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Biosensors Preliminary Concepts and Its Principles with Applications in the Engineering Perspective

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ABSTRACT

Biosensor is rapid detection of any infectious disease at the early stages is critical for supporting public health and ensuring effective healthcare outcomes. A timely and accurate diagnosis of a disease is necessary for an effective medical response where is biosensor takes place. The design and development of biosensors have taken a centre stage for researchers or scientists in the recent decade owing to the wide range of biosensor applications, such as health care and disease diagnosis, environmental monitoring, water and food quality monitoring, and drug delivery and lately it shown great potential for use in tissue engineering and regenerative medicine. Biosensors are ideally suited to many diagnostic and real-time detection problems due to their use of biological molecules, tissues, and cells, and their high capacity for precision and accuracy promises to continue this trend. Biosensors will become even more widespread and essential to the industrial, agricultural, scientific, and health care as biotechnology tools advance to allow additional biosensor growth.

Keywords: *biosensor, biosensor historical perspective, biosensor parameters, biosensor application.*

BIOSENSOR IN GENERAL

Rapid detection of any infectious disease at the early stages is critical for supporting public health and ensuring effective healthcare outcomes. A timely and accurate diagnosis of a disease is necessary for an effective medical response where is biosensor takes place**[1]**. So, biosensor is an abbreviation for biological sensor, which is a system made up of a transducer and a biological element such as an enzyme, an antibody, or a nucleic acid. The transducer converts the biological reaction to an electrical signal after the biological part or bio element interacts with the analyte being measured. In the last couple of decades, the intelligent use of new materials, including organic small molecules, inorganic materials, hydrogels, hybrids, or emerging nanomaterials and structures, has resulted in numerous new methods and techniques and enhanced biosensor performance, resulting in increased sensitivities and lower limits-of-detection by several orders of magnitude**[2]**. This themed issue features a series of outstanding recent developments in the novel construction of biosensors and bioelectronics, as well as their diverse uses in healthcare and biomedical diagnosis**[3]**. The question of defining what we can consider as a biosensor is difficult. However, the most known term today is a system consisting of a biological recognition feature connected to or inserted into a transducer.

THE HISTORICAL PERSPECTIVE

An evaluation of biosensor perspective staring from early 80’s to lately 90’s shown in table 1

Table 1: Historical development of biosensor[4]

Year	Development of Biosensor
1980	Peterson demonstrated the first fiber-optic pH sensor for in vivo blood gases
1981	Journal of Medical Engineering & Technology
1982	Fiber-optic biosensor for glucose detection by Schultz
1983	Liedberg et al. observed surface plasmon resonance (SPR) immunosensor
1983	Roederer and Bastiaans developed the first immunosensor based on piezoelectric detection
1983	First mediated amperometric biosensor: ferrocene used with a glucose oxidase for glucose detection
1985	The development and application of FET-based biosensors[5]
1986	A method for evaluating in vivo the functional characteristics of glucose sensors[6]
1987	Electrochemical biosensors
1990	SPR-based biosensor by Pharmacia Biacore
1991	Miniaturized thin-film biosensors using covalently immobilized glucose oxidase[7]
1992	Handheld blood biosensor by i-STAT
1993	Bispecific interaction analysis using biosensor technology.[8]
1994	Sol-gel encapsulation methods for biosensors
1996	Biosensors for chemical and biological agents of defense interest[9]
1998	Dendritic nucleic acid probes for DNA biosensors[10]
1990	Prochiral et al. demonstrated the first nanobiosensor
2000	A highly sensitive and selective catalytic DNA biosensor for lead ions[10]

OVERVIEW OF BIOSENSOR AND ITS IMPORTANCE

Medical biosensors are becoming highly important in medical diagnostics and patient monitoring. Biosensors are ideally suited to many diagnostic and real-time detection problems due to their use of biological molecules, tissues, and cells, and their high capacity for precision and accuracy promises to continue this trend**[3]**. Also, Because of their outstanding results, biosensors have been commonly used in several scientific disciplines. Biosensors can be used in medicine to identify cancers, bacteria, high blood glucose levels in diabetic patients, and other contaminants, among other things**[4]**. However despite the complexity of the biosensor but it always easy the life with its capability to employed in the hardest field such as: developing any use of biosensors in the food industry to maintain consistency and protection, as well as to differentiate between organic and synthetic; in the food industry and the carbonization process to detect precise glucose levels**[11].**

BIOSENSOR TECHNOLOGIES

Significant aspects of biosensors and their use in medical research include early-stage identification of human interleukin causing cardiovascular disease, immediate identification of human papillomavirus, and so on. Biosensor models are mainly used in plant biology to identify missing signals in metabolic processes. Other applications are involved in defense, the clinical sector, and marine applications. Biosensor substances are categorised into three types based on their structures: biocatalytic, bio affinity, and microbe-based**[12]**.

Types of biosensors

Biosensors include enzyme-based, tissue-based, immunosensors, DNA biosensors, thermal, and piezoelectric biosensors.

Applications of biosensors

Table 2: Example of biosensor types and its parameters

No	Type of biosensor	Application	Design parameters
1	Enzyme-based	Food industry	It was factional by evaluating the signal on MATLAB using spatial and temporal methods; glucose and sucrose reflect natural sugars, while saccharin and cyclamate represent chemical sweeteners. [14].
2	Immunosensors, DNA biosensors	Medical industry	It is important to identify end-stage heart failure patients who are at risk of harmful impact during the early stages with transplantation of a left ventricular aided device A novel hafnium oxide-based biosensor was used to detect human interleukin (IL)-10 in its early stages. For early cytokine detection, the interaction of recombinant human IL-10 with corresponding monoclonal antibody is being tested After device implantation[14].
3	tissue-based	Fluorescent biosensors	limited scaffolds attached with one or even more fluorescent probes through a receptor. The receptor recognises a particular target, resulting in the emission of a fluorescent signal that can be easily sensed and measured. Probes gene expression, protein localization, and conformation in fields along with signal transduction, transcription, cell cycle, and apoptosis[3].

Biosensors have been used in a variety of areas, including the food industry, the medical industry, and the marine market, and they offer greater stability and sensitivity as compared to traditional approaches**[13]**. For example, shown in Table 2

BIOSENSOR ENGINEERING PERSPECTIVE

Biosensors have lately shown great potential for use in tissue engineering and regenerative medicine. Tissue engineering and regenerative medicine are both increasingly expanding areas of biomedical engineering that hold real potential for the creation of engineered tissue structures for recovering the missing functions of diseased or injured tissues and organs**[15]**.

As an example, for the applications, we got:

- Detection of Small Molecules
- Detection of Functional Protein Molecules
- Detection of Other Analytes.

And as shown in the previous applications are about detection methods where is the importance of the engineer comes to make it work starting from the receptor to the analysis with all the process in between how it engineers However, improvement has been sluggish. Even though numerous optical, electrochemical, magnetic, acoustic, thermometric, and piezoelectric sensors. The electrochemical and optical applications have been the most competitive among the min Tissue engineering technologies have been the most successful, when thermometric technologies seem to be the least effective, and magnetic transductions have had little practical effects **[15]**.

DESIGN CONSIDERATION

The strength of biosensors to identify substances quickly and reliably Because of their ability to detect a wide range of molecules, they are especially useful in a variety of industrial, science, and medical applications**[16]**. Nucleic acids, proteins, and transcription factors are among the main biosensor groups. At their most basic, biosensors interface with a target ligand, undergo some form of change and output a signal. As an example, for protein detection

What it is?

It's electrochemical for protein biomarkers in biological samples.

Why it used?

It is appealing to increase the sensitivity, efficiency, and repeatability of the existing biochemical assays for protein investigation. The electrochemical biosensor instrumentation is divided into four functional blocks: signal processing, readout circuit, potentiate, and signal generator which significantly influences the sensitivity of the overall measurement.

How it used?

It functions by regulating the potential difference between the reference electrode (RE) and the working electrode (WE)**[17]**. Additionally, a potentiate also measures the flow of current between WE and an auxiliary electrode, usually referred to as a counter electrode (CE). Based on the functions, this analysis grouped potentiates into three main groups (potentiometric, impedimetric, and voltametric) and stated their measurement characteristics.Overall, this analysis outlines the design requirements for potentiates and how technology is progressing toward developing compact, programmable, highly sensitive, miniaturized potentiates., and real-time potentiates, opening the possibility of POC testing without going to the laboratory**[17]**.

CONCLUSION

Biosensors are an enabling technology as well as a cutting-edge application in the field of biotechnology. Based on DNA processing, biological system modelling, modularity of components, and increased screening performance have all enhanced the diversity and effectiveness of biosensors. There is a large variety of biosensor types that have now been used in a wide range of biomedical application. Although the strengths and disadvantages of various biosensor designs, as well as their suitability for various applications, are highly complicated, some design criteria can be used to direct biosensor production for applications. Biosensors will become even more widespread and essential to the industrial, agricultural, scientific, and health care as biotechnology tools advance to allow additional biosensor growth. Biosensors are used in the different applications such as to increase surface plasmon resonance in the sensing devices **[18]**, likewise in the process of increasing the seeding time **[19]** and also in migratory phenotype**[20]**.

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