Physiology of peripheral nerves

By

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2024-2025

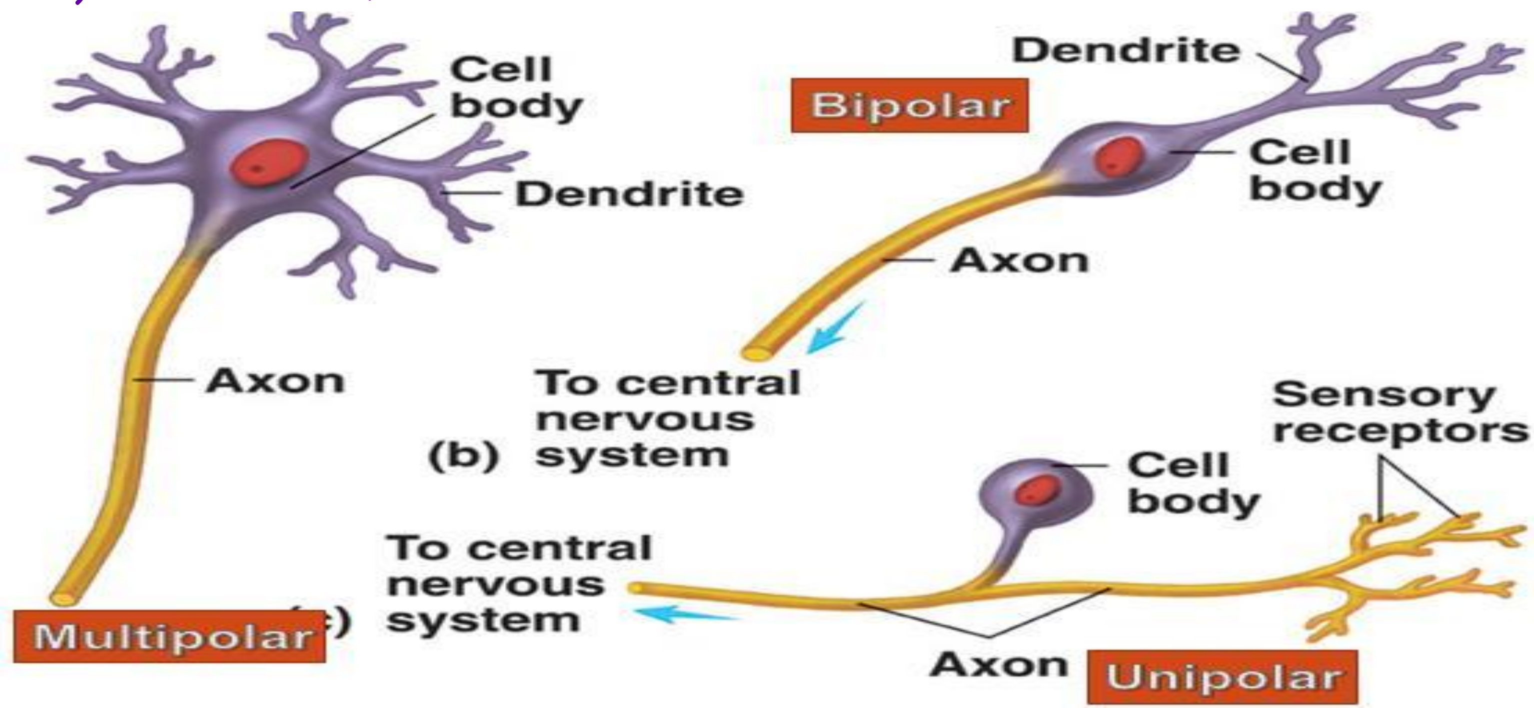
Types of neurons → structural unite of CNs (building)

- **According to the processes: (shape)**

Unipolar: e.g. cells in dorsal root ganglia. → 1st order neuron

Bipolar: e.g. bipolar cells of the retina.

Multipolar: e.g. cells of cerebral cortex.
↳ most common



- **According to function:**

Ascending
1) **Sensory** (**A**fferent) which carry sensations from organs to the CNS.

descending
2) **Motor** (**E**fferent) which arise from CNS to carry orders to organs.

- **According to myelination:**

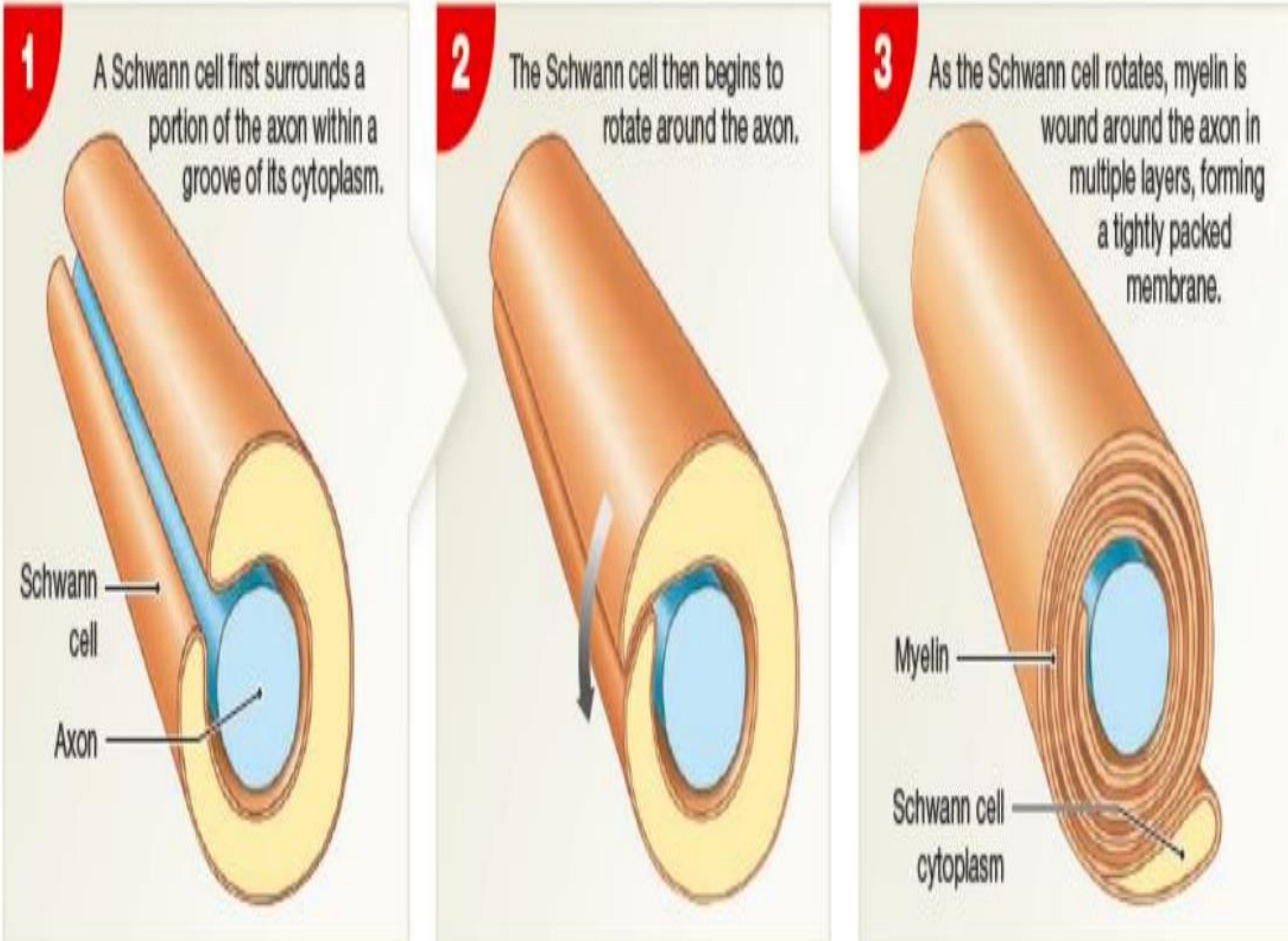
1) **Myelinated** nerve fiber: e.g. preganglionic neuron. → Type-B fibers

2) **Non-myelinated** nerve fiber: e.g. postganglionic neuron. → Type-C fibers

The myelin sheath

→ insulator

- It is a thick layer around the axon formed of **lipoprotein** substance.
- It is covered by *outer neuro-lemmal* tube.
- It is Insulator to electric currents.
- So, Increase speed of conduction.
- It is Interrupted by nodes of Ranvier through which ions can pass. → de and re polarization
- Formed by the **Schwann cell** which rotates around the axon many times forming multiple layers.
- In CNS, the myelin sheath is formed by oligodendroglia cells.



1
A Schwann cell first surrounds a portion of the axon within a groove of its cytoplasm.
Schwann cell
Axon
2
The Schwann cell then begins to rotate around the axon.
3
As the Schwann cell rotates, myelin is wound around the axon in multiple layers, forming a tightly packed membrane.
Myelin
Schwann cell cytoplasm

Mechanism of Nerve Impulse Conduction

→ energy consuming

- **A. In the unmyelinated nerve fibers:**

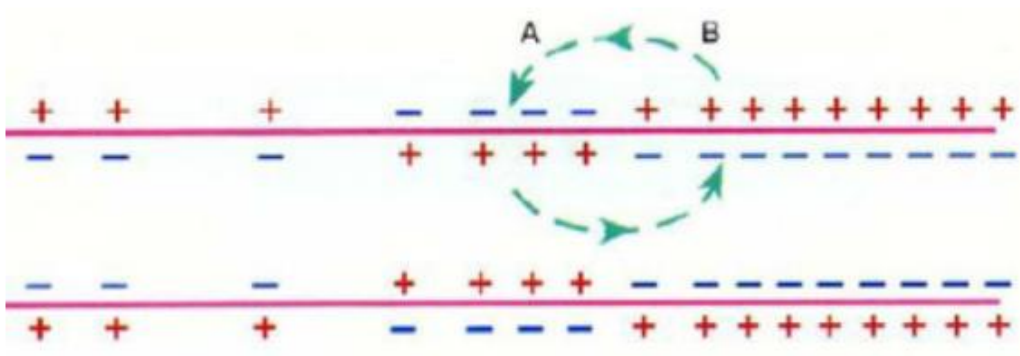
During rest, membrane is polarized. (+ve outside).

At site of stimulation the membrane is depolarized (-ve outside).

Then a **local current flow** occurs between the depolarized area and surroundings areas:

هيي يلي بتتحرك →

- *In the inner surface:* +ve charges migrate from the point of depolarization to the surrounding sites.
- *In the outer surface:* +ve charges migrate from the surrounding sites to point of depolarization.



- **The results are:**

➢ Point of stimulation begins to repolarize.

➢ The surrounding sites being to depolarize partially till they reach the firing level ⇨ action potential

This is repeated. So, conduction occurs along the nerve fiber.

It is called the (**Current sink**). → energy consuming

The speed of propagation is directly proportional to the diameter of the nerve.

↳ ↑ inter-nodal distance

B. In the myelinated nerve fibers

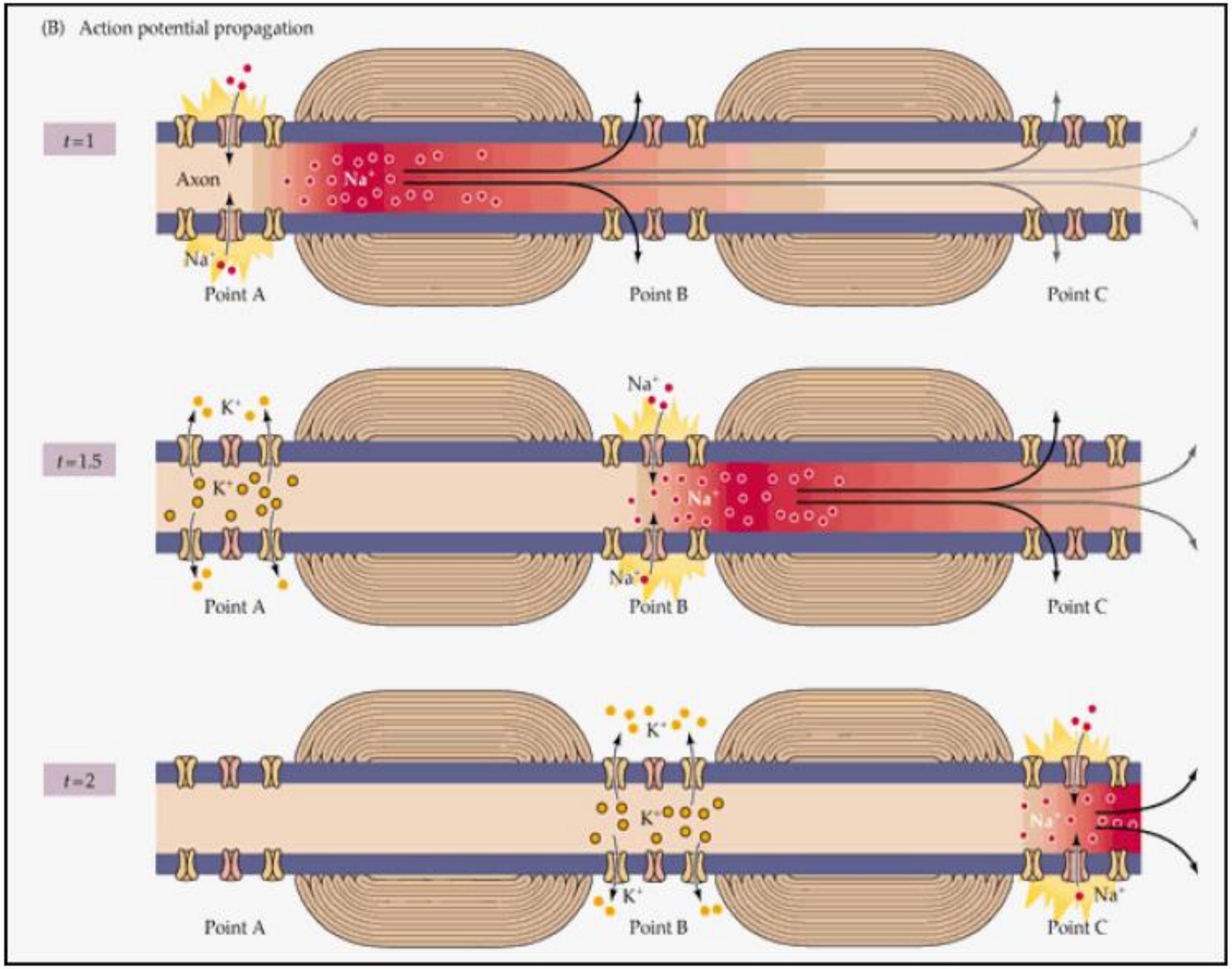
The same mechanism as in the unmyelinated ,But the impulse jump from one node of Ranvier to the other because the myelin is insulator for current

So, it is called (**Jumping** or **Saltatory** or **Node to node**) conduction

It is characterized by:

1) The rate of conduction in the myelinated nerve is 50 to 100 times faster than in the unmyelinated.

2) It occurs with less energy .



(B) Action potential propagation
t = 1
Axon
Na⁺
Na⁺
Point A
Point B
Point C
t = 1.5
K⁺
K⁺
Na⁺
Na⁺
Na⁺
Point A
Point B
Point C
t = 2
K⁺
K⁺
K⁺
Na⁺
Na⁺
Point A
Point B
Point C

Excitability of nerve

- **Definition**

It is the ability of the living tissue to **respond** to an adequate **stimulus**.

→reach threshold and has perfect sepecificity

- **The stimulus**

It is the **change** in the environment of the living tissue which may be electrical, chemical, mechanical or thermal.

most suitable for laboratory
⊛ leaving tissue without damage

- **Factors determine the effectiveness of the stimulus**

❖ ***Intensity (strength) of the stimulus:***

Threshold stimulus: it is the minimal intensity which produces nerve impulse in the nerve fiber.

propagated action potential not local

Subthreshold stimulus: ⇨ no impulse (but local response).

Suprathreshold stimulus: ⇨ the same impulse of the threshold. But, in less time.

N.B

The **single nerve fiber** obeys **all or none law**.

PROPERTIES OF THE MIXED NERVE

- As the **mixed nerve** consisted of **many nerve fibers**, these fibers have different diameters and excitability. → speed of conduction

- So, stimulation of the mixed nerve depends on the intensity of stimulus and is called the **compound action potential**:

1) Subthreshold stimulus → no response. → causes local but no propagated
2) Threshold stimulus → excitation of the most excitable fibers.
3) Suprathreshold stimulus → more fibers are excited → more response.
4) Maximal stimulus → all fibers are excited → maximal response.
5) Supramaximal stimulus → the same as maximal response.
   ↳ less duration

❖ *Duration of the stimulus:*

⇧ Duration of stimulus ⇨ ⇩ intensity needed to give response →inverse relation

❖ *Rate of rise of intensity of the stimulus:*

If a **subthreshold** stimulus is applied to the nerve and increased **slowly**, the nerve accommodate itself to the passage of the current ⇨ **no response**

If intensity increased **rapidly**, (slowly) accommodation is not observed ⇨ **response**

★Strength-duration curve

It is a relationship between the **intensity** of the stimulus & the **time** of its application to the nerve to give a response.

Within limits, **the stronger** the stimulus, **the shorter** its duration →inversely

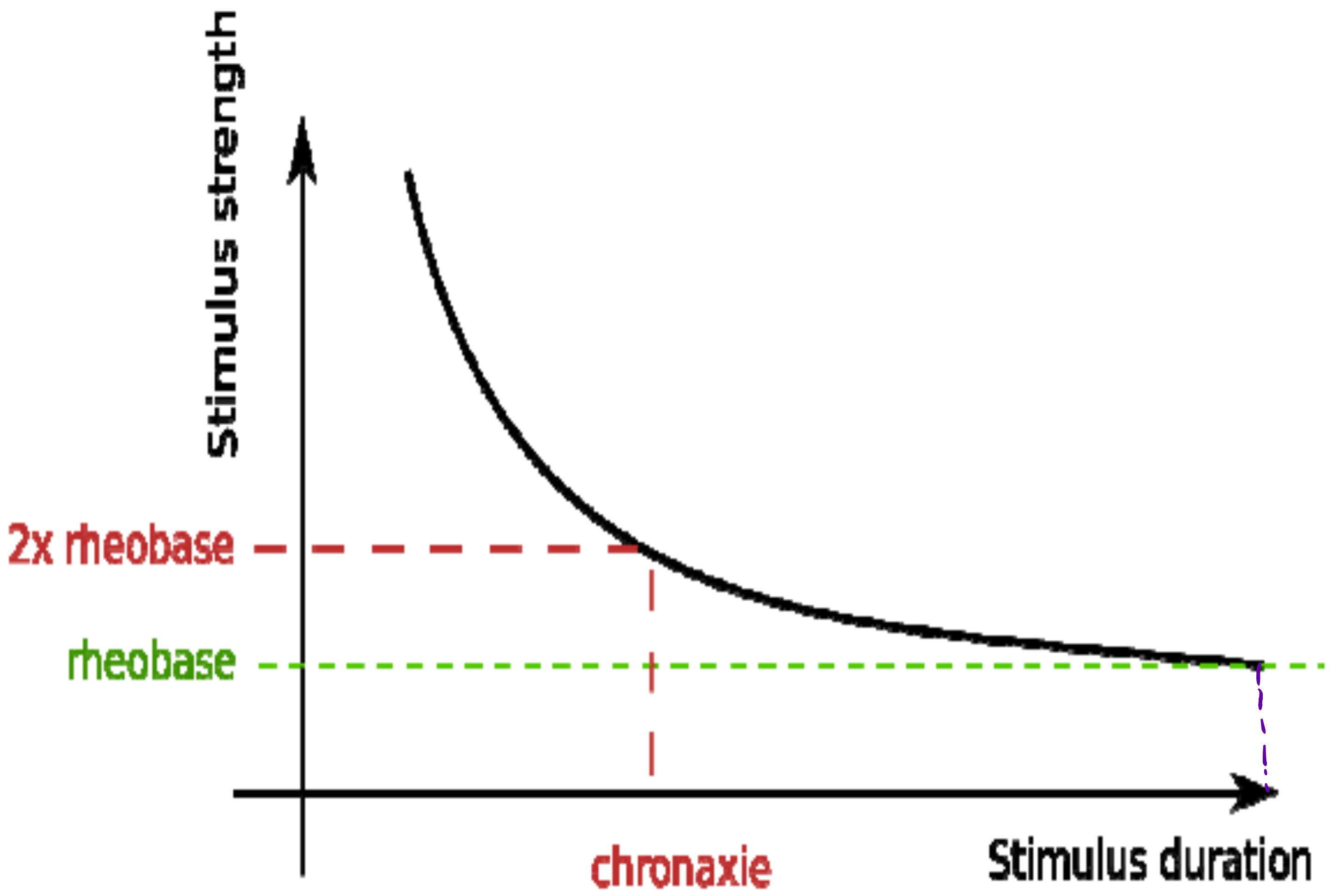
From the curve

- **Rheobase**

It is the minimal strength of current that can excite the nerve (threshold).

- **Utilization time**

It is the time needed for excitation by **Rheobase**


Stimulus strength
2x rheobase
rheobase
chronaxie
Stimulus duration

- **Chronaxie**

It is the time needed by a current double the rheobase to excite the nerve.

It's used to **measure the excitability** *The longer the chronaxie the less the excitability*

- **Minimal time**

It is the minimal time below which no excitation occurs whatever the strength of the stimulus i.e. stimuli of extreme short duration will not excite.

Factors Affecting the Excitability of Nerves

→Type-A

- **Temperature**: *Cooling* decreases nerve excitability While *warming* increases it.
- **Pressure**: Mechanical pressure on a nerve reduces its excitability.
- **Blood supply**: Nerve excitability is decreased in cases of ischemia.
- **Oxygen supply**: O2 lack decreases nerve excitability

→Type-B

- **H+ concentration**: **Alkalinity increases while acidity decreases the excitability of nerves.
- **Chemicals**: nerve excitability is decreased by *excess CO2* and *alcohol* and anesthetic drugs e.g., *ether*, *chloroform* and *novocaine*.

↳Type-C (slow pain)

• Electrolytes

A. *Ionic changes that* increase *nerve excitability*

extracellular → competition with Na^+

1- **Decreased Ca^{2+} concentration**: This increases the membrane permeability to Na+

2- **Increased Na+ concentration**: This facilitates the process of depolarization. → extracellular

B. *Ionic changes that* decrease *nerve excitability*

1- Increased Ca^{2+} concentration: This decreases the membrane permeability to Na+

2- Decreased Na+ concentration: This decreases nerve excitability by delaying the process of depolarization.

Electrotonic Potentials (ETPs)

- ETPs are **localized potential changes** that occur in nerves when stimulated by **subthreshold constant** currents.
- Such currents are obtained from batteries and either the cathode (-ve electrode) or the anode (+ve electrode) can be used for stimulation.

→ attract cations

→ attract anion

Anelectrotonic potential (or AN- electrotonus)

anode

- This is the potential change that occurs when using anodal (+ve) currents for stimulation. It is a state of **hyperpolarization** caused by net addition of +ve charges at the outer surface of the nerve membrane.
- It is associated with **a decrease of excitability** of the nerve so, the nerve excitability may be completely lost **(anodal block).**

Catelectrotonic potential (CAT –electrotonus)

cathode

- This is the potential change that occurs when using cathodal (–ve) currents for stimulation. It is a state of partial depolarization
- Caused by net addition of –ve charges at the outer surface of the nerve membrane It is associated with an increase of excitability of the nerve.
- However, the decrease of the membrane polarity leads to an increase in both K+ efflux & Cl- influx which repolarizes the membrane and restores the resting membrane potential.

N.B.: Stimulation at the cathodal end resulted in three types of depolarization:

	catelectrotonus	*local response*	*firing level*
-Stimulus	Subthreshold	Subthreshold	Threshold or more
-Depolarization	Less than 7mv.	From 7 to 25	25 or more → large sized nerve fiber
-Mechanism	Passive	Passive and partial active)	active
-Forces affect the membrane	Repolarization mask this effect	Repolarization mask this effect	Depolarization force is more& action potential resulted

Types of Nerve Fibers

- **1. Group A nerve fibers:**

These have the largest *diameters* **(1-20 μ)** and the **highest** ***speeds of conduction*** **(**20 -120 **m/sec)**.

They are further subdivided into:

- *Alpha (α) *Beta (β) *Gamma (γ) *Delta (δ)
- They are most sensitive to **pressure**
- **2. Group B nerve fibers:** → preganglionic
- These have smaller diameters **(1 – 5 μ)** and **moderate speed** of conduction **(5 -15 m/sec).**
- They are most susceptible to **O2 lack.**
- **3. Group C nerve fibers:**
- These have the smallest diameters **(Less than 1 μ)** and the **slowest**
- **speed** of conduction **(0.5 - 2 m/sec).**
- They are most susceptible to **local anesthetic drugs** (e.g., cocaine and Novocain).


Thanks