SNS COLLEGE OF ALLIED HEALTH SCIENCE

Affiliated to The Tamil Nadu Dr. M.G.R Medical University, Chennai

DEPARTMENT OF PHYSICIAN ASSISTANT

COURSE NAME : PHYSIOLOGY

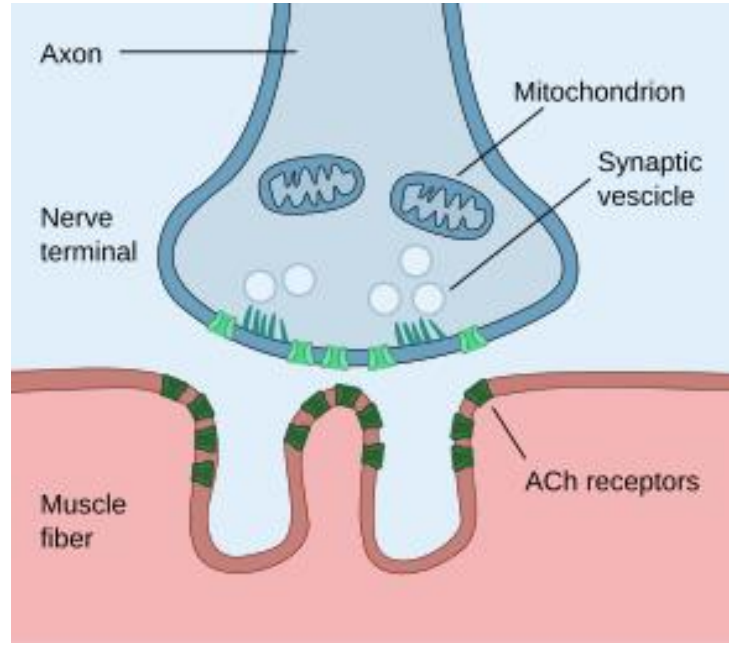
UNIT : INTRODUCTION TO PHYSIOLOGY

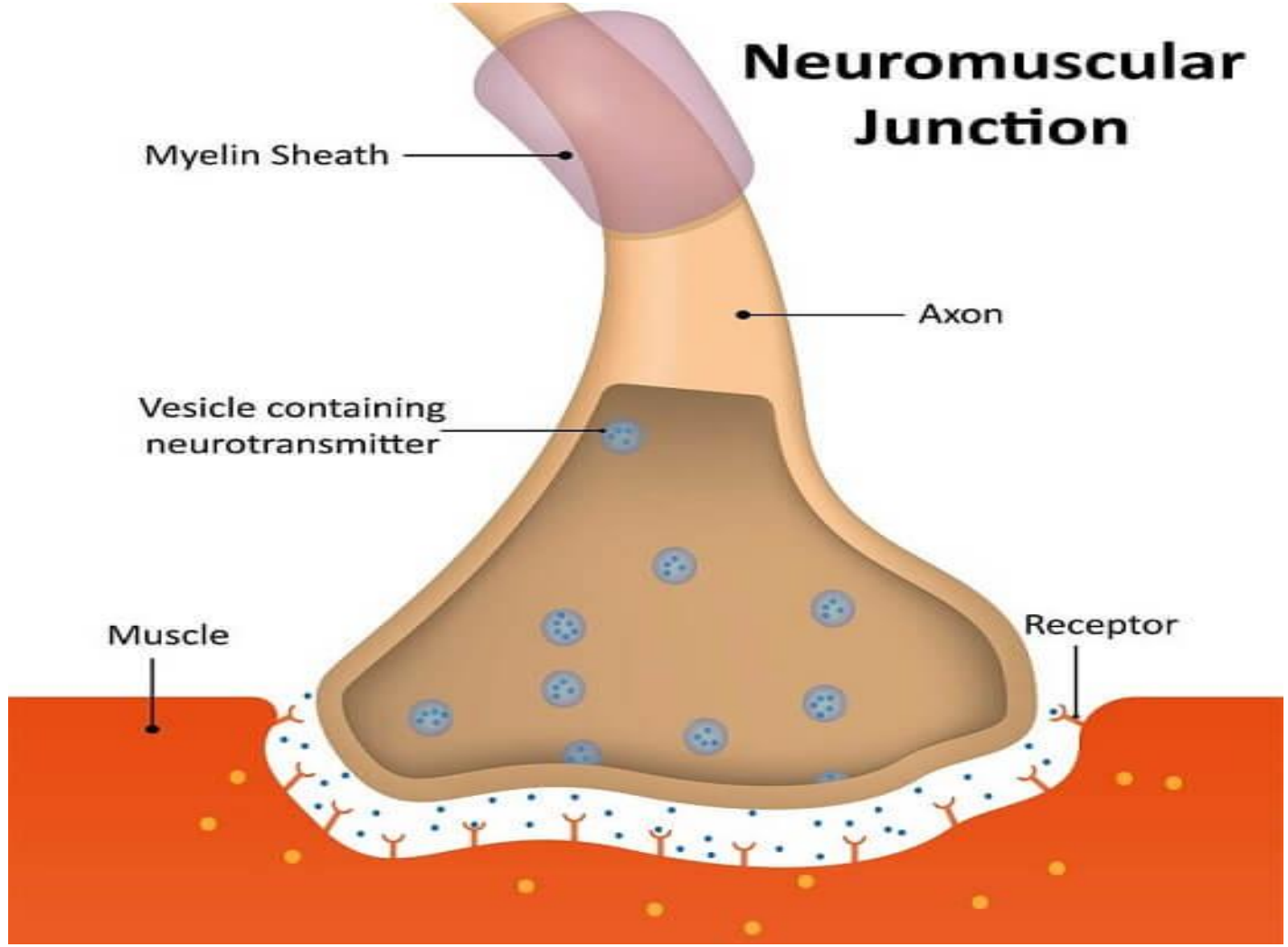
TOPICS : NEUROMUSCULAR JUNCTION AND MUSCLE CONTRACTION

FACULTY NAME : Ms. SINEKA M

INTRODUCTION (Define)

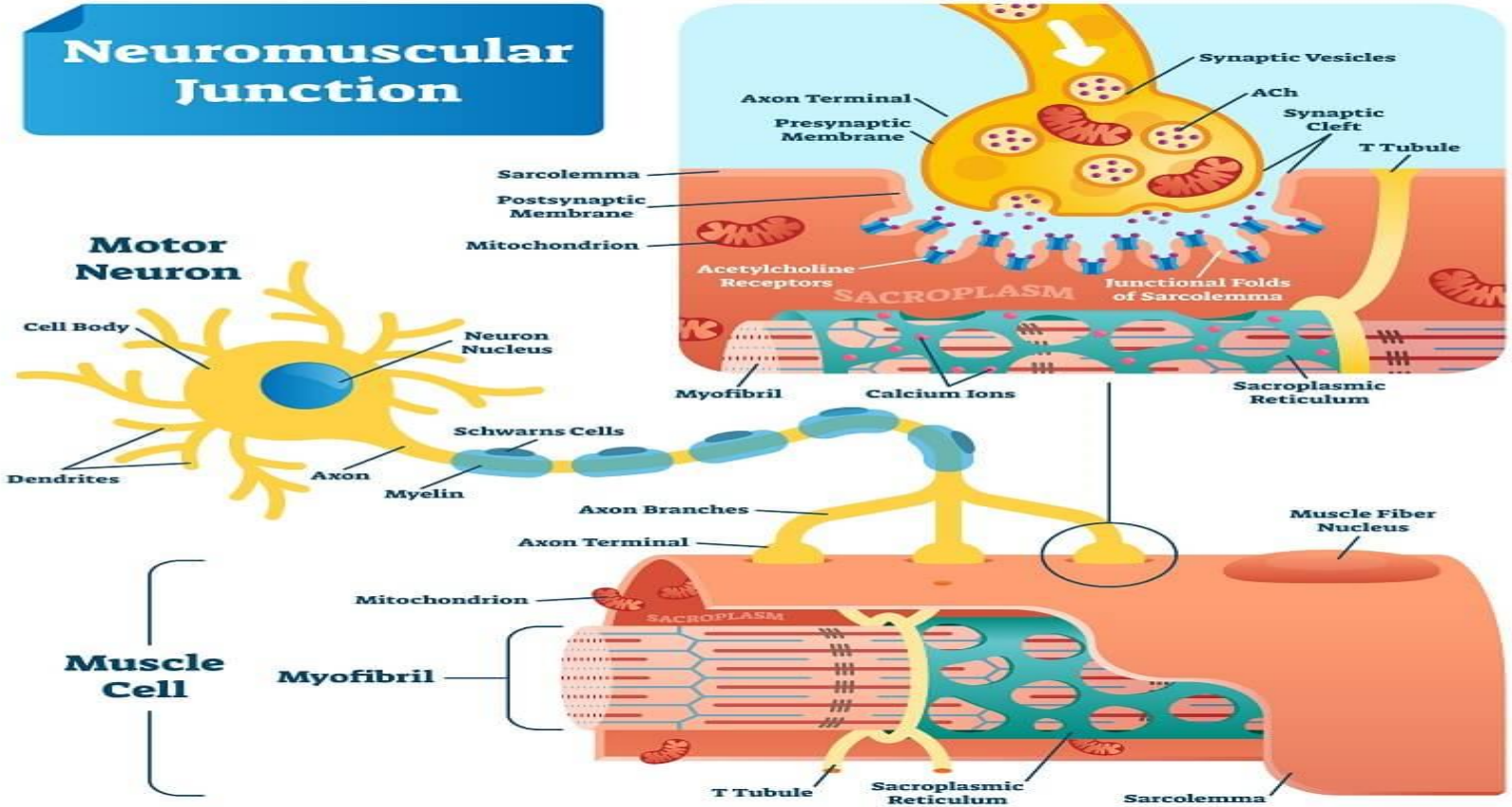
- The neuromuscular junction is the specialized **synapse where a motor neuron communicates with a skeletal muscle fiber** to initiate contraction.
- It's a chemical synapse that ensures precise, rapid transmission of signals from the nervous system to the muscle, enabling voluntary movements.




Neuromuscular Junction
Myelin Sheath
Axon
Vesicle containing neurotransmitter
Muscle
Receptor

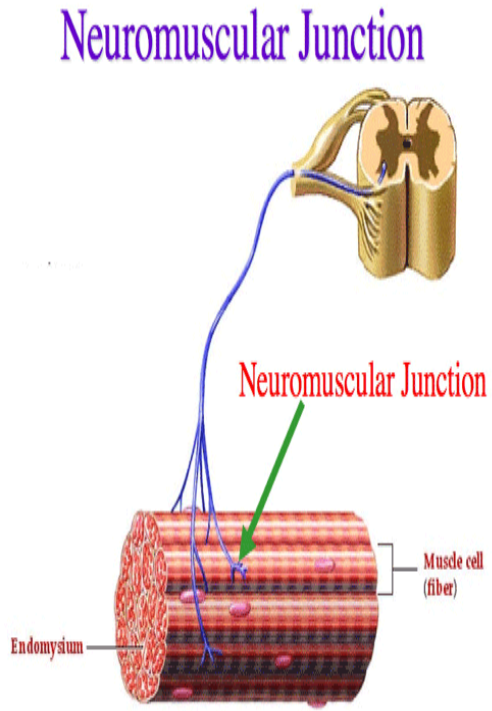
THREE MAIN COMPONENTS

- **Presynaptic terminal**: The end of the motor neuron axon, containing synaptic vesicles filled with the neurotransmitter acetylcholine (ACh).
- **Synaptic cleft**: A narrow gap (~20-50 nm) between the neuron and muscle, filled with extracellular fluid.
- **Postsynaptic membrane**: The muscle cell's sarcolemma, featuring junctional folds that increase surface area and contain nicotinic acetylcholine receptors (nAChRs).

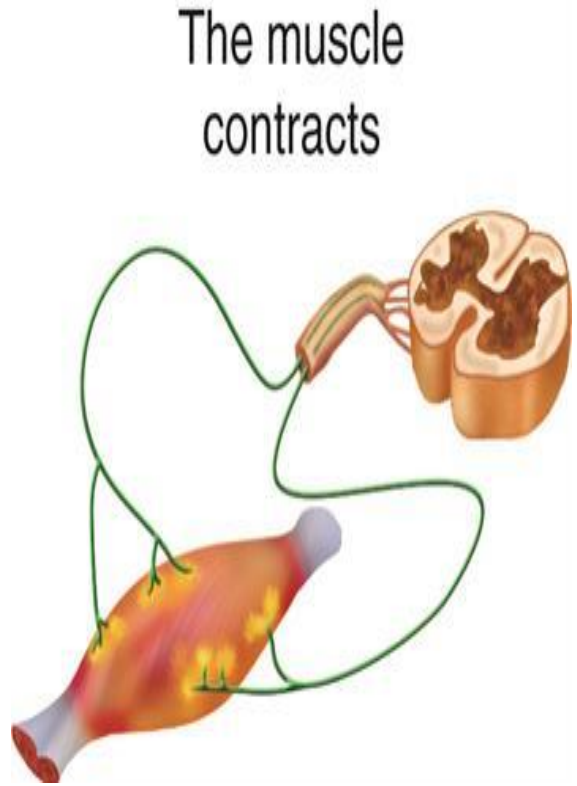

Neuromuscular Junction
Synaptic Vesicles
Axon Terminal
ACh
Presynaptic Membrane
Synaptic Cleft
T Tubule
Sarcolemma
Postsynaptic Membrane
Mitochondrion
Motor Neuron
Acetylcholine Receptors
SACROPLASM
Junctional Folds of Sarcolemma
Cell Body
Neuron Nucleus
Myofibril
Calcium Ions
Sacroplasmic Reticulum
Schwarns Cells
Dendrites
Axon
Myelin
Axon Branches
Muscle Fiber Nucleus
Axon Terminal
Mitochondrion
SACROPLASM
Muscle Cell
Myofibril
T Tubule
Sacroplasmic Reticulum
Sarcolemma

MECHANISM OF MUSCLE CONTRACTION

- **Action Potential Arrival:** An action potential (nerve impulse) travels down the motor neuron axon to the presynaptic terminal, depolarizing the membrane.
- **Calcium Influx and Vesicle Release:** Voltage-gated calcium channels open, allowing Ca^{2+} to enter the terminal. This triggers synaptic vesicles to fuse with the presynaptic membrane and release ACh into the synaptic cleft by exocytosis.

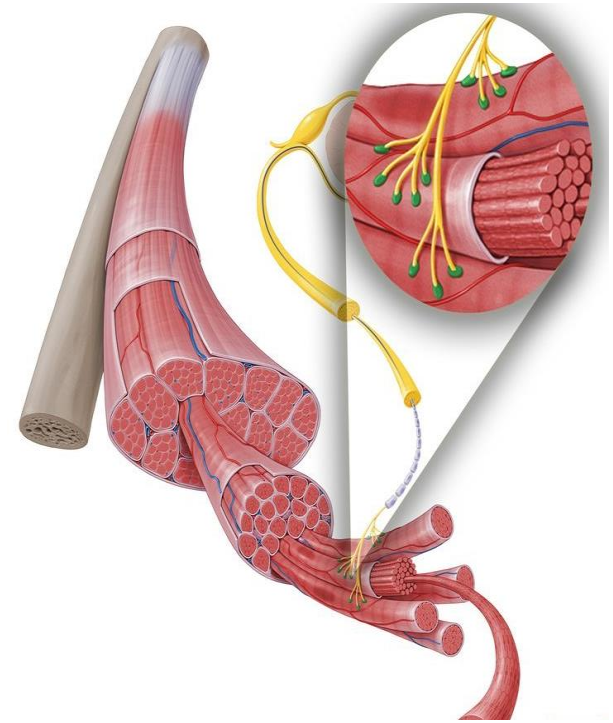


- **Neurotransmitter Binding:** ACh diffuses across the cleft and binds to nAChRs on the postsynaptic membrane. These ligand-gated ion channels open, permitting Na^+ influx, which depolarizes the membrane - this is the **End-plate potential.**
- **Muscle Action Potential Generation:** If the EPP reaches threshold (~15-20 mV), it triggers voltage-gated sodium channels along the sarcolemma, generating a propagating action potential in the muscle fiber.



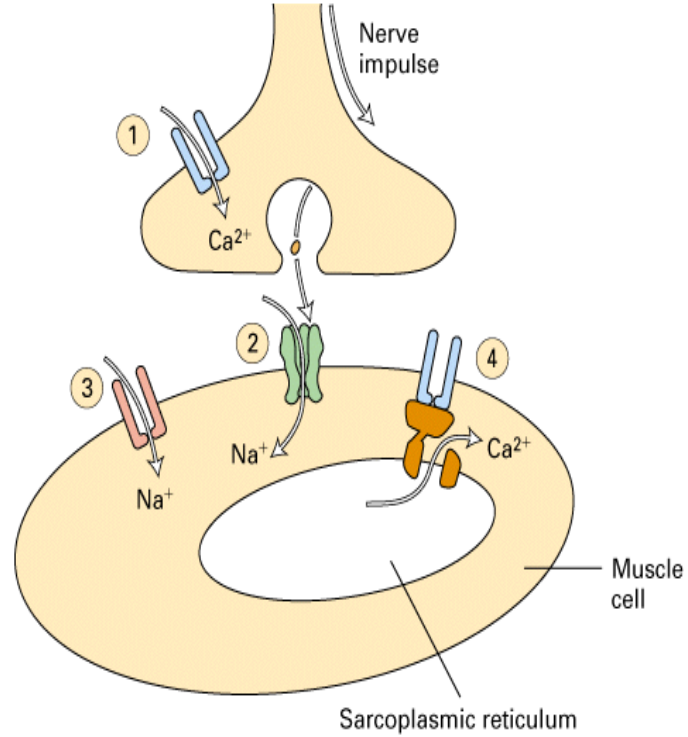
Excitation-Contraction Coupling:

- The action potential spreads via T-tubules (invaginations of the sarcolemma) into the muscle fiber.
- This activates dihydropyridine receptors (DHPRs), which mechanically open ryanodine receptors (RyRs) on the sarcoplasmic reticulum (SR), releasing stored Ca^{2+} into the cytosol (a process called **calcium-induced calcium release**).



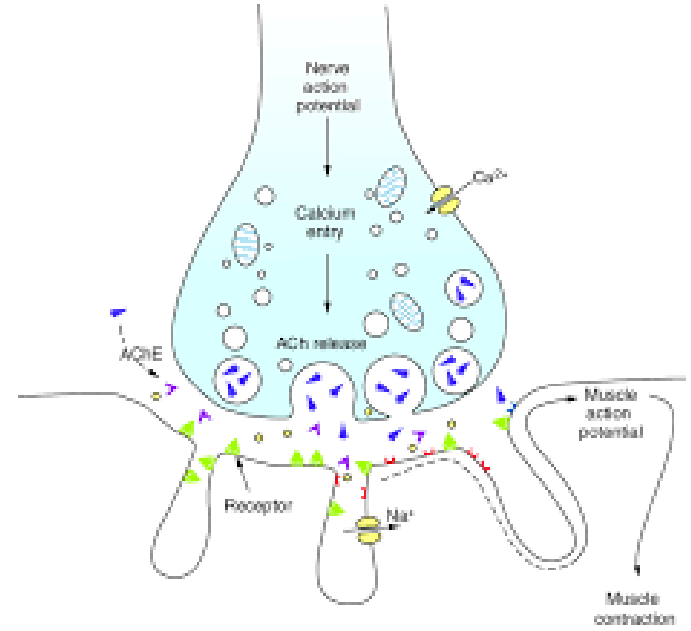
Cross-Bridge Cycling (Sliding Filaments):

- Ca^{2+} binds to troponin on thin filaments (actin), shifting tropomyosin to expose myosin-binding sites.
- Myosin heads bind actin, forming cross-bridges. Powered by ATP hydrolysis, myosin pulls actin filaments toward the sarcomere center, shortening the muscle (contraction).
- Cycle repeats as long as Ca^{2+} and ATP are available.

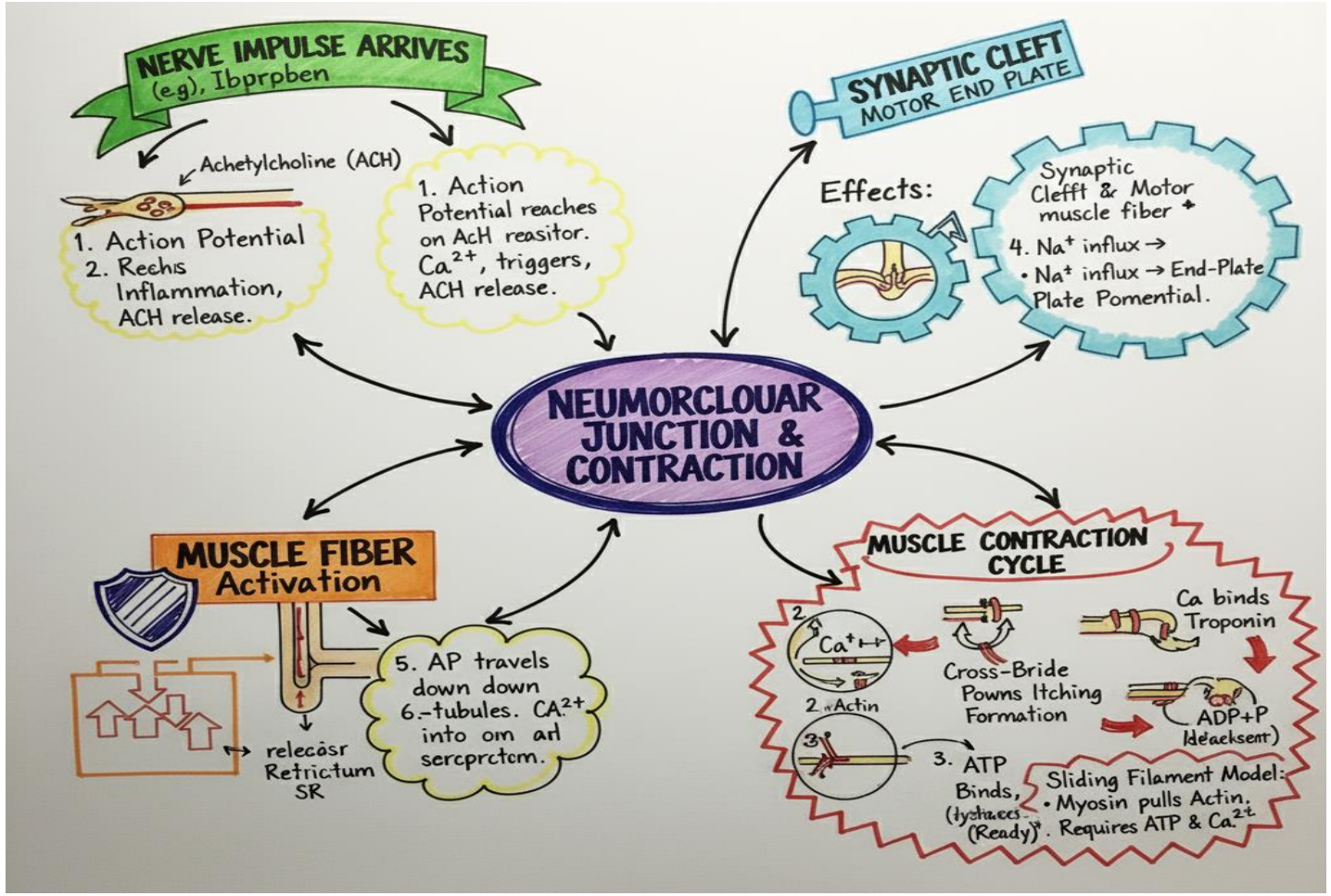


Relaxation:

- ACh is rapidly degraded by acetylcholinesterase (AChE) in the cleft, ending the EPP.
- Ca^{2+} is pumped back into the SR by SERCA pumps.
- Tropomyosin blocks binding sites again, allowing filaments to slide back (passive relaxation aided by elastic elements like titin).



SUMMARY


NERVE IMPULSE ARRIVES
(e.g), Ibprpben
Achetylcholine (ACH)
1. Action Potential
2. Reehis Inflammation, ACH release.
1. Action Potential reaches on AcH reasitor. Ca2+, triggers, ACH release.
SYNAPTIC CLEFT
MOTOR END PLATE
Effects:
Synaptic Clefft & Motor muscle fiber
4. Na+ influx →
• Na+ influx → End-Plate Plate Pomential.
NEUMORCLOUAR JUNCTION & CONTRACTION
MUSCLE FIBER Activation
relecasr Retrictum SR
5. AP travels down down 6.-tubules. CA2+ into om arl sercprctcm.
MUSCLE CONTRACTION CYCLE
Ca binds Troponin
Cross-Bride Powns Itching Formation
ADP+P
2 Actin
3. ATP Binds,
Sliding Filament Model:
• Myosin pulls Actin.
(Ready). Requires ATP & Ca2+

References

- https://open.oregonstate.education/anatomy2e/chapter/muscle-fiber-excitation/
- https://www.sciencedirect.com/topics/neuroscience/neuromuscular-junction
- https://www.ncbi.nlm.nih.gov/books/NBK470413/