9.3: Biotechnology and Genetic Engineering

Agricultural biotechnology is a range of tools, including traditional breeding techniques, that alter living organisms, or parts of organisms, to make or modify products; improve plants or animals; or develop microorganisms for specific agricultural uses. Modern biotechnology today includes the tools of genetic engineering. Genetic engineering is the name for certain methods that scientists use to introduce new traits or characteristics to an organism (known also as genetically modified organism or GMO). For example, plants may be genetically modified to produce characteristics to enhance the growth or nutritional profile of food crops.

Benefits of Genetic Engineering

Advocates of modern biotechnology and genetic engineering say that the application of biotechnology in agriculture has resulted in benefits to farmers, producers, and consumers.

Enhanced nutrition. Advances in biotechnology may provide consumers with foods that are nutritionally-enriched (Figure below) or longer-lasting, or that contain lower levels of certain naturally occurring toxicants present in some food plants. Developers are using biotechnology to try to reduce saturated fats in cooking oils, reduce allergens in foods, and increase disease-fighting nutrients in foods. Biotechnology may also be used to conserve natural resources, enable animals to more effectively use nutrients present in feed, decrease nutrient runoff into rivers and bays, and help meet the increasing world food and land demands.
Figure \(\PageIndex{1}\): White rice and Golden rice. Genetically engineered “Golden Rice” contains up to 35 μg β-carotene per gram of rice.

**Cheaper and more manageable production.** Biotechnology may provide farmers with tools that can make production cheaper and more manageable. For example, some biotechnology crops can be engineered to tolerate specific herbicides, which make weed control simpler and more efficient. Other crops have been engineered to be resistant to specific plant diseases and insect pests, which can make pest control more reliable and effective, and/or can decrease the use of synthetic pesticides. These crop production options can help countries keep pace with demands for food while reducing production costs.

**Improved pest control.** Biotechnology has helped to make both insect pest control and weed management safer and easier while safeguarding crops against disease. For example, genetically engineered insect-resistant cotton has allowed for a significant reduction in the use of persistent, synthetic pesticides that may contaminate groundwater and the environment. In terms of improved weed control, herbicide-tolerant soybeans, cotton, and corn enable the use of reduced-risk herbicides that break down more quickly in soil and are non-toxic to wildlife and humans.

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**Concerns about Genetically modified Organisms**

The complexity of ecological systems presents considerable challenges for experiments to assess the risks and benefits and inevitable uncertainties of GMOs. Assessing such risks is extremely difficult, because both natural and human-modified systems are highly complex, and fraught with uncertainties that may not be clarified until long after an experimental introduction has been concluded. Critics of GMOs warn that the cultivation of GMOs, with their potential benefits and hazards to the environment, should be carefully considered within broader ecosystems.

**Interbreeding with native species.** When the genetically modified organisms are allowed to breed with the organisms which are not genetically engineered, then these organisms may affect the genetic of non-genetically engineered organisms. Due to this reason the whole ecological system might get affected. The main concern is that genetically modified organisms might lead the non-GM organisms to extinction and reduce biodiversity.

**GM food labeling.** In order to verify whether people have been harmed over the years by consuming GMF, specifically in countries like the US where people’s dietary are mainly composed of such products, the law for mandatory labeling is
highly required. However, the labeling is not just about health issue rather, it is about consumer rights to make an informed choice. Although a consensual system on GMO labeling is crucial, it seems unlikely that an internationally agreed labeling system can be set up in proximate future. Nevertheless, different GMO labeling schemes have been established in different countries, ranging from stringent to extremely lenient or even non existent legislations. While the EU has established strict labeling regulations, in the US, Canada and Argentina, three big producers of GMO food, such laws have been put forward but not enacted by these governments. A proper labeling represents the “GM” word, along with additional information on changed characteristics and the external source of the inserted gene. Negative labeling such as “GM free” is not suggested, because it might give the wrong impression to the consumers. The law for compulsory labeling of genetically modified food products has been established in more than 40 countries. Surveys commissioned by different organizations have shown that people across the world are seeking for transparency and consumer choice and believe that compulsory labeling scheme on GM ingredients is highly required: 88% Canadians, 92% Americans and 93% French.

Consumers right to choose. The International Federation of Organic Agriculture Movement has made stringent efforts to keep GMOs out of organic production, yet some US organic farmers have found their corn (maize) crops, including seeds, to contain detectable levels of genetically engineered DNA. The organic movement is firm in its opposition to any use of GMOs in agriculture, and organic standards explicitly prohibit their use. The farmers, whose seed is contaminated, have been under rigid organic certification, which assures that they did not use any kind of genetically modified materials on their farms. Any trace of GMOs must have come from outside their production areas. While the exact origin is unclear at this time, it is most likely that the pollution has been caused by pollen drift from GMO-fields in surrounding areas. However, the contamination may have also come from the seed supply. Seed producers, who intended to supply GMO-free seed, have also been confronted with genetic contamination and cannot guarantee that their seed is 100% GMO-free.

Ecological long-term effects. The Bt corn produces wind-borne pollen that kills the caterpillars of the Monarch butterfly. If the life cycles of this butterfly are disrupted, the Monarch butterflies might be endangered. Agriculture might be affected as the weeds acquire the modified genes to become more competitive. The risk of the evolution of common plant viruses to become more resistant or form new strains will be greatly increased. If genetic modification is carried out extensively, new viruses with greater potential to harm humankind may evolve, and the probability of this occurring can be quite high.

Human health risk. At least some of the genes used in GMOs may not have been used in the food supply before, so GM foods may pose a potential risk for human health. Much of the GM production currently grown worldwide is destined for animal feed. The FAO has concluded that risks to human and animal health from the use of GM crops and enzymes derived from GM microorganisms as animal feed are negligible. But scientists acknowledge that little is known about the long-term safety of consuming food made from GM products. WHO recognizes the need for continued safety assessments on genetically modified foods before they are marketed to prevent risks to human health and for continued monitoring.

The potential of GM crops to be allergenic is one of the main suspected adverse health effects. Many scientific data indicate that animals fed by GMO crops have been harmed or even died. Rats exposed to transgenic potatoes or soy had abnormal young sperm; cows, goats, buffalo, pigs and other livestock grazing on Bt-maize, GM cottonseed and certain biotech corn showed complications including early deliveries, abortions, infertility and also many died. However, this is a controversial subject as studies conducted by company producing the biotech crops did not show any negative
effects of GM crops on mice.

Although Agri-biotech companies do not accept the direct link between the GMOs consumption and human health problems, there are some examples given by the opponents. For example: The foodborne diseases such as soy allergies have increased over the past 10 years in USA and UK and an epidemic of Morgellons disease in the US. There are also reports on hundreds of villagers and cotton handlers who developed skin allergy in India. Recent studies have revealed that Bacillus thuringiensis corn expresses an allergenic protein which alters overall immunological reactions in the body. The aforementioned reports performed by independent GMO researchers have lead to a concern about the risks of GMOs and the inherent risks associated with the genetic technology.

**Intellectual property rights** are one of the important factors in the current debate on GMOs. The GM crops are patented by Agri-business companies leading to monopolization of the global agricultural food and controlling distribution of the world food supply. Social activists believe that the hidden reason why biotech companies are eager to produce GMO crops is because they can be privatized, unlike ordinary crops which are the natural property of all humanity. It is argued for example that to achieve this monopoly, the large Agri-biotech company, Monsanto, has taken over small seed companies in the past 10 years and has become the biggest Agri-biotech Corporation in the world. The patent right for vegetable forms of life also affect the livelihoods of family farmers as they are required to sign a contract preventing them from saving and re-planting the seeds, thus they have to pay for seeds each year.

Critics, thus advise that the risks for the introduction of a GMOs into each new ecosystem need to be examined on a case-by-case basis, alongside appropriate risk management measures, such as through the precautionary principle in the Cartagena Protocol and the IPPC’s Pest Risk Assessment (PRA).