Definitions

- **Ion**  Charged particle (molecule / atom)
  - Cation  + Ion
  - Anion  - Ion

- **Oxidation**  Loss of e⁻ by molecule / atom / ion
- **Reduction**  Gain of e⁻ by molecule / atom / ion
- **Electrolyte**  Solution containing ions

Polarizable Electrodes

- No chemical reaction / electron / ion exchange
- Charge accumulates on surface of electrode like a capacitor

- High pass filter
- Biosignals: (high or low frequency?)
  - EKG : 150 Hz
  - EEG : 50 Hz
  - EMG : 20 Hz
Percutaneous Electrodes

- Polarizable
- Hook minimizes motion artifact
- Pull hard to remove

Non-Polarizable Electrodes

- Metal + neutral electrolyte (containing the metal)
  - Concentration grad
  - Diffusion current
    - Ions: metal to gel
    - Electrons: gel to metal
  - Half-cell Potential ($V_{hc}$)
    - Steady state charge at metal/electrolyte boundary
Current Carriers

- **Body**
  - Na\(^+\) ions
  - K\(^+\) ions
  - Cl\(^-\) ions
    - Present but not involved in nerve stimulation

- **Electric Circuit**
  - Electrons e\(^-\)
  - Holes h\(^+\)

- **Electrode**
  - Electron / ion transducer

Equivalent Impedance

- CJ = junction capacitance
- RJ = junction resistance
- RE = electrolyte resistance
Measured Electrode Impedance

Fig 5.6 (MI): Experimentally Determined Impedance

Measured Electrode Impedance

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Electrode Frequency Response

\[
Z(s) = (R_E + R_j) \frac{s}{R_E R_j C_j} \left(1 + \frac{s}{R_j C_j} \right)
\]

\[
Z(s) \approx R_j \frac{1}{s R_E C_j} \frac{1}{1 + \frac{1}{R_j C_j}}
\]

Electrode Properties

- **NonPolarizeable**
  - Sweat reacts with electrolyte (AgCl)
  - Motion artifact

- **Polarizeable**
  - Percutaneous (crosses skin boundary)
  - Invasive
  - Reduced motion artifact
  - SS, Platinum or Gold plated