Nerve action potential and conduction

- Resting potential
- Action potential
- Local potential

Resting potential

Injury potential 19th century

Membrane theory Bernstein 1902

\[ E = \frac{RT}{ZF} \ln \frac{[\text{Ion}]_o}{[\text{Ion}]_i} \]

Nernst equation

Hodgkin & Huxley

1. Giant axon intracellular recording 1939
2. Goldman equation

Nongated ion channels
**Action potential**

Excitability

*Excitation*

- Nerve cells, Muscle cells, Secretory cells
- **Stimuli**
  - Electric stimulus
  - *Stimulation Parameters:*
    - Intensity
    - Duration
    - Time-base ratio

*Strength-duration curve* — *Excitability*

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**Action potential (AP)**

1. **“all or none”**
2. **Refractory period**

**Mechanics**

- **Ionic theory** 1949

- **Sodium pump**

- **TTX**
- **TEA**
- Voltage-gated Na⁺ channel
- Voltage-gated K⁺ channel

- **Resting** — Active — Inactive
  - (close) — (open)

- **Positive feedback**
  - Depolarization
    - Inward Na⁺ current
      - $P_{Na⁺}$
      - the peak close to $E_{Na}$

- **Repolarization**

- **Voltage clamp** 1950s
- **Hodgkin & Huxley**
- **Patch clamp** 1970s
- **Neher & Sakmann**
Local potential
- Local
- Not "all or none"
- Summation

Propagation of the AP
- "All or none"
- In one direction

Local current theory
- Unmyelinated axons: slow
- Myelinated axons: Saltatory conduction, fast

Conduction velocity

Compound action potential
- Nerve trunks
  - Biphasic AP & Monophasic AP
  - Graded with stimulus strength
  - Different peaks visible

Summary:
- RP
- AP "all or none" ①②
- Refractory period
- Threshold potential, threshold stimulus
Human and animal physiology; Action potential
Human and animal physiology; Action potential

[Graph 1: Minimal stimulation time vs. intensity of stimulus.]

[Graph 2: Membrane potential (mV) vs. time.]

- Overshoot
- Rising phase
- Peak
- Repolarization
- Threshold
- After-hyperpolarization
- Resting level
Human and animal physiology; Action potential
Human and animal physiology; Action potential
Human and animal physiology; Action potential
Human and animal physiology; Action potential

Diagram A: Ion current vs. time (msec) showing the inward and outward currents, $I_{Na} + I_{K}$.

Diagram B: Ion current vs. time (msec) showing the inward current $I_{Na}$ and the outward current $I_{K}$.
Human and animal physiology; Action potential
Human and animal physiology; Action potential
Human and animal physiology; Action potential
Human and animal physiology; Action potential
Human and animal physiology; Action potential
Human and animal physiology; Action potential
Human and animal physiology; Action potential