



FISILOGI BIOLISTRIK

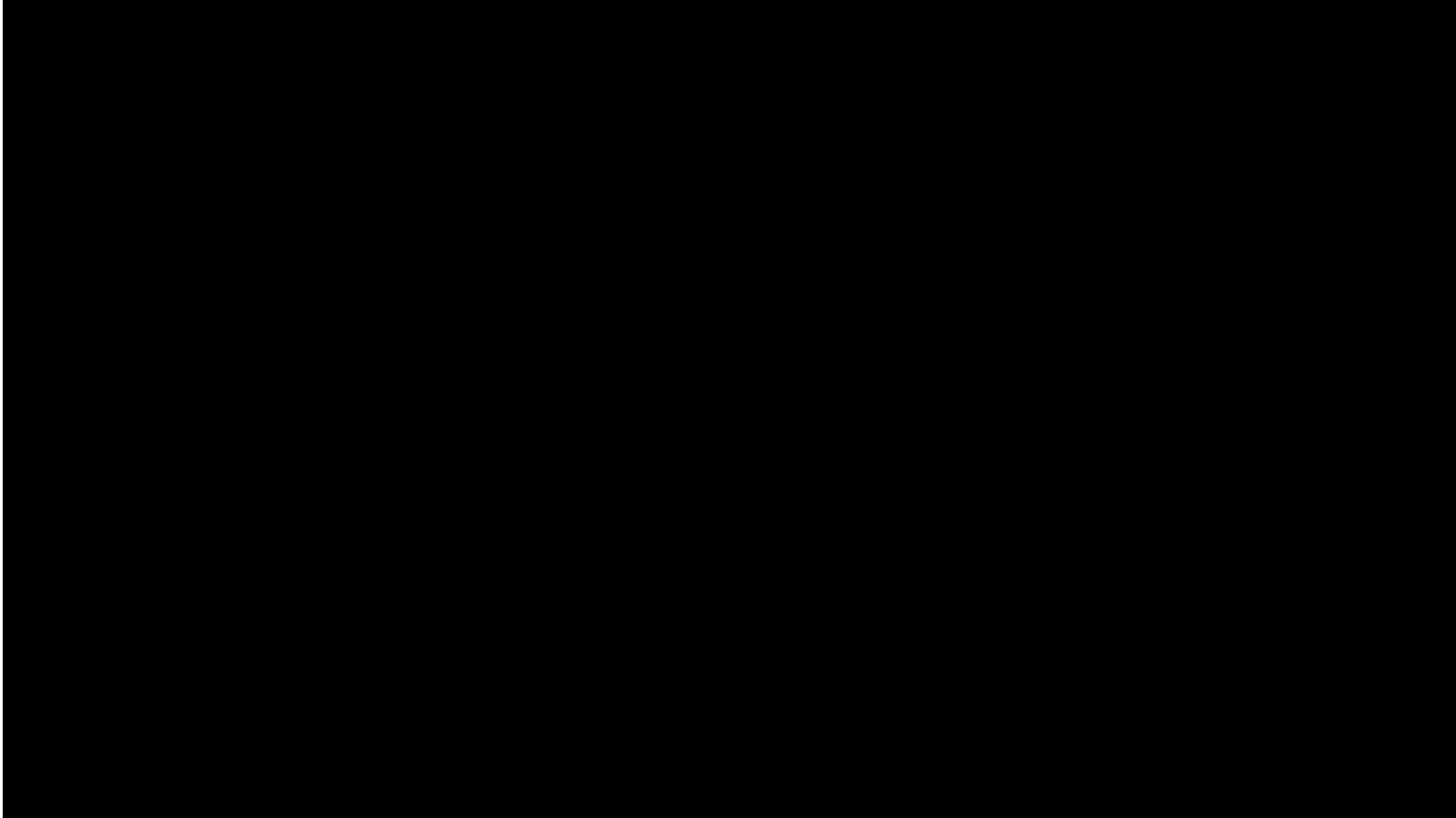
dr. Juni Chudri, MARS, AIFO-K

Pengantar Biolistrik

- Aktivitas listrik dihasilkan oleh perbedaan konsentrasi ion antar sisi membran sel.
- Ditemukan pada jaringan peka rangsang: neuron, otot rangka, otot jantung.
- Fungsi utama: transmisi impuls saraf & kontraksi otot.
- Contoh klinis: EEG, ECG, EMG.



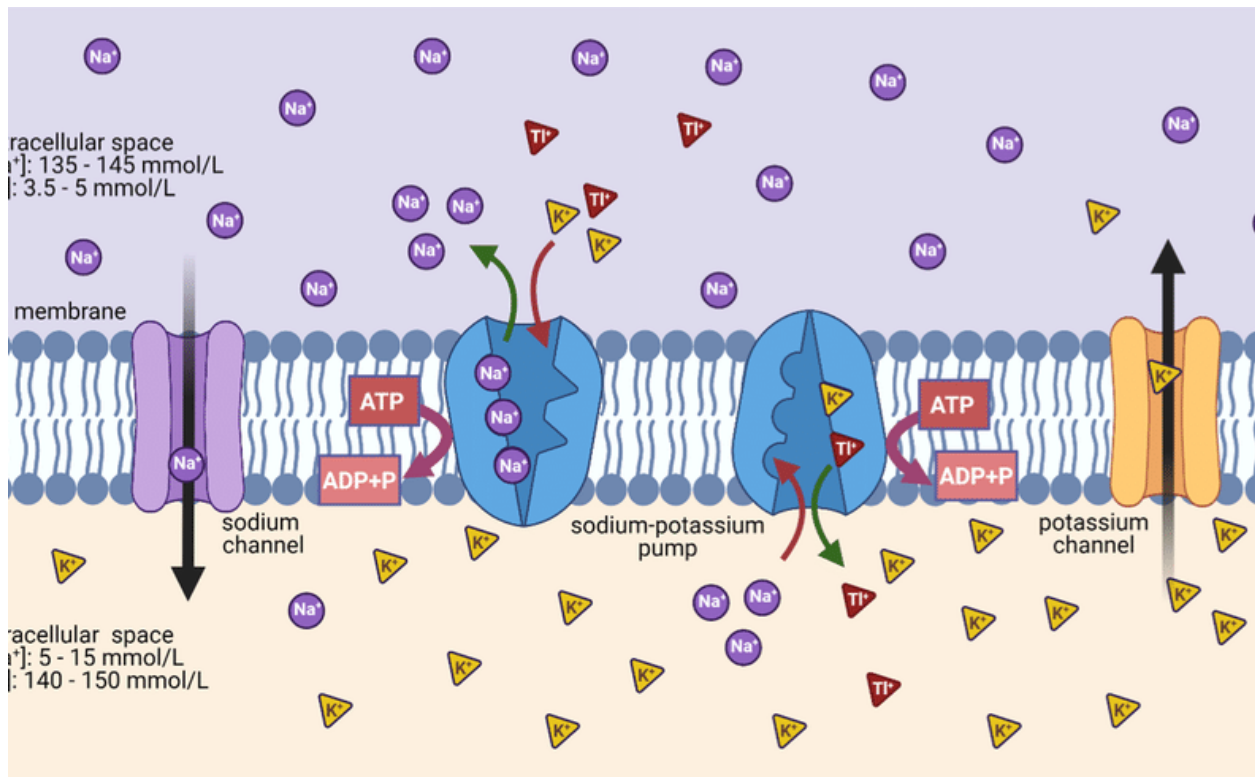
Neuron – Axon hillock



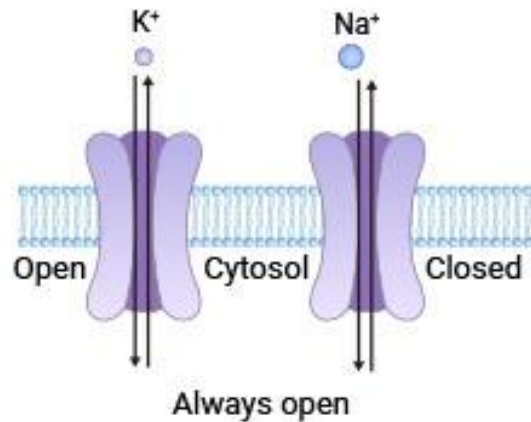
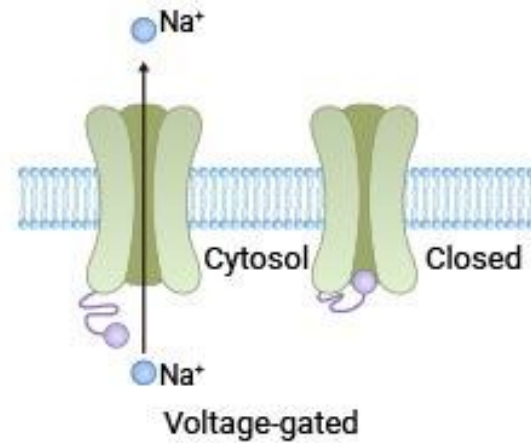
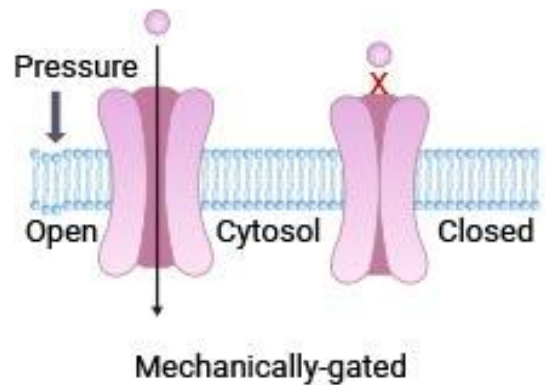
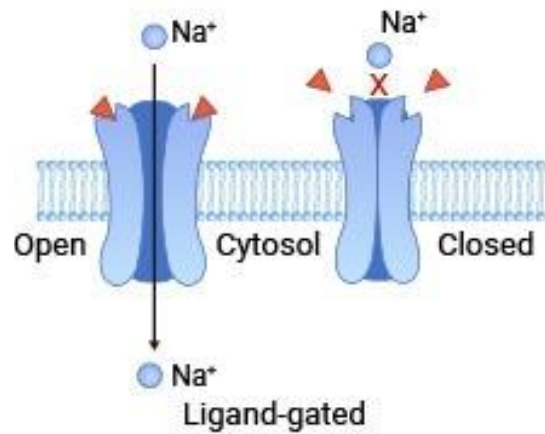
Action Potential in the Neuron



Mekanisme Transport Ion



- **Transport Pasif:** tanpa energi, mengikuti gradien konsentrasi (difusi Na⁺, K⁺, Cl⁻).
- **Transport Aktif:** memerlukan ATP, melawan gradien (pompa Na⁺/K⁺-ATPase).
 - Mengeluarkan **3 Na⁺** dan memasukkan **2 K⁺** per siklus → menjaga muatan negatif intrasel.



PINTU ION

3 jenis pintu ion :

- Voltage gate :

membuka bila dilalui aliran listrik

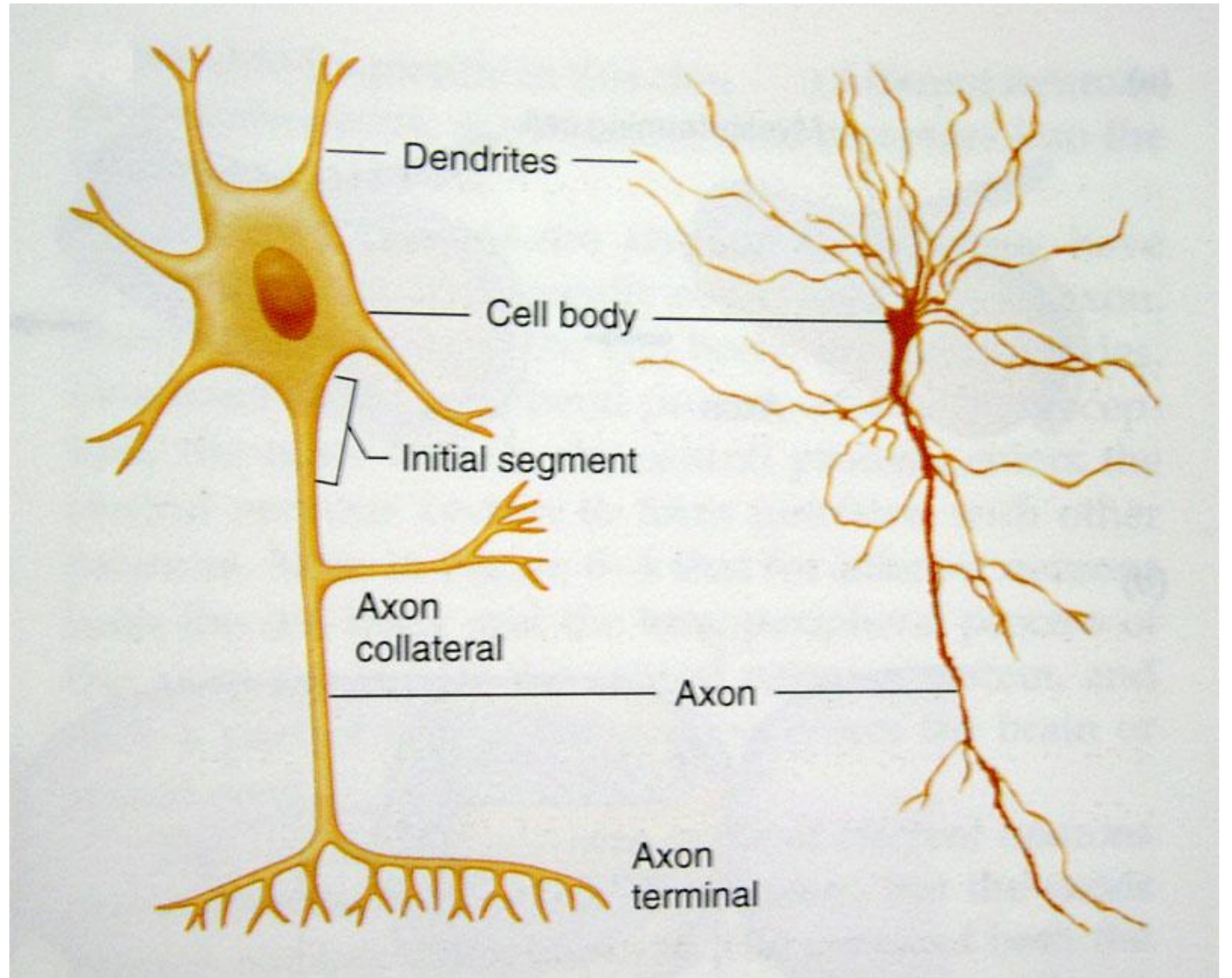
- Ligand gate / chemical gate :

terbuka bila reseptornya berikatan dengan zat tertentu

- Mechanical gate :

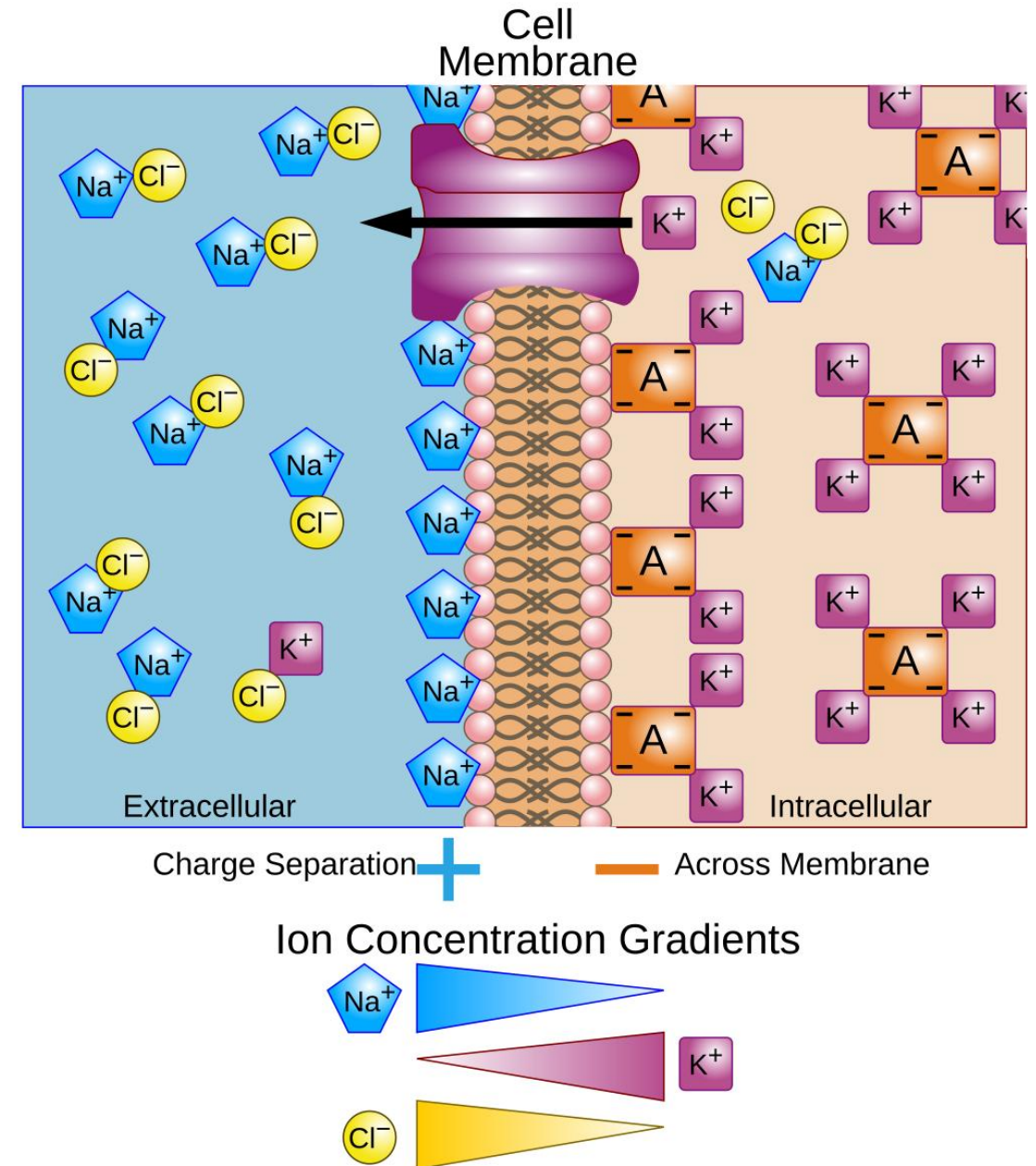
terbuka bila terjadi perubahan mekanik pada permukaan membran sel

Neuron

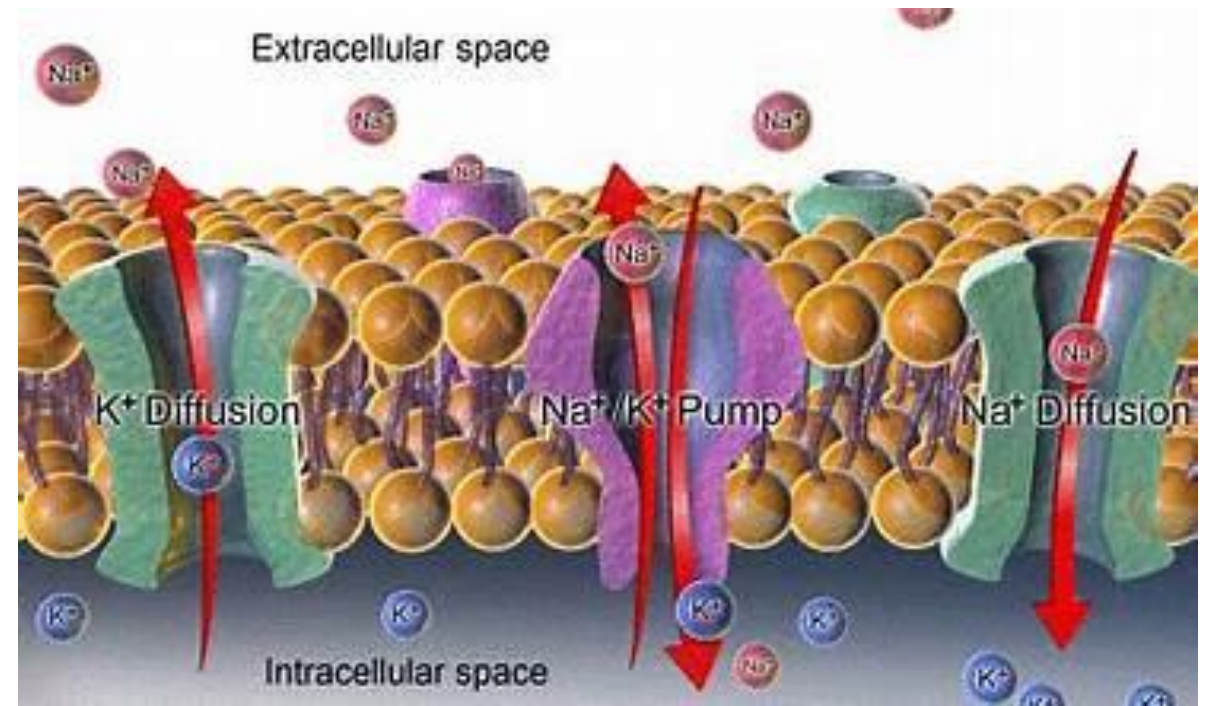
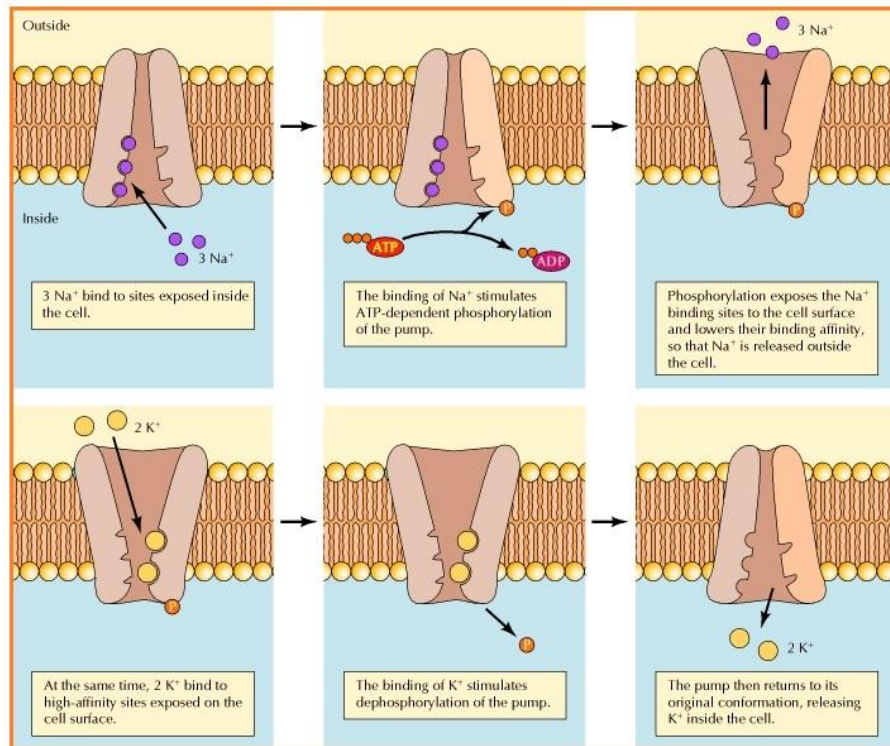


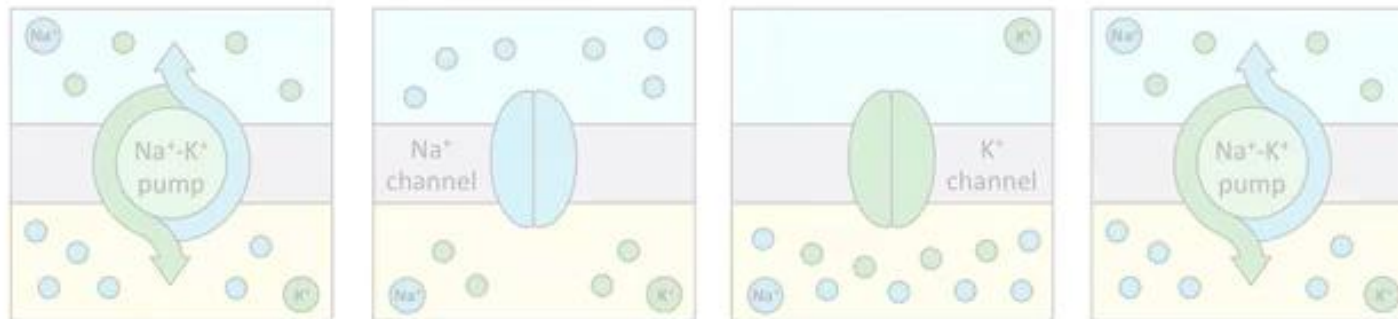
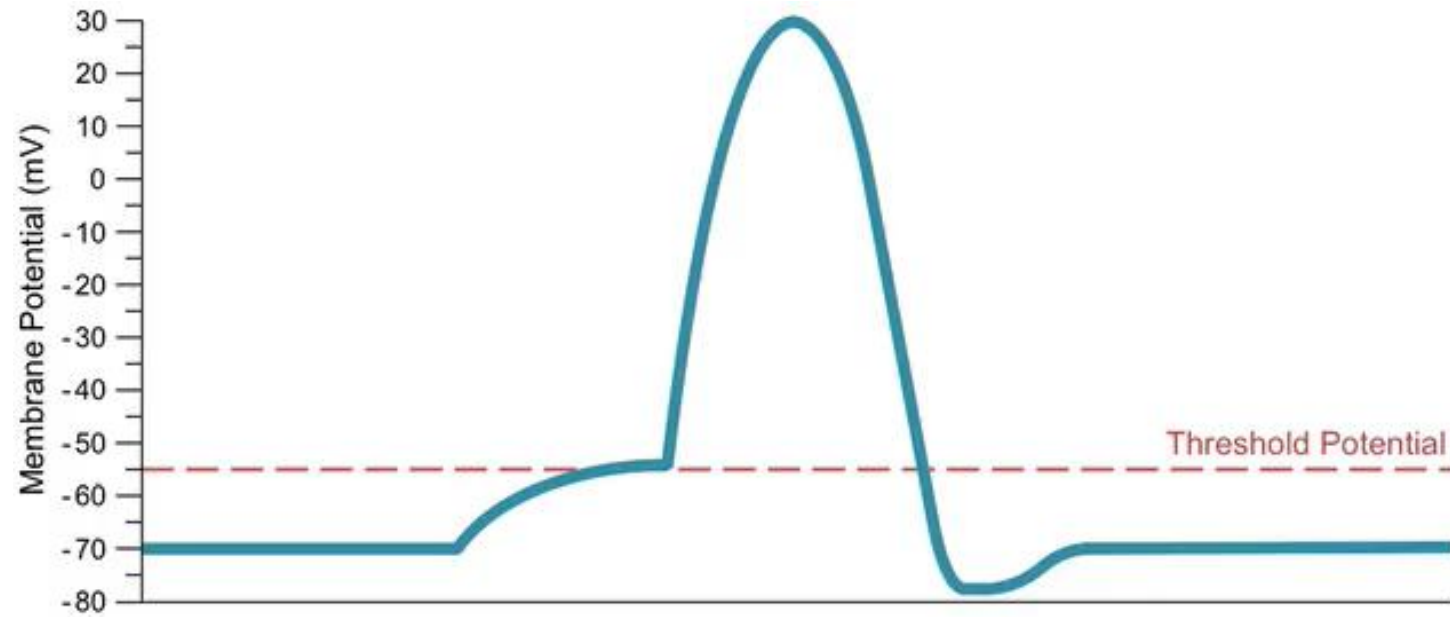
Potensial Membran Istirahat (Resting Membrane Potential)

- Terjadi karena ketidakseimbangan ion:
 - Dalam sel: K^+ tinggi, Na^+ rendah.
 - Luar sel: Na^+ tinggi, K^+ rendah.
- Nilai tipikal: -70 mV (neuron), -90 mV (otot).
- Dipertahankan oleh:
 - Difusi K^+ keluar
 - Pompa Na^+/K^+
 - Anion besar (protein) yang tidak dapat keluar



Potensial Membran Istirahat

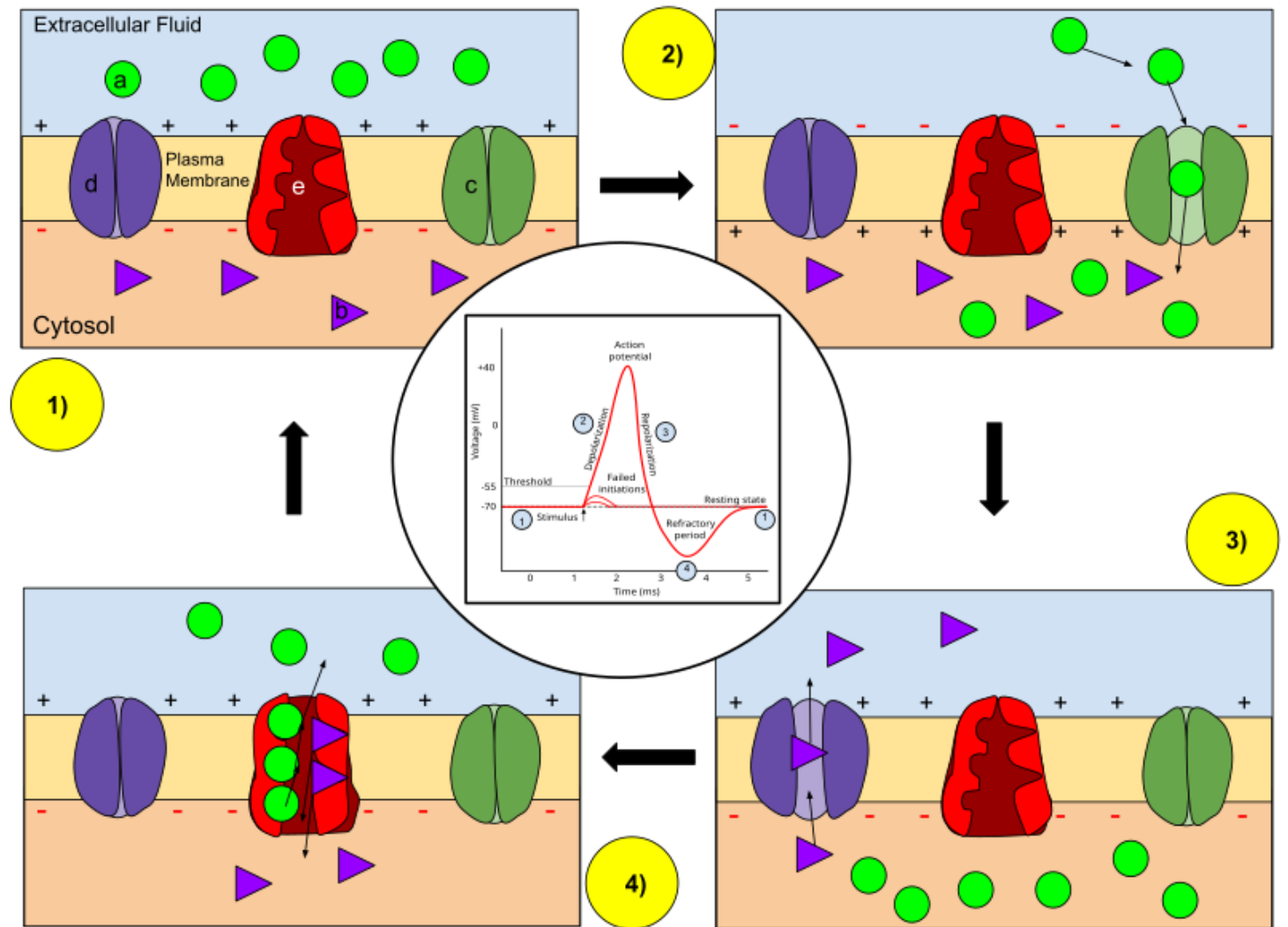




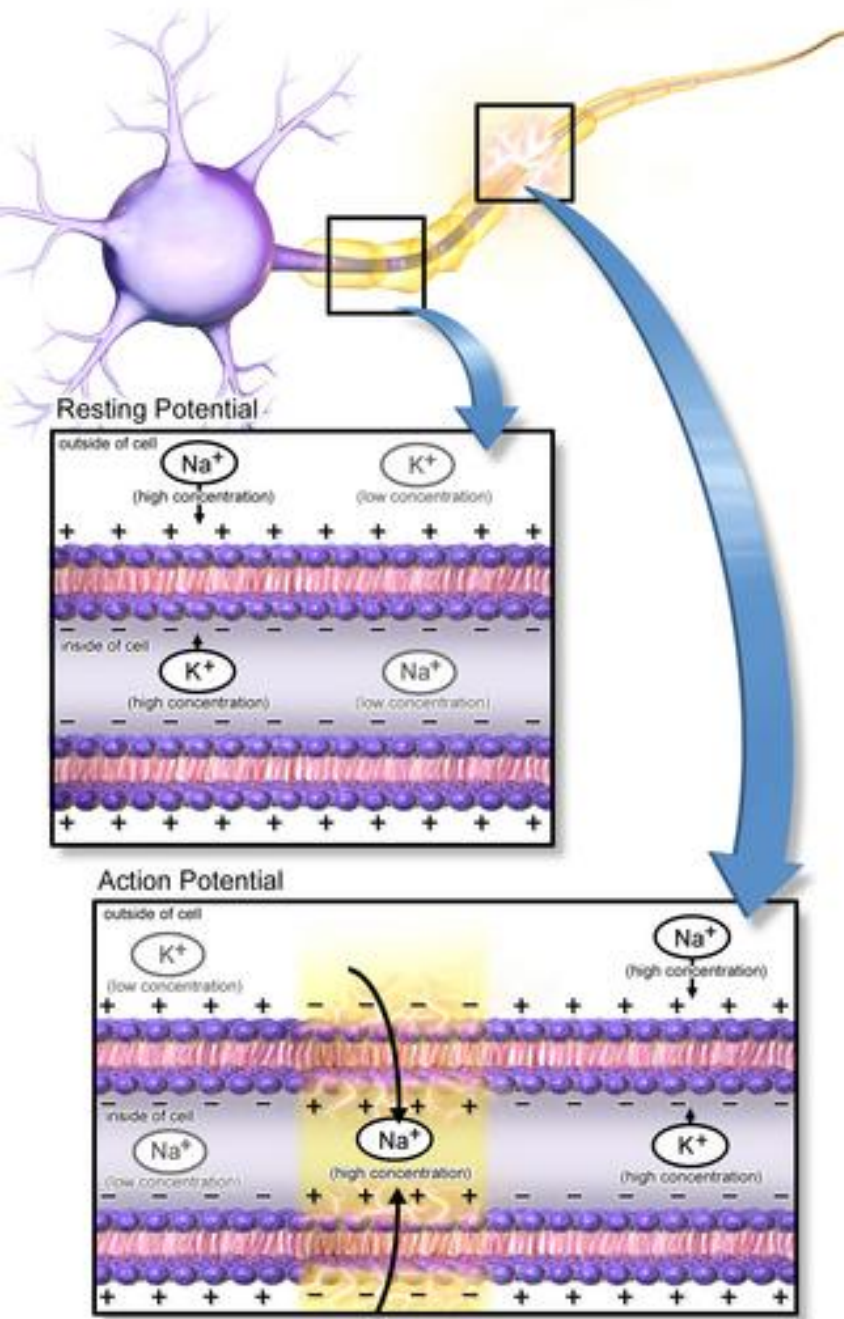
Penghantaran
Impuls

Pemberian stimulus

- Pemberian stimulus pada sel saraf/otot akan menyebabkan perubahan pada potensial membran.
- Rangsang positif akan menyebabkan depolarisasi/hipopolarisas, dan sebaliknya rangsang negatif akan menimbulkan hiperpolarisasi.



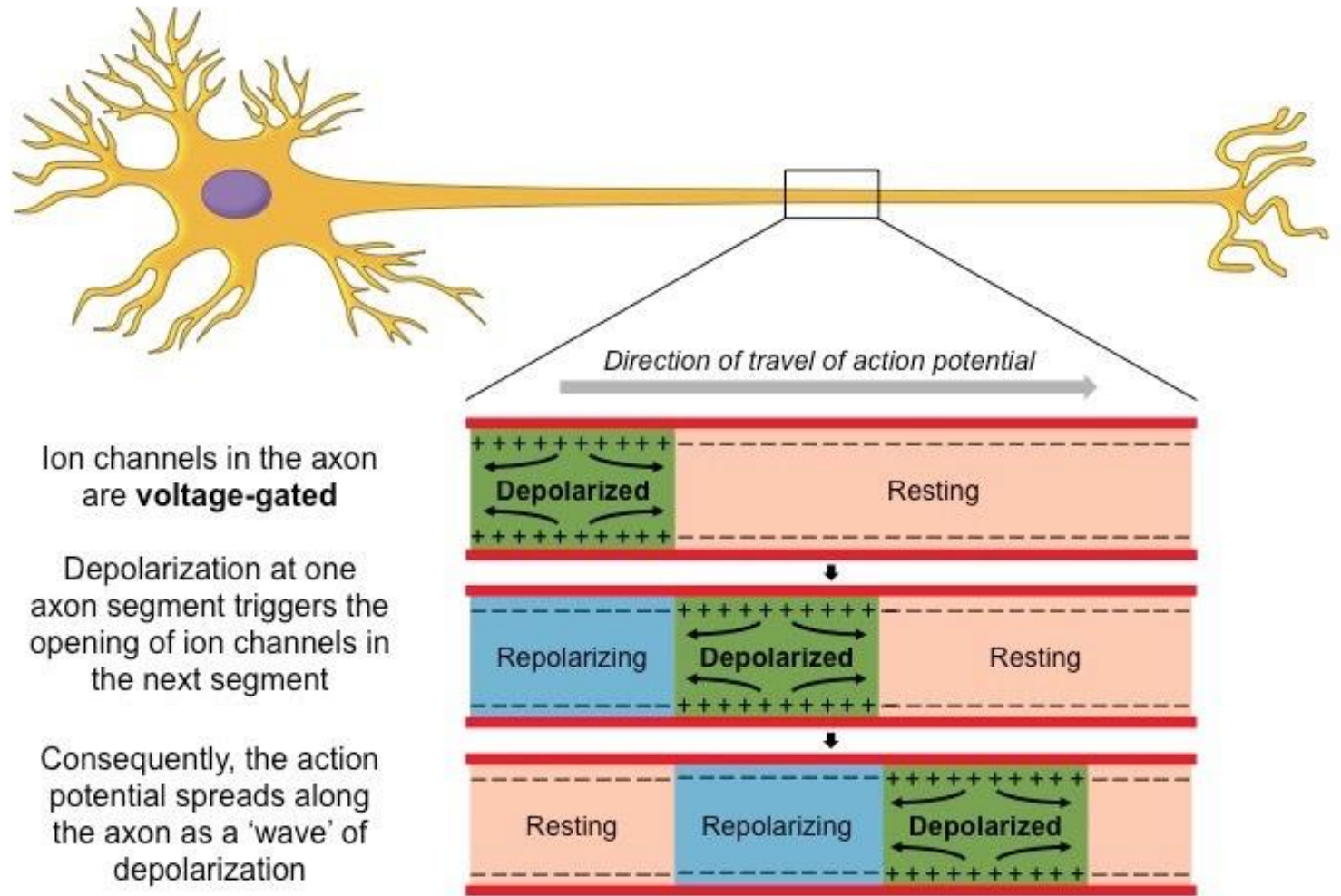
a) Sodium (Na^+) ion. b) Potassium (K^+) ion. c) Sodium channel. d) Potassium channel. e) Sodium-potassium pump.



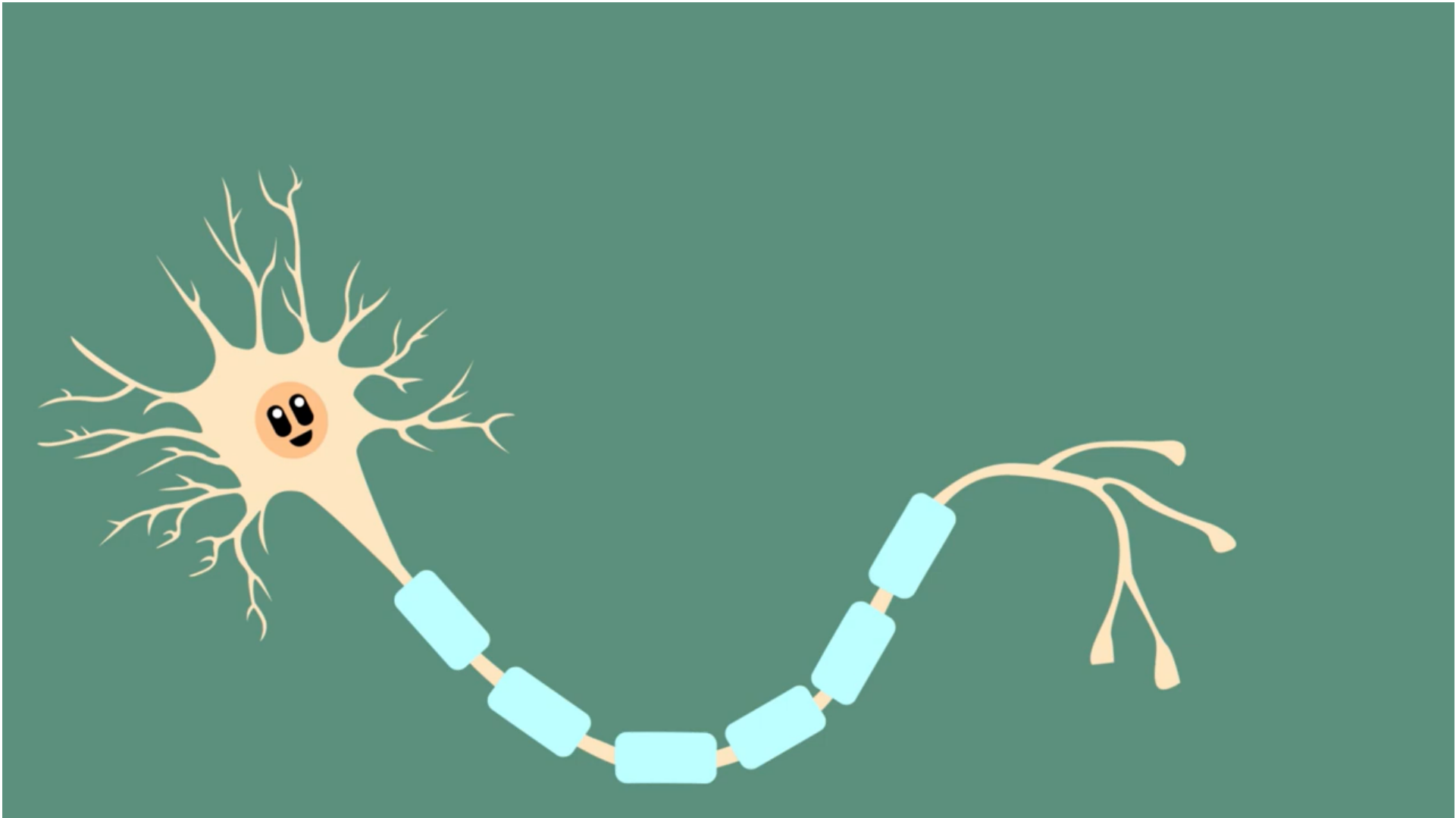
Potensial aksi

- Timbul bila suatu rangsang yang menyebabkan depolarisasi mencapai ambang letup suatu neuron/sel otot
- Terjadi peningkatan permeabilitas membran secara menyeluruh terhadap ion Na^+

Potensial aksi

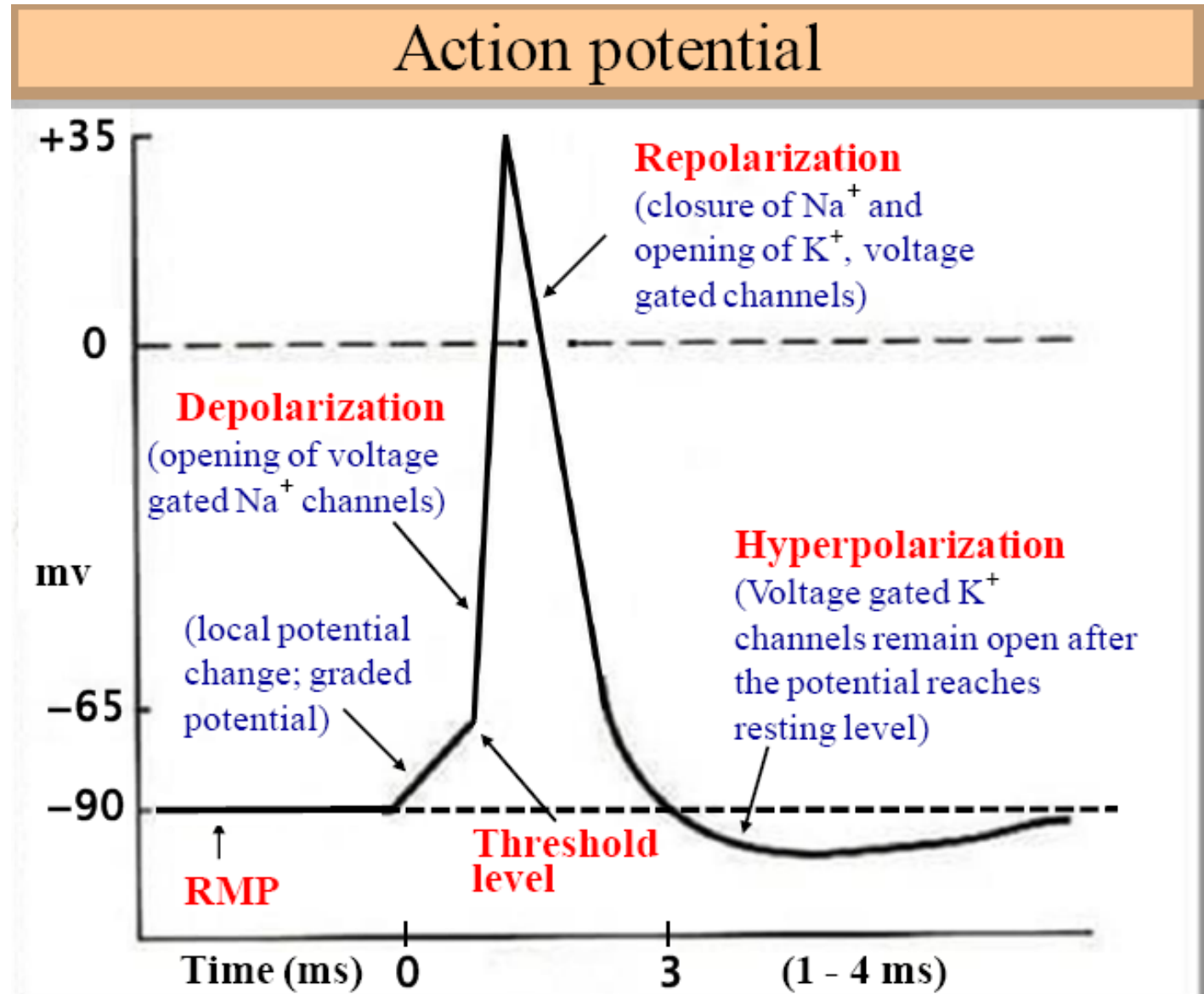


Potensial aksi



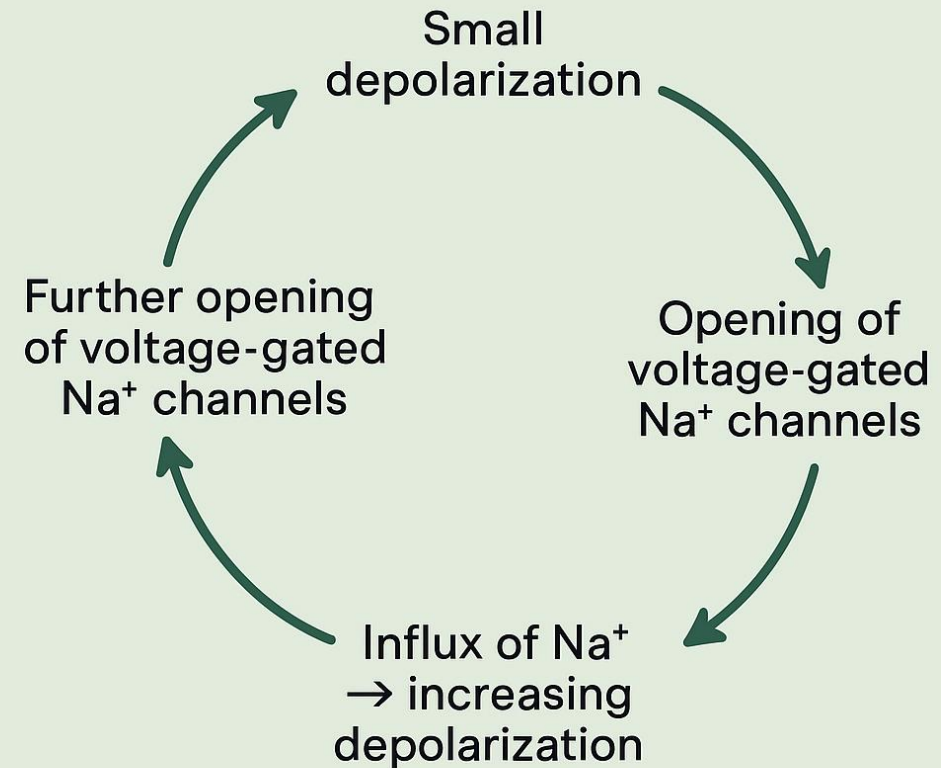
POTENSIAL AKSI

- Fase-fase yang terjadi pada potensial aksi
 - Fase depolarisasi
 - Kaduk julang/*overshoot*
 - Fase repolarisasi cepat
 - Fase repolarisasi lambat/*after depolarization*
 - Fase *afterhyperpolarization*

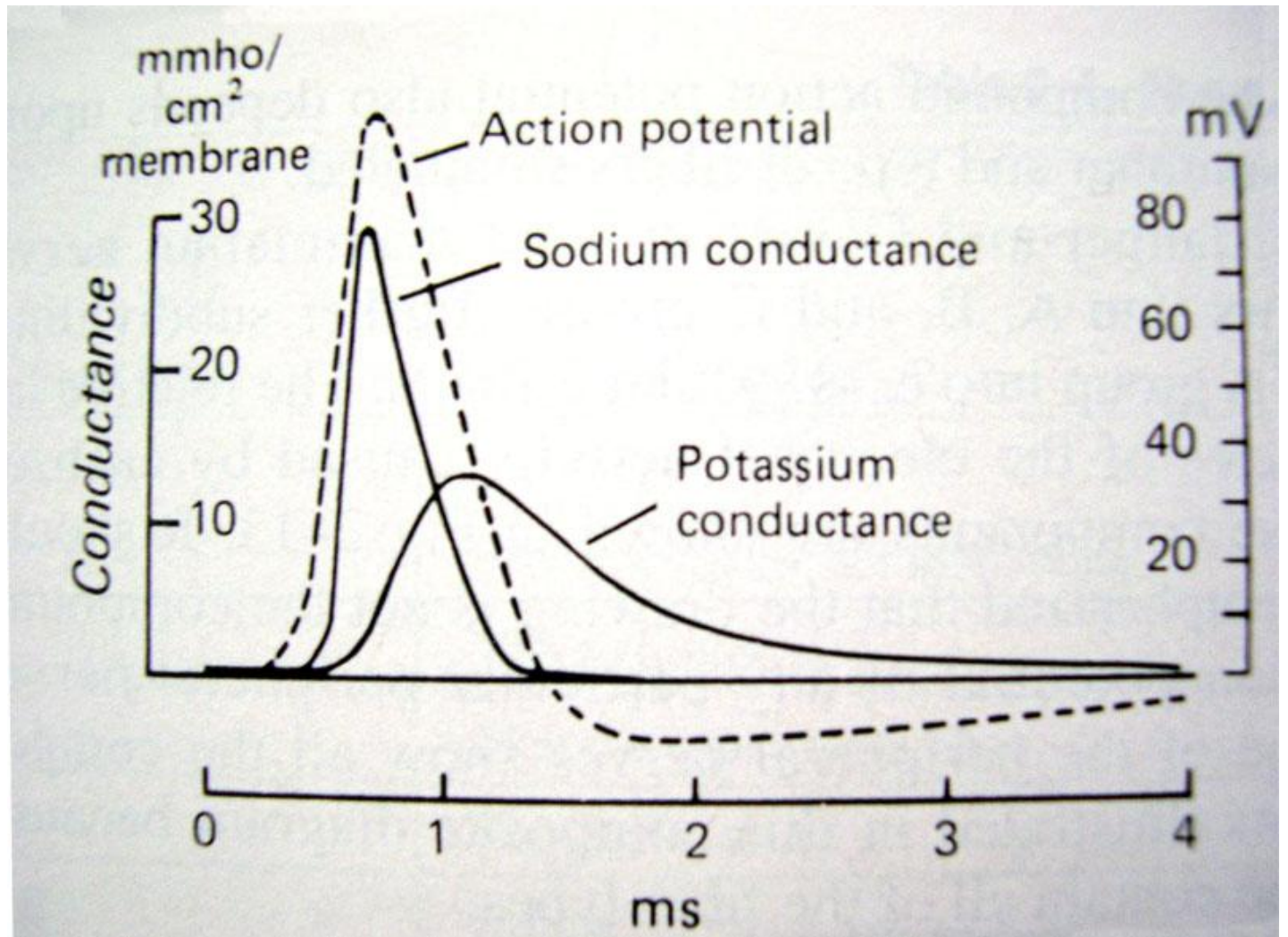


SIKLUS HODGKIN

HODGKIN'S CYCLE



Perubahan
yang terjadi
selama
potensial aksi



Local response

- Adalah suatu respons yang timbul bila rangsang yang diberikan tidak cukup kuat untuk mencapai ambang letup/*firing level*.
- Timbul akibat perubahan permeabilitas membran terhadap ion², dan hanya bersifat setempat (tidak pada seluruh permukaan membran sel)

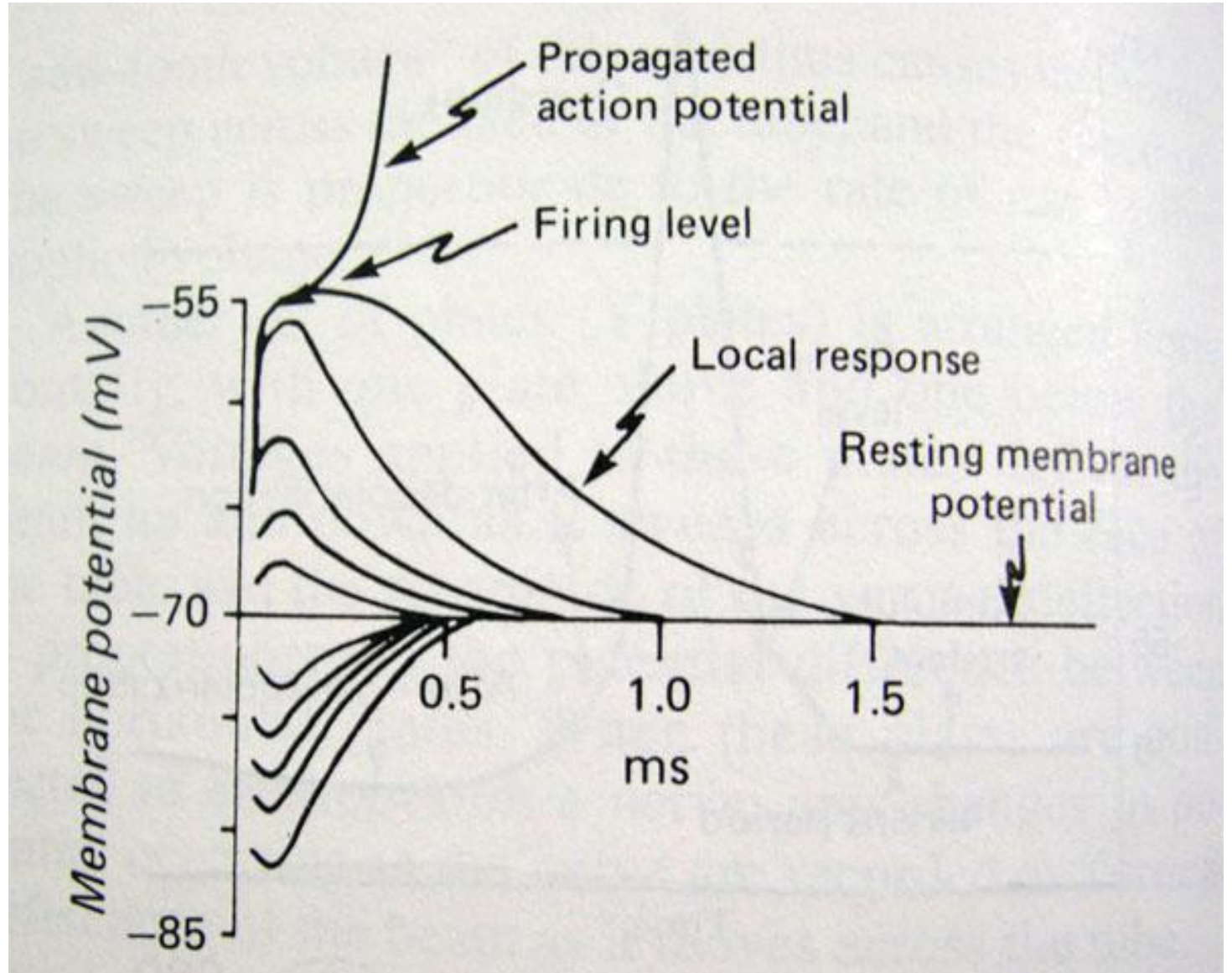
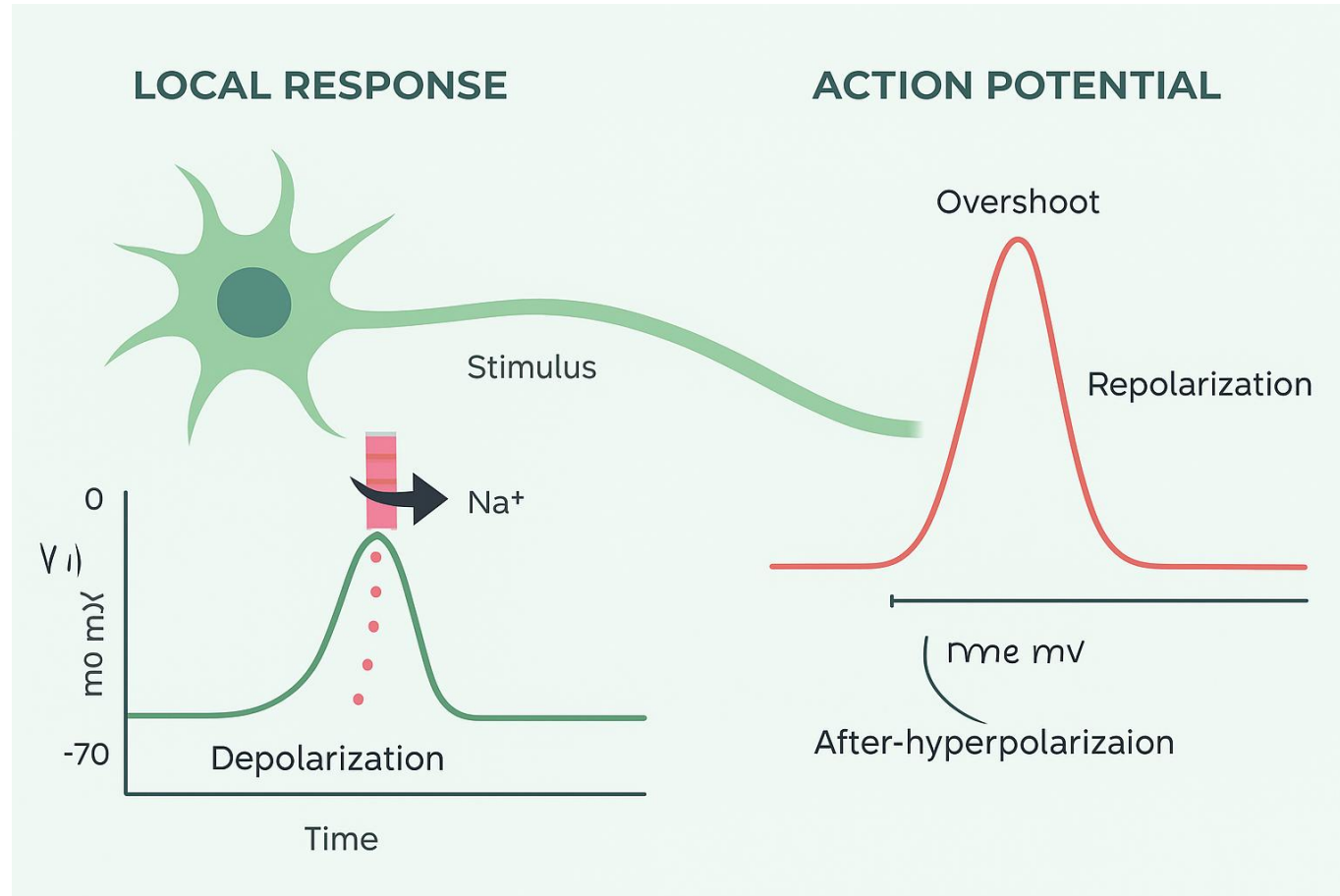
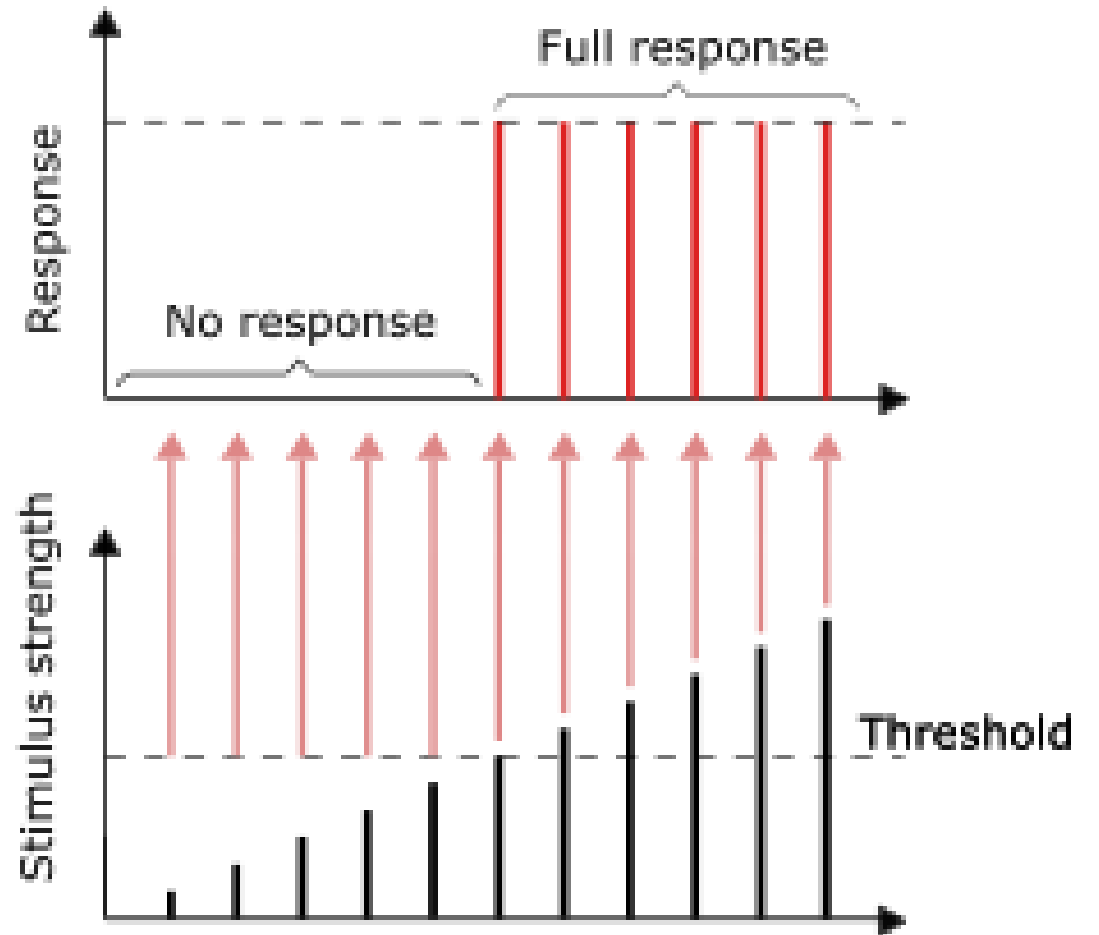


Diagram gabungan visual : *respon lokal* → *potensial aksi*



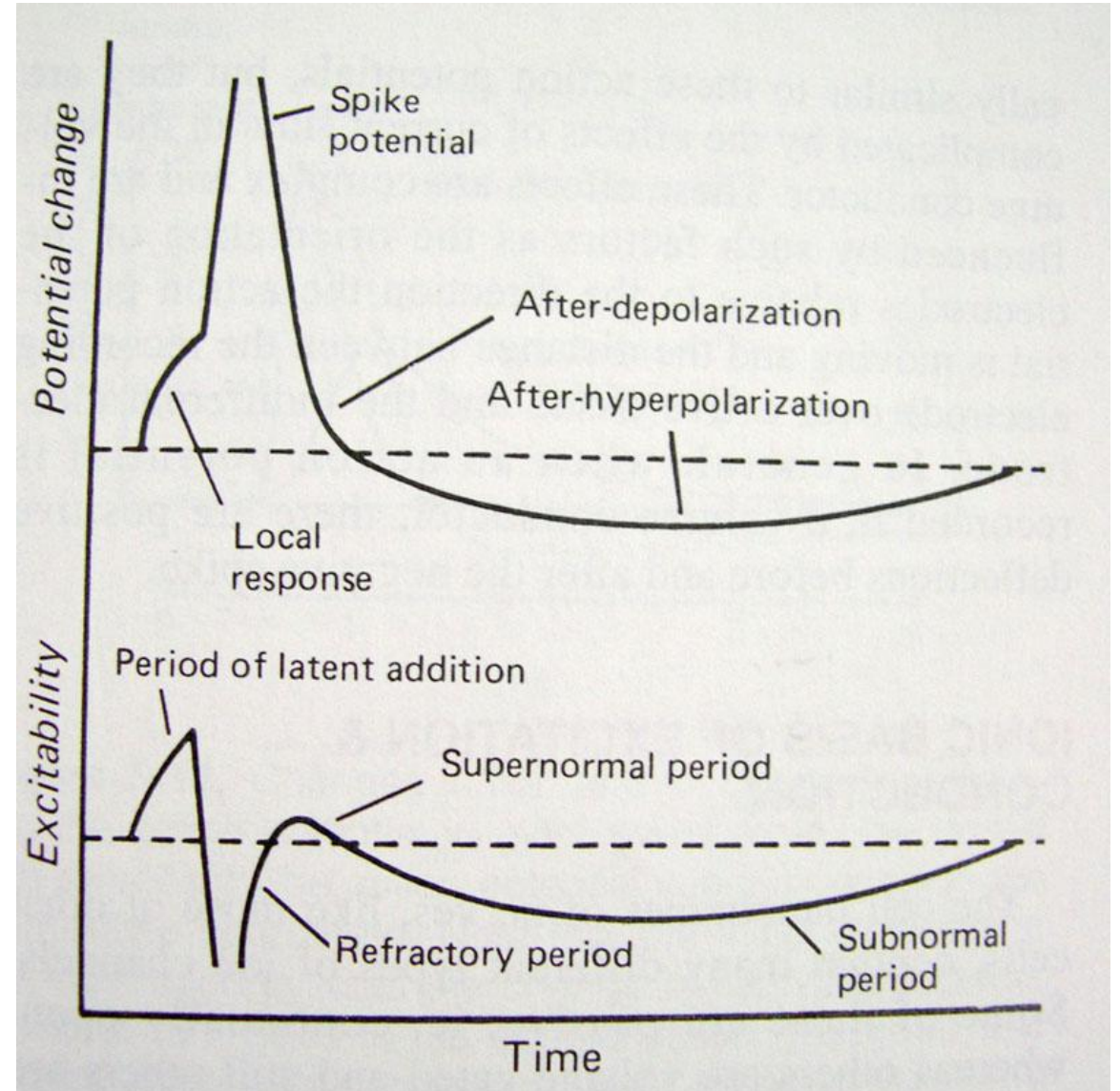
Hukum All or None

- Suatu serat saraf / otot bila dirangsang akan memberikan jawaban maksimal atau tidak memberikan jawaban sama sekali.
- Hanya berlaku pada 1 serat saraf/otot.



Masa Refrakter

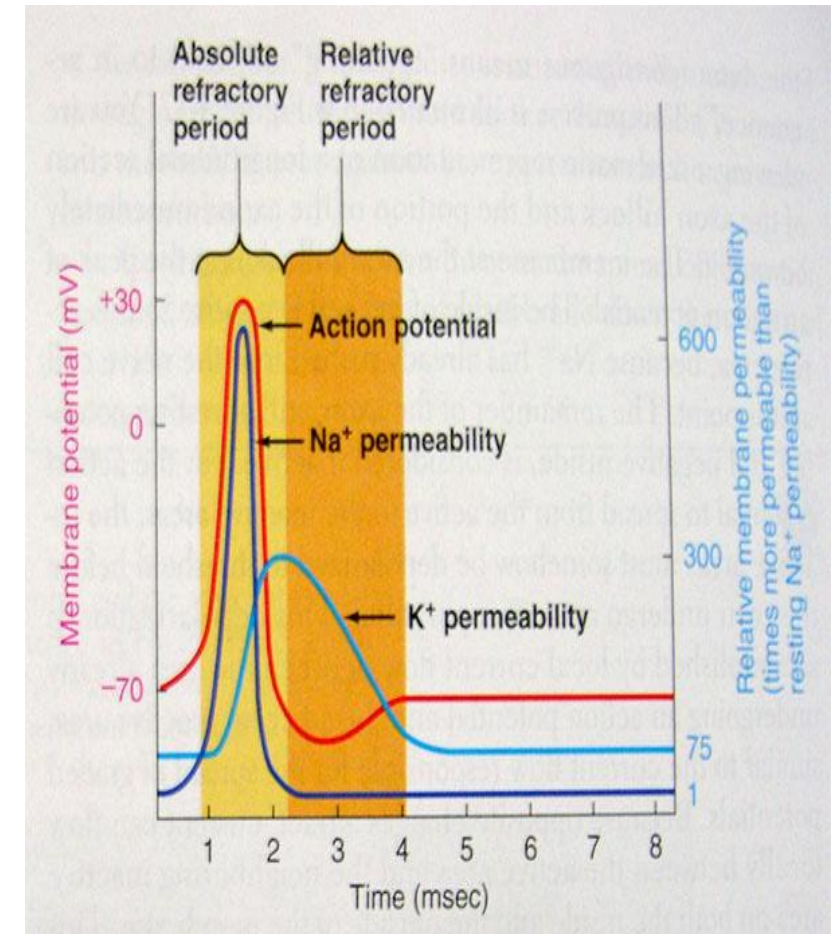
- Merupakan periode di dalam potensial aksi dimana kepekaan sel terhadap rangsang berkurang



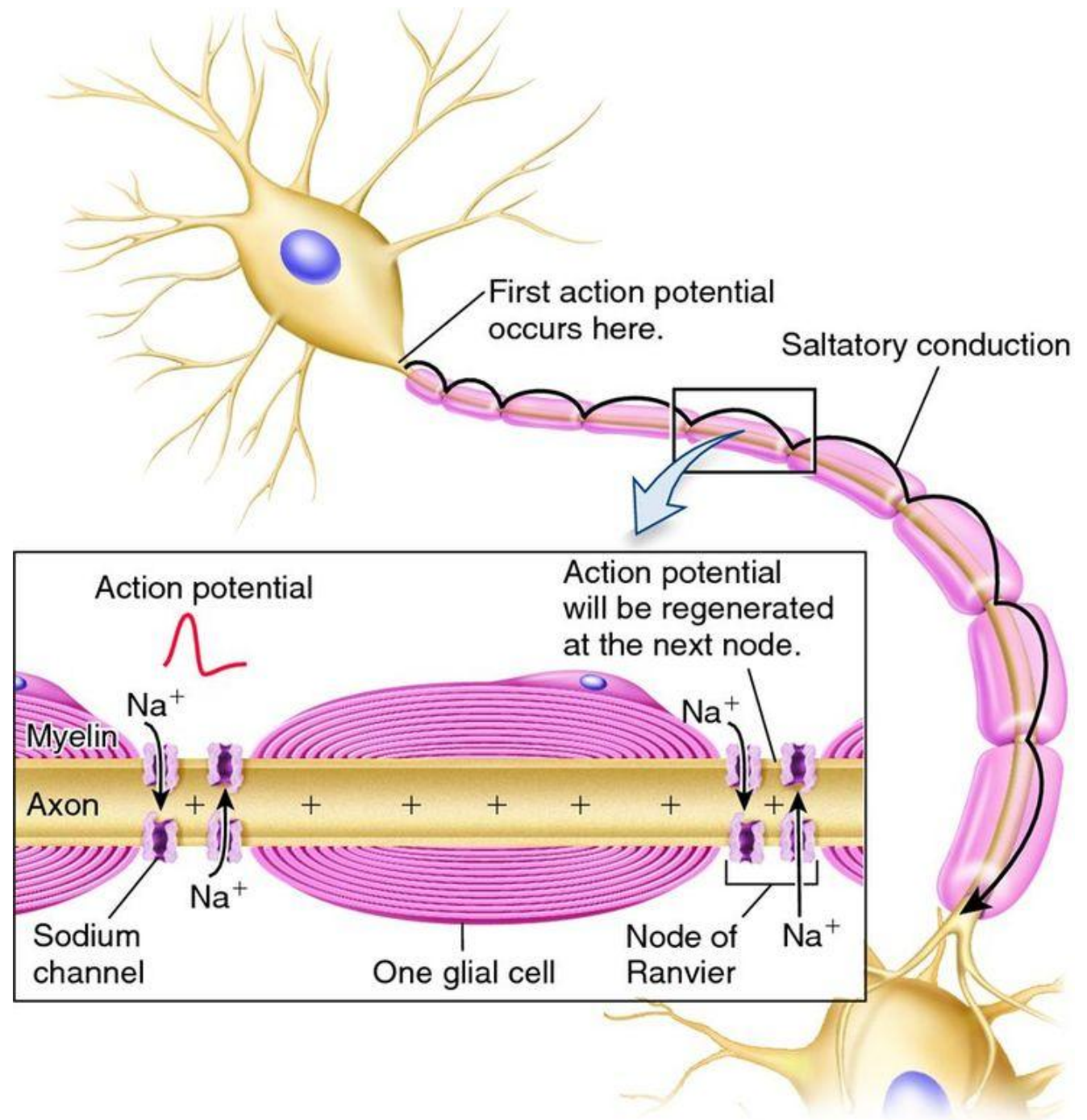
Masa Refrakter

Masa Refrakter Absolut :
rangsang sebesar apapun tidak akan menghasilkan potensial aksi baru

Masa Refrakter Relatif :
memerlukan kekuatan rangsang yang sangat besar untuk mencetuskan potensial aksi baru

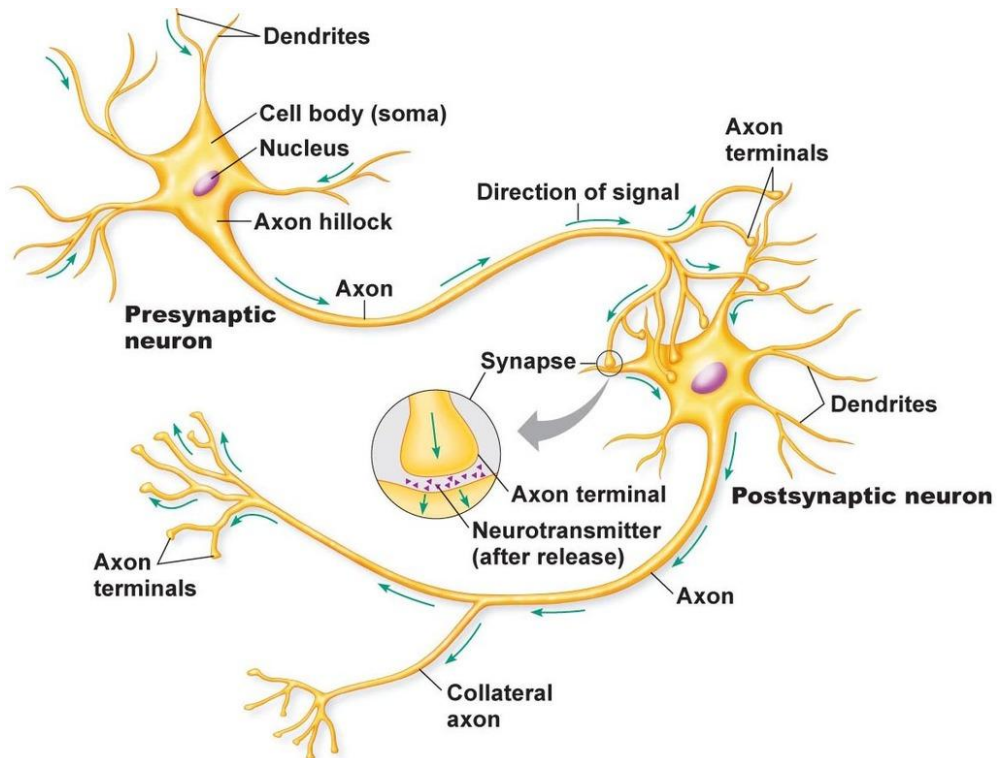


Penghantaran Impuls Neuron Ber-myelin



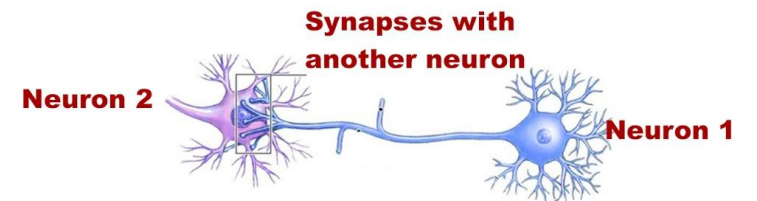
SINAPS

Hubungan neuron dengan sel lain

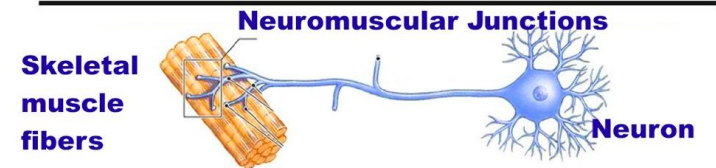


Types of Synapses

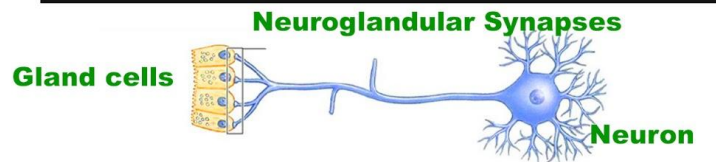
Synapses with another neuron



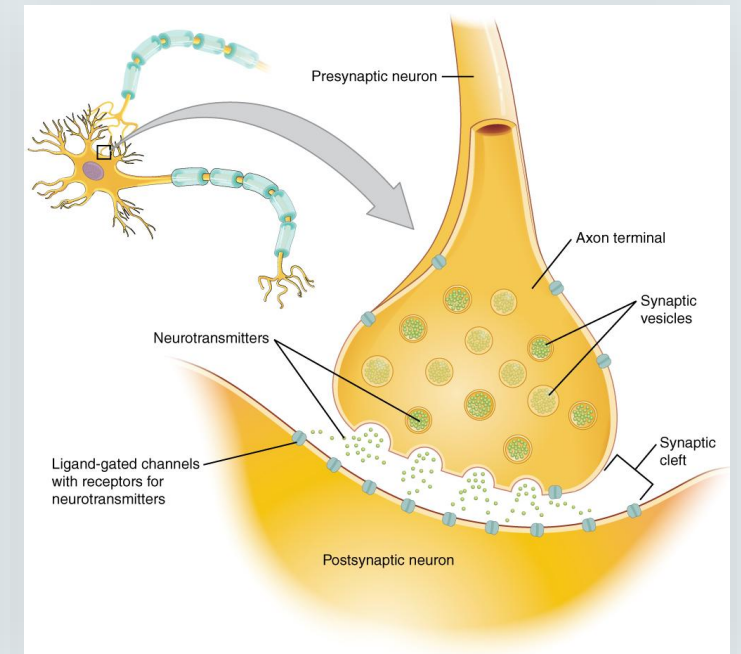
Neuromuscular Junctions



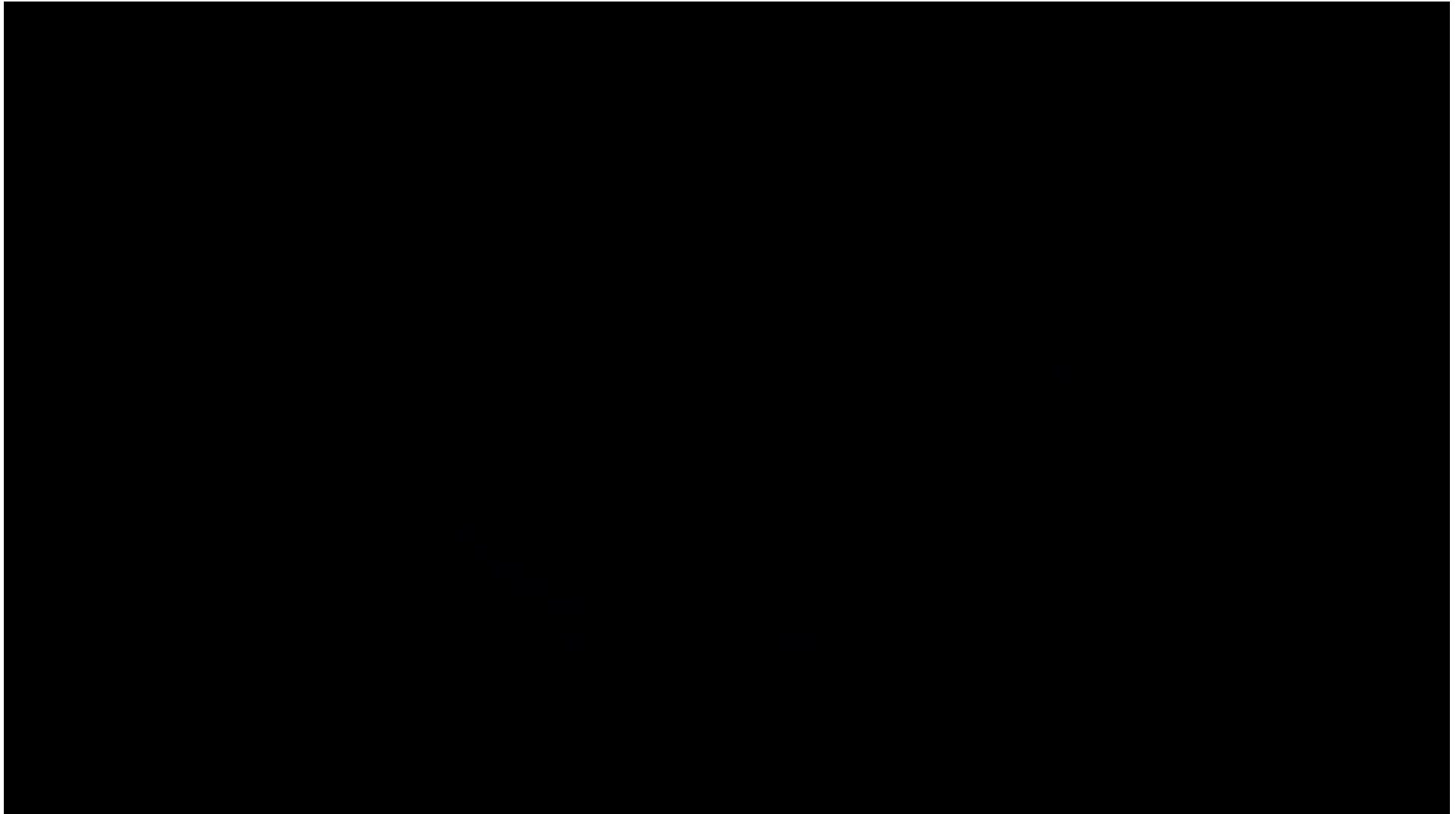
Neuroglandular Synapses



Anatomi sinaps

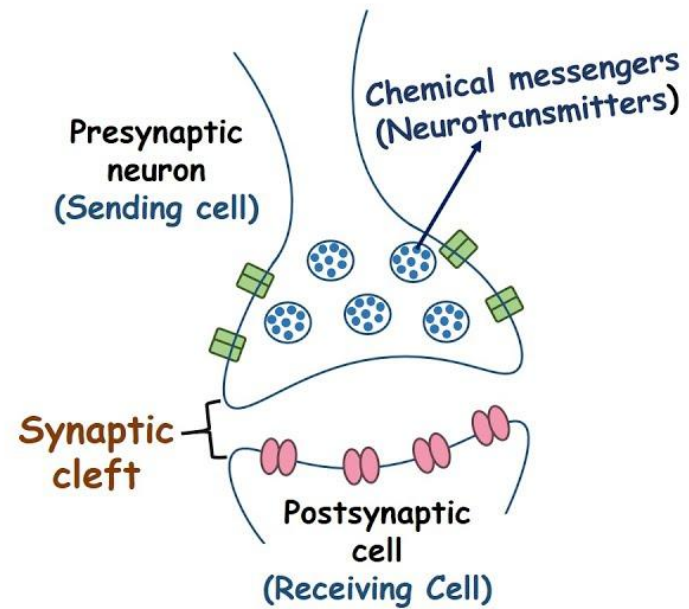


Synapse Structure

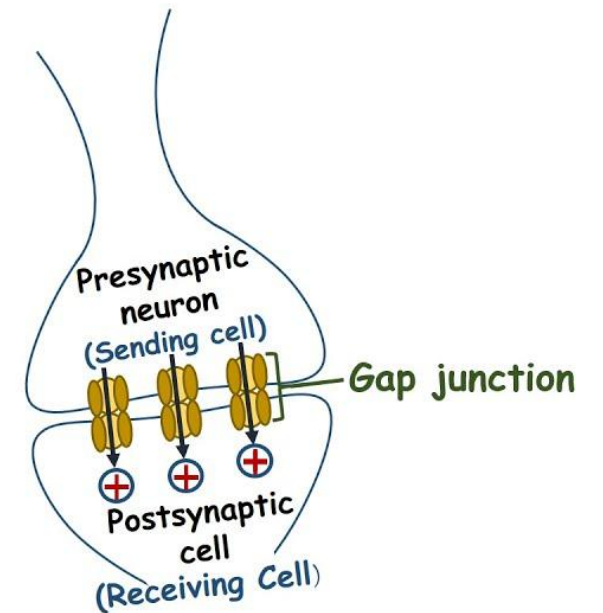


Klasifikasi sinaps

Chemical Synapse

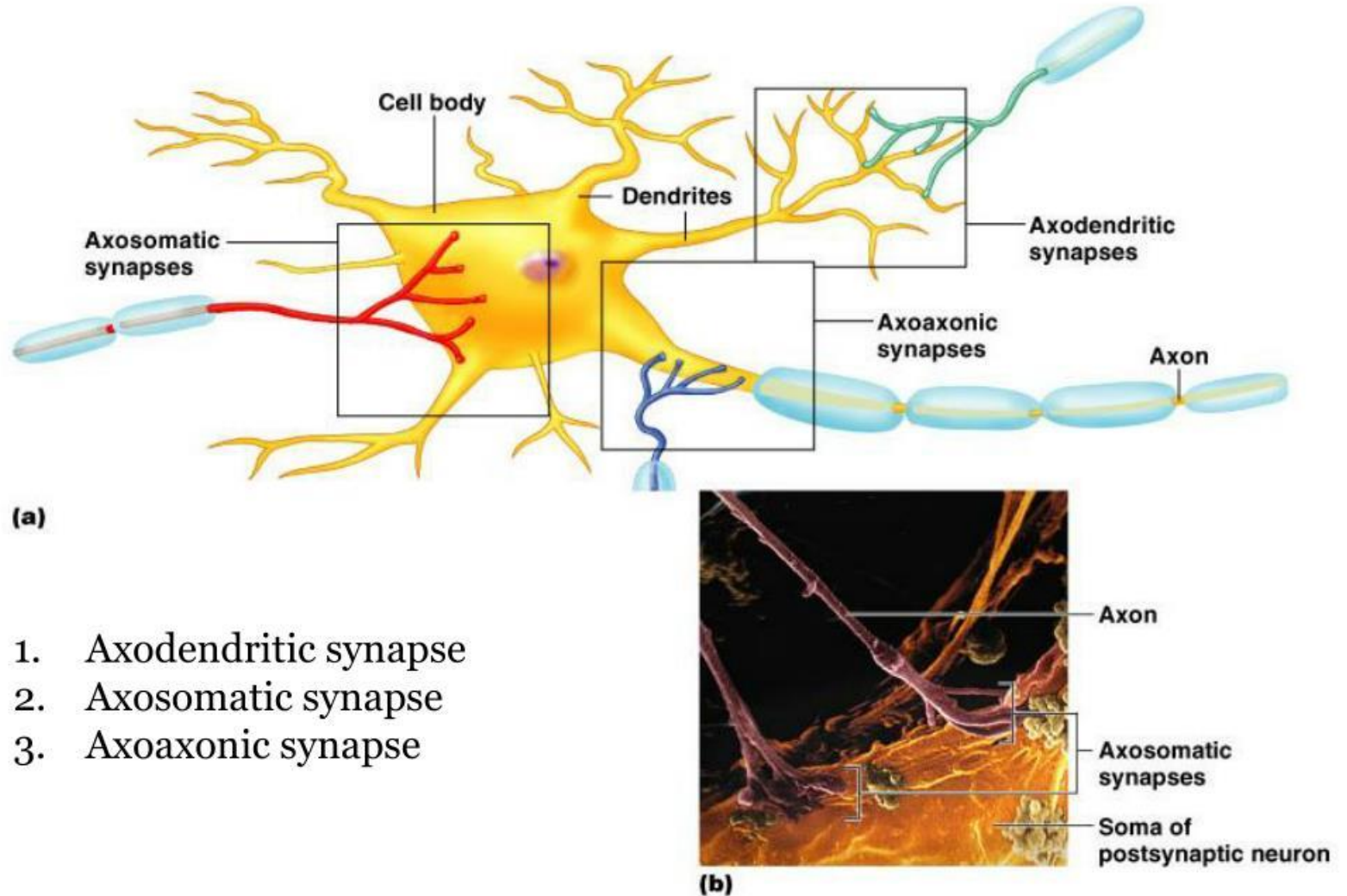


Electrical Synapse

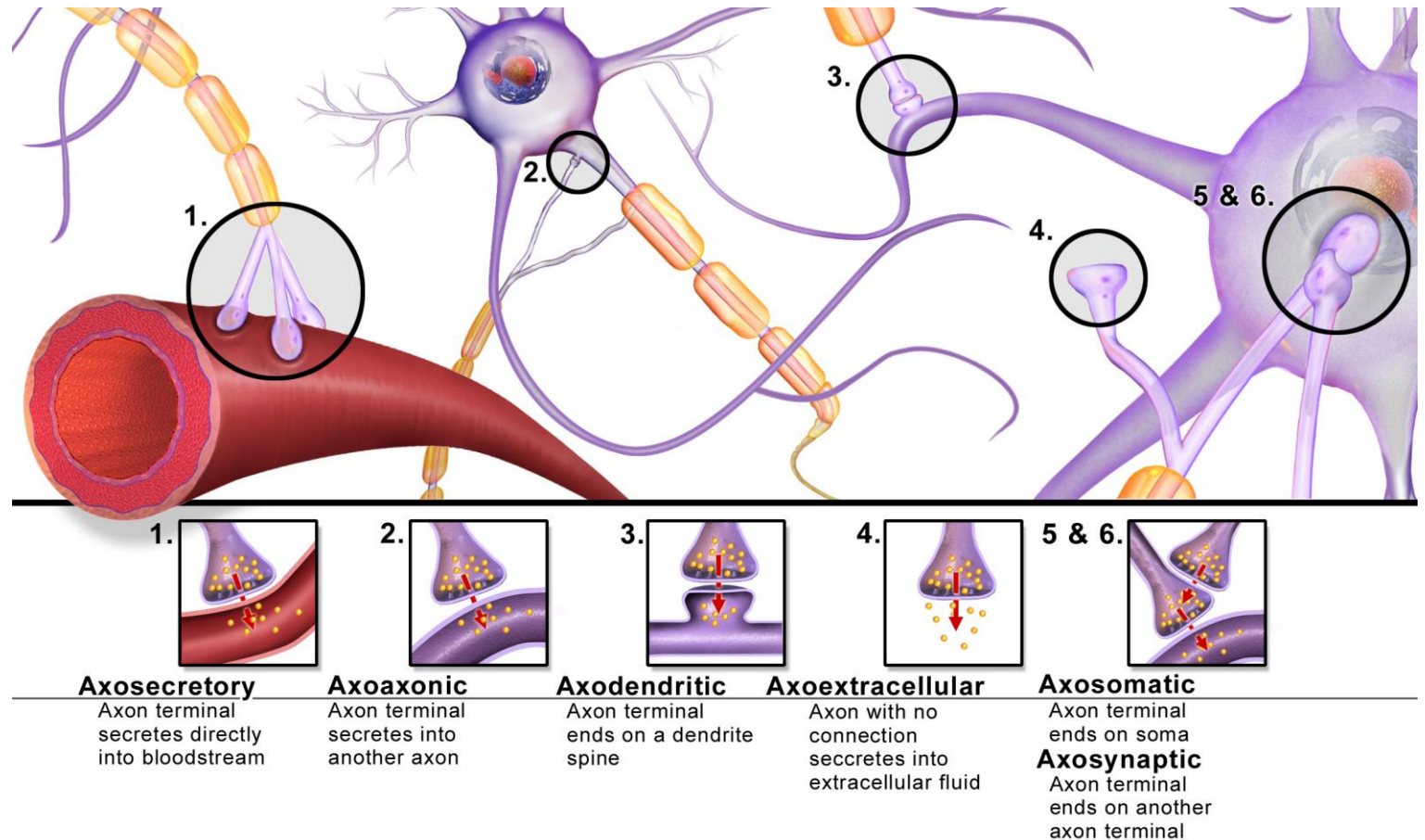


Synapses

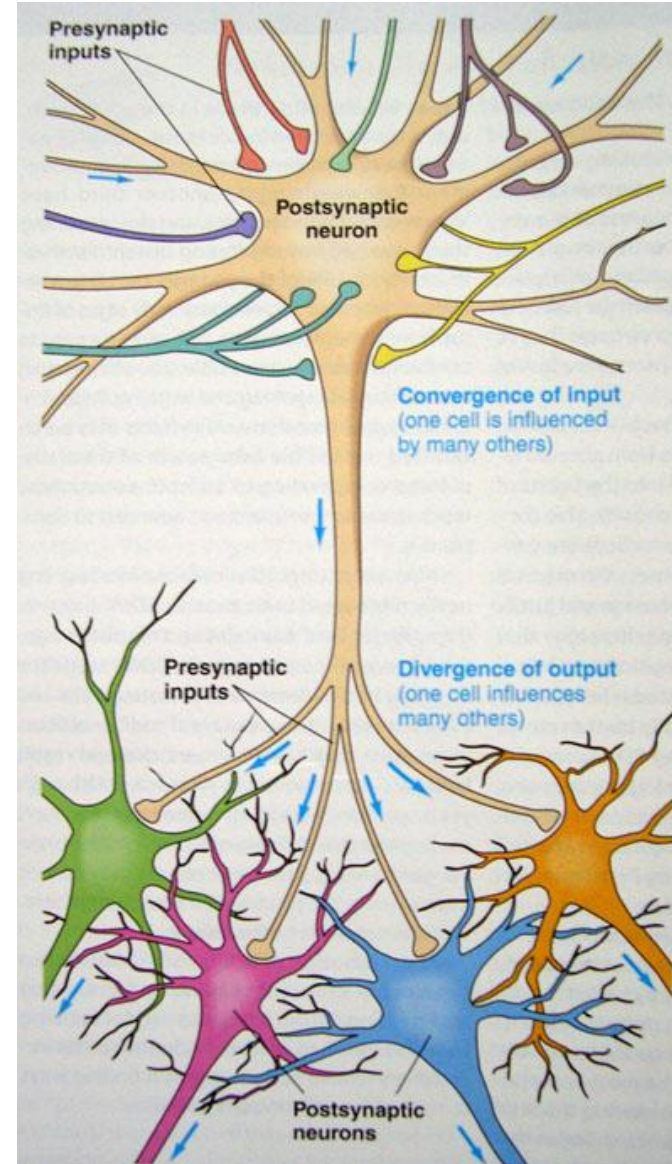
Klasifikasi sinaps



Klasifikasi sinaps

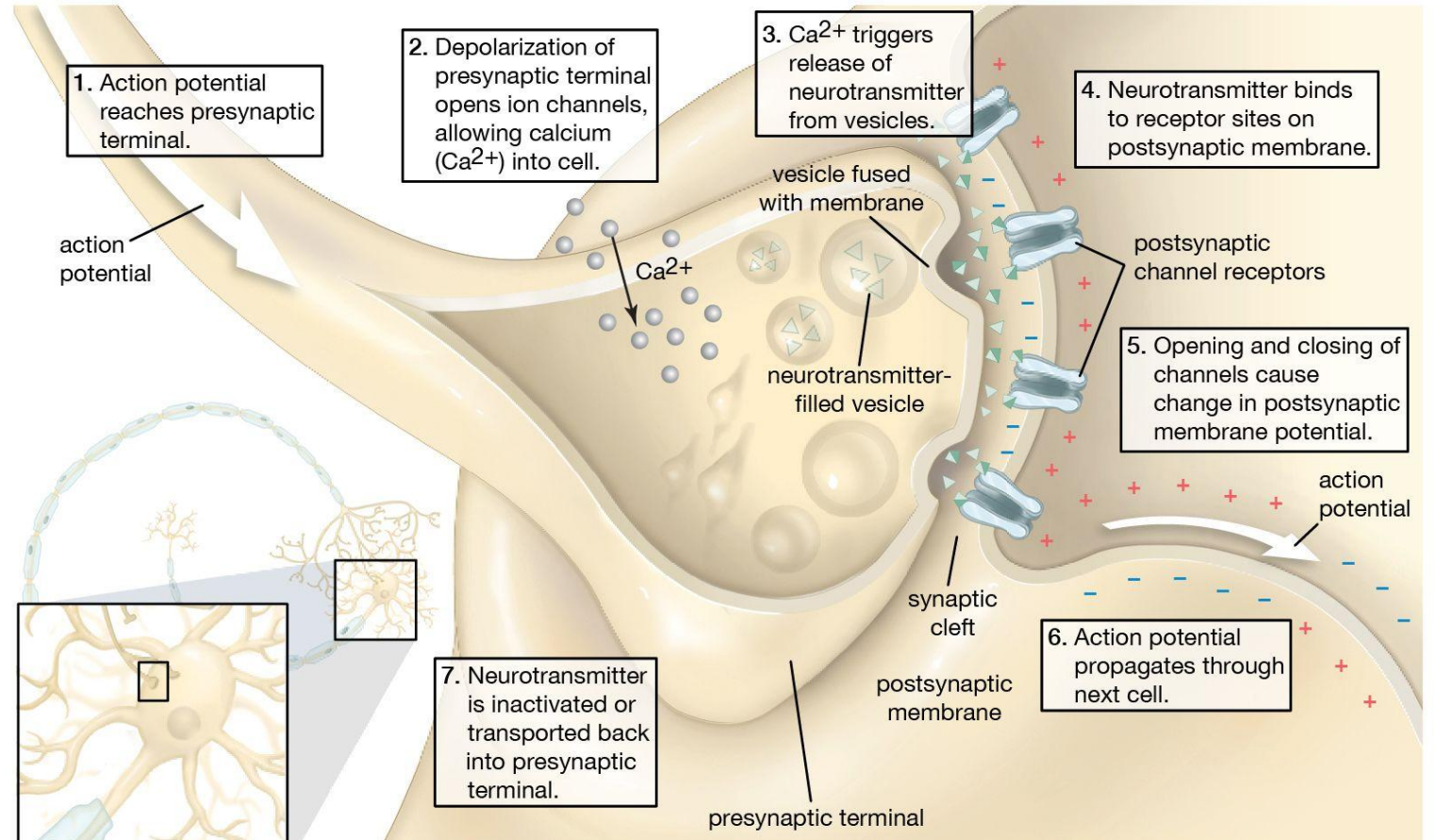


Klasifikasi sinaps

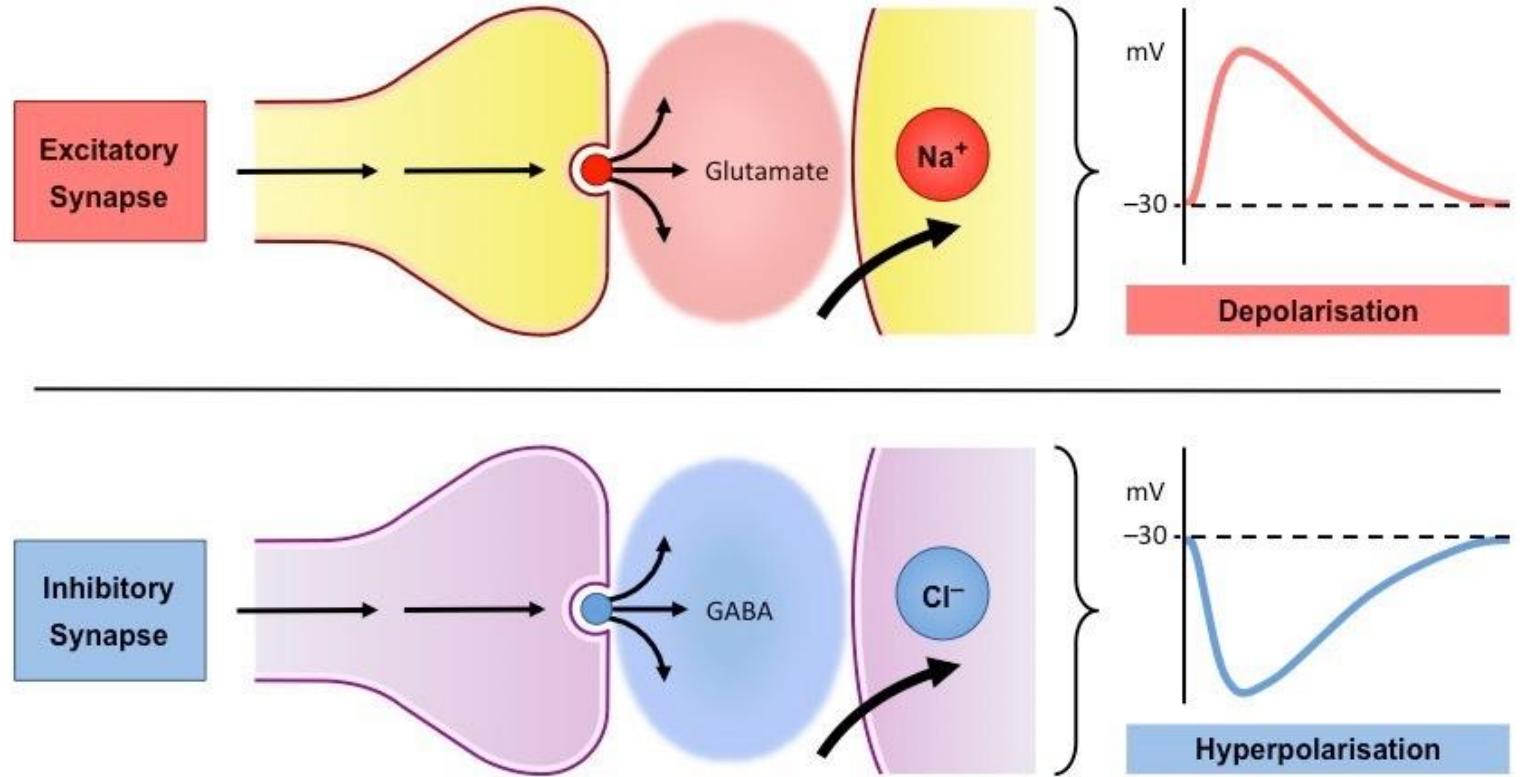




Fisiologi sinaps



Potential postsinaps



EPSP, IPSP, Slow EPSP, Slow IPSP

Jenis Potensial	Mediator	Kanal	Efek	Durasi
Fast EPSP	Glutamat, ACh	Na ⁺ masuk	Depolarisasi	10–20 ms
Fast IPSP	GABA, Glisin	Cl ⁻ masuk / K ⁺ keluar	Hiperpolarisasi	10–30 ms
Slow EPSP	Dopamin, Serotonin	Ca ²⁺ masuk / K ⁺ tertutup	Depolarisasi lambat	Detik–menit
Slow IPSP	Dopamin, GABA-B	K ⁺ keluar lama	Hiperpolarisasi lambat	Detik–menit

SINAPS – NEUROMUSCULAR JUNCTION



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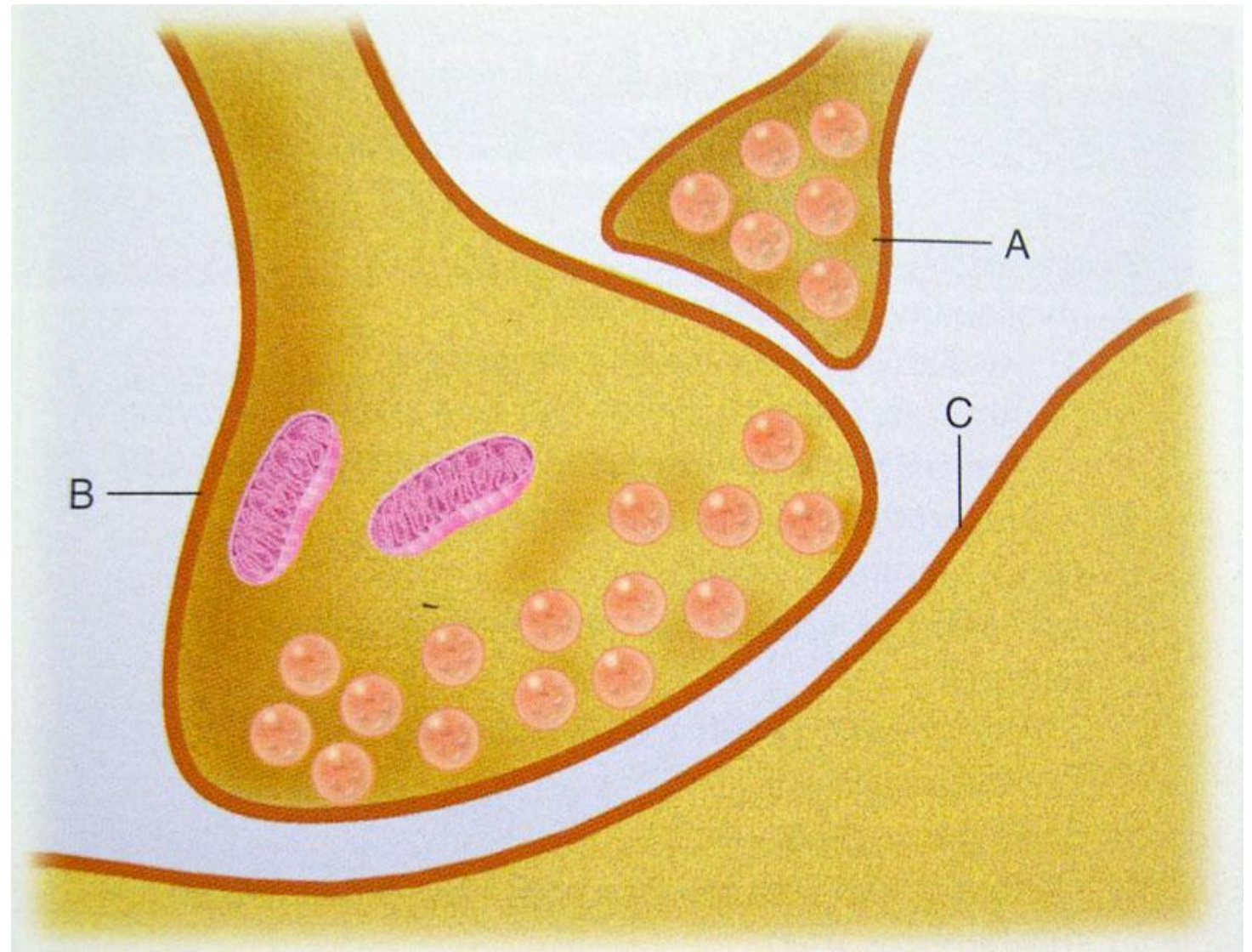
Proses yang mempengaruhi pencetusan potensial aksi

- Fasilitasi :

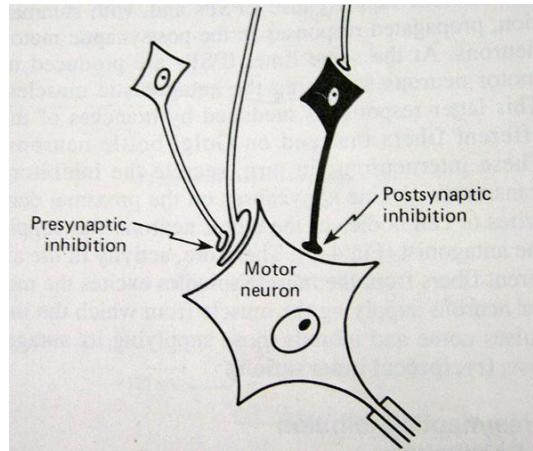
Proses yang mempermudah terjadinya potensial aksi pada sel postsinaps

- Inhibisi :

Proses yang menghambat terjadinya potensial aksi



Inhibisi



Inhibisi postsinaps :

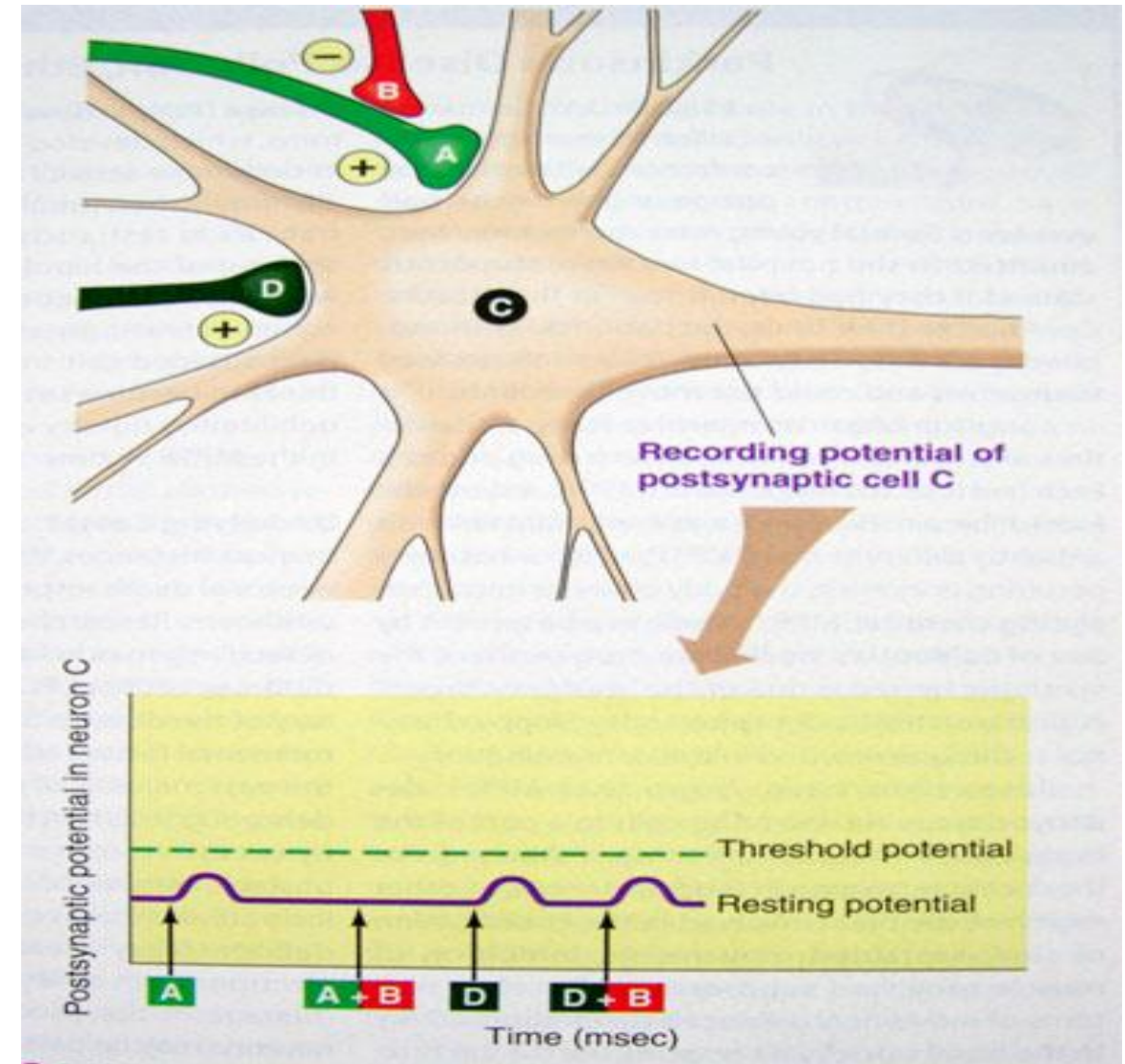
Direk / langsung IPSP
melalui interneuron

Indirek / tidak langsung
masa refrakter, masa
after hiperpolarization

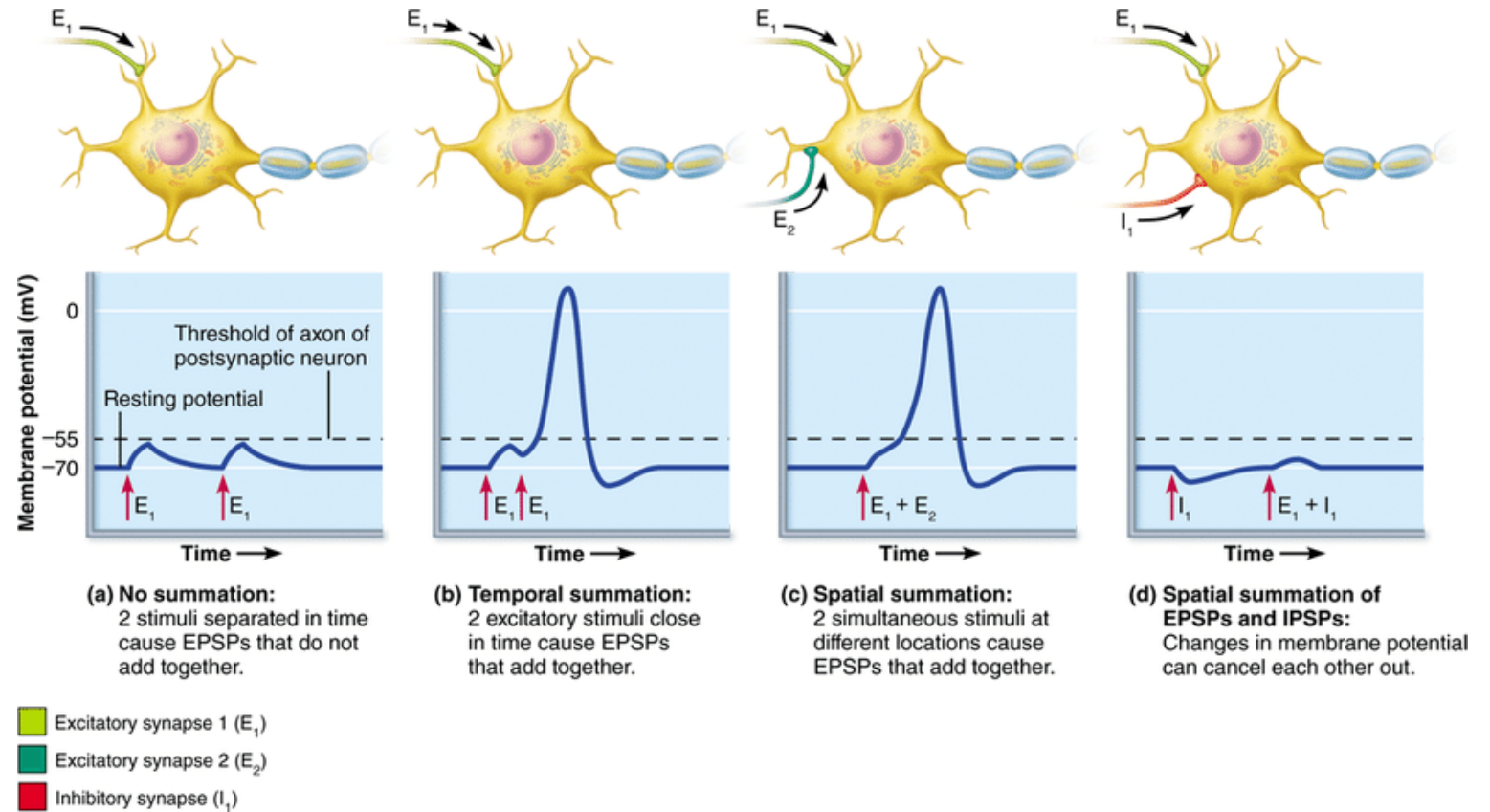


Inhibisi presinaps

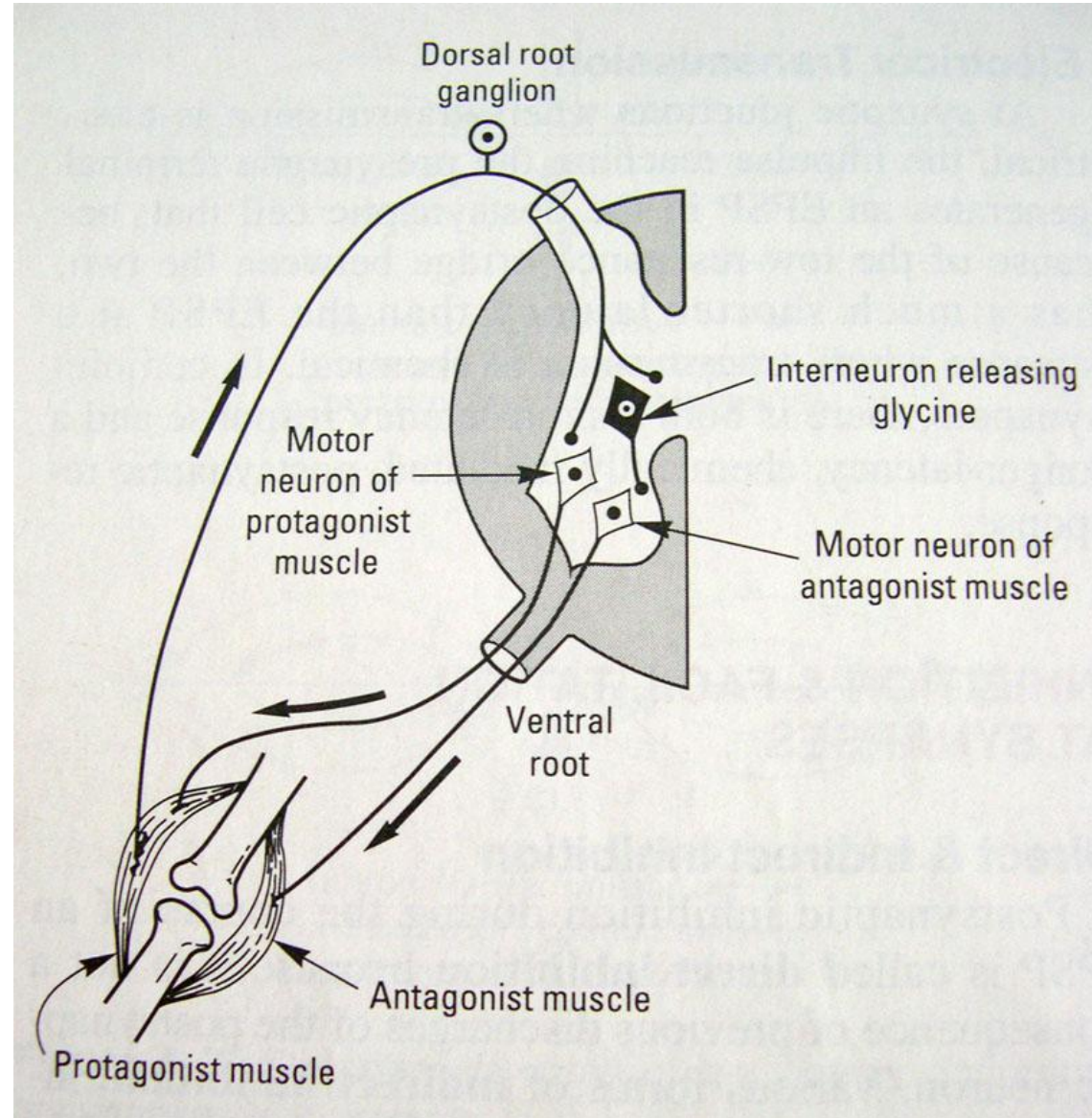
melalui struktur
presynaptic synapse



Potensial postsinaps



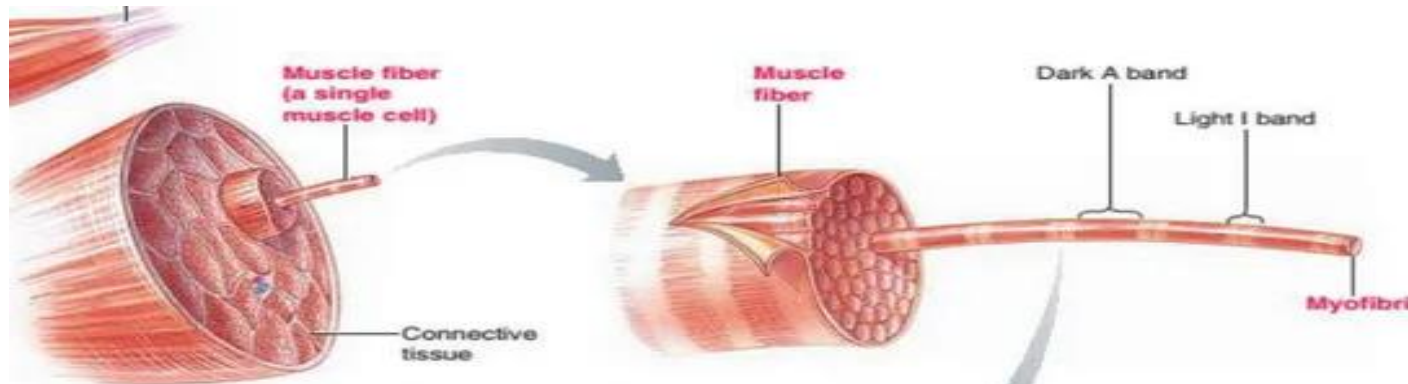
Persarafan resiprokal



FISIOLOGI OTOT LURIK

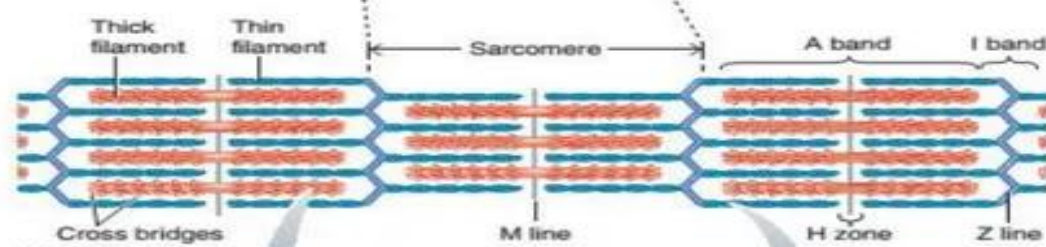
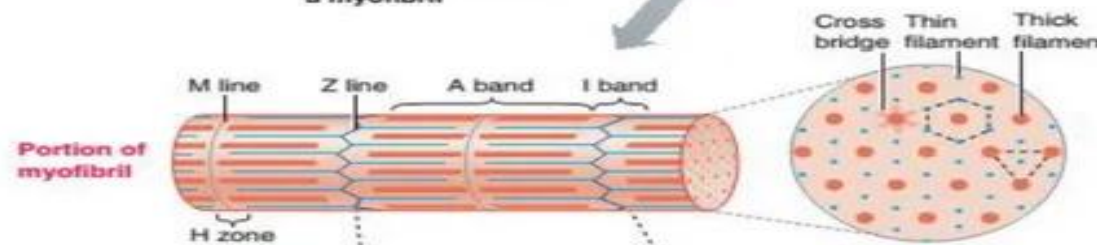


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a whole muscle and a muscle fiber

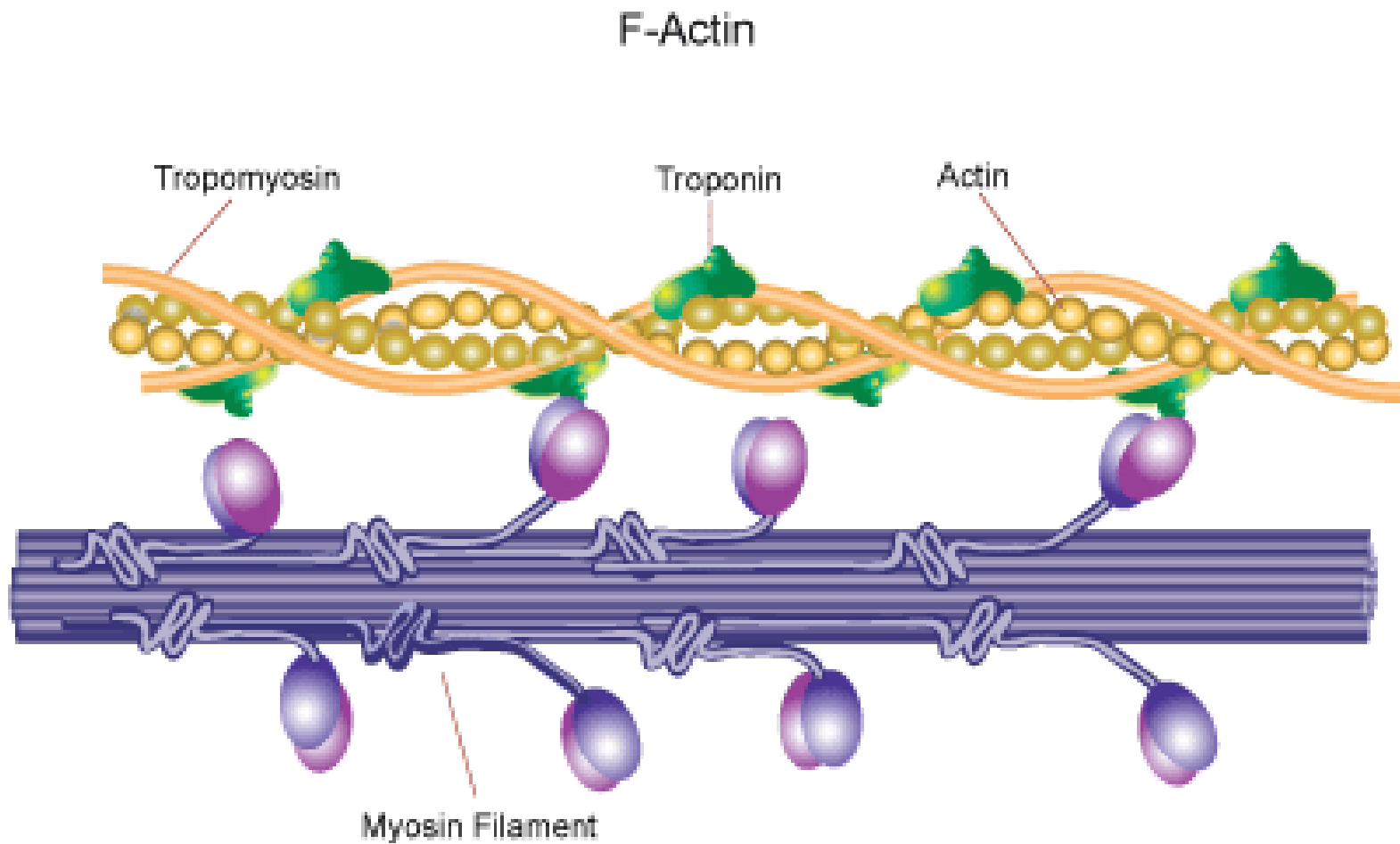
(b) Relationship of a muscle fiber and a myofibril



(c) Cytoskeletal components of a myofibril



FISIOLOGI OTOT LURIK



ACTIN & MIOSIN

KONTRAKSI OTOT

- Kontraksi otot terjadi karena adanya impuls listrik dari motoneuron yang disampaikan ke sel otot
- Proses kontraksi otot disebut juga dengan *excitation-contraction coupling*
- Peristiwa pemindahan impuls yang terjadi $\approx$ pada sinaps





Hubungan saraf-
otot rangka
(Neuromuscular
junction)

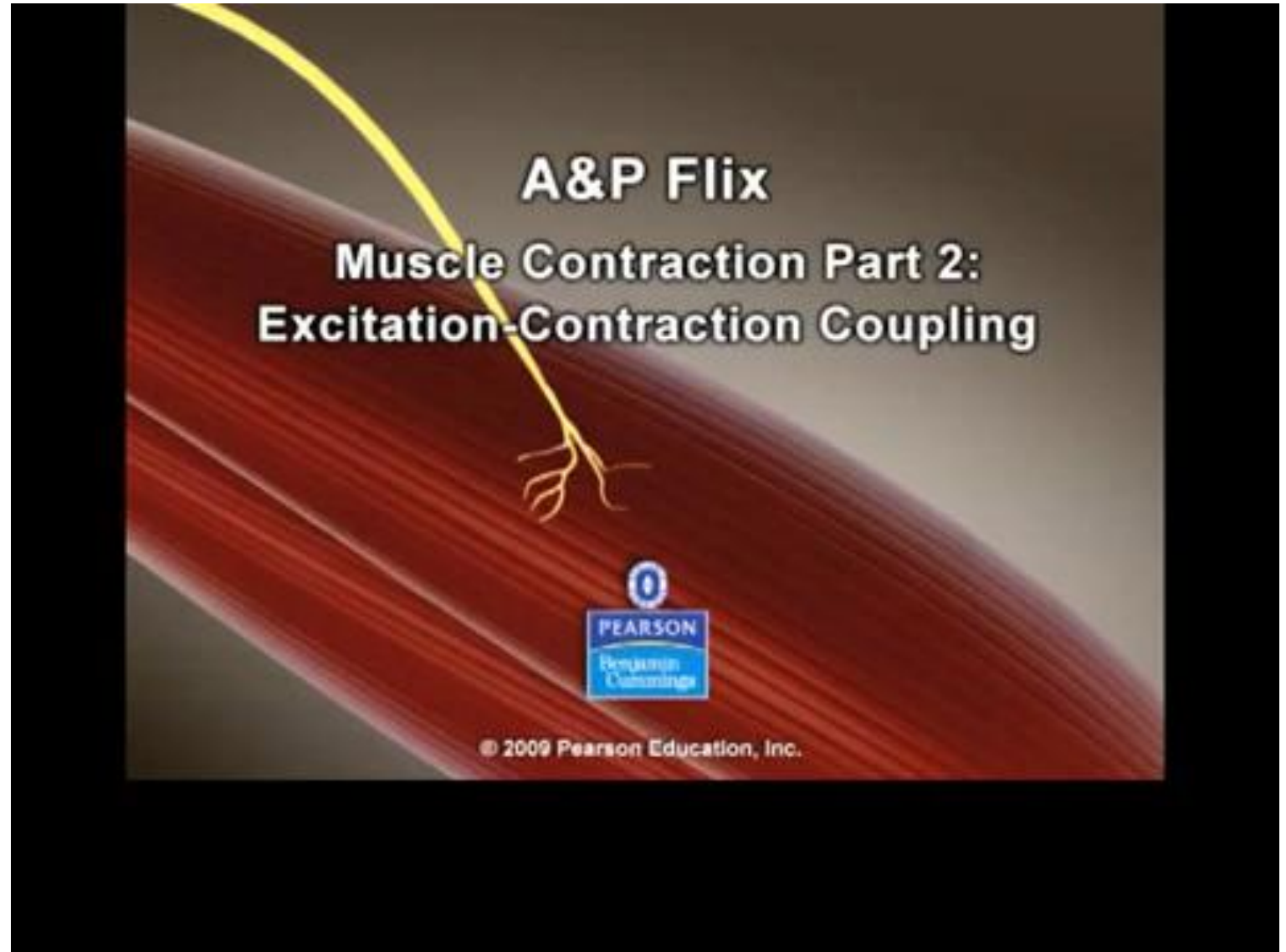
Excitation- Contraction Coupling

A&P Flix Muscle Contraction Part 1: Events at the Neuromuscular Junction

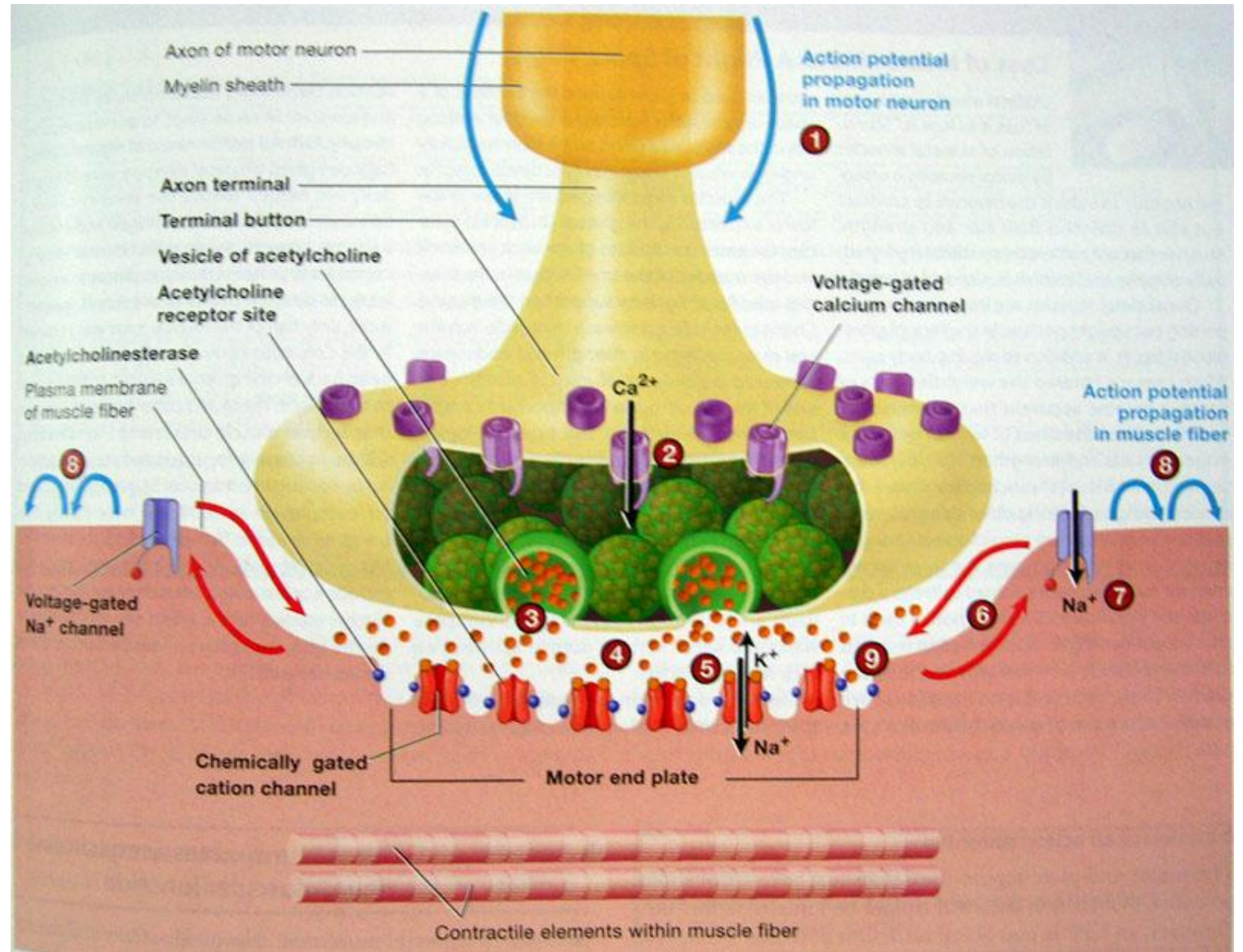


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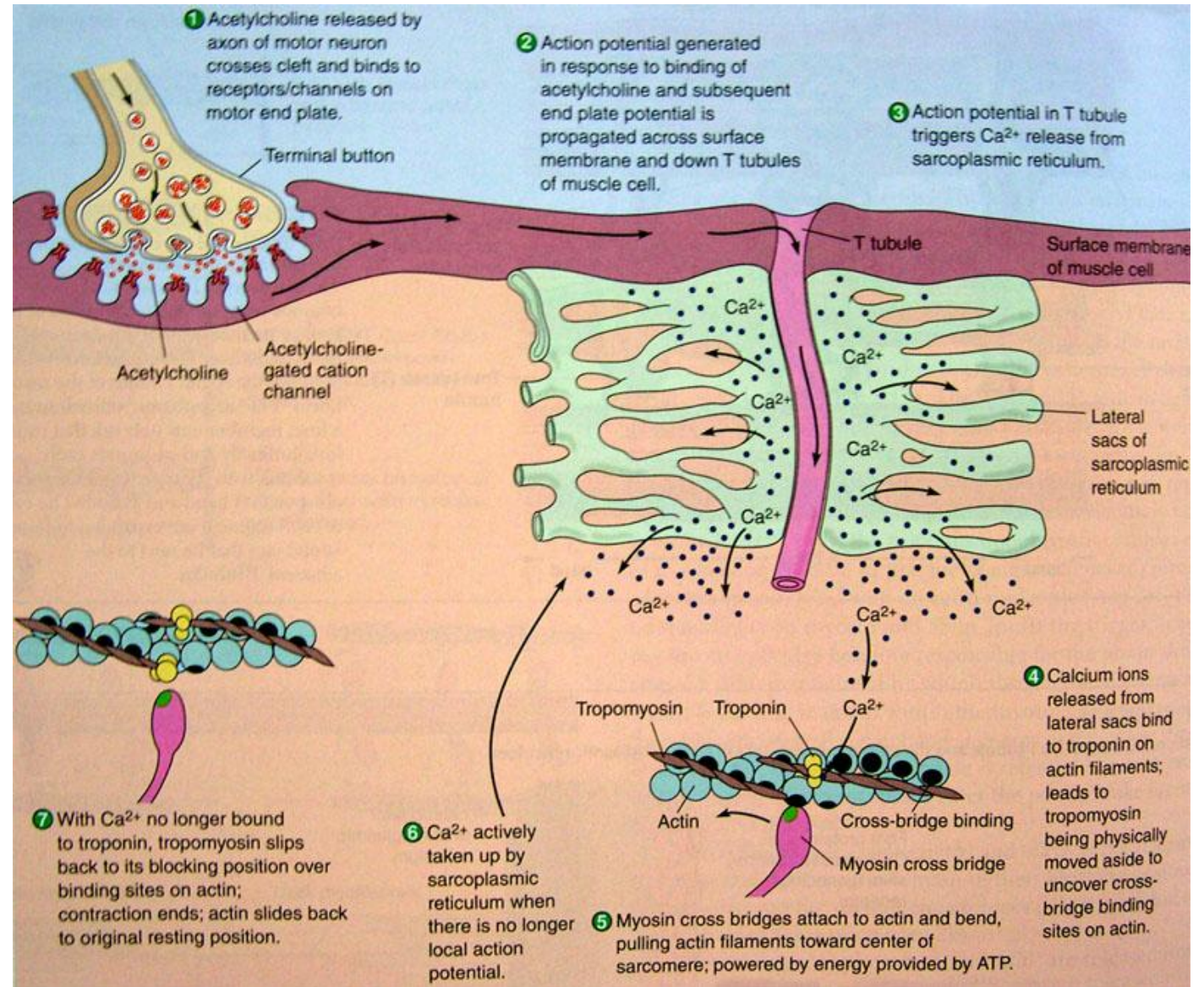
Excitation- Contraction Coupling



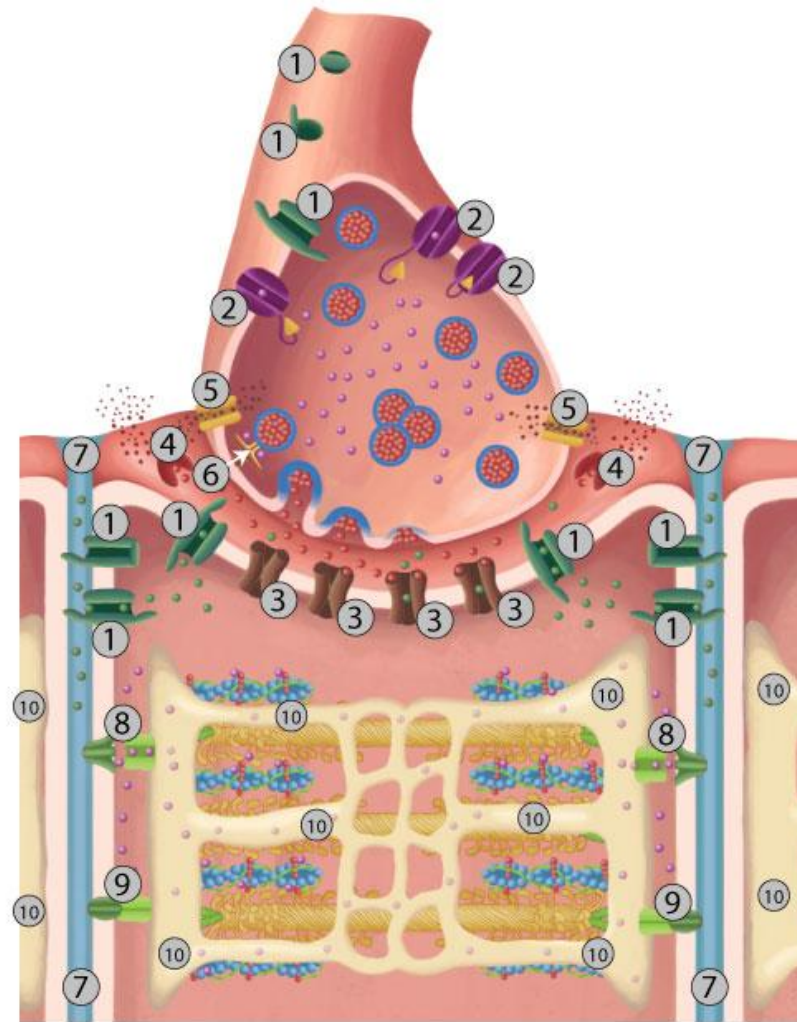
Neuro-Muscular Junction



Neuro-Muscular Junction

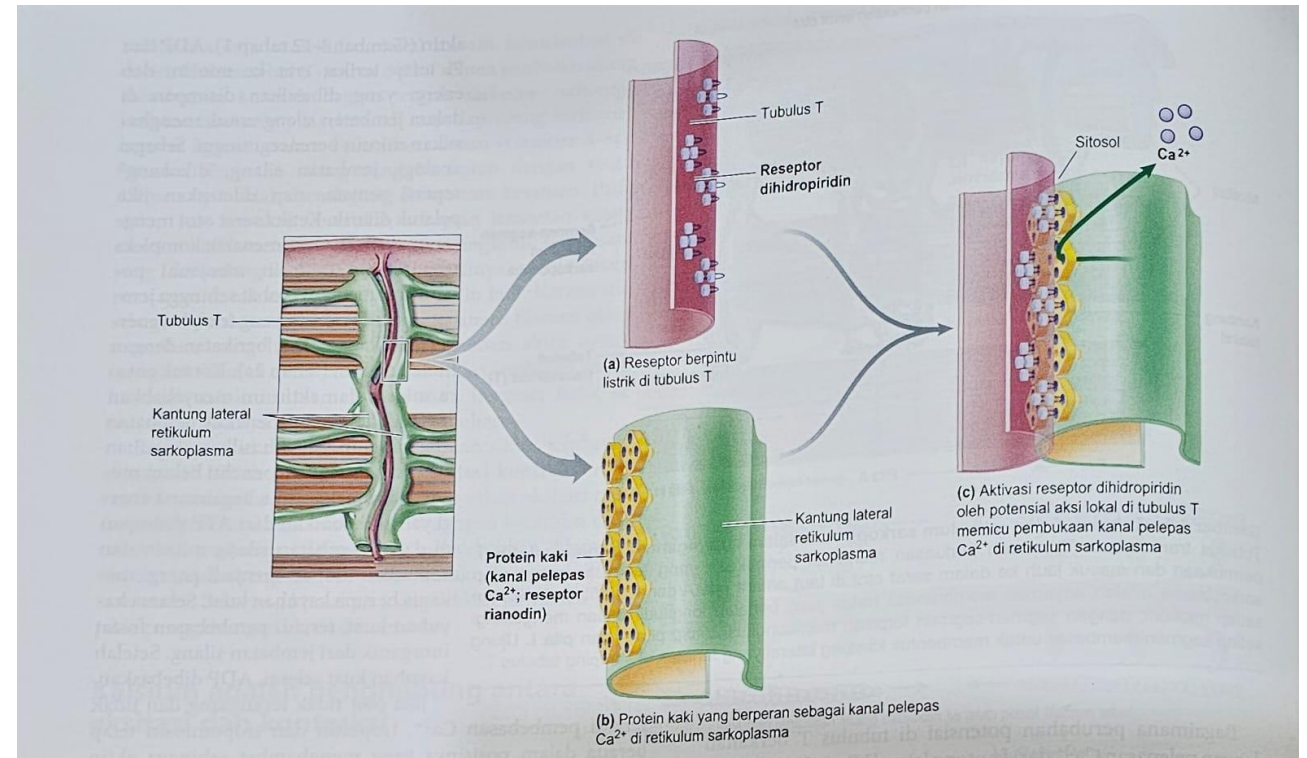
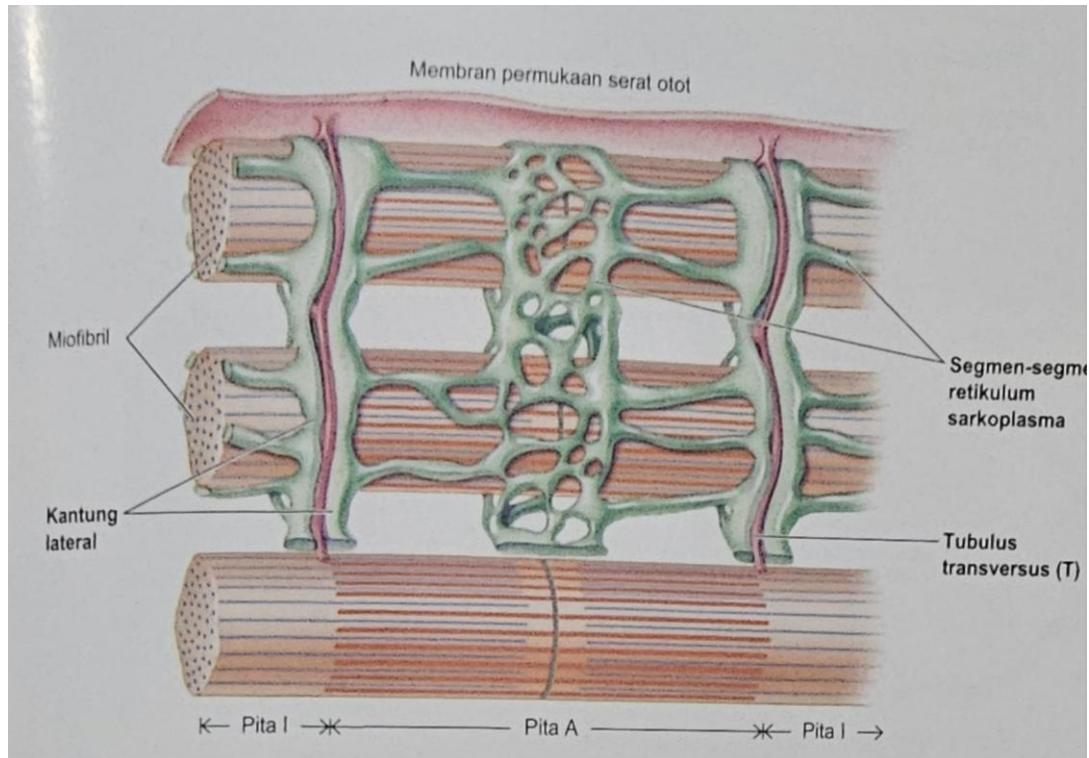


Neuro-Muscular Junction

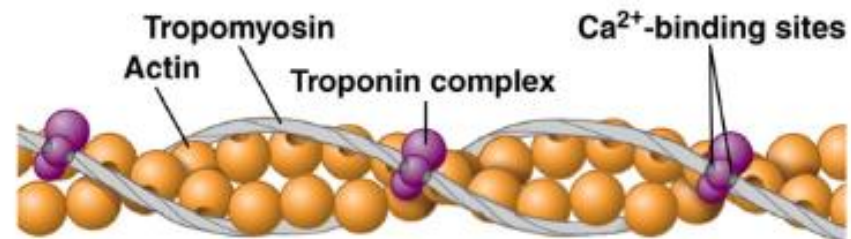


- ① Voltage Gated Sodium Channels
- ② Voltage Gated Calcium Channels
- ③ Ligand (Acetylcholine) Gated Channels
- ④ Acetylcholinesterase
- ⑤ Choline Transporters
- ⑥ SNARE Proteins
- ⑦ T-tubule
- ⑧ DHPR complex that is activated (by depolarization)
- ⑨ DHPR complex that is resting and not activated
- ⑩ Sarcoplasmic Reticulum
- The purple colored spheres represent Calcium
- The green colored spheres represent Sodium
- The red colored spheres represent Acetylcholine
- The large spheres with multiple red spheres represent vesicles full of acetylcholine
- The red spheres being broken down into smaller spheres (see # 4) represent acetylcholine being broken down into choline and acetate. The choline will be recycled (see #5) and the acetate will simply diffuse away from the synaptic cleft.

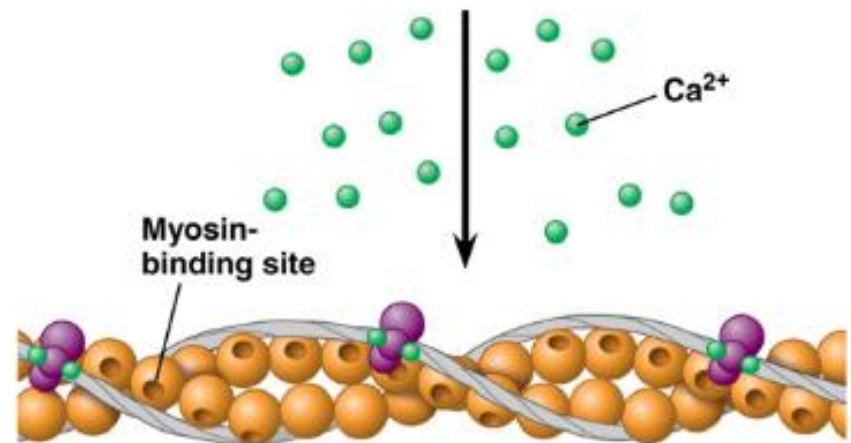
Neuro-Muscular Junction



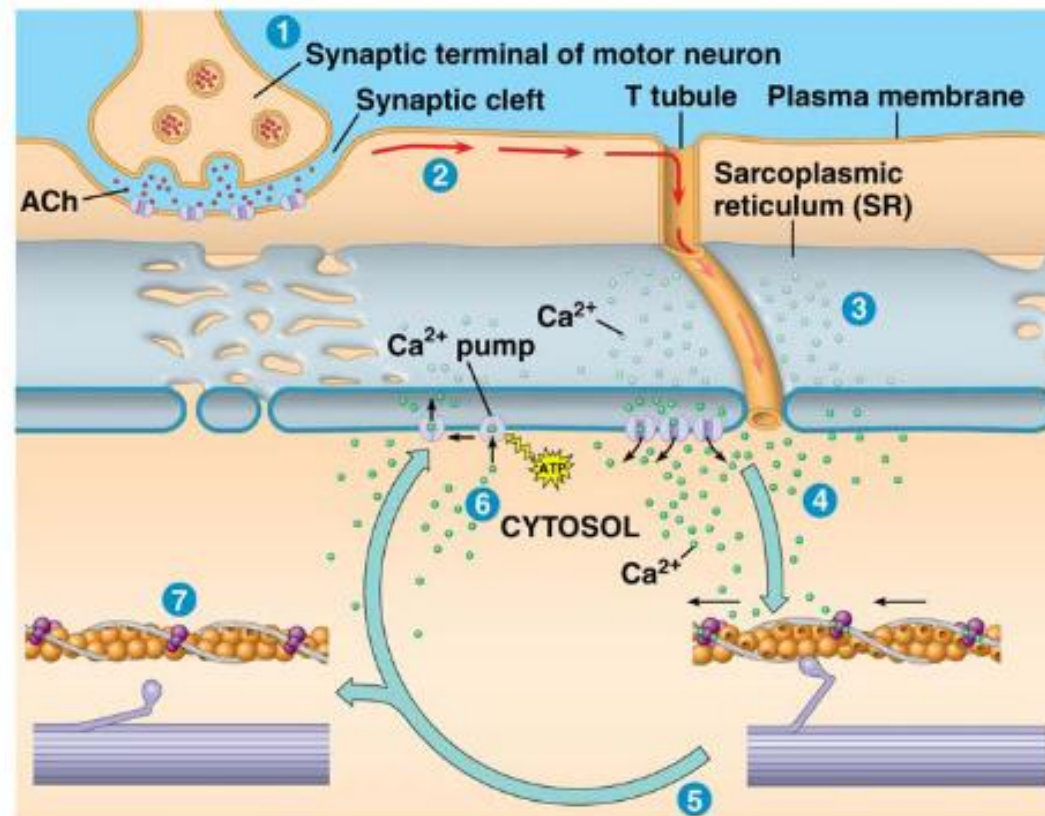
PERAN KALSIUM



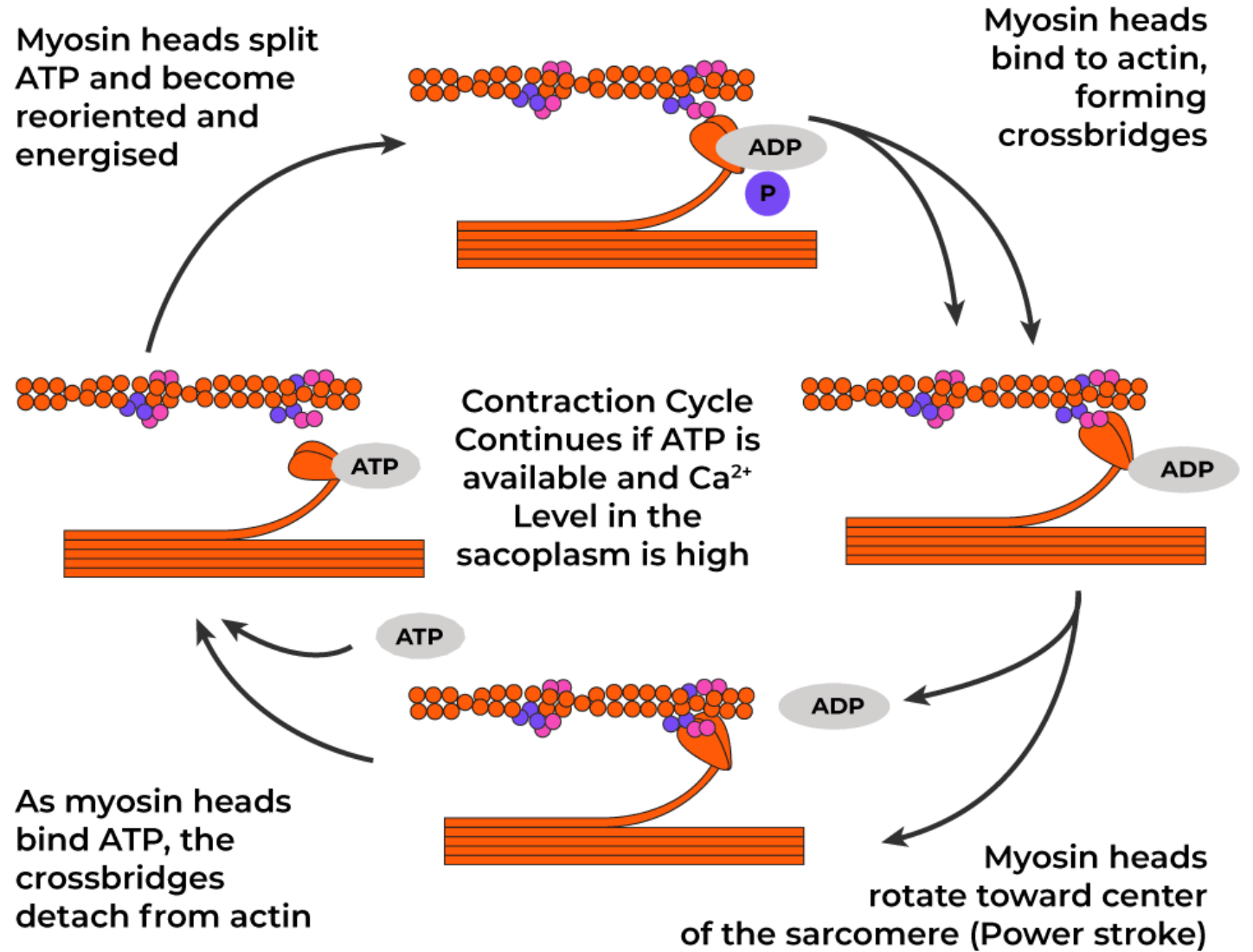
(a) Myosin-binding sites blocked



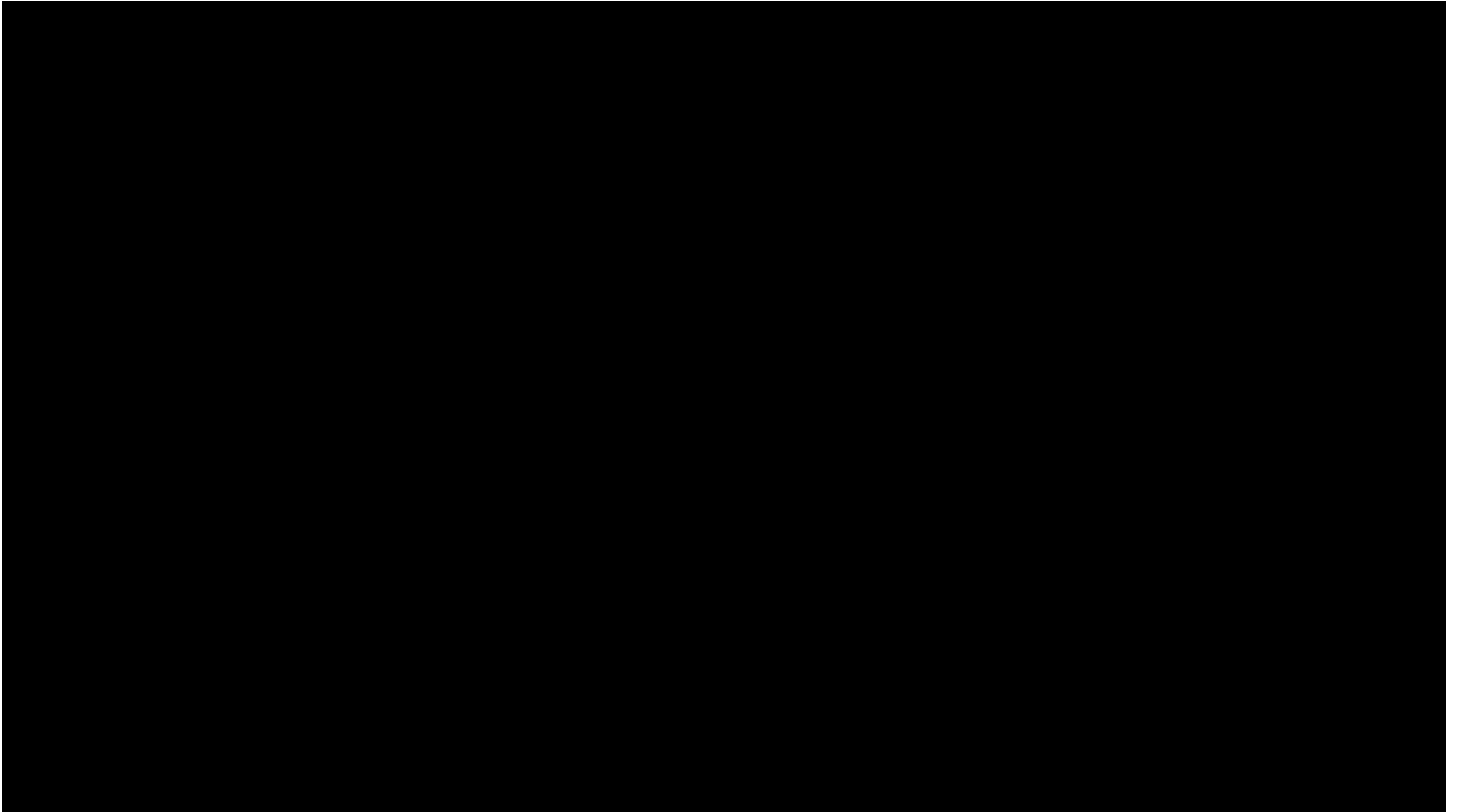
(b) Myosin-binding sites exposed



SIKLUS JEMBATAN SILANG



How Your Muscles Work



POWER STROKE

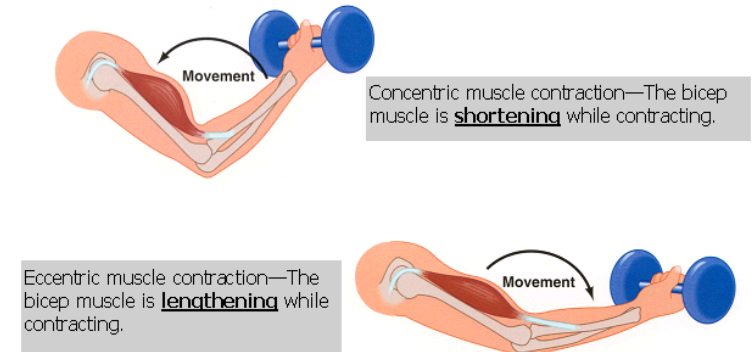
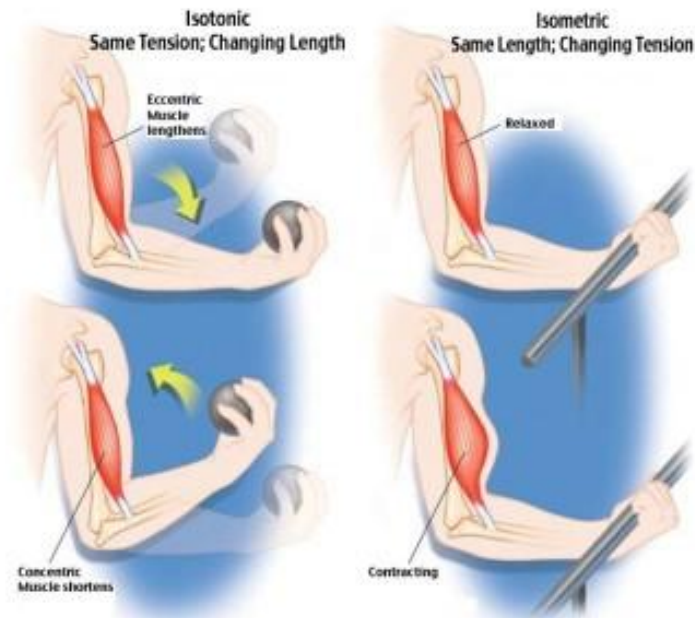
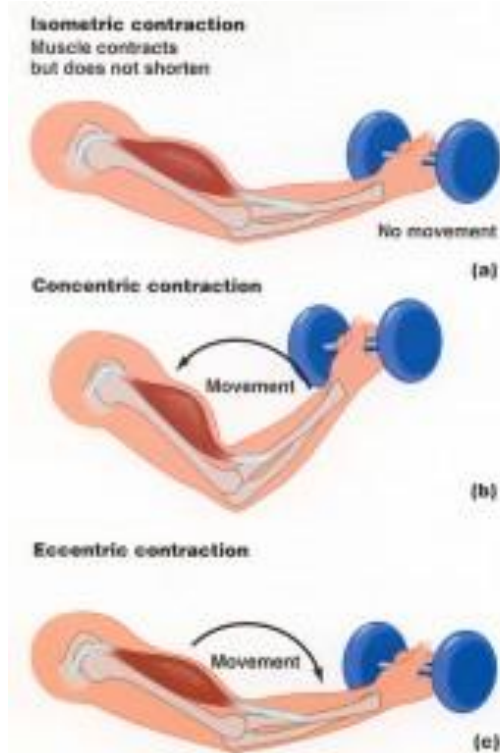
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Muscle Contraction Types

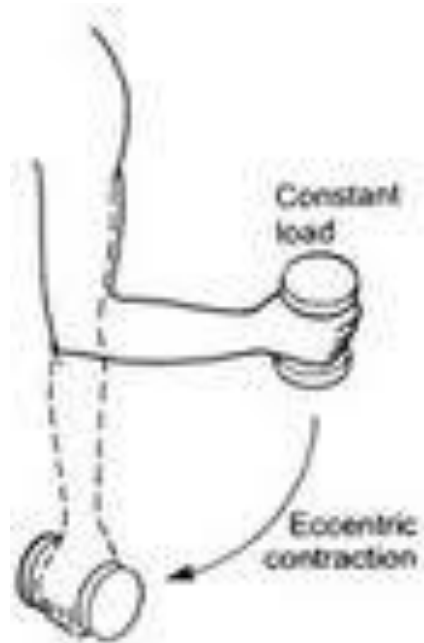


Jenis Kontraksi

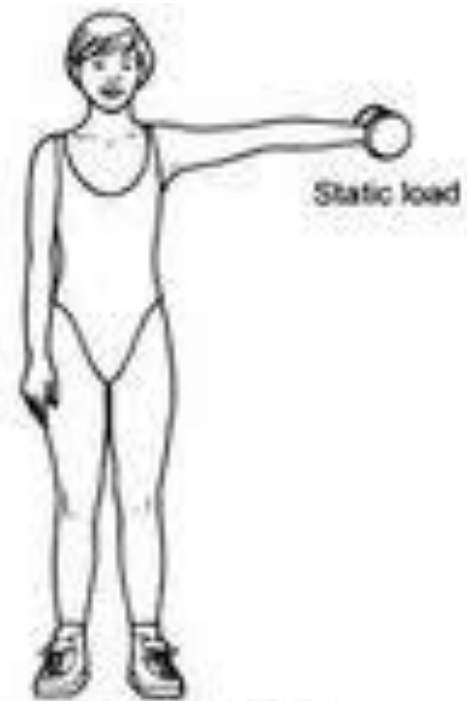
1. Kontraksi Isotonik
 - kontraksi konsentrik
 - kontraksi eksentrik
2. kontraksi isometrik



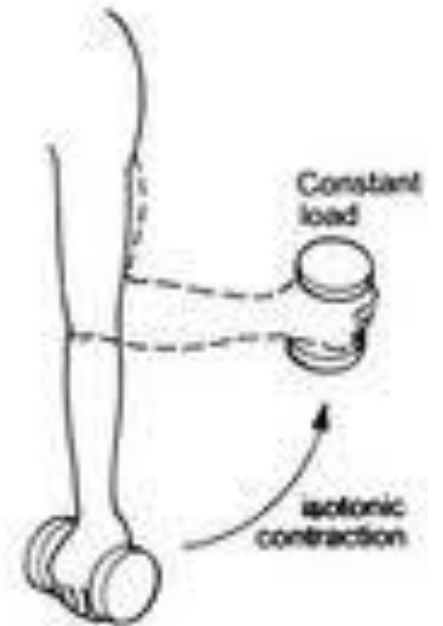
Jenis Kontraksi



eccentric contraction



isometric contraction



Isotonic contraction

Muscle Contraction Types

**MUSCLE
& MOTION**

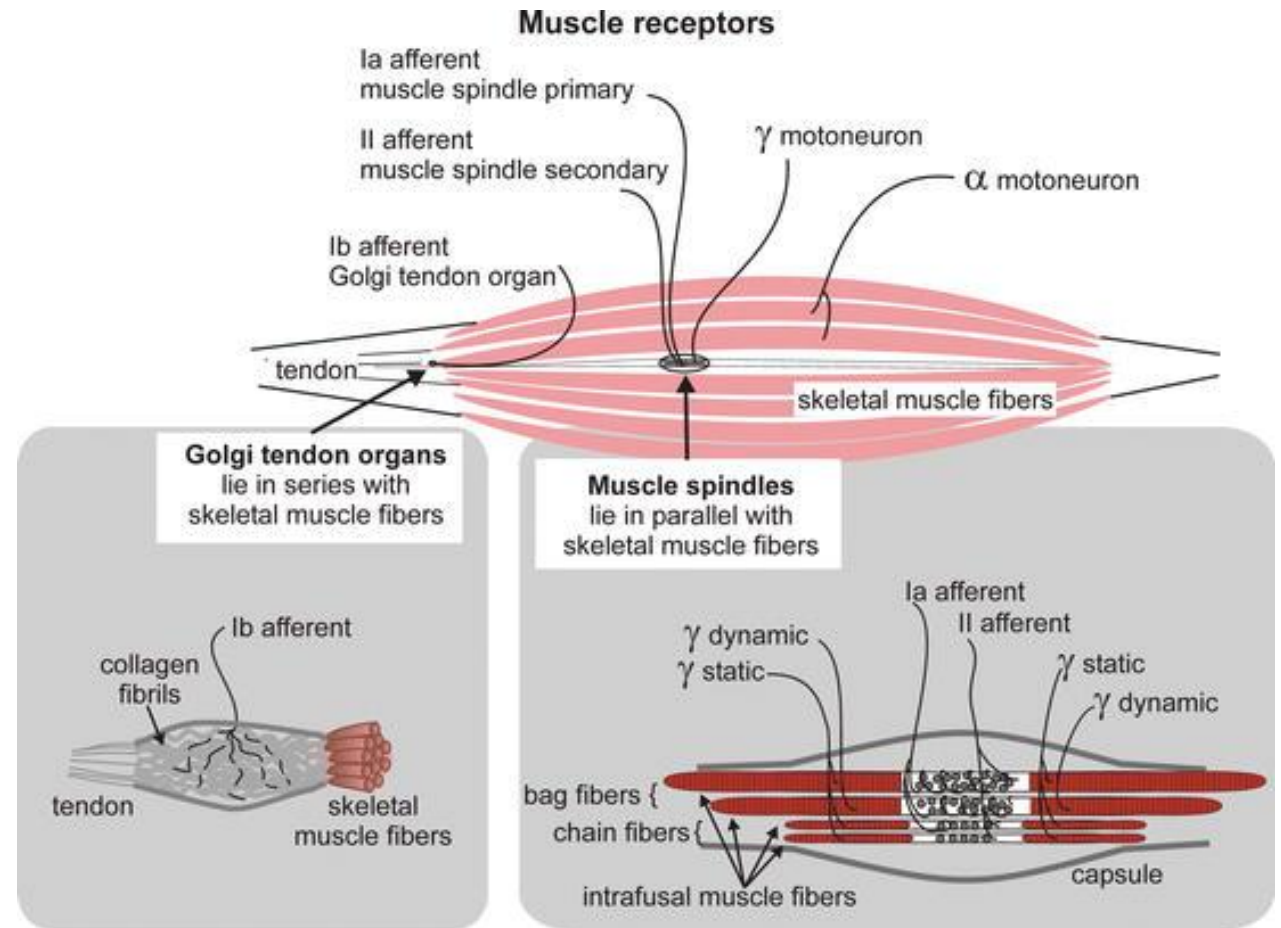
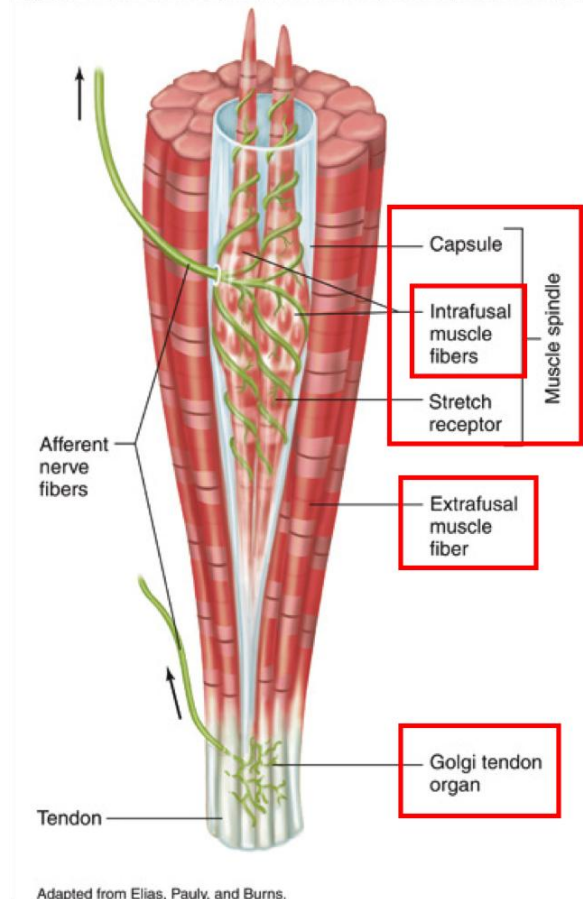


Jenis Kontraksi



MUSCLE SPINDLE & GOLGI TENDON ORGAN

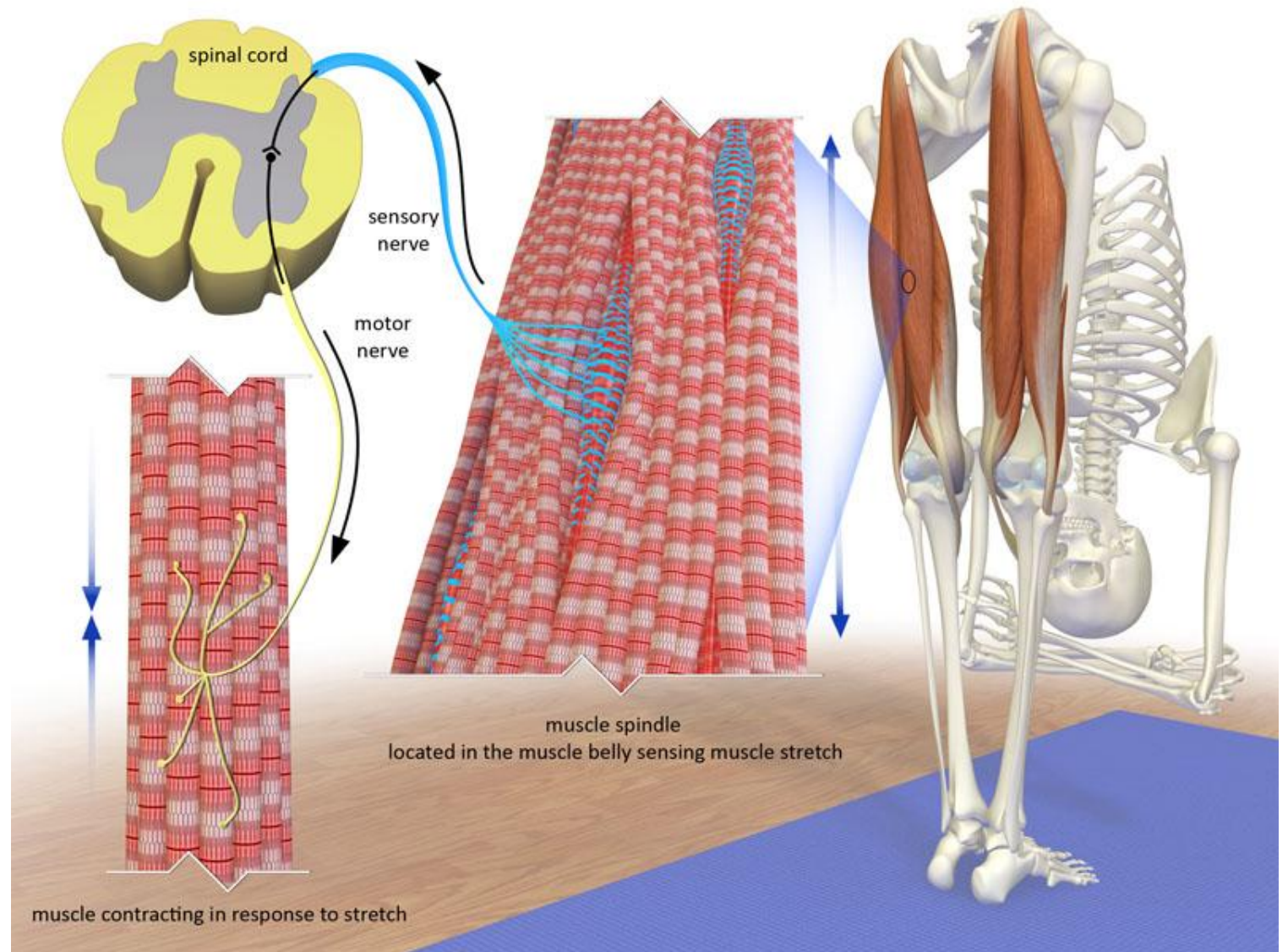
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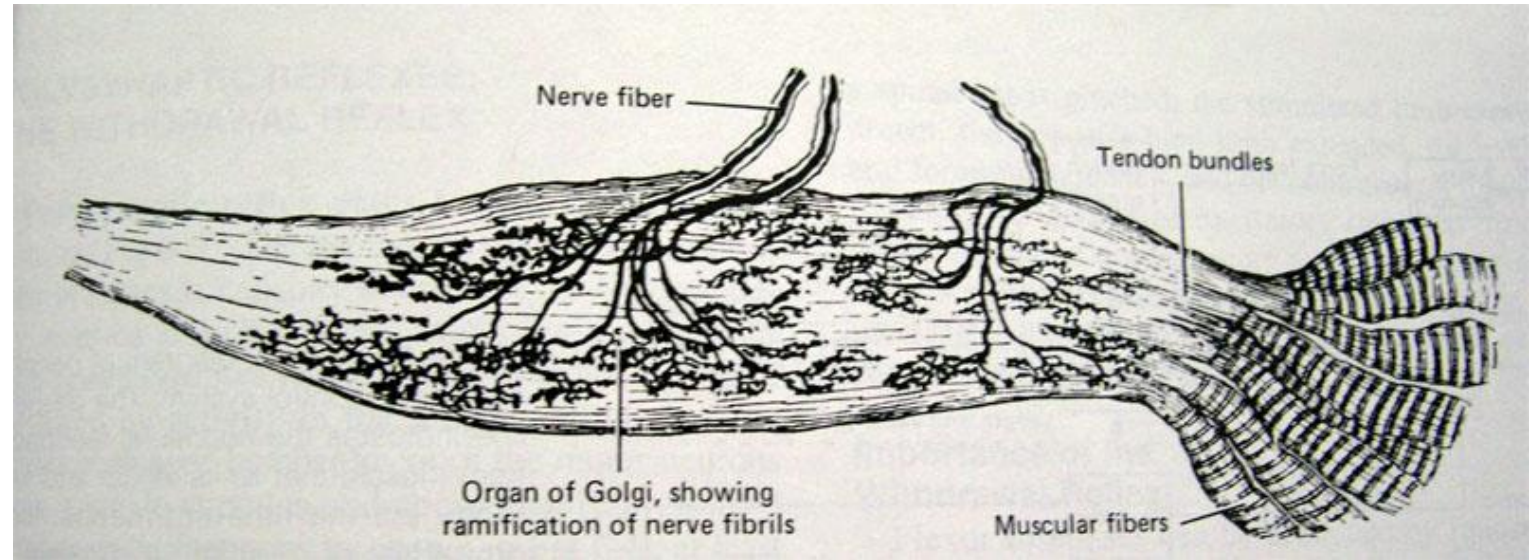
Muscle Spindle



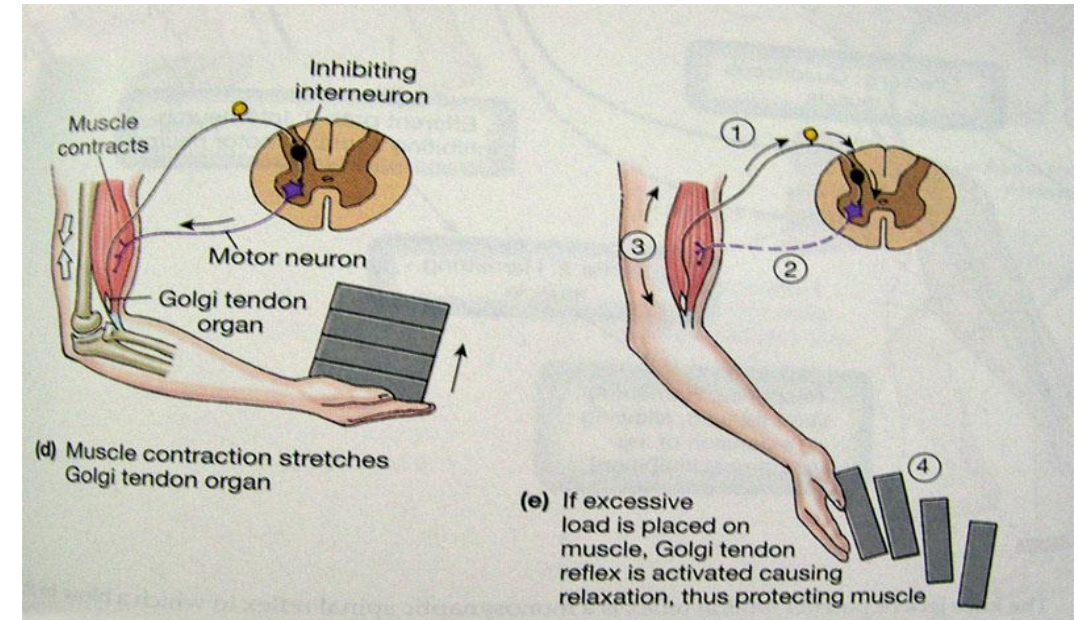
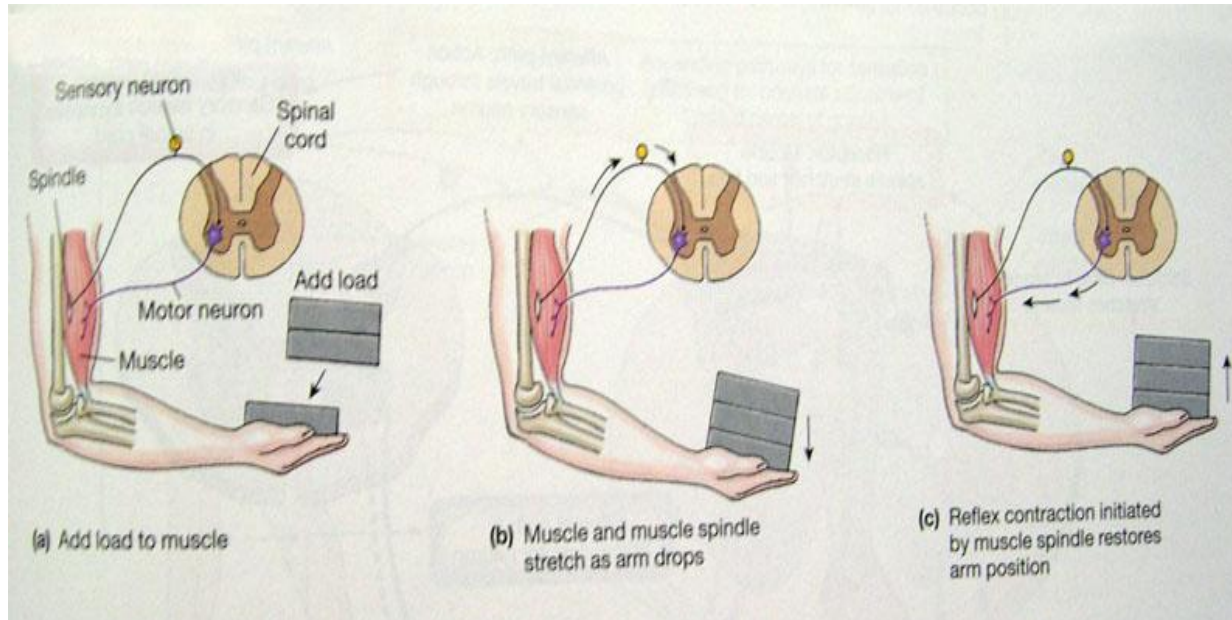
Muscle Spindle



Golgi Tendon Organ

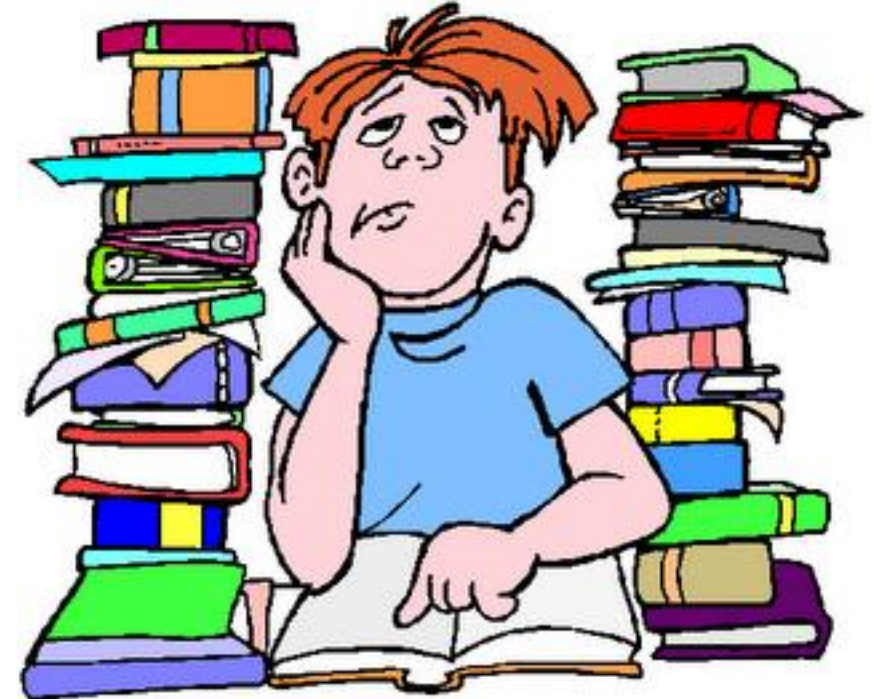


Muscle spindle reflex + GTO reflex

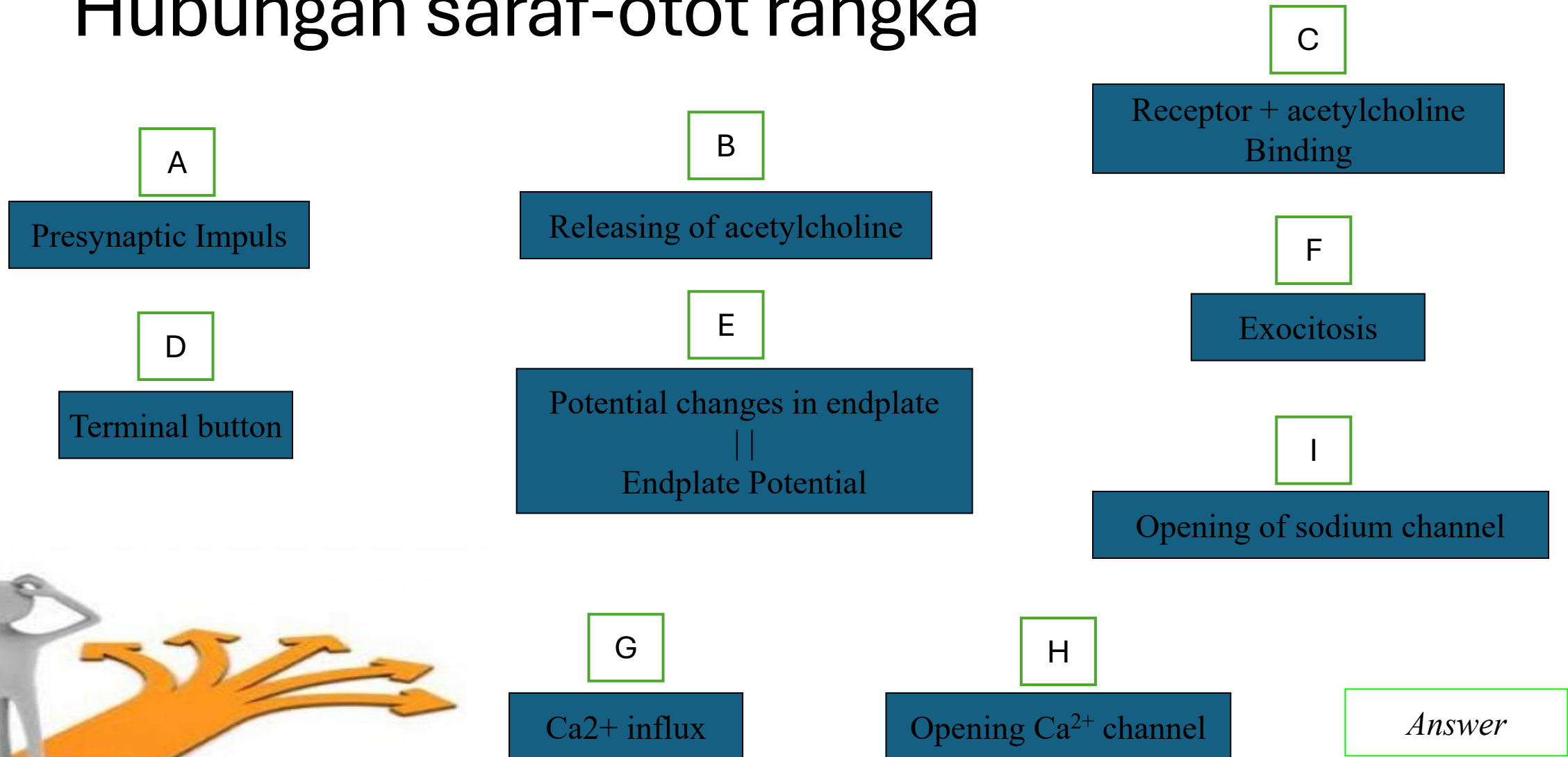


REMINDER

- Potensial aksi yang tercetus akan dihantarkan ke sepanjang akson untuk kemudian disampaikan ke sel berikutnya.
- Mekanisme penyampaian impuls ini terjadi melalui sinaps
- Perubahan yang terjadi pada postsinaps tergantung dari jenis neurotransmitter dan jenis reseptornya.
- Mekanisme kontraksi otot = mekanisme sinaps
- Penggunaan energi pada mekanisme kontraksi otot terjadi pada saat ?
- Dari mana saja sumber energi untuk kontraksi otot ?
- Fungsi Muscle Spindle dan GTO ?



Hubungan saraf-otot rangka



1. GOLGI TENDON
ORGAN

2. TROPONIN C

3. PERMEABILITAS
TERTINGGI

4. NATRIUM

5. NEUROTRANSMITTER
EKSITATORIK

6. CL- INFLUX

7. TRIGGER ZONE

8. GLISIN

A. NEUROTRANSMITTER
INHIBITORIK

B. IPSP

C. ION EKSTRASEL

D. FASE DEPOLARISASI

E. DETEKSI TEGANGAN
OTOT

F. AXON HILLOCK

G. RESEPTOR KALSIUM

H. ASPARTAT



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