MedCrave
Step into the World of Research
Journal of Applied Biotechnology and Bioengineering

Review Article
Open Access
CrossMark

Microbiology in the modern era

Abstract

Microorganisms are involved in essential roles in our lives that sometimes we do not pay attention to or give the importance it requires. Microbes are involved in various natural processes like nutrient cycling, degradation, carbon cycle, food spoilage, climate change, and fermentation, and they can cause and cure diseases. Microorganisms are involved in the biotech industry and played a crucial role in the creation of the first biotech industry, Genentech. Genentech's first approach was to use bacteria like E. coli as factories to synthesize mammalian proteins. Their scientists succeeded in creating plasmid and inserting it into E. coli, which then produced somatostatin, insulin, and growth hormone.

Volume 10 Issue 2 - 2023

Leonellis Cruz-Ruiz, Bill Tawil
California State University Channel Islands, USA

Correspondence: Bill Tawil, California State University Channel Islands, USA, Email btawil@seas.ucla.edu

Received: March 20, 2023 | **Published:** April 10, 2023

Definition

Microbiology studies all living organisms that are too small to be visible to the naked eye (Figure 1); this includes bacteria, viruses, archaea, protozoa, prions, fungi, and algae.[1] Now, let us stop and review every single of the microorganisms mentioned above, starting with bacteria. According to NIH, bacteria are single-celled organisms found almost everywhere on Earth and are vital to the planet's ecosystems.[2] Bacteria have various shapes (spherical, rods, commas, corkscrews, or spirals) and reproduce by binary fission. Viruses, on the other hand, are infectious microbes that consist of segments of nucleic acid (DNA or RNA) surrounded by a protein coat. This type of microbes cannot replicate by itself and needs to infect cells to make copies of itself. As we all experienced these last couple of years with the pandemic caused by the SARS-CoV-2 virus, these can spread from host to host, cross the species barrier, cause illness, and even kill the host. Fungi can be single-cell or multicellular organisms the ones that concern us in this discussion are the single-cell ones, which include yeast and molds. Protozoa are one-celled eukaryotes with a complex internal structure and carry out complex metabolic activities.[3] Algae are organisms capable of producing oxygen, and like fungi, they can be multicellular organisms and microscopic cells. Now let us move to a particular type of microorganism, the archaea; these microbes are called extremophiles as they can be found living in extreme ecosystems like geysers, near rift vents in the deep sea, and in the ice in Antarctica. Archaea cell wall differs in structure from bacteria, making them more stable in extreme conditions. To finish with the definition of all types of microorganisms, we got prions. The CDC defines prions as abnormal, pathogenic agents that are transmissible and can induce abnormal folding of specific normal cellular proteins;[4] in summary, they are abnormally folded proteins that can cause brain damage and diseases like Kuru, fatal familial insomnia, and bovine spongiform encephalopathy which is also known as Mad Cow disease. Now we have access to all this information and keep discovering more about these microorganisms, but how has everything started?

Figure 1 Types of microbes.

History of microbiology

Everything started with the observation of Anthony Leeuwenhoek of little animals in 1676 while he was observing lake water. Almost 100 years later, Edward Jenner created the vaccine for smallpox caused by the variola virus after this discovery. Then in 1840, J. Henle proposed that germs are the cause of diseases, followed by the golden age of

microbiology between 1857-1914, where discoveries made mainly by Pasteur, and Robert Koch helped to establish microbiology as a field of study. Louis Pasteur introduces the terms aerobic and anaerobic in describing yeast growth at the expense of sugar in the presence or absence of oxygen. Robert Koch demonstrates that bacteria cause Anthrax and introduces pure laboratory culture techniques. In 1882 the use of agar plates was introduced by Walther Hesse and Angelina Franny as a culture medium, and two years later, the Gram stain was introduced by Christian Gram. Both discoveries are essential in this field as gram stain is used to identify gram-positive (stain purple) and gram-negative (stain pink); the difference between these two is the composition of the cell wall in bacteria, gram-positive microorganisms have higher peptidoglycan content, whereas gram-negative organisms have higher lipid content. Now back to the timeline (Figure 2), in 1928, Frederick Griffith discovered genetic transformation in bacteria, and his finding was followed by the discovery of the first antibiotic (*penicillium*) by Alexander Fleming. In 1944 Avery, MacLeod, and McCarty demonstrated that Griffith's Transforming principle is DNA. An essential contribution to microbiology and the whole biology field was the description of how restriction enzymes work, which are bacterial defense mechanisms but are now vital tools for DNA sizing. From this, we pass to using a heat-stable enzyme from *Thermus aquaticus* to establish a polymerase chain reaction or PCR technology discovered by Karys Mullis in 1988. During the boom of the Human Genome Project in 1995, the first complete nucleotide sequence of a bacterial chromosome (*Haemophilus influenzae*) was done by J. Craig Venter and his team. After this travel back in time and to discoveries that create this field and contribute to many other fields, we will study the applications or uses of microorganisms in different industries.

Figure 2 Microbiology's fifty most significant events during the past 125 years.[40]

Microorganisms in the food industry

Microbiology is essential to food safety, production, processing, preservation, and storage.[5] Microorganisms are involved in different processes in food production and have been since ancient times to make bread, cheese, yogurt, and wine. Food manufacturers continue to use microorganisms to make a wide range of food products through fermentation. Fermentation is a process in which sugars are transformed into a new product through chemical reactions by microorganisms.[6] There are two types of fermentation, lactic acid fermentation, and alcoholic fermentation, and it depends on the microorganisms used. Let us start with lactic acid fermentation, which creates products like yogurt, sauerkraut, pickles, cheese, tempeh, miso, soy sauce, and fermented meats like salami. This bacterial metabolic process starts with a six-carbon sugar, and bacteria convert them into lactic acid, lowering the media's pH and inhibiting other harmful bacteria's growth. Some of the bacteria used today in the food industry for this process are *Lactobacillus* spp., *Lactococcus*, *Streptococcus thermophilus*, and leuconostocs. Alcoholic fermentation or ethanol fermentation is a process in which mostly yeast convert sugars (fructose and glucose) into ethyl alcohol and carbon dioxide. Wine, beer, and cider are some products made with this process carried out by yeast (Schizosaccharomyces, *Saccharomyces cerevisiae*). Like any other process, there are some cases where two types of microorganisms are used, like in the now-popular kombucha, a fermented drink made with tea, sugar, bacteria, and yeast.[7]

Biotechnology industry

Biotechnology is defined as the "Application of the principles of engineering and biological science to create new products from raw materials of biological origin, for example, vaccines or food."[8] as the microbiology field grows and expands; it opens the door for using microorganisms as tools to manipulate and act in a specific way. As mentioned before, the first time a microorganism was used and manipulated to produce a human hormone was by Genentech to create human insulin; for this to happen, the scientist introduced a modified plasmid into Escherichia coli and, like this, propagated the information and have as a final product the hormone. Some other products of this industry are vaccines and biofuels, but also this field is used in agriculture to produce bacterial and viral resistance crops. A couple of years ago, the biotech industry started researching the use of viruses as a treatment for cancer, and as a result, they found oncolytic viruses, which are defined as genetically engineered or naturally occurring viruses that can selectively replicate in and kill cancer cells without harming normal tissues, one treatment that the FDA has approved is the Oncolytic Virus Treatment (Imlygic®) produce by Amgen. We can't forget the findings of the palindromic repeats in bacteria by Francisco Mojica that now with the following breakthrough discoveries, was transformed in the CRISPR Cas9 system used in gene therapy (Figure 3).[9–20]

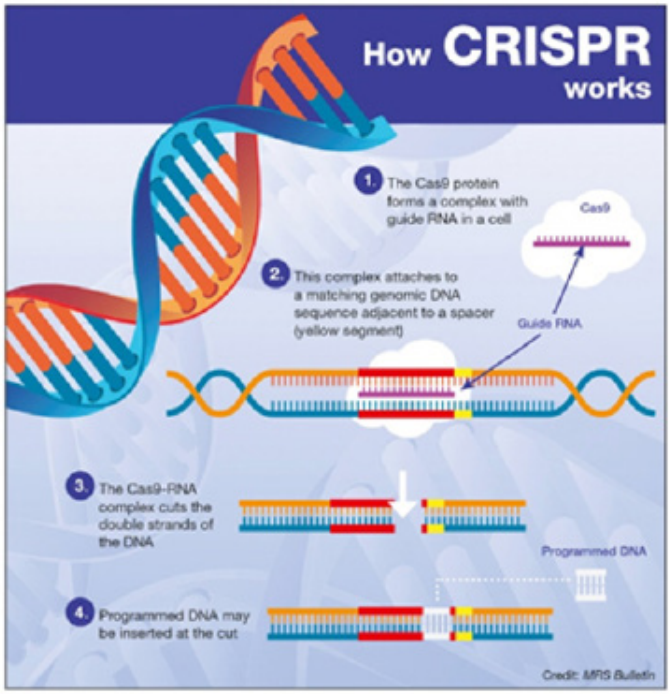

Figure 3 How CRISPR works.[41]

As for the agricultural side of the biotech industry, this one has more people against it and its products, GMOs, or genetically modified organisms. GMOs are organisms whose genetic material has been modified through genetic engineering, which sometimes creates combinations that do not occur in nature or by crossbreeding methods (Figure 4). Right now, there is a wide variety of these products or organisms on the market, for example, corn, soy, canola, potatoes, summer squash, apples, papayas, and salmon. All GMO products are considerate save to consume and, in some cases, help crops to disappear, as in the case of the Hawaiian papaya. All these examples mentioned before look for the population's overall well-being, but microorganisms are not always used for good purposes.[21–26]

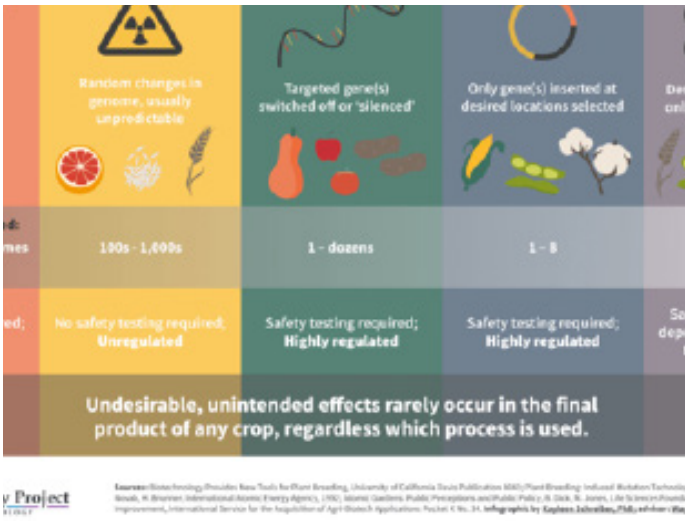

Figure 4 How crops are genetically modified.[39]

Biological weapons

Biological and toxin weapons are either microorganisms like viruses, bacteria, or fungi or toxic substances produced by living organisms that are produced and released deliberately to cause disease and death in humans, animals, or plants, as defined by the WHO.[9] Some of the microorganisms used are Anthrax, botulism toxin, and plague. The first known use of microorganisms as bioweapons were by the Japanese in 1940, in which they spread plague-infected fleas in the north of China, followed by using Anthrax to attack villages southwest of Shanghai. As all can remember, in 2001, they found Anthrax in letters sent by the post mail service in the United States. If one of these biological weapons is used, it can cause a catastrophe in our lives; everything will be affected the economy, food availability, medical services, and shortage of the drugs necessary to fight back the illness.[27–41]

Conclusion

Microbiology is a field that keeps expanding and whose discoveries rise every year, bringing more information that is transformed into technology. Not all the new techniques are well received by the population, and some divide the scientific community's opinion on what is wrong or not. We must keep in mind that as this field is evolving, our planet and its organisms too, which means there is more knowledge waiting for us in the future.

Acknowledgments

None.

Conflicts of interest

There are no conflicting interests declared by the authors.

References

1. What is Microbiology?
2. Bacteria.
3. Yaeger RG. Protozoa: Structure, Classification, Growth, and Development. In: Baron S, editor. Medical Microbiology. 4th ed. Galveston (TX): University of Texas Medical Branch at Galveston; 1996;77.
4. Prions Diseases.
5. Lorenzo JM, Munekata PE, Dominguez R, et al. Main Groups of Microorganisms of Relevance for Food Safety and Stability: General Aspects and Overall Description. *Innovative Technologies for Food Preservation*. 2018; 53–107.
6. Taveira I, Nogueira K, Oliveira D. Fermentation: Humanity's Oldest Biotechnological Tool. Front. Young Minds. 2021.
7. Zeratsky K. Consumer Health. 2022.
8. Verma AS, Agrahari S, Rastogi S, et al. Biotechnology in the realm of history. *Journal of pharmacy & bioallied sciences.* 2011;3(3):321–323.
9. World Health Organization. Biological Weapons.
10. Russo, E. Special Report: The birth of biotechnology. *Nature*. 2003;421:456–457.
11. Okafor N. Taxonomy, Physiology, and Ecology of Aquatic Microorganisms. *Environmental Microbiology of Aquatic and Waste Systems*. 2011;47–107.

12. Ahmadjian V, Alexopoulos Constantine John, Moore David. Fungus organism. 2023.

13. Pasteur L. Animalcules infusoires vivant sans gaz oxygene libre et determinant des fermentations. *Compt Rend Acad Sci (Paris).* 1861;52:344–347.

14. Koch R. Studies on bacteria V. The etiology of anthrax disease based on the evolutionary history of *Bacillus anthracis.* In: Thomas D Brock, editor. Contribution z Biol D Plants. In Milestones in Microbiology: 1556 to 1940. ASM Press; 1876. 89 p.

15. Belay ED, Schonberger LB. The public health impact of prion diseases. *Annual review of public health.* 2005;26:191–212.

16. Guillemin J. Scientists and the history of biological weapons. A brief historical overview of the development of biological weapons in the twentieth century. *EMBO reports*. 2006;*7 Spec No*(Spec No):S45–S49.

17. European Feed and Culture Association. Microorganism in food production.

18. Green America. How Pervasive are GMOs in Animal Feed? 2013.

19. National Cancer Institute. Oncolytic Virus Therapy: Using Tumor–Targeting Viruses to Treat Cancer. 2018.

20. Tripathi N, Sapra A. Gram Staining. In: StatPearls, Treasure Island (FL): StatPearls Publishing; 2022.

21. Shugar D, Baranowska J. Studies on the gram stain; the importance of proteins in the Gram reaction. *Acta Microbiol Pol.* 1954;3(1):11–20.

22. Walther, Angelina Hesse: Early Contributors to Bacteriology, ASM News 58. 1992. 425 p.

23. Smith HO, KW Wilcox. A restriction enzyme from *Haemophilus influenzae*: I. Purification and general properties. *J Mol Biol*. 1970;51:79–391.

24. In Microbiology: A Centenary Perspective. In: Wolfgang K Joklik, editor. ASM Press; 1999. 164 p.

25. Saiki RK, DH Gelfand S Stoffel, SJ Scharf, et al. Primer–directed enzymatic amplification of DNA with a thermostable DNA polymerase. *Science*. 1988;239:487–491.

26. Lorenzo JM, Munekata PE, Dominguez R, et al. Main Groups of Microorganisms of Relevance for Food Safety and Stability: General Aspects and Overall Description. *Innovative Technologies for Food Preservation*. 2018;53–107.

27. Paul Ross R, Morgan S, Hill C. Preservation and fermentation: past, present and future. *Int J Food Microbiol.* 2002;79:3–16.

28. National Research Council (US) Panel on the Applications of Biotechnology to Traditional Fermented Foods. Applications of Biotechnology to Fermented Foods: Report of an Ad Hoc Panel of the Board on Science and Technology for International Development. Washington (DC): National Academies Press (US); 1992. 5 p.

29. Fukuhara H, Ino Y, Todo T. Oncolytic virus therapy: A new era of cancer treatment at dawn. *Cancer science*. 2016;107(10):1373–1379.

30. IMLYGIC®. (2022).

31. Fernandez–Cornejo Jorge, Seth James Wechsler, Mike Livingston, et al. "USDA ERS – Adoption of Genetically Engineered Crops in the U.S.: Recent Trends in GE Adoption." USDA ERS – Adoption of Genetically Engineered Crops in the U.S.: Recent Trends in GE Adoption. United States Department of Agriculture, Economic Research Service. 2015.

32. GMO Crops, Animal Food, and Beyond. U.S Food & Drug Administration. 2022.

33. History of Microbiology. Bio Explorer. 2022.

34. Cartaxo Taveira I, Vieira Nogueira K, Gadelha De Oliveira D, et al. Fermentation: Humanity's Oldest Biotechnological Tool. 2021.

35. European Feed and Culture Association.

36. Yaeger RG. Protozoa: Structure, Classification, Growth, and Development. In: Baron S, editor. Medical Microbiology. 4th edition. Galveston (TX): University of Texas Medical Branch at Galveston; 1996;77.

37. Virus. 2022.

38. Viruses.

39. Schreiber K. Infographic: Are genetically engineered crops less safe than classically–bred food? 2019.

40. American Society for Microbiology. *Microbiology's Fifty Most Significant Events During the Past I25 Years...* 1999.

41. Ball Phillip. How CRISPR works. CRISPR: Implications for materials science. 2016.