THE HYPOTHALAMUS

I. The hypothalamus

A. The hypothalamus, which is part of the diencephalon, integrates somatic and visceral responses to maintain homeostasis

B. The portion of the hypothalamus that borders the third ventricle (periventricular zone of the hypothalamus) has two major functions

1. Secretes hormones

a. The hypothalamohypophyseal portal system secretes releasing (or inhibiting) hormones that act on the anterior pituitary (the anterior hypophysis or adenohypophysis)

b. The hypothalamohypophyseal tract secretes oxytocin (pitocin) and antidiuretic hormone (vasopressin) that are released by the posterior pituitary (the posterior hypophysis or neurohypophysis)

2. Controls the autonomic nervous system

a. The sympathetic nervous system: fight or flight (intruder in your apartment)

b. The parasympathetic nervous system: rest and digest (after Thanksgivingdinner)

II. Chemical Control: The EndocrineSystem

A. The pituitary gland (hypophysis) releases hormones, which are chemical messengers that modulate function

1. Hormones travel in the blood to target organs, which have specific receptors to respond to specific hormones

2. Hormones can affect one or multiple organs and functions

3. Hormones belong to one of three classes of compounds

a. Amino acids and amines: epinepherine, norepinepherine, thyroid hormone

b. Peptides and proteins: adrenocorticotropic hormone, follicle stimulating hormone, growth hormone, insulin, luteinizing hormone, oxytocin, prolactin, thyroid stimulating hormone and antidiuretic hormone

c. Steroids: aldosterone, glucocorticoids, estrogens,progesterone, testosterone

B. The pituitary gland is really two glands:

1. The anterior pituitary, which is derived from the roof of the mouth
   - a. It is a gland and is known as the adenohypophysis
   - b. The cells of anterior pituitary synthesize and secrete a variety of hormones
   - c. Secretion by the anterior pituitary is controlled by releasing (or inhibiting) hormones from the hyopthalamus

2. The posterior pituitary is an outgrowth of the hypothalamus
   - a. It is composed of nervous tissue and is known as the neurohypophysis
   - b. Neurons of the hypothalamus synthesize oxytocin and antidiuretic hormone which are released from their axon terminals in the posterior pituitary

C. Hypothalamohypophyseal portal system

1. Capillaries that run from the hypothalamus to the anterior pituitary

2. Transport releasing (or inhibiting hormones) from the hypothalamus to the anterior pituitary

D. Hypothalamohypophyseal tract

1. Nerve cell bodies of neurosecretory cells are located in the hypothalamus; their axons pass down into the posterior pituitary

2. These nerve cell bodies synthesize the hormones, which are released in the posterior pituitary
The hormones are transported down their axons and released at the axon terminals

3. Hormones enter the systemic circulation

III. Nervous System Control: The AutonomicNervous System

A. The autonomic nervous system is two-neuron motor system that innervates glands, myocardium and smooth muscle

1. The first neuron located in the central nervous system
   The first neuron sends its preganglionic axon to synapse with the second neuron, which is located in an autonomic ganglion
   Acetyl choline is the neurotransmitter released by the first neuron

2. The second neuron sends its postganglionic axon to synapse with the effector cell

3. Parasympathetic, postganglionic axons release acetyl choline to the effector cell

4. Sympathetic, postganglionic axons release norepinepherine to the effector cell

B. Comparison of the sympathetic and parasympathetic nervous systems

Characteristic	Sympathetic	Parasympathetic
Location of preganglionic nerve cell bodies	Intermediate horn of the thoracic and lumbar spinal cord	Brainstem and intermediate horn of the sacral spinal cord
Location of postganglionic nerve cell bodies	Sympathetic chain ganglia and the three ganglia near the organs innervated	Ganglia near on in the wall of the organ innervated
Neurotransmitter	Preganglionic: acetyl choline Postganglionic: norepinepherine	Preganglionic and postganglionic: acetyl choline
General function	Action	Relaxation

IV. Comparison of somatic motor system and autonomic motor system

Characteristic	Somatic motor system	Autonomic motor system
Innervates	Skeletal muscle	Myocardium, smooth muscle and glands
Neuron(s)	α-motor neuron	Preganglionic and postganglionic neurons
Location of neuron(s)	Ventral horn of the spinal cord	Preganglionic: Brainstem and intermediate horn of the thoracic, lumbar and sacral spinal cord Postganglionic: autonomic ganglia
Neurotransmitter	Acetyl choline at the ionotropic receptor Produces EPSPs	Preganglionic: acetyl choline binds to ionotropic receptors to produce EPSPs and to metabolic receptors to produce EPSPs or IPSPs Postganglionic: acetyl choline binds to metabotropic receptors in the parasympathetic system Norepinepherine binds to metabotropic receptors in the sympathetic system
Major controlling structure	Precentral gyrus	Hypothalamus

Emotions

I. Emotion is a mental state involving feeling, tone and physiological behavior

A. Emotion includes a range of internal feelings that are expressed through physiological responses
Different emotions can be accompanied by the same physiological actions
1. Love: increased heart rate

2. Hate: increased heart rate

B. Emotions are signaled by facial expressions (Compare spontaneous vs posed facial expressions) and "body language"

C. Emotion colors cognitive behavior

II. Theories

A. James-Lange theory: emotion is the perception of peripheral changes, it is the response to physical changes

stimulus --> produces visceral responses-->perceived bybrain-->emotions

stimulus --> crying ---> perception --> feel sad

If this is true, then why do we cry when we feel happy?

If a person couldn't cry, could he feel sad?

B. Cannon-Bard theory: neural centers regulating emotion affect peripheral structures and higher brain centers

stimulus --> perceived by brain --> emotions and visceral responses

stimulus --> perception --> feel sad --> may or may not cry

C. Information from patients with spinal cord injury

1. Sensory input to brain decreased or absent as a result of the lesion

2. The higher the level of the lesion, the less emotion perceived

3. The "raw, visceral" component of emotion absent

D. James-Lange-Schachter-Damasio theory (somaticmarker theory): emotion is a cognitive explanation of the body's reactions

III. Anatomical basis of emotions is the limbic system and the Papez circuit

A. The limbic system structures perceive and express emotion

1. The limbic system is an old part of brain
2. The limbic system forms a border or ring around the brainstem

B. Components:

1. Hypothalamus: responsible for visceral control and homeostatic maintenance either directly through its neural pathways or indirectly through its control of the endocrine system

2. Amygdala, part of the temporal lobe

3. Hippocampal formation, part of the temporal lobe

4. Cingulate gyrus, composed of parts of the temporal and parietal lobes

5. Septal area

6. Fornix: neuronal pathway interconnecting all the structures of the limbic system

C. Papez circuit: pathway by which emotion reaches consciousness

D. Human case study: Phineas Gage who suffered massive frontal lobe lesion
He became fitful, irreverent, grossly profane, "no longer Gage"

E. Frontal lobotomy: previously used for psychotic and depressed patients, but produced decreased emotions, decreased ability to concentrate, decreased ability to plan and to carry out day to day functions

Gender & Behavior

I. Gender determination in embryo

A. Embryo/fetus defaulted to develop into a female

B. Male gender determined by the Y chromosome

1. Testis determining factor (TDF) is produced by the sex determining region of the Y chromosome

2. TDF causes the undifferentiated gonad to become a testis

3. In the fetal testis, the Y chromosome also directs the production of:

a. Testosterone, which directs the development of male external genitalia and neuronal imprinting

b. A duct-inhibiting hormone, which suppresses the formation of the uterus and oviducts

C. No hormones are produced by the female embryo/fetus

II. Sexually dimorphic behavior

A. Sexually dimorphic behavior refers to certain behaviors are characteristically exhibited by one gender

1. Female rats

Ear wiggling, hopping, darting: receptive behavior

Lordosis: receptive behavior

2. Male rats

Mounting

Males also exhibit lordosis to indicate submissiveness to adominant male

B. Male hormones produced during fetal life and perinatally affect morphology as well as behavior

1. Inject testosterone into pregnant guinea pigs:

a. Female offspring are genetically female, but exhibit male external genitalia

Have female internal reproductive organs (no duct inhibiting hormone produced because there is no Y chromosome to produce the enzymes necessary to synthesize this hormone)

b. As adults, they exhibit less lordosis and more mounting

c. If these females are treated with testosterone as adults, they exhibit the mounting behavior of normal males and no lordosis

2. Male rats castrated between postnatal Day 1-5 exhibited female behavior
Male rats castrated after Day 10 exhibited little female behavior

Male rats treated with testosterone inhibitor within 8 hours of birth behaved as females
Thus, there seems to be a critical neonatal period in which testosterone affects later behavior

3. Female rats treated with testosterone played like normal males (mock fighting)

4. In humans, prenatal exposure to increased testosterone led to
   a. Girls preferred "boy" toys (ages 3-8)

   b. Girls preferred boy playmates

   c. But girls engaged in rough and tumble play played for a shorter time periods than did normal boys

III. Testosterone, estradiol, and estrogen pass through the cell membrane of target neurons and bind to nuclear receptor proteins causing a conformational change in these proteins; the receptor protein is believed to bind to a promotor or inhibitor area for a specific gene

A. Male neuronal imprinting by testosterone

B. Most of the testosterone is metabolized intracellularly to estradiol, a female hormone

C. Maternal estrogen does not masculinize the female fetus because it is bound to α-fetoprotein; testosterone does not bind to α-fetoprotein

D. Steroid receptor proteins are found in
   1. Subcortical areas of the brain: the hypothalamus, especially the preoptic area; amygdala; midbrain; spinal cord

   2. Cortical areas of the brain: frontal lobe and cingulate gyrus

   3. Hypothalamus, amygdala, midbrain, frontal lobe and cingulated gyrus are involved in emotions

IV. Information on human behavior
A. Congenital adrenal hyperplasia (CAD)

   1. Adrenal cortex secretes increased male hormones prenatally leading to abnormal sexual development

   2. The developing female fetus is masculinized
      a. Clitoris enlarged and resembles a penis
      b. Labia majora enlarged and fused, resembling a scrotum
      c. CAD females are five times more likely to prefer females sexual partners
      d. CAD females score higher on visual spatial skills

B. Androgen insensitivity syndrome results from a decreased (or no) androgen receptor sites on target cells

1. Testosterone is produced by the male fetus, but it fails to masculinize the body

2. The fetus develops female external genitalia, not male external genitalia

3. Female secondary sex characteristics develop: there is a female body type, but no menstrual periods

4. Since duct-inhibiting hormone is present, there are no female internal reproductive organs

5. These individuals exhibit female behavior

C. 5-alpha reductase deficiency

1. Testosterone is metabolized to dihydrotestosterone, an active form, by 5-alpha reductase

2. In the male fetus, the development of ducts is under testosterone influence and is normal in these patients; however, differentiation of male external genitalia is under the influence of dihydrotestosterone

3. Thus, externally these males resemble females and are raised as females

4. At puberty, these males develop male external genitalia because at this period of life, testosterone, not dihydrotestosterone, causes enlargement of male external genitalia

5. In addition, testosterone acts to bring about mental changes and male behavior

6. Dihydrotestosterone acts in utero; testosterone acts afterwards

7. Thus, gender identity appears to be due to biology not rearing

V. Sex linked differences

A. Rats and fetal position: a female fetus between two males tends to exhibit more masculine behavior

B. Human morphological differences

1. Sexually dimorphic nucleus of the preoptic area(SDN-POA) of the hypothalamus

a. Larger in males

b. Increased size of this area occurs perinatally

c. SDN-POA appears to control sexual functions such as male sexual behavior and release of luteinizing hormone-releasing hormone

2. Interstitial nuclei of the thalamus (INAH):

a. There are four of these nuclei

b. INAH-2 and 3 are two to three times larger in males (INAH-1& 4 are the same size in males and females)

c. INAH-3 is twice as large in heterosexual males as in females and homosexual males

3. Bed nucleus of the stria terminalis is 2.5 times larger in males

4. In the spinal cord, the neurons controlling the bulbocavernosus muscle are larger and more numerous in the male by 25% (this muscle moves the penis in the male and constrict the vaginal opening in the female)

When female rat pups were injected with testosterone neonatally, fewer of these neurons degenerated and those that remained enlarged, similar to what occurs in the male

5. The male brain is larger

6. The cerebral hemispheres of the female brain may be more interconnected

a. The corpus callosum is the same size in both genders, but appears to be proportionally larger in females in relation to overall brain size

b. The massa intermedia which connects the two thalami is more often present in females (86%) than males (72%)

c. The anterior commissure, another area of interhemespheric connection, is 12% larger in females

7. Imaging studies: females tend to use both hemispheres in processing information while processing is more lateralized in themale brain

V. Behavior and skills in males and females

Females	Males
Verbal fluency	Visual, spatial skills
Perceptual speed	Math skills
Fine motor skills better	Fine motor skills weaker
Less physical violence	More physical violence
Less risk taking behavior	More risk taking behavior