Biomedical Instrumentation

Introduction

We use the term “bio” to denote something related to life. When basics of physics and chemistry get applied to the living things, and we name them as Biophysics and Biochemistry. So when the discipline of engineering and medicine interacts, it is called Biomedical Engineering. Biomedical engineering is the application of knowledge and technologies to solve the problem of the living system. It involves diagnosis, treatment and prevention of disease in human. As the medical field is emerging, the area of Biomedical Engineering is expanding.

Biomedical Instrumentation

It involves measurement of biological signals like ECG, EMG, or any electrical signals generated in the human body. Biomedical Instrumentation helps physicians to diagnose the problem and provide treatment. To measure biological signals and to design a medical instrument, concepts of electronics and measurement techniques are needed.

Components of Biomedical Instrumentation System

Any medical instrument consists of the following functional basic parts

1. Measurand: The measurand is the physical quantity, and the instrumentation systems measure it. Human body acts as the source for measurand, and it generates bio-signals. Example: body surface or blood pressure in the heart

2. Sensor / Transducer: The transducer converts one form of energy to another form usually electrical energy. For example, the piezoelectric signal which converts mechanical vibrations into the electrical signal. The transducer produces a usable output depending on the measurand. The sensor is used to sense the signal from the source. It is used to interface the signal with the human.

3. Signal Conditioner: Signal conditioning circuits are used to convert the output from the transducer into an electrical value. The instrument system sends this quantity to the display or recording system. Generally, signal conditioning process includes amplification, filtering,

analogue to digital and Digital to analogue conversions. Signal conditioning improves the sensitivity of instruments.

4. Display: It is used to provide a visual representation of the measured parameter or quantity. Example: Chart recorder, Cathode Ray oscilloscope (CRO). Sometimes alarms are used to hear the audio signals. Example: Signals generated in Doppler Ultrasound Scanner used for Fetal Monitoring.

5. Data Storage and Data Transmission: Data storage is used to store the data and can be used for future reference. Recent days Electronic Health records are utilized in hospitals. Data transmission is used in Telemetric systems, where data can be transmitted from one location to another remotely.

What is a Biochip?

A biochip is a set of diminished microarrays that are placed on a strong substrate that allows many experiments to be executed at the same time to obtain a high throughput in less time. This device contains millions of sensor elements or biosensors. Not like microchips, these are not electronic devices. Each and every biochip can be considered as a microreactor that can detect a particular analyte like an enzyme, protein, DNA, biological molecule or antibody. The main function of this chip is to perform hundreds of biological reactions in a few seconds like decoding genes (a sequence of DNA).

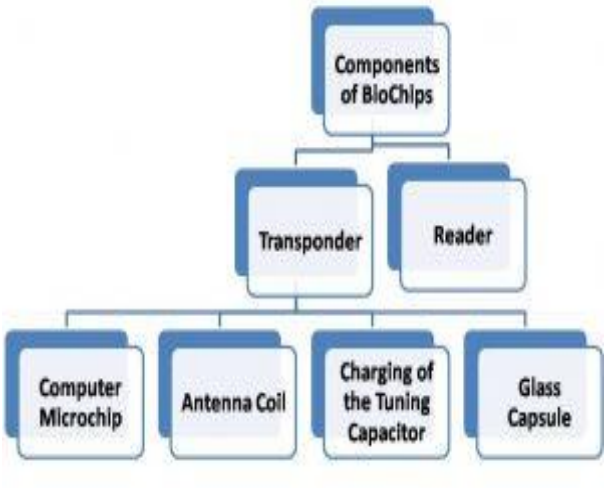
Working Principle of a Biochip:

The working of Biochip mainly includes the following steps.

1. Step1: The operator generates a low-power electromagnetic field through radio signals
2. Step2: The fixed biochip gets turn on
3. Step3: The activated chip transmits the identification code reverse to the operator through radio signals
4. Step4: Reader strengthens the received code to change it into digital form and finally exhibits it on LCD.

Components of BioChips

The Biochip comprises two components namely the transponder as well as reader.



Components of BioChips

1) Transponder

Transponders are two types' namely active transponder and passive transponder. This is a passive transponder which means that it doesn't contain any of its own energy or battery whereas in passive, it is not active until the operator activates it by giving it a low electrical charge. This transponder consists of four parts such as antenna coil, computer microchip, glass capsule, and a tuning capacitor.

- The computer microchip stores a unique identification (UID) number that ranges from 10 digits to 15 digits long.
- The antenna coil is very small, primitive and this type of antenna is used to send and receive the signals from the scanner or reader.
- The charging of the tuning capacitor can be done with the small signal i.e, 1/1000 of a watt which is sent by the operator.
- The glass capsule holds the antenna coil, capacitor, and microchip, and it is made with a biocompatible material namely soda lime glass.

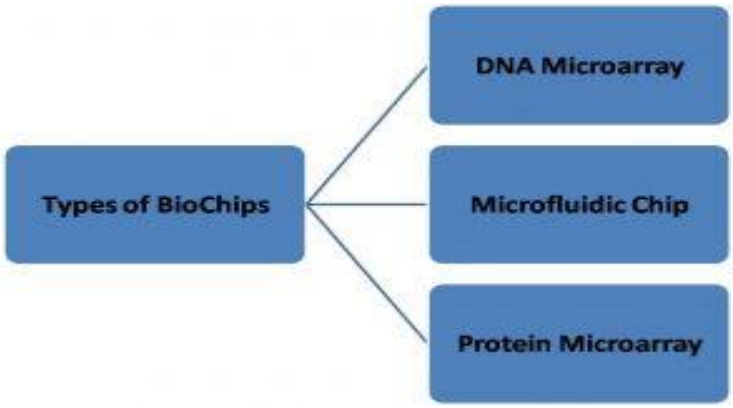
2) Reader

The reader comprises of a coil namely "exciter" and it forms an electromagnetic field through radio signals. It offers the required energy (<1/1000 of a watt) to activate the biochip. The

reader carries a receiving coil for receiving the ID number or transmitted code sent back from the excited implanted biochip.

Types of BioChips

There are three types of Biochips available namely DNA microarray, microfluidic chip, and protein microarray.



Types of BioChips

1) **DNA Microarray**

A DNA microarray or DNA biochip is a set of tiny DNA spots fixed to a strong surface. A researcher utilizes to calculate the expression levels for a large number of genes. Every DNA mark comprises picomoles of particular genes which are termed as probes. These can be a short segment of a genetic material under high rigidity situations. Usually, probe-target hybridization is noticed and counted by recognition of fluorophore or chemiluminescence labeled targets to decide the relative quantity of nucleic acid series in the target. Innovative arrays of nucleic acid were macro arrays about 9 cm X 12 cm and the initially automated icon based analysis was published in the year 1981.

2) Microfluidic Chip

Microfluidic biochips or lab-on-a-chip are a choice to usual biochemical laboratories and are transforming several applications like DNA analysis, molecular biology procedures, proteomics which is known as the study of proteins and diagnostic of diseases (clinical pathology). These chips are becoming more complex by using 1000’s of components, but

those components are designed physically called as bottom-up full-custom plan, which is a very large workforce.

3) Protein Microarray

A protein microarray or protein chip method is used to follow the actions as well as connections of proteins, and to find out their function on a large scale. The main advantage of protein microarray is that we can track a large number of proteins in parallel. This protein chip comprises of a surface for supporting like microtitre plate or bead, nitrocellulose membrane, the glass slide. These are automated, rapid, economical, very sensitive, consumes less quantity of samples. The first methodology of protein chips was introduced in antibody microarrays of scientific publication in the year 1983. The technology behind this chip was quite easy to develop for DNA microarrays, which have turned into the most generally used microarrays.

Biochips Advantages and Disadvantages

The advantages of biochip include the following.

- The biochip is used to rescue the sick
- Very small in size, powerful and faster.
- Biochips are useful in finding the lost people
- Biochips can be used to identify the persons individually
- Biochips perform thousands of biological reactions in a few seconds.