BIOSENSORS

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Abstract:

Biosensors are one of the most important inventions in engineering history, and biosensors are one of them. Biosensors have been under development for over 35 years, becoming more prominent in the last 15 years. Silicon Nanowires, for example, has paved the way for a flood of new signal transduction methods in biosensors, illustrating the field's advancement. Recently, NASA has been developing better physiologic sensor and biotelemetry system technologies, to continuously assess basic physiological indicators in unrestrained space beings, such as heart rate, blood pH, and body temperature, which is a challenging problem to solve. Approximately 20 to 25 years ago, biosensors were one of the mysterious topics in engineering as they connected two different fields (electronic and biology). But now, from the detection of Covid-19 in medical science to the detection of microorganisms in space technology, biosensors are used on a large scale and have become the most popular choice for manufacturers. In this review, we will encounter every prospect, application, and type of biosensor.[(1)]

Key words: 1.Biosensors Introduction, 2.Elements of Biosensors, 3.Types of Biosensors, 4.Characteristics of Biosensors, 5.Application of Biosensors.

1.Introduction:

The history of biosensors started in the year 1962 with the development of enzyme electrodes by the scientist Leland C. Clark. Since then, research communities from various fields such as VLSI, Physics, Chemistry, and Material Science have come together to develop more sophisticated, reliable and mature biosensing devices for applications in the fields of medicine, agriculture, biotechnology, as well as the military and bioterrorism detection and prevention.

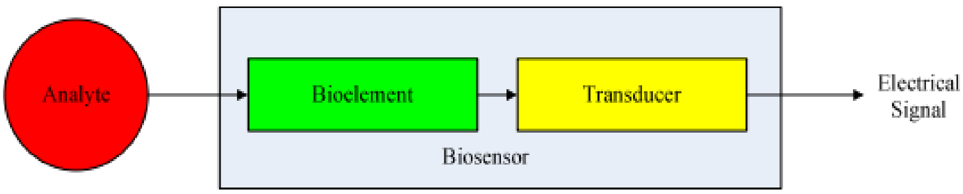

Fig 1: A Schematic Representation of Biosensors

Working:

If you observe a device, you will notice that a biosensor are composed of three main parts:

- Recognition of analyte.
- Converting collected data to signal.
- Reading the signal.[(2)]

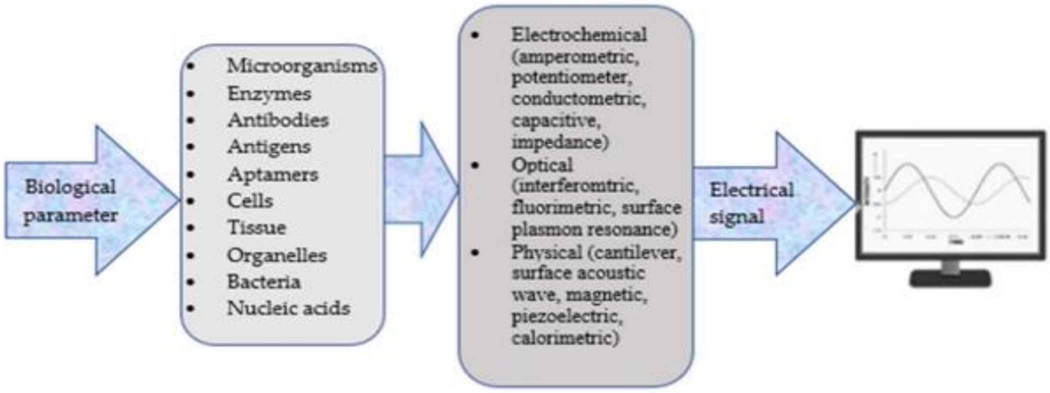

Fig. 2: Illustration of principal components of a biological sensor device: (1) bioreceptor–detector layer of immobilized biomaterial; (2) physicochemical transducer, (3) signal-conditioning and recording the signal for human interpretation.

2.Elements of Biosensors:

The important components of a biosensor are:

(1) A Bioreceptor (e.g., enzymes, antibody, microorganism, or cells).

(2) A Transducer of the physicochemical signal.

(3) A Signal processor to interpret the information that has been converted.

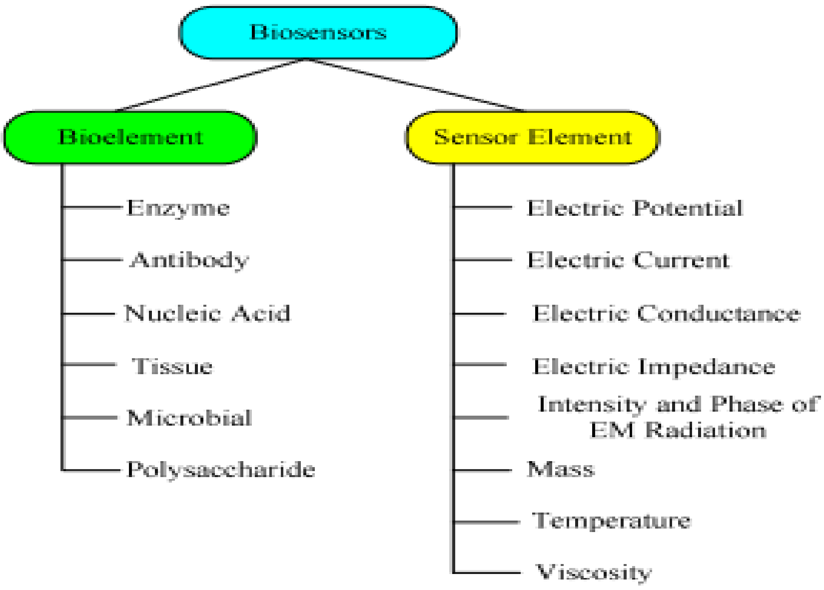

Fig. 3: Elements of Biosensors

3.Types of Biosensors:

- Electrochemical Biosensors
  - Conductimetric Biosensor
  - Amperometric Biosensor
  - Potentiometric Biosensor
- Thermometric Biosensors
- Optical Biosensors

- Piezoelectric sensors
- Whole-Cell Biosensors
- Immuno-Biosensors
- Resonant Biosensors
- Ion-Sensitive Biosensor

3.1 Electrochemical Biosensors: Many electrochemical biosensors have been created and presented in recent years for the identification of multiple medical conditions based on specific indicators, utilizing their properties which were discussed in the previous section.

3.2 Amperometric Biosensor: As we have previously discussed the invention of "CLARK ELECTRODE'', in 1962 (nearly ten years later) he used the same glucose oxidized enzyme and reversed its polarity of the electrode to create the first Amperometric Biosensor.

3.3Potentiometric Biosensor: Potentiometric biosensor in simple terms converts mechanical displacement into voltage difference.

3.4 Conductive Biosensor: When a constant potential is supplied between a reference electrode and a polymer modified electrode, a change in electrical conductivity or resistivity is detected against the analyte concentration in conductometric conducting polymer-based biosensors.

3.5Thermometric Biosensors: Thermal sensors and calorimetric biosensors are other names for these biosensors.

3.6 Optical Biosensor: The optical biosensor works on the premise of light output during a reaction or light absorbed by the difference in reactant and product concentration. Let's have a look at an optical biosensor as an example

3.7Piezoelectric sensors: Because they function with the idea of sound, piezoelectric biosensors are also known as acoustic sensors. Positive and negative charge crystals have a certain frequency of vibration. Electronic equipment can detect the resonance frequency. There are certain disadvantages to using a piezoelectric sensor. [(3)]

3.8 Ion-Sensitive Biosensors: These are semiconductor FETs having an ion-sensitive surface. The surface electrical potential changes when the ions and the semiconductor interact. This change in the potential can be subsequently measured. The Ion Sensitive Field Effect Transistor (ISFET) can be constructed by covering the sensor electrode with a polymer layer. This polymer layer is selectively permeable to 4 analyte ions.

4.Characteristics of Biosensors:

4.1 Sensitivity: Sensitivity is the most important characteristic of a sensor. It is the detection limit, which is the minimal amount (or concentration) of analyte that can be detected.

4.2 Selectivity: Selectivity means that the sensor detects a certain analyte and does not react with added mixtures and contaminants

4.3 Stability: The stability of a sensor refers to the signal drifting under constant conditions, which could cause errors.[(4)]

4.4 Reproducibility: Due to the delicate conditions under which biosensing is required, it is necessary that a biosensor produces consistent output results, under the same or similar conditions, using the same analyte.

4.5 Response Time: A biosensor’s response time is the amount of time it takes to read and produce a signal after its bioreceptor meets the specific analyte. For example, glucose oxidase–based sensors have a response time between 5 and 30 s.

4.6 Range of Linearity: The linearity of a biosensor is its ability to exhibit variation in its output proportional to different analyte concentrations. [(5)]

5.Applications of Biosensors:

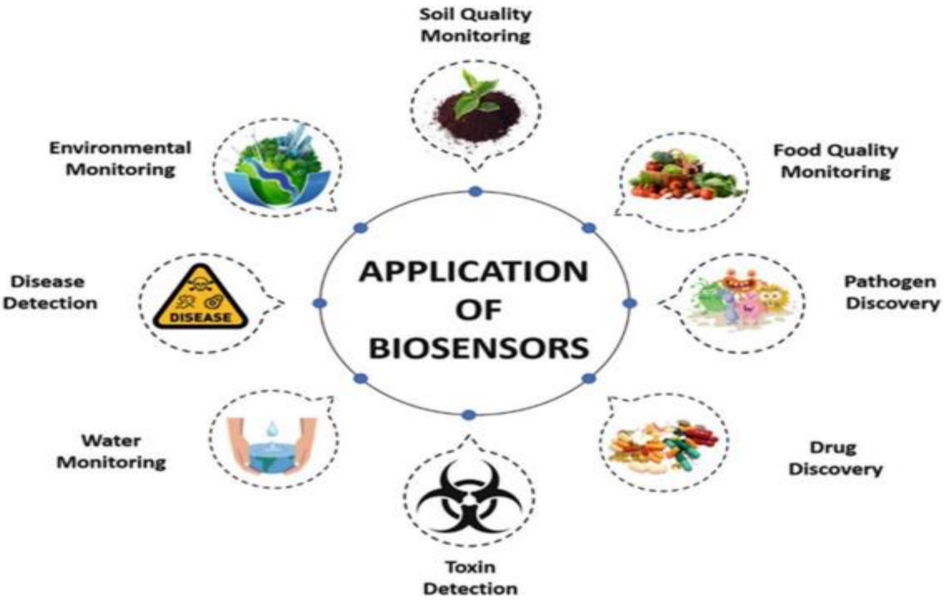

Fig:4 Different applications of biosensors

5.1 Environmental Science: Our environment has acquired different pollutants as a result of recent industrialization and modernization. Heavy metals, herbicides, complex hydrocarbons, and several other substances are among them. However, numerous biosensors have been developed solely to address environmental issues.

5.2 Heavy metal Detection: As we all know the environment contains both vital and hazardous metals. Toxic heavy metal accumulation in humans may cause a range of major health problems, including damage to the liver, kidneys, brain system, and even our reproductive system. An enzyme can respond to a variety of heavy metals, but it won't be able to respond to all of the heavy metals in the environment.

5.3 Pesticide Detection: We all know the disadvantages of using pesticides as they can be dangerous to human health. If farmers are exposed to pesticides without using any suitable protective equipment, they may develop major long-term health problems such as cancer. (6)

5.4 BOD (Biochemical oxygen demand) biosensors: BOD is the quantity of oxygen required by aerobic living organisms in water to break down organic molecules present in a particular water sample during a specific time and at a certain temperature. The elements utilized to determine BOD are primarily pure cultures of a combination of known microorganisms.

5.5 Medical Science:

Cancer detection: Cancer is the biggest cause of mortality in the world, and its incidence has increased

Wearable Biosensors: In the old days, patients used to have to go to the doctor to discuss their sugar levels, their weight if they had heart failure, or their breathing if they had COPD or asthma.(7)

5.6 Food Technology:

Quality of Food: Food can degrade as a result of digestion in microbial development, and tracking such deviations over time might provide us with an overall estimate of food quality. Biosensors enable smart and responsive packing for food product freshness monitoring, which plays a significant role in food science.

Detection of allergen: Food allergies are becoming a serious public health and food safety problem worldwide. People who are allergic to certain foods have negative reactions. Because it's incurable, the best course of action is to avoid it.

Market Analysis: From 2021 to 2030, the biosensors market is estimated to increase at a CAGR (Compound annual growth rate) of approximately 8%, from USD 25.5 billion in 2021 to USD 36.7 billion. The development of nanotechnology-based biosensors, considerable technological advances in recent years, growing need for biosensors for monitoring glucose levels in diabetes patients, surging demand for portable and easy to use devices in the COVID-19 pandemic, and increasing social programs toward medical therapies are some of the important primary drivers in the biosensors business (Biosensors based on nanotechnology are created of nanoparticles with diameters size less than 100 nanometers.[8]

Conclusion:

Biosensors are becoming increasingly popular as a result of their numerous uses. This technology is progressing at the same rate as demand. According to me, the scientist must concentrate on three major elements to increase the quality of biosensors: specificity, detection limit, and detection time. Biosensors have a bright future ahead of them, with widespread applications in screening tests, food analysis, smart manufacturing, and remote sensing.

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