

العلوم	الكلية
علوم الحياة	القسم
Biotechnology and genetic engineering	المادة باللغة الانجليزية
التقنيات الاحيائية والهندسة الوراثية	المادة باللغة العربية
الرابعة	المرحلة الدراسية
سعد طه مطلق حميدان بيكات	اسم التدريسي
Biosensors	عنوان المحاضرة باللغة الانجليزية
أجهزة الاستشعار الحيوية	عنوان المحاضرة باللغة العربية
الثالثة	رقم المحاضرة
Jones and Bartlett Publishers, (October 20, 2010) Introduction to Biotechnology and Genetic Engineering, 1st Edition.	المصادر والمراجع
Gao, J. (2012). Tissue culture and rapid multiplication techniques of Apocynum L. Agricultural Science & Technology, 13(11), 2269.	



What are Biosensors?

A **biosensor** is a diagnostic device used to investigate the concentration and presence of a specific substance in a biological sample. It is an analytical device that convert a biological response into an electrical signal. Essentially biosensors must be highly specific, independent of physical parameters such as pH and temperature and should be reusable¹.

Construction of biosensors, its materials, transducing devices, and control methods requires multidisciplinary research in chemistry, biology, and engineering. The materials used in biosensors are categorized into three groups based on their mechanisms: biocatalytic group comprising enzymes, bioaffinity group including antibodies and nucleic acids, and microbe based containing microorganisms.

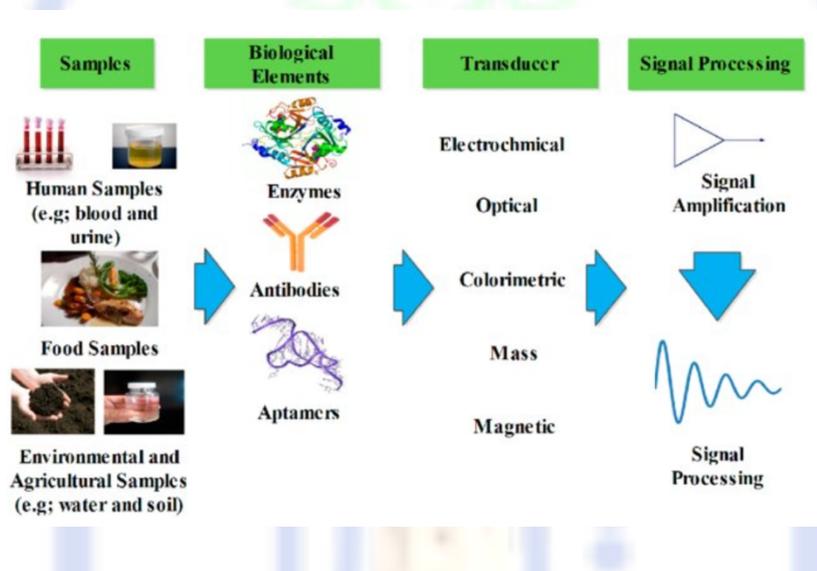


Figure.1 Schematic of different parts of a biosensor including biological recognition elements, transducers, and detectors.

Types of biosensors

Biosensors started in the 1960s by the pioneers **Clark** and **Lyons**. Various types of biosensors being used are enzyme-based, tissue-based, immunosensors, DNA biosensors, and thermal and piezoelectric biosensors.

Enzyme-based biosensors have been devised on restriction methods such a adsorption of enzymes by van der Waals forces, ionic bonding or covalent bonding. The commonly used enzymes for this purpose are oxidoreductases, polyphenol oxidases, peroxidases, and aminooxidases.²

Tissue-based sensors arise from plant and animal sources. The analyte of interest can be an inhibitor or a substrate of these processes. Organelle-based sensors were made using membranes, chloroplasts, mitochondria, and microsomes. However, for

this type of biosensor, the stability was high, but the detection time was longer, and the specificity was reduced.

Immunosensors were established on the fact that antibodies have high similarity towards their respective antigens such as antibodies specifically bind to pathogens or toxins, or interact with components of the host's immune system.

The DNA biosensors were devised on the property that single-strand nucleic acid molecule is able to recognize and bind to its complementary strand in a sample. The interaction is due to the formation of stable hydrogen bonds between the two nucleic acid strands.

Magnetic biosensors: miniaturized biosensors detecting magnetic micro- and nanoparticles in microfluidic channels using the magnetoresistance effect have great potential in terms of sensitivity and size.

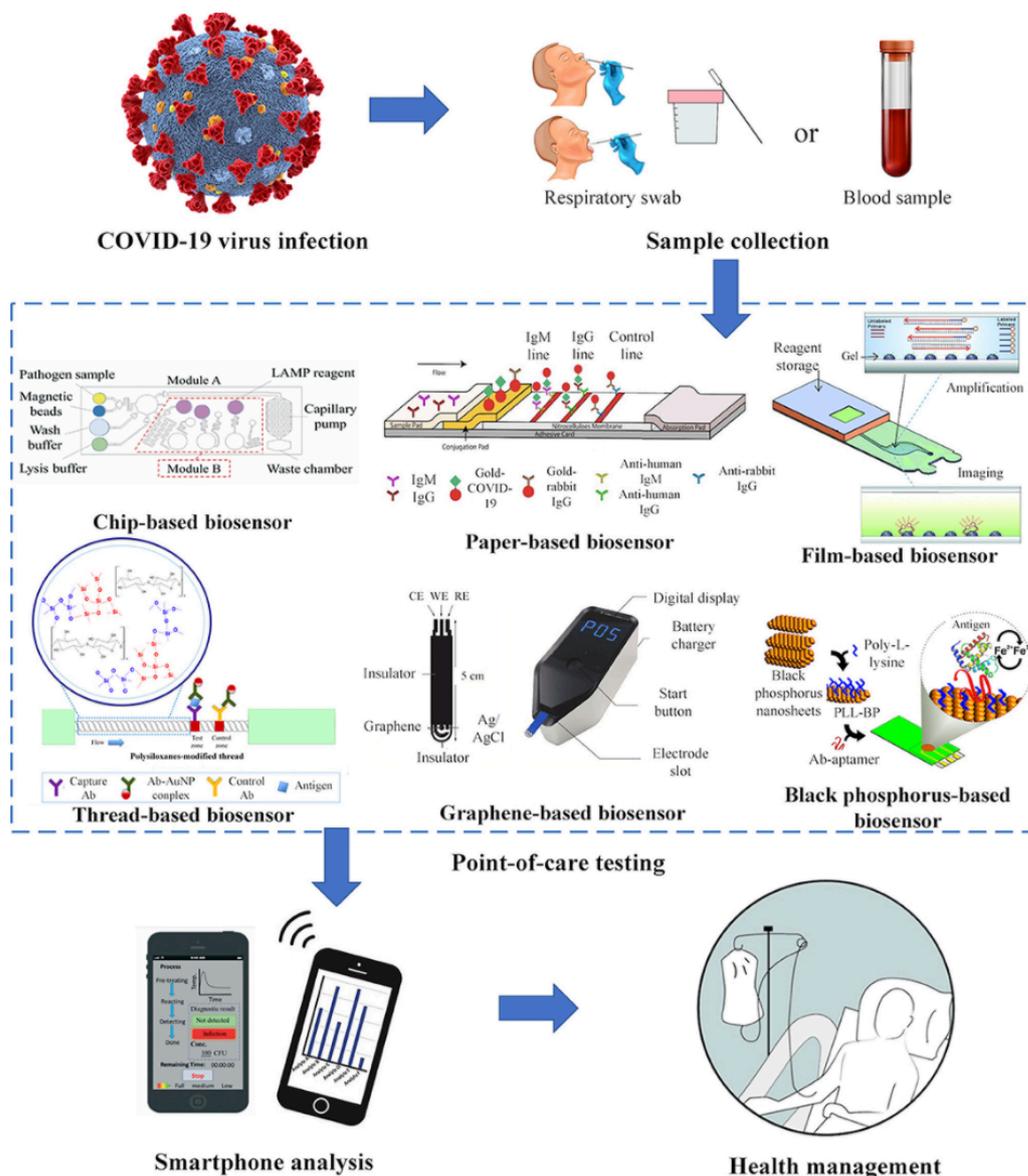
Thermal biosensors or calorimetric biosensors are developed by assimilating biosensor materials as mentioned before into a physical transducer.

Piezoelectric biosensors are of two types: the quartz crystal microbalance and the surface acoustic wave device. They are based on the measurement of changes in resonance frequency of a piezoelectric crystal due to mass changes on the crystal structure.

Optical biosensors consist of a light source, as well as numerous optical components to generate a light beam with specific characteristics and to beeline this light to a modulating agent, a modified sensing head along with a photodetector.³

Green fluorescent protein and the subsequent auto fluorescent protein (AFP) variants and genetic fusion reporters have aided the development of genetically-encoded biosensors⁴. This type of biosensor is user-friendly, easy to engineer, manipulate and transfer into cells. Peptide and protein biosensors are easily manufactured through synthetic chemistry followed by enzymatic labelling with synthetic fluorophores.

UNIVERSITY OF ANBAR



Applications of biosensors:

Biosensors have been applied in many fields namely food industry, medical field, marine sector etc., and they provide better stability and sensitivity as compared with the traditional methods.

1. In food processing, monitoring, food authenticity, quality and safety):

An arduous quandary in food processing industry is of quality and safety, maintenance of food products and processing. The development of biosensors in response to the demand for simple, real-time, selective and inexpensive techniques is seemingly favourable.

Biosensors are used for the detection of pathogens in food in which presence of *Escherichia coli* in vegetables, is a bioindicator of faecal contamination in food⁵.

One of the popular food additives extensively used today are **sweeteners**, which are adversely causing undesirable diseases including dental caries, cardiovascular diseases, obesity and type-2 diabetes.

2. In fermentation processes:

In fermentation industries, process safety and product quality are crucial. Thus effective monitoring of the fermentation process is imperative to develop, optimize and maintain biological reactors at maximum efficacy. Biosensors precisely control the fermentation industry and produce reproducible results due to their simple instrumentation, formidable selectivity, low prices and easy automation. Nowadays, several kinds of commercial biosensors are accessible; capable of detecting biochemical parameters (glucose, lactate, lysine, ethanol etc.) and are widely used in China, occupying about 90% of its market.

3. Biosensing technology for sustainable food safety:

The term food quality refers to the appearance, taste, smell, nutritional value, freshness, flavour, texture and chemicals. Smart monitoring of nutrients and fast screening of biological and chemical contaminants are of paramount importance, when it comes to food quality and safety. Material science, nanotechnology, electromechanical and microfluidic systems are striding in to make sensing technology imminent for use in market. Efforts are being made for developing control systems ensuring food quality and safety and, as a consequence, human health. **Glucose** monitoring becomes indispensable as during storage the food content and composition may get altered⁶.

4. In medical field:

Glucose biosensors are widely used in clinical applications for diagnosis of diabetes mellitus, which requires precise control over blood-glucose levels⁷. Blood-glucose biosensors usage at home accounts for 85% of the gigantic world market⁸.

5. Fluorescent biosensors:

Fluorescent biosensors are imaging agents, for use in cancer and drug discovery. These are small scaffolds onto which one or several fluorescent probes are mounted (enzymatically, chemically or genetically) through a receptor. Fluorescent biosensors are used in drug discovery programmes for early detection of biomarkers in molecular and clinical diagnostics, for monitoring disease progression and response to treatment/therapeutics, for intravital imaging and image guided surgery⁹. A genetically-encoded FRET biosensor developed for detection of Bcr-Abl kinase

activity was used on cancer patient cells to assess Bcr-Abl kinase activity and to establish an interrelation with the disease status in chronic myeloid leukaemia.

6. Biodefense biosensing applications:

Biosensors can be used for military purposes at times of biological attacks. The main motive of such biosensors is to sensitively and selectively identify organisms posing threat in virtually real time called biowarfare agents (BWAs) namely, bacteria (vegetative and spores), toxins and viruses.

7. In metabolic engineering:

Environmental concerns and lack of sustainability of petroleum-derived products are gradually exhorting need for development of microbial cell factories for synthesis of chemicals. They have also envisioned that a substantial fraction of fuels, commodity chemicals and pharmaceuticals will be produced from renewable feedstocks by exploiting microorganisms rather than relying on petroleum refining or extraction from plants.

8. Biosensors in plant biology:

Revolutionary new technologies in the areas of DNA sequencing and molecular imaging, have led to advancements in plant science. However, this information can be easily successfully tapped using biosensors. Roger Tsien's lab was the first to develop protein prototype sensors to measure caspase activity and control levels of calcium in live cells¹⁰. Biosensors can be utilized to identify missing components pertinent to metabolism, regulation, or transport of the analyte.

