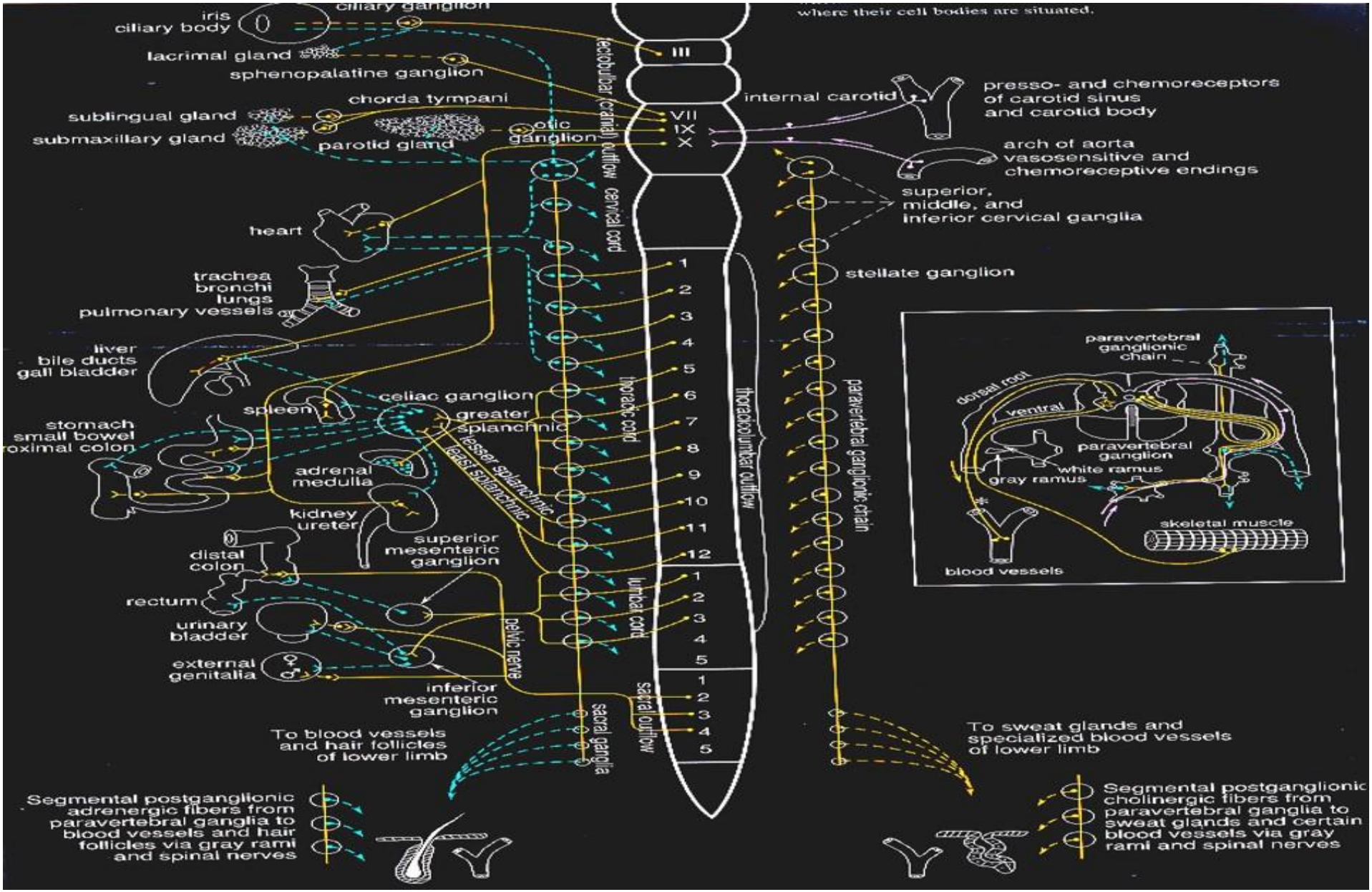
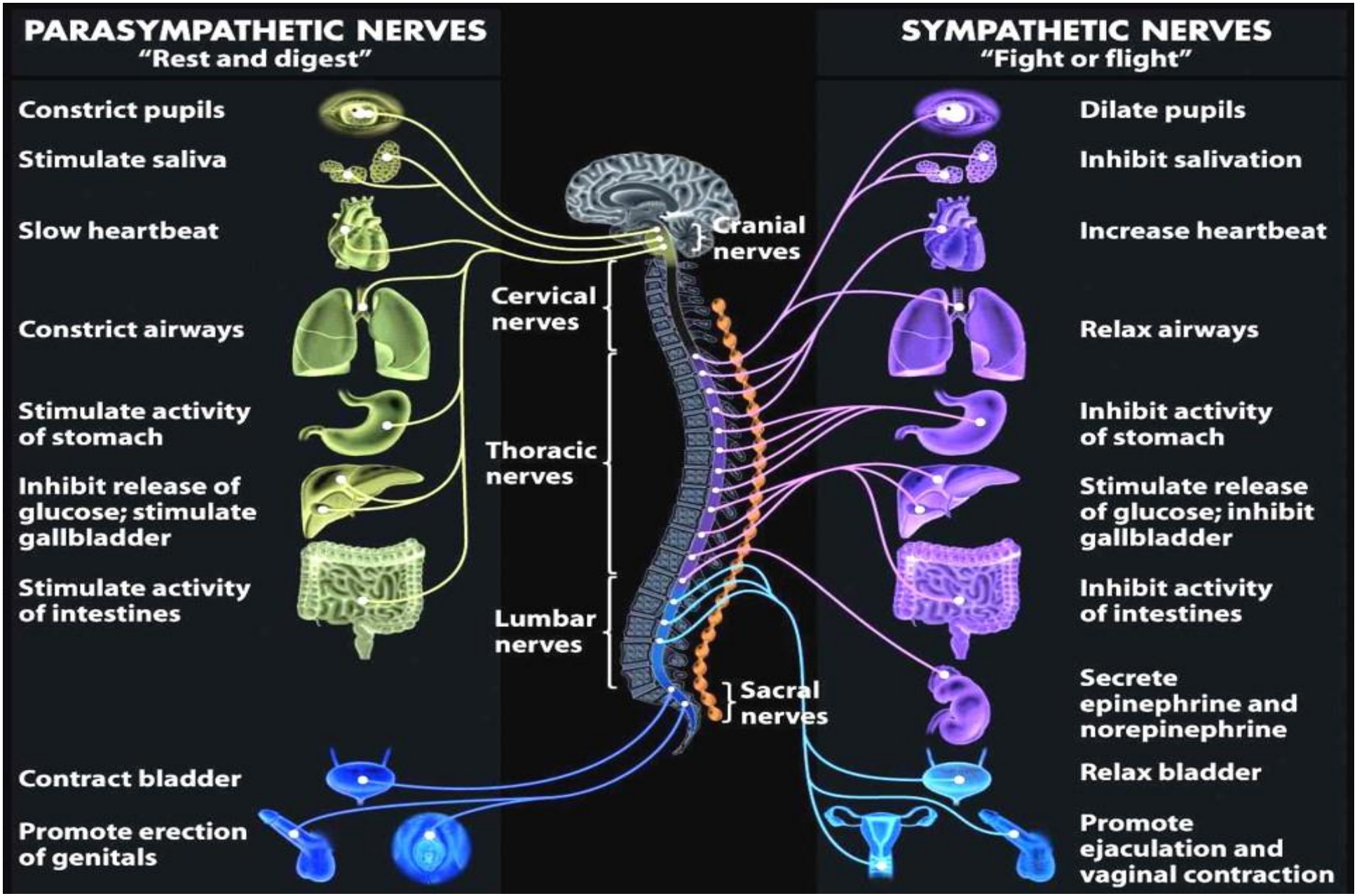
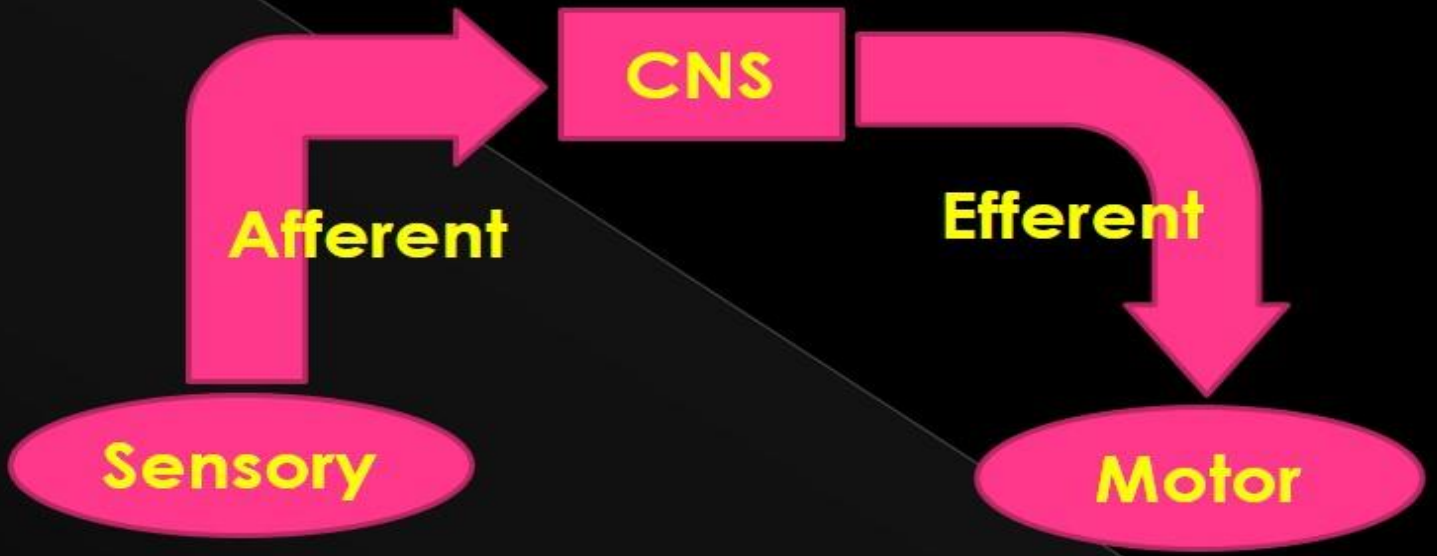
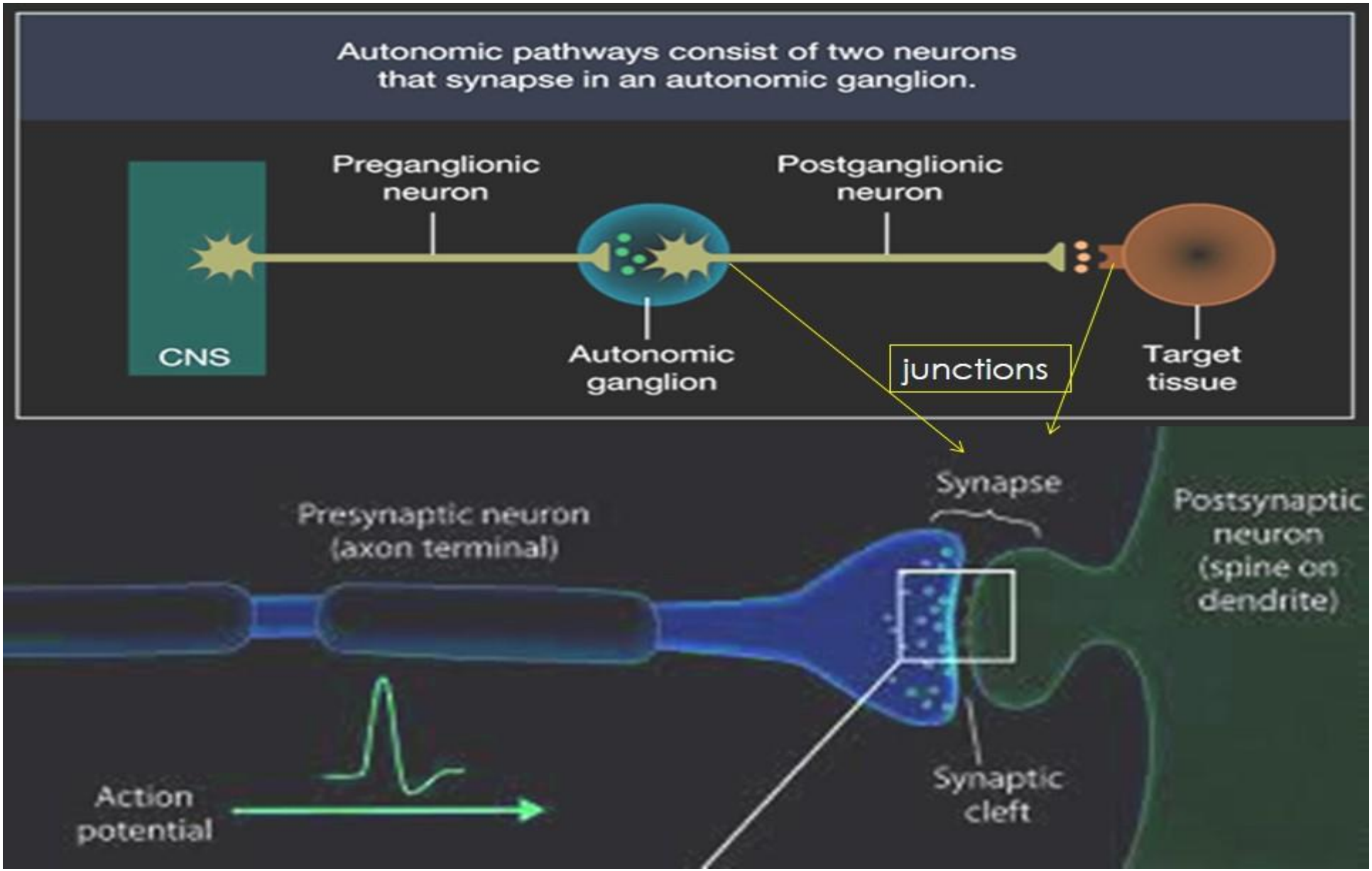

where their cell bodies are situated.
iris
ciliary body
ciliary ganglion
lacrimal gland
sphenopalatine ganglion
chorda tympani
sublingual gland
submaxillary gland
parotid gland
otic ganglion
III
VII
IX
X
internal carotid
presso- and chemoreceptors of carotid sinus and carotid body
arch of aorta
vasosensitive and chemoreceptive endings
superior, middle, and inferior cervical ganglia
stellate ganglion
craniobulbar (cranial) outflow
cervical cord
thoracic cord
thoracolumbar outflow
lumbar cord
sacral outflow
sacral ganglia
paravertebral ganglionic chain
heart
trachea
bronchi
lungs
pulmonary vessels
liver
bile ducts
gall bladder
spleen
celiac ganglion
greater splanchnic
lesser splanchnic
least splanchnic
stomach
small bowel
proximal colon
adrenal medulla
kidney
ureter
superior mesenteric ganglion
distal colon
rectum
urinary bladder
external genitalia
pelvic nerve
inferior mesenteric ganglion
To blood vessels and hair follicles of lower limb
Segmental postganglionic adrenergic fibers from paravertebral ganglia to blood vessels and hair follicles via gray rami and spinal nerves
To sweat glands and specialized blood vessels of lower limb
Segmental postganglionic cholinergic fibers from paravertebral ganglia to sweat glands and certain blood vessels via gray rami and spinal nerves
paravertebral ganglionic chain
dorsal root
ventral
paravertebral ganglion
white ramus
gray ramus
skeletal muscle
blood vessels

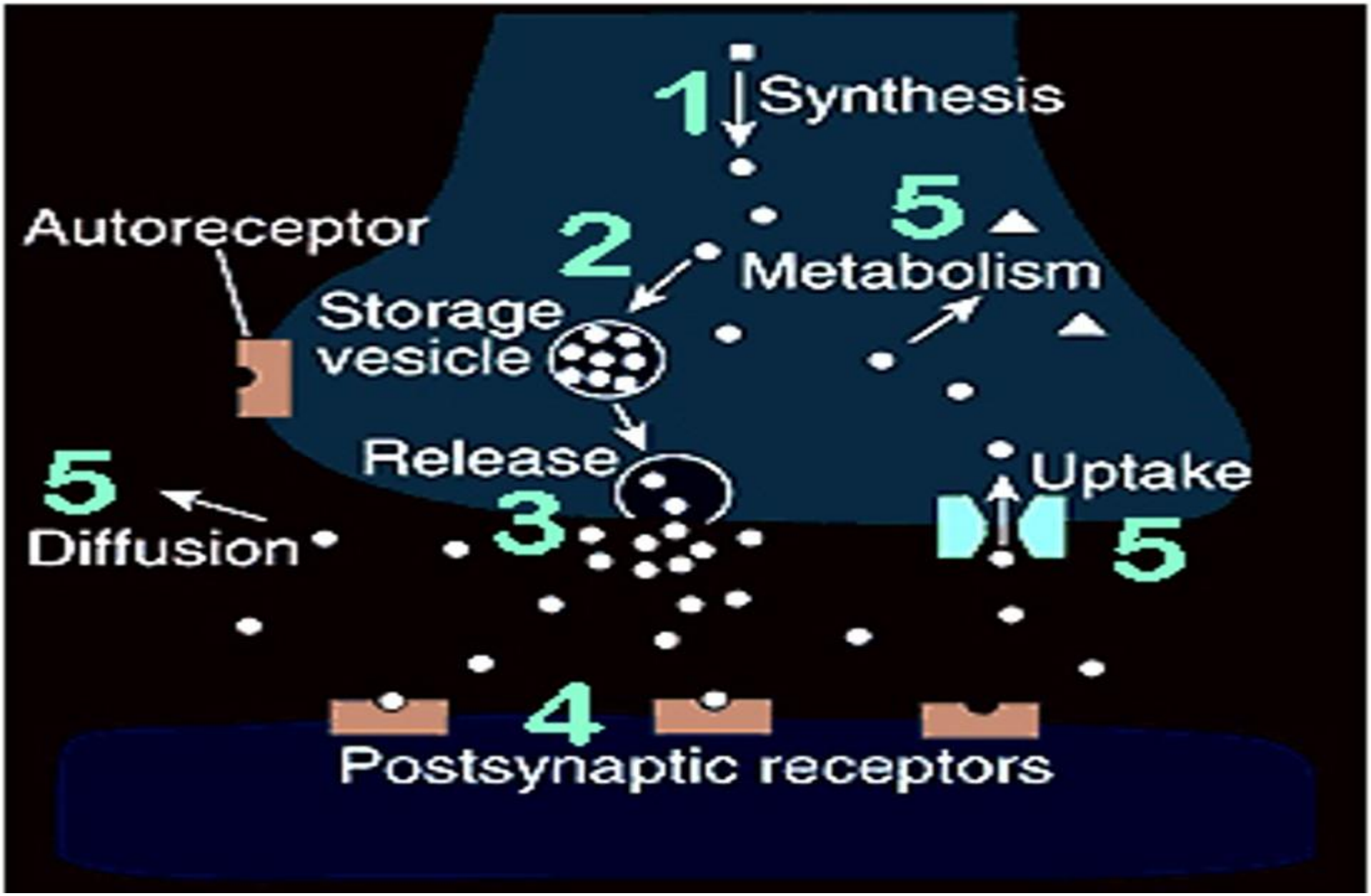

PARASYMPATHETIC NERVES
"Rest and digest"
Constrict pupils
Stimulate saliva
Slow heartbeat
Constrict airways
Stimulate activity of stomach
Inhibit release of glucose; stimulate gallbladder
Stimulate activity of intestines
Contract bladder
Promote erection of genitals
SYMPATHETIC NERVES
"Fight or flight"
Dilate pupils
Inhibit salivation
Increase heartbeat
Relax airways
Inhibit activity of stomach
Stimulate release of glucose; inhibit gallbladder
Inhibit activity of intestines
Secrete epinephrine and norepinephrine
Relax bladder
Promote ejaculation and vaginal contraction
Cranial nerves
Cervical nerves
Thoracic nerves
Lumbar nerves
Sacral nerves

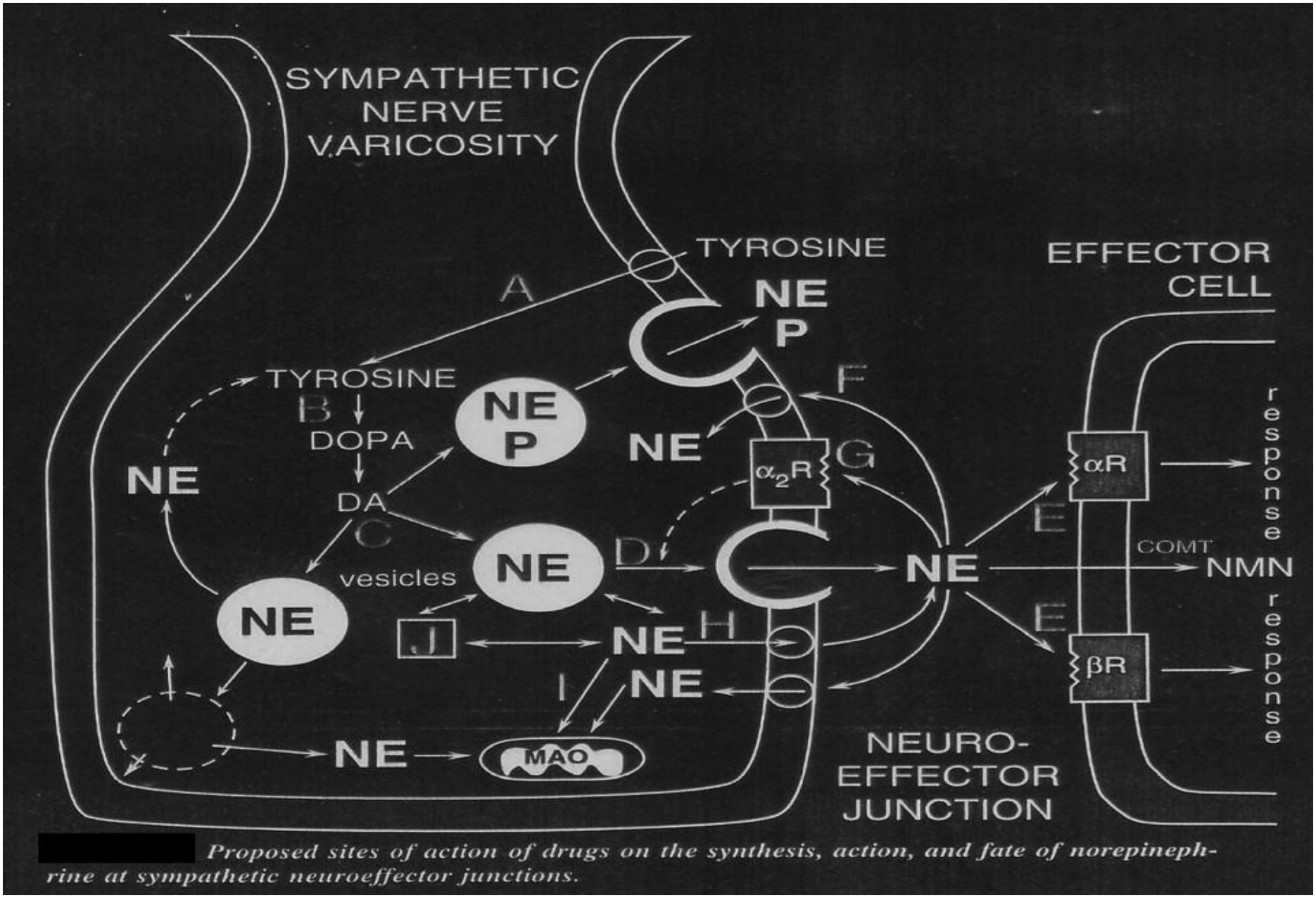
Autonomic Reflex Arch (ARA)



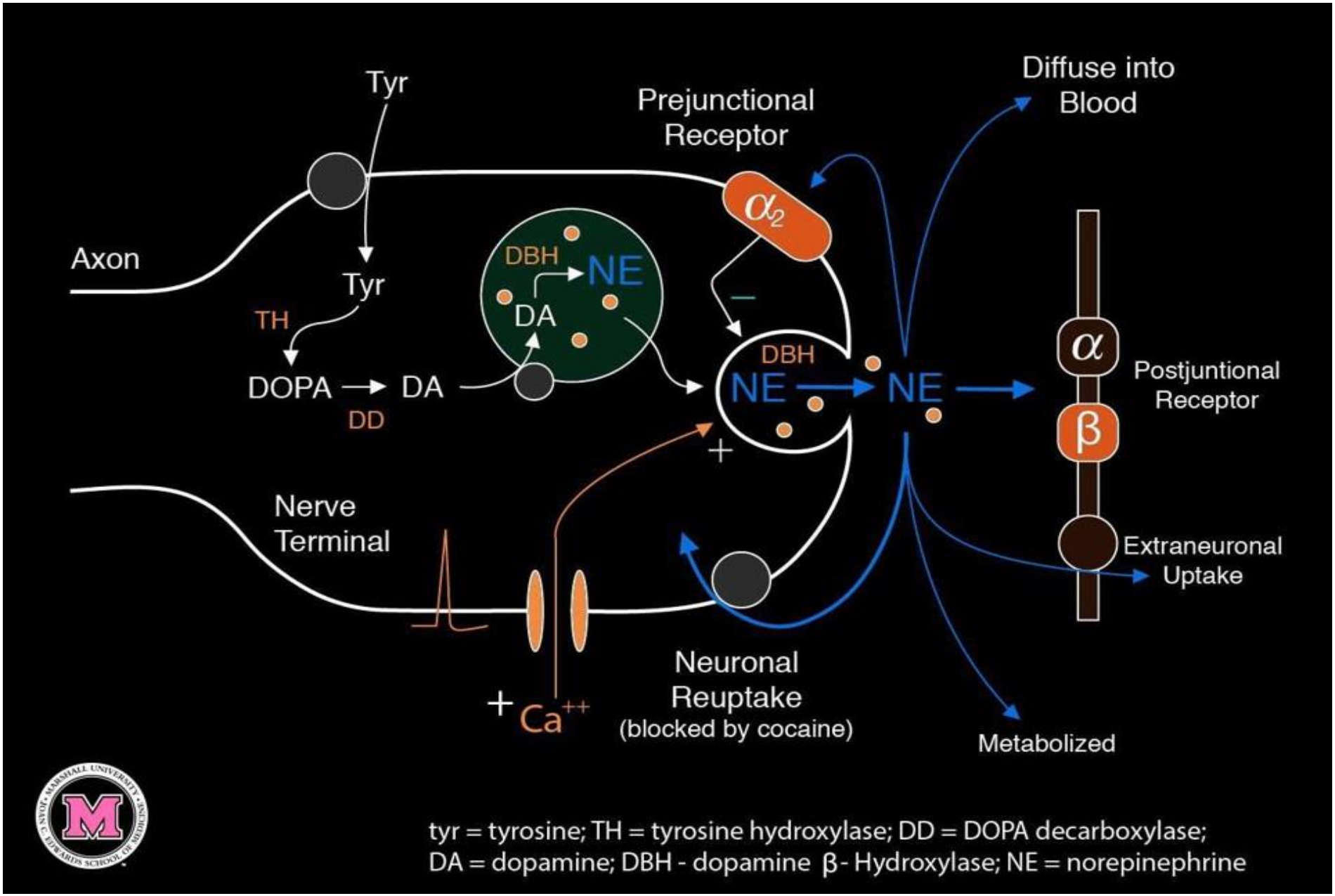
- **Afferent neuron:** cholinergic
- **Efferent neuron:**
  - ✓ Cholinergic
  - ✓ adrenergic

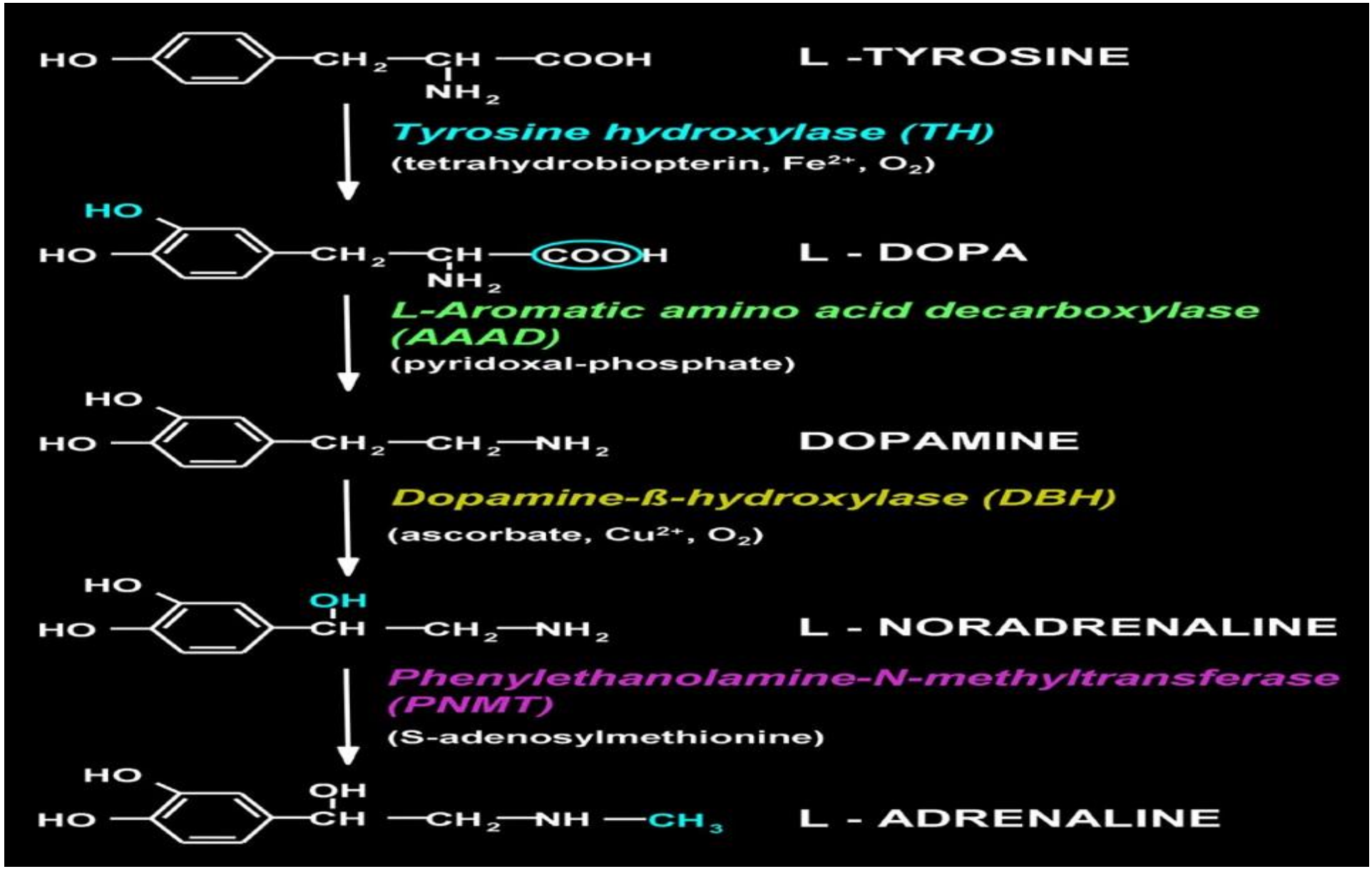

Autonomic pathways consist of two neurons that synapse in an autonomic ganglion.
Preganglionic neuron
Postganglionic neuron
CNS
Autonomic ganglion
junctions
Target tissue
Synapse
Presynaptic neuron (axon terminal)
Postsynaptic neuron (spine on dendrite)
Action potential
Synaptic cleft


1
Synthesis
5
Metabolism
Autoreceptor
2
Storage
vesicle
Release
5
Diffusion
3
Uptake
5
4
Postsynaptic receptors



Proposed sites of action of drugs on the synthesis, action, and fate of norepinephrine at sympathetic neuroeffector junctions.


Tyr
Prejunctional Receptor
Diffuse into Blood
Axon
Tyr
TH
DOPA
DD
DA
DBH
NE
DA
DBH
NE
NE
α2
α
β
Postjuntional Receptor
Extraneuronal Uptake
Nerve Terminal
+
+ Ca++
Neuronal Reuptake
(blocked by cocaine)
Metabolized
tyr = tyrosine; TH = tyrosine hydroxylase; DD = DOPA decarboxylase;
DA = dopamine; DBH - dopamine β- Hydroxylase; NE = norepinephrine


L -TYROSINE
Tyrosine hydroxylase (TH)
(tetrahydrobiopterin, Fe2+, O2)
L - DOPA
L-Aromatic amino acid decarboxylase (AAAD)
(pyridoxal-phosphate)
DOPAMINE
Dopamine-ß-hydroxylase (DBH)
(ascorbate, Cu2+, O2)
L - NORADRENALINE
Phenylethanolamine-N-methyltransferase (PNMT)
(S-adenosylmethionine)
L - ADRENALINE

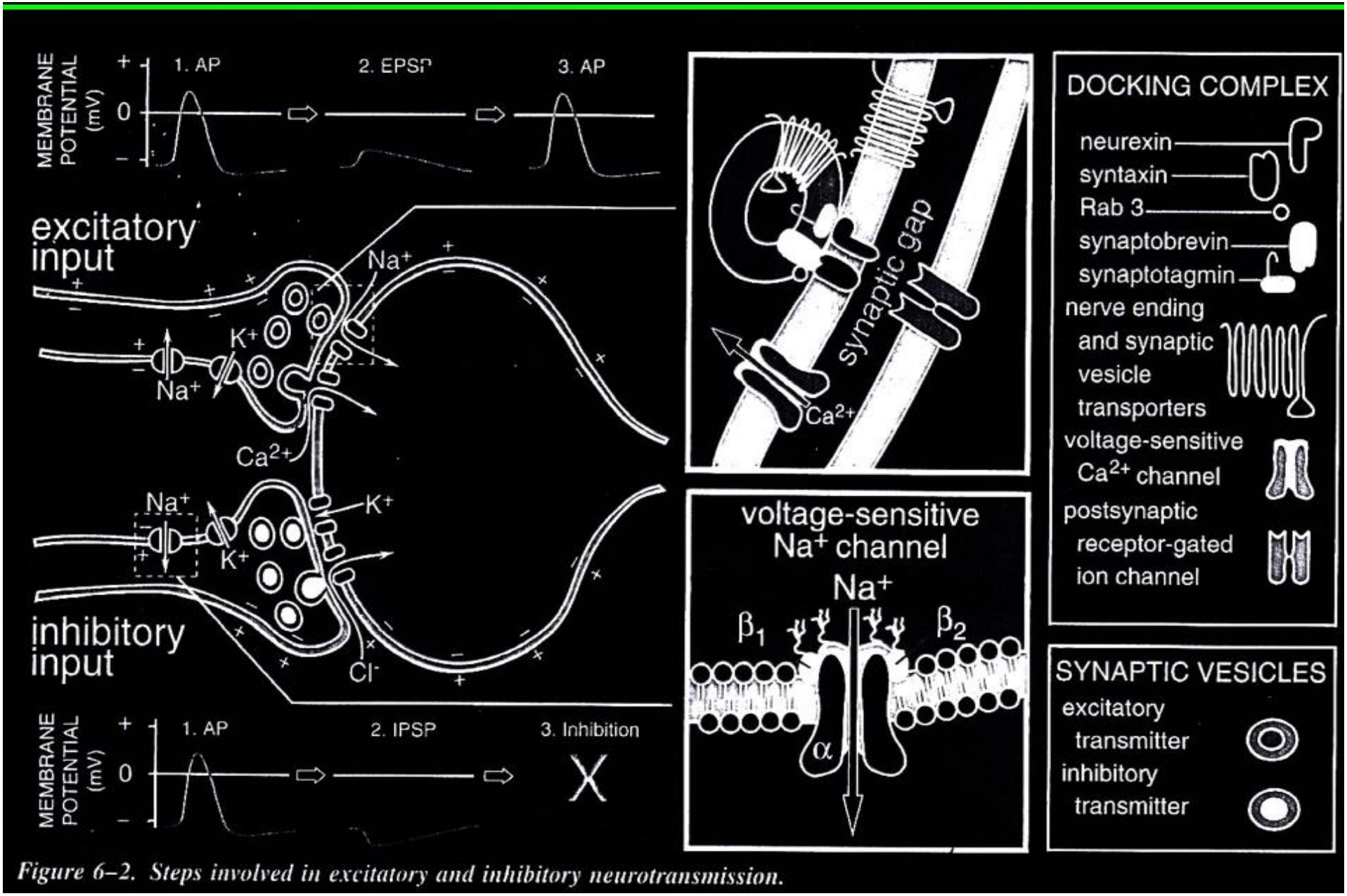


Figure 6–2. Steps involved in excitatory and inhibitory neurotransmission.

Types of Action of Representative Agents at Peripheral Cholinergic and Adrenergic Synapses and Neuroeffector Junctions

MECHANISM OF ACTION	SYSTEM	AGENTS	EFFECT
1. Interference with synthesis of transmitter	Cholinergic	Choline acetyl transferase inhibitors	Minimal depletion of ACh
	Adrenergic	α-Methyltyrosine	Depletion of norepinephrine
2. Metabolic transformation by same pathway as precursor of transmitter	Adrenergic	Methyldopa	Displacement of norepinephrine by false transmitter (α-methylnorepinephrine)
3. Blockade of transport system of membrane of nerve terminal	Adrenergic	Cocaine, imipramine	Accumulation of norepinephrine at receptors
	Cholinergic	Vesamicol Hemicholinium	Block of choline uptake with consequent depletion of ACh
4. Blockade of transport system of storage granule membrane	Adrenergic	Reserpine	Destruction of norepinephrine by mitochondrial MAO, and depletion from adrenergic terminals
	Cholinergic	Vesamicol	Block of ACh storage

Table Cont.

5. Displacement of transmitter from axonal terminal	Cholinergic	Black widow spider venom	Cholinomimetic followed by anticholinergic
	Adrenergic	Amphetamine, tyramine	Sympathomimetic
6. Prevention of release of transmitter	Cholinergic	Botulinus toxin	Anticholinergic
	Adrenergic	Bretylium, guanethidine	Antiadrenergic
7. Mimicry of transmitter at postsynaptic receptor	Cholinergic Muscarinic Nicotinic	 Muscarine, methacholine Nicotine	 Cholinomimetic Cholinomimetic
	Adrenergic α_1 α_2	 Phenylephrine Clonidine	 Sympathomimetic Sympathomimetic (periphery) Reduced sympathetic outflow (CNS)
	$\beta_{1,2}$	Isoproterenol	Nonselective β-adrenomimetic
	β_1	Dobutamine	Selective cardiac stimulation
	β_2	Terbutaline	Selective inhibition of smooth muscle contraction

Types of Action of Representative Agents at Peripheral Cholinergic and Adrenergic Synapses and Neuroeffector Junctions *(Continued)*

MECHANISM OF ACTION	SYSTEM	AGENTS	EFFECT
8. Blockade of endogenous transmitter at postsynaptic receptor	Cholinergic Muscarinic Nicotinic, N_M Nicotinic, N_N	Atropine Tubocurarine Trimethaphan	Muscarinic blockade Neuromuscular blockade Ganglionic blockade
	Adrenergic α $\beta_{1,2}$ β_1	Phenoxybenzamine Propranolol Metoprolol	α-Adrenergic blockade β-Adrenergic blockade Selective adrenergic blockade (cardiac)
9. Inhibition of enzymatic breakdown of transmitter	Cholinergic	Anti-ChE agents (physostigmine, diisopropyl phosphorofluoridate [DFP])	Cholinomimetic
	Adrenergic	MAO inhibitors (pargyline, nialamide, tranylcypromine)	Little direct effect on norepinephrine or sympathetic responses; potentiation of tyramine

Responses f Effector Organs to Autonomic Nerve Impulses

Effector Organs	Adrenergic Impulses[1]		Cholinergic Impulses[1]
	RECEPTOR TYPE[2]	RESPONSES[3]	RESPONSES[3]
Eye			
Radial muscle, iris	α_1	Contraction (mydriasis) ++	—
Sphincter muscle, iris		—	Contraction (miosis) +++
Ciliary muscle	β_2	Relaxation for far vision +	Contraction for near vision +++
Heart[4]			
SA node	β_1, β_2	Increase in heart rate ++	Decrease in heart rate; vagal arrest +++
Atria	β_1, β_2	Increase in contractility and conduction velocity ++	Decrease in contractility, and shortened AP duration ++
AV node	β_1, β_2	Increase in automaticity and conduction velocity ++	Decrease in conduction velocity; AV block +++
His-Purkinje system	β_1, β_2	Increase in automaticity and conduction velocity +++	Little effect
Ventricles	β_1, β_2	Increase in contractility, conduction velocity, automaticity, and rate of idioventricular pacemakers +++	Slight decrease in contractility

Artenoles			
Coronary	α_1, α_2; β_2	Constriction +; dilatation[5] ++	Constriction +
Skin and mucosa	α_1, α_2	Constriction +++	Dilatation[6]
Skeletal muscle	α; β_2	Constriction ++; dilatation[5,7] ++	Dilatation[8] +
Cerebral	α_1	Constriction (slight)	Dilatation[6]
Pulmonary	α_1, β_2	Constriction +; dilatation[5]	Dilatation[6]
Abdominal viscera	α_1; β_2	Constriction +++; dilatation[7] +	—
Salivary glands	α_1, α_2	Constriction +++	Dilatation ++
Renal	α_1, α_2; β_1, β_2	Constriction +++; dilatation[7] +	—
Veins (Systemic)	α_1, α_2; β_2	Constriction ++; dilatation ++	—
Lung			
Tracheal and bronchial muscle	β_2	Relaxation +	Contraction ++
Bronchial glands	α_1; β_2	Decreased secretion; increased secretion	Stimulation ++

Stomach			
Motility and tone	α_1, α_2; β_2	Decrease (usually)[9] +	Increase +++
Sphincters	α_1	Contraction (usually) +	Relaxation (usually) +
Secretion		Inhibition (?)	Stimulation +++
Intestine			
Motility and tone	α_1, α_2; β_1, β_2	Decrease[9] +	Increase +++
Sphincters	α_1	Contraction (usually) +	Relaxation (usually) +
Secretion	α_2	Inhibition	Stimulation ++
Gallbladder & Ducts	β_2	Relaxation +	Contraction +
Kidney			
Renin secretion	α_1; β_1	Decrease +; increase ++	—
Urinary bladder			
Detrusor	β_2	Relaxation (usually) +	Contraction +++
Trigone and sphincter	α_1	Contraction ++	Relaxation ++
Ureter			
Motility and tone	α_1	Increase	Increase (?)

Responses of Effector Organs to Autonomic Nerve Impulses (Continued)

Effector Organs	*Adrenergic Impulses*[1]		*Cholinergic Impulses*[1]
	RECEPTOR TYPE[2]	RESPONSES[3]	RESPONSES[3]
Uterus	α_1; β_2	Pregnant: contraction (α_1); relaxation (β_2). Nonpregnant: relaxation (β_2)	Variable[10]
Sex Organs, Male	α_1	Ejaculation ++	Erection +++
Skin			
Pilomotor muscles	α_1	Contraction ++	—
Sweat glands	α_1	Localized secretion[11] +	Generalized secretion +++
Spleen Capsule	α_1; β_2	Contraction +++; relaxation +	—
Adrenal Medulla		—	Secretion of epinephrine and norepinephrine (primarily nicotinic and secondarily muscarinic)

Skeletal Muscle	β_2	Increased contractility; glycogenolysis; K^+ uptake	—
Liver	α_1; β_2	Glycogenolysis and gluconeogenesis[12] +++	—
Pancreas			
Acini	α	Decreased secretion +	Secretion ++
Islets (β cells)	α_2	Decreased secretion +++	—
	β_2	Increased secretion +	—
Fat Cells	α_2; β_1 (β_3)	Lipolysis[12] +++ (thermogenesis)	—
Salivary Glands	α_1	K^+ and water secretion +	K^+ and water secretion +++
	β	Amylase secretion +	
Lacrimal Glands	α	Secretion +	Secretion +++
Nasopharyngeal Glands		—	Secretion ++
Pineal Gland	β	Melatonin synthesis	—
Posterior Pituitary	β_1	Antidiuretic hormone secretion	—