CHAPTER SEVEN

Biosensors

A biosensor is an analytical device, used for the detection of an analyte, that combines a biological component with a physicochemical detector

or biosensors are analytical devices that convert a biological response into an electrical signal.

It is so as biological entities are very complex and are directly associated with the existence of a healthy environment. The design of biosensors also has witnessed significant changes in the recent past. Biosensors are finding diverse applications and gradually becoming an integral part in a variety of analytical applications such as;

Applications of Biosensors:

- **Drug discovery**
- **Food quality estimation**
- **Environmental monitoring**
- **Disease detection**
- **DNA biosensors**
- **Water quality**
- **Diagnosis of clinical**

For more details about analytical applications of biosensor device, Figure 6.1 indicates different areas of research where biosensors have been used. Nanotechnology has bestowed some highly exciting ingredients for the improvement of sensing phenomenon.

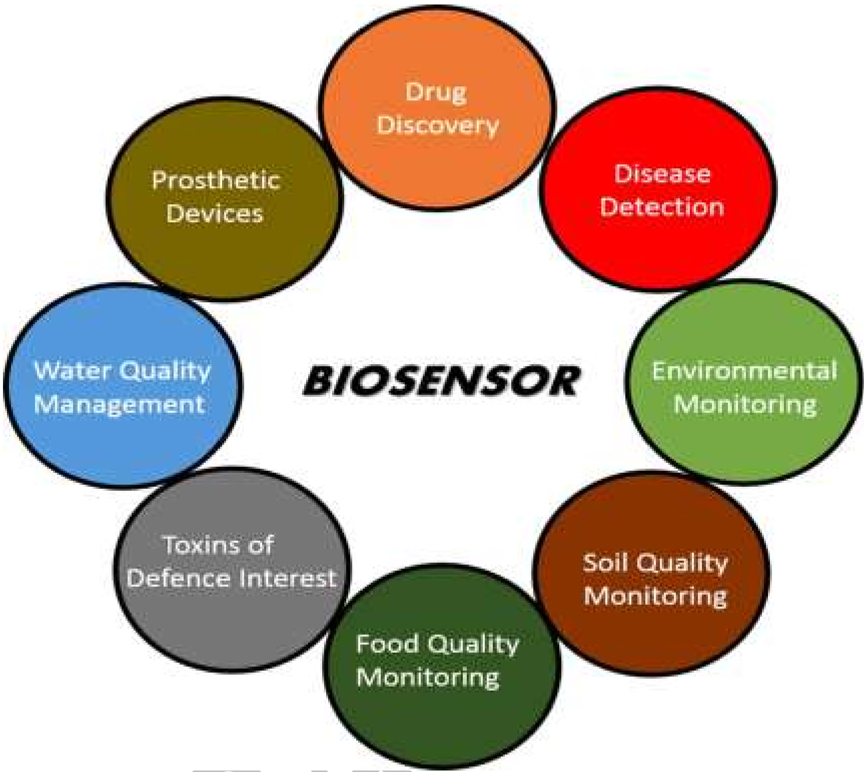


Figure 6.1: Major areas of applications for biosensors.

A typical biosensor is consists of the following components:

1- **<u>Analyte:</u> It is a material of interest that needs detection. For example glucose is an 'analyte' in a biosensor designed to detect glucose**.

2- **<u>Bio-receptor:</u> It is an analytical device, used for the detection of a chemical material (analyte) (such as enzymes, cells, DNA, antibodies, bacterium, and antibodies), that combines a biological component with a physicochemical detector. The process of**

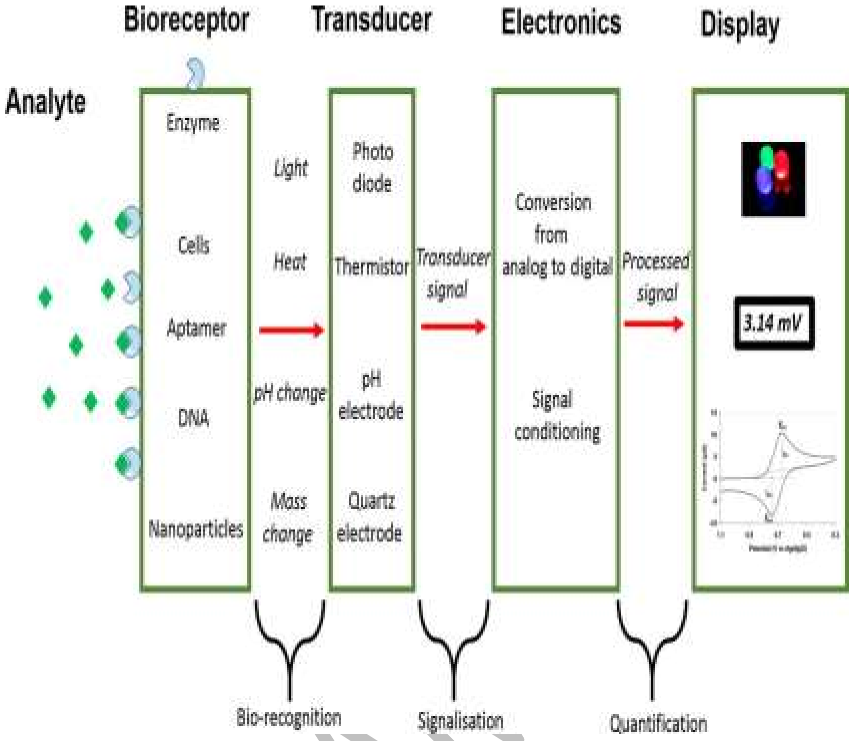
generation of a signal (in the form of light, heat, pH, charge or mass change, etc.) upon interaction of the bio-receptor with the analyte is describe as bio-recognition.

3- **Transducer: The transducer is an element that converts one form of energy into another. In a biosensor the role of the transducer is to convert the bio-recognition event into a measurable signal. Most transducers produce either optical or electrical signals** that are usually proportional to the amount of analyte/bioreceptor interactions.

4- **Electronics: This is the part of a biosensor that processes the transduced signal and prepares it for being displayed**. It consists of complex electronic circuitry that performs signal conditioning such as amplification and conversion of signals from analog to the digital form. The processed signals are then quantified by the display unit of the biosensor.

5- **Display: The display consists of a user interpretation system such as liquid crystal display of a computer or a direct printer that generates numbers or curves understandable by the user.** This part often consists of a combination of hardware and software that generates results of the biosensor in a user friendly manner. The output signal on the display can be numeric, graphic, tabular or an image, depending on the requirements of the end user.

where the bio-reaction converts the substrate to product. This reaction is determined by the transducer, which converts it to an electrical signal. The output from the transducer is amplified to processed and then displayed the results.



Characteristics of a Biosensor

There are certain static and dynamic attributes that every biosensor possesses. The optimisation of these properties is reflected on the performance of the biosensor.

- **Selectivity: Selectivity is the ability of a bio-receptor to detect a specific analyte in a sample** containing other admixtures and contaminants. The best example of selectivity is depicted by the interaction of an antigen with the antibody. Classically, antibodies act as bioreceptors and are immobilised on the surface of the transducer. A solution (usually a buffer containing salts) containing the antigen is then exposed to the transducer where antibodies interact only with the antigens. To construct a biosensor, selectivity is a main consideration that should be taken into account while choosing bioreceptors.

- **Reproducibility: Reproducibility is the ability of the biosensor to generate identical responses for a repeated experimental.** The reproducibility is characterised by precision and accuracy of the transducer and electronics in a biosensor. Precision is the ability of the sensor to provide alike results every time a sample is measured and accuracy indicates the sensor's capacity to provide a mean value close to the true value when a sample is measured more than once. Reproducible signals provide high reliability and robustness to the inference made on the response of a biosensor.
- **Stability: Stability is the degree of the sensitivity to ambient conditions in and around the bio sensing system.** These disturbances can cause a drift in the output signals of a biosensor under measurement. This can cause an error in the measured concentration and can affect the precision and accuracy of the biosensor. Stability is the most crucial feature in applications where a biosensor requires long incubation steps or continuous monitoring. The response of transducers and electronics can be temperature sensitive, which may influence the stability of a biosensor. Therefore appropriate tuning of electronics is required to ensure a stable response of the sensor. Another factor that can influence the stability is the affinity of the bioreceptor. Affinity is the degree to which the analyte binds to the bioreceptor. Bioreceptors with high affinities encourage either strong electrostatic bonding or covalent linkage of the analyte that fortifies the stability of a biosensor. Another factor that affects the stability of a measurement is the degradation of the bioreceptor over a period of time.
- **Sensitivity: The minimum amount of analyte that can be detected by a biosensor defines its limit of detection (LOD) or sensitivity.** In a number of medical and environmental monitoring applications, a biosensor is required to detect analyte concentration of as low as ng/ml or even fg/ml to confirm the present of traces of

analytes in a sample. For instance, prostate specific antigen concentration of 4 ng/ml in blood is associated with prostate cancer for which doctors suggest biopsy tests. Hence sensitivity is considered as an important property of a biosensor.

- **Linearity: It is the attribute that shows accuracy of the measured response (for a set of measurements with different concentrations of analyte) to a straight line, mathematically represented as $y = mc$, where c is the concentration of the analyte, y is the output signal and m is the sensitivity of the biosensor.** Linearity of the biosensor can be associated with the resolution of biosensor and range of the analyte concentrations under test. The resolution of the biosensor is defined as the smallest change in the concentration of an analyte that is required to bring a change in the response of the biosensor. Depending on the application, a good resolution is required as most biosensor applications not only require analyte detection but also to measure concentrations of analyte within a wide working range. Another term associated with linearity is linear range that is defined as the range of analyte concentrations for which the biosensor response changes linearly with the concentration.