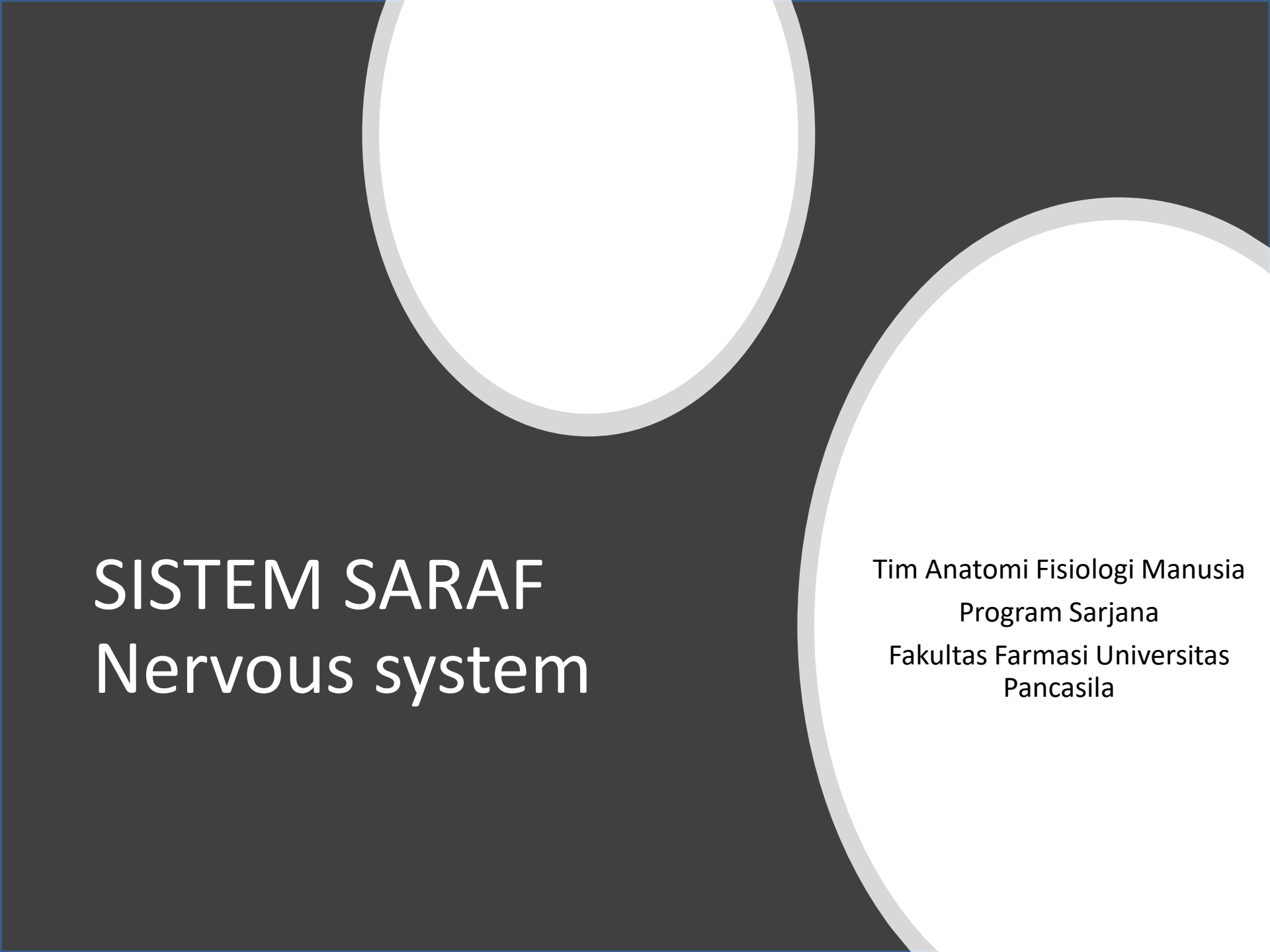




SISTEM SARAF

Nervous system

Tim Anatomi Fisiologi Manusia
Program Sarjana
Fakultas Farmasi Universitas
Pancasila

Topik Bahasan (1)

1. Sistim saraf; fungsi, klasifikasi, transmisi impuls
 - a. Sistim Saraf Pusat (CNS);
 - b. Sistim Saraf Perifer (PNS)
2. CNS : Otak dan MS
3. PNS :
 - a. S. Saraf Somatik (MNS)
 - b. S. Saraf Otonom (ANS) :
 - b.1. S. S. Simpatis (SNS)
 - b.2. S.S. Para simpatis (PSNS)

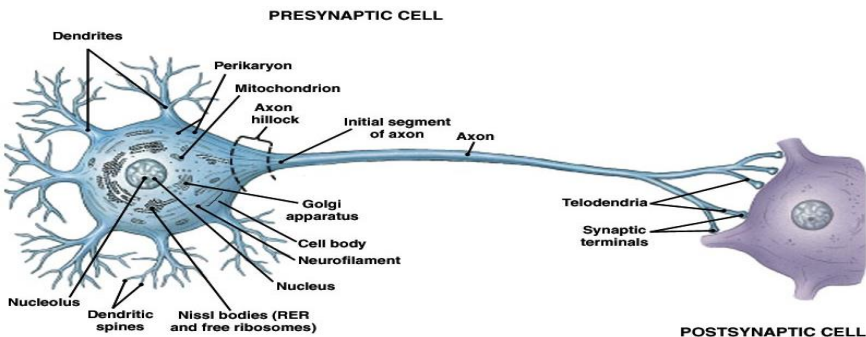
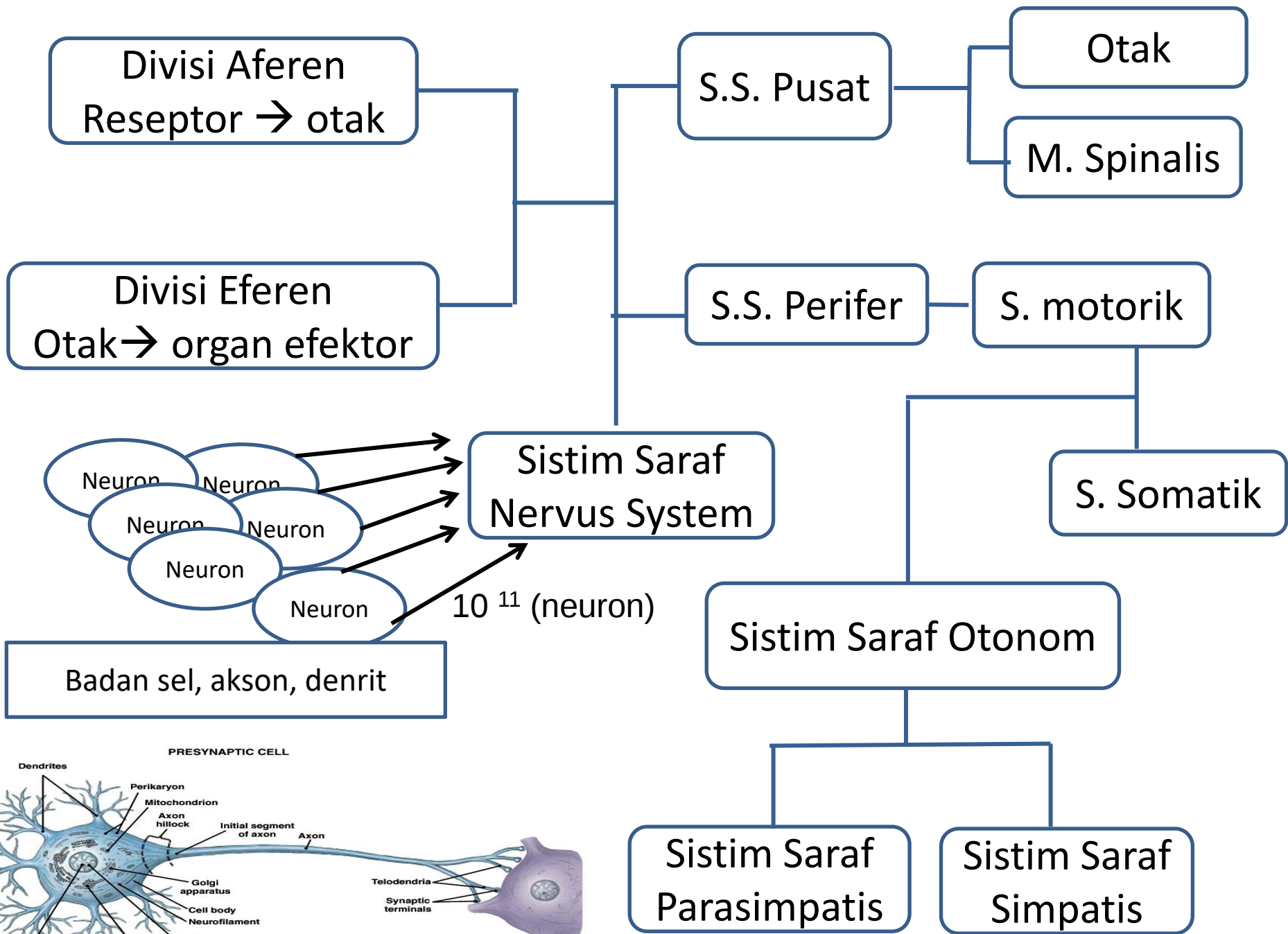
Topik Bahasan (2)

4. Neuron:

- a. struktur dan jenis neuron,
- b. jumlah ion Na, K, Cl (in-out membrane),
 - c. komunikasi antar neuron (NAP, depolarisasi, hiperpolarisasi, graded potential,
- 5. Sinaps: inter neuron; neuron-organ (neuro muscular junction, neuro-glandula junction)
- depolarisasi, hiperpolarisasi, EPSP, IPSP
- neurotransmitter (Ach, Epi, Dopamin, GABA, serotonin)

Sistem Saraf

- Suatu *network* yang terdiri atas 10^{11} sel saraf (neuron) yang saling berhubungan.
- Komponen: otak, medula spinalis, sel saraf, dan reseptor sensorik dan organ motorik.
- Sub-divisions
 - Central nervous system (CNS)
 - Peripheral nervous system (PNS)
- Fungsinya umum → Pusat integrasi untuk :
 - Aktivitas mental, berpikir, persepsi, sensasi
 - Homeostasis bersama kelenjar endokrin
 - Gerakan organ efektor (otot dan kelenjar)



Central Nervous System

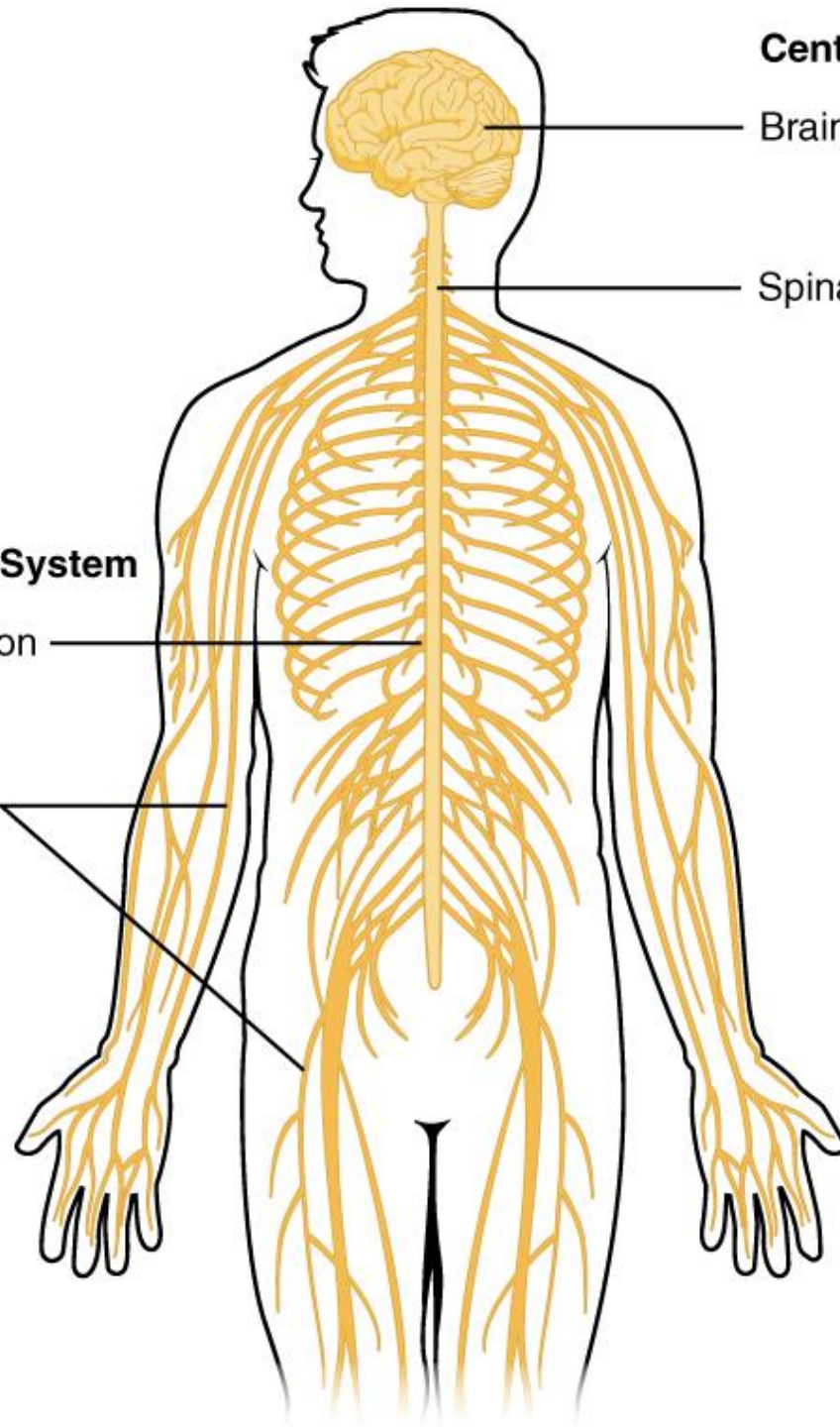
Brain

Spinal cord

Peripheral Nervous System

Ganglion

Nerve



Fungsi Dasar Sistem Saraf

1. *Sensory* (penginderaan)

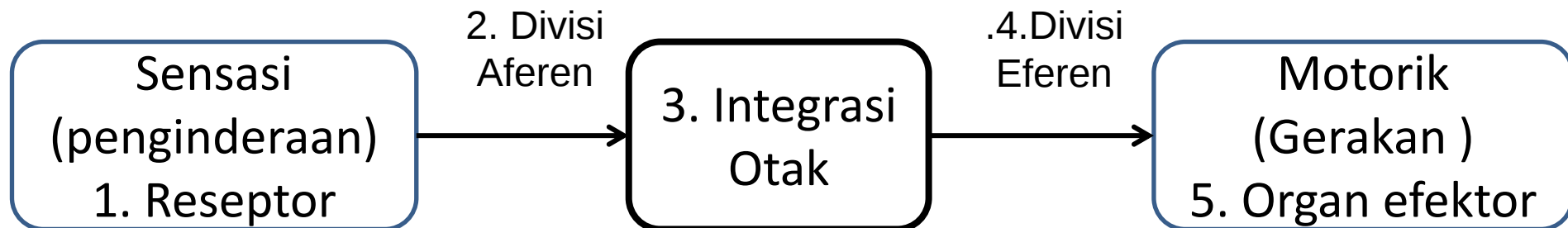
Mendeteksi stimulus → **informasi** diteruskan ke otak & spinal cord melalui saraf aferen.

2. Integrasi

Proses **analisis** dan **interpretasi** suatu informasi sensorik untuk **menentukan respons** yang tepat.

3. Motorik

– **Aktivasi organ efektor yaitu : otot dan kelenjar**



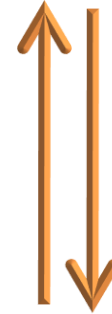
Sistem Pengendali/Pengontrol

- **Sistem pengendali /kontrol homeostatis tubuh:**
 - Sistem saraf → koordinasi → respon cepat
 - Sistem endokrin → pengaturan kembali → respon lama
- **Sistem saraf terdiri dari:**
 - Susunan saraf pusat (SSP): otak & medula spinalis
 - Sistem saraf perifer: terdiri atas
 - divisi aferen; stimulus dari saraf sensoris menuju SSP
 - divisi eferen; **SSP** – Saraf motorik → organ motorik/efektor.



Jalur asenden

Jalur desenden



Devisi aferen

Devisi eferen

Sensorik

Motorik

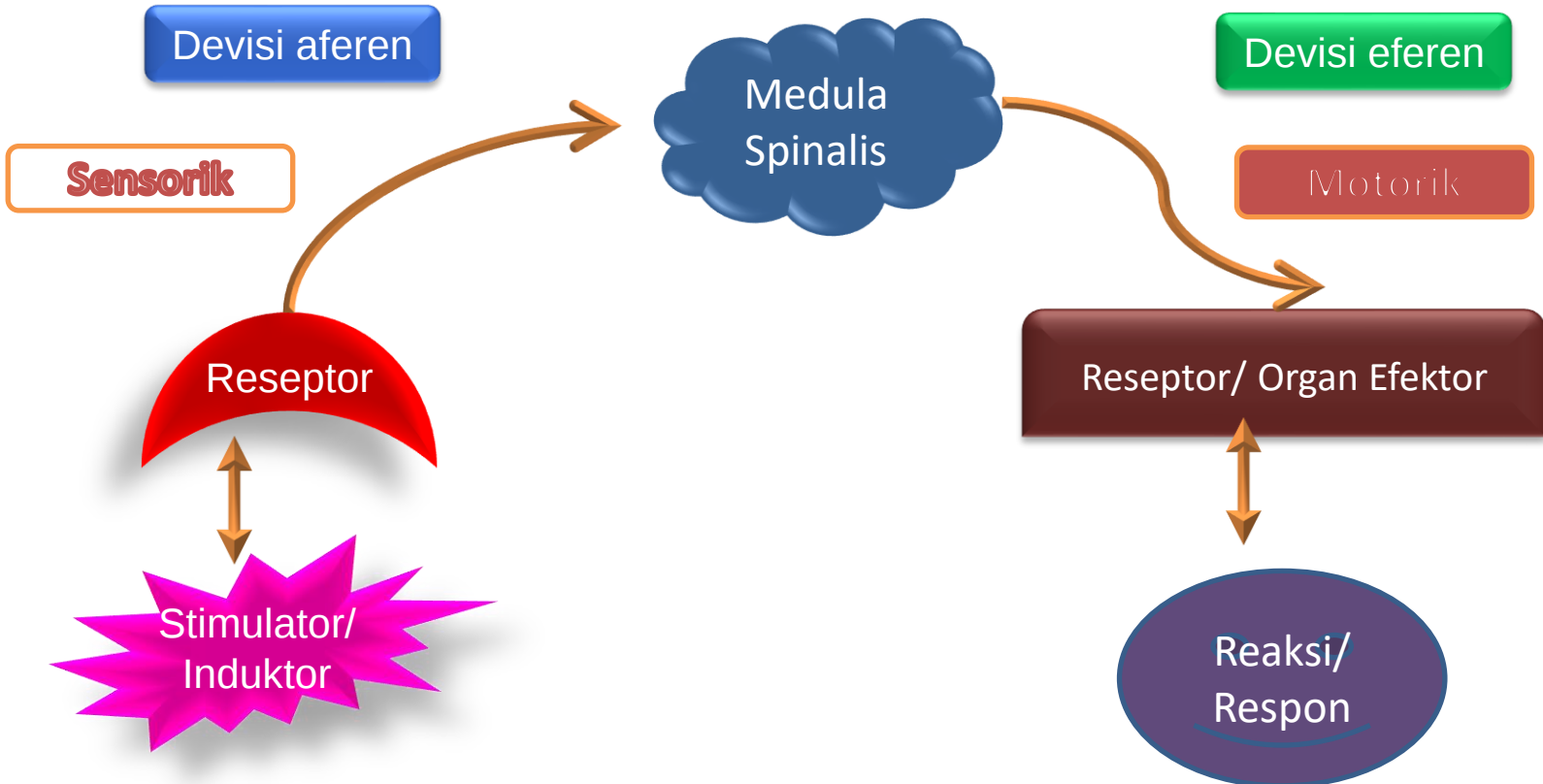
Medula
Spinalis

Reseptor

Reseptor/ Organ Efektor

Stimulator/
Induktor

Reaksi/
Respon



Struktur Utama Sistem Saraf

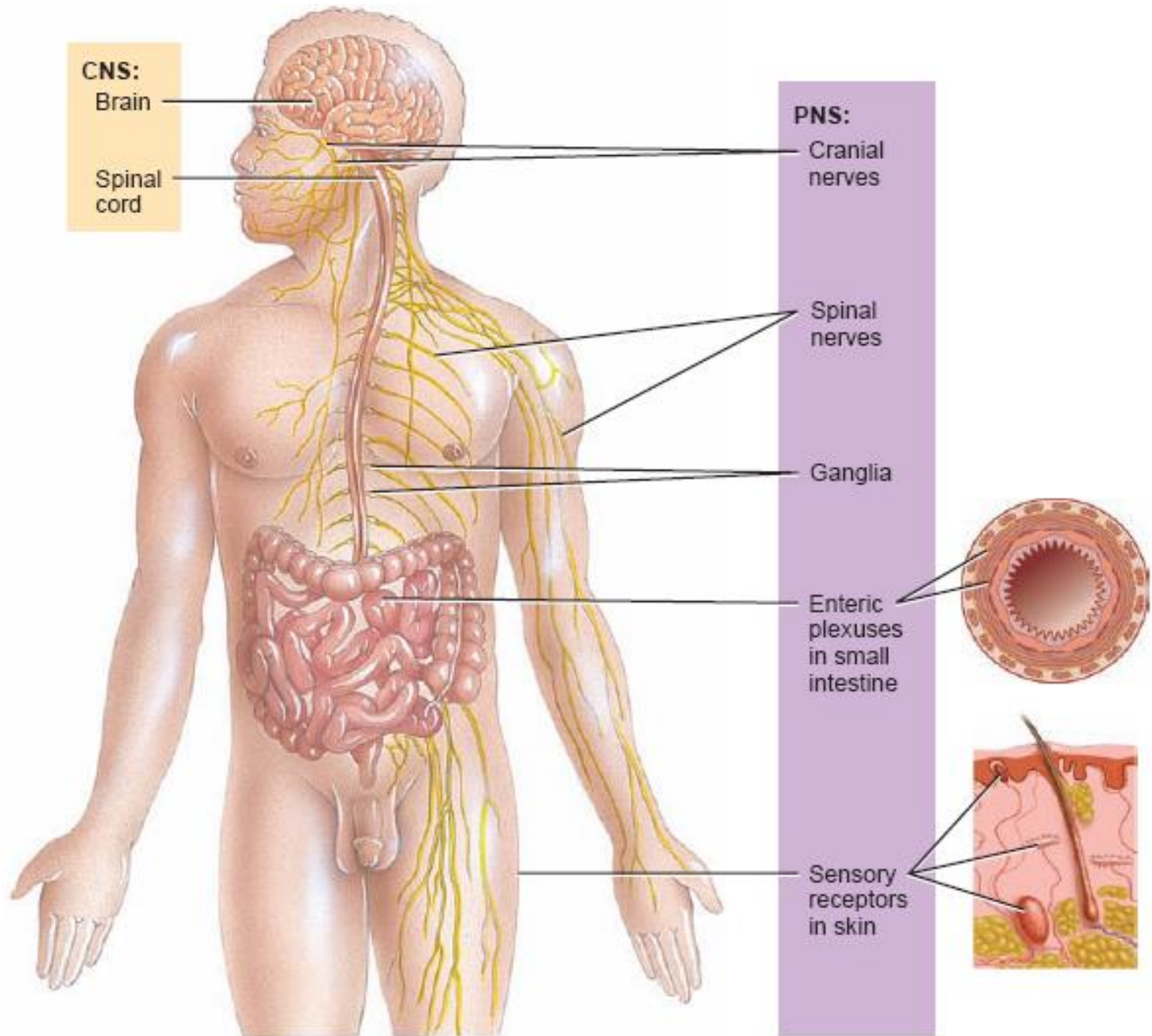
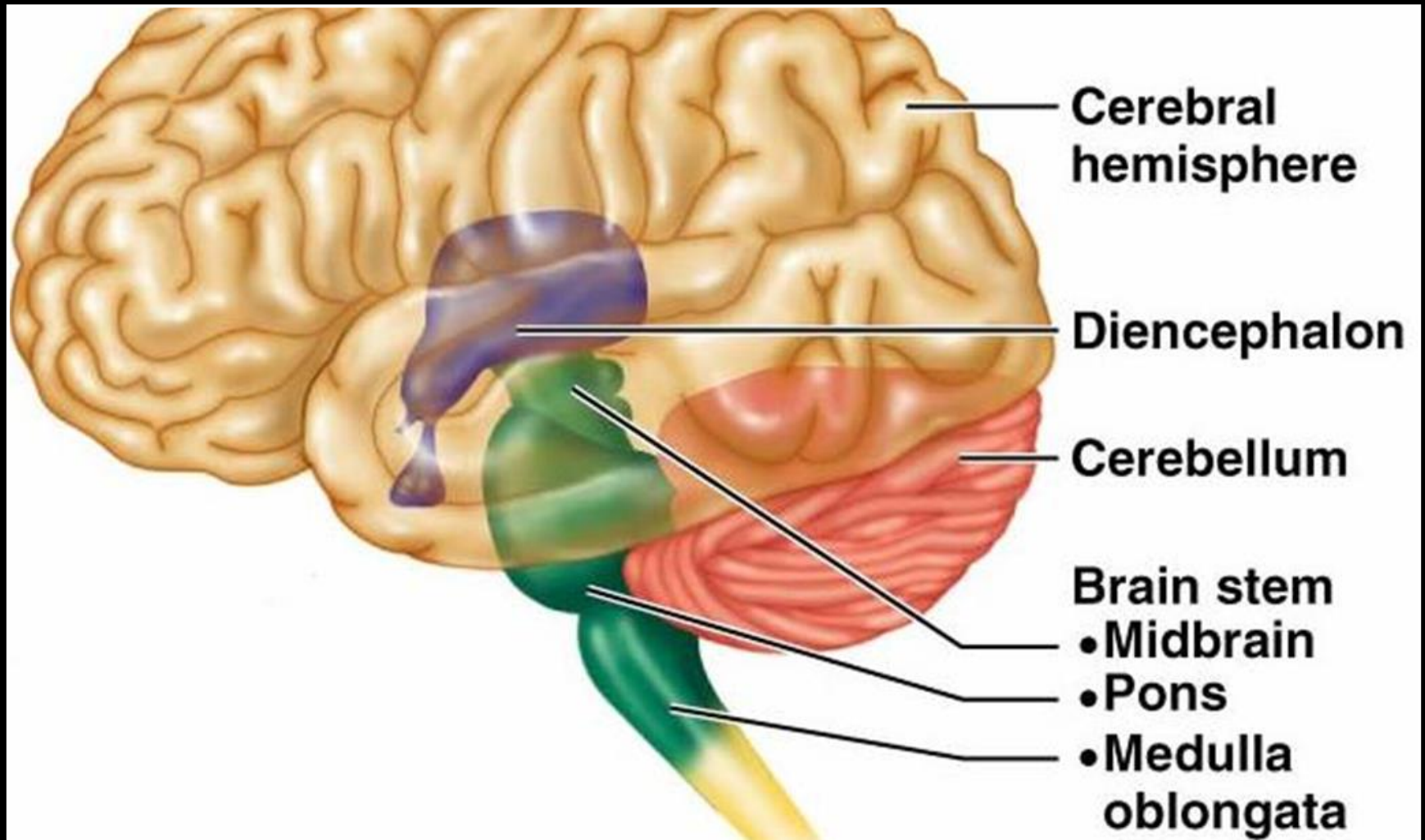


Figure 12.1.
Major structure of
the nervous system
(Tortora, p. 416)



Central Nervus System (CNS)



Hemisfere dan 4 lobus
frontal, occipital, parietal, temporal

Sistim Saraf Perifer

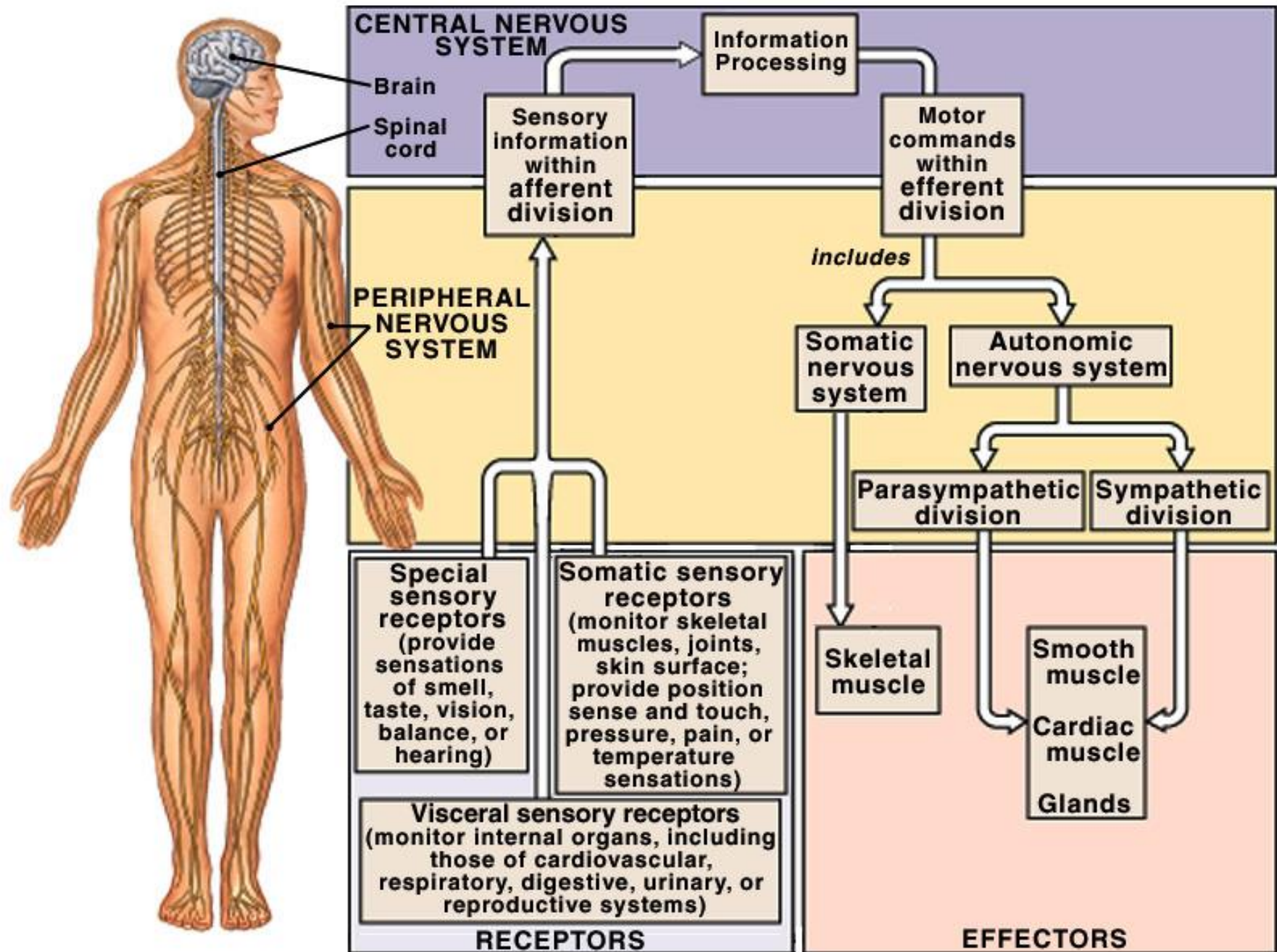
Devisi Eferent/sistim motoric

S.S. Somatik (SNS) ; skeletal muscle

- Anggota gerak; tungkai atas-bawah

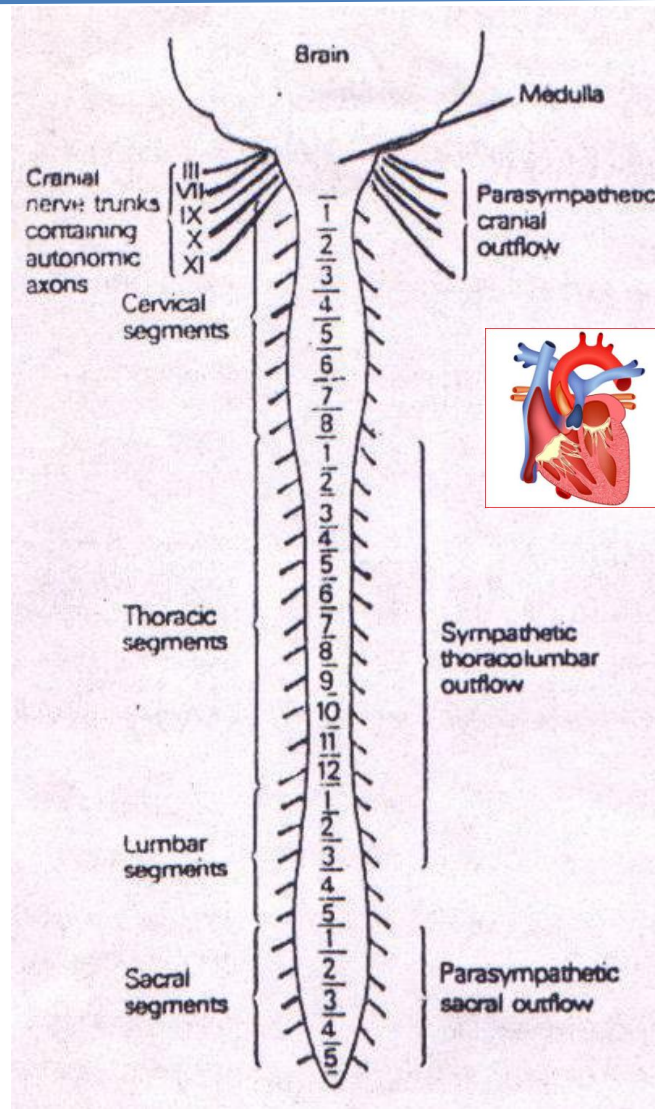
S. S. Otonom (ANS); otot polos, otot jantung, kelenjar

- S.S. Simpatis (SNS)
- S.S. Parasimpatis (PSNS)



Sistim Saraf Otonom (ANS)

Simpatis
(SNS)



Parasimpatis
(PSNS)

Sel Saraf (Neuron)

1. Neuron/sel saraf

- **Fungsi unik sistem saraf** seperti penginderaan, berfikir, mengingat, mengendalikan aktivitas otot dan mengatur sekresi kelenjar.
- Menerima stimulus dan mentransmisikan potensial aksi

2. Neuroglia atau sel glial

- **Mendukung, memelihara dan melindungi neuron** serta menjaga **homeostasis** cairan interstitial.

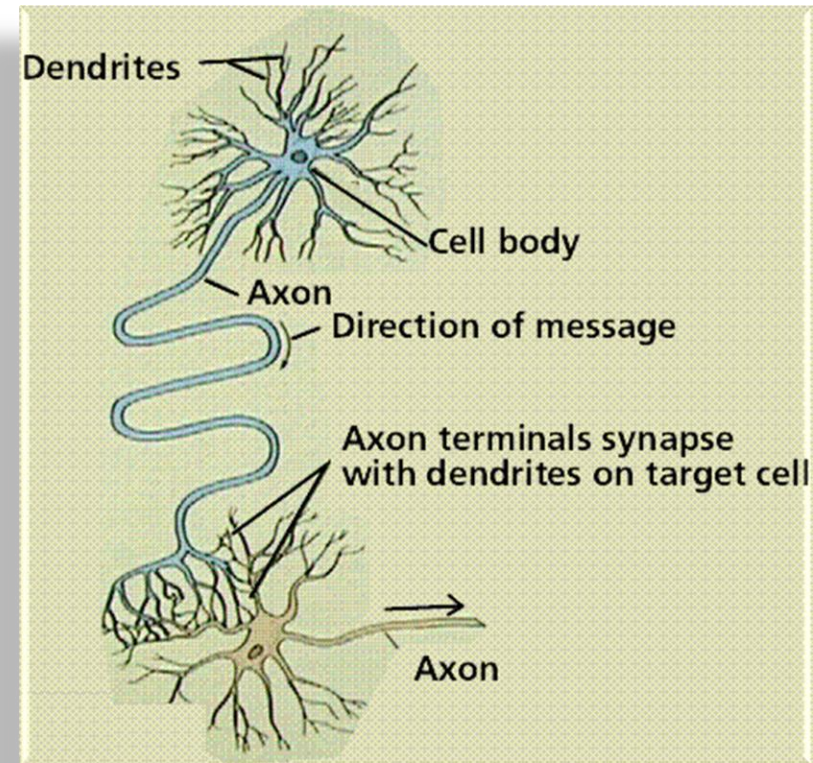
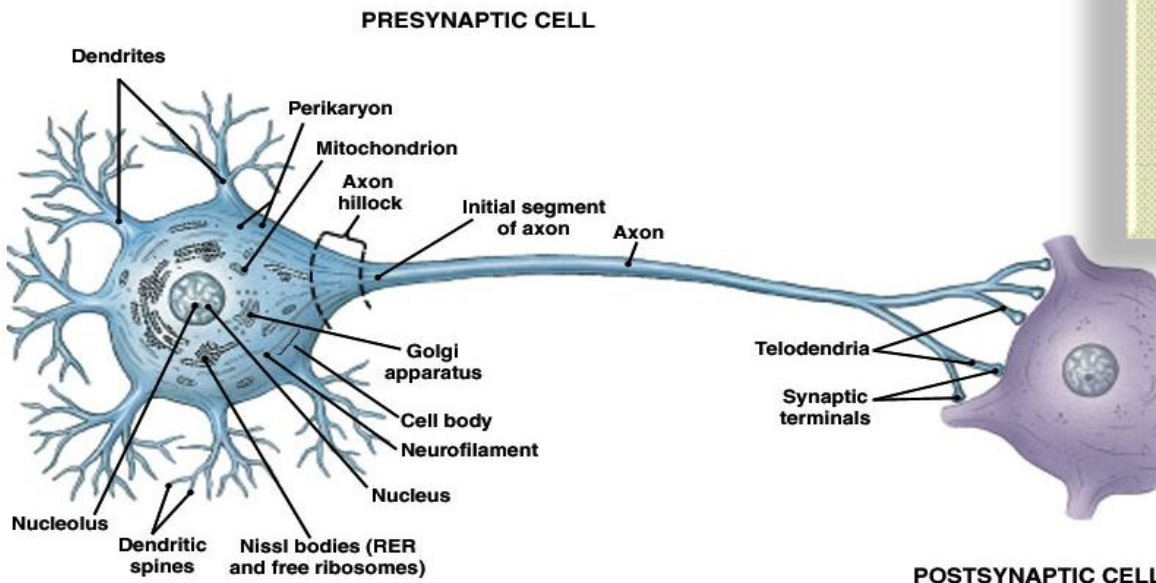
3. Pembuluh darah : Transportasi nutrisi

Neuron

https://www.youtube.com/watch?v=iBDXOt_uHTQ

— Organisasi neuron:

- **Badan sel/peprikaryon/soma**
- **Dendrit:** Input
- **Akson:** Output; propagasi impuls saraf ke neuron lainnya

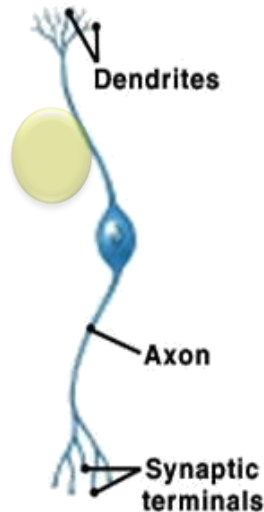


Klasifikasi Neuron

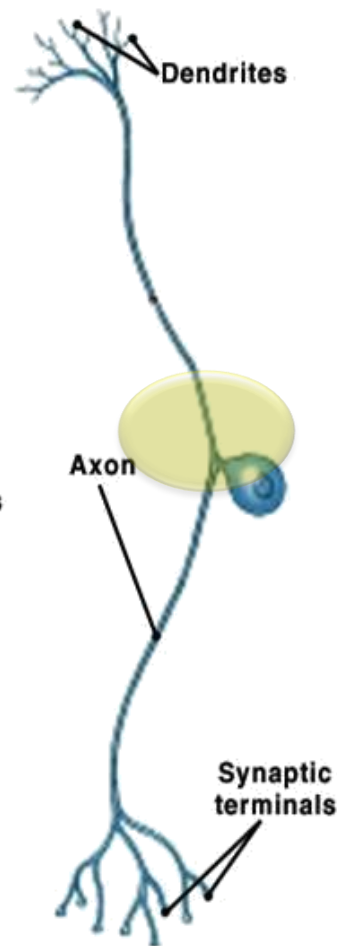
Klasifikasi neuron berdasarkan strukturnya:



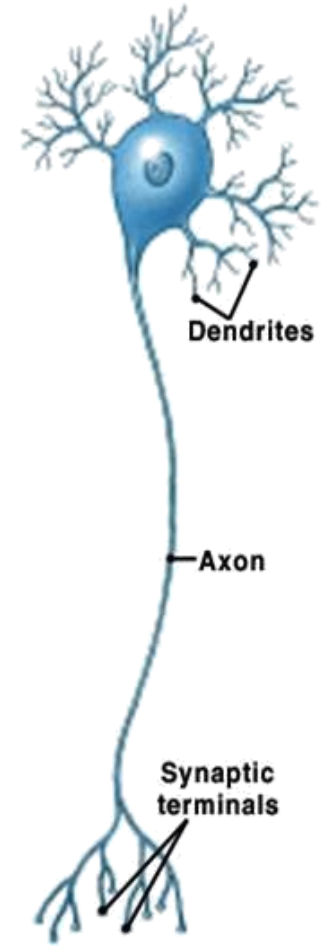
(a) Anaxonic neuron



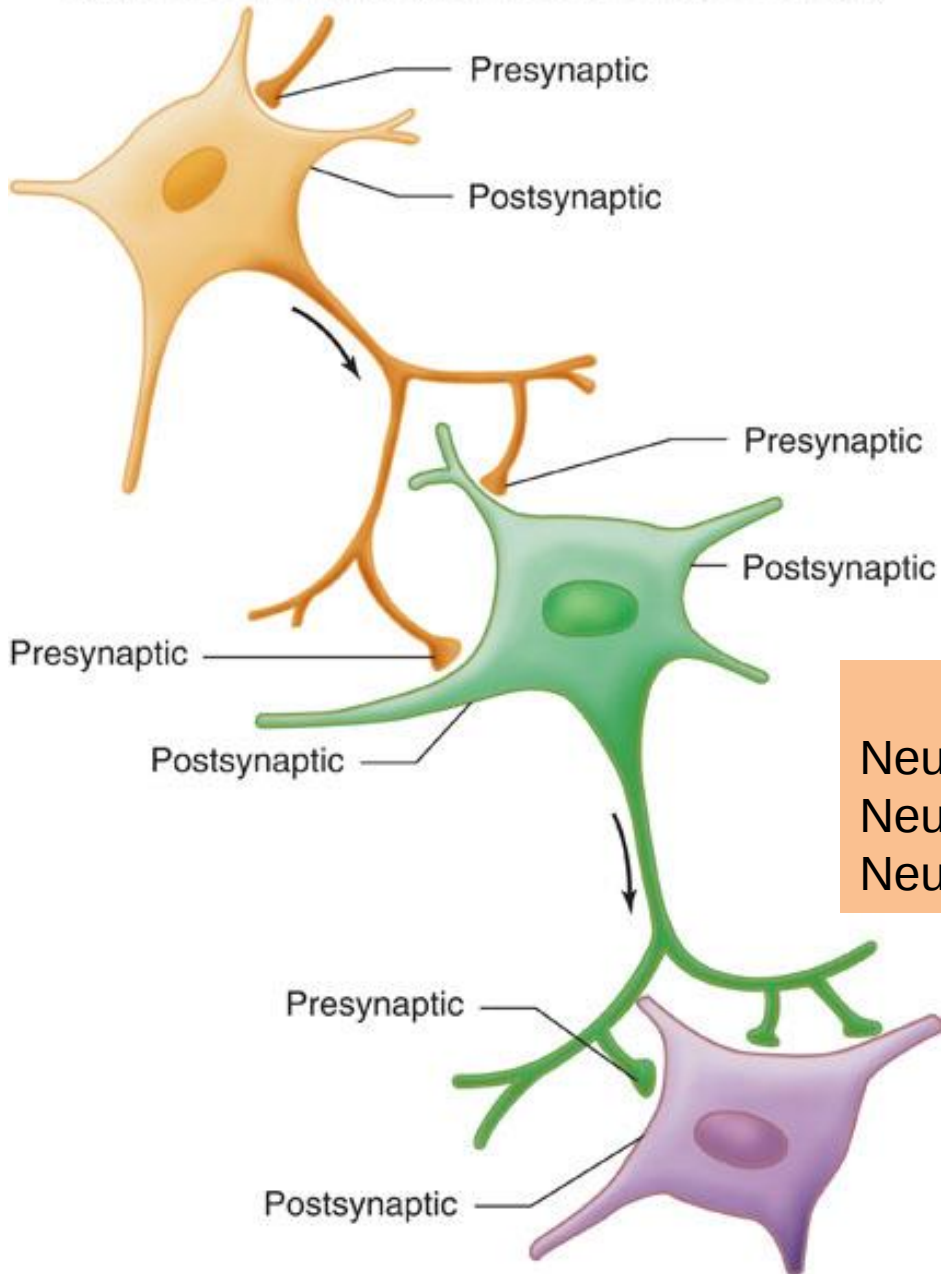
(b) Bipolar neuron



(c) Unipolar neuron

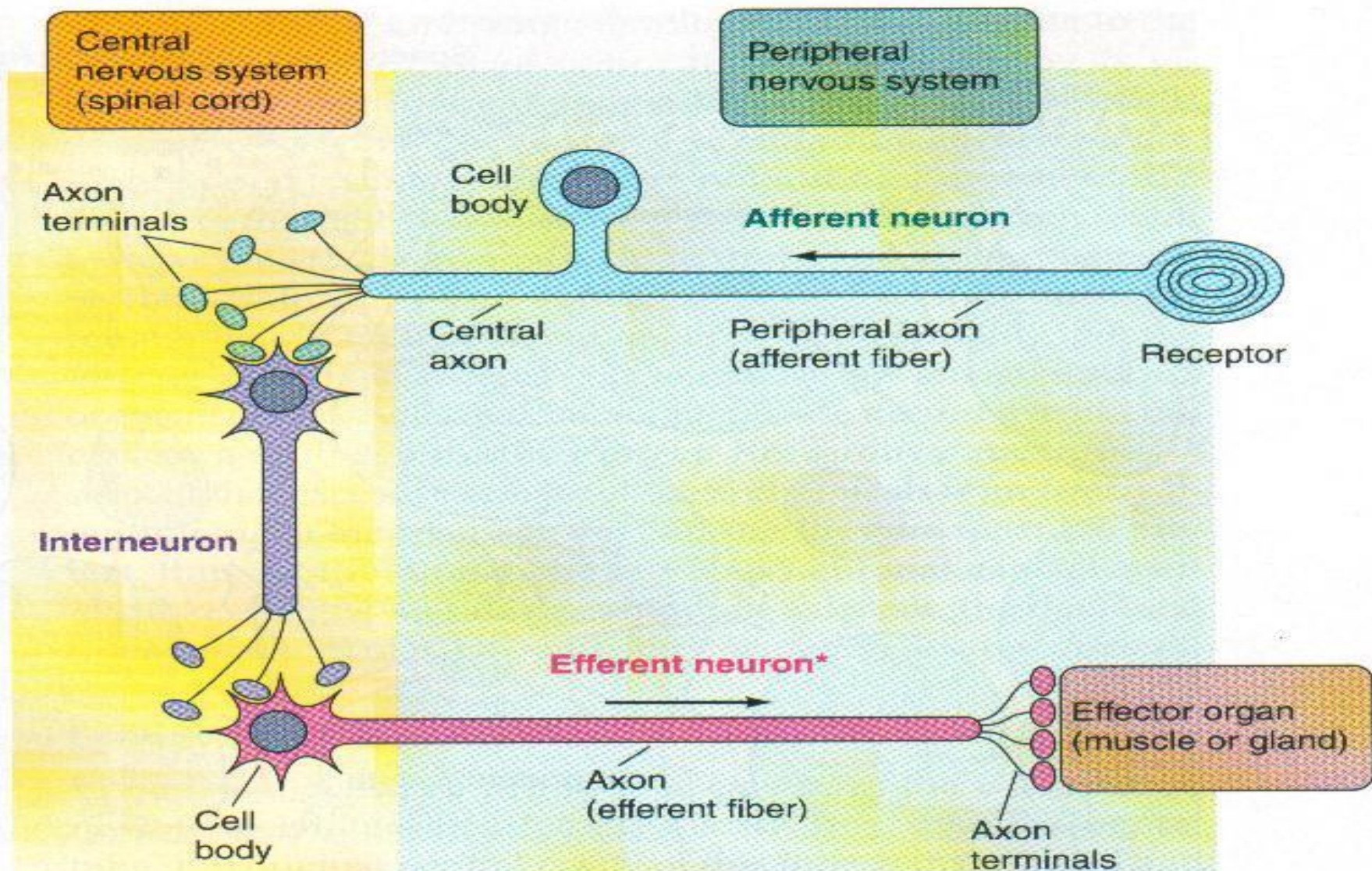


(d) Multipolar neuron



Neuron post-sinaps dari suatu sel dapat menjadi pre-sinaps untuk sel lainnya.

Penamaan sinaps antara
Neuron-neuron: interneuron
Neuron-Otot: Neuromuscular Junction
Neuron-kelenjar : Neuro-glandular Junction



* Efferent autonomic nerve pathways consist of a two-neuron chain between the CNS and the effector organ.

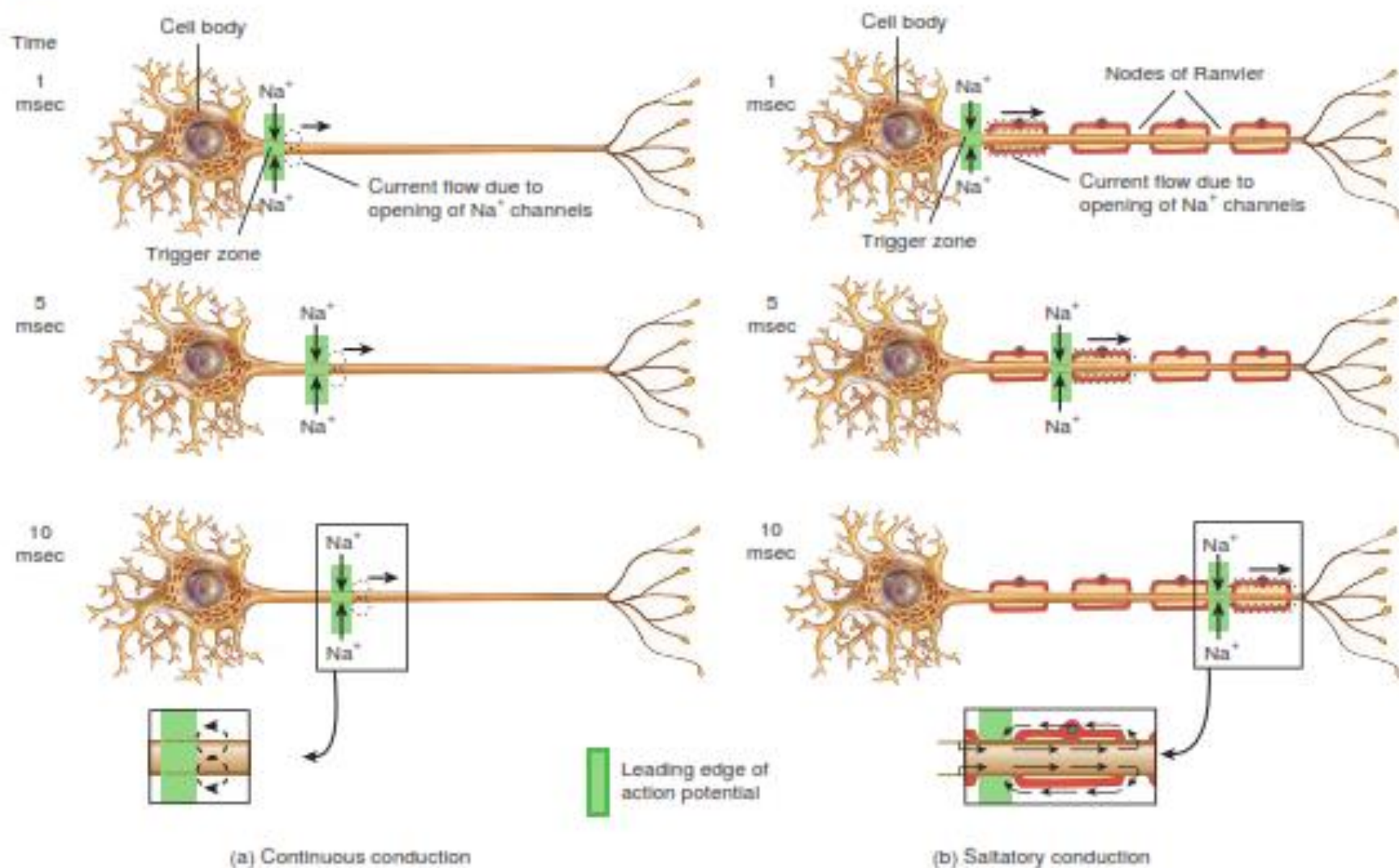
● FIGURE 5-2

Structure and location of the three classes of neurons

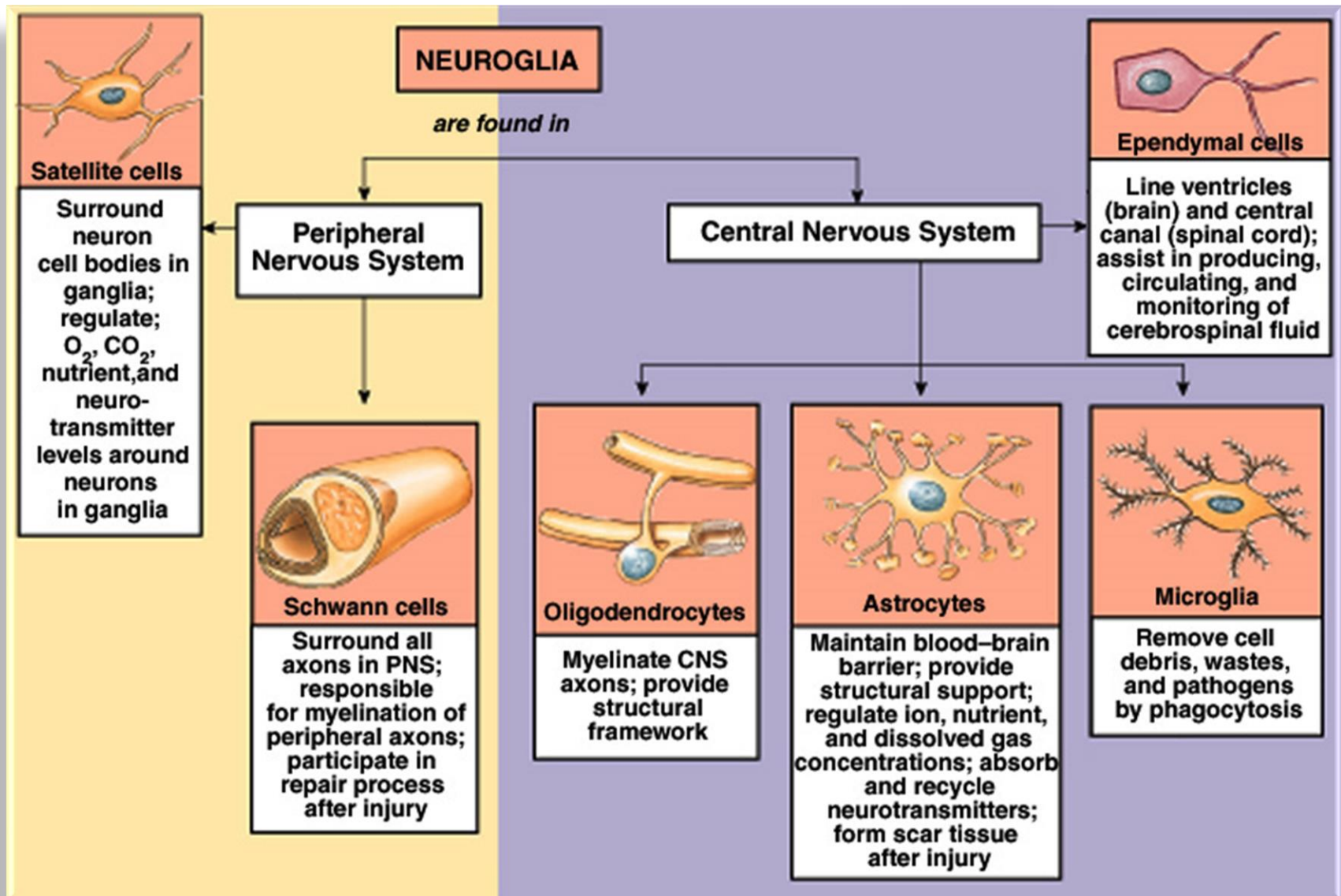


Figure 12.22 Propagation of an action potential in a neuron after it arises at the trigger zone. Dotted lines indicate ionic current flow. The insets show the path of current flow. (a) In continuous conduction along an unmyelinated axon, ionic currents flow across each adjacent segment of the membrane. (b) In saltatory conduction along a myelinated axon, the action potential (nerve impulse) at the first node generates ionic currents in the cytosol and interstitial fluid that open voltage-gated Na^+ channels at the second node, and so on at each subsequent node.

 Unmyelinated axons exhibit continuous conduction; myelinated axons exhibit saltatory conduction.



Jenis-jenis Neuroglia

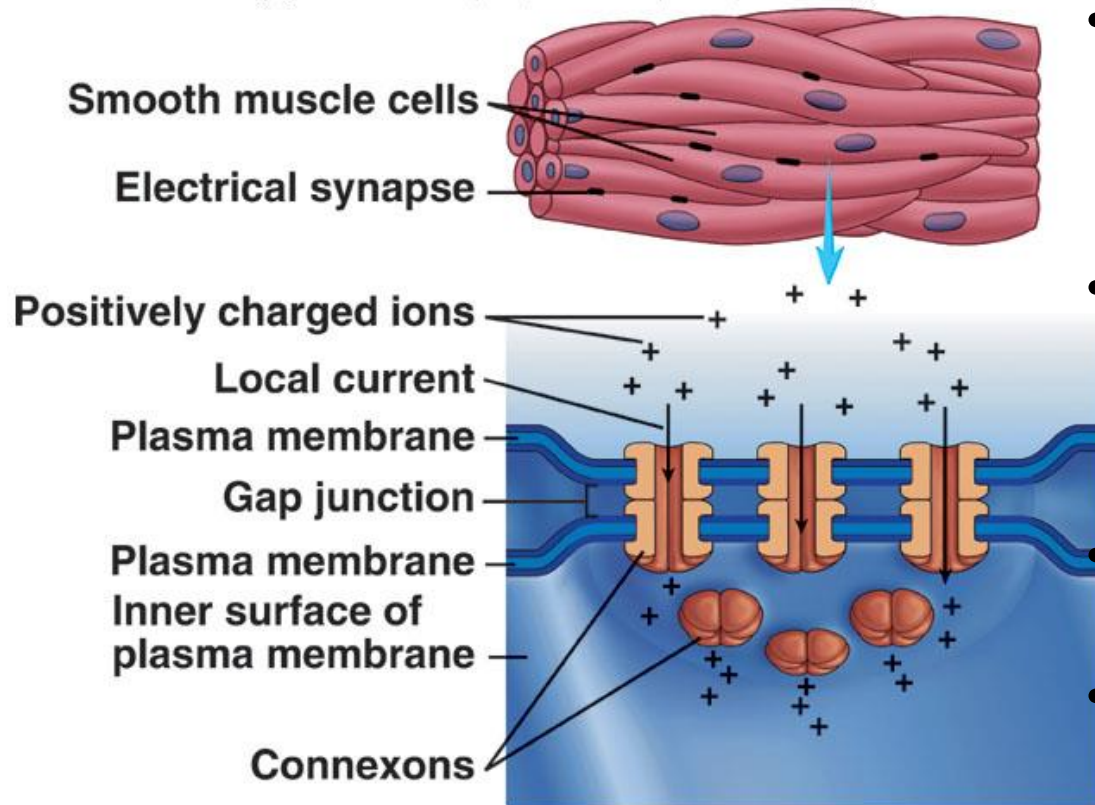


Action Potential

- *Action potential* (AP) atau **impuls**: sekuens yang berjalan cepat untuk menurunkan dan mengembalikan potensial membran serta menjaganya pada stadium istirahat.
 - Fase **depolarisasi**: membran potensial yang negatif $\rightarrow$ nol $\rightarrow$ positif.
 - Fase **repolarisasi**: membran potensial pd stadium istirahat, yaitu -70mV.
 - Fase **hiperpolarisasi**: membran potensial lebih negatif daripada stadium istirahat.
- Pada saat potensial aksi dihasilkan, dua tipe **voltage-gated channels** akan terbuka dan tertutup.
 - *voltage-gated Na channels* akan terbuka dimana Na akan masuk ke dalam sel sehingga menyebabkan terjadinya fase depolarisasi.
 - *voltage-gated K channels* akan terbuka sehingga ion K akan keluar membran dan terjadi fase repolarisasi.
 - Hiperpolarisasi terjadi ketika *voltage-gated K channels* menjadi terbuka setelah fase repolarisasi berakhir.

Sinaps

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- **Ruangan yang terdapat di antara 2 sel** (ujung akson terminal dengan dendrit sel lain)
- Neuron ber**komunikasi** dengan sel lainnya melalui sinaps, dimana membran plasma dari dua sel akan berdekatan.
- Fungsi: **transmisi impuls** dari satu neuron ke neuron lainnya
- Tipe:
 - **Pre-sinaps**
 - **Post-sinaps**

Potensial Aksi (Action Potential = AP)

- Potensial aksi terjadi pada axon neuron membran ketika depolarisasi mencapai ambang batas → **threshold** (sekitar 55 mV pada kebanyakan neuron).
- Pembentukan potensial aksi tergantung dari kemampuan stimulus untuk mencapai *threshold*.
 - ✦ **Sub-threshold** stimulus: potensial aksi tidak akan terjadi
 - ✦ **Supra-threshold** → stimulus yang sangat kuat, depolarisasi melebihi *threshold* → amplitudo potensial aksi sama dengan stimulus *threshold*

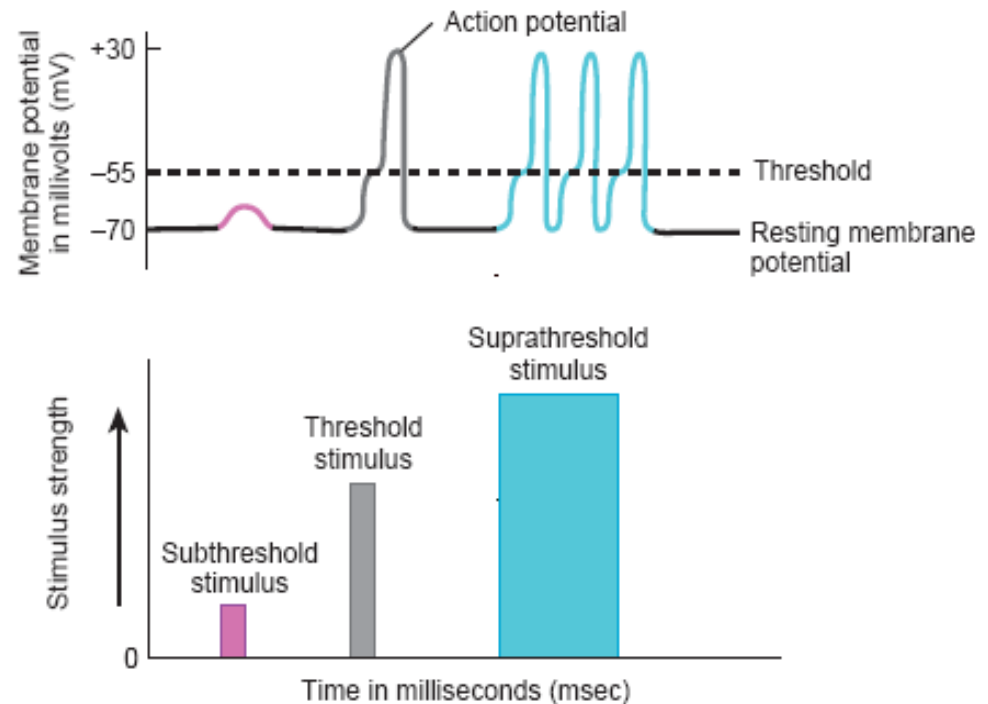
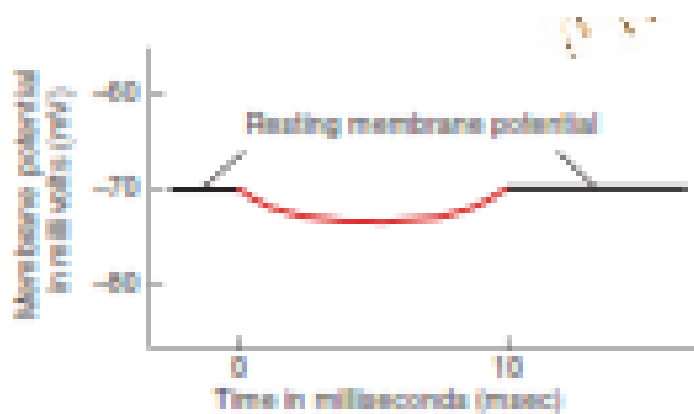
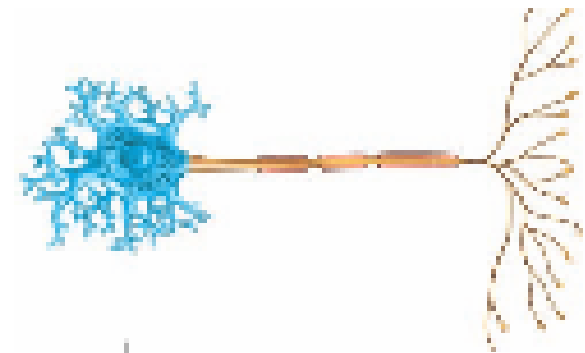
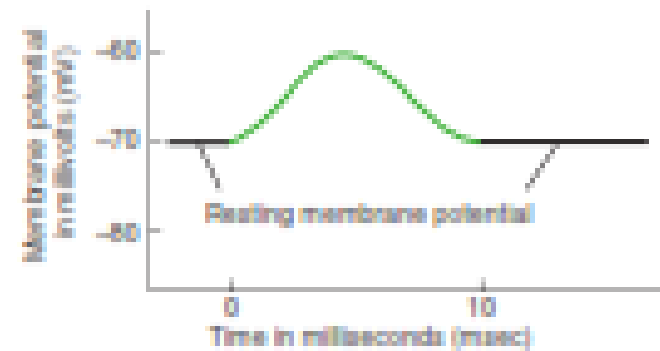


Figure 12-15. Graded Potential

Most graded potentials occur in the dendrites and cell body (areas colored blue inset)



(a) Hyperpolarizing graded potential



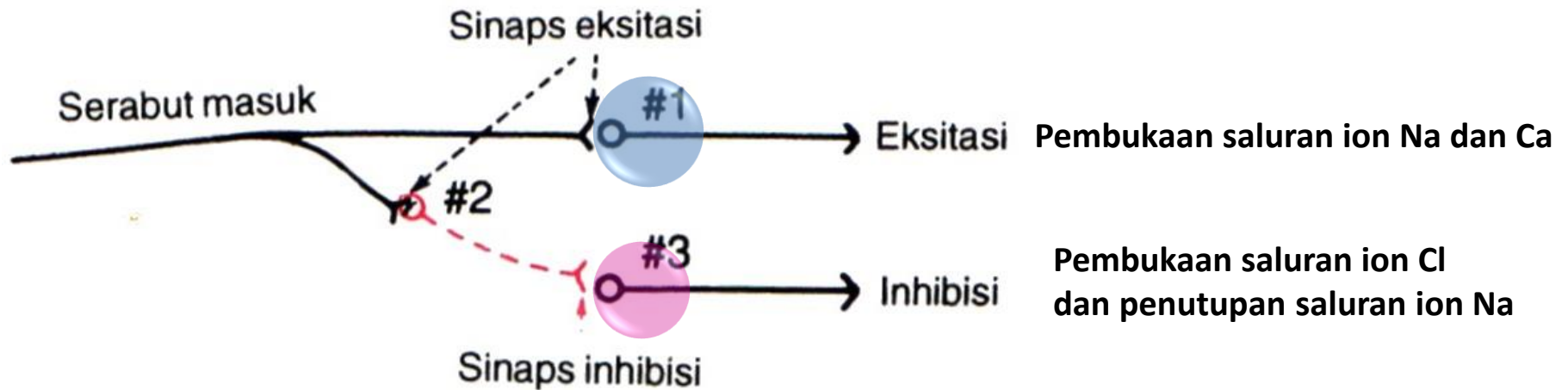
(b) Depolarizing graded potential

(a) Hyperpolarizing graded potential

(b) Depolarizing graded potential

- ❑ What kind of graded potential describes a change in membrane potential from -70 to -60 mV ?
From -70 to -80 mV ?

Sinyal yang memasuki sekumpulan neuron dapat menyebabkan impuls keluar berupa sinyal inhibisi atau eksitasi

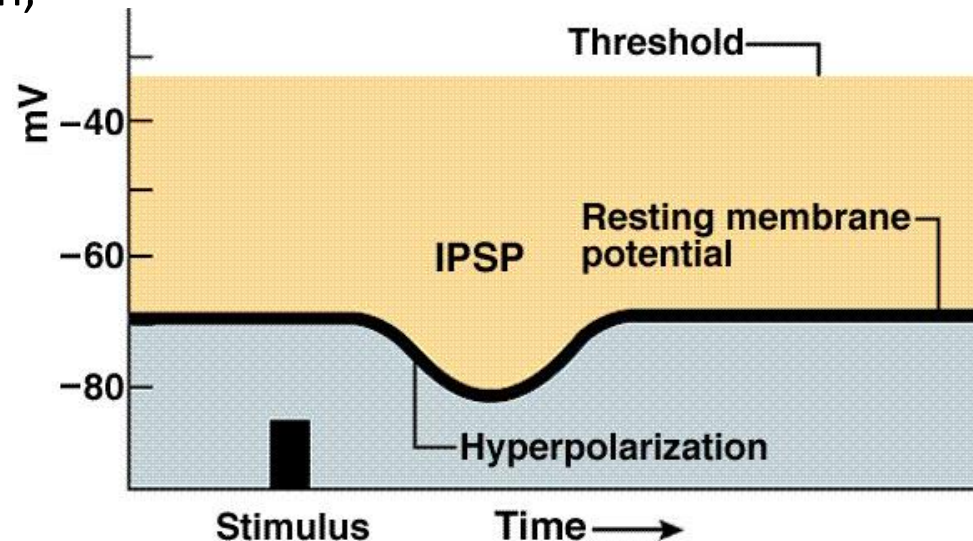
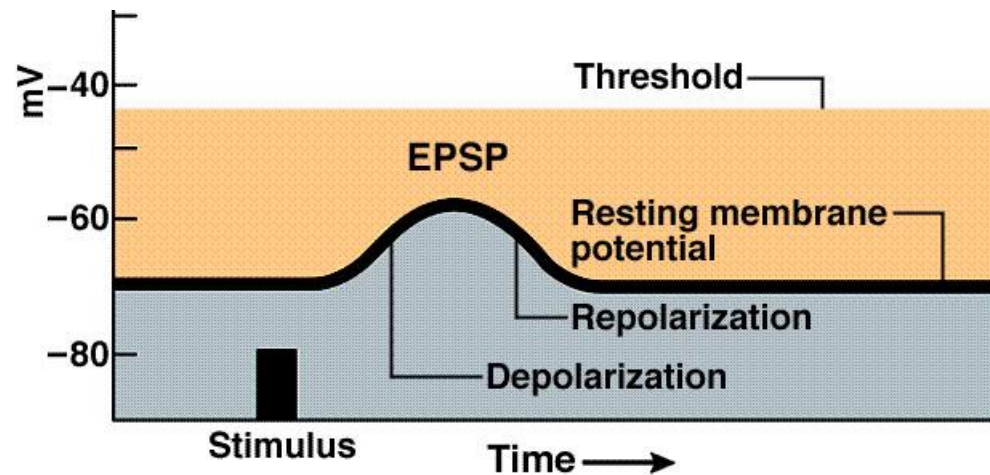


Role of Inhibitory Neurons

Inhibisi neuron membantu koordinasi respon pada efektor, seperti otot.

EPSPs & IPSPs

- Neurotransmitter dapat menyebabkan eksitasi atau inhibisi *graded potential*.
 - Neurotransmitter yang dapat mendepolarisasi post-sinaps membran dapat membawa muatan dekat ambang batas → eksitasi ~ **excitatory postsynaptic potential** atau EPSP.
 - Neurotransmitter yang menyebabkan hiperpolarisasi post-sinaps membran, menjauhkan muatan dari ambang batas → inhibisi ~ **inhibitory postsynaptic potentials** atau IPSPs.



NEUROTRANSMITER DAN SALURAN ION

- ✦ **Neurotransmitter ionotropik:** neurotransmitter yang akan mempengaruhi secara **langsung** pembukaan saluran ion, Contoh: Ach – nAChR
- ✦ **Neurotransmitter metabotropik:** neurotransmitter yang tidak secara langsung mempengaruhi pembukaan ion tetapi melalui **protein transmembran intrasitoplasmik** (misalnya Protein G) yang akan menginisiasi kaskade sinyal melalui protein intra-sitoplasmik lain untuk induksi pembukaan saluran ion, Contoh: Ach – mAChR

Saluran ion yang terbuka karena perubahan muatan listrik pada membran sel (*voltage-gated channel*), kalau terbuka karena ligan (*Ligan-gated channel*), kalau terbuka karena ATP (*ATP-gated channel*)

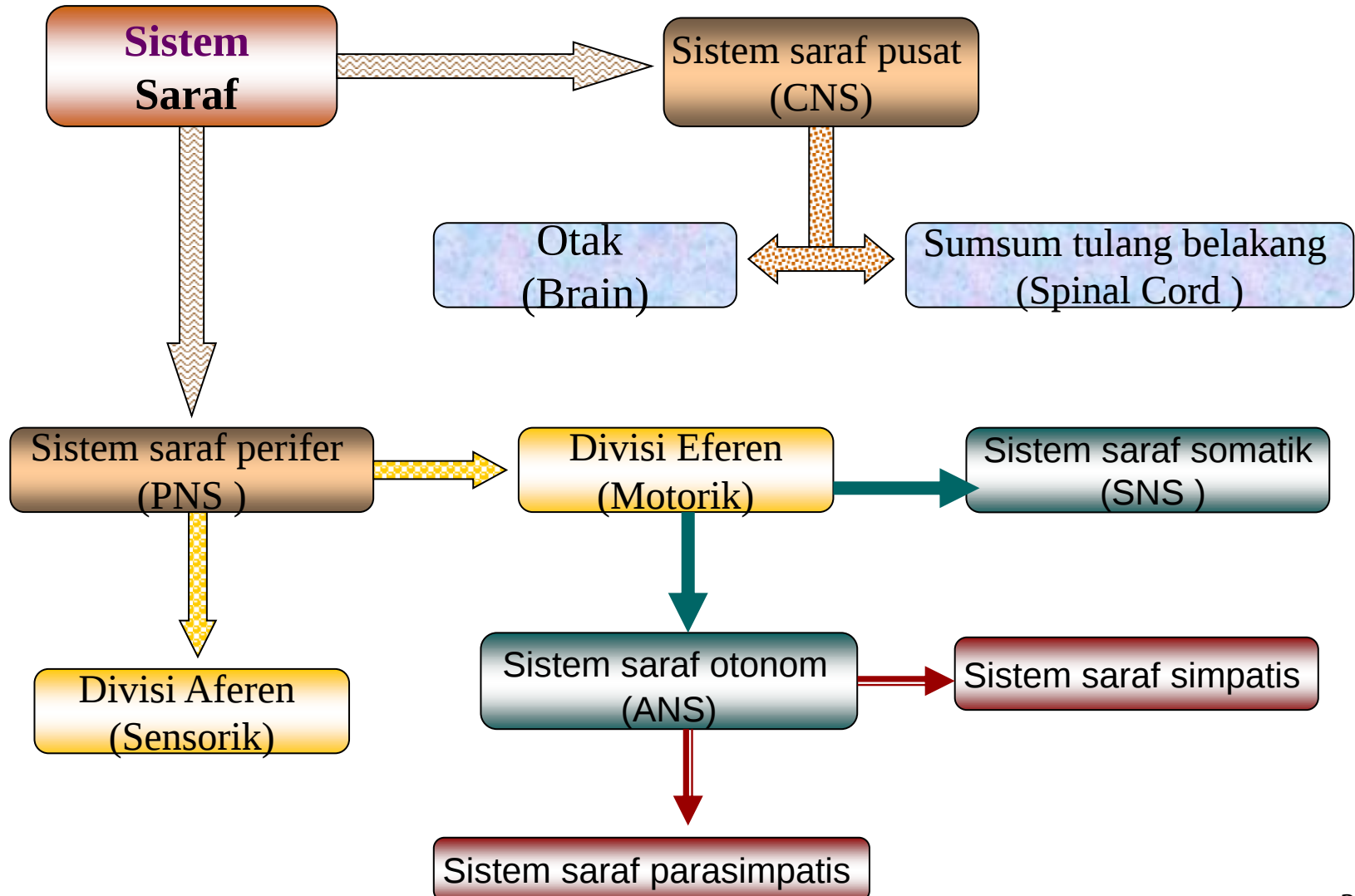
Sistem saraf otonom :

- Sistem saraf yang berfungsi mengatur aktivitas otot polos, otot jantung dan kelenjar eksokrin tertentu
- Sistem saraf yang dapat mengatur diri sendiri (*self governing*)

Fungsi SSO : mengontrol

- denyut jantung
- tekanan darah
- bronkodilatasi
- sekresi (keringat, saliva, lambung)
- akomodasi mata
- diameter pupil
- motilitas saluran cerna

SSP ~ SSO (CNS ~ ANS)



Pengertian dan singkatan

- Sistem saraf pusat = Central nervous system=CNS
- Sistem saraf perifer = Peripheral nervous system (PNS)
- Divisi aferen: membawa informasi dari perifer ke SSP
- Divisi eferen: membawa sinyal dari SSP (otak & sumsum tulang belakang /medula spinalis) ke jaringan perifer
- Sistem saraf somatik (SNS) = Somatic nervous system= menghantarkan informasi dari SSP ke otot rangka
- Sistem saraf otonom (ANS) = Autonomic Nervous system; Menghantarkan informasi dari SSP ke otot polos, otot jantung dan kelenjar .

Istilah persarafan SSO

Table 6-1. Definition (Katzung, 44) → Part 1

Term	Definition
Adrenergic	A nerve ending that releases norepinephrine as the primary transmitter; also a synapse in which norepinephrine is the primary transmitter
Adrenoceptor	A receptor that binds- and is activated by – one of the catecholamine transmitters (norepinephrine, norepinephrine, or dopamnie) and related drugs
Autonomic effector cells or tissues	Cells or tissues that have adrenoceptors or cholinoceptors which, when activited , after the function of those cells or tissues, eg, smooth muscle, heart, glands, cells,
Baroreceptor reflex	The neuronal homeostatic mechanism that the body uses to maintain blood pressure constant; the sensory limb of originates in the baroreceptors of the carotid sinus

Table 6-1. Definition (Katzung, 44) → Part 2

Term	Definition
Cholinergic	A nerve ending that releases acetylcholine as the primary transmitter; also a synapse in which acetylcholine is the primary transmitter
Cholinoceptor	A receptor that binds- and is activated by, acetylcholine transmitters and related drugs
Dopaminergic	A nerve ending that releases dopamine as the primary transmitter; also a synapse in which dopamine is the primary transmitter
Homeostatic reflex	A neuronal compensatory mechanism for maintaining a body function at a predetermined level, eg, baroreceptor reflex for blood pressure

Table 6-1. Definition (Katzung, 44) → Part 3

Term	Definition
Parasympathetic (P ANS)	The part of autonomic nervous system that originates in the cranial nerves and the sacral part of the spinal cord
Postsynaptic receptor	Receptor located on the distal side of the synaps, eg, on the effector cell; contrast with presynaptic receptors
Presynaptic receptor	Receptor located on the nerve ending in a synapse; modulates the release of the transmitter
Sympathetic (S ANS)	The part of autonomic nervous system that originates in the thoracic nerves and lumbal parts of the spinal cord

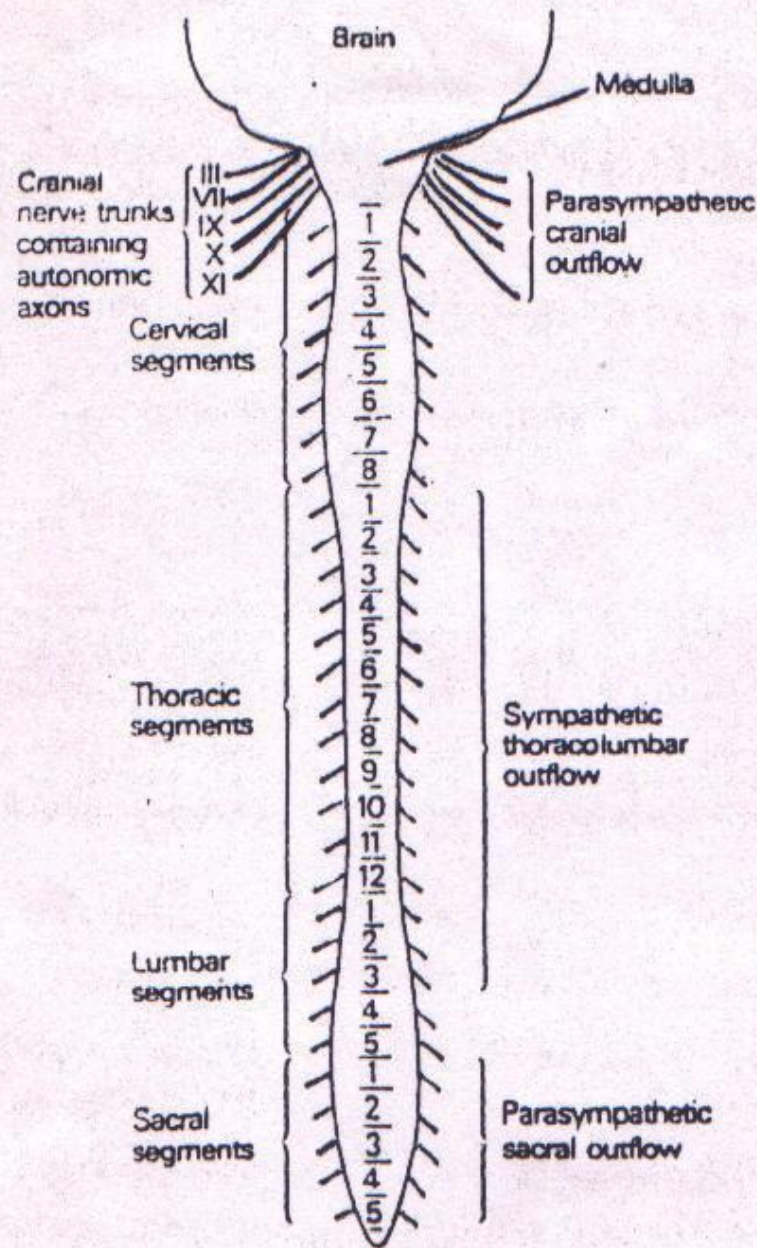
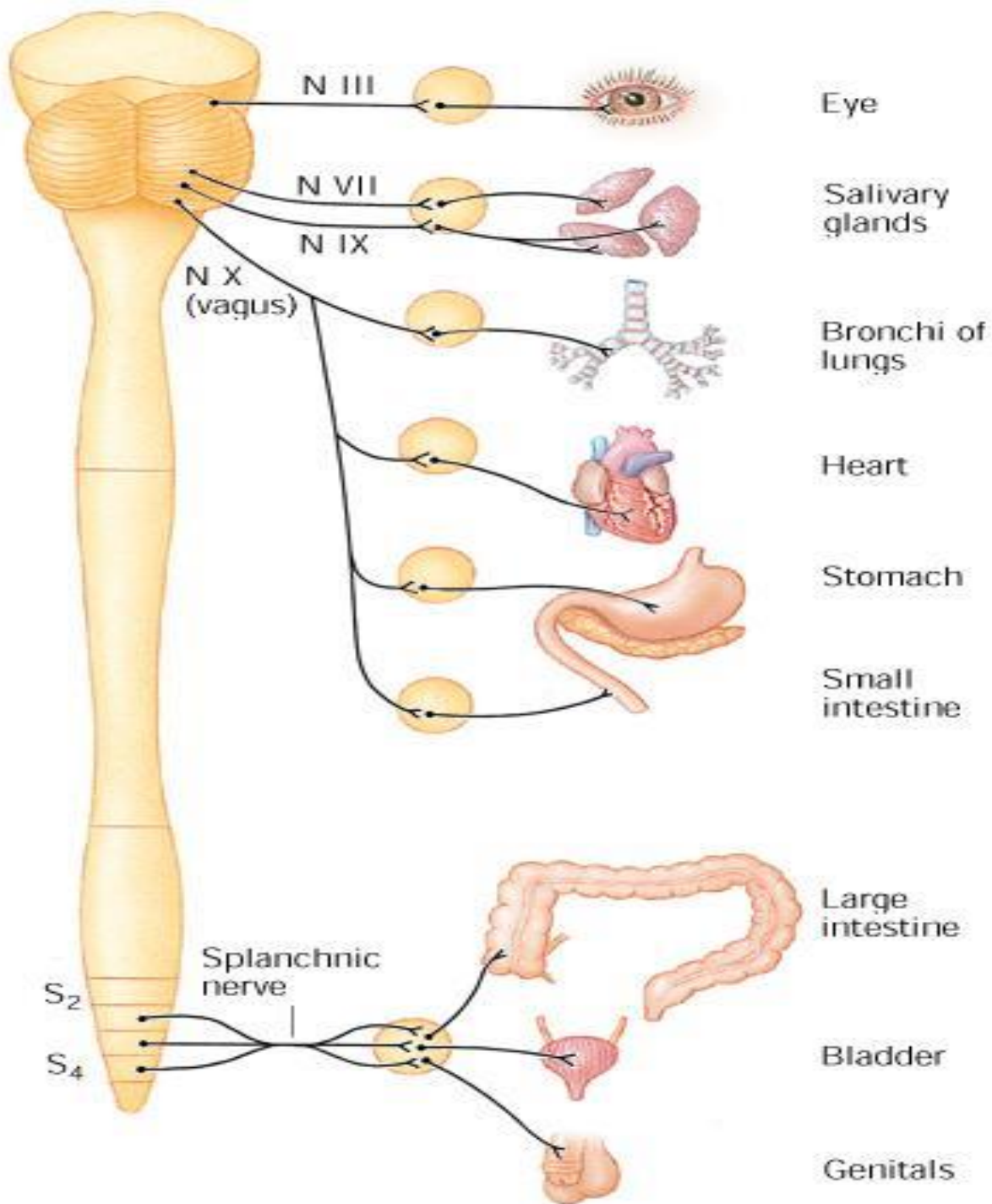
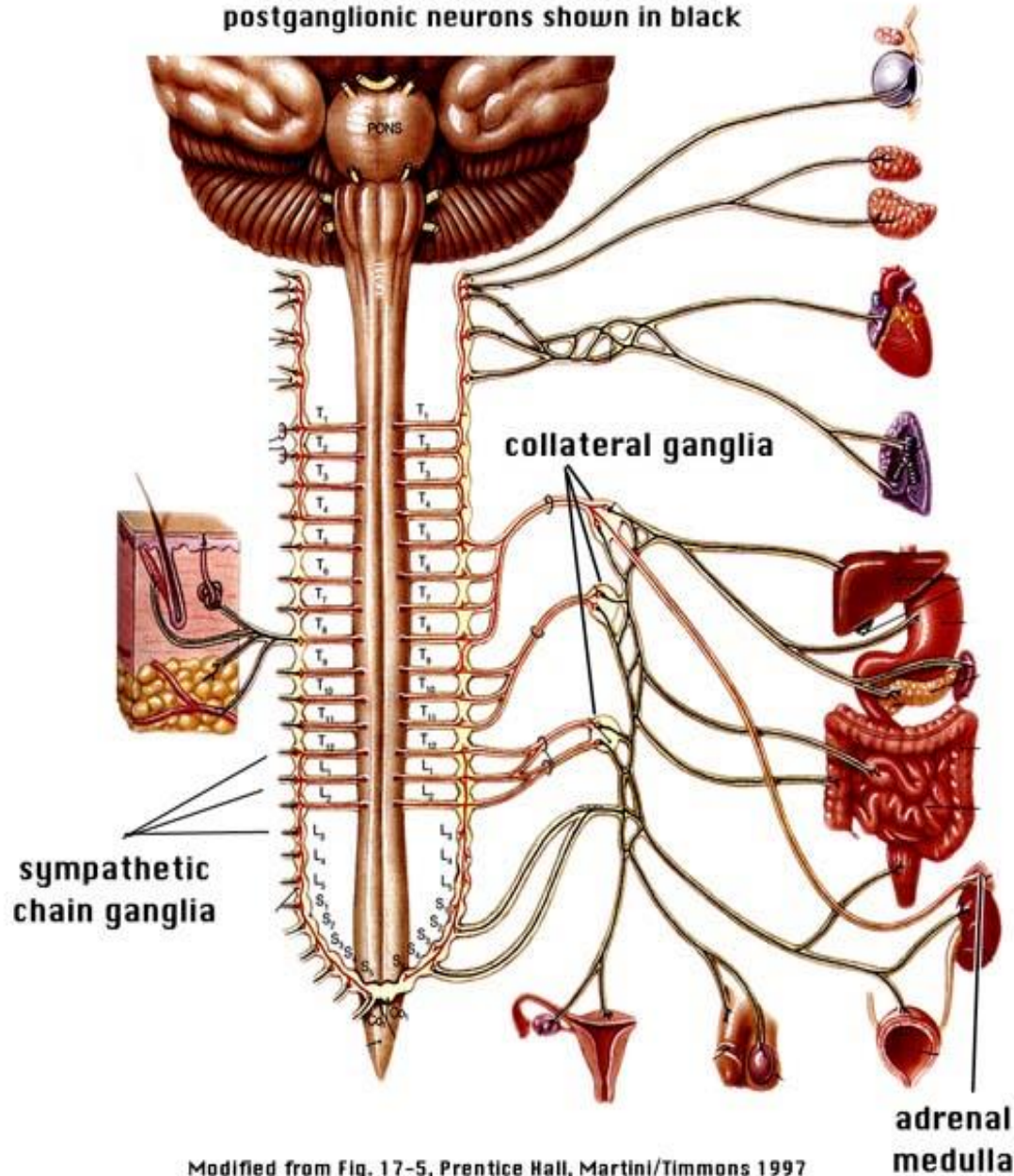


FIG. 9.1. The preganglionic autonomic nervous outflow from the central nervous system (brain and spinal cord) showing the sympathetic (thoracolumbar) and parasympathetic (cranial and sacral) divisions.



Sympathetic Nervous System

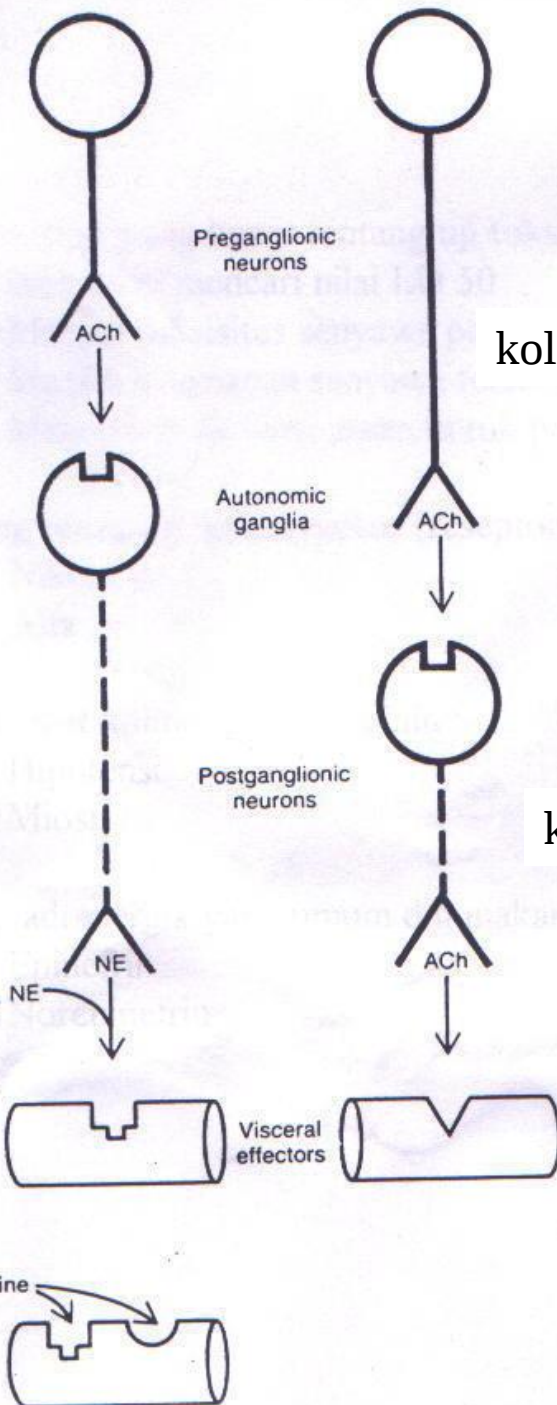
preganglionic neurons shown in red
postganglionic neurons shown in black



Saraf simpatis

kolinergik

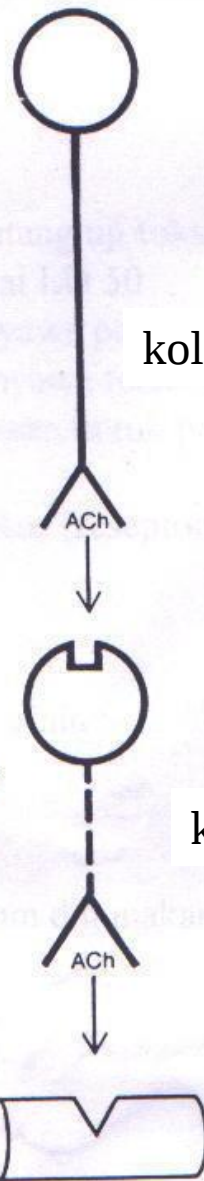
adrenergik



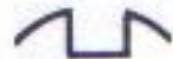
Saraf parasimpatis

kolinergik

kolinergik



Key:



= Nicotinic receptor



= Muscarinic receptor



= Alpha (α) receptor



= Beta (β) receptor



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TERIMAKASIH
