

Biotechnology

Agricultural Cyberbiosecurity Education Resource Collection

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What is Biotechnology?

Biotechnology is already a part of our daily lives. We can find it in pharmacies, on our phones, and in supermarkets, among many other places. Despite having existed for millennia, the term “biotechnology” was created only in the last century by Hungarian engineer Karl Ereky. Great discoveries of humanity include fermentation to produce beverages, the manufacture of bread, cheeses, vinegar, and yogurts, the discovery of medicines such as penicillin, and more recently, the cloning of animals associated with biotechnology. With so many technological advances over the years, we ask ourselves, What is the limit? And if that limit exists, where can this type of technology take us in the future?

Biotechnology can be best defined as technology based on biology. Biotechnology utilizes biological processes to develop products and can fall into three main focuses: agriculture, manufacturing, and medicine. Biotechnology is widely used in agriculture and in the medical field. In these fields, biotechnology primarily focuses on **gene** editing. This includes manipulating the genes of organisms for a beneficial trait, marking genes so they are visible in experiments, and the identification and potential treatment of genetic diseases. Each of the three domains mentioned approach biotechnology differently.

Agricultural Biotechnology

For centuries, farmers have been selectively breeding crops for specific traits. Now, with biotechnology, scientists can make precise changes to genes in a short amount of time. Biotechnology in the agricultural industry is synonymous with genetically modified organisms (GMOs). Starting in the 1990s, advancements in DNA and computer technology allowed scientists to select specific genes to edit in crops. Changes to genes can provide

tolerance to adverse weather conditions, resistance to herbicides and insects, and increased nutritional value. These changes can help provide more consistent or larger harvests, decreased environmental risk, and benefits to public health.

One example of genetic modification is the papaya. In the 1990s, the papaya ringspot virus was threatening to destroy the papaya industry in Hawaii. The virus stunts tree growth and leaves a distinctive black ring on the fruit. Researchers at the University of Hawaii and Cornell University developed a GMO papaya that had total immunity to the ringspot virus. After introducing GMO papaya, the industry rebounded. GMOs are not without criticism. The safety of these crops needs to be evaluated on a case-by-case basis to ensure there are no side effects from the gene modification. Additionally, efforts are being made to protect heritage or wild varieties of these crops to maintain **genetic diversity**.

Industrial Biotechnology

Industrial biotechnology, sometimes called **biomanufacturing**, is the use of biological processes to produce chemicals, energy, and materials for industrial use. Biomanufacturing on its own has agricultural, industrial, and medicinal applications. Organisms such as bacteria, fungi, microorganisms, and plants are utilized to create biofuels, biogas, textiles, paper, and more. Industrial biotechnology is beneficial for the environment by lowering greenhouse gases and conserving resources. For more information on biomanufacturing, please refer to its specific factsheet.

Medical Biotechnology

This is the use of living cells to develop technologies for the improvement of human health. Production of pharmaceutical products, vaccines, antibiotics, genetic testing, and drug treatments are benefits of medical biotechnology. A recent example of this is CRISPR-cas9. CRISPR-cas9 is a naturally occurring enzyme that modifies DNA. Its natural purpose is to remove damaged pieces of DNA to prevent harm to a person. Dr. Jennifer Doudna and Emmanuelle Charpentier found a way to “train” CRISPR-cas9 to target specific abnormalities. Now genetic modification can happen with a high degree of precision, making treatments and cures for Alzheimer’s, Huntington’s disease, and HIV, among others.



"[Emmanuelle Charpentier and Jennifer Doudna](#)" by [For Emmanuelle Charpentier's portrait credit: Bianca Fioretti of Hallbauer & Fioretti. For Jennifer Doudna's portrait credit: User: Duncan Hull and The Royal Society](#) is licensed under [CC BY-SA 4.0](#).

Connection to Cyberbiosecurity

The protection of biotechnology is one of the top priorities in cyberbiosecurity. Changing genetic codes for agriculture, storing medical information, and creating industrial products all pose serious security risks. Protecting data and intellectual property is a primary focus. Medical data and data describing a company’s specific seed variant are important to protect customer privacy as well as provide a competitive advantage in the marketplace. Secondly, protecting access to biotechnology can protect processes and products from cyber-physical attacks. Relying on automation and computers to carry out these tasks increases efficiency but also opens up potential pathways for hackers, terrorists, and foreign governments to intervene.

Glossary

Biomanufacturing: A process that produces commercially relevant biological materials.

Gene: A collection of DNA found in chromosomes that controls what characteristics are passed on to a person, animal, or plant.

Genetic diversity: The total number of genetic traits possible in a population of organisms.

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About this project

Cyberbiosecurity is an emerging field that focuses on creating security measures for digital aspects of our food and agriculture systems, creating a structure and opportunity for a safe food system that can meet the large needs of a growing population and world. This educational resource was developed as part of a project to support formal and non-formal agricultural educators in integrating cyberbiosecurity topics and research-based strategies for engaging middle-school-aged girls in STEM into their educational programs.

The entire resource collection can be accessed here:
<https://doi.org/10.21061/cyberbiosecurity>

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