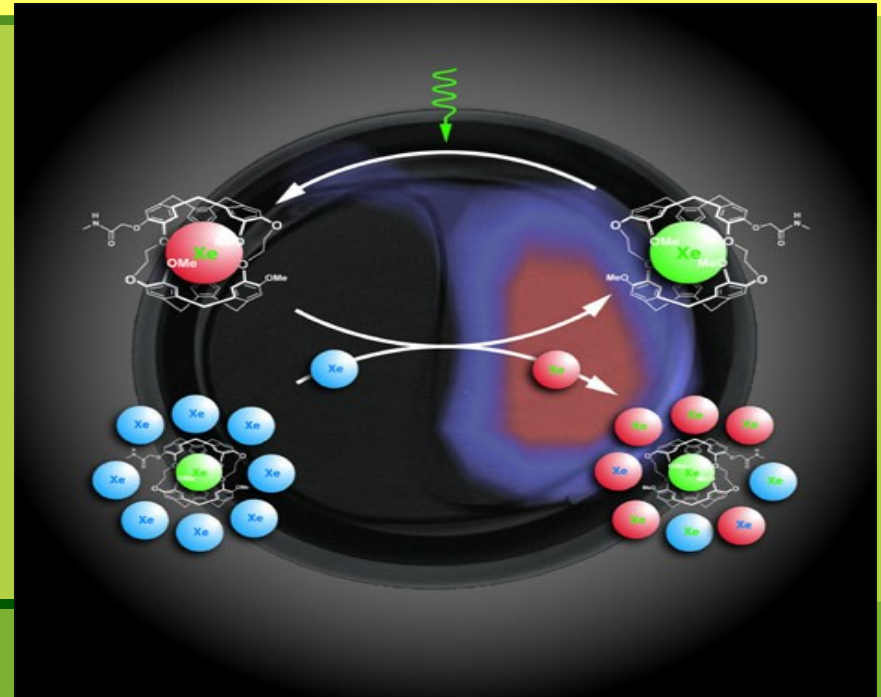
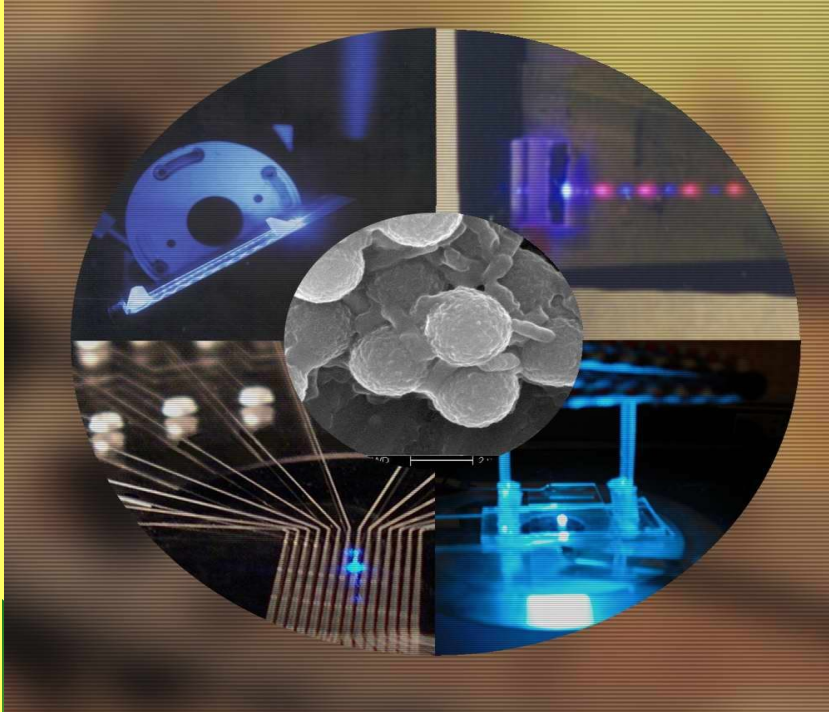


# BIOSENSOR

(General principles and applications)



# What is a Biosensor?

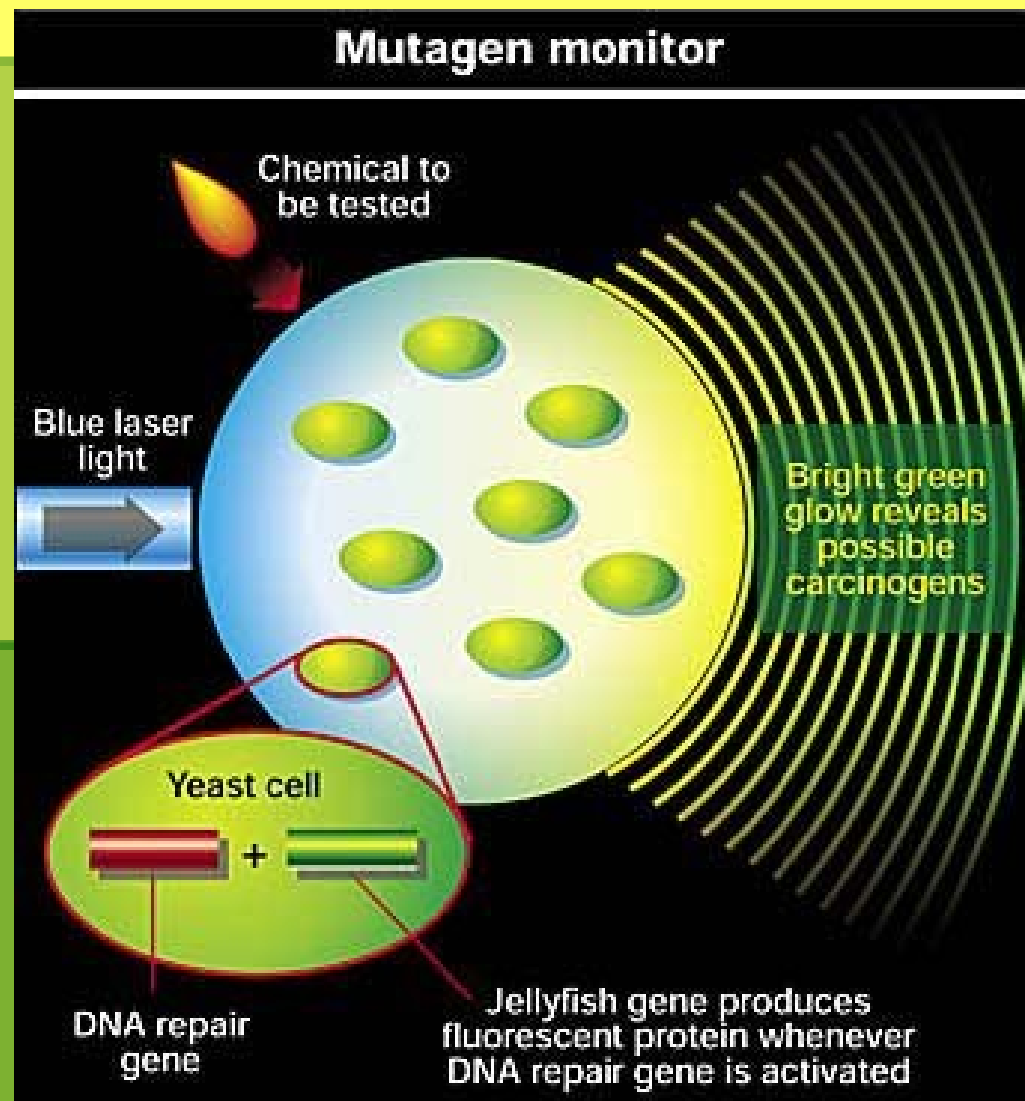
*A biosensor is a self-contained integrated device that is capable of providing specific quantitative or semi-quantitative analytical information using a biological recognition element which is in direct spatial contact with a transduction element (IUPAC, 1996)*



**1) Biosensor  $\neq$  Bioanalytical system**

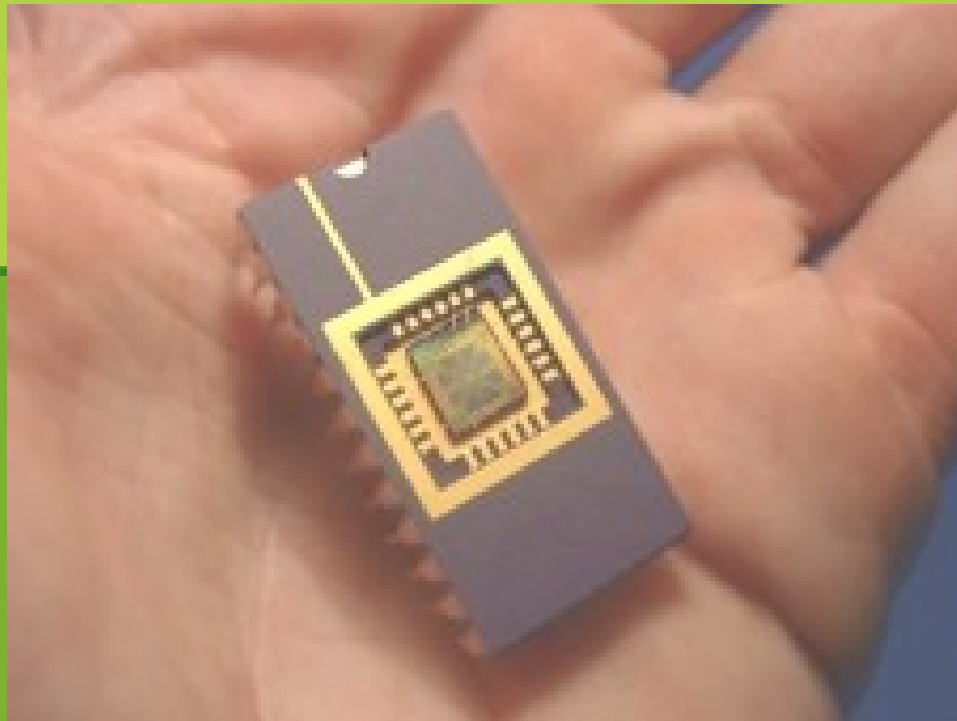
**2) An enzyme electrode is a biosensor**

**“Biosensor”** – Any device that uses specific biochemical reactions to detect chemical compounds in biological samples.

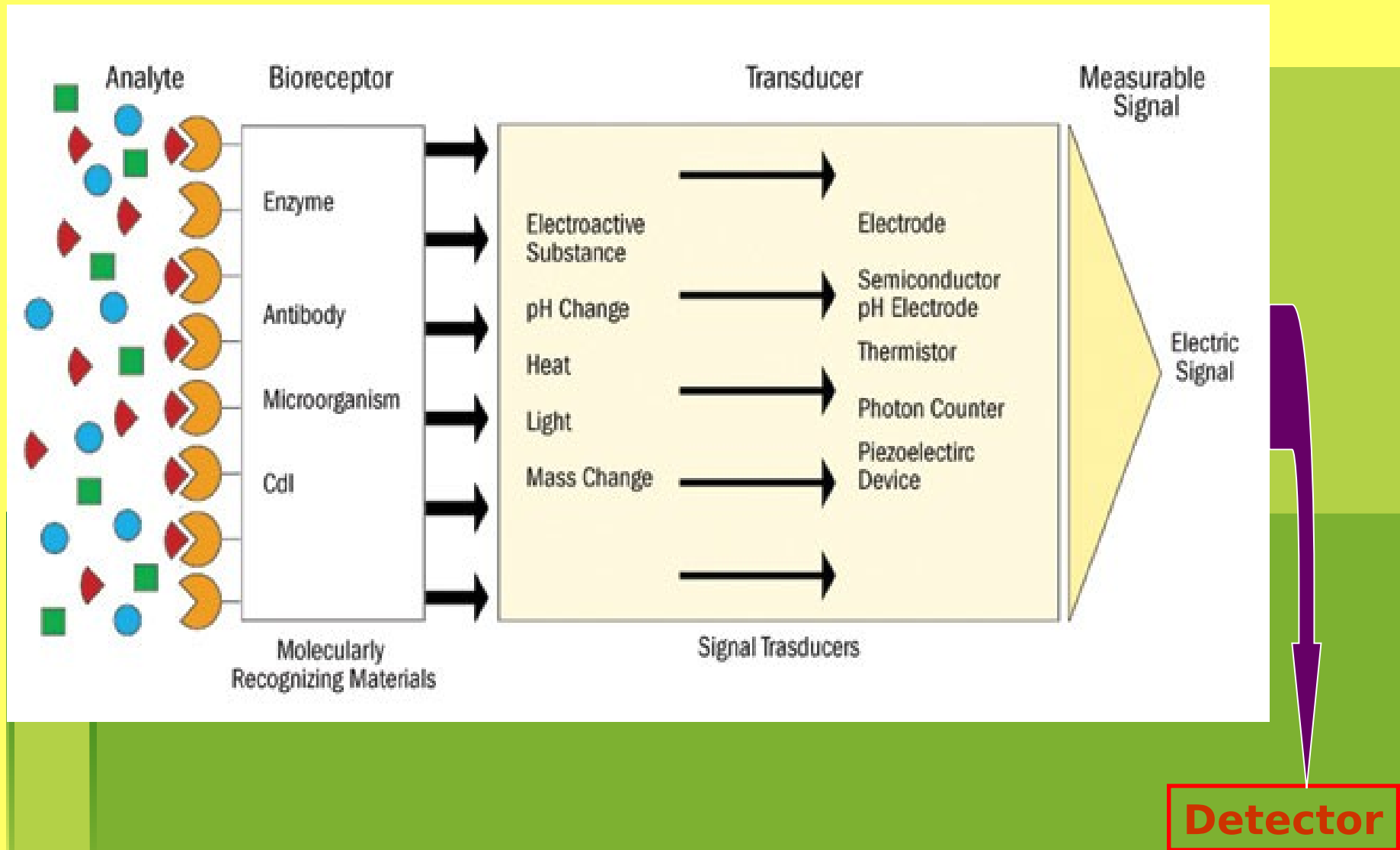


# Current Definition

**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 Jr  
1918–2005**

# History of Biosensors

- **1916** First report on immobilization of proteins : adsorption of invertase on activated charcoal
- **1922** First glass pH electrode
- **1956** Clark published his definitive paper on the oxygen electrode.
- **1962** First description of a biosensor: an amperometric enzyme electrode for glucose (Clark)
- **1969** Guilbault and Montalvo – First potentiometric biosensor: urease immobilized on an ammonia electrode to detect urea
- **1970** Bergveld – ion selective Field Effect Transistor (ISFET)
- **1975** Lubbers and Opitz described a fibre-optic sensor with immobilised indicator to measure carbon dioxide or oxygen.

# History of Biosensors

- **1975** First commercial biosensor ( Yellow springs Instruments glucose biosensor)
- **1975** First microbe based biosensor, First immunosensor
- **1976** First bedside artificial pancreas (Miles)
- **1980** First fibre optic pH sensor for in vivo blood gases (Peterson)
- **1982** First fibre optic-based biosensor for glucose
- **1983** First surface plasmon resonance (SPR) immunosensor
- **1984** First mediated amperometric biosensor: ferrocene used with glucose oxidase for glucose detection

# History of Biosensors

- **1987** Blood-glucose biosensor launched by MediSense ExacTech
- **1990** SPR based biosensor by Pharmacia BIACore
- **1992** Hand held blood biosensor by i-STAT
- **1996** Launching of Glucocard
- **1998** Blood glucose biosensor launch by LifeScan FastTake
- **1998** Roche Diagnostics by Merger of Roche and Boehringer mannheim
- **Current** Quantum dots, nanoparicles, nanowire, nanotube, etc

# Basic Characteristics of a 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.

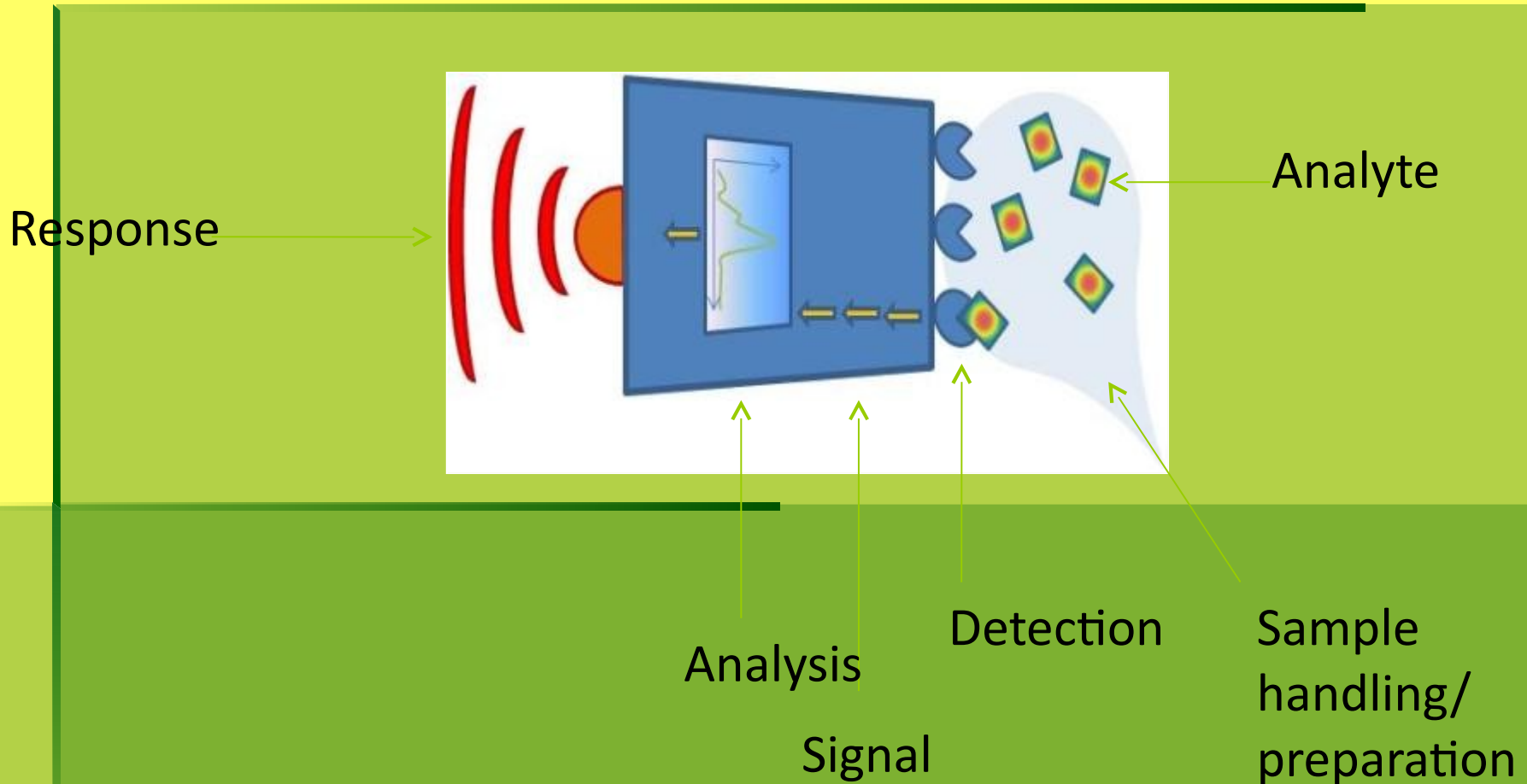
## 3. SELECTIVITY

Chemicals Interference must be minimised for obtaining the correct result.

## 4. RESPONSE TIME

Time necessary for having 95% of the response.

# Biosensor



# Biosensor

## 1. The Analyte (What do you want to detect)

*Molecule - Protein, toxin, peptide, vitamin, sugar, metal ion*

## 2. Sample handling (How to deliver the analyte to the sensitive region?)

*(Micro) fluidics - Concentration increase/decrease),  
Filtration/selection*

# Biosensor

## ❖ 3. Detection/Recognition

(How do you specifically recognize the analyte?)

## 4. Signal

(How do you know there was a detection)

# Example of biosensors



## Pregnancy test

Detects the hCG protein in urine.



## Glucose monitoring device (for diabetes patients)

Monitors the glucose level in the blood.

# Example of biosensors



Infectious disease biosensor  
from RBS



Old time coal miners' biosensor

# Research Biosensors



**Biacore Biosensor platform**

# 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<sup>-</sup> 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

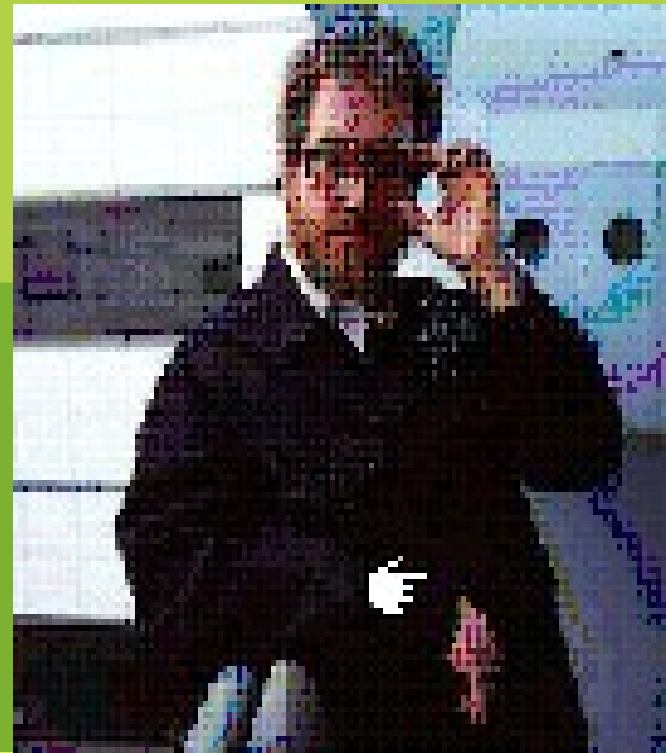
- Electrodes
- Chips
- Crystals

# Wearable Biosensors



Ring Sensor

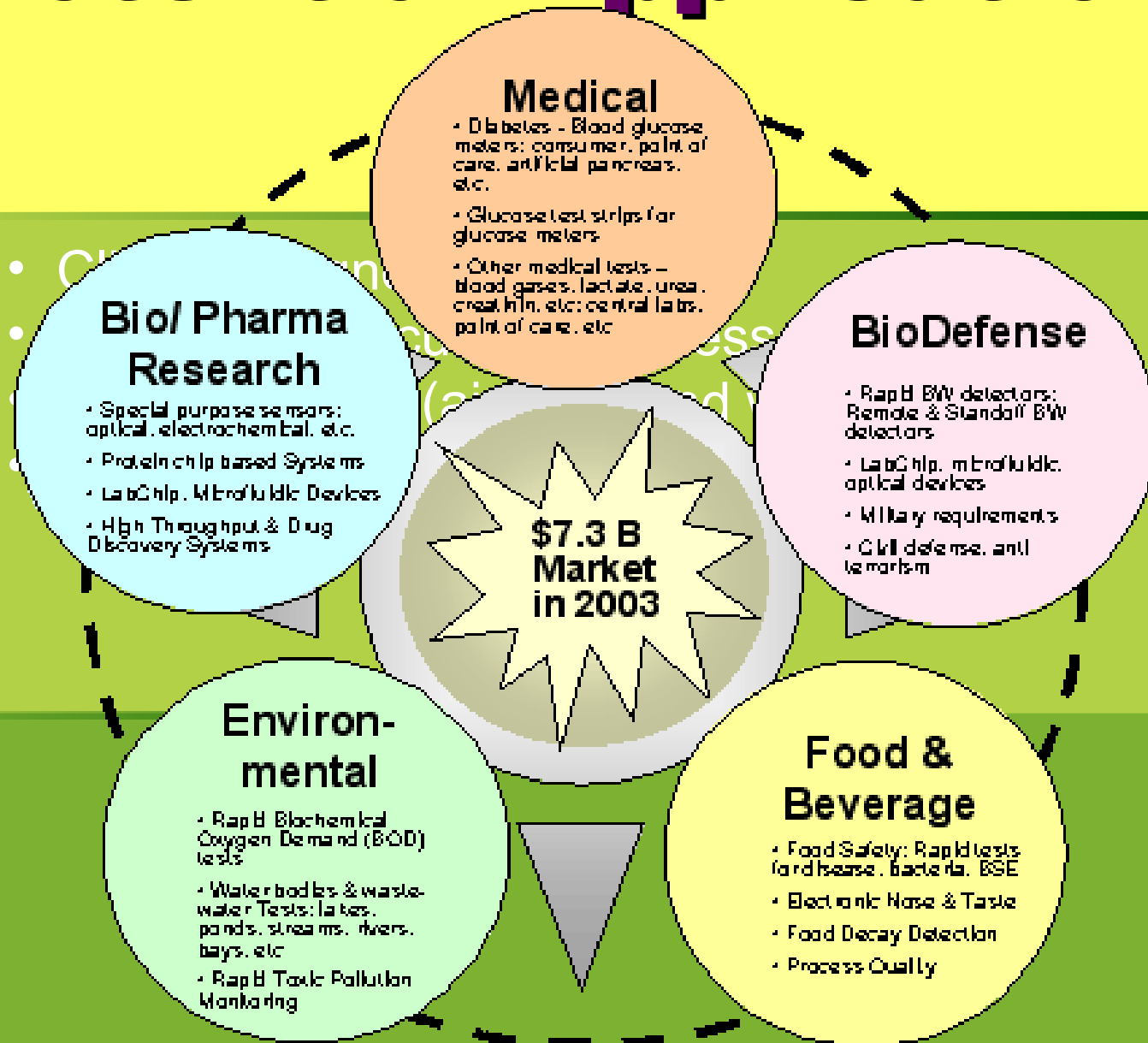
Smart Shirt



# 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 antibody based piezoelectric nanobiosensor to be used for anthrax, HIV hepatitis detection.

# Potential Applications



# 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

