

# Functions of autonomic nervous system



# The autonomic nervous system

- The autonomic nervous system helps to regulate the activities of ***cardiac muscle, smooth muscles, and glands***. These effectors are part of the **visceral organs** (***organs within the body cavities***) and of **blood vessels**.
- Autonomic motor nerves innervate organs whose functions are not usually ***under voluntary control***.
- The involuntary effects of autonomic innervation contrast with the voluntary control of skeletal muscles by way of somatic motor neurons.

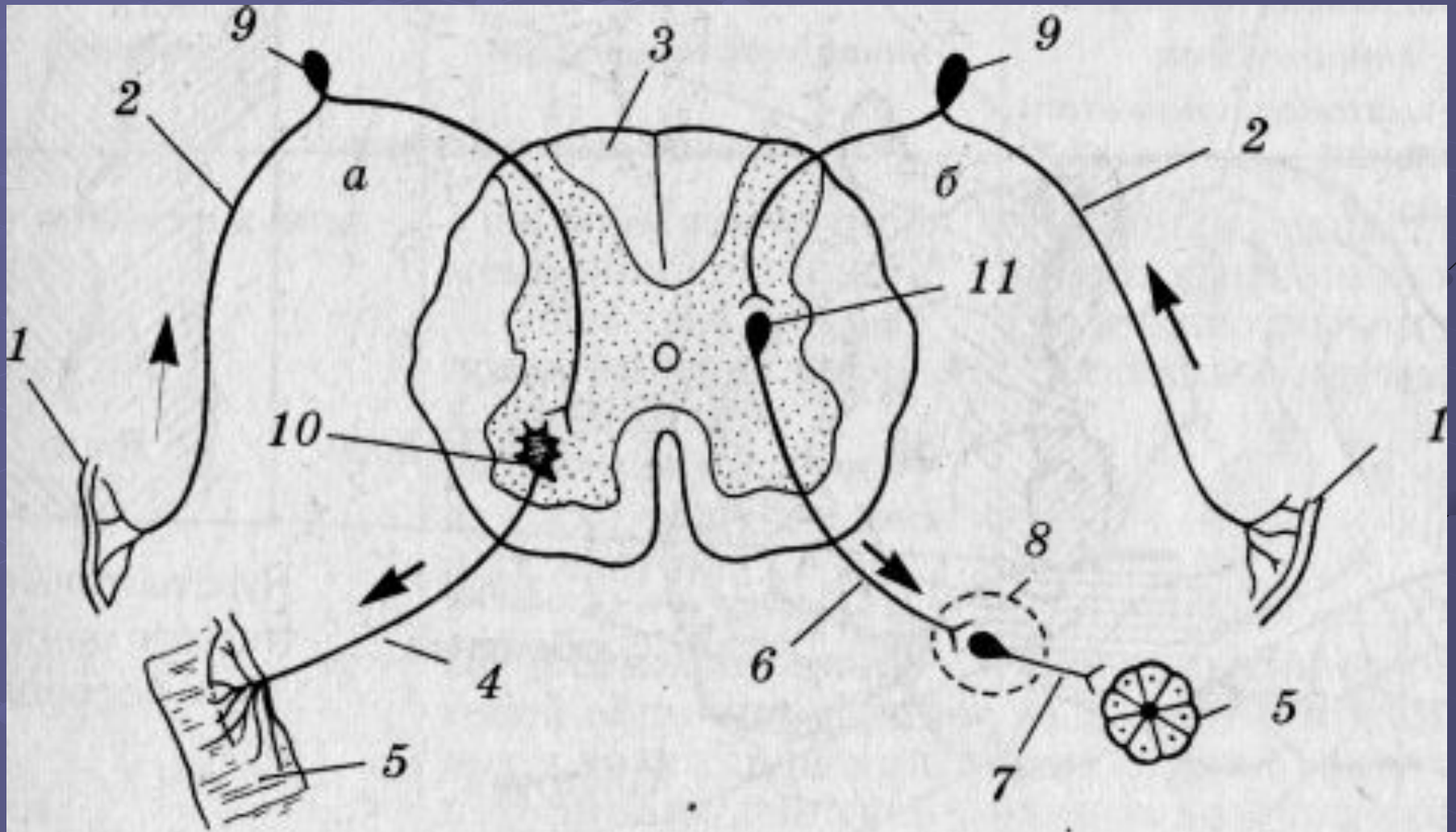
# SOMATIC FUNCTIONS

- the perception of external irritations
- impellent reactions of skeletal muscles
- are under the control of consciousness

# VEGETATIVE FUNCTIONS

- Metabolism, growth and reproduction
- work of the visceral system
- are independent from consciousness

# A comparison of the arrangement of the autonomic neurons with the organization of the somatic motor nerves





# FEATURES OF NERVOUS FIBERS

## SOMATIC:

- Myelinated fibers, diameter - 20  $\mu\text{m}$ , A-type, speed - 120 m/sec, AP - 1 msec, Lability - 200 imp/sec

## VEGETATIVE:

- Preganglionic fibers - myelinated, B-type, diameter - 5  $\mu\text{m}$ , 3-18 m/sec, postganglionic fibers – unmyelinated, C-type, diameter - 2  $\mu\text{m}$ , 0,5-3 m/sec
- AP - 300 msec
- Lability - 10 - 15 imp/sec

# STRUCTURE OF ANS

## THE CENTRAL DEPARTMENT

The segmentary centers –

spinal cord, bulbar and midbrain

Supersegmentary centers –

hypothalamus, cerebellum, basal ganglia, cortex and limbic system

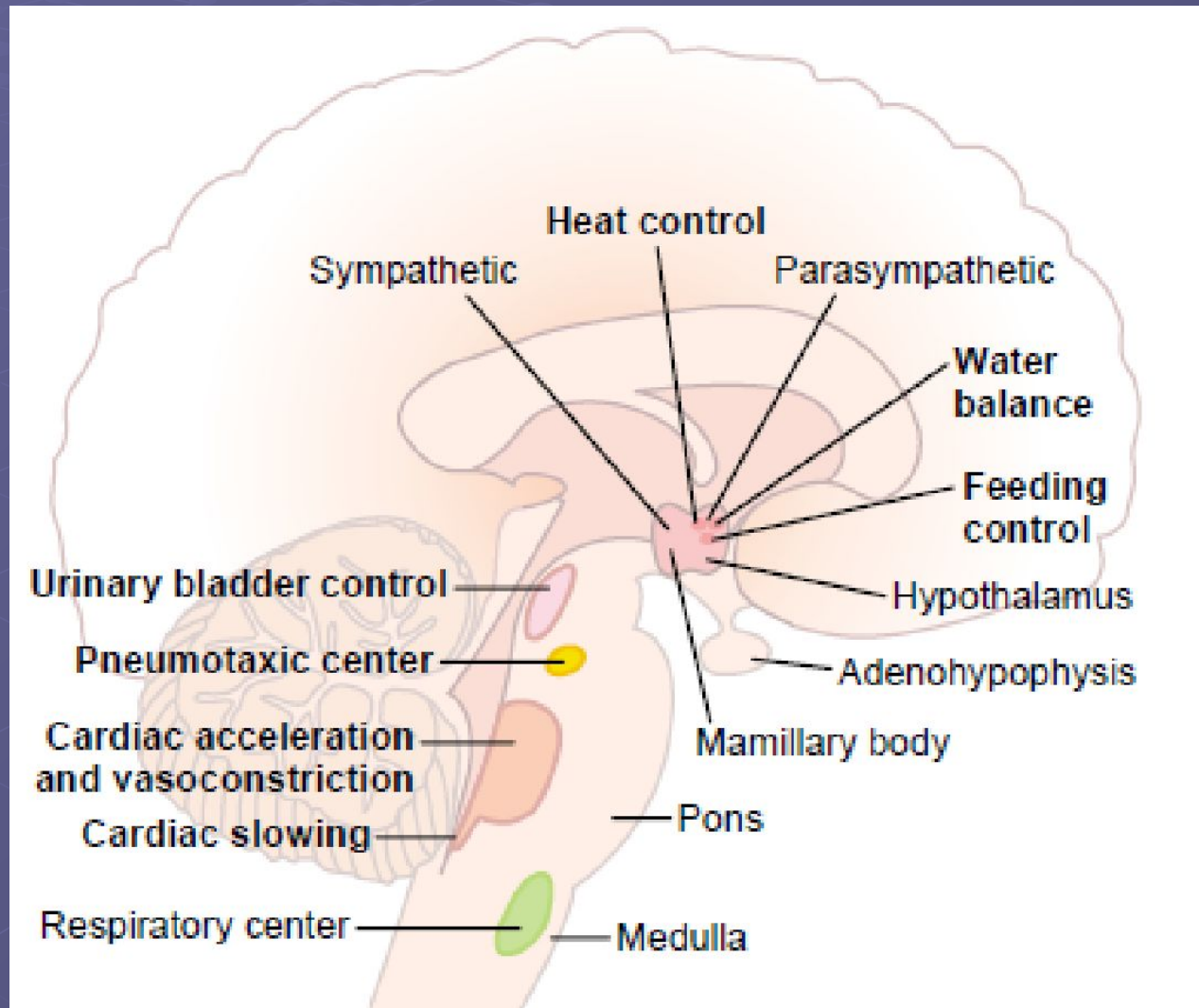
## PERIPHERAL DEPARTMENT

microganglia of the metasympathetic nervous system para- and prevertebral ganglia preganglionic and postganglionic fibres

# Medullary, Pontine, and Mesencephalic Control of the Autonomic Nervous System

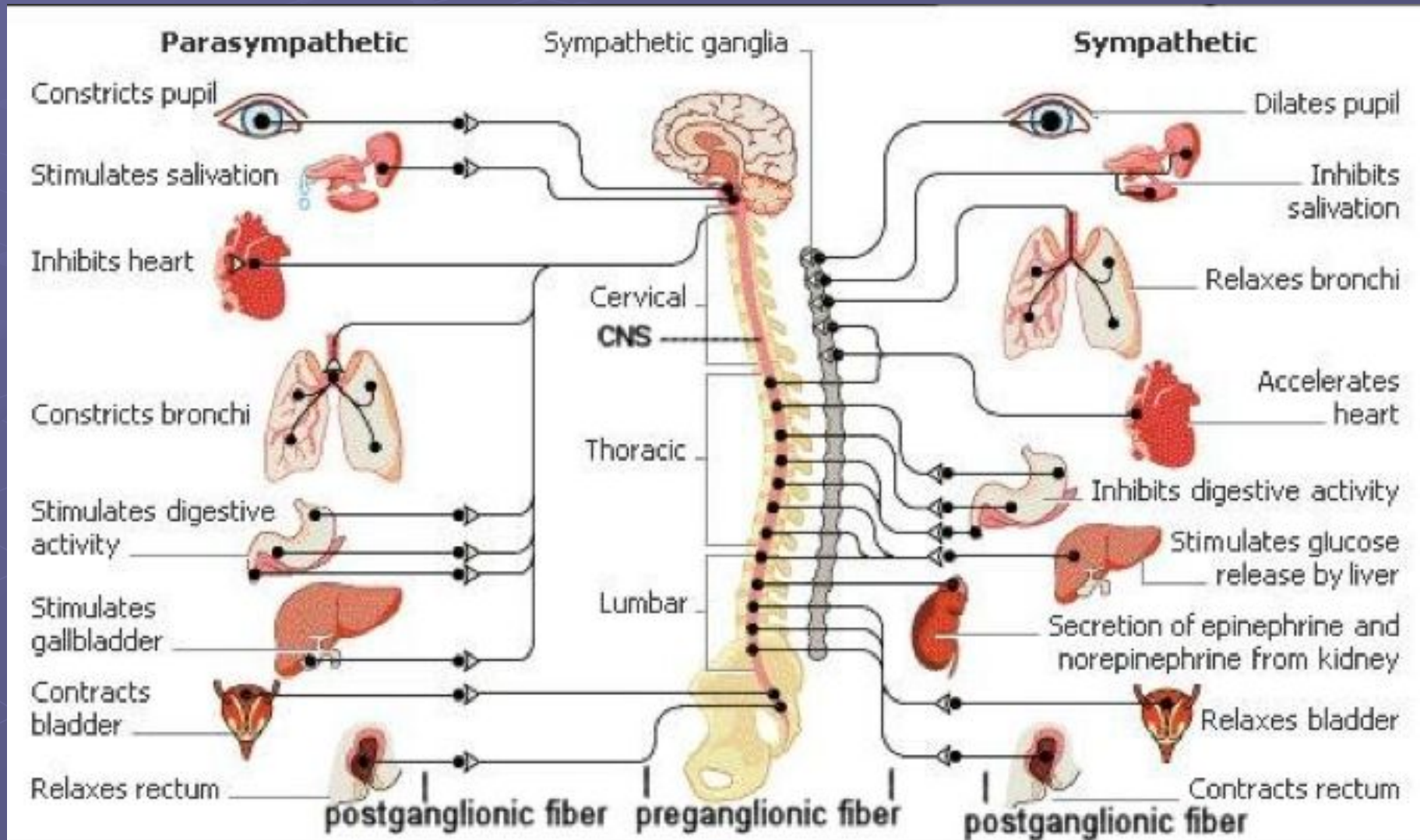
- Many neuronal areas in the brain stem reticular substance and along the course of the tractus solitarius of the medulla, pons, and mesencephalon, as well as in many special nuclei, control different autonomic functions such as arterial pressure, heart rate, glandular secretion in the gastrointestinal tract, gastrointestinal peristalsis, and degree of contraction of the urinary bladder

# Autonomic control areas in the brainstem and hypothalamus

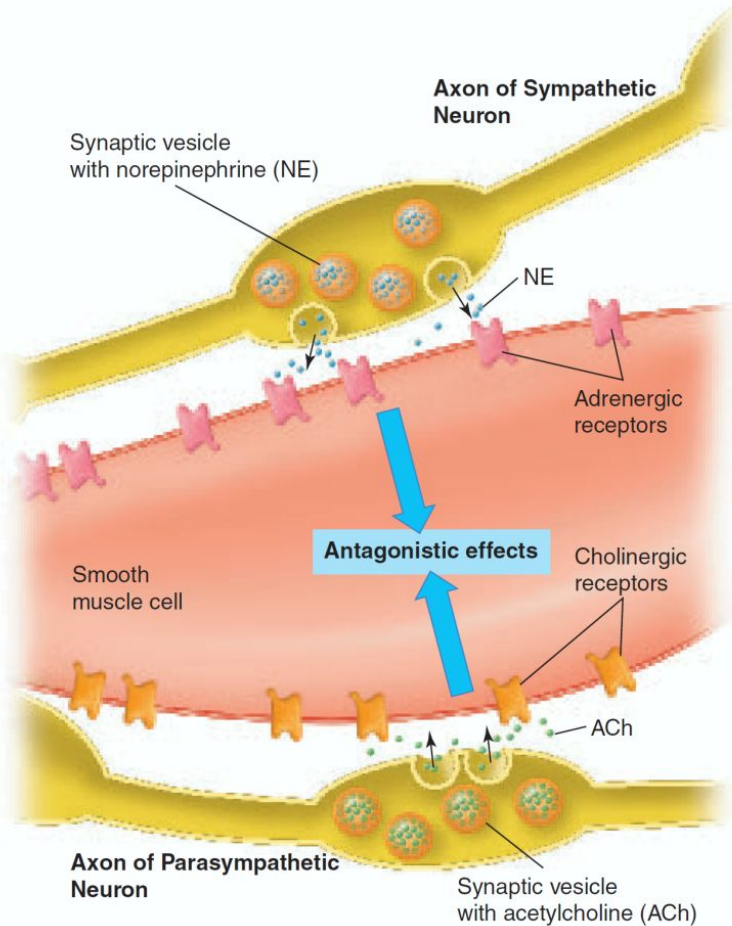
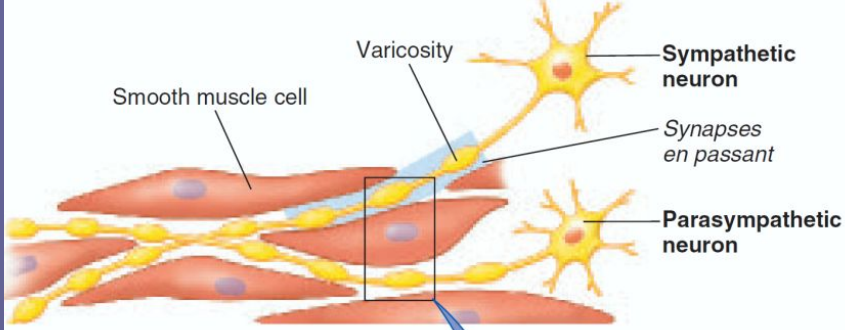




# The organization of the autonomic nervous system



# Sympathetic and Parasympathetic innervations



# “Alarm” or “Stress” Response of the Sympathetic Nervous System

- 1. Increased arterial pressure
- 2. Increased blood flow to active muscles concurrent with decreased blood flow to organs such as the gastro-intestinal tract and the kidneys that are not needed for rapid motor activity
- 3. Increased rates of cellular metabolism throughout the body

# “Alarm” or “Stress” Response of the Sympathetic Nervous System

- 4. Increased blood glucose concentration
- 5. Increased glycolysis in the liver and in muscle
- 6. Increased muscle strength
- 7. Increased mental activity
- 8. Increased rate of blood coagulation



# Autonomic Effects on Various Organs of the Body

Organ	Effect of Sympathetic Stimulation	Effect of Parasympathetic Stimulation
Eye		
Pupil	Dilated	Constricted
Ciliary muscle	Slight relaxation (far vision)	Constricted (near vision)
Glands	Vasoconstriction and slight secretion	Stimulation of copious secretion (containing many enzymes for enzyme-secreting glands)
Nasal		
Lacrimal		
Parotid		
Submandibular		
Gastric		
Pancreatic		
Sweat glands	Copious sweating (cholinergic)	Sweating on palms of hands
Apocrine glands	Thick, odoriferous secretion	None
Blood vessels	Most often constricted	Most often little or no effect
Heart		
Muscle	Increased rate Increased force of contraction	Slowed rate Decreased force of contraction (especially of atria)
Coronaries	Dilated ( $\beta_2$ ); constricted ( $\alpha$ )	Dilated
Lungs		
Bronchi	Dilated	Constricted
Blood vessels	Mildly constricted	? Dilated
Gut		
Lumen	Decreased peristalsis and tone	Increased peristalsis and tone
Sphincter	Increased tone (most times)	Relaxed (most times)

Organ	Effect of Sympathetic Stimulation	Effect of Parasympathetic Stimulation
Liver	Glucose released	Slight glycogen synthesis
Gallbladder and bile ducts	Relaxed	Contracted
Kidney	Decreased output and renin secretion	None
Bladder		
Detrusor	Relaxed (slight)	Contracted
Trigone	Contracted	Relaxed
Penis	Ejaculation	Erection
Systemic arterioles		
Abdominal viscera	Constricted	None
Muscle	Constricted (adrenergic $\alpha$ ) Dilated (adrenergic $\beta_2$ ) Dilated (cholinergic)	None
Skin	Constricted	None
Blood		
Coagulation	Increased	None
Glucose	Increased	None
Lipids	Increased	None
Basal metabolism	Increased up to 100%	None
Adrenal medullary secretion	Increased	None
Mental activity	Increased	None
Piloerector muscles	Contracted	None
Skeletal muscle	Increased glycogenolysis Increased strength	None
Fat cells	Lipolysis	None

# PROPERTIES OF THE VEGETATIVE GANGLIAS

- Divergention
- Convergence
- Spatial and temporal summation
- Lability
- Synaptical a delay - 1,5 - 30 msec
- Long after-hyperpolarization
- Transformation of a rhythm<sub>15</sub>

# VEGETATIVE REFLEXES

- The central reflexes
- Peripheral reflexes
- Intraorganic
- Interorganic
- Axon-reflex



# VEGETATIVE REFLEXES

- Viscero-visceral
- Viscero-somatic
- Somato-visceral
- Viscero-dermal
- Dermo-visceral
- Viscero-sensitive



**Table 9.6** Cholinergic Receptors and Responses to Acetylcholine

<b>Receptor</b>	<b>Tissue</b>	<b>Response</b>	<b>Mechanisms</b>
Nicotinic	Skeletal muscle	Depolarization, producing action potentials and muscle contraction	ACh opens cation channel in receptor
Nicotinic	Autonomic ganglia	Depolarization, causing activation of postganglionic neurons	ACh opens cation channel in receptor
Muscarinic (M <sub>3</sub> , M <sub>5</sub> )	Smooth muscle, glands	Depolarization and contraction of smooth muscle, secretion of glands	ACh activates G-protein coupled receptor, opening Ca <sup>2+</sup> channels and increasing cytosolic Ca <sup>2+</sup>
Muscarinic (M <sub>2</sub> )	Heart	Hyperpolarization, slowing rate of spontaneous depolarization	ACh activates G-protein coupled receptor, opening channels for K <sup>+</sup>

**Table 9.7 Adrenergic and Cholinergic Effects of Sympathetic and Parasympathetic Nerves**

Organ	Effect of			
	Sympathetic		Parasympathetic	
	Action	Receptor*	Action	Receptor*
<i>Eye</i>				
<i>Iris</i>				
Radial muscle	Contracts	$\alpha_1$	—	—
Circular muscle	—	—	Contracts	M
<i>Heart</i>				
Sinoatrial node	Accelerates	$\beta_1$	Decelerates	M
Contractility	Increases	$\beta_1$	Decreases (atria)	M
<i>Vascular Smooth Muscle</i>				
Skin, splanchnic vessels	Contracts	$\alpha, \beta$	—	—
Skeletal muscle vessels	Relaxes	$\beta_2$	—	—
	Relaxes	M**	—	—
<i>Bronchiolar Smooth Muscle</i>	Relaxes	$\beta_2$	Contracts	M
<i>Gastrointestinal Tract</i>				
<i>Smooth Muscle</i>				
Walls	Relaxes	$\beta_2$	Contracts	M
Sphincters	Constricts	$\alpha_1$	Relaxes	M
Secretion	Decreases	$\alpha_1$	Increases	M
Myenteric plexus	Inhibits	$\alpha_1$	—	—
<i>Genitourinary Smooth Muscle</i>				
Bladder wall	Relaxes	$\beta_2$	Contracts	M
Urethral sphincter	Constricts	$\alpha_1$	Relaxes	M
Uterus, pregnant	Relaxes	$\beta_2$	—	—
	Contracts	$\alpha_1$	—	—
Penis	Ejaculation	$\alpha_1$	Erection	M
<i>Skin</i>				
Pilomotor smooth muscle	Contracts	$\alpha_1$	—	—
<i>Sweat glands</i>				
Thermoregulatory	Increases	M	—	—
Apocrine (stress)	Increases	$\alpha_1$	—	—

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\*Adrenergic receptors are indicated as alpha ( $\alpha$ ) or beta ( $\beta$ ); cholinergic receptors are indicated as muscarinic (M).

\*\*Vascular smooth muscle in skeletal muscle has sympathetic cholinergic dilator fibers.

# The role of cholinergic and adrenergic innervation in the autonomic nervous system

