9.01 Introduction to Neuroscience
Fall 2007

9.01 Monday Recitation, Nov. 19

Chapter 15 – Chemical Control of the Brain and Behavior

Patterns of communication in the nervous system (Figure 15.1, page 483)
- point-to-point systems
- hormones released by the hypothalamus
- networks of neurons of ANS activate tissues in the body
- diffuse modulatory systems have divergent axonal projections

Secretory Hypothalamus (p. 484-89)

Regulates homeostasis

Homeostasis is the maintenance of the body's internal environment, including temperature regulation (i.e. shivering when cold), regulation of blood volume, pressure, oxygen and glucose concentration.

Structure
- Three functional zones: lateral, medial, and periventricular
- Periventricular zone:

  Lies right next to wall of third ventricle, includes groups of cells –
  1. **SCN (suprachiasmatic nucleus) – synchronizes circadian rhythms**
  2. **controls autonomic nervous system**
  3. **neurosecretory cells**

Control of posterior pituitary
- *Magnocellular neurosecretory cells* extend axons down stalk of pituitary and into posterior lobe
- These neurons release chemicals – *neurohormones* – directly into capillaries of the posterior lobe
- Oxytocin

  Released during final stages of childbirth, causes contractions, stimulations ejection of milk
  Oxytocin release stimulated by sight, sound, touch of baby – sensory information relayed through the thalamus reaches the cortex and is then sent to the hypothalamus

- Vasopressin **(aka ADH, antidiuretic hormone)**

  Regulates blood volume, salt concentration
  See Figure 15.5
  Kidney detects low blood volume or high salt concentration → kidney releases renin into the blood, certain peptides are formed that stimulate the hypothalamus → increased ADH → feeling of thirst
  Vasopressin acts on the kidneys – water retention, reduced urine protection

Control of anterior pituitary
- **Anterior pituitary is an actual gland, while posterior pituitary is part of the brain**
- The anterior lobe secretes *hormones* that regulate other glands; anterior pituitary is considered "master gland" of endocrine system
- *Parvocellular neurosecretory cells* do not extend axons all the way into anterior lobe
- These neurons secrete *hypophysiotropic hormones* into special capillary bed called the *hypothalamopituitary portal circulation*; the capillaries run down stalk of pituitary and branch into anterior lobe; hypophysiotropic hormones secreted bind to receptors on pituitary – activation of receptors causes cells to secrete or stop secreting hormone
- Cortisol

  Adrenal glands (just above kidneys) has two parts – cortex and medulla. Adrenal cortex produces the steroid hormone cortisol, which is released during times of stress. Cortisol mobilizes energy stores, inhibits immune system.

Parvocellular neurosecretory cells → when stressed, releases corticotrophin-releasing hormone (CRH) into blood portal → anterior pituitary releases corticotrophin (ACTH) into blood circulation → adrenal cortex releases cortisol

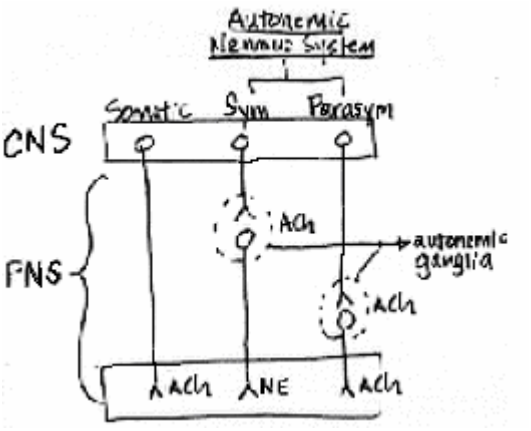
Autonomic Nervous System (hypothalamus also controls the ANS)

ANS circuits (autonomic ganglia, postganglionic neurons, preganglionic neurons)

Somatic motor system controls targets via a **monosynaptic pathway**; ANS uses a **disynaptic pathway**.

- Sympathetic vs. parasympathetic ANS

	Sympathetic	Parasympathetic
General effect	**Fight, flight, fear, sex Increases heart rate Decreases digestion**	**Rest, digestion Decreases heart rate Increases digestion**
Point of origin	**Middle of spinal cord (thoracic / lumbar)**	**Brain stem, sacral spinal cord**
Ganglion location	**Closer to cord**	**Closer to target organ**
Neurotransmitter	**Preganglionic: Acetylcholine Postganglionic: Norepinephrine (except adrenal medulla, where it's both Norepinephrine and Epinephrine)**	**Preganglionic: Acetylcholine Postganglionic: Acetylcholine**



- Enteric division ("little brain")

  Neural system found in the lining of the esophagus, stomach, intestines, pancreas, and gallbladder
  Controls the physiological process of transport and digestion of food
  Monitors tension and stretch of gastrointestinal walls, chemical composition of stomach, hormone levels in blood
  System is relatively independent from CNS but has supplementary control provided by sympathetic and parasympathetic axons that can supersede functions of enteric system (i.e. increased activity of sympathetic nervous system → decreases digestive function during stress response)

- Central control of ANS
  - Hypothalamus is main regulator of autonomic preganglionic neurons
  - Connections of periventricular zone to preganglionic neurons essential for control
  - Nucleus of solitary tract

    Part of the medulla; integrates sensory information from internal organs and coordinates output to autonomic brain stem nuclei

Diffuse Modulatory Systems

Principles:

- **core system is small set of neurons**
- **neurons arise from core of brain, most from brain stem**
- **slower, long-lasting effect**
- **divergent targets**
- **neurons may influence many others (axon may contact more than 100,000 pathways)**
- **not classical synapses**
- **synapses release neurotransmitter molecules into extracellular fluid; can diffuse to many neurons**
- **G-protein coupled receptors**
- **sets brain tone**

Diffuse Modulatory Systems: Neurotransmitter:	Origin → Target	Function	Disorder associated w/it	Treatment	Drugs that effect it
Norepinephrine (NE)	Locus coeruleus (pons) → all over brain	novelty detector wakefulness	Depression	MAO ⊖ tricyclics	
Dopamine (DA)	Ventral tegmental (midbrain) → nucleus accumbens	motivating behavior	Schizophrenia	haloperidol	Amphet, Heroin Nicotine
	Substantia nigra → striatum	movement	Parkinson's	l-dopa	
Seratonin (5HT)	Raphe nuclei (brain stem) → all over brain	mood, pain control, wakefulness	Depression	MAO ⊖ fluoxetine tricyclics	LSD
Acetylcholine (ACh)	Basal Nucleus Meynert → cortex Medial septal nuclei → hippo-campus	learning, memory	Alzheimer's		
	Pons/Midbrain tegmentum → thalamus	modulates sensory stimuli			

Drugs – **psychoactive drugs, "mind altering"**

- Hallucinogens – **produces hallucinations**

  LSD (produces dreamlike states, heightened awareness)
  Chemical structure of LSD is close to serotonin – acts on the serotonergic system
  Agonist at serotonin receptors on presynaptic terminals – inhibits raphe nuclei from firing
  Results in decreased outflow of serotonergic system

- Stimulants

  Cocaine and amphetamine – blocks catecholamine uptake → prolonged effects of neurotransmitter
  Works on DA and NE systems
  Increases alertness, decreases appetite
  Mimics sympathetic ANS: "sympathomimetic"

Review Questions for Ch. 15

1. SSRI's, a class of drugs used to treat depression, have which of the following effects on the brain:
   a) They destroy the enzymes that degrades serotonin in the synaptic cleft.
   b) The block the reuptake of serotonin in the presynaptic neuron.
   c) They prevent axoplasmic transport from delivering serotonin to the axon terminal.
   d) They increase the production of serotonin in the presynaptic neuron.

2. Which of the following is TRUE regarding the stress response:
   a) Stress triggers the release of ACTH from the Hypothalamus.
   b) CRH is released from the Anterior Pituitary.
   c) Physiologic changes occur supporting the fight or flight response
   d) All of the above

3. All of the following structures play a role in the release of cortisol into the blood stream EXCEPT
   a) parvocellular cells of the hypothalamus
   b) magnocellular cells of the hypothalamus
   c) anterior pituitary
   d) hippocampus
   e) adrenal cortex

4. All of the following are characteristics of the diffuse modulatory systems in the brain EXCEPT
   a) they tend to activate ionotropic receptors
   b) axons are widely divergent
   c) a small set of neurons form the core center for each system
   d) most core centers are located in the brainstem

5. Which statement accurately describes some important differences between the parasympathetic and sympathetic components of the autonomic nervous system?
   a) the parasympathic system uses norepinephrine as its postganglionic neurotransmitter whereas the sympathetic system uses acetylcholine.
   b) the parasympathetic ganglia are located closer to the target organ than to the central nervous system, whereas the sympathetic ganglia are located closer to the central nervous system than to the target organ.
   c) the sympathetic nervous system is more active during non-REM sleep whereas the parasympathetic system is more active during REM sleep.
   d) the sympathetic system can sympathize with us in our times of need, whereas the parasympathetic system is just too selfish to even care.

6. Many hallucinogens share a common structure with
   a) dopamine
   b) norepinephrine
   c) serotonin
   d) acetylcholine

Answers for Review Questions

1. **B**
2. **C**
3. **B**
4. **A**
5. **B**
6. **C**