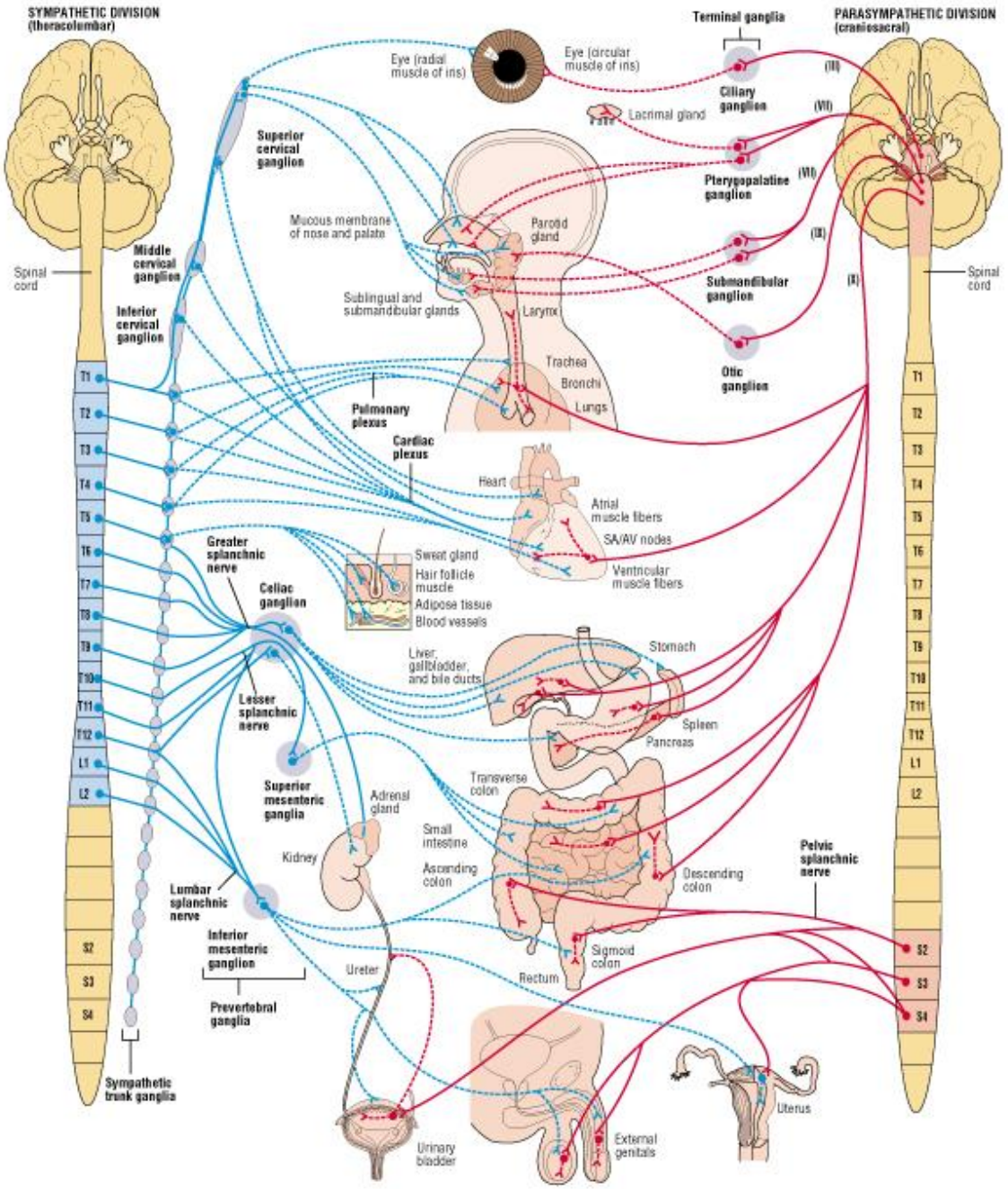
Autonomic Nervous System

Autonomic Nervous System

Ref: **Textbook of Medical Physiology,** Guyton, 14th Ed.:763-773, 13th ed.: 773-784. 12th ed: 729-738, and 11th ed. P748-760.

Fig.17.02


SYMPATHETIC DIVISION
(thoracolumbar)
PARASYMPATHETIC DIVISION
(craniosacral)
Terminal ganglia
Eye (radial muscle of iris)
Eye (circular muscle of iris)
Ciliary ganglion
(III)
Lacrimal gland
(VII)
Superior cervical ganglion
Pterygopalatine ganglion
(VII)
Mucous membrane of nose and palate
Parotid gland
(IX)
Middle cervical ganglion
Spinal cord
Submandibular ganglion
(X)
Spinal cord
Sublingual and submandibular glands
Larynx
Inferior cervical ganglion
Otic ganglion
Trachea
Bronchi
Lungs
Pulmonary plexus
Cardiac plexus
Heart
Atrial muscle fibers
SA/AV nodes
Ventricular muscle fibers
Greater splanchnic nerve
Sweat gland
Hair follicle muscle
Adipose tissue
Blood vessels
Celiac ganglion
Stomach
Liver, gallbladder, and bile ducts
Lesser splanchnic nerve
Spleen
Pancreas
Superior mesenteric ganglia
Adrenal gland
Transverse colon
Kidney
Small intestine
Ascending colon
Descending colon
Pelvic splanchnic nerve
Lumbar splanchnic nerve
Inferior mesenteric ganglion
Sigmoid colon
Ureter
Rectum
Prevertebral ganglia
Sympathetic trunk ganglia
Urinary bladder
External genitals
Uterus
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
L1
L2
S2
S3
S4

General functions

Control and Adaptation of body systems to internal and/or external changes

Example of adaptation to external stimuli

Fight and Flight Reaction

-Increase heart rate and force of contraction.

-Widely dilated pupils.

-Pallor (pale of fear) as blood is directed to the skeletal muscle.

-Goose pimples.

-Cold sweat.

-Dry mouth.

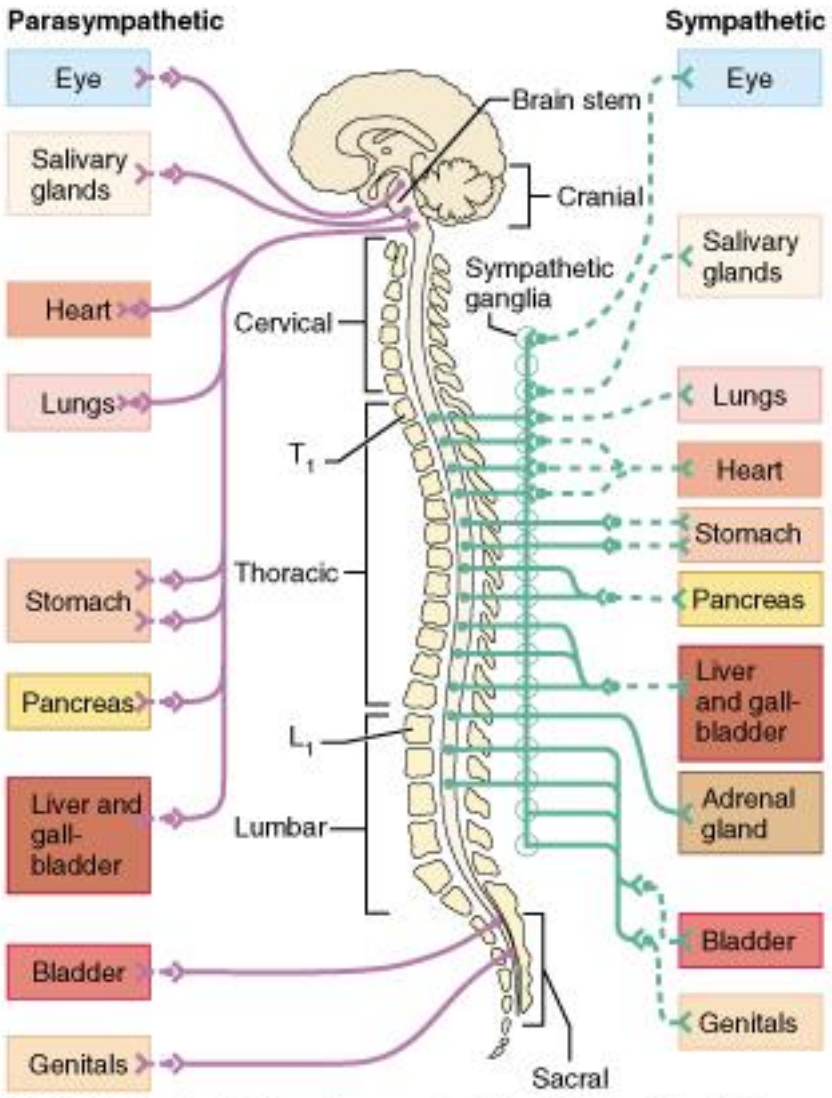
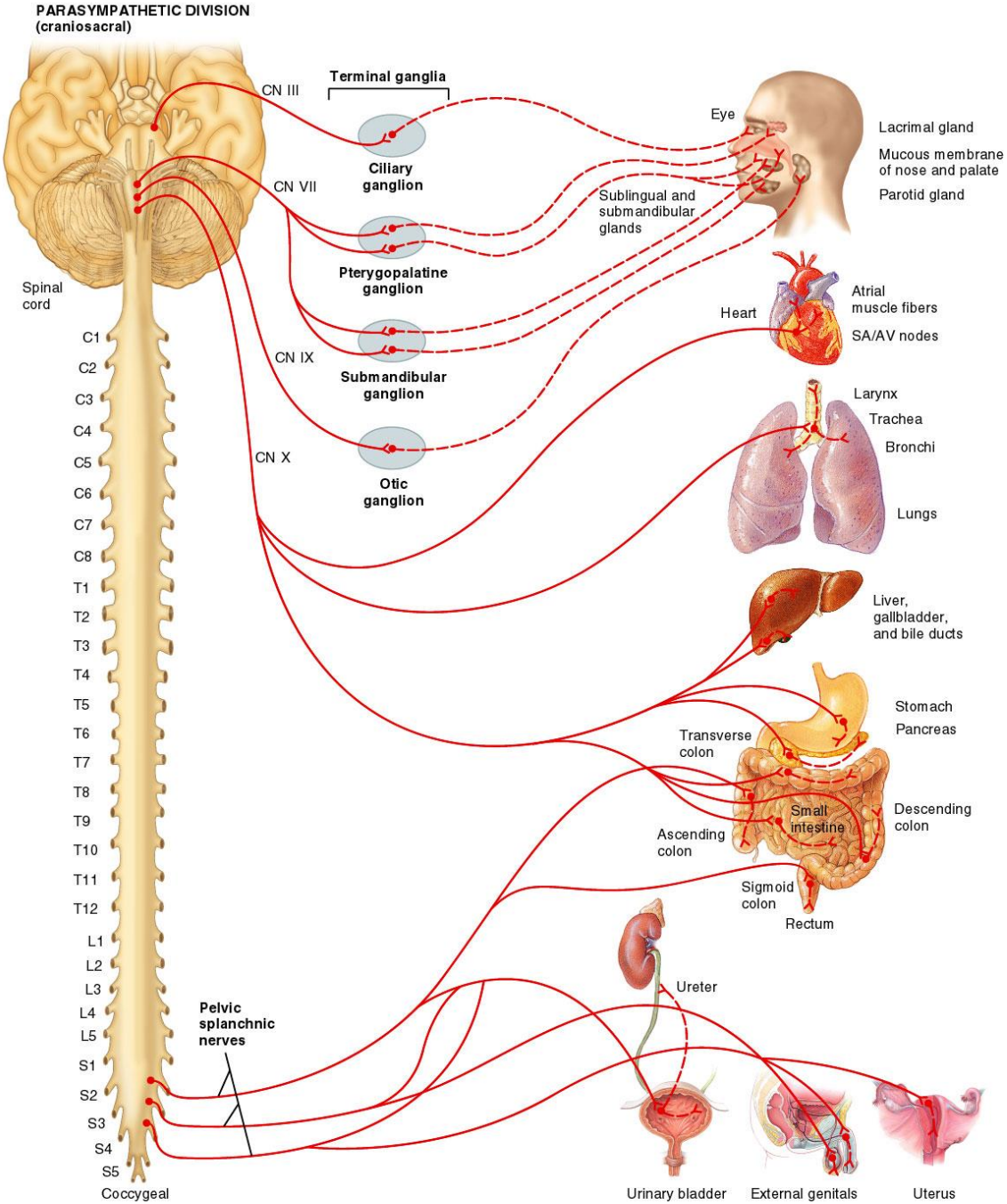


Fig. 17.03


PARASYMPATHETIC DIVISION
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CN III
Terminal ganglia
Ciliary ganglion
CN VII
Pterygopalatine ganglion
Submandibular ganglion
CN IX
Otic ganglion
CN X
Eye
Lacrimal gland
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C1
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C3
C4
C5
C6
C7
C8
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T7
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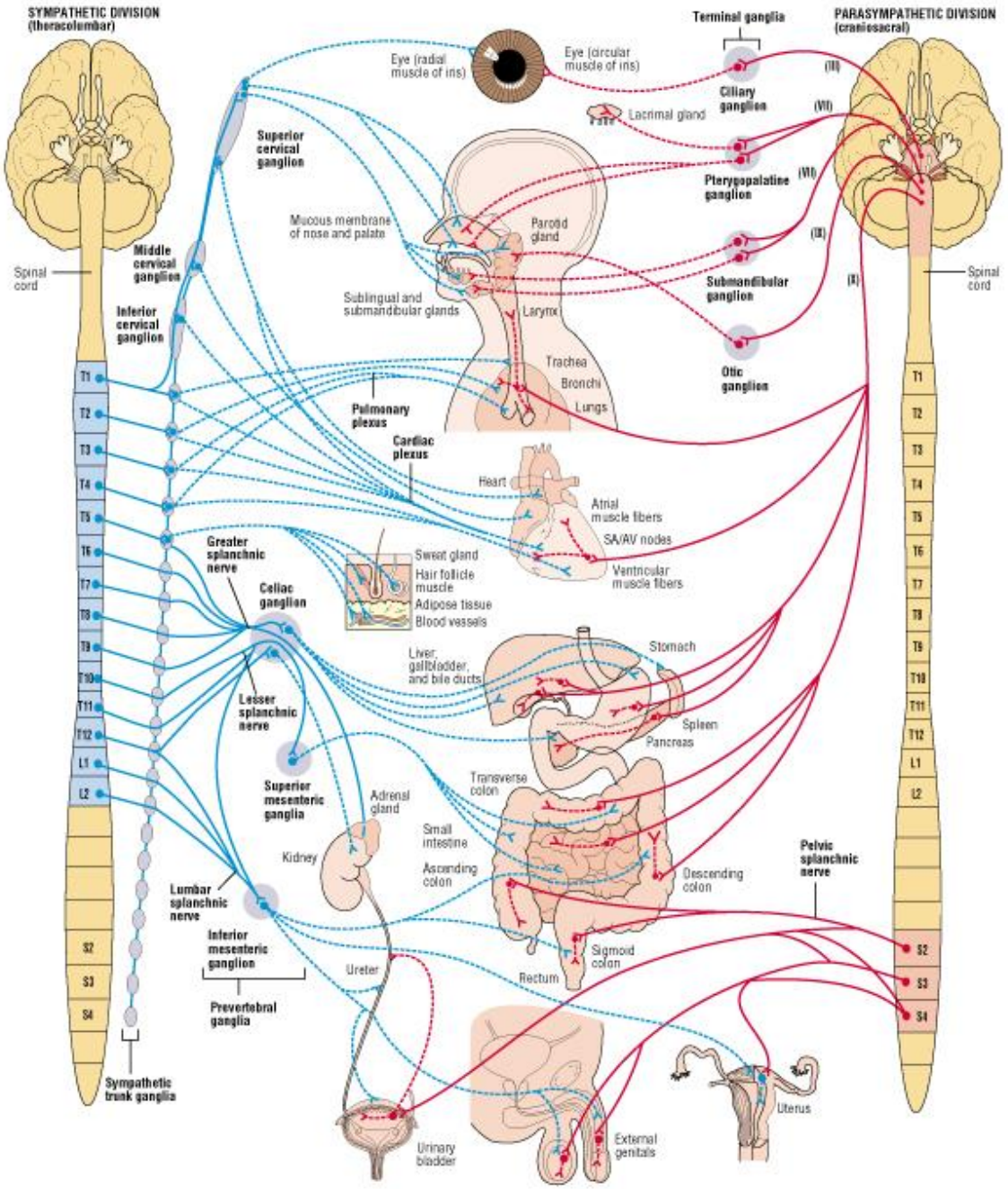
T9
T10
T11
T12
L1
L2
L3
L4
L5
S1
S2
S3
S4
S5
Coccygeal
Pelvic splanchnic nerves

ANS characteristics

Anatomical characteristics and Synaptic organization of ANS

Fig.17.02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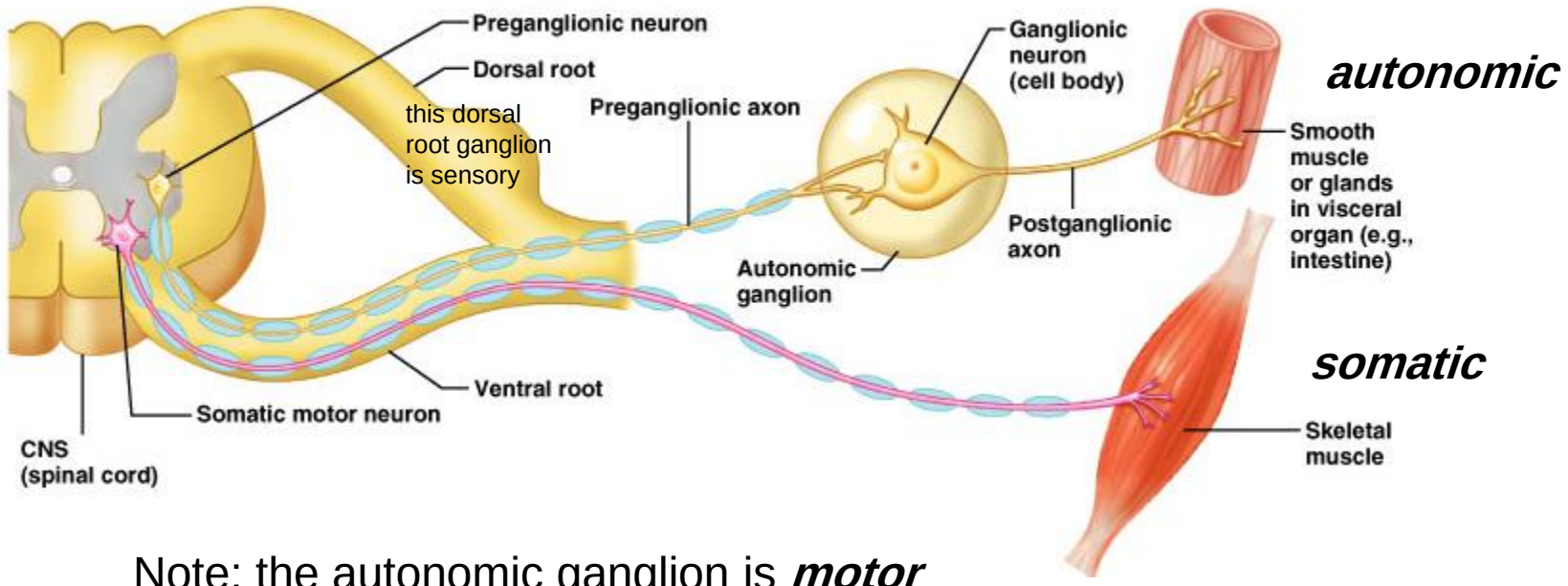
L1
L2
S2
S3
S4

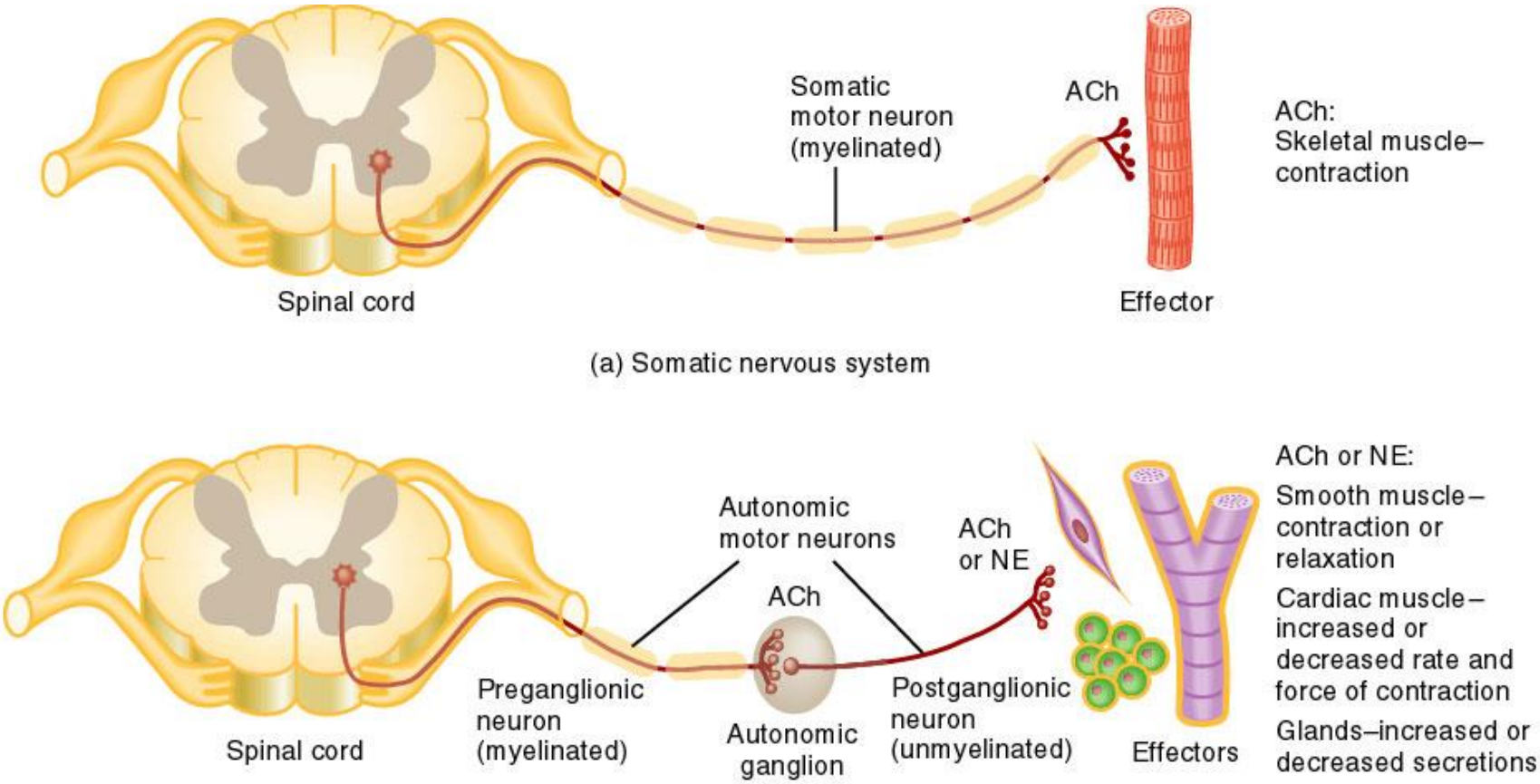
- Axon of 1st (*preganglionic*) neuron leaves CNS to synapse with the 2nd (*ganglionic*) neuron
- Axon of 2nd (*ganglionic*) neuron extends to the organ it serves

Diagram contrasts somatic (lower) and autonomic:



Note: the autonomic ganglion is ***motor***

Fig.17.01



17.01

Synaptic organization of ANS

Convergence and Divergence in Sympathetic division

Fig. 17.05

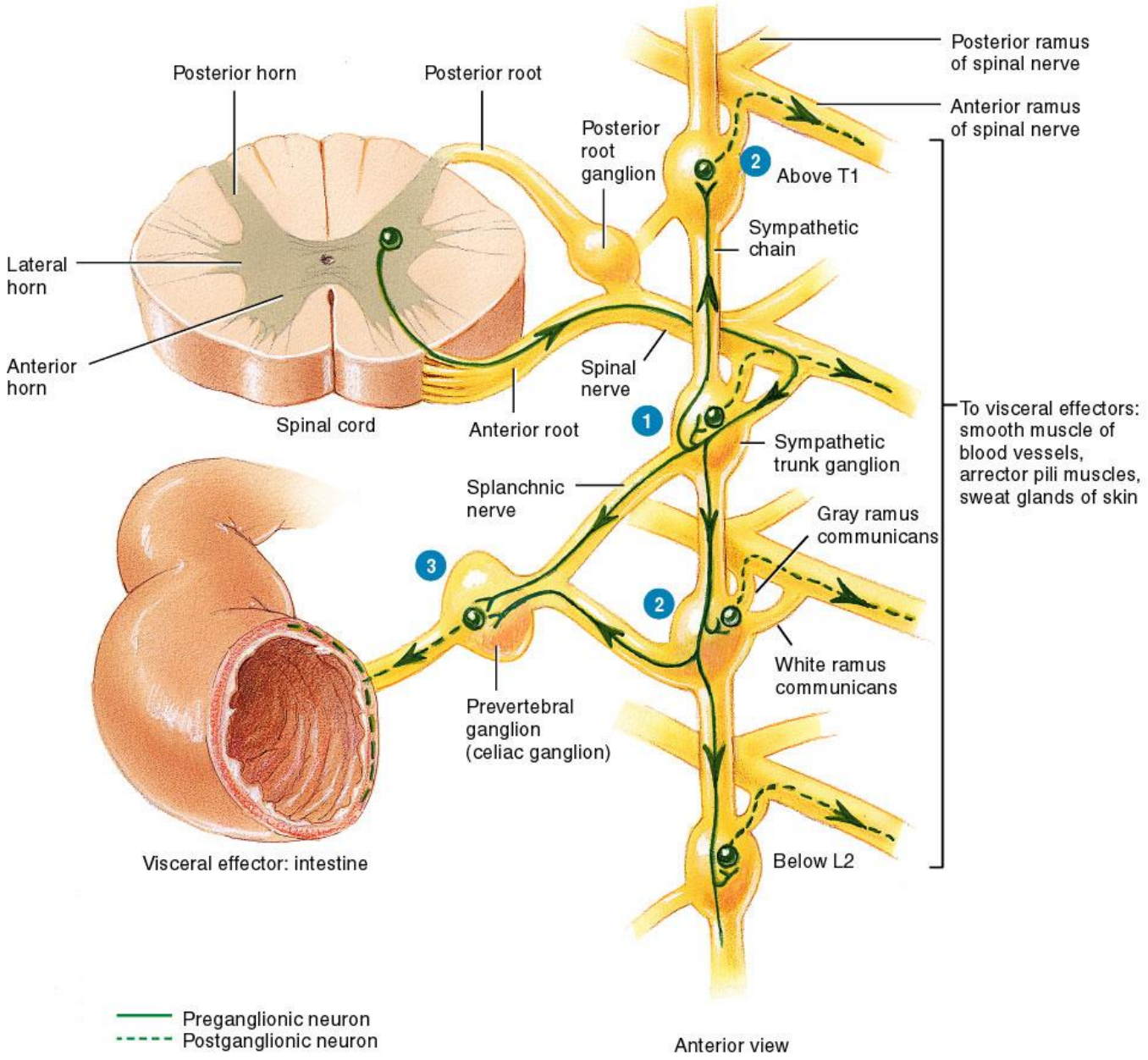
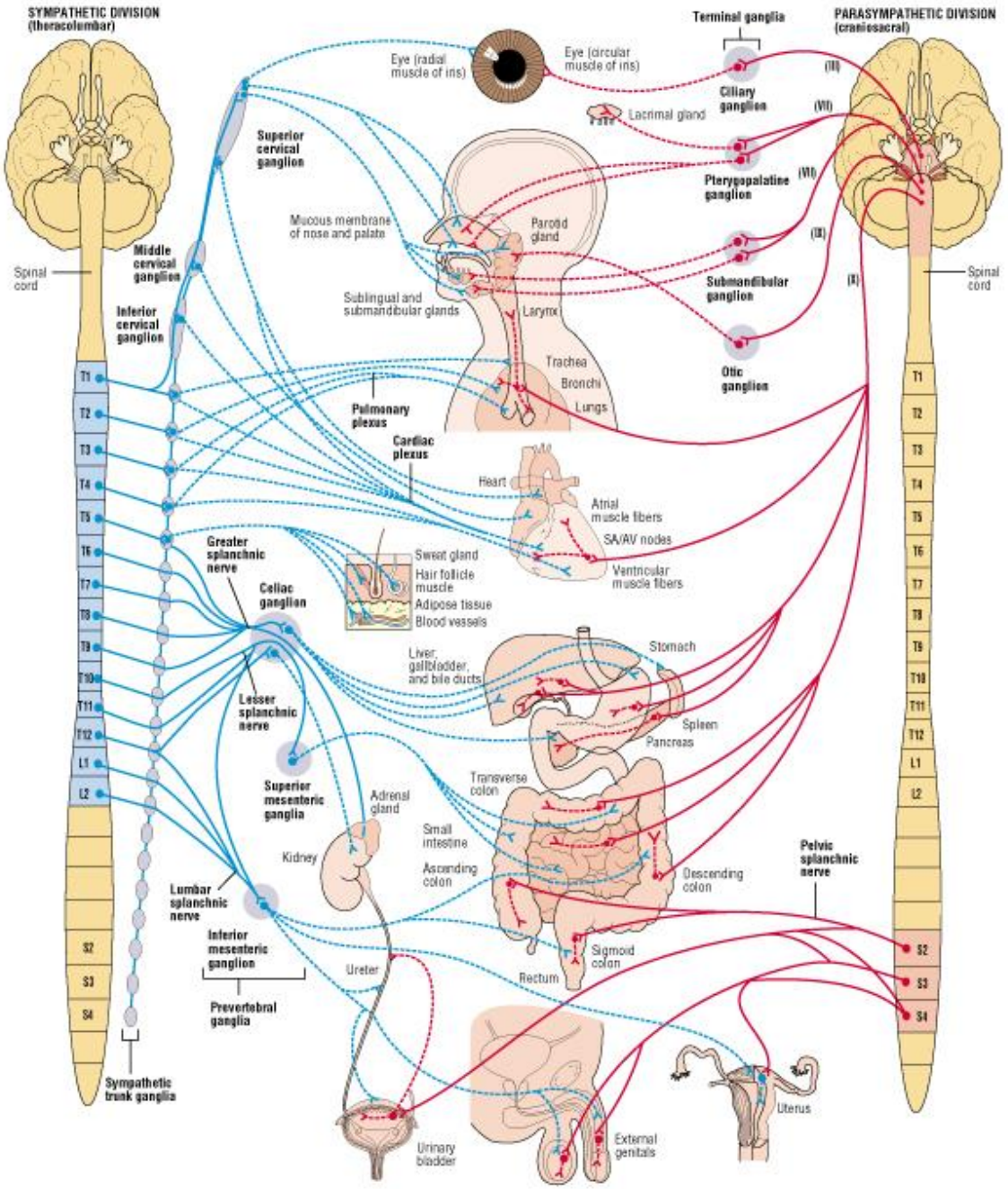

Posterior horn
Posterior root
Posterior root ganglion
Posterior ramus of spinal nerve
Anterior ramus of spinal nerve
2
Above T1
Sympathetic chain
Lateral horn
Anterior horn
Spinal nerve
Spinal cord
Anterior root
1
Sympathetic trunk ganglion
To visceral effectors: smooth muscle of blood vessels, arrector pili muscles, sweat glands of skin
Splanchnic nerve
Gray ramus communicans
3
2
White ramus communicans
Prevertebral ganglion (celiac ganglion)
Visceral effector: intestine
Below L2
Preganglionic neuron
Postganglionic neuron
Anterior view

Fig.17.02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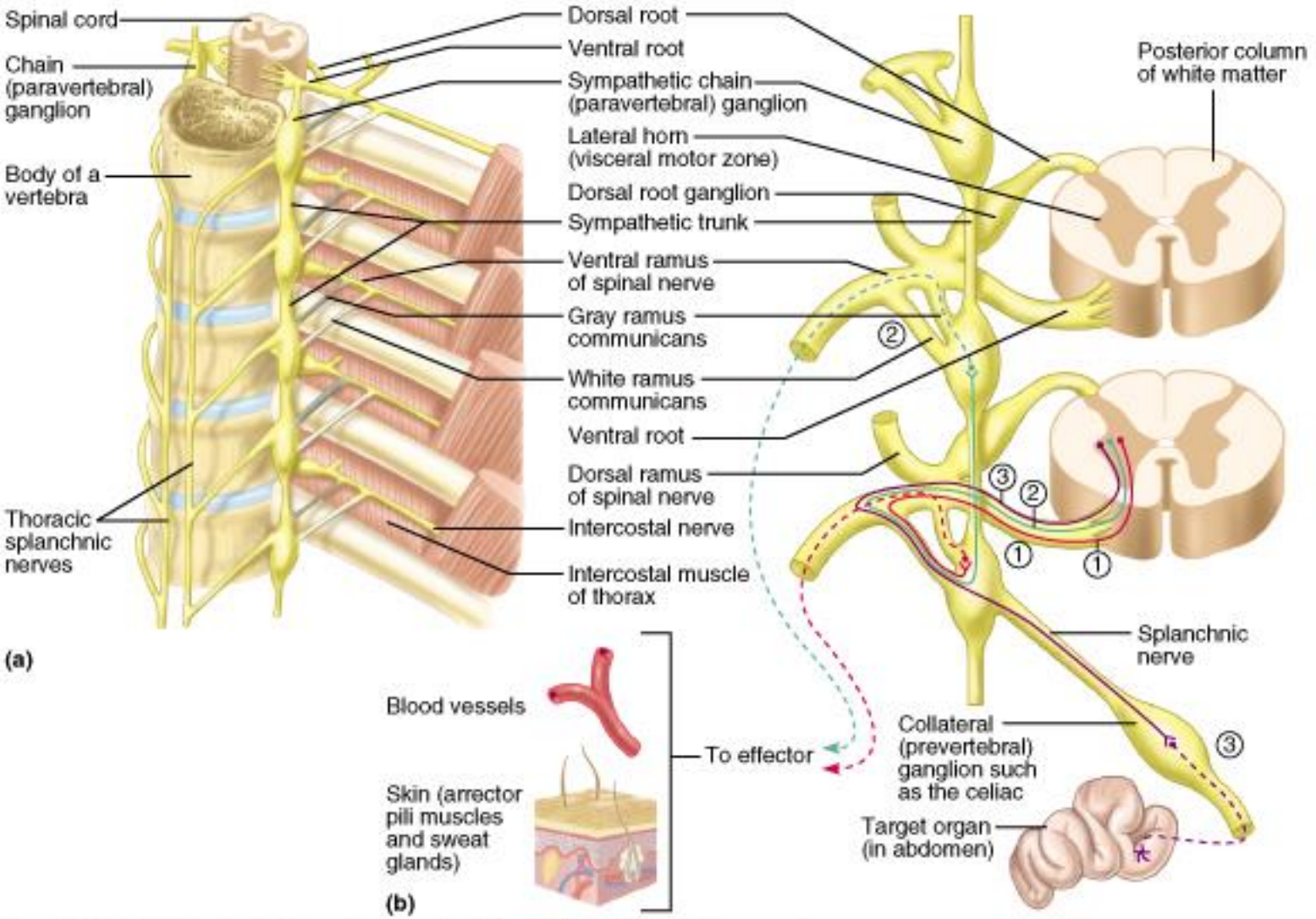
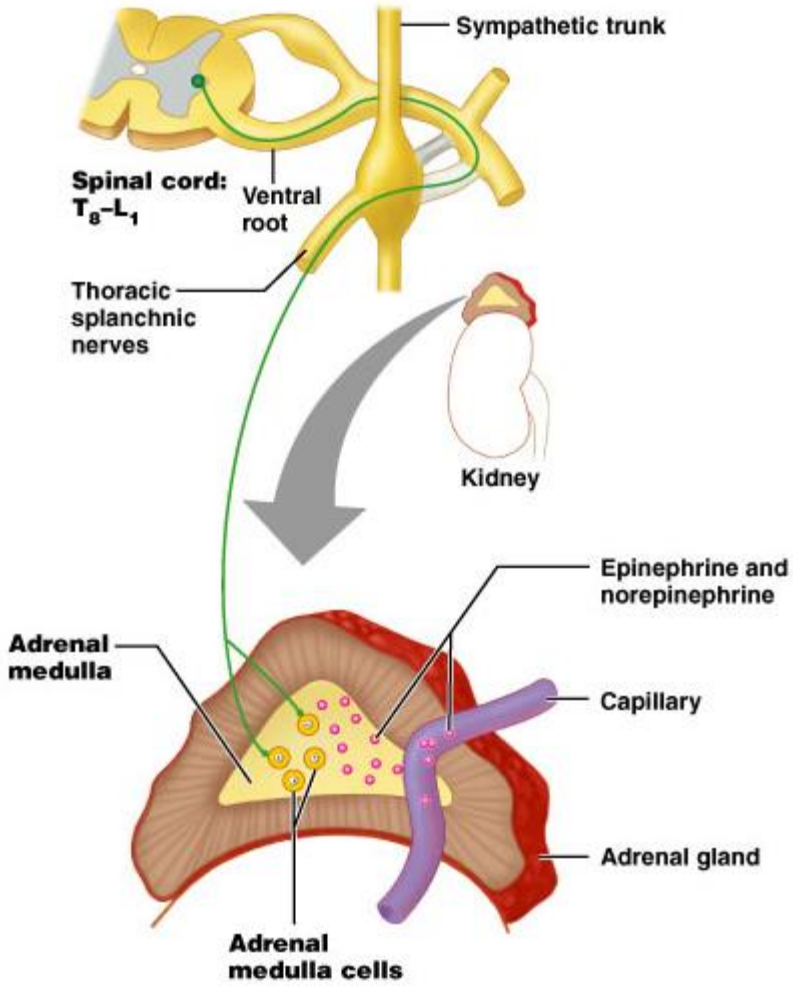
S4



Adrenal gland is exception

- Synapse in gland
- Can cause body-wide release of epinephrine



Physiological characteristics of ANS

- High speed of onset:
- Automatic nature:
- Tonic activity:

Effects of sympathetic stimulation

-**Blood pressure** (blood vessels supplying skeletal muscle are major players). In addition to that the effect on heart also contributes in regulation of blood pressure.

- **Body temperature** by the sympathetic effects on cutaneous blood vessels and sweat glands.

Effects of sympathetic stimulation

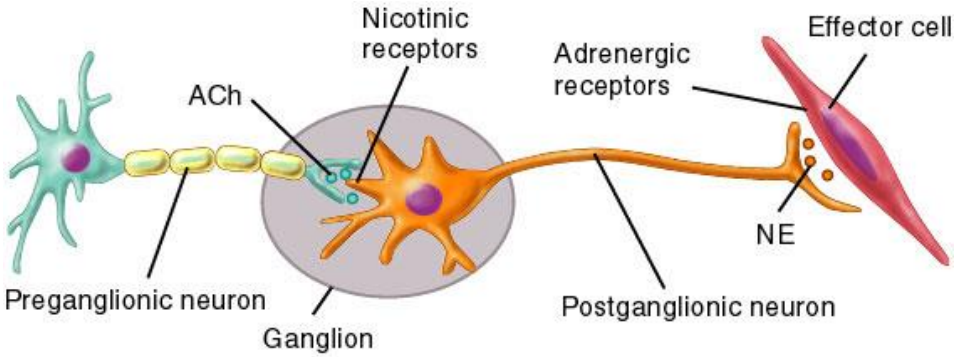
- **Cardiovascular system**: effects on vessels will result in redistribution of blood by enhancing blood flow to skeletal muscle and reducing blood flow to skin and mesentery.
- **Effects on heart**: increasing cardiac output (volume of blood pumped per minute).
- **Respiratory system**: causes relaxation of bronchial muscle which result in bronchodilation.
- **Digestive system**: inhibition of motility and secretion.
- **Metabolic effects**:
  * Mobilization of glucose.
  * Increased lipolysis.
  * Increased metabolic rate.

Effects of parasympathetic stimulation

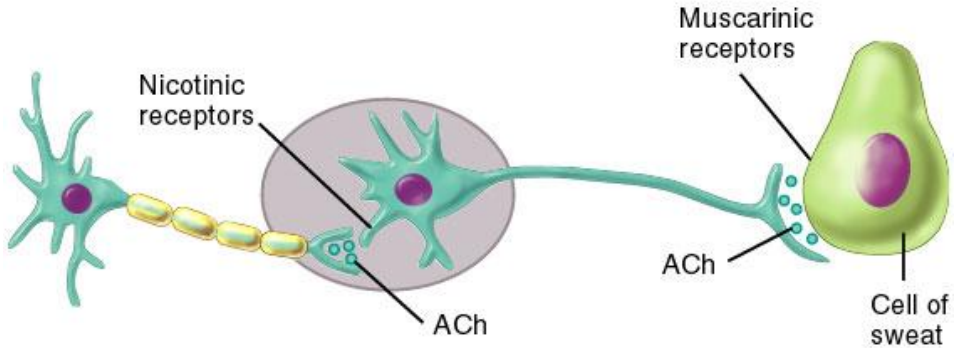
- **Gastrointestinal system**: increases motility and secretory activity.
- **Glands:** increases secretory activity (but remember sweat glands are under sympathetic control).
- **Heart**: decrease rate of contraction (bradycardia).
- **Pupil**: control pupil diameter by papillary light reflex (miosis) (regulates the amount of light falling on retina).
- Accommodation of the **lens** for near vision.
- Voiding the **urinary bladder** (micturation).

MOLECULAR BASIS OF PHYSIOLOGICAL ACTIONS OF THE ANS

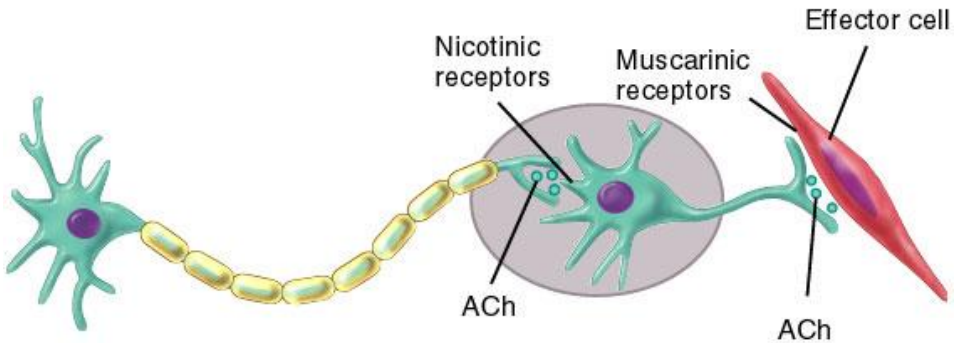
Fig. 17.06



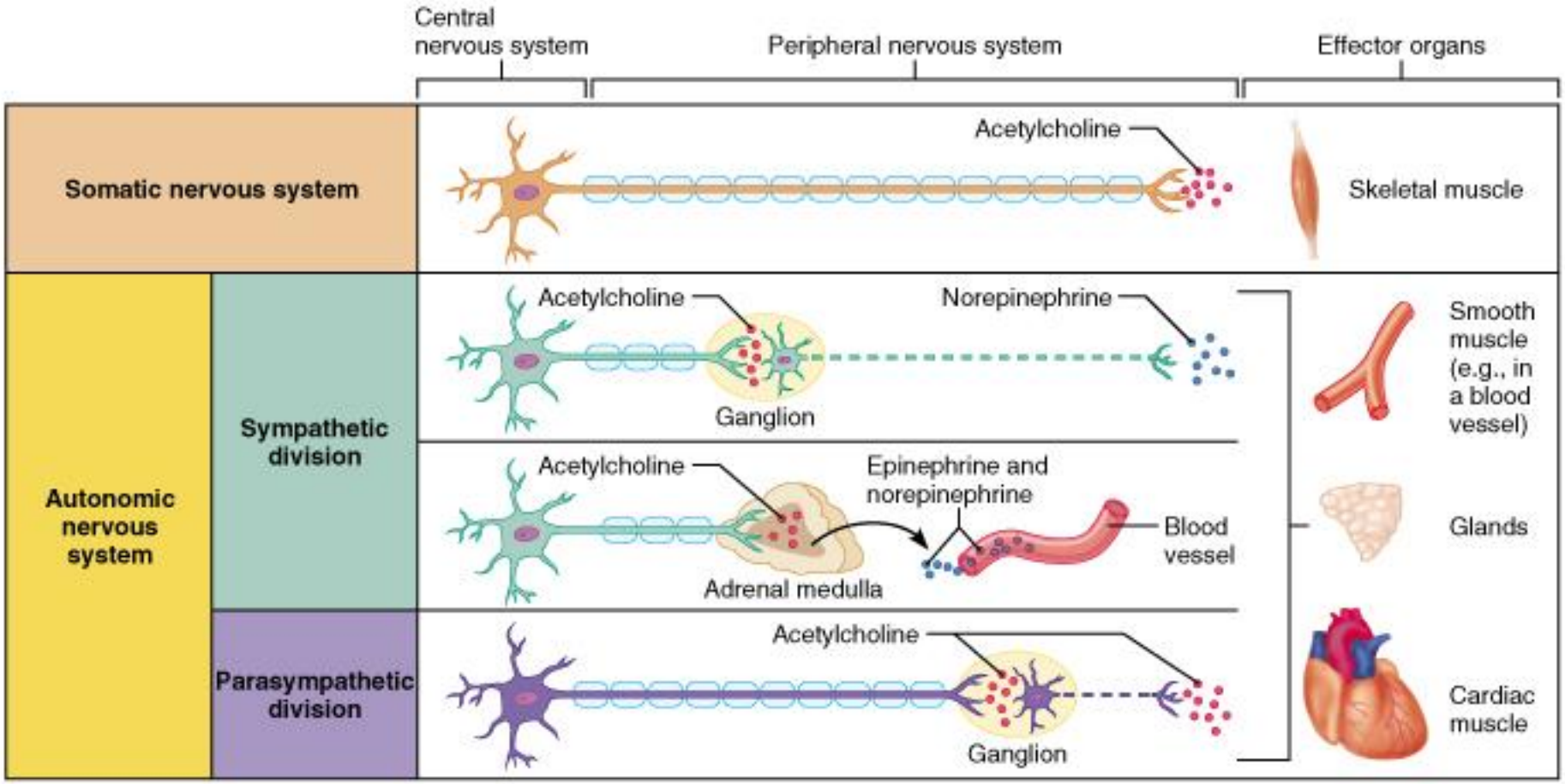
(a) Sympathetic division–innervation to most effector tissues



(b) Sympathetic division–innervation to most sweat glands



(c) Parasympathetic division



Key:

= Preganglionic axons (sympathetic)
= Postganglionic axons (sympathetic)
= Myelination
= Preganglionic axons (parasympathetic)
= Postganglionic axons (parasympathetic)

– Neurotransmitters

- **At ganglion**: preganglionic neurons of both sympathetic and parasympathetic release **acetylcholine** (Ach).
- **Effector organs:**

  - parasympathetic fibers release **acetylcholine**

  - Sympathetic: **norepinephrine**.
- **An exception** for sympathetic nerves to **sweat glands**, which release **acetylcholine** (Ach).

Receptors and Signal transduction mechanisms

-**At ganglia**: sympathetic and parasympathetic have **nicotinic** receptors at the post synaptic membrane

-**on effector cells: Muscarinic receptors**.

Receptors and Signal transduction mechanisms

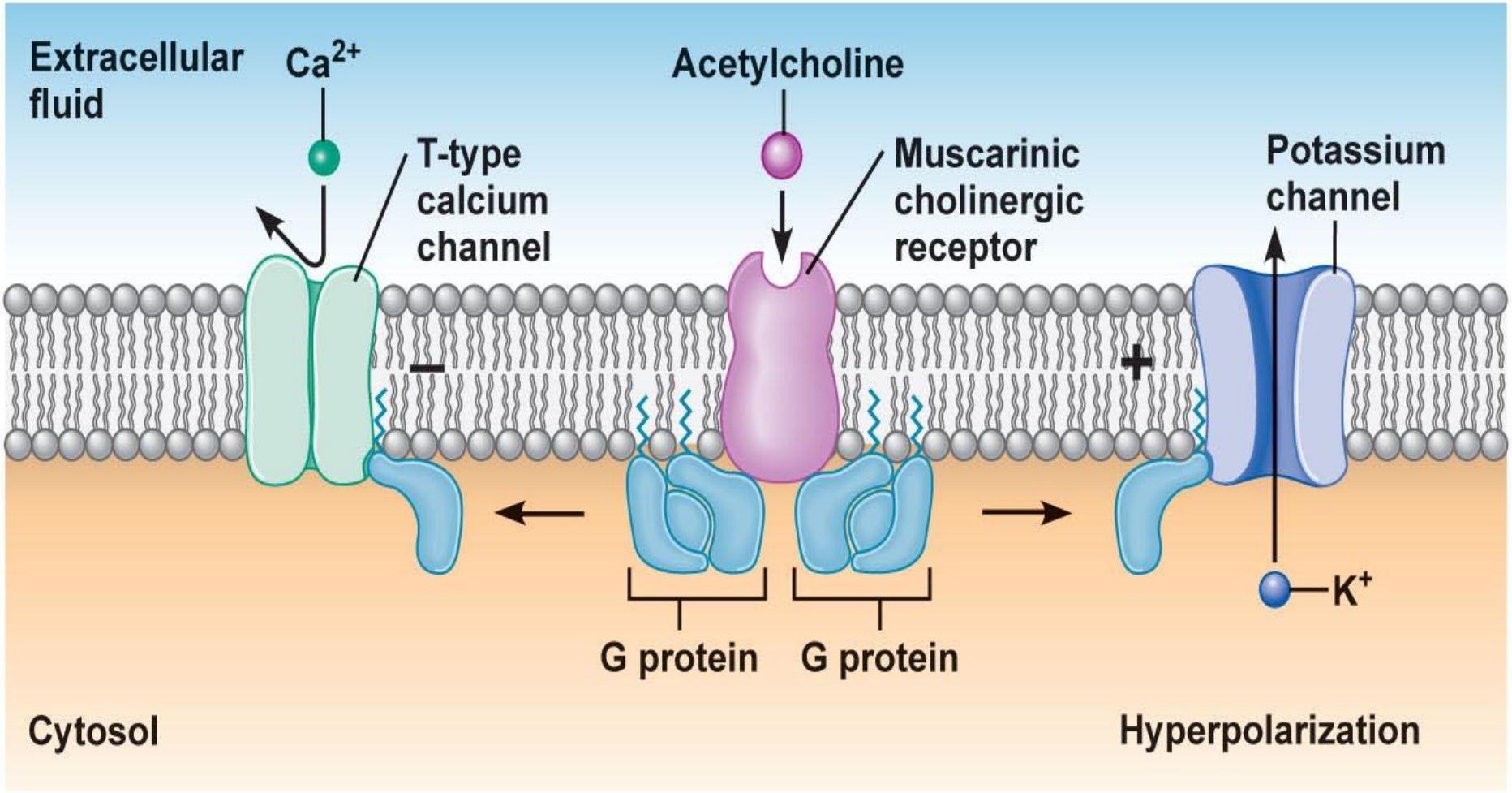
Muscarinic Receptors (M1-M5)

Inhibitory:

-**M2 in the heart**: G protein→K+ channel → slow the rate of depolarization.

-Other inhibitory receptors:

Gi→adenylyl Cyclase→ reduce cAMP



(b) Parasympathetic

Receptors and Signal transduction mechanisms

Muscarinic Receptors (M1-M5)

Excitatory Rceptors: (M1, M3, M5)

Found on **smooth muscle** **and** **glands** are coupled

Gq protein →phospholipase C.

This enzyme increases production of inositol-1,4,5-trisphosphate (**IP3**)

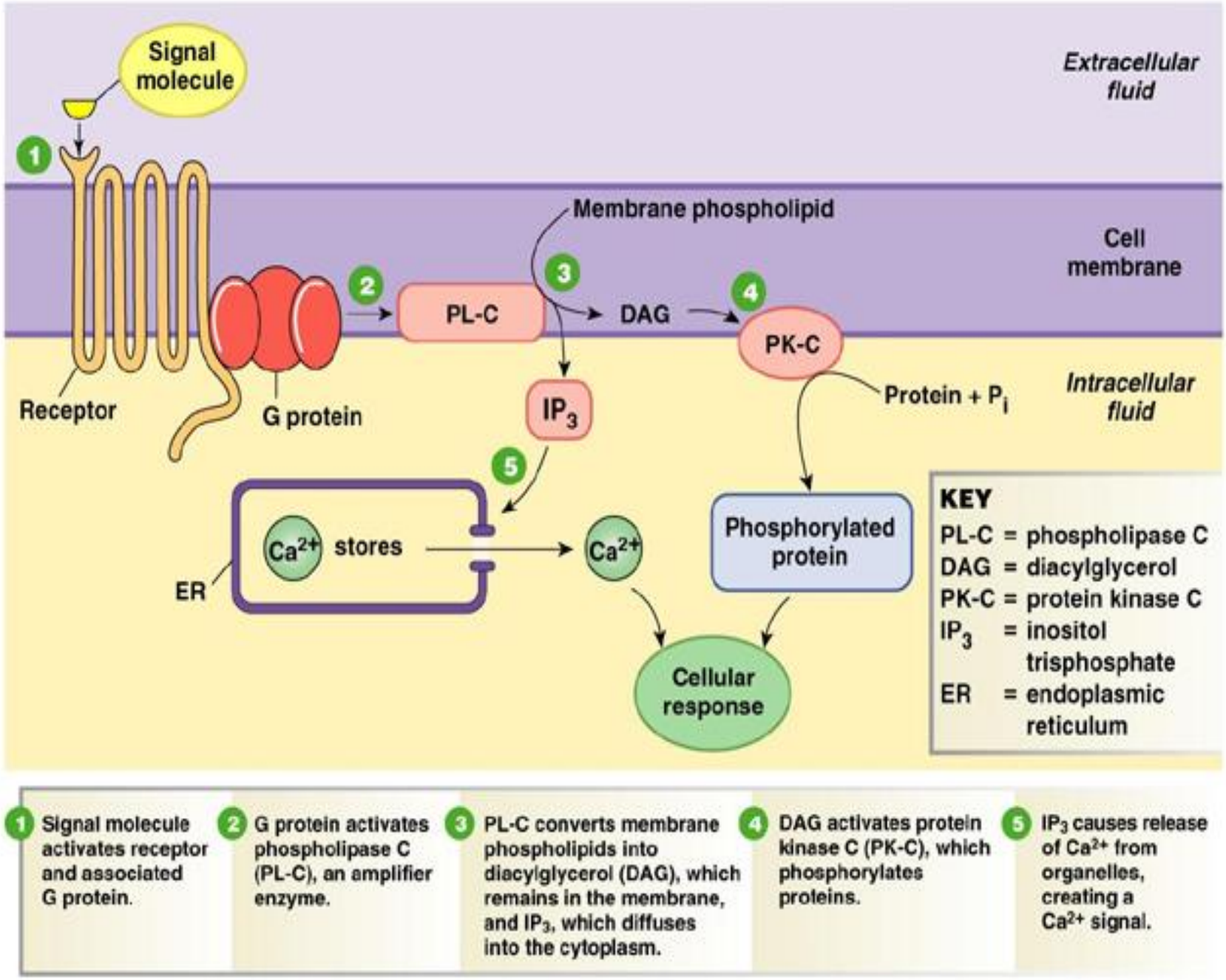


Fig. 6-12

Activation of Muscarinic Receptors

- Stimulation of secretory activity: salivation, tearing, sweating, nasal and bronchial secretion.
- Increase gastrointestinal tract motility→ vomiting and diarrhea.
- Contraction of urinary bladder →urination.
- Slowing of the heart →Bradycardia.

Blocking of Muscarinic Receptors by ATROPIN

- Inhibition of glandular secretions→ dry mouth, dry eyes, and dry nasal passages.
- Tachycardia. (increase heart rate).
- Loss of pupillary light reflex.
- Loss of ability to focus the lens for near vision.

Receptors and Signal transduction mechanisms

Adrenergic receptors:

These receptors respond to **catecholamines:** (epinephrine (EP) and norepinephrine (NE)).

Receptors and Signal transduction mechanisms

Alpha receptors:

- The alpha 1 (α_1): Excitatory: PLC→ IP3

- Alpha2 receptors: Nerve Adrenergic terminals→ reduce NE release

Alpha 2 Heteroreceptors: Nonadrenergic -

Gi→ Adenylyl cyclase→ decrease cAMP

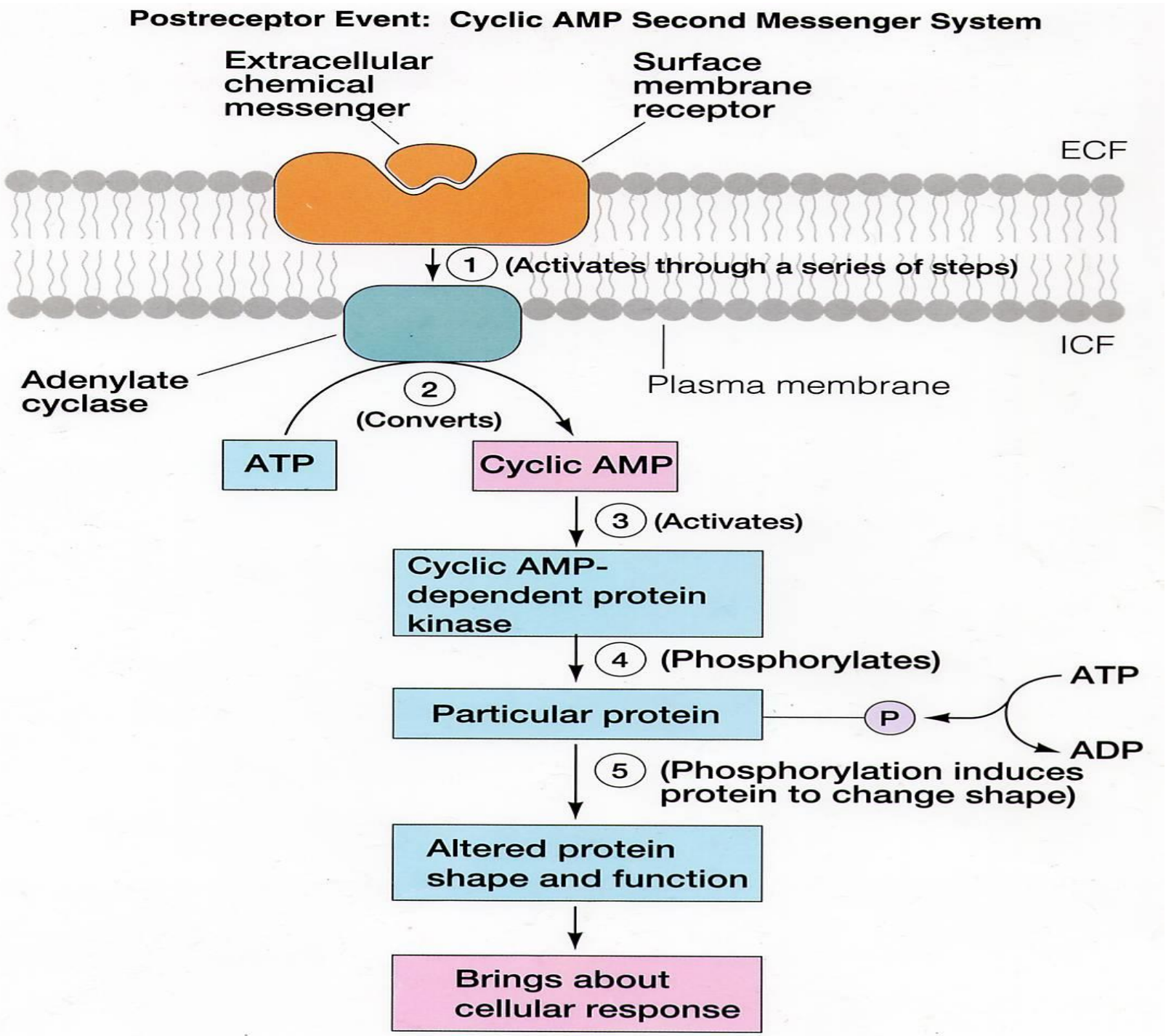
Receptors and Signal transduction mechanisms

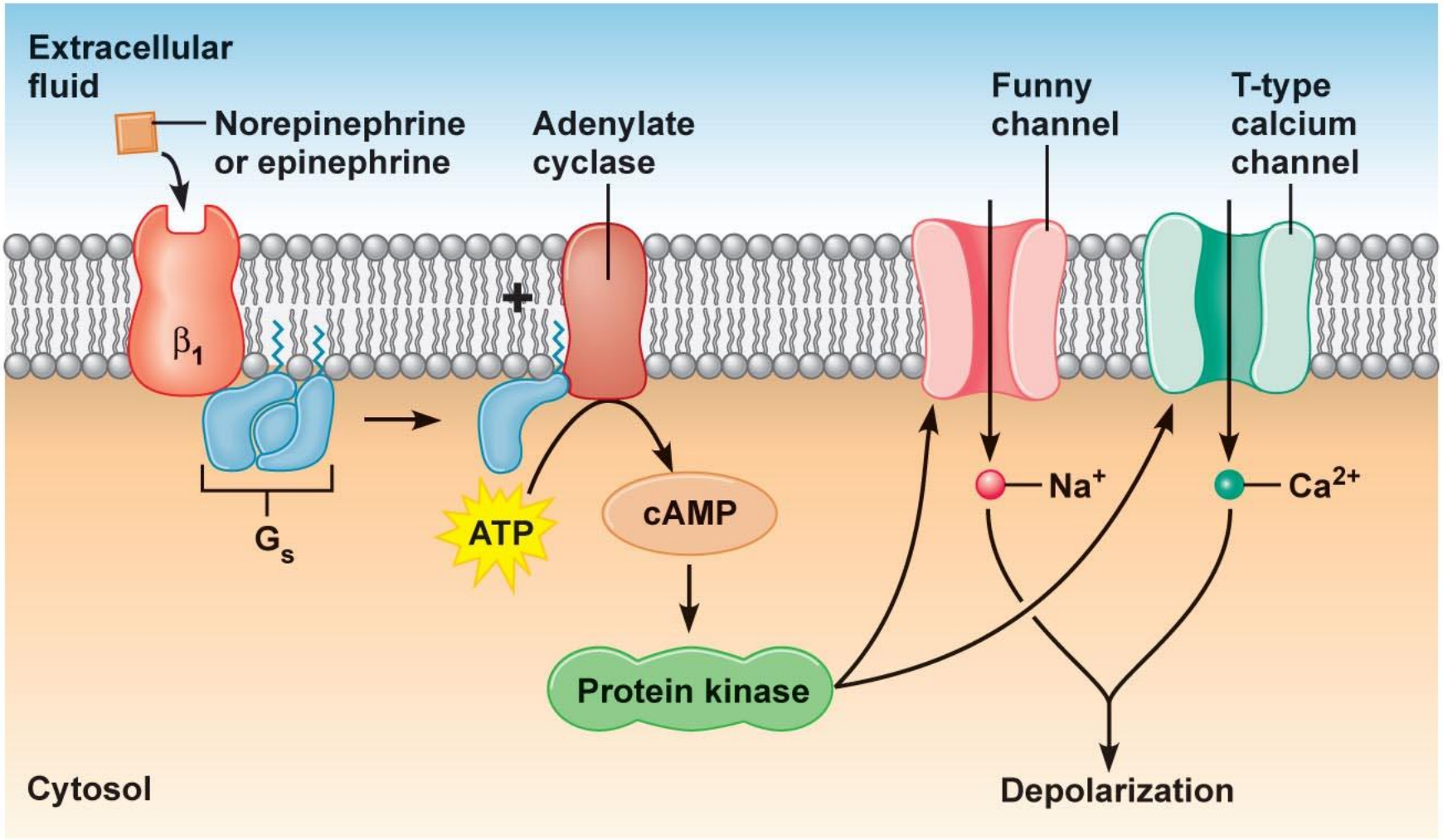
Beta receptors:

- **Beta 1 (β_1) receptors**: found on heart

- **Beta 2 (β_2) receptors**: found on tracheal and bronchial smooth muscle, in the gastrointestinal tract, and on smooth muscles of blood vessels supplying skeletal muscles

Gs→Adenylyl cyclase→ increase cAMP


Postreceptor Event: Cyclic AMP Second Messenger System
Extracellular chemical messenger
Surface membrane receptor
ECF
1 (Activates through a series of steps)
ICF
Adenylate cyclase
Plasma membrane
2 (Converts)
ATP
Cyclic AMP
3 (Activates)
Cyclic AMP-dependent protein kinase
4 (Phosphorylates)
Particular protein
P
ATP
ADP
5 (Phosphorylation induces protein to change shape)
Altered protein shape and function
Brings about cellular response



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