**Basic Concepts of Biosensor and Its Applications**

**Book series ID: IIPV3EBS16\_G3**

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**ABSTRACT**

Biosensors are devices that acquire impulses from the body and convert them into quantifiable electrical signals. It needs the integration of biological entities like DNA, RNA, and proteins/enzymes to electrochemical transducers in order to detect and observe specific biological analytes, such as the interaction between antibodies and antigens. There are five sections to it. We give a thorough overview of biosensors and biosensing technologies, as well as information on significant developments in the area and illustrations of the various biomolecular sensing methods. The use of biosensors has produced better outcomes and success in a variety of settings, including microbial detection, the environment, food bioanalysis, and medical labs. A variety of biological analytes can be detected with biosensors.

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**Introduction**

An analytical tool known as a biosensor produces signals proportional to the concentration of an analyte in the reaction in order to detect biochemical responses. Biosensors are utilized for tasks like disease surveillance, drug development, and the detection of pollutants, disease-causing microorganisms, and disease-markers in human fluids (saliva, blood, sweat, urine) [1]. Biosensors are devices having receptor-transducer designs that could be used to read the biophysical or biochemical characteristics of the medium, according to theory. A biological/organic recognition aspect, which permits 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 characteristically be made up of an antibody, enzyme, nucleic acid, cell, 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 the location of sample collection [6, 7, 8].

Typical biosensors include the following components.

Analyte: A risky substance that must be located. For example, glucose is used as a "analyte" in the analysis of a biosensor designed to detect glucose.

Bioreceptor: A molecule known as a bioreceptor is one that recognizes the analyte in a certain manner. 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 form of energy is changed into a different via a component referred to as a transducer. In a biosensor, the transducer's job is to convert a bio-recognition experience into a calculable signal. Signalization is the duration for this energy transformation progression. Maximum transducers provide electrical or optical signals.

Electronic: The electronics component of the biosensor prepares the transduced signal for display by processing it. It is made up of intricate electrical circuitry that amplifies signals and converts analog signals into digital signals, among other signal conditioning tasks. The biosensor's display gadget then quantifies the signals that have been processed.

Display: An operator interpretation system gives the worker understandable figures or curves, similar to a computer's liquid crystal display or a direct printer. This element often comprises of a hardware-software setup that generates understandable biosensor results. The output signal can be numerical, visual, horizontal, or even an image liable on the display's necessities [1].

**Components of biosensor**

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

**Characteristics of a biosensor:**

Each biosensor has a unique set of static and dynamic characteristics. The optimisation of these features has an impact on the biosensor's functionality.

Selectivity:

Selectivity may be the greatest important feature of a biosensor. The ability of a bioreceptor to recognize a specific analyte in a sample that contains different admixtures and contaminants is referred to as selectivity. The best example of selectivity is the relationship between an antigen and an antibody. On the surface of the transducer, antibodies are frequently immobilized and used as bioreceptors. The next step is exposing the antigen to a solution (typically a buffer such as salts), which is then exposed to the transducer, where antibodies only bind with the antigens. When choosing bioreceptors to construct a biosensor, selectivity is the main consideration.

Reproducibility:

The ability of the biosensor to give the same results under the same testing circumstances is referred to as reproducibility. Reproducibility is defined by the transducer and electronics of a biosensor, which are precise and accurate. When a sample is tested more than once, precision refers to the sensor's ability to consistently return the identical results, whereas accuracy refers to the sensor's ability to provide a mean value that is close to the true value. Reliable and robust inferences about a biosensor's reaction are made possible by reproducible signals.

Stability:

The stability of the biosensing system describes how vulnerable it is to environmental perturbations both inside and outside of it. These interruptions may cause the output signals of a biosensor that is being measured to drift. This can distort the concentration being measured and jeopardize the precision and accuracy of the biosensor. Stability is the most crucial factor in applications where a biosensor needs extended incubation times or continuous monitoring. The stability of a biosensor might be impacted by the response of electronics and transducers, which may be temperature-sensitive. The sensor must be properly tuned in order to produce a consistent response. The degree to which the analyte binds to the bioreceptor and its affinity may also have an impact on stability. The stability of a biosensor is increased by high affinity bioreceptors, which encourage the analyte's covalent or robust electrostatic interaction. Another factor that affects how steady a measurement is the ageing of the bioreceptor over time.

Sensitivity:

The lowest concentration of analyte that a biosensor can detect is known as its sensitivity or limit of detection (LOD). In many medical and environmental monitoring applications, a biosensor is required to verify the presence of analyte traces in a sample at analyte concentrations as low as ng/ml or even fg/ml. In particular, when circulating blood levels of the prostate-specific antigen (PSA) are 4 ng/ml or higher, doctors prescribe prostate cancer biopsy procedures. Sensitivity is therefore considered to be a crucial aspect of a biosensor.

Linearity:

Linearity is a property that shows the accuracy of the measured response to a straight line for a set of measurements with various analyte concentrations in the mathematical equation y=mc, where c is the analyte concentration, y is the output signal, and m is the sensitivity of the biosensor. The linearity of the biosensor can be impacted by equally the biosensor's resolution and the range of analyte concentrations being tested. The slightest alteration in an analyte's concentration necessary to cause a variation 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 required not only analyte recognition but also monitoring of analyte concentrations over a broad operating range. The array 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 categorized by means of a variety of methods [9,10].

a) Biosensors can be categorized into classes such as mass dependent, electrochemical, radiation sensitive, optical, 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 nucleic acid, enzyme, saccharides, proteins, ligands, oligonucleotides, etc [12].

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

**Applications of biosensors**

Biosensors can be applied to improve quality of life in a variety of ways. This includes using them for a variety of purposes, such as disease detection, environmental monitoring, defence, food safety, and drug development. One of the foremost applications of biosensors is the recognition of biomolecules that are either disease markers or drug targets.

Electrochemical biosensing approaches, for instance, 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 linked with the presence of small biomolecules (such as glucose, adenosine, hydrogen peroxides, etc.) [20].

**Applications in food sector**

Identifying drug residues in food, including antibiotics and growth stimulants, with a focus on meat and honey. Salmonella, Listeria monocytogenes, campylobacter, E. coli strain 0157:H7 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 establishment becomes polluted 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 exposure and identification of organophosphates, and the identification of contaminants in river water, such as heavy metal ions [26].

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