Bioeconomy

Agricultural Cyberbiosecurity Education Resource Collection

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What is the Bioeconomy?

How much money are all the apples in the United States worth? Have you ever had a thought like this? When you eat an apple, you might know how much it costs but how much do all the apples grown in the United States cost? Let's think about it. There are fresh apples, dried apples, preserved apples, apples used for juice, jams, and pie fillings. If we check USDA sales reports, all of these forms of apples equal almost 1 billion dollars! That's a lot of money, but do we stop there? What about the benefits we got from researching apples? What about new jobs in agriculture because of the apple industry? When we consider the economic impact of agriculture, biotechnology, computer science, and engineering, we're talking about the bioeconomy.

While there are a lot of engineers, scientists, and researchers working on apples, it's far from the only crop. The bioeconomy takes all the hard work scientists, farmers, and computer engineers put into their innovations and technology that go along with producing plants, animals, and microbes. Finding where the bioeconomy stops can be a little tricky because scientists using plants, animals, and microbes fit into all different types of careers. Generally, we can think of the bioeconomy as fitting within three domains: agriculture, bioindustry, and biomedicine. Within these domains, we can have people from all over helping. For example, the process that developed the COVID-19 vaccine is part of the bioeconomy. Many of the COVID-19 vaccines are mRNA vaccines. This means the cells in the human body are given a piece of messenger RNA from the virus so the immune system can identify it. Developing this vaccine took people from the federal government, universities, and medicine manufacturers to work together. Because COVID-19 is a virus (a microbe), we can count all of that work toward the bioeconomy.

Bioeconomy Domains

Agriculture

Agriculture as an industry has always been an innovative part of the bioeconomy. Agriculture's role in the bioeconomy is rooted in genetic engineering, data processing, food production, and the harvesting of raw resources. While selective breeding for beneficial crop varieties has been around as long as agriculture, our ability to genetically modify crops and livestock streamlines this process. Now scientists can develop drought-resistant crops and cattle that are more heat-tolerant.

As agricultural processes become more advanced and technologically driven, agricultural data is becoming a bigger part of the bioeconomy. Tractors and soil sensors are actively collecting data from the fields in which they operate. This data is used to inform manufacturers of farmers' needs and give farmers additional perspectives on their land. Future projects in food production and land management have even led the industry to explore lab-grown meat. This involves using muscle cells from livestock to produce livestock products without the use of resources, pharmaceuticals, or the loss of animal life.

Bioindustry

The bioindustrial domain relies on transitioning away from chemical processes in favor of natural and sustainable processes. For example, chemicals can be used to break down sugar into specific molecules used in other products. However, a strain of bacteria can do the same thing. Rather than producing and handling those chemicals, a company can decide to grow those bacteria to produce their desired molecules. Using a biological process rather

than a chemical one can make a company less dependent on fossil fuels, use less water, and reduce energy use.

Biomedicine

The biomedical domain involves medicine that is developed from biological materials. The medicine produced from biological materials is called **biopharmaceuticals** or biologics. The COVID-19 vaccine was developed in the biomedical domain. This is because it uses a cell's ability to decode mRNA to produce a product, rather than an artificial or chemical process. Increasingly, new medicines are being developed through computer models to determine an appropriate molecular structure. While beginning on a computer, the testing process for these pharmaceuticals still requires significant biological research and development. Additionally, new products like brain-controlled prosthetics are slowly being developed. This intersection between technology, biology, and engineering is a great example of the bioeconomy.

Relating the Bioeconomy to Cyberbiosecurity

The need for cyberbiosecurity evolves from the larger objective of "Safeguarding the Bioeconomy." "Safeguarding the Bioeconomy" is an idea proposed by the National Academies of Sciences, Engineering, and Medicine (NASEM) in 2014. This idea recognizes that computers make it easy for people to access many different parts of the bioeconomy. The increased use of computers, sensors, and data in agriculture, economics, and medicine introduces more opportunities for cyberbiosecurity threats to cause harm. To make sure financial information, research, and personal information stay protected, the bioeconomy will need professionals trained in computer science and cybersecurity. As agriculture, bioindustry, and biomedicine become more dependent on technology, the need for cyberbiosecurity systems will continue to grow.

Glossary

Biotechnology: The application of biology to an industrial process.

Stakeholders: A group of people or entities that affect the success or failure of a business.

Intellectual property: A unique idea that someone could apply for protected rights.

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Additional Resources

https://research.cnr.ncsu.edu/sustainablebioproducts/resources/bioeconomy-careers/

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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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