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.

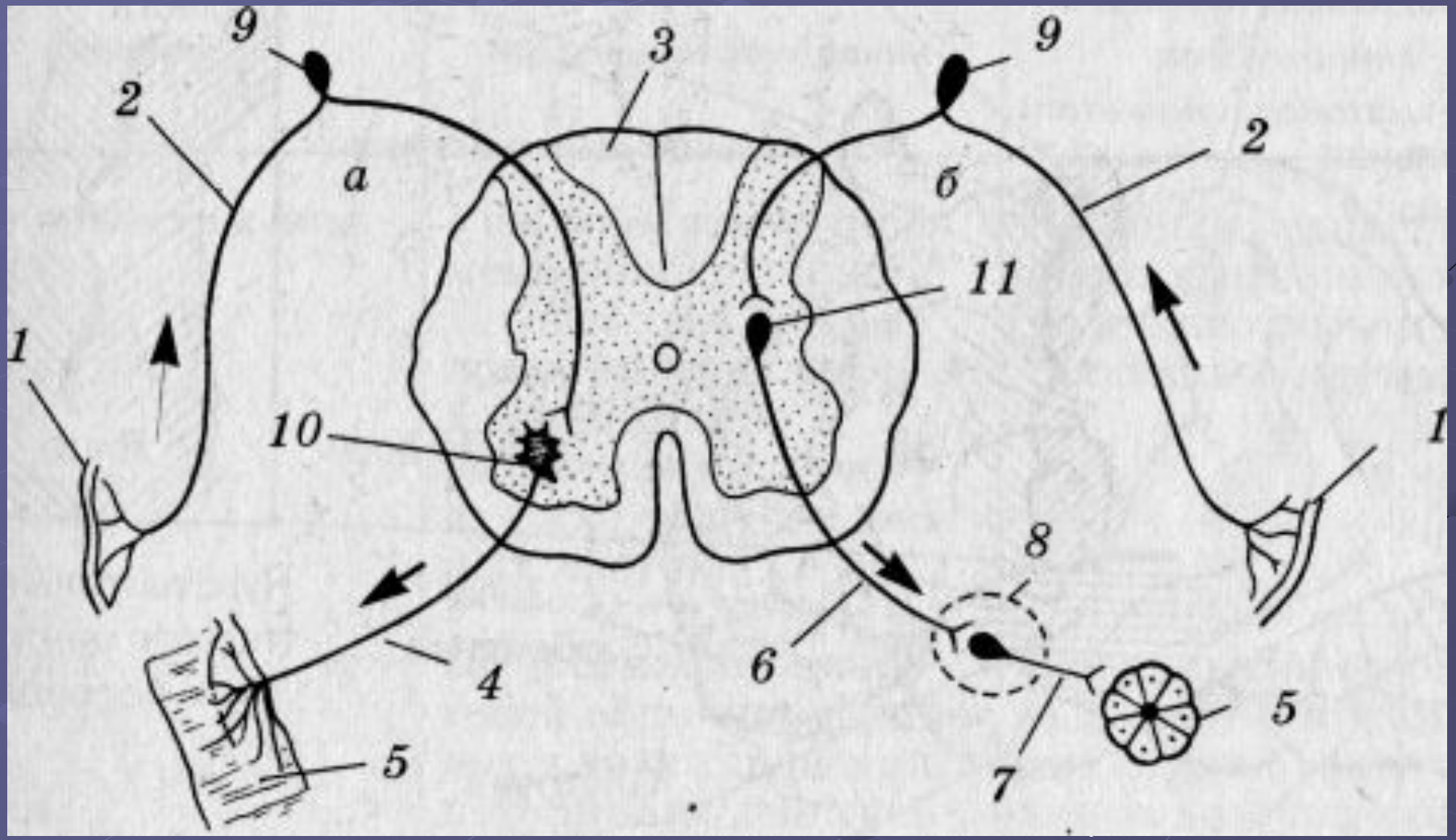
SOMATIC FUNCTIONS

- 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 mcm, A-type, speed - 120 m/sec, AP - 1 msec, Lability - 200 imp/sec

VEGETATIVE:

- Preganglionar fibers - myelinated, B-type, diameter - 5 mcm, 3-18 m/sec, postganlionic fibers – unmyelinated, C-type, diameter - 2 mkm, 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 ganglias, cortex and limbic system

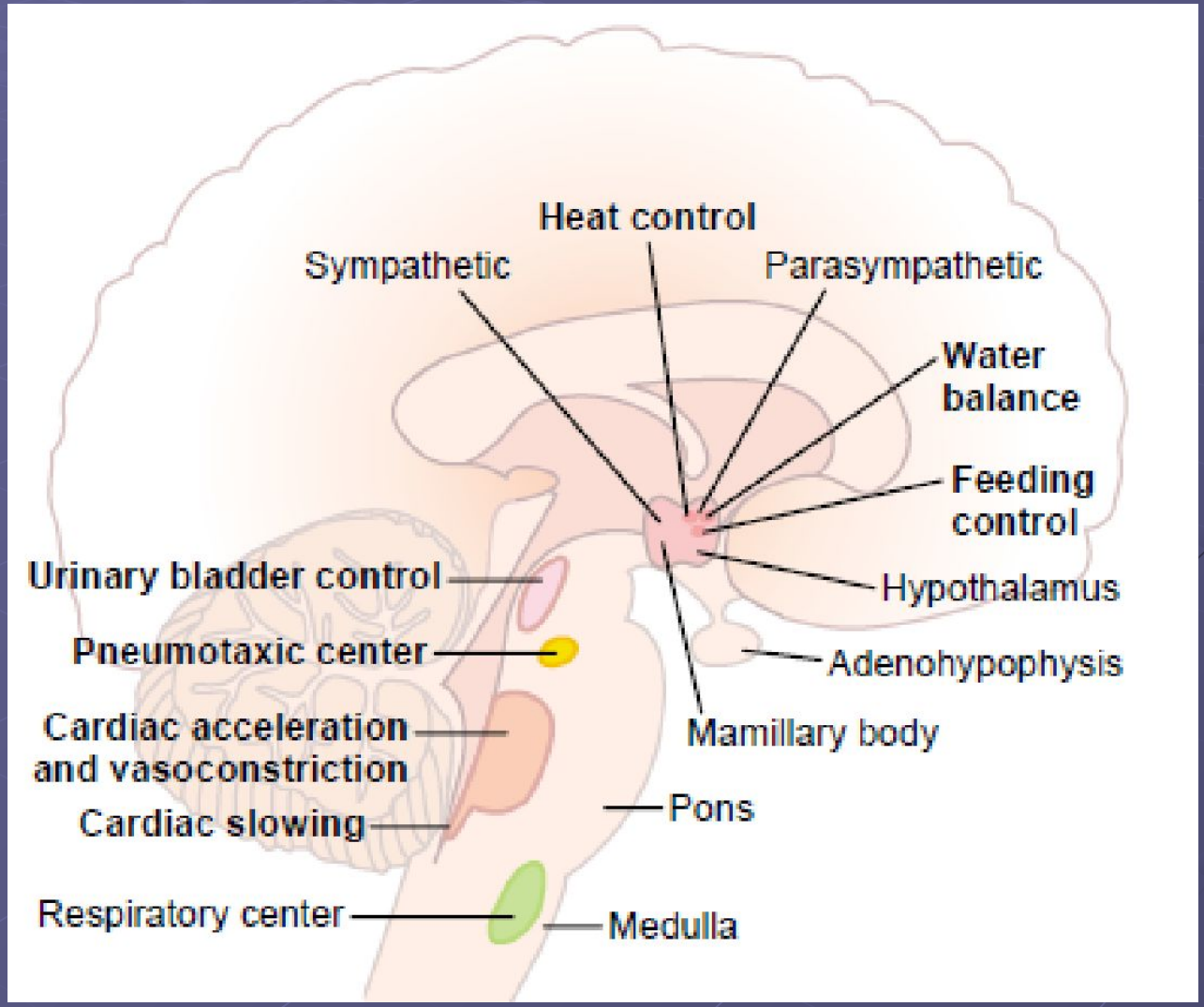
PERIPHERAL DEPARTMENT

microganglias of the metasympathetic nervous system para- and prevertebral ganglia preganglionic and postgangli- onic fibres

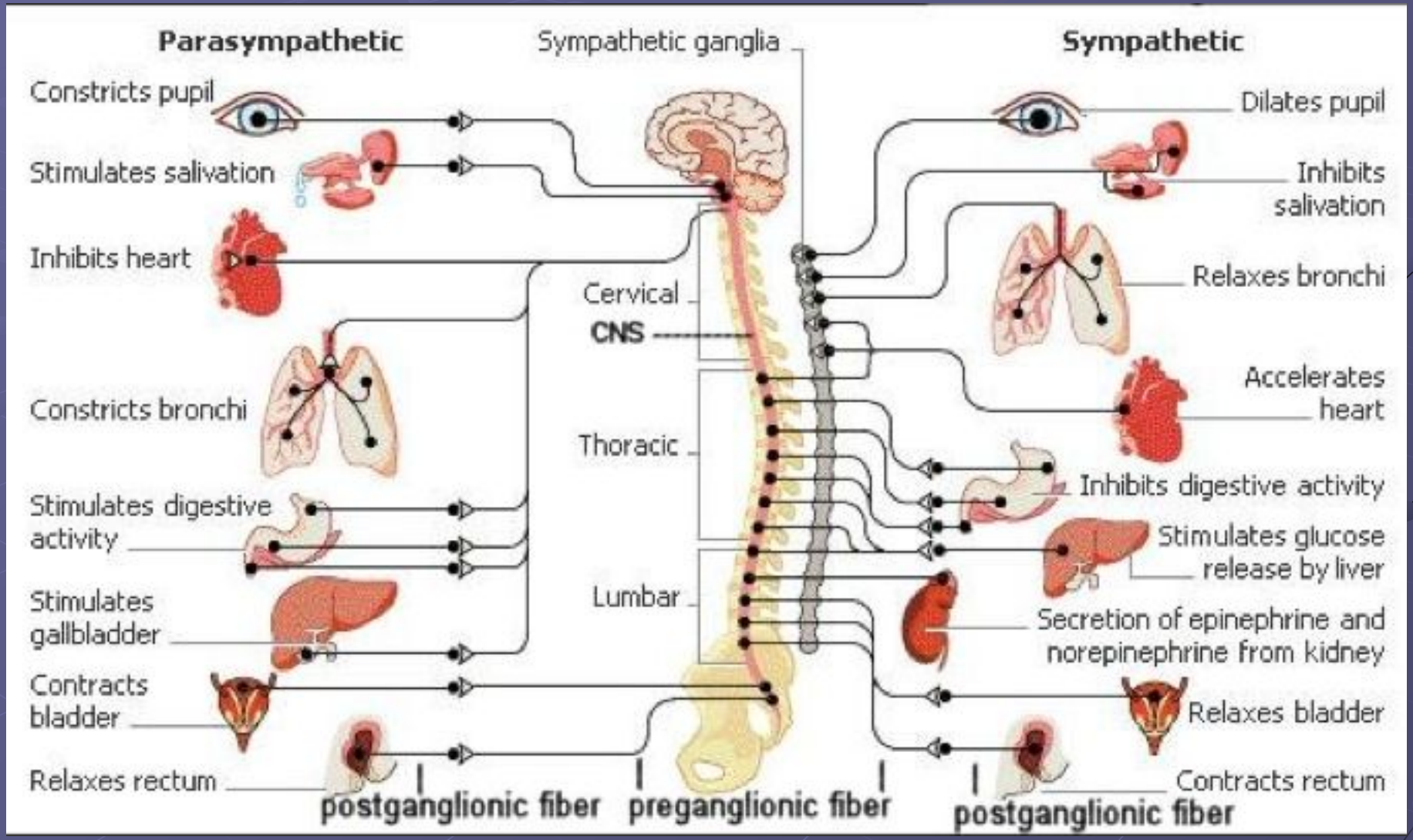
Medullary, Pontine, and Mesencephalic Control of the Autonomic Nervous System

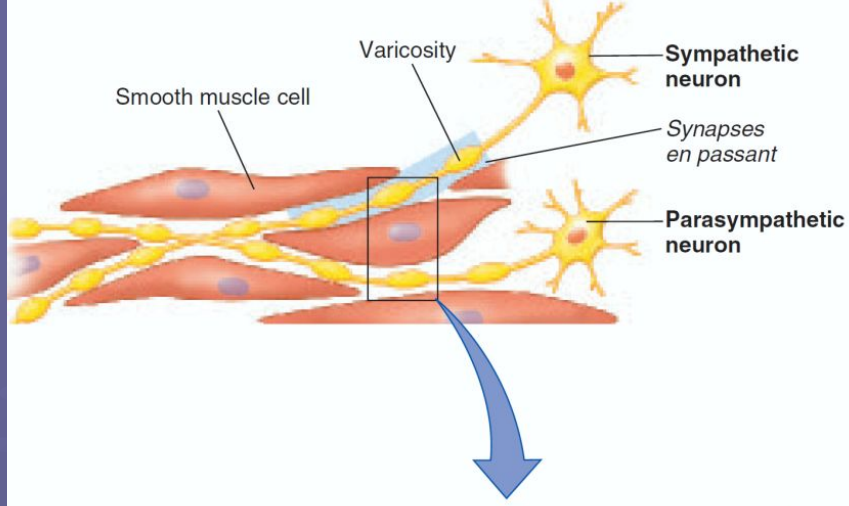
- Many neuronal areas in the brain stem reticular substance and along the course of the tractus solitarius of the medulla, pons, and mesencephalon, as well as in many special nuclei, control different autonomic functions such as arterial pressure, heart rate, glandular secretion in the gastrointestinal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

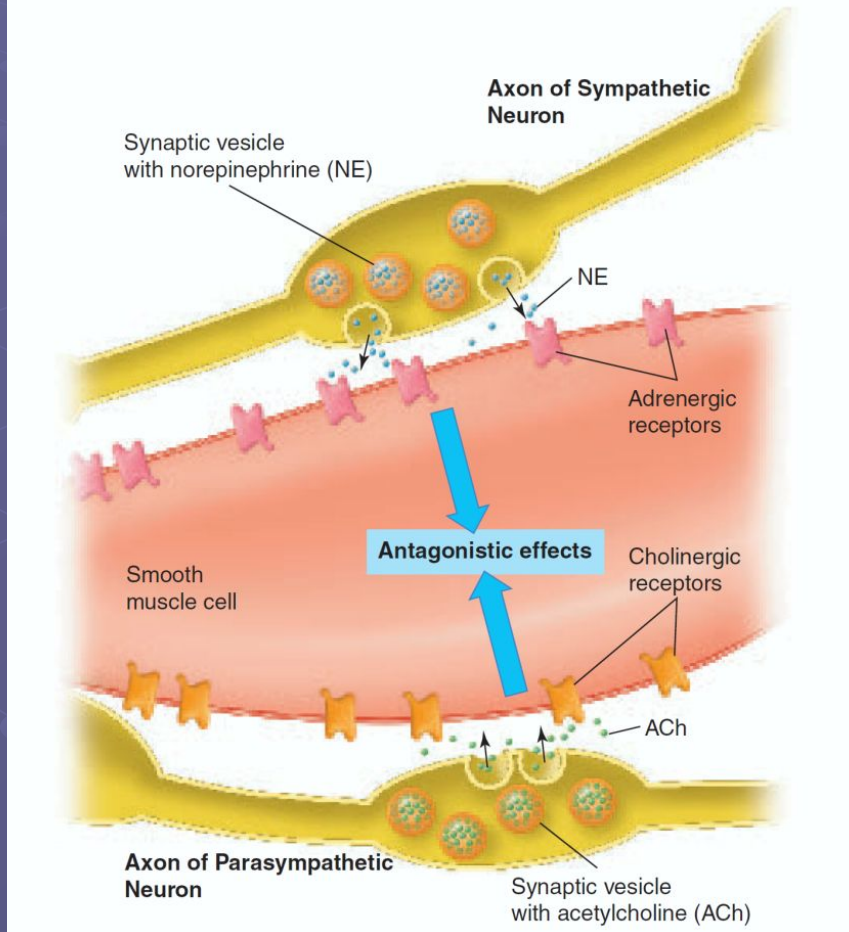
Autonomic control areas in the brainstem and hypothalamus



The organization of the autonomic nervous system







Sympathtic and Pparasympathetic 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	Slowed rate
	Increased force of contraction	Decreased force of contraction (especially of atria)
Coronaries	Dilated (β_2); constricted (α)	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 α) Dilated (adrenergic β_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

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

Receptor	Tissue	Response	Mechanisms
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_3, M_5)	Smooth muscle, glands	Depolarization and contraction of smooth muscle, secretion of glands	ACh activates G-protein coupled receptor, opening Ca^{2+} channels and increasing cytosolic Ca^{2+}
Muscarinic (M_2)	Heart	Hyperpolarization, slowing rate of spontaneous depolarization	ACh activates G-protein coupled receptor, opening channels for K^+

Table 9.7 Adrenergic and Cholinergic Effects of Sympathetic and Parasympathetic Nerves

	Effect of			
	Sympathetic		Parasympathetic	
Organ	*Action*	*Receptor**	*Action*	*Receptor**
Eye				
Iris				
Radial muscle	Contracts	α_1	—	—
Circular muscle	—	—	Contracts	M
Heart				
Sinoatrial node	Accelerates	β_1	Decelerates	M
Contractility	Increases	β_1	Decreases (atria)	M
Vascular Smooth Muscle				
Skin, splanchnic vessels	Contracts	α, β	—	—
Skeletal muscle vessels	Relaxes	β_2	—	—
	Relaxes	M**	—	—
Bronchiolar Smooth Muscle	Relaxes	β_2	Contracts	M
Gastrointestinal Tract				
Smooth Muscle				
Walls	Relaxes	β_2	Contracts	M
Sphincters	Constricts	α_1	Relaxes	M
Secretion	Decreases	α_1	Increases	M
Myenteric plexus	Inhibits	α_1	—	—
Genitourinary Smooth Muscle				
Bladder wall	Relaxes	β_2	Contracts	M
Urethral sphincter	Constricts	α_1	Relaxes	M
Uterus, pregnant	Relaxes	β_2	—	—
	Contracts	α_1	—	—
Penis	Ejaculation	α_1	Erection	M
Skin				
Pilomotor smooth muscle	Contracts	α_1	—	—
Sweat glands				
Thermoregulatory	Increases	M	—	—
Apocrine (stress)	Increases	α_1	—	—

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*Adrenergic receptors are indicated as alpha (α) or beta (β); 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