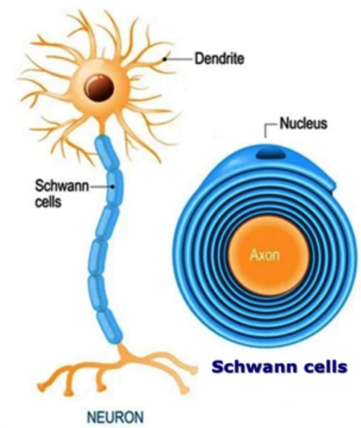
Unmyelinated Fibers (Axons)

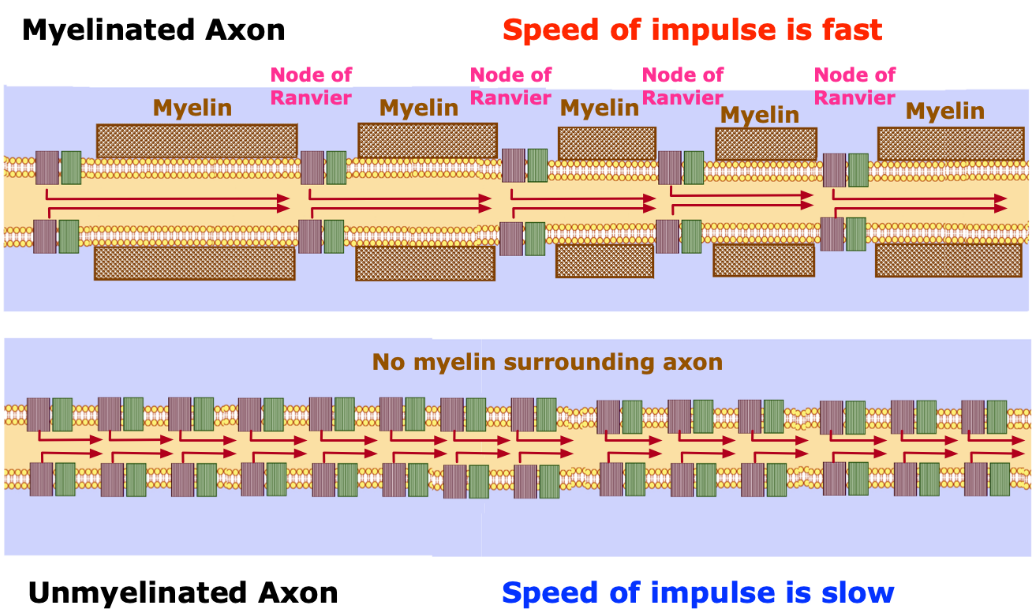
As we've seen, neural fibers (axons) are often myelinated, that is, the length of the axon has a regular protective covering (myelin) which serves to insulate the axon. In the CNS the myelin comes from ***oligodendrocytes***, a type of glial cell, whereas in the PNS, the myelin comes from ***Schwann cells*** which wrap themselves around the axon (see figure on right). In myelinated axons, there are always small gaps between the myelin which are called Nodes of Ranvier. These nodes are the locations on the axon where there is no insulation and both NA+ (sodium) and K+ (potassium) voltage gates are found.



https://www.news-medical.net/health/What-are-Schwann-Cells.aspx

Credit: Designua / Shutterstock

However, both the CNS and the PNS contain neural fibers/axons which are **unmyelinated**, that is, the is no insulation along the length of the axon. Indeed many of the neurons in the peripheral nervous system that are involved in sensory and autonomic functions (we will talk about autonomic functions later on) are unmyelinated.



A significant difference between these two types of fibers is seen with myelinated axons transmitting signals/action potentials at a much faster speed than unmyelinated axons for which the impulse is much slower, e.g., among touch fibers, myelinated axons transmit at a rate of about 15 m/sec while unmyelinated axons communicate at about 1 m/sec. As you examine the figure above, you see that the presence of myelin allows signals to jump from one node of Ranvier to the next node at a much faster rate than in axons with no insulation.

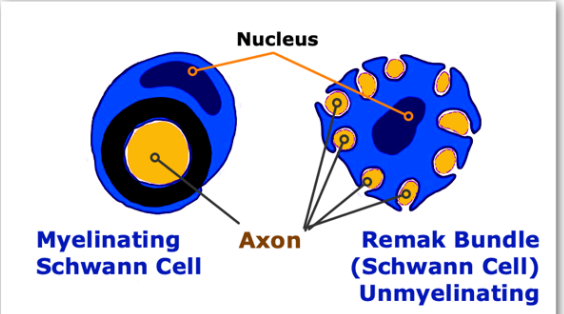
Touch and Pain

The sensory receptors on the surface of our skin can detect light pressure, deep pressure, vibrations, skin stretching, itch, and hot and cold temperature.

- These sensations are generally carried to the spine by **Alpha- (A-) fibers** which are myelinated. When the sensation is a sharp or acute pain, A-fibers will convey that sensation.

- However, there is a second class of fibers which are known as **C-fibers**. The axons of these neurons **are unmyelinated** and convey nociceptive sensations (nociceptive means "painful") at a much slower speed. C-fibers are associated with chronic pain signals.

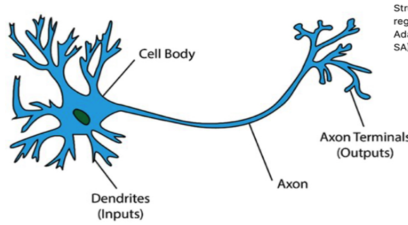
  C- fiber axons are grouped together into what are known as **Remak bundles**. These occur when a **non-myelinating Schwann cell** bundles the axons close together by surrounding them. The Schwann cell keeps them from touching each other by squeezing its own cytoplasm between the axons.



from Harty & Monk (2017) Fig. 2

New Discoveries about Axon Shape

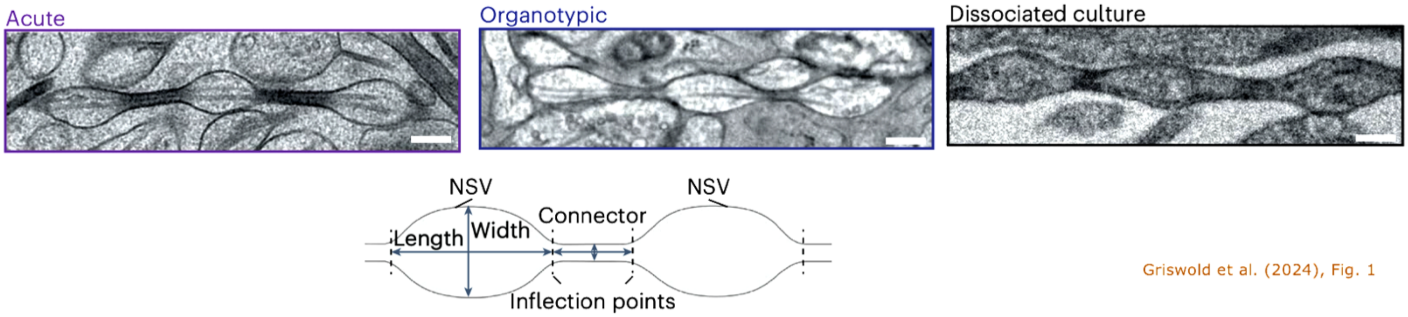
The generic or typical neuron is usually described as having multiple branching dendrites, a single central soma or body, and an axon which extends from the soma ***in the form of a long tube*** at the end of which are various terminal fibers/terminal buttons.



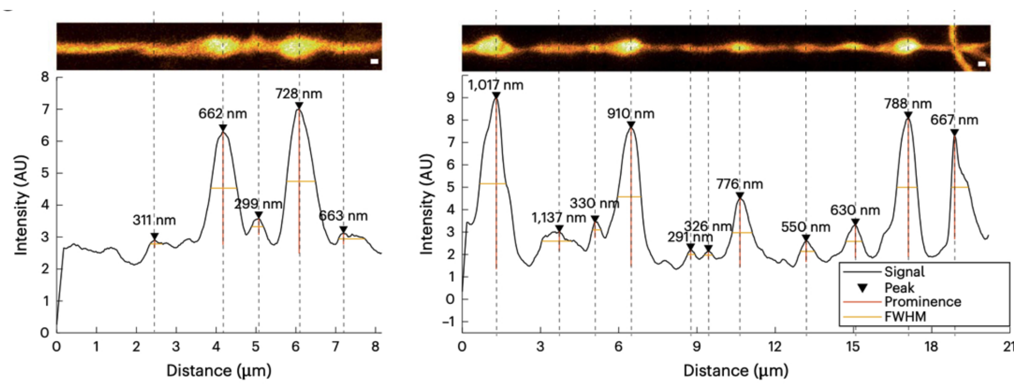
Structure of a generic neuron, with different regions and the flow of information labeled. Adapted from image by Jarosz 16 (CC BY-SA).

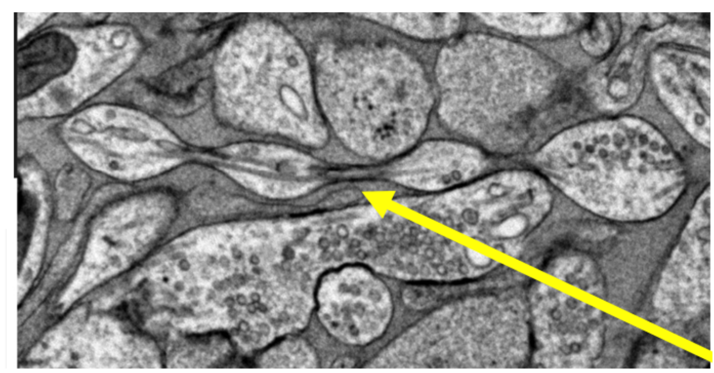
https://www.researchgate.net/publication/333111460_The_motivation_principles_and_state_of_neuromorphic_engineering/figures?lo=1

Over the last couple of years and particularly toward the end of 2024, researchers have raised questions whether the axon is always shaped like a smooth and cylindrical tube. In a somewhat controversial study published in January 2025, graduate student researcher, Jacqueline Griswold (working in the lab of Shigeki Watanabe of the Johns Hopkins University School of Medicine) demonstrated "that unmyelinated axons of the mouse central nervous system have nonsynaptic nanoscopic varicosities ~ 200 nm in diameter repeatedly along their length interspersed with a thin cable ~60 nm in diameter ***like pearls-on-a-string***" (Griswold et al. 2024, Abstract, emphasis added). [See next page for illustrations]. These areas suggest a process of "***beading***" and seem to reflect various biomechanical/biochemical forces within the axon which cause these shapes.



Griswold et al. (2024), Fig. 1





Quaglia, 2024

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Posted: February 1, 2025