Chapter III: Biotechnology and health

1. What is biotechnology?

Biotechnology is the use of biology to develop new products, methods and organisms intended to improve human health and society. Biotechnology, often referred to as biotech, has existed since the beginning of civilization with the domestication of plants, animals and the discovery of fermentation.

Early applications of biotech led to the development of products such as bread and vaccines. However, the discipline has evolved significantly over the last century in ways that manipulate the genetic structures and biomolecular processes of living organisms. The modern practice of biotechnology draws from various disciplines of science and technology, including the following:

- molecular biology
- chemistry
- bionics
- genetic engineering
- genomics
- nanotechnology
- informatics

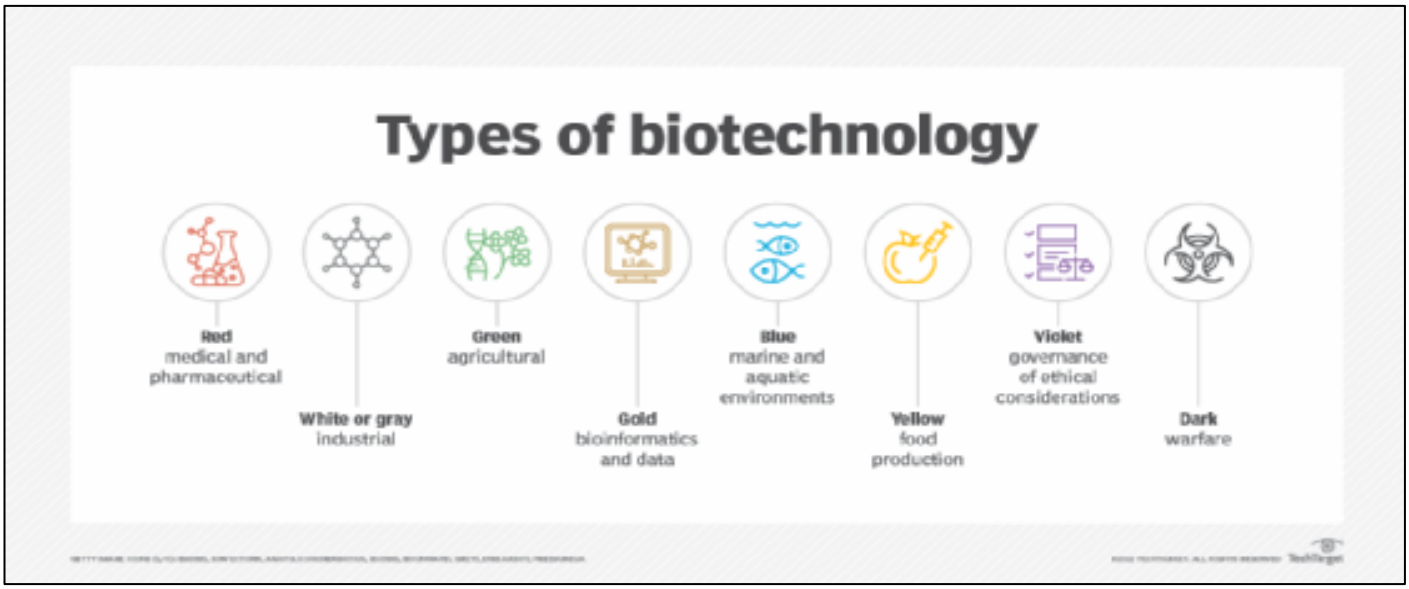
This approach has resulted in innovations and breakthroughs in the following areas:

- **medicines and therapeutics** that prevent and treat disease;
- **medical diagnostics** such as pregnancy tests;
- **biofuels** that are sustainable, reducing waste and pollution;
- **genetically modified organisms (GMOs)** that lead to more efficient and cost-effective agriculture.

2. Types of biotechnology

The science of biotechnology is broken down into subdisciplines that are color-coded based on common uses and applications.

- **Red biotechnology** involves medical processes, such as using organisms to produce new drugs and stem cells to regenerate damaged human tissues and grow and regrow entire organs.
- **White or Gray** refers to industrial processes, such as the development of new chemicals or new biofuels for vehicles.
- **Green** covers agricultural processes, such as producing pest-resistant crops, disease-resistant animals and environmentally friendly agricultural practices.
- **Gold**, also known as bioinformatics, is a cross between biological processes and informatics. It refers to the methods healthcare workers use to gather, store and analyze biological data to treat patients.
- **Blue** encompasses processes in marine and aquatic environments, such as converting aquatic biomass into fuels and pharmaceuticals.
- **Yellow** refers to processes that aid food production, the most popular application being the fermentation of alcohol and cheese.
- **Violet** ensures the practice of biotechnology is in compliance with laws and ethical standards governing each field.
- **Dark** is the use of biotechnology for weapons or warfare.



There are eight, color-coded categories of biotechnology.

3. Uses and applications of biotechnology

The use and commercialization of modern biotechnology often fall into four main fields: environment, medicine, industry and agriculture.

3.1. Medicine

Medical biotechnology, also known as biopharma, aims to fight and prevent disease and improve healthcare. Biotechnology and biomedical research are the basis of the modern pharmaceutical industry. Uses include the following:

- stem cell research that helps replace or repair dead or defective cells;
- antibiotics development;
- gene therapies for diseases such as Leukemia;
- research into dangerous pathogens and the antibodies that fight them;
- 3D printing or growing of organs and bones in labs;
- mRNA vaccines, monoclonal antibody treatments and research for COVID-19.

3.2. Industry

Industrial biotechnology involves using microorganisms to produce industrial goods. Examples include the following:

- fermentation and the use of enzymes and microbes to streamline chemical manufacturing and reduce operational costs and chemical emissions;
- biofuels that use renewable crops such as corn to produce combustible fuel instead of natural, non-renewable fossil fuel resources, such as petroleum and oil;
- biodegradable garments and textiles made from the proteins of living organisms, such as the silk proteins of spiders.

3.3. Agriculture

Agricultural biotechnology genetically engineers' plants and animals to produce more efficient agriculture, increase nutritional value and reduce food insecurity. Some examples of agricultural biotechnology are the following:

- biologically produced pesticides and herbicides that are less harmful to humans than chemical ones;
- drought-resistant crops;

- minimal space-resilient crops;
- meat grown in labs or using 3D printers;
- gluten-free grains friendly to sufferers of celiac;
- selective breeding that produces healthier, bigger livestock and crops;
- nutrient supplementation that infuses food with added nutrients to improve diets and medical treatments.

3.4. Environment

The aim of environmental biotechnology is to develop sustainable environmental practices that reduce pollution and waste. The following are examples of environmental biotech:

- **Phytoremediation** uses genetically engineered microorganisms to purify soils of heavy metals and other pollutants.
- **Bioremediation** introduces microorganisms into waste sites in order to organically break down nonrecyclable waste.
- **Plastic-eating bacteria** breaks down waste such as plastic in soils and water.
- **GMO foods** stay fresher longer and reduce food waste.
- **Genetic restoration** attempts to restore endangered species such as the American chestnut tree.
- **Cover-crops** such as corn are used as biofuels, replacing traditional fuel sources that produce greenhouse gas emissions when extracted and used.

4. What are the advantages of biotechnology?

Biotechnology production offers a variety of solutions to critical problems. The main ones are:

- reducing pollution and waste to reverse catastrophic climate change and environmental damage;
- creating healthier, stronger and more-sustainable food products that boost nutrition and combat food insecurity;
- treating diseases in children before they are born by altering their genomes;
- designing medicine to boost the health and longevity of people, animals and plants;
- cutting costs of farm supplies such as pesticides, while increasing crop yields and profits.

5. What are the disadvantages of biotechnology?

Biotechnology also comes with disadvantages and misuse. The main disadvantages include the following:

- **Biological warfare.** The potential exists for the development of pathogens and epidemics that could be used in a conflict zone to infect populations.
- **Decrease in biodiversity.** Monocropping or the farming of only a small number of genetically engineered crops could shrink the natural gene pool of species and make them less resilient and adaptable to sudden changes in environment.
- **Loss of soil fertility.** Bio-enhanced plants require more nutrients from soil and yield more crops.
- **High costs.** Biotechnology products often cost more than traditional products and have the potential to raise pricing structures in various industries.
- **Ethical considerations.** Gene manipulation raises a range of ethical issues, such as the genetic engineering of humans.
- **Safety questions.** Various groups have raised safety concerns about the health risks of GMOs and biotech-related medical developments, such as mRNA vaccines.