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REVIEW ARTICLE

BIOBOTS - THE FUTURE OF BIOMEDICAL ENGINEERING: A MINI REVIEW

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Abstract

Biobots (Biorobots), engineered living systems, are poised to revolutionize the fields of medicine, biotechnology and environmental science. They can be created from either normal living cells and/or post-mortem cells. This short paper shades light into the fundamental concepts, design principles and diverse applications of biobots. The state-of-the-art advancements in biomaterials, cell engineering and control systems that underpin the development of these intricate machines will be explored. Furthermore, the ethical implications and regulatory considerations associated with their deployment are discussed. By highlighting current research and future perspectives in this emerging technology, this article aims to explore the potential of biobots to revolutionize healthcare, particularly in the areas of drug delivery, tissue engineering and regenerative medicine.
Keywords: Biobots, biomaterials, biosensors, regenerative medicine, synthetic biology, tissue engineering.

INTRODUCTION

The convergence of biology and engineering has given rise to a new era of innovation, where the boundaries between the living and the artificial are blurring[1]. Biobots, or biological robots, represent a prime example of this convergence. These engineered living systems, constructed from biological materials such as cells and tissues, offer unique advantages over traditional robots, including biocompatibility, self-repair and adaptability[2].

Post-mortem cellular survival: A novel approach to biobot construction

A recent breakthrough in the field of biobot research involves the utilization of post-mortem cellular survival[3]. By harnessing the viability of cells from deceased organisms, scientists can create biobots with unique properties and capabilities[4]. This approach offers several advantages, including-

Abundant source of cells: Post-mortem cells provide a readily available and ethical source of biological material for biobot construction[5].

Reduced ethical concerns: Utilizing cells from deceased organisms alleviates concerns related to the ethical implications of using living cells[6].

Potential for novel biomaterials: Post-mortem cells can be engineered to produce novel biomaterials with specific properties, such as enhanced strength, conductivity or biodegradability[7].

Design principles and fabrication techniques

The design and fabrication of biobots involve a multidisciplinary approach, combining principles from biology, engineering and materials science[8].

Key considerations include.

Material selection: The choice of biomaterials is crucial for the successful construction of biobots. Biocompatible materials, such as hydrogels, collagen and extracellular matrix components, are commonly used to provide structural support and a suitable environment for cell growth[9]. Post-mortem tissues can also be utilized as a source of biomaterials[10].

Cell engineering: The selection and engineering of cells are essential for imparting specific functions to biobots[11]. Stem cells, due to their pluripotency, offer a versatile platform for creating biobots with diverse capabilities. Additionally, post-mortem cells can be reprogrammed to acquire specific functions[12].

Assembly and fabrication: Various techniques, such as 3D bioprinting, microfluidics and self-assembly, are employed to assemble biobots into desired shapes and structures[13]. 3D bioprinting allows for the precise spatial arrangement of cells and biomaterials, while self-assembly enables the spontaneous formation of complex structures[14]. Post-mortem cells can be integrated into these fabrication techniques to create functional biobots[15].

Applications of biobots

Apart from military and space exploarion biobots hold immense potential for a wide range of applications, including:

Medicine and healthcare:

Drug Delivery: Biobots can be engineered to deliver drugs directly to target cells, minimizing side effects and maximizing therapeutic efficacy[16].

Tissue engineering: Biobots can be used to create functional tissues and organs for transplantation, addressing the shortage of donor organs[17]. Post-mortem cells can be incorporated into these tissues constructs to enhance their biocompatibility and functionality[18].

Diagnostics: Biobots can be equipped with sensors to detect specific biomarkers, enabling early disease diagnosis[19].

Surgical tools: Biobots can be used as minimally invasive surgical tools, performing intricate procedures with precision and accuracy[20]. Post-mortem cells can be used to create biocompatible surgical tools[21].

Environmental monitoring and remediation:

Biobots can be deployed to monitor environmental pollutants and toxins, providing real-time data on water quality, air pollution and soil contamination with hazardous compounds[22].They can be used to clean up oil spills, degrade toxic substances and remediate contaminated sites[23]. Post-mortem cells can be engineered to degrade specific pollutants or to absorb toxic substances[24].

Materials science: Biobots can be used to create novel materials with unique properties, such as self-healing materials and smart materials[25]. Post-mortem cells can be incorporated into these materials to enhance their biocompatibility and functionality[26]. They can be employed in the development of advanced sensors and actuators[27].

Challenges and future directions

While the potential of biobots is immense, several challenges must be addressed to realize their full potential[28-33].

Power supply: Developing efficient and sustainable power sources for biobots is a major challenge[34].

Control and communication: Developing precise control mechanisms to direct the behavior of biobots and enabling communication between them and other biorobots is essential[35].

Biocompatibility and biodegradation: Ensuring the biocompatibility and biodegradability of biobots is crucial to avoid adverse effects and environmental impact[36].

Ethical considerations: Addressing ethical concerns related to the creation and use of living machines is essential. Future research directions include-

Advanced materials: Developing novel biomaterials with enhanced properties, such as improved mechanical strength, electrical conductivity and biodegradability.

Synthetic biology: Engineering cells with specific functions, such as drug delivery, sensing and actuation.

Artificial Intelligence (AI) and Machine Learning (ML): Integrating AI and ML techniques to enable autonomous decision-making and adaptive behavior in biobots.

Ethical guidelines and regulations: Developing a robust ethical framework to govern the development and use of biobots.

CONCLUSIONS

The emergence of biobots signifies a paradigm shift in biomedical engineering, offering unprecedented opportunities to address complex health challenges. By integrating post-mortem cellular survival, researchers can unlock novel avenues for biobot development, expanding their potential applications. However, significant challenges, such as ethical considerations, long-term biocompatibility and precise control mechanisms, must be addressed to fully realize the transformative potential of biobots. Future research should focus on developing advanced biomaterials, reliable control systems and rigorous ethical frameworks to ensure the safe and effective deployment of these living machines. Ultimately, the successful integration of biobots into clinical practice, pharmaceutical/biopharmaceutical and environmental applications could revolutionize healthcare, sustainability and the understanding of the interface between biology and technology.

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None to declare.

AUTHOR'S CONTRIBUTIONS

Eissa ME: conceived the idea, writing the manuscript, literature survey, formal analysis, critical review.

DATA AVAILABILITY

Data will be made available on request.

CONFLICT OF INTEREST

None to declare.

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