PROPAGATION OF ACTION POTENTIAL

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Lec 3

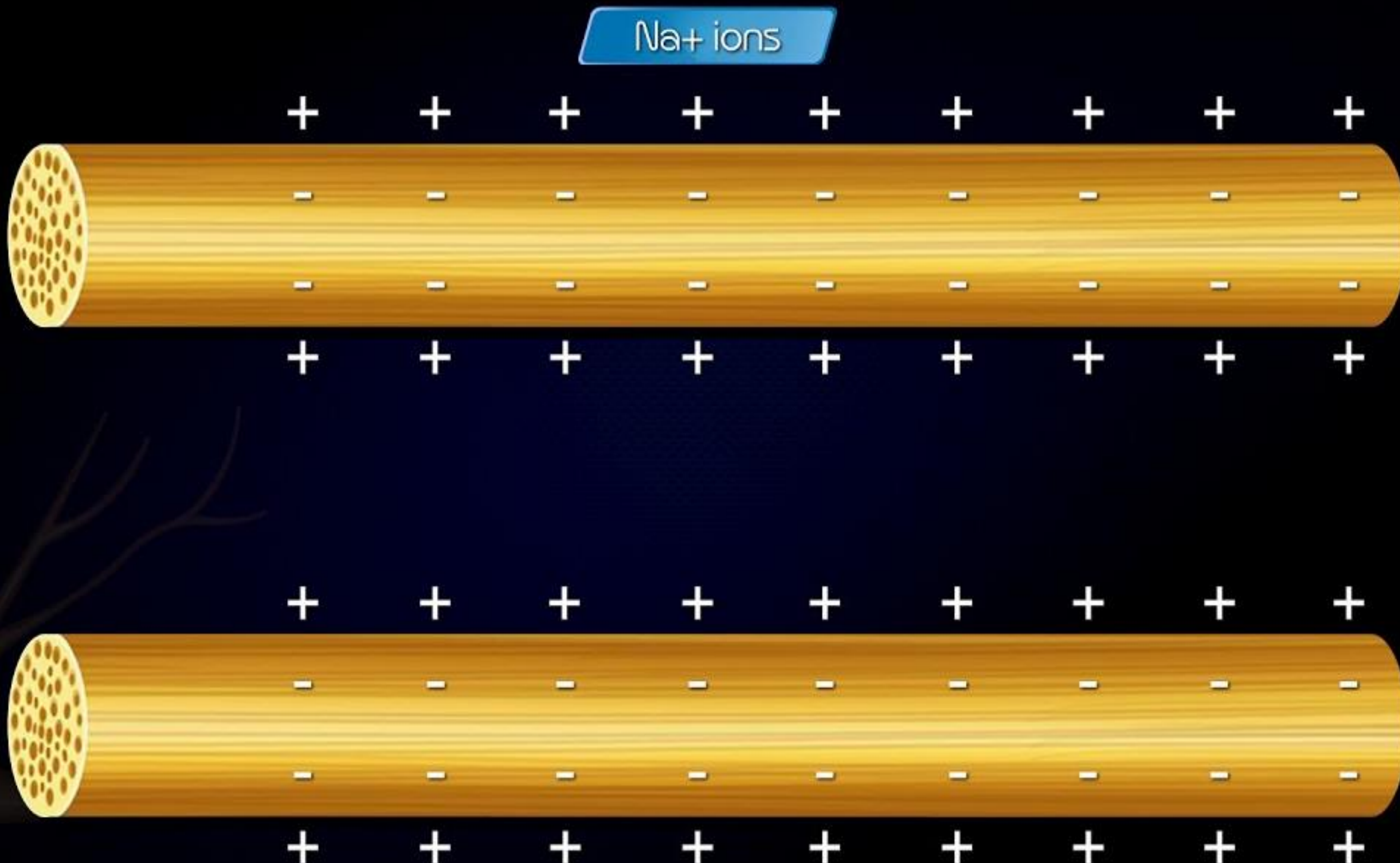
- Once an action potential is initiated in an axon, it is propagated down the length of the axon from the trigger zone(the site where neuronal action potential is triggered and generated) to the axon terminal without decrement.
- Absolute refractory periods help direct the action potential down the axon, because only channels further downstream can open and let in depolarizing ions.

- The propagation mechanisms differ, however, depending on whether the axon is **unmyelinated or myelinated**

Propagation of Action Potentials in Unmyelinated Axons

- **Electrotonic conduction** :
- is the passive spread of voltage changes along a neuron, away from the site of origin, (is the mechanism by which action potentials are propagated in unmyelinated axons).

Propagation of action potential in an unmyelinated axon

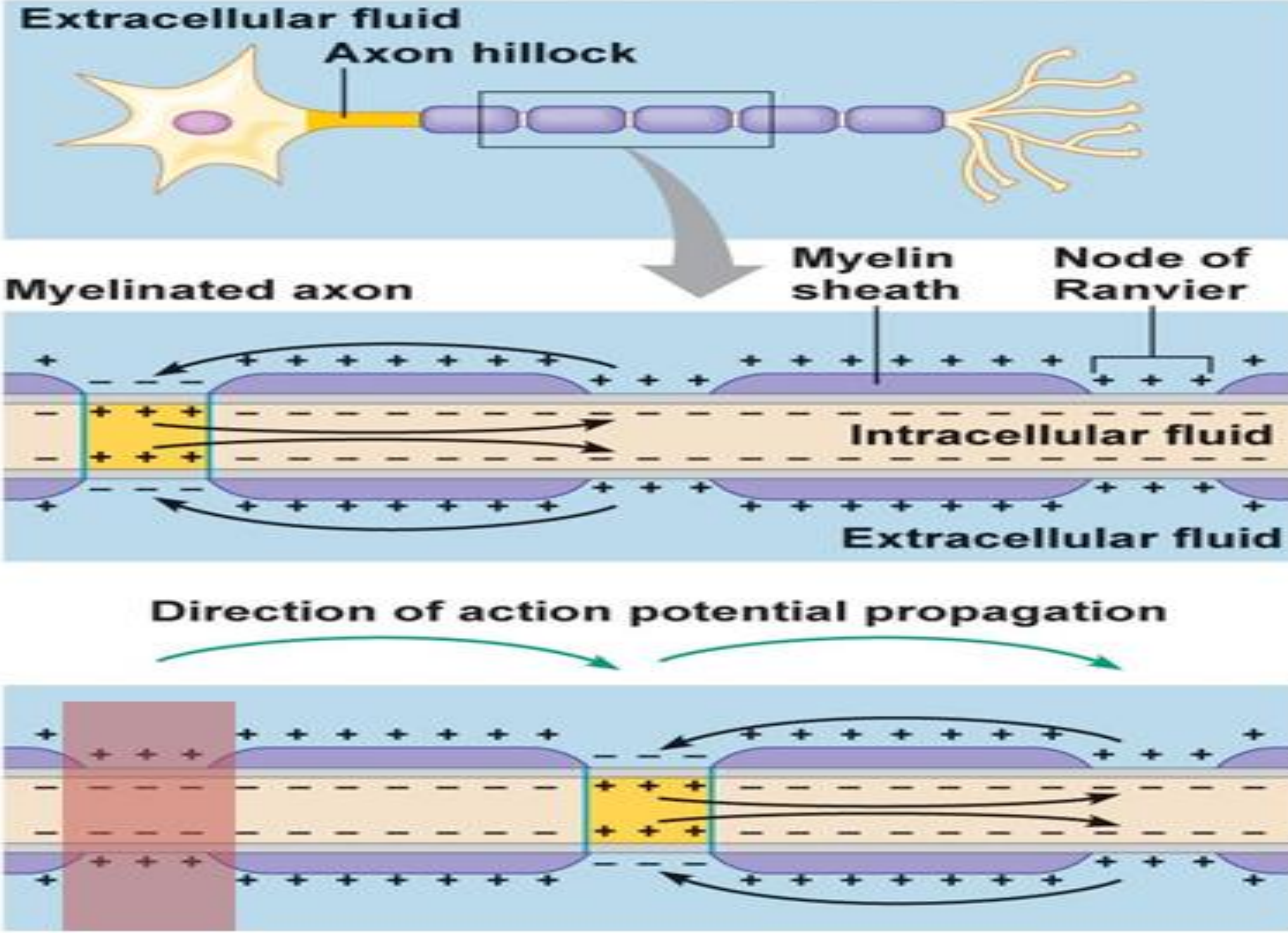


- When a particular region of an axon is depolarized during an action potential, the resulting currents travel downstream to adjacent regions of the membrane by reversing the sign of the membrane potential, such that the inside of the cell becomes positive and the outside becomes negative.

Action Potential Propagation in Myelinated Axons

- In axons that are sheathed in myelin, action potentials are propagated by a specialized type of conduction called **Saltatory conduction**.
- Myelin provides high resistance to ion movement across the plasma membrane.
- The nodes of Ranvier are gaps in the myelin where the axon membrane lacks insulation, is exposed to the interstitial fluid, and has a high concentration of voltage-gated sodium and potassium channels.

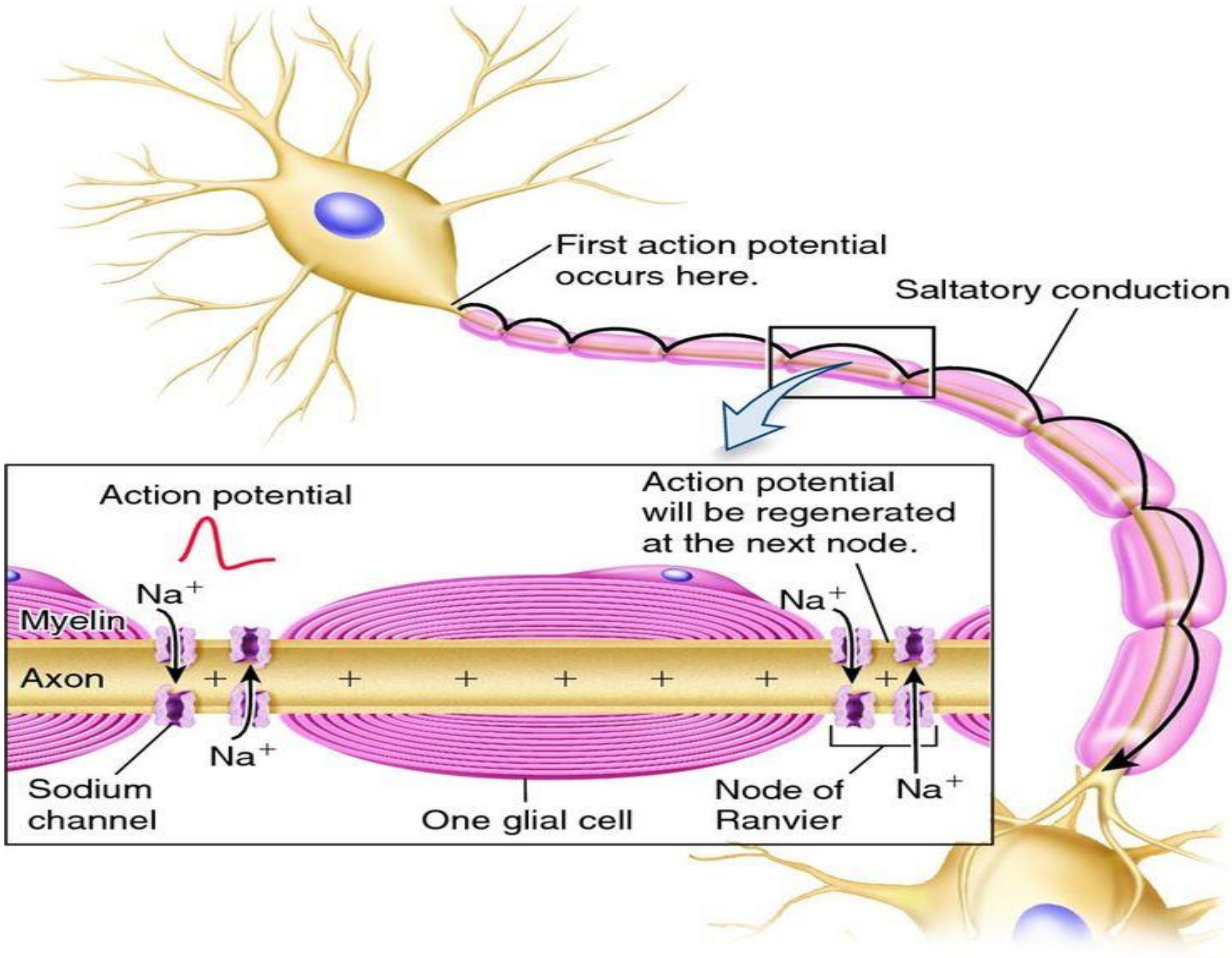
- In between the nodes, the membrane potential is conducted passively, without the necessity of regenerating the action potential. In other words, electrical current excites successive nodes one after the other by passing through the axoplasm inside the axon. As a result, the nerve impulse jumps along the fiber, giving rise to the word "saltatory."



NB the zone behind the active zone is still in the relative refractory period, preventing retrograde conduction

- In myelinated fibers, action potentials are produced at the nodes of Ranvier. Therefore, the current flow or jump from one node of Ranvier to the next until it reach axon terminal
- Saltatory conduction is of value for two reasons.
- **First**, by causing the depolarization process to jump long intervals along the axis of the nerve fiber, this mechanism increases the velocity of nerve transmission in myelinated fibers as much as 5- to 50-fold.

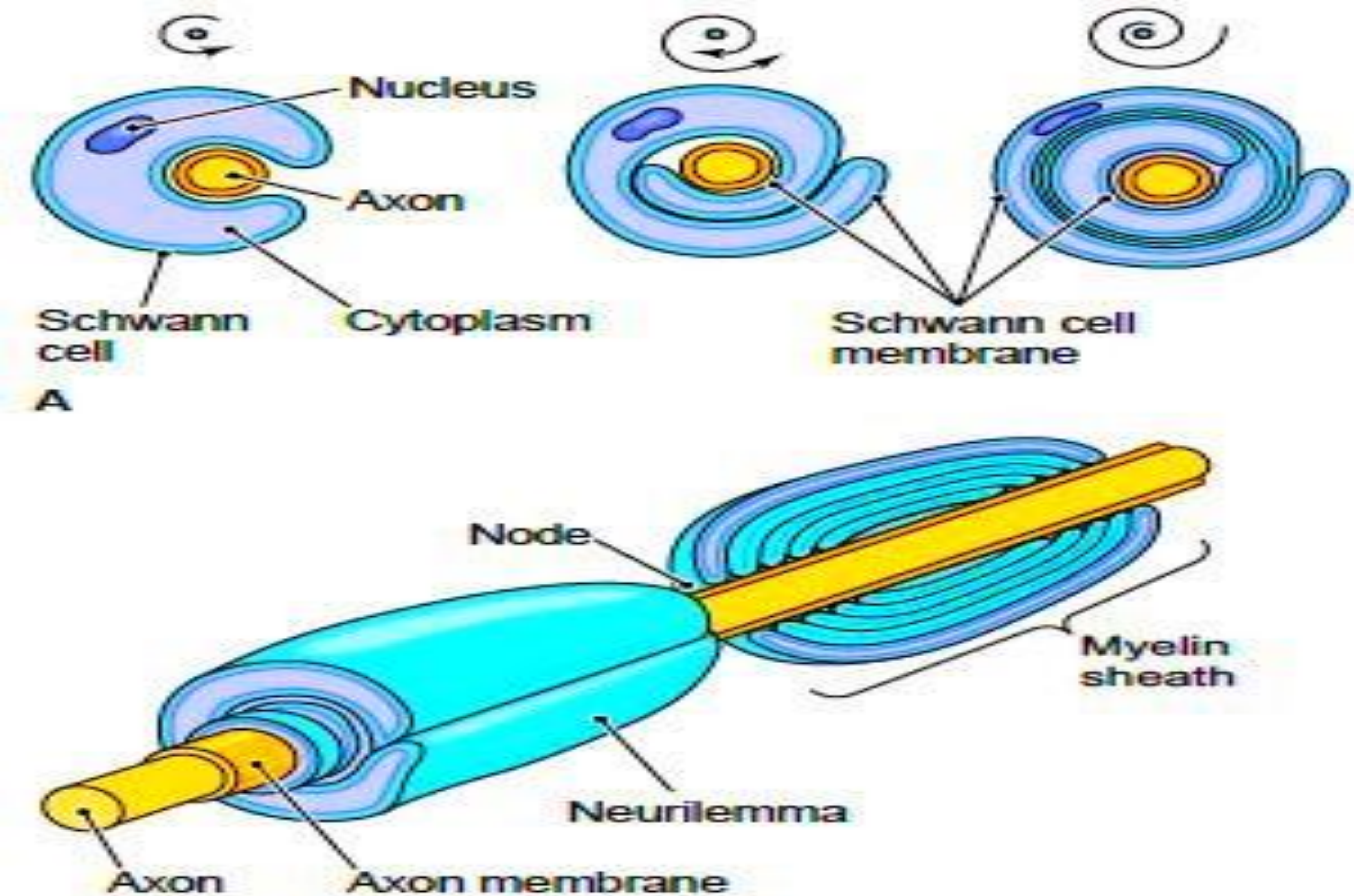
- **Second**, saltatory conduction conserves energy for the axon because only the nodes depolarize, allowing perhaps 100 times less loss of ions than would otherwise be necessary, and therefore requiring little energy expenditure for re-establishing the sodium and potassium concentration differences across the membrane after a series of nerve impulses.



First action potential occurs here.
Saltatory conduction
Action potential
Action potential will be regenerated at the next node.
Na+
Myelin
Axon
Na+
Sodium channel
One glial cell
Node of Ranvier
Na+
Na+

- The myelin sheath is deposited around the axon by Schwann cells in the following manner
- The membrane of a Schwann cell first envelops the axon. The Schwann cell then rotates around the axon many times, laying down multiple layers of Schwann cell membrane containing the lipid substance sphingomyelin.
- This substance is an excellent electrical insulator that decreases ion flow through the membrane about 5000-fold

- At the juncture between each two successive Schwann cells along the axon, a small uninsulated area only 2 to 3 micrometers in length remains where ions still can flow with ease through the axon membrane between the extracellular fluid and the intracellular fluid inside the axon. This area is called **the node of Ranvier**.



formation of myelin sheath

- **Velocity of Conduction in Nerve Fibers:**
- The velocity of action potential conduction in nerve fibers varies from as little as 0.25 m/sec in small unmyelinated fibers to as great as 100 m/sec in large myelinated fibers.
- Velocity depends on many factors, the most important are:

1. Heaviness of myelination, heavily myelinated nerve fibers conduct action potential faster than lightly myelinated nerve fibers.

2. Diameter of nerve fiber (axon), the larger diameter the faster transmission of impulses (Larger diameter axons conduct faster due to less resistance).

Demyelination

- According to the function of myelin sheath, diseases that cause demyelination (damage to myelin sheath), will affect transmission of nerve impulse along nerve fiber and so if demyelination is partial there will be delay of transmission while if there is complete demyelination (loss of entire myelin segment) there will be block of electrical transmission.

- Guillian Barre syndrome is example of demyelinating disease that attacks Schwann cells in the peripheral nervous system while multiple sclerosis is example of demyelinating disease that attacks oligodendrocyte of central nervous system.