# NERVE FIBERS:
## CLASSIFICATION AND PROPERTIES

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# Classification of nerve fibres

| | |
|---|---|
| **Structural** | Medullated / myelinated<br>Non-medullated or unmyelinated |
| **Functional** | Afferent /interneuron /efferent |
| **Origin basis** | Cranial and spinal |
| **NT basis** | Cholinergic /Adrenergic /Dopaminergic |
| **Sensory** | Group- *1, 2, 3 and 4* |
| **ERLANGER GASSER** | A (alpha, beta, gamma, theta),<br>B and C |

## Scientists contributed

***Joseph Erlanger***
*(1874–1965)*

***Herbert S. Gasser***
*(1888–1963)*

The **Nobel Prize in Physiology or Medicine for the year 1944** was awarded jointly to two neurophysiologists from USA, **Joseph Erlanger** and **Herbert Spencer Gasser,** *"for their discoveries relating to the highly differentiated functions of single nerve fibers".* They worked extensively on nerve fiber types and the classification of nerve fibers is named after them '**Erlanger-Gasser classification**').

Comprehensive textbook of Physiology, Dr. G K Pal.

# ERLANGER GASSER'S CLASSIFICATION: MOST IMPORTANT CLASSIFICATION

| | TYPE | FUNCTION | DIAMETER (MICRO METERS) | CONDUCTION VELOCITY (MTS/SEC) |
|---|---|---|---|---|
| Myelinated fibers of spinal nerves (motor & sensory) | A alpha<br>A beta<br>A gamma<br>A delta | Proprioception (A), somatic motor(E)<br>Touch, pressure (A)<br>Motor to muscle spindle (E)<br>Pain, touch, cold (A) | 12-20<br>5-12<br>3-6<br>2-5 | 70-120<br>30-70<br>15-30<br>12-30 |
| Myelinated efferent preganglionic | B | Preganglionic autonomic nerve fibers (E) | <3 | 3-15 |
| unmyelinated | C | Pain, touch, temperature (A) Postganglionic autonomic (E) | 0.4-1.2 | 0.5-2 |

## Numerical classification for sensory neurons:

| Numerical | Origin | Type |
|---|---|---|
| Ia | Muscle spindle, annulospiral ending | A alpha |
| Ib | Golgi tendon organ | A alpha |
| II | Muscle spindle, touch, pressure | A beta |
| III | Pain and temperature receptor | A delta |
| IV | Pain | Dorsal root C fibers |

# Susceptibility of nerve fibers to sensations

| SENSITIVITY TO | TYPE OF NERVE FIBER | | |
|---|---|---|---|
| | MOST SUSCEPTIBLE | INTERMEDIATE SUS. | LEAST SUS. |
| PRESSURE | A ( E.G. SITTING CROSSED LEGS, SLEEPING WITH ONE HAND BELOW HEAD) | B | C |
| HYPOXIA | B (E.G. AUTONOMIC FNS) | A | C |
| LOCAL ANAESTHETICS | C (E.G. LOCAL ANAESTHESIA) | B | A |

# NEUROTROPINS (NERVE GROWTH FACTOR):

## 1) Nerve growth factor

First growth factor to be isolated.
Present in salivary glands, plasma and other tissues.
Transported in retrograde fashion

2) Brain derived neurotrophic factor
3) Neurotropins 3, 4 & 5.

Other growth factors are:
Insulin like growth factor I
Fibroblast growth factor
Platelet derived growth factor
Ciliary neurotrophic factor
Glial cell like neurotrophic factor
Leukemia inhibitory factor
Transforming growth factor

# PROPERTIES OF NERVE FIBERS

- EXCITABILITY: CHRONAXIE, RHEOBASE, ACTION POTENTIAL
- CONDUCTIVITY: SALTATORY CONDUCTION
- REFRACTORY PERIOD: ABSOLUTE/RELATIVE

* SUMMATION r
* ACCOMODATION

- INFATIGABILITY
- ALL OR NONE LAW

# EXCITABLE TISSUES– NERVE & MUSCLE

**Excitability- if adequate stimulus is applied, action potential (ap) or impulse is produced**

**Stimulus - stimulus is defined as any change in the environment that elicits response from the excitable tissue. Types of stimuli are thermal, mechanical, chemical, electrical.**

## RHEOBASE

The minimum strength of current (when allowed to pass through the excitable tissue for infinite length of time) which can excite the excitable tissue, is called a rheobase.
Time taken by rheobasic current to stimulate excitable tissue is called utilization time.

## CHRONAXIE

Minimum time required to stimulate the excitable tissue when strength of the current used is double the rheobase is called chronaxie
Chronaxie measures excitability, lesser the chronaxie more the excitability.
Large myelinated nerve fiber is the most excitable tissue in the body and have least chronaxie

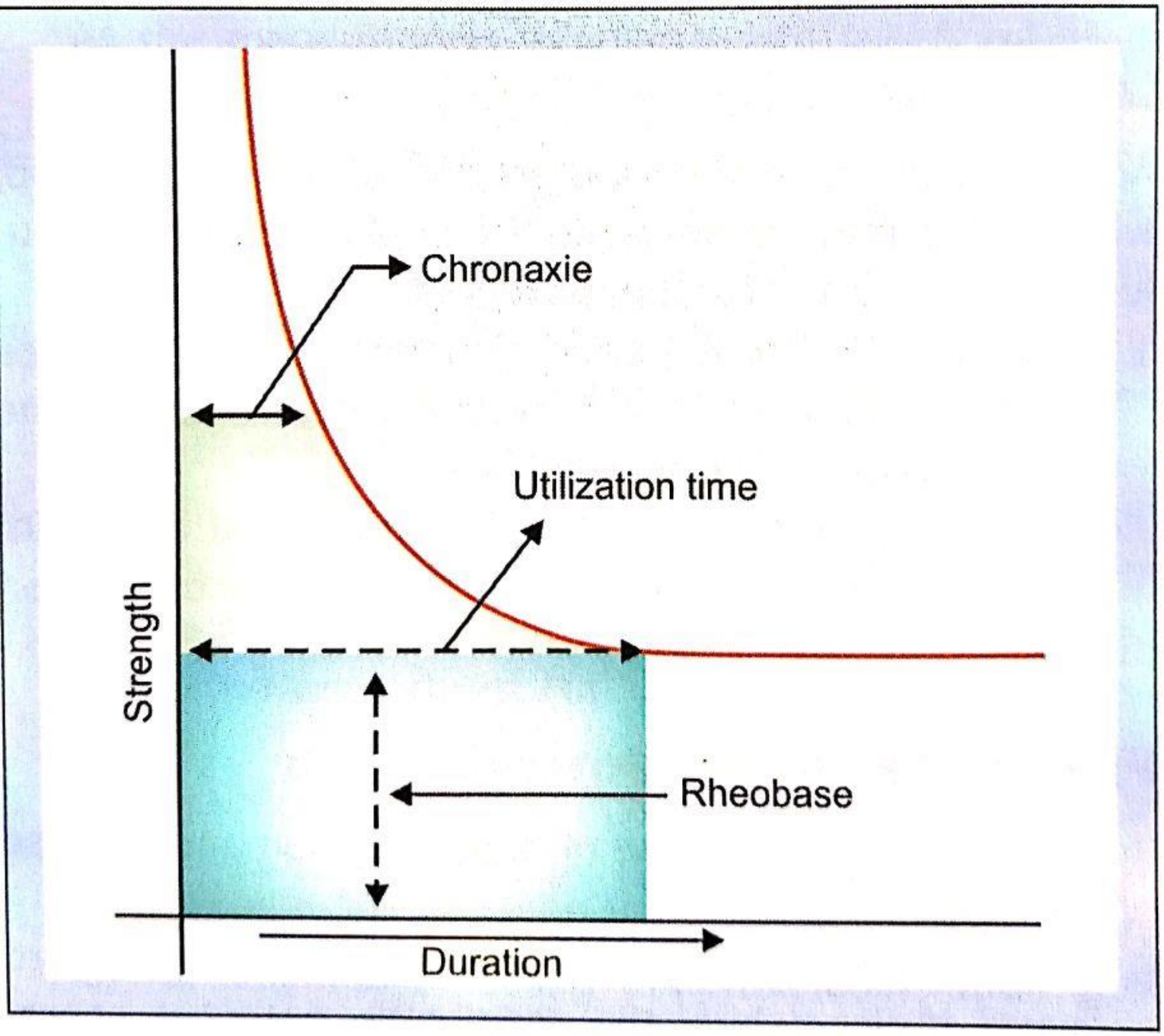



**Fig. 23.2:** Strength-duration curve.

Comprehensive textbook of Physiology, Dr. G K Pal.

# LOCAL POTENTIAL, ELECTROTONIC POTENTIAL

- SUBTHRESHOLD STIMULUS
- SMALL AMOUNT OF VOLTAGE GATED Na+ CHANNELS OPEN
- FIRING LEVEL OF -60MV IS NOT REACHED.
- POSITIVE SIDE=DEPOLARIZING :CATELECTROTONIC POTENTIAL) OR
- NEGATIVE SIDE= HYPERPOLARIZING ANELECTROTONIC POTENTIAL.
- E.G. EPSP, IPSP, RECEPTOR POTENTIAL, PACEMAKER POTENTIAL.

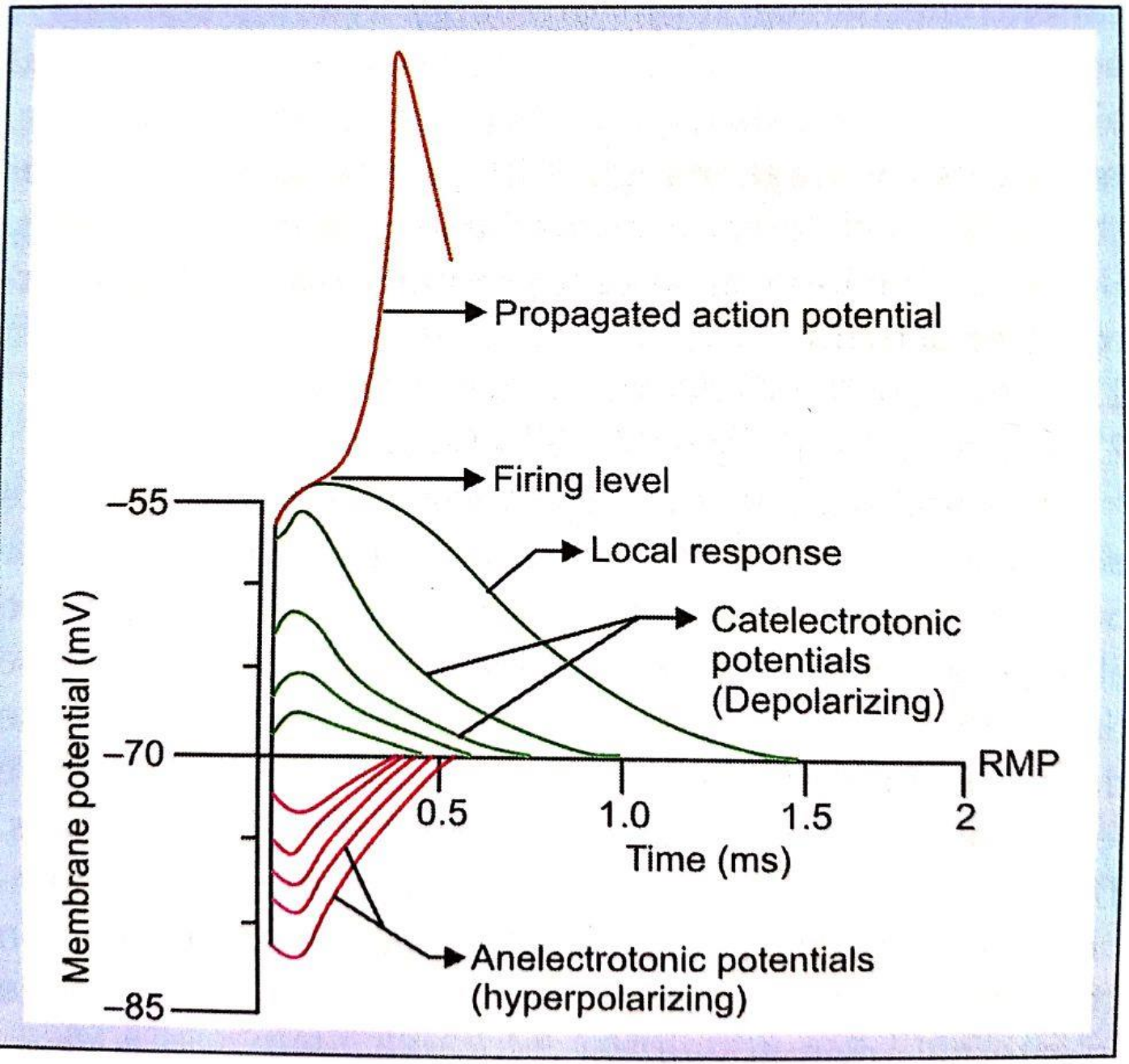



**Fig. 23.1:** Electrotonic potential and local response. (RMP: Resting membrane potential).

Comprehensive textbook of Physiology, Dr. G K Pal.

## LOCAL POTENTIAL:

- CANNOT PROPAGATE, DO NOT HAVE REFRACTORY PERIOD AND THEY DO NOT FOLLOW ALL OR NONE LAW.
- DO NOT HAVE ANY THRESHOLD OR LATENT PERIOD

## ACTION POTENTIAL:

- PROPAGATIVE, HAS REFRACTORY PERIOD AND FOLLOWS ALL OR NONE LAW.
- IT HAS THRESHOLD OR LATENT PERIOD

# INITIATION OF ACTION POTENTIAL

- IN A MOTOR NEURON ACTION POTENTIAL :BEGINS FROM THE AXON HILLOCK REGION BECAUSE VOLTAGE GATED Na+ AND K+ CHANNELS ARE MAXIMUM AT THIS PART.
- IN SENSORY NEURONS ACTION POTENTIAL BEGINS IN FIRST NODE OF RANVIER.
- THESE AREAS (AXON HILLOCK AND FIRST NODE OF RANVIER) ARE CALLED AS TRIGGER ZONES.

# Na+ CHANNELS

- IN MYELINATED NEURONS, THE NUMBER OF Na+ CHANNELS PER SQUARE MICROMETER OF THE MEMBRANE IS AS FOLLOWS-

- CELL BODY 50-75
- *AXON HILLOCK* ***350-500***
- *NODES OF RANVIER* ***2000-12000***
- AXON TERMINALS 20-75
- CHANNELS ARE MAXIMUM IN NODES OF RANVIER AND AXON HILLOCK REGION.

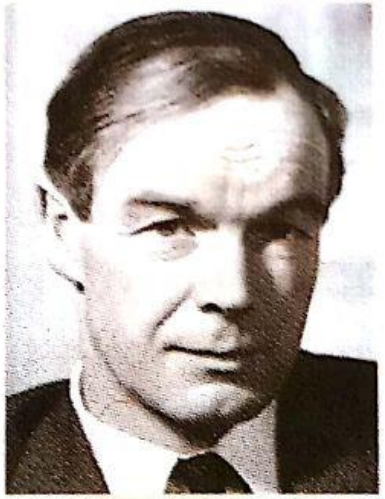
- **CHANNELOPATHIES:** THE DISEASES RESULTING IN STRUCTURAL OR FUNCTIONAL DEFECTS OF ION CHANNELS ARE CALLED CHANNELOPATHIES.

# CONDUCTION / PROPAGATION OF ACTION POTENTIAL

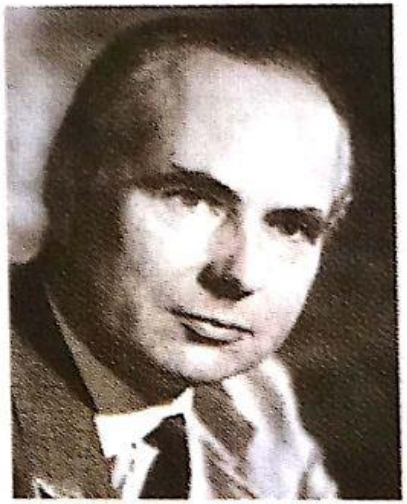
- Conducted along whole membrane in both direction without decrement.
- Circuit of current (current sink) or circular current flow : start between stimulated area and adjacent areas.
- ***Orthodromic:*** forward conduction (common)
- Antidromic: backward conduction: axon reflex

## Scientists contributed

***Sir John Carew Eccles***
*(1903–1997)*



***Alan Lloyd Hodgkin***
*(1914–1998)*



***Andrew Fielding Huxley***
*(1917–2012)*

The **Nobel Prize in Physiology or Medicine 1963** was awarded jointly to **Sir John Carew Eccles, Alan Lloyd Hodgkin** and **Andrew Fielding Huxley** "for their discoveries concerning the ionic mechanisms involved in excitation and inhibition in the peripheral and central portions of the nerve cell membrane". They worked extensively in the field of neurophysiology related to nerve impulse transmission.

Comprehensive textbook of Physiology, Dr. G K Pal.

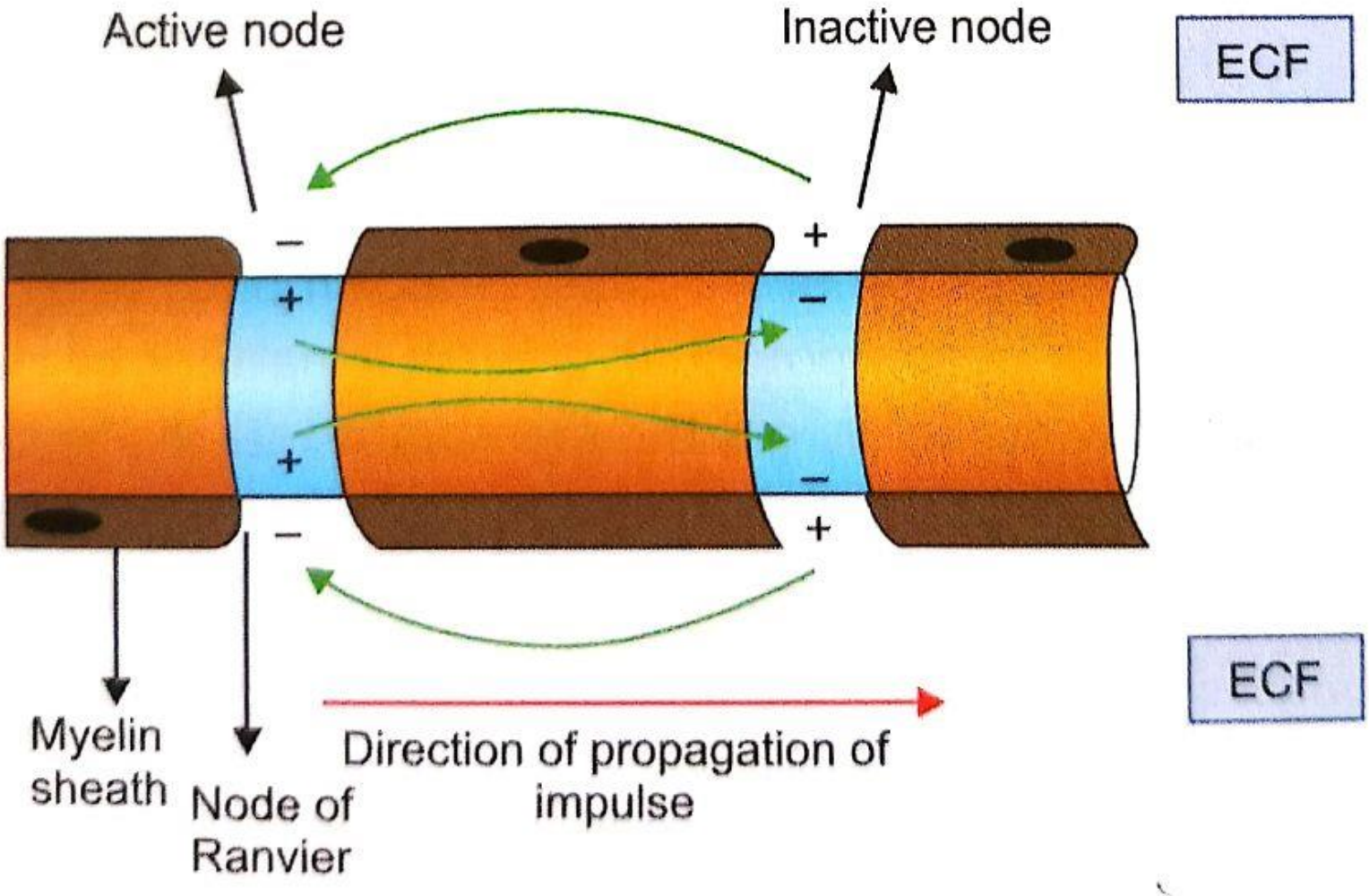



**Fig. 23.9:** Propagation of action potential in myelinated axon.

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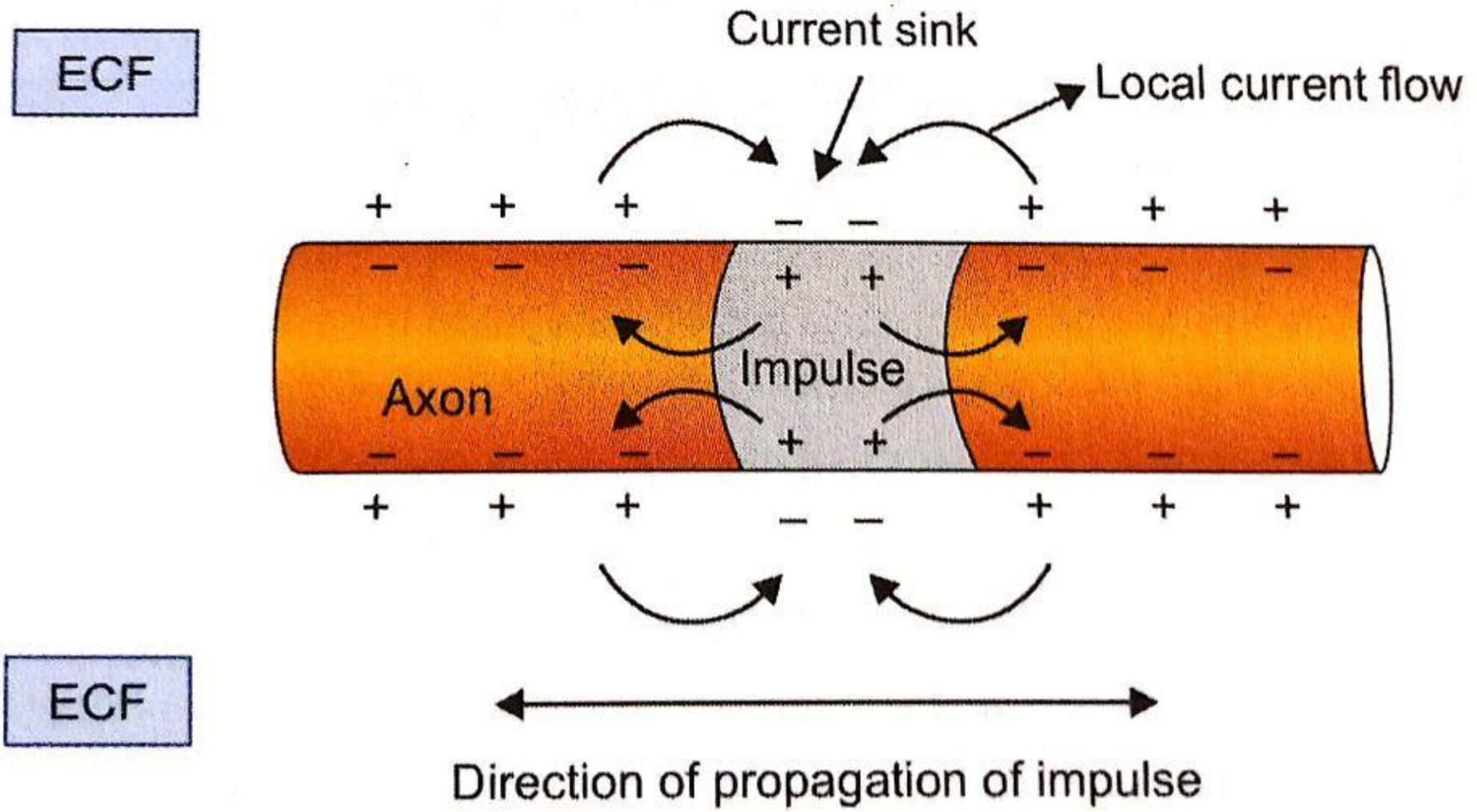


**Fig. 23.8:** Propagation of action potential in unmyelinated axon.

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# REFRACTORY PERIOD

- Refractory means non-responsive.
- The duration for which action potential is not produced due to 2nd stimulus is called refractory period.
- **absolute refractory period**:-how ever strong the strength of stimulus, the next AP is not produced. from firing level until one third of repolarization.
- **relative refractory period**:-stronger stimulus. end of ARP to 2/3rd of repolarisation.

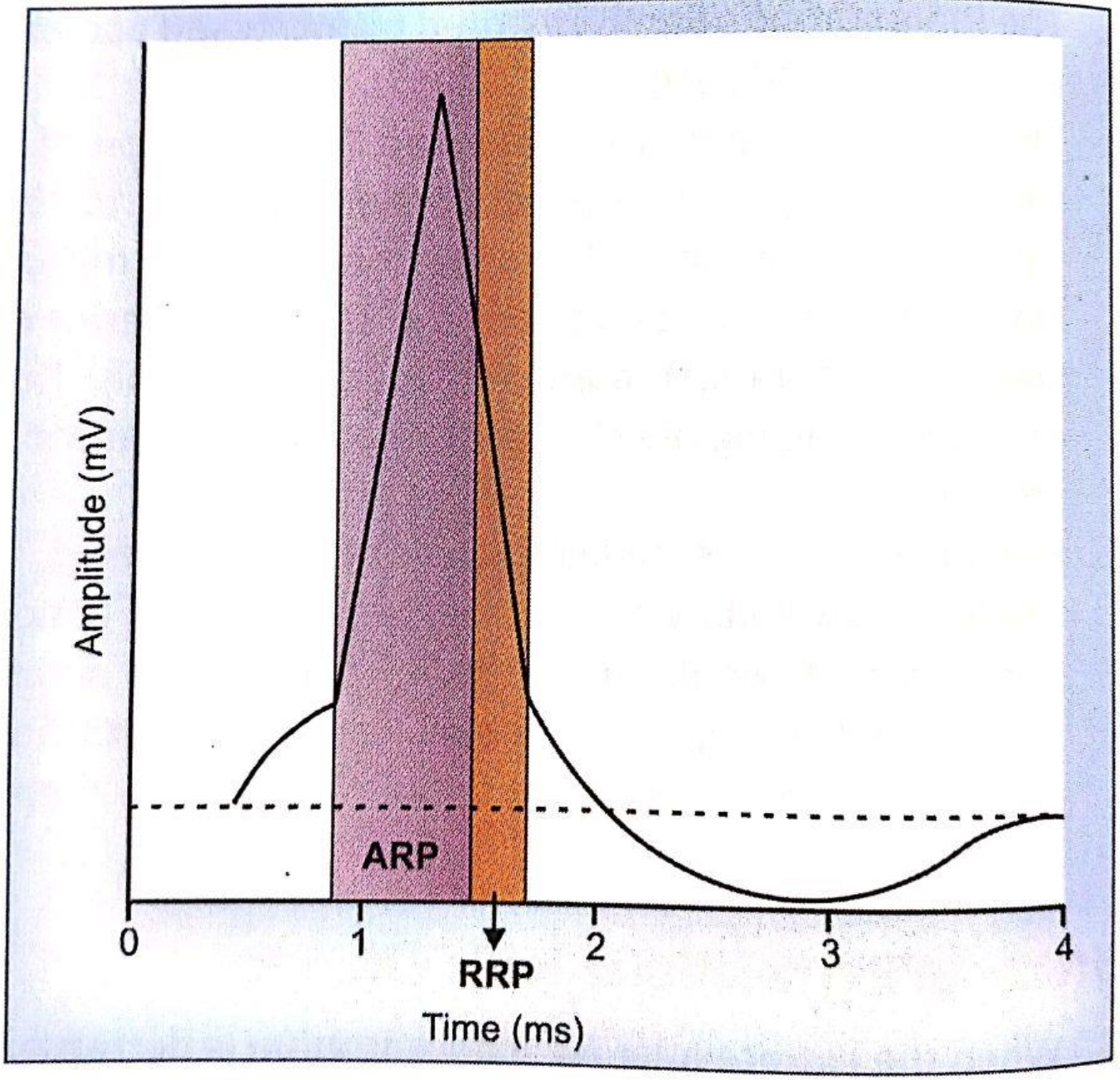


**Fig. 23.7:** Refractory periods of nerve action potential. (ARP: Absolute refractory period; RRP: Relative refractory period).

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# Na+ channels

- **Leaky/non gated**: resting state
- **Voltage gated**: when stimulated
- 2 gates: outer one: activation gate
  Inner one: inactivation gate
- During rest: inactivation gate: open
  Activation gate: closed
- Stimulus: activation gate: opens (both gates: open)
- At +35 (end of depolarisation):
  inactivation gate: close
  Activation gate: open

* End of repolarisation: inactivation gate: open
  Activation gate: closed

| | |
|---|---|
| **ABSOLUTE RP** | **Inactivation of vg fast na+ channels by closure of inactivation gates** |
| **RELATIVE RP** | **Very strong stimuli open inactivation gates** |
| **SUPERNORMAL PERIOD:**<br>**HYPEREXCITABLE STATE** | **Threshold is decreased**<br>**After depolarization period:**<br>**Potential is near firing level** |
| **SUBNORMAL PERIOD** | **Low excitability**<br>**Hyperpolarisation:**<br>**More –ve potential** |

# ONE WAY CONDUCTION

- ***ORTHODROMIC:*** FORWARD CONDUCTION (COMMON): FROM CELL BODY TO AXON TERMINAL
- ANTIDROMIC: BACKWARD CONDUCTION: RARE * AXON REFLEX
- WHY ?????
- BECAUSE AREA BEHIND STIMULATED PART IS REFRACTORY TO 2$^{ND}$ STIMULUS, HENCE AP CANNOT PROPAGATE BACK.

# ACCOMODATION

- ADAPTATION
- IF FIRING LEVEL IS REACHED SUDDENLY, AP IS PRODUCED

- WHEN STIMULUS IS INCREASED SLOWLY TO FIRING LEVEL: NO ACTION POTENTIAL
- Na+ CHANNELS OPEN BUT GET INACTIVATED WITHIN 1 msec.

# INFATIGUABILITY

- NERVE FIBER CANNOT BE FATIGUED.
- ABSOLUTE REFRACTORY PERIOD

# SUMMATION

- 1 SUBMINIMAL STIMULI: NO RESPONSE
- MANY SUBMINIMAL STIMULI: GET SUMMATED, PRODUCE MINIMAL STIMULI, ACTION POTENTIAL IS PRODUCED

## ALL OR NONE LAW

MINIMAL STIMULI: FULL AP

SUBMINIMAL STIMULI: NO AP

THERE'S NOTHING LIKE HALF AP

# THANK YOU