Transducers & Instrumentation

Module 06

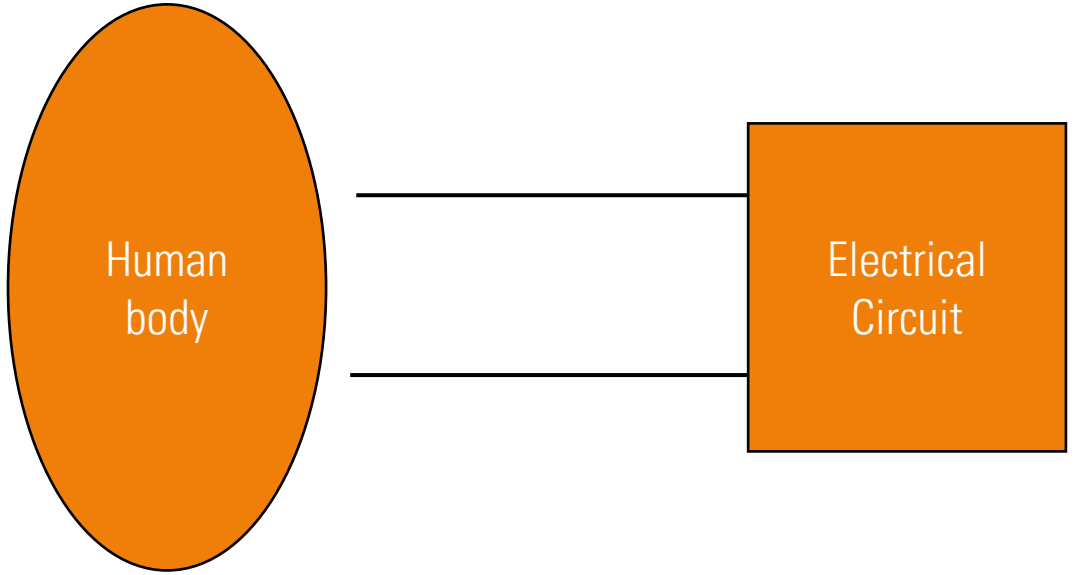
Biopotential Electrodes

Biopotential sources in the body

- The body is a good conductor of electricity.
- There are several biological sources of biopotentials.
- Every cell has an electric potential difference across its cell membrane.
- This potential can change transiently in excitable cells such as nerves and muscles → This results in volume conduction in the body → Potential distribution within and on the surface of the body.
- These current sources are the driving forces behind all electrical activity recorded from different tissue: EEG, EMG, ECG, EOG, ECoG, etc.
- Currents within the body are due to the flow of ions in the body fluids.

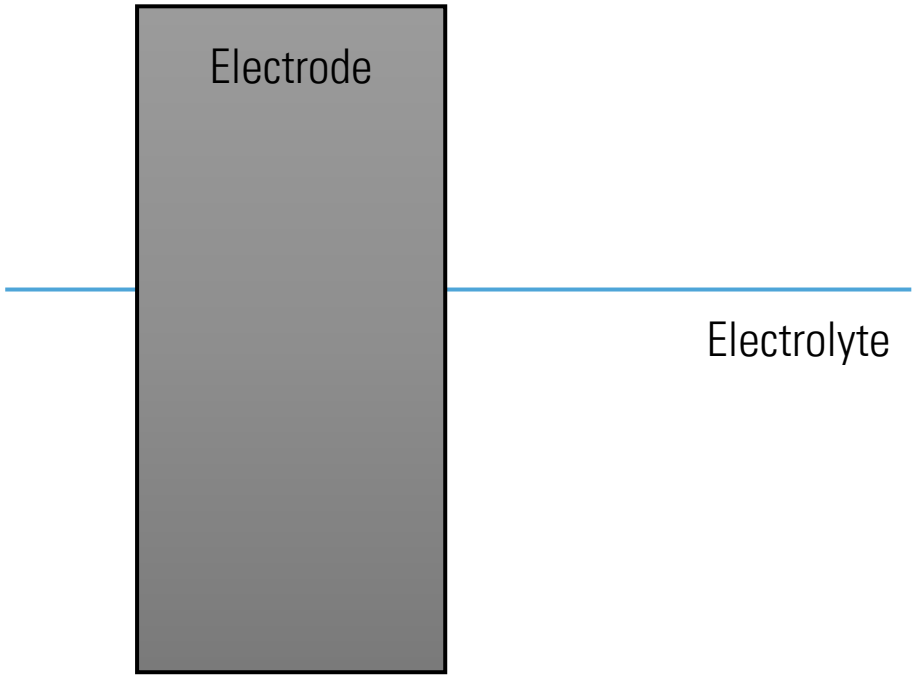
Biopotential electrodes as transducers of currents

- Electrical currents in circuits is due to the flow of electrons.



- Biopotential electrodes act as transducers that convert ionic current to electronic current and vice versa.

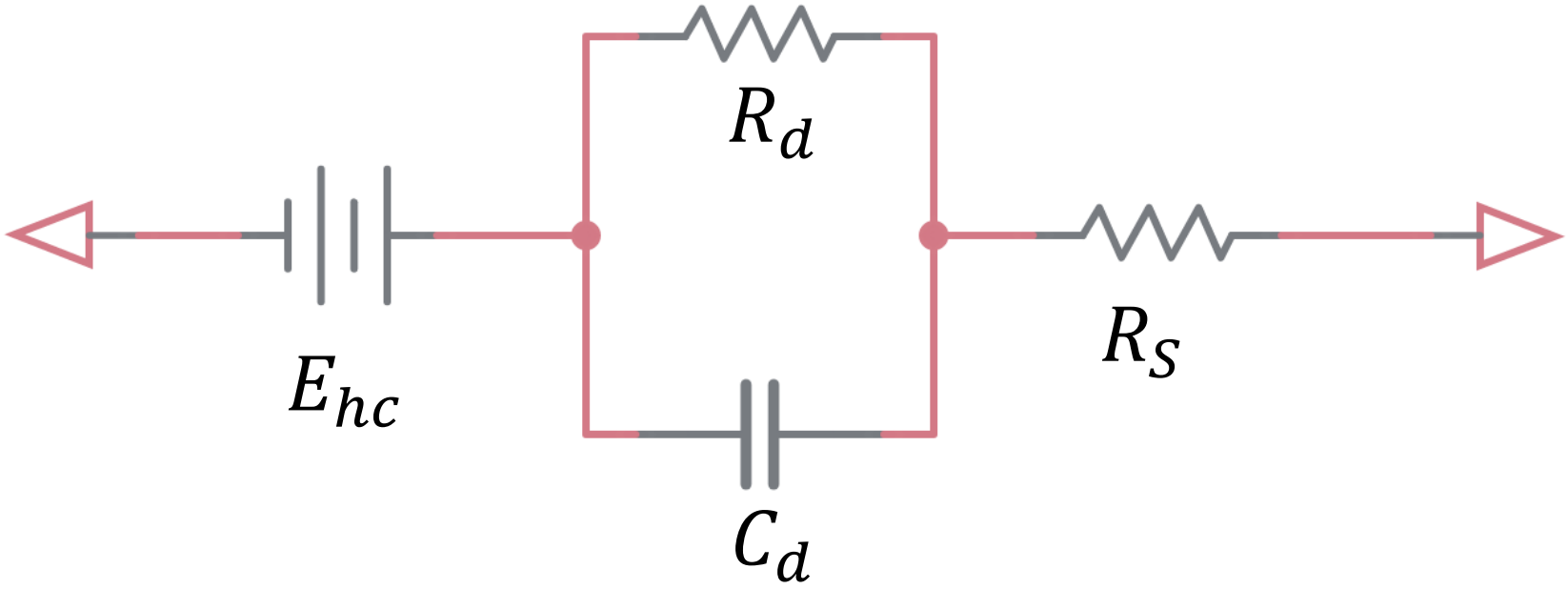
Basic electrochemistry



$$C \leftrightarrows C^{n+} + ne^{-}$$

Half-Cell Potential

Biopotential electrode equivalent circuit

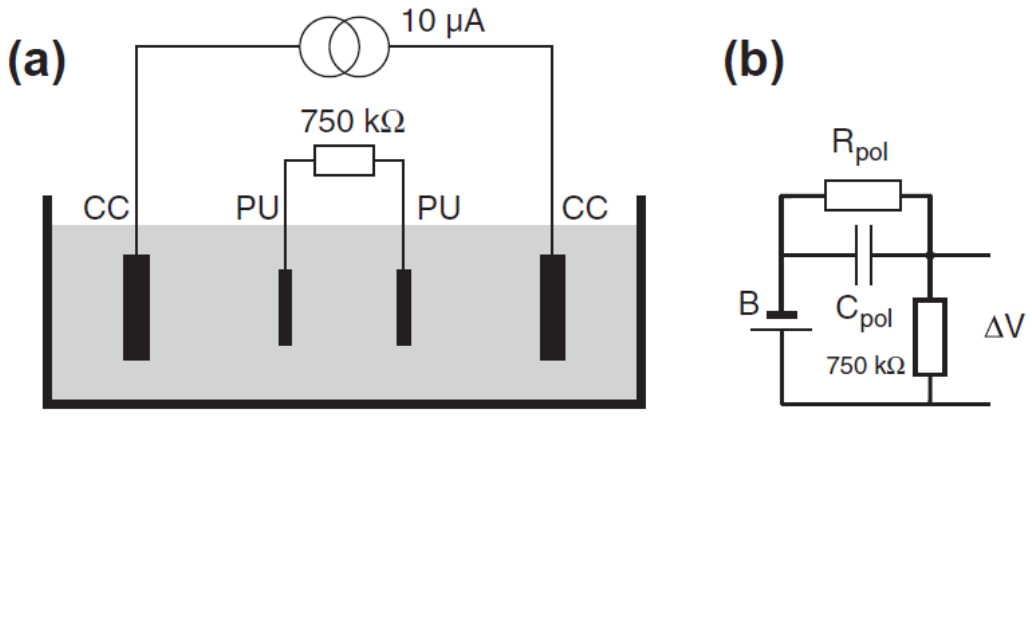


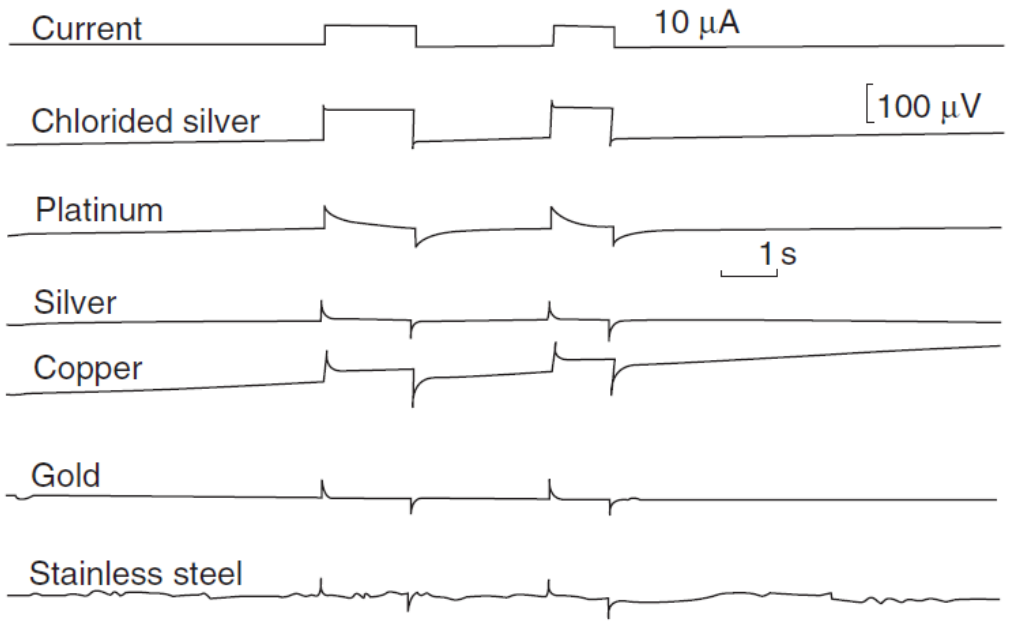
Polarizable and Non-polarizable Electrodes

- Nature of current flow through the electrodes.
- **Ideally Polarizable electrodes.**
  - No actual current flows across the electrode-electrolyte interface.
  - Electrode acts as a capacitor.
  - E.g. Platinum electrode

- **Ideally Non-polarizable electrodes.**
  - Current flows through the electrode-electrolyte interface.
  - Electrode acts as a short.
  - E.g. Ag-AgCl electrode.

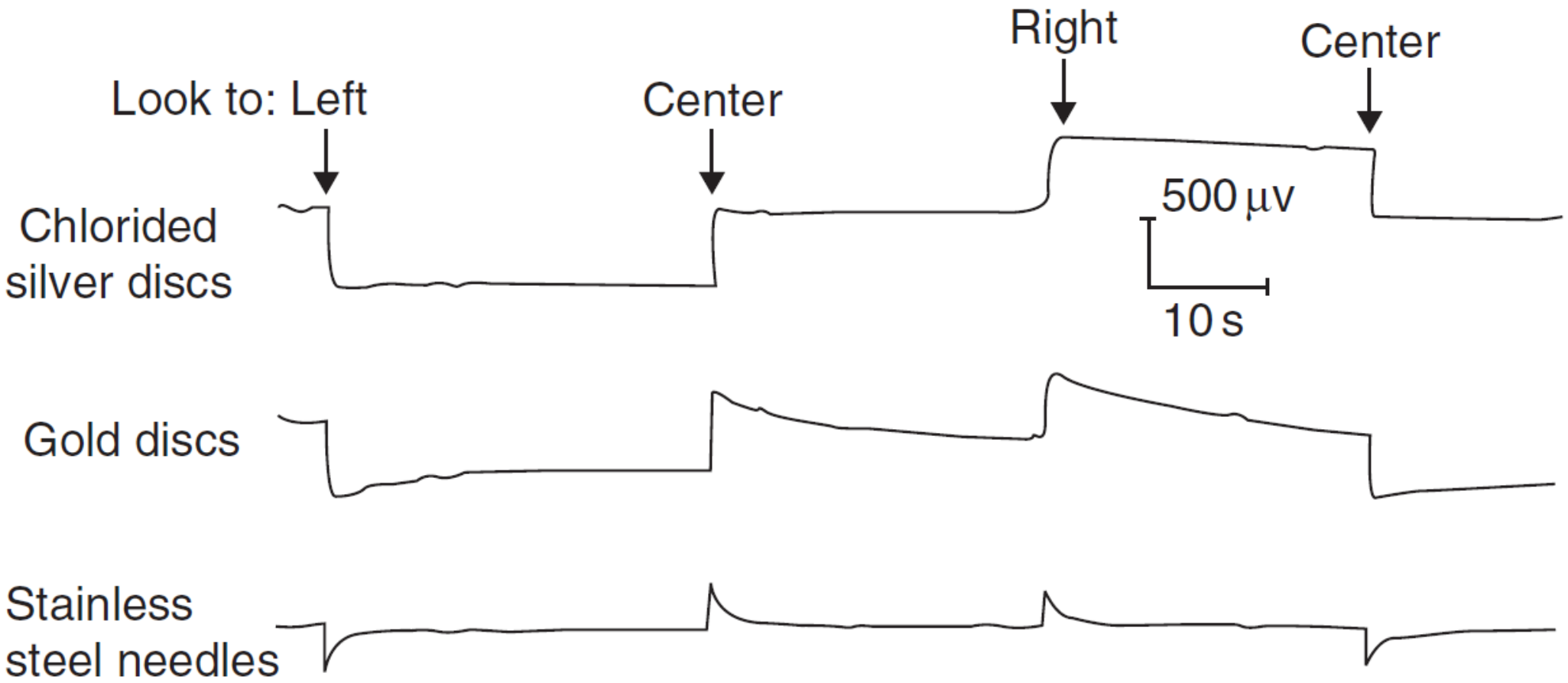
Polarizable vs. Non-polarizable electrode





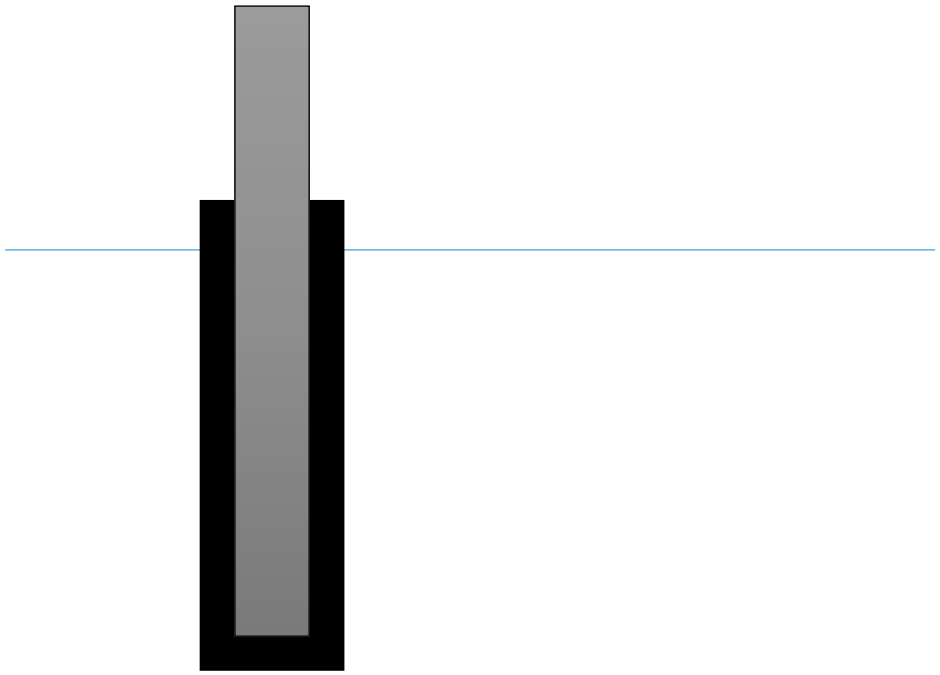
Grimnes, Sverre, and Orjan G. Martinsen. *Bioimpedance and bioelectricity basics*. Academic press, 2011.

Polarizable vs. Non-polarizable electrode

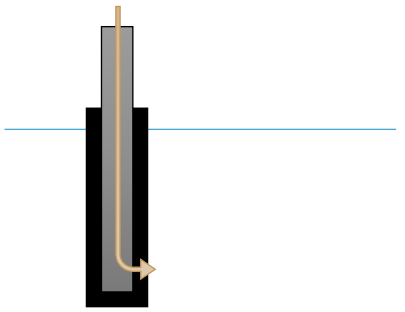


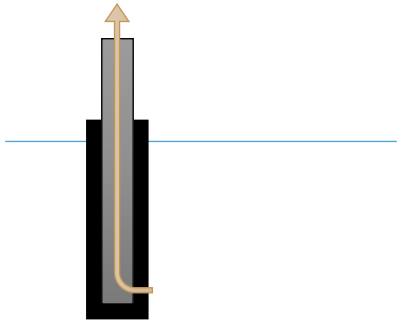
Grimnes, Sverre, and Orjan G. Martinsen. *Bioimpedance and bioelectricity basics*. Academic press, 2011.

Ag-AgCl Electrode



- Silver metal with AgCl coating.
- AgCl layer provides the Chloride ions for converting electronic current to ionic current.

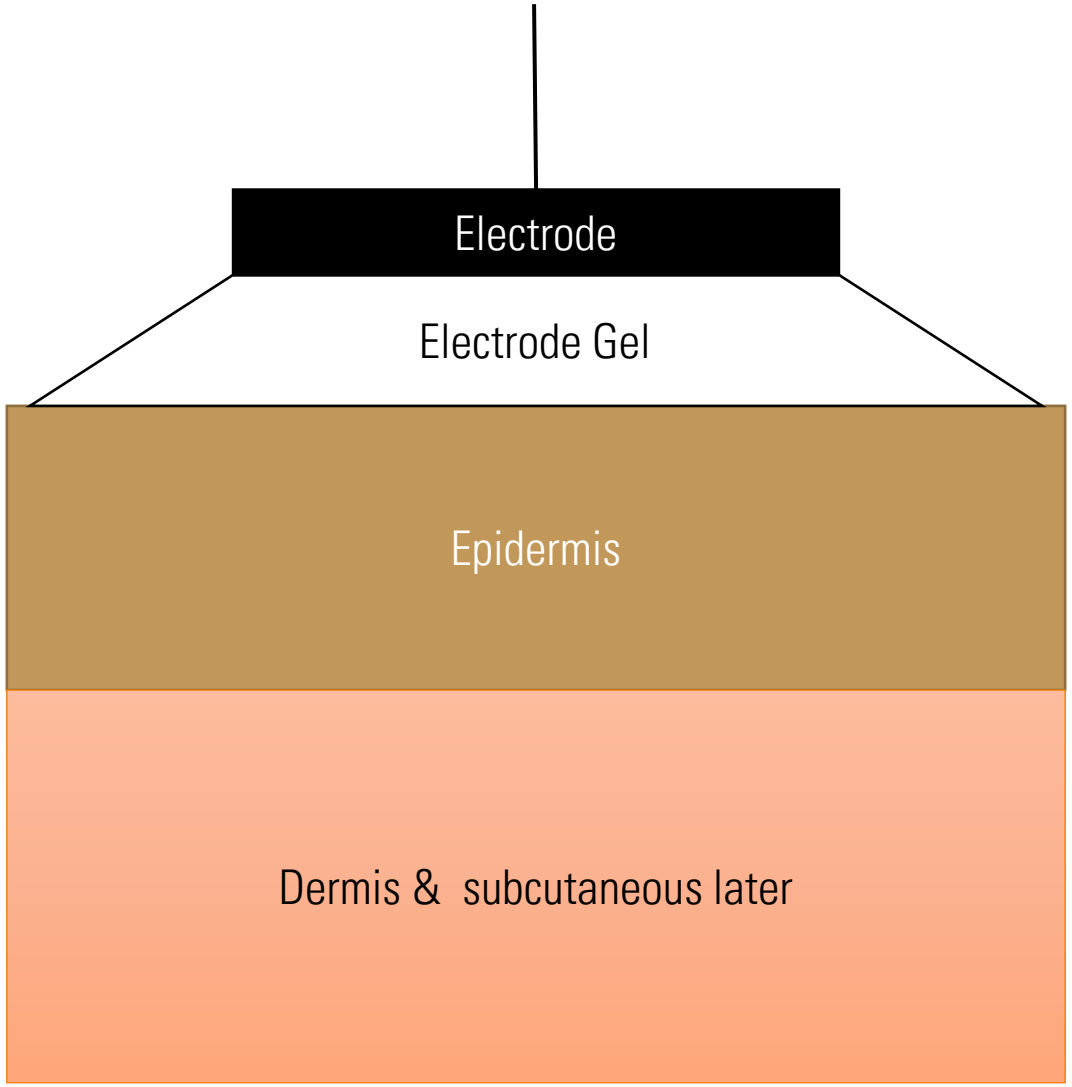




Ag-AgCl Electrode

- Has a half cell potential of 0.23V.
- Provide stable recordings compared to Ag electrodes.
- Use commonly for recording biopotentials from the surface of the body.
- AgCl deposition on the metal is done through electroplating or through sintering.

Electrode-Skin Interface



Electrodes for stimulation of tissue

- Same principle as recording electrodes but deal with larger current density.
- Net current crossing the electrode-electrolyte interface might not be zero.
- The nature of the electrodes used must consider the nature of the chemical reactions at the interface.
  - Oxidation of the metal can lead to toxic ions in the body.
  - Use of noble metals at high current density/voltage can result in electrolysis at the electrodes.
  - Ag/AgCl electrodes can lead to change in local electrolyte concentration underneath the electrode.