►Read the text below and do the tasks that follow. Did you use any of the tips listed on the previous page? Which one(s)? Did you find it / them helpful?

A Brief History of Biotechnology

Throughout history, humans have used biology to manipulate living organisms, from altering bacteria to enhance fermentation to selectively breeding plants or animals to improve desired traits. Such careful manipulation of their biology has created the modern organisms we see and use today. If one were to compare the modern apple with its ancestral counterpart, one would be shocked at the difference. Ancestral apples were small and tart. Through selective breeding principles, the modern apple is significantly larger and sweeter. These breeding principles are an example of how biotechnology can be used to change an organism.

The identification of bacteria and their role in fermentation and disease, together with technological advancements in biology, such as the development of pure bacterial cultures, paved the way for the development of modern biotechnology. With the discovery of DNA and its role in heredity and genetics, new means for manipulating living organisms became available. In 1973, the first genetically-modified organism (GMO) was created by Stanley Cohen and Herbert Boyer, who used biotechnology procedures to introduce foreign DNA into a bacterial genome. In 1977, Herbert Boyer and Keiichi Itakura succeeded in inducing genetically-modified bacteria to produce the first human protein (i.e., somatostatin). Their recombinant somatostatin was found to be identical to its natural counterpart and their studies marked the start of the biotechnology industry. One year later, the first synthetic "human" insulin was produced using genetically-engineered *E. coli* bacteria. In 1982, Humulin®, human insulin used for diabetes, was the first medication developed using biotechnology and the first recombinant pharmaceutical approved by the FDA for commercial use in the United States.

The importance of biotechnology and its creation of Humulin® cannot be understated. Prior to the advent of biotechnology, scientists relied either on chemically synthesized human therapeutics made in the laboratory, or on a microbe or animal that naturally produced the desired compound. Prior to 1982, Type I diabetics used insulin extracted from cows and pigs. These animal-derived insulin therapies induced minor allergic reactions in some patients. Furthermore, fears emerged that demand for insulin would soon outstrip the supply from pigs and cows. Through biotechnology and its creation of Humulin®, diabetic patients now had the option to use genetically-engineered insulin that was cheaper, safer, and could be mass produced.

The 1970s were marked by the development of the first commercial method for sequencing DNA. Developed by Frederick Sanger in 1977, the 'Sanger method', or dideoxy sequencing, revolutionized biotechnology by allowing scientists to determine the precise order of nucleotides in DNA. In the following decades, advancements in sequencing technologies, such as the development of automated sequencing machines in the 1980s and the introduction of next-generation sequencing (NGS) in the early 2000s, exponentially increased sequencing speed and reduced costs for those working in the biotechnology field. The Human Genome Project, completed in 2003, marked a monumental achievement, providing a complete map of the human genome and ushering in a new era of genomics. Today, sequencing technologies continue to evolve, with techniques enabling real-time sequencing and expanding our understanding of genetics and its applications in medicine, agriculture, and beyond.

The 1980s was a decade of significant breakthroughs in the production of more advanced and refined GMOs. The first patent for a GMO was issued in 1980 to Ananda Chakrabarty, who engineered *Pseudomonas sp.* bacteria to break down crude oil spills as a means of bioremediation.

This patent became the first one to be granted to a living organism[1] and paved the way for future biotechnology patents on modified plants, animals, and other organisms. This GMO would later be used in the 1989 cleanup of the Exxon oil spill at Prince William Sound, Alaska. In 1981, the first genetically-modified animal, also known as a *transgenic animal*, was produced in mice. Two years later, genetic modifications using biotechnology were being applied to sheep, pigs, and cattle, significantly impacting the livestock industry. In 1983, the first transgenic plant, a tobacco plant, was introduced to the agriculture market. Two years later, Agracetus[2] received the first patent for its genetically-modified cotton. Since then, GMOs have become widespread in many research fields and commercial markets. In 2020, genetically-modified plants accounted for about 55 percent of the total harvested cropland in the United States. Most of the corn, soybeans and cotton planted in the US have been genetically-modified either to resist pest or to be resistant to herbicides. Today, genetically modifying flies, fish, or mice are a common and essential tool in research labs.

Advancements in biotechnology are currently growing at an exponential rate with improvements in techniques, such as the evolution of sequencing methods mentioned above, or creation of new methodologies constantly occurring.

Glossary

counterpart: sb/sth with a similar purpose, function, or position to another one in a different place, organization, or situation

ancestral: relating to **ancestors** (= members of your family from the past)

tart: tasting sour or acidic (characteristic of unripe fruit or citrus)

selective breeding (also ***artificial selection***): the process by which humans select animals or plants with desirable traits in order to breed them and produce offspring with those traits

enhance: to improve or increase the quality, value, strength, or effectiveness of sth

fermentation: a metabolic process in which microorganisms break down organic compounds (e.g., carbohydrates) into acids, gases, or alcohol, usu. in the absence of oxygen

induce: to cause sth to happen; to persuade sb to do sth

advent: the arrival or beginning of sth significant

bacterial culture: a laboratory method used to grow, multiply, and identify bacteria or other microorganisms in a sample

account for: 1) to be the cause of, 2) to form a part of a total, 3) to give an explanation for

emerge: to appear or become visible; to come into existence (n. **emergence**)

outstrip: to do better than sb/sth or be greater than sb/sth in amount, degree, or success

DNA sequencing: the process of determining the exact order of nucleotides in a DNA molecule

exponential: 1) increasing or expanding rapidly, often proportionally to the current value, 2) (math.) relating to an exponent (= a constant raised to a power), e.g., *3^4 is an exponential expression*

bioremediation: the use of living organisms (fungi, bacteria, or plants) to remove or break down pollutants from soil, water, etc.

livestock: domesticated animals (cattle, sheep, pigs, etc.) kept or traded as a source of income

[1] The U.S. Supreme Court ruled that a human-made living microorganism was ***patentable*** (= could be patented under U.S. law), marking an important milestone in biotechnology.

[2] Agracetus: an agricultural biotechnology company, later acquired by Monsanto

Practice

►Activity 1: Choose the correct option: *a*, *b*, or *c*:

1) *The organisms we see and use today are the products of years of* _____.
   a. manipulation of their biology by man **b.** natural evolution throughout history
   c. comparing ancestral and modern counterparts
2) *Choose the FALSE option: The first human protein to be synthesized was*_____.
   a. somatostatin **b.** through the modification of bacteria **c.** by Stanley Cohen and Herbert Boyer
3) *Before the creation of Humulin®, there were concerns that insulin derived from animals would* _____.
   a. cause allergic reactions to all patients **b.** not be enough for all patients
   c. become disproportionally expensive
4) *The first recombinant pharmaceutical to be approved for commercial use in the USA was* _____.
   a. genetically-engineered *E. coli* bacteria **b.** Humulin® **c.** human insulin
5) *The development of automated sequencing machines in the 1980s is a monumental achievement that* _____.
   a. has not been surpassed by newer developments
   b. led to the completion of the Human Genome Project
   c. made the life of biotechnologists a lot easier
6) *The sentence "The patent for a GMO was issued in 1980 to Ananda Chakrabarty…" (underlined) means that*_____.
   a. Chakrabarty was the recipient of the patent **b.** Chakrabarty created the patent
   c. the GMO was named after Chakrabarty
7) *The first transgenic organism to be produced was a* _____.
   a. plant **b.** mouse **c.** cattle
8) *Today, biotechnologists modify* _____.
   a. a wide variety of organisms **b.** cropland **c.** corn, soybeans, and cotton

►Activity 2: Based on the information in the text, write the *timeline* of the history of biotechnology. Some examples are given:

Timeline

1970s	*Development of pure bacterial cultures.* *Discovery of DNA's role in heredity and genetics.*
1980	*First GMO patent (Ananda Chakrabarty) to a living organism.*
2000s	*Introduction of next-generation sequencing (NGS) speeds up DNA analysis.*
2010s–present	*Rapid expansion of biotechnology applications; increasing use of GMOs in research and agriculture; 55% of US cropland (by 2020) uses GM crops.*

►Activity 3: Match the words in Row A with their synonyms in Row B:

Row A: traits / manipulate / alter / identical / prior to / understate / extract

Row B: the same / characteristics / obtain / handle or control / before / underestimate / change

►Activity 4: <u>Underline</u> in the text all the words/phrases denoting progress, major changes, or significant achievements (e.g., *paved the way*).

►Activity 5: In Activity 4 on p. 56, you came across phrases such as *is renowned* and *is widely recognized*. Below are some more adjectives used to describe someone who has *achieved recognition and prominence* in their field. Be careful! Two of them usually imply that someone is well known for a *negative* quality or action, so they do not belong in the list. Cross them out!

reputable / esteemed / acclaimed / famous / notorious / renowned / famed / celebrated / distinguished / prominent / notable / infamous / legendary / well-known

Lexicogrammar – the first, second, last, etc. to do sth

This sentence appeared in the text: *The patent became the first one to be granted to a living organism.*

The structure *to be / become the first to do sth* is commonly used to express the notion of pioneering. Go through the following sentences and tick the ones in which this structure is used.

1. William Harvey was the first to describe the circulation of blood in the human body.
2. The first widely used classification system to be developed was by Carl Linnaeus.
3. The first known book on biology is believed to be Aristotle's 'Historia Animalium'.
4. The microscopists were the last to leave the lab.
5. Antonie van Leeuwenhoek observed microorganisms for the first time in 1674.

Language Work – 'Out' words

In the text, you encountered the word *<u>out</u>strip*, which is formed with the prefix **out-**. In such compound words, ***out-*** means *to be better / more important, to do sth better, or to exist longer than sb else*.

►Activity 1: Which of the following 'out-' words do not have the meaning described above? Cross out the ones that do <u>not</u> mean 'to be / do better than':

outfit / outnumber / output / outperform / outlet / outsmart / outlast

►Activity 2: Choose the correct option:

1. State-of-the-art grafts are engineered to **outlive / outnumber** conventional grafts, as they provide greater durability and resistance to corrosion.
2. By using sophisticated techniques, hackers are often able to **outstrip / outwit** security systems.
3. In many urban areas, electric vehicles now **outsmart / outnumber** traditional gasoline-powered cars. This is because their advantages **outweigh / outwork** their disadvantages.
4. Microorganisms found frozen in Siberian permafrost have **outlasted / outperformed** other life forms by surviving for thousands of years at sub-zero temperatures.
5. Her academic achievements continue to **outpower / outpace** those of her peers.
6. Despite the challenging conditions, the team managed to **outdistance / outdo** their previous record.