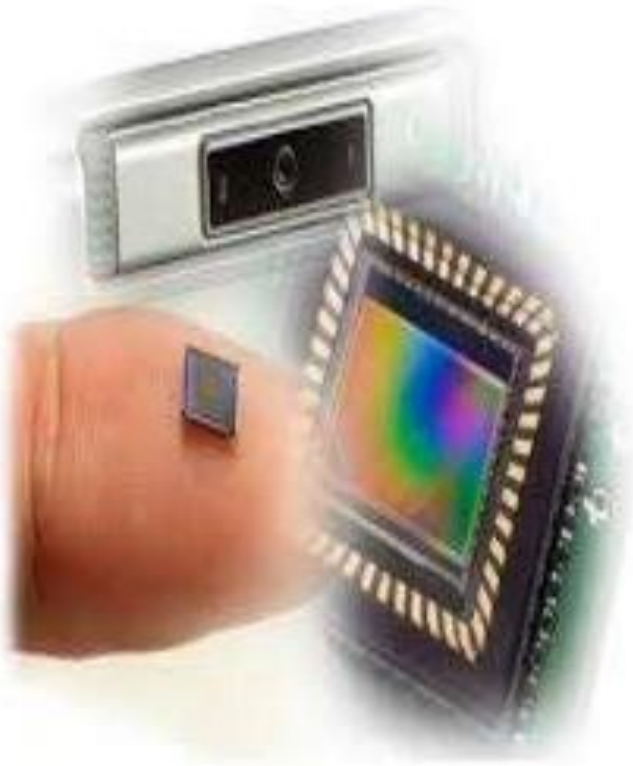
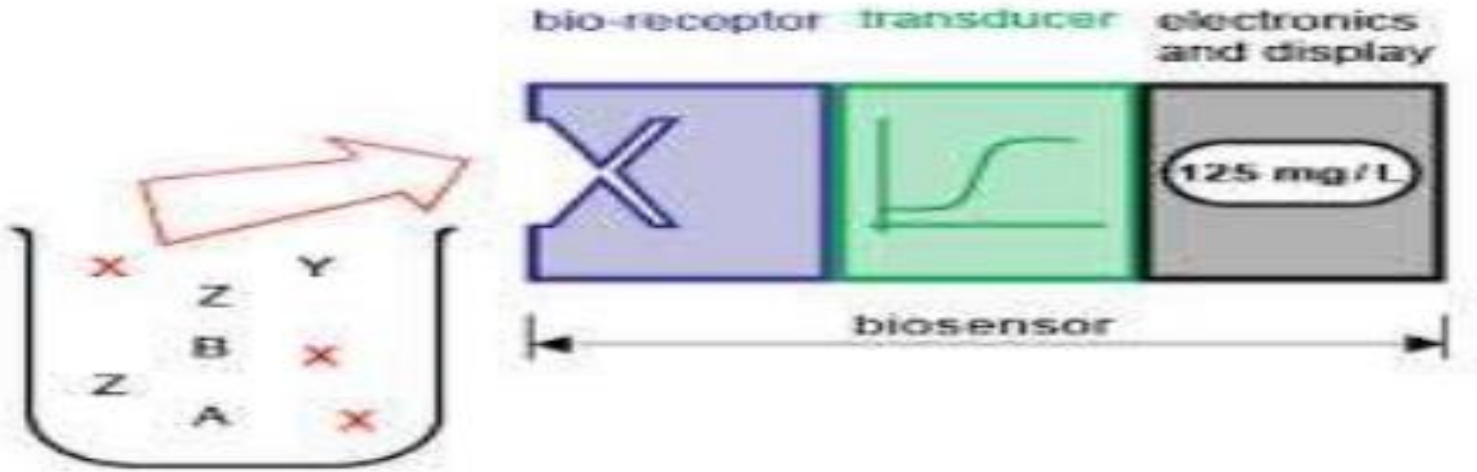
BIOSENSORS

WHAT IS SENSOR...??



A sensor is a converter that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument.

WHAT IS BIO - SENSOR...??



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

BIO - SENSOR...??

Father of the Biosensor

Professor Leland C Clark Jnr
1918–2005

- A device incorporating a biological sensing element either intimately connected to or integrated within a transducer.
- Recognition based on affinity between complementary structures like:
  - enzyme-substrate, antibody-antigen and receptor-hormone complex.
- Selectivity and specificity depend on biological recognition systems connected to a suitable transducer.

BIO - SENSOR...??

- It is an analytical device which converts a biological response into an electrical signal.
- It detects, records, and transmits information regarding a physiological change or process.
- It determines the presence and concentration of a specific substance in any test solution.

BASIC PRINCIPLE OF BIOSENSOR

Basic priciple of biosensor involved in three element :-

- First biological recognization element which highly specific towards the biological material analytes produces.
- Second transducesrs detect and transduces signal from biological target - receptor molecule to electrical signal which is due to reaction occur.
- Third after transduction sinal from biological to electrical signal where its amplification is necessary and takes place and read out in detector after processing the values are displayed for monitor and controlling the system .

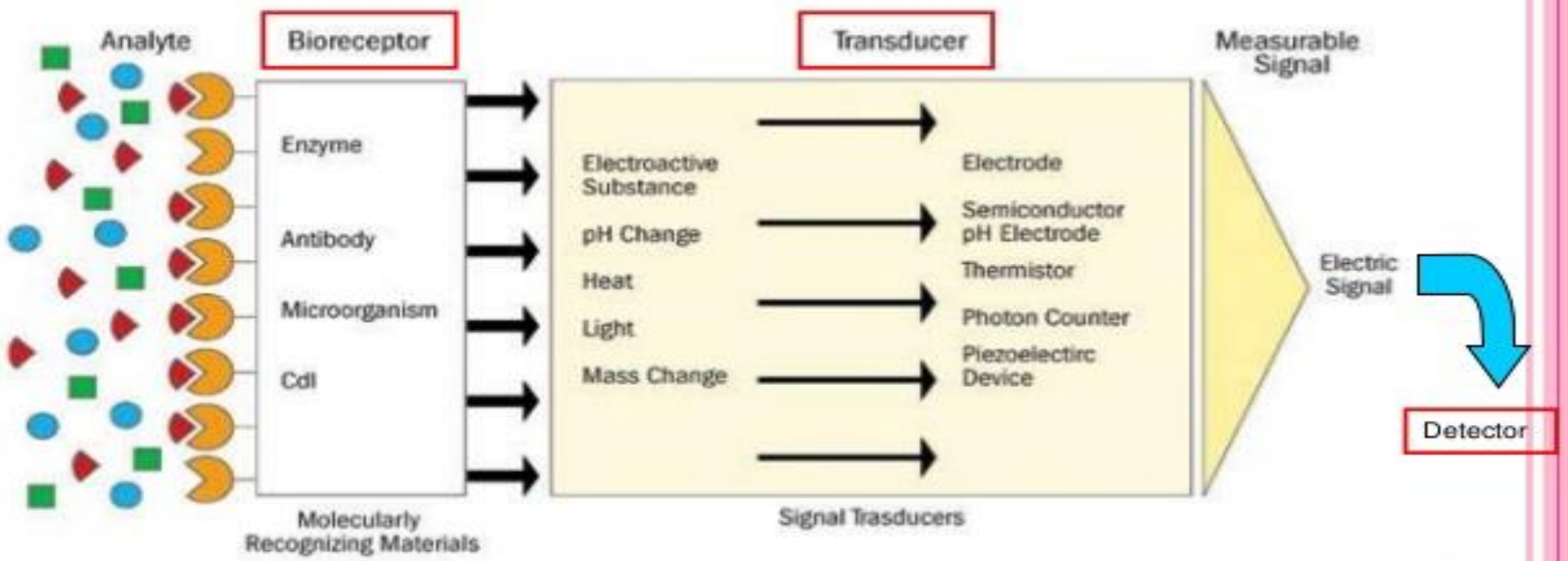
BASIC PRINCIPLE OF BIOSENSOR

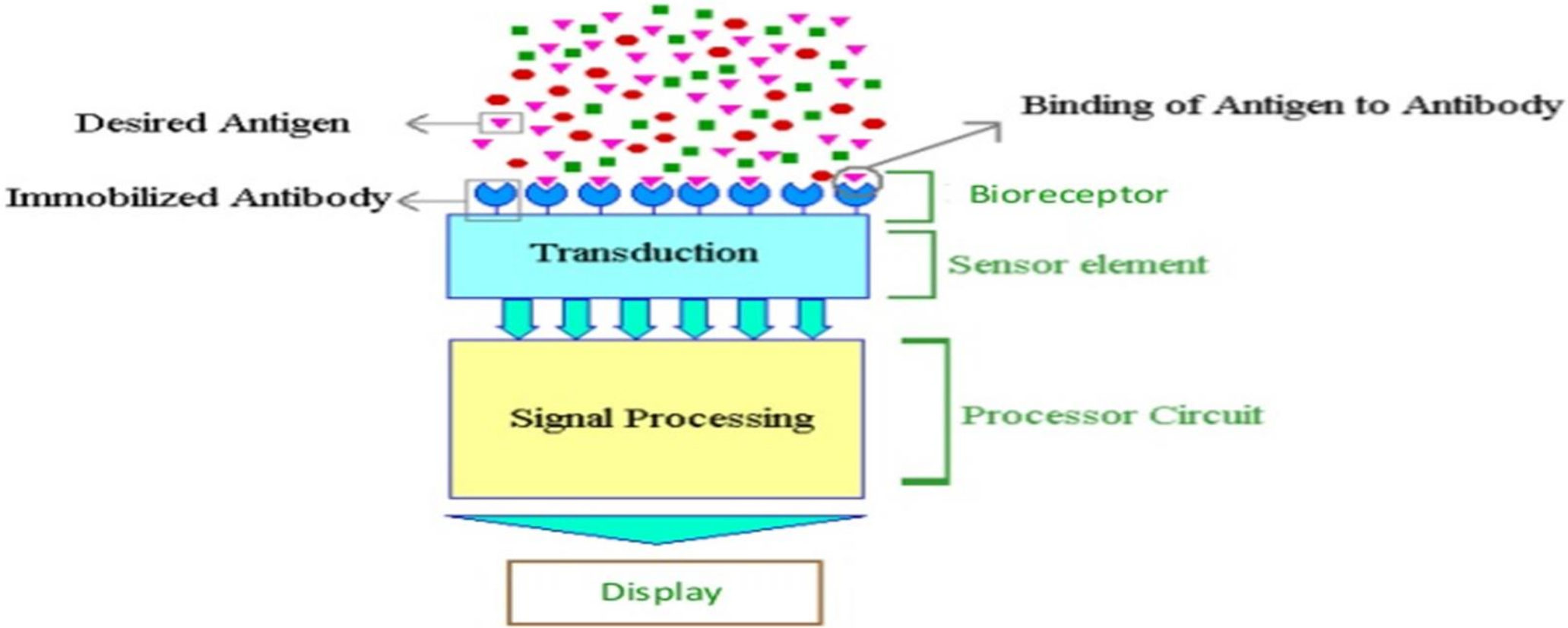
- The biological material is immobilized and a contact is made between the immobilized biological material and the transducer

- The analyte binds to the biological material to form a *bound analyte* which in turn produces the electronic response that can be measured.

- Sometimes the analyte is converted to a product which could be associated with the release of heat, gas (oxygen), electrons or hydrogen ions. The transducer then converts the product linked changes into electrical signals which can be amplified and measured

COMPONENTS OF BIOSENSOR





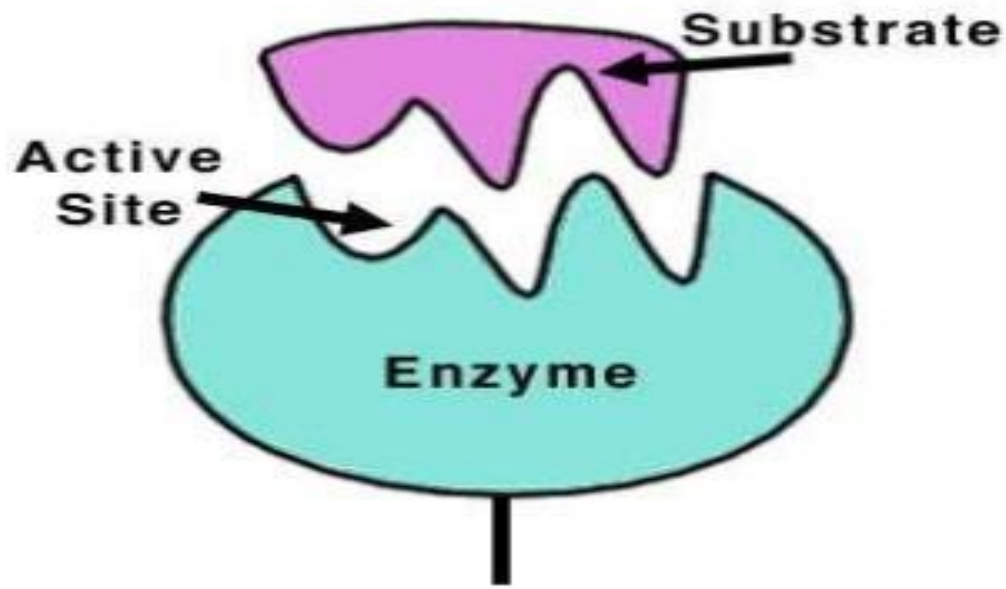
Adapted from www. newtech.tabrizu.ac.ir/Files/**Biosensor**%20seminar(2)**.ppt**

1st COMPONENT – BIOLOGICAL ELEMENT

The component used to bind the target molecule.

Must be highly specific, stable under storage conditions, and immobilized.

Microorganism
Tissue
Cell
Organelle
Nucleic Acid
Enzyme
Enzyme Component
Receptor
Antibody



1st COMPONENT – BIOLOGICAL ELEMENT

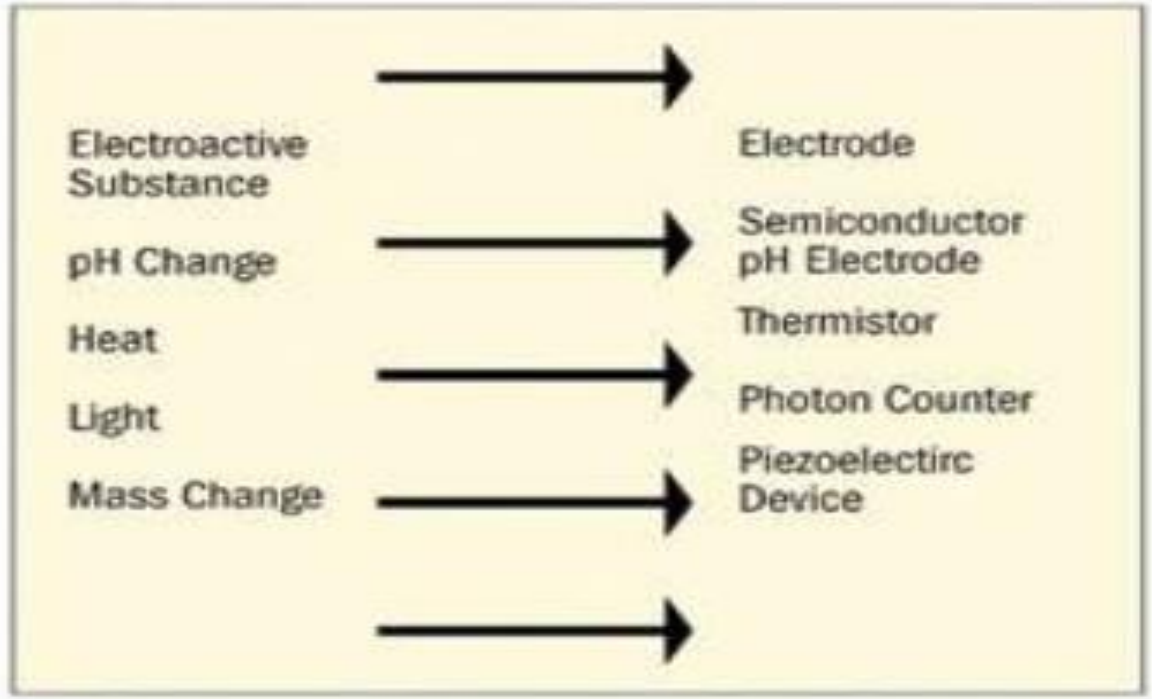
- Function

  To interact specifically with a target compound i.e. the compound to be detected.

- It must be capable of detecting the presence of a target compound in the test solution.
- The ability of a bio-element to interact specifically with target compound (specificity) is the basis for biosensor.

2nd COMPONENT – PHYSIOCHEMICAL TRANSDUCER

Acts as an interface, measuring the physical change that occurs with the reaction at the bioreceptor then transforming that energy into measurable electrical output.



3rd COMPONENT – DETECTOR

Signals from the transducer are passed to a microprocessor where they are amplified and analyzed.

The data is then converted to concentration units and transferred to a display or/and data storage device.

PRINCIPLE OF DETECTION

PIEZOELECTRIC	**Measures change in mass**
ELECTRO-MECHANICAL	**Measures change in electric distribution**
OPTICAL	**Measures change in light intensity**
CALORIMETRIC	**Measures change in heat**

HOW DOES THEY WORK…??

- Biosensors basically involve the quantitative analysis of various substances by converting their biological actions into measurable signals.

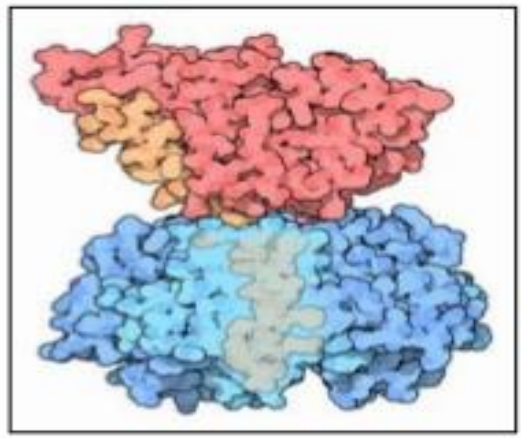
- Generally the performance of the biosensors is mostly dependent on the specificity and sensitivity of the biological reaction, besides the stability of the enzyme.

THE ANALYTE.

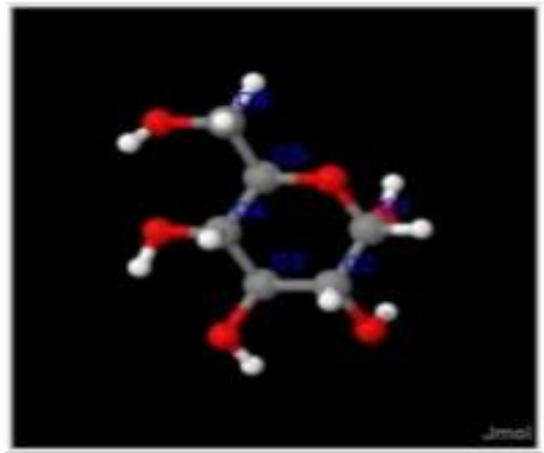
(What do you want to detect?)

Molecule

Protein, toxin, peptide, vitamin, sugar, metal ion



Cholera toxin



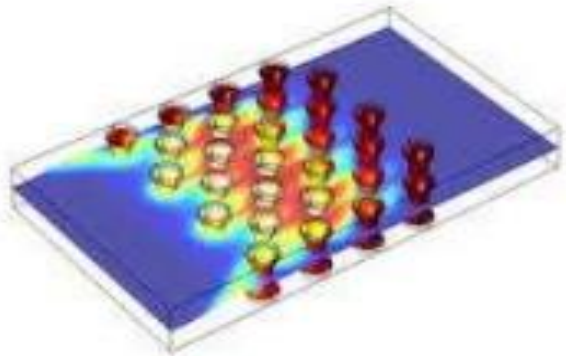
Glucose

IDEAL BIOSENSOR

- The output signal must be relevant to measurement environment.
- The functional surface must be compatible with the transducer.
- High specificity and selectivity (low interference).
- Sufficient sensitivity and resolution .

IDEAL BIOSENSOR

- ✓ Sufficient accuracy and repeatability
- ✓ Sufficient speed of response
- ✓ Sufficient dynamic range.
- ✓ Insensitivity to environmental interference or their effects must be compensated



BASIC CHARACTERISTICS OF BIOSENSOR

1. **LINEARITY -** Linearity of the sensor should be high for the detection of high substrate concentration.

2. **SENSITIVITY -** Value of the electrode response per substrate concentration.

3. **SELECTIVITY -** Chemicals Interference must be minimised for obtaining the correct result.

4. **RESPONSE TIME -** Time necessary for having 95% of the response.

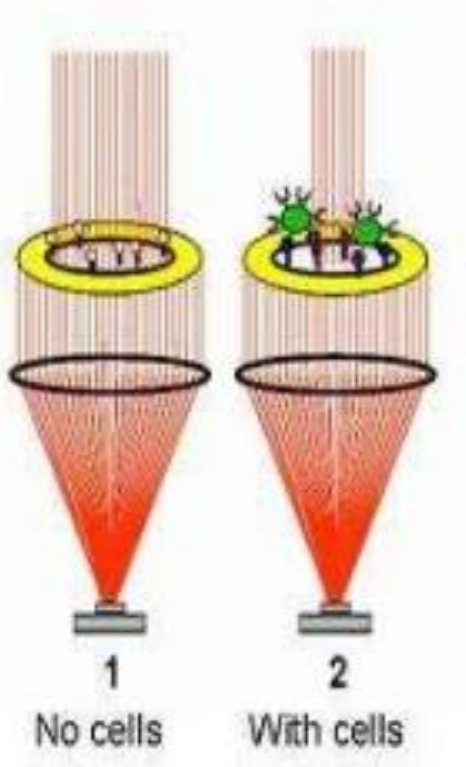
TYPES OF BIOSENSOR

- **Based on bioreceptors**
  - Enzyme biosensor
  - Microbial biosensor
  - Affinity biosensor
- **Based on transducer**
  - Potentiometric
  - Amperometric
  - conductometric
  - Optical
  - Acoustic or piezoelectric etc.

OPTICAL BIOSENSORS

- Colorimetric for color: Measure change in light adsorption as reactants are converted to products.

- Photometric for light intensity: Photon output for a luminescent or fluorescent process can be detected with photomultiplier tubes or photodiode systems.



CALORIMETRIC BIOSENSORS

If the enzyme catalyzed reaction is exothermic, two thermistors may be used to measure the difference in resistance between reactant and product and hence the analyte concentration.

POTENTIOMETRIC BIOSENSORS

For voltage: Change in distribution of charge is detected using ion-selective electrodes, such as pH-meters.

PIEZO - ELECTRIC BIOSENSORS

Piezo-electric devices use gold to detect the specific angle at which electron waves are emitted when the substance is exposed to laser light or crystals, such as quartz, which vibrate under the influence of an electric field.

The change in frequency is proportional to the mass of absorbed material.

ELECTROCHEMICAL BIOSENSORS

- Principle

Many chemical reactions produce or consume ions or electrons which in turn cause some change in the electrical properties of the solution which can be sensed out and used as measuring parameter.

- Classification

(1) Amperometric biosensor

(2) Conductimetric biosensor

(3) Potentiometric biosensor

ELECTROCHEMICAL BIOSENSORS

•Amperometric for applied current: Movement of e- in redox reactions detected when a potential is applied between two electrodes.

•Potentiometric for voltage: Change in distribution of charge is detected using ion-selective electrodes, such as pH-meters.

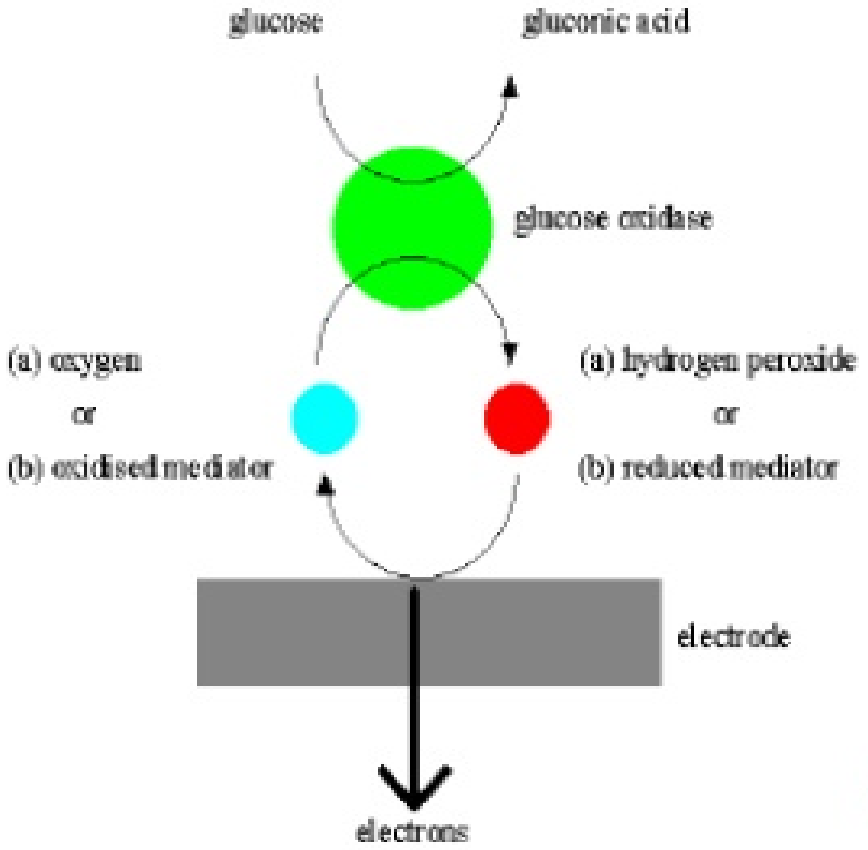
•Conductimetric for impedance

AMPEROMETRIC BIOSENSORS

- Measuring parameter : Electric current
- Based on oxidase enzymes that generate H_2O_2 and consume oxygen.
- Formation of H_2O_2 can be detected by the help of Pt-electrode.

GLUCOSE BIOSENSORS

- Glucose reacts with glucose oxidase(GOD) to form gluconic acid. Two electrons & two protons are also produced.
- Glucose mediator reacts with surrounding oxygen to form H2O2 and GOD.
- Now this GOD can reacts with more glucose.
- Higher the glucose content, higher the oxygen consumption.
- Glucose content can be detected by Pt-electrode.



EXAMPLE OF BIOSENSOR

Glucose monitoring device (for diabetes patients)

Monitors the glucose level in the blood.

Glucose monitoring device (for diabetes patients)

Monitors the glucose level in the blood.

The enzyme glucose oxiadase is used
by blood glucose biosensor to break down of blood glucose.

First it oxidizes glucose and uses two electrons to reduce the FAD (a component of the enzyme) to FADH2 which in turn is oxidized by the electrode in a number of steps.

The resulting current is a measure of the concentration of glucose.

In this case, the electrode is the transducer and the enzyme is the bioreceptor.

EXAMPLE OF BIOSENSOR

Pregnancy test - Detects the hCG protein in urine.

APPLICATIONS OF BIOSENSORS

- In food industry, biosensors are used to monitor the freshness of food.
- Drug discovery and evaluation of biological activity of new compounds.
- Potentiometric biosensors are intended primarily for monitoring levels of carbon dioxide, ammonia, and other gases dissolved in blood and other liquids.
- Environmental applications e.g. the detection of pesticides and river water contaminants.

continue...

APPLICATIONS OF BIOSENSORS

- Determination of drug residues in food, such as antibiotics and growth promoters.
- Glucose monitoring in diabetes patients.
- Analytical measurement of folic acid, biotin, vitamin B12 and pantothenic acid.
- Enzyme-based biosensors are used for continuous monitoring of compounds such as methanol, acetonitrile, phenolics in process streams, effluents and groundwater.