenoid that produces dark pigments in plant foods.

- As vitamin A affects a wide range of body functions, a deficiency can lead to a variety of problems. These include:
  - night blindness
  - a higher risk of infections, especially in the throat, chest, and abdomen
  - leading to dry, bumpy skin.
  - fertility issues
  - delayed growth in children
- Vitamin A deficiency (VAD) **afflicts around 250 million people worldwide**.
- **Women and children are the most vulnerable to VAD,** the leading cause of childhood blindness and inability of the immune system to combat disease.
- Vitamin A availability could prevent 1.3–2.5 million of the nearly 8 million late-infancy and preschool-age child deaths annually in developing countries with the highest risk.
- **Multiple approaches are needed to combat VAD,** including nutrition education and consuming a diverse and nutrient rich diet; promoting breastfeeding and complementary feeding practices; vitamin A capsule supplementation;
- **food fortification;** and other public health measures aimed at the control of infectious diseases.

What is Fortification of Food?

- Fortification is the **addition of key vitamins and minerals** such as Iron, Iodine, Zinc, Vitamins A & D **to staple foods** such as rice, wheat, oil, milk and salt to improve their nutritional content.
- These **nutrients may or may not have been originally present** in the food before processing or may have been lost during processing.
- **Micronutrient malnutrition, also known as hidden hunger,** is a serious health risk.
- Sometimes due to **lack of consumption of a balanced diet, lack of variety in the diet or unavailability of food** one does not get adequate micronutrients.
- Hence fortification of food is a safe method of improving nutrition among people as the **addition of micronutrients to food does not pose a health risk** to people.
- It **does not alter the characteristics of the food** like the taste, aroma or the texture of the food.

According to the **National Family Health Survey (NFHS-4)**

- 58.4 percent of children (6-59 months) are anaemic.
- 53.1 percent of women in the reproductive age group are anaemic.
- 35.7 percent of children under 5 are underweight.

In August, 2018, FSSAI introduced the **Food Safety and Standards (Fortification of Foods) Regulations, 2018,** to regulate the provisions regarding fortified food.

Features:

- It **prescribes the standards of addition of micronutrients** for the purpose of food fortification. The manufacturers of the fortified food have to provide a quality assurance undertaking.
- **Packaging and labelling has to state the food fortificant added**, **+F logo and the tagline "Sampoorna Poshan Swasth Jeevan".**
- It should be in **compliance to** the Food Safety and Standards (Packaging and Labeling) Regulations, 2011.

Fortified salt: In 1950, Indians were among the first countries in Asia to implement mandatory salt iodisation. It is fortified with Iodine.

Fortified wheat: The flour is fortified with iron, vitamin A and folic acid.

Fortified rice: Iron, Folic Acid, Vitamin B12.

Fortified milk: Studies suggest the intake of fortified milk by children not only increased mean serum vitamin D levels but also decreased morbidity rates. It is fortified with Vitamin A, Vitamin D.

Fortified oil: Is fortified with vitamin A and D.