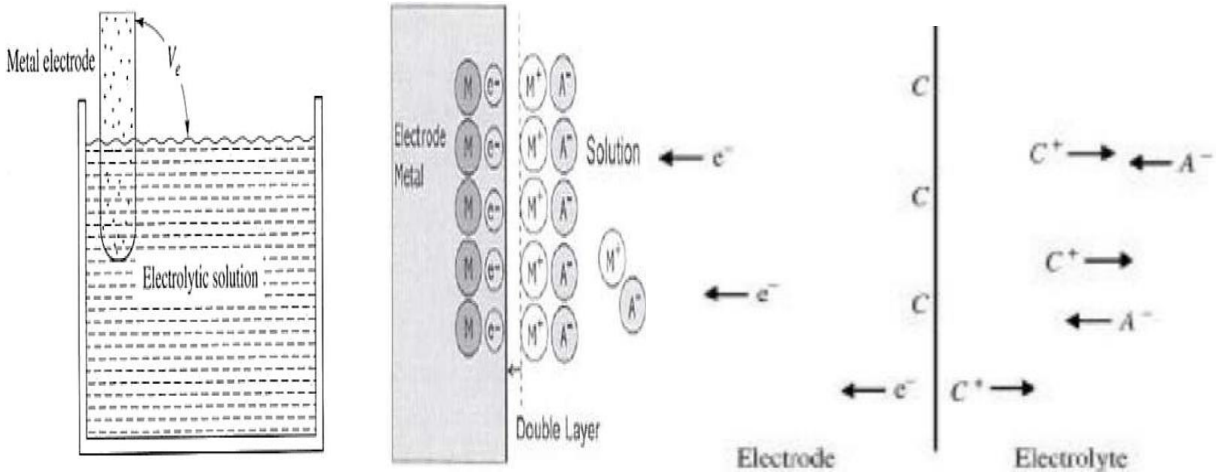
ELECTRODES

Electrodes are devices that convert ionic potentials into electronic potentials. The type of electrode used for the measurements depends on the anatomical location of the bioelectric event to be measured. In order to process the signal in electronic circuits, it will be better to convert ionic conduction into electronic conduction.



Electrode Theory

To measure bioelectric potentials, a transducer is required. Electrical signals produced by various body activities are used in monitoring / diagnosis.

• In order to measure and record potentials and, hence, currents in the body, it is necessary to provide some interface between the body and the electronic measuring apparatus. Bio-potential electrodes carry out this interface function.

• A transducer consists of two electrodes, which measure ionic potential difference between two points.

• The designation of the Bio potential waveform ends with "Gram". The name of the instrument bio potential normally ends with "Graph". Propagation of action potential through different body tissues produces final waveform recorded by electrodes

• Electrical activity is explained by differences in ion concentrations within the body (sodium, Na+; chloride, Cl–; potassium, K+). A potential difference (voltage) occurs between 2 points with different ionic concentrations

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Nernst Relation

- It can be shown that an electric potential *E* will exist between the solutions on either side of the membrane, based upon the relative activity of the permeable ions in each of these solutions. This relationship is known as the Nernst equation.
- The relationship between the ionic concentration (activity) and the electrode potential is given by the Nernst equation:
- When no electric current flows between an electrode and the solution of its ions or across an ion permeable membrane, the potential observed should be the half-cell potential or the Nernst potential, respectively. If, however, there is a current, these potentials can be altered.

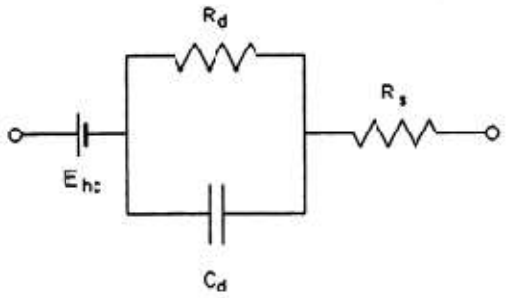
$$E = -\frac{RT}{nF}\ln\left(C1F1 / C2F2\right)$$

where

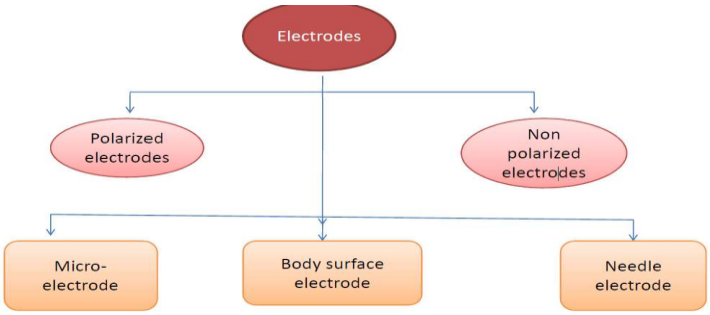
R –	universal gas constant [8.31 J/(mol K)]
T –	absolute temperature in K
n –	valence of the electrode material
F –	Faraday constant [96,500 C/(mol/valence)
C1,C2-	Concentration of ion on either side of membrane
f1,f2-	Respective activity coefficientsof ionson either side

Equivalent circuit for bio-potential electrode

- Where Rd and *Cd* are components that represent the impedance associated with the electrode-electrolyte interface and polarization at this interface.
- *Rs* is the series resistance associated with electrode materials.
- The battery Ehc represents the half-cell potential



Classification of Electrodes



Electrode is an interface to connect the measurement devices and measure bioelectrical potentials, electrode is used as an interface, however. The electrode is also a transducer

Perfectly Polarizable Electrodes

– Perfectly polarizable electrodes are those in which no actualcharge crosses the electrode–electrolyte interface when acurrent is applied.

–there has to be current across the interface and theelectrode behaves as though it were a **capacitor**

Perfectly Polarizable Electrodes or Perfectly Reversible

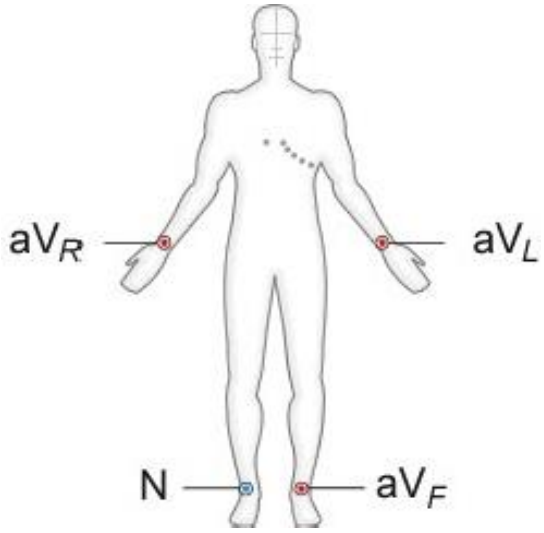
– Perfectly non-polarizable electrodes are those in which currentpasses freely across the electrode–electrolyte interface,requiring no energy to make the transition.

– Thus, for perfectly non-polarizable electrodes there are no overpotentials.

– Electrode interface impedance is represented as a **resistor**

Limb Electrodes

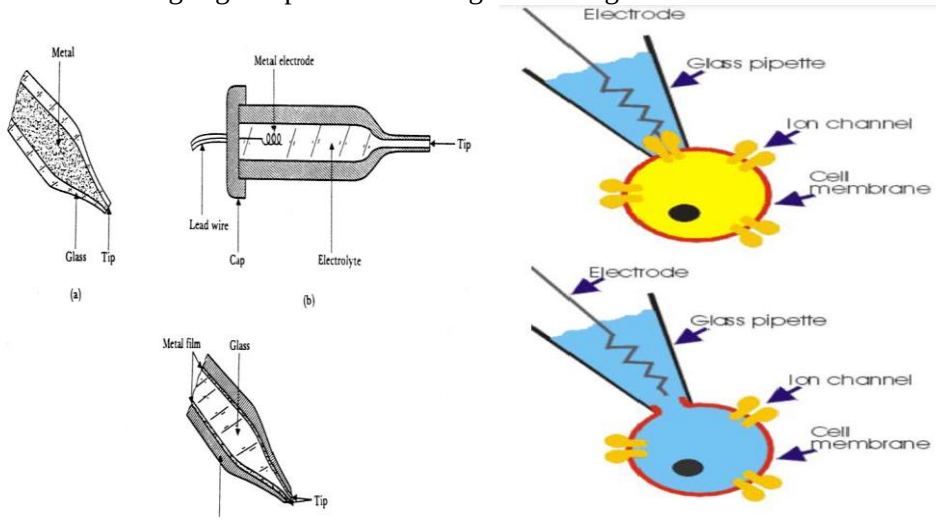
Limb leads are made up of 4 leads placed on the extremities: left and right wrist; left and right ankle.
The lead connected to the right ankle is a neutral lead, like you would find in an electric plug. It is there to complete an electrical circuit and plays no role in the ECG itself.



Micro Electrodes

Microelectrodes are electrodes with tips having tips sufficiently small enough to penetrate a single cell in order to obtain readings from within the cell.

- The tips must be small enough to permit penetration without damaging the minute cell.
- The main functions of microelectrodes are potential recording and current injection.
- Microelectrodes are having high impedances in mega ohm range because of their smaller size.



Types

- Metal microelectrode
- Micropipette

Metal microelectrode

Metal microelectrodes are formed by electrolytic ally etching the tip of fine tungsten to the desired size and dimension.
Then the wire is coated almost to the tip with any type of insulating material.
The metal-ion interface takes place where the metal tip contacts the electrolyte

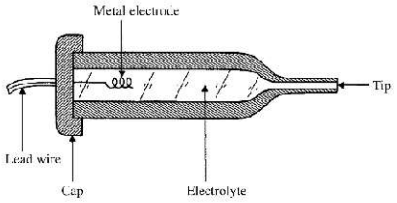
The main features of metal microelectrodes are
1. Very good S/N ratio
2. Strong enough to penetrate
3. High biocompatibility

Micropipette

The micropipette type of microelectrode is a glass micropipette with its tip drawn out to the desired size

The micropipette is filled with an electrolyte which should be compatible with the cellular fluids

A micropipette is a small and extremely fine pointed pipette used in making microinjections.

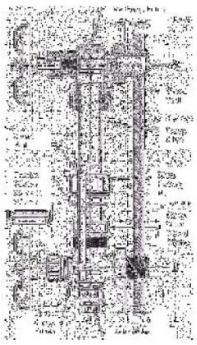


Surface Electrodes

Surface electrodes are those which are placed in contact with the skin of the subject in order to obtain bioelectric potentials from the surface.

• Body surface electrodes are of many sizes and types. In spite of the type, any surface electrode can be used to sense ECG, EEG, EMG etc.

Immersion electrodes

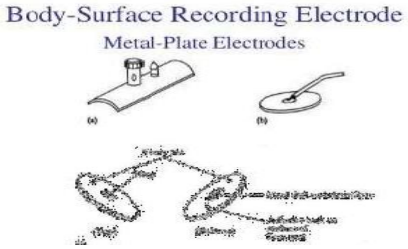


They are one of the first type of bioelectric measuring electrodes.

• Immersion electrodes were simply bucketing of saline solution in which the subject placed his hands and feet.

• So, it was not a comfortable type of measurement and hence it was replaced with plate electrodes.

Plate electrodes

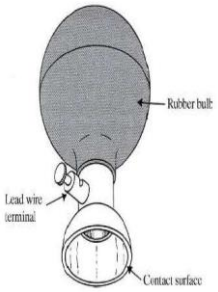


• The plate electrodes have generally smaller contact area and they do not totally seal on the patient.
• The electrode slippage and displacement of plates were the major difficulties faced by these types of electrodes because they have a tendency to lose their adhesive ability as a result of contact with fluids on or near the patient.
• Since these types of electrodes were very sensitive, it led to measurement errors

Disposable electrodes

Normally plate electrodes, floating electrodes etc can be used more than one time.
• This requires the cleaning and cares after each use.
• We can use disposable electrodes which can be used only once and be disposed after the use.
• These types of electrodes are now widely used

Suction electrodes



These types of electrodes arewell suited for the attachment toflat surfaces of body and toregions where the underlyingtissue is soft, due to thepresence of contact surface.
• An advantage of these type ofelectrodes is that it has a smallsurface area.
• These types of electrodes aremainly used for themeasurement of ECG.
• Suction electrodes used a plasticsyringe barrel to house suctiontubing and input cables to an ACamplifier

Ear clip & Scalp electrodes:

These types of electrodes are widely used in the measurement of EEG exclusively.

- Scalp electrodes can provide EEG easily by placing it over bare head. A typical ear clip electrode is shown in figure below.
- The most common method for EEG measurement is 10 – 20 electrode placement system and here we use scalp electrode usually.

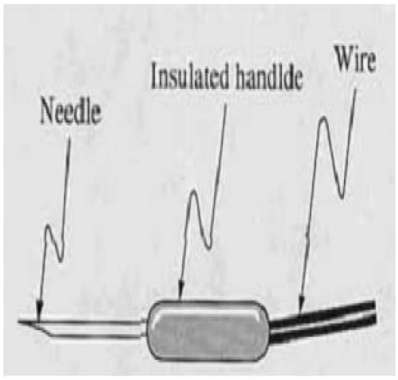
- They can avoid measurement errors and movement errors. During labour internal monitoringmay be needed and is usually in the form of an electrode placed under the baby's scalp.
- It is called fatal scalp electrode which is used to monitor baby's heartbeat while still in uterus.

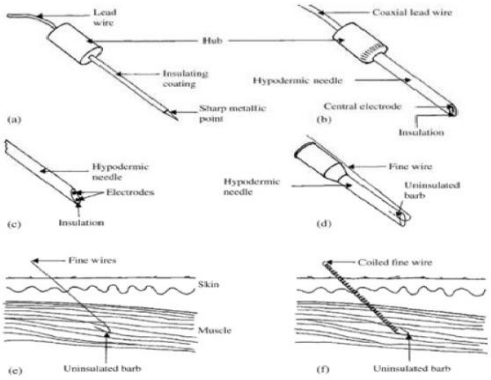
Needle Electrodes

To reduce the interface and noise (artifact) caused due to electrode movement, during the measurement of EEG, EMG etc we can use small sub-dermal needle electrodes which penetrate the scalp.

• The needle electrodes are not inserted into the brain. They nearly penetrate the skin; they are simply inserted through a small section of the skin just beneath the skin parallel to it.

The needle electrodes for EMG measurement consist of fine insulated wires placed in such away that their tips are in contact with themuscle, nerve or other tissues from which themeasurement is made. The needle creates thehole necessary for insertion and the wiresforming the electrodes are carried inside it.





One of the main advantages of needle electrodes is that they are less susceptible to movement errorsthan surface electrodes.

• The needle electrodes have lower impedances when compared to surface electrodes as it makes direct contact with the sub-dermal tissues or intracellular fluid.