

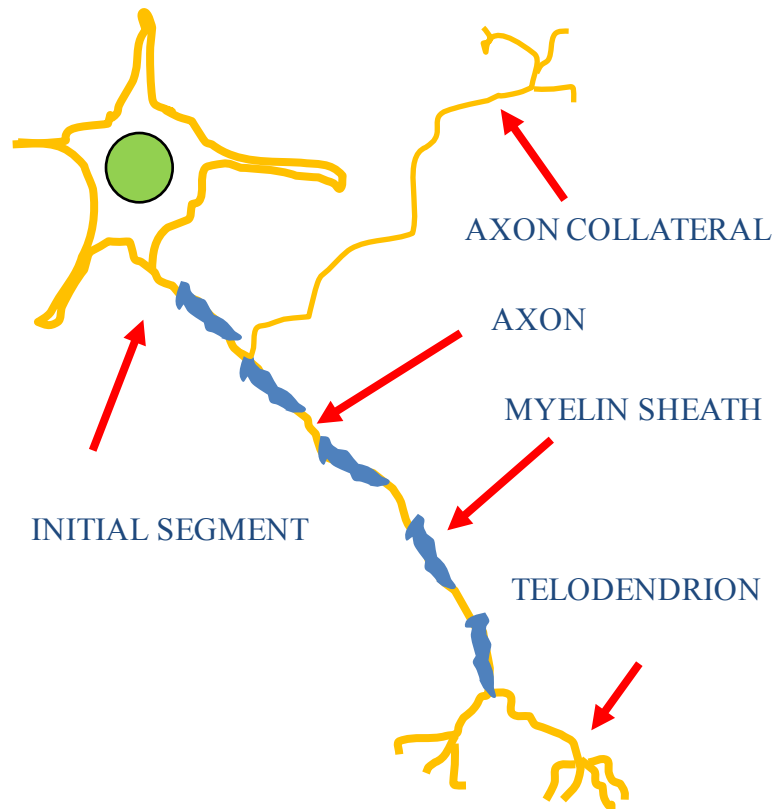
BASICS OF NEUROBIOLOGY

NERVE FIBERS

ZSOLT LIPOSITS

Basics of Neurobiology: Nerve fibers

HISTOLOGICAL CLASSIFICATIONS OF NERVE FIBERS



SCHEME OF A NEURON WITH A
PROJECTING MYELINATED AXON

- I. NAKED AXONS
- II. NON-MYELINATED AXONS
- III. AXONS MYELINATED BY SCHWANN CELLS
- IV. AXONS MYELINATED BY OLIGODENDROCYTES

Basics of Neurobiology: Nerve fibers

I. NAKED AXONS

THE THINNEST AXONS IN THE NERVOUS SYSTEM

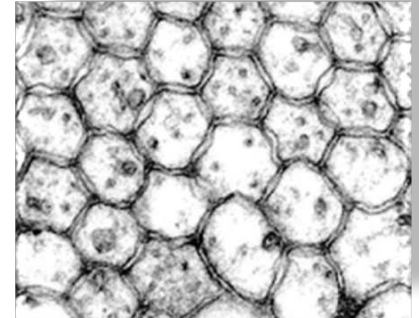
THEIR DIAMETER IS IN THE RANGE OF 0.1-0.3 MICROMETERS

THEY DO NOT HAVE ANY INSULATING SHEATH, THEREFORE, THEIR AXOLEMMA IS IN DIRECT CONTACT WITH THE EXTRACELLULAR SPACE AND FLUID

THEY OCCUR IN AXON BUNDLES WITHIN THE CNS

THEIR CONDUCTION VELOCITY IS LOW, ABOUT 0.5-2 m/sec

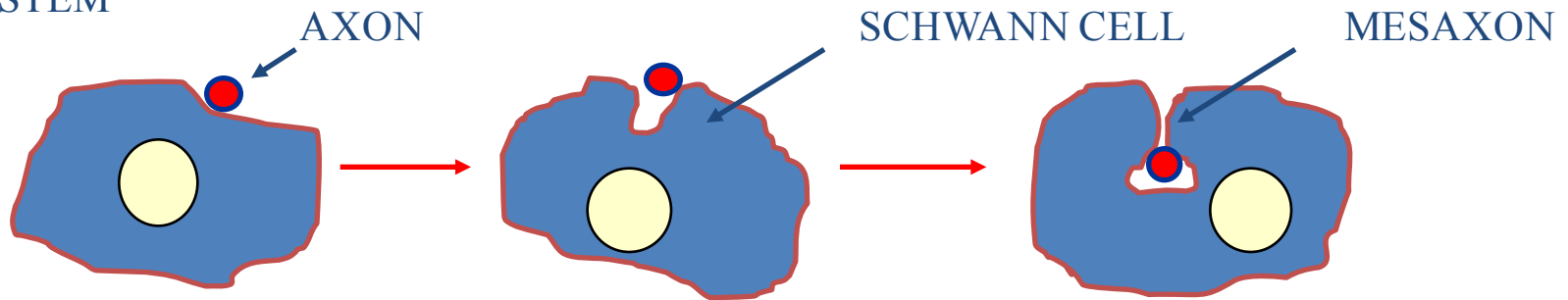
THE INITIAL AND THE TERMINAL SEGMENTS OF NEURONS ARE NAKED AS WELL



Basics of Neurobiology: Nerve fibers

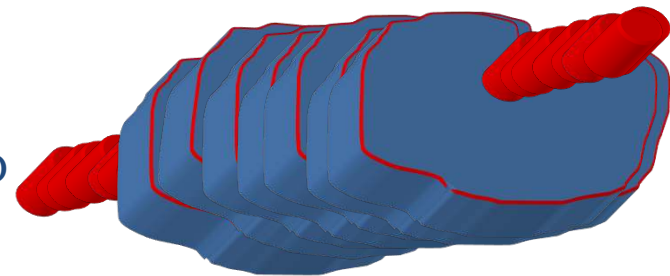
II. NON-MYELINATED AXONS

DURING DEVELOPMENT THESE AXONS ESTABLISH CLOSE CONNECTIONS WITH SCHWANN CELLS, THE PRINCIPAL GLIAL CELLS OF THE PERIPHERAL NERVOUS SYSTEM

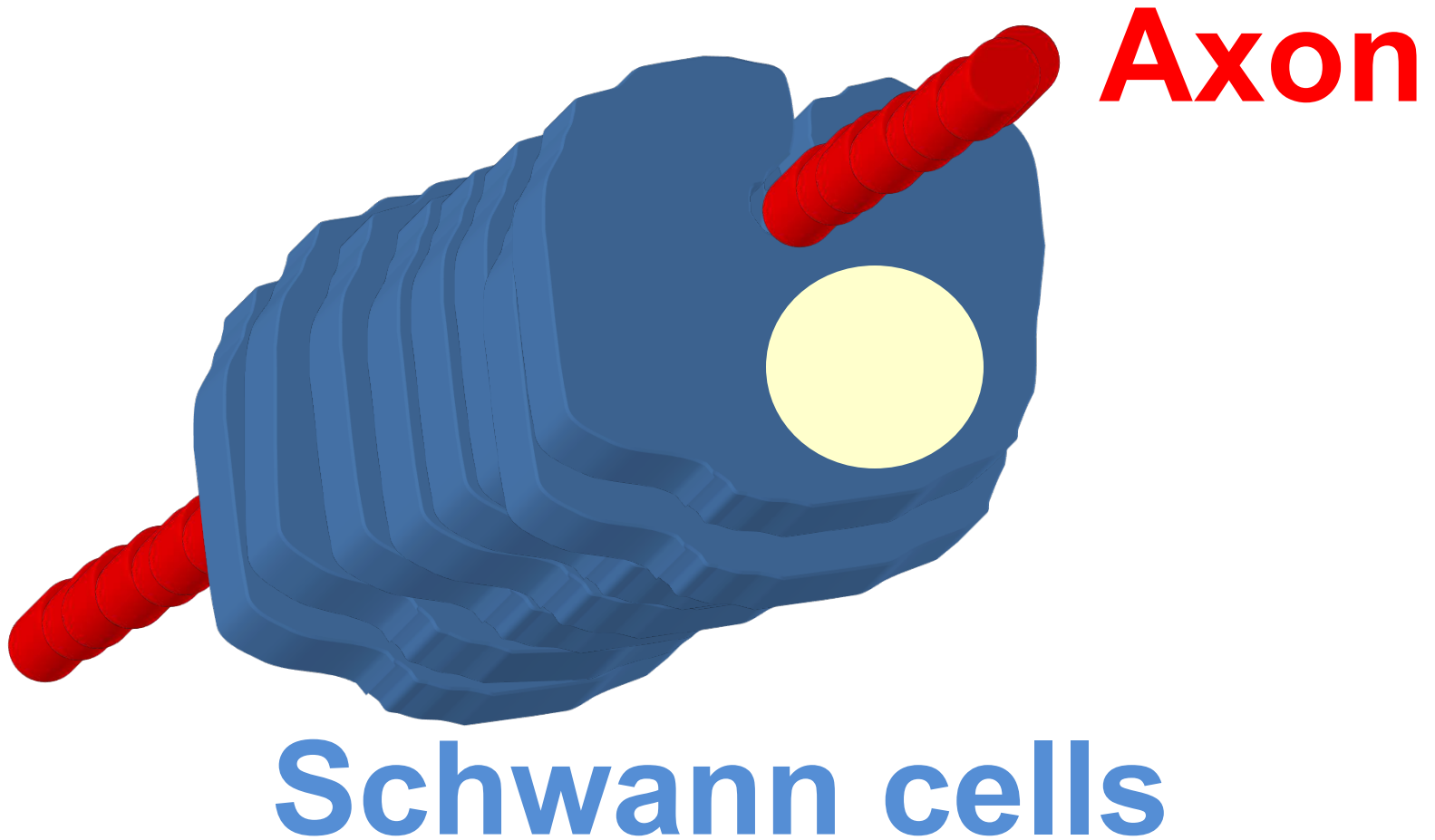


SCHWANN CELLS (LEMMOCYTES) APPEAR ALONG THE COURSE OF THE AXON. THE AXON GRADUALLY GETS INVAGINATED INTO THE SCHWANN CELL WHOSE CELL MEMBRANE ENSHEATHS THE AXON. THE AXON IS SUSPENDED BY THE MESAXON, A DUPLICATE OF THE SCHWANN CELL MEMBRANE

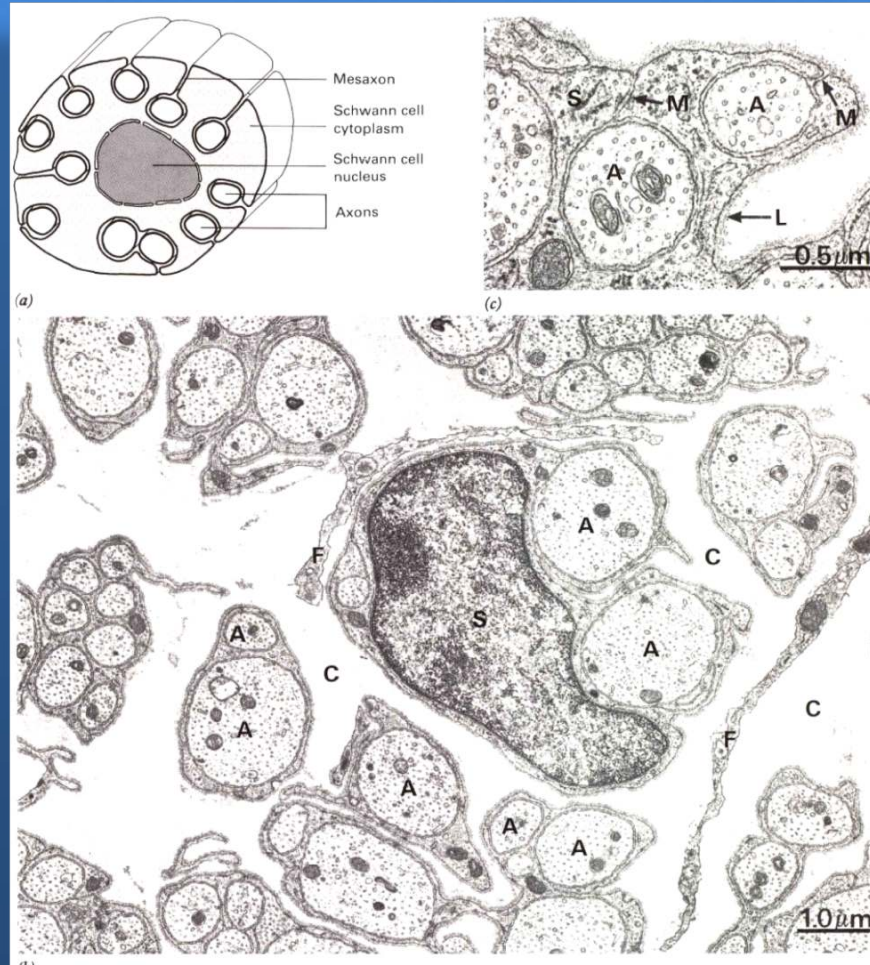
NEIGHBORING SCHWANN CELLS, SITUATED NEXT TO EACH OTHER, WRAP AROUND AND INSULATE THE AXON



Basics of Neurobiology: Nerve fibers



Basics of Neurobiology: Nerve fibers



Basics of Neurobiology: Nerve fibers

NON-MYELINATED AXONS

INDIVIDUAL SCHWANN CELLS ENCLOSE 150-200 MICROMETER SEGMENTS OF THE AXON

A SINGLE SCHWANN CELL HOSTS SEVERAL AXONS IN ITS CELL BODY

FIBERS BELONGING TO THIS CATEGORY ARE:

1. POST-GANGLIONIC FIBERS OF THE AUTONOMIC NERVOUS SYSTEM
2. SENSORY FIBERS CARRYING CRUDE TOUCH, TEMPERATURE AND PAIN SENSATIONS

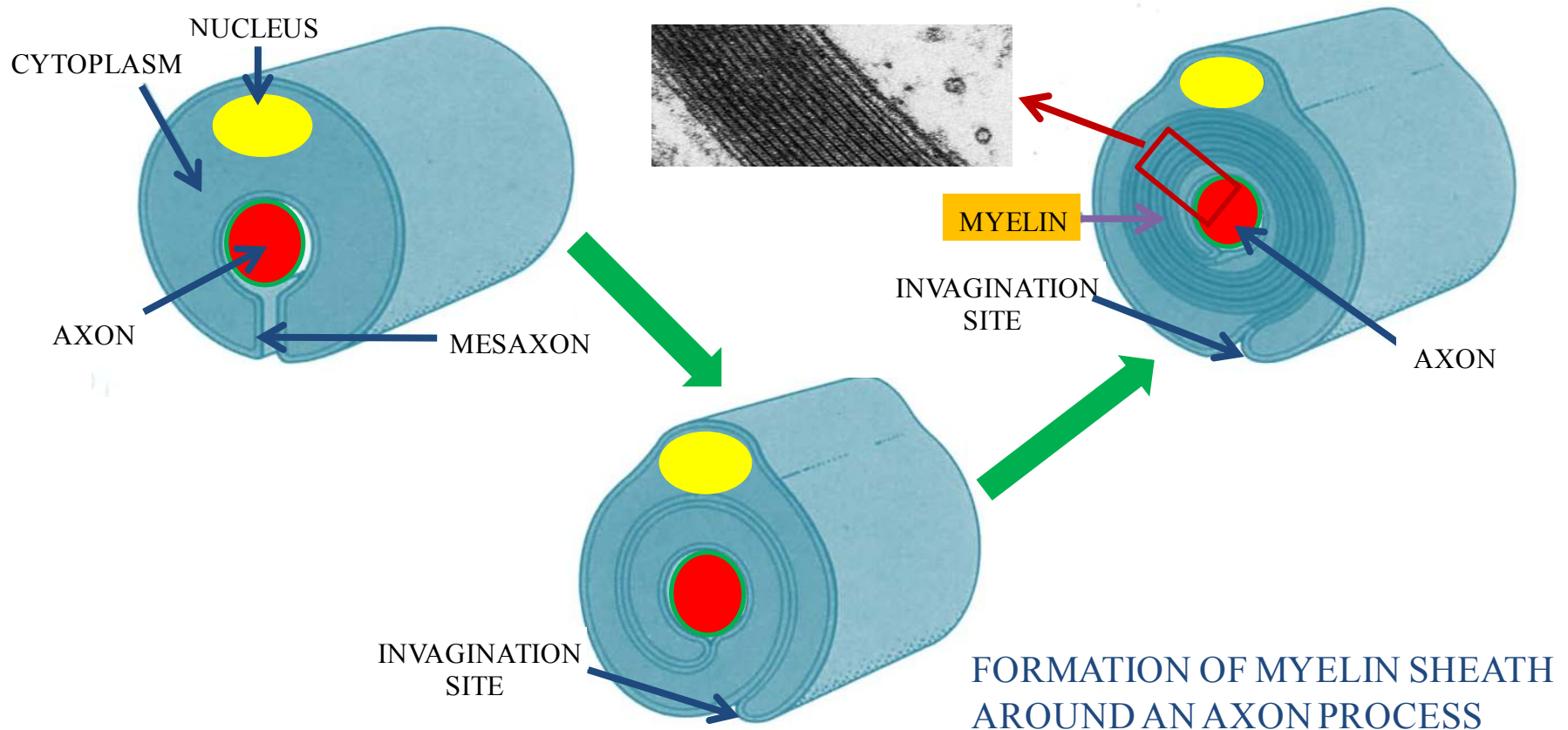
SCHWANN CELLS ARE OBLIGATORY TO THE PROPER FUNCTION OF THE AXON

SCHWANN CELL DERIVES FROM THE NEURAL CREST

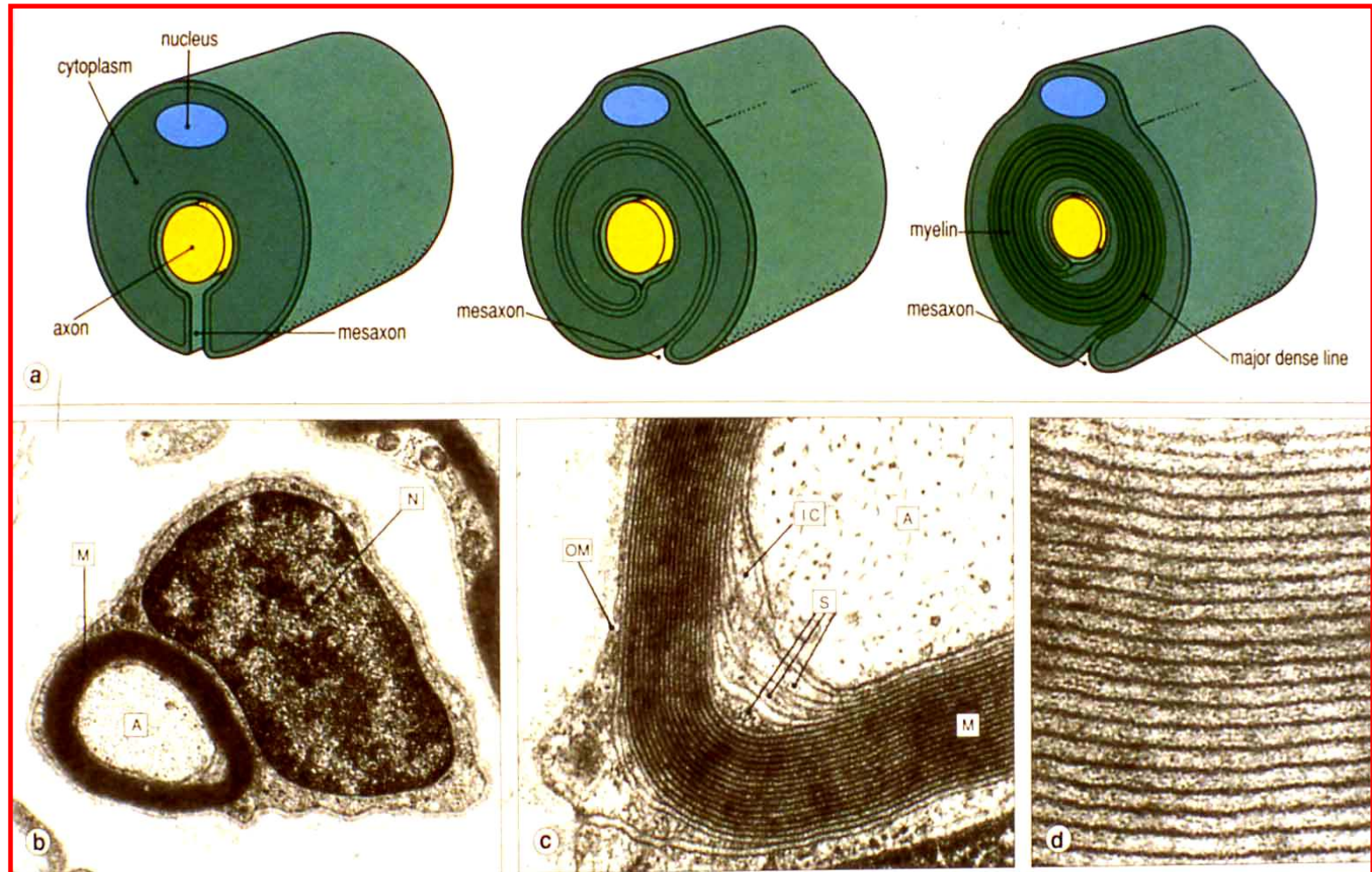
THESE NON-MYELINATED FIBERS ARE ALSO CALLED AS REMAK-FIBERS

Basics of Neurobiology: Nerve fibers

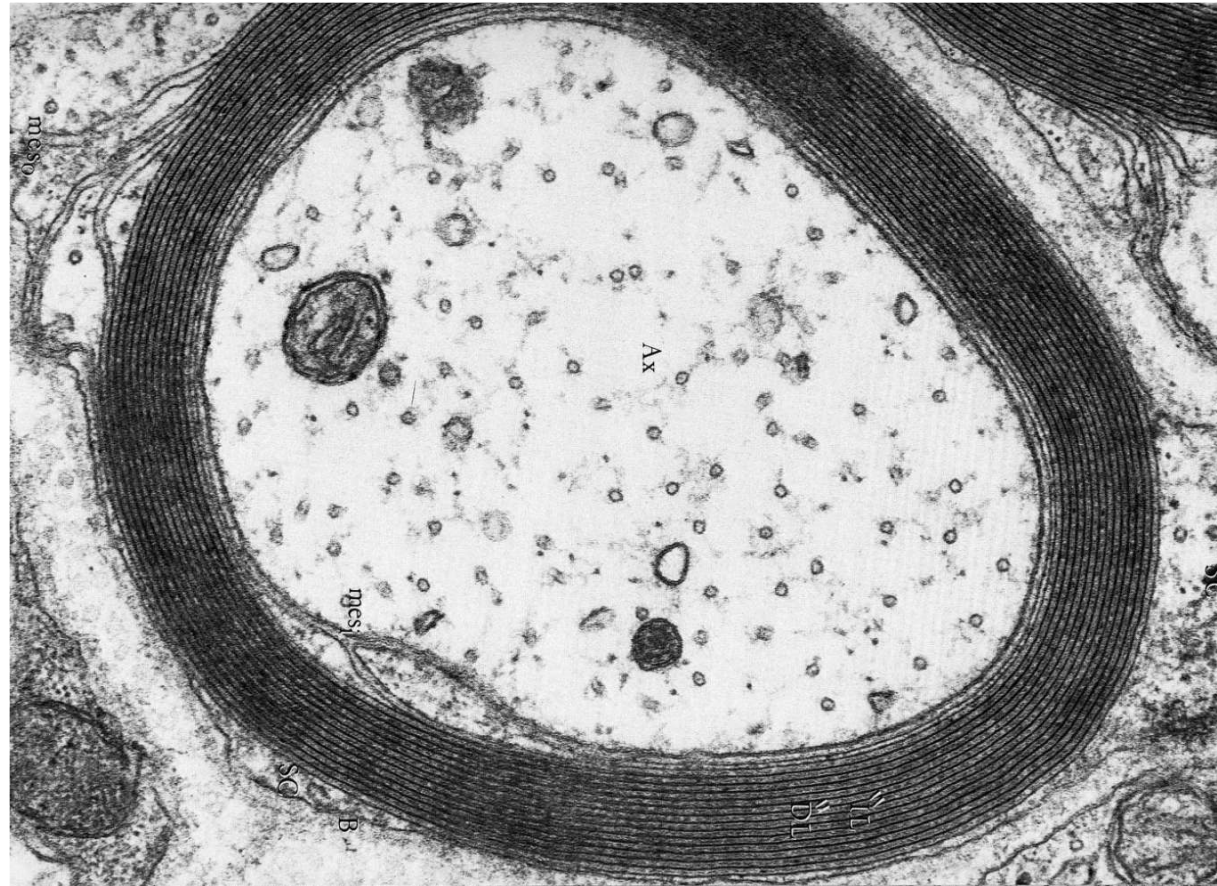
III. AXONS MYELINATED BY SCHWANN CELLS: MYELINATED FIBERS IN THE PERIPHERAL NERVOUS SYSTEM



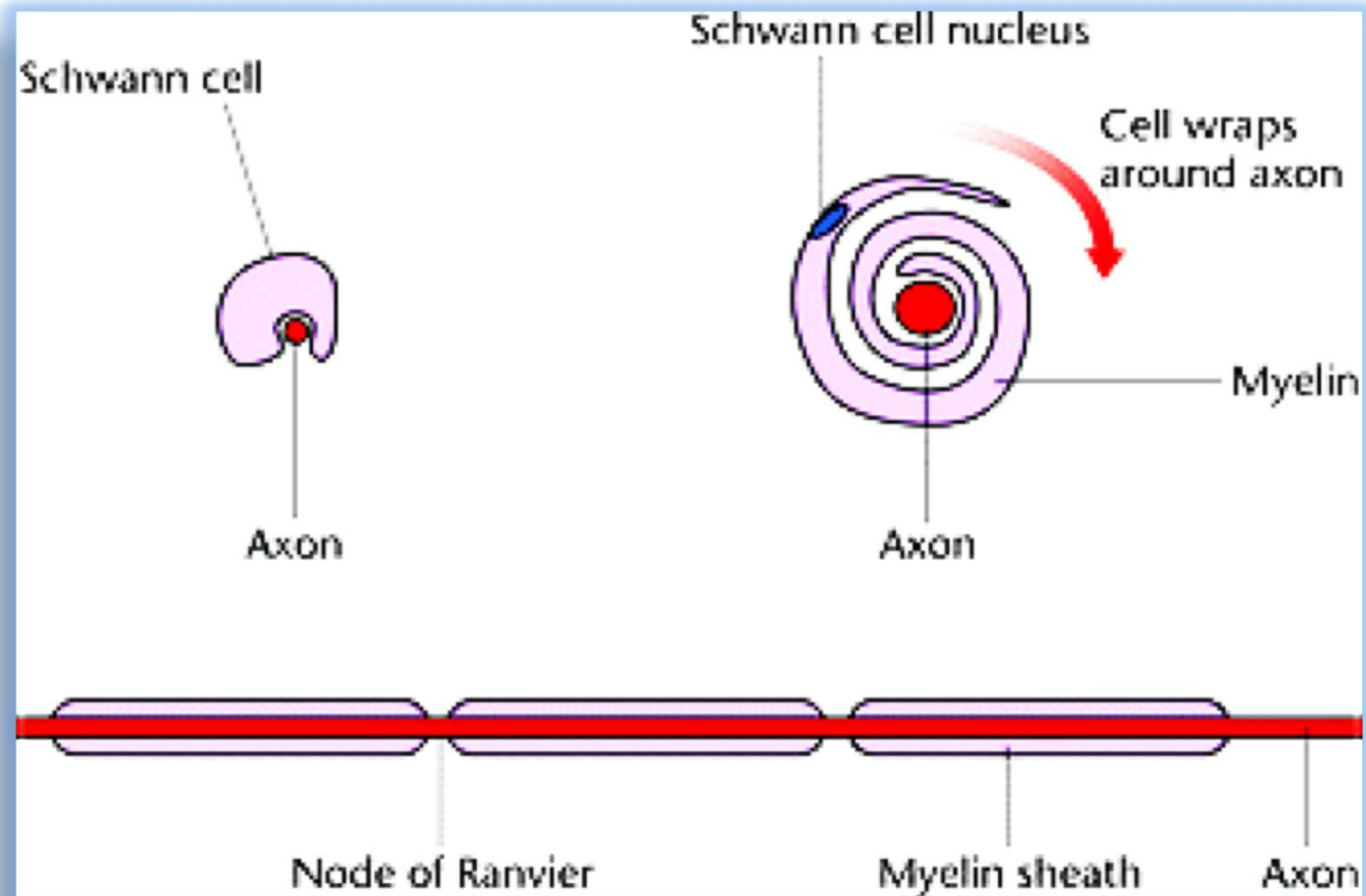
Basics of Neurobiology: Nerve fibers



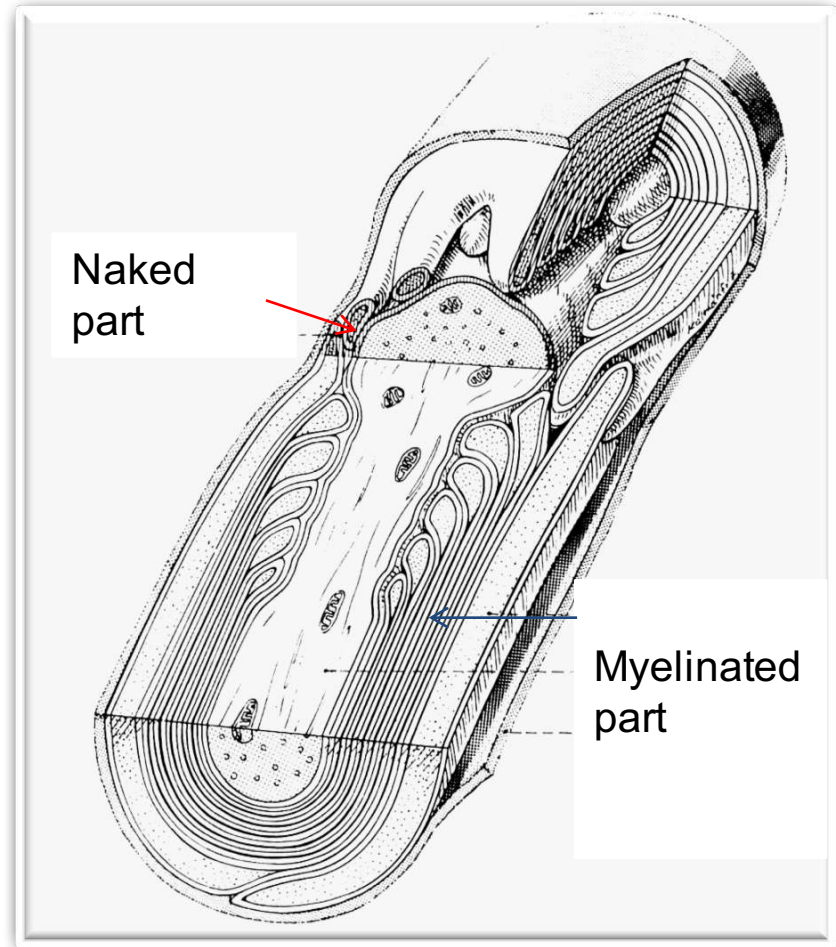
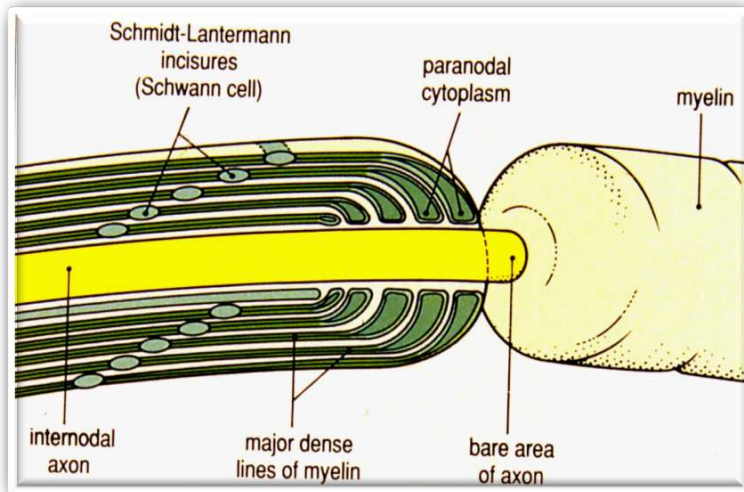
Basics of Neurobiology: Nerve fibers



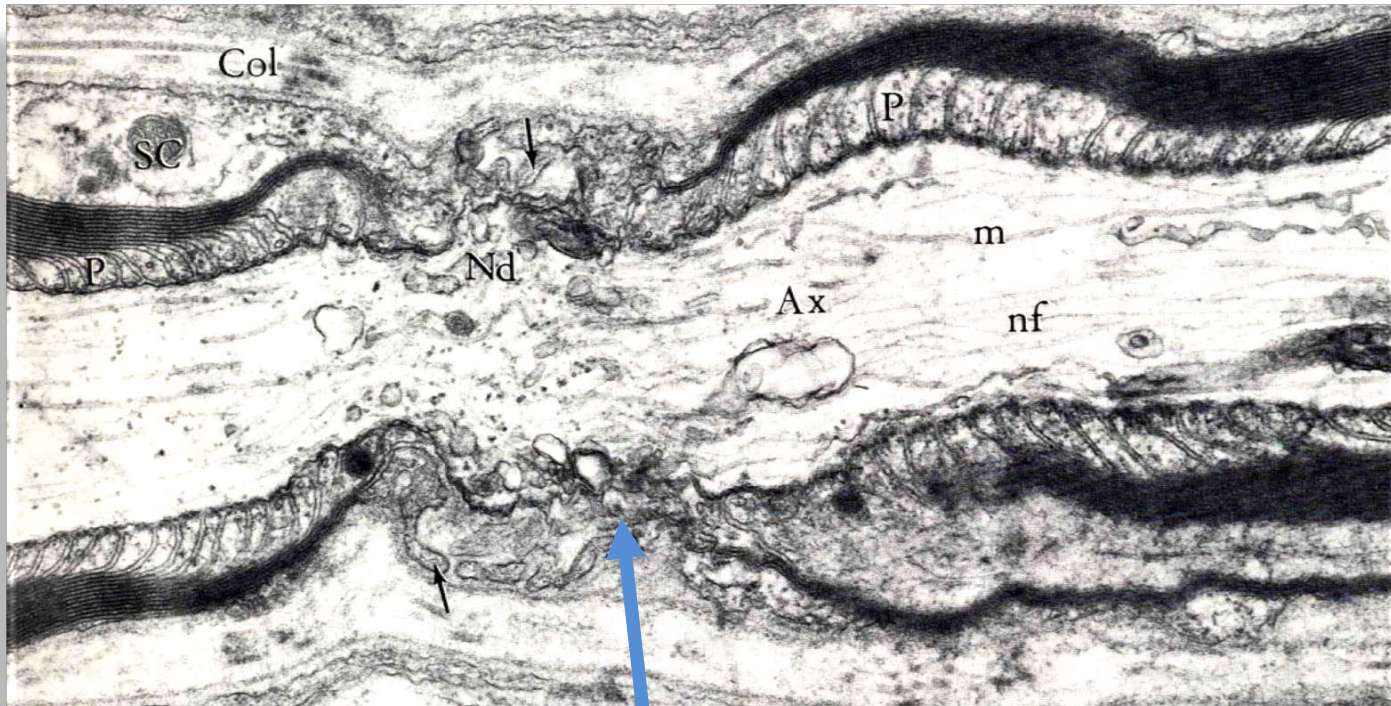
Basics of Neurobiology: Nerve fibers



Basics of Neurobiology: Nerve fibers



Basics of Neurobiology: Nerve fibers



Ranvier node

Basics of Neurobiology: Nerve fibers

FEATURES OF MYELINATED FIBERS IN THE PNS

DURING AXONAL OUTGROWTH, THE SCHWANN CELLS ROTATE AROUND THE AXON, THEIR MESAXONS WRAP AROUND THE AXON PROCESS RESULTING IN THE FORMATION OF A CONCENTRIC, MULTI-LAMINAR, MEMBRANE STRUCTURE CALLED MYELIN. 80% OF THE MYELIN IS COMPOSED OF LIPIDS, PROTEINS ACCOUNT FOR THE REMAINING 20%.

OUTSIDE THE MYELIN SHEATH, THE COMPRESSED SCHWANN CELL BODIES OCCUR

THE MYELIN INSULATION OF AXONS IS NOT CONTINUOUS, THERE ARE GAPS BETWEEN MYELIN ENCLOSURES BELONGING TO NEIGHBORING SCHWANN CELLS. THESE MYELIN FREE, NUDE SEGMENTS ARE THE RANVIER NODES.

AT THE RANVIER NODES, THE AXOLEMMA HAS ACCESS TO THE EXTRACELLULAR FLUID COMPARTMENT. AT THESE SITES, ION MOVEMENTS BETWEEN THE INTRA- AND EXTRACELLULAR COMPARTMENTS TAKE PLACE

THE MYELIN SHEATH SPEEDS UP THE PROPAGATION OF THE INFORMATION IN THE AXON

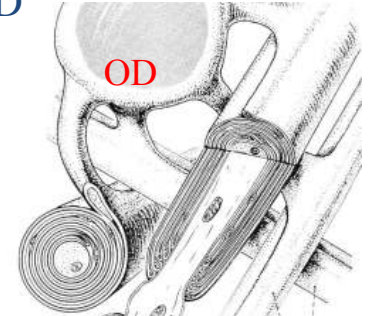


Basics of Neurobiology: Nerve fibers

IV. AXONS MYELINATED BY OLIGODENDROCYTES: MYELINATED FIBERS WITHIN THE CNS

SIMILAR TO THE PERIPHERY, THE CNS ALSO CONTAINS MYELINATED FIBERS

IN THE CNS, MYELIN IS FORMED BY THE PROCESSES OF SPECIAL GLIAL CELLS, SO-CALLED OLIGODENDROCYTES (OD)



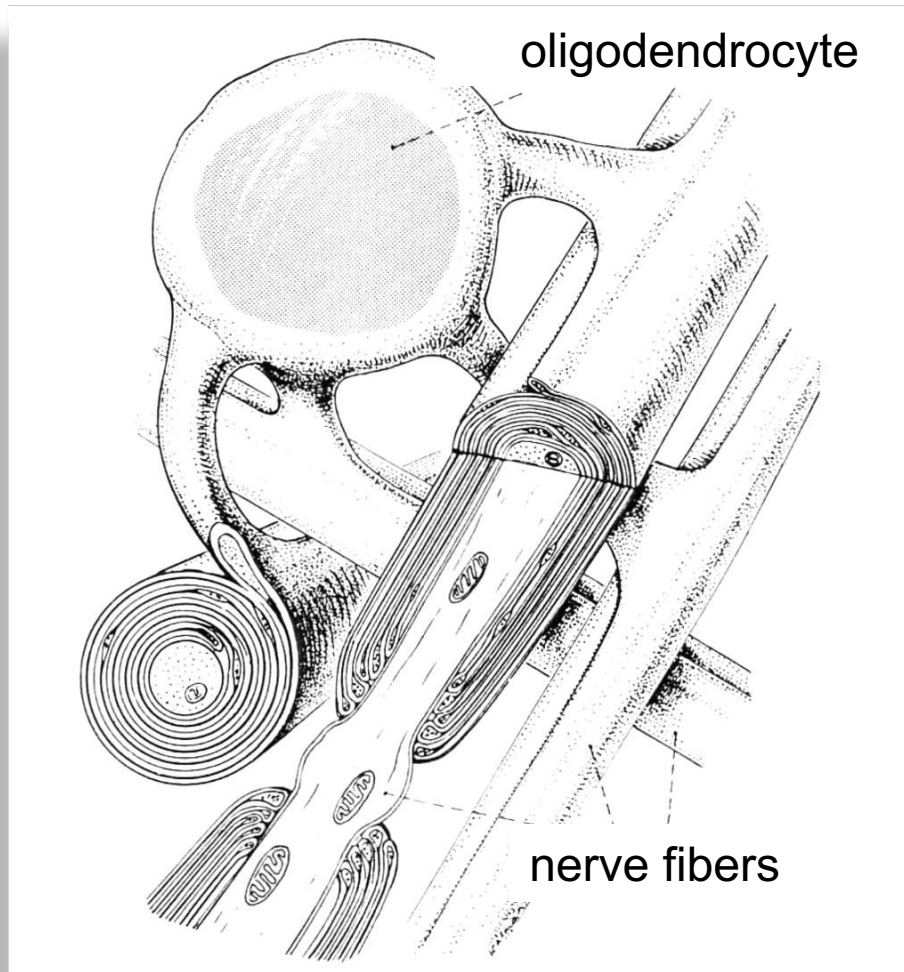
THEIR PROCESSES WRAP AROUND AXONS. A SINGLE OLIGODENDROCYTE CAN INSULATE ABOUT 50 AXONS

RANVIER NODES ALSO EXIST BETWEEN THE ADJACENT MYELIN INSULATIONS

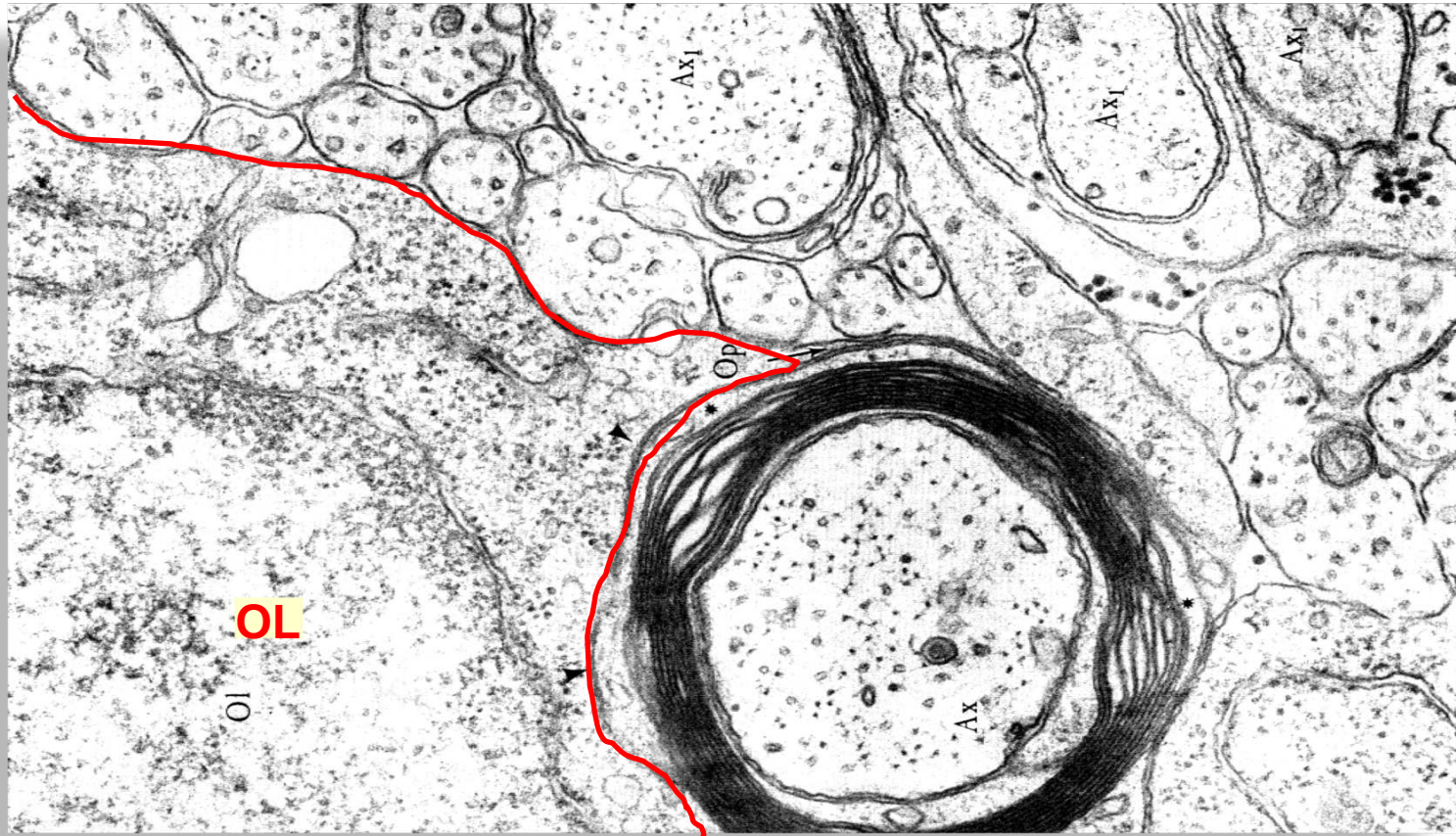
MYELINATED AXONS PROPAGATE ACTION POTENTIALS IN A SALTATORY MANNER FROM ONE RANVIER NODE TO THE OTHER

DEMYELINATION, THE LOSS OF MYELIN INSULATION OF AXONS DUE TO DYSFUNCTION AND DEGENERATION OF OLIGODENDROCYTES, LEADS TO SEVERE AND DIFFUSE NEURAL DISEASES (SCLEROSIS MULTIPLEX)

Basics of Neurobiology: Nerve fibers



Basics of Neurobiology: Nerve fibers



Basics of Neurobiology: Nerve fibers

PERIPHERAL NERVES

NEURAL FIBERS COMPOSE BUNDLES THAT FORM PERIPHERAL NERVES

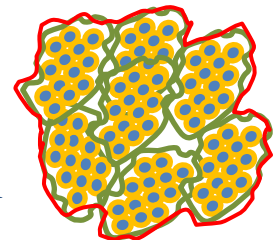
IN PERIPHERAL NERVES, THE INDIVIDUAL NEURAL FIBERS, AS WELL THE FIBER BUNDLES ARE WRAPPED BY CONNECTIVE TISSUE BEING RICH IN COLLAGEN AND RETICULIN FIBERS. THE CONNECTIVE TISSUE COVERINGS ESTABLISH THE **ENDO-**, **PERI-** AND **EPINEURIUM**

PERIPHERAL NERVES HAVE SENSORY, MOTOR OR MIXED PHENOTYPES

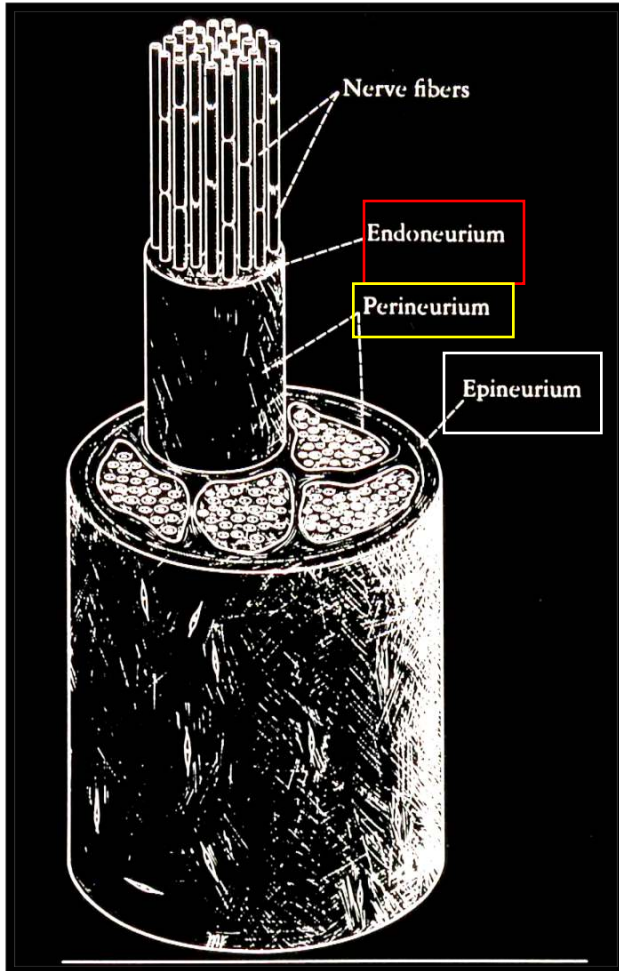
STRUCTURALLY THEY ARE COMPOSED OF SCHWANN CELLS, FIBROBLASTS AND AXONS. THEY ARE EMBEDDED IN THE GROUND SUBSTANCE PRODUCED BY FIBROBLASTS. CONNECTIVE TISSUE FIBERS SUPPORT AND HOLD TIGHTLY THIS CABLE LIKE STRUCTURE

TRANSECTED PERIPHERAL NERVES MIGHT REGENERATE

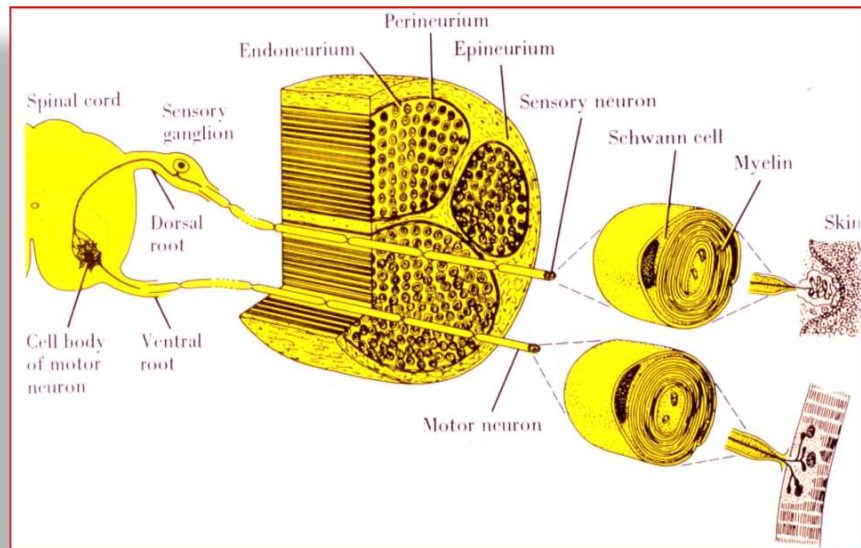
PERIPHERAL NERVES ESTABLISH CONNECTIONS WITH RECEPTOR AND EFFECTOR STRUCTURES



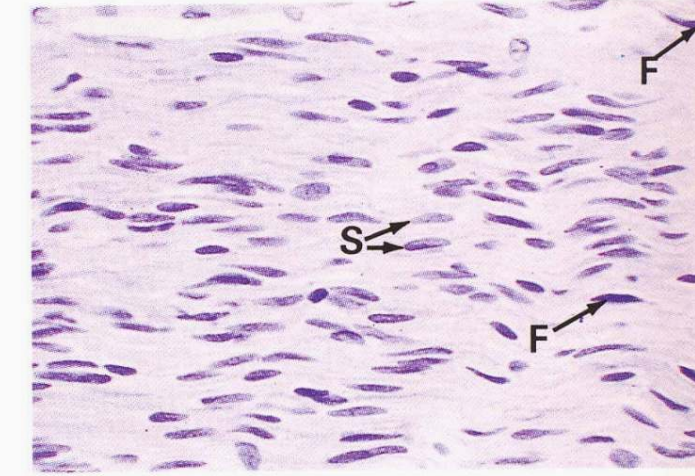
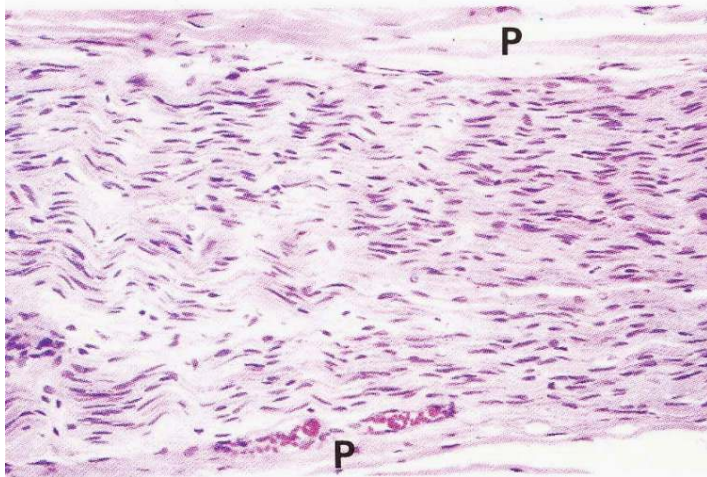
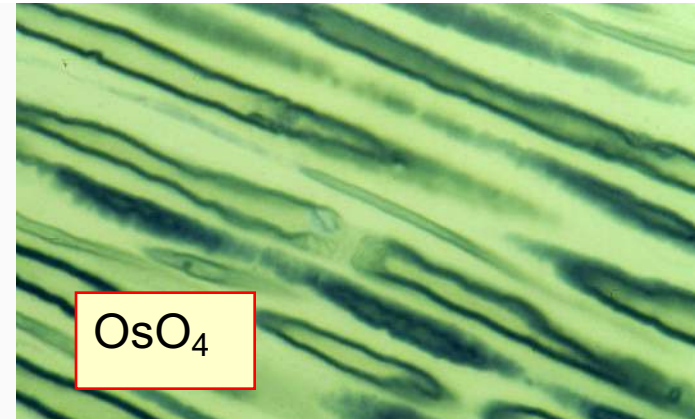
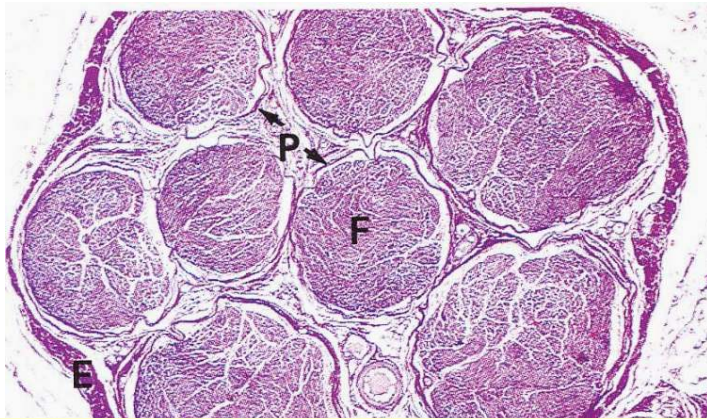
Basics of Neurobiology: Nerve fibers



PERIPHERAL NERVE



Basics of Neurobiology: Nerve fibers



This electron micrograph shows a developing nerve. A large, myelinated axon (Ax2) is visible in the upper left, with a clear myelin sheath (mes) and a terminal (T1). A smaller, developing axon (Ax1) is in the center, surrounded by a myelin sheath (mes) and containing mitochondria (m) and nerve fibers (nf). The blood/lumen (bl/ll') is visible at the bottom. The myelin sheath (mes) is labeled in three locations, and the axon (Ax1) is labeled in two locations. Mitochondria (m) and nerve fibers (nf) are also labeled.

Basics of Neurobiology: Nerve fibers

CLASSIFICATION OF NERVE FIBERS

TYPE	ASSOCIATION, FUNCTION	DIAMETER (μm)	CONDUCTING VELOCITY (m/s)	PEAK POTENTIAL (ms)	ABSOLUTE REFRACTORY PERIOD (ms)
A α	EXTRAFUSAL MUSCLE FIBER PRIMARY MUSCLE SPINDLE FIBER	12-20	70-120	0,4-0,5	0,4-1
A β	CUTANEOUS MECHANORECEPTORS SECONDARY MUSCLE SPINDLE FIBER	5-12	30-70		
A γ	INTRAFUSAL MUSCLE FIBER	3-6	15-30		
Ad	PAIN, COLD, TOUCH, PRESSURE	2-5	12-30		
B	PREGANGLIONIC	< 3	3-15	1,2	1,2
C	POSTGANGLIONIC	0,4-1,2	0,5-2	2	2

Basics of Neurobiology: Nerve fibers

ACTION POTENTIAL

ACTION POTENTIAL (AP) TRANSMITS SIGNALS FROM THE CELL BODY TOWARD THE AXON TERMINAL

IT IS DUE TO A SUDDEN CHANGE IN THE DISTRIBUTION AND CONCENTRATION OF IONS IN THE INTRA- AND EXTRACELLULAR FLUID COMPARTMENTS SEPARATED BY THE AXON MEMBRANE

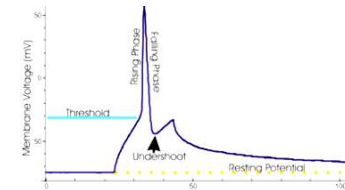
AP HAS THREE SUCCESSIVE STAGES:

1. RESTING STAGE. MEMBRANE IS POLARIZED, -70 mV MEMBRANE POTENTIAL
2. DEPOLARIZATION STAGE. SODIUM ION INFLOW, +50 mV MEMBRANE POTENTIAL
3. REPOLARIZATION STAGE. SODIUM CHANNELS CLOSE, OPENING POTASSIUM CHANNELS ALLOW THE OUTFLOW OF K^+ FROM INSIDE

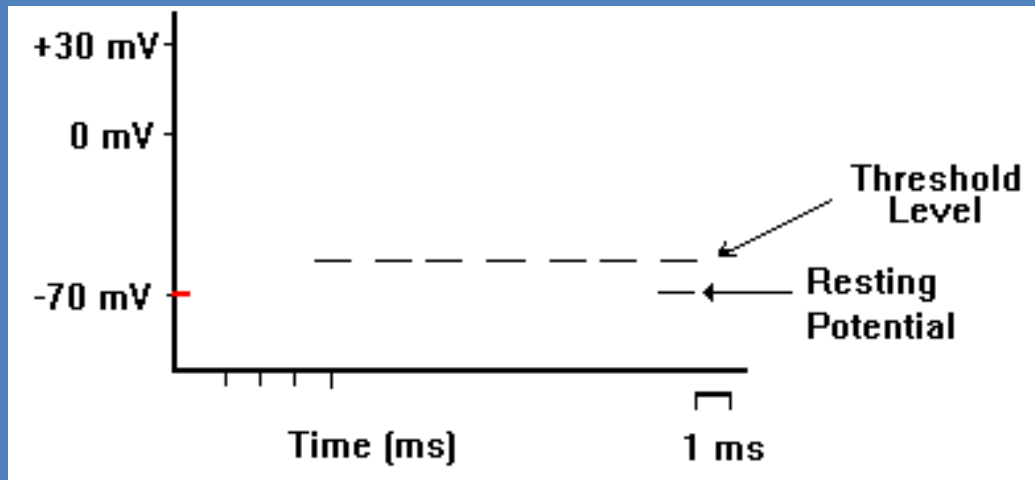
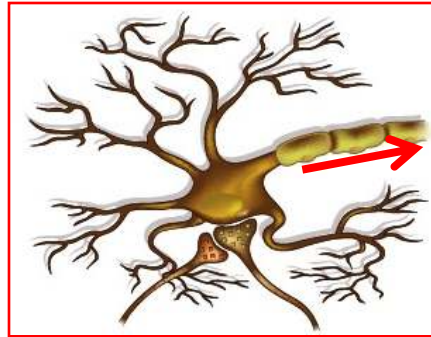
AFTERHYPERPOLARIZATION

REFRACTORY PERIOD

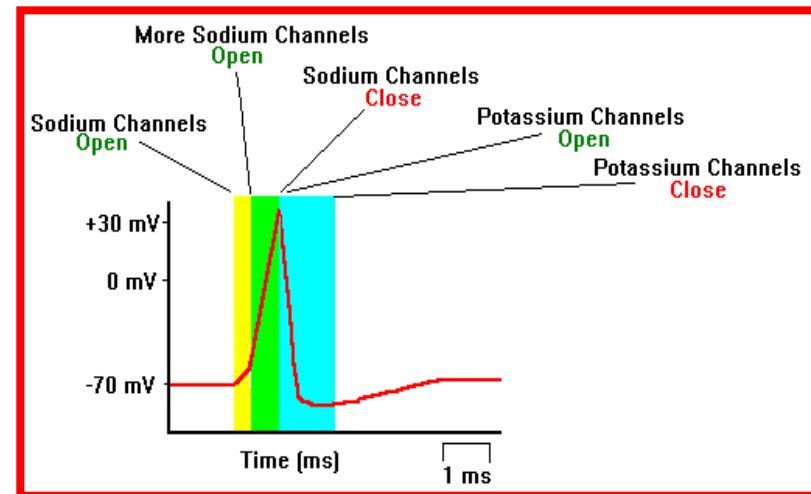
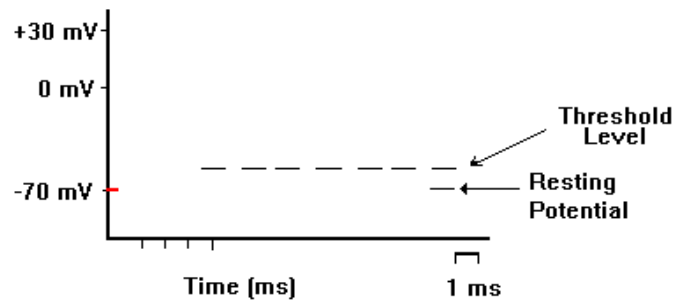
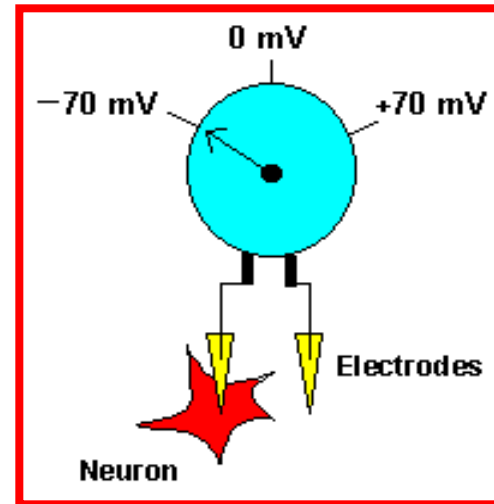
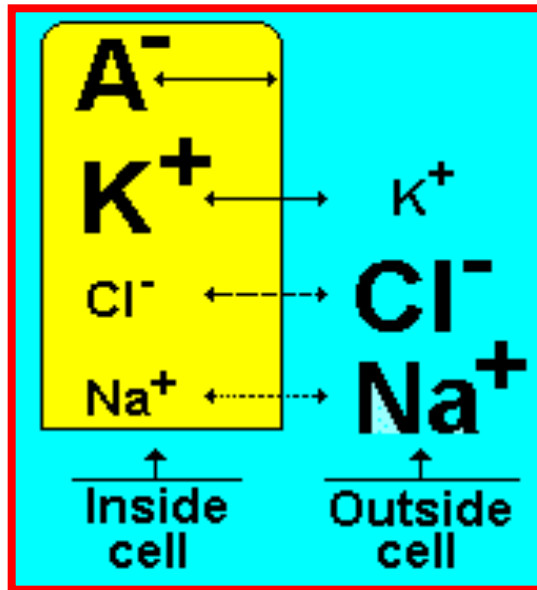
SALTATORY AND WAVE LIKE CONDUCTIONS OF AP



Basics of Neurobiology: Nerve fibers

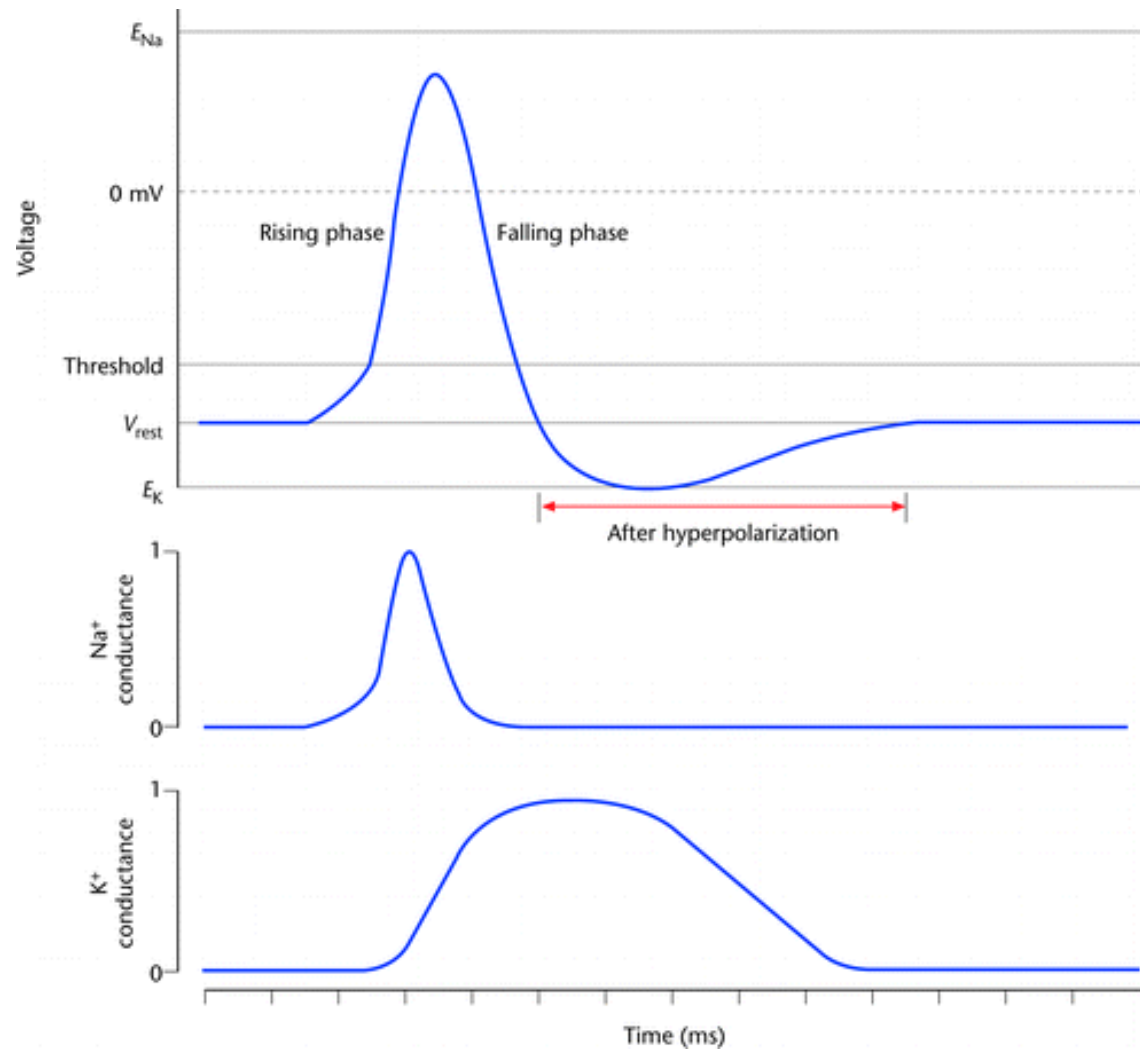


Basics of Neurobiology: Nerve fibers



Animation: voltage-gated channels
and the action potential

Basics of Neurobiology: Nerve fibers



Animation: propagation of action potential in unmyelinated axon

Animation: propagation of action potential in non-myelinated and myelinated axons

Basics of Neurobiology: Nerve fibers

