International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 8 Issue 6, Nov-Dec 2024 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Biotechnology

Paul A. Adekunte[1], Matthew N. O. Sadiku[2], Janet O. Sadiku[3]

[1]International Institute of Professional Security, Lagos, Nigeria
[2]Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX, USA
[3]Juliana King University, Houston, TX, USA

ABSTRACT

Biotechnology is a multidisciplinary field that involves the integration of natural science and engineering sciences in order to achieve the application of organisms and parts thereof for products and services. Biotechnology has to do with harnessing biological systems and organisms, like bacteria, yeast, and plants to perform specific tasks or produce valuable substances. Biotechnology has great impacts on many areas of society, from medicine to agriculture and to environmental science. Biotechnological applications are very diverse and have led to the development of essential products such as life-saving drugs, biofuels, genetically modified crops, and innovative materials. Despite its numerous benefits, there are ethical and societal challenges with regards to genetic modification and intellectual property rights.

The paper looks at the diverse applications, uses, benefits of biotechnology and the challenges and the way out of them for the benefit of man.

KEYWORDS: *Biotechnology, zymotechnology or zymurgy, fermentation, food security, environmental sustainability, biofuels, biosensor, genetic engineering*

How to cite this paper: Paul A. Adekunte | Matthew N. O. Sadiku | Janet O. Sadiku "Biotechnology" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-8 | Issue-6, December 2024, pp.908-912, URL: www.ijtsrd.com/papers/ijtsrd72721.pdf

IJTSRD72721

HISTORICAL BACKGROUND

Biotechnology has been principally associated with food by addressing such issues as malnutrition and famine, as shown in Figures 1, 2, and 3. The history of biotechnology is said to begin with zymotechnology [1], which commenced with the focus on brewing techniques for beer. After World War l, zymotechnology or zymurgy expanded to tackle larger industrial issues, for which the potential of industrial fermentation gave rise to biotechnology. In 1975 at the Asilomar Conference, Joshua Lederberg was the most outspoken supporter for the emerging field in biotechnology. By 1978 and with the development of synthetic human insulin, Lederberg's claims proved valid, and the biotechnology industry grew rapidly. Each new scientific advance became a media event designed to gain and capture public support, and by the 1980s, biotechnology grew into a promising real industry. In 1988, only five proteins from genetically engineered cells were approved as drugs by the United States Food and Drug Administration (FDA), but the number skyrocketed to over 125 by the end of the 1990s. The field of genetic engineering remains a heated topic of discussion in today's society with the advent of gene therapy, stem cell research, cloning, and genetically modified food. While it seems only natural nowadays to link pharmaceutical drugs as solutions to health and societal problems, this relationship of biotechnology serving social needs began centuries ago [2]. Biotechnology arose from the field of zymotechnology or zymurgy, giving rise to a better understanding of industrial fermentation, particularly beer. In Germany, in the late 19th century, brewing of beer contributed much to the gross national product as steel, and taxes on alcohol proved to be significant sources of revenue to the government [3]. It was Karoly Ereky, an Hungarian who coined the word "biotechnology" in 1919 to describe a technology based on converting raw materials into a more useful product [2], therefore for Ereky, the term "biotechnologie" indicated the process by which raw materials could be biologically upgraded into socially useful products [4]. In the 1940s, penicillin was discovered in England, but was produced industrially in the US by the use of deep fermentation process originally developed in Peoria, Illinois [5].

Fermentation technology in the 1950s advanced into the production of steroids on an industrial scale [6]. There was also the improved semi-synthesis of cortisone which simplified the old 31 step synthesis to 11 steps [7], and with this advance estimated to reduce the cost of the drug by 70%, making the medicine inexpensive and available [8].

The first biosensor was invented in 1962 by Leland C. Clark and Champ Lyons [9, 10], and while Biosensor MOSFETs were later developed and now widely used to measure physical, chemical, biological and environmental parameters [11]. The first BioFET was the ion-sensitive field-effect transistor (ISFET), invented by Piet Bergveld in 1970 – is a special type of MOSFET, where the metal gate is replaced by an ion-sensitive membrane, electrolyte solution and reference electrode [12, 13]. The ISFET is widely used in biomedical applications, such as the detection of DNA hybridization, biomarker detection from blood, antibody detection, glucose measurement, pH sensing, and genetic technology [13], as shown in Figure 4.

BIOTECHNOLOGY APPLICATIONS

Biotechnology applications are in the following major industrial areas, which are in health care (medical), crop production and agriculture, non-food (industrial) uses of crops and other products (e. g. biodegradable plastics, vegetable oil, biofuels), and environmental uses [14]. Biotechnology is also used to recycle, treat waste, and clean up sites contaminated by industrial activities (bioremediation), and also to produce biological weapons [2].

The several branches of biotechnology have been identified as follows [15]:

- Bioinformatics (or “gold biotechnology)
- Blue or marine biotechnology
- Green or natural biotechnology
- Red or clinical biotechnology
- White or ultramodern biotechnology
- Yellow biotechnology
- Gray biotechnology
- Brown biotechnology
- Violet biotechnology
- Microbial biotechnology, and
- Dark biotechnology

BENEFITS AND CHALLENGES OF BIOTECHNOLOGY

The Office of Agricultural Policy (AGP) keeps markets open for US biotechnology products. Biotechnology has a proven safety record and benefits farmers, consumers and the environment by producing more food per acre while conserving and reducing the need for chemicals, pesticides/insecticides, protects biodiversity, reduces erosion, increases tolerance to droughts and floods, improves nutrition and tilling. It also enhances the nutritive value of staple foods to improve overall nutrition and health [16].

Agricultural biotech can boost food production in both developed and developing worlds, reduce vulnerability to pests, viruses, and drought as the world’s population is expected to reach nearly 10 billion in 2050. To this end, and to meet this challenge, global food production must more than double and should be environmentally sustainable. It is a useful tool to combat food insecurity and malnutrition. There is an increasing understanding and acceptance of this concept, since genetically engineered crops since 2019 were grown in 29 countries and while 42 additional countries imported these crops, as shown in Figures 5, 6, and 7. The countries that grow biotech crops include ten in Latin America, six in Africa, two in Europe, and nine in Asia. International acceptance is expected to grow as science-based, risk-proportionate regulations are developed with respect to the cultivation and trade of biotech crops and people experience the benefits. There is still the persistent misunderstanding about this technology, its safety, and the breath of its potential. Foods derived through advanced agricultural technology normally undergo extensive risk assessment procedures by a variety of national bodies like the Environmental Protection Agency, the United States Department of Agriculture, and the Food and Drug Administration. Furthermore, biotech crops also undergo analysis by international entities such as the European Food Safety Agency. Therefore any biotech crops approved by these bodies are designated as safe for both people and the environment [16].

Biotech is very useful in our every day life, from creating revolutionary products and technologies that fight against debilitating and rare diseases to reducing carbon emission, promoting effective industrial manufacturing processes, creating pest-resistant crops, and ebeni in challenging areas such as forensic sciences (DNA fingerprinting) and biodefence and public safety. Blended biofuels are used in road transportation to help reduce carbon impact [17].

Some of the challenges to biotechnology are [18]:

- Regulatory compliance and approval processes
- Funding and financial challenges
- Ethical considerations and public perception
- Technological advancements and rapid innovation
- Talent acquisition and retention
- Intellectual property protection and patent challenges

CONCLUSION

Regardless of these challenges, they however present opportunities for innovation and growth in the biotech industry. When the challenges are holistically faced or addressed by biotech companies via their coming together, these problems can be resolved and great success achieved to move the industry forward. There is also the need for the biotech companies to improve their public perception by the use of transparent communication, community engagement, and the demonstration to the commitment to ethical and responsible innovation. Through the collaboration of the biotech companies, there would be great improvement in people's lives and solutions to global problems such as food insecurity, environmental sustainability, poverty, and so on.

REFERENCES

[1] S. D. Sharma (2006), Stanly Wolpert (ed.), "Biotechnology revolution," *Encyclopedia of India*, vol. 1, Thomson Gale: 2006, pp 154-157. ISSN 0-684-31350-2.

[2] "History of biotechnology," Wikipedia, the free encyclopedia, https://en.m.wikipedia.org/history-of-biotechnology

[3] A. Thackray (1998), "Private science: Biotechnology and the rise of the molecular sciences," Philadelphia: University of Pennsylvania Press, pp 6-8. ISBN 9780812234282.

[4] Fiecher, T. Beppu (2000), "History of modern biotechnology," (1st ed.), Berlin: Springer Science & Business Media, pp 153 & 170. ISBN 9783540677932.

[5] J. J. Gordon et al. (1947), "Methods of penicillin production in submerged culture on a pilot-plant scale," *Microbiology*, vol. 1, no 2, pp 187-202.

[6] M. Capek, H. Oldrich, C. Alois (1966), "*Microbial transformations of steroids*," Prague: Academia Publishing House of Czechoslovak Academy of Sciences, doi: 10. 1007/978-94-011-7603-3. ISBN 9789401176057.

[7] H. M. Leigh et al. (1952), "Microbial transformations of steroids 11, introduction of oxygen at carbon-11 of progesterone," *Journal of the American Chemical Society*, vol. 73, no 23, pp 5933-5936. doi: 10. 1021/ja01143a033.

[8] A. Liese, K. Seelbach, C. Wandrey (2006), "*History of industrial biotransformations – Dreams and realities,*" (2nd ed.), New York: Wiley. doi: 10. 1002/9783527608188.ch1. ISBN 9783527310012.

[9] J. Park et al. (2014), "Applications of field-effect transistor (FET) – Type biosensors," *Applied Science and Convergence Technology,* vol. 23, no 2, pp 61-71.

[10] L. C. Clark, C. Lyons (1962), "Electrode systems for continuous monitoring in cardiovascular surgery," *Annals of the New York Academy of Sciences*, vol. 102, no 1, pp 29-45.

[11] P. Bergveld (October 1985), "The impact of MOSFET-based sensors," (PDF) *Sensors and Actuators*, vol. 8, no 2, pp 109-127.

[12] P. Bergveld (January 1970), "Development of an ion-sensitive solid-state device for neurophysiological measurements," *IEEE Transactions on Biomedical Engineering*, BME, vol. 17, no 1, pp 70-71.

[13] M. Schoning, A. Poghossian (September 10, 2002), "Recent advances in biologically sensitive field-effect transistors (BioFETs)," (PDF) *Analyst*, vol. 127, no 9, pp 1137-1151.

[14] Amarakoon et al. (October 20, 2023), "Biotechnology: Principles and applications," *Pharmacognosy*, pp 627-645.

[15] "Biotechnology," Wikipedia, the free encyclopedia, https://en.m.wikipedia.org/biotechnology

[16] "Biotechnology," https://www.state.gov/biotechnology

[17] "How is biotechnology used in everyday life?" https://aimst.edu.my/how-is-biotechnology-used-in-everyday-life

[18] "Top 6 issues facing the biotechnology industry," October 22, 2024, https://www.drugpatentwatch.com/top-6-issues-facing-the-biotechnology-industry

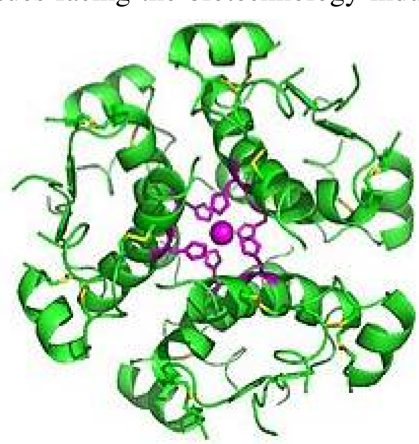

Figure 1. Biotechnology

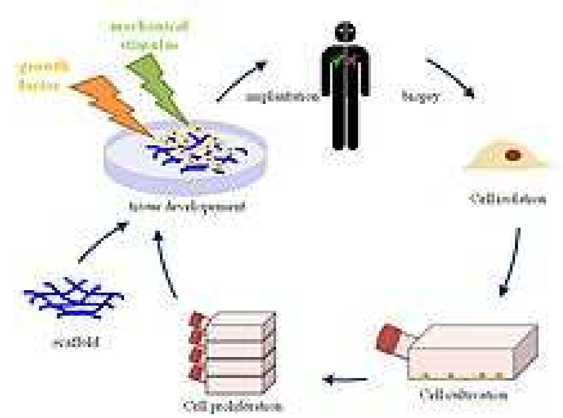

Figure 2. Biotechnology

Source:https://www.google.com/search?sca_esv=f020a7a3a9c0faaa&sxsrf=ADLYWIK8PI1v2vk6g-NJbBgW3O0N9aThZw:1733212570279&q=images+on+biotechnology+by+wikipedia&udm=2&fbs=AEQNm0Aa4sjWe7Rqy32pFwRj0UkWd8nbOJfsBGGB5IQQO6L3JyJJclJuzBPl12qJyPx7ESJehObpS5jg6J88CCM-RK72qUv4GOvBp3LxAsC-35pUAVd1mVJIz_kJEl7OpW0Y42rOM96fEVibRmxJCzmEqh53sBnJMLdHFyYMnh1J8SLKdTBIS0c&sa=X&ved=2ahUKEwi3h8n8j4uKAxUDVEEAHS6IBaUQtKgLegQIFRAB&biw=1036&bih=539&dpr=1#vhid=12dKqjGShhErTM&vssid=mosaic

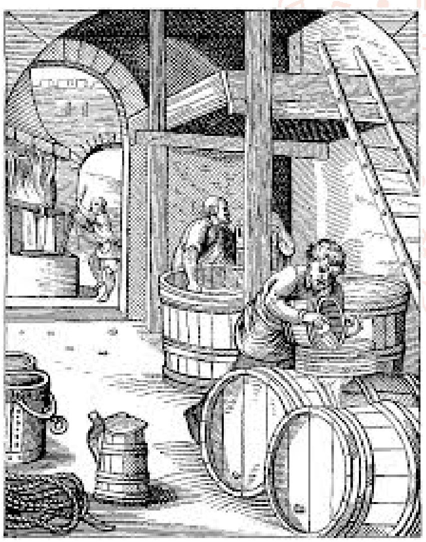

Figure 3. History of biotechnology

Source:https://www.google.com/search?sca_esv=f020a7a3a9c0faaa&sxsrf=ADLYWIK8PI1v2vk6g-NJbBgW3O0N9aThZw:1733212570279&q=images+on+biotechnology+by+wikipedia&udm=2&fbs=AEQNm0Aa4sjWe7Rqy32pFwRj0UkWd8nbOJfsBGGB5IQQO6L3JyJJclJuzBPl12qJyPx7ESJehObpS5jg6J88CCM-RK72qUv4GOvBp3LxAsC-35pUAVd1mVJIz_kJEl7OpW0Y42rOM96fEVibRmxJCzmEqh53sBnJMLdHFyYMnh1J8SLKdTBIS0c&sa=X&ved=2ahUKEwi3h8n8j4uKAxUDVEEAHS6IBaUQtKgLegQIFRAB&biw=1036&bih=539&dpr=1#vhid=EP4MvDFq9R7ZNM&vssid=mosaic

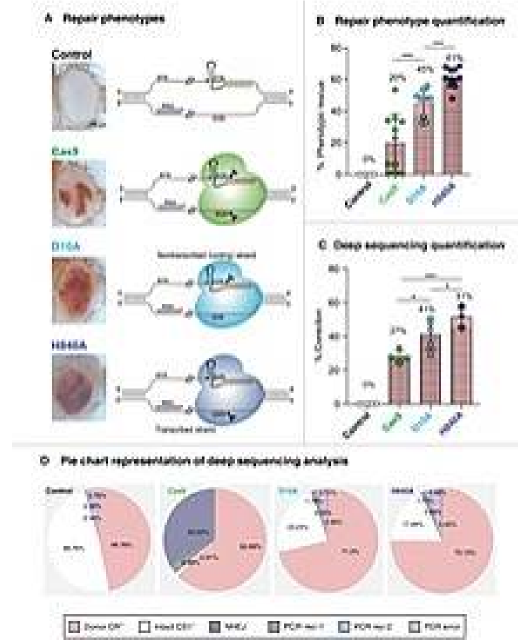

Figure 4. Timeline of biotechnology

Source:https://www.google.com/search?sca_esv=f020a7a3a9c0faaa&sxsrf=ADLYWIJB86eF4xNbMOHKodqMpn8te9nsOw:1733214030268&q=images+on+biotechnology+by+wikipedia&udm=2&fbs=AEQNm0Aa4sjWe7Rqy32pFwRj0UkWd8nbOJfsBGGB5IQQO6L3JyJJclJuzBPl12qJyPx7ESJehObpS5jg6J88CCM-RK72qUv4GOvBp3LxAsC-35pUAVd1mVJIz_kJEl7OpW0Y42rOM96fEVibRmxJCzmEqh53sBnJMLdHFyYMnh1J8SLKdTBIS0c&sa=X&ved=2ahUKEwia6t-0lYuKAxW_UEEAHWmyFmoQtKgLegQIExAB&biw=1036&bih=539&dpr=1#vhid=06_GGW07c5UKGM&vssid=mosaic

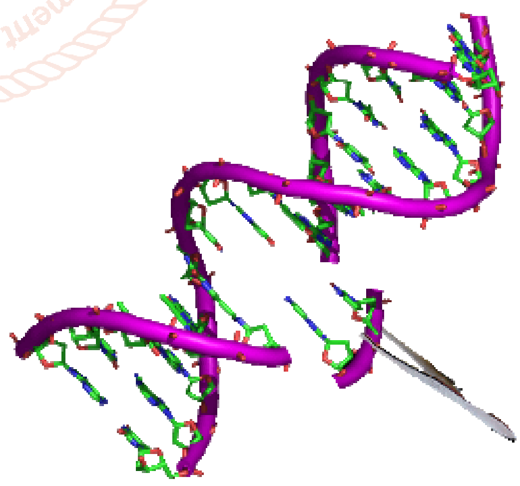

Figure 5. Genetic engineering

Source:https://www.google.com/search?sca_esv=f020a7a3a9c0faaa&sxsrf=ADLYWIJB86eF4xNbMOHKodqMpn8te9nsOw:1733214030268&q=images+on+biotechnology+by+wikipedia&udm=2&fbs=AEQNm0Aa4sjWe7Rqy32pFwRj0UkWd8nbOJfsBGGB5IQQO6L3JyJJclJuzBPl12qJyPx7ESJehObpS5jg6J88CCM-RK72qUv4GOvBp3LxAsC-35pUAVd1mVJIz_kJEl7OpW0Y42rOM96fEVibR

mxJCzmEqh53sBnJMLdHFyYMnh1J8SLKdTBIS0c&sa=X&ved=2ahUKEwia6t-0lYuKAxW_UEEAHWmyFmoQtKgLegQIExAB&biw=1036&bih=539&dpr=1#vhid=wo0tQ7iBYnQ0OM&vssid=mosaic

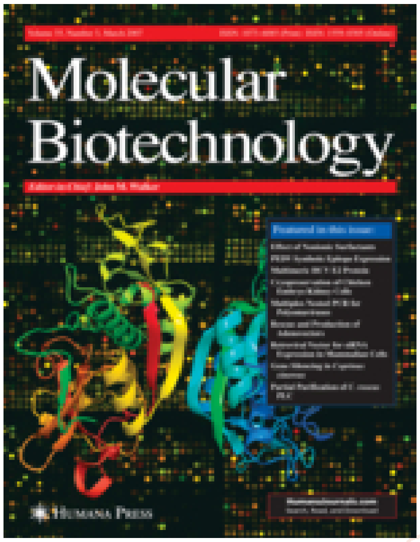

Figure 6. Molecular biotechnology

Source:https://www.google.com/search?sca_esv=f020a7a3a9c0faaa&sxsrf=ADLYWIJB86eF4xNbMOHKodqMpn8te9nsOw:1733214030268&q=images+on+biotechnology+by+wikipedia&udm=2&fbs=AEQNm0Aa4sjWe7Rqy32pFwRj0UkWd8nbOJfsBGGB5IQQO6L3JyJJclJuzBPl12qJyPx7ESJehObpS5jg6J88CCM-RK72qUv4GOvBp3LxAsC-35pUAVd1mVJIz_kJEl7OpW0Y42rOM96fEVibR

mxJCzmEqh53sBnJMLdHFyYMnh1J8SLKdTBIS0c&sa=X&ved=2ahUKEwia6t-0lYuKAxW_UEEAHWmyFmoQtKgLegQIExAB&biw=1036&bih=539&dpr=1#vhid=xwGMX5w5xu0QiM&vssid=mosaic

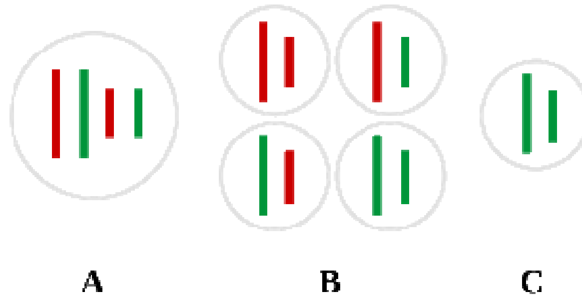

Figure 7. DNA sequencing

Source:https://www.google.com/search?sca_esv=f020a7a3a9c0faaa&sxsrf=ADLYWIJB86eF4xNbMOHKodqMpn8te9nsOw:1733214030268&q=images+on+biotechnology+by+wikipedia&udm=2&fbs=AEQNm0Aa4sjWe7Rqy32pFwRj0UkWd8nbOJfsBGGB5IQQO6L3JyJJclJuzBPl12qJyPx7ESJehObpS5jg6J88CCM-RK72qUv4GOvBp3LxAsC-35pUAVd1mVJIz_kJEl7OpW0Y42rOM96fEVibRmxJCzmEqh53sBnJMLdHFyYMnh1J8SLKdTBIS0c&sa=X&ved=2ahUKEwia6t-0lYuKAxW_UEEAHWmyFmoQtKgLegQIExAB&biw=1036&bih=539&dpr=1#vhid=TgNh7Af-SzFiIM&vssid=mosaic