

□ Nerve Cells

Nervous System

- Three Parts of the Nervous System
- Central Nervous System (**CNS**): brain and spinal cord.
- Peripheral Nervous System (**PNS**): nerves of the body
- Autonomic Nervous System (**ANS**): has parts of the CNS and PNS. Controls autonomic function (blood pressure, digestion, etc).
 - Sympathetic division
 - Parasympathetic division

Basic Divisions of the Nervous System

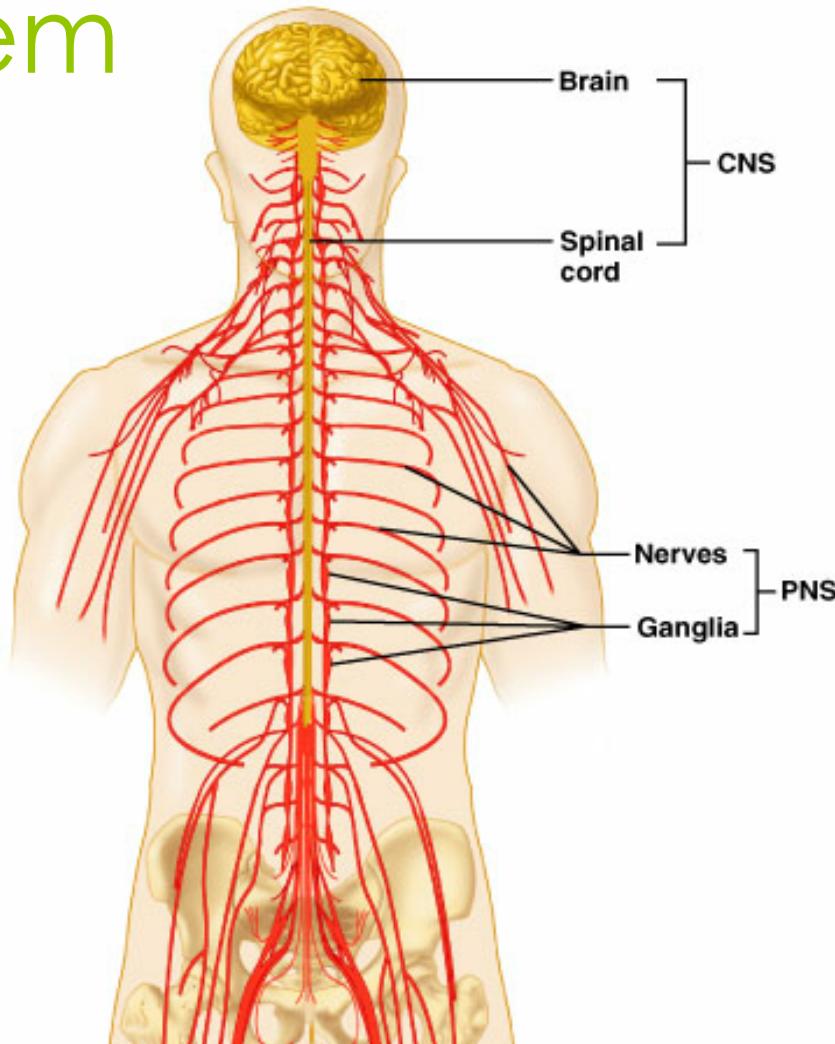


Figure 12.2

Basic Divisions of the Nervous System

- Central nervous system (CNS)
 - Brain and spinal cord
 - Integrating and command center

Basic Divisions of the Nervous System

- Peripheral nervous system (PNS)
 - Outside the CNS
 - Consists of nerves from brain and spinal cord
 - Cranial nerves
 - Spinal nerves
 - Peripheral nerves link all regions of the body to the CNS

Nervous System Classification

□ **Somatic Nervous System**

- Motor nerves to skeletal muscle
- Reflexes
- Sensory nerves

□ **Autonomic Nervous System**

- Motor nerves to smooth and cardiac muscle
 - Sympathetic
 - Parasympathetic

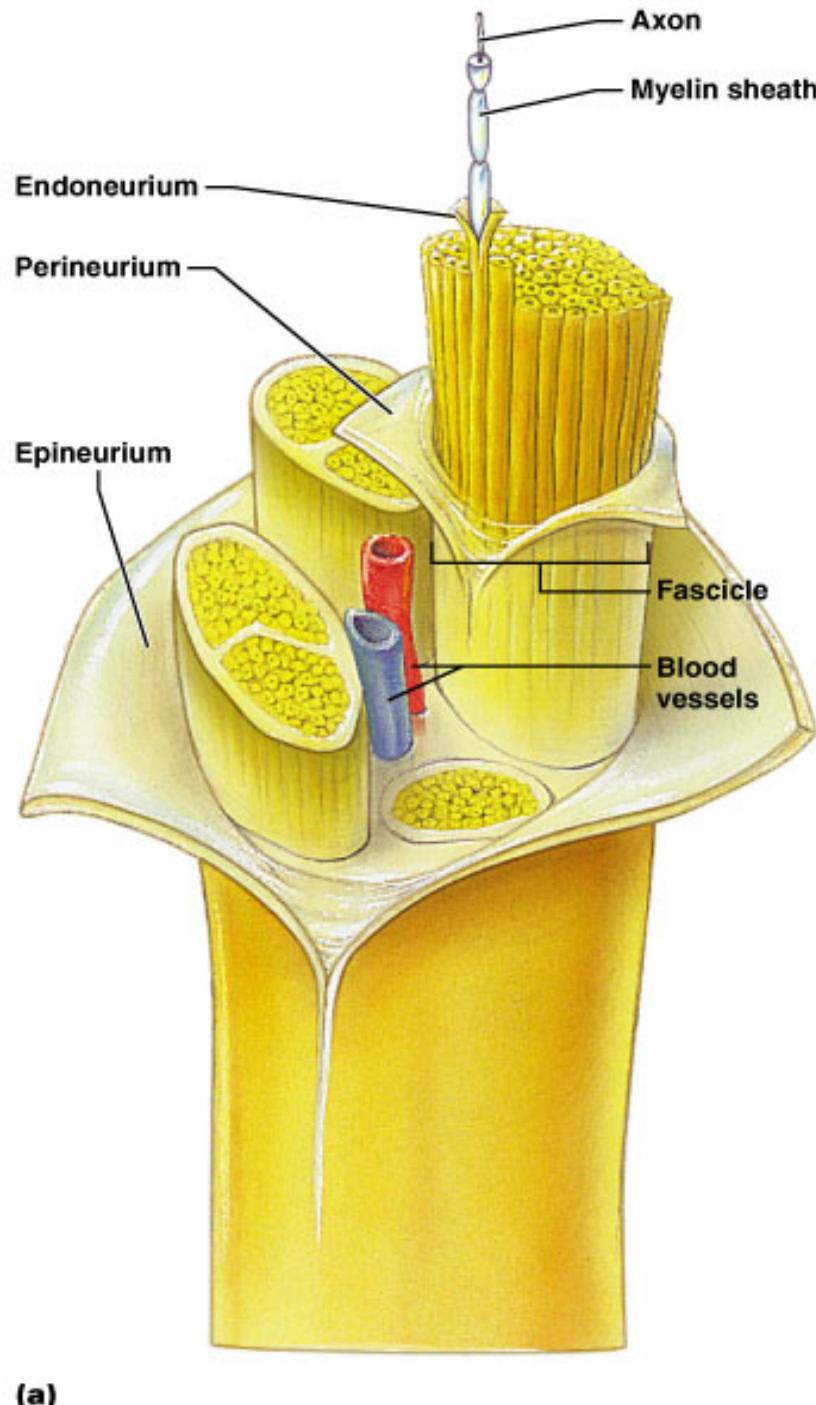
Neurons

- The nervous system is made up of more cells than any other system.
- For instance, the brain has about 100 billion cells.
- There are also a number of different cell types, the most important is the neuron.

Structure of a Nerve

A neuron is a cell shaped like a starfish with a long tail called an axon. The axon of each neuron is surrounded by a sheath called the **endoneurium**. Some axons have an additional sheath called myelin.

A bundle of neurons travel together in a fascicle, and are surrounded by



(a)

12.16a

NEURON

- All neurons do three things:
- Receive a signal. Can be any type of stimulus, depending on what type of neuron it is (touch, vibration, light, sound, chemicals, signal from another neuron, etc).
- Transmit a signal to another location. E.g. finger touching something □ signal to spinal cord or brain.
- Stimulate another cell
 - Another neuron □ transmit signal
 - Muscle □ contraction
 - Gland □ secretion
 - Blood vessel □ constriction

The Neuron

- Other special characteristics
 - Longevity – can live and function for a lifetime
 - Do not divide – fetal neurons lose their ability to undergo mitosis because their centrioles no longer function and cannot pull the chromosomes apart; neural stem cells are an exception
 - High metabolic rate – require abundant oxygen and glucose

Classification of Neurons

- **Structure** (Appearance)
 - Unipolar
 - Bipolar
 - Multipolar
- **Function**
 - Sensory
 - Motor
 - Interneurons

Structural Classification of Neurons

Multipolar neurons

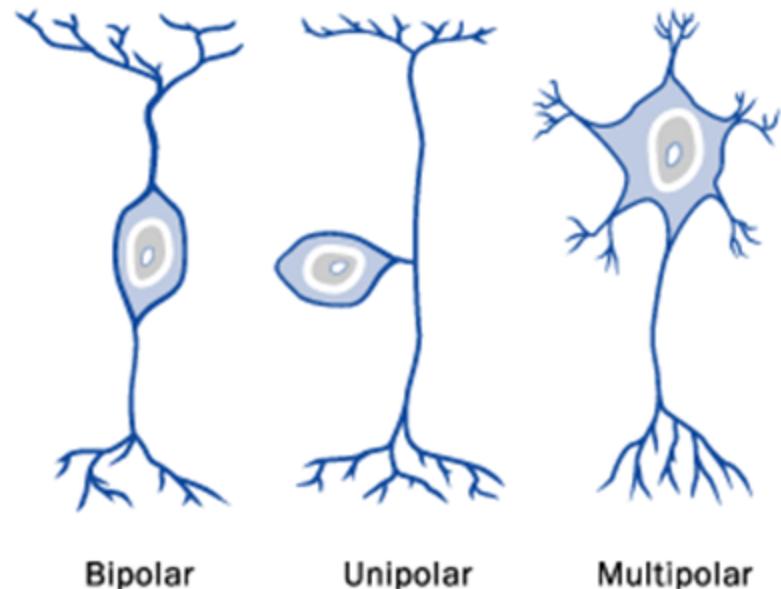
- Most neurons are this type, having many dendrites and one axon.

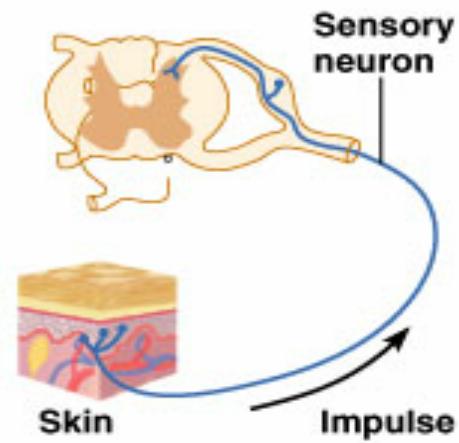
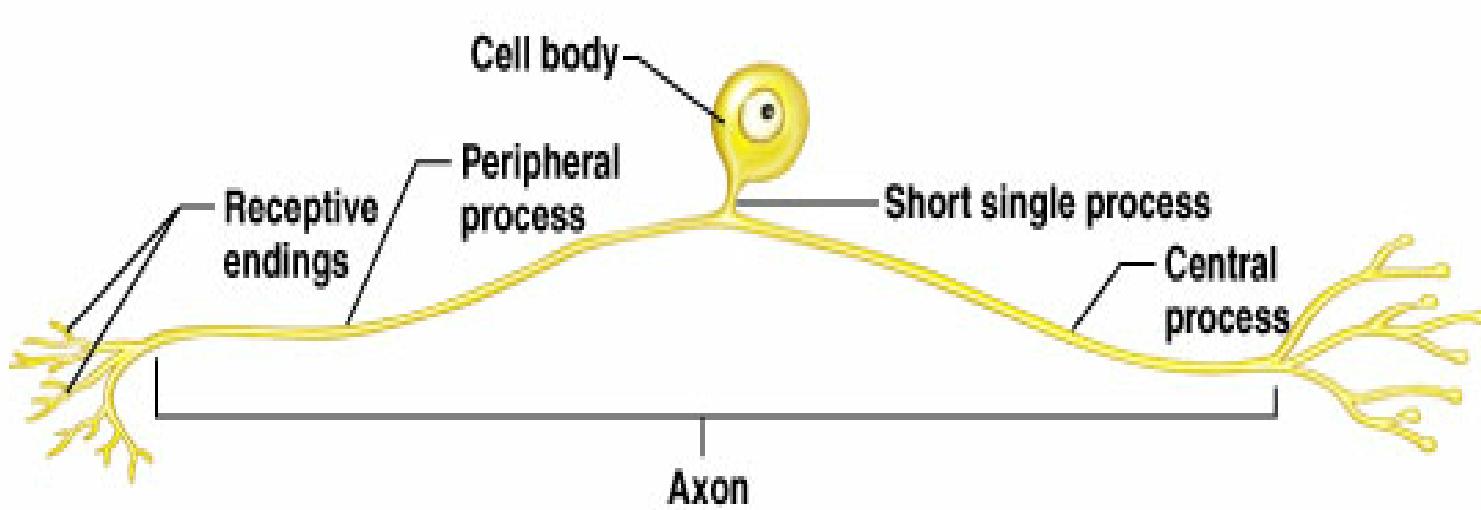
Bipolar neurons

- Have two processes that extend from opposite sides of the cell body. Some sensory neurons are bipolar.

Unipolar neurons

Have one short process emerging from the cell body, which then branches into a “T”. Sensory neurons in the PNS are unipolar.





Functional Classification

- Neurons are grouped functionally according to the direction the nerve impulse travels relative to the CNS.
- **Sensory Neurons** (afferent neurons) transmit impulses toward the CNS. Their impulses originate in the PNS and terminate in the CNS.
- **Motor Neurons** (efferent neurons) transmit impulses from the CNS to effector organs (muscles, glands, and blood vessels). Their impulses originate in the CNS and terminate in the PNS.
- **Interneurons** (association neurons) connect sensory neurons to motor neurons within the spinal cord and brain. They originate and terminate in the CNS. They make up 99.98% of the neurons in the body. They form complex neuronal pathways, reflecting the vast amount of information processed in the CNS.

Neurons Classified by Function: Sensory vs. Motor Neurons

Sensory neurons enter the spinal cord.
Motor neurons leave the spinal cord.
Interneurons connect the sensory and motor neurons.

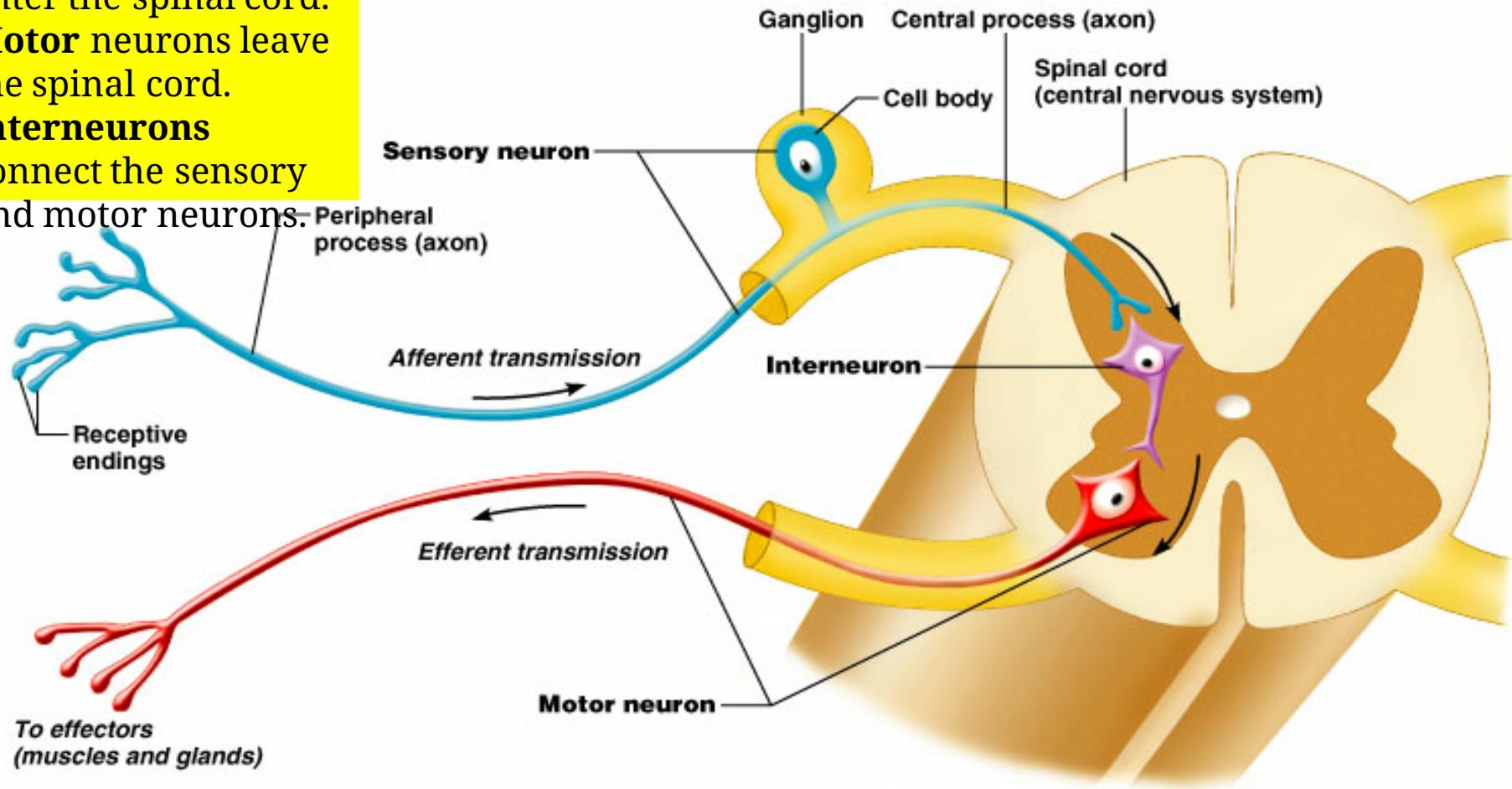
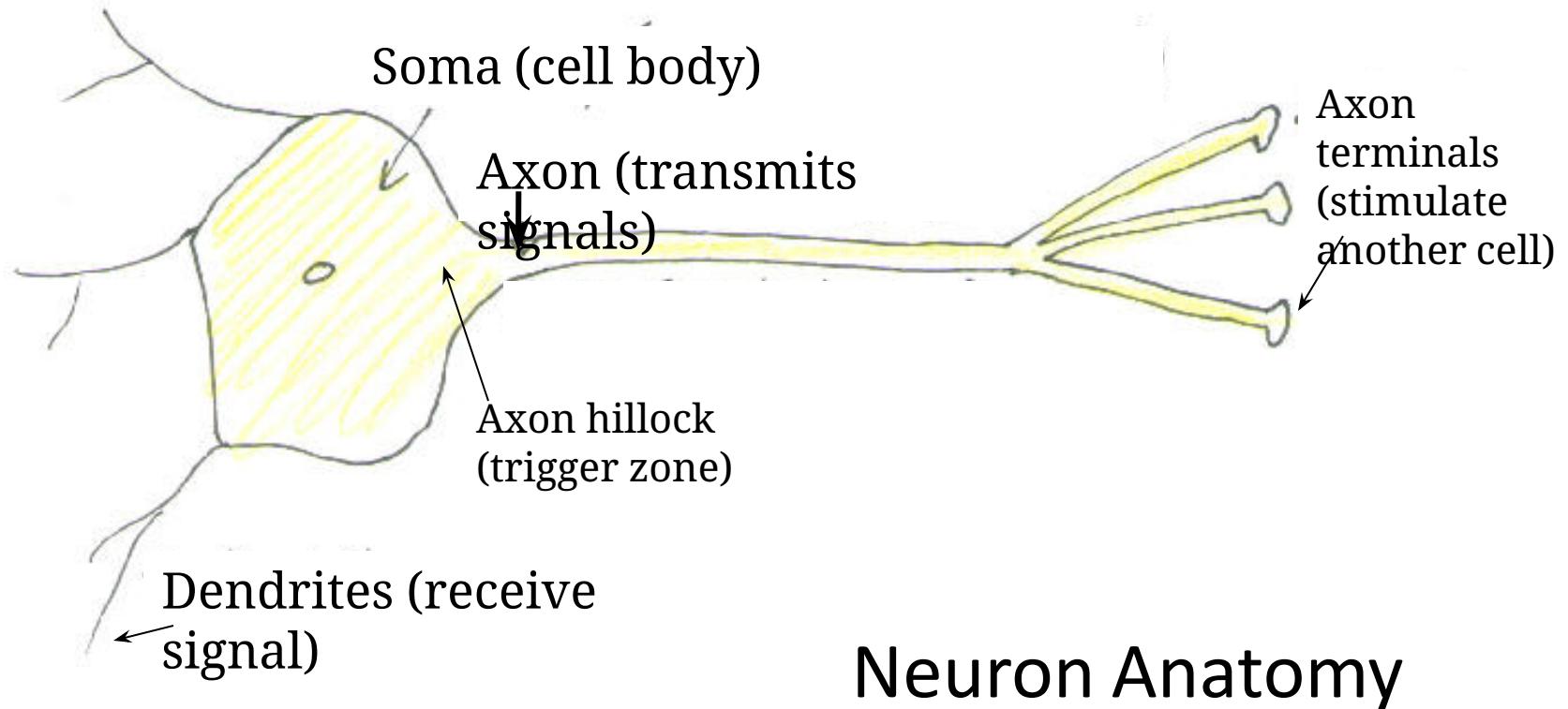


Figure 12.11

- There are hundreds of different types of sensory neurons, each one is specialized for a particular task (they have receptors for either light, smell, taste, pain, light touch, vibration, or position in space).
- Motor neurons transmit signals for muscle contraction (skeletal muscle or organ contraction, blood vessel constriction), gland secretion.
- They all share certain characteristics.
 - Longevity (can last a lifetime)
 - High metabolic rate
 - Cannot divide to reproduce
 - Cannot survive without oxygen

Neuron Anatomy

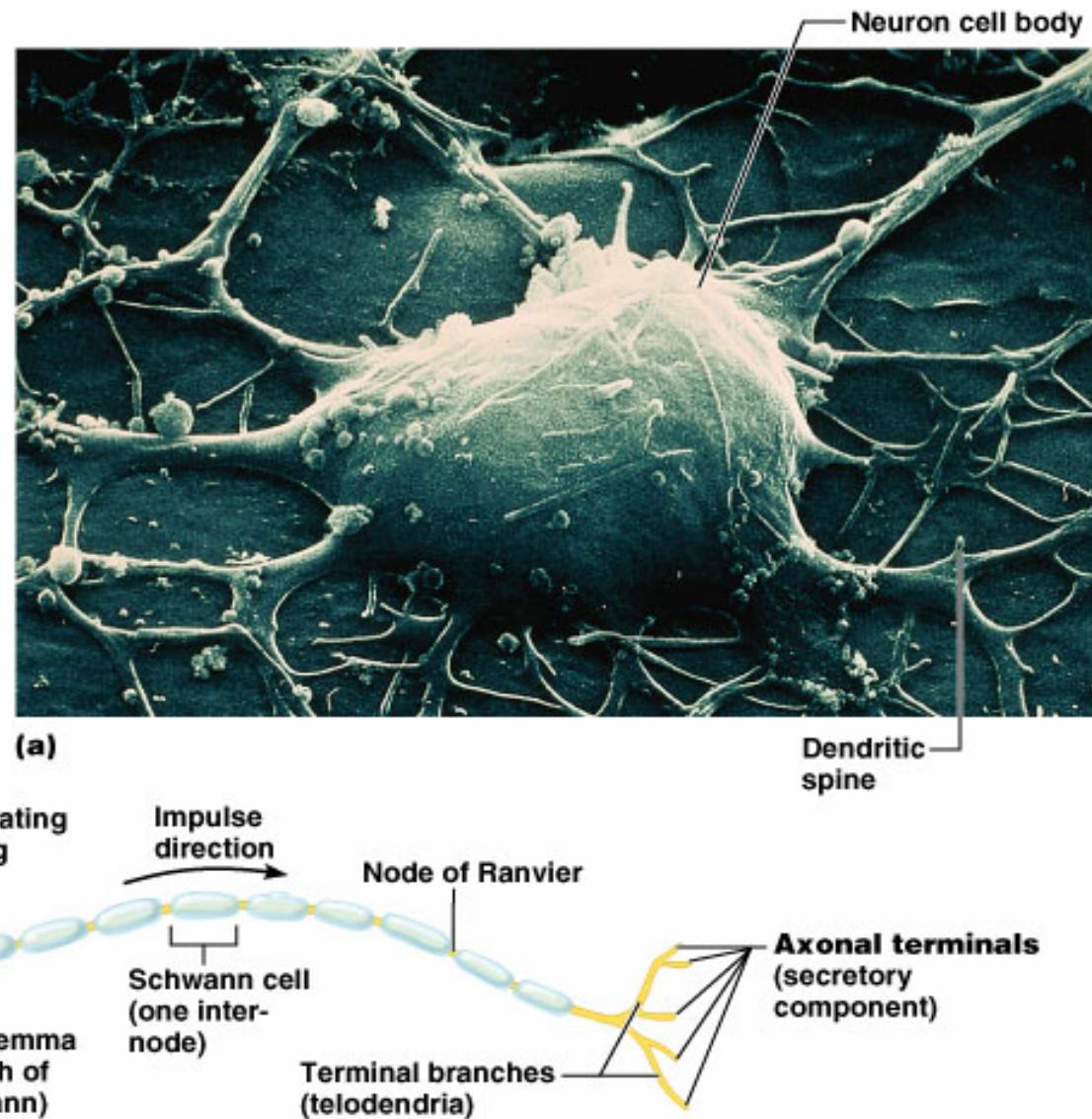
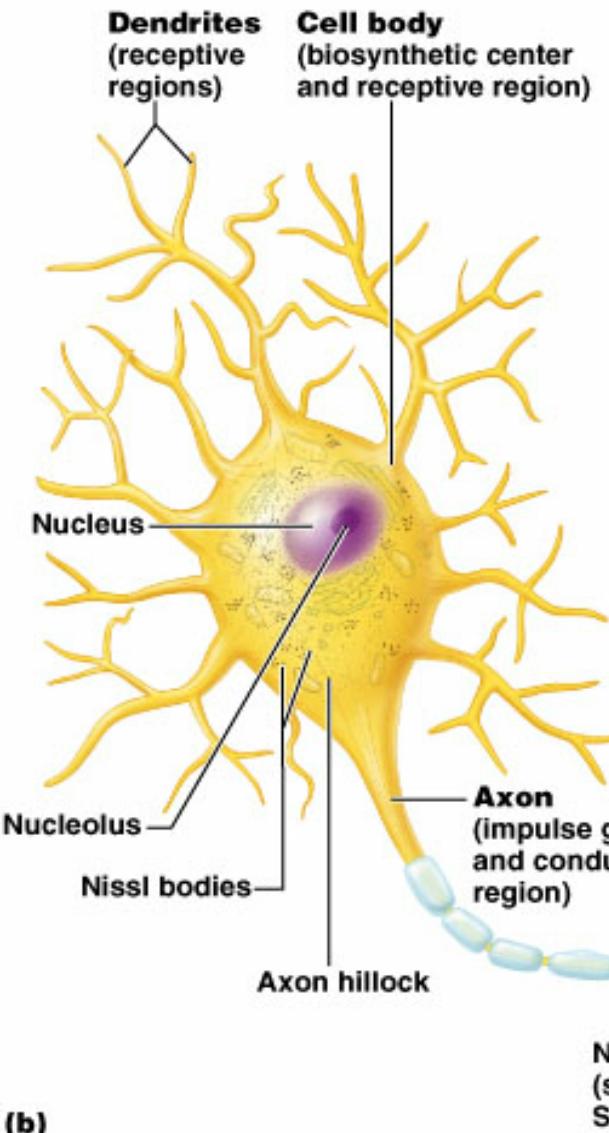


- **NEUROLEMMA** is the name of the plasma membrane (outermost covering) of a neuron.
- **DENDRITES** function to receive the signal and transmit the nerve conduction toward the cell body.
- **SOMA** (cell body) is where the nucleus, ribosomes, and most organelles are located
- **AXON HILLOCK** is the area on the soma where the action potential (electrical charges) of the neuron builds up before it transmits the signal down the axon.
- **AXON** function is to transmit signals. Some cells have more than one axon, some axons are short, and some are long.
- **AXON TERMINALS (also called boutons or synaptic knobs)** contain vesicles with a liquid neurotransmitter which, when released, stimulates another cell.
- **A SYNAPSE** is where one neuron “touches” another neuron or its target cell. Neurons may have a couple of synapses, or hundreds. There are synapses on each dendrite and each axon terminal.
- **AXOPLASMIC TRANSPORT:** Movement of nutrients, wastes, and organelles between the cell body and axon terminals

Nerve Impulses (action potentials)

- A nerve impulse (called an **action potential**) is typically **generated at the axon hillock**, and is conducted along the axon to the axon terminals, where it causes the release of neurotransmitters into the extracellular space.
- **These neurotransmitters excite or inhibit the dendrites of the adjacent neuron (or the target organ).**
- If they excite the dendrites of an adjacent neuron, the action potential is carried to the cell body of the second neuron, and then it continues down the axon to excite a third neuron, and so on, until the target organ is reached.

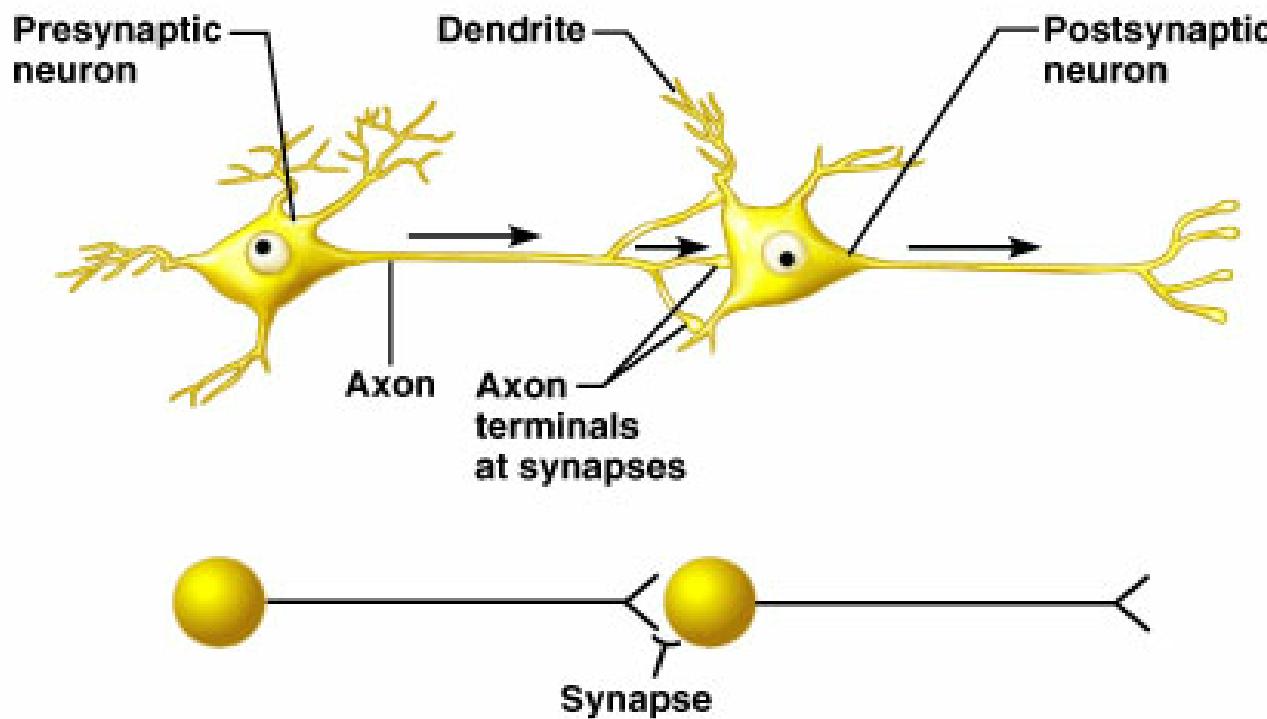
Structure of a Typical Large Neuron



Synapse

- A **synapse** is the site at which two neurons communicate, or a neuron and its target organ.
- The neuron that conducts the signals towards the synapse is called the presynaptic neuron.
- The neuron that transmits the signals away from the synapse is called the postsynaptic neuron.
- Most neurons function as pre-synaptic and post-synaptic neurons.
- The neurons don't physically touch each other at the synapse. The space between them is called the **synaptic cleft**.

Two Neurons Communicating at a Synapse



Know this order: The action potential travels from the Axon of presynaptic neuron → SYNAPTIC CLEFT → dendrite of post synaptic neuron

Figure 12.6

Types of Synapses

- Axosomatic (axon touches soma)
- Axodendritic (axon touches dendrite)
- Axoaxonic (axon touches another axon)

Axosomatic Synapse

(b)

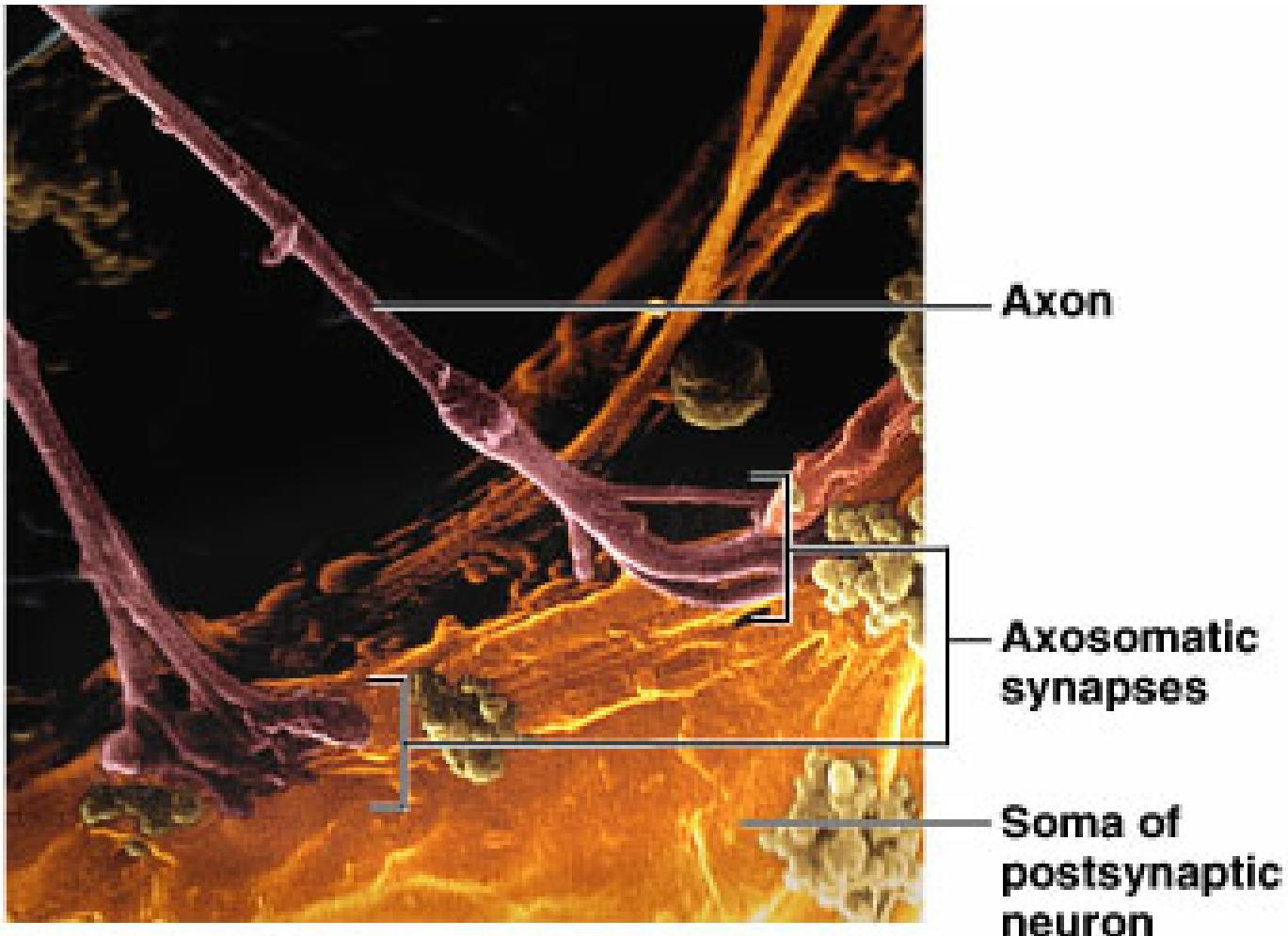
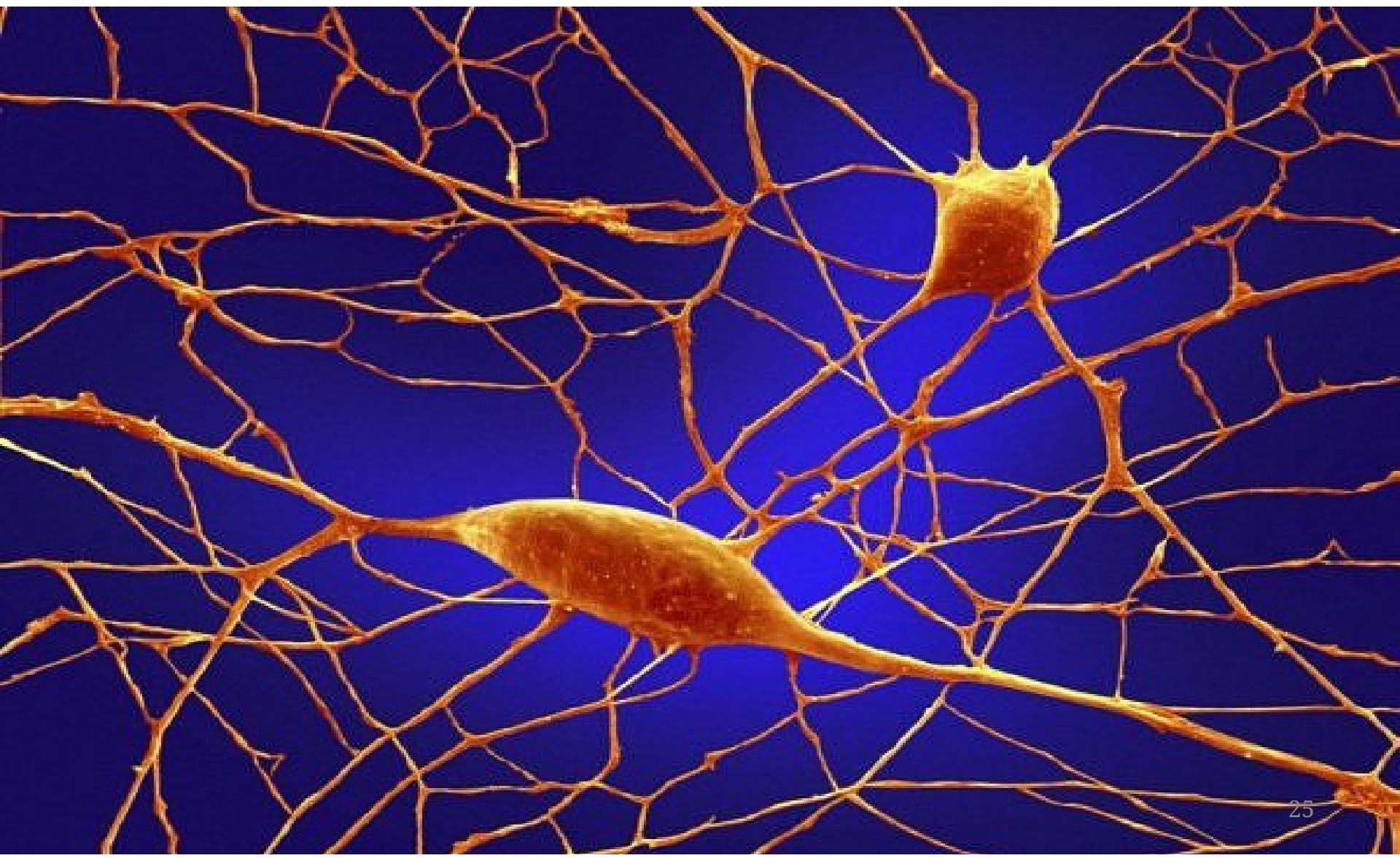


Figure 12.47

Axodendritic Synapses



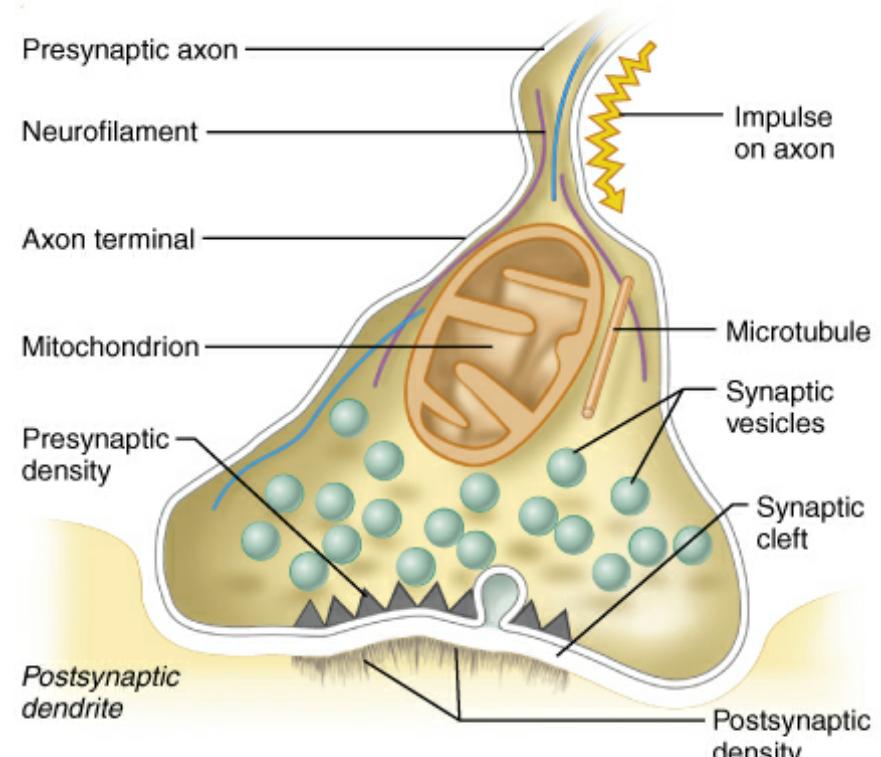
- How does the signal go through the space? By a chemical transmission.
- The axon terminals have vesicles filled with a neurotransmitter that transmits the signal across the synapse.
- Each type of neuron uses a particular type of neurotransmitter, and there are many types of neurotransmitters (about 45).
- Most neurotransmitters excite the adjacent neuron, and some are inhibitory.

Structure of a Synapses

Chemical substances released from the presynaptic terminal:

May inhibit or stimulate an action in the postsynaptic cell

May be broken down by enzymes or taken back up into the vesicles and recycled.

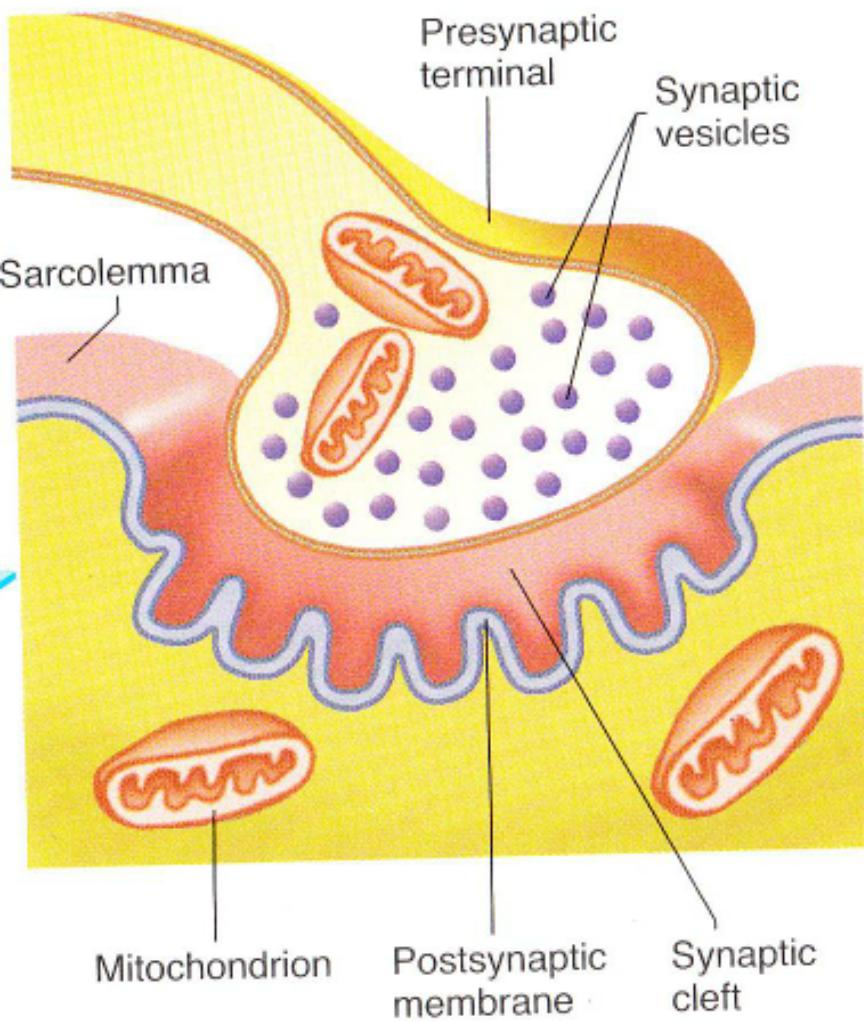


(b)

Figure 12.8a, b

Fun Fact

- Children under 3 years of age have twice as many synapses as adults. That is why they learn languages better.
- A child must learn a second language before the age of ten, or they probably will not have the proper native accent of that language.



- The axon terminal of the nerve cell rests in indentations in the cell membrane of the muscle fiber, called the end plate.
- The enlarged knob of the axon is called the **presynaptic terminal**
- The space between the presynaptic terminal and the muscle fiber membrane is the **synaptic cleft**
- The muscle fiber membrane is the **postsynaptic membrane with the end plate on it**.
- If this neuron innervates skeletal muscle, the vesicles of its axon terminal will contain the neurotransmitter **acetylcholine**.

- An action potential causes the release of **Ach** (acetylcholine; the neurotransmitter at the neuromuscular junction) into the synaptic cleft.
- Ach binds to receptor sites on the muscle fiber (muscle cell) membrane and starts an electrical impulse called an action potential, which travels along the length of the muscle fiber and causes it to contract.
- The Ach that was released is rapidly broken down by an enzyme, **Ach-ase or AchE** (acetylcholinesterase). This ensures that the action potential will result in only one contraction of each muscle fiber.
- A neuron might be temporarily unable to transmit an impulse to another cell if its supply of neurotransmitters is exhausted.

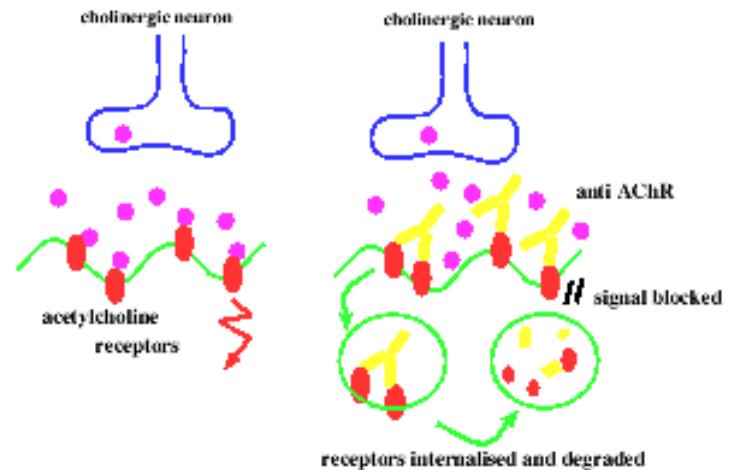
AchE Blockers

- Physostigmine
- **Neostigmine**

Used to treat ptosis
(drooping eyelids) in
the autoimmune
disease Myasthenia
Gravis



Blocking autoantibodies cause Myasthenia Gravis



Myasthenia gravis

- Myasthenia gravis is an autoimmune disorder in which antibodies attack and destroy some acetylcholine receptors in muscles of the face, especially the eyelids.
- Acetylcholine is therefore less likely to stimulate muscle contraction, resulting in muscle weakness and fatigue.
- Symptoms usually begin in the eyelid and facial muscles, and manifests as drooping muscles on half or both sides of the face, drooping eyelids, and slurred speech.
- **Neostigmine** is an anti-cholinesterase drug which reduces the symptoms by **inhibiting Ach-ase activity**, preventing the breakdown of Ach. Consequently, Ach levels in the synapse remain elevated, so Ach is available to bind to those few functional Ach receptors that are left.

AchE irreversible inhibitor

- Sarin gas
- Chemical warfare
- Spastic paralysis
- Ventilator until new AchE can be made (several weeks)

MASSACRE BY POISON GAS



Scenes of choking commuters inside of Tokyo's St. Luke's Hospital after inhaling a deadly nerve gas, thought to have been released during a subway attack on at least three trains during the rush-hour

Many die, 1,200 collapse in Tokyo Tube attack

SIX people died today and more than 1,200 panic-stricken commuters collapsed as clouds of Nazi nerve gas swept through Tokyo's rush-hour subway system.

The city's emergency services and hospitals struggled to cope with the victims, dozens of whom were critical, as the Japanese government denounced the attack as "unjustifiable

warfare". With a massive manhunt underway for the perpetrator, police rounded their first poison gas was left in a subway car and two others were found dead and two were severely injured.

It was mixed with liquid ammonia and packed into "bombs" and "grenades" which were wrapped in newspaper and placed on all three trains.

One of those who died was identified to be a general

Continued on Page 2 Col 6

Sarin Gas Attack by Syria, 2013

- <https://www.youtube.com/watch?v=doytZVNltc4>
- Video

Forensic Details in U.N. Report Point to Assad's Use of Gas



AP/Lopdalgona Times-Presse — Getty Images
Syrian rebels wear Sunday in the northern city of Aleppo gas masks in a demonstration on how to respond to a chemical attack.

By RICHARD STONE and CLAUDIO CHAMORRO
Published: September 10, 2013 | 10:42 AM EDT

A United Nations report released on Monday confirmed that a deadly chemical arms attack caused a mass killing in Syria last month and for the first time provided extensive forensic details of the weapons used, which strongly implicated the Syrian government.



Acetylcholine-esterase Blocker

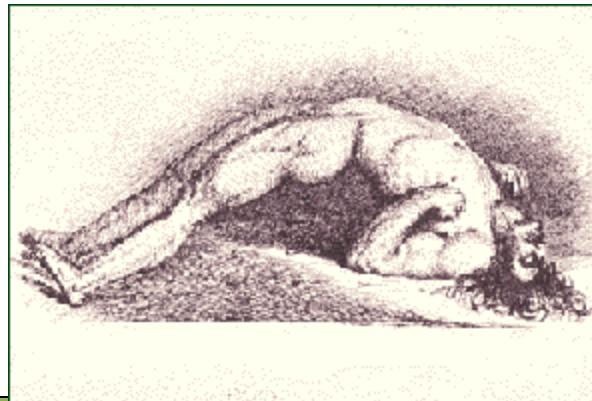
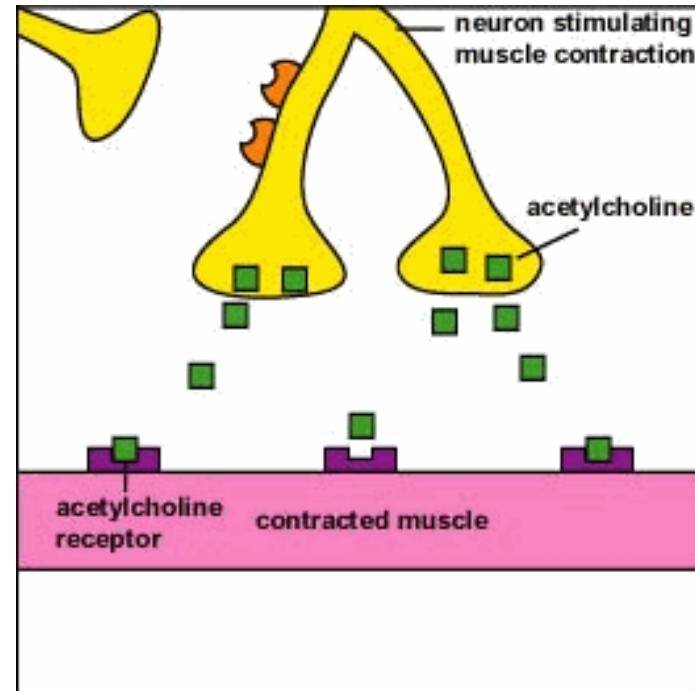
- Like saran gas, some **INSECTICIDES** inhibit acetylcholinesterase, so **Ach accumulates in the synaptic cleft and acts as a constant stimulus to the muscle fiber. The insects die because their respiratory muscles contract and cannot relax.**

Acetylcholine Antagonists

- Other poisons, such as **CURARE**, the poison used by South American Indians in poison arrows, **bind to the Ach receptors** on the muscle cell membrane and prevent Ach from working. That **prevents muscle contraction, resulting in flaccid paralysis.**

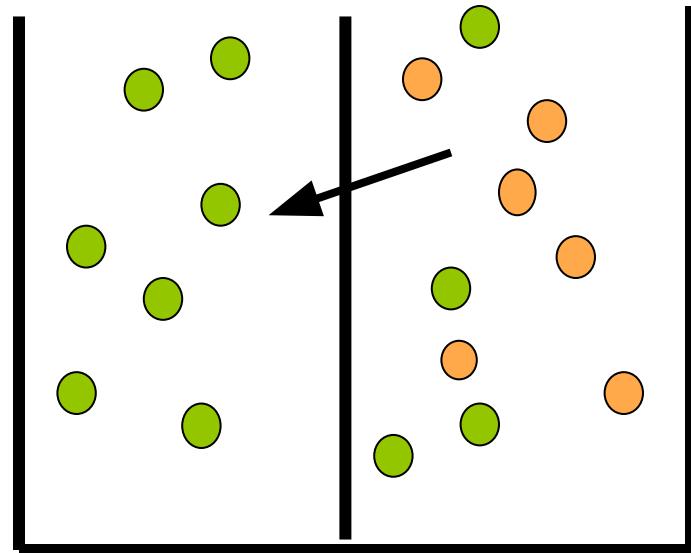
Inhibitory Neuron Blockers

- Tetanus exotoxin
- Blocks release of inhibitory neurotransmitters
- Muscles can't relax
- Spastic paralysis
- Opposing flexor and extensor muscles contract



Cell Membranes

- What **two** conditions must be met for diffusion of a substance across a semipermeable membrane?
 - Is the membrane **permeable** to it?
 - Does it have a **concentration gradient**?
- If the answer is **yes to both questions**, then the substance will diffuse (Which way? Down its gradient)



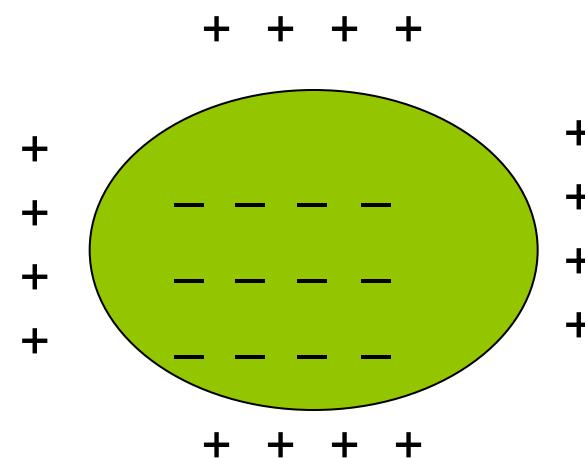
- Each cell in our body is surrounded by a cell membrane composed of a phospholipid **BI-LAYER**.
- That means that our cell membranes have two layers: an outer layer, and an inner layer.
- The inside layer of each cell membrane in the body, (including each neuron) has a charge (usually negative), and the outside layer of each cell membrane has a charge (usually positive).

- The reason for the charge difference is that there are many proteins inside of cells, and proteins are made of amino acids, most of which have a negative charge. Because proteins are negatively charged, the inside layer of the cell membrane has a negative charge.
- Outside of the cell, there are many electrolytes, especially sodium (Na^+), which have a positive charge. They stay outside of the cell because they cannot get in unless sodium channels in the cell membrane are open, which they usually are not. That's why the outside of the cell membrane usually has a positive charge.

- What is a sodium channel? Proteins embedded in the cell membranes form channels which only allow certain ions to cross the cell membrane.
- A sodium ion can only get into the cell by way of a sodium channel. A potassium ion can only get in by way of a potassium channel, etc.
- Charged ions, such as potassium (K^+), sodium (Na^+), calcium (Ca^{++}), and chloride (Cl^-) are called electrolytes. When they move from one side of the cell membrane to the other (when their channels are open), they carry their electrical charge with them.
- This changes the overall charge of the inside and outside of the cell membrane.

Not just separation of solutes, but charges, too!

- Inside of the cell is negative due to :
 - Abundance of proteins, which have a negative charge
 - The cell membrane is very permeable ("leaky") to K^+ , so it can LEAVE the cell whenever it wants. That leaves the inside of the cell more negative.



Sidedness

“Sidedness” of the membrane

- Sidedness means that the electrical charges on one side of the membrane (positive or negative) are different than on the other side.

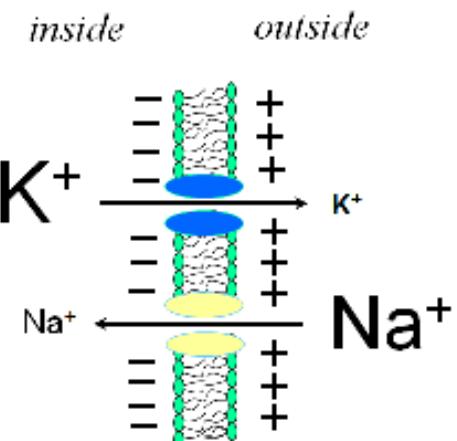
Why does sidedness exist?

- The cell membrane has different permeabilities to each ion; for instance the cell is more permeable to K⁺ than any other ion.
- Pumps exist which force particular ions into or out of the cell
- Channels made out of protein selectively allow particular ions into or out of the cell. These channels may be open or closed at any given time.

- Every cell has a positive charge on the outside of the membrane and a negative charge on the inside of the cell membrane, when the cell is at rest (not being stimulated).
- K⁺ constantly leaks out of the cell because it wants to diffuse down its concentration gradient. That means it wants to go from its area of high concentration (the inside of the cell) to an area where it is in low concentration (the outside of the cell).
 - Na⁺ wants to get into the cell, too, but its channel is closed.
 - Because of this separation of chemicals and electrical charges, every cell has a Resting Membrane “Potential”.

There is a difference in electrical charge across the membrane (a potential difference)

More negative inside; more positive outside
 Resting membrane potential is minus 70 to minus 90mV



- As K⁺ leaves the cell, it takes a positive charge outside with it, so the inside is more negative.
- However, as the inside of the cell is becoming more negative, the outside of the cell is becoming more positive, and the positive charges will want to flow back inside of the cell since they are attracted to the negative charges.
- This is what keeps K⁺ from just leaving the cell until it is in equal numbers on both sides of the cell. Before it can reach such an equilibrium, it gets pulled back into the cell because its positive charges are drawn into the inside of the cell, where the charge has become strongly negative (because proteins are on the inside of the cell and they have a negative charge).
- Other positively charged ions, like Na⁺, want to go into the cell also, but they are blocked by protein gates that only K⁺ can get through.

ACTION POTENTIAL

- The resting membrane potential
 - Occurs because the cell membrane is more permeable to potassium ions than sodium ions
 - Occurs because there are negatively charged proteins and ions inside the cell
- The action potential occurs if the membrane potential reaches a certain threshold.

What if.....

- What if a membrane suddenly became MORE PERMEABLE to Na^+ ? ? ? ? ?
- Even for just a moment in time.....
- What would Na^+ do? (Ask yourself the 3 questions)

Which way is the electrochemical gradient for Na^+ ?

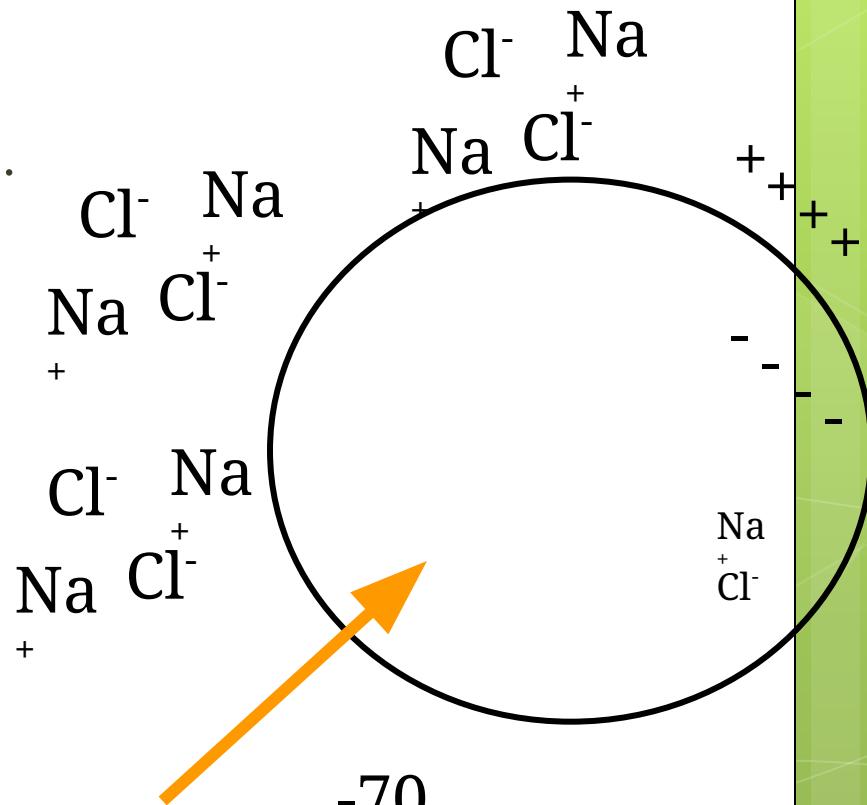
Electrical: inward

Chemical: inward

Answer:

Most definitely INWARD
Sodium WANTS IN!

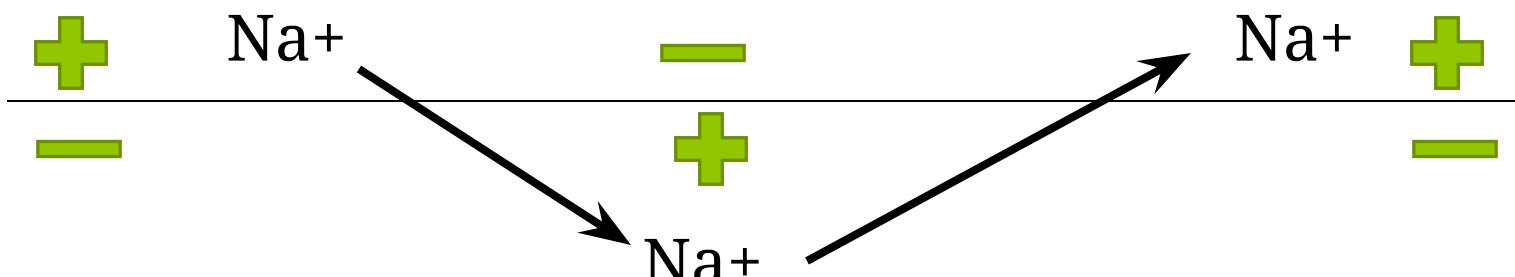
Can it get in?



What would happen to
the membrane potential
of the cell when this
event occurs?

Know the following:

- **Direction of impulse**
- **Ions involved, charges**
- **States: resting potential, depolarization, repolarization**



Resting potential

Outside of membrane is positive charge at resting potential.

Depolarization

Na^+ enters and K^+ leaves, so outside of membrane becomes negative charge. This is depolarization

Repolarization

When stimulus is over, Na^+ leaves and K^+ enters the cell, so outside of membrane returns to positive charge. This is repolarization

Direction of impulse

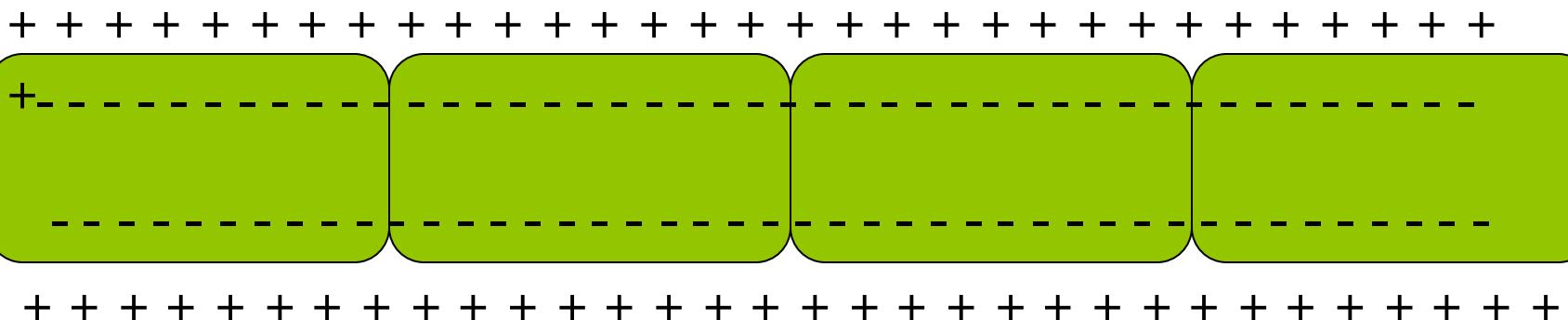
- What would happen to the membrane potential of the cell when you open up a sodium channel?
- If we instantly increase sodium permeability, sodium will enter the cell, changing the charge of the inside of the cell so that it goes from negative to positive. The outside layer of the cell membrane would then go from positive to negative (the charges flip). This is called **DEPOLARIZATION**.
- However, when this occurs, Na^+ will be in higher concentration on the inside of the cell, so it wants to diffuse back out of the cell.
- Once it leaves the cell again, the membrane potential of the inside of the cell membrane will return to a negative charge. This is called **REPOLARIZATION**.

Spread of Depolarization

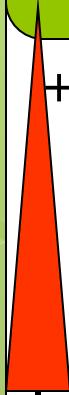
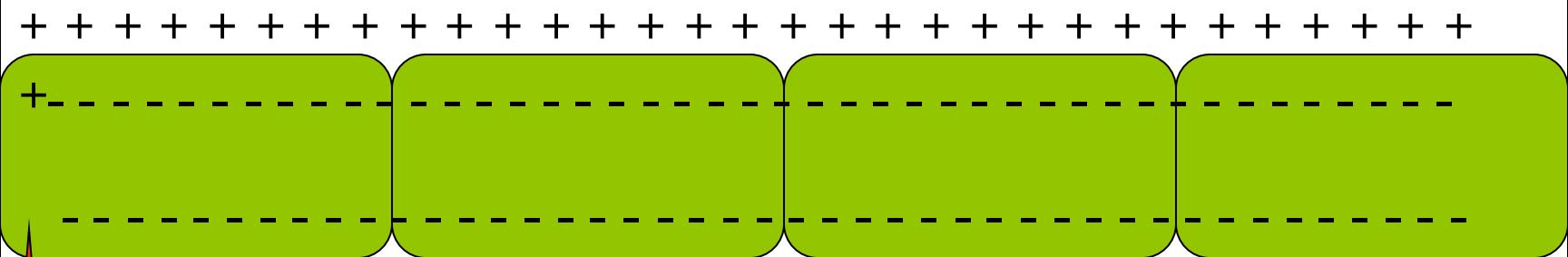
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Direction of Depol

Resting Cell

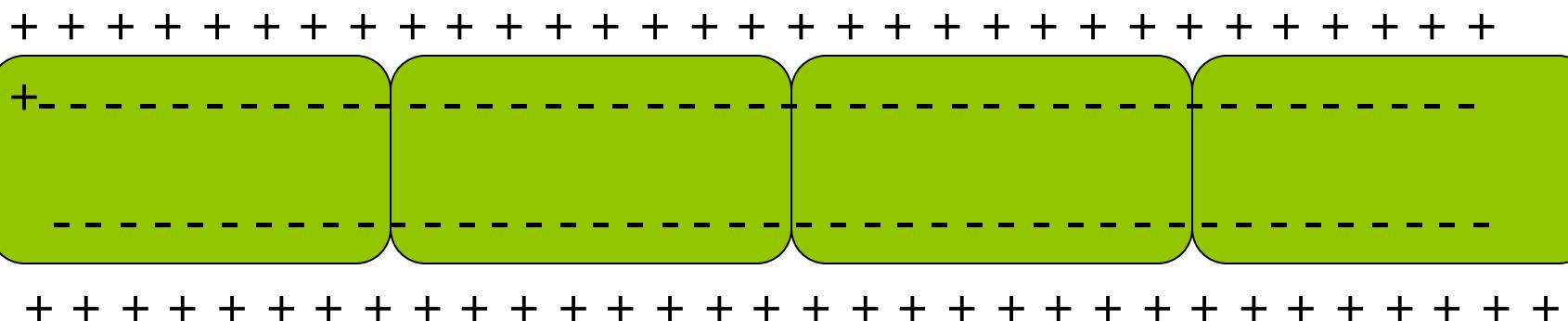


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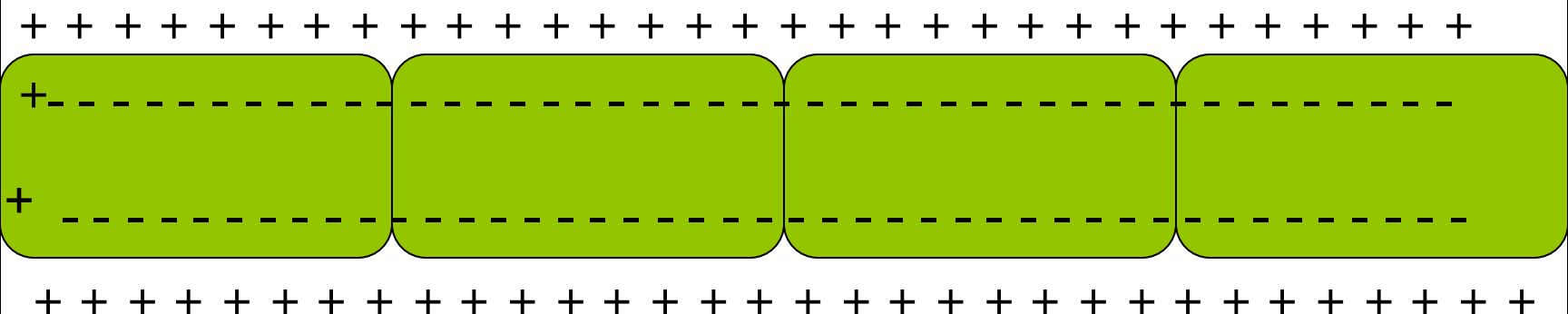


Sodium channels
open

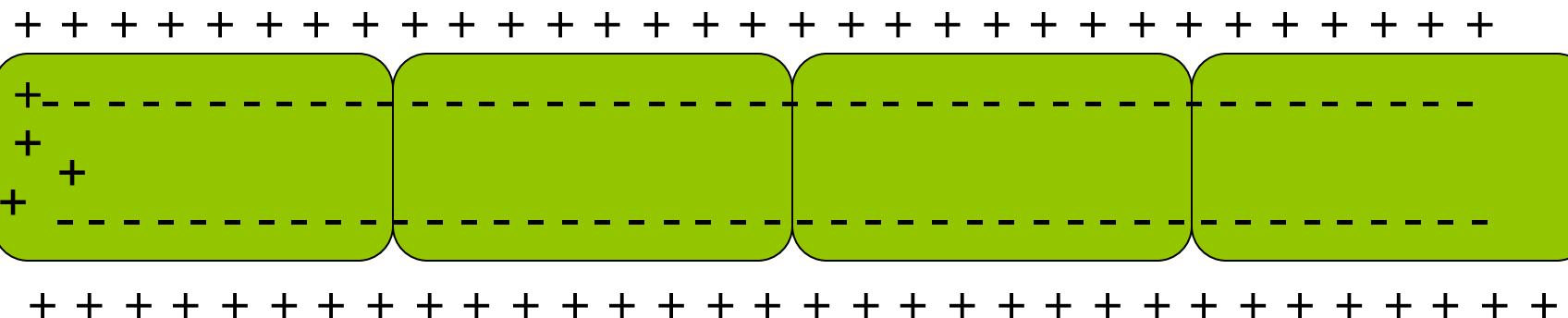
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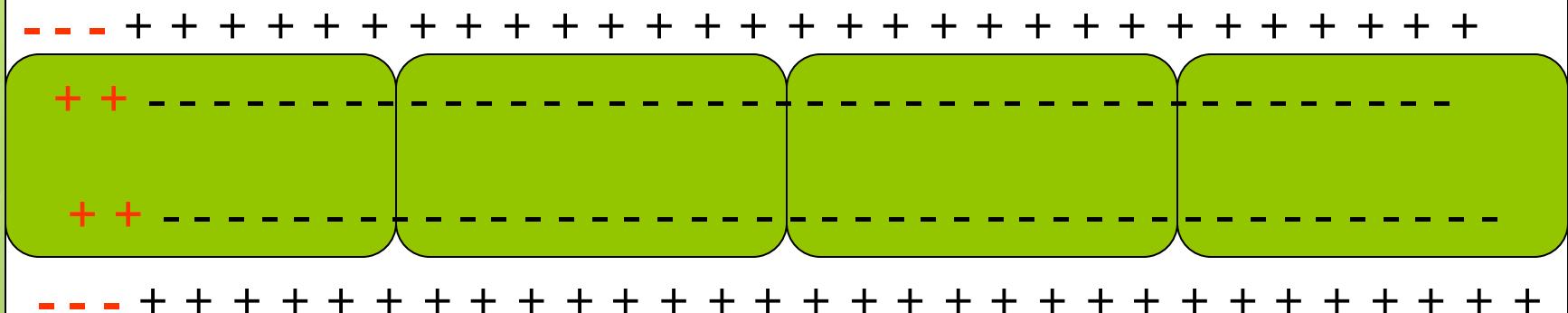
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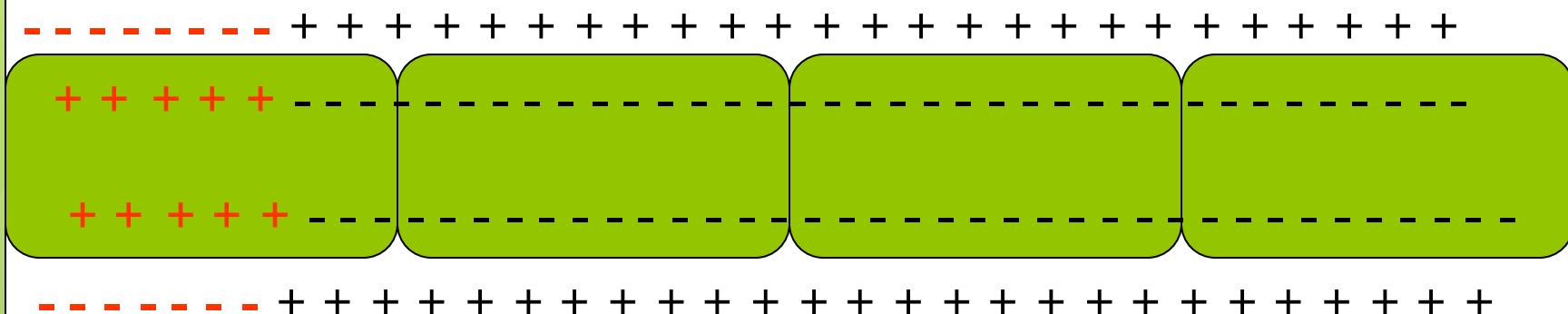
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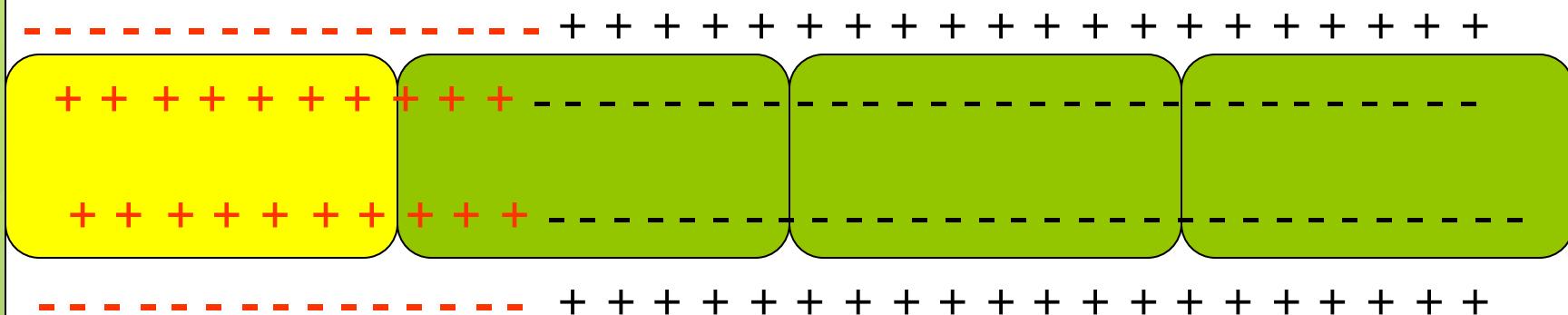
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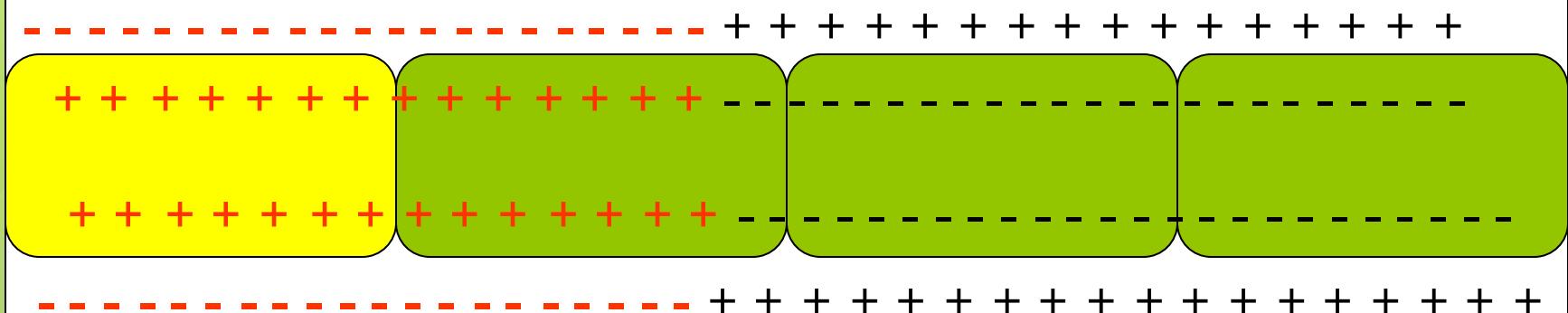
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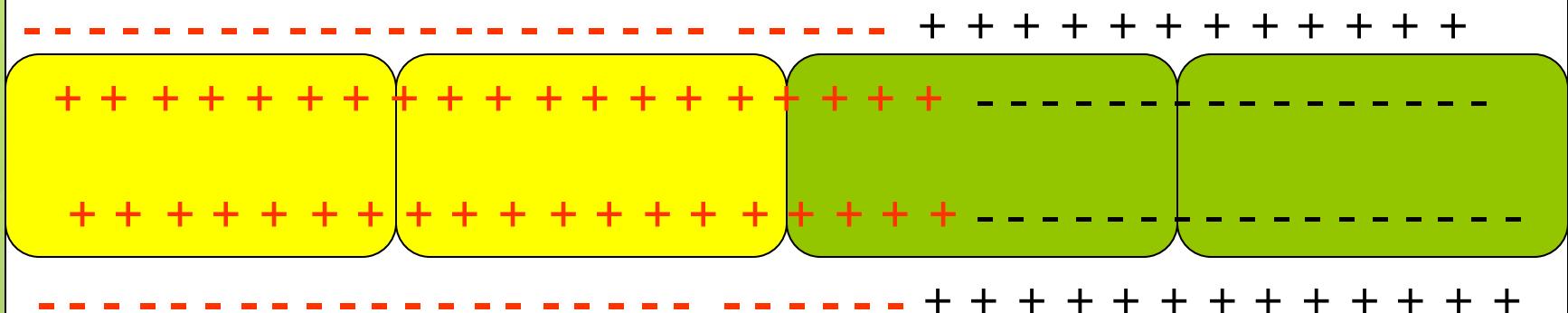
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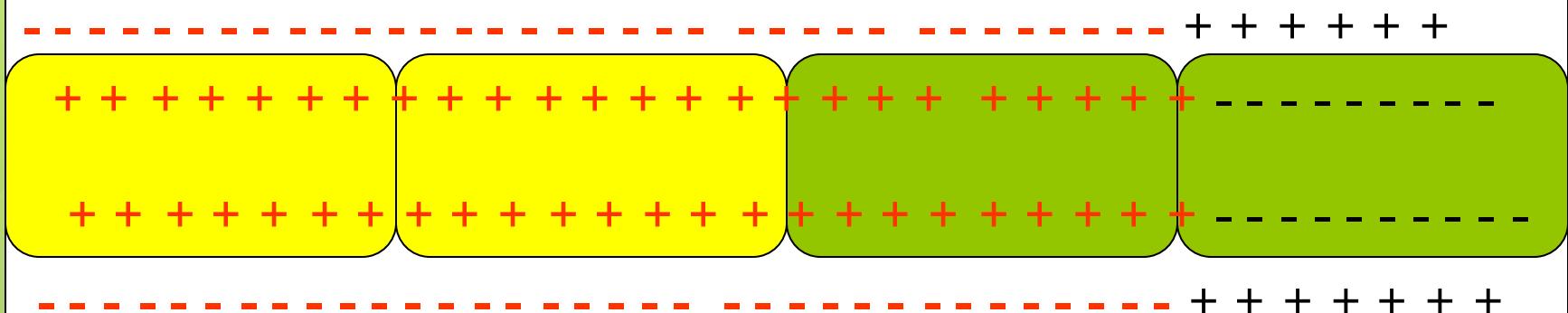


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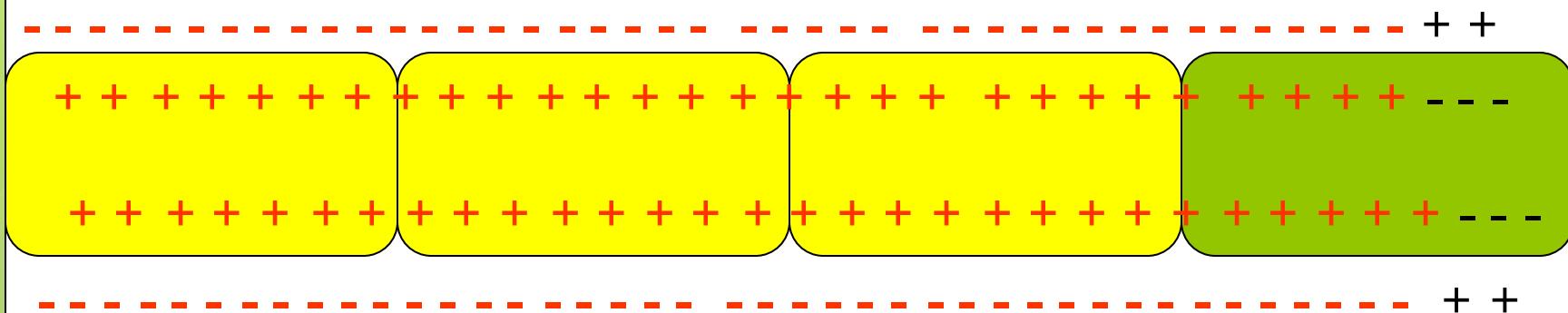


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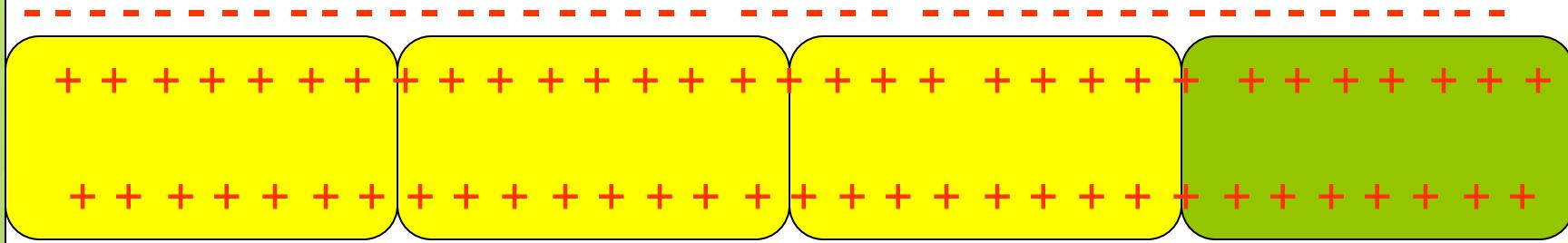
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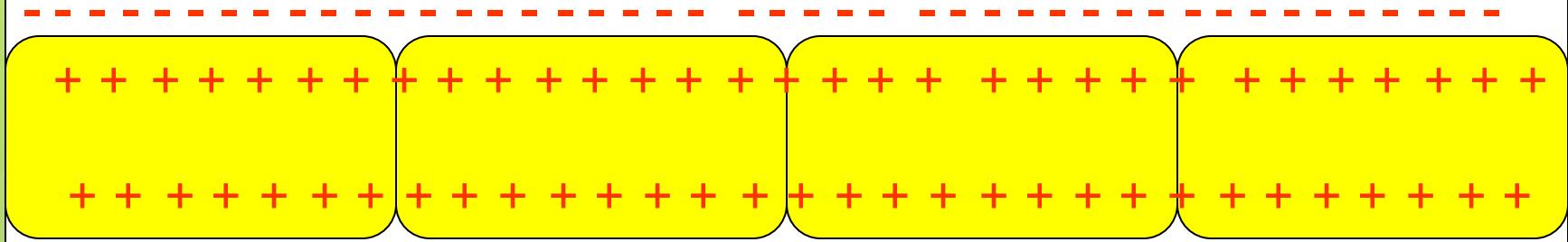
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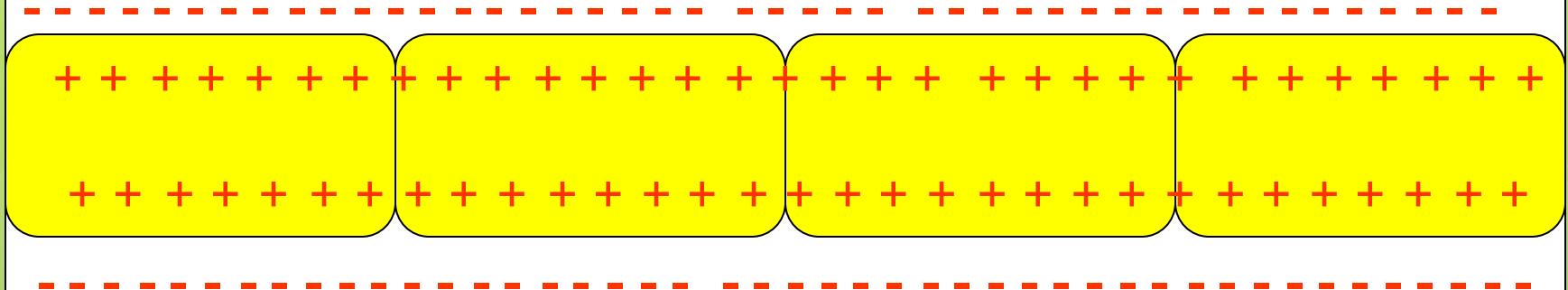
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Direction of Depol



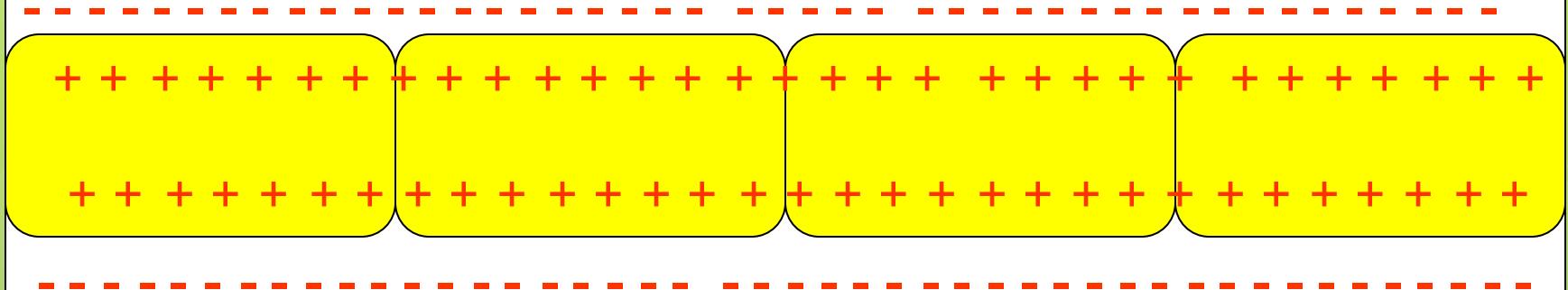
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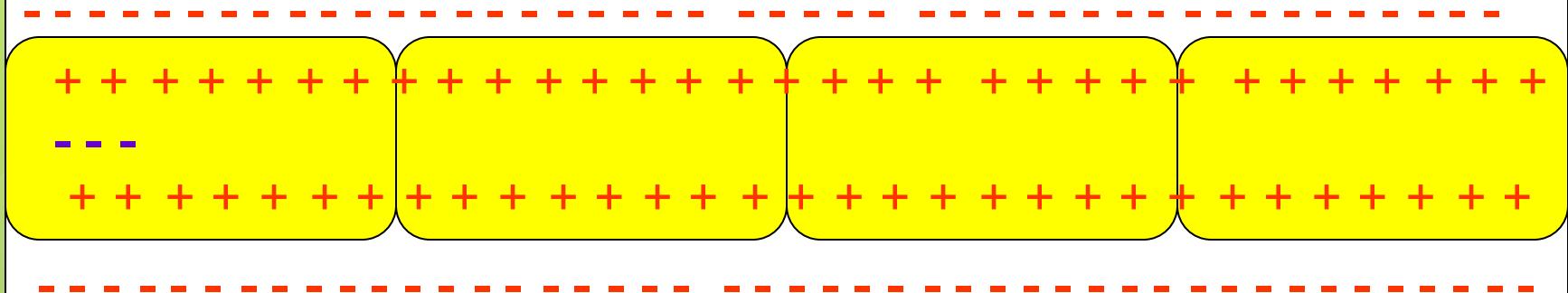
Depol = spread of surface NEG charge

Direction of
Repolarization

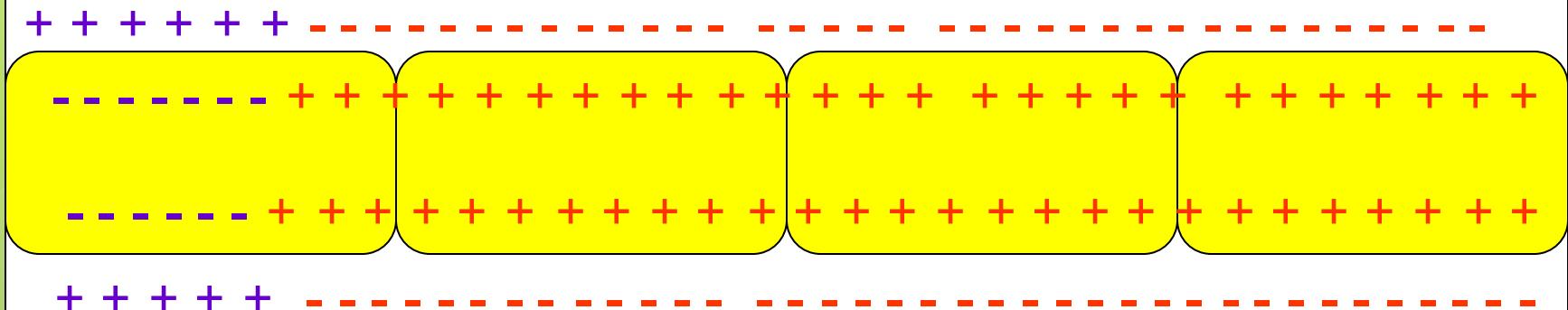
When Na^+ is pumped back out, Repolarization begins



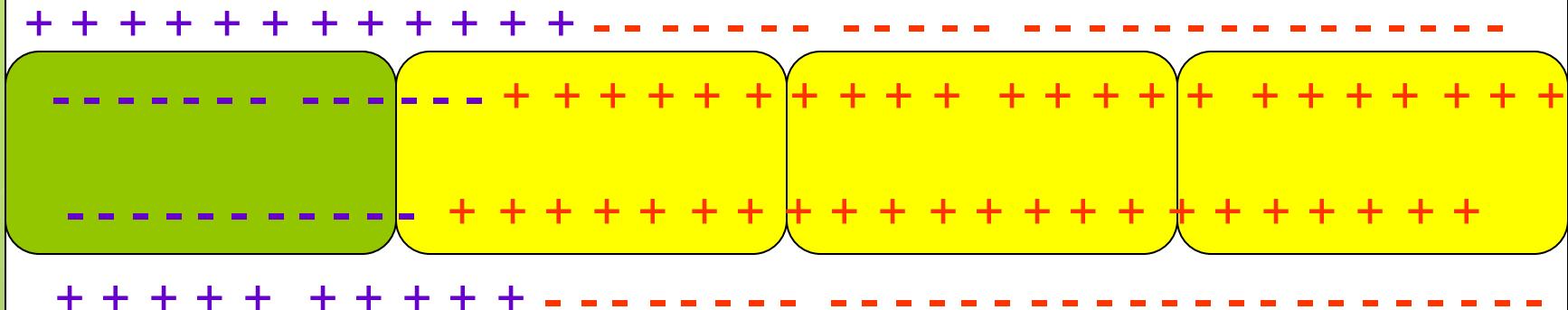
Direction of Repolarization



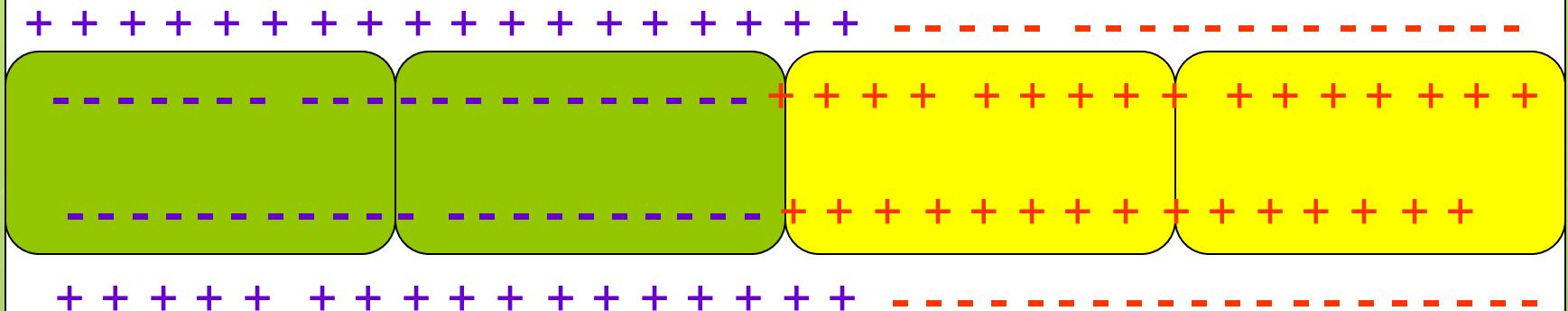
Direction of Repolarization



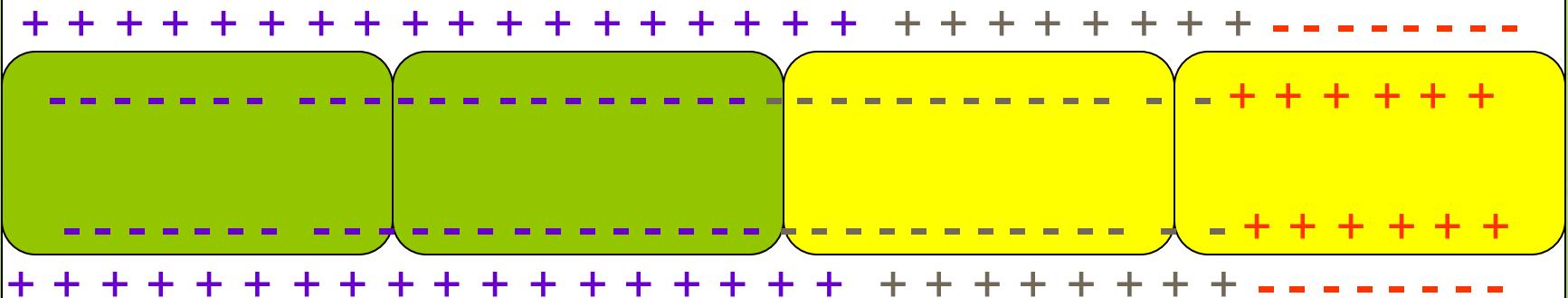
Direction of Repolarization



Direction of Repolarization

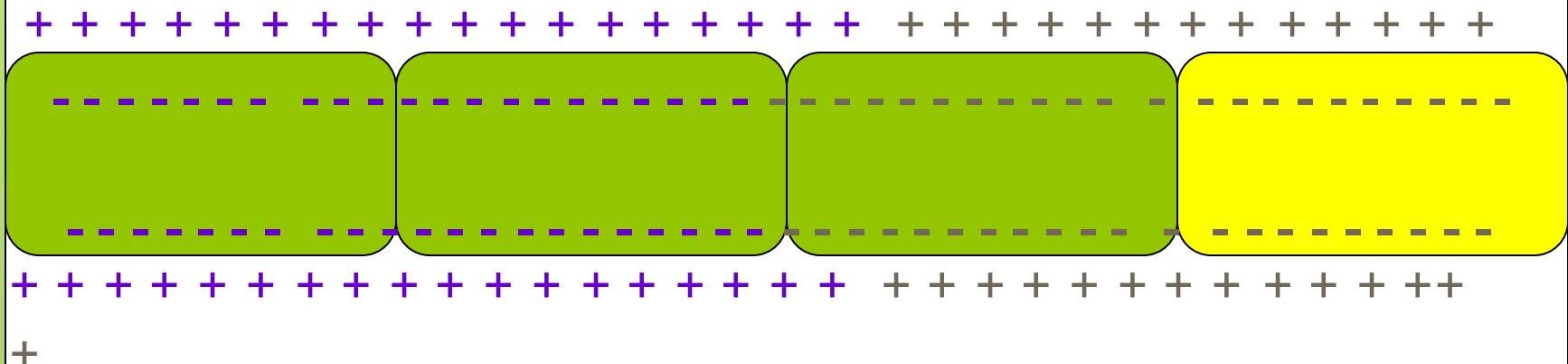


Direction of
Repolarization

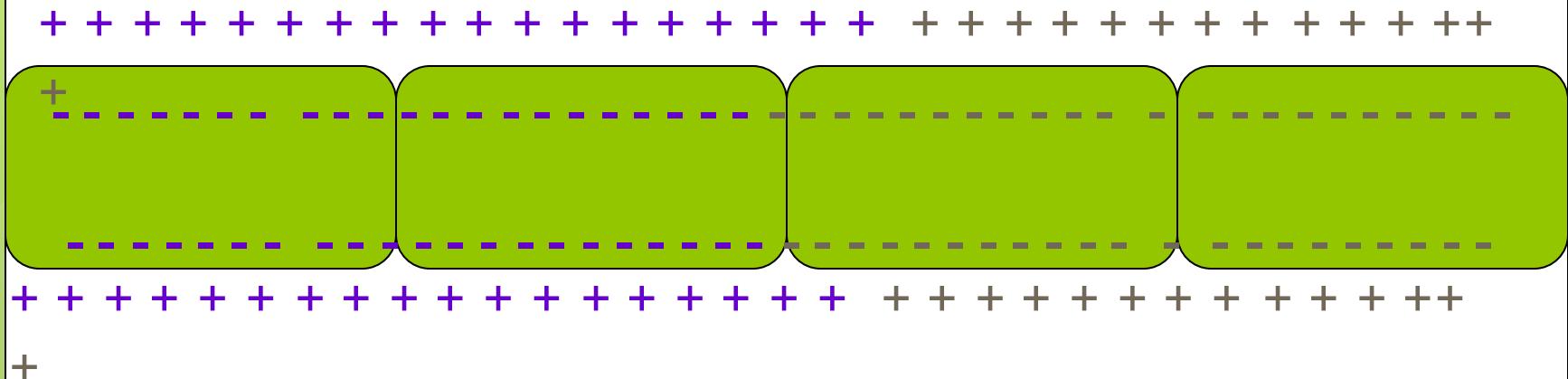


Repolarization= spread of positive surface charge

Direction of Repolarization



Direction of Repolarization



- Excitable cells (neurons and muscles) are those that want this large electrical current to use for work.
- They have proteins embedded in their cell membranes that are sodium channels (allow Na^+ to pass into the cell for a short time after stimulation).
- Muscle cells use the electrical force to contract, and neurons use it to excite the neurons touching them.

Excitable Cells

- Cells that can experience a momentary change in membrane voltage are “excitable” cells (muscles and nerve cells)
- That temporary change in voltage is due to a momentary change in permeability of Na^+
- The membrane, for only a moment, becomes more permeable to Na^+ than to K^+
- When the outside and inside of the cell membrane reverse their charges (inside becomes positive and outside becomes negative), and then reverts back to normal, this process (depolarization + repolarization) is called an **ACTION POTENTIAL.**
- The reversal of charges (action potential) is carried like a wave down the length of the cell, and into the next cell touching it, and so on.

ACTION POTENTIAL

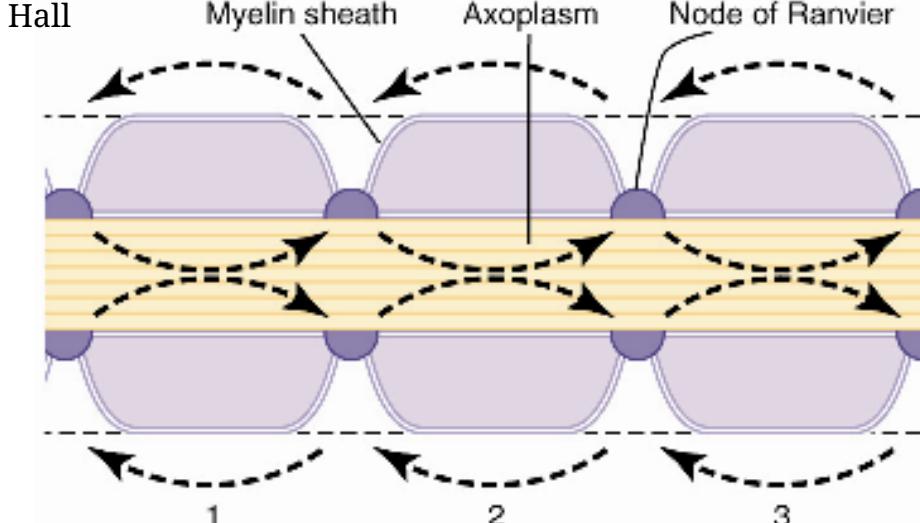
- **The action potential occurs when the membrane potential (how negatively charged the inside of the cell is) reaches a certain threshold.**
- When the Na^+ rushes into the cell, the membrane potential becomes less and less negative. Eventually, it reaches zero charge, and as more Na^+ enters the cell, the inside of the cell becomes positively charged.
- When it becomes positively charged enough ($+30 \text{ mV}$), an action potential will sweep down the length of the cell membrane, like a wave of electricity. This is how one neuron stimulates a cell (a muscle cell, gland, or another neuron).
- If the neuron stimulates a muscle cell, it contracts. If it stimulates a gland, it secretes. If it stimulates another neuron, the action potential is carried further along the nerve pathway, until it reaches the target organ.

VIDEOS

- [Neuron Synapse](#) 3 mins
- [Neuron Resting Potential](#) 4 mins

- Healthy kidneys clean the blood and remove excess potassium so that the level of potassium in the blood remains within a very narrow range.
- If potassium levels get too high, nerves begin to misfire.
- This can cause irregular heartbeats and even heart attacks.
- If a patient's potassium levels rise above 5.0 mg/dl, the nephrologist often suggests that he limit his potassium intake to prevent nerve problems.
- Lethal injections are potassium.

Figure 5-17; Guyton &



Saltatory Conduction

[http://www.brainviews.com/
abFiles/AniSalt.htm](http://www.brainviews.com/abFiles/AniSalt.htm)

The AP is a passive event: ions diffuse down their EC gradients when gated channels open.

A “wave of depolarization” occurs along the neighboring areas.

Occurs in one direction along the axon; actually, AP *regenerates* over and over, at each point by diffusion of incoming Na⁺WHY?
Refractory period (Na⁺ channels become inactivated).

Saltatory Conduction

- This type of conduction is found with myelinated axons.
- AP's only occur at the nodes (*Na channels concentrated here!*)
- increased velocity
- energy conservation

Na/K ATPase Pump

[http://www.youtube.com/
watch?v=GTHWig1vOnY](http://www.youtube.com/watch?v=GTHWig1vOnY)

Other Types of Neurons: Supporting Cells

Neurons are only one type of cell; there are others, which are supporting cells, with a special name:

GLIA (short for “neuroglia”, meaning “nerve glue”) are the supporting cells of the nervous system. These are only brain cells that can reproduce. Since cancerous cells are those that reproduce, all brain tumors originate from glial cells.

There are five types of glial cells that we will cover:

1. Oligodendrocytes
2. Schwann cells
3. Astrocytes
4. Microglia
5. Ependymal cells

Types of Glial Cells

1. OLIGODENDROCYTES ("few branches").

They are found in the CNS, are very large and complex cells. Oligodendrocytes form **MYELIN SHEATHS in the CNS**. This sheath is a covering around an axon to speed up the nerve conduction. Myelin is mostly made of lipid (fat), which is an electrical insulator. The electricity jumps over the sheath and shoots right to the next bare area of the axon.

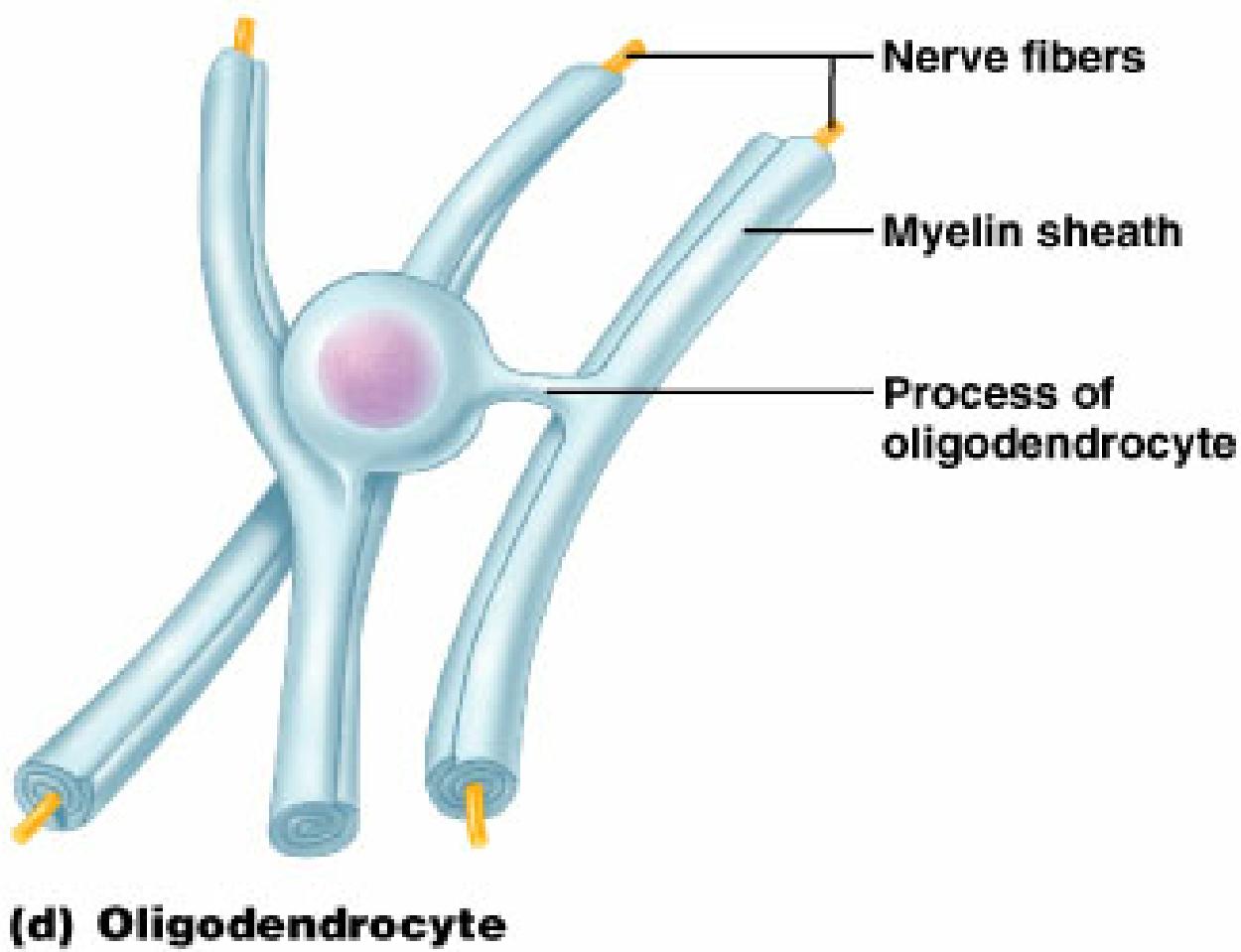
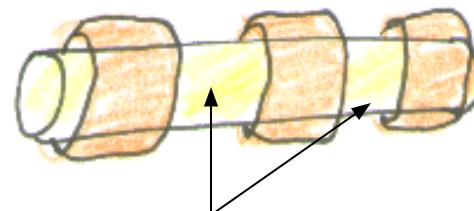


Figure 12.12c, d

- A sheet of paper is like an Oligodendrocyte, and it wraps itself around a pencil (axon), so there are many layers.
- The myelin sheath is an electrical insulator. BETWEEN the sheaths are **NODES OF RANVIER**; these are **BARE** regions of axonal membranes only found in myelinated axons.



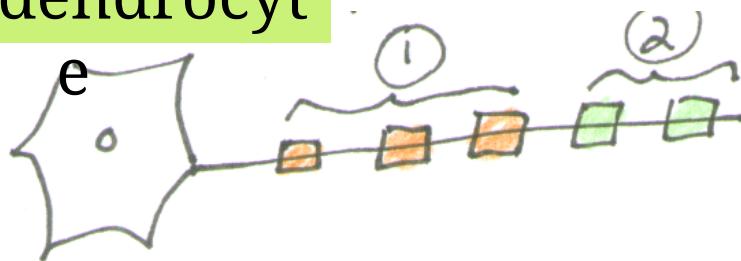
Nodes of
Ranvier

- The action potential jumps from one Node of Ranvier (the bare area) to the next Node, skipping the myelin that is between the bare areas. This speeds up the overall nerve conduction. https://www.youtube.com/watch?v=i30Bv_E0qAU
- Therefore, a myelinated axon conducts impulses faster than an unmyelinated axon.

- Why aren't all neurons myelinated? Isn't it good for everything to be faster?
- No, myelin is a living cell, so it uses nutrients!
- We'd better save the myelin for where we need it.
- It is not necessary for things like digestion to start at 1/10 of a second rather than one second, or start sweating in 1/20 of a second rather than 1 second.
- Walking and thinking are things that need to be quick.

- An oligodendrocyte is like an octopus that can wrap around one neuron in many locations, and neurons can have many oligodendrocytes on their axons.

Oligodendrocyt



MULTIPLE SCLEROSIS is an **autoimmune disease where the oligodendrocytes (the myelin sheaths) are destroyed (demyelination)**, interfering with the neuron functions in the CNS.

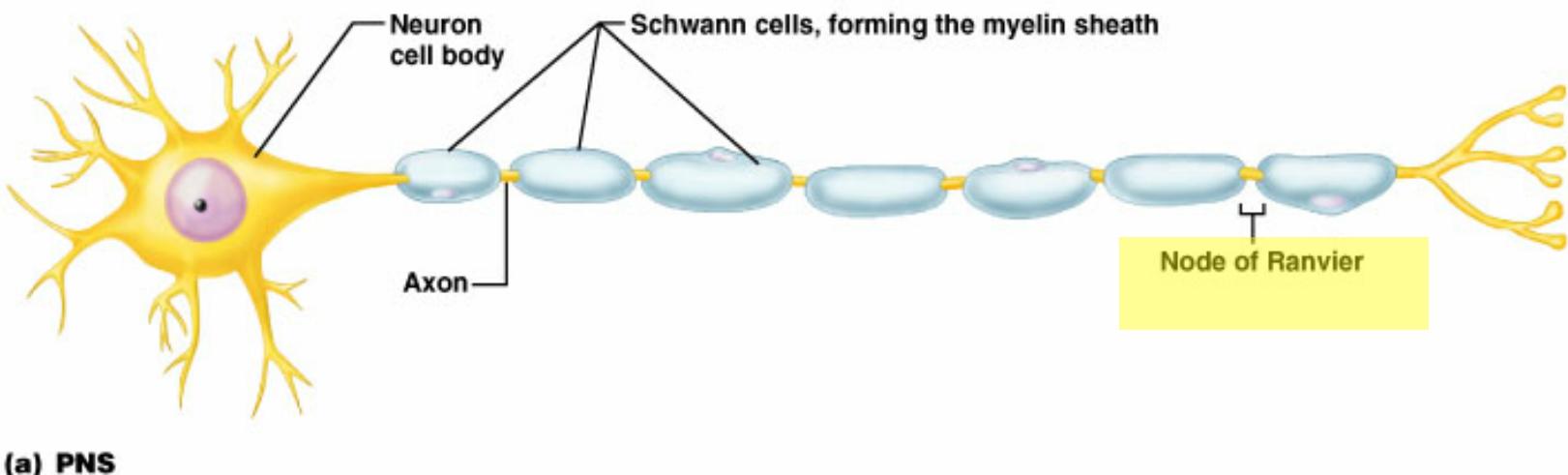
Oligodendrocytes cannot regenerate.

MS is the most common neurological disease of young adults. Starts to manifest in late teens and early 20's.

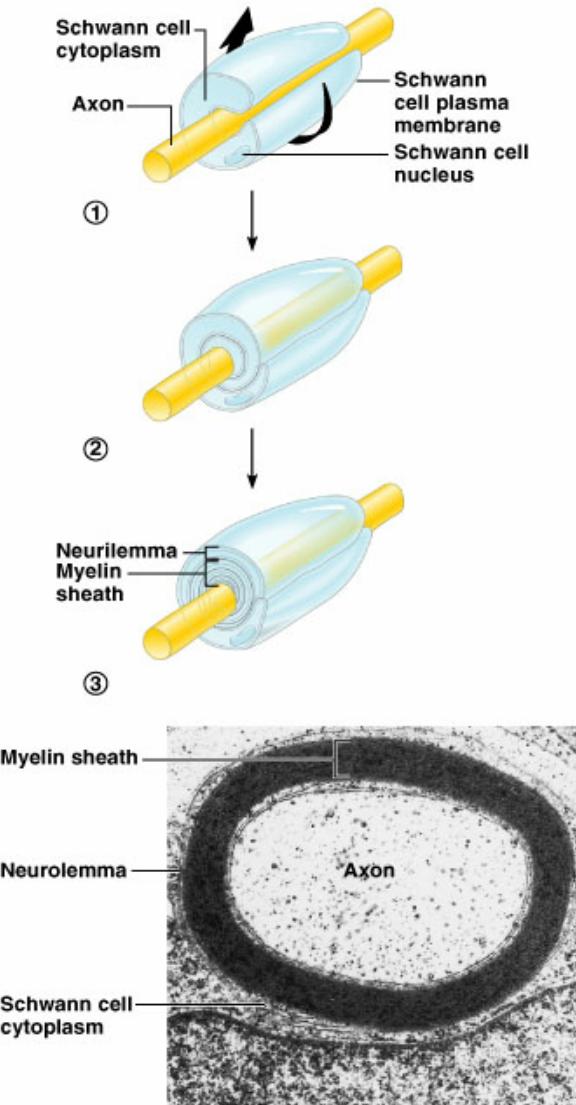
It progresses to paralysis and sometimes death.

One in 1000 people get it. There are treatments, but no cure.

2. **SCHWANN CELL** is another cell that forms myelin sheaths, but **in the PNS**. Each cell only forms one myelin sheath. Instead of being like an octopus with several arms, it is more like a clam, attaching at one point.



Schwann Cells: Myelin Sheaths in the PNS



(a) Schwann cells on myelinated axon

Neurofibromatosis (NF)

- Genetically-inherited disorder in which the nerve tissue grows tumors (neurofibromas) that may be harmless or may cause serious damage by compressing nerves and other tissues.
- The disorder affects Schwann cells and melanocytes.
- Proliferation causes tumors and abnormal skin pigmentation.
- The tumors may cause nothing but bumps under the skin and colored spots, or they may cause skeletal problems, pressure on spinal nerve roots, and other neurological problems.

Neurofibromatosis (NF)

- Neurofibromatosis affects males and females equally and is dominant (only one copy of the affected gene is needed to get the disorder).
- If only one parent has neurofibromatosis, the children have a 50% chance of developing the condition.
- In half of cases there is no other affected family member because a new mutation has occurred.

Neurofibromatosis (NF)

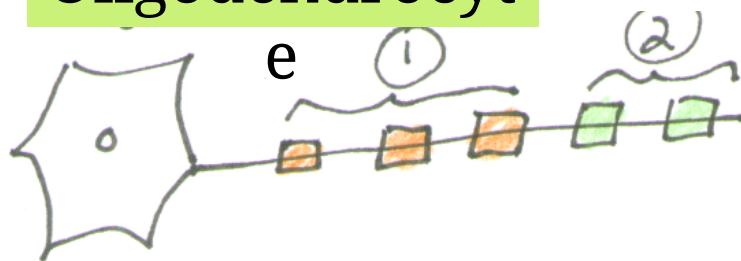
Diagnostic Criteria

- Two or more neurofibromas
- Freckling of the groin or the axilla
- Six or more Café au lait spots (coffee with milk colored pigment)

Difference between oligodendrocytes and Schwann cells

Found in CNS
only

Oligodendrocyt



One cell may
form 3 sheaths,
another cell
may form 2
sheaths

Found in PNS
Schwann cell



One cell
always forms
only one
sheath.

3. **ASTROCYTE** ("star cell") is another very large, complex cell, in the CNS. Its function is to wrap some of its arms around capillaries like a starfish while it wraps other arms around neurons to physically support them.

- Physically supports the neurons
- Transmits materials from capillaries to neurons
- **Forms blood-brain barrier (BBB)**

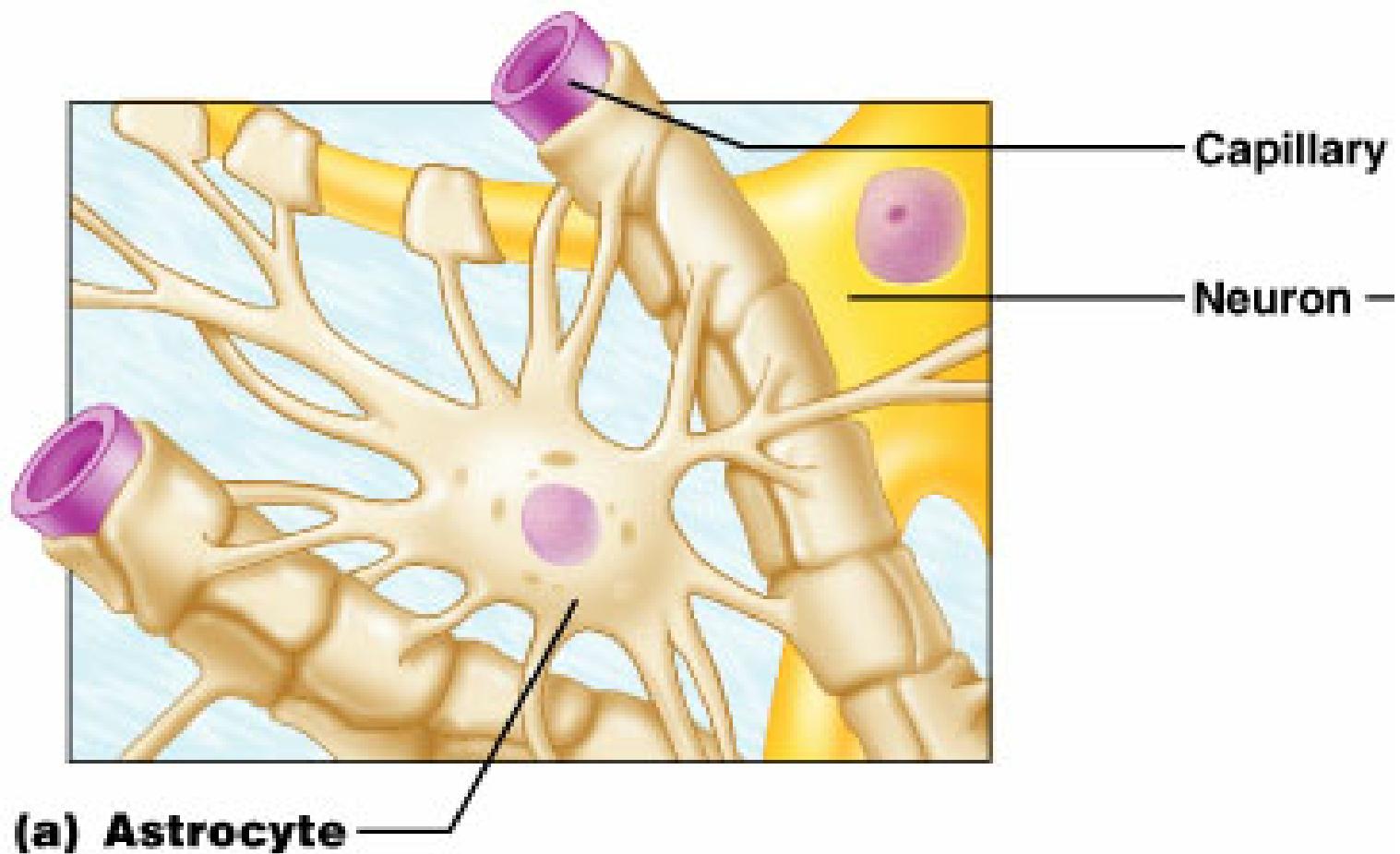


Figure 12.12a

Blood-Brain-Barrier

- The **BBB** prevents a lot of certain types of materials from leaving the blood and entering the brain (e.g. hormones, drugs).
- The brain still gets its nourishment from the blood, without the toxins.
- The capillaries have leakage, but are surrounded by astrocytes, so not everything can leak out.
- Certain antibiotics can't cross the BBB (such as antifungals), so they can't be used for brain infections.
- The only function of the blood-brain barrier is to help **protect** the central nervous system.

Brain Tumors from Neuroglia

Astrocytoma: tumor of the astrocytes

- **80% of Brain tumors are from astrocytes**
- All cancers are graded from I to IV in severity, with IV being the worst prognosis.
- Astrocytoma grades I and II have a good (80%) chance of survival if treated by surgery, radiation, and chemotherapy. They tend to occur in 1/100,000 young people under age 20.
- Grade IV survival rate is 3 months without treatment, and only about 12 months with treatment. They are more common in ages 65-75.

- Symptoms of an astrocytoma tumor are a result of growing pressure inside the skull.
- These symptoms include headache, vomiting, impaired balance, and mental status changes.
- Other symptoms may occur, depending on the location of the tumor.

Suzanne; 20 year old Saddleback student, 2003



- Grade 3 Astrocytoma, size of ping pong ball, pressing on optic nerve.
- Underwent surgical, radiation, and chemotherapy, but died 2.5 years later.
- Main symptoms were frequent headaches throughout High School.

4. MICROGLIA (one word, two errors!). These are not micro, nor are they glia.

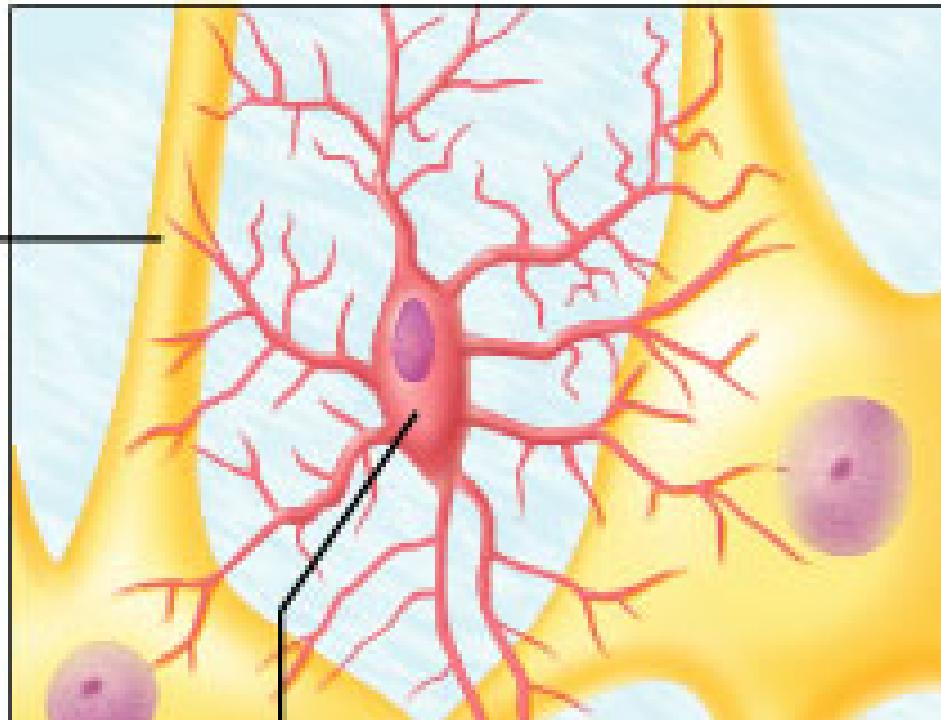
They are macrophages, the same size as everywhere else in the body.

They are called micro because they are much smaller than real glia cells.

They pick up bacteria and dead cell, etc.

Capillary

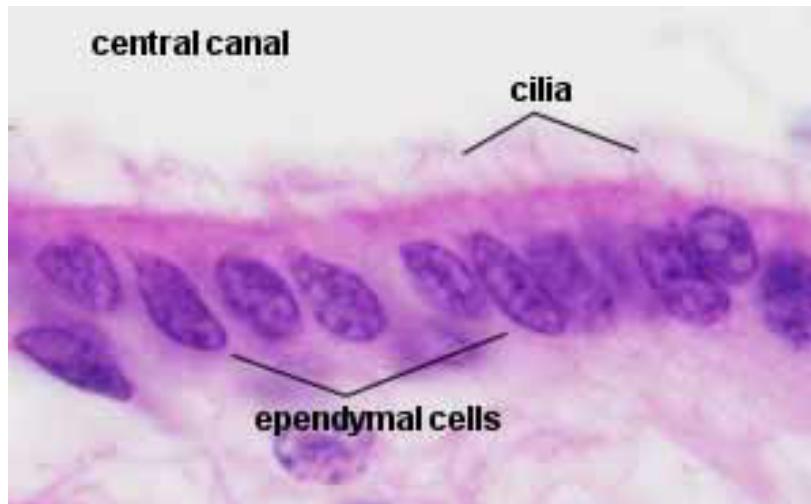
Neuron



(b) Microglial cell

Ependymal Cells

- Ependymal cells line the cavities of the CNS and make up the walls of the ventricles.
- These cells create and secrete cerebrospinal fluid (CSF) and beat their cilia to help circulate the CSF and make up the Blood-CSF barrier.
- They are also thought to act as neural stem cells.



TERMINOLOGY

- **WHITE MATTER:** that portion of the CNS with myelinated axons; the myelin makes the area look white.
- **GREY MATTER:** that portion of the CNS that is unmyelinated (cell bodies of neurons, dendrites, and unmyelinated axons).
- **NERVE:** collection of axons in the PNS. No cell bodies, dendrites, or synapses; just axons.
- **TRACT:** collection of axons in the CNS.
- **SYNAPSES:** Where information is processed. Most synapses are in the CNS

TERMINOLOGY

- **GANGLION:** A collection of cell bodies in the PNS
- **NUCLEI:** A collection of cell bodies in the CNS
- **NERVE PLEXUS:** A network of nerves (nerves don't run by themselves, they go in groups)
- **WALLERIAN DEGENERATION:** process that results when a nerve fiber is cut or crushed, in which the part of the axon separated from the neuron's cell body degenerates distal to the injury.

Ganglion: Collection of cell bodies in the PNS

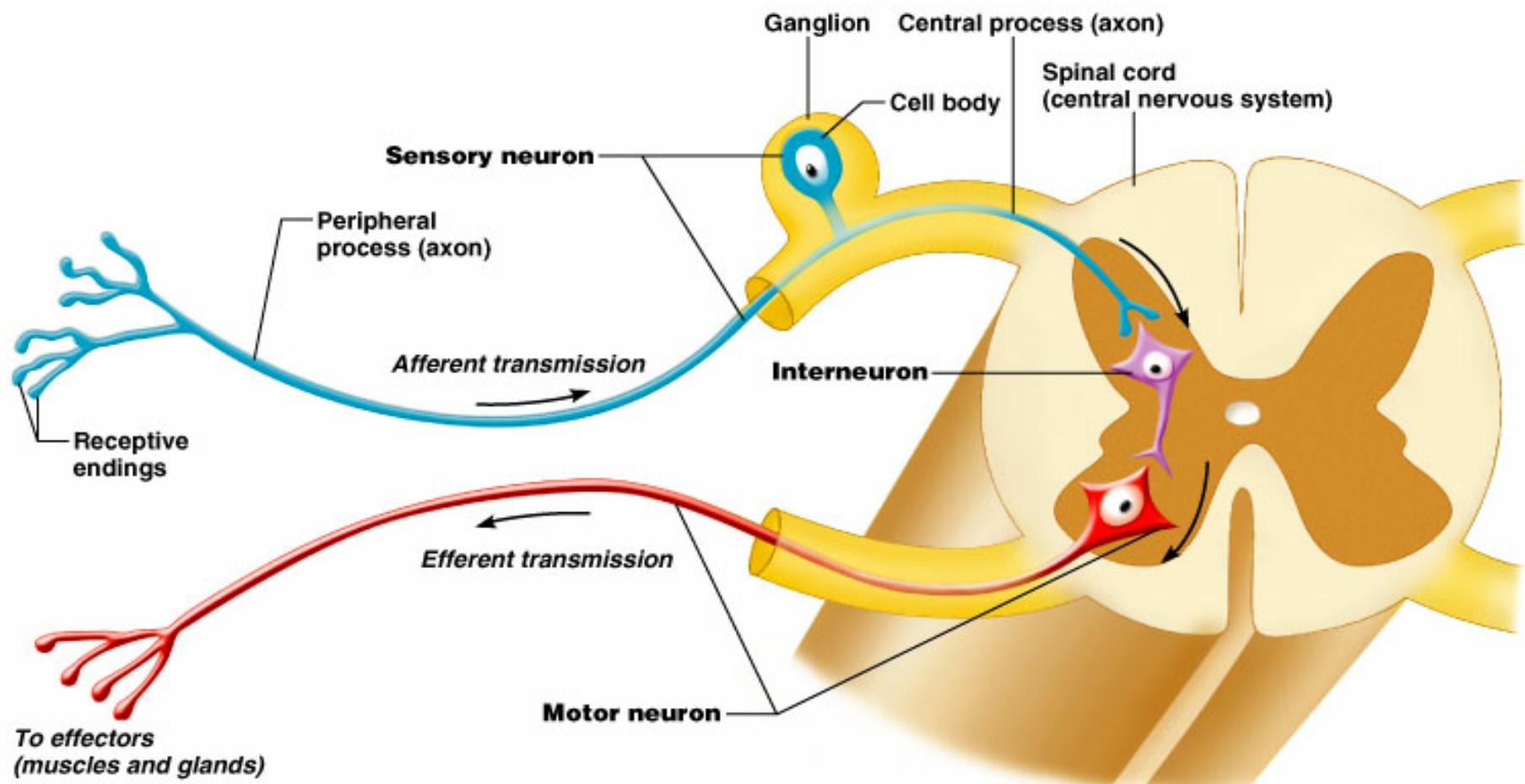


Figure 12.11

Nerve Regeneration

- In humans, axons outside the brain and spinal cord can regenerate, but not those inside. After injury, axons in the human central nervous system degenerate, resulting in permanent loss of nervous function. This is not so in cold water fish and amphibians, where axon regeneration in the central nervous system does occur.
- So far, investigators have identified several proteins that seem to be necessary to axon regeneration in these central nervous system of these animals, but it may be a long time before biochemistry can offer a way to bring about axon regeneration in the human central nervous system.
- It is possible though, that one day these proteins will become drugs or that gene therapy might be used to cause humans to produce the same proteins when such injuries occur.

Nerve Regeneration

- In the meantime, some accident victims are trying other ways to bring about a cure. In 1995, Christopher Reeve, best known for his acting role as Superman, was thrown headfirst from his horse, crushing the spinal cord just below the neck's top two vertebrae. Immediately, his brain lost almost all communication with the portion of his body below the site of damage and he could not move his arms and legs.
- Many years later, Reeve could move his left index finger slightly and could take tiny steps while being held upright in a pool. He had sensation throughout his body and could feel his wife's touch.

Nerve Regeneration

- Reeves improvement was not the result of cutting edge drugs or gene therapy-- it was due to exercise. Reeves exercised as much as five hours per day, especially using a recombinant bike outfitted with electrodes that made his leg muscles contract and relax.
- The bike cost him \$16,000. It could cost less if commonly used by spinal cord injury patients in their own homes. Reeves, who was an activist for the disabled, was pleased that insurance would pay for the bike about 50% of the time.

Nerve Regeneration

- It's possible that Reeves advances were the result of improved strength in bone density, which led to stronger nerve signals.
- Normally, nerve cells are constantly signaling one another, but after a spinal cord injury, this signal ceases. Perhaps Reeves' intensive exercise brought back some of the normal communication between nerves. His physician is convinced that his axons were regenerating. Reeves was convinced that stem cell therapy would one day allow him to be off his ventilator and functioning normally; however, Reeve died in 2004.
- So far, researchers have shown that both embryonic stem cells and bone marrow stem cells can differentiate into neurons in the laboratory. Bone marrow stem cells apparently can also become neurons when injected into the body.