BOOKLET #1

WELCOME TO BIOLOGY 30

LETS GET STARTED…

HOMEOSTASIS

and the Nervous System

Learner outcomes…
What you need to know!

- describe, using an example, the organization of neurons into nerves and the composition and function of reflex arcs
- describe the general structure and function of a neuron and myelin sheath, explaining the formation and transmission of an action potential, including all-or-none response and intensity of response; the transmission of a signal across a synapse; and the main chemicals and transmitters involved, i.e., norepinephrine, acetylcholine and cholinesterase

Outcomes continued…

- identify the principal structures of the central and peripheral nervous systems and explain their functions in regulating the voluntary (somatic) and involuntary (autonomic) systems of the human organism; i.e., cerebral hemispheres and lobes, cerebellum, pons, medulla oblongata, hypothalamus, spinal cord, sympathetic and parasympathetic nervous systems, and the sensory-somatic nervous system

Terms you need to know…

- Homeostasis
- Nervous System
- Endocrine System
- Negative Feedback
- Peripheral Nervous System
- Central Nervous System
- Somatic Nerves
- Autonomic nerves
- Sympathetic
- Parasympathetic
- Neurons
- Glial Cells

Terms you need to know…

- Dendrites
- Axon
- Myelin Sheath
- Schwan Cell
- Node of Ranvier
- Neurilemma
- Axon terminal
- Saltatory conduction
- Continuous conduction
- Interneuron
- Sensory and Motor Neuron
- Reflex Arc

Terms you need to know…

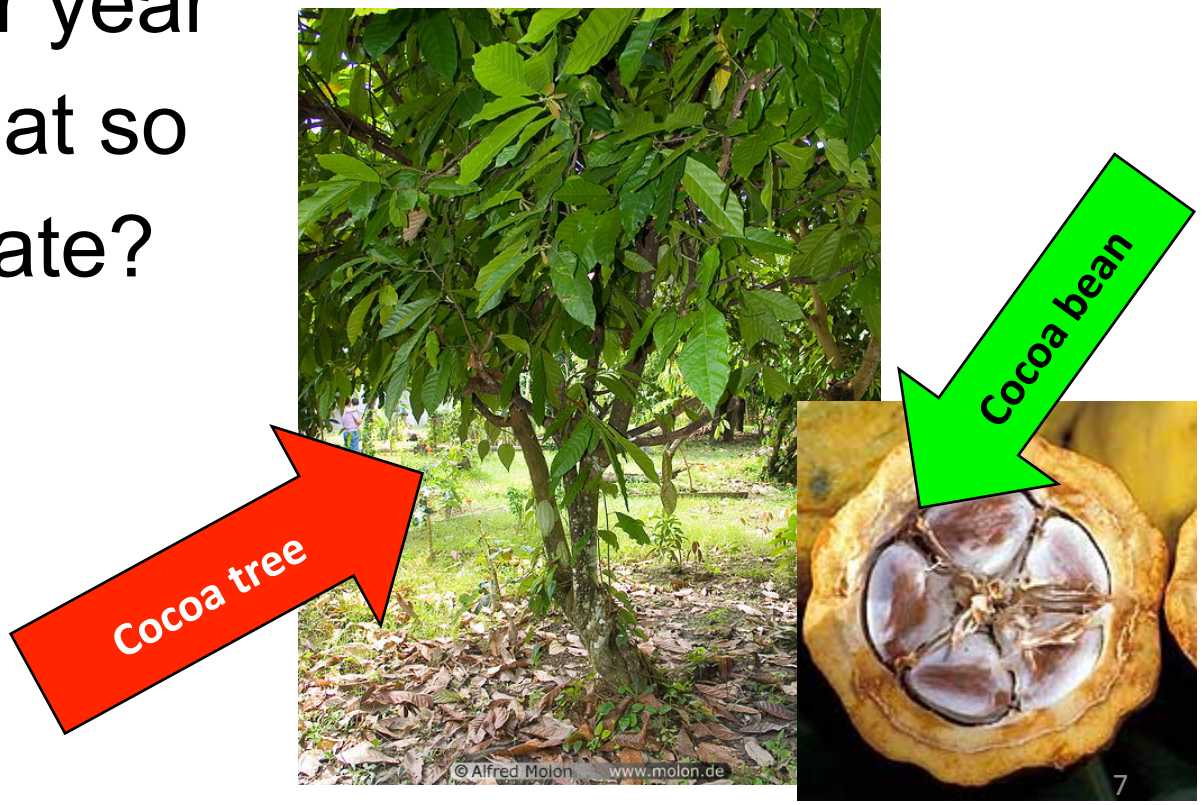
- Affector
- Effector
- Resting Potential
- Action Potential
- Threshold potential
- Polarization
- Depolarization
- Repolarization
- Refractory Period
- Hyperpolarization
- Unidirectional Propagation
- All-or-None Response
- Inhibitory

Homeostasis

- **Chocolate** comes from the cocoa bean
- The average person eats **11 pounds** of chocolate per year
- Why do we eat so much chocolate?

  It makes us

  HAPPY!



Why does chocolate make me happy?

- Chocolate contains **380 chemicals**, including theobromine
  - Theobromine is poisonous to dogs and chickens
- Chocolate also cause the production of natural **opiods** in the brain
- **Opiods** (such as opium) produce the feeling of euphoria

Why does chocolate make me happy?

- Chocolate also contains substances that act as **cannabinoids**
  - Cannabinoids are found in marijuana
  - This causes an increase in **dopamine** (neurotransmitter) production
  - Also **anandamides** stay in the brain longer without being broken down

So can you get high off chocolate?

You would have to eat 25lbs of chocolate to get the same effects of marijuana!

Homeostasis

Similar

Balance

Homeostasis is a process that allows a constant internal environment to be maintained despite changes in the external environment.

Is controlled by the nervous system AND endocrine system

Ex. Body temperature ($37^{o}C$)
Blood glucose
Electrolytes (Cl^-, Na^+, K^+)
Blood gasses (O_2, CO_2)

Homeostasis

For your internal environment to remain constant you must have a

1. **Monitor** to detect the problem
2. **Control** to fix it

This is like the thermostat in a house.

If room temperature is set to 21°C, then the thermostat continuously checks to see if the temperature has gone down.

If the temperature drops below 21°C, then the thermostat turns on the furnace, which blows hot air into the house, heating it. Once the temperature is above 21°C, then the furnace is shut off.

Homeostasis

You have a control mechanism like this in your body for blood sugar levels.

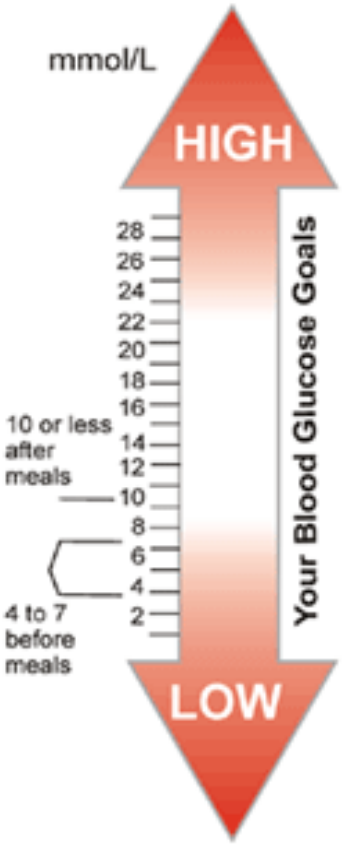
Your house may have a control mechanism like this to cool down your air temperature.

If your blood sugar is too high, then the pancreas(monitor) detects it and secretes insulin, which stimulates the liver (control) to store glucose, which decreases blood sugar levels. Once your blood sugar levels are normal, then the pancreas stops releasing insulin.

If your house is too hot, then the thermostat (monitor) detects it and turns on the AC, which stimulates the compressor (control) to absorb heat, which decreases air temp. Once the room temperature is normal, then the thermostat stops running the AC.

Homeostasis

This controlling method is called NEGATIVE FEEDBACK or FEEDBACK INHIBITION

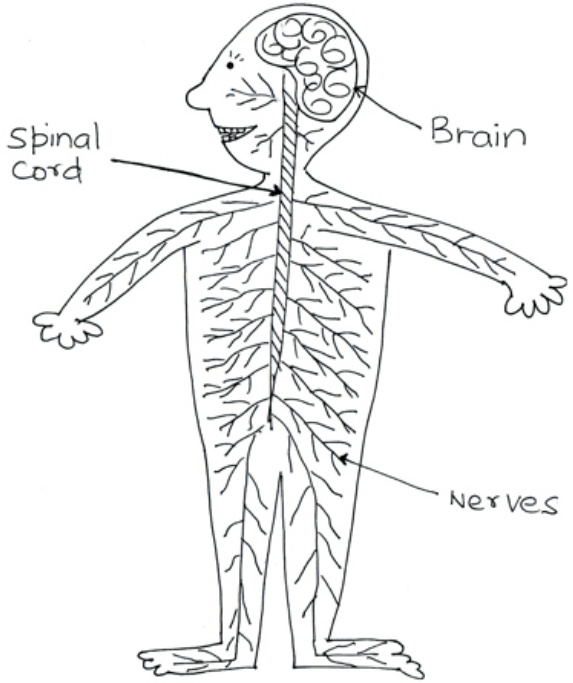


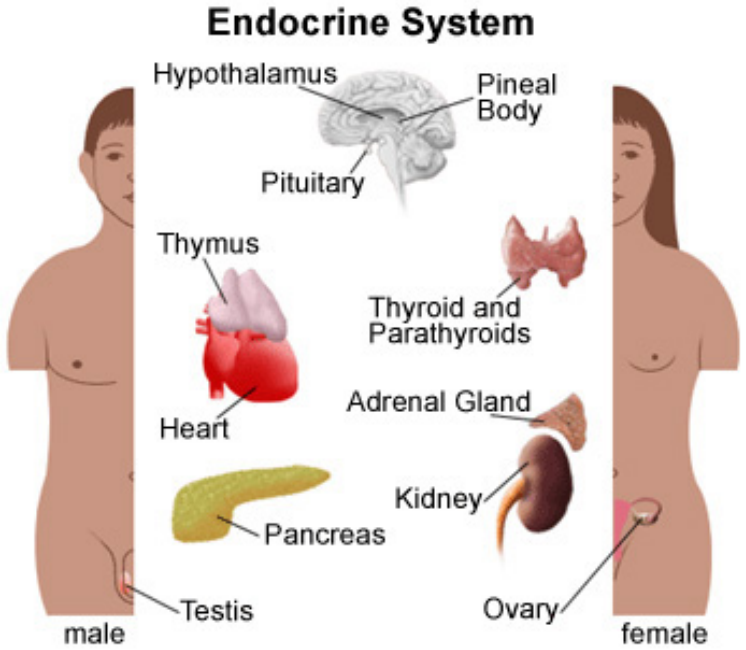
How do our bodies maintain homeostasis?

The **endocrine system, ALONG WITH the nervous system**, functions in the regulation of body activities.

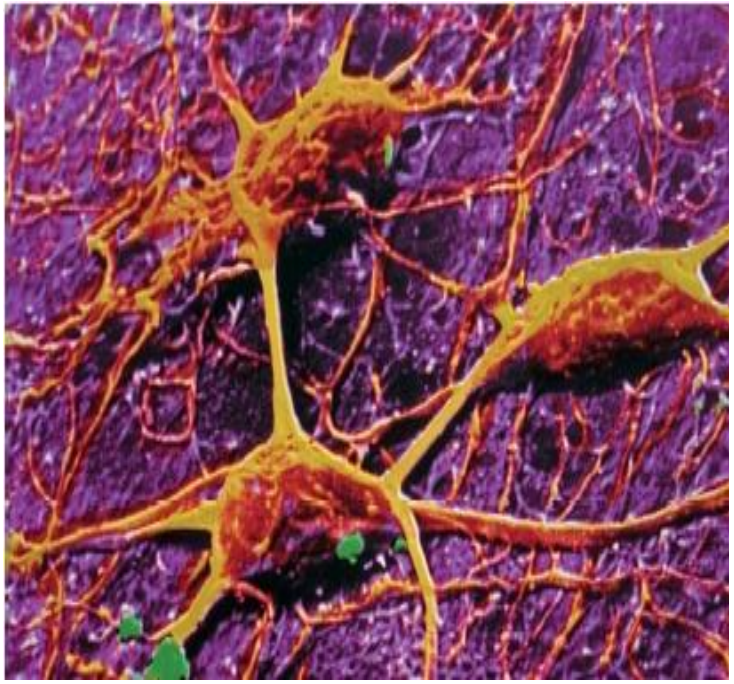
1. Nervous System – brain, spinal cord and neurons

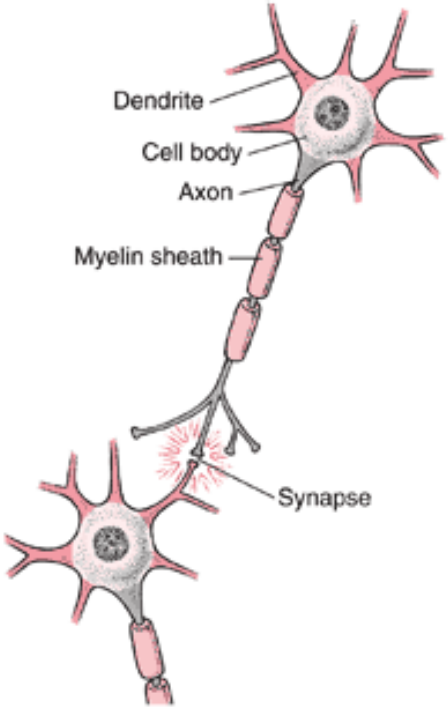
2. Endocrine glands and hormones that they secrete

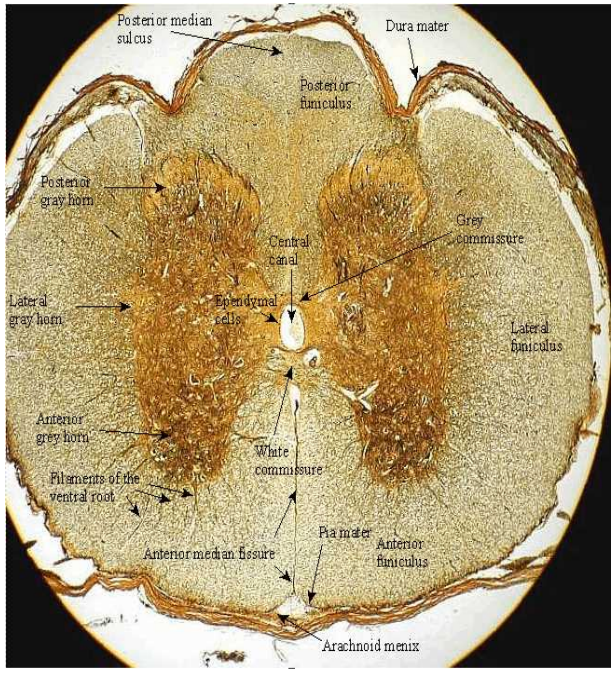




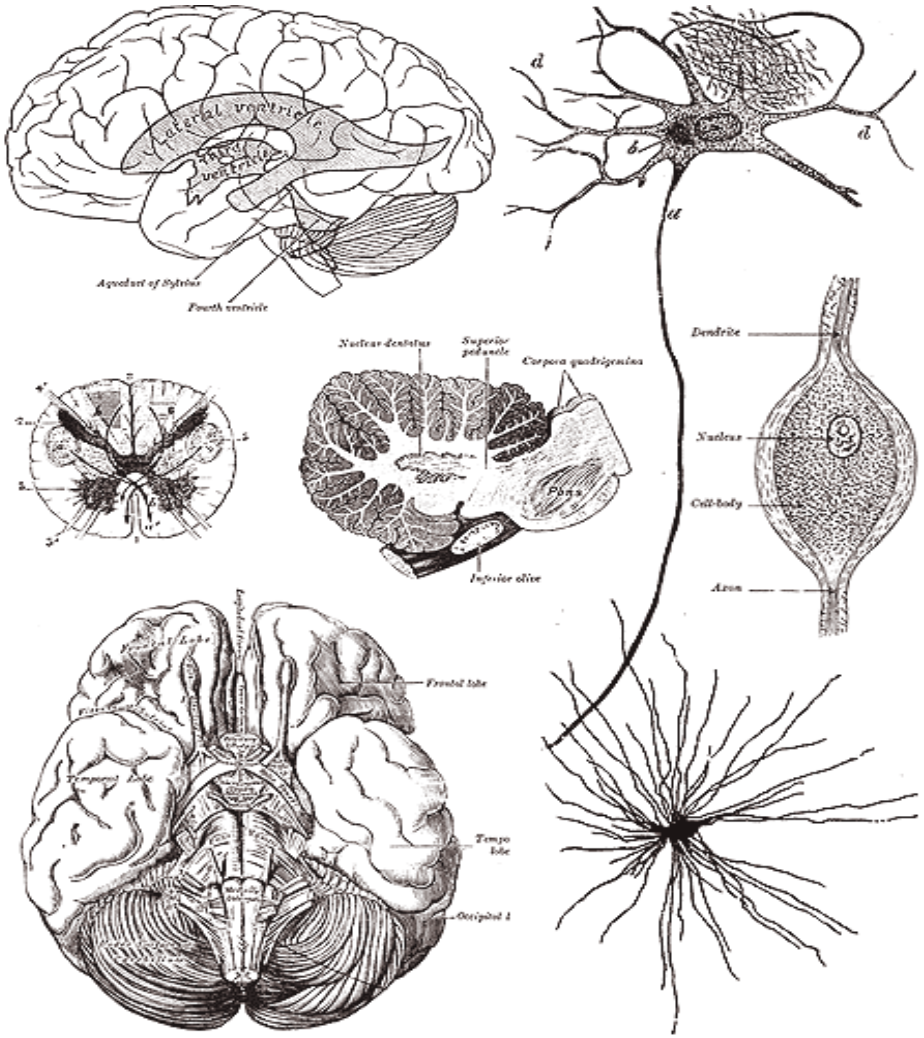
Homeostasis and the nervous system







Interesting Facts About the Nervous System



- We have 100 billion neurons in the brain
  - That's more than the number of stars in the milky way
  - 3171 years of seconds
- Each neuron has up to 10,000 connections
- Octopus have the majority of their neutrons in their arms at about 500 million
- Brain size is not everything
  - Birds have small brains but very concentrated…WHY?
- Not all animals have a brain
  - Some, such as a leech, have a ganglia = cluster of neurons
- Neurons can transmit 1000 impulses per second

About Octopuses

Octopus Escape

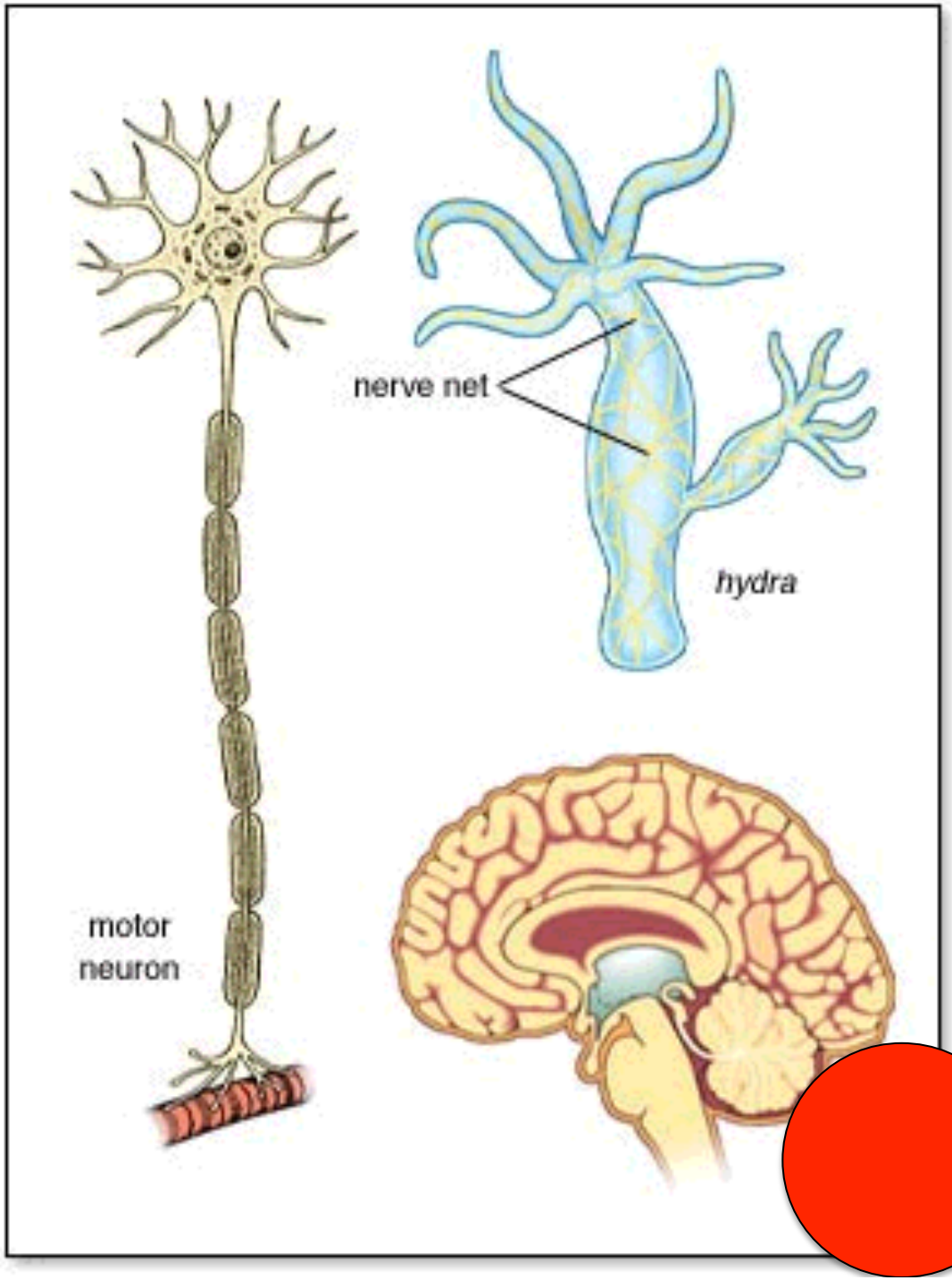
Some Organisms have Nerve Cells

↓

Some have Nerve net

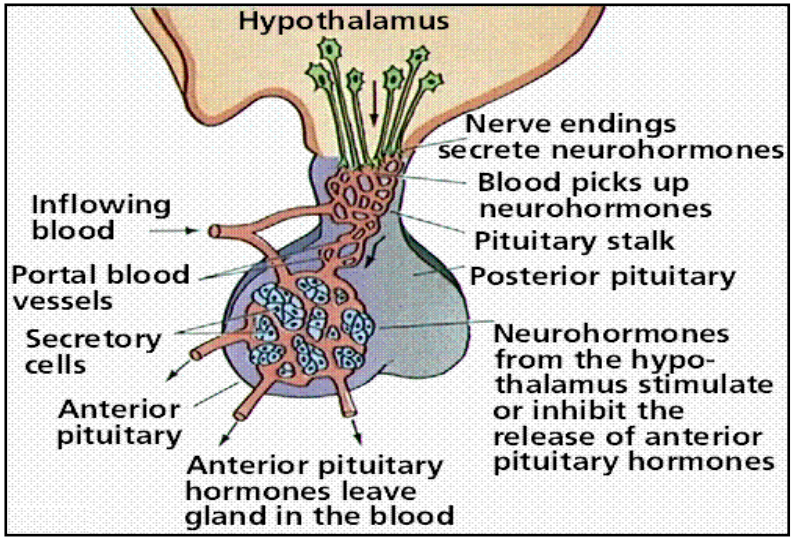
↓

Most complex have a Brain



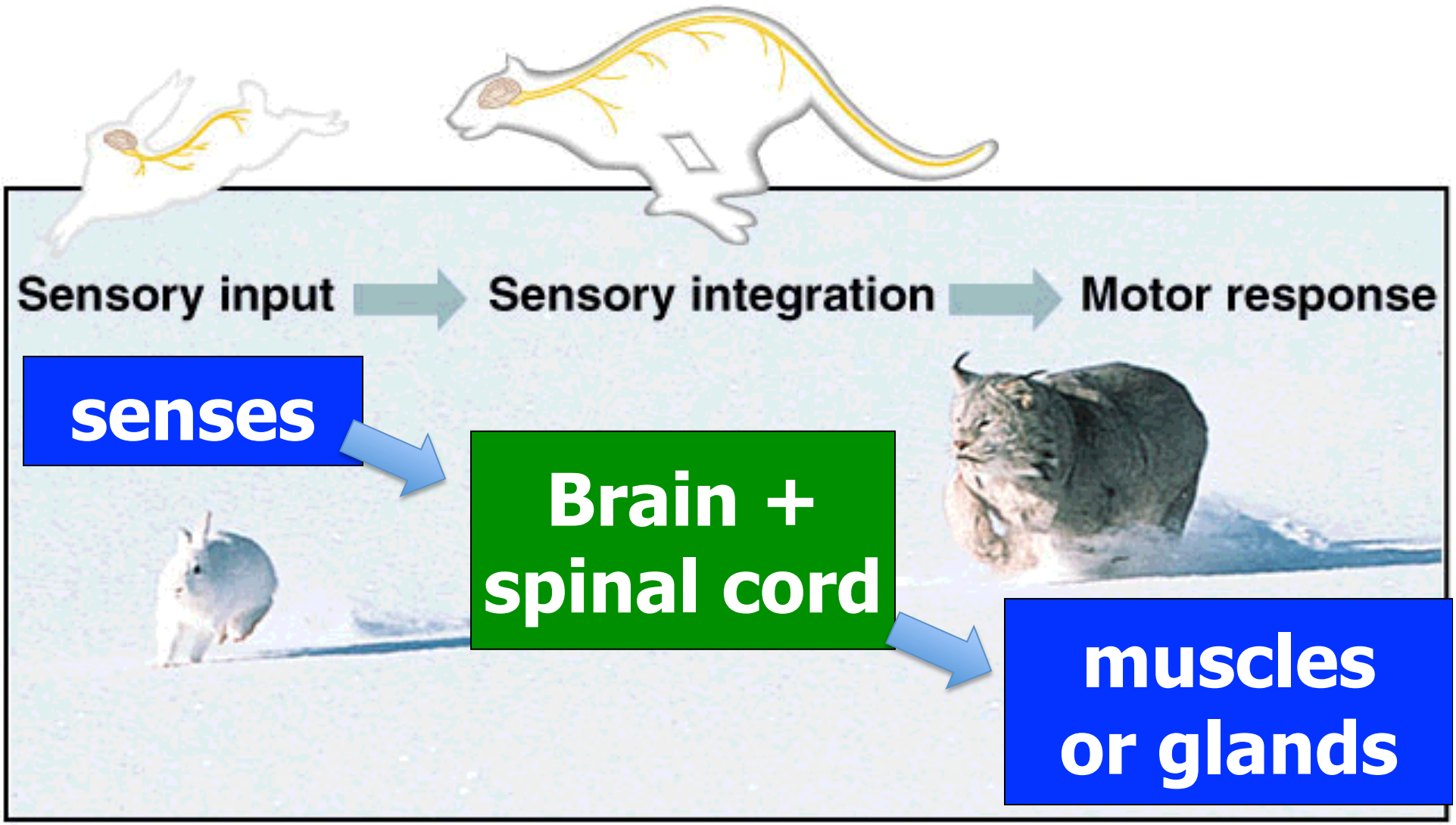
Nervous vs. Endocrine System

- **Nervous** and **endocrine** system **work together** to maintain homeostasis

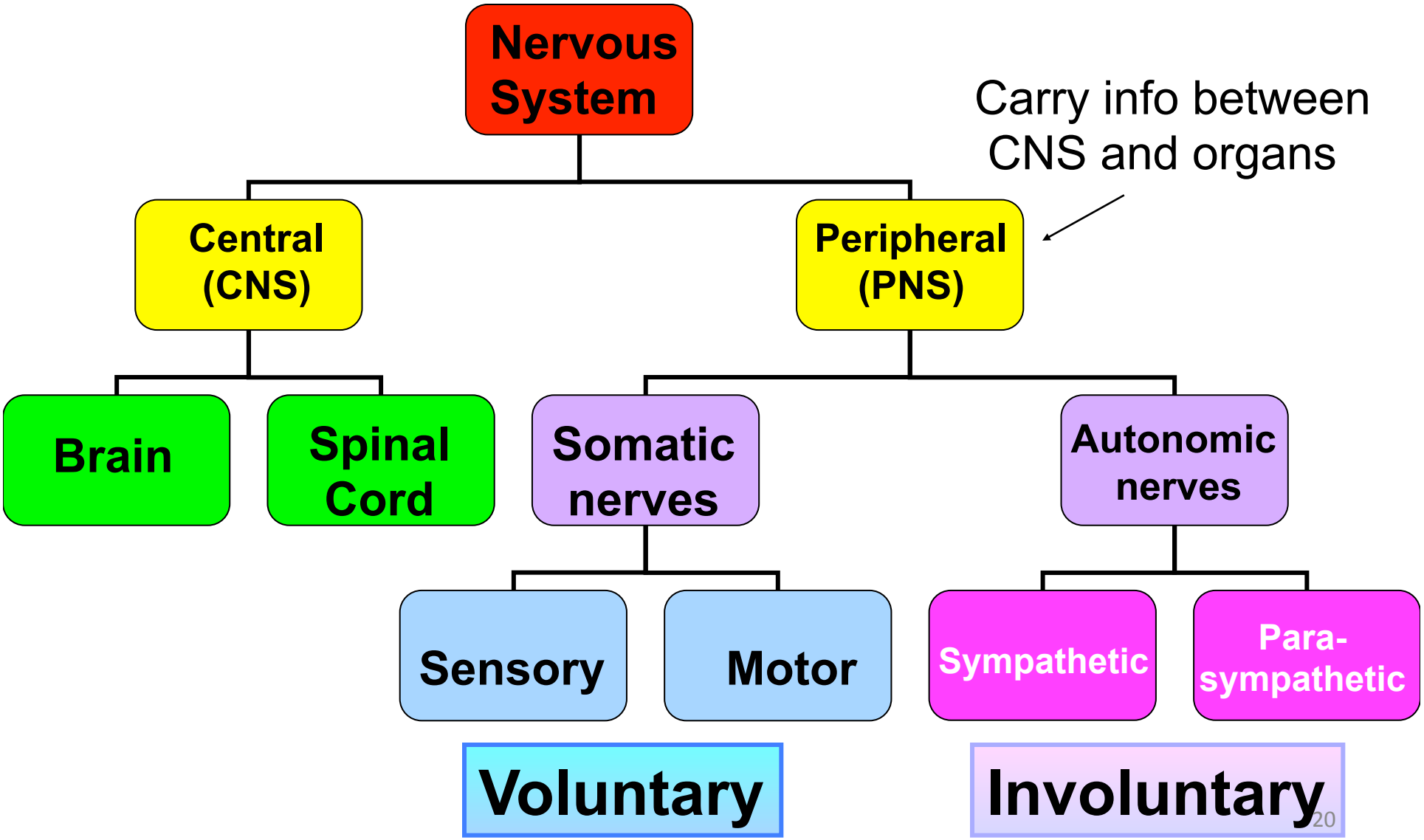


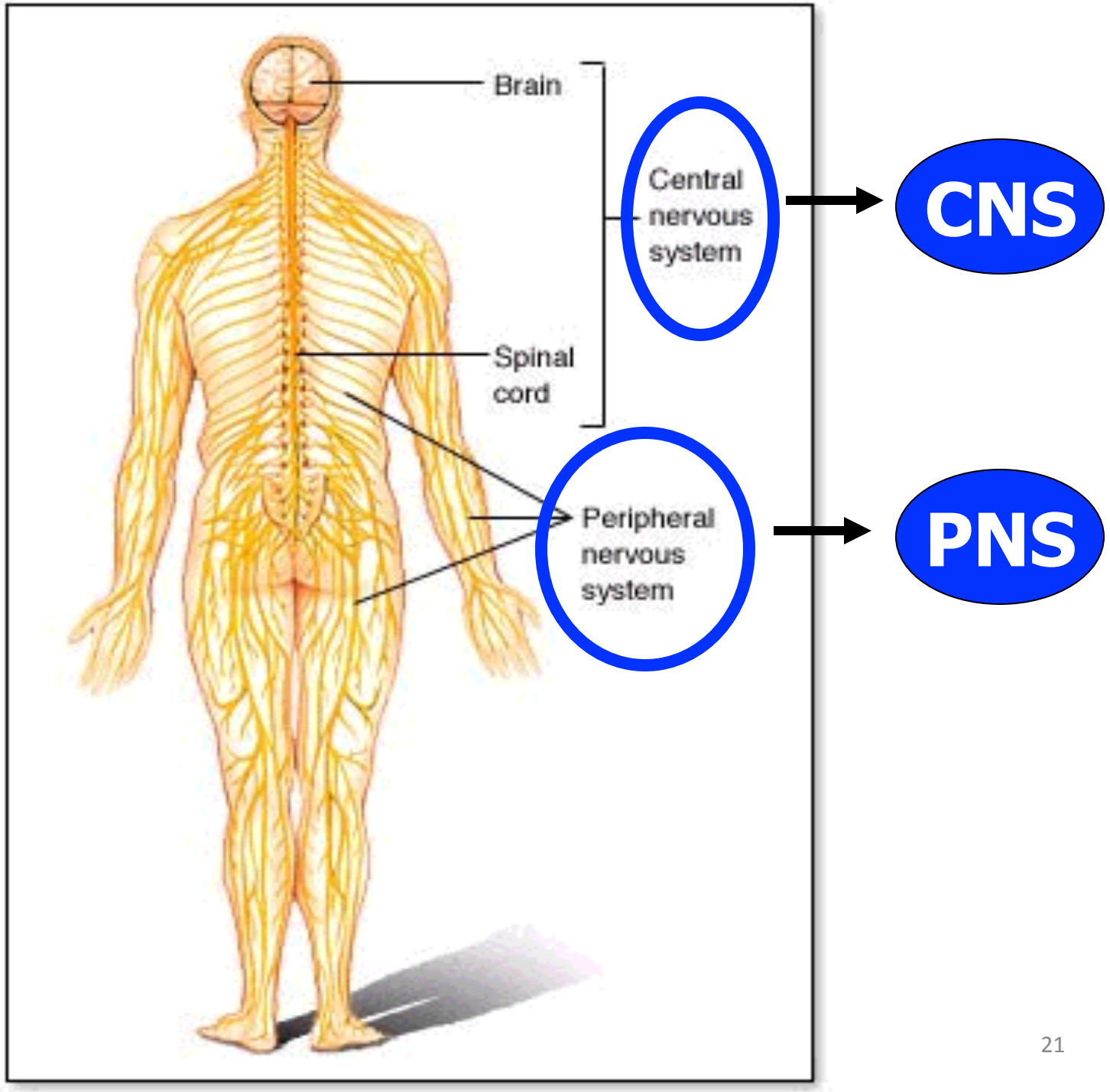
- Nervous System is faster than the **endocrine** system
- Nervous System relies on **electrochemical** signals
- Endocrine system relies on chemicals and **hormones**

Nervous System in Action



Divisions of the Nervous System

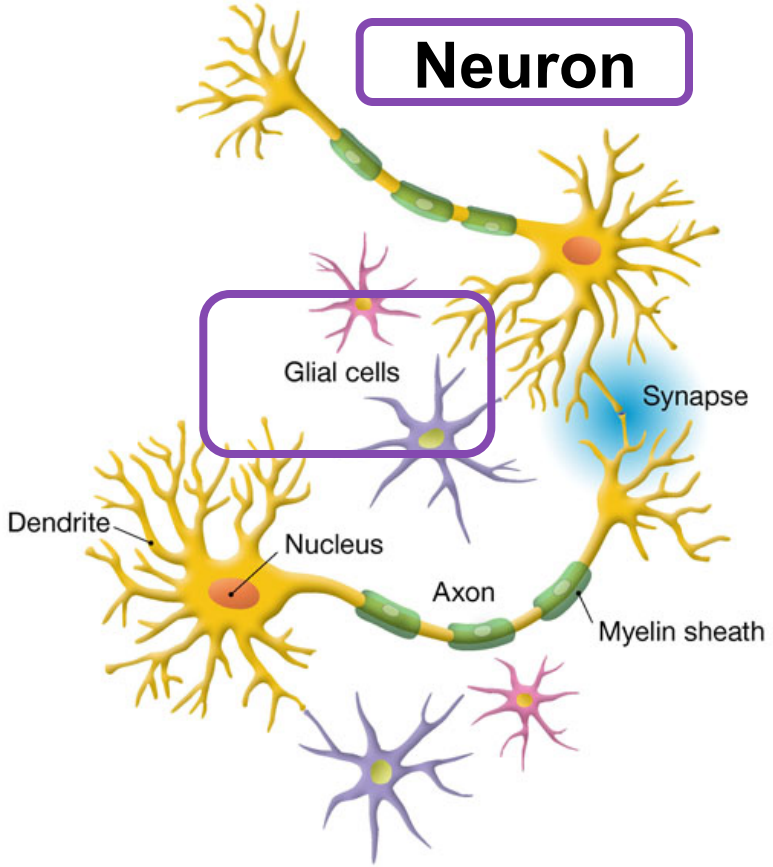



Brain
Central nervous system
Spinal cord
Peripheral nervous system
CNS
PNS

Cells of the Nervous System

Glial Cells

- Non-conducting
- Used for support and metabolism
- Helps hold neurons close together
- The word "glial" means glue

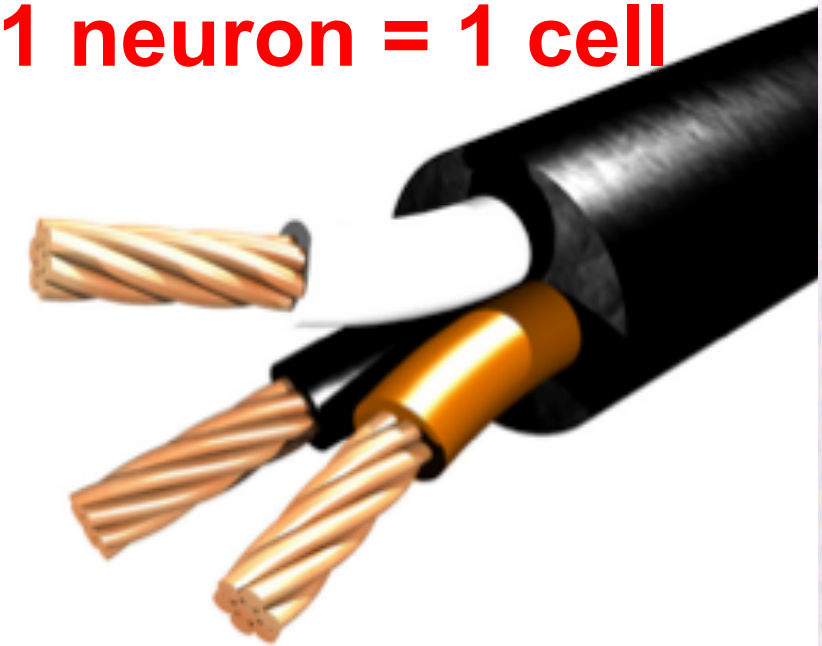


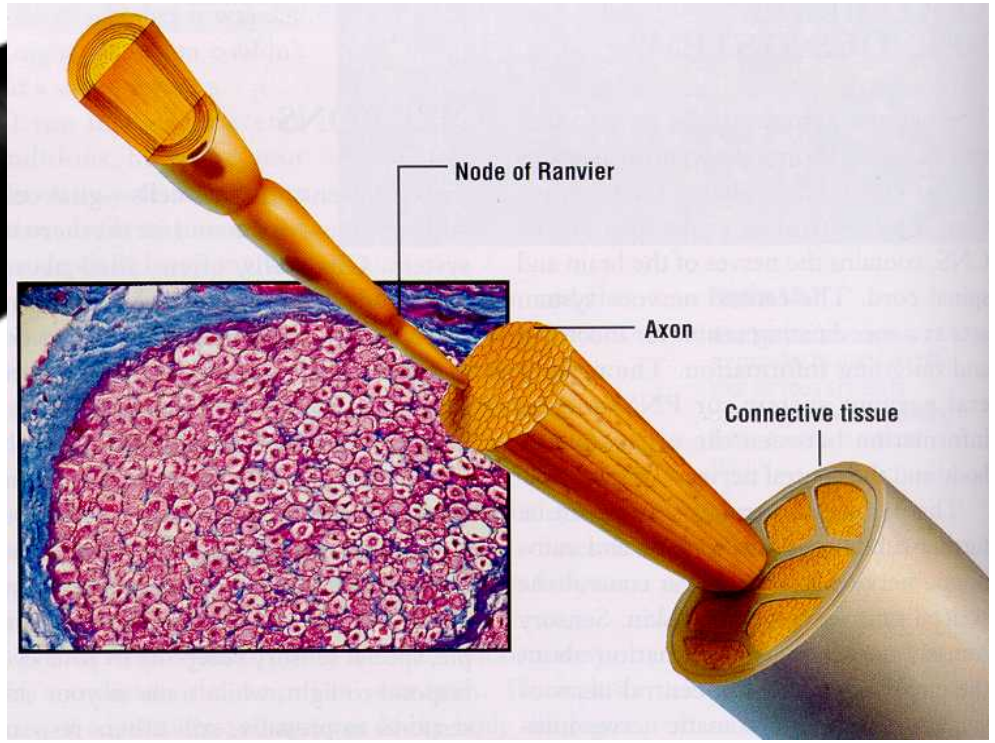
Neurons

- Conducting
- Carries the nerve (electrochemical) impulse

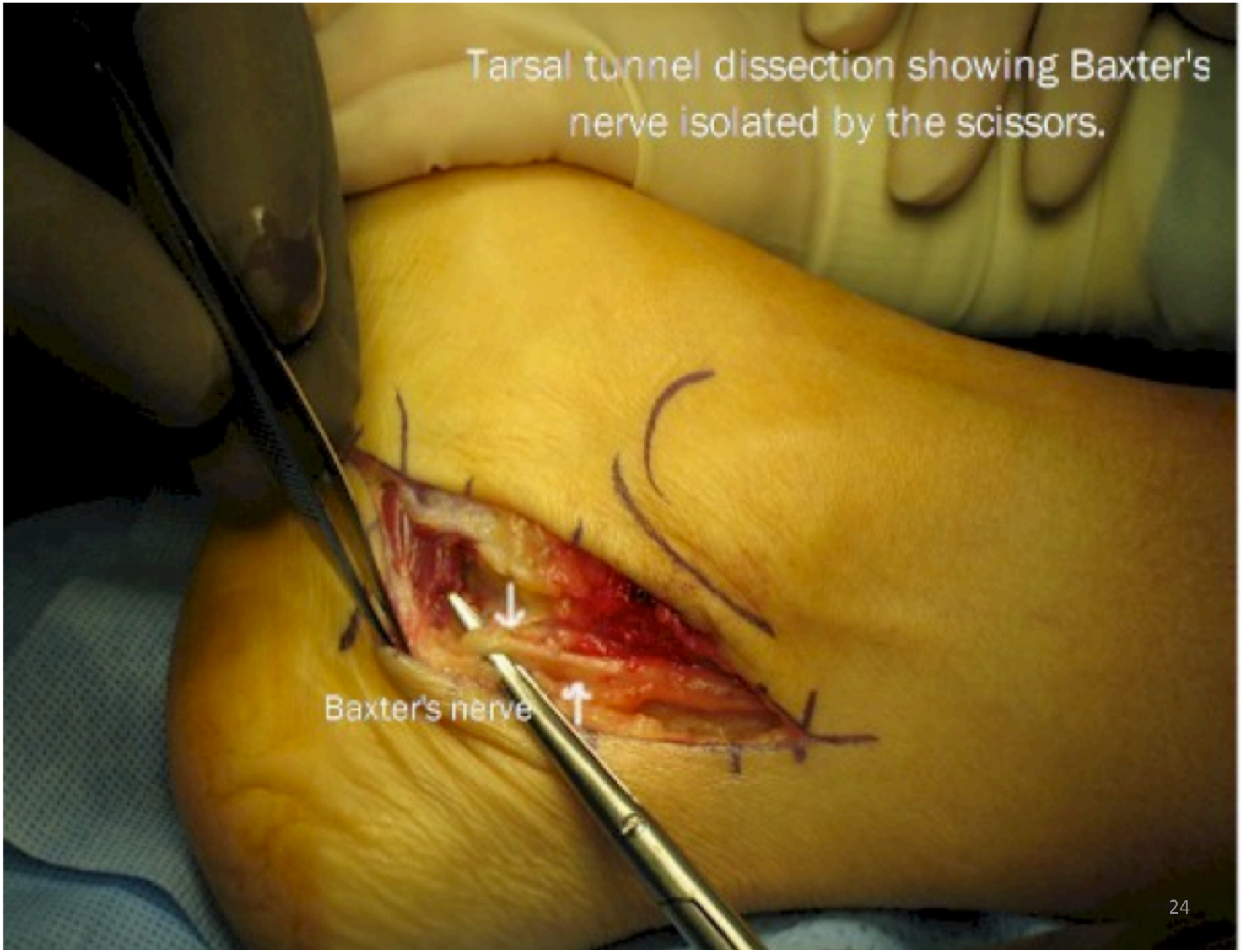
Neurons vs. Nerves

- Neurons are the individual units that make up the nervous system
- Nerves are made up of many neurons
- 1 neuron = 1 cell

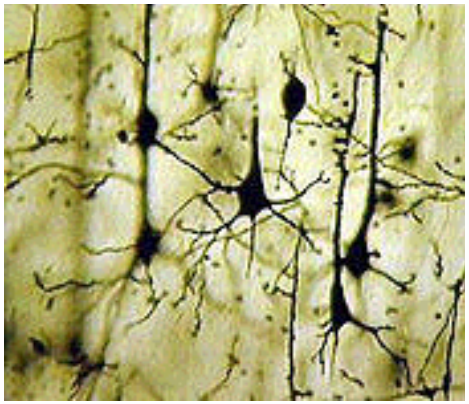


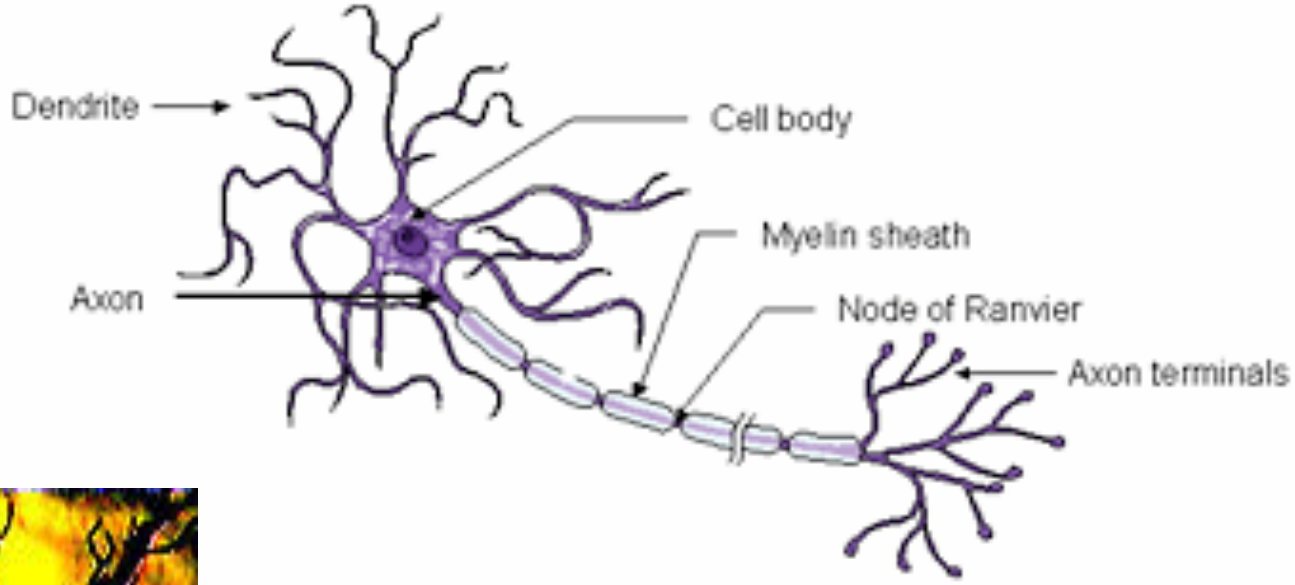


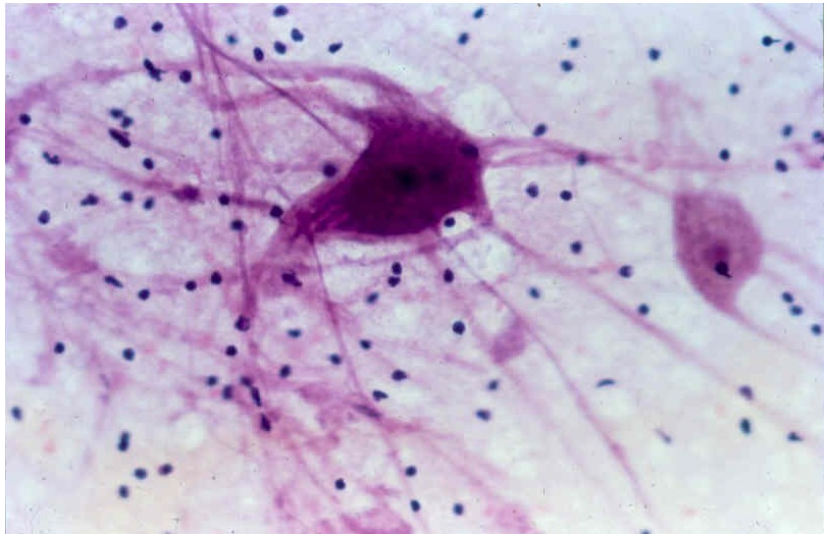
- A motor neuron is about 1 meter long


Tarsal tunnel dissection showing Baxter's nerve isolated by the scissors.
Baxter's nerve

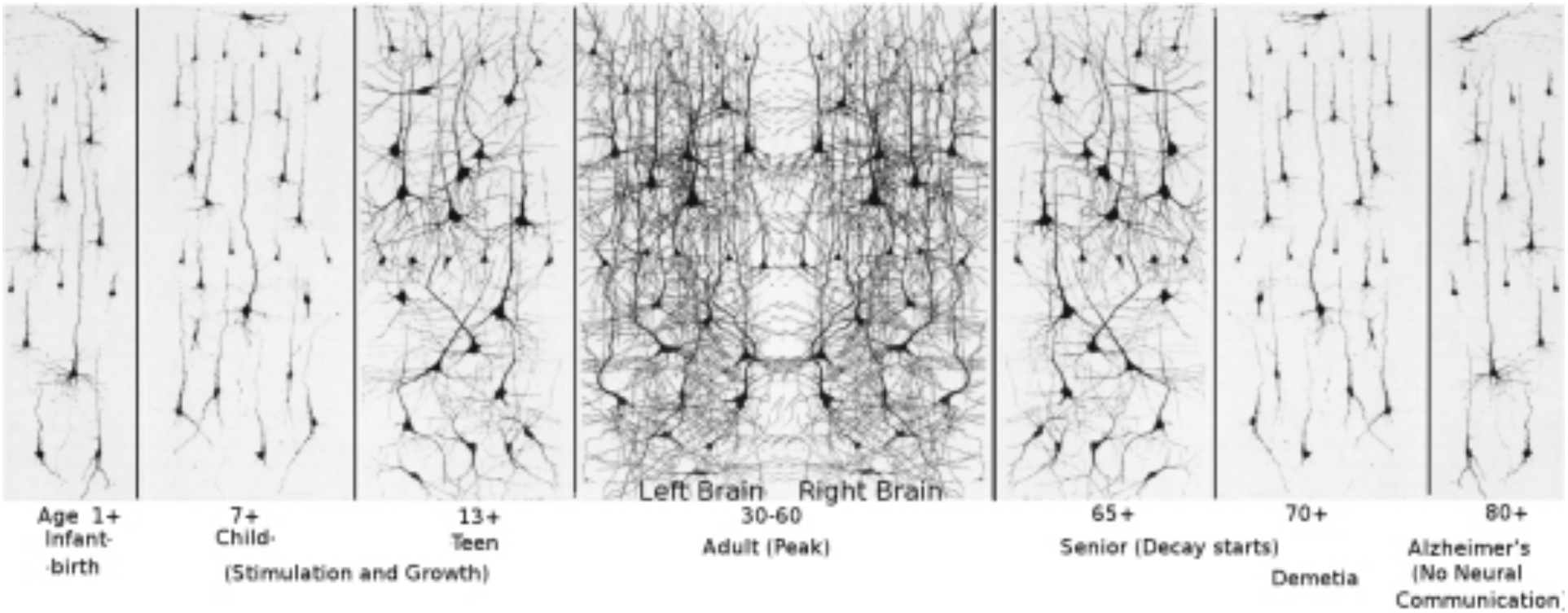
Structure of Neurons

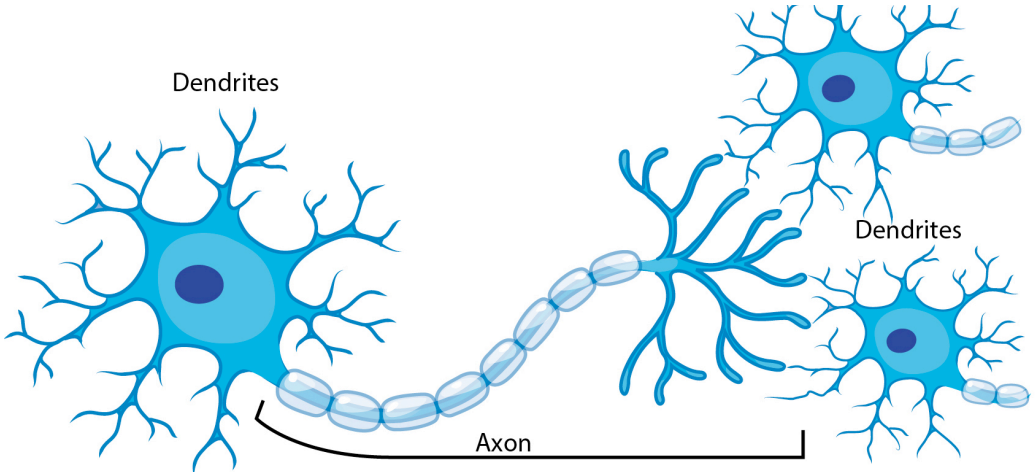






IN THE BRAIN: Neurons grow more connections to other neurons as we learn



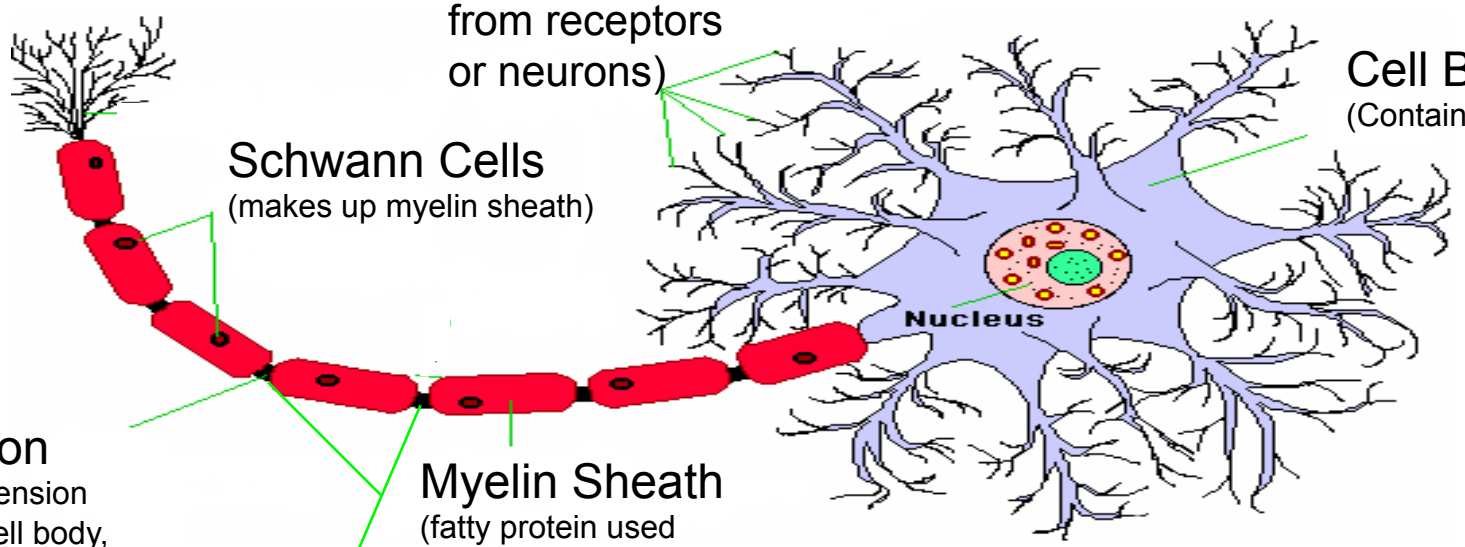


Neurons can connect to other neurons, muscles, glands, or sensory organs.

Parts of a Neuron

Direction of Nerve Impulse

(From cell body to nerve endings)



Nerve endings
(contain synaptic vesicles)

Dendrites
(receives info from receptors or neurons)

Cell Body
(Contains the nucleus)

Schwann Cells
(makes up myelin sheath)

Axon
(extension of cell body, carries info away from cell body)

Myelin Sheath
(fatty protein used for insulation . Speeds up transmission)

Nodes of Ranvier
(gap between myelin sheath, used for saltatory conduction)

The larger the diameter of the axon, the faster the speed of nerve transmission

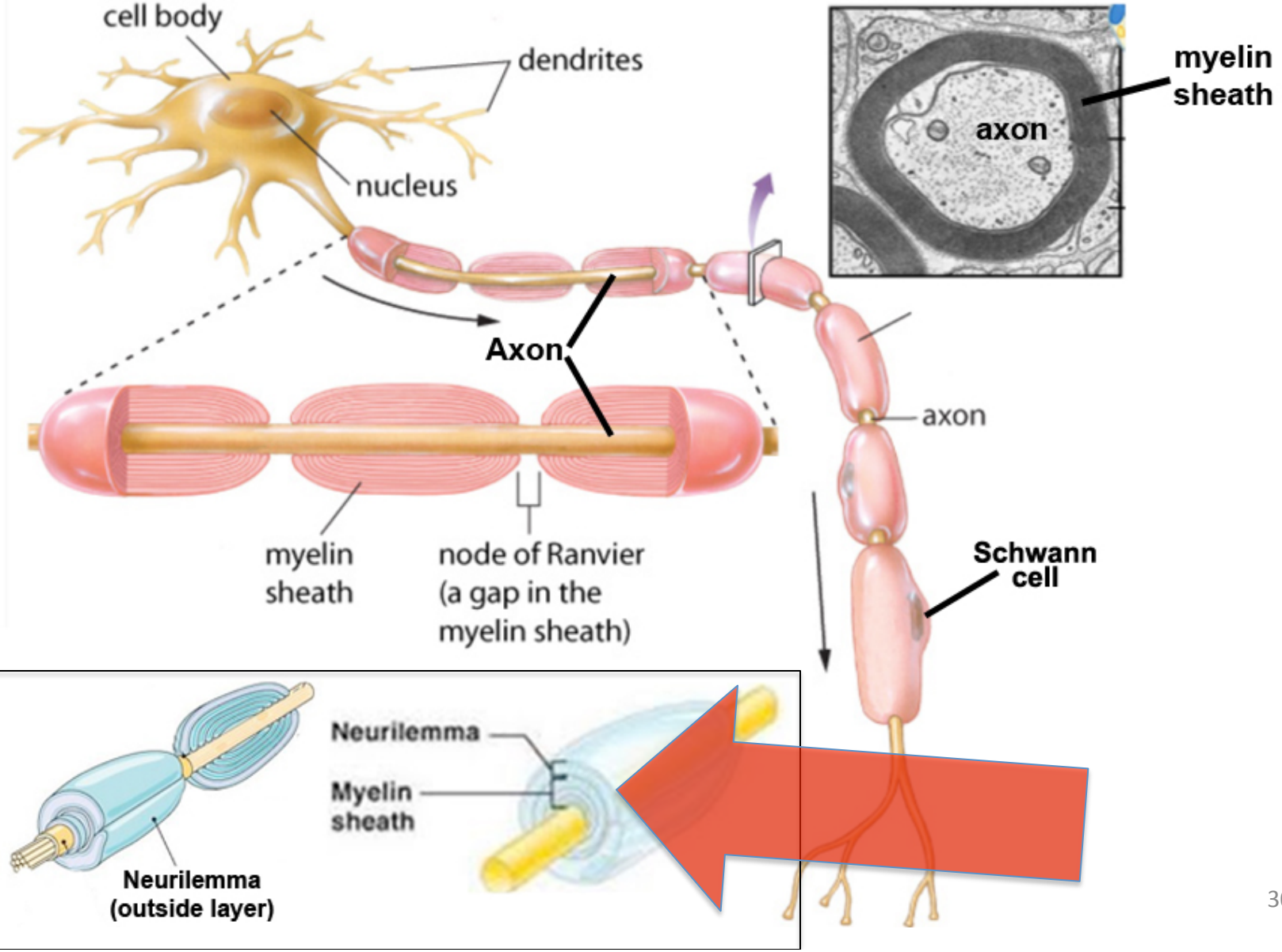
Parts of a Neuron

Neuron Part	Function
Dendrites	Receive info from receptors or neurons -conduct impulses TOWARD the cell body
Cell Body	-Contains the nucleus and other organelles
Axon	-Longest extension of cell body. Carries the impulse. -Conducts impulses AWAY from the cell body
Myelin Sheath	-Fatty protein -Acts as an **insulation**; increases the speed of the impulse -White matter
Schwann cells (glial cells)	Forms myelin sheath

Parts of a Neuron

Part of Neuron	Function
Nodes of Ranvier	**Gap** between Schwann cells. Nerve impulses jump from one node to the next. (**Saltatory conduction).**
Neurilemma	Promotes the regeneration of damaged neurons (axons). Healing. Mostly in PNS.
Nerve ending or axon ending or **axon terminals**	Has synaptic vesicles containing **neurotransmitters**. Distributes (sends) the impulse to the postsynaptic membrane.

Myelin Sheath & Neurilemma

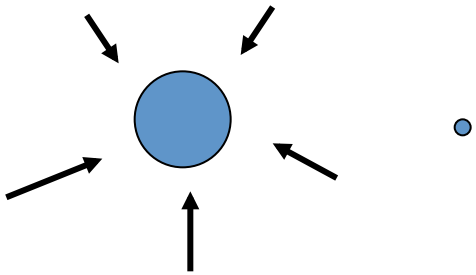


Build-Your-Own Neuron

Using the Playdough, create a neuron.
Be sure to include the following structures:

-Cell Body
-Dendrites
-Axon
-Axon Terminal
-Myelin
-Schwann Cells

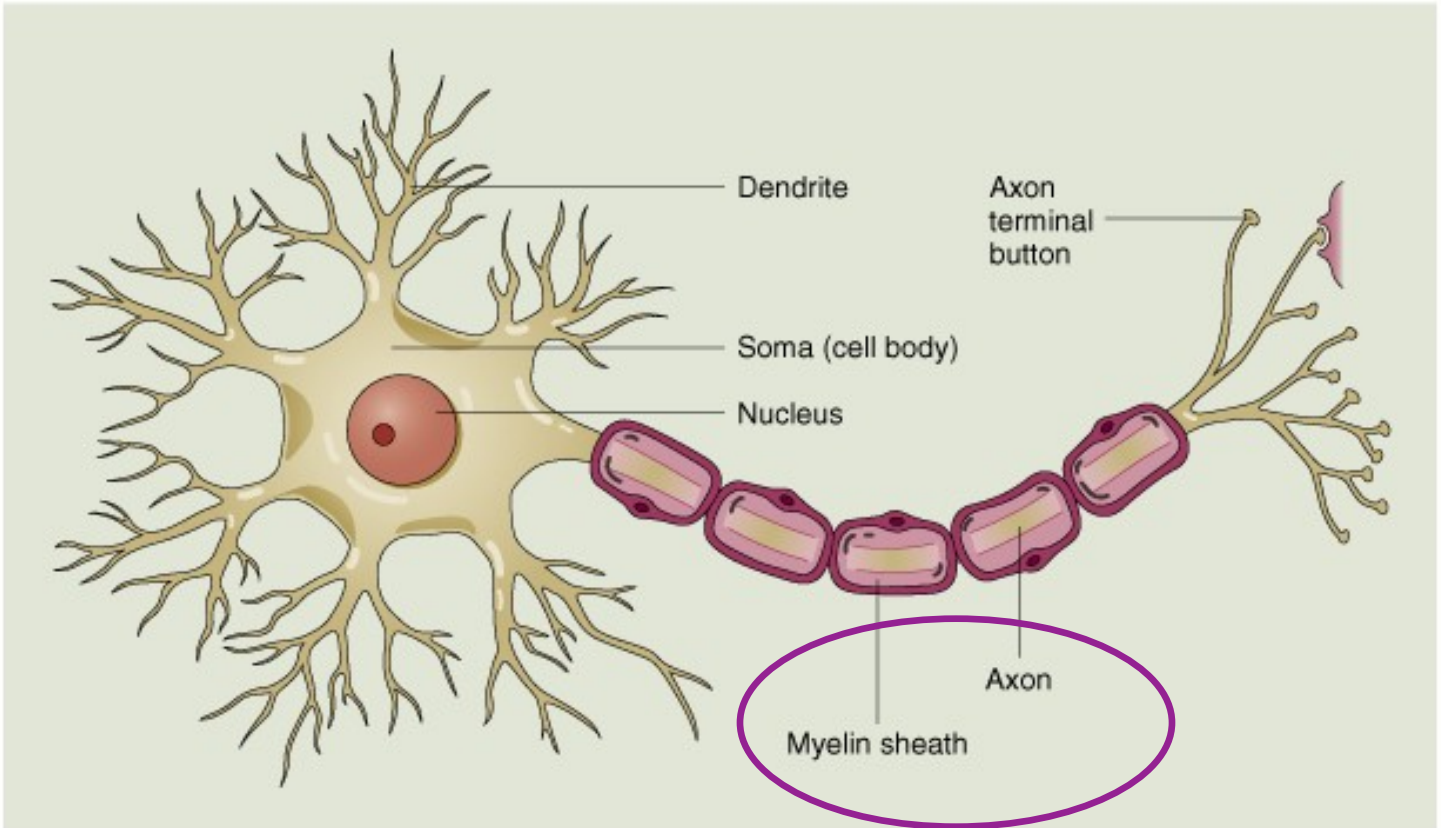
Speed of nerve transmission **is increased by:**



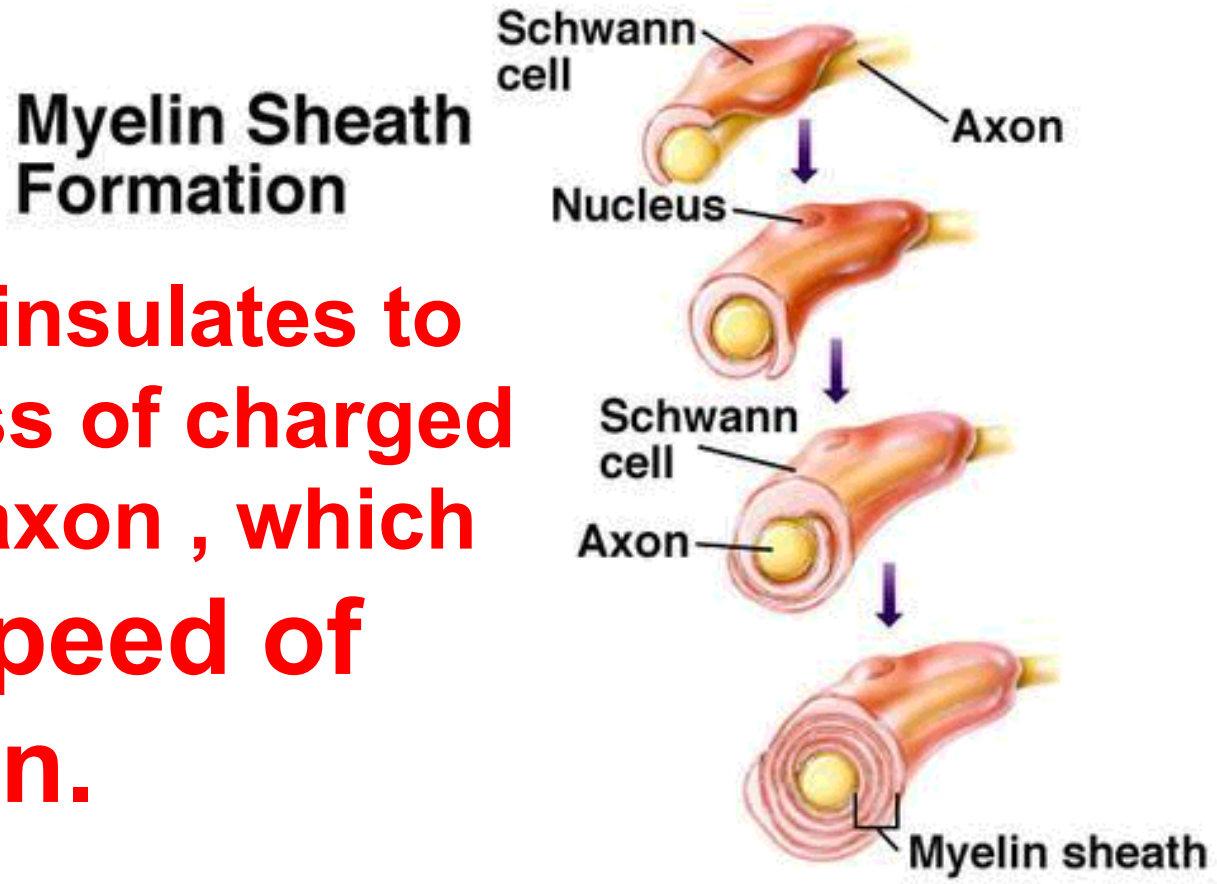
a **BIGGER axon** diameter

and

a **myelin sheath** around the axon



Purpose:



Myelin sheath insulates to prevent the loss of charged ions from the axon , which increases speed of transmission.

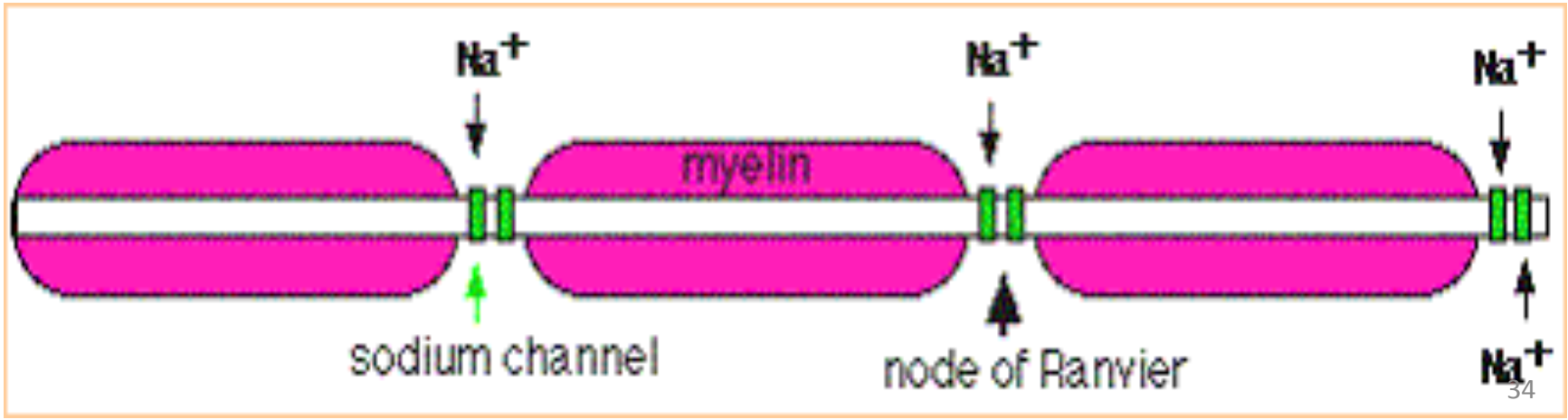
Formed by:

Schwann cells wrapping around the axon.

Nodes of Ranvier

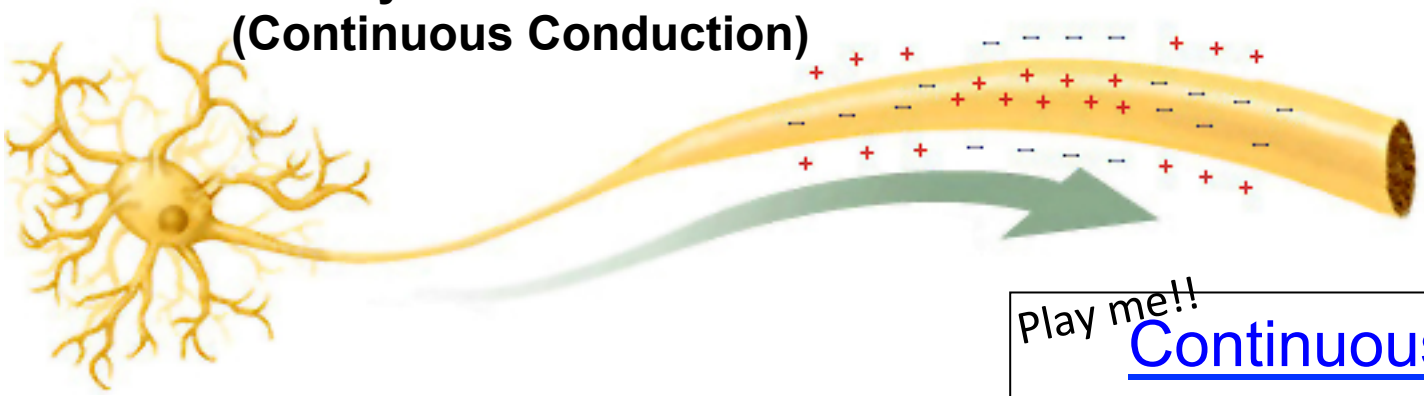
- **Gaps between the myelin sheath.**
- **Nerve impulses jump from node to node = saltatory conduction**
- **Nerve impulse slow at nodes because the axon has to become depolarized however…**

Overall speed is 100 X faster than non-myelinated axon



Nodes of Ranvier

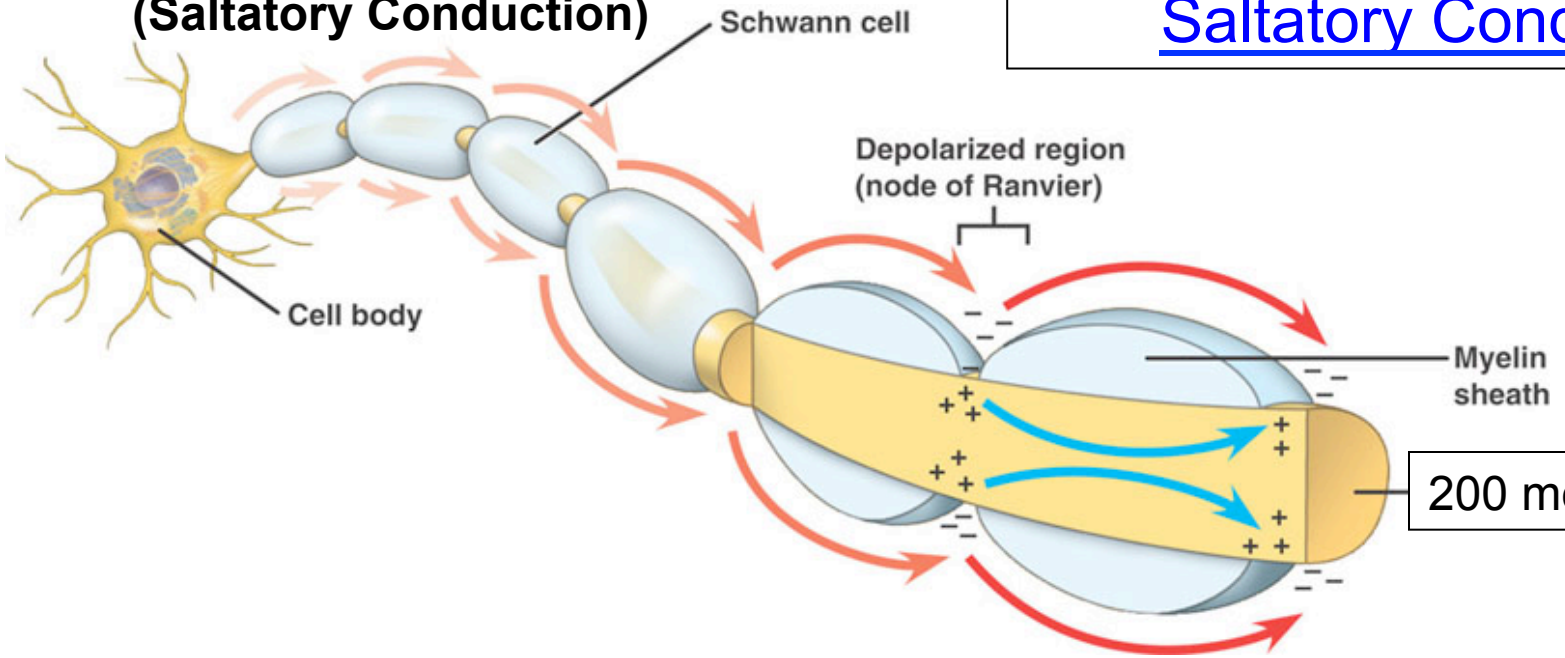
non-myelinated neuron
(Continuous Conduction)



2 meters / second

Play me!!
Continuous Conduction
vs.
Saltatory Conduction

myelinated neuron
(Saltatory Conduction)



200 meters / second

Neurilemma

Promotes regeneration of damaged neurons = Healing

– Ex. Paper cut

•Found on all PNS neurons

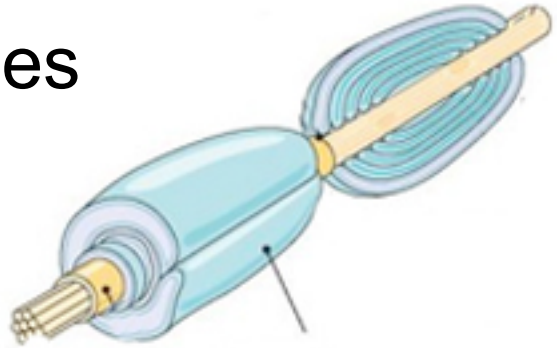
–Sensory neurons

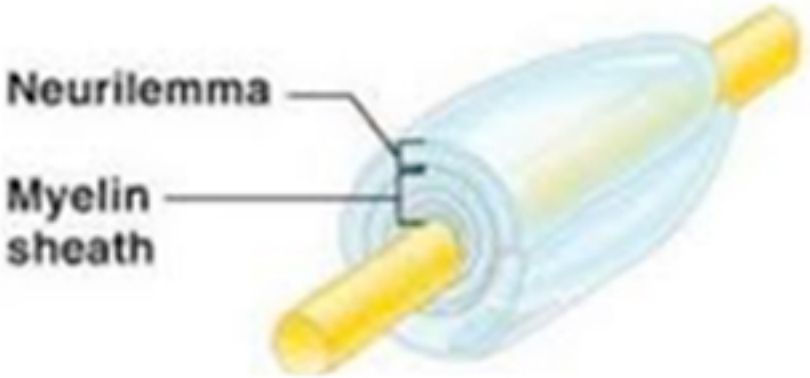
–Motor neurons

•CNS DOES NOT CONTAIN NEURILEMMA SO **CAN NOT REGENERATE**

-spinal cord injuries

-brain injuries



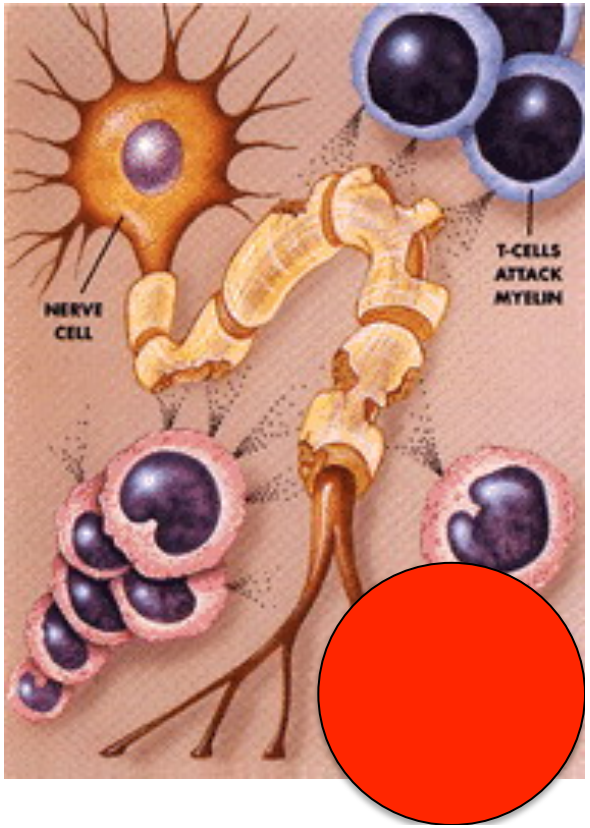


Multiple Sclerosis (MS)

- Autoimmune disease → **the body's own immune system breaks down the myelin sheath on the neuron**
- Due to destruction of the **myelin sheath** = *inefficient* nerve transmission

Myelin in brain and spinal cord is destroyed and hardens, forming scars

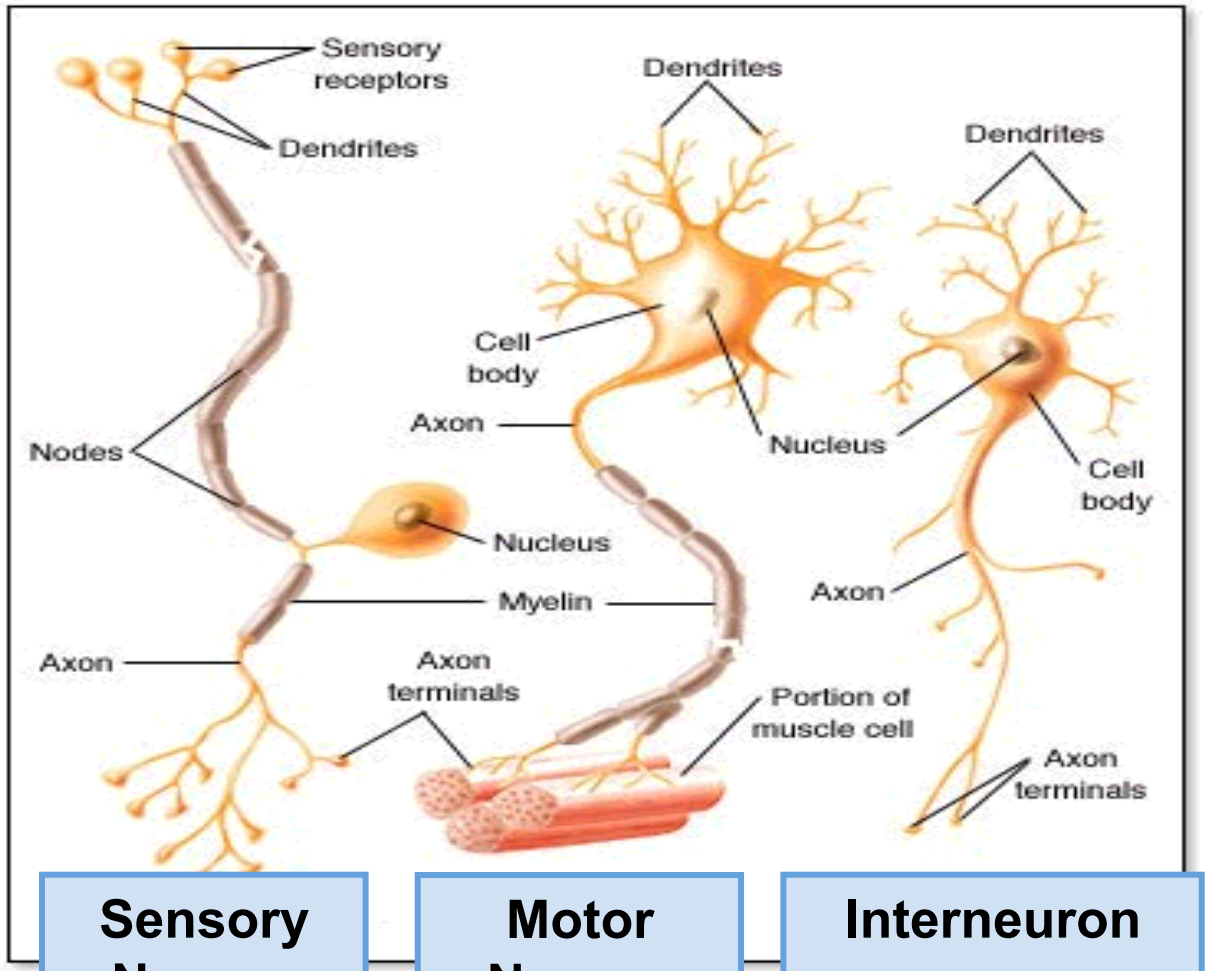
Causes: Genetics, viruses or the **environment**



Symptoms: double vision, jerky limb movements, partial paralysis

Treatment: wheelchairs, medications to stop myelin destruction, leg braces, occupational therapy, physical therapy, gene therapy

3 Types of Neurons



Sensory Neuron

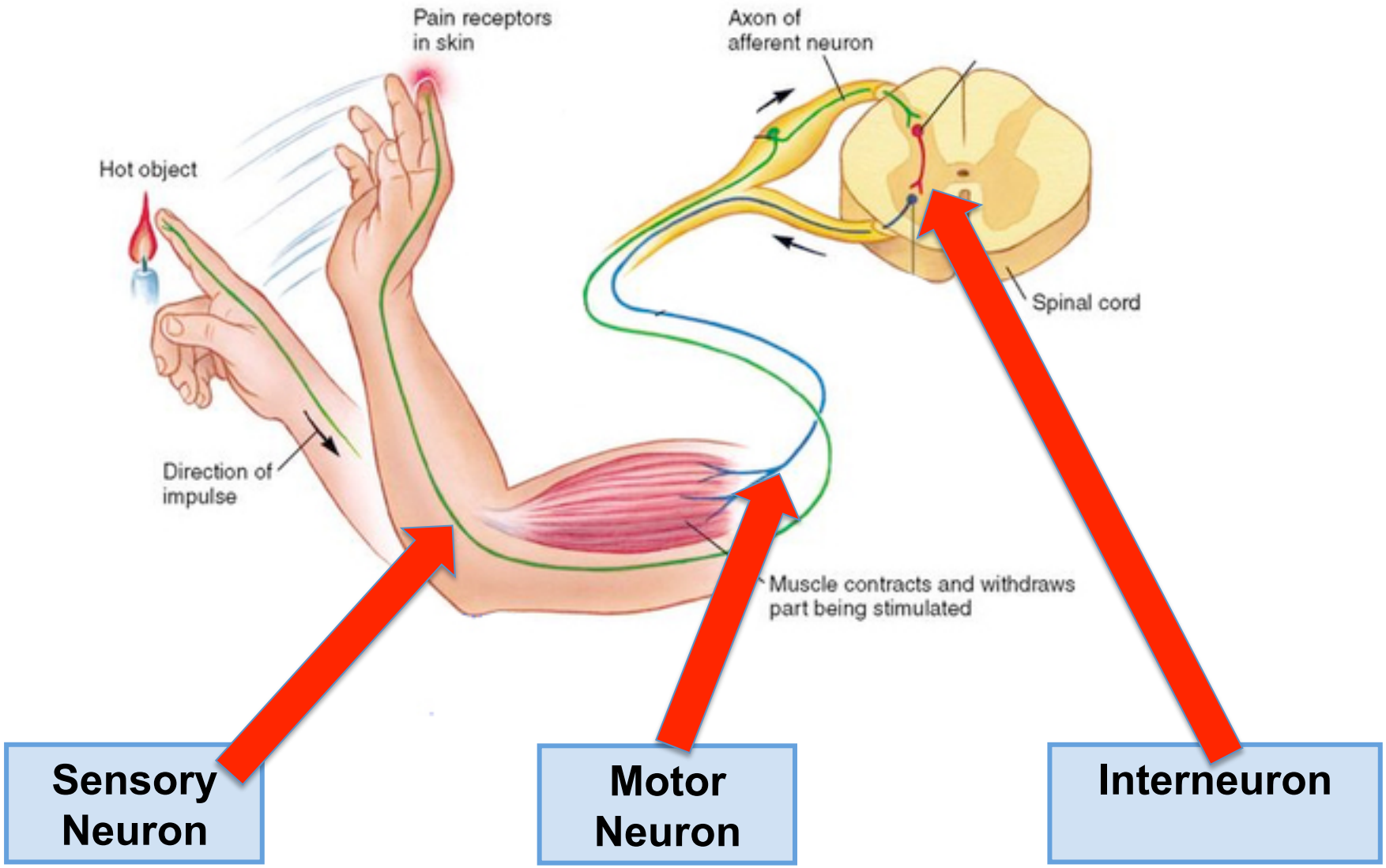
Motor Neuron

Interneuron

Interneurons
-shorter
-do not have a myelin sheath

Sensory & Motor Neurons
-long
-have a myelin sheath.

Where are these neurons?



3 Types of Neurons

Unipolar
(Sensory Neuron)

Sensory neuron: carries information…

from sensory receptors (affectors)
to Central Nervous System (CNS)

IN

3 Types of Neurons

Bipolar
(Interneuron)

Interneurons: carries information…

between sensory and motor neurons

BETWEEN

Mostly in brain and spinal cord

- **Integrate and interpret info**
- **short, no myelin**

3 Types of Neurons

Motor neuron: carries information…

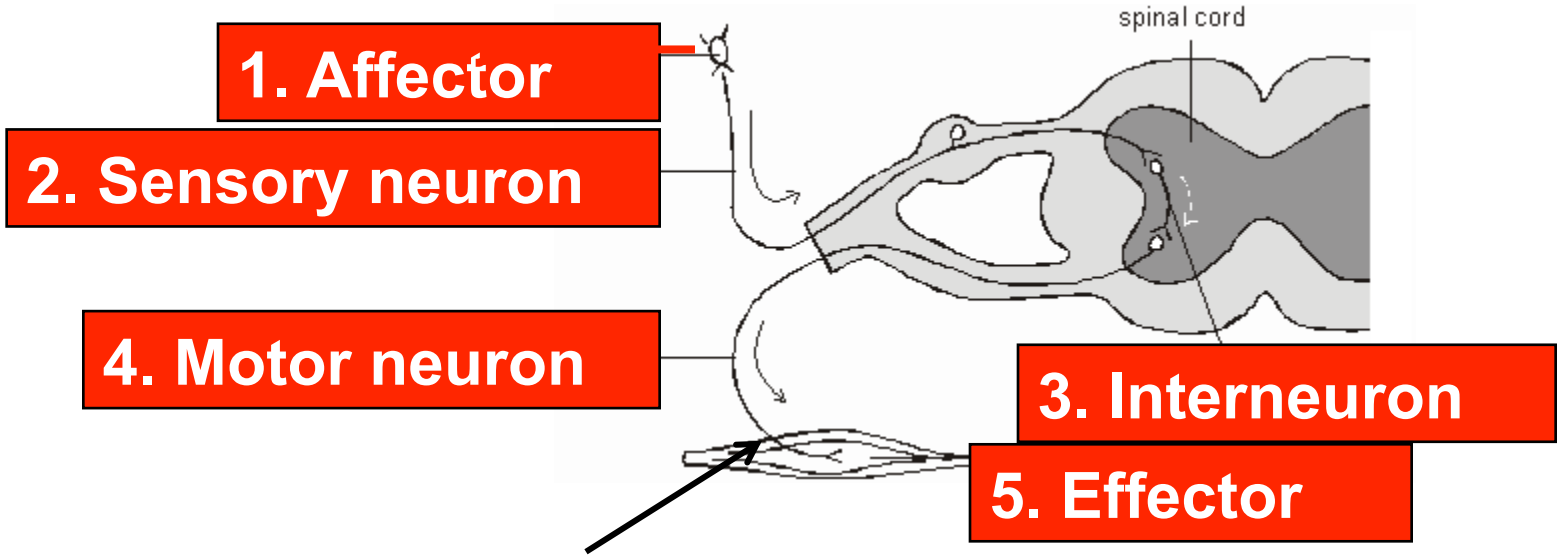
from **Central Nervous System**
to effectors which include glands and muscles

OUT

Reflex arc

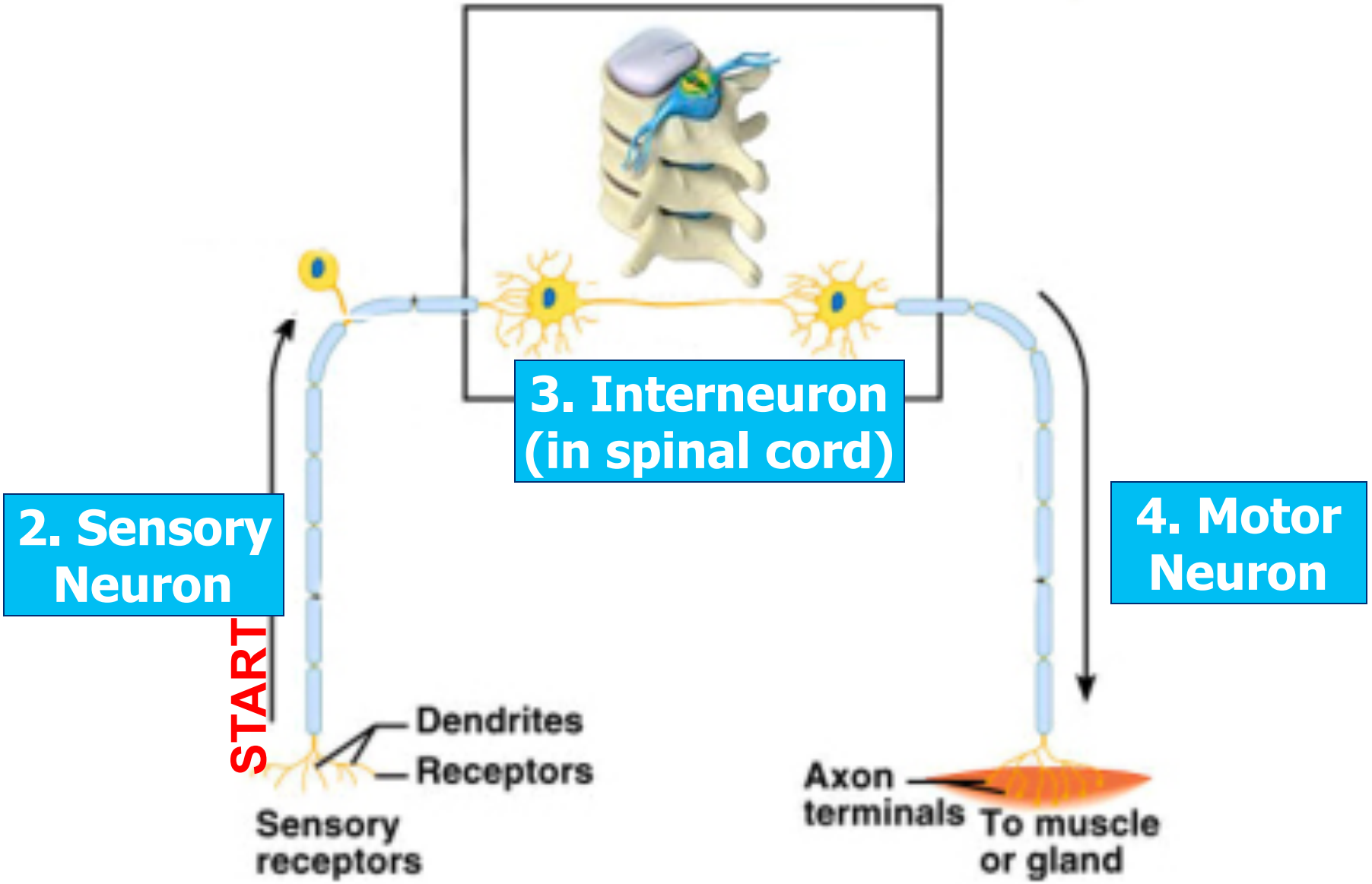
- **Involuntary and unconscious**
  - **Bypasses the brain** Ex. Touching a hot stove, blinking
- Purpose: **to make quick responses (without thinking)**

5 main components



Neuromuscular junction or synapse
(where the motor neuron meets the muscle)

Input → Integration→ Response

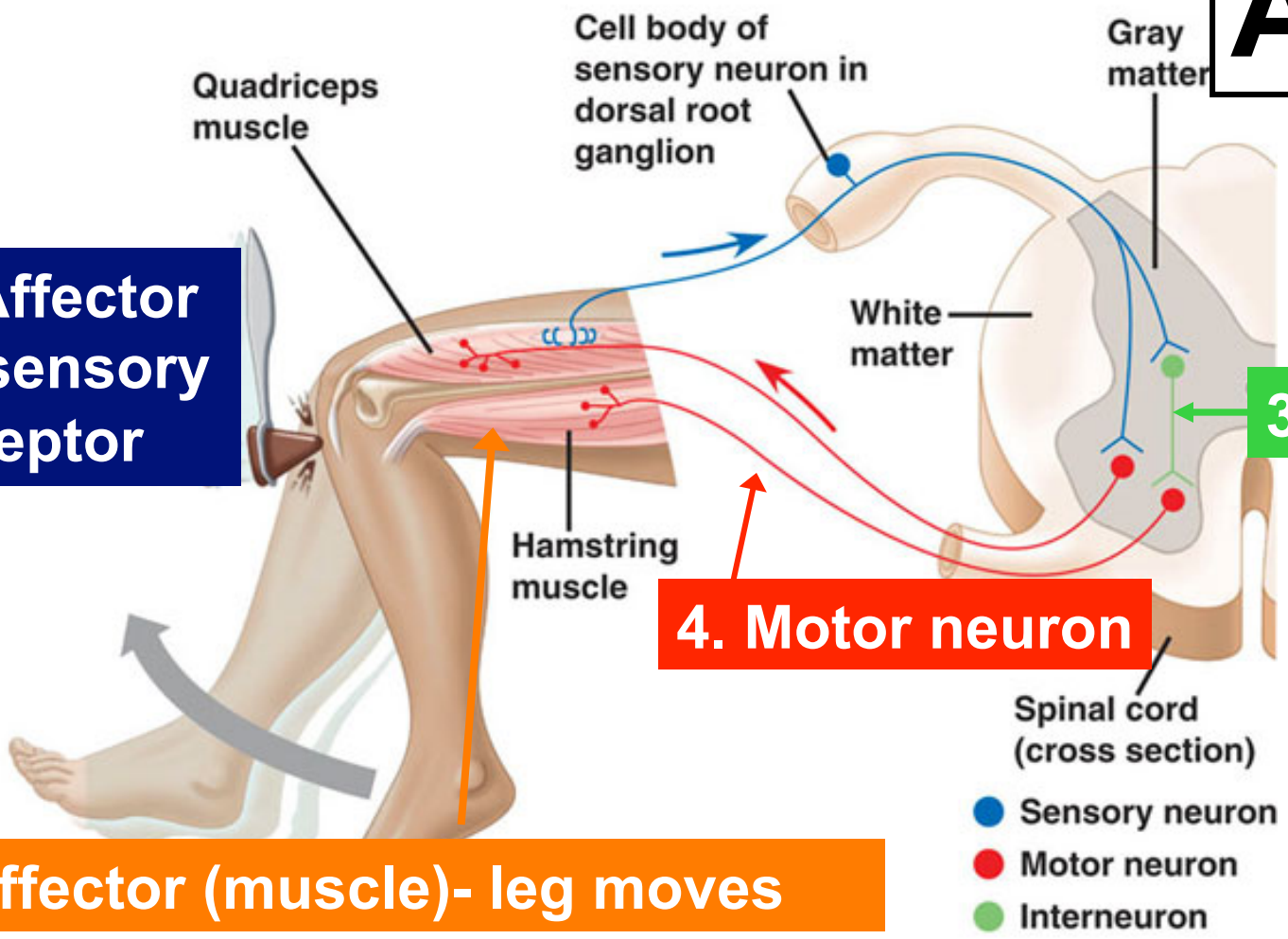


NAME THE STEPS: Reflex arc

How to Remember…

ASIME

2. Sensory neuron

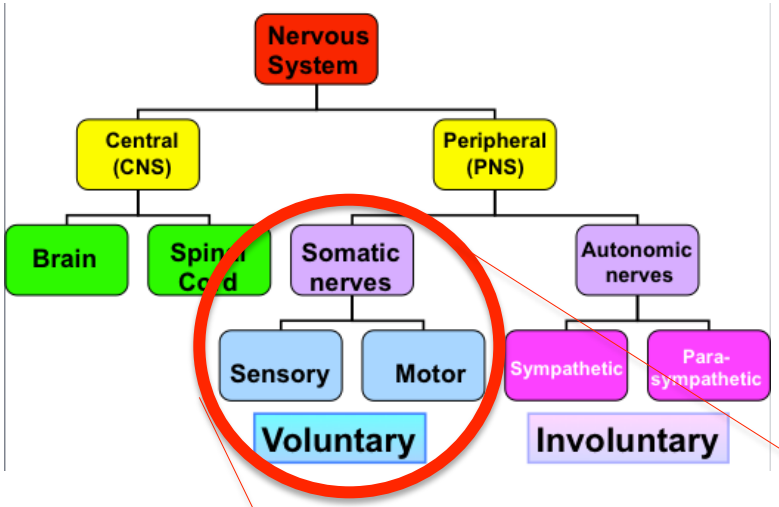


1. Affector or sensory receptor

3. Interneuron

4. Motor neuron

5. Effector (muscle)- leg moves



REFLEX ARC part of **SOMATIC NERVOUS SYSTEM** but CONTROLLED by the Central nervous system (interneuron)

Peripheral (PNS)

Somatic nerves

Autonomic nerves

Voluntary

Sensory

Motor

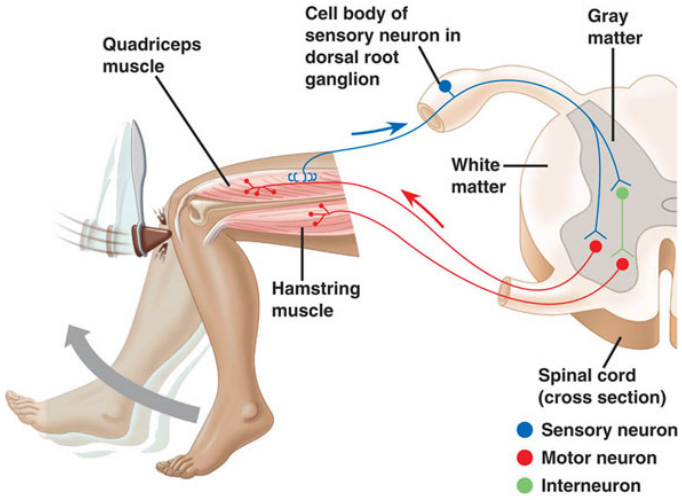
sensory neurons from **sensory organs** (ie) skin, taste, sight, muscles

Motor neurons affecting **skeletal** muscles

Reflex Arc

ASIME

1. **Affector- receptor (senses) detects stimulus and nerve impulse initiated**

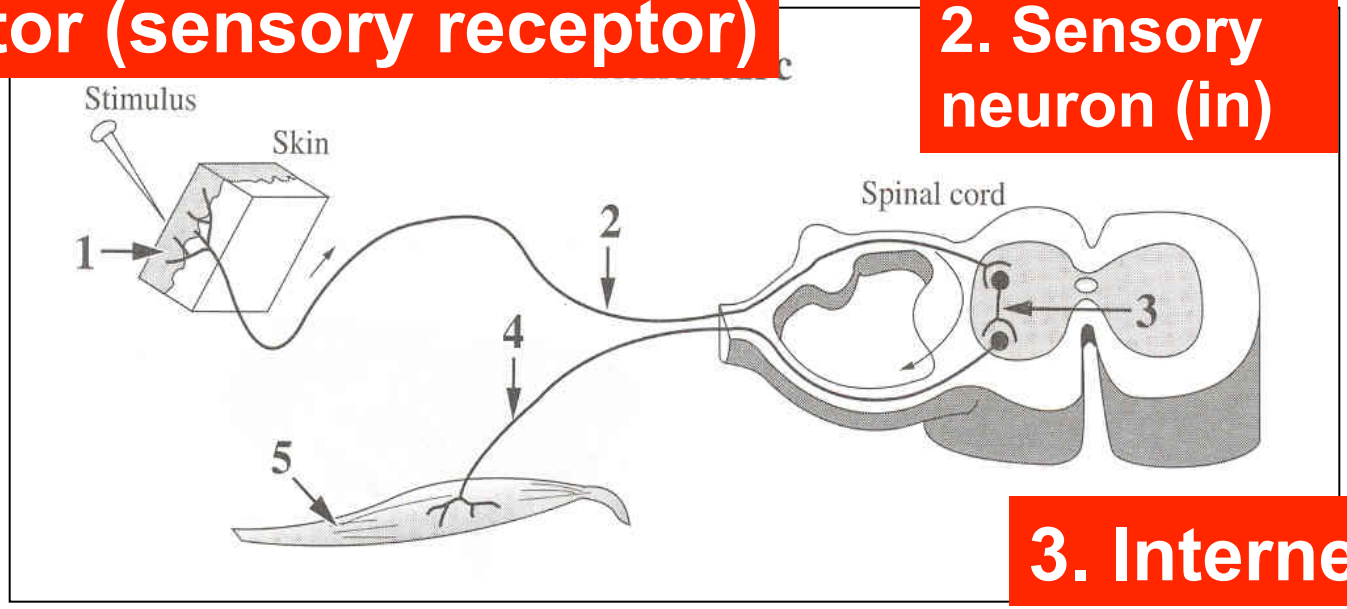


2. **Sensory neurons carry impulse to spinal cord**
3. **Interneuron Co-ordination & Interpretation. Carries impulse to motor neuron.**
4. **Motor neurons carry impulse from spinal cord**
5. **Effector – muscle or gland that responds**

Reflex arc video:
http://www.youtube.com/watch?v=Y5nj3ZfeYDQ&feature=related

NAME THE Reflex Arc PARTS

1. Affector (sensory receptor)



2. Sensory neuron (in)

3. Interneuron

4. Motor neuron

5. Effector (muscle)

Patellar reflex video:
http://www.youtube.com/watch?v=QmNQdLkkJHM&feature=related

Patellar or Knee Jerk Reflex

1. The subject is to sit on the edge of the lab table with the legs able to swing freely. (One partner will be the subject first and the other partner the tester, then you'll switch.)
2. Once the legs are relaxed and swing freely, the tester should use the side of their hand to "tap" the subject just below the kneecap.

What happened? Record your results in the data table.

3. Now have the person sit with their leg straight out. Tap the knee in the same place. Observe and record your results.
4. Switch places with your partner and repeat steps 1-3.

Record the data for both partners in your data table.

Papillary Reflex

- Have the subject close his or her eyes for one minute (no peeking). After one minute, stare into the subject's eyes and tell him/her to open his/her eyes.
- Observe and record what happens to the pupils.
- After the subject has been tested switch places and repeat with the partner.

Babinski's Response

•Have the subject remove one shoe and sock. Have the subject sit on the lab table with his/her foot extending just over the edge. Using a pen cap or fingernail, the experimenter is to scratch the subject's foot in one smooth stroke motion from toe to heel.

•Describe the response in the toes in your data table.

•After the subject has been tested switch places and repeat with the partner.

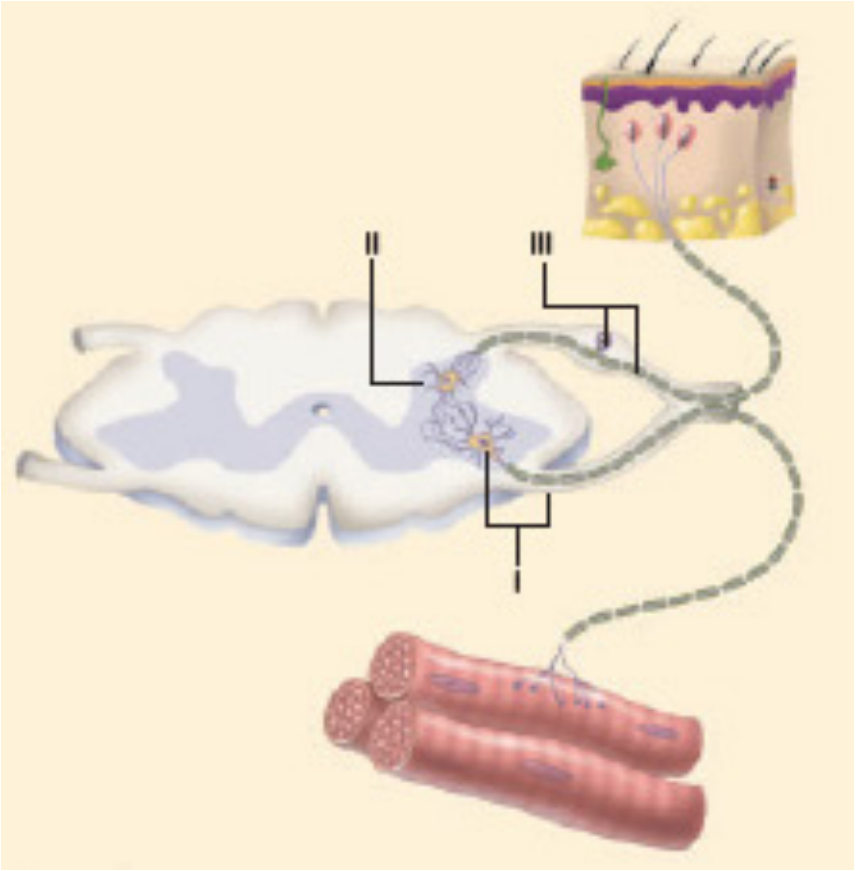
Blink Reflex

•Have the subject hold a sheet of clear plastic (transparency) in front of their face. Crumple up a small piece of paper and toss it toward their eyes. Observe what happens and record your data.

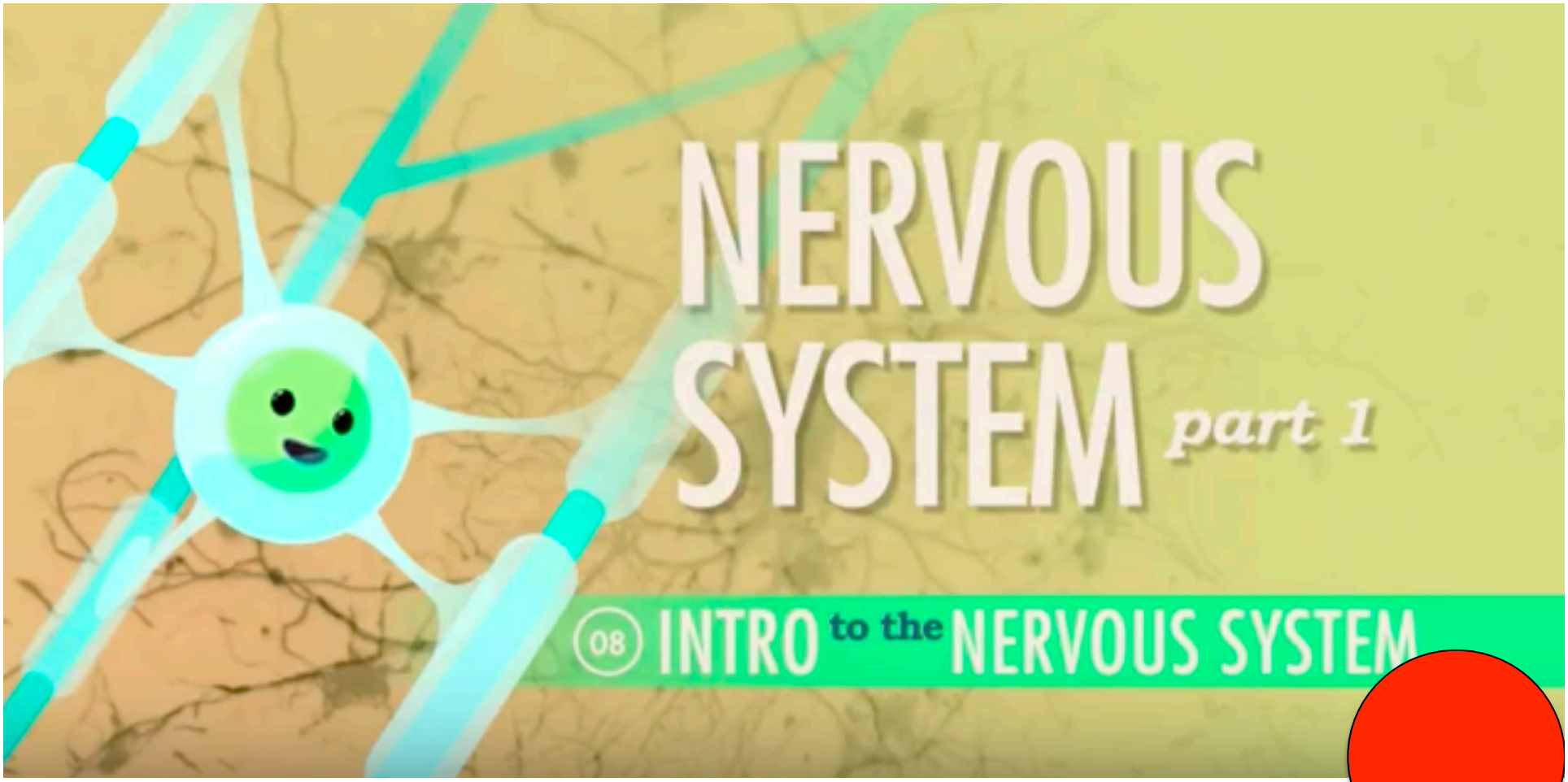
•After the subject has been tested switch places

Tasks to be completed:

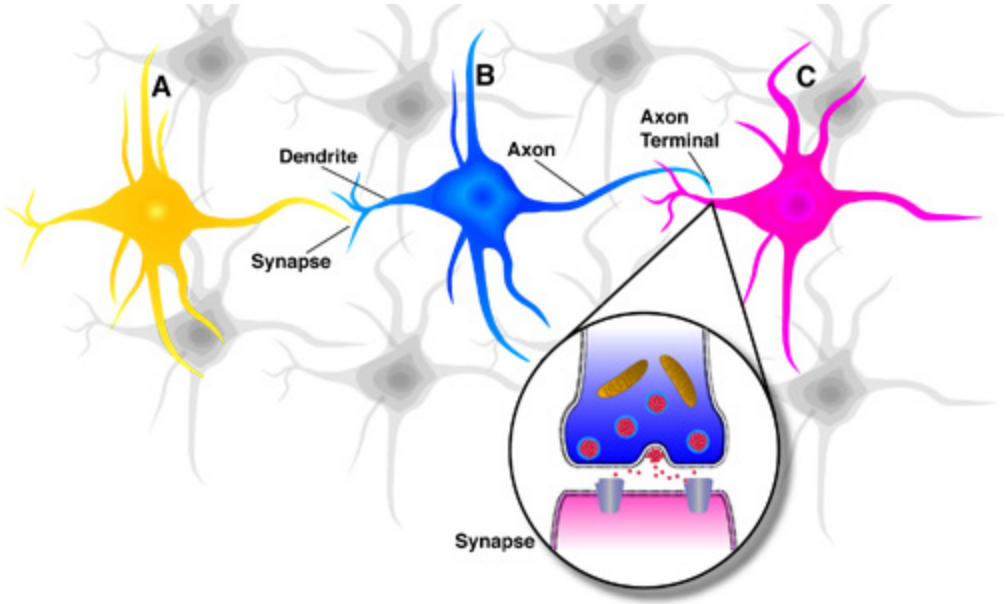
- **Try Practice Problems 1-4 on page 410**
- **Complete Section 13.1 Questions:**
  - **Page 414 #1-3**

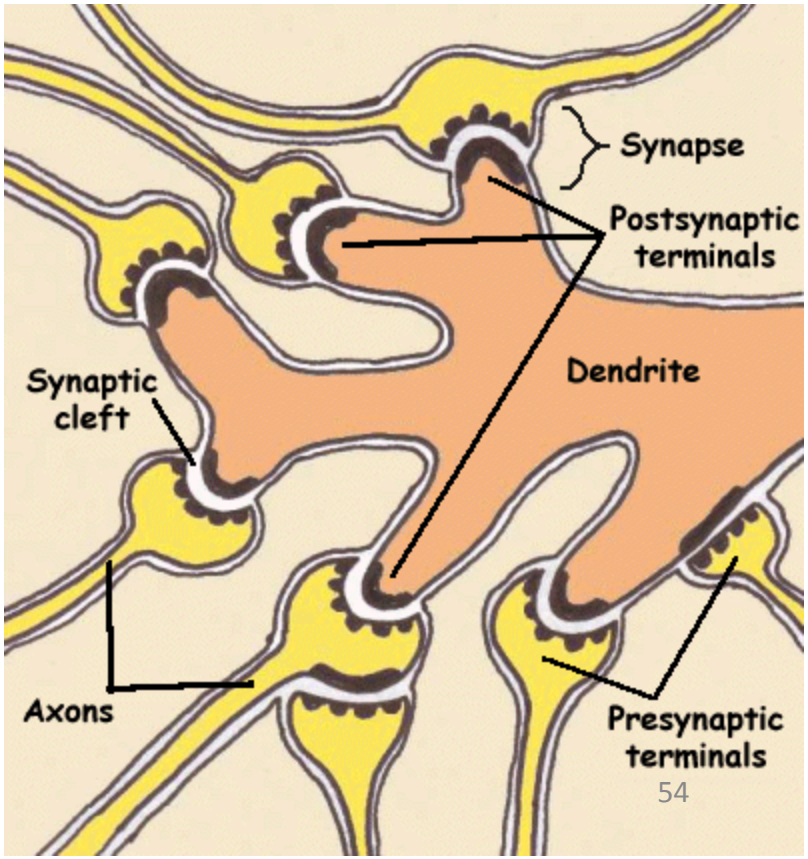


Let's Review…

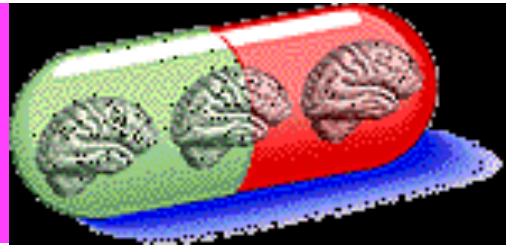


How does information within our nervous system travel?

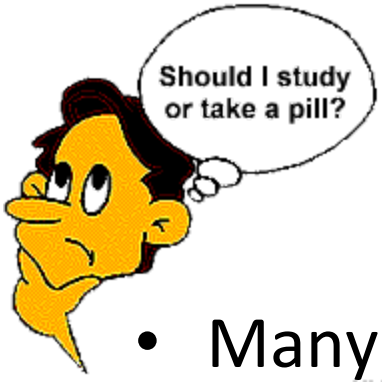




Smart Drugs

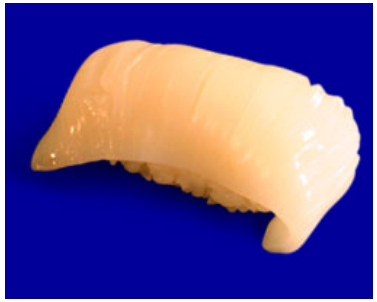


- Wouldn't it be nice if you could take a pill and not study for exams?
- There are drugs called **"cognitive enhancers"** or "smart drugs"
    - Originally intended to treat Alzheimer's or Parkinson's disease
- These improve memory, learning, attention, concentration, problem solving, reasoning, social skills, decision making and planning.



Would you buy a smart drug?

- Many companies make "smart" drinks, smart power bars and diet supplements containing certain "smart" chemicals
- **Ginkgo Biloba** is believed to increase blood flow in the brain = smartness!
- **Question:** Should it be illegal to pop a smart pill before a test? Would this be like taking a stimulant before a swim race? Would this be cheating?

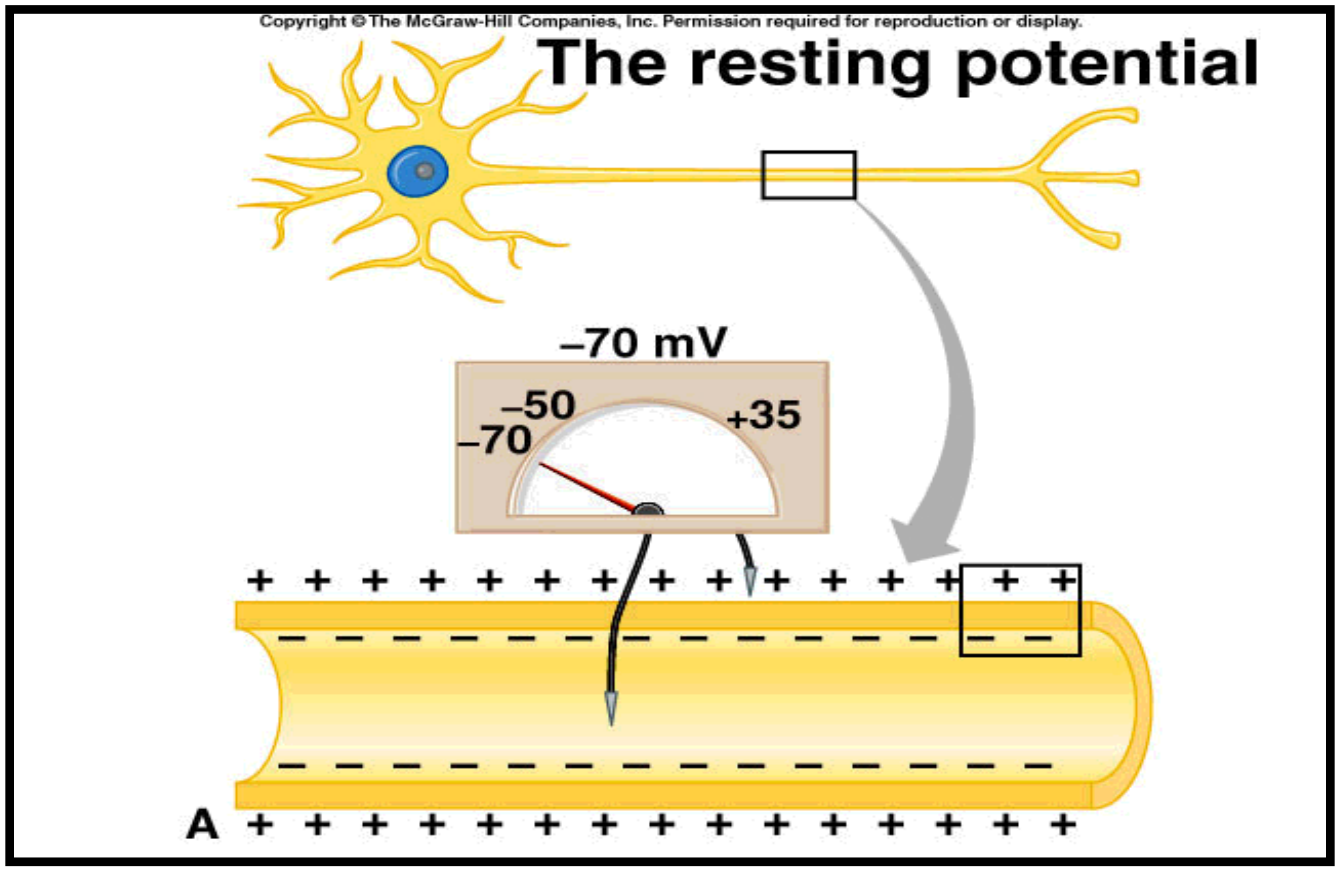


Electrochemical properties of neurons

- How do we know what a nerve impulse is and how is it created?
- K.S. Cole and J.J Curtis studied the **giant squid axon**
  - They placed electrodes inside the nerve of the squid

How do Nerves Work Animation?
TED talk

Voltage = - 70 mV, inside the axon



OK!!

Lets start with some basic neuron properties…

1. The neuron is either sitting idle (resting membrane potential)

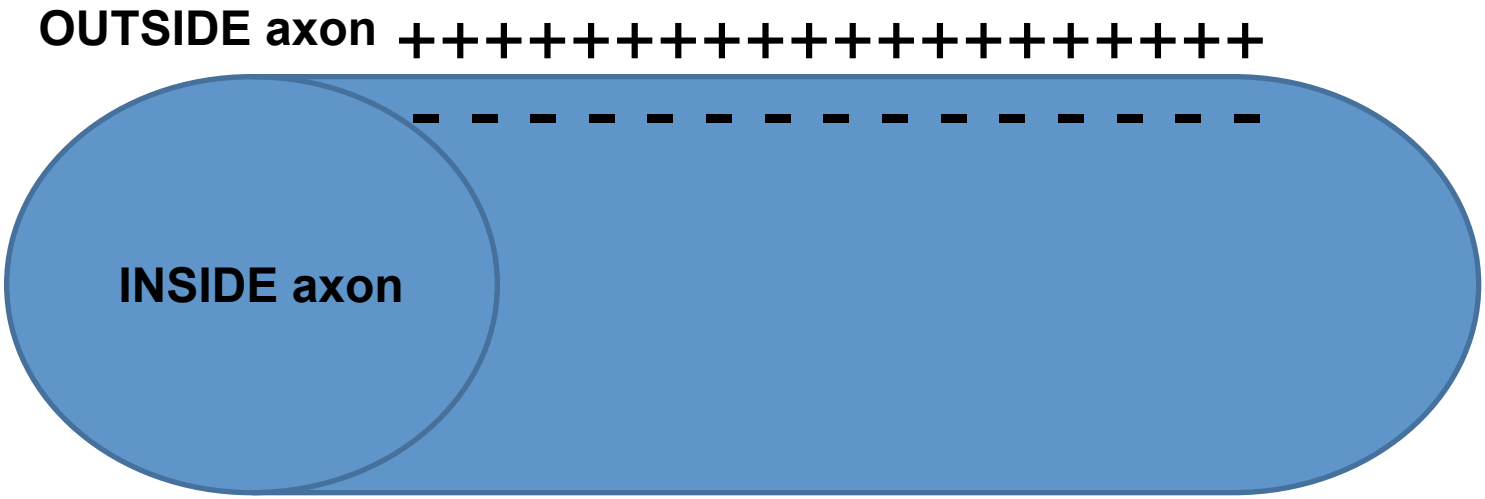
2. Or it is excited (action potential)…sending a signal

Resting membrane potential = -70mV

This is when the neuron is **not active**

An unstimulated axon is negative on the inside in respect to the outside

Unstimulated Axon



The difference between the POS (+) and NEG (-)

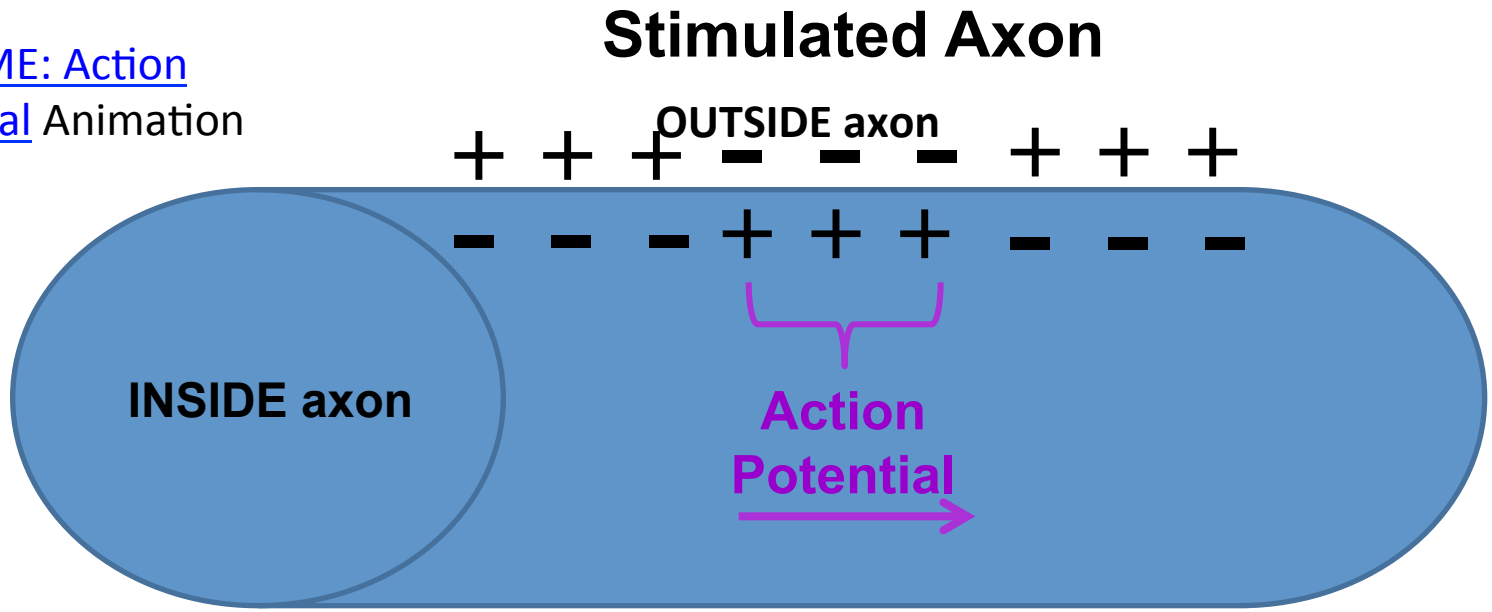
is -70mV while at rest in humans

Action potential = +40mV

This is when the axon **becomes excited.**

Every time the axon is stimulated, there is a change in charge across the membrane.

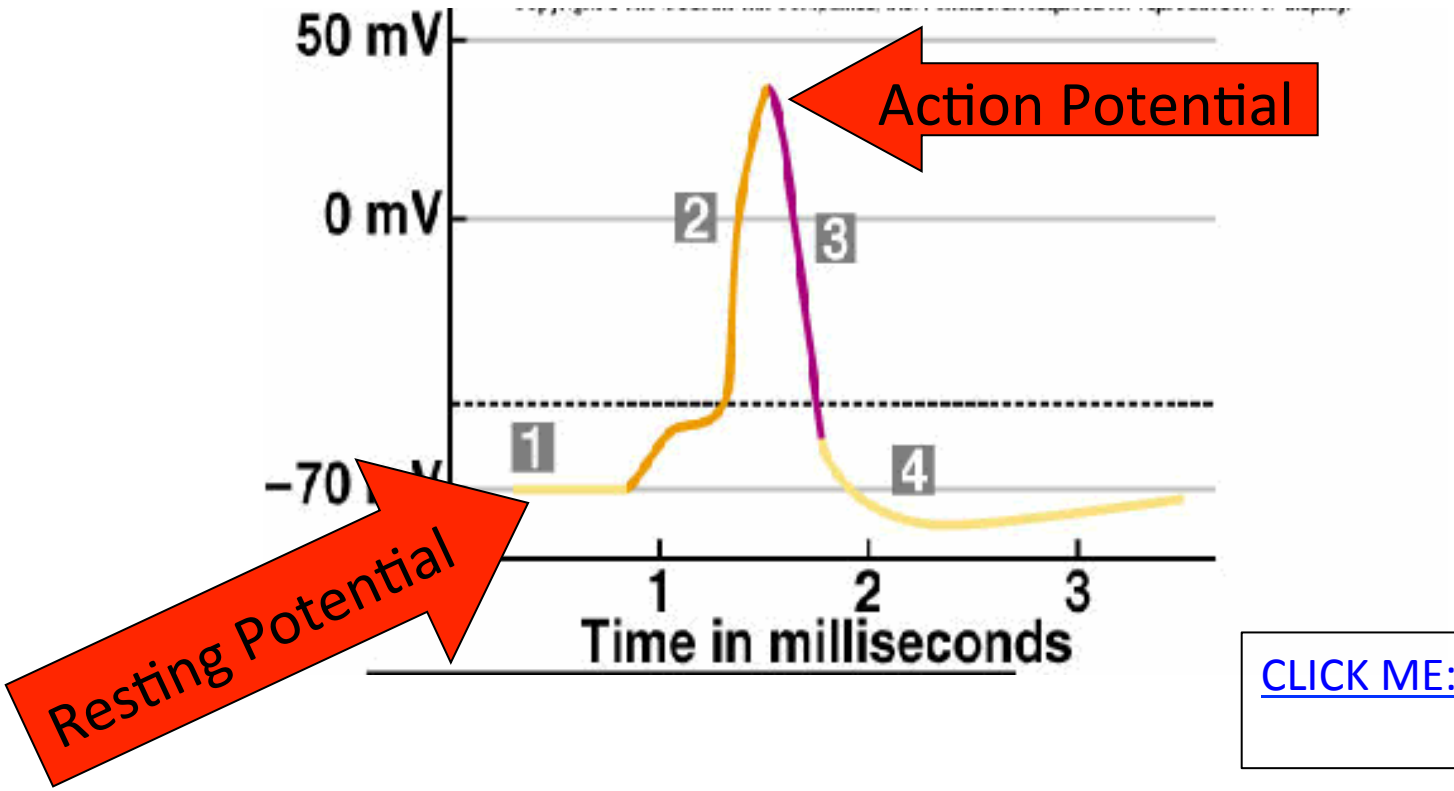
CLICK ME: Action Potential Animation



When excited, the axons Action Potential has a charge of +40mV in humans.

GRAPHING an Action Potential

- If a neuron is excited enough, an action potential is generated (a signal is sent)



CLICK ME: Roach Beatbox

THAT'S GREAT! BUT HOW or WHY DOES THIS ALL HAPPEN?

Two types of ions are involved in producing the ACTION POTENTIAL!

1. **Sodium (Na)**
2. **Potassium (K)**

RESTING NEURON – What creates the charge difference?

- **The charge difference is due to positive ions**
- **There are more sodium ions (Na^+) outside than potassium ions (K^+) inside along with other inside negatively charged proteins inside the neuron**

(negative separate from positive)

polarization = separation of charge **-70mv**

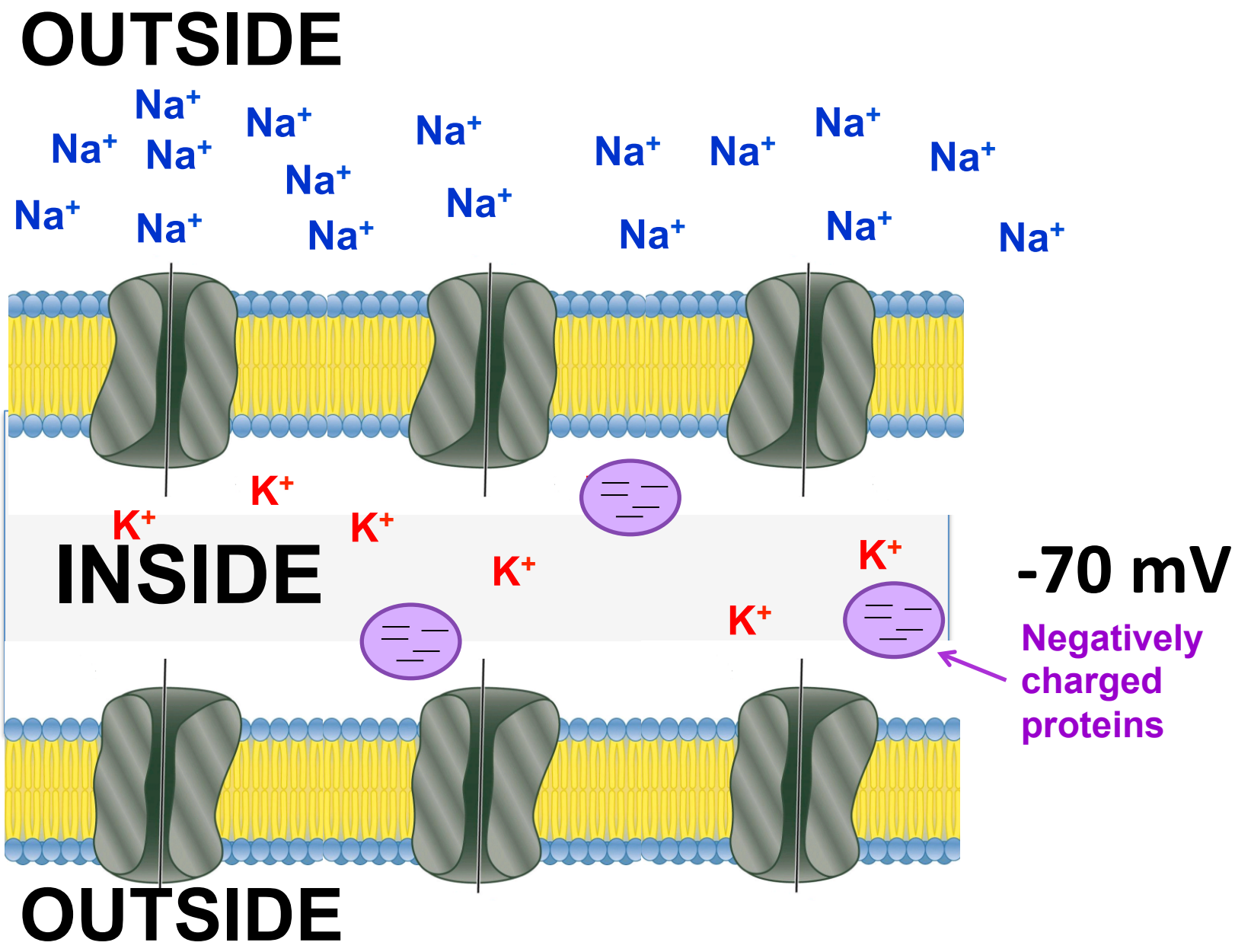
depolarization=

repolarization=

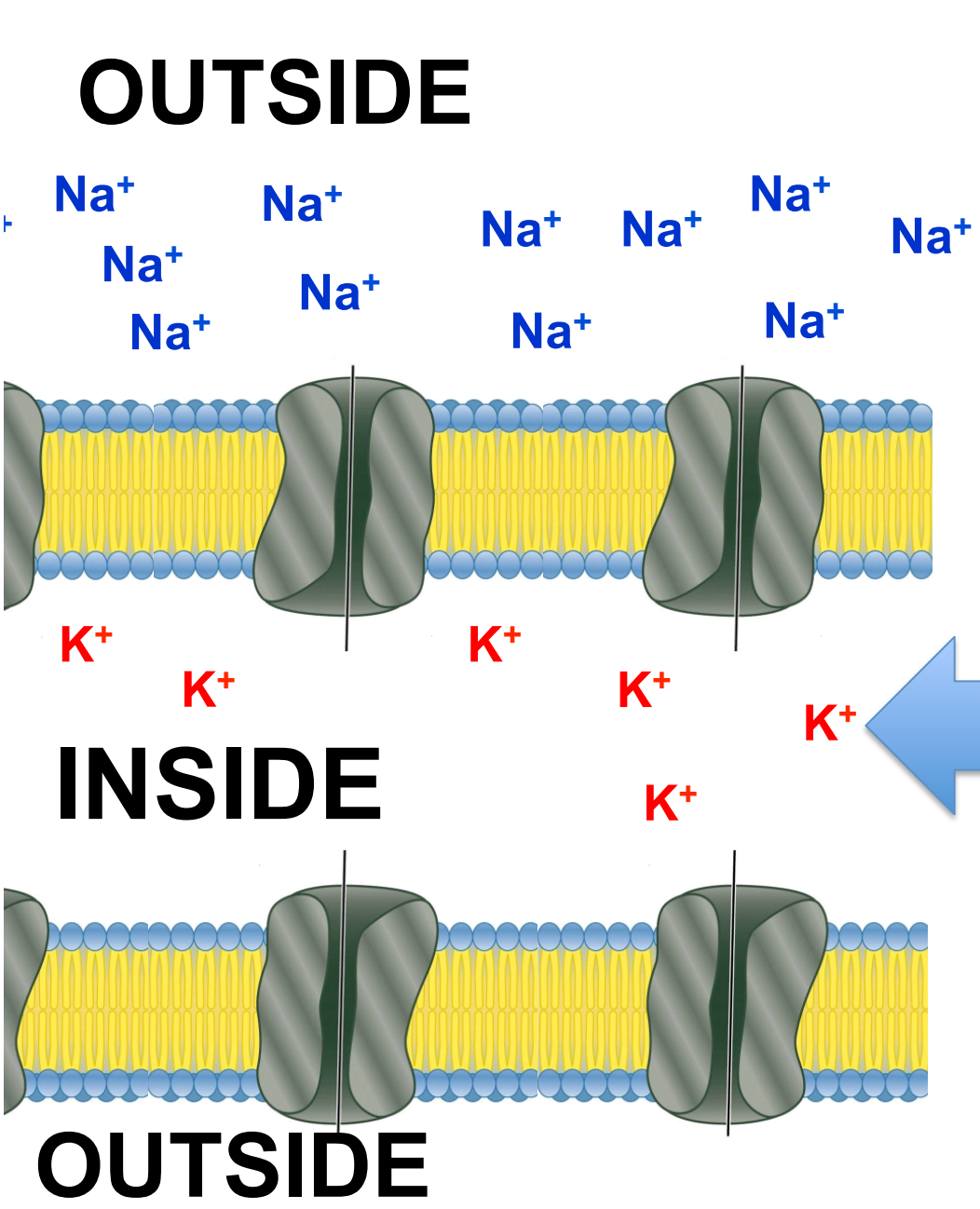
hyperpolarization=

Action Potential = fuse animation

RESTING NEURON– Axon Membrane

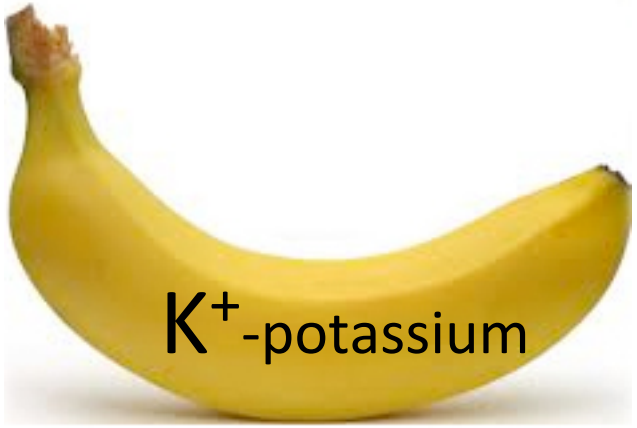


RESTING NEURON– Axon Membrane



Na^+-sodium

SALTY BANANA



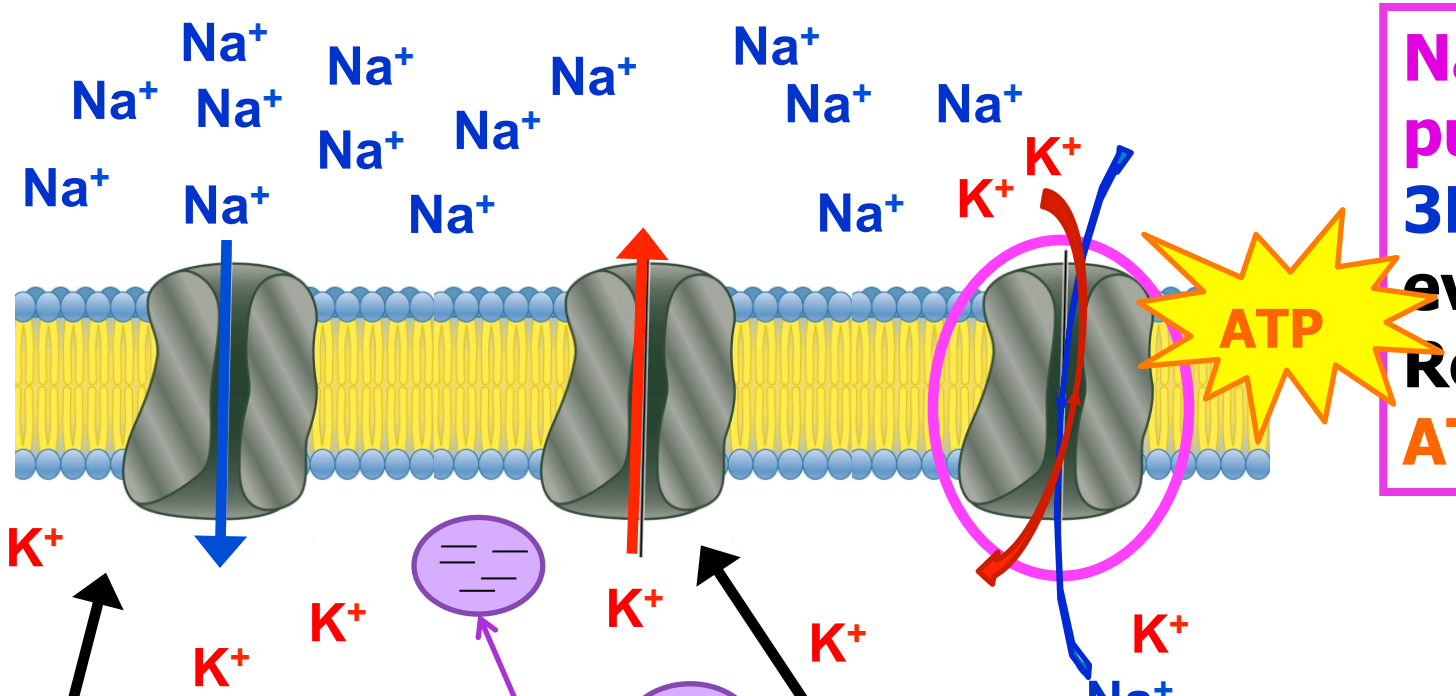
K^+-potassium

RESTING NEURON– What else is happening?

3 types of channels (**sodium, potassium, Na/K pump**)

-Some ion diffusion is taking place

-Na^+ / K^+ Pump is working



Na^+/K^+ pump moves $3Na^+$ out for every $2K^+$ in. Requires ATP

Na^+ channels allow Na^+ to diffuse

Negatively charged proteins

K^+ channel allows K^+ to diffuse

INSIDE

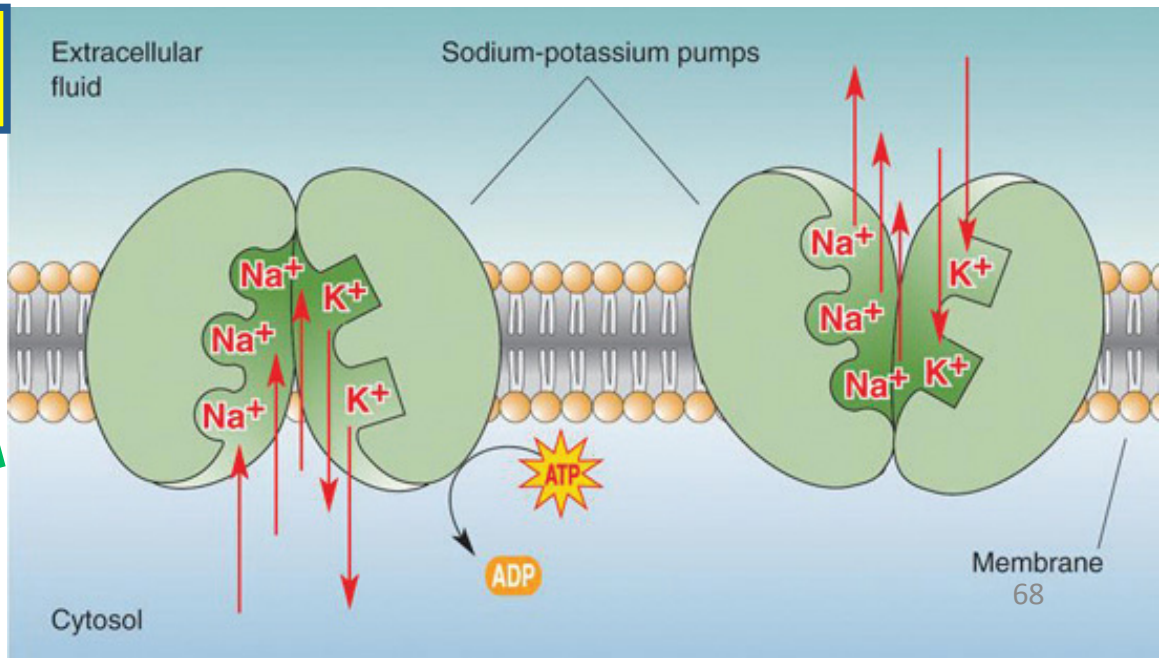
Sodium – Potassium Pump **(reset)**

- **The sodium – potassium pump actively takes 3 Na^+ out and brings 2 K^+ in by using ATP**
- **This means that there are more positive charges found on the outside than the inside**

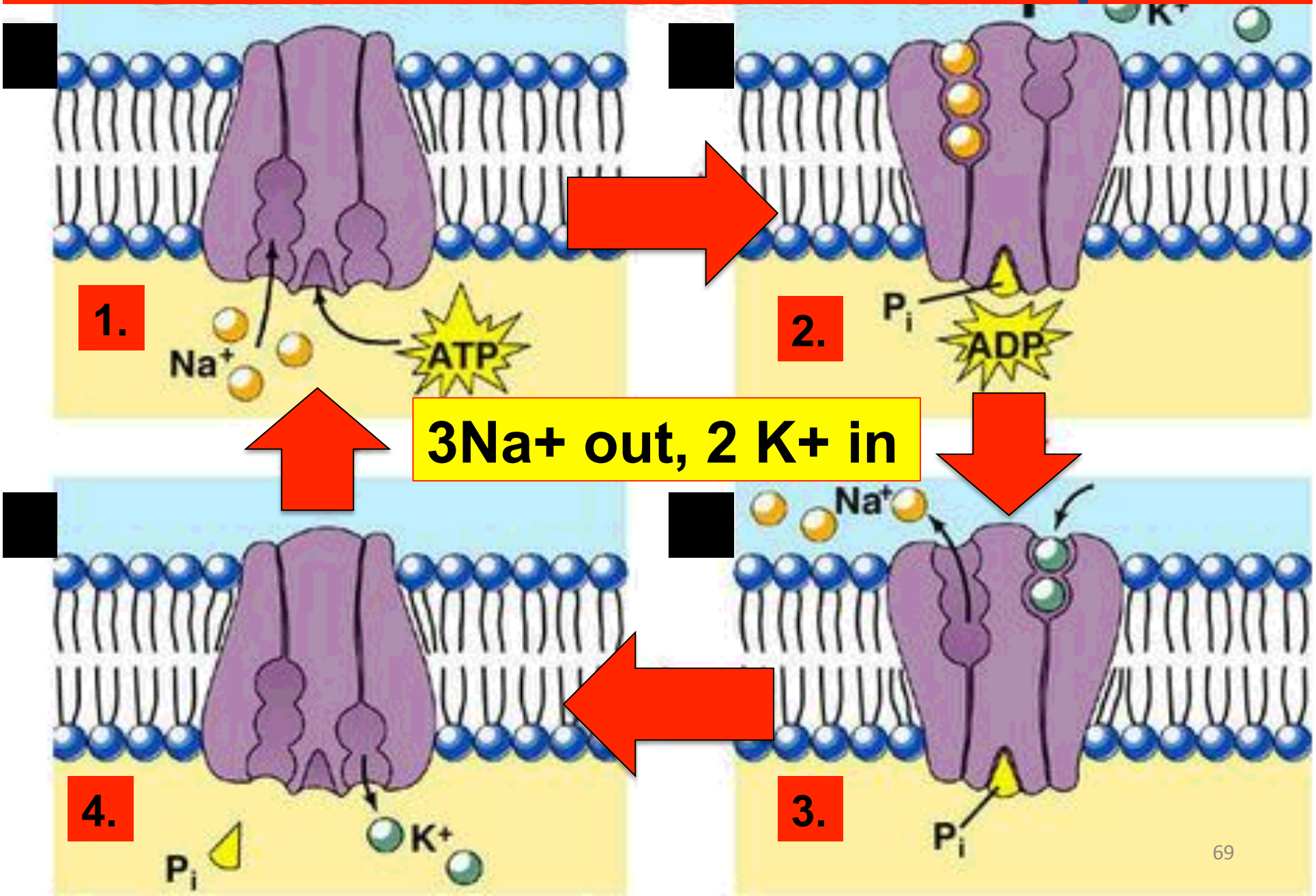
3 Na^+ out: 2 K^+ in

CLICK ME: Sodium Potassium Pump

Neural impulse animation



Sodium – Potassium Pump



LETS REVIEW THE STEPS SO FAR ON HOW AN IMPULSE INITIATES AND TRAVELS…

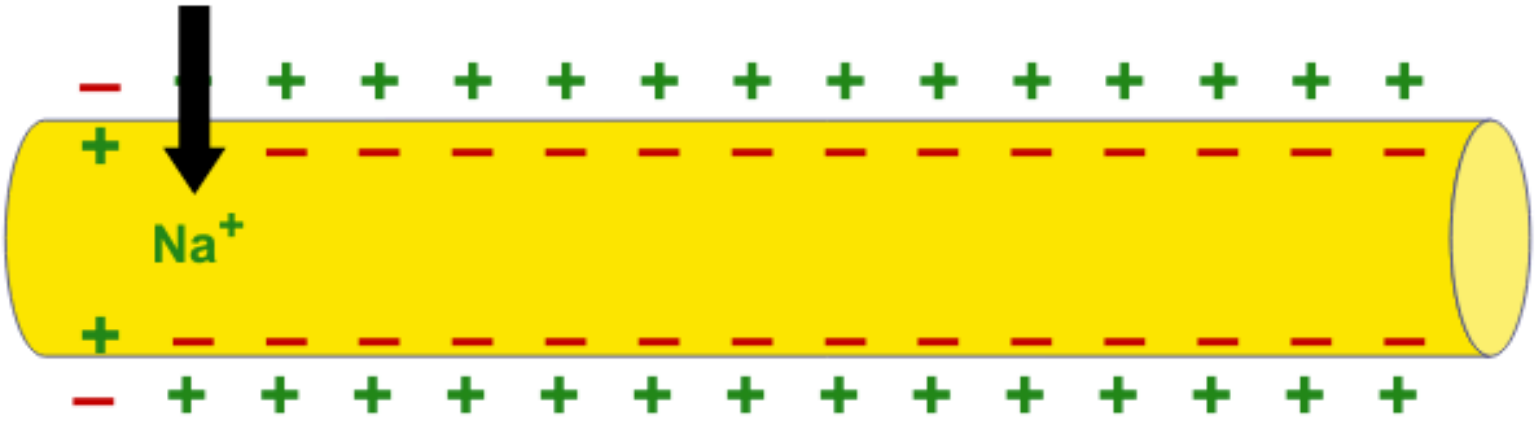
1. Resting State
2. Threshold Reached
3. Depolarization (action potential)
4. Repolarization (reset)

5. More to learn…
6. More to learn…

How does a nerve impulse travel?

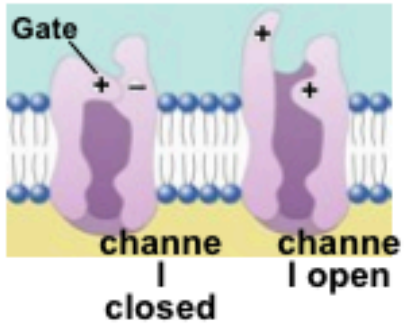
- **Stimulus**: nerve is stimulated
  - reaches **threshold potential**
    - open Na^+ channels in cell membrane
    - Na^+ ions diffuse into cell
  - charges reverse at that point on neuron
    - positive inside; negative outside
    - cell becomes depolarized

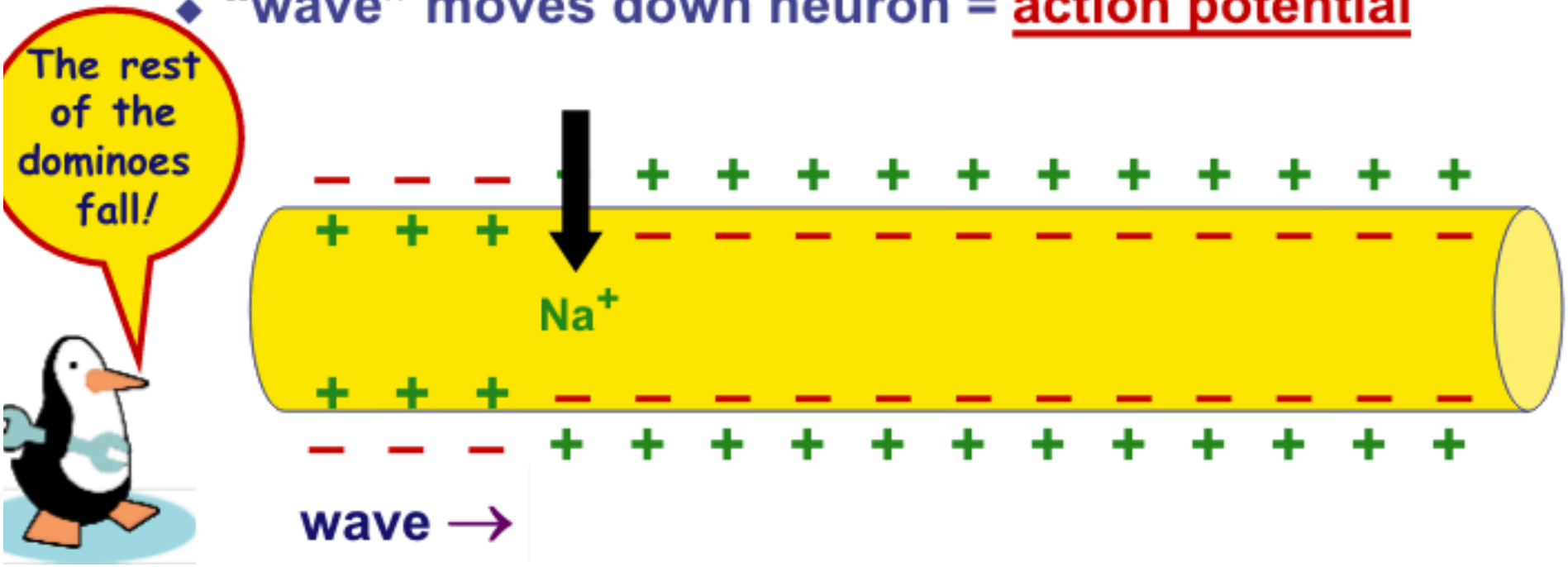
Draw Stimulated Dendrites



Depolarization

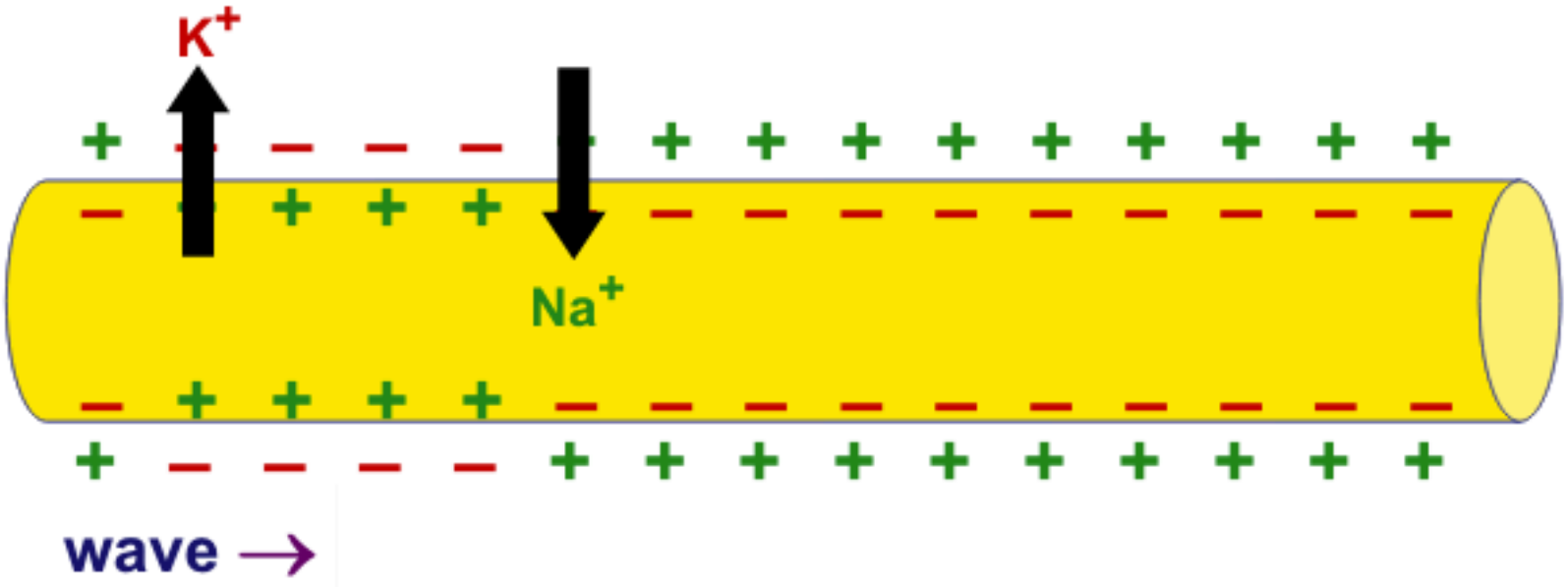
- **Wave**: nerve impulse travels down neuron
  - change in charge opens next Na^+ gates down the line
    - "voltage-gated" channels
  - Na^+ continues to diffuse down neuron
  - "wave" moves down neuron = action potential





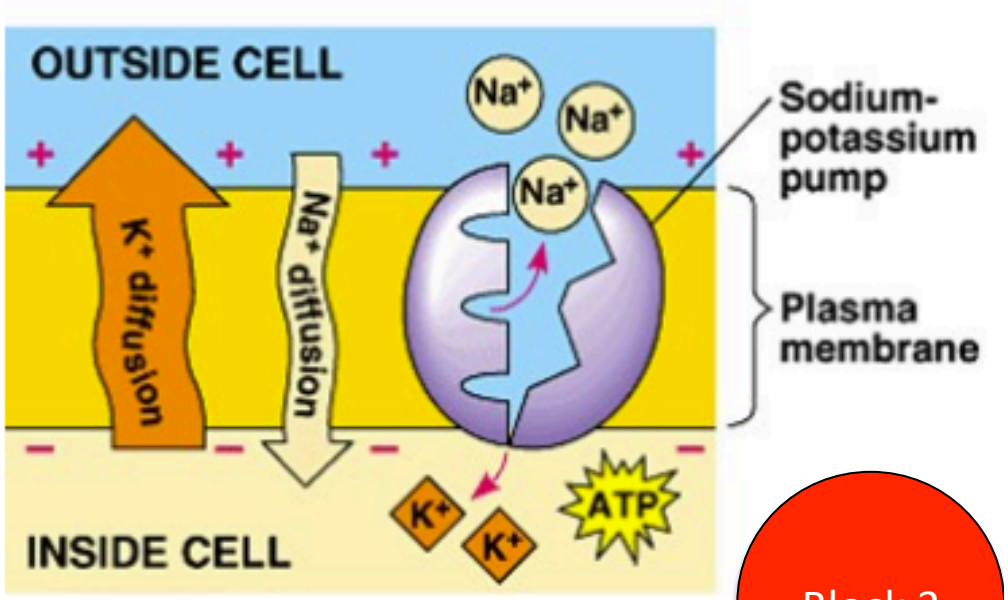
Repolarization

- **Re-set**: 2nd wave travels down neuron
  - K^+ channels open
    - K^+ channels open up more slowly than Na^+ channels
  - K^+ ions diffuse out of cell
  - charges reverse back at that point
    - negative inside; positive outside

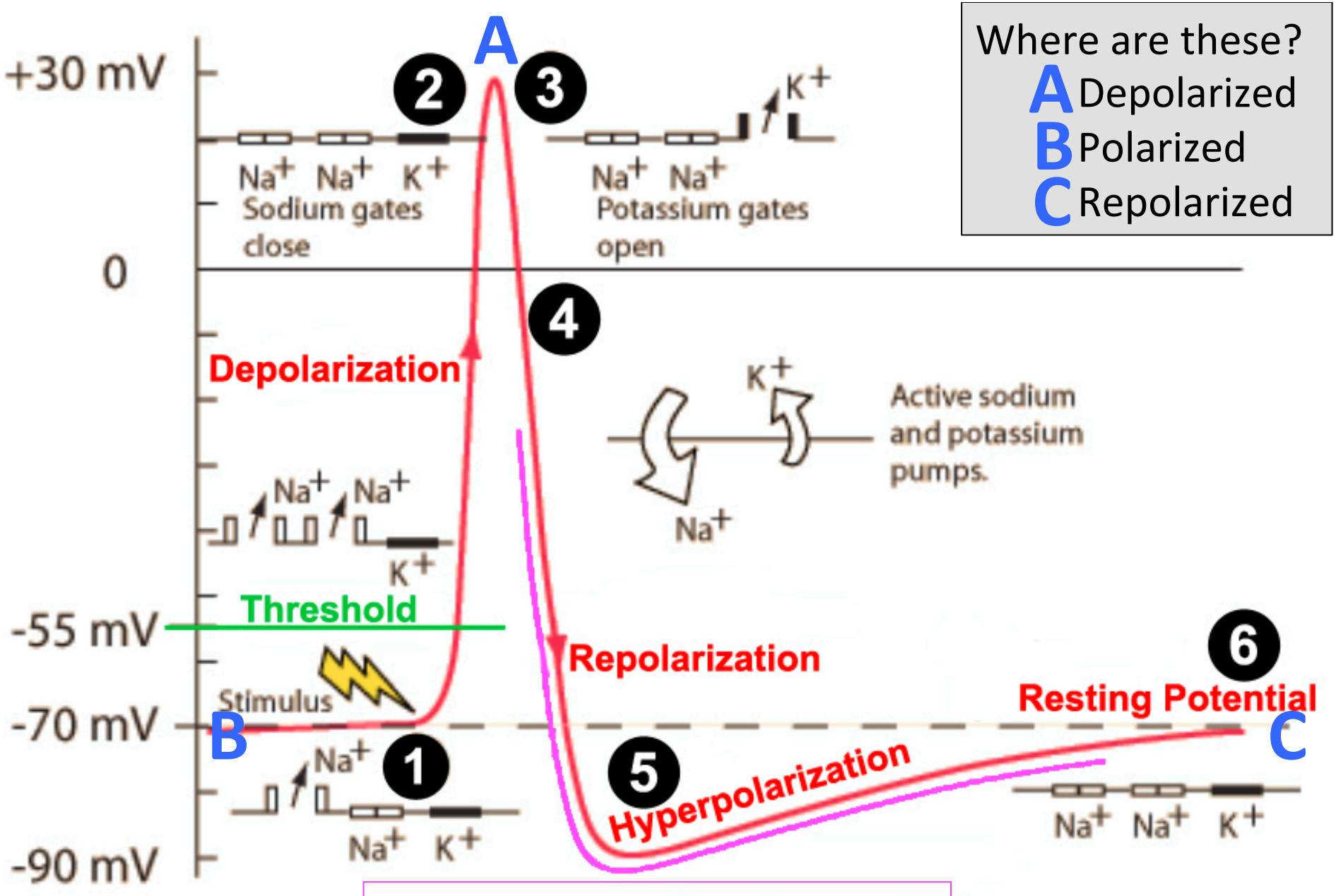


How does the nerve re-set itself?

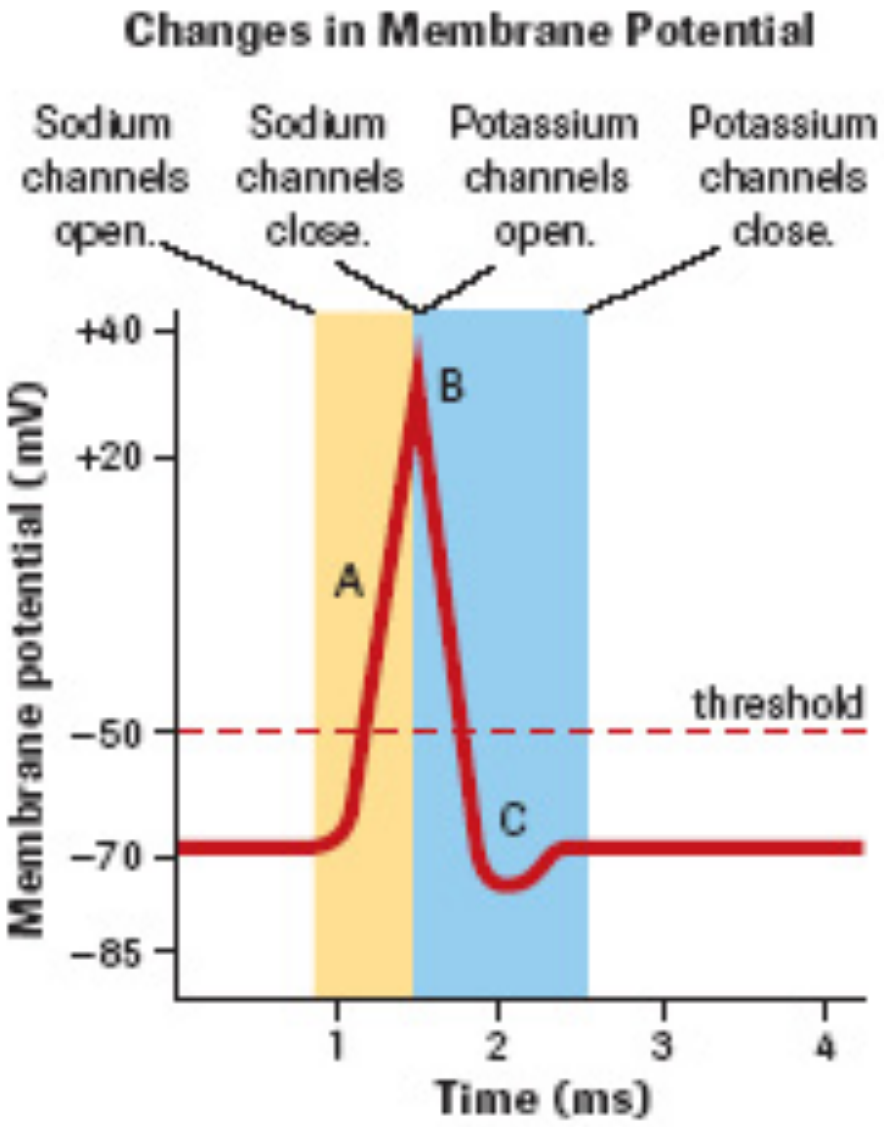
- **Sodium-Potassium pump**
  - active transport protein in membrane
    - requires ATP
  - 3 Na^+ pumped out
  - 2 K^+ pumped in
  - re-sets charge across membrane



Block 3


Where are these?
A Depolarized
B Polarized
C Repolarized
+30 mV
0
-55 mV
-70 mV
-90 mV
A
B
C
1
2
3
4
5
6
Na+ Na+ K+
Sodium gates close
Na+ Na+ K+
Potassium gates open
Depolarization
Threshold
Stimulus
Repolarization
Hyperpolarization
Resting Potential
K+
Active sodium and potassium pumps.
Na+
Refractory Period:
Time for neuron to recover before another AP can occur.

What are the potassium and sodium channels doing?

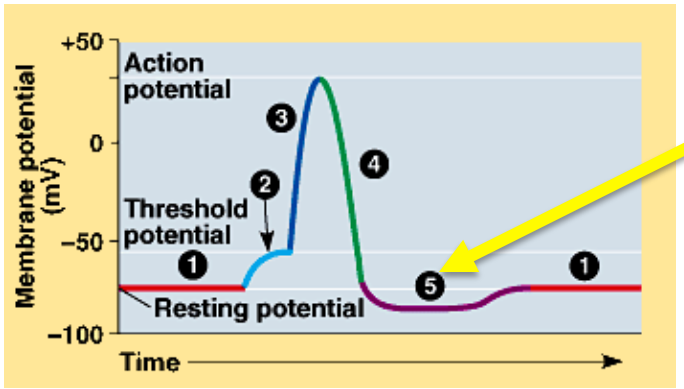


Unidirectional Propagation (going in one direction only)

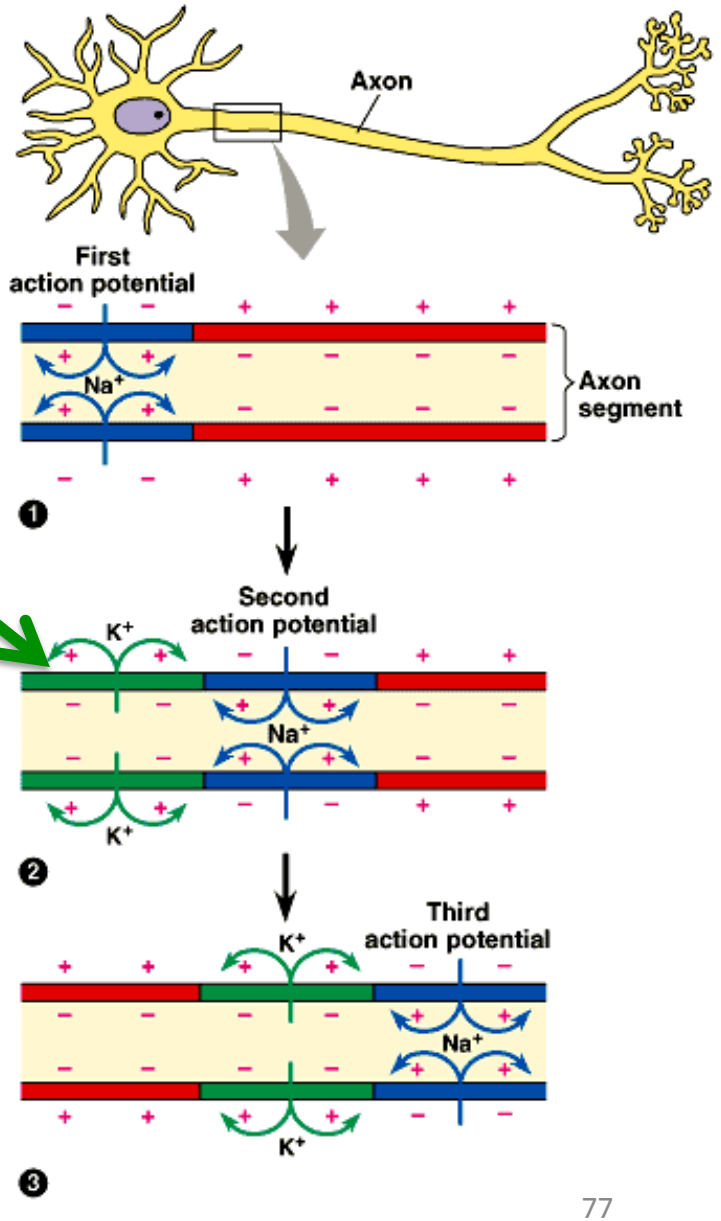
Propagation of the action potential only moves in **one direction**, from the cell body to the axon terminals.

The region just recovering from an action potential (**K^+ outflow region in green**) <u>cannot</u> be stimulated.

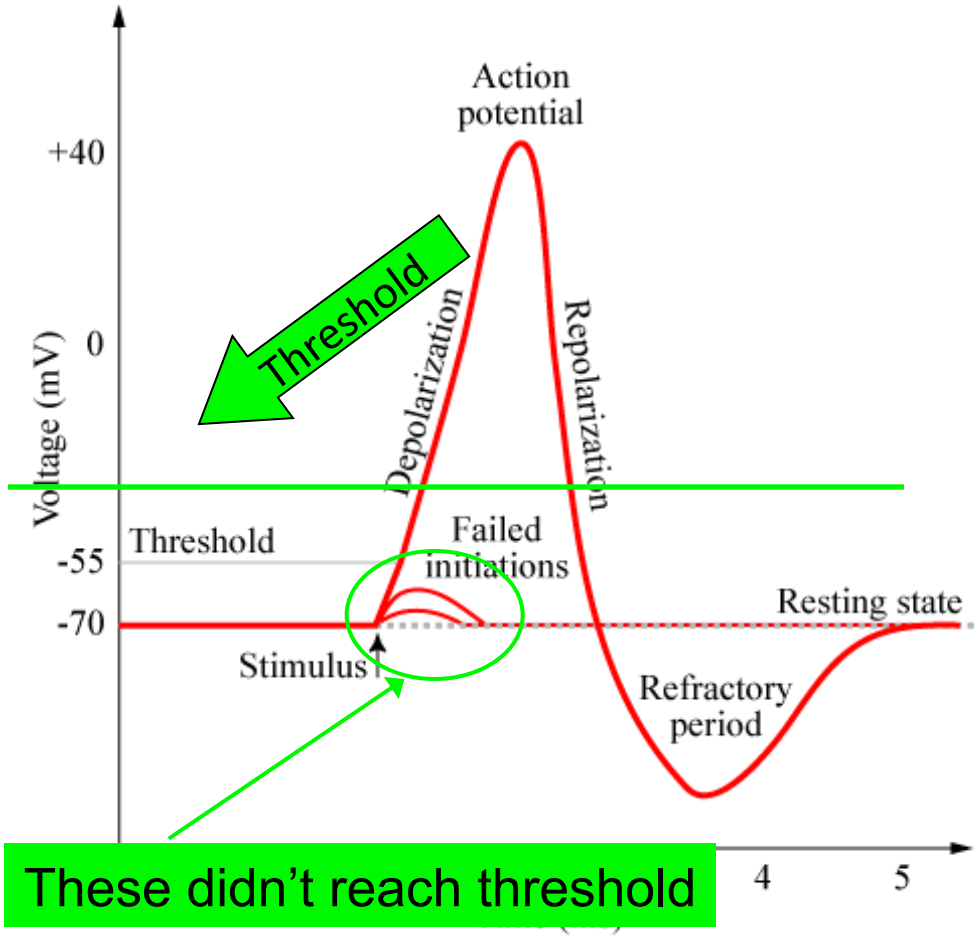
During repolarization, gates of the Na^+ channels are still closed, blocking any Na^+ influx = NO DEPOLARIZATION!



Refractory period



THRESHOLD & ALL-OR-NONE RESPONSE



Threshold level is the MINIUMUM level of stimulus required to produce a response: -**55mV**

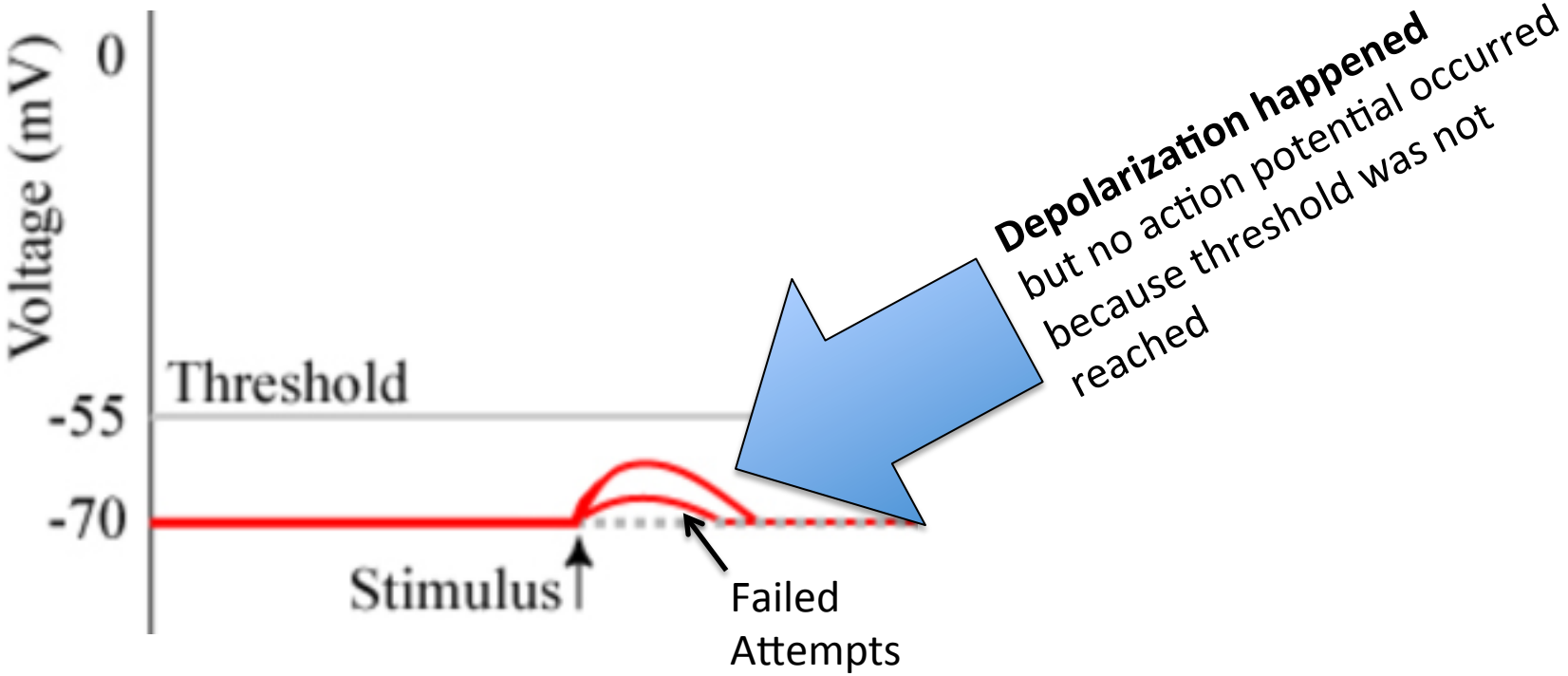
All-or-none response: neurons either reach threshold and fire or they don't

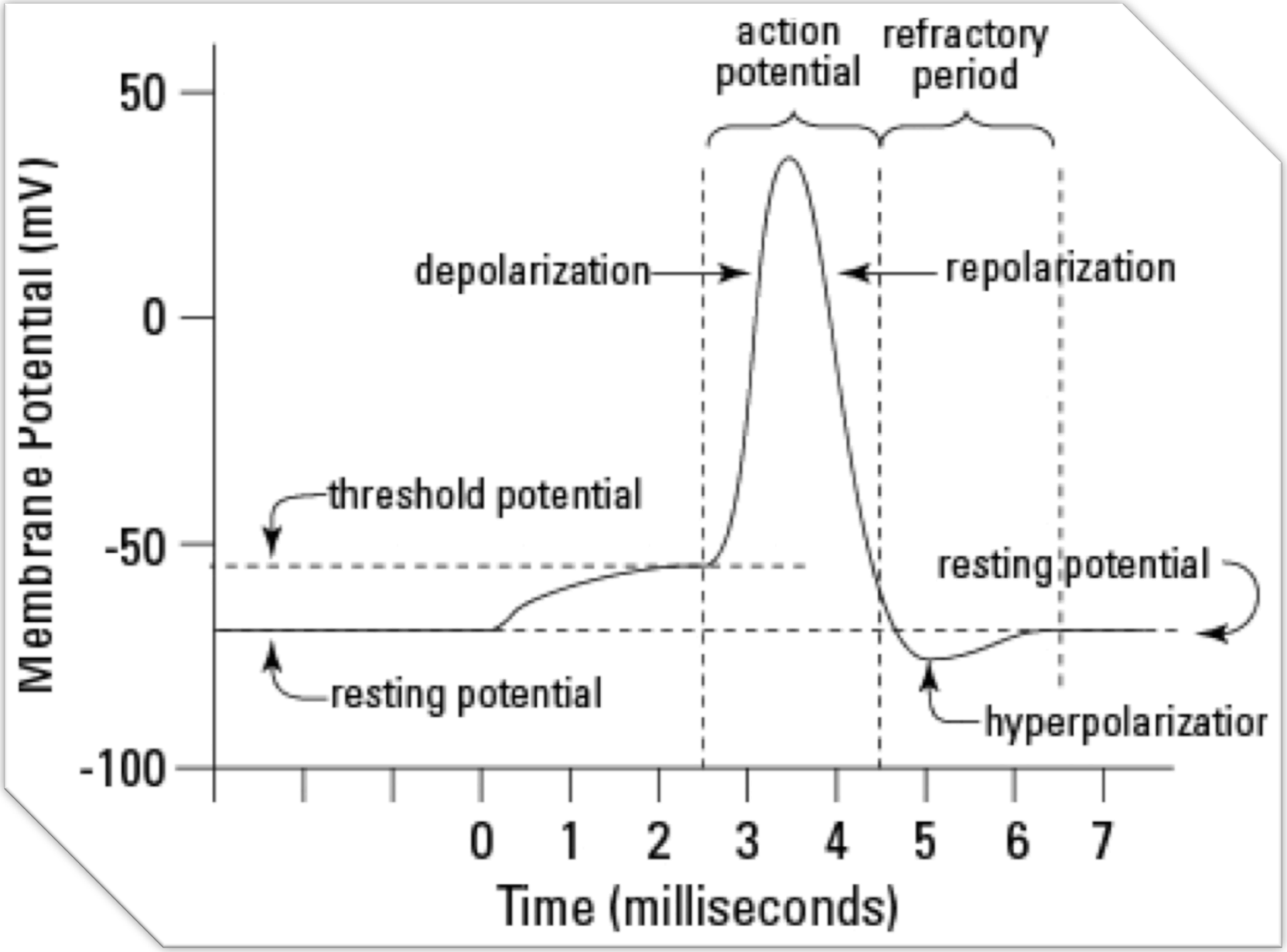
Intensity and speed of nerve transmission remain the same

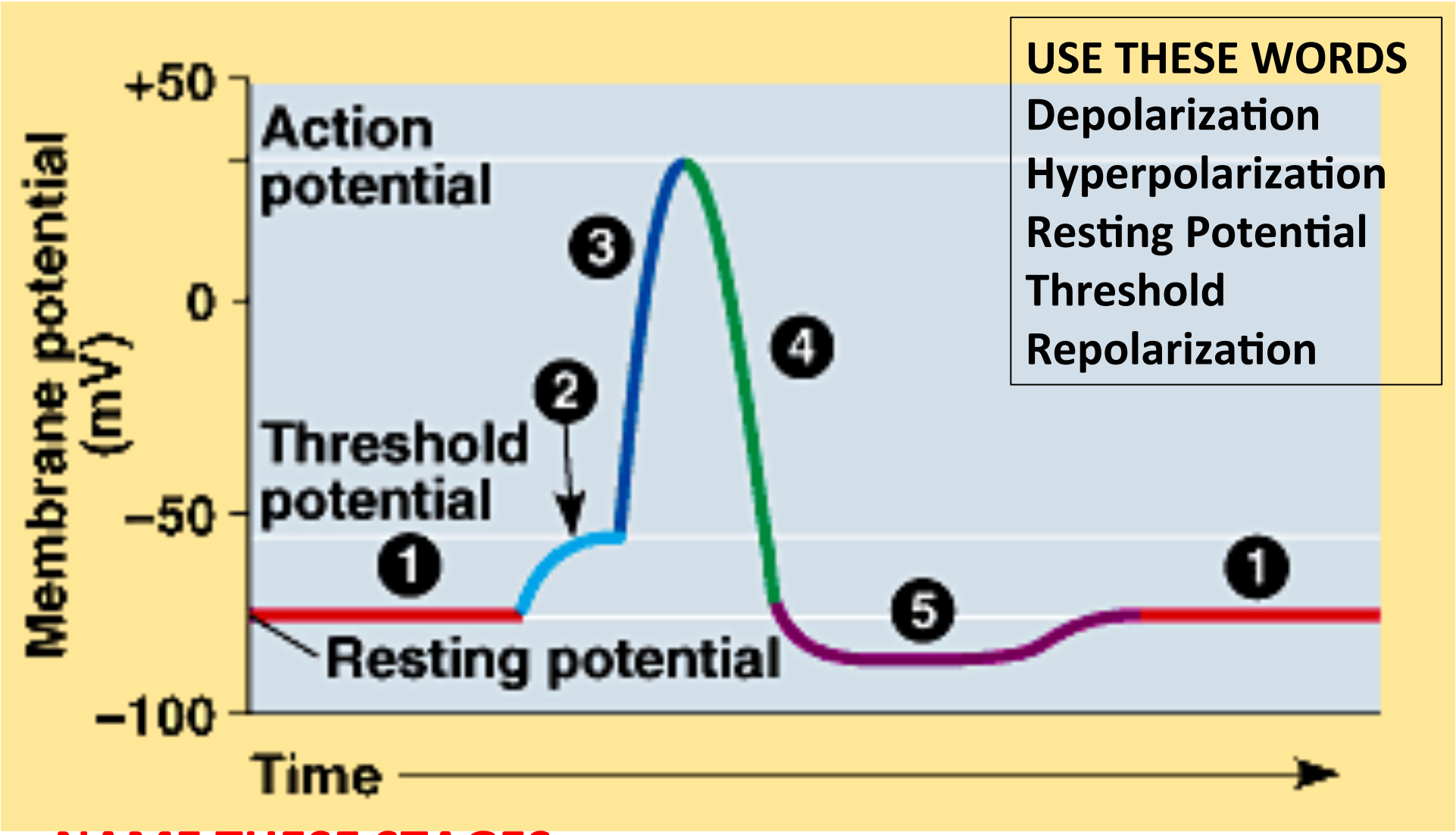
THRESHOLD & ALL-OR-NONE RESPONSE

IMPORTANT!!

It is important to understand that when a neuron is stimulated, **SOME** DEPOLARIZATION OCCURS EVERY TIME, however, **if there is not enough stimulus and the threshold is not achieved (-55mV), NO ACTION POTENTIAL OCCURS**




action potential
refractory period
50
0
-50
-100
Membrane Potential (mV)
depolarization
repolarization
threshold potential
resting potential
resting potential
hyperpolarizatior
0 1 2 3 4 5 6 7
Time (milliseconds)

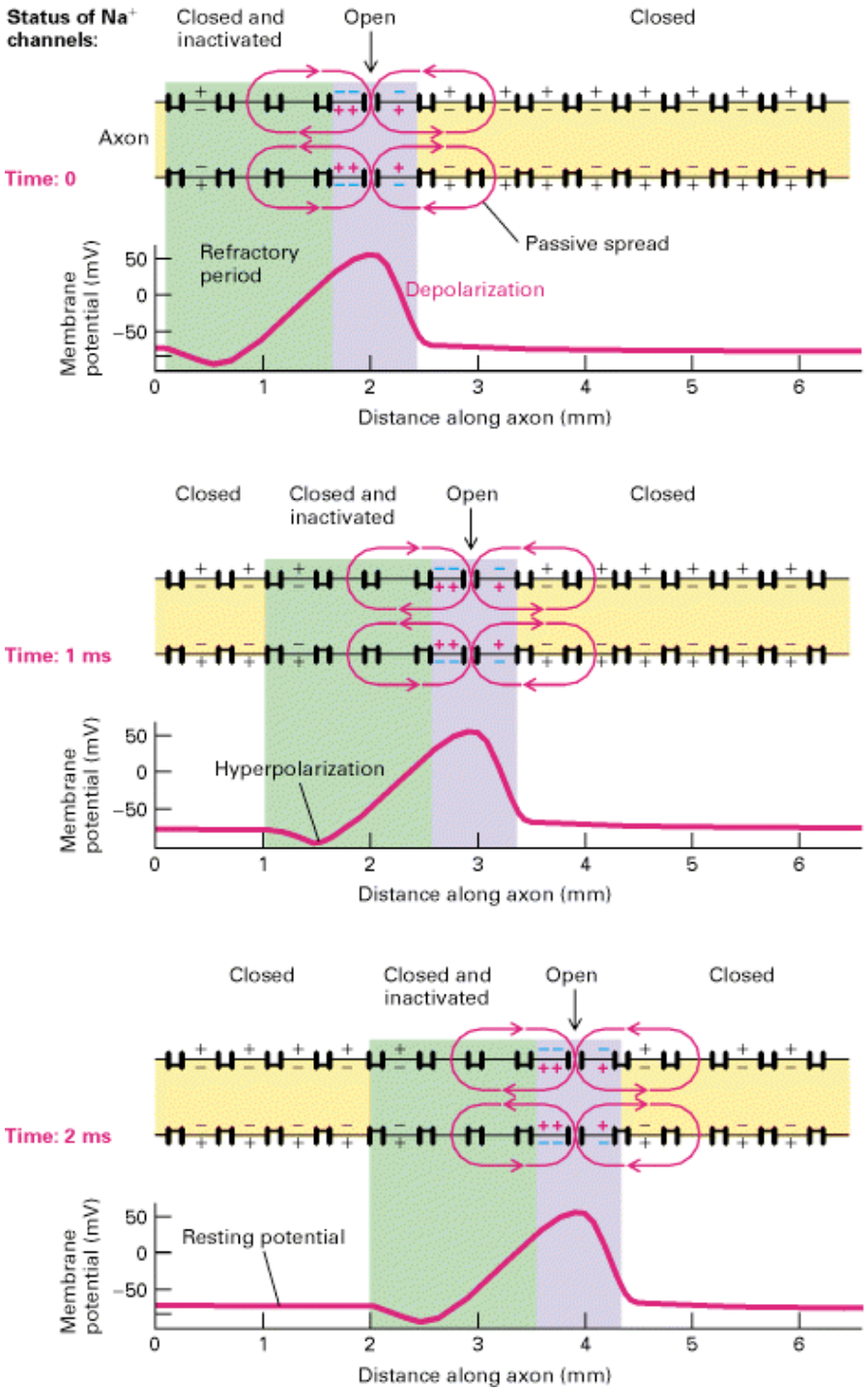


NAME THESE STAGES…

1. Resting Potential
2. Threshold
3. Depolarization
4. Repolarization
5. Hyperpolarization

A look at how the action potential sweeps across an axon

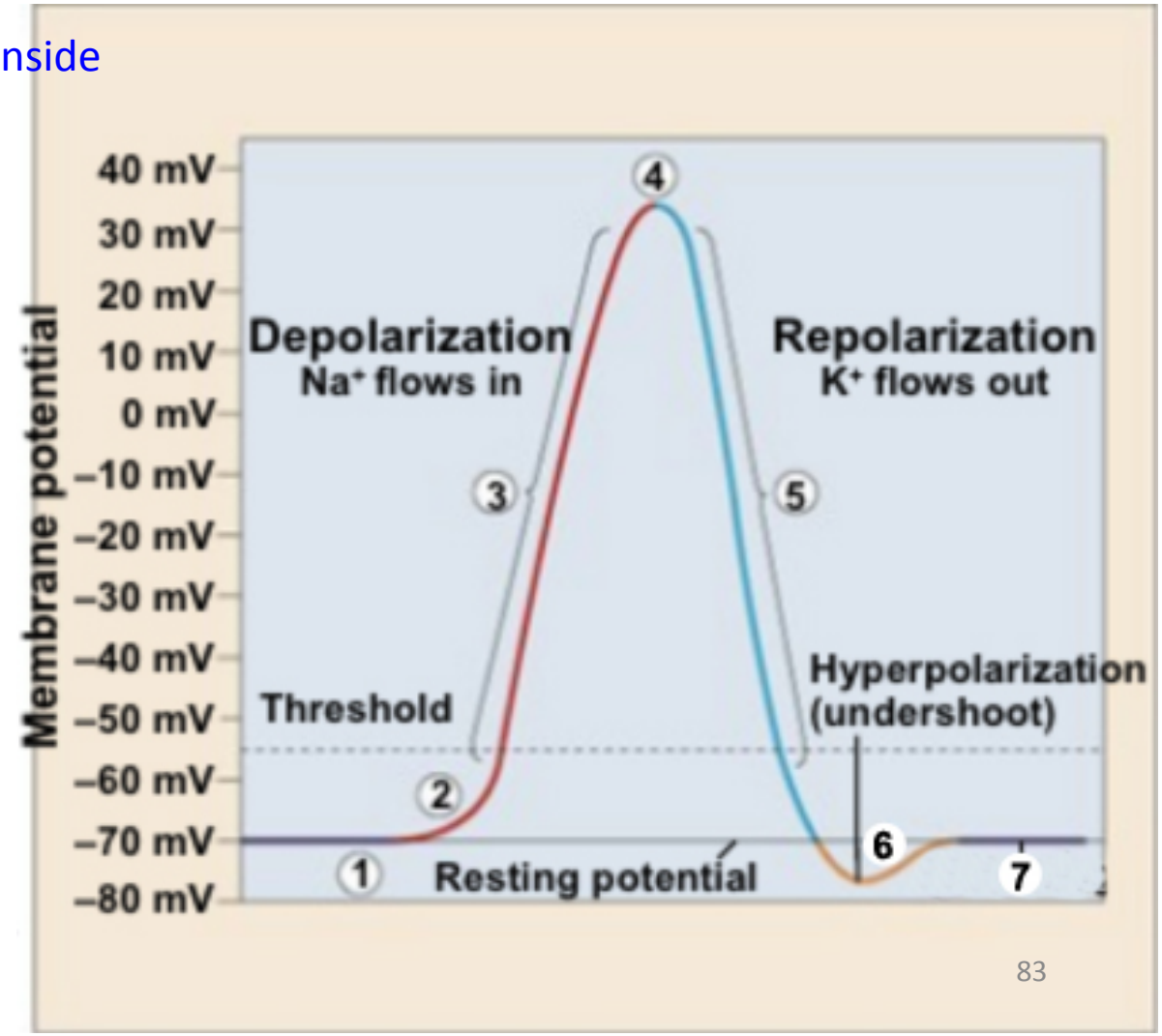
Many action potentials are generated one after another along the cell membrane, cause **a "wave of depolarization"**



ACTION POTENTIAL GRAPH and ION CHANNELS REVIEW

1. **Resting Potential** (-70mV)
   - Na^+ channels are closed
   - K^+ channels are closed
2. **Threshold** (-55mV) reached by enough stimulus
3. **Depolarization**
   - Na^+ channels open- Na^+ floods inside
   - K^+ channels are closed
4. **ACTION POTENTIAL** (-40mV)
   - Na^+ channels close
   - K^+ channels open
5. **Repolarization**
   - K^+ floods outside
   - Na^+ / K^+ pumps "kick-in"
6. **Hyperpolarization** (Undershoot)
   - K^+ channels close slowly so too much potassium on outside

7. Back to original **Resting Potential**
   - Na^+ channels are closed
   - K^+ channels are closed



Hot or Really Hot?

- How does our brain differentiate between hot and really hot if all AP's have the same intensity and speed?

2 ways:

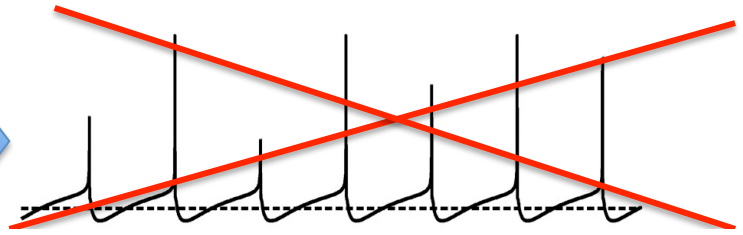
a. The number of neurons that are excited.

Hot = few neurons

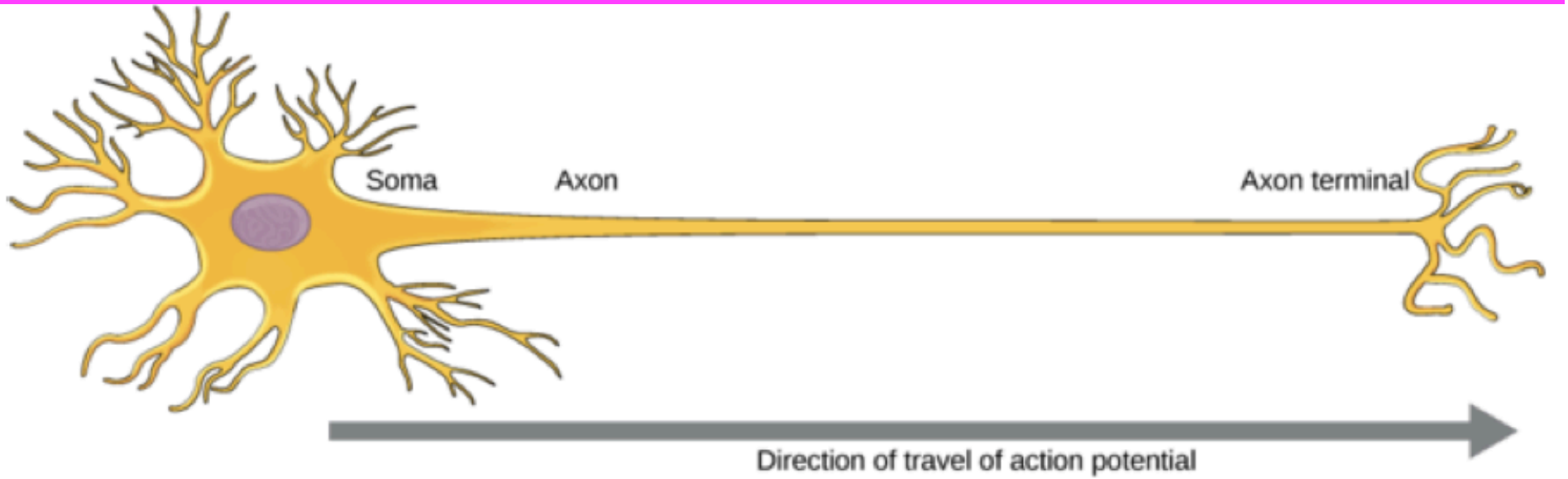
Really Hot = **many** neurons

b. The frequency of action potentials

NO SUCH GRAPH
(A.P.'s should all be the same or not at all



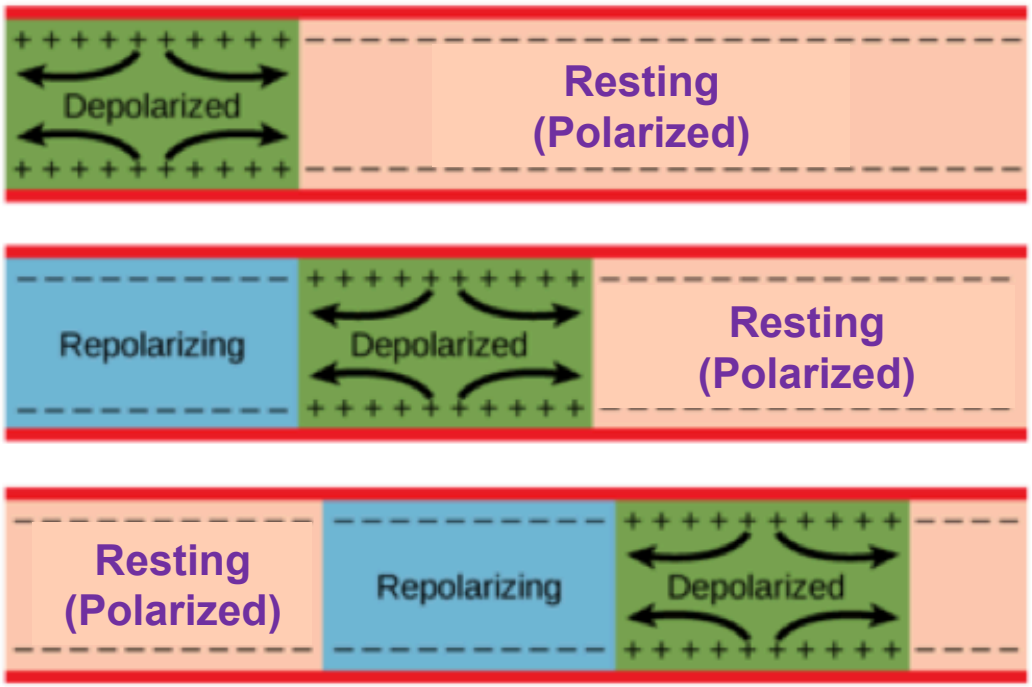
Nerve Impulses



a. In response to a signal, the soma end of the axon becomes depolarized.

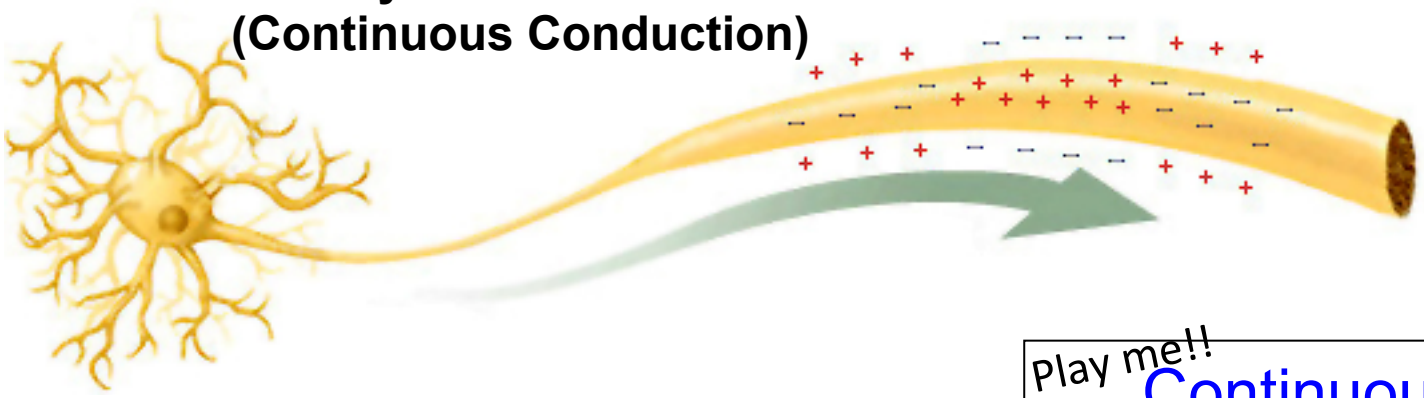
b. The depolarization spreads down the axon. Meanwhile, the first part of the membrane repolarizes. Because Na^+ channels are inactivated and additional K^+ channels have opened, the membrane cannot depolarize again.

c. The action potential continues to travel down the axon.



remember the: Nodes of Ranvier

non-myelinated neuron
(Continuous Conduction)

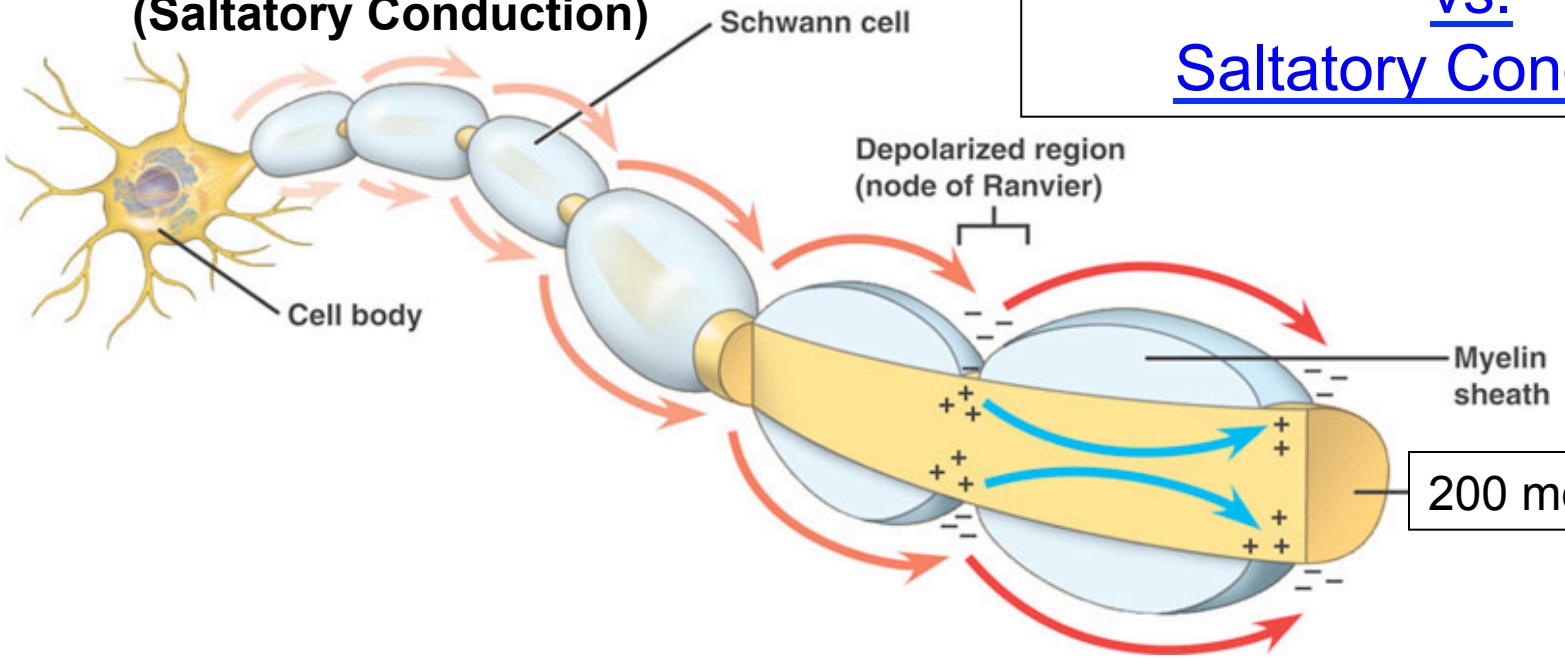


2 meters / second

Play me!!

Continuous Conduction
vs.
Saltatory Conduction

myelinated neuron
(Saltatory Conduction)



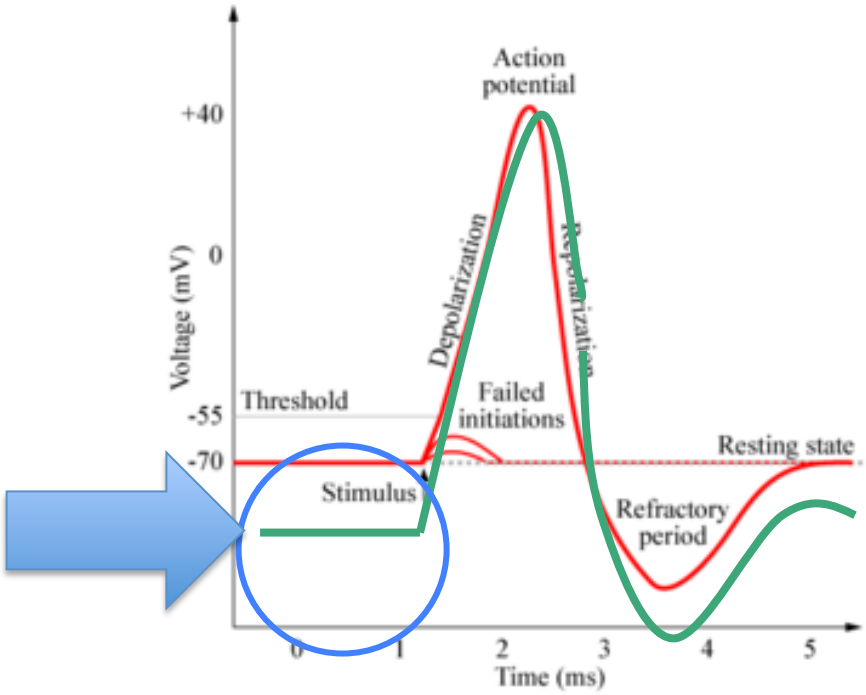
200 meters / second

Inhibitory Drugs?

- Inhibitory drugs will **lower resting potential** making it harder to generate an AP

  (its harder to reach the threshold)

- Alcohol(inhibitory) affects acetylcholine in the brain



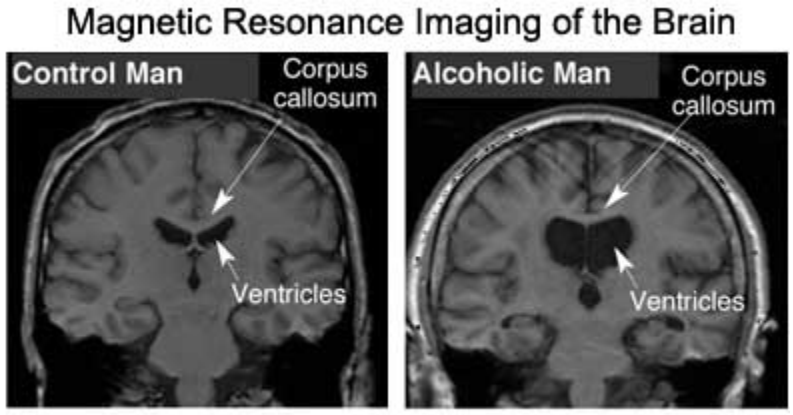
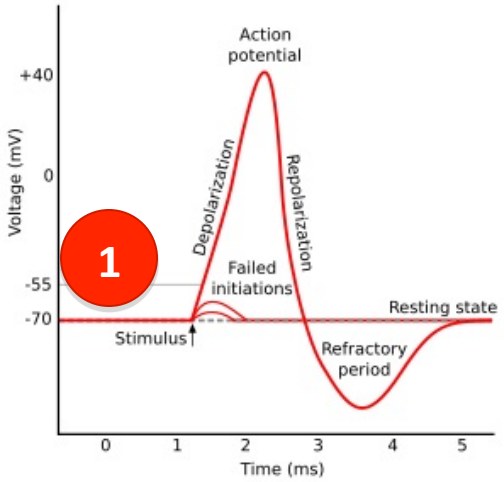


Image courtesy of the National Institute on Drug Abuse

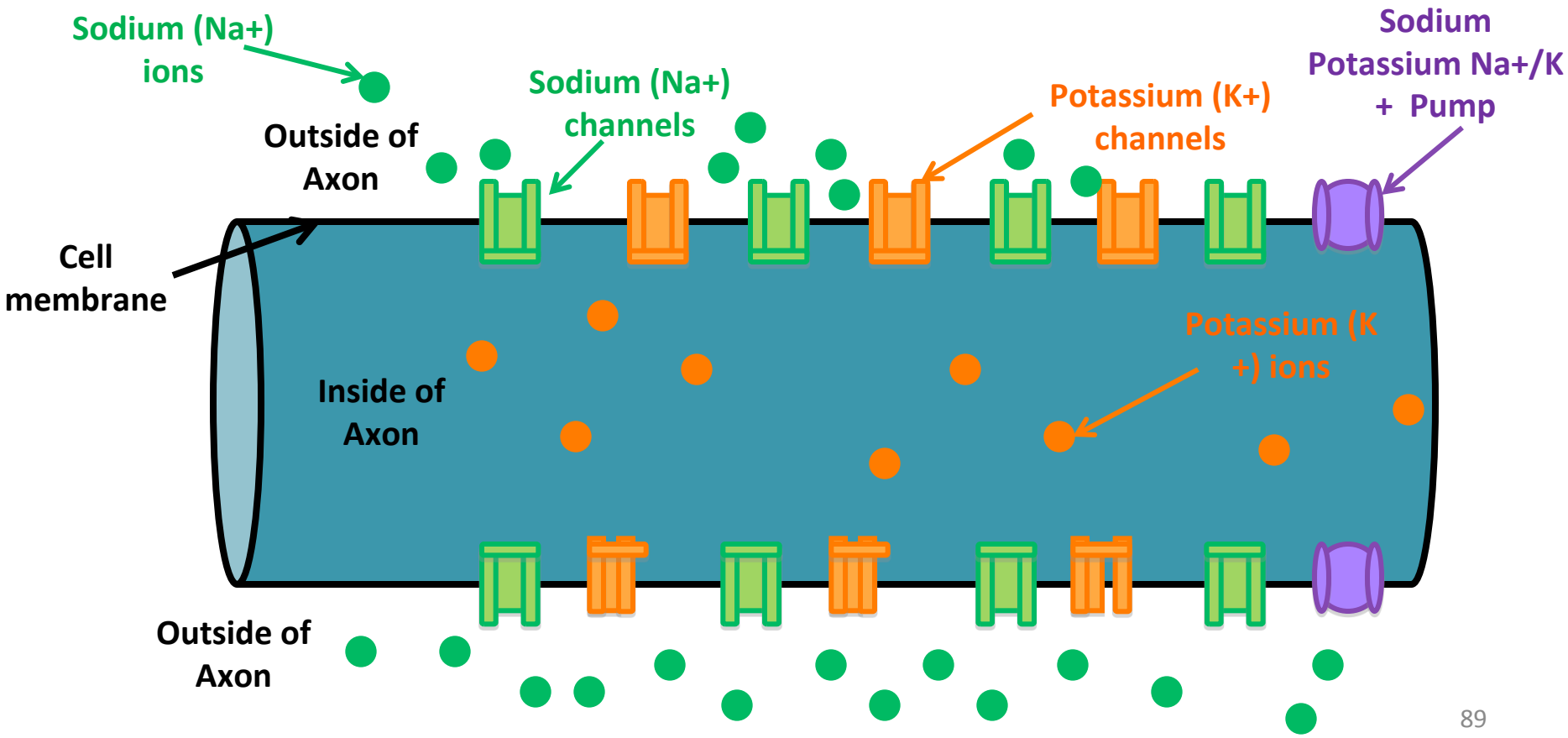
REVIEW

Generating an Action Potential

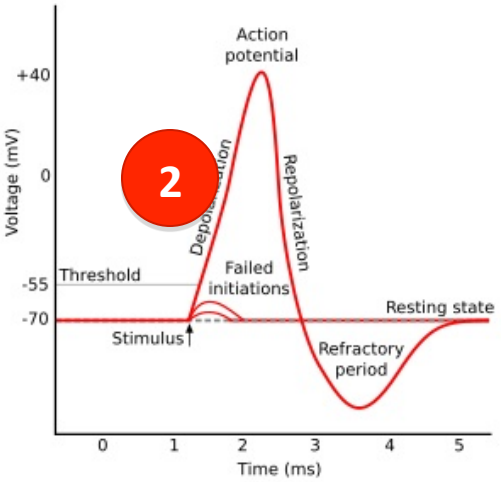


1. **Resting State (Polarized)**

- Voltage activated Na+ and K+ channels are closed
- More Na+ outside relative to K+ inside

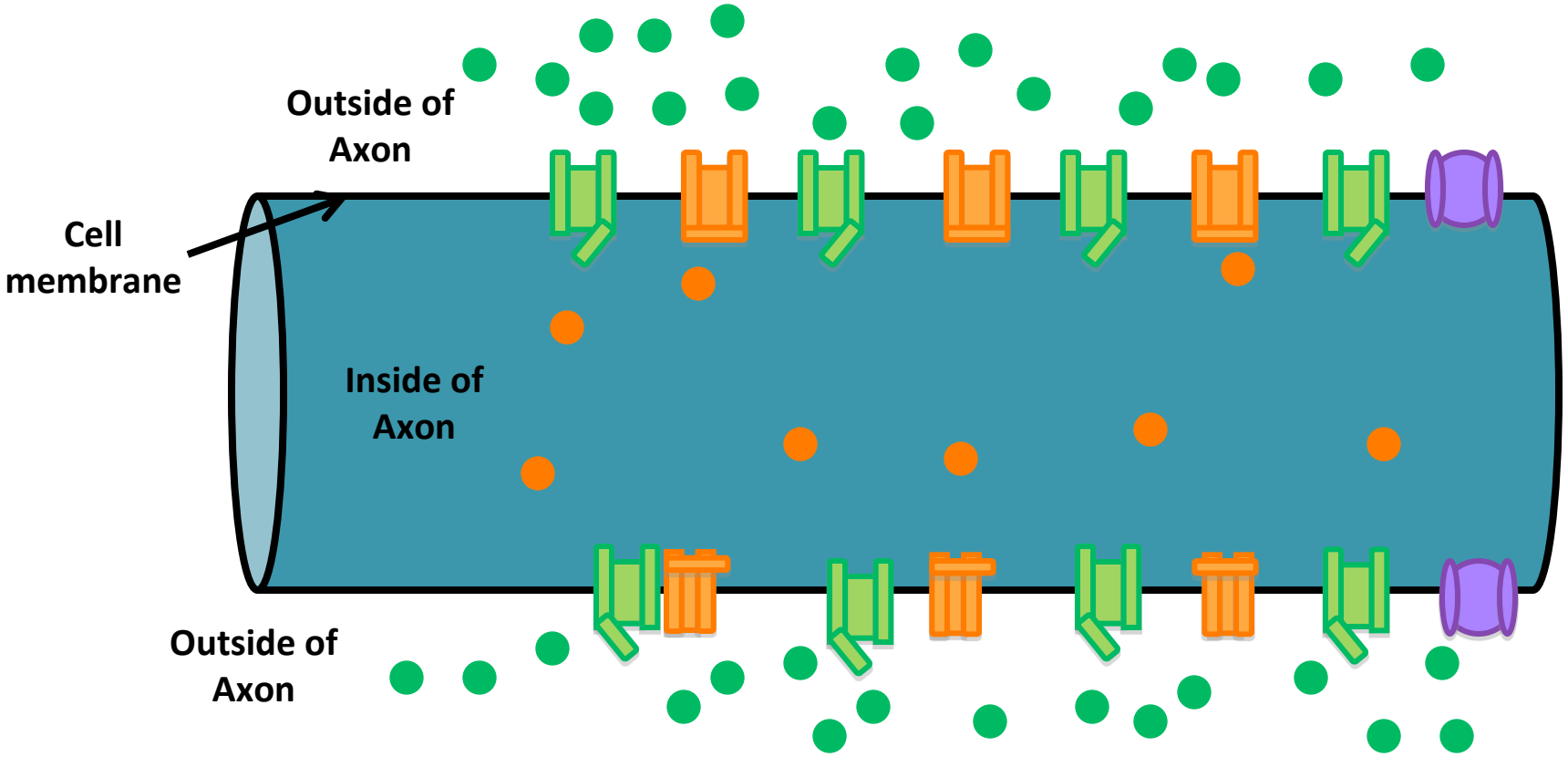


Generating an Action Potential

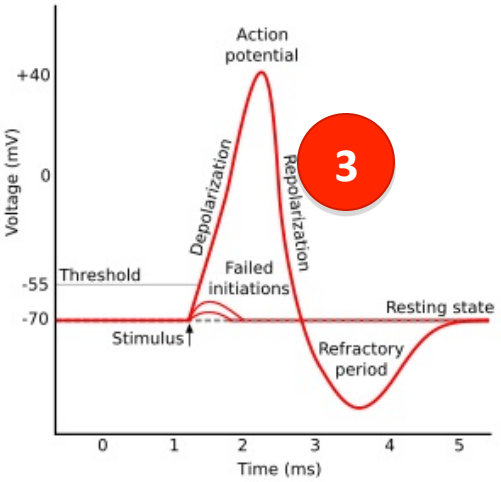


2. Depolarization

- Na+ channels open and sodium **rushes** into neuron
- Inside becomes positive relative to outside

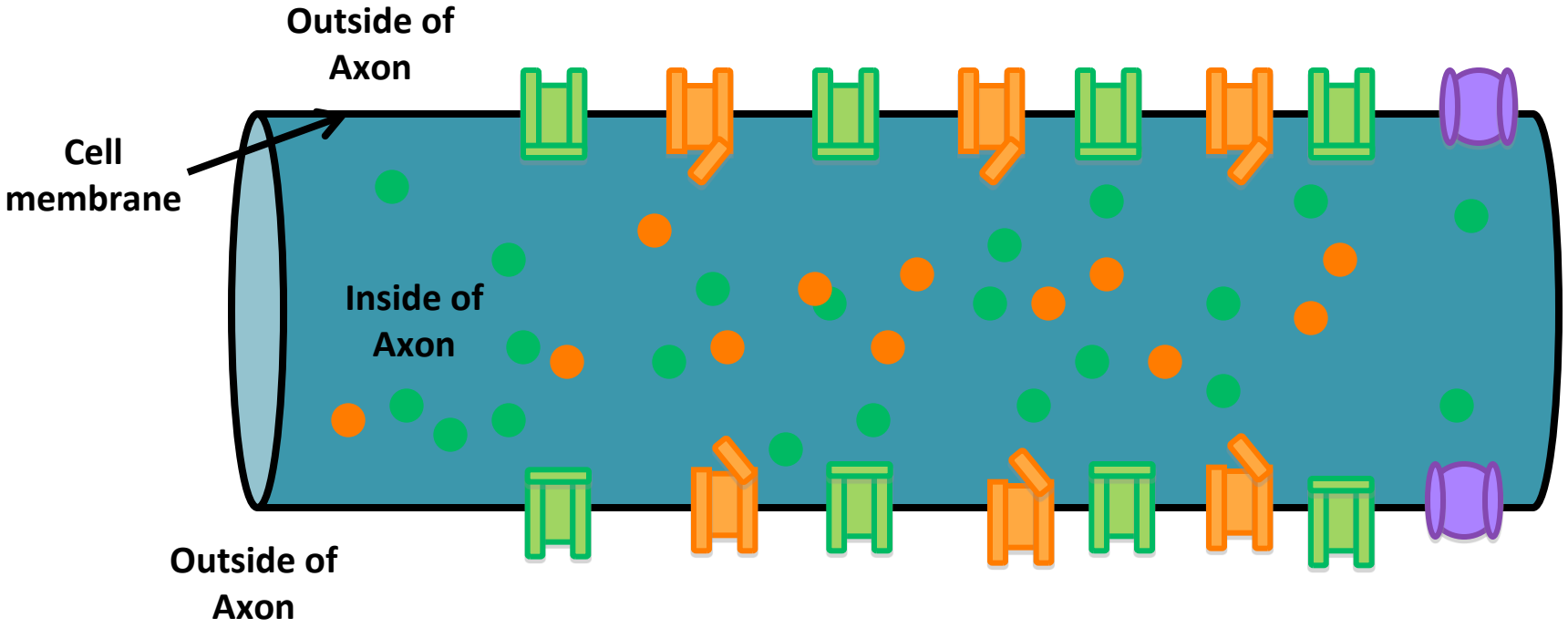


Generating an Action Potential

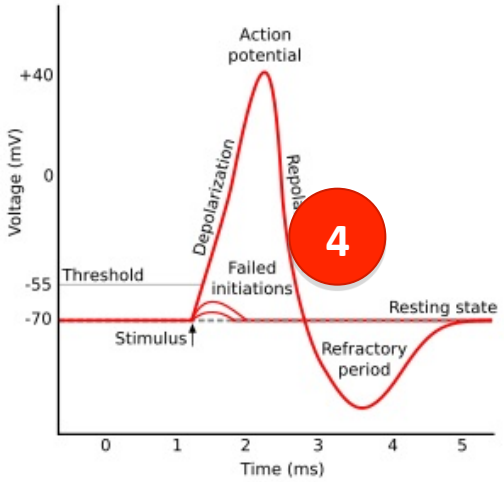


3. Repolarization

- Na+ channels close and K+ channels open;
  K+ ions move out of cell
- Negative charge is restored to inside of the cell

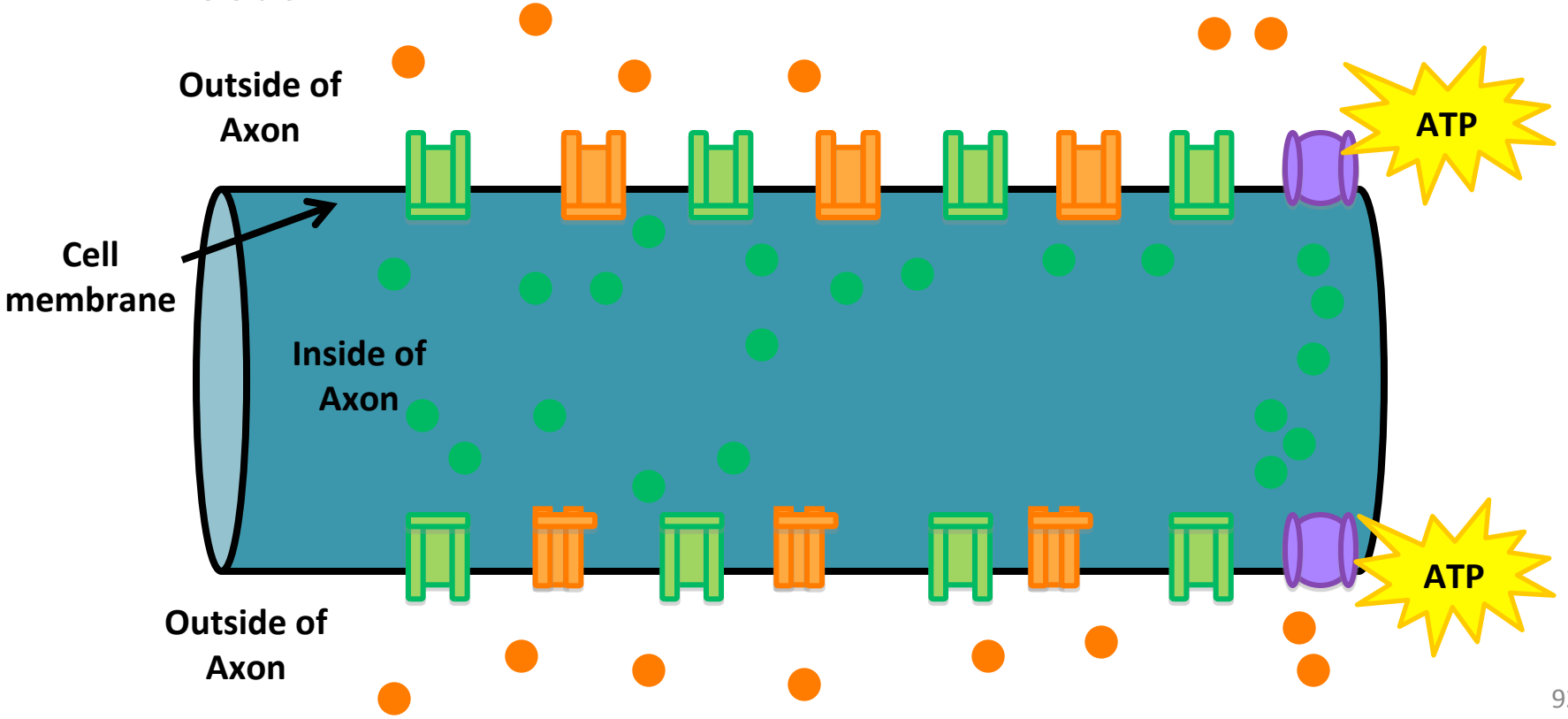


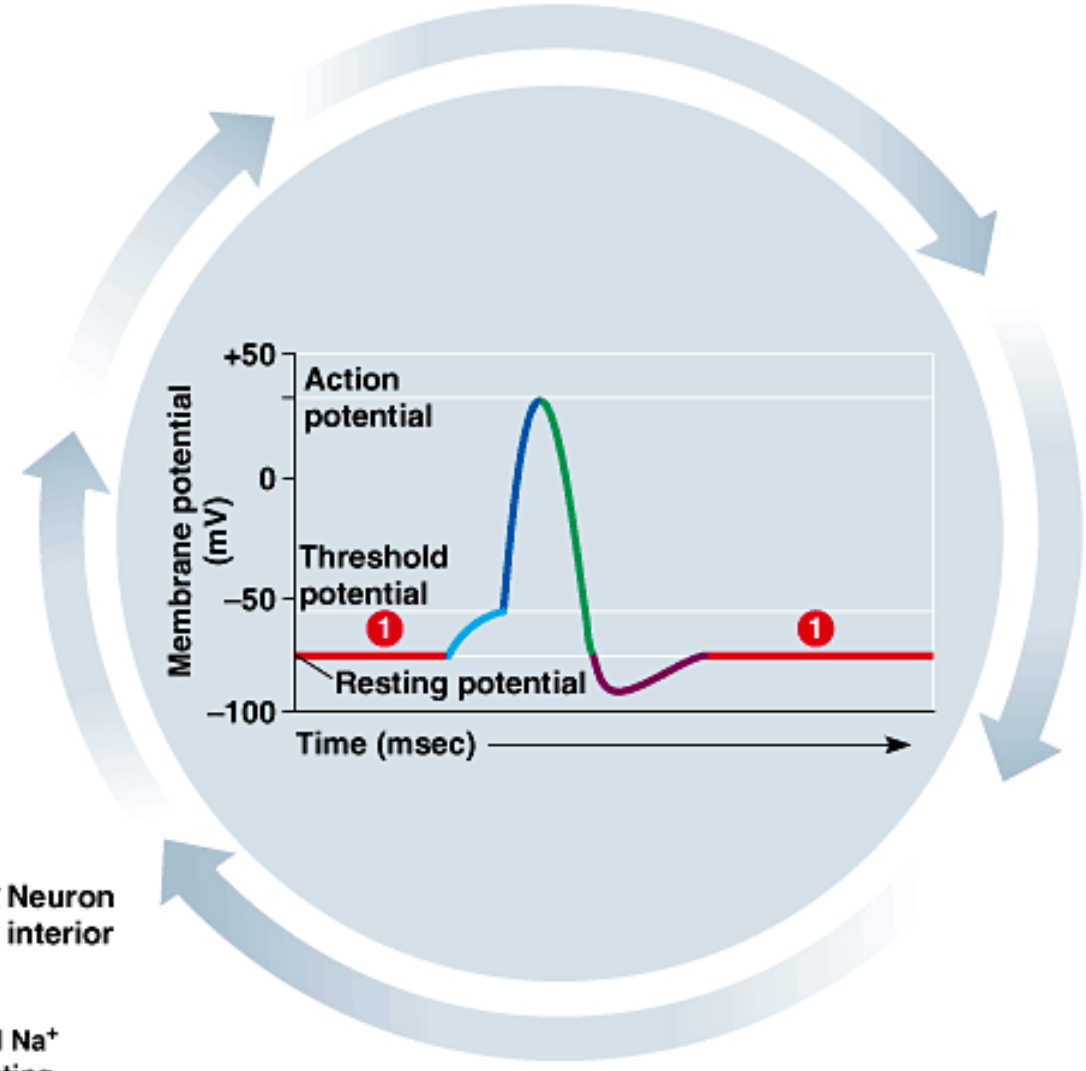
Generating an Action Potential

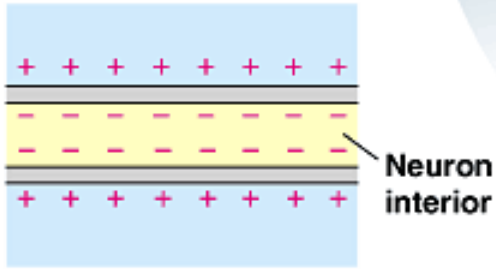


4. Return to Resting State

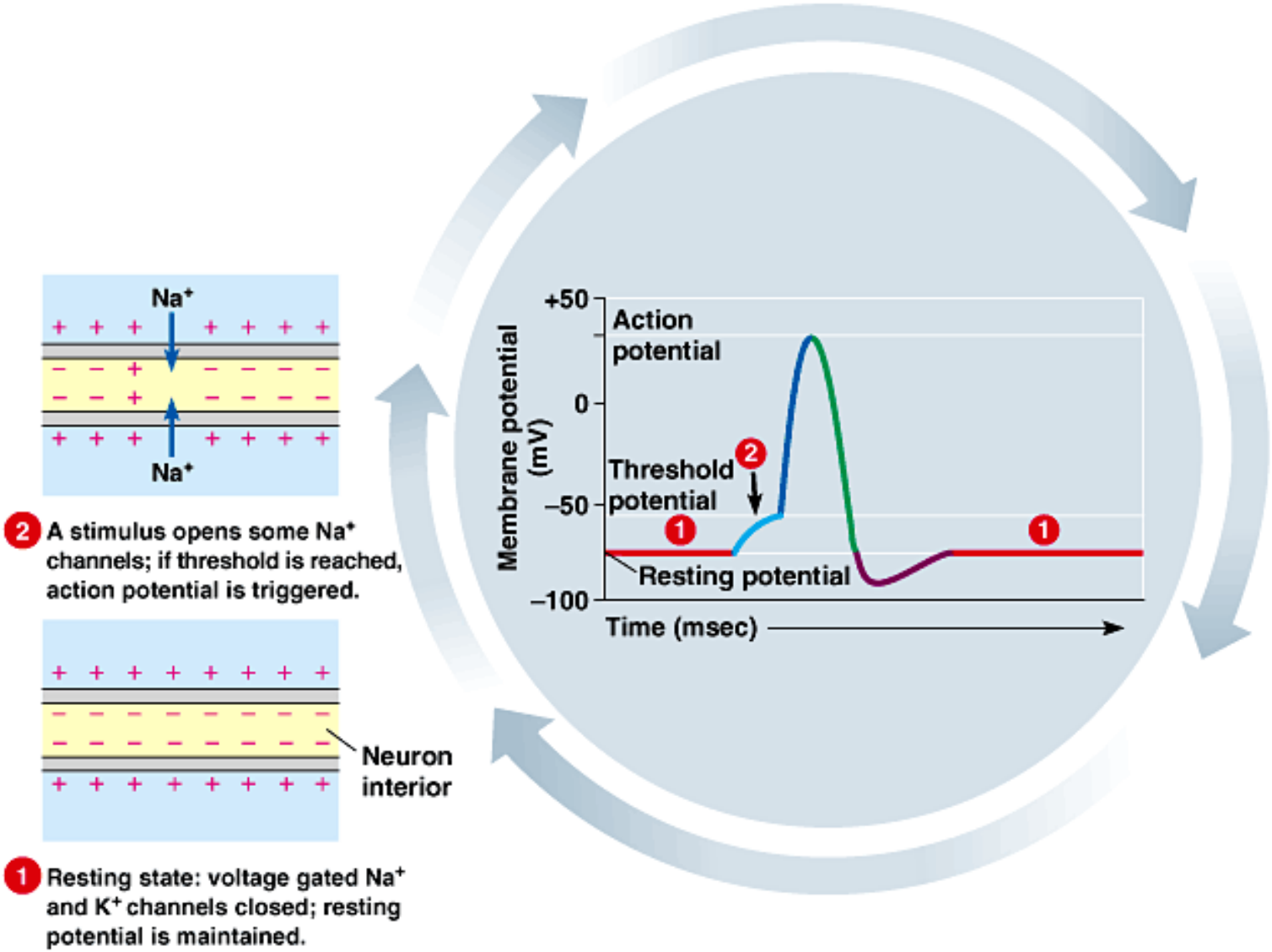
- Na+ and K+ channels close
- Na+/K+ pump restores original concentrations of sodium and potassium (Actively transports 3Na+ out and 2K+ in) → Needs ATP!

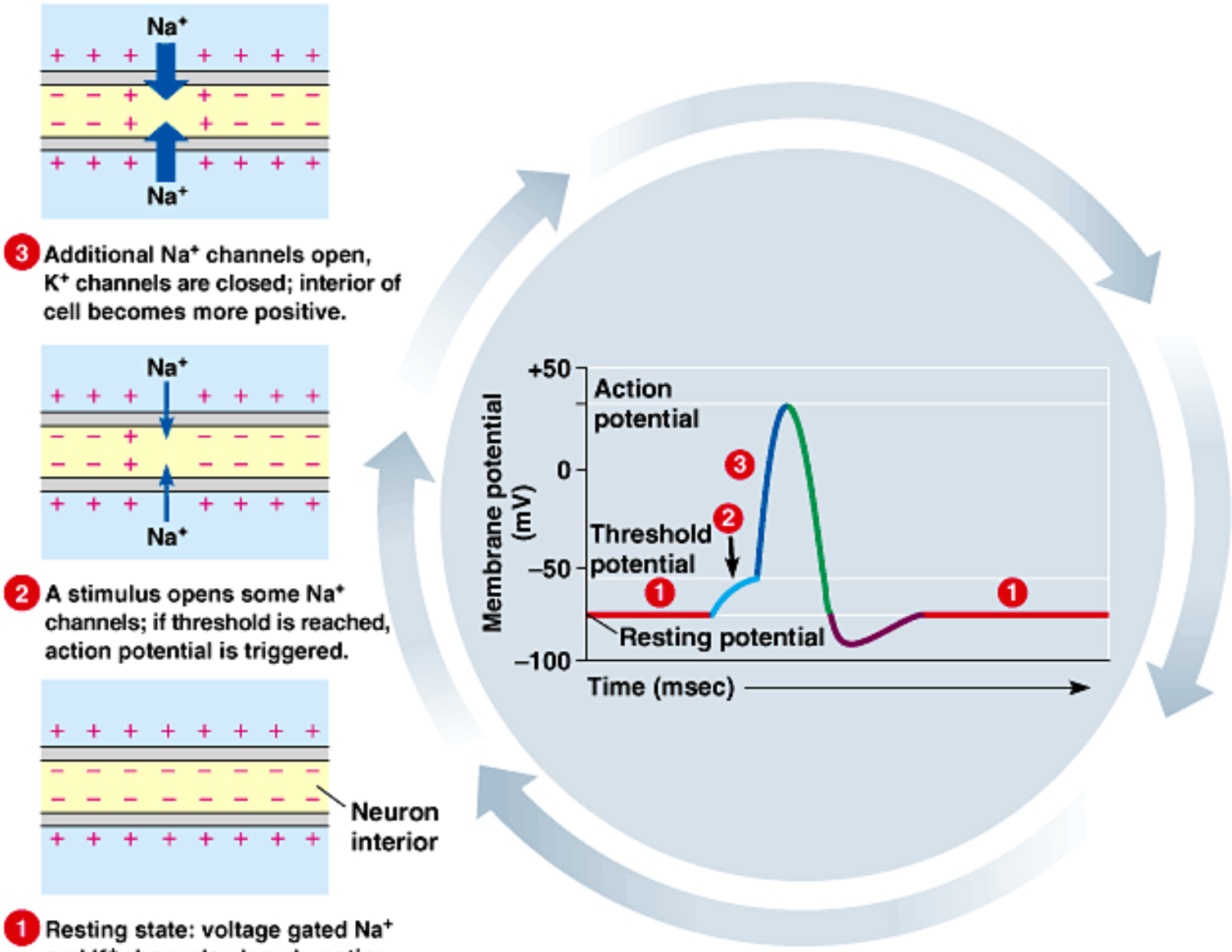


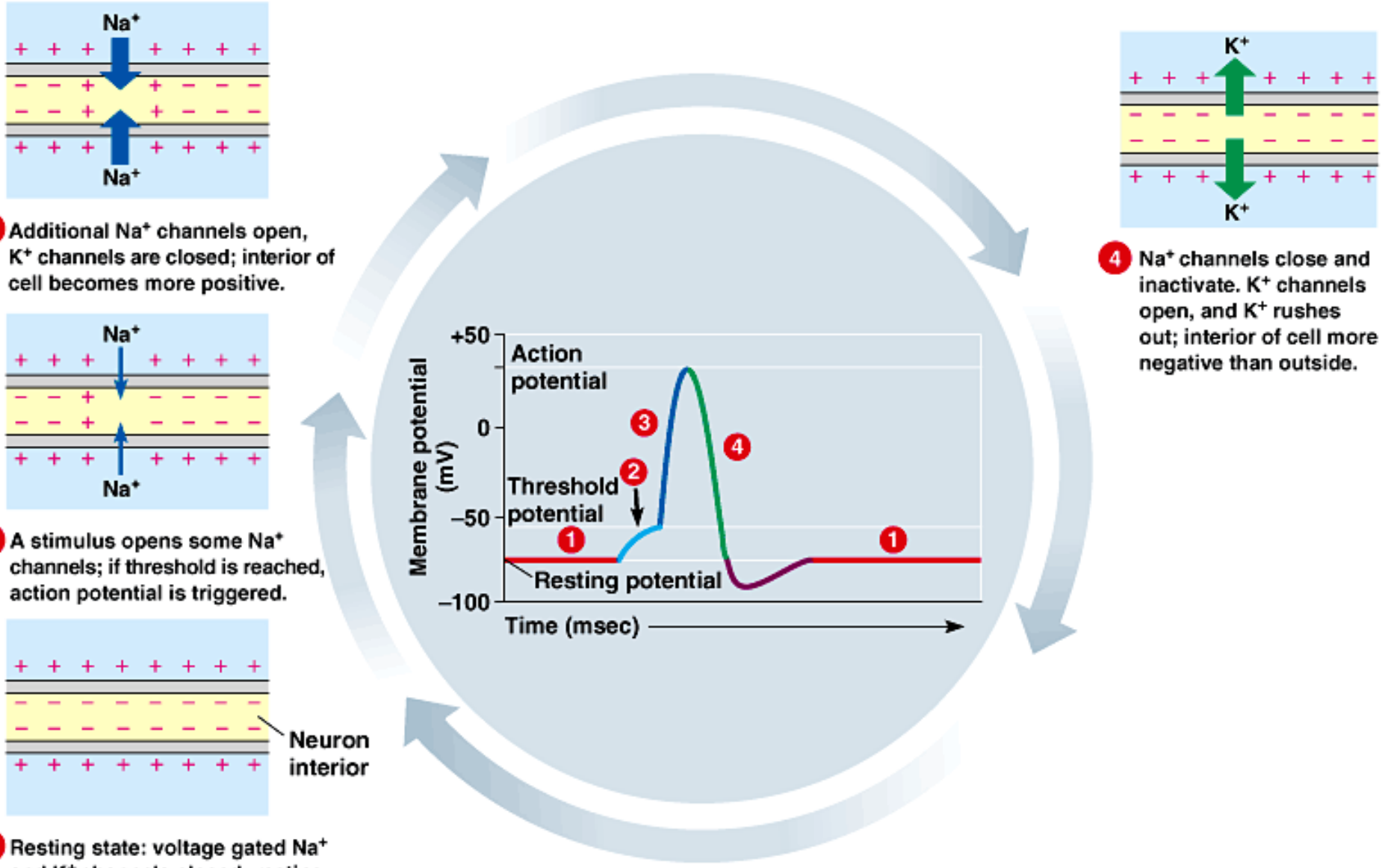


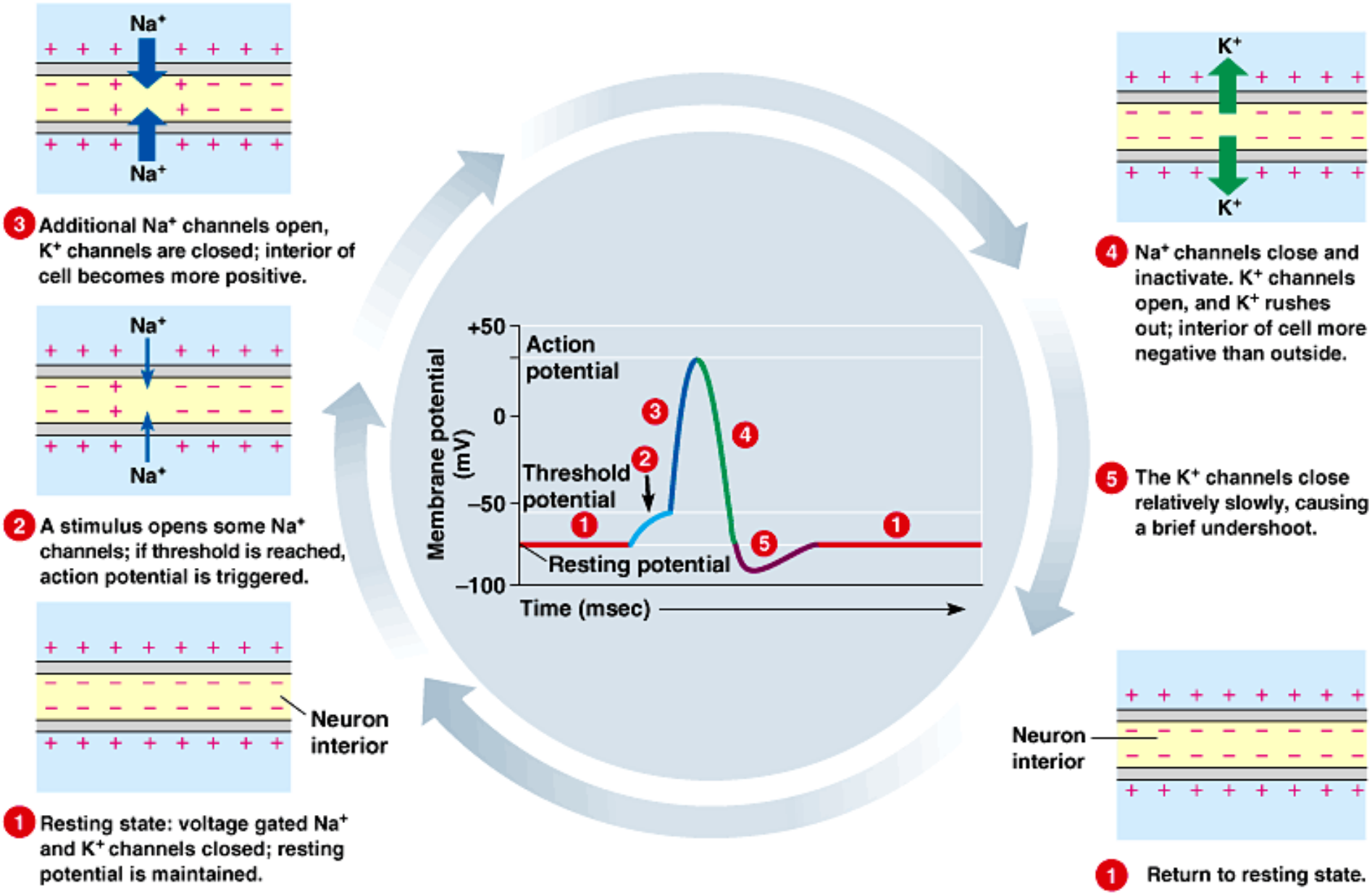


1 Resting state: voltage gated Na^+ and K^+ channels closed; resting potential is maintained.



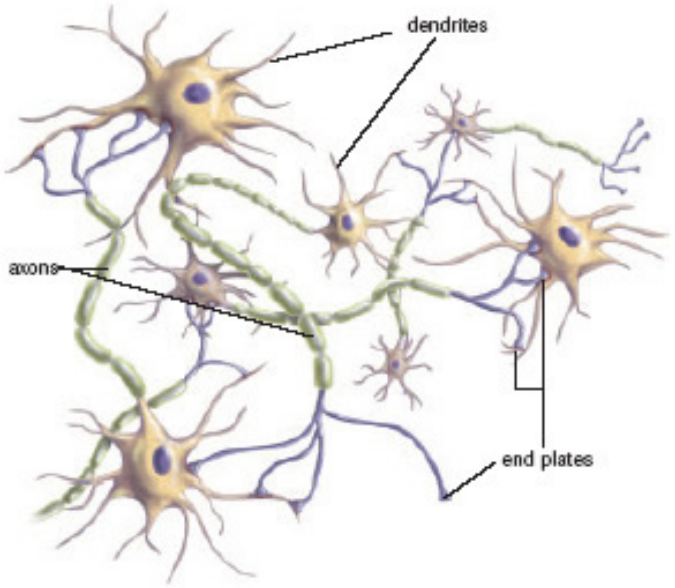






Check Your Understanding

1. Summarize the events that occur as an impulse is propagated along the length of the neuron using diagrams and/ or a flow chart.
2. Why are action potentials only conducted in one direction?
3. Compare the structure and functions of myelinated neurons and unmyelinated neurons.
4. How does myelination of the axon speed up transmission of an action potential?
5. What is the all-or-none response?



Answers

Let's Review…