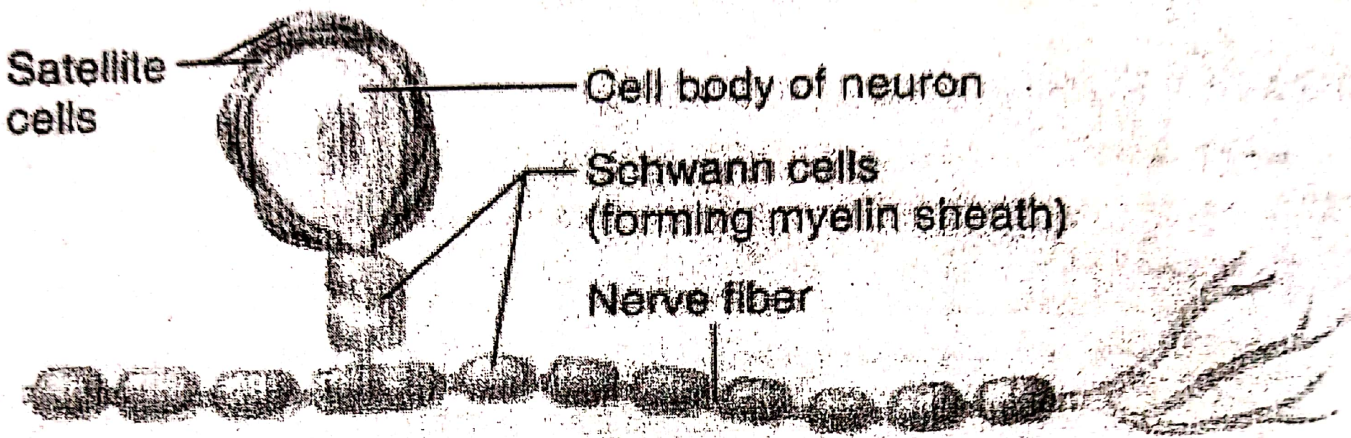
Muscle & Nerve

Types of glia in PNS:

a. Schwann Cells: Produce myelin sheath and neurilemma in peripheral neurons. In addition to insulation, they aid in regeneration of damaged peripheral nerve fibers.

b. Satellite cells: Surround cell bodies in PNS and have many of the same functions as astrocytes in CNS. i.e. Nutrional function and aid in transmission of neurotransmitter through blood brain barier.

Fig. 1



Resting membrane potential

All living cells (whether animal or plant cells) exhibit potential difference across their plasma membranes when microelectrodes are inserted into these cells where the membrane interior is negative in relation to the membrane exterior. This is called resting membrane potential **(RMP)** and it is due to uneven distribution of ions inside and outside the membrane.

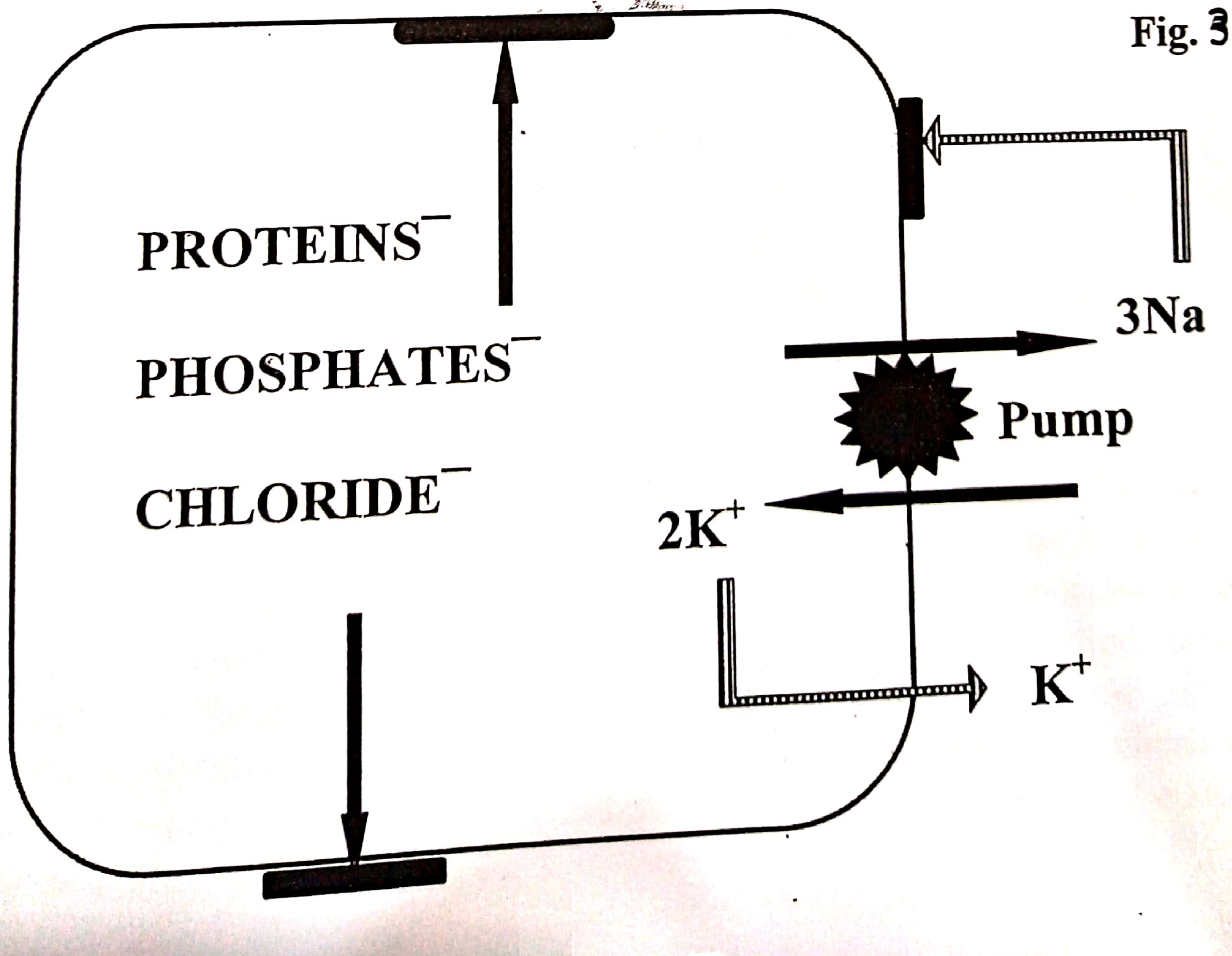
Ion	Extracellular	Intracellular
Na^+	142 mEq/L	10 mEq/L
K^+	4 mEq/L	140 mEq/L
Cl^-	103 mEq/L	4 mEq/L
Phosphates	4 mEq/L	75 mEq/L
Proteins	30 mg/dL	200 mg/dL

Accordingly, RMP of nerve cell is –70 mV, RMP of skeletal muscle is –90 mV, RMP of cardiac muscle is –85 mV, and lastly RMP of smooth muscle is variable but nearly about –50 mV.

The following ionic fluxes are responsible for the **electric phenomenon** of resting membrane potential:

1. Sodium-Potassium pump: This is called Na^+-K^+ ATPase pump which extrudes three sodium ions outside the cell and intrudes two potassium ions inside. This results in much positive ions outside plasma membrane.
2. Sodium channels are inactive at rest. They are voltage gated channels i.e. they are activated by electric current. This means that sodium **influx** is not possible unless membrane potential is changed from resting to action potential.
3. Potassium channels allow continuous passive diffusion of K^+ outside the cell due to concentration gradient. This K^+ **efflux** results in **diffusion potential** and increased positive charges outside plasma membrane which is the major factor responsible for resting membrane potential.
4. Chloride ions stand still inside the cell due to their higher concentration outside the cell. This conserves negative charges inside plasma membrane.
5. Anionic proteins and phosphates can not leave the cell due to their large size making plasma membrane impermeable to their efflux. This adds to the negativity of plasma membrane interior.

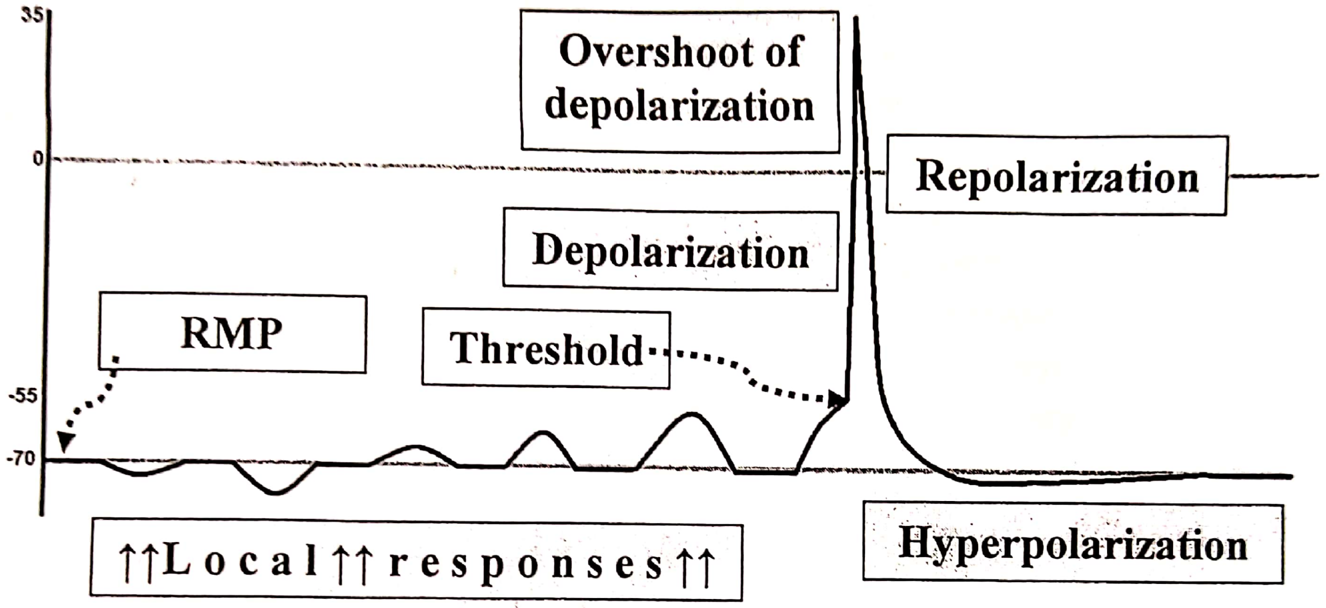
Fig. 3



Action potential and Local responses

Nerve and muscle cells are excitable cells i.e. they have the ability to reverse the negativity of their membrane potential in **response** to a sufficient external **stimulus.** The external stimulus may be electrical, chemical, physical or other types of stimuli. This change in membrane potential is called **action potential.** The response in nerve cell is **transmission** of action potential (nerve **impulse**) while the response in muscle cell is **contraction.**

Fig. 4: Curves of local responses and action potential in neuron



Weak external stimuli when applied to the neuron may cause **local responses** which may increase or decrease with the charge and amplitude of stimuli and the responses subside after removal of these stimuli. Local responses may be cathodal (+ve) or anodal (-ve). Catelectrotonic stimuli cause less negative membrane potential, while anelectrotonic stimuli cause more negative membrane potential.

When a sufficient stimulus raises the membrane potential 15 mV above RMP (i.e. from –70 mV to –55 mV); action potential phases will start and does not stop until complete cycle occurs. This is called **all-or-none rule.** The membrane potential at which action potential starts is called **threshold potential** or **firing potential. Subthreshold** stimuli may not affect the membrane potential or cause only local responses while **supramaximal** stimuli induce the same effects as threshold stimuli and do not change the shape of action potential curve.

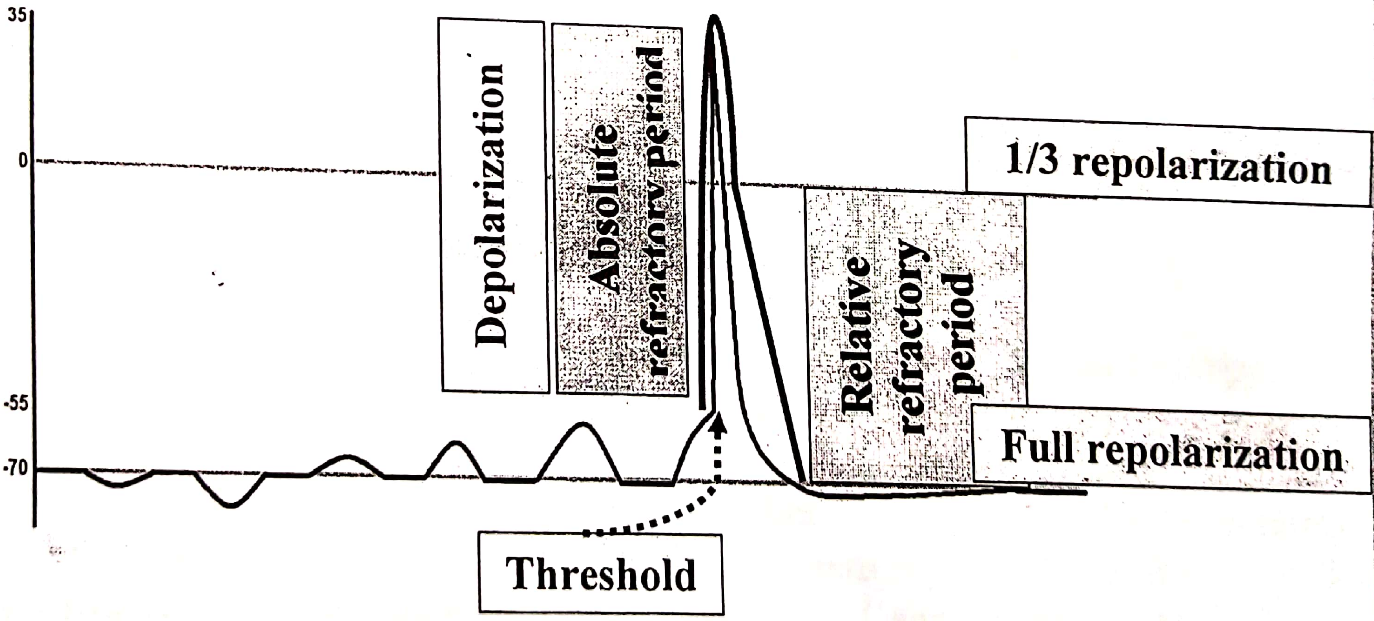
The ***phases of action potential curve in neurons*** are:

1-Depolarization phase: Sharp rise of curvè toward zero membrane potential which **overshoots** to reach about +35 mV. This phase is due to activation of all fast Na^+ channels with inrush of huge number of Na^+ ions causing plasma membrane to lose its negativity.
2-Repolarization phase: Rapid fall of the curve toward the previous negative potential which occurs due to fast inactivation of Na+ channels and continuous pumping of Na^+ and passive diffusion of K^+ outside the cell.
3-Hyperpolarization phase: Decline of the curve to a more negative potential than RMP which is here about –72 mV and it is due to slow closure of K^+ channels. After that, the membrane regains its RMP.

Any stimulus, however large, does not induce any new action potential at time of previous depolarization until third repolarization is complete. This is called **absolute refractory period** because Na^+ channels cannot be reactivated immediately after previous activation. i.e. 100% electronegativity.

From the point of third repolarization to the end of repolarization phase a stronger stimulus is needed to induce new, but weaker, action potential because fewer Na^+ channels can be activated. This is called **relative refractory period.**

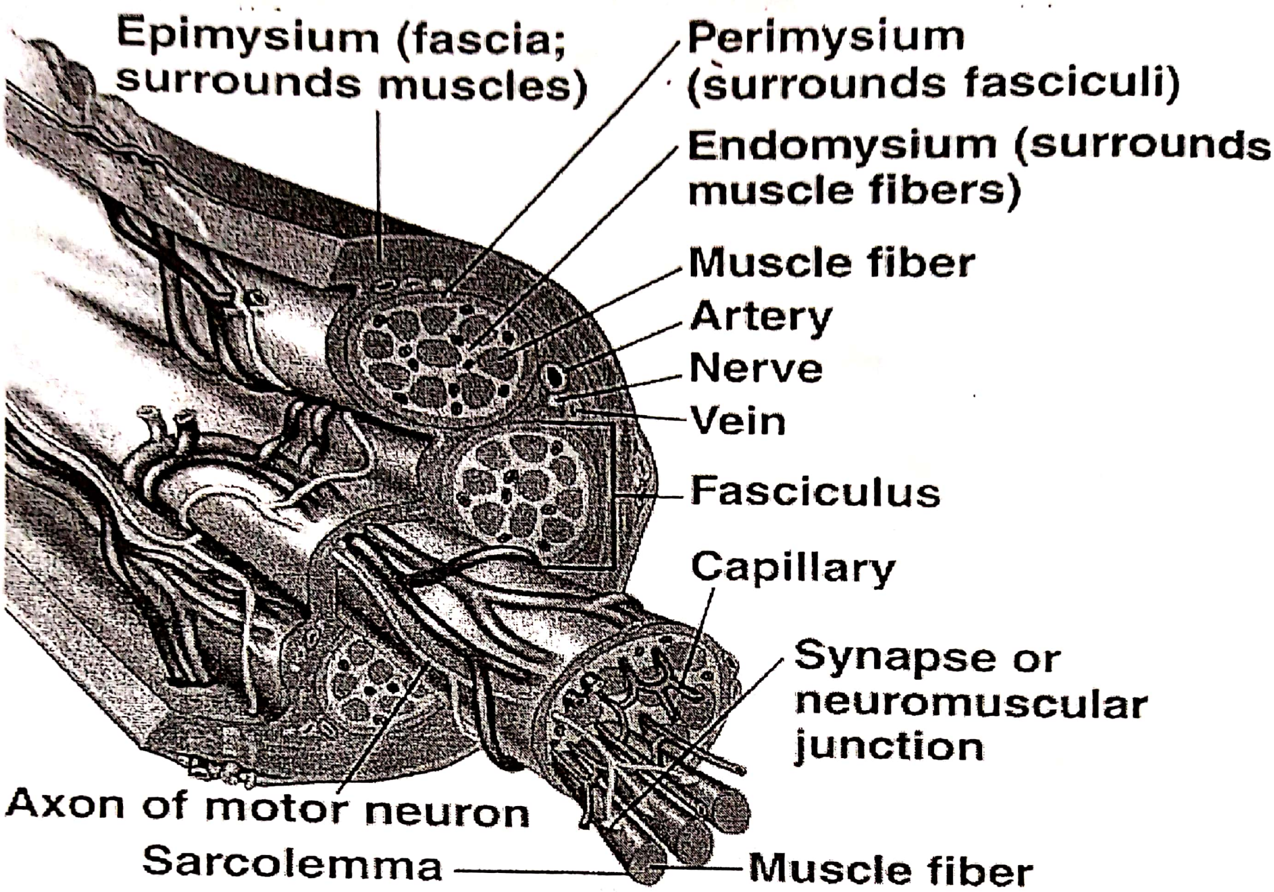
Fig. 5:



Calcium ions stabilize the membrane by increasing threshold potential (toward more positive position) so, lack of Ca^{++} results in lower threshold potential which makes the membrane very excitable and continuously firing **(tetanus).**

II. Muscle

Fig:7.



I. ***Skeletal muscle***: General functions of skeletal muscle are:

Movement
Maintenance of posture
Stabilization of joints
Temperature homeostasis

It is striated voluntary muscle surrounded by **epimysium** and composed of **fasciculi**. Each **fasciculus** is surrounded by **perimysium** and composed of **muscle fibers** (elongated **muscle cells**). Muscle fibers are separated from each other by **endomysium** and each muscle fiber is surrounded by **sarcolemma** (plasma membrane) and composed of **sarcoplasm** (cytoplasm of muscle cells), **myofibrils, multiple nuclei, mitochondria** and **sarcoplasmic reticulum** in addition to other cellular components. Myofibrils are composed of **myofilaments (thick** and **thin** contractile elements of skeletal muscle which give the muscle its striation).

II. Cardiac Muscle

It is branched and interdigitated and functions as **syncytium** due to presence of **intercalated discs and gap junctions.** Its RMP is about -85 mV and its AP is slow and characterized by presence of plateau. The AP phases are:

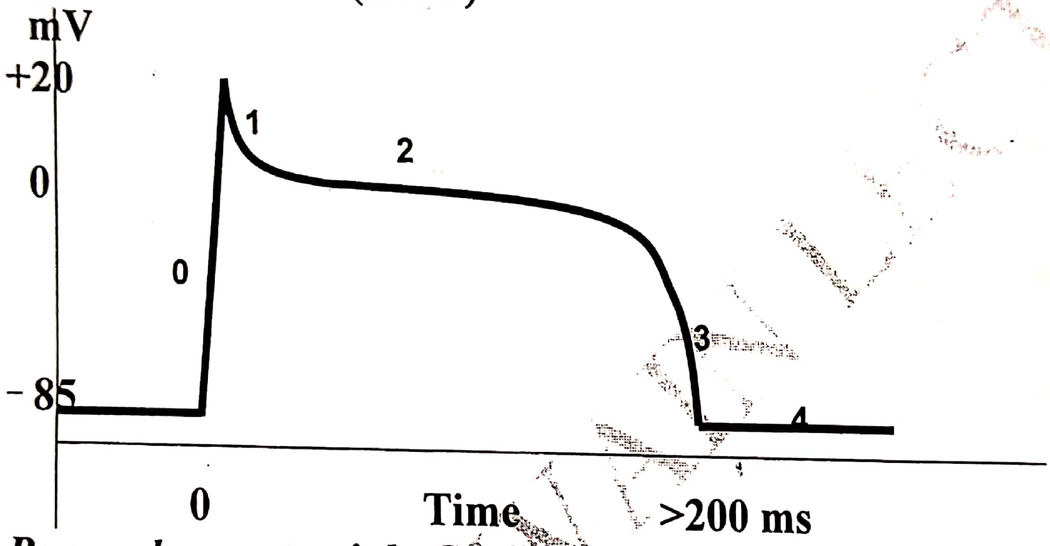
Phase 0: Depolarization lasts about 2 ms and occurs due activation of all Na^+ channels with huge influx of Na^+ ions.

Phase 1: Initial rapid repolarization occurs due fast inactivation of Na^+ channels.

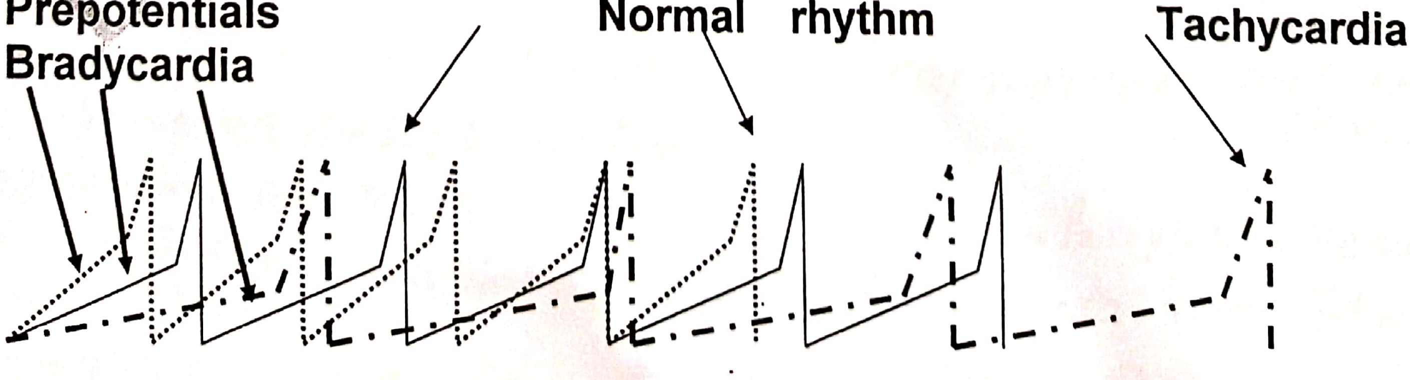
Phase 2: Plateau lasts about 200 ms and occurs due to opening of Ca^{2+} channels and influx of Ca^{2+} ions.

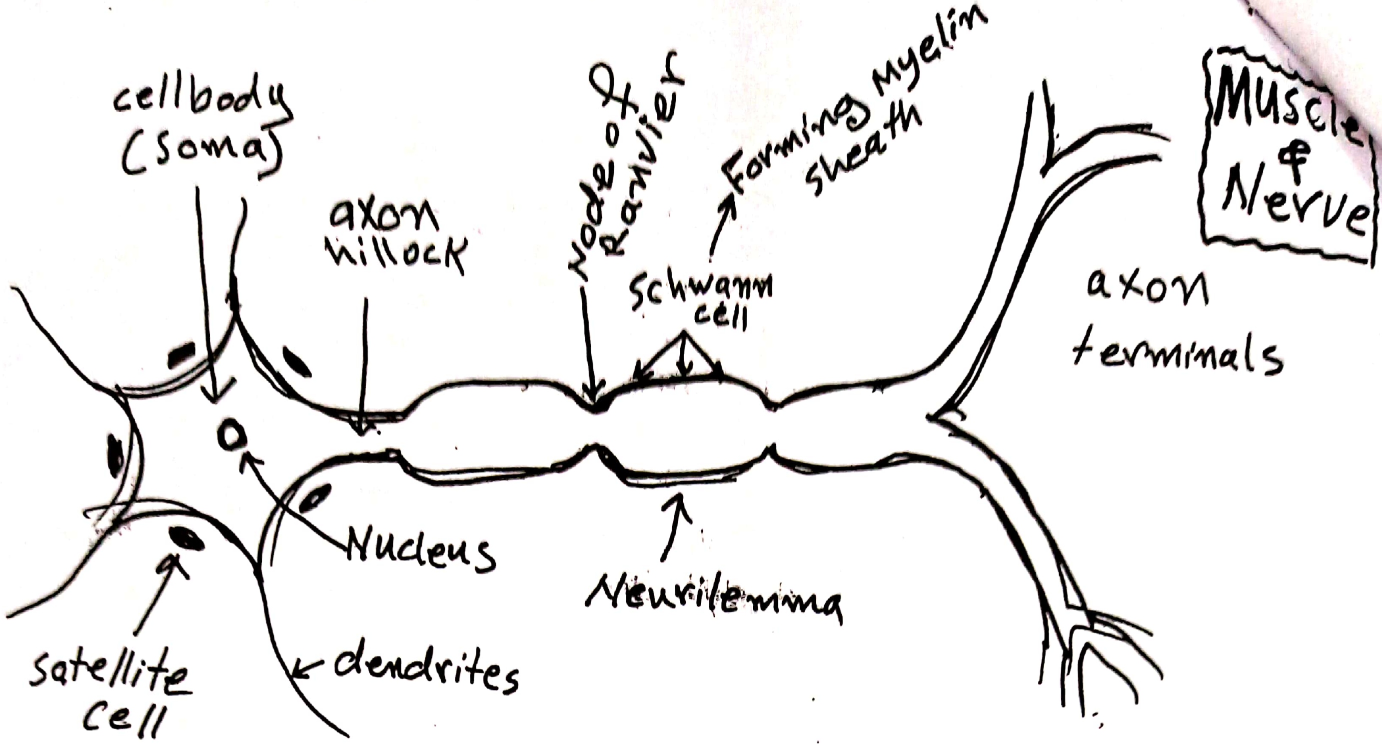
Phase 3: Late rapid repolarization occurs due to closure of Ca^{2+} channels.

Phase 4: Base line (RMP)



Pacemaker potential: Cardiac muscle contraction is **myogenic** (originated inside the muscle) not **neurogenic** (initiated by nerve) and the nerve supply is only regulatory. This due to the presence of specialized conductive tissue in the heart called **pacemaker tissue**. This tissue has unstable low membrane potential called prepotential or pacemaker potential which declines and depolarizes continuously and steadily (due to slow decrease in K^+ efflux) which spreads the impulses all over the heart. Steeper prepotentials result in **tachycardia**, while lower prepotentials result in **bradycardia**.





⊗ BBB : Blood Brain Barrier.

Neuron
(cellbody + axon + dendrites)

Neuron : Is the unit structure of the CNS.

Glia : Is supporting elements in CNS.

Function of Neuron :-

1. Conduct impulse from one neuron to other.
2. The speed of nerve Impulse is the function of axon diameter.
3. Neural signals either afferent (to the cell body) or Efferent (away from the cell body)

Glia : Type of Glia in Peripheral nervous system: (PNS)

A. Schwann cell: Function :

1. produce Myelin sheath of Neurilemma in Peripheral neuron
2. aid in regeneration of damaged Peripheral nerve Fiber
3. Insulation.

B. satellite cell: ① surround cell body of PNS. ② Nutrional Func ③ Help in transmission of neurotransmitter through BBB. ⊗

Sarcomere
Functional
unit of
skeletal
Muscle