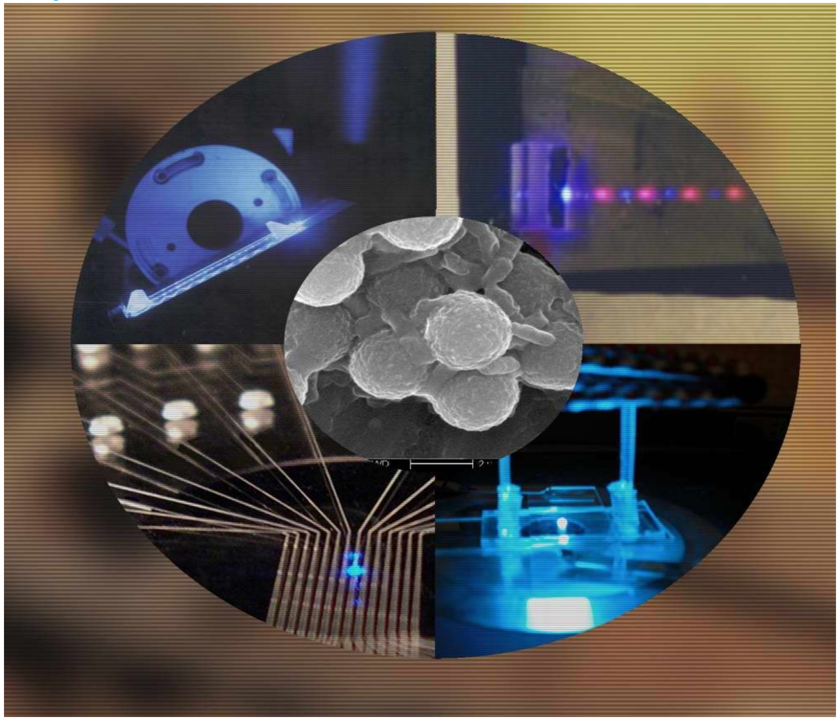
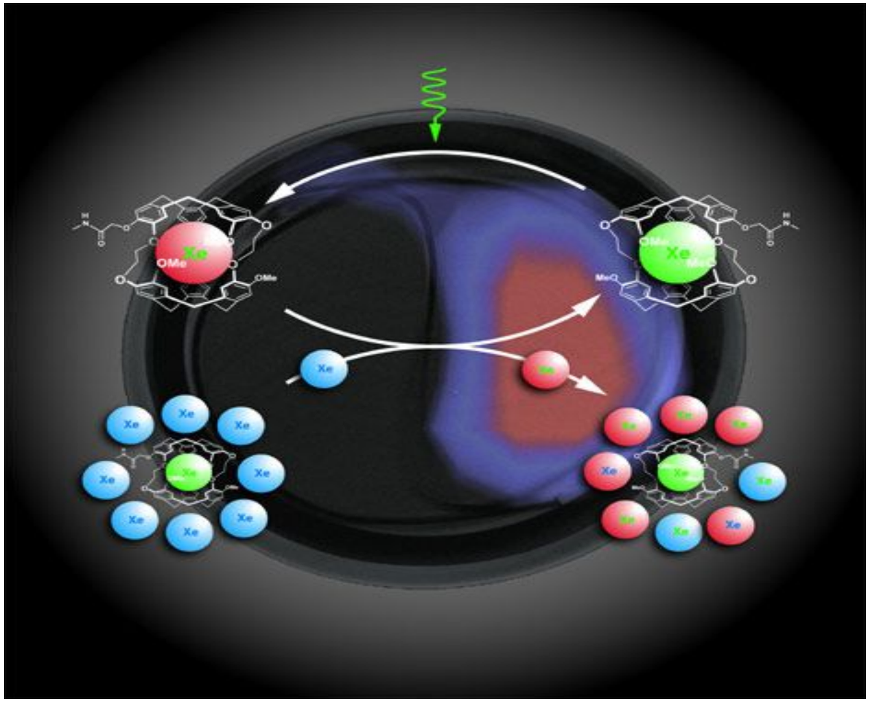
BIOSENSOR





WHAT IS BIOSENSOR?

Chemical Sensors:

“A chemical sensor is a device that transforms chemcial information, ranging from the concentration of a specific sample component to total composition analysis, into an analytically useful signal” – IUPAC

Biosensors: are analytical tools for the analysis of bio-material samples to gain an understanding of their bio-composition, structure and function by converting a biological response into an electrical signal. The analytical devices composed of a biological recognition element directly interfaced to a signal transducer which together relate the concentration of an analyte (or group of related analytes) to a measurable response.

A biosensor is an analytical device containing an immobilized biological material (enzyme, antibody, nucleic acid, hormone, organelle or whole cell) which can specifically interact with an analyte and produce physical, chemical or electrical signals that can be measured.

An analyte is a compound (e.g. glucose, urea, drug, pesticide) whose concentration has to be measured.

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

A great majority of biosensors have immobilized enzymes.

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

General Features of Biosensors:

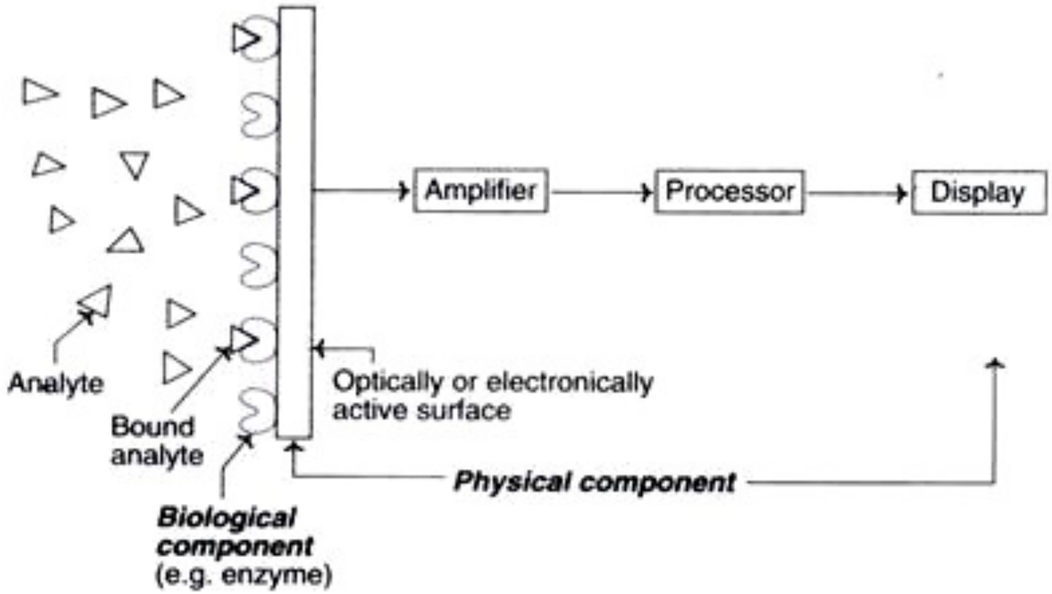


Fig. 21.13 : A diagrammatic representation of a biosensor.

1. Biological component—enzyme, cell etc.
2. Physical component—transducer, amplifier etc.

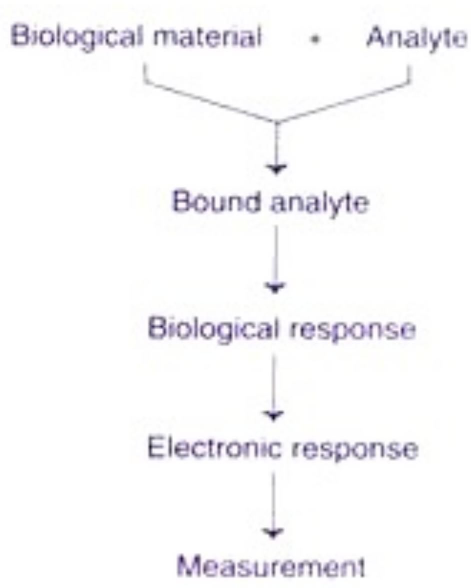
The biological component recognises and interacts with the analyte to produce a physical change (a signal) that can be detected, by the transducer.

In practice, the biological material is appropriately immobilized on to the transducer and the so prepared biosensors can be repeatedly used several times (may be around 10,000 times) for a long period (many months).

Principle of a Biosensor:

The desired biological material (usually a specific enzyme) is immobilized by conventional methods (physical or membrane entrapment, non- covalent or covalent binding).

This immobilized biological material is in intimate contact with 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.

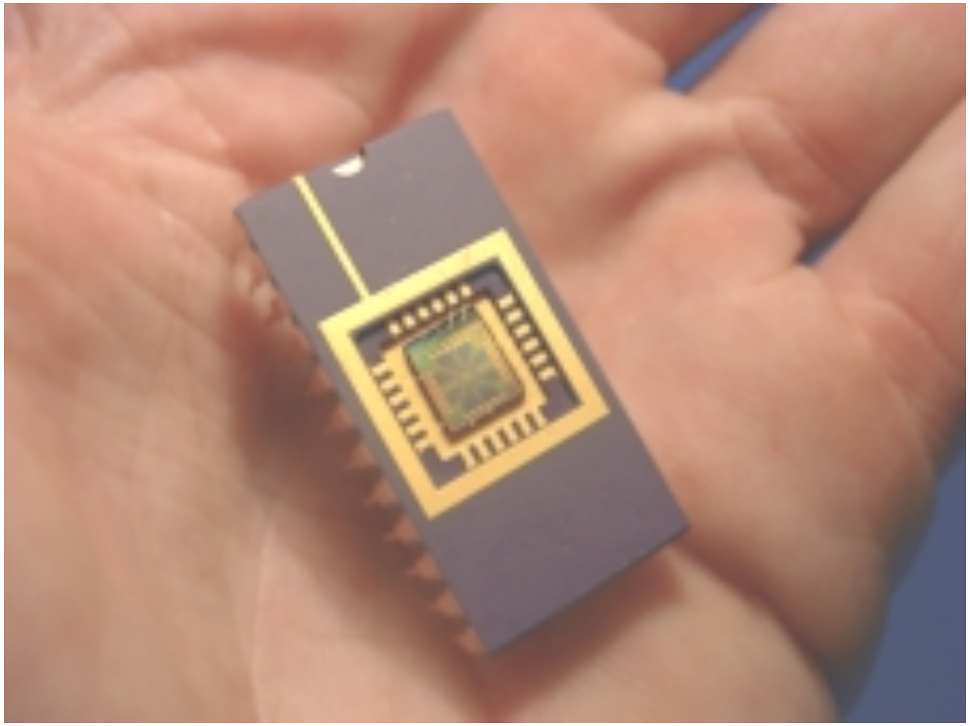


In some instances, the analyte is converted to a product which may be associated with the release of heat, gas (oxygen), electrons or hydrogen ions.

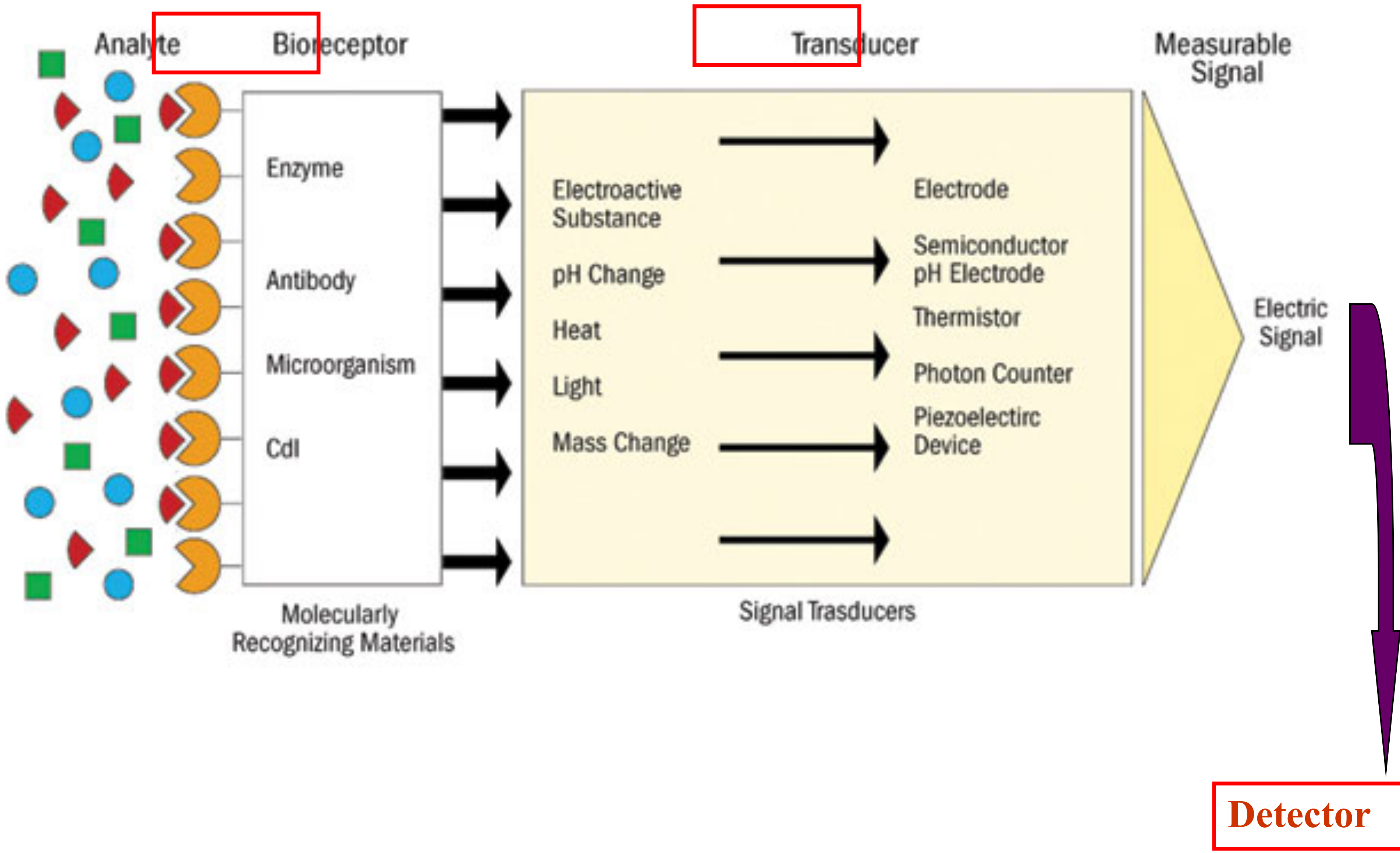
The transducer can convert the product linked changes into electrical signals which can be amplified and measured.

CURRENT DEFINITION

A sensor that integrates a biological element with a physiochemical transducer to produce an electronic signal proportional to a single analyte which is then conveyed to a detector.



COMPONENTS OF A BIOSENSOR



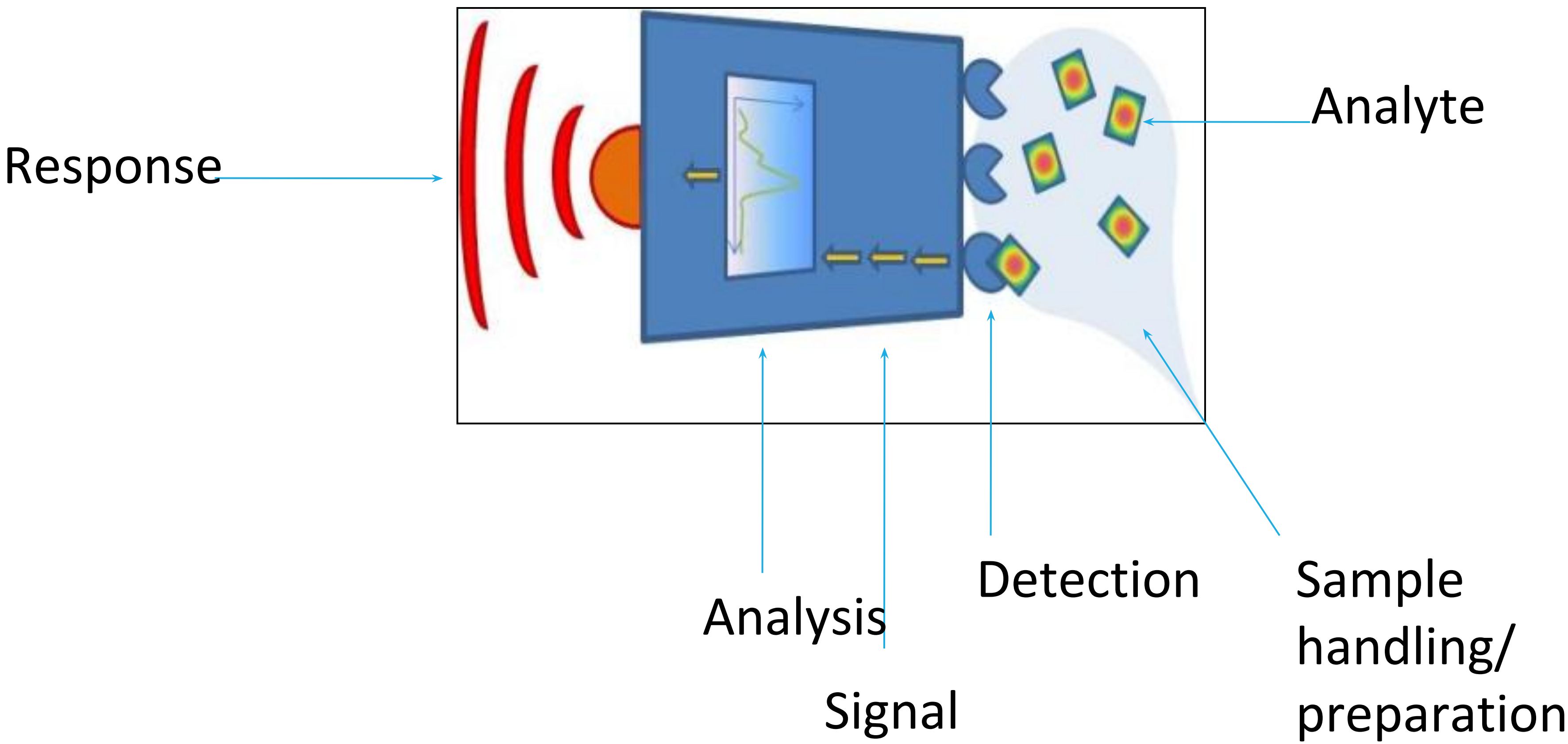
Father of the Biosensor

Professor Leland C Clark Jnr
1918–2005

Basic Characteristics of a Biosensor

1. **LINEARITY** Linearity of the sensor should be high forthe 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.

BIOSENSOR


Response
Analyte
Analysis
Signal
Detection
Sample
handling/
preparation

EXAMPLE OF BIOSENSORS

<u>Pregnancy test</u>

Detects the hCG protein in urine.

<u>Glucose monitoring device (for diabetes patients)</u>

Monitors the glucose level in the blood.

EXAMPLE OF BIOSENSORS

<u>Infectous disease biosensor from RBS</u>

<u>Old time coal miners' biosensor</u>

Typical Sensing Techniques for Biosensors

- ✔Fluorescence
- ✔DNA Microarray
- ✔SPR Surface plasmon resonance
- ✔Impedance spectroscopy
- ✔SPM (Scanning probe microscopy, AFM, STM)
- ✔QCM (Quartz crystal microbalance)
- ✔SERS (Surface Enhanced Raman Spectroscopy)
- ✔Electrochemical

TYPES OF BIOSENSORS

1. **Calorimetric Biosensor**
2. **Potentiometric Biosensor**
3. **Amperometric Biosensor**
4. **Optical Biosensor**
5. **Piezo-electric Biosensor**

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

- **For applied current: Movement of e- in redox reactions detected when a potential is applied between two electrodes.**

POTENTIOMETRIC BIOSENSOR

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

Optical Biosensors

- Colorimetric for color

  Measure change in light adsorption

- 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.

ELECTROCHEMICAL DNA BIOSENSOR

- **Steps involved in electrochemical DNA hybridization biosensors:**
  - **Formation of the DNA recognition layer**
  - **Actual hybridization event**
  - **Transformation of the hybridization event into an electrical signal**

DNA biosensor

Motivated by the application to clinical diagnosis and genome mutation detection

TYPES DNA BIOSENSORS

Electrodes

Chips

Crystals

BIOSENSORS ON THE NANOSCALE

- ❑ Molecular sheaths around the nanotube are developed that respond to a particular chemical and modulate the nanotube's optical properties.

- ❑ A layer of olfactory proteins on a nanoelectrode react with low-concentration odorants (SPOT-NOSED Project). Doctors can use to diagnose diseases at earlier stages.

- ❑ Nanosphere lithography (NSL) derived triangular Ag nanoparticles are used to detect streptavidin down to one picomolar concentrations.

- ❑The School of Biomedical Engineering has developed an anti-body based piezoelectric nanobiosensor to be used for anthrax,HIV hepatitis detection.

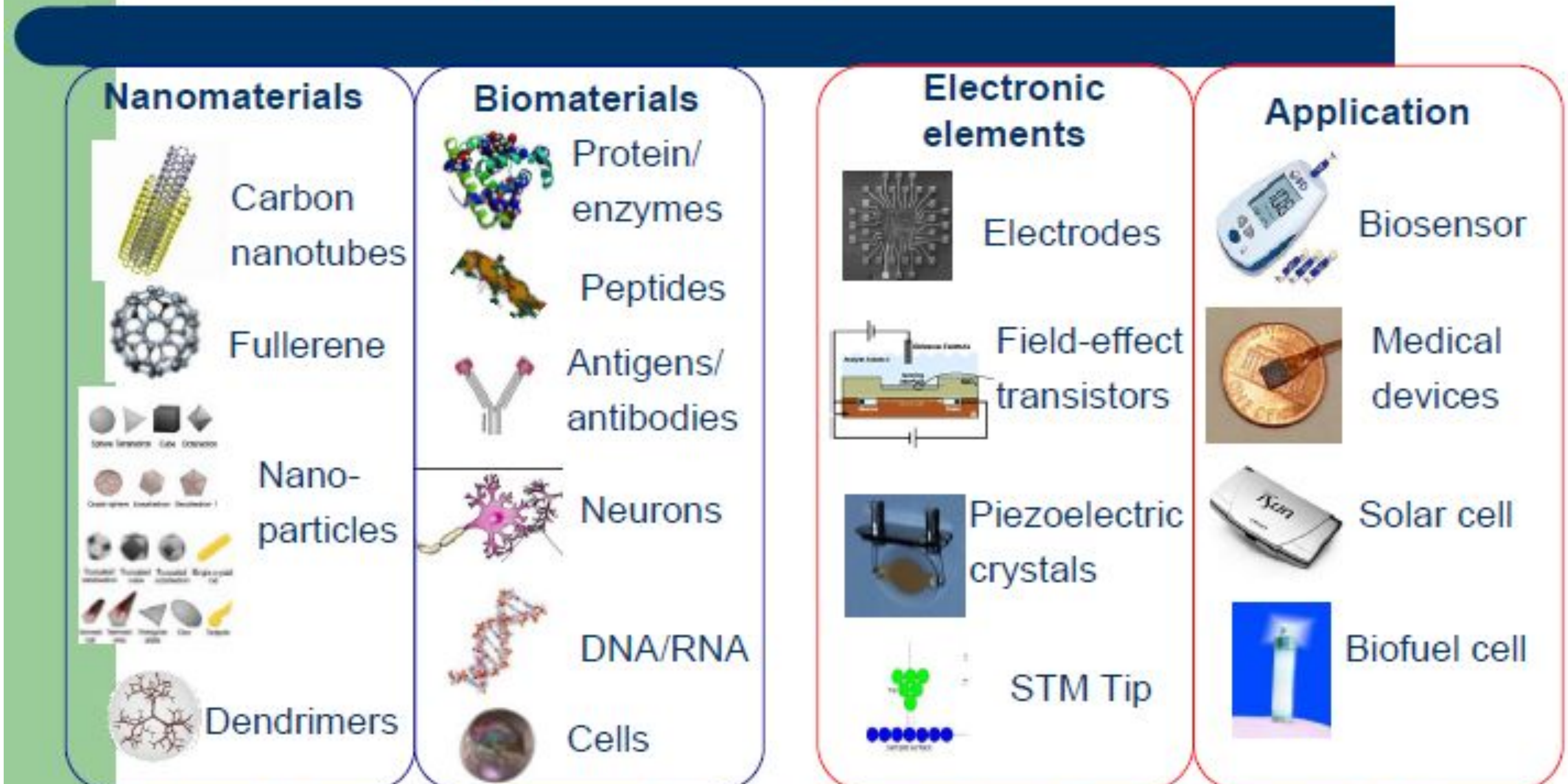
Application of Biosensor

- ❖ Food Analysis
- ❖ Study of biomolecules and their interaction
- ❖ Drug Development
- ❖ Crime detection
- ❖ Medical diagnosis (both clinical and laboratory use)
- ❖ Environmental field monitoring
- ❖ Quality control
- ❖ Industrial Process Control
- ❖ Detection systems for biological warfare agents
- ❖ Manufacturing of pharmaceuticals and replacement organs

Biosensors play a part in the field of environmental quality, medicine and industry mainly by identifying material and the degree of concentration present

Nano-Biotechnology

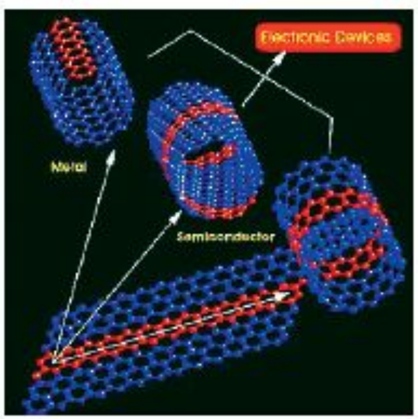
Current, Potential, Impedance, Electrical power

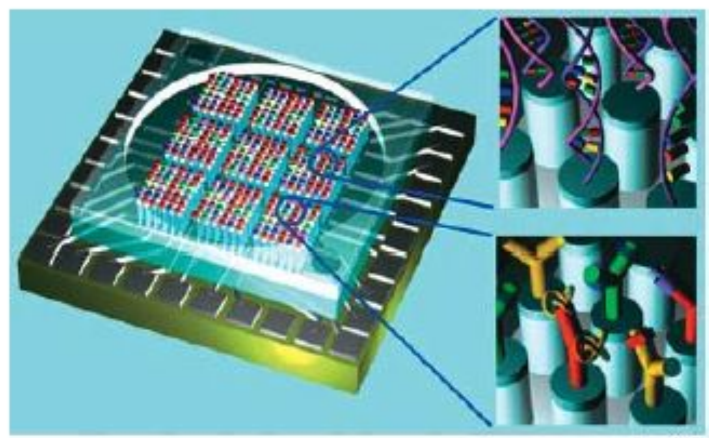


Biological Sciences – Pharmacy – Chemistry/Biochemistry –Physics – Biomedical Eng. – Electrical Eng. – Mechanical Eng. – Material Eng. – Bioinformatics

Nanotechnology will enable us to design sensors that are much smaller, less power hungry, and more sensitive than current micro- or macrosensors.

- **Nano Materials:** **Carbon Nanotube-Electrodes; Metallic Nanoparticles-sensor probes and electrodes; Nanorod-sensor probes; Magnetic Particles-sensor probes; Nanowires-FET sensing system, quantam dot (AsSe, CdSe, etc.)**
- **Bio-Nanomaterial Hybrids: DNA-Np; DNA-CNTs; Drug-Nps, Peptide-CNTs, etc.**

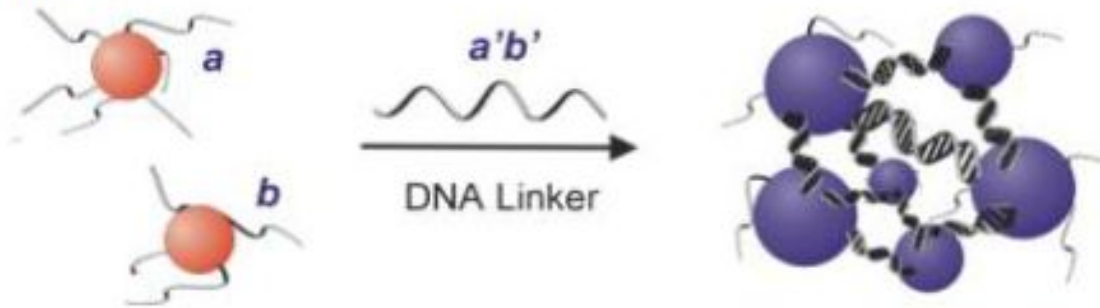




Source: NASA

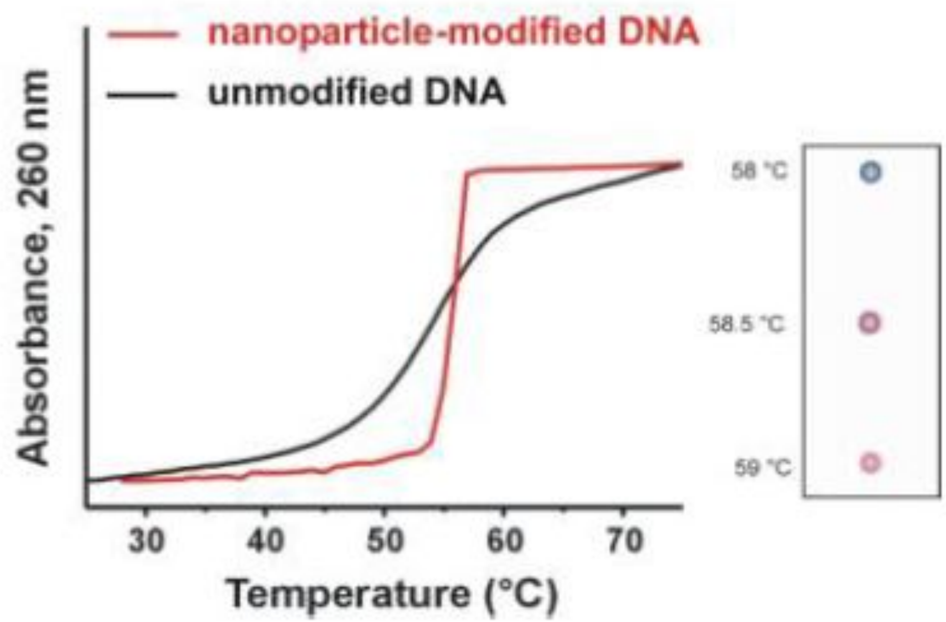
Integration of nano-scale technologies could lead to tiny, low-power, smart sensors that could be manufactured cheaply in large numbers.

sensing the interaction of a small number of molecules, processing and transmitting the data with a small number of electrons, and storing the information in nanometer-scale structures

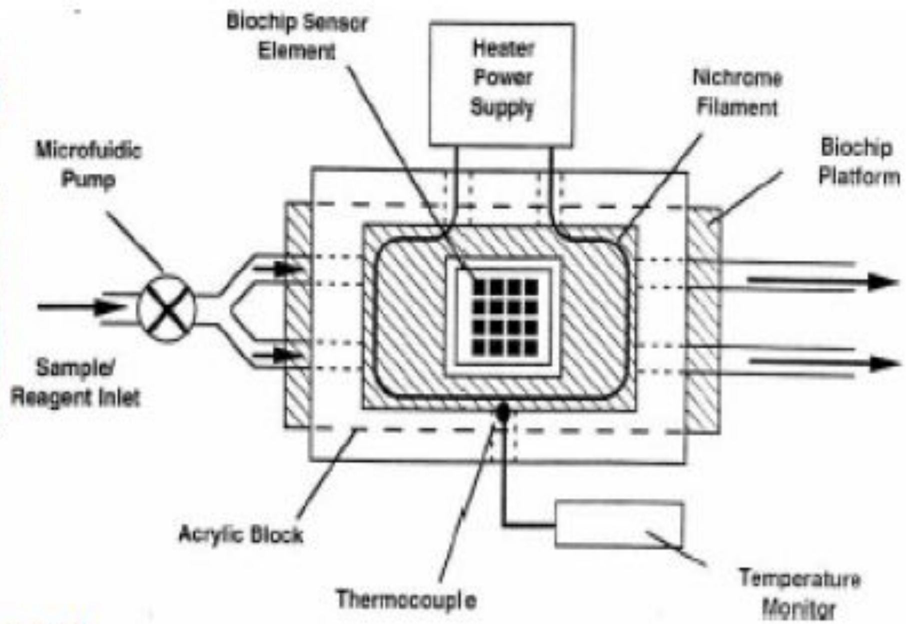


without DNA linker

with DNA linker



- **Nano/Micro-Electro-Mechanical Systems (N/MEMS) for Sensor Fabrication**
- **BioMEMS/BioNEMS, Lab-on –Chip, Microfluidic System, Sensor Arrays, Implantable Sensor**



SnifferSTAR is a nano-enabled chemical sensor integrated into a micro unmanned aerial vehicle