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The impact of philosophy on contemporary bioengineering

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Abstract

This review assesses modern bioengineering philosophical foundations to exhume modern bioengineering's rational framework. Both the physical and biological sciences require engineering as the ultimate mechanism for transforming knowledge into practice. Engineering's emerging biosciences has acknowledged addressing major issues in environmental ecology and human health. Scientists and engineers should be familiar with the technology in order to fully realize the potential of modern bioengineering and lay a solid foundation for green technology. Bioengineering philosophy teaches scientists the broad principles of scientific study and identifies the endeavor's intrinsic goals "how" questions of the physical world and normative "why" issues of values. Not only must scientists and bioengineers be motivated, but they must also be educated about their ethical and societal duties, which necessitate an interdisciplinary approach. We examined the mechanical approach of physical sciences, the functional approach of biological processes, and the integrated method after establishing the bioengineering conceptual framework.

In addition, the review examined a variety of bioscience disciplines. It has concluded that an interdisciplinary approach is essential for unlocking the potential of bioengineering and laying the foundation for green technology based on moral values. Bioengineering research and education must acquire both epistemological and normative knowledge in order to achieve such a noble goal. The first is critical for new ideas and inventions, while the second helps bioengineers understand their ethical and moral obligations.

Keywords: Systems Biology; Ethics; Integrated Approach; Philosophy; Bioengineering

1. Introduction

The interdisciplinary approach to engineering that integrates physical and biological sciences is becoming a focus in modern science philosophy. It provides opportunity for scientists to develop methods to improve human health while also protecting the environment. The ability to use such opportunities to address the challenges posed by ecological crises is a major benefit of bioengineering science, which promotes an integrated approach. A group of people from different fields of study must work together in a positive way to save natural resources and improve the chances of life on Earth [1].

One of the major goals of bioengineering philosophy is to integrate the two traditional methods of scientific explanation. In the modern history of science, causal and teleological explanations have been the dominant philosophies of scientific

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inquiry. The physical world's processes are mechanical and deterministic in nature, while biological processes are functional and purposeful, according to modern science philosophy (goal-guided). Thus, the causal explanation is primarily concerned with the physical world, whereas the teleological explanation is concerned with biological and behavioral organisms' goal-directed processes. The main distinction between the two modes of explanation is the context in which cause and effect are related to one another [2, 3]. In goal-guided biological processes, the future (the goal) is very important in determining the present act. In causal explanations of physical processes, the past is very important in determining the present act and the future act.

In other words, predicting the behavior of biological processes based on knowledge of their individual components is difficult [4]. This significant distinction between the biological and physical worlds has a significant impact on their research and methods. We do acknowledged math and computer simulations to help us learn about the inside and outside of living things, as well as predict how they will look and how they will interact with their environment [4].

Unlike traditional philosophies, the integrated approach assumes no essential distinction between motivational and causal explanations in biology and physics. According to the integrated method, physical and biological processes can be approached either through causal explanation, as Carl G. Hempel and Paul Oppenheim [2] emphasize, or through application of the teleological method to physical sciences, as perfectly demonstrated by producing goal-directed systems like plastic missiles. "Cybernetics" is the name given to this multidisciplinary approach. One of the foundational works on this method is the work of eminent mathematician Norbert Wiener, "Cybernetics," published in 19484.

It is self-evident that biological processes are an integral part of the contemporary philosophy of science's integrated approach. As a result, the modern philosophy of science is focusing on the philosophical foundations of bioscience, and developing relevant approaches to understanding complex systems of life. These are the main points that this paper will focus on. This paper aims to articulate the fundamentals of the integrated approach by reflecting on the philosophical foundations of bioengineering. It also looks into the ethical issues that come up in bioengineering research and practice. The paper's main content is divided into three sections: a conceptual framework, philosophical foundations of bioengineering, and ethical concerns of bioengineering, where the Islamic perspective on bioresearch's negative effects will be presented. The paper's conclusions and findings are found in the final section.

2. The Conceptual Framework of Bioengineering

In modern philosophy of science, the term "science" referenced different contexts. Bioengineering includes biomedical engineering, bioinformatics, and systems biology, among other sciences that integrate engineering and life science and their applications. Biosciences, in contrast to the traditional definition of "biology," are primarily applied sciences. Engineering education focuses on developing conceptualizing and calculation skills, whereas biology education focuses on developing and structures tissue [5]. The common goal of bioscience, on the other hand, is to gain a practical understanding of life's complex systems.

According to a comparative and analytical study, bioengineering collaborates with philosophical fields, particularly systems biology and bioinformatics. Henceforth, bioscience can be divided into two major groups based on their end goals [6]. The first group represents an efficient method of analyzing complex life systems, whereas the second group is concerned with the application of cumulative knowledge. The first group aims to generate knowledge through data collection and analysis, while the second group aims to put existing knowledge into practice. Bioinformatics and systems biology, for example, are concerned with creating databases, analyzing, and molding the complexities of biological phenomena when referencing them. Bioengineering and biomedical engineering, on the other hand, are about using knowledge to make things that help people and the environment stay healthy at the same time.

2.1. Analytic Techniques

The collection, that deal with analysis and modeling of biological data for practical purposes refers to biosciences, which referenced “analytic”. In addition, analytic does not imply to sciences that are less practical than “applied sciences”, but they are successful tools or methods for creating databases for understanding methods or tools for creating databases for acknowledging complex biological systems. Bioinformatics and systems biology are two types of bioscience that considered important substance of analytical approaches providing acceptable methods for bioengineers to understand and build systematic databases. For analysis, design, and modeling, both rely heavily on mathematics and computer science.

2.1.1. Bioinformatics

Bioinformatics deals with is an interdisciplinary field of study referencing software tools and methods for analyzing biological data. In addition, the fundamental approach to bioscience research that acknowledged the analysis and creation of databases. Bioinformatics science can be defined as the process of collecting, storing, and analyzing biological data. Bioinformatics is an interdisciplinary approach to biological data analysis and interpretation that combines computer science, statistics, mathematics, and engineering [7].

Bioinformatics techniques primarily used in systems biology projects to conduct data analysis. One of the most basic applications of bioinformatics methods is the annotation of genome sequences. Many biologists, including Clair and Alistair, believe that the bioinformatics field is shifting away from focusing on the functions of single genes and toward considering the larger relationships between genes as they interact in pathways and networks. In other words, as molecular systems biology questions become more prevalent in bioinformatics, the question of bioinformatics' true contribution to the new emerging science of systems biology may arise. Bioinformatics can help systems biology in a number of ways, but two of the most important are as follows: first, it provides methods for extracting systems information from large databases, which can then be used to analyze and generate new data. Second, bioinformatics is regarded as a critical method in the context of data management because it is concerned with the development of appropriate standards and databases for proper archiving [7].

2.1.2. System Biology

Systems biology, why does it matter and how does it work? Such inquiries are necessary in order to comprehend the emerging approach to interpreting biological phenomena, which includes a variety of explanation methods. The structure and function of biological systems such as organisms, cells, and biomolecules are highly organized. Biologists have devised a variety of methods for explaining and comprehending such systems. Experiment, modeling, mathematical and computational analysis, on the other hand, are used to develop a qualitative and quantitative understanding. These characteristics distinguish systems biology as a useful tool for comprehending life's complexity. Researchers from various disciplines [4] have referenced the structure and functional organization of cells, as well as the continuous refinement by mutation and selection.

Biologists still address a number of critical issues, referencing problem of aging and death acknowledged by the authors of "Systems Biology and defining systems biology as the study of biological systems as a whole, with the goals of investigating the components of cellular networks and their interactions [4]. Klipp and her colleagues have compiled a list of the major factors that have contributed to the growth of systems biology. While the systemic approach to biology is not new, it has recently gained traction because of the development of useful experimental and computational methods, according to the authors. It is based on ever-increasing biological knowledge, new experimental techniques in genomics and proteomics, mathematical modeling of biological processes, exponentially more powerful computers, and the internet, which is the primary means of sharing information quickly and thoroughly [4] [8, 9].

A systemic approach focuses on gaining a qualitative and quantitative understanding of biological systems. The ultimate goal of systems biology is to better understand the structure and function of physiological and pathophysiological systems so that successful biotech approaches can be developed. A thorough understanding of complex biological processes allows for the solution of many real-world problems, particularly in the health sciences [8]. Systems biology knowledge can pave the way for disease control, prevention, and treatment and has many advantages.

2.2. The Applied Approaches

For any product, the engineering process is usually divided into three stages referencing analysis, synthesis, and design, which comprehend their function. Synthesis is the process of putting the systems under study into practice. Both steps contribute to engineering's ultimate goal, which is the product's final design. Bioscience approaches that are useful in transforming theoretical knowledge into technologies and practical methods are those that have practical value. The most practical aspects of bioscience are bioengineering and biomedical engineering. Both aim to apply biological knowledge applications, development and biological processes in industry. In the sense that biomedical engineering is a subset of bioengineering that focuses on medical and health sciences, some researchers believe these two effective bioscience approaches are interchangeable. Others, on the other hand, consider these two sciences to be separate fields. Bioengineering is concerned with the development of tools and technologies, whereas biomedical engineering is concerned with the practical application of those technologies in the field of health care, they say.

2.2.1. Bioengineering

The terms "bioengineering" and "biological engineering" refer to an interdisciplinary approach in which physical and life sciences are combined in mathematical applications. It is the scientific and mathematical principles to understand and employ life systems for practical purposes," according to the technical definition. The National Institute of Health (NIH) defines bioengineering as "the application of engineering knowledge to the fields of medicine and biology"[10].

Bioengineering has emerged as the primary means of putting life science knowledge into practice as an applied science. There are a number of basic mechanisms, as well as the essential mystery of life in the history of molecular biology, according to Harvard University Bioengineering. For example, biomedical engineering has produced ground-breaking innovations such as new imaging modalities, prosthetic devices, dialysis, and drug delivery systems, and it is poised to address the increasingly complex and sophisticated problems of daily life"[11].

Bioengineering has persuaded engineering professors to call for an integrated engineering curriculum in today's scientific platform. They propose combining biology with the three basic sciences that engineering students have traditionally studied physics, chemistry, and mathematics. They emphasize that during their undergraduate years, all engineers, regardless of specialization, must be exposed to biological sciences. Professor Johnson discusses the importance of future engineers being true synthesizers, not just designers, in his book.

2.2.2. Biomedical Engineering

Bioengineering acknowledged by the application of scientific principles to solve real-world problems [12]. In addition, biomedical engineering is the most common application field of bioengineering, with the terms frequently interchanged; engineers are deeply involved in many medical ventures because of technology's significant impact on medical care. As a result, biomedical engineers are relatively new members of the health-care delivery team, and they have to come up with new ways to solve the many problems that modern society faces.

Others [13] have defined biomedical engineering as “the technology, application of engineering disciplines, and design concepts to medicine and biology”. All of these attempts demonstrate how biomedical engineering combines "engineering" and "medicine," bridging the gap between the two. As Fazel-Reza points out, building such a bridge necessitates a deep understanding as well as significant inter-disciplinary efforts from researchers, engineers, and physicians working in health institutions, research centers, and industry sectors. There are many different kinds of biomedical engineering, like bioinstrumentation and biostatistics, biomaterials, biomechanics, biosignals, and cellular engineering are important parts.

However, as other important medical field emerges, the field of biomedical engineering continues to grow referencing the application of physical science methodology; aim to improve overall health care [14]. Despite the fact that medical science has been going on for a long time, the technologically based health-care system has been able to provide a wide range of health-care options, such as effective diagnostic tools and highly therapeutic treatment options, despite the fact that medical science has been going on for a long time.

3. Philosophical Foundations of Modern Bioengineering

The two components of bioengineering, biology and engineering, define the philosophical foundations of the field, which imply the application of engineering methods to biological systems. Biology philosophy, in general, is concerned with the theoretical aspects of life science. This includes problems in traditional biology as well as problems in emerging bioscience approaches such as systems biology (SB), evolutionary systems biology (ESB), and bioengineering. Scientists acknowledge differences between natural laws that referenced physical processes and those that referenced living systems. According to Rudolf Carnap, physical laws are mechanistic in the sense that they generalized through observation; biological patterns, on the other hand, are theoretical in the sense that they cannot be generalized through simple observation. [15] [7]. Physical science methods are extremely successful in approaches to comprehending and controlling the physical world. Despite significant efforts, however, the mechanistic approach of the physical sciences appears to be ineffective in answering many critical questions in the life sciences. It is therefore necessary to investigate the philosophical foundations of emerging biosciences such as SB, ESB, and bioengineering in order to formulate their rational framework. This would make it possible to address bioscience's theoretical, ethical, and methodological issues, as well as open up new avenues for understanding biological processes for practical purposes.

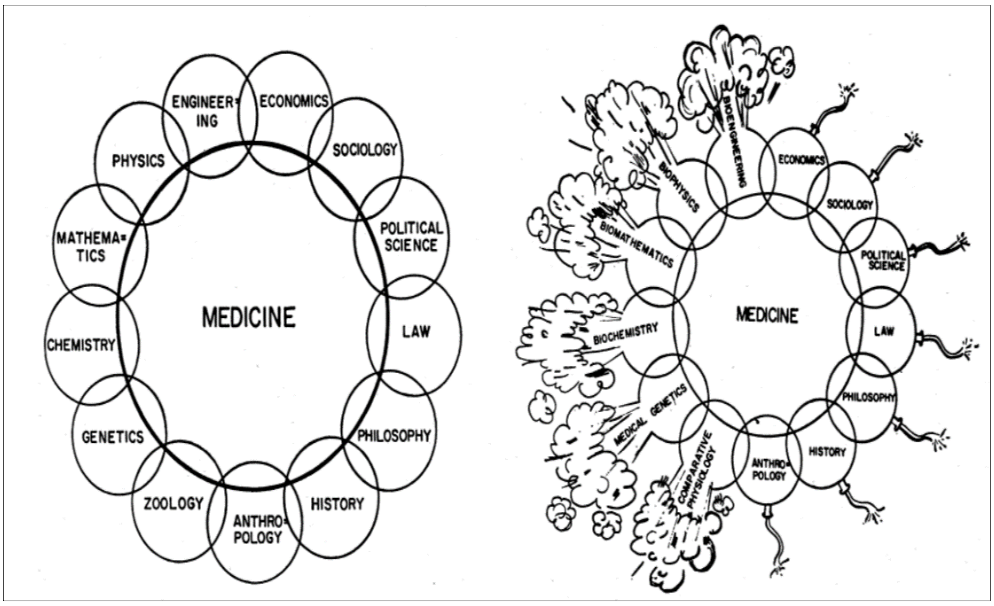

Figure 1 (Left) Medicine's "sphere" intersects with a number of well-established physical, biological, and social sciences. (Right) In the past, the rapid changes that happened at these interfaces were alarming

3.1. Philosophical Underpinnings of Physical Sciences

The foundations, methods, and applications of the sciences are all investigated in the general philosophy of science. It is primarily concerned with scientific theoretical, ethical, and methodological issues that lead to the perfection of scientific inquiry. This includes issues with scientific research methodology, concept clarification, classifications, theory reliability, and the ultimate goal of scientific endeavor. The physical sciences, which include physics, chemistry, astronomy, and other related subjects, are disciplines concerned with the study of inanimate natural objects [16]. The life sciences, also known as biology, are the opposite of the physical sciences. The bioengineering science method attempts to integrate biological and physical sciences by applying physical science methods to life sciences for practical purposes.

Referencing some important figures of modern philosophy of science, such as C. D. Broad, Rudolf Carnap, and Karl R. Popper, all studied the philosophy of physical sciences in the 70s. Many of Rudolf Carnap's books, such as "Introduction to Philosophy of Science" and "Philosophical Foundations of Physics," are devoted to the philosophy of science. He distinguishes two types of natural laws when it comes to comprehending the physical world. According to Carnap, empirical laws and theoretical laws contain processes that can be observed directly with the eyes or measured with relatively simple techniques. They include both qualitative and quantitative laws derived from simple measurements, such as "All metals are good conductors of electricity. “This type of law governs the pressure, volume, and temperature of gases [15].

The difference between these two theoretical laws, according to Carnap, is not that they are not well established, but that they contain terms of a different type. Even when the physicist's broad definition is used, the terms of a theoretical law do not refer to observables. A static large-scale field is one that can be measured with simple equipment; however, if the field varies over very small distances or changes rapidly in time, perhaps billions of times per second, it cannot be measured directly with simple techniques. Physicists [15] would not consider such a field observable. Theoretical laws are often referred to as micro or macro processes because they deal with non-observables in the physical world. Carnap uses the term "theoretical law" in a broader sense to refer to all laws that do not have anything that cannot be seen, whether micro- or macro-concepts [15].

3.2. Philosophy of Biology

According to the available literature on science philosophy, modern philosophy is more focused on the physical sciences. To put it another way, many fields of life science remain unexplored philosophically. This could be due to the historical fact that the physical sciences were developed first, but it also highlights the fact that philosophers of science are increasingly turning their attention to biology.

3.2.1. Biological Philosophy's Subject Matter

Biology philosophy is concerned with the methodological, theoretical, and ethical issues that arise in the life sciences. This includes traditional biology questions like the origin of life or the diversity and source of change in living creatures, as well as critical questions raised by emerging biotechnology and bioengineering branches like systems biology and evolutionary systems biology. According to some authors, modern biology philosophers have been debating about evolutionary biology, which is the study of how living systems come to be, and third, they are debating biological functions and causal explanations [17].

In contrast to the philosophical acknowledged that, modern philosophy of science hardly explored the nature, method, and functional issues of life sciences. Aside from traditional questions about the evolution of living things, modern biology philosophy should concentrate on molecular and experimental biology. As many authors have noted, the rise of genetics and molecular biology has necessitated this philosophical trend.

3.3. Philosophy of Evolutionary Biology

The theory of biological evolution is crucial in modern biology. The philosophical underpinning explains why there are so many different types of organisms on Earth, as well as their similarities and differences. Evolution, according to its proponents, is the process by which today's organisms descend from their ancient ancestors. It explains how living creatures develop morphologically, physiologically, and genetically. "On the Origin of Species," published in 1859, Charles Darwin developed this theory in depth as a comprehensive philosophical approach to understanding living organisms. In this book, Darwin addresses two fundamental questions about living organisms: the origin of life and the causes of change in living creatures; and (ii) the source of diversity and fascinating characteristics of living creatures. Both of these issues are philosophical. Natural selection, according to Darwin's theory, gradually evolved the various forms of life on Earth. If an organism has many good things that make it more likely to stay alive and reproduce over time, they will keep getting better over time. This process is called evolution and adaptation, and it happens over time [18].

3.3.1. Criticism of Evolutionary Theory

The evolution theory became contentious, resulting in a variety of opposing viewpoints among biologists and other intellectuals. The theory's proponents emphasize that nothing in biology makes sense unless it is viewed through the lens of evolution [19]. They go on to say that, accepting evolution as the seat of physical laws at work, but also had to take into account history and, more importantly, the observed changes over time [9].

Despite the theory's excellent capabilities in exposing humanity to the understanding of living creatures, other philosophers argue that its major flaw is its basic assumption, which proposes an explanation that eliminates the role of any external force in the evolution process. Many academics argue that this assumption leaves many critical concerns about the perfect structural ordering and systematic functions of living creatures unsolved. Since the start of religious thought, theologians have employed the "design argument" to argue the existence of God (the Intelligent Mind) as the single creator and designer of life systems.

However, both evolutionists and creationists agree that the theory of evolution has significant understanding in the history of biological science. The evolution theory, on the other hand, has nothing to do with the question of an organism's efficient cause, which has been a major concern of the teleological approach. The philosophical foundations of modern biology, as articulated by Darwin, are descriptive rather than predictive, asserting understanding organisms' histories, particularly their genetic histories, and a catalog of what molecules are made up of referencing what separates evolutionary biology and systems biology philosophies. The former looks into how living systems came to be, whereas systems biology looks into how they are or should be. The profound difference is between the biology of being and the biology of becoming. The objective of systems biology is to figure out how interactions of living organisms' constituents affect their functional properties and behavior [17].

3.4. Philosophy of Systems Biology

Systems biology's emergence as a new science needed the development of philosophical foundations. Systems biology is, in reality, one of the most promising and practical approaches to life science. As a result, it will take a significant amount of effort to develop its own philosophical foundations. The available literature focuses on systems biology's fundamentals, principles, functions, and applications [3]. Only a few works in the field of systems biology have addressed the issue of philosophy acknowledging Hans V. Wester off, is one of the most comprehensive works on this topic (first edition 2007) [16]. Systems biology, according to the book's authors, is the pinnacle of biology. The authors explain the goal of systems biology in the first section, titled "Towards Philosophical Foundations of Systems Biology."

It is to comprehend how the interactions of living organisms' constituents affect their functional properties and behavior. They acknowledged that modern systems biology-growing field that is a natural successor to molecular biology and mathematical biology and biophysics on the other.

The authors also emphasized systems biology's interdisciplinary nature, stating that the major difference between molecular biology and systems biology is well defined. According to them, the goal of molecular biology is to characterize the molecular constituents of living organisms. It evaluates each component's properties as well as its location within the living cell in molecular cell biology. Its methods and outcomes are stunning and significant, but they are straightforward and do not require any philosophical foundations beyond those of physics. Systems biology, on the other hand, is concerned with how molecules and cells interact. It is about how molecular functional properties emerge from the specific organization and interactions of molecular processes. Using models, systems biology generates new ideas about how cells function as molecular systems. Following that, these models are applied to a variety of cell types and organisms [17].

4. Ethical Concerns in Bioengineering

Bioengineering science's pragmatic nature may make it the science of the new millennium, especially in terms of improving human health and preserving environmental ecosystems. However, in order to fully exploit the potential of bioengineering, ethical concerns must be addressed. In fact, advanced bioengineering research and applications, particularly in biomedical engineering, raise serious ethical and legal concerns. It is not just the traditional ethical issues that modern biomedical engineering has brought up. There are more serious ethical issues at all stages of development, from research to use.

Bioengineering ethics are currently being researched in a variety of fields, including bioethics, biomedical ethics, and engineering ethics. For the purposes of this article, however, the basic structure of the ethical enterprise can be divided into three major groups:

- Bioethics
- Research ethics
- Clinical ethics. Clinical research ethics is primarily concerned with ethical issues involving living organisms, particularly human participants, in medical research.

This is something that could be applied to any medical practice or profession. As a result, clinical ethics necessitates both personal ethics, such as honesty and sincerity, and medical profession-imposed protocols, which must be followed regardless of religious affiliation. These protocols are necessary to achieve the goal of good medical practice. Personal ethics are intertwined with research ethics, and both are necessary for proper knowledge production and scientific progress. Fabrication, falsification, and plagiarism (FFP), as well as other types of research misconduct that fall outside of these three categories, are the main topics of research ethics.

Because of its grave implications for life, human health, and the environment, "bioethics" is a major concern of bioengineering philosophy. The term "bioethics" refers to all ethical concerns about new life sciences technologies (bioengineering), whether in the medical field, such as genetic and tissue engineering (biomedical ethics), or in general, such as genetic modification and cloning (biotechnology ethics). Traditional issues like organ transplantation, abortion, and euthanasia can be divided into two categories: (i) advanced bioengineering issues like stem cells, genetic modification, reproduction technology, biomedical imaging, and neural engineering [20].

4.1. Advanced Bioengineering's Ethical Issues

Advanced bioengineering ethics encompasses all aspects of advanced biotechnology research and practice, including genetic modification, tissue engineering, biomaterials and prosthetics, and biomedical imaging ethics. In fact, scientific advancement in both the physical and biological sciences has created complex ethical issues. As a result, "ethics" has become a common theme in a variety of scientific fields. Norbert Wiener, the father of "cybernetics," whose theories were instrumental in the development of goal-guided missiles during WWII, has expressed grave concern about the social and ethical implications of scientific progress. He emphasizes the importance of ethical considerations in advanced technologies in particular. In his discussion of ethical concerns about modern technology, Wiener observes the effects of advanced technologies on environmental ecology, human health, and social life. By combining advanced technologies with moral values, Wiener was attempting to articulate the foundations of a meaningful life. His eminent works, "The Human Use of Human Beings" and "God and Golem," in which he discussed ethical issues in depth, were written for that purpose.

4.2. Christian and Islamic Perspectives on Bioengineering Ethics

In a Christian context, ethics is the concept and definition of personhood is at the heart of today's ethical debates. While there are guidelines for moral behavior, beyond the general rule of love, according to Lehmann, there are no absolute moral norms. According to Lehmann, Christians should act in every situation in ways that are consistent with God's humanizing purposes, but what that entails varies from situation to situation and requires strong, faith-based discernment. The Library of Theological Ethics is a collection of books that focuses on theological and ethical thinking. It provides easy access to a number of important and otherwise unavailable texts. The volumes in this series will allow for a long-term conversation with your predecessors. They will look at some of the most important works in the field.

Stanley Rudman's 1997 contend that person concepts are socially constructed and that the relational understanding of persons in various theological discussions can serve as a useful counterbalance to the individualistic notions of persons that have dominated secular philosophy since the Enlightenment. Early Christians thought that God spoke, communicated, and had relationships with three people called the Trinity. These ideas can help us figure out how to live an ethic that thinks about how people interact with each other, the environment, and God. Human life requires elements for proper development of first, natural resources to sustain life and oneself and maintain justice and tranquility in society. The foundations of law, ethics, and moral values are of the latter type. As the final mode of divine revelation, Islam has fully addressed and provided both of these elements. As a result, the Islamic code of ethics is capable of governing all human affairs, including daily life, social interactions, scientific research, and personal affairs. There is no specific code of ethics for scientific research and application, but there are general principles that can be used to guide the process. Early Muslim scholars compiled and summarized these principles into five major objectives of Islamic law, known as Maqasid al-Shariah, which included: religious freedom; (ii) human life; (iii) mind; (iv) human progeny; and (v) property preservation. The sixth goal, according to contemporary Muslim scholars, is to preserve nature.

The Islamic legal system's entire philosophy is based on promoting these principles and safeguarding human rights (Maslah). These principles, in addition to God's commandments, provide all of the necessary guidelines for determining what is permissible and what is not (halal and haram) in Islam. The principle of human life preservation, for example, aims to promote human dignity and maintain a meaningful life; as a result, it prohibits all acts and activities that humiliate human dignity or cause death, such as the use of human subjects for research purposes without their free and informed consent. Furthermore, the principle of progeny preservation, which is based on the principle of human dignity, aims to maintain human reproduction. As a result, it will consider some modern bioengineered reproduction methods to be illegal. These two principles can be used to figure out that Islam does not allow the reproduction of "motherless-babies" or "fatherless-babies."

The lack of a universal criterion for judging may be the most significant source of disagreement among Muslim scholars on many issues of bioengineering ethics. Following the rules of Islamic law, called "Maqasid al-Shariah," would make it possible to judge a wide range of human activities, especially those involving bioengineering technology.

5. Conclusion

According to traditional scientific philosophy, natural processes, both physical and chemical, are understood through causal explanation. Meanwhile, teleological explanations are used to explain biological (goal-directed) processes and conscious acts of humans. The relationship between cause and effect is the most significant difference between the two methods. In biological processes, the future determines the present, whereas the past determines the future in physical processes. The distinction between physical and biological processes, on the other hand, is unnecessary in the integrated approach. The "cybernetics research method" is used to develop theories such as goal-directed control and information feedback control, which emphasize the integrated approach. Indeed, the new integrated method of scientific inquiry has had profound effects on both the physical and biological sciences. The tremendous progress in bioengineering science over the last few decades has had a significant impact on biological research. The advancement of bioengineering has brought biology, in the traditional sense, to a fork in the road. Biology is now only prepared to deal with physical science methods, forming a strong bond with mathematics, engineering, and computer science in order to meet the practical needs of humanity on Earth. This new approach to biological research places a strong emphasis on the quantitative method, which allows scientists to predict biological processes and develop new methods for controlling them. It is necessary to acquire both practical and theoretical knowledge of bioengineering in order to fully exploit the potential of modern bioengineering. Prof. Johnson emphasizes that bioengineers need to understand the conceptual and philosophical framework of biological science, which is critical for bioengineering fundamentals. This means that ideal bioengineers must be able to incorporate ethical, aesthetic, and environmental considerations into processes and products. The authors of this article emphasize the following three requirements for the actualization of such a motivating proposal: First, engineering students should be exposed to biological sciences, particularly the systems biology approach, regardless of their area of specialization. Second, all science and engineering students should be familiar with modern science's philosophical foundations. This point may need to be emphasized by making science philosophy courses mandatory for all students. Third, bioengineering research must be based on ethical and moral values in order to make green technologies that do not harm the environment or people's health.

Compliance with ethical standards

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The authors declare no conflict of interest.

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