LECTURE 2

NERVOUS SYSTEM

NEURONS AND SYNAPSES

Dr . Abeer Mohammed Hussain
Dr. Israa Sekar Salman

NERVOUS SYSTEM

- 2 TYPES OF CELLS IN THE NERVOUS SYSTEM:
  - NEURONS.
  - SUPPORTING CELLS.
- NERVOUS SYSTEM IS DIVIDED INTO:
  - CENTRAL NERVOUS SYSTEM (CNS):
    - BRAIN.
    - SPINAL CORD.
  - PERIPHERAL NERVOUS SYSTEM (PNS):
    - CRANIAL NERVES.
    - SPINAL NERVES.

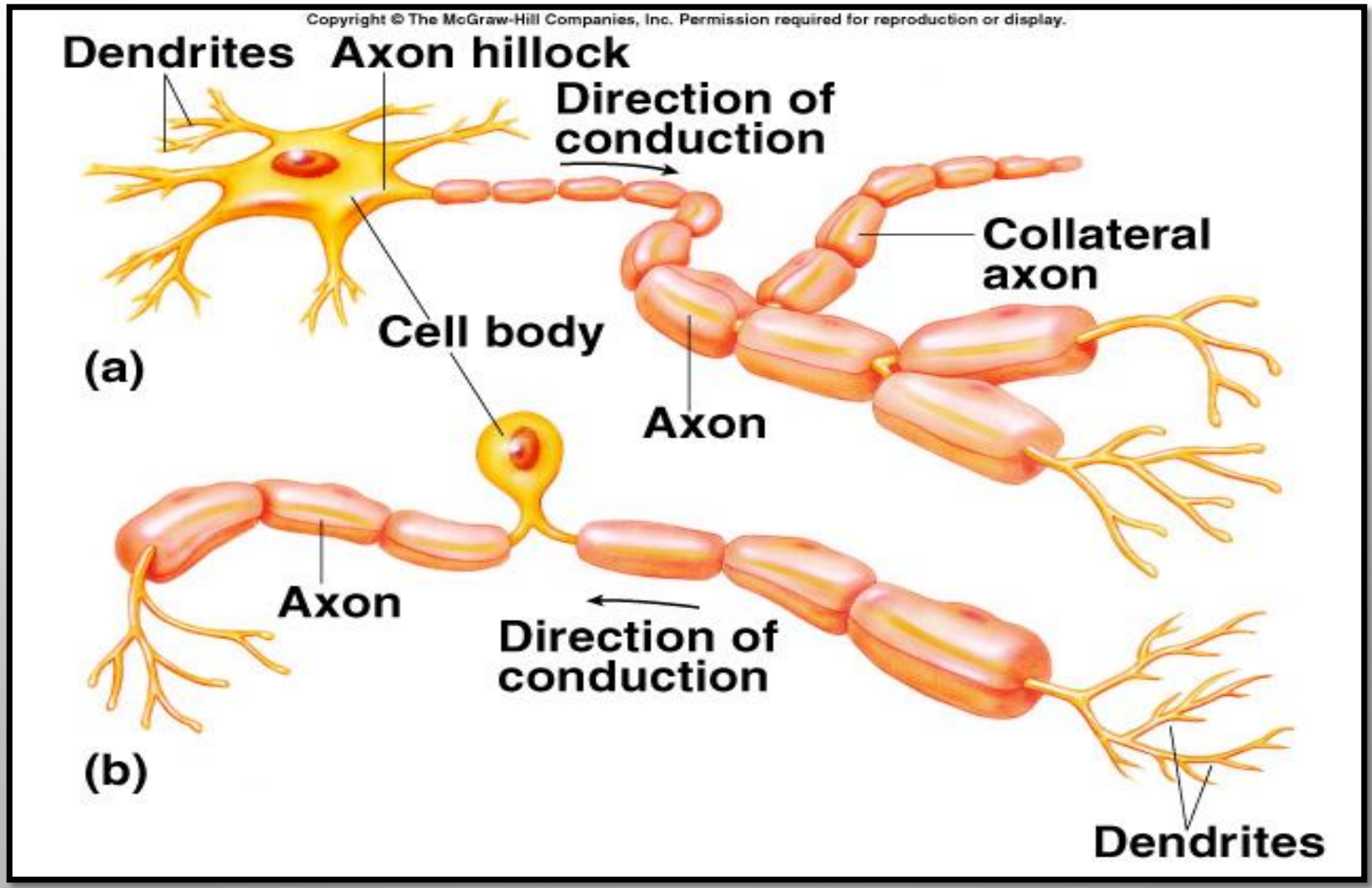
NEURONS

- BASIC STRUCTURAL AND FUNCTIONAL UNITS OF THE NERVOUS SYSTEM.
  - CANNOT DIVIDE BY MITOSIS.
- RESPOND TO PHYSICAL AND CHEMICAL STIMULI.
- PRODUCE AND CONDUCT ELECTROCHEMICAL IMPULSES.
- RELEASE CHEMICAL REGULATORS.
- NERVE:
  - BUNDLE OF AXONS LOCATED OUTSIDE CNS.
  - MOST COMPOSED OF BOTH MOTOR AND SENSORY FIBERS.

NEURONS

- **CELL BODY (PERIKARYON):**
  - **“NUTRITION CENTER.”**
  - **CELL BODIES WITHIN CNS CLUSTERED INTO NUCLEI, AND IN PNS IN GANGLIA.**
- **DENDRITES:**
  - **PROVIDE RECEPTIVE AREA.**
  - **TRANSMIT ELECTRICAL IMPULSES TO CELL BODY.**
- **AXON:**
  - **CONDUCTS IMPULSES AWAY FROM CELL BODY.**
  - **AXOPLASMIC FLOW:**
    - **PROTEINS AND OTHER MOLECULES ARE TRANSPORTED BY RHYTHMIC CONTRACTIONS TO NERVE ENDINGS.**
  - **AXONAL TRANSPORT:**
    - **EMPLOYS MICROTUBULES FOR TRANSPORT.**
    - **MAY OCCUR IN ORTHOGRADE OR RETROGRADE DIRECTION.**

NEURONS


Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.
Dendrites
Axon hillock
Direction of conduction
Collateral axon
Cell body
(a)
Axon
Axon
Direction of conduction
(b)
Dendrites

FUNCTIONAL CLASSIFICATION OF NEURONS

- **BASED UPON DIRECTION IMPULSES CONDUCTED.**

1 - SENSORY OR AFFERENT:

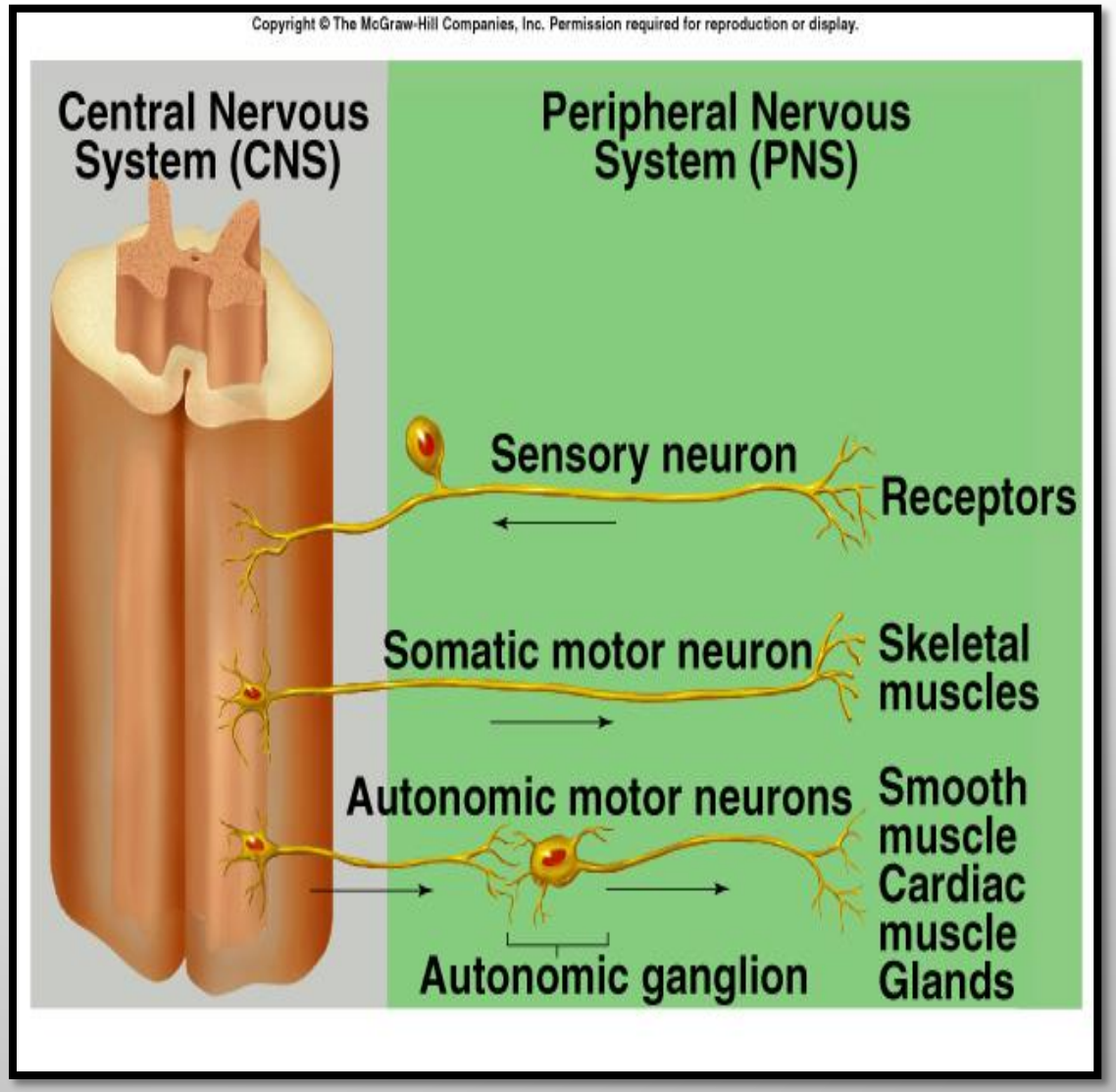
- **CONDUCT IMPULSES FROM SENSORY RECEPTORS INTO CNS.**

2 - MOTOR OR EFFERENT:

- **CONDUCT IMPULSES OUT OF CNS TO EFFECTOR ORGANS.**

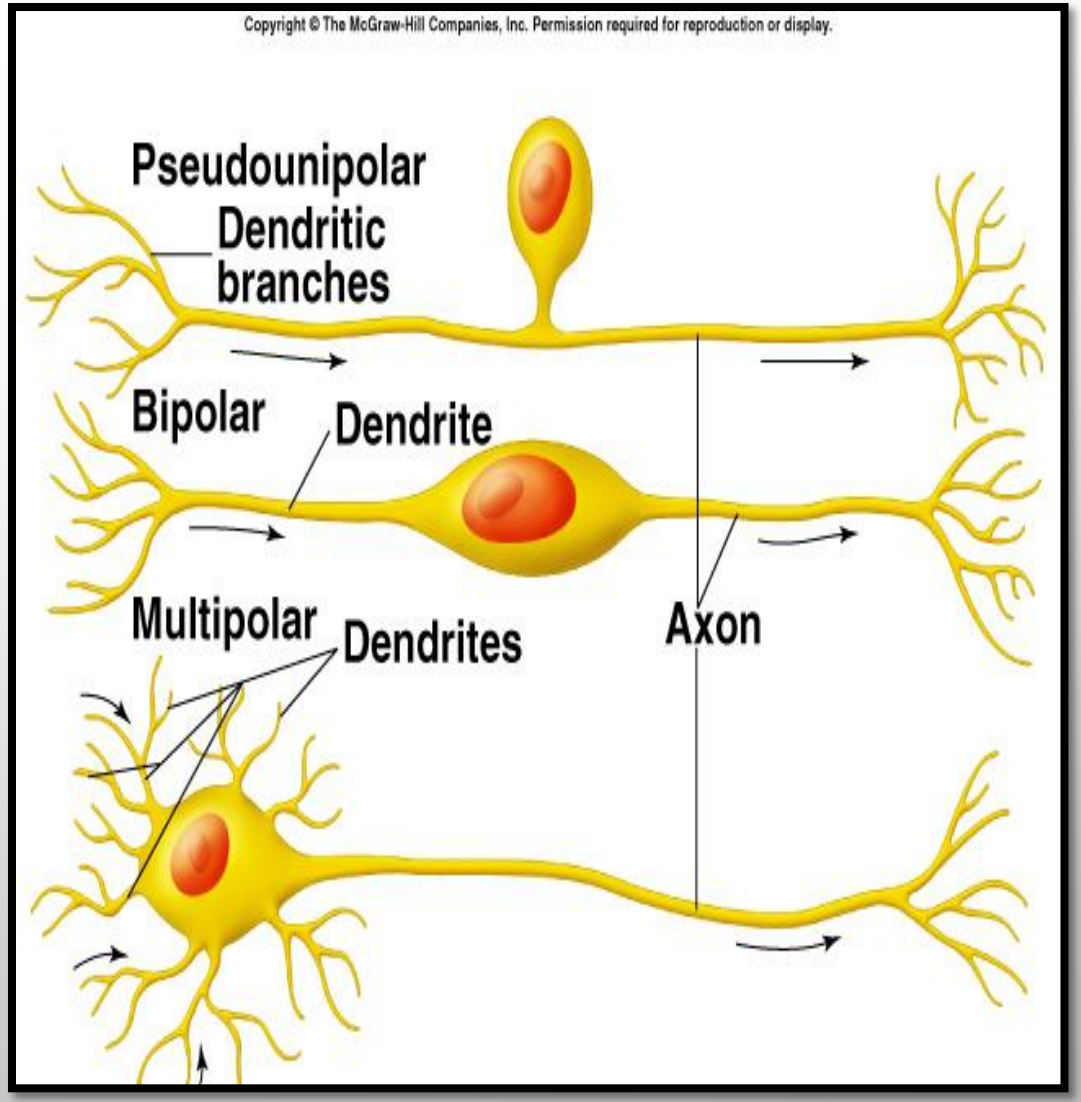
3 - ASSOCIATION OR INTERNEURONS:

- **LOCATED ENTIRELY WITHIN THE CNS.**
- **SERVE AN INTEGRATIVE FUNCTION.**



STRUCTURAL CLASSIFICATION OF NEURONS

- **BASED ON THE PROCESSES THAT EXTEND FROM CELL BODY.**
  - **1 - PSEUDOUNIPOLAR:**
    - **SHORT SINGLE PROCESS THAT BRANCHES LIKE A T.**
    - **SENSORY NEURONS.**
  - **2 - BIPOLAR NEURONS:**
    - **HAVE 2 PROCESSES.**
    - **RETINA OF THE EYE.**
  - **3 - MULTIPOLAR:**
    - **HAVE SEVERAL DENDRITES AND 1 AXON.**
    - **MOTOR NEURON.**



PNS SUPPORTING CELLS

1- SCHWAAN CELLS:

- SUCCESSIVE WRAPPING OF THE CELL MEMBRANE.
- OUTER SURFACE ENCASED IN GLYCOPROTEIN BASEMENT MEMBRANE.
- PROVIDE INSULATION.

• NODES OF RANVIER:

- UNMYELINATED AREAS BETWEEN ADJACENT SCHWAAN CELLS THAT PRODUCE NERVE IMPULSES.

2 - SATELLITE CELLS:

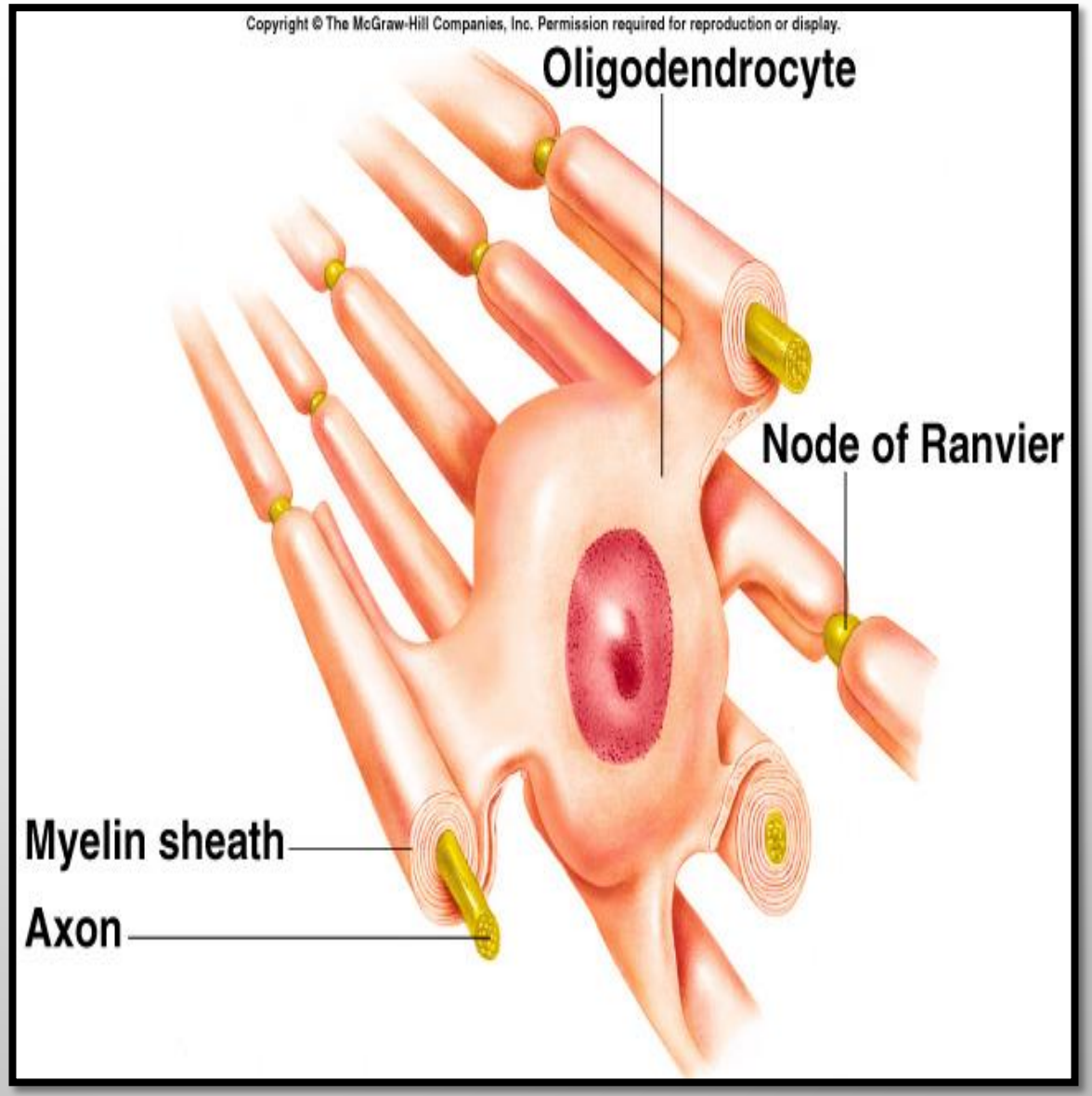
- SUPPORT NEURON CELL BODIES WITHIN GANGLIA.

CNS SUPPORTING CELLS

1 -

OLIGODENDROCYTES:

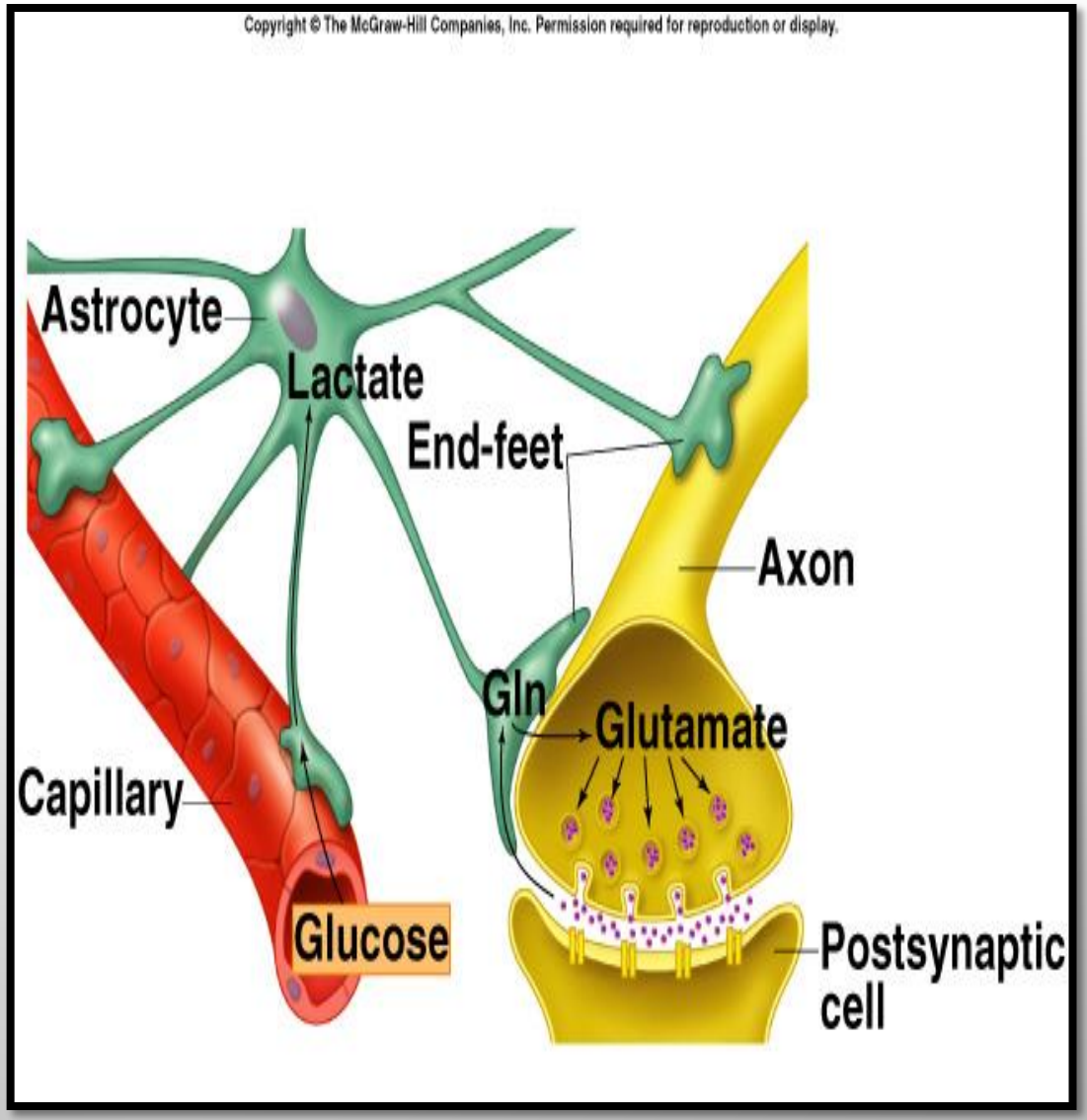
- **PROCESS OCCURS MOSTLY POSTNATALLY.**
- **EACH HAS EXTENSIONS THAT FORM MYELIN SHEATHS AROUND SEVERAL AXONS.**
  - **INSULATION.**



CNS SUPPORTING CELLS

2 - ASTROCYTES:

- MOST ABUNDANT GLIAL CELL.
- VASCULAR PROCESSES TERMINATE IN END-FEET THAT SURROUND THE CAPILLARIES.
- STIMULATE TIGHT JUNCTIONS, CONTRIBUTING TO BLOOD-BRAIN BARRIER.
- REGULATE EXTERNAL ENVIRONMENT OF K^+ AND PH.
- TAKE UP K^+ FROM ECF, NTS RELEASED FROM AXONS, AND LACTIC ACID (CONVERT FOR ATP PRODUCTION).
  - OTHER EXTENSIONS ADJACENT TO SYNAPSES.



CNS SUPPORTING CELLS

3 - MICROGLIA:

- **PHAGOCYTES, MIGRATORY.**

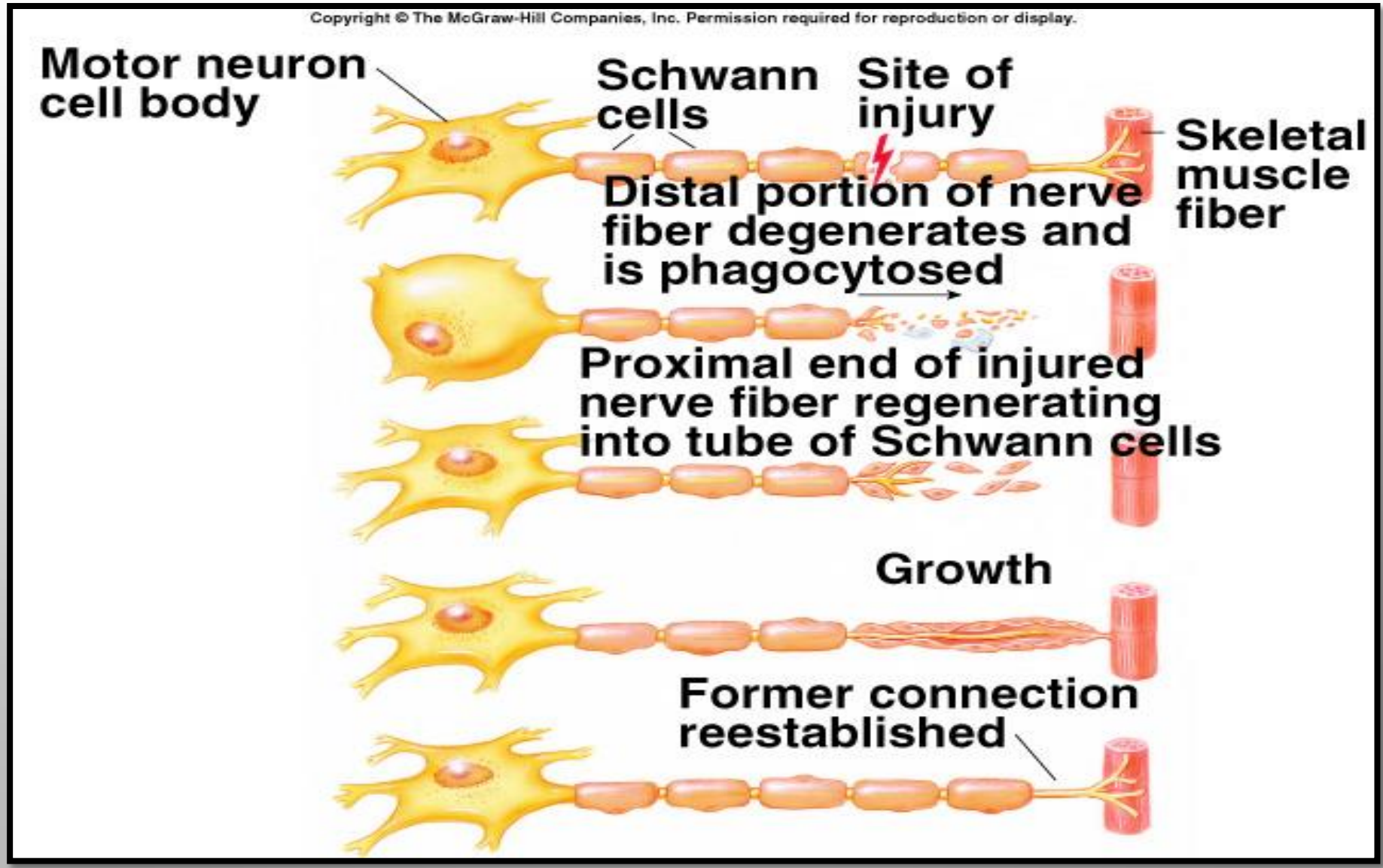
4 - EPENDYMAL CELLS:

- **SECRETE CSF.**
- **LINE VENTRICLES.**
- **FUNCTION AS NEURAL STEM CELLS.**
- **CAN DIVIDE AND PROGENY DIFFERENTIATE.**

NERVE REGENERATION

- **SCHWANN CELLS:**
  - **ACT AS PHAGOCYTES, AS THE DISTAL NEURONAL PORTION DEGENERATES.**
  - **SURROUNDED BY BASEMENT MEMBRANE, FORM REGENERATION TUBE:**
    - **SERVE AS GUIDE FOR AXON.**
    - **SEND OUT CHEMICALS THAT ATTRACT THE GROWING AXON.**
    - **AXON TIP CONNECTED TO CELL BODY BEGINS TO GROW TOWARDS DESTINATION.**

NERVE REGENERATION



NERVE REGENERATION

- **CNS HAS LIMITED ABILITY TO REGENERATE:**
  - **ABSENCE OF CONTINUOUS BASEMENT MEMBRANE.**
  - **OLIGODENDROCYTES MOLECULES INHIBIT NEURONAL GROWTH.**

NEUROTROPHINS

- **PROMOTE NEURON GROWTH.**
- **NERVE GROWTH FACTORS INCLUDE:**
  - **NERVE GROWTH FACTOR (NGF), BRAIN-DERIVED NEUROTROPHIC FACTOR (BDNF), GLIAL-DERIVED NEUROTROPHIC FACTOR (GDNF), NEUROTROPHIN-3, AND NEUROTROPHIN-4/5.**
- **FETUS:**
  - **EMBRYONIC DEVELOPMENT OF SENSORY NEURONS AND SYMPATHETIC GANGLIA (NGF AND NEUROTROPHIN-3).**

NEUROTROPHINS

- **ADULT:**
  - **MAINTENANCE OF SYMPATHETIC GANGLIA (NGF).**
  - **MATURE SENSORY NEURONS NEED FOR REGENERATION.**
  - **REQUIRED TO MAINTAIN SPINAL NEURONS (GDNF).**
  - **SUSTAIN NEURONS THAT USE DOPAMINE (GDNF).**

BLOOD-BRAIN BARRIER

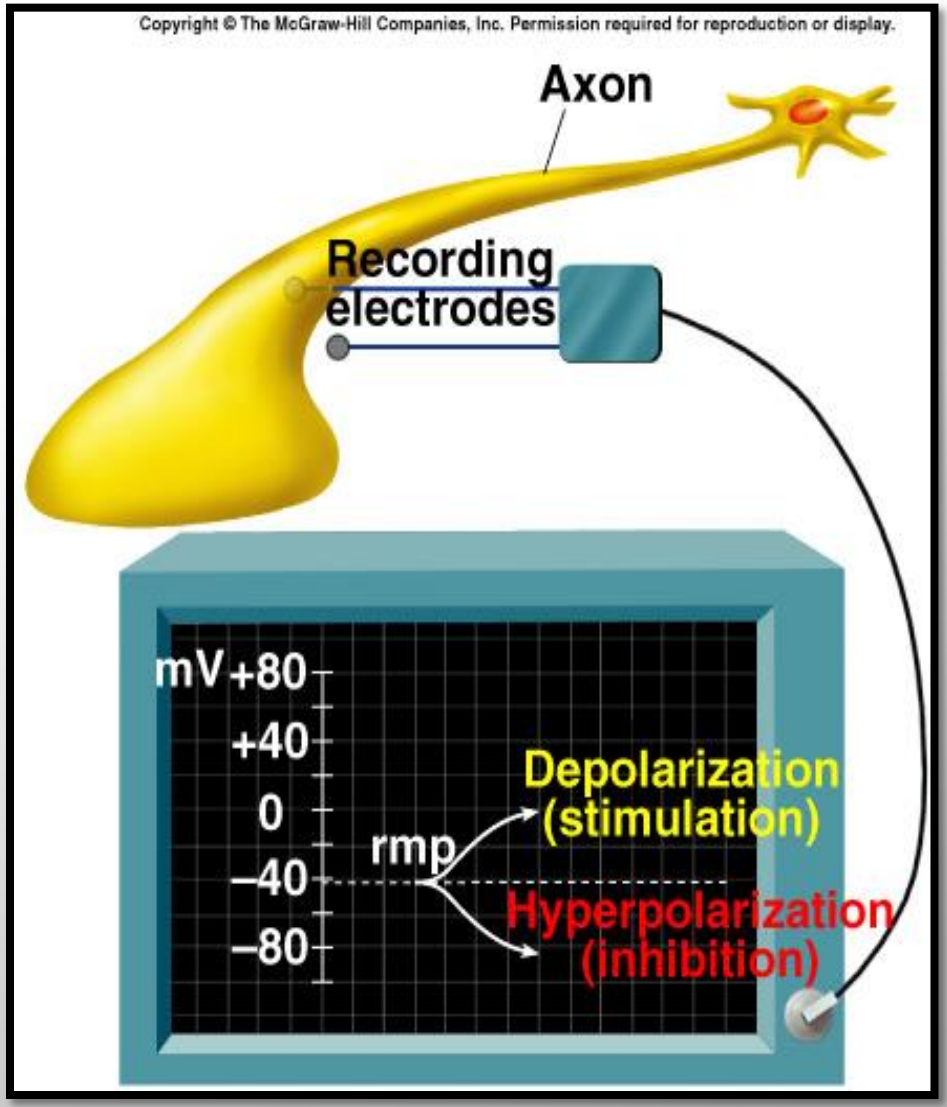
- **CAPILLARIES IN BRAIN DO NOT HAVE PORES BETWEEN ADJACENT ENDOTHELIAL CELLS.**
  - **JOINED BY TIGHT JUNCTIONS.**
- **MOLECULES WITHIN BRAIN CAPILLARIES MOVED SELECTIVELY THROUGH ENDOTHELIAL CELLS BY:**
  - **DIFFUSION.**
  - **ACTIVE TRANSPORT.**
  - **ENDOCYTOSIS.**
  - **EXOCYTOSIS.**

ELECTRICAL ACTIVITY OF AXONS

- **ALL CELLS MAINTAIN A RESTING MEMBRANE POTENTIAL (RMP):**
  - **POTENTIAL VOLTAGE DIFFERENCE ACROSS MEMBRANE.**
    - **LARGELY THE RESULT OF NEGATIVELY CHARGED ORGANIC MOLECULES WITHIN THE CELL.**
    - **LIMITED DIFFUSION OF POSITIVELY CHARGED INORGANIC IONS.**
  - **PERMEABILITY OF CELL MEMBRANE:**
    - **ELECTROCHEMICAL GRADIENTS OF NA^+ AND K^+.**
    - **NA^+/K^+ ATPASE PUMP.**
- **EXCITABILITY/IRRITABILITY:**
  - **ABILITY TO PRODUCE AND CONDUCT ELECTRICAL IMPULSES.**

ELECTRICAL ACTIVITY OF AXONS

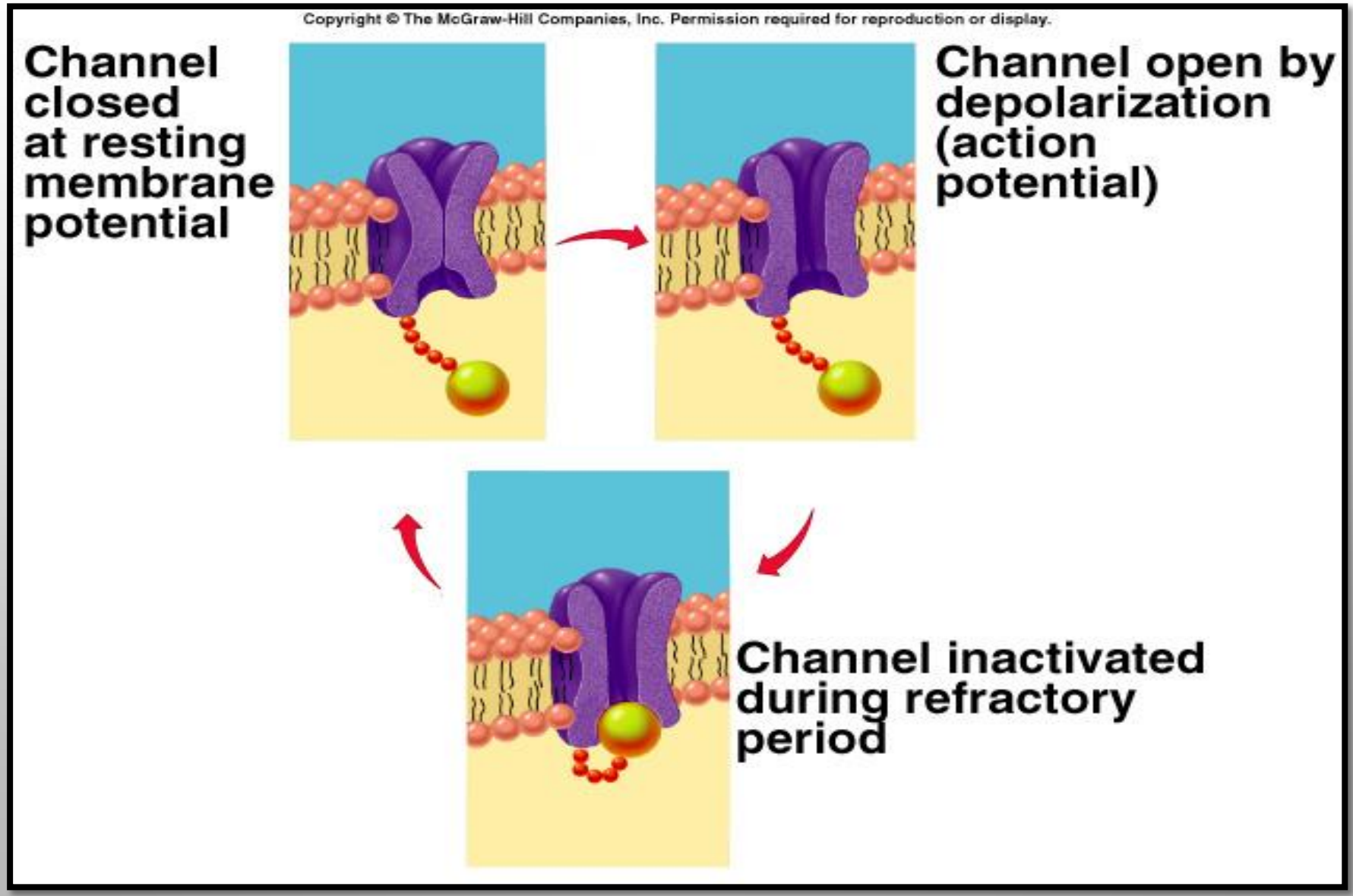
- **INCREASE IN MEMBRANE PERMEABILITY FOR SPECIFIC ION CAN BE MEASURED BY PLACING 2 ELECTRODES (1 INSIDE AND 1 OUTSIDE THE CELL).**
- **DEPOLARIZATION:**
  - **POTENTIAL DIFFERENCE REDUCED (BECOME MORE POSITIVE).**
- **REPOLARIZATION:**
  - **RETURN TO RESTING MEMBRANE POTENTIAL (BECOME MORE NEGATIVE).**
- **HYPERPOLARIZATION:**
  - **MORE NEGATIVE THAN RMP.**



ION GATING IN AXONS

- **CHANGES IN MEMBRANE POTENTIAL CAUSED BY ION FLOW THROUGH ION CHANNELS.**
- **VOLTAGE GATED (VG) CHANNELS OPEN IN RESPONSE TO CHANGE IN MEMBRANE POTENTIAL.**
  - **GATED CHANNELS ARE PART OF PROTEINS THAT COMPRISE THE CHANNEL.**
    - **CAN BE OPEN OR CLOSED IN RESPONSE TO CHANGE.**
  - **2 TYPES OF CHANNELS FOR K^+:**
    - **1 ALWAYS OPEN.**
    - **1 CLOSED IN RESTING CELL.**
  - **CHANNEL FOR NA^+:**
    - **ALWAYS CLOSED IN RESTING CELLS.**
    - **SOME NA^+ DOES LEAK INTO THE CELLS.**

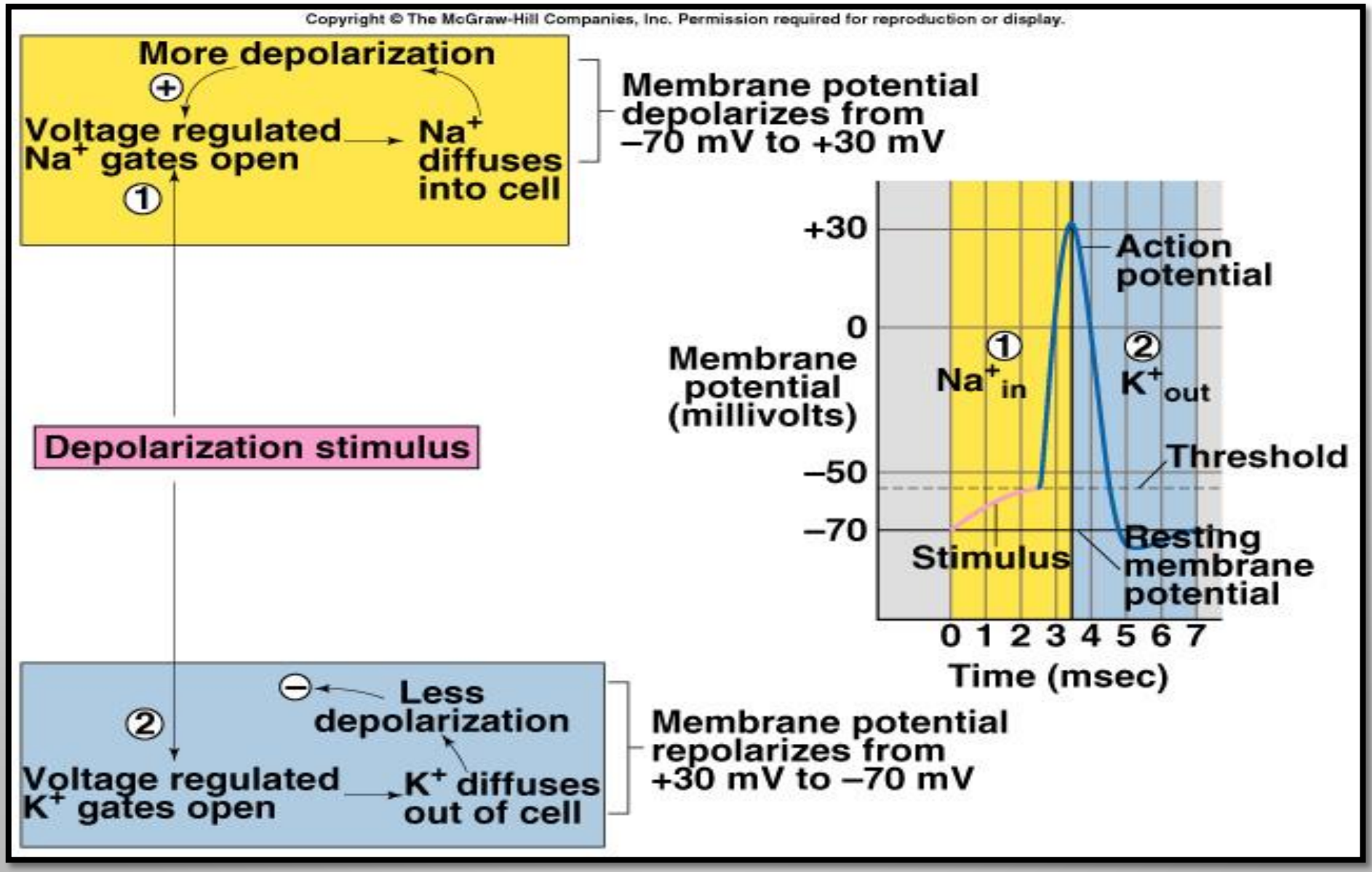
ION GATING IN AXONS



ACTION POTENTIALS (APS)

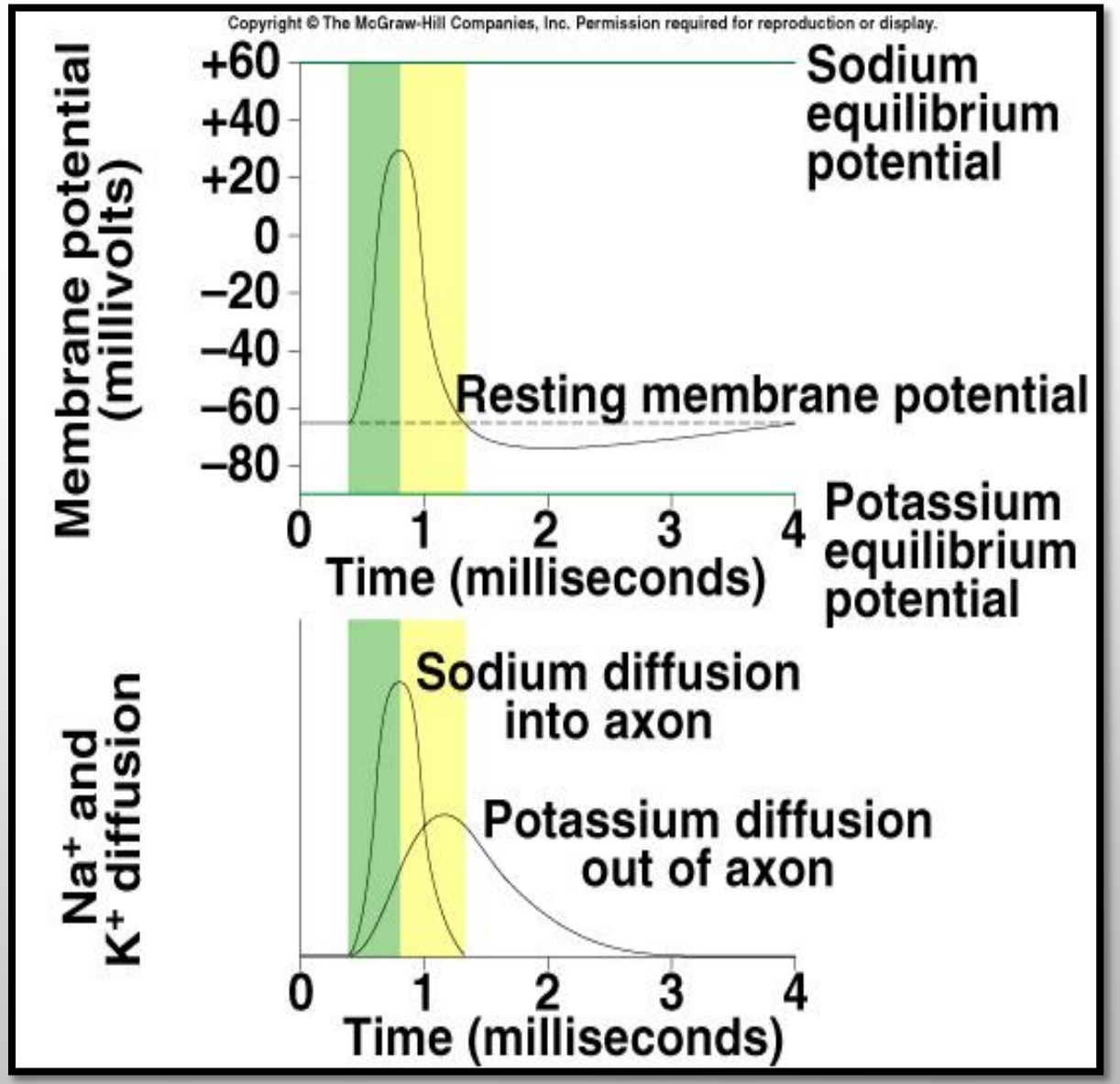
- **STIMULUS CAUSES DEPOLARIZATION TO THRESHOLD.**
- **VG NA^+ CHANNELS OPEN.**
  - **ELECTROCHEMICAL GRADIENT INWARD.**
    - **+ FEEDBACK LOOP.**
  - **RAPID REVERSAL IN MEMBRANE POTENTIAL FROM –70 TO + 30 MV.**
  - **VG NA^+ CHANNELS BECOME INACTIVATED.**
- **VG K^+ CHANNELS OPEN.**
  - **ELECTROCHEMICAL GRADIENT OUTWARD.**
  - **- FEEDBACK LOOP.**
  - **RESTORE ORIGINAL RMP.**

ACTION POTENTIALS (APS)



MEMBRANE PERMEABILITES

- **AP IS PRODUCED BY AN INCREASE IN NA^+ PERMEABILITY.**
- **AFTER SHORT DELAY, INCREASE IN K^+ PERMEABILITY.**



ACTION POTENTIALS (APS)

- **DEPOLARIZATION AND REPOLARIZATION OCCUR VIA DIFFUSION, DO NOT REQUIRE ACTIVE TRANSPORT.**
  - **ONCE AP COMPLETED, NA^+/K^+ ATPASE PUMP EXTRUDES NA^+, AND RECOVERS K^+.**
- **ALL OR NONE:**
  - **WHEN THRESHOLD REACHED, MAXIMUM POTENTIAL CHANGE OCCURS.**
  - **AMPLITUDE DOES NOT NORMALLY BECOME MORE POSITIVE THAN + 30 MV BECAUSE VG NA^+ CHANNELS CLOSE QUICKLY AND VG K^+ CHANNELS OPEN.**
  - **DURATION IS THE SAME, ONLY OPEN FOR A FIXED PERIOD OF TIME.**
- **CODING FOR STIMULUS INTENSITY:**
  - **INCREASED FREQUENCY OF AP INDICATES GREATER STIMULUS STRENGTH.**
- **RECRUITMENT:**
  - **STRONGER STIMULI CAN ACTIVATE MORE AXONS WITH A HIGHER THRESHOLD.**

REFRACTORY PERIODS

- **ABSOLUTE REFRACTORY PERIOD:**
  - **AXON MEMBRANE IS INCAPABLE OF PRODUCING ANOTHER AP.**
- **RELATIVE REFRACTORY PERIOD:**
  - **VG ION CHANNEL SHAPE ALTERS AT THE MOLECULAR LEVEL.**
  - **VG K^+ CHANNELS ARE OPEN.**
  - **AXON MEMBRANE CAN PRODUCE ANOTHER ACTION POTENTIAL, BUT REQUIRES STRONGER STIMULUS.**