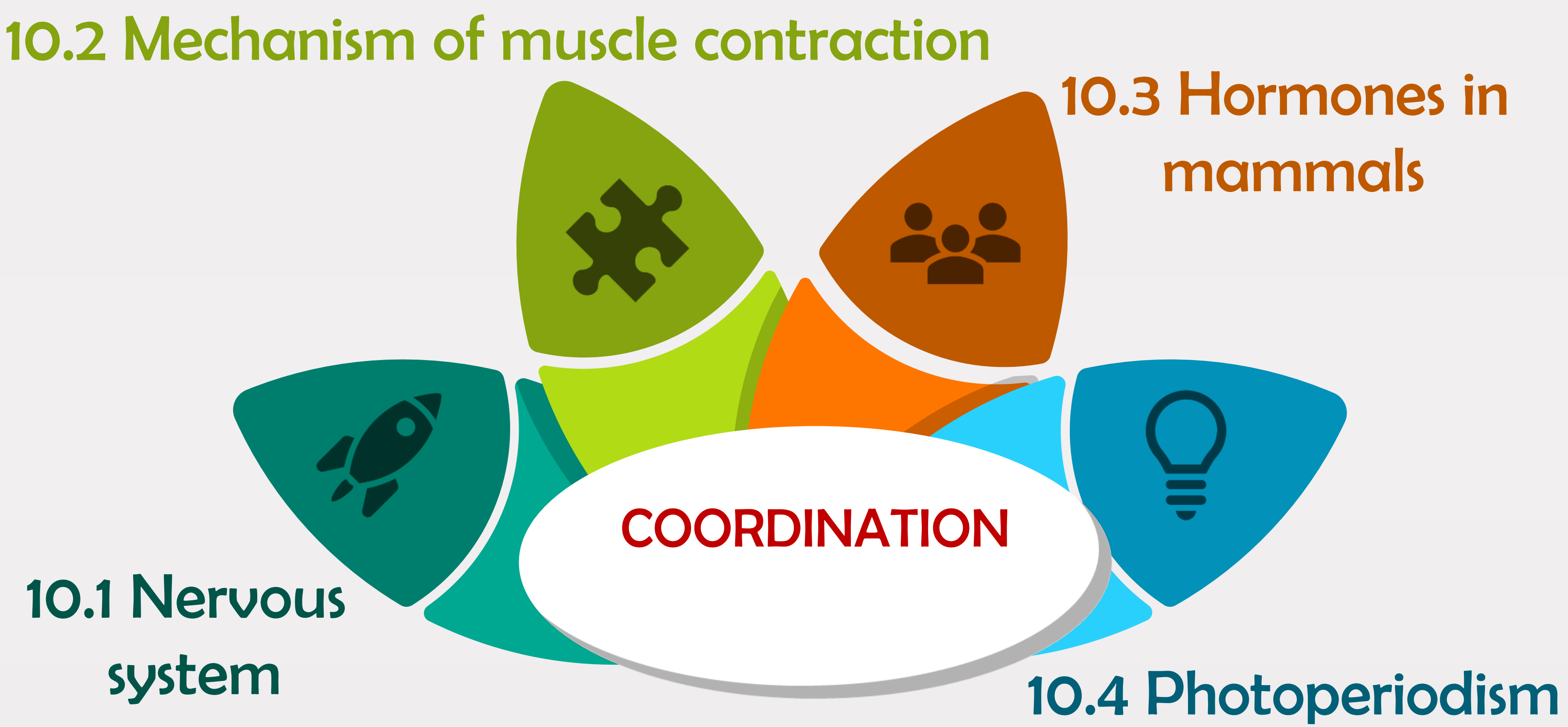
CHAPTER 10 : COORDINATION

OVERVIEW TOPIC COORDINATION



LEARNING OUTCOME 10.1

(a) State the organization of the nervous system

(b) Explain formation of resting and action potential

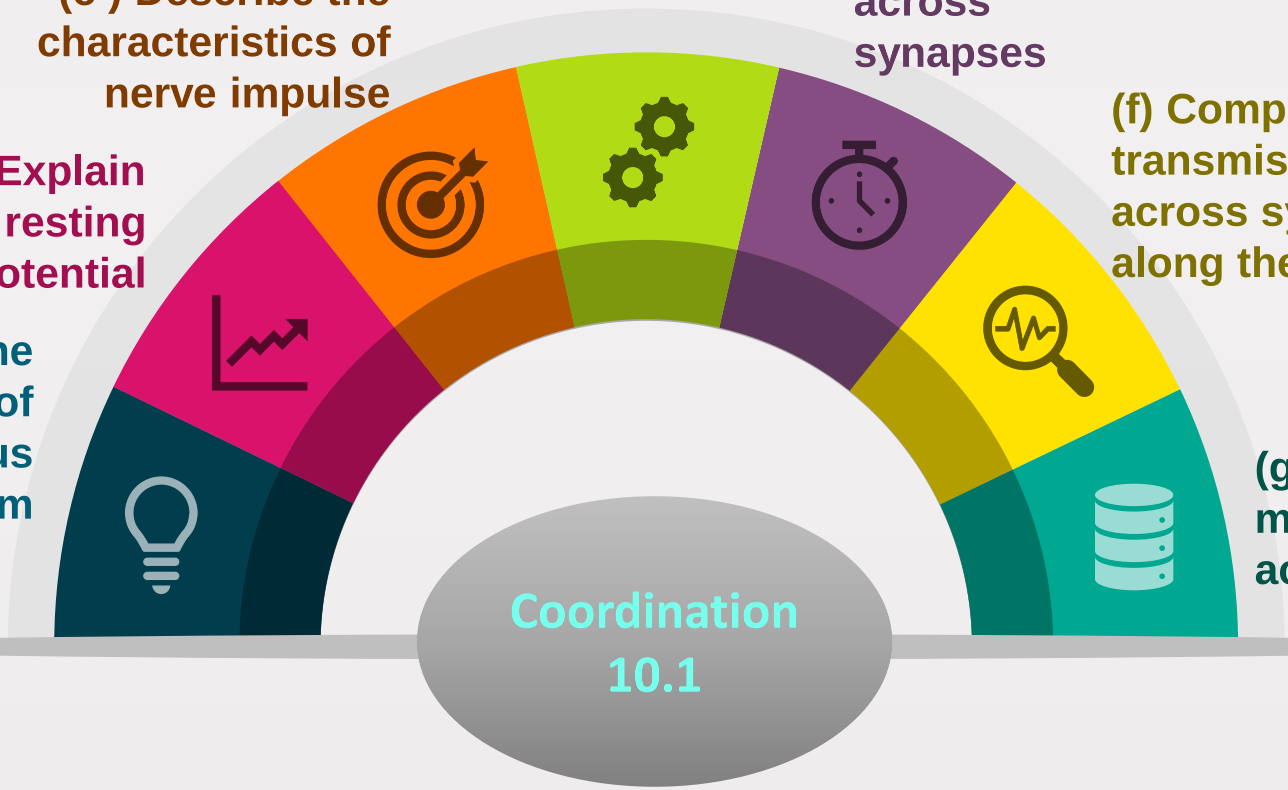
(c) Describe the characteristics of nerve impulse

(d) Describe the structure of synapse

(e) Explain the mechanism of synaptic transmission across synapses

(f) Compare the transmission of impulse across synapse and along the axon.

(g) Explain the mechanism of action of drug



Learning Outcomes 10.2

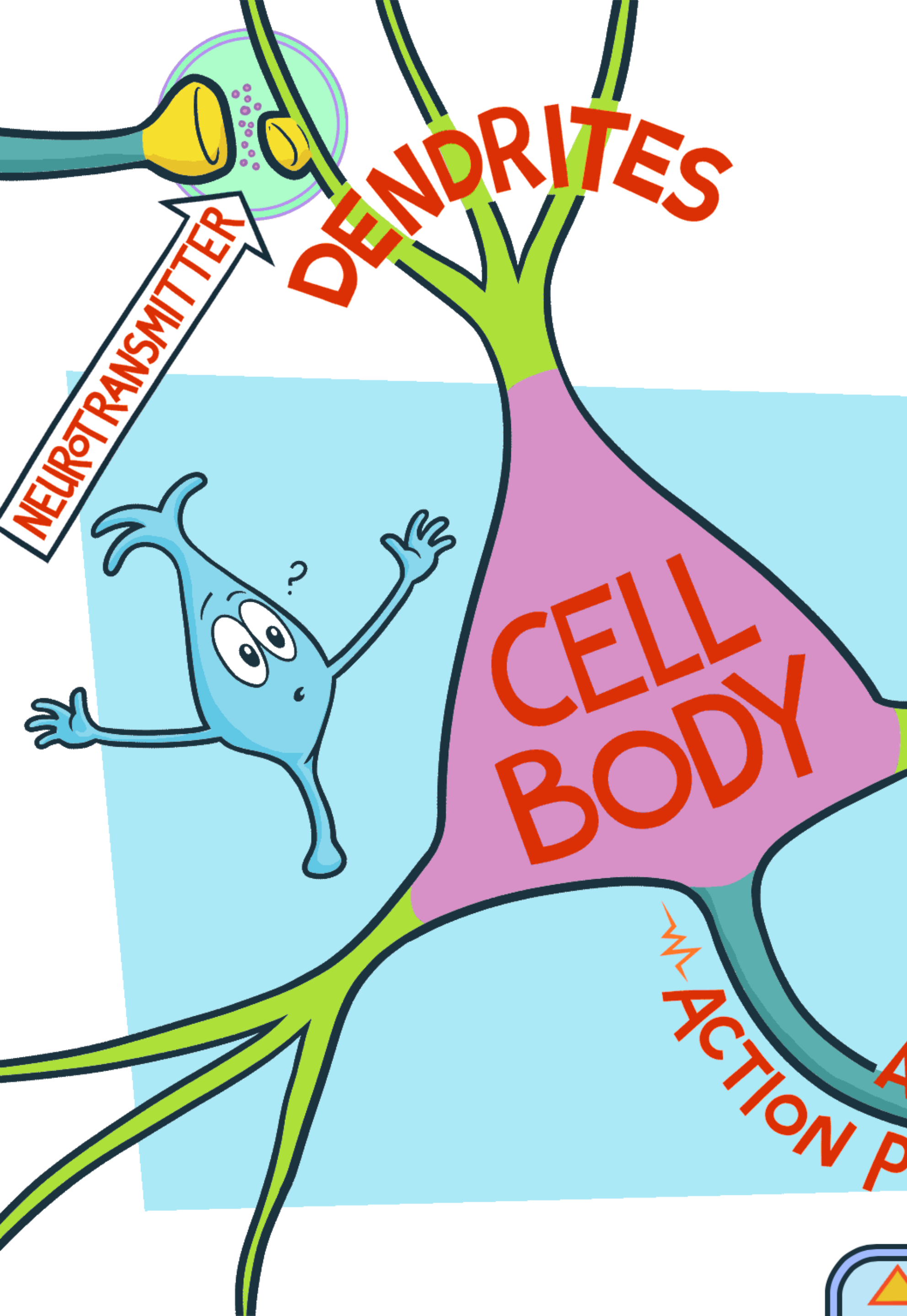
01 Describe the structure of neuromuscular junction

02 Explain impulse transmission at the neuromuscular junction

03 Describe the structure of sarcomere

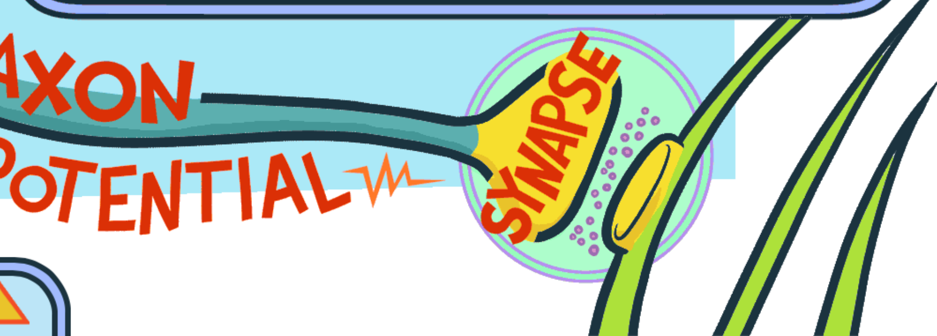
04 Explain the mechanism of muscle contraction based on Sliding filament theory

WHAT IS A NEURON?

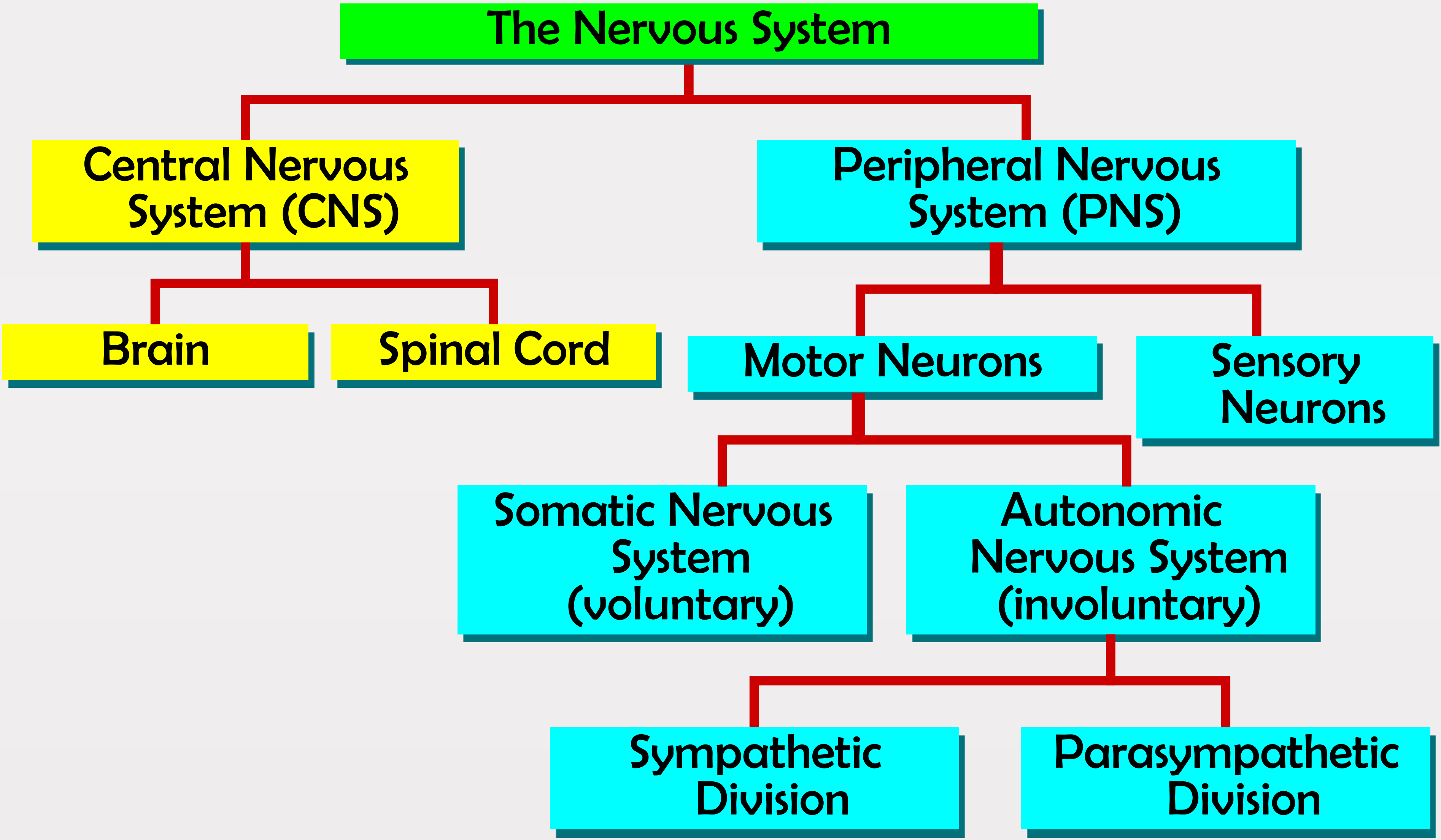


Neuron

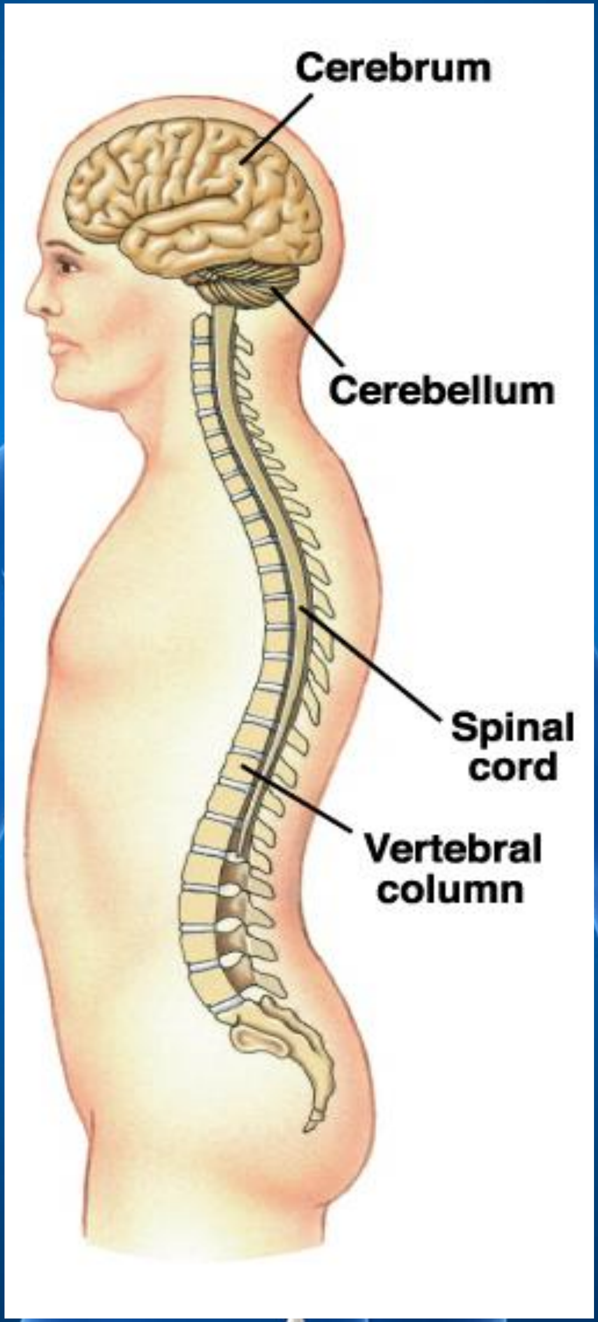
Neurons are the main cells that make up your brain and the rest of the nervous system. Your brain has 100s of billions of neurons! That is around 20 times more than all the people who live on earth! Neurons have special parts like axons, dendrites and synapses that allow them to send messages to each other. You are able to think, feel, act and sense the world around you because you have billions of neurons talking to each other inside your head! Touch on different parts of the neuron to learn what they each do.



10.1 (a)- STATE THE ORGANIZATION OF NERVOUS SYSTEM



Central Nervous System (CNS)

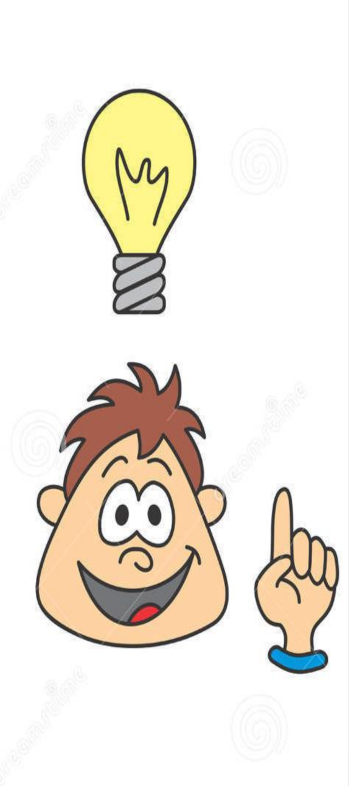


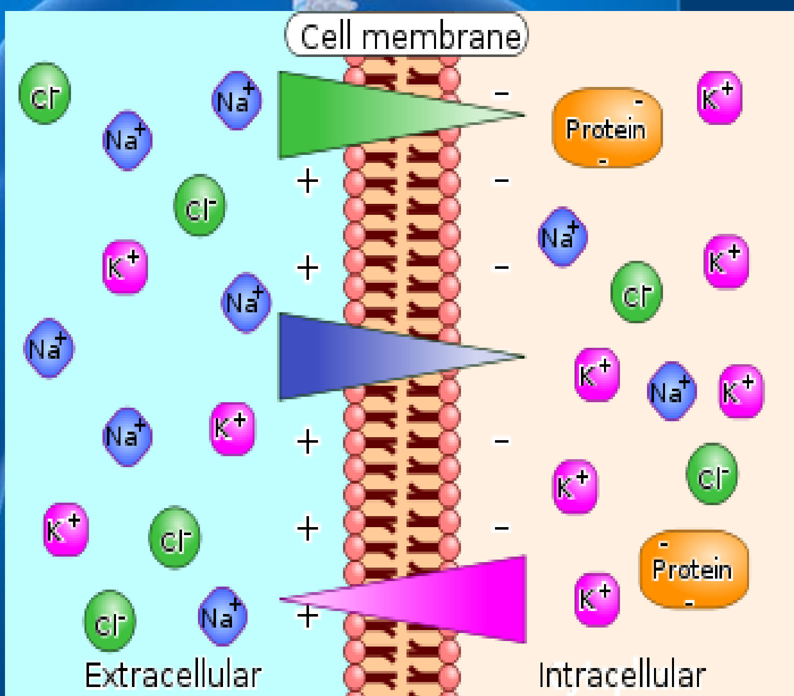
- Receives & processes information
- Initiates action
- Consist of:
  - Brain
  - Spinal cord

10.1 (b) Explain formation of resting and action potential.

TERMINOLOGIES

- Membrane Potential
- Resting Potential
- Action Potential
- Voltage-gated Ion Channel
- Sodium Potassium Pump
- Passive Ion Channel
- Threshold Level
- Depolarization
- Repolarization
- Hyperpolarization



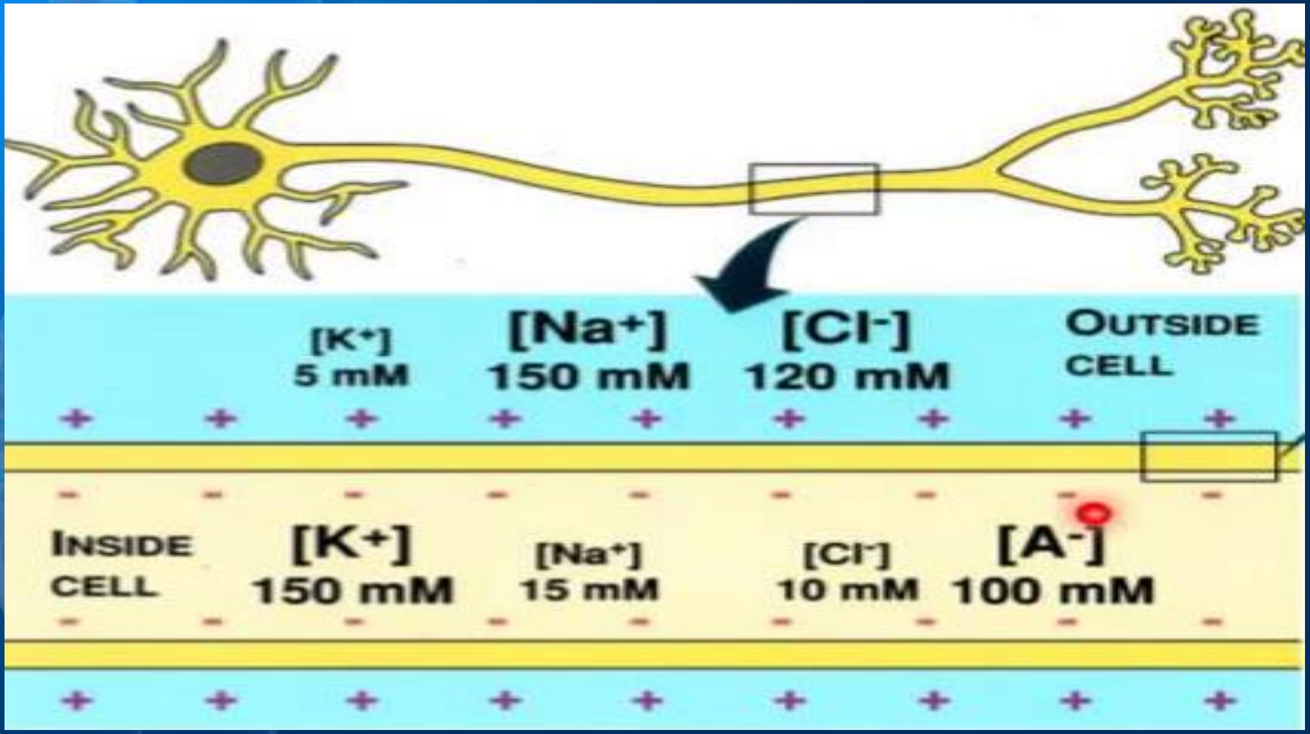


MEMBRANE POTENTIAL

- The difference in electrical charge (voltage) across a cell's plasma membrane due to the differential distribution of ions.
  - (Campbell, 11th Edition)

RESTING POTENTIAL

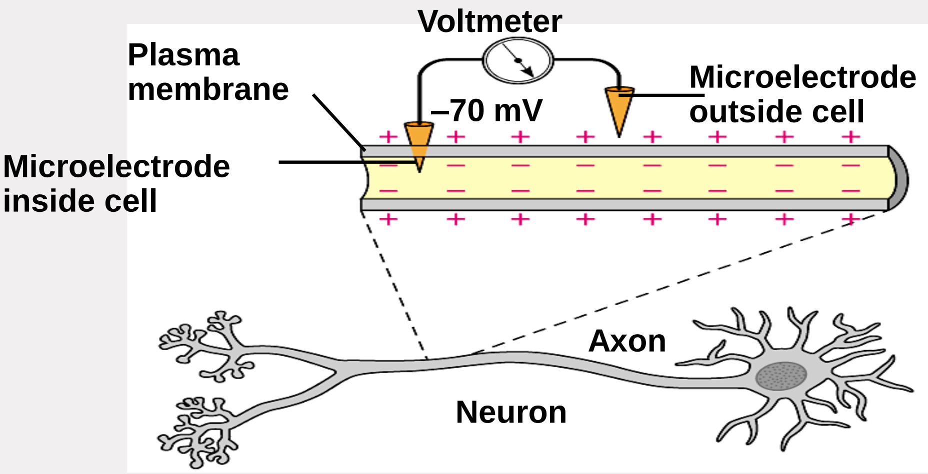
- The membrane potential characteristic of a non conducting excitable cell, with the inside of the cell more negative than the outside.
  - (Campbell, 10th Edition)



RESTING POTENTIAL

- The voltage measured across the plasma membrane is about -70 mV.

- Inside the neurons,
  - Higher K^+ concentration.
  - Lower Na^+ concentration.

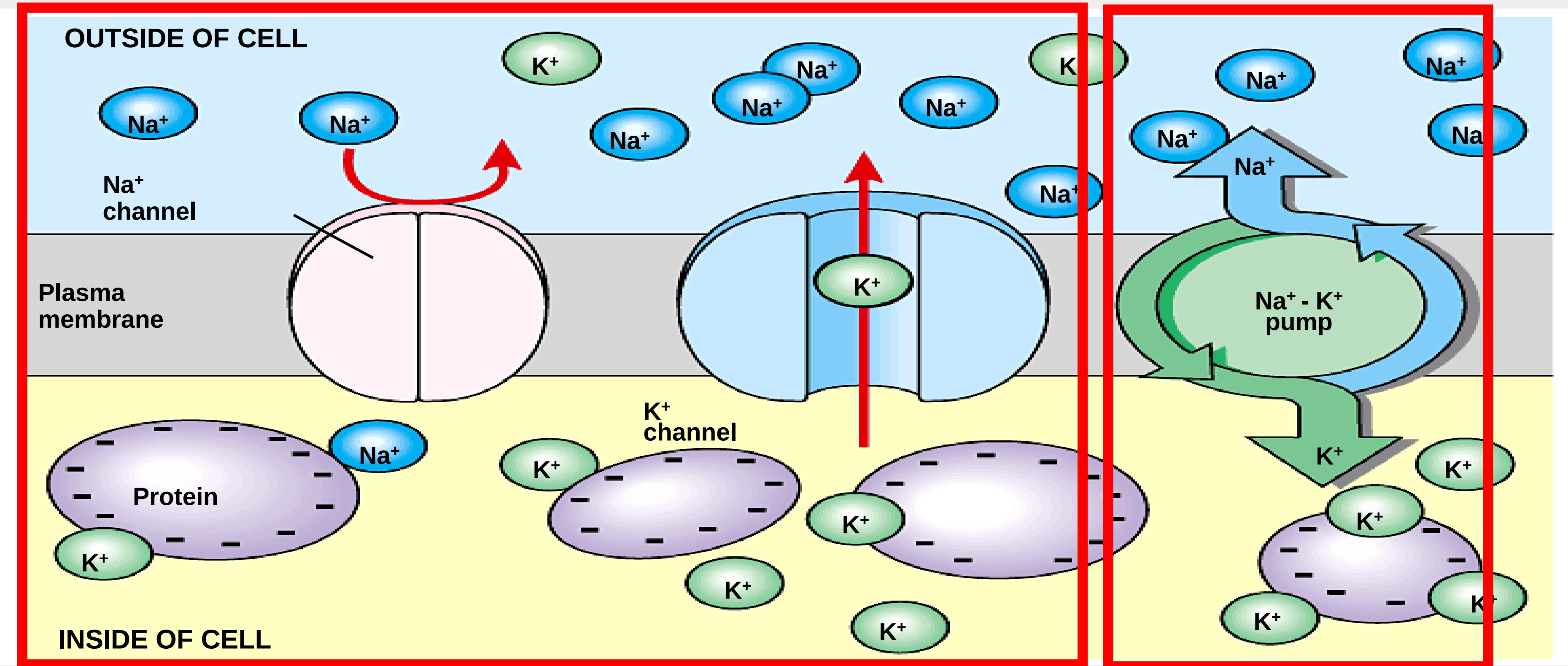


- Outside the neurons,
  - Higher Na^+ concentration.
  - Lower K^+ concentration.

RESTING POTENTIAL IS GENERATED AND MAINTAINED BY:

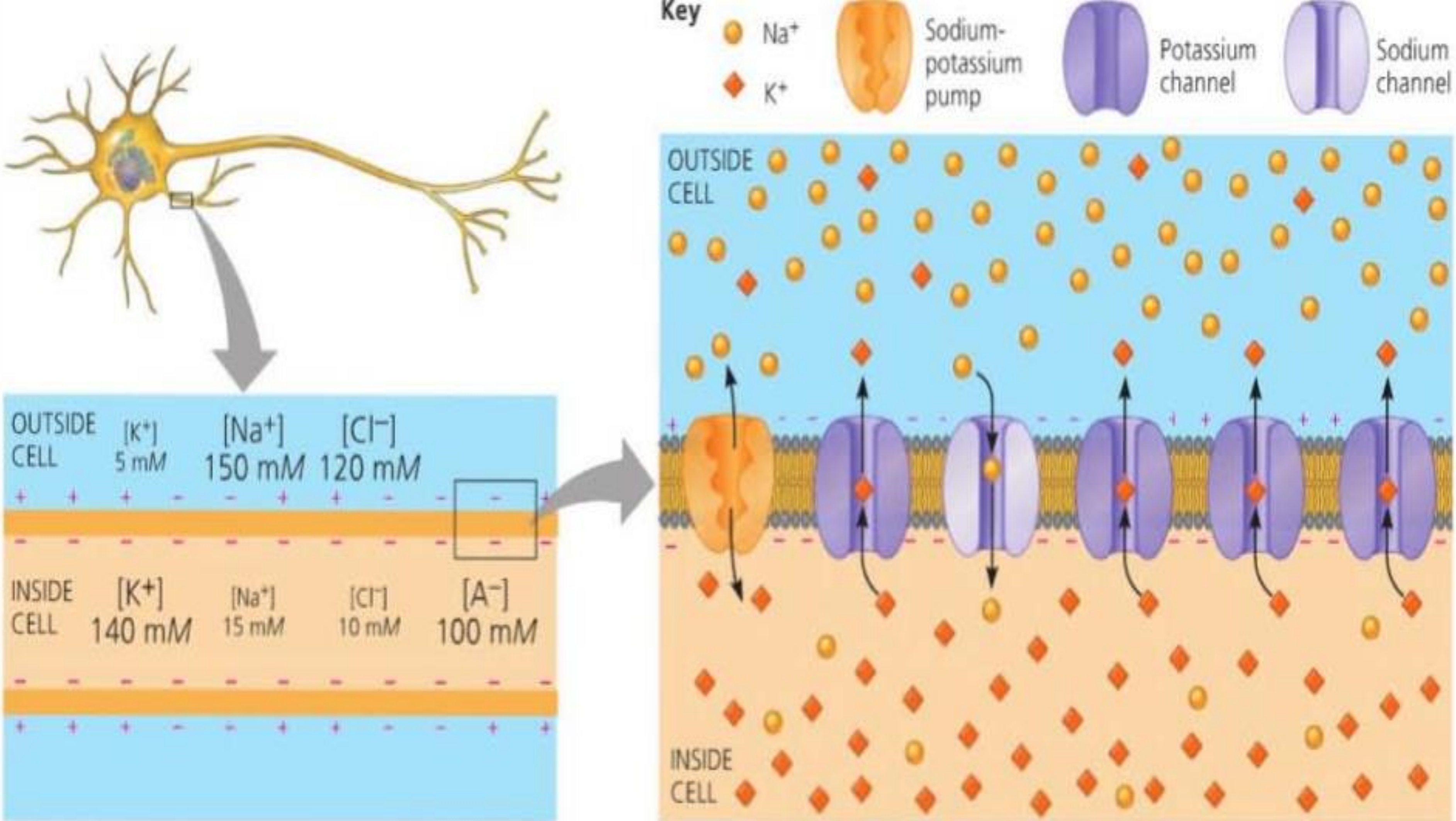
1) **SODIUM-POTASIUM PUMP**	2) **PASSIVE ION CHANNEL**	
	a) PASSIVE POTASSIUM ION CHANNEL	b) PASSIVE SODIUM ION CHANNEL
Active Transport	Passive Transport	
Pump **three Na^+ out of the cell** and **two K^+ into the cell**.	**K^+ diffuse out from the cell**. • Plasma membrane of neuron is **highly permeable to K^+** . • Most common type of passive ion channel. • So, K^+ pumped by sodium-potassium pump into the neuron can diffuse out.	**Slow diffusion of Na^+ into the cell.** • Plasma membrane of neuron is **low permeable to Na^+.** • So, Na^+ pumped out of the neuron by sodium-potassium pump cannot easily pass back into the cell.

RESTING POTENTIAL



Passive Ion Channel

Sodium-potassium pump

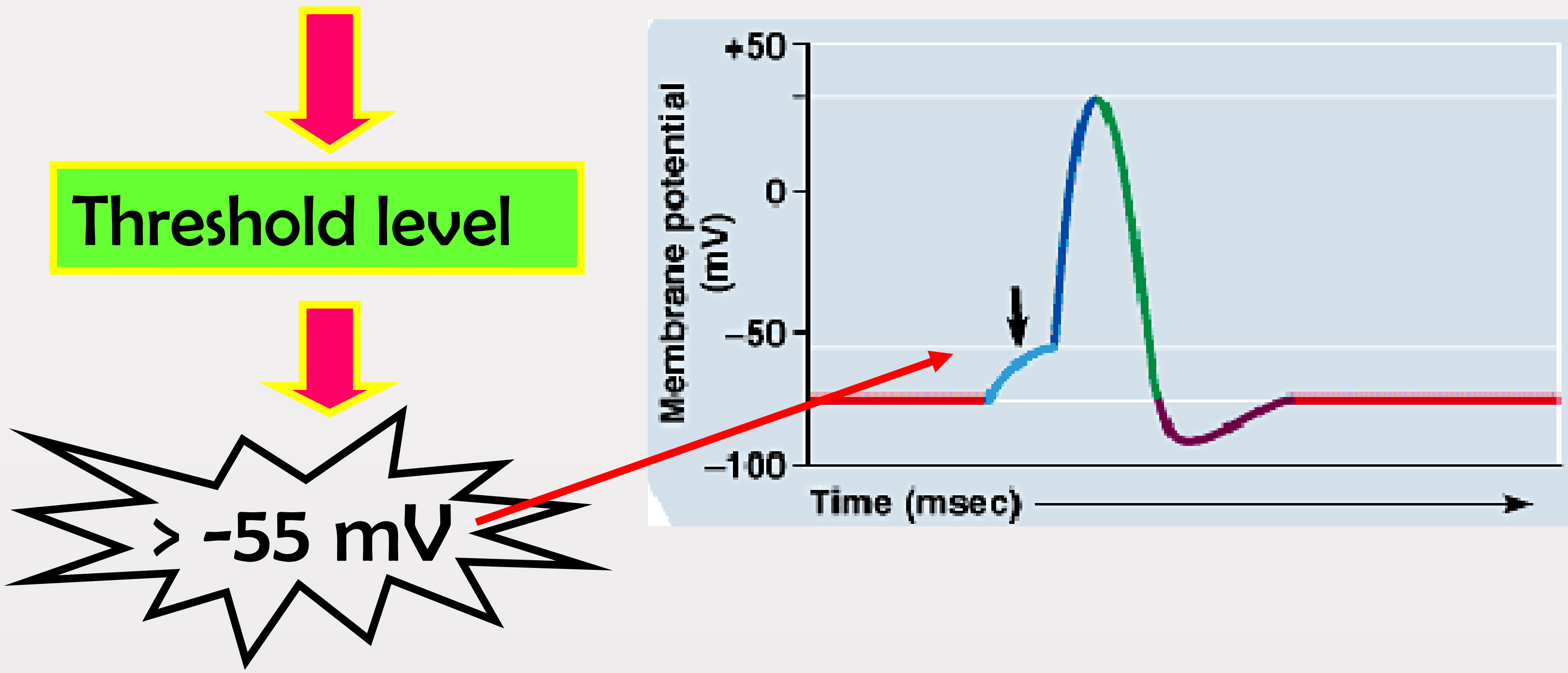


(a) The values shown represent the approximate concentrations in millimoles per liter (m*M*) for ions in the fluids within and surrounding a mammalian neuron: $[K^+]$ = potassium concentration; $[Na^+]$ = sodium concentration; $[Cl^-]$ = chloride concentration; and $[A^-]$ = other anions.

(b) The sodium-potassium pump generates and maintains the ionic gradients of Na^+ and K^+ shown in (a). The pump uses ATP to actively transport Na^+ out of the cell and K^+ into the cell. Although there is a substantial concentration gradient of sodium across the membrane, very little net diffusion of Na^+ occurs because there are very few open sodium channels. In contrast, the large number of open potassium channels allow a significant net outflow of K^+. Because the membrane is only weakly permeable to chloride and other anions, this outflow of K^+ results in a net negative charge inside the cell.

ACTION POTENTIAL

An action potential is generated when the voltage reaches a certain critical point.



	Depolarization		Repolarization	Hyperpolarization
	After received stimulus (before threshold level)	Above threshold level		
Voltage-gated sodium channel	Some **OPEN**	Mostly **OPEN**	Close	Close
Voltage-gated potassium channel	Close	Close	**OPEN**	Slowly Close
Movement of ions	Na^+ diffuse into the cell	More Na^+ diffuse into the cell	K^+ diffuse out from the cell	Excess K^+ diffuse out from the cell
Membrane potential	Become positive	Become more positive	Become negative	Become more negative

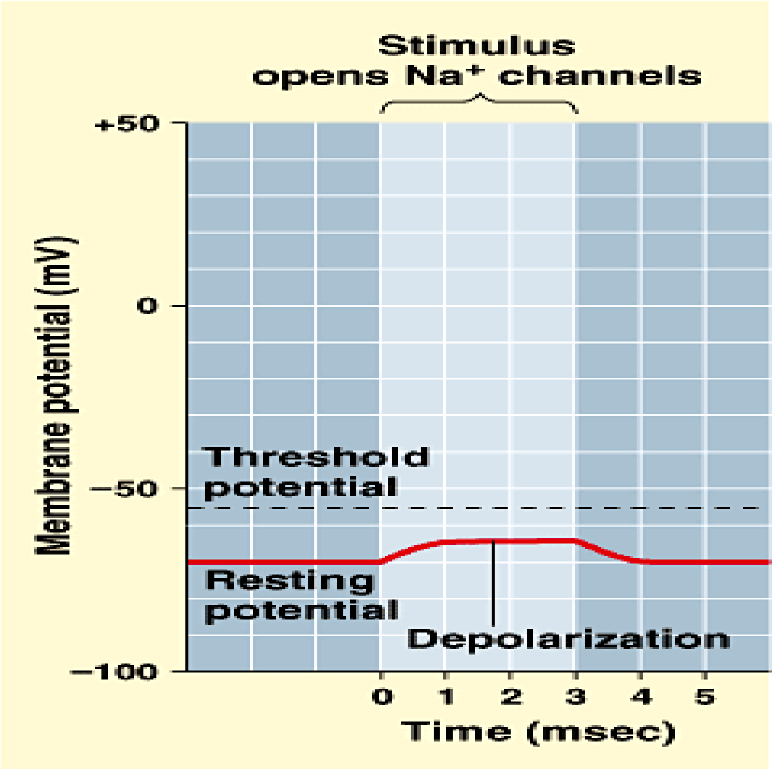
10.1 (c) DESCRIBE THE CHARACTERISTICS OF NERVE IMPULSE

01
1. ALL OR NONE EVENT

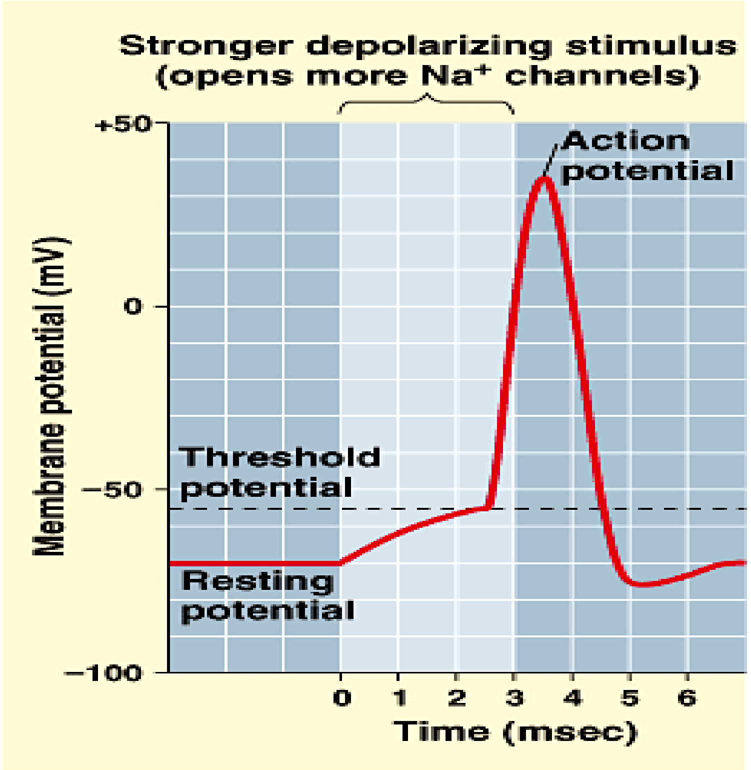
02
2. THE REFRACTORY PERIOD

03
3. SPEED OF CONDUCTION

1- ALL OR NONE EVENT



(b) Graded potential:
depolarization



(c) Action potential

Below threshold level

- No action potential triggered

Above threshold level

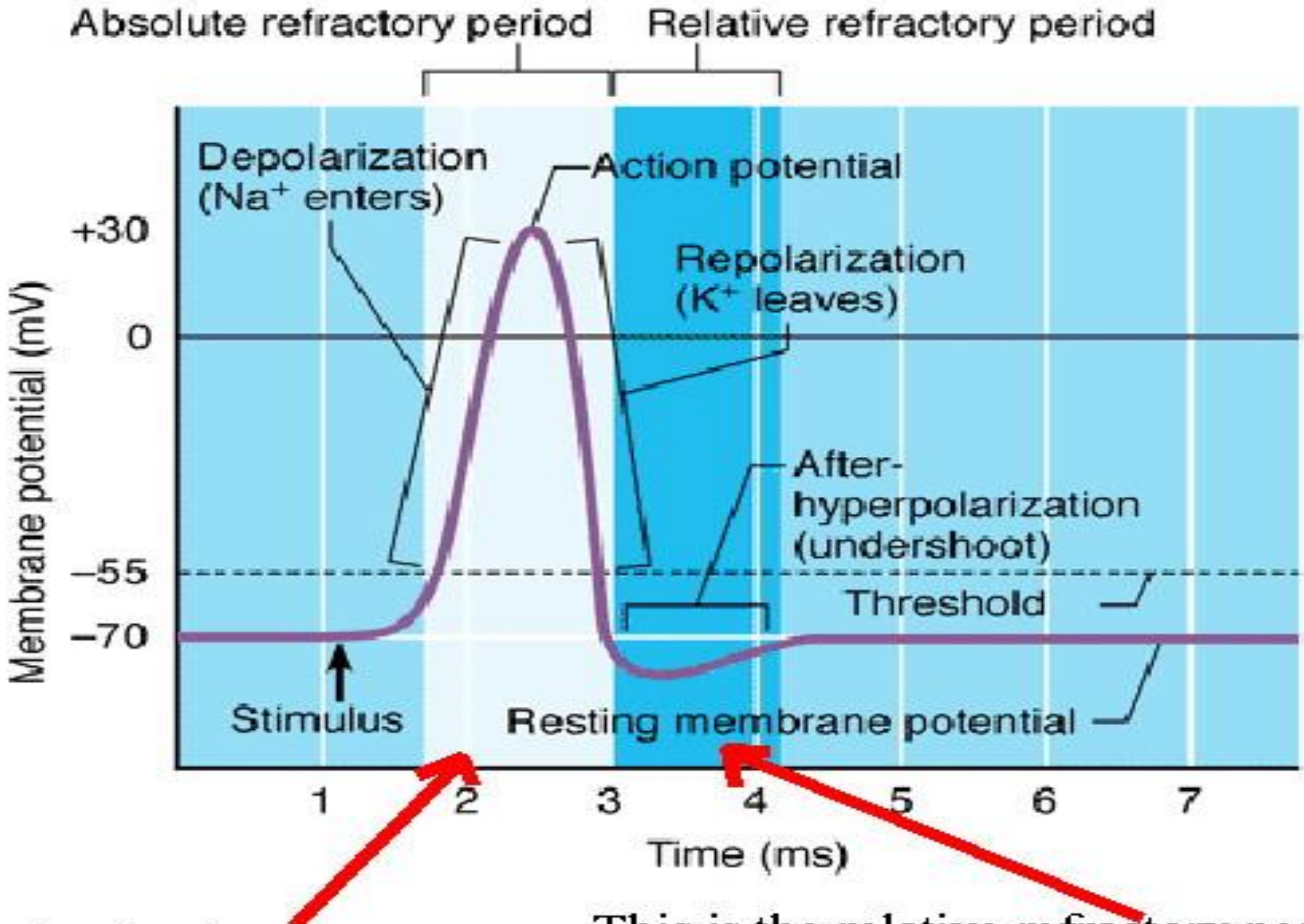
- Action potential triggered

2- REFRACTORY PERIOD

The short time immediately after an action potential in which the neuron cannot respond to another stimulus. (Campbell, 10^{th})

Can be divided into 2:

1. Absolute refractory period
2. Relative refractory period



This is the absolute refractory period, when the muscle cannot be stimulated because it is depolarized.

This is the relative refractory period, when the membrane is hyperpolarized and requires a greater than normal stimulus.

Analogy…

Imagine….In the toilet….

When you pull the handle, water floods the bowl.

Takes a couple of seconds and you cannot stop it in the middle.

Once the bowl empties, the flush is complete.

The upper tank is empty.

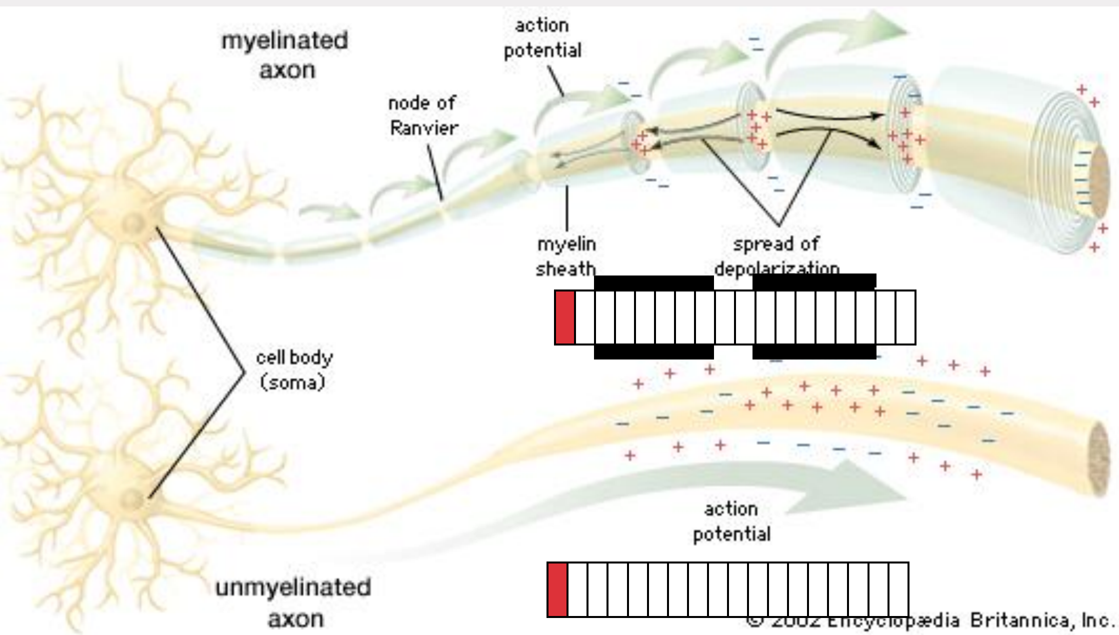
If you try pulling the handle at this point, nothing happens (*absolute refractory*).

Wait for the upper tank to begin refilling.

You can now flush again, but the intensity of the flushes increases as the upper tank refills *(relative refractory)*

3- SPEED OF CONDUCTION

- Depends on:
    - Presence of myelin sheath
    - Diameter of axon.



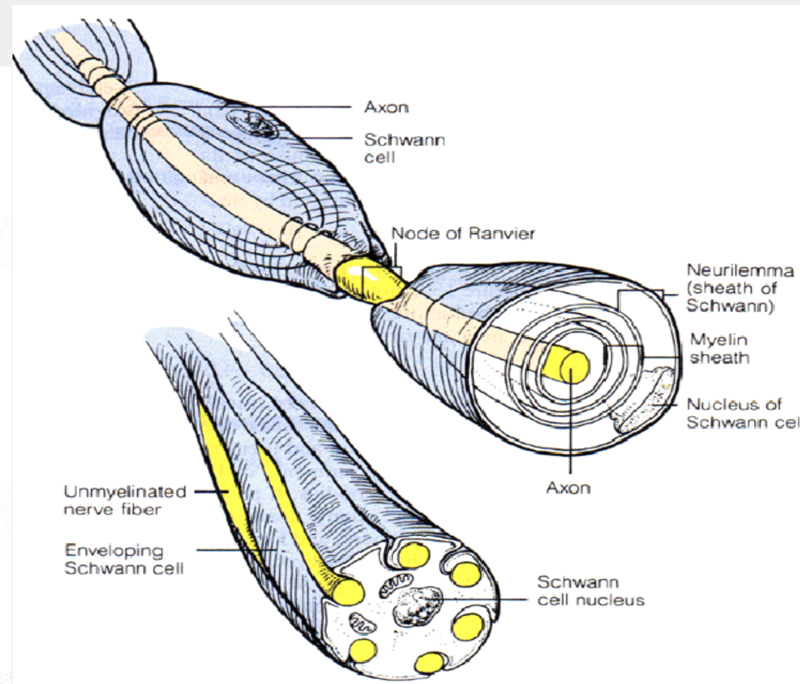


FIGURE 1.3 Schwann cells

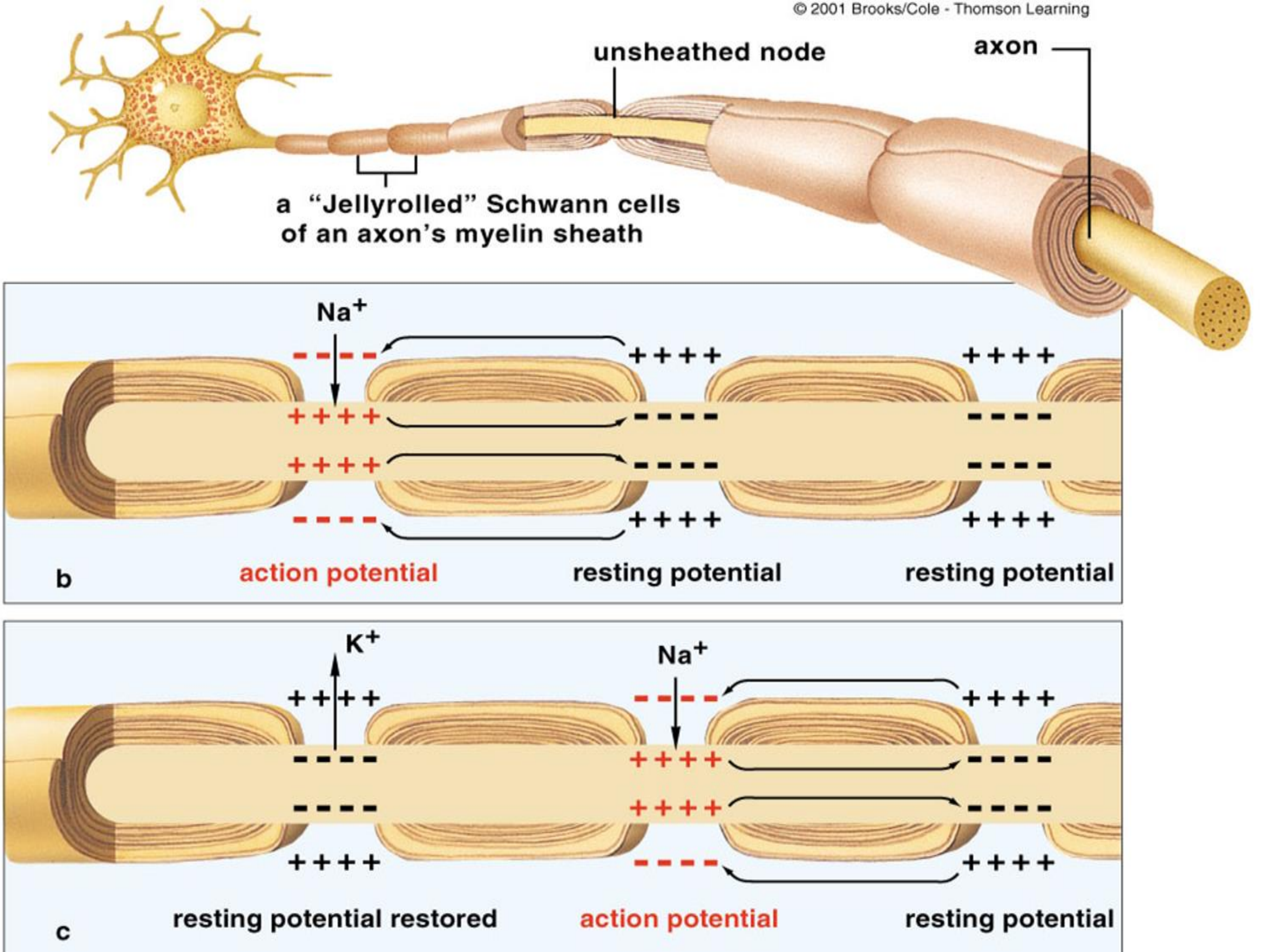
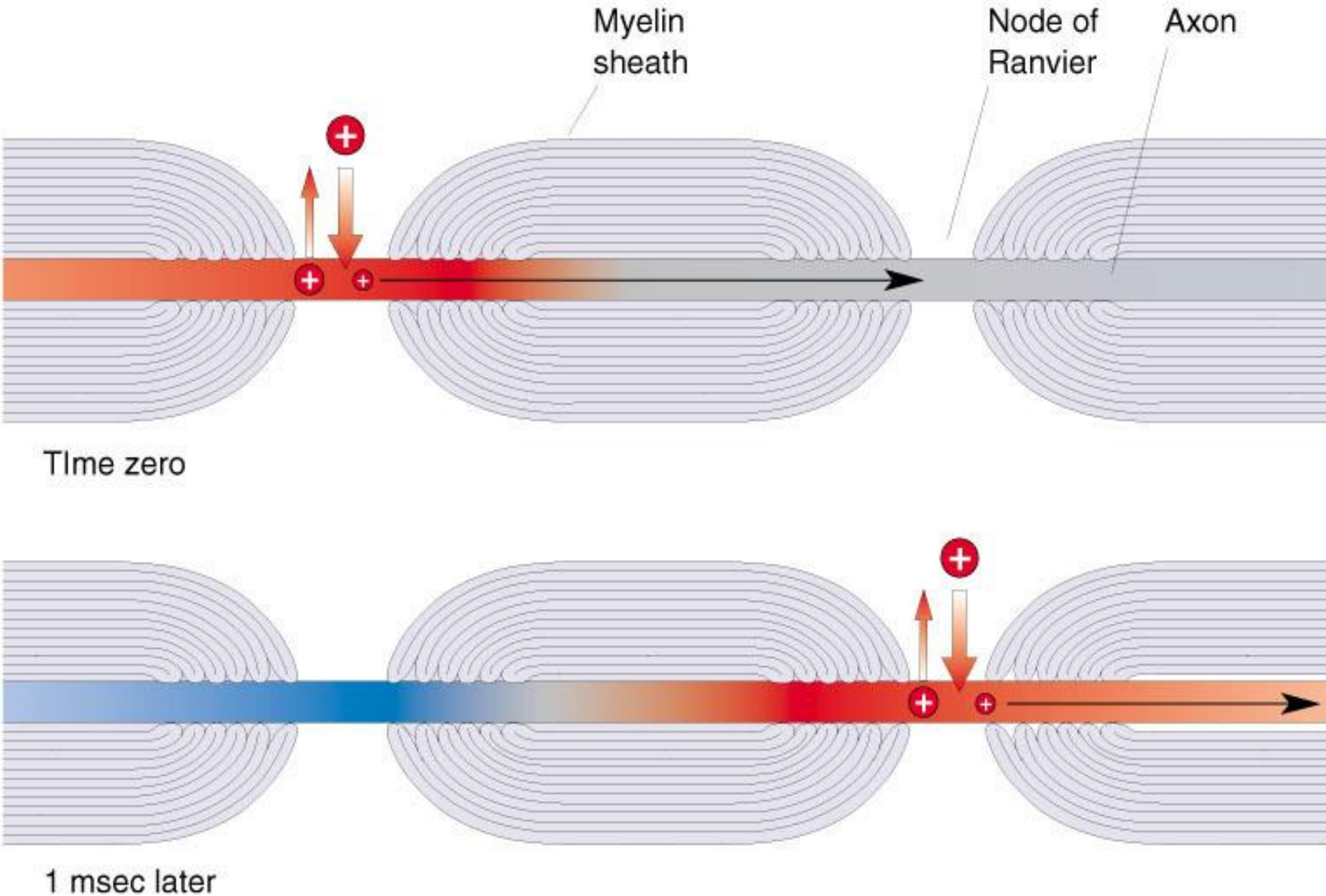
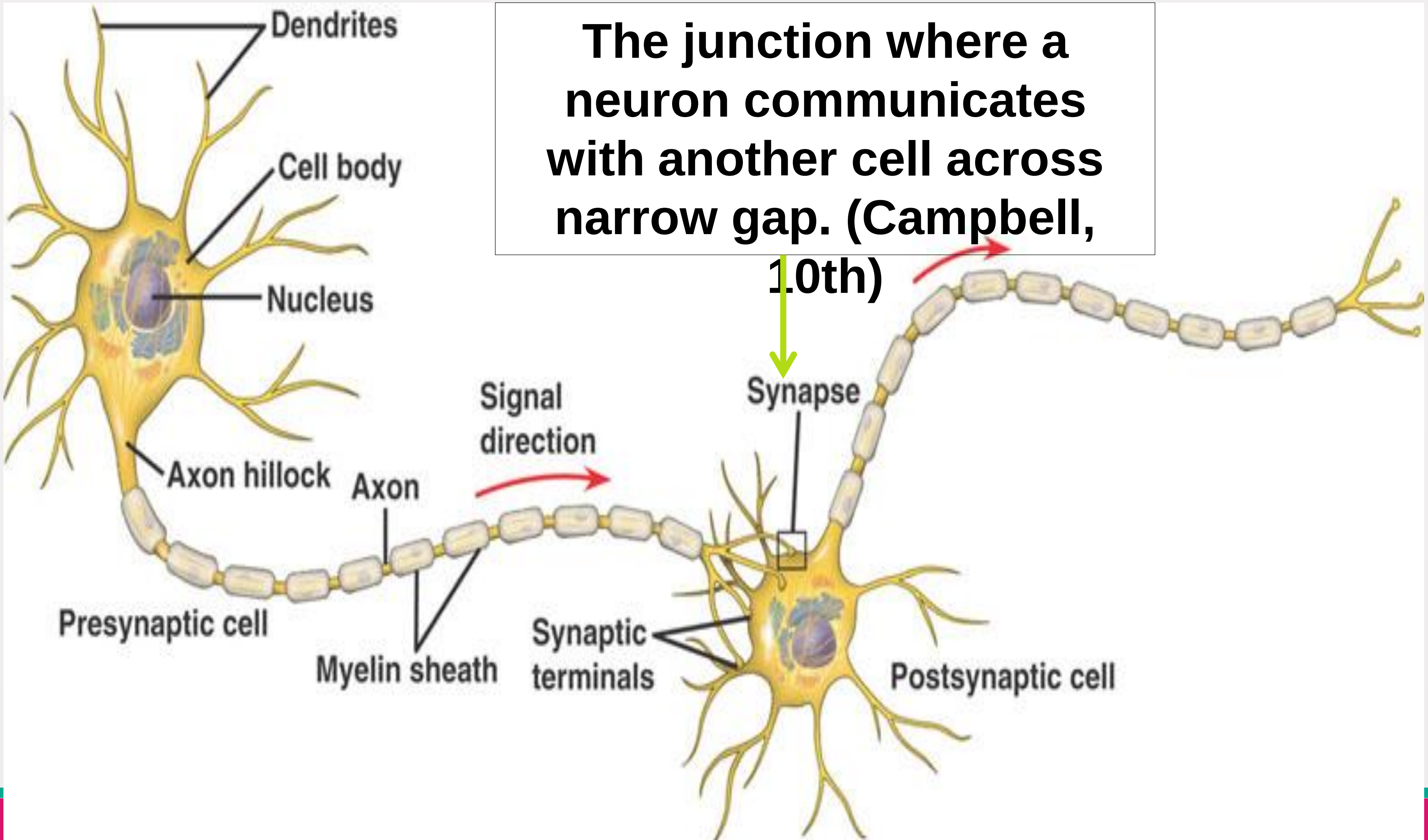

unsheathed node
axon
a "Jellyrolled" Schwann cells
of an axon's myelin sheath
Na+
b
action potential
resting potential
resting potential
K+
Na+
c
resting potential restored
action potential
resting potential

Figure 4.13
Saltatory conduction. Myelin allows current to spread farther and faster between nodes, thus speeding action potential conduction. Compare this figure with



10.1 (d) – DECSRIBE THE STRUCTURE OF SYNAPSE

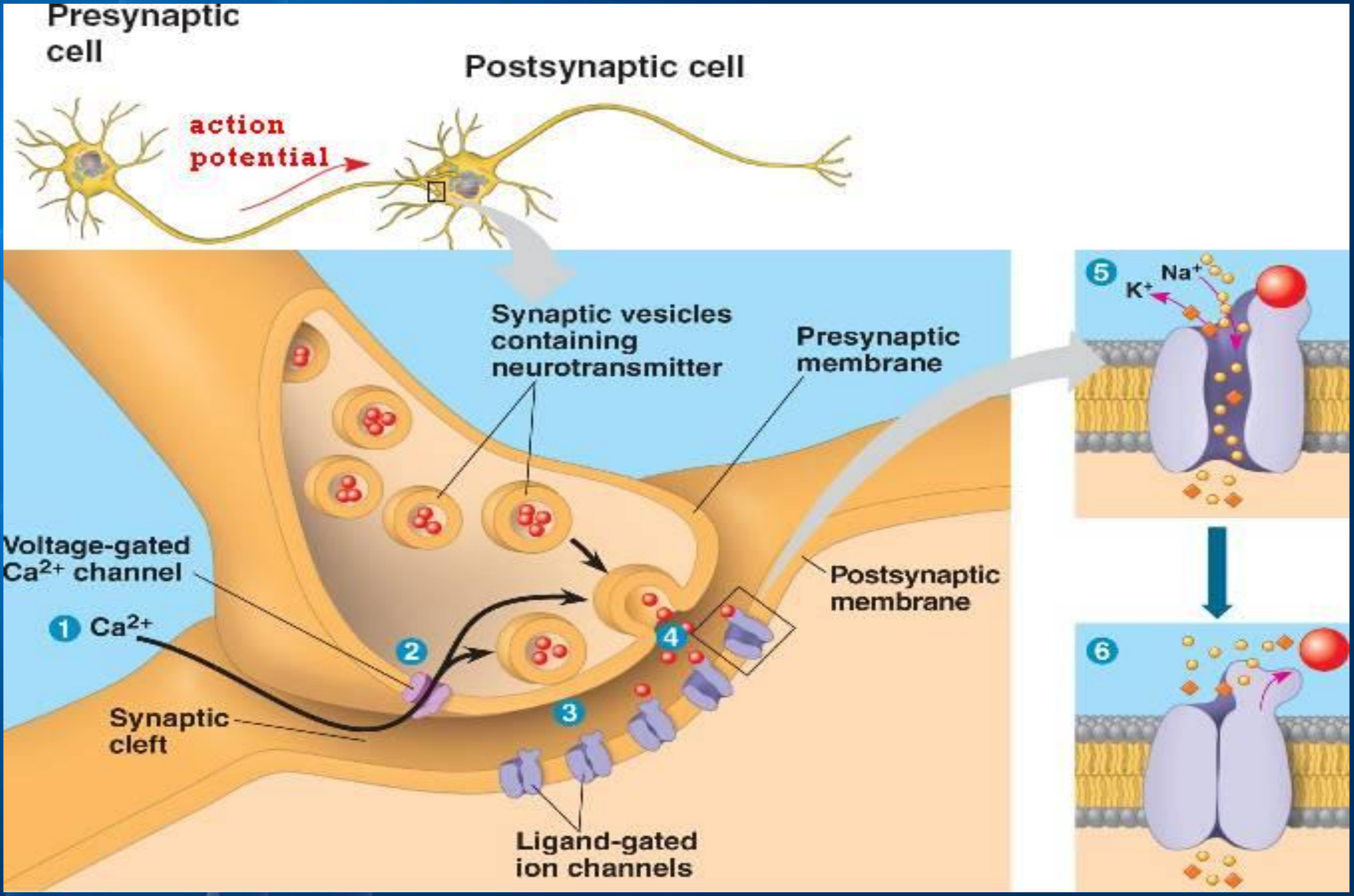
The junction where a neuron communicates with another cell across narrow gap. (Campbell, 10th)



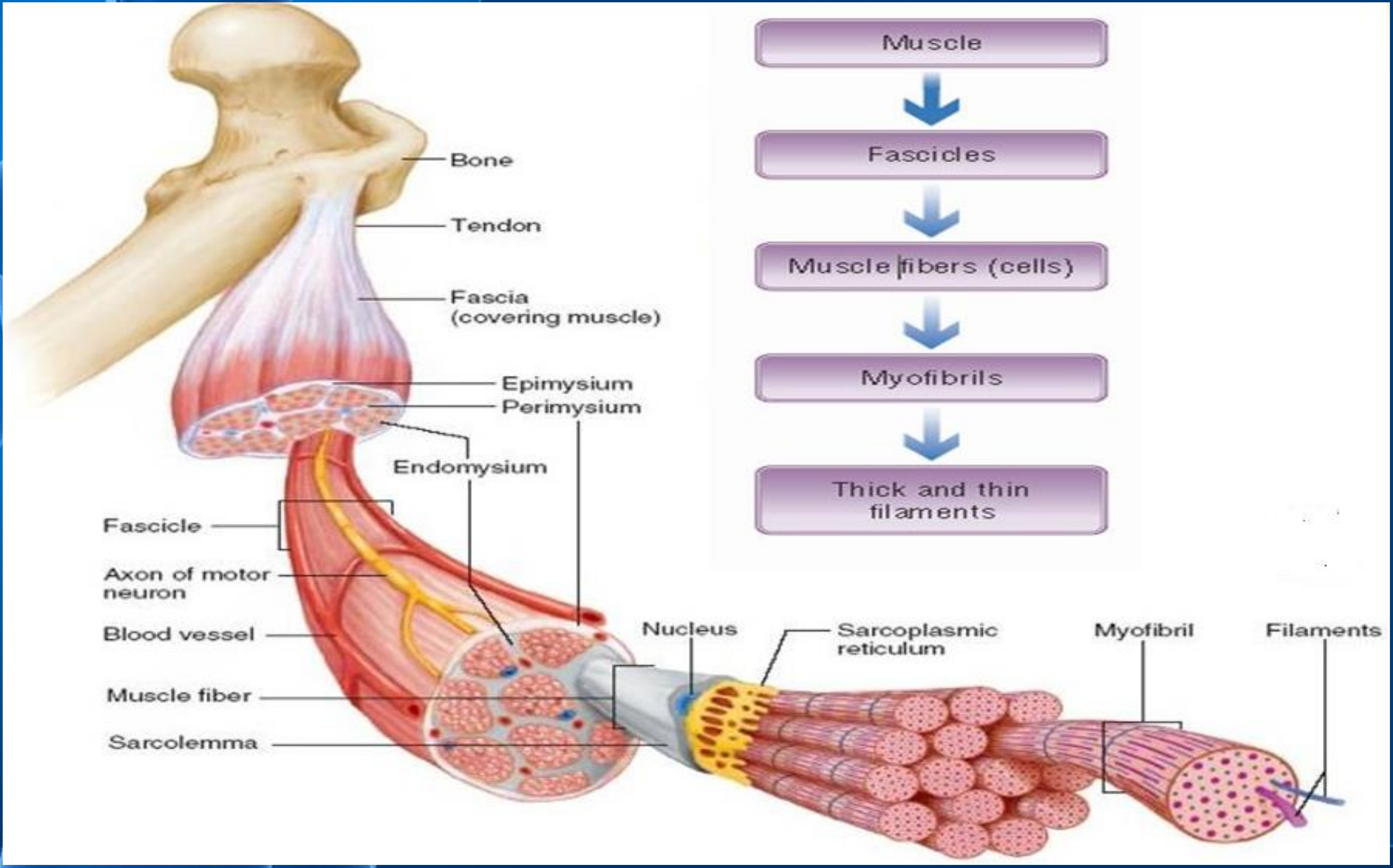
TYPES OF SYNAPSE

ELECTRICAL SYNAPSE	CHEMICAL SYNAPSE
• Pre and postsynaptic membrane are very close together •No synaptic cleft •No neurotransmitter • Allow electrical current to flow directly from one neuron to another	• Most common • Pre and postsynaptic membrane are separated by synaptic cleft • Involve the release of chemical neurotransmitter into the synaptic cleft

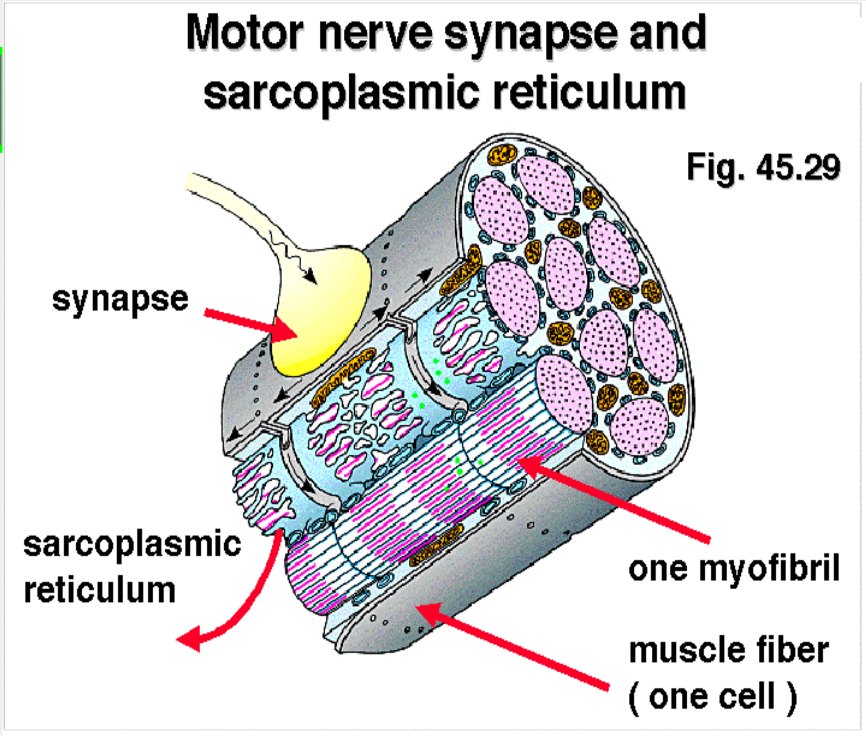
STRUCTURE OF SYNAPSE



10.2 (a) – DESCRIBE THE STRUCTURE OF NEUROMUSCULAR JUNCTION



STRUCTURE OF SKELETAL MUSCLE



Muscle fiber

- → Myofibrils
  - → Actin (thin filament)
  - → Myosin (thick filament)
- → cytoplasm → Sarcoplasm
  - → Internal membranes → Sarcoplasmic reticulum

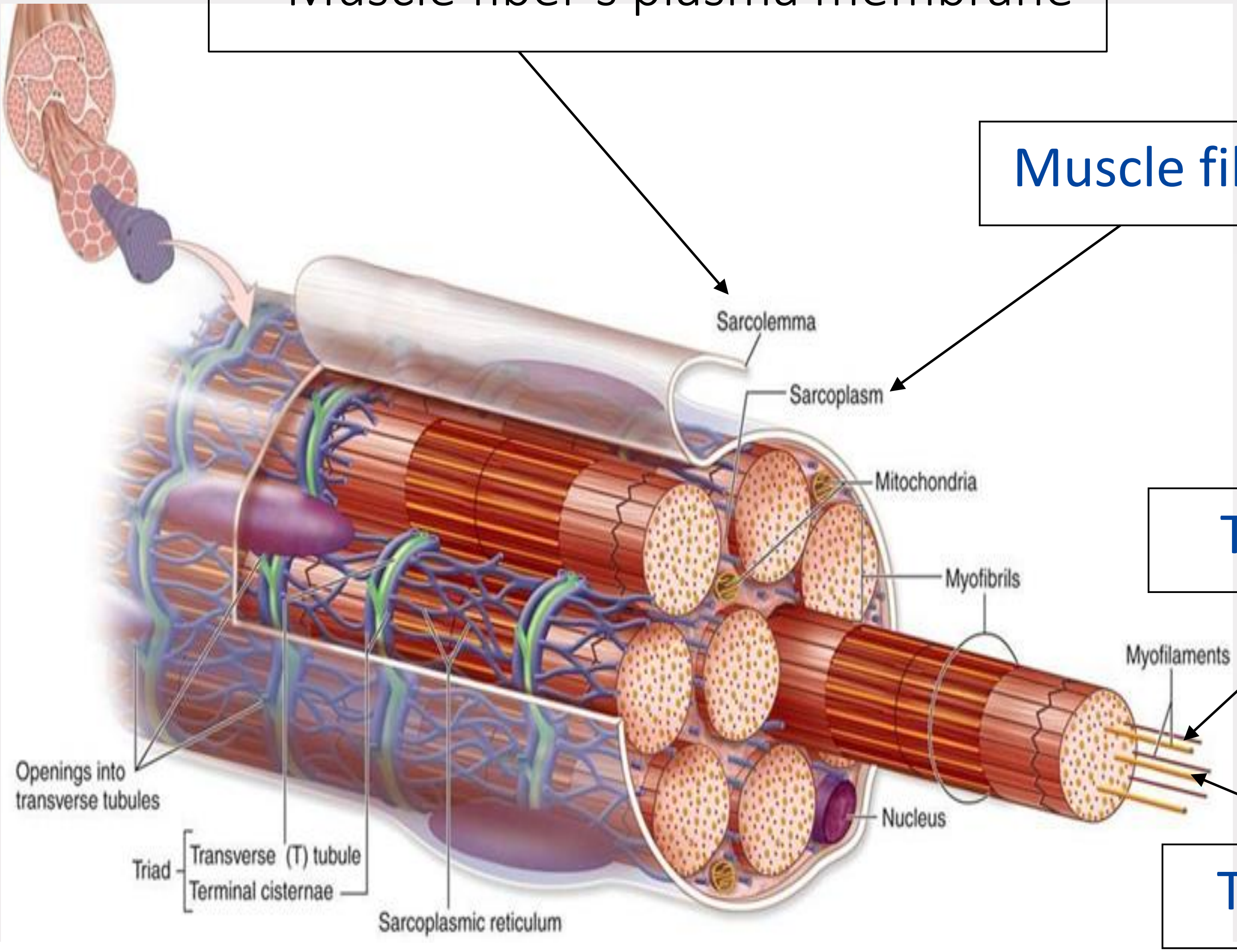
STRUCTURE OF SKELETAL MUSCLE

- Muscle fiber's plasma membrane

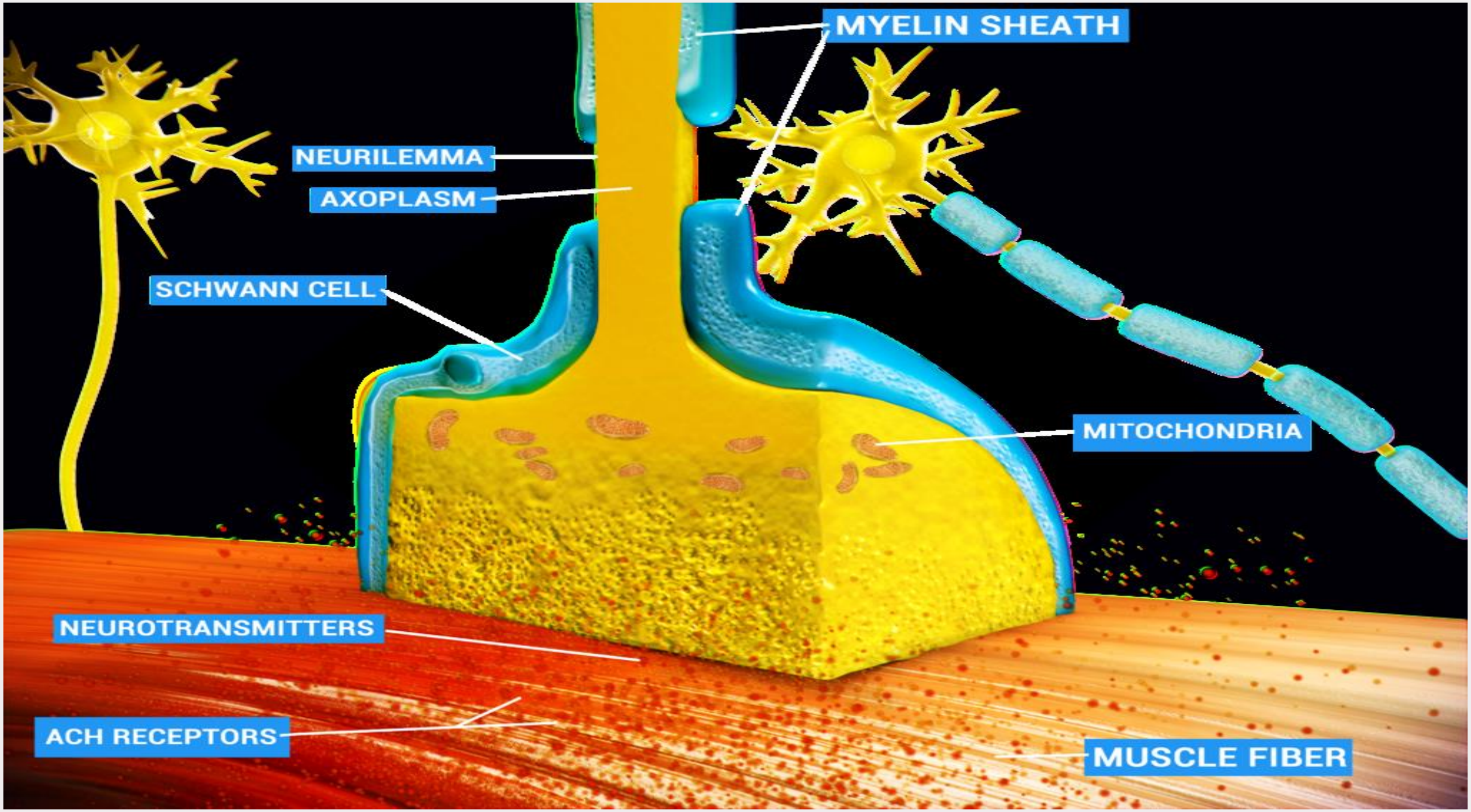
Muscle fiber's cytoplasm

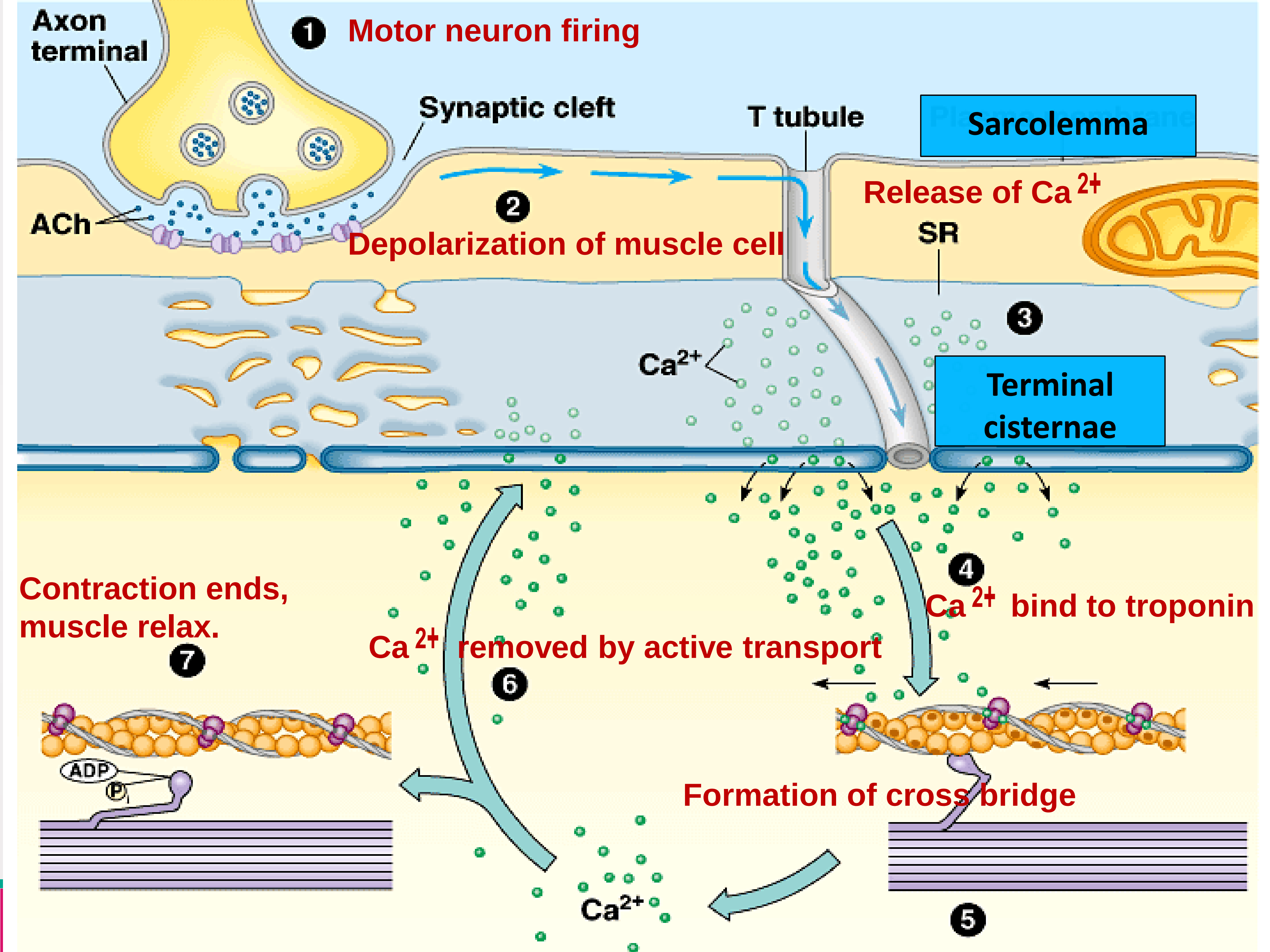
Thin filament

Thick filament



10.2 (b) – EXPLAIN IMPULSE TRANSMISSION AT THE NEUROMUSCULAR JUNCTION




Axon terminal
1 Motor neuron firing
Synaptic cleft
T tubule
Sarcolemma
ACh
2
Depolarization of muscle cell
Release of Ca 2+
SR
3
Ca2+
Terminal cisternae
4
Ca 2+ bind to troponin
Contraction ends, muscle relax.
7
Ca 2+ removed by active transport
6
ADP
P
Formation of cross bridge
Ca2+
5

NEXT : COORDINATION (PART 2)