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The Future is Bioengineered: Consequences, Directions, and Regulation

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Abstract

Biotechnology is changing how people interact with health, life, and the environment very quickly. This article talks about how new tools in genetic engineering, synthetic biology, and bioinformatics are making it possible for scientists to build and change biological things with more accuracy than ever before. Biotechnology is changing several fields, from making personalised medical treatments and disease-resistant crops to making biofuels and materials that break down naturally. The talk focuses on important new technologies including CRISPR-based gene editing, lab-grown tissues, and microbial engineering. It also talks about the moral, environmental, and legal problems that come with these technologies. As society evolves toward a future with bioengineering, it is important to find a balance between innovation and accountability. In the end, this essay stresses that biotechnology is not only a scientific field, but also a potent tool that will shape the future of human health, food security, and sustainability in the 21st century.

Keywords: Biotechnology, genetic engineering, biology that is made by humans, CRISPR, bioinformatics, medicine that is tailored to you, long-term viability

INTRODUCTION

Biological systems and species have consistently constituted a fundamental aspect of social, political, and economic existence. The history of society and biotechnologies are closely linked. The introduction of these new ideas has shaped and continues to shape the course of important world events. Every technical, scientific, and social leap has changed how the economy, public health, and education have changed in the past and will change in the future. To keep ecosystems on Earth stable, improve human health and longevity, respect the natural environment in space colonies, and support other bioengineering advances like artificial intelligence, we need to bioengineer living organisms, change their genes, or create or simulate organisms. More and more synthetic inter-organisms or organisms that have been produced by humans are being made. It is more important than ever to comprehend the big trend in making synthetic creatures, changing their genomes, and changing biological structures because they are all connected to AI, ecology, and space research.

Every century saw a big change in how things were organised and how fast life moved. At the start of the 17th century, engineers still only knew how to employ natural building materials in the best way possible. Three important breakthrough technologies were repeated in the history instructions. Every right forecast came with a warning about using these advances too much [1]. Bioengineering is one of the newest big changes in society and technology, thus it’s a good idea to plan out how to make predictions for the near future. Information regarding the current outlook for tomorrow shows that tomorrow is coming faster than usual.

Biotechnology is the study and use of technology to improve biological processes. It is at the crossroads of biology and technology. Since 1953,

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life on Earth has embarked on a passionate voyage of unification, guided by the continuously evolving genetic code. In 1973, biological systems were expanded from the makeup of an organism to the ability to replicate and evolve particular behaviours. The initial view of life formed a little part of the earth sciences. An increased comprehension of life yielded novel biological engineering instruments to regulate biomolecular and biocatalyst domains within human classifications. The contemporary perspective emerged around 1983. When life was limited by the space, time, and expansion of Earth's continents, it was impossible to imagine large biomolecules that optical microscopes couldn't see. The discovery of biotechnology and the clear view of lifestyles drew attention from many sectors since they had a direct effect on society and the economy. The Fourth Industrial Revolution controls how the digital, biological, and physical worlds work together.

THE HISTORY AND BASIS OF BIOENGINEERING

Three major events led to the birth of new sectors of science and technology: the scientific revolution of the 17th century, the industrial revolution of the 18th century, and the digital revolution of the late 20th century. The methodical imitation of natural processes has resulted in the formation of bioengineering, which is officially defined as the application of biological knowledge to create new processes, systems, or products. The phrase "bioengineered" crops has become more common, yet it is still not clear what it means. It often refers to novel plant varieties produced through genetic engineering, which can be regarded as frameworks for constructing living systems via computer-assisted engineering of biological components, or as substances generated through biomimetic modelling of either living organisms or processes observed within those organisms [2].

SCIENTIFIC FRONTIERS AND TECHNOLOGICAL PATHWAYS

A group of scientific frontiers is coming together to speed up the discovery, development, and use of bioengineering technologies like never before. Bioengineering is based on a wide range of scientific fields and areas of knowledge that are connected to each other, such as molecular biology and engineering design. Many people think of bioengineering as a new field, although using living things in industry goes back thousands of years to ancient fermentation-based methods for making bread, beer, and wine. Scientific and technological advancements have facilitated more systematic and sophisticated approaches to manipulate organisms and biological systems. Bioengineering is set to change health care, farming, and the biosciences in four important ways. Each represents a domain of scientific inquiry that has reached an advanced level of development while continuing to progress swiftly [3]. These technological advancements are collectively engendering a novel zeitgeist and prompting ethical deliberations and governance difficulties that markedly differ from previous bioengineering paradigms.

1) synthetic biology and genome editing; 2) regenerative and translational medicine; 3) bioinformatic and computational breakthroughs; and 4) agricultural and environmental bioengineering are all scientific fields that could change how we think about biology.

Editing genomes and Synthetic Biology

Bioengineering is the use of engineering principles, design, and building on living things. The goal is to comprehend and redesign the physical and biological realms, ultimately leading to the creation of entirely artificial life forms or entities characterised by innovative architecture, composition, and functionality [4]. Bioengineering is all about building new systems that don't exist in nature.

Synthetic biology has developed as a subdiscipline of bioengineering, integrating foundational principles with advanced techniques for extensive genomic alteration. Traditional methods of genetic engineering apply these ideas to biological systems that are already in place [5]. The extent of modification is rapidly increasing, as systems like the Human Genome Project-write enable the synthetic assembly of entire human genomes, potentially revealing essential features of the genetic sequence, its evolution, and subsequent effects on human health.

The modern synthetic biology agenda is focused on three main areas of genome modification: quickly and cheaply making sophisticated plasmids, which are parts that change how cells work, and making whole genomes [6]. Synthetic genomics is the merging of molecular synthesis and genomic assembly. It raises organismal biology to the same level of engineering as circuits, mechanical systems, and other completely engineered systems. It makes it easier to design and redesign whole genomes for synthetic biology in a very exact way.

Regenerative and Translational Medicine

Regenerative medicine concentrates on treatments that enhance the body's regenerative capacities, substitute or restore human tissues or organs, and involves the engineering of biomaterials, stem cells, and organoids [7]. Cell therapy, immunomodulation, and tissue engineering are all part of this field. Stem cells injected into damaged tissues speed up healing, biomolecules released by stem cells send signals that change the immune system and grow new blood vessels, and biomaterials and stem cells work together outside the body to make tissues or organs that can be implanted. To create effective pro-regenerative interventions, it is crucial to enhance the understanding of endogenous healing mechanisms and associated methods to augment them. Since 1953, scientists have been interested in the regeneration abilities of certain adult cells. Some mature animal organs can heal themselves better than others. The heart lacks regenerating capacity post-infancy, but the human liver and dermis have remarkable regenerative activity. Adipose grafts implanted in diverse tissue beds activate distinct endogenous regeneration pathways, consistently provoking a robust progenitor cell response. The fat graft endures as an essential amalgamation of angiogenic, pro-regenerative, and inductive elements. Figuring out how to make adult tissue regenerate over time would change regenerative medicine from replacing and building tissue to re-scaffolding and reprogramming without losing delicate physiological control.

Advances in Bioinformatics and Computing

To move bioengineering forward, protect it, and make it more stable, it is important to extract, analyse, store, and model biological, chemical, and environmental data [3]. In the life sciences, data generation is still faster than Moore's Law, hence data mining is a top focus. Configurable computational models can reproduce experimental techniques on a large scale, and graphical programming languages make it easier to share. Evolutionary algorithms keep performance high by changing modelling schemes when they find new anti-microbial chemicals, which costs a lot of money. Methods for reasoning in extensive knowledge graphs assist in pinpointing potential subsequent experiments that tackle the evolution of antibiotic resistance in microorganisms. These models make it possible to efficiently calculate a system with numerous known intermediate and final products from beginning elements that are also chosen for possible bioengineering. As engineering with biology gets more complicated, it needs more high-level descriptions, more thorough validation, and an understanding of uncertainty built into the modelling process.

Bioengineering for the Environment and Agriculture

Research on agricultural bioengineering is presently happening all over the world. Gene transformation has been utilised to make numerous genetically modified plants. Hundreds of field trials have been done around the world, and these plants are currently being sold on several continents. More and more genetically modified crops are being sold commercially. Most of the approvals around the world are for crops that are resistant to herbicides, insects, and have a longer shelf life. No genetically modified crops have been licensed for growing in Europe yet, but research is still going on [1].

Developing nations are being urged to engage aggressively in bioengineering research, especially in agriculture, which sustains 70% of the population in these regions. More and more, companies in the commercial sector are looking for partnerships with universities in bioengineering, especially in synthetic biology. Intellectual property rights including patent protection, licensing procedures, freedom to operate, and others are becoming very important factors that affect bioengineering projects and collaboration.

ETHICAL CONSIDERATIONS AND SOCIETAL EFFECTS

Bioengineering poses significant enquiries regarding the fair allocation of technologies. In the last few decades, scientific research has made great strides, from figuring out the genome sequence to isolating stem cells. Still, underdeveloped countries still have a lot of ailments that the pharmaceutical sector doesn't pay enough attention to or doesn't do enough to fix. Bioengineering could help developing countries get or make cheap tests and treatments, which would greatly improve the health of both people and animals. Also, certain common technologies used in the Global North, such personal computers, the Internet, and biotechnology, didn't speed up growth in the Global South. Instead, they have made the income difference even bigger. In this situation, which countries and groups are most likely to gain from bioengineering technologies? Making simple bioproducts after unauthorised cloning or quickly finding viral outbreaks may be the best way for bioengineering technology to spread.

To make sure that technology are useful for solving big problems that affect everyone, people need to be involved in society. Different approaches work for different situations, yet the fact that certain problems are global makes people look for global answers. People's trust in biomedical gains from synthetic biology varies widely, with some areas having none at all. Different ways of getting people involved in public issues work better than others. Interactive discussion is usually better than one-way information sharing, and collaboration is usually better than competition. Potentially disruptive technologies are already sparking the kind of debate that is good for synthetic biology. Open-source biotechnology is related to social and economic issues since it is connected to access and innovation goals. The growth of distributed biology also brings up biosafety and biosecurity concerns that are being talked about all around the world. These issues are already on the agenda of important scientific bodies, which has caused enough concern to warrant serious and proactive participation [3].

Fairness, Access, and World Health

Research and development in science, technology, and engineering are frequently shaped by the interests, preferences, and conventions of particular groups within society. The characteristics and impact of modern biological engineering and bioengineering are similarly notable. Issues of geographical scale – local, national, regional, continental, and global – are especially important when it comes to fairness and access to bioengineered products, processes, or inventions. When viewed through the lens of equity and access, the discourse on modern bioengineering relates to the systems, organisations, processes, and networks that provide or disseminate bioengineered products, processes, innovations, and information to individuals, communities, or societies [1]. Developing countries and communities around the world are particularly interested in how fairly people may get these things and how easy it is for them to make or create them. The unequal distribution of scientific and technological resources and the potential benefits arising from advancements in the twenty-first century, examined through a historical lens grounded in the West, highlight another aspect of equity concerning the necessity for socio-technical systems, such as education, training, research, and development, to enhance local capacity for regenerative and translational medicine.

When viewed through the lens of equity and access, the conversation about modern bioengineering is about the systems, organisations, processes, and networks that provide or distribute bioengineered products, processes, innovations, and information to people, communities, or societies. The relative fairness of access to these goods and the ability to make or create them is something that developing countries and people around the world are very interested in. When viewed through a historical lens based in the West, the unequal distribution of scientific and technological resources and potential benefits from advances in the twenty-first century highlights another aspect of equity: the need for socio-technical systems like education, training, research, and development to strengthen local capacity for regenerative and translational medicine.

Risk, Safety, and Biosecurity

Societal and ethical factors magnify bioengineering's impact on communities, economies, and environments. These considerations differ between domains, although the advancement of bioengineering poses a risk of surpassing governance and societal adaptability [8]. The worldwide effects of the COVID-19 pandemic and the growth of AI-powered information technologies like ChatGPT show how important it is to have timely, broad-scope anticipatory governance. The United

States National Research Council has identified global bioengineering awareness, accountability, safety, and security as a primary scientific and technology challenge. Addressing these issues requires comprehensive and sustained social responses, which are rare in today's culture of reactive incident-driven reactions [9]. If bioengineering happens too quickly, too much, or in the wrong way, society will have to deal with tough problems like starvation or worsening living conditions for certain groups of people, even while technology can help with these problems.

In bioengineering, risk is defined by the evaluation or perception of possible negative outcomes, typically combined with ambiguity and an understanding of how to reduce risk. The rise of microbial life, including bacteria that create targeted organic insecticides and yeast that synthesises chemicals for natural textile colouration, exemplifies an adaptive strategy to climate change. These products also become more responsive to stricter global limits on raw materials by using less fertiliser, which helps meet climate-related goals (The Royal Society, 2022). Biorisks linked to bioengineering are on the rise because synthetic biology and genome editing allow for the creation of simpler, less durable creatures with new functions. Biorisks are either foreseen harms or a general decline in the biosphere that come from the unpredictable growth of changed organisms that are already in the environment. In theory, bioengineering hazards transcend environment-specific factors, including hydrology, governance, fragmentation, and cross-system connection, as alterations to bacteria, for instance, are independent of surrounding infrastructures. Still, uncertainty makes it harder to find identified hazards early on and figure out how bad they are. So, communicating information quickly is still very important to reduce risks and damage.

Privacy and Data Management in Biotechnologies

Bioengineering has a lot of potential to help solve global problems related to health and the environment. At the same time, biotechnologies are becoming more and more linked to unexpected risks and problems in society. Biotechnologies and their use to solve problems in society must be thought about carefully from both a social and moral point of view. The private sector is crucial and is expected to be at the forefront of bioengineering innovation. However, governmental institutions are still very important to making sure that biotechnologies and bioengineering live up to their huge promise and potential in a fair and long-lasting way. Even if there are many ways to get input from stakeholders, good governance puts openness, inclusion, and engagement with stakeholders first. Stakeholder engagement means talking about and agreeing on the possible dangers of biotechnologies to help bioengineering technology projects. The enhanced ability of states and companies to produce, collect, and analyse comprehensive data regarding persons and groups represents a significant ethical concern in bioengineering. Biometric-enabling technologies like genome editing, human cell-line implants, anatomical-system modelling, and more are being used to collect, link, and analyse personal information in order to figure out complicated behaviours and preferences, even when the people and organisations involved are not clear. Data about personal health include a variety of sensitive and private details. Regulation should concentrate less on constraining biotechnologies and more on their implementation in a way that protects confidentiality, anonymity, and other facets of personal security, even when the information's content may reveal unwanted behavioural tendencies. Biobanking projects and platforms like BBMRI-ERIC, P3G, and the GA4GH Data Sharing and Data Use frameworks are already giving us valuable ideas about how to control these kinds of things [10].

THE ECONOMY AND INDUSTRY ARE CHANGING

Biotechnology is about to change economies, industries, and the way new ideas are made. Five years ago, a big study of the nascent bioengineering field predicted that the bio-based economy would flourish and that a new industrial revolution would happen, bringing huge benefits to the economy and society. Bioengineering is expected to fuel the next wave of innovation through new economic models, products, and services, spurring an anticipated "second bio-economy centred on living systems and extending beyond fuels and chemicals to include materials, textiles, plastics, foods, and pharmaceuticals." Throughout history, major revolutions, from the agricultural to the digital, have propelled new business models such as the large-scale Greek olive oil and wine trade, the establishment of universal commodity money and paperwork, the establishment and standardisation of regulatory control systems along commodity chains, the introduction of the European Coffee and Exchanges in 1700s, and even the establishment of the United Nations all the way to commodity cheeses and spices. Even while progress is being made, we still need to pay more attention to conversations, regulatory arrangements, and evolving frameworks that will help, guide, and protect this new change. Alternatively, a more effective biobased continuous economy can be realised through current scientific advancements, a precautionary-pragmatic methodology, equitable development frameworks, and consistent updates to policies and regulations that aim to maximise benefits while minimising harm [3].

Ecosystems for Intellectual Property and Innovation

Synthetic biology and related fields, such as bioinformatics and genome editing, have had a big effect on innovation, collaboration, and the relationship between science and industry. The sharing of knowledge between universities, government organisations, and private companies affects where scientific progress is made. The pharmaceutical and biotechnology industries have been the key actors in biological innovation, but now other industries including electronics, energy, information technology, materials, and telecommunications are also getting involved. There are now open-source projects and quick approvals for things that are good for society. Even Nevertheless, patents are still vital for getting investors interested in new businesses and making it easier for institutions to share their technology [11, 12].

Rules, Standards, and Following the Rules

Long after genetically modified (GM) crops and crops made using newer genome editing methods became available for sale in many countries, the governance of agricultural biotechnology is still a big problem. As synthetic biology becomes more common in biotechnology, these problems are expected to get worse. Regulatory frameworks and obligations that are in place now were made when biotechnology was simpler and easier to understand [13]. As a result, there are doubts about whether and to what degree they deal with regular GM crops, items made with newer genome editing methods, or more general uses of synthetic biology or other more advanced methods.

The number of social, ethical, and regulatory problems related to agricultural biotechnology has grown throughout the years. People are now worried about more than just human health and the safety of the environment. They are also worried about things like intellectual property rights, corporate control of seed markets, the rights of farmers and consumers, and the coexistence of multiple agricultural systems. The Royal Society said in 1999 that regulatory frameworks for agriculture shouldn't just be based on scientific risk assessment. Since then, many attempts have been made to come up with a broader social risk strategy. Industry stakeholders concur that the acceptable level of governance must be established on an individual basis; nonetheless, the emergence of novel technologies such as CRISPR, gene drives, and synthetic biology intensifies the pressure for identifying appropriate frameworks.

International Cooperation and Public-Private Partnerships

Public–private partnerships (PPPs) in bioengineering that involve academics and government have exceptional prospects for the expedited advancement of systematic worldwide transformation in the forthcoming decade. A transatlantic viewpoint underscores the necessity for global leadership from all sectors of society to establish frameworks that significantly reduce systemic risk to the biological safety and economic security of nations globally, while also addressing public apprehensions related to global issues such as food supply, water purity, air quality, soil contamination, renewable energy, infectious disease management, and various chronic health conditions. New bioengineering technologies could change civilisations in a big way. Knowing what could happen with these technologies will help us see more clearly how to introduce them safely, fairly, and properly into underdeveloped and emerging economies. International engagement and collaborations will maintain the momentum of bioengineering innovation while facilitating the transfer of knowledge, technology, and ownership from developed to underdeveloped nations.

GOVERNANCE, POLICY, AND INVOLVEMENT OF THE PUBLIC

Long-term planning and foresight are not prevalent in the governance of science and technology; nonetheless, bioengineering has significant opportunities that necessitate the consideration of extended timeframes [14]. Current anticipatory frameworks inadequately address the culture of rapid invention in bioengineering and its ramifications for debate and adaptation [3]. The habit of setting up distinct agencies or offices for each new technology can lead to administrative silos that make it harder for different institutions to work together. To lead the long-term future of bioengineering, we need integrated systems that combine anticipation with adaptive governance. Three intersecting tracks are especially important: responsible innovation frameworks to guide the ongoing development of methods; proactive risk communication to engage and inform stakeholders; and workforce development and education to build capacity for bioengineering and its effects, and thus get people ready for the bioengineered future.

Responsible Innovation Frameworks

Synthetic biology, genome editing, and other bioengineering industries are making huge changes that will have big effects on many areas of life. People and society can better direct future improvements if they comprehend these advances better. Complexity in bioengineering fuels public interest and concern but also generates uncertainty about advantages and risks, when advances arrive, potential use, and oversight. Questions can frequently evolve into societal discussions characterised by minimal substantial understanding of the subject and sporadic extremist viewpoints. This kind of division makes it harder for society to oversee and manage new bioengineering technologies and advances, which in turn makes it harder for people to make decisions democratically.

The responsible innovation approach can help organise the talk about the problems that bioengineering brings up and get more people involved in these discussions. This framework is still new when it comes to agricultural bioengineering, but it is already making prototypes, use patterns, and evaluation methods to figure out how well it works in this new field. The initial two-generation-round developments occurred inside European projects and have been succinctly encapsulated. To create a responsible innovation framework for bioengineering, you need to ask big questions at the macro level. You may then follow the progress of society based on certain values and processes [15].

Risk Communication and Involvement of Stakeholders

Biotechnology advances bring many benefits, but they also create new problems for society. Technologies like gene editing and synthetic biology can be dangerous for the environment, raise biosecurity issues, and make people less trusting of other technologies. Even if regulatory barriers are lowered and the requisite scientific expertise is attained, advancements in biotechnology may be impeded if public apprehensions prevail in licensing discussions [16]. Engaging stakeholders to meet societal needs can make it easier to use technology and ease long-term worries about society [11].

Talking to stakeholders about uncertainties in a clear way might change the direction of research to benefit society as a whole, spark interest in disruptive biotechnology, and bring to light key social issues that haven't been fully addressed. Stakeholders could see the hazards of genome editing and synthetic biology, as well as economic models based on open-source biotechnology, in ways that are different from how scientists see them. Dealing with these frameworks gives you the freedom to change projects to fit diverse release venues, helps technology spread in places with few rules, and gets people involved to help improve technologies and business models.

Literacy, Education, and Workforce Development

Bioengineering provides remarkable prospects to improve living systems and tackle significant societal issues, including health, agriculture, and climate. These improvements bring up a lot of moral, social, economic, and governance problems that need to be thought about carefully. It is very important to get the future generation ready to answer these issues. All levels of education need to reconsider and update their curricula, equipment, teaching methods, and teacher training in order to inspire new scientists and explain how bioengineering affects society.

Many studies show that students don't know much about synthetic biology, bioengineering breakthroughs, or how they affect society. Students in middle school don't do a good job of defining the field or talking about connected developments. People have very different ideas about the risks, benefits, and effects of synthetic biology depending on how it is used. For example, microbial and plant interventions are usually seen as better than those that involve animals or people [17].

There are three main reasons why younger people want to learn. The media's coverage of genetically modified organisms (GMOs), the COVID-19 pandemic, and genome editing is what got people interested in these matters in the first place. Second, bioengineering is a big area of research that is getting a lot of attention since it has many real-world uses. Third, the growth of do-it-yourself (DIY) biology and open-source biotechnology has made it possible to get commercial products, data, and experimental instruments outside of traditional classrooms.

POSSIBLE FUTURES AND PATHS FOR THE NEXT TEN YEARS

During this decade, we should expect big advances in bioengineering. Mendel's rules on heredity still apply to plants, medicine, and microorganisms. Scenarios [18] illustrate potential trajectories for the future of human genome editing (HGE) shaped by the ramifications of CRISPR. An "Optimistic Path" envisions swift advancements in human genome editing (HGE) following CRISPR regulations, facilitating germline interventions, enhancements surpassing treatment, and expansion into epigenetics and embryos. The "Medium Path" moves forward with medical HGE for sickle cell disease and other critical illnesses, using somatic therapies. However, only rich countries can get to it. The "Cautious Path" hinders HGE's progress because of problems in society, such as unfairness and government policies that aren't clear.

The next ten years will see bioengineering become a part of everyday life in human communities. There are already important contributions that will help improve and bring about different expected situations. The scenarios contain pertinent enquiries and stakeholder concerns already identified by governmental and other organisations [19] regarding these topics. Inputs and implementations emerge from biological contextual phenomena; yet, certain subjects remain ancillary, particularly those perceived to have intermittent inhibiting effects of technology.

Positive Scenarios of Medical Advances

The mechanistic perspective on disease that emerged in the early twentieth century was linked to significant progress in biochemistry, which propelled the creation of systematic approaches for drug discovery that would greatly improve efficiency. By the 1940s, significant categories of pharmaceuticals, such as vaccines, antibiotics, and hormones, had been developed through the examination of fundamental biological mechanisms. In the 1950s and 1960s, new ways to make pharmaceuticals using synthetic organic chemicals were created, which sped up the process of bringing new drugs to market even more [20]. Computational prediction methods were used to develop molecules with specific biological activity based on their physical features. In the 1970s, both types of synthetic nanotechnology were integrated and expanded to figure out the molecular structure that starts synthetic compounds and stops biological activity. Genetic engineering formed the foundation for a secondary modular technology platform in biomedicine [18]. Bioengineering is a broad and fast-changing field that includes a wide range of applicable experimental investigations and a growing number of enabling platform technologies.

Moderate Progress with Steady Integration

If things stay the same, bioengineering will keep making progress without causing a lot of public worry or criticism. International research communities that work closely together will endeavour to get the most out of scientific achievements by forming partnerships across academia, industry, and civil society. People will still want little, useful new things like food supplements, better immunisations, and biostimulants. Safe items that have been there for a long time will help new technology get used, and regulated markets will make it easier for new products to hit the market without people worrying about going too far.

But worries about safety, ownership, and the environment will slow down progress. People are worried about CRISPR, lab-on-a-chip gadgets, and synthetic cells, which will make investors less likely to put money into things that are medically, ecologically, and politically controversial. Bioengineering is likely to advance, but its range will continue to be more constrained than that of virtual, cognitive, and mobile technologies. Because there won't be any big changes, biology will slowly and steadily become more integrated with information, cognitive, and engineering paradigms. This will lead to bioengineering 2.0.

Slow Progress and Changes in Society

How well society can use new technologies often has an effect on how well they work. In the field of biotechnology, where the effects of certain technologies might be very big, it's important to make sure that society is ready to deal with the new products, services, and information that come with them. That is one of the reasons why it is important to learn about the social effects of biotechnology: to find the changes that could lead to various situations and, as a result, new policies to avoid inertia or backlash [3].

In the next ten years, bioengineering is likely to make more progress (Ivanov, 2020). However, three main assumptions are made about how society will be able to handle these changes: (1) progress continues, but useful applications are slow to appear; (2) advances allow bioengineering principles and feelings to be introduced gradually; and (3) worries about unintended consequences make people question human control. A culture that affects how people utilise technology is made up of individual, community, and business interests. Three things shape bioengineering's cultural involvement: values, legitimacy, and monitoring.

CONCLUSION

Imagining the future leads to a gloomy environment where the only paths for civilisation are degradation, decay, and poverty. All efforts put on bioengineering are still useless. So, bioengineers are kept apart, and they feel more and more pressure to think about their position and duties in relation to human life. World governments' broken political structures don't work to control the creative intellect. The marketplace determines the direction of scientific inquiry. It is hard to believe that market principles will protect a country that doesn't have the basics of life: energy, food, water, shelter, and safety.

Setting aside the tragic failures of human governments throughout history and the collapse of enormous national empires, Moore's Law shows a cyclical, exponential growth in biotechnological capacities. In 2023, this bioengineering cycle is shown by the amazing things that can be done with the bioengineering toolbox [3]. The global epidemic generated by COVID-19 serves as compelling evidence that contemporary society has the scientific knowledge, capability, and technical resources to annihilate civilization – should there be the motive and purpose to achieve such a catastrophic outcome [18].

Consequently, it is essential to take actions to address the fundamental question: "What is the future vision of bioengineering that civil society should strive for, pursue, and actualise for the benefit of humanity in a world of valued, safeguarded resources, integrity, prosperity, and civilisation? The emerging society resembles a Garden of Eden for mortals to inhabit joy de vivre. The sad question: "Will this vision ever come true on Earth?" – still open. The final decision will be made by civilisations that exist now and those that will exist in the future.

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