Νευροφυσιολογία και Αισθήσεις

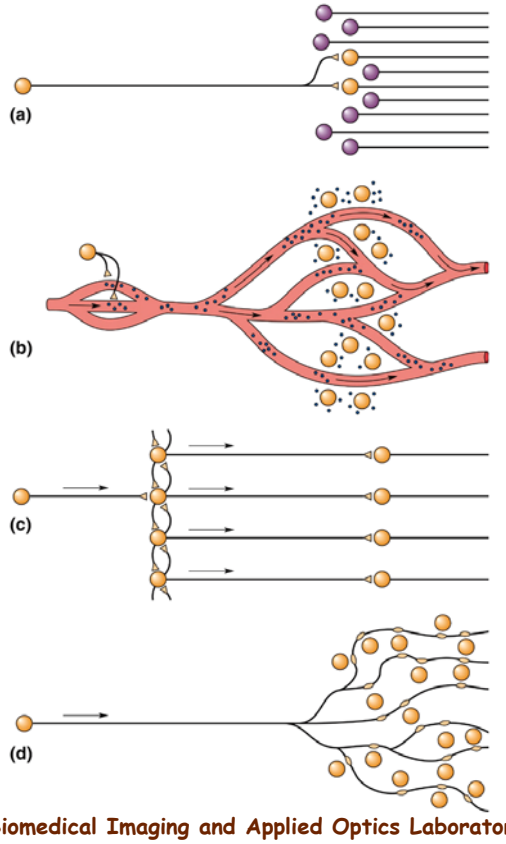
Διάλεξη 15

Χημεία του Εγκεφάλου και της Συμπεριφοράς

(Chemical Control of the Brain and Behavior)

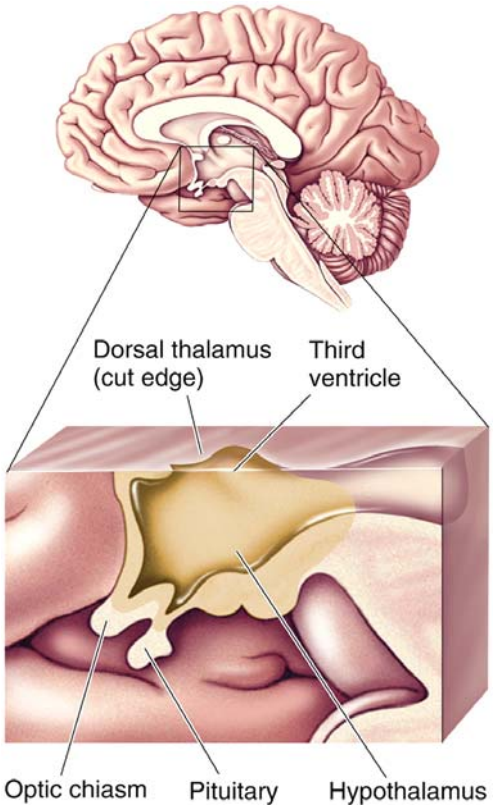
Introduction

- **Synaptic Connections**
  - Point-to-point
    - Mechanism to restrict synaptic communication
    - Brief transmission
    - Degradation of neurotransmitter
    - Presynaptic “autoreceptors”
  - Three broad nervous system components
    - Secretory hypothalamus
    - Autonomic nervous system (ANS)
    - Diffuse modulatory systems



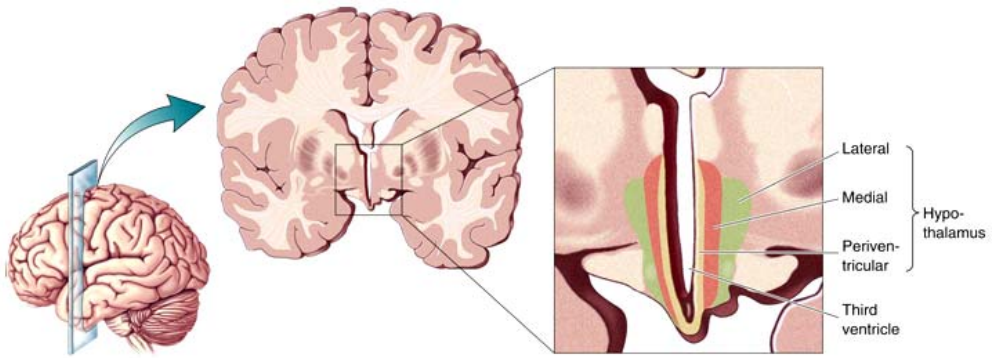
The Secretory Hypothalamus

- **Function → Homeostasis**
  - Different for hypothalamus and dorsal thalamus
  - Dorsal thalamus defect
    - Blind spot, lack of feeling
  - Hypothalamus defect
    - Fatal disruption to body function
- **Homeostasis**
  - Regulatory process: Regulates body temperature and blood composition levels
    - Hypothalamus commands in cold weather
      - Shiver, goosebumps, turn blue
    - Hypothalamus commands in hot weather
      - Turn red, sweat



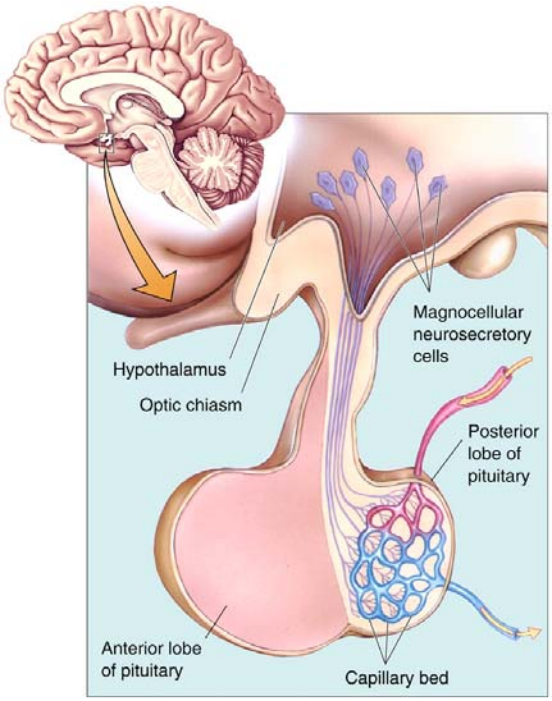
The Secretory Hypothalamus

- **Structure and Connections of the Hypothalamus**
  - Lateral and Medial Zones
    - Output to brain stem and telencephalon
    - Regulate behaviour
  - Periventricular Zone
    - control of circadian rhythms
      - Input from retina
    - ANS control
    - Neurosecretory action



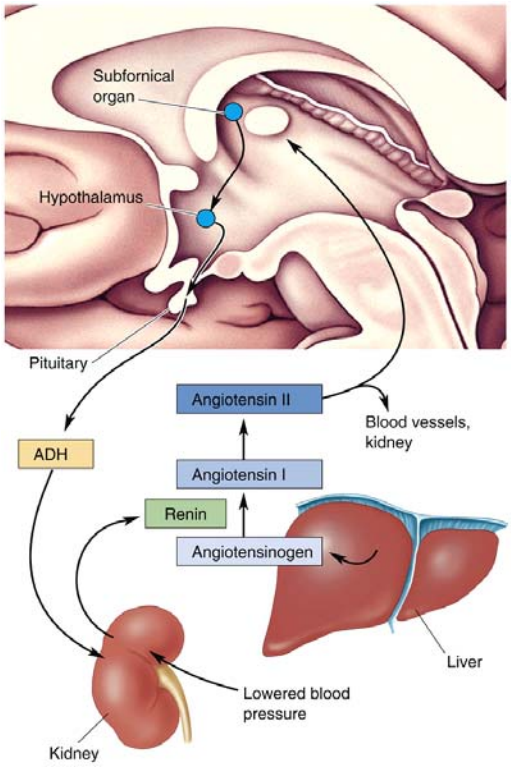
The Secretory Hypothalamus

- **Posterior Pituitary**
  - Magnocellular cells → Two neurohormones
  - Oxytocin
    - Initiates child birth, lactation,
    - Cortex can suppress release
    - Positive feedback
      - Pressure on cervix
      - External stimuli
    - Negative feedback
      - Child birth
      - Lack of external stimuli
      - Stress, anxiety
  - Vasopressin
    - Regulate blood volume and salt concentration



The Secretory Hypothalamus

- **Regulation of blood volume and salt concentration**
  - Lower blood volume, increased salt concentration
    - Pressure receptors in CV system
    - Salt receptors in hypothalamus
  - Kidneys → Renin → Angiotensin II
  - Subfornical Organ (no BBB) → stimulation of hypothalamus
  - Hypothalamus → ADH & thirst sensation

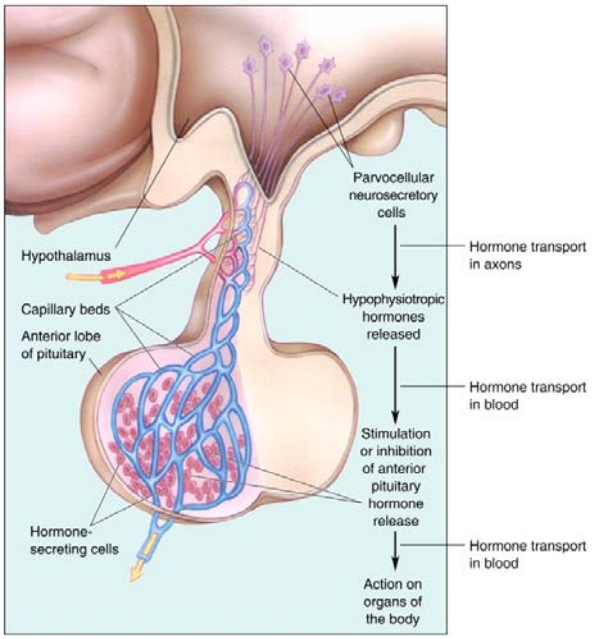


The Secretory Hypothalamus

- **Hypothalamic Control of the Anterior Pituitary**
  - Anterior lobe
  - Controlled by parvocellular neurosecretory cells
    - Secrete hypophysiotropic hormone
      - Pituitary cell receptor activation → Pituitary cells secrete or stop secreting hormones
- **Anterior Pituitary Hormones**
  - Wide range of action

Table 15.1 **Hormones of the Anterior Pituitary**

HORMONE	TARGET	ACTION
Follicle-stimulating hormone (FSH)	Gonads	Ovulation, spermatogenesis
Luteinizing hormone (LH)	Gonads	Ovarian, sperm maturation
Thyroid-stimulating hormone (TSH); also called thyrotropin	Thyroid	Thyroxin secretion (increases metabolic rate)
Adrenocorticotropic hormone (ACTH); also called corticotropin	Adrenal cortex	Cortisol secretion (mobilizes energy stores; inhibits immune system; other actions)
Growth hormone (GH)	All cells	Stimulation of protein synthesis
Prolactin	Mammary glands	Growth and milk secretion



The Secretory Hypothalamus

- **Adrenal glands**
  - Adrenal cortex and adrenal medulla
- **Adrenal Cortex**
  - Stress response → cortisol
    - Negative feedback on pituitary
    - Alterations in brain physiology

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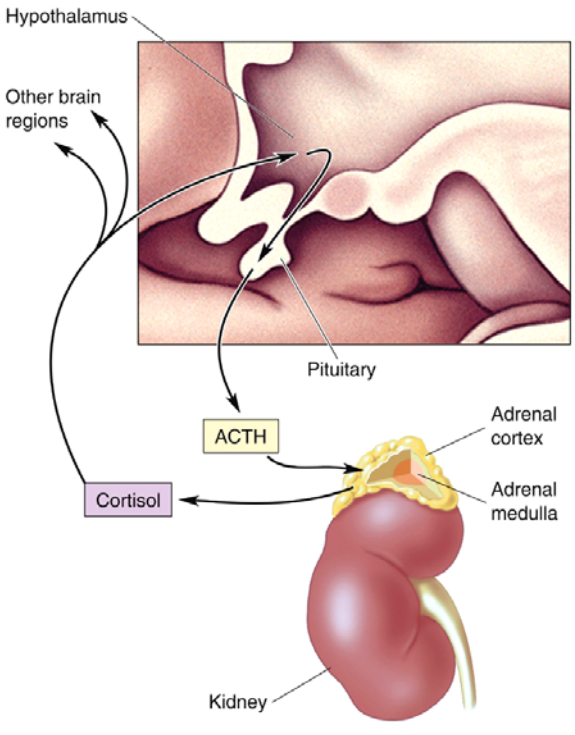

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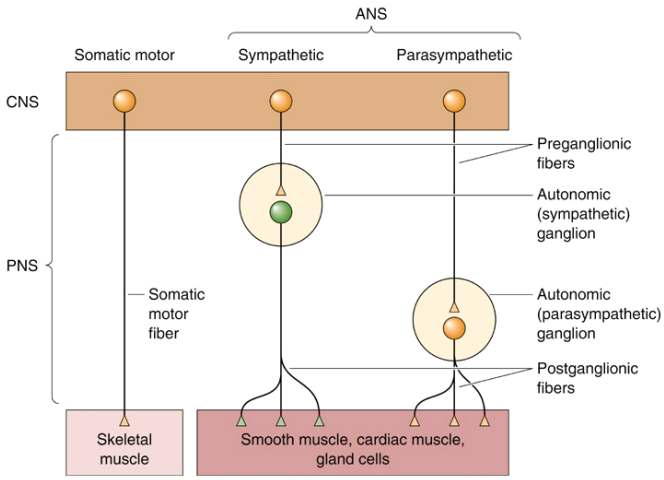
The Autonomic Nervous System

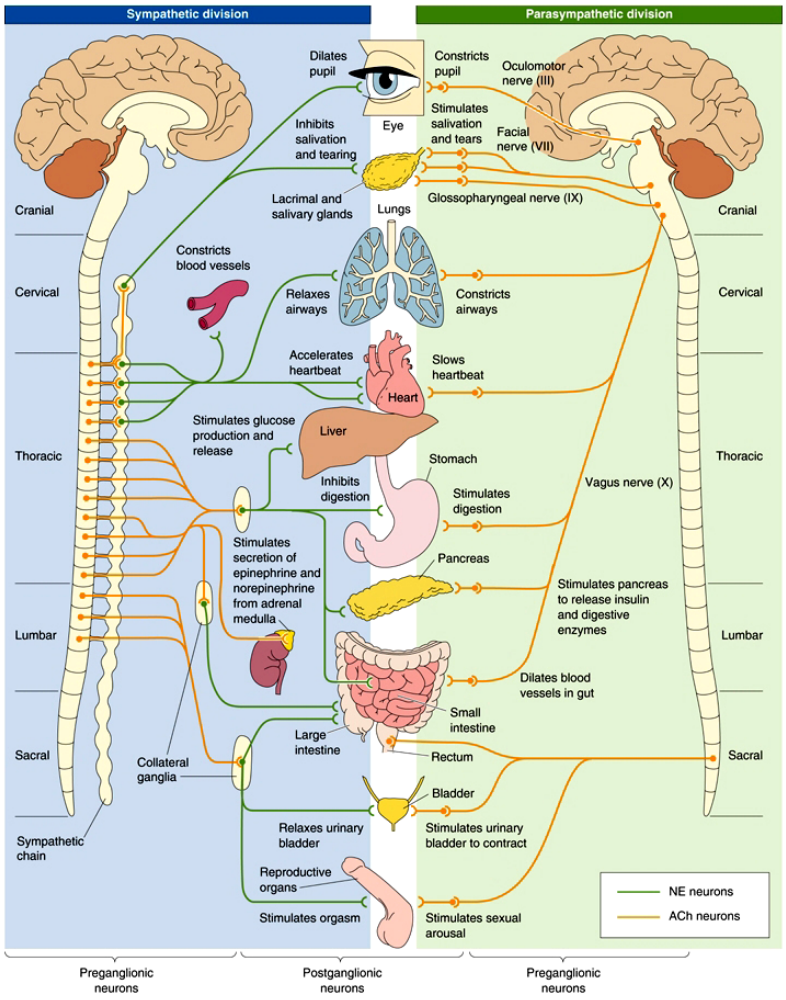
- **Divisions of autonomic nervous system (ANS)**
  - Sympathetic division → "fight or flight"
    - Increased heart rate and blood pressure
    - Depressed digestive function
    - Mobilized glucose reserves
  - Parasympathetic division → "rest and digest"
    - Slower heart rate, fall in pressure
    - Increased digestive functions
    - Stop sweating

The Autonomic Nervous System

- **ANS Circuits versus Somatic Motor System**
  - ANS
    - Actions multiple, widespread, slow
    - Wide coordinated and graded control
    - Commands all tissue and organ except skeletal muscle
    - Outside CNS
    - Disynaptic pathway
  - Somatic
    - Rapid and accurate
    - Only peripheral targets
    - Commands only skeletal muscle
    - Within CNS
    - Monosynaptic pathway

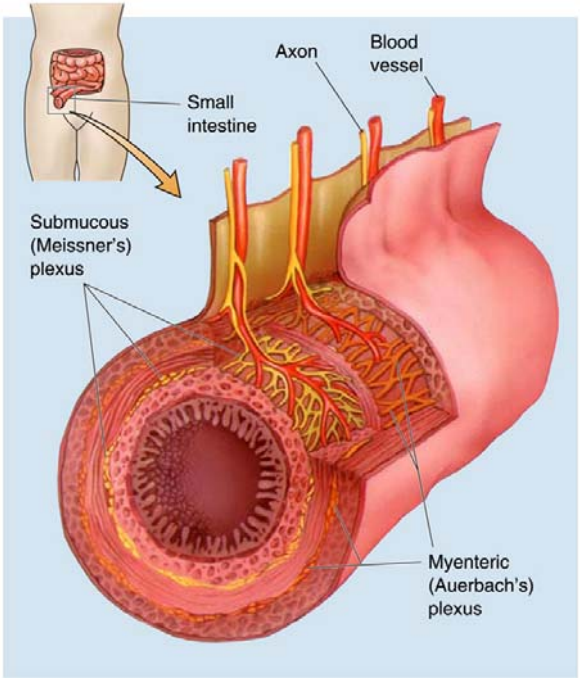


Sympathetic Nervous System	Parasympathetic Nervous System
Fibers originate in thoracic and lumbar regions of spinal cord	Fibers originate from cranial and sacral areas of CNS
Most preganglionic fibers are short	Preganglionic fibers are longer
Long postganglionic fibers	Very short postganglionic fibers
Preganglionic fibers release acetylcholine (Ach)	Preganglionic fibers release acetylcholine (Ach)
Most postganglionic fibers release noradrenaline (norepinephrine)	Postganglionic fibers release acetylcholine



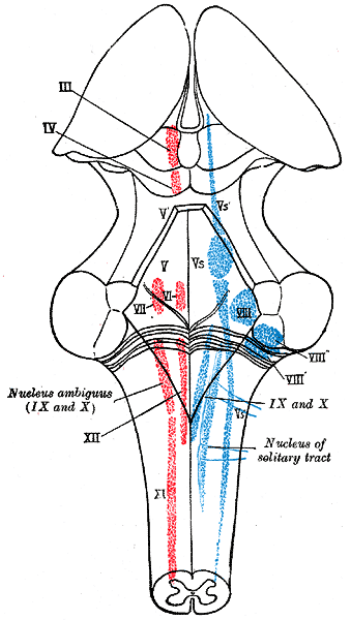
The Autonomic Nervous System

- **The Enteric Division**
  - Location
    - Lining of esophagus, stomach, intestines, pancreas, and gallbladder
  - Composition
    - Two complicated networks- myenteric (Auerbach's) plexus and submucous (Meissner's) plexus
  - Function
    - Control physiological processes involved in transport, digestion of food
  - Inputs
    - From brain via axons of the sympathetic and parasympathetic divisions



The Autonomic Nervous System

- **Central Control of the ANS**
  - Connections for autonomic control
    - Periventricular zone connections to brain stem and spinal cord nuclei
    - Nucleus of solitary tract
  - Function of solitary nucleus
    - In the medulla
    - Integrates sensory information from internal organs and coordinates output



The Autonomic Nervous System

- **Neurotransmitters**
  - ANS: Better understanding of drug mechanisms influencing synaptic transmission (vs. CNS)
- **Preganglionic Neurotransmitters**
  - Primary transmitter: ACh
  - ACh: Binds to nAChR, evokes fast EPSP
  - Ganglionic ACh: Activates mAChR, slow EPSPs and IPSPs
  - Neuroactive peptides: Small EPSPs, last for minutes, modulatory
- **Postganglionic Neurotransmitters**
  - Parasympathetic: Release Ach
    - Local effect
  - Sympathetic: Release NE
    - Far-reaching effects

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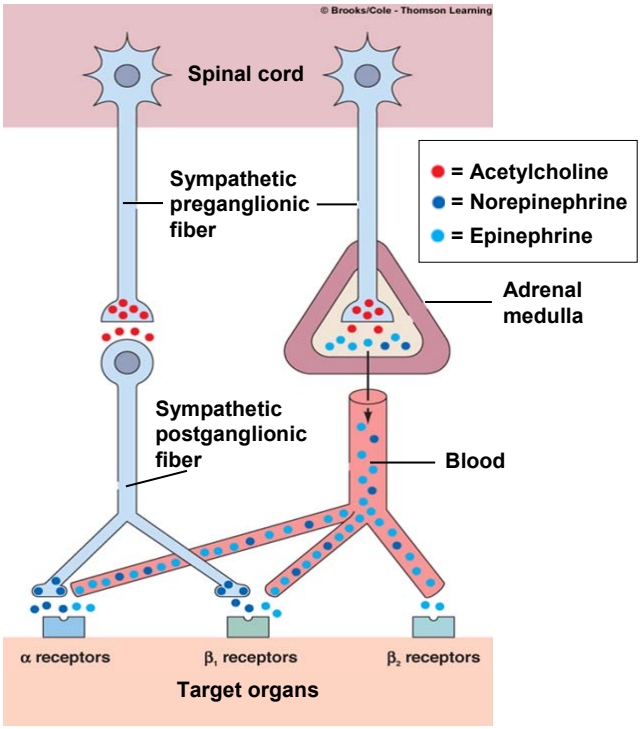
The Autonomic Nervous System

- **Adrenal medulla is a modified part of sympathetic nervous system**
  - Modified sympathetic ganglion that does not give rise to postganglionic fibers
  - Stimulation of preganglionic fiber prompts secretion of hormones into blood
    - About 20% of hormone release is norepinephrine
    - About 80% of hormone released is epinephrine (adrenaline)
  - Reinforces the activity of the sympathetic response
    - More long-acting and sustained



	Sympathetic		Paraympathetic	
	Action	**Receptor**	**Action**	**Receptor**
General Homeostasis	-stress response (fight or flight) -expends energy		-maintains homeostasis -conserves energy	
Heart				
Cardiac muscle	-↑ rate -↑ contractility	β1 β1	-↓ rate (atria only) -↓ contractility (atria only)	M2 M2
Smooth muscle				
Blood vessels -skeletal m. -skin -penis and clitoris	 -dilation -constriction -constriction	 β2 α α	 -dilation	 M
Spleen	-contraction	α		
Bronchi	-dilation	β2	-constriction	M3
G.I. tract -walls -sphincters	 -↓ motility -contraction	 α2 & β2 α1	 -↑ motility -relaxes	 M3 M3
Genitourinary tract -bladder wall -sphincter -penis	 -relaxation -contraction -ejaculation	 β2 α2 α	 -contraction -relaxation -erection	 M3 M3 M
Glands				
Salivary	-↑viscous secretion (small amounts)	α1	-↑ watery secretion	
Sweat -Thermoregulation -Stress	 -↑ secretion -↑ secretion	 M α		
Metabolism				
Liver **Adipose** **Kidney**	-glycogenolysis -lipolysis -renin release	α, β2 β3 β1		
Eye				
Iris **Ciliary muscle**	-dilation	α1	-constriction -contraction	M3 M3

The Autonomic Nervous System

- **Pharmacology of Autonomic Function**
  - Parasympathomimetic
    - Mimic or promote muscarinic actions of ACh or inhibit actions of NE
  - Sympathomimetic
    - Mimic or promote NE actions or inhibit muscarinic actions of ACh

Autonomic Nervous System

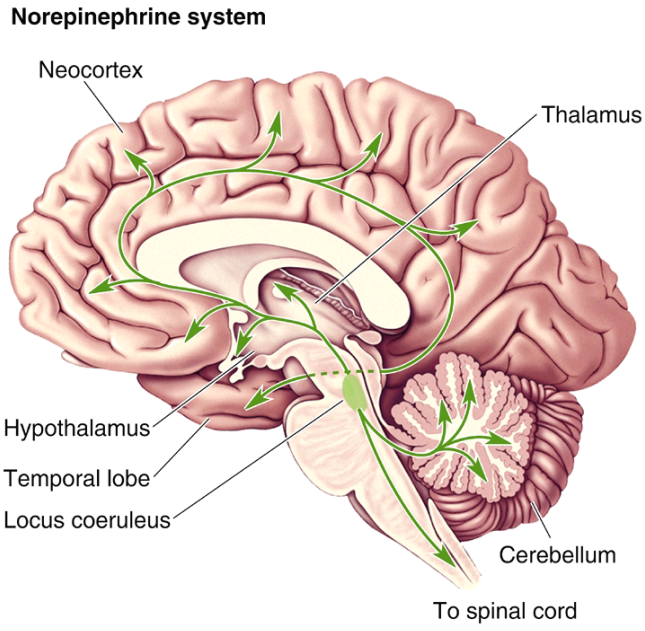
- **Agonists**
  - Bind to same receptor as neurotransmitter
  - Elicit an effect that mimics that of neurotransmitter
  - E.g.
    - Salbutamol
      - Activates β_2 receptors
      - Treatment of asthma
    - Phenylephrine
      - Stimulates both α_1 & α_2 receptors
      - Vasoconstrictor
      - Used as nasal decongestant
    - Pilocarpine
      - Stimulates muscarinic receptors
      - Useful for both narrow and wide angle glaucoma
      - Side effects include sweating.

Autonomic Nervous System

- **Antagonists**
  - Bind with receptor
  - Block neurotransmitter's response
  - E.g.
    - Succinylcholine
      - Stimulates the nicotinic receptor
      - Causes prolonged depolarization marked first by muscle fasciculations followed by flaccid paralysis
    - Atenolol
      - Selective β_1 blocker
      - Blockage produces bradycardia and decrease in blood pressure

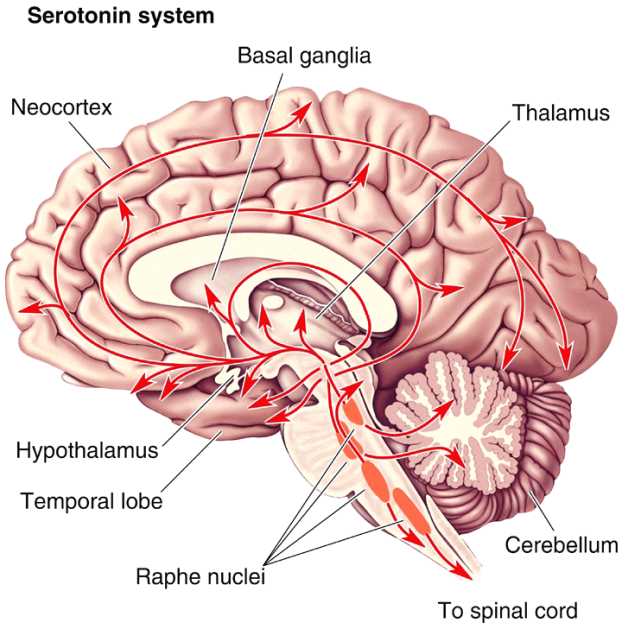
The Diffuse Modulatory Systems of the Brain

- **Anatomy and Functions**
  - Different structure and function, common principles
    - Small set of neurons at core
    - Arise from central core of brain
    - One neuron influences others
    - Synapses release transmitter molecules into extracellular fluid
- **The Nonadrenergic Locus Coeruleus**
  - Path
    - Axons innervate cerebral cortex, thalamus, hypothalamus, olfactory bulb, cerebellum, midbrain, spinal cord
  - Function
    - Regulation of attention, arousal, sleep-wake cycles, learning and memory, anxiety and pain, mood, brain metabolism
  - Activation
    - New, unexpected, nonpainful sensory stimuli



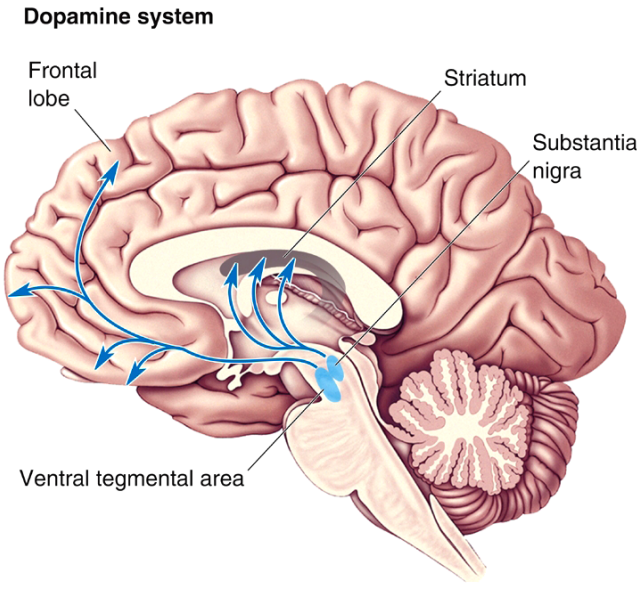
The Diffuse Modulatory Systems of the Brain

- **The Serotonergic Raphe Nuclei**
  - Path
    - Spinal cord
    - Most of brain
  - Function
    - Modulate pain signals
    - Involved in wake and arousal
    - Involved in stages of sleep
    - Control mood and emotion
  - Activation
    - Wakefulness



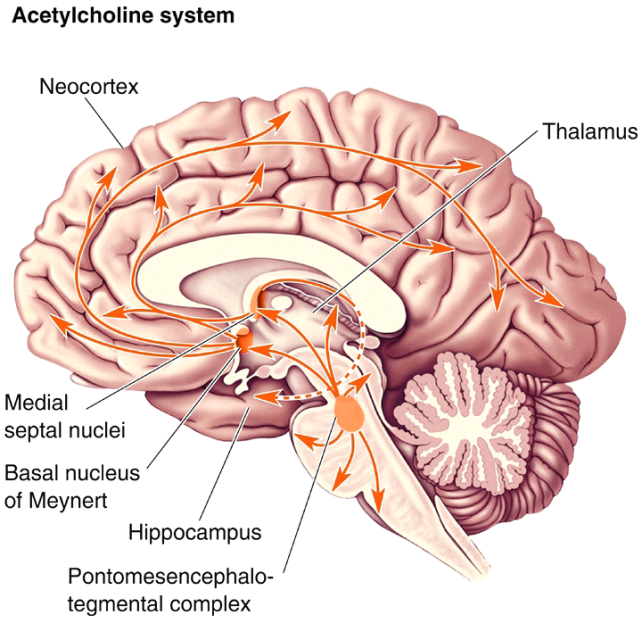
The Diffuse Modulatory Systems of the Brain

- **Dopaminergic Cells**
  - Substantia Nigra
    - Projects axons to the striatum
    - Facilitates the initiation of voluntary movements
  - Ventral tegmental area
    - Innervates circumscribed region of telecephalon
      - Mesocorticolimbic dopamine system: Dopaminergic projection from midbrain
    - Involved in reward and reinforcement



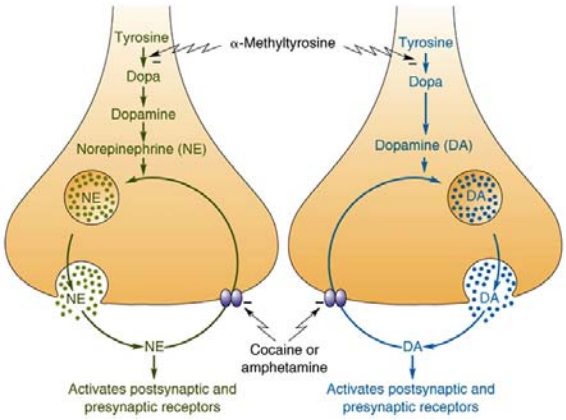
The Diffuse Modulatory Systems of the Brain

- **Cholinergic Systems**
  - Basal forebrain complex
    - Core of telencephalon, medial and ventral to basal ganglia
    - Function: Unknown, participates in learning and memory
  - Pontomesencephalotegmental complex
    - Releases ACh
    - Function: Regulates excitability of thalamic sensory relay nuclei



The Diffuse Modulatory Systems of the Brain

- **Drugs and the Diffuse Modulatory Systems**
  - Psychoactive drugs: Act on CNS
  - Many drugs of abuse act on modulatory systems
    - Noradrenergic
    - Dopaminergic
    - Serotonergic
- **Hallucinogens**
  - LSD discovery: Accidentally by Swiss chemist Albert Hofmann
  - LSD chemical structure: Close to serotonin, potent agonist
  - Effect: Dreamlike state, mixing of perceptions – cortical areas
- **Stimulants**
  - Cocaine → DA reuptake
  - Amphetamine → DA and NE reuptake and ↑ release of DA
    - Increased energy, euphoria (reward centers)
    - Addiction



Conclusion

- **Three Components of the Nervous System That Have Great Reach of Their Influences**
  - Secretory hypothalamus (all over the body)
  - Autonomic nervous system (all over the body)
  - Diffuse modulatory systems (all over the brain)
- **Detailed level**
  - Each system performs different functions
- **General level**
  - All work to maintain brain homeostasis

Επόμενη Διάλεξη …

Διάλεξη 16

Κίνητρα Συμπεριφοράς ή Υποκίνηση

(Motivation)