**Basic Concepts of Biosensor and Its Applications**

**Book series ID: IIPV3EBS16\_G3**

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**ABSTRACT**

The tools that collect biological signals and transform them into measurable electrical signals are known as biosensors. In order to detect and observe specific biological analytes, such as the interaction between antibodies and antigens, it requires the integration of biological entities like DNA, RNA, and proteins/enzymes to electrochemical transducers. It consists of five parts. We provide a comprehensive review of biosensors and biosensing technologies, as well as major advancements in the field and examples of the variety of biomolecular sensing techniques. The usage of biosensors has demonstrated better results and success in medical labs, food bioanalysis, microbial detection, the environment, etc. Biosensors can be used for the detection of a wide range of biological analytes.

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**Introduction**

A biosensor is an analytical device that recognizes biological or chemical reactions by generating signals proportional to the concentration of an analyte in the reaction. Biosensors are utilized for tasks like disease surveillance, drug development, and the detection of pollutants, disease-causing microorganisms, and disease-markers in human fluids (blood, urine, saliva, and sweat) [1]. Theoretically, biosensors are instruments with receptor-transducer architectures that could be employed for interpreting the biophysical or biochemical properties of the medium. A biological/organic recognition aspect, which enables the identification of specific biological components in the medium, is an intriguing characteristic that sets these sensors apart from others [2].

**Biosensor system and its** **components:**

A biosensor typically consists of an enzyme, antibody, cell, nucleic acid, or aptamer as the bio-receptor, a semi-conducting material or nanomaterial as the transducer, and an electronic system that includes a signal amplifier, processor, and display.[3] In CMOS-based microsensor systems, for instance, electronics and transducers can collaborate [4].[5]. Frequently referred to as a "bioreceptor," the recognition component interacts with the target analyte using biomolecules or receptors produced from biological systems. This interaction is measured by the biotransducer, which generates a detectable signal proportional to the concentration of the target analyte in the sample. The primary objective of a biosensor's design is to deliver rapid, practical testing at the facility of care or concern where the sample was collected [6, 7, 8].

Typical biosensors include the following components.

Analyte: a material of concern that needs to be found. For instance, a biosensor created to detect glucose uses glucose as a "analyte" in its analysis.

Bioreceptor: A bioreceptor is a molecule that recognises the analyte in a particular way. A few examples of bioreceptors are cells, enzymes, DNA, aptamers and antibodies. The process of producing a signal (in the form of light, heat, pH, charge or mass shift, etc.) in response to the bioreceptor coming into contact with the analyte is known as bio-recognition.

Transducer: One type of energy is changed into another via a component referred to as a transducer. In a biosensor, the transducer's job is to convert a bio-recognition event into a quantifiable signal. Signalization is the term for this energy conversion process. Most transducers provide optical or electrical signals.

Electronic: The electronics component of the biosensor prepares the transduced signal for display by processing it. It consists of complex electrical circuitry that performs signal conditioning functions like signal amplification and analog-to-digital conversion. The processed signals are then quantified by the biosensor's display device.

Display: Like a computer's liquid crystal display or a direct printer, the display is made up of a user interpretation system that gives the user readable figures or curves. This element often comprises of a hardware-software setup that generates understandable biosensor results. The output signal can be numerical, visual, tabular, or even an image depending on the display's requirements [1].

**Components of biosensor**

 **Analyte Bioreceptor** **Transducer**  **Electronics** **Display**

**Characteristics of a biosensor:**

Every biosensor possesses a certain set of static and dynamic properties. The performance of the biosensor is affected by the optimization of these features.

Selectivity:

Selectivity may be the most important feature of a biosensor. A bioreceptor's selectivity refers to its capacity to identify a particular analyte in a sample that contains various admixtures and pollutants. The interaction of an antigen and an antibody is the best illustration of selectivity. Antibodies often serve as bioreceptors and are immobilized on the transducer's surface. The antigen is then exposed to a solution (often a buffer including salts), which is exposed to the transducer, where antibodies only interact with the antigens. Selectivity is the primary factor to be taken into account when selecting bioreceptors to build a biosensor.

Reproducibility:

The biosensor's reproducibility refers to its capacity to produce the same results under identical testing conditions. The transducer and electronics in a biosensor are precise and accurate, which defines reproducibility. When a sample is tested more than once, accuracy refers to the sensor's capability to offer a mean value that is close to the true value while precision refers to the sensor's ability to produce identical findings every time. Reliable and robust inferences about a biosensor's reaction are made possible by reproducible signals.

Stability:

The biosensing system's stability refers to how susceptible it is to environmental disturbances inside and outside of it. A biosensor under measurement may experience a drift in its output signals as a result of these disruptions. This could skew the concentration being measured and compromise the biosensor's precision and accuracy. In applications where a biosensor needs lengthy incubation periods or ongoing monitoring, stability is the most important component. The reaction of electronics and transducers may be temperature-sensitive, which could affect a biosensor's stability. The sensor must be properly tuned in order to produce a consistent response. Stability may also be influenced by the bioreceptor's affinity and the degree to which the analyte binds to it. High affinity bioreceptors promote the analyte's covalent or strong electrostatic connection, which strengthens a biosensor's stability. The deterioration of the bioreceptor over time is another element that influences how stable a measurement is.

Sensitivity:

The limit of detection (LOD) or sensitivity of a biosensor is the lowest concentration of analyte that it can detect. A biosensor is necessary in a number of medical and environmental monitoring applications to confirm the existence of traces of analytes in a sample at analyte concentrations as low as ng/ml or even fg/ml. For instance, doctors advise biopsy procedures for prostate cancer when blood levels of the prostate-specific antigen (PSA) are 4 ng/ml or above. As a result, sensitivity is thought to be a key characteristic of a biosensor.

Linearity:

In a mathematical equation, y=mc, where c is the analyte concentration, y is the output signal, and m is the sensitivity of the biosensor, linearity is the property that demonstrates the accuracy of the measured response to a straight line for a set of measurements with various analyte concentrations. Resolution of the biosensor and the range of analyte concentrations under test can both affect the biosensor's linearity. The smallest change in an analyte's concentration necessary to cause a change in the biosensor's response is known as the resolution of the biosensor. A good resolution may be needed depending on the application, as the majority of biosensor applications need not only analyte detection but also monitoring of analyte concentrations over a broad operating range. The range of analyte concentrations for which the biosensor response alters linearly with the concentration is referred to as the term "linear range," which is also related to linearity [1].

**Classification of biosensors**

According to the sort of biotransducer they use, biosensors can be categorised using a variety of methods [9,10].

a) Biosensors can be categorized into classes such as electrochemical, mass dependent, optical, radiation sensitive, and more [11] depending on the transduction principle that is being used.

b) If bioelement is taken into account as the foundation of classification, then the numerous sets of biosensors that might be acquired include enzyme, nucleic acid, proteins, saccharides, oligonucleotides, ligands, etc [12].

c) Classes of DNA, glucose, toxins, mycotoxins, medicines, or enzyme-based biosensors could be developed depending on the type of detected analyte [13].

**Applications of biosensors**

Biosensors can be applied to improve quality of life in a variety of ways. Their use for a range of objectives, including as environmental monitoring, disease detection, food safety, defence, and drug research, falls under this category. One of the main applications of biosensors is the detection of biomolecules that are either disease markers or drug targets.

Electrochemical biosensing approaches, for example, can be used to produce clinical instruments for the detection of protein cancer biomarkers [14–16], glucose monitoring in diabetic patients, and other health-related targets [17,18,19].

**Applications in tissue engineering**

Biosensors are crucial to the viability of many tissue engineering applications, including the production of "organ specific onchips" and preserving the 3-D integrity and configuration of cell cultures, where the fate of tissues and cells is directly correlated with the presence of small biomolecules (such as adenosine, glucose, hydrogen peroxides, etc.) [20].

**Applications in food industry**

Identifying drug residues in food, including antibiotics and growth stimulants, with a focus on meat and honey. Salmonella, E. coli strain 0157:H7, Listeria monocytogenes, campylobacter, and E. coli are some of the bacteria that frequently cause food to degrade and pose health risks. These bacteria are frequent issues for the food industry because they decrease consumer demand for food if the food supplied by the company becomes contaminated with these biological agents that cause food to degrade [21]. In addition to bacteria, fungus are another prevalent source of food spoilage and serious health issues that, in many instances, can be fatal. Common fungal species that contaminate food include Botrytis sp., Aspergillus, Colletotrichum, and many others. Fungal toxins can also be identified utilizing optical Surface Plasmon Resonance (SPR) biosensors because of their amazing selectivity, decreased prices, and simplicity and speed of monitoring through biosensors [22,23,24,25].

**Environmental applications of biosensors**

Applications in the environment include the detection of pesticides, the detection and identification of organophosphates, and the identification of pollutants in river water, such as heavy metal ions [26].

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