ENVIRONMENTAL STUDIES AND LIFE SCIENCES

BIOSENSORS

- Biosensors can be defined as analytical devices which include a combination of biological detecting elements like sensor system and a transducer.
- The sensitive biological element, e.g. tissue, microorganisms, organelles, cell receptors, enzymes, antibodies, nucleic acids, etc., is a biologically derived material that interacts with, binds with, or recognizes the analyte under study.
- Biosensors are nowadays ubiquitous in biomedical diagnosis, point-of-care monitoring of treatment and disease progression, environmental monitoring, food control, drug discovery, forensics and biomedical research.
- A wide range of techniques can be used for the development of biosensors.
- Their coupling with high-affinity biomolecules allows the sensitive and selective detection of a range of analytes.

A typical biosensor consists of the following components.

- **Analyte**:
- A substance of interest that needs detection.
- For instance, glucose is an 'analyte' in a biosensor designed to detect glucose.

Bioreceptor:

- A molecule that specifically recognizes the analyte is known as a bioreceptor.
- Enzymes, cells, aptamers, deoxyribonucleic acid (DNA) and antibodies are some examples of bioreceptors.
- The process of signal generation (in the form of light, heat, pH, charge or mass change, etc.) upon interaction of the bioreceptor with the analyte is termed bio-recognition.

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.
- This process of energy conversion is known as signalisation.
- Most transducers produce either optical or electrical signals that are usually proportional to the amount of analyte–bioreceptor interactions.
- The transducer works in a physicochemical way: optical, piezoelectric, electrochemical, electrochemiluminescence etc., resulting from the interaction of the analyte with the biological element, to easily measure and quantify.

Electronics:

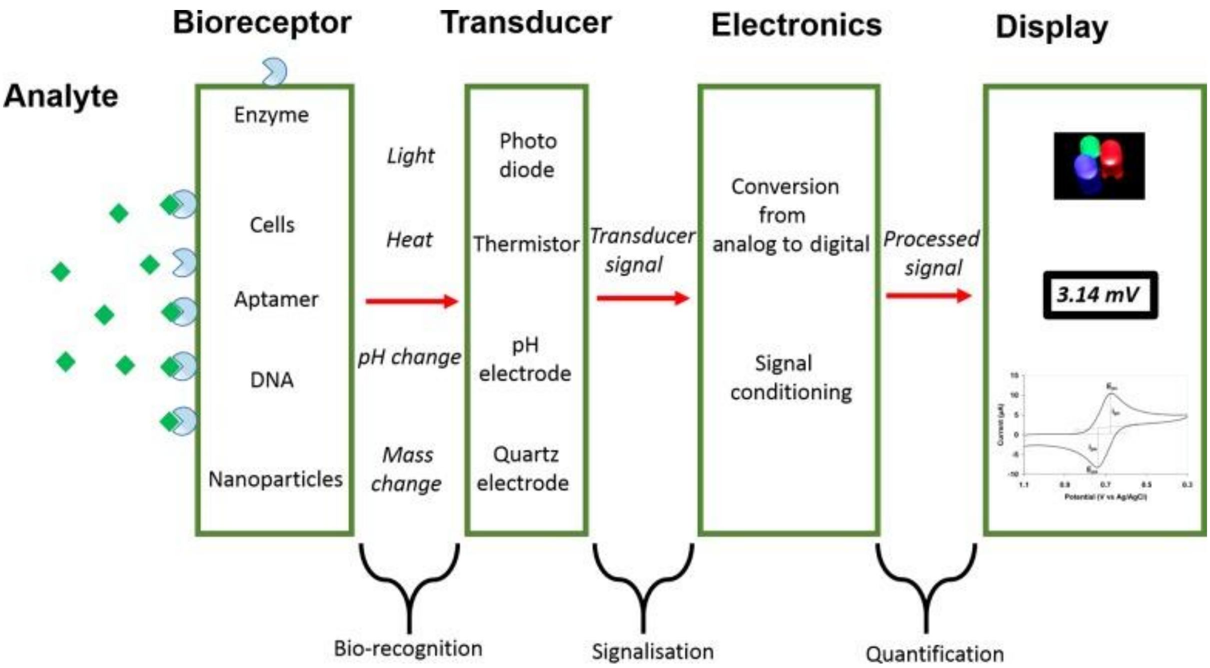
- This is the part of a biosensor that processes the transduced signal and prepares it for display.
- It consists of complex electronic circuitry that performs signal conditioning such as amplification and conversion of signals from analogue into the digital form.

- The processed signals are then quantified by the display unit of the biosensor.

Display:

- The display consists of a user interpretation system such as the 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.

- In a summary a biosensor typically consists of a bio-receptor (enzyme/antibody/cell/nucleic acid), transducer component (semi-conducting material/nanomaterial), and electronic system which includes a signal amplifier, processor & display
- In a biosensor, the bioreceptor is designed to interact with the specific analyte of interest to produce an effect measurable by the transducer.
- High selectivity for the analyte among a matrix of other chemical or biological components is a key requirement of the bioreceptor.



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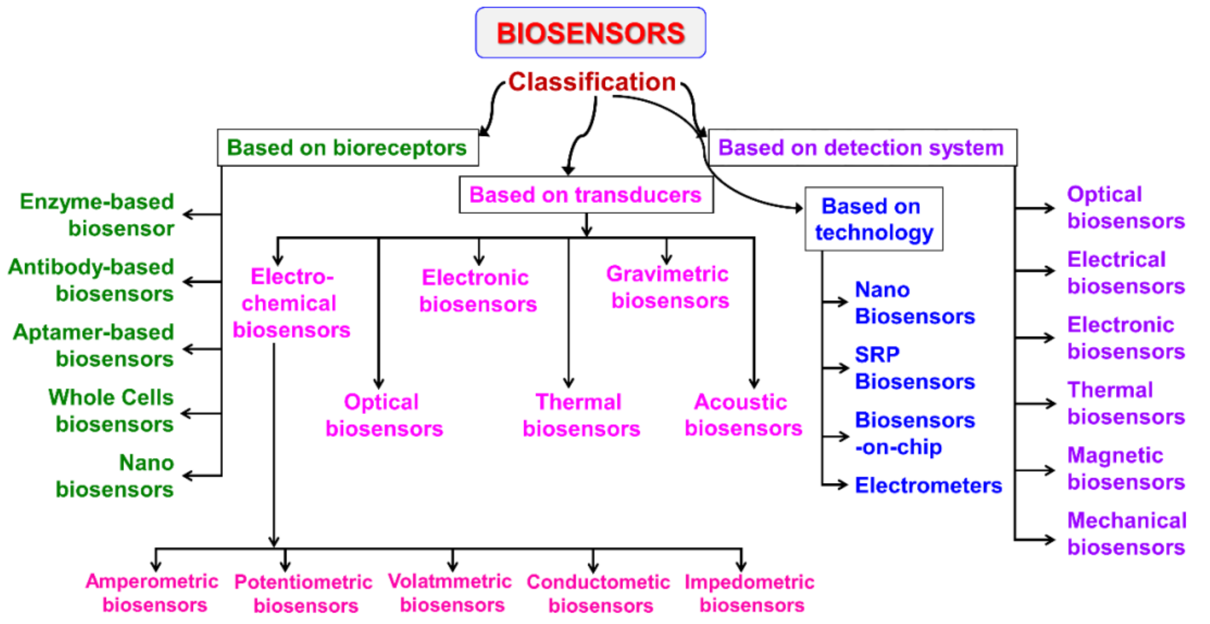

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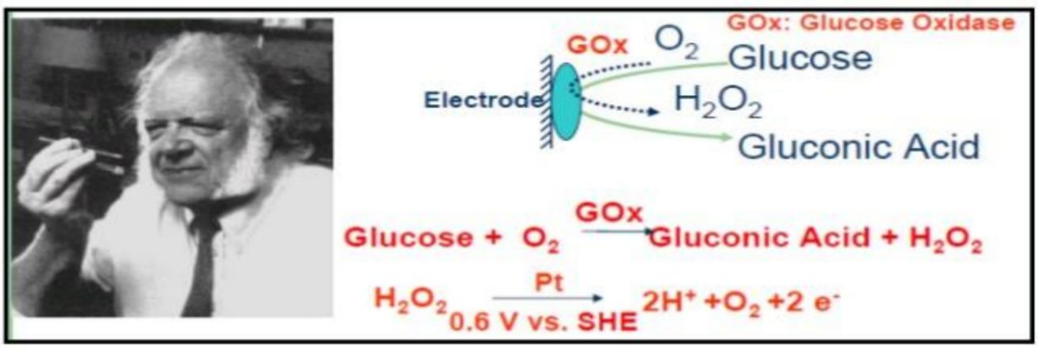
- The first 'true' biosensor was developed by Leland C. Clark in 1956 for oxygen detection. He is known as the 'Father of Biosensors' and his invention of the oxygen electrode bears his name: 'Clark electrode'

Professor Leland C Clark (1918–2005)



The first and the most widespreadly used commercial biosensor: the blood glucose biosensor – developed by *Leland C. Clark in 1962*

There are certain static and dynamic attributes that every biosensor possesses.

- **Selectivity**
- Selectivity is the most important feature of a biosensor.
- Selectivity is the ability of a bioreceptor to detect a specific analyte in a sample containing other admixtures and contaminants.
- **Reproducibility**
- Reproducibility is the ability of the biosensor to generate identical responses for a duplicated experimental set-up.
- Reproducibility is characterised by the 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.

Stability

- Stability is the degree of susceptibility to ambient disturbances in and around the biosensing system.
- These disturbances can cause a drift in the output signals of a biosensor under measurement causing an error in the measured concentration and can affect the precision and accuracy of the biosensor.

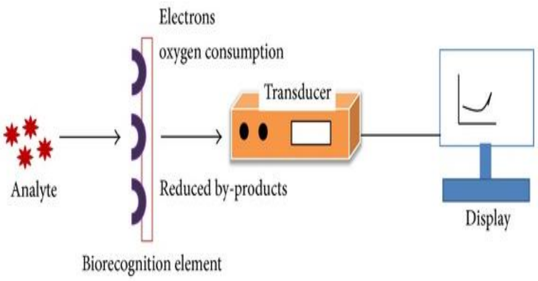
Sensitivity

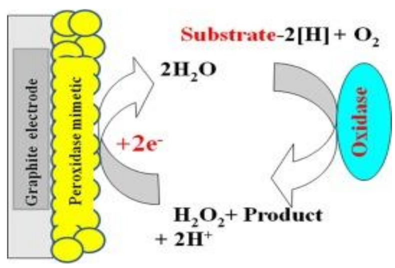
- The minimum amount of analyte that can be detected by a biosensor defines its limit of detection (LOD) or sensitivity.
- In a number of medical and environmental monitoring applications, a biosensor is required to detect analyte concentration of as low as ng/ml or even fg/ml to confirm the presence of traces of analytes in a sample.

Linearity

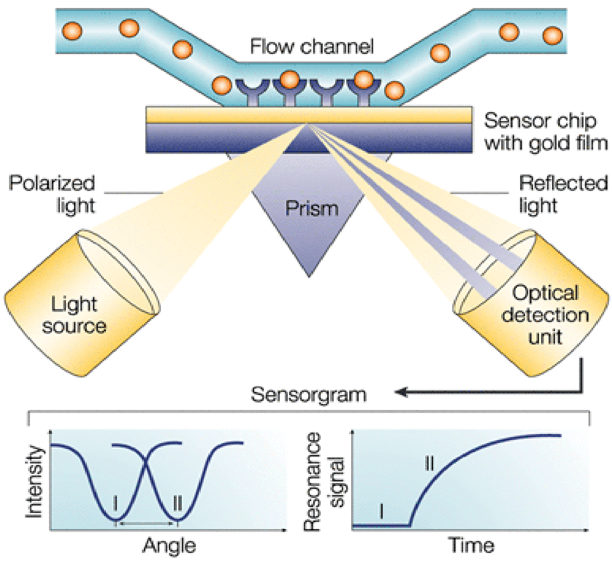
- Linearity is the attribute that shows the accuracy of the measured response (for a set of measurements with different concentrations of analyte) to a straight line, mathematically represented as $y=mc$, where c is the concentration of the analyte, y is the output signal, and m is the sensitivity of the biosensor.
- Linearity of the biosensor is associated with the resolution of the biosensor and range of analyte concentrations under test.
- The resolution of the biosensor is the smallest change in the concentration of an analyte that is required to bring a change in the response of the biosensor.
- **Linearity**: Linearity of the sensor should be high for the detection of high substrate concentration.
- **Sensitivity**: Value of the electrode response per substrate concentration
- **Selectivity**: Chemical interference must be minimized for obtaining correct result
- **Response time**: Time necessary for having 95% of the response

ELECTROCHEMICAL BIOSENSORS





OPTICAL BIOSENSORS



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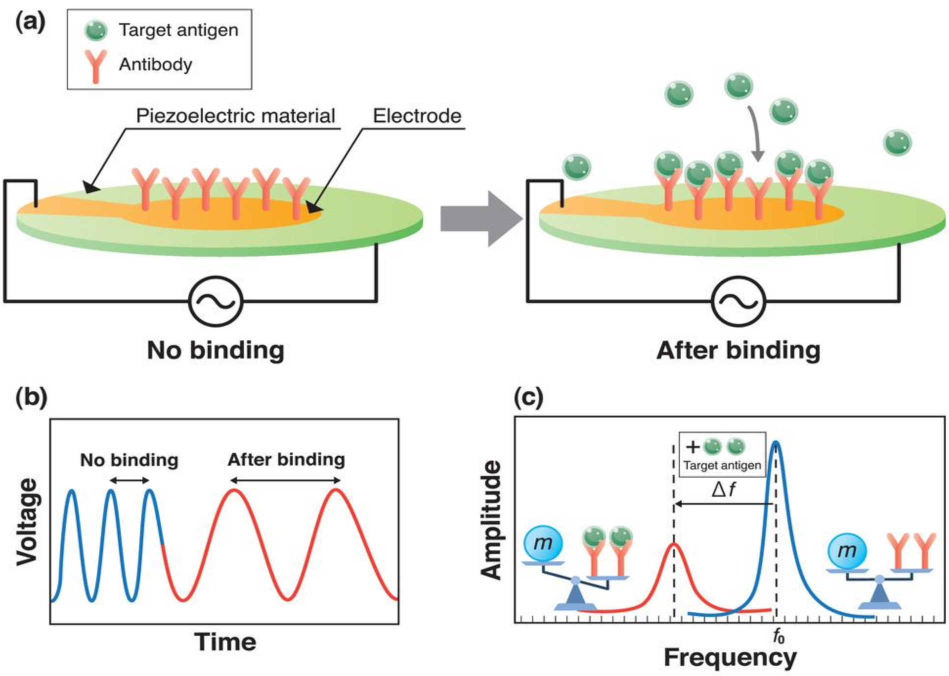
PIEZOELECTRIC BIOSENSORS



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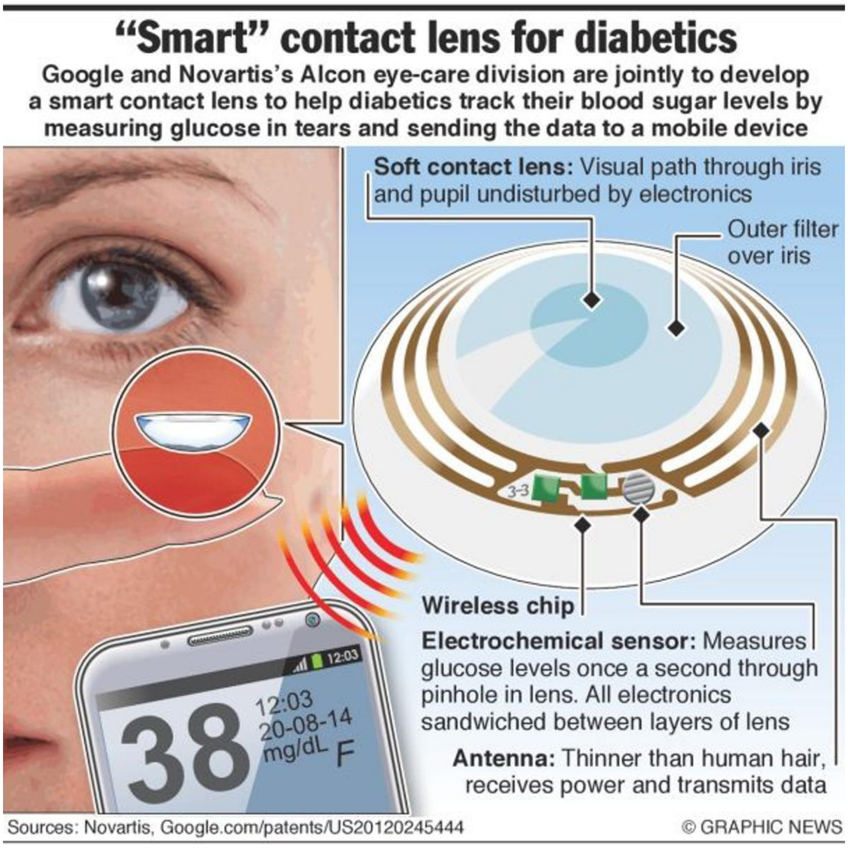

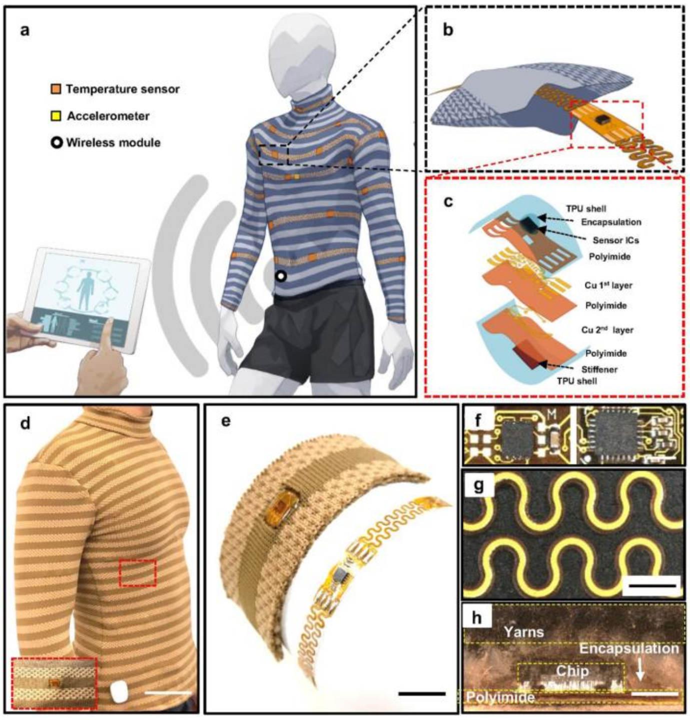

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