I) INTRO
   A) Nervous system discussed so far
      1) Specific
      2) Fast
   B) Other systems – extended in space and time
      1) Nonspecific
      2) Slow
   C) Three components that operate in this fashion
      1) Secretory hypothalamus
      2) ANS
      3) Diffuse modulatory system

II) Secretory hypothalamus
   A) Overview of the hypothalamus
      1) Dorsal thalamus connected to all pathways going to the neocortex; therefore, damage to the dorsal
         thalamus produces specific sensory and motor disturbances
      2) Hypothalamus damage is much more severe
         (a) Disrupts array of bodily functions
         (b) Often fatal
   B) Hypothalamus controls homeostasis (the following are all monitored by the hypothalamus)
      1) Body temperature
      2) Blood volume
      3) Salinity
      4) pH levels
      5) O₂ levels
      6) Glucose levels
   C) Structure and connections

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Figure 15.3
Zones of the hypothalamus. The hypothalamus is usually divided into three zones: lateral, medial, and
periventricular. The periventricular zone receives input from the other zones, the brain stem, and the
telencephalon. Neurosecretory cells in the periventricular zone secrete hormones into the bloodstream.
Other periventricular cells control the ANS.
1) Basic structure and connections
   (a) note that the periventricular area contains the suprachiasmatic nucleus; therefore the connection to the retina is relevant
2) Pathways to the pituitary
   (a) Posterior pituitary
   (b) Anterior pituitary
3) Hypothalamic control of the posterior pituitary
   (a) Posterior pituitary affected by neurohormones released by the magnocellular neurosecretory cells of the hypothalamus

Two magnocellular neurohormones

(i) Oxytocin
   - Milk letdown (lactation)
   - Uterine contractions
   - Maternal bonding
   - Sexual stimulation
   - There is also cortical control of oxytocin release

(ii) Vassopressin (antidiuretic hormone – ADH)
   - Blood salinity: detected by the hypothalamus
   - Blood volume: blood volume is detected by pressure receptors in the cardiovascular system
4) Hypothalamic control of the anterior pituitary
   (a) Anterior lobe of the pituitary is a gland – it is the master gland and is connected to many other important glands

(b) The anterior pituitary is controlled by the hypothalamus
(c) Parvocellular neurosecretory cells send signals through the blood to the anterior hypothalamus.
(d) The stress response is mediated through the anterior pituitary

(i) Chronic stress is harmful
- Cortisol causes more Ca\(^{2+}\) to enter the neurons through voltage-gated channels, which has the short-term effect of helping the brain cope with stress better because it presumably facilitates brain function.
- Chronic exposure to cortisol leads to dendrites to atrophy and eventually leads to cell death.
  - Too much calcium results in excitotoxicity
  - Premature aging results from chronic stress
  - The hippocampus is particularly vulnerable

III) THE AUTONOMIC NERVOUS SYSTEM
A) Basic structure of the nervous system
1) Two major systems
   (a) CNS
   (b) PNS
     (i) Somatic
     (ii) Autonomic or visceral
        - Sympathetic: fight, flight, fright, orgasm and ejaculation
        - Parasympathetic: energy conservation, genital arousal

B) Characteristics of ANS function
1) The actions of the ANS are multiple, diffuse, and slow.
2) The ANS balances excitation and inhibition to achieve widely coordinated and graded control. This is different from the somatic system, which only excites peripheral targets.

C) ANS circuitry
1) Both systems have upper motor neurons in the brain that send signals to lower motor neurons
2) Somatic nervous system pathways from lower motor neurons to target are:
   (a) monosynaptic.
   (b) Lower motor neuron in CNS
3) ANS pathways from lower motor neurons to targets are:
   (a) Disynaptic
   (b) Lower motor neurons in PNS
4) Differences between sympathetic and parasympathetic circuitry
   (a) Sympathetic
      (i) Preganglionic neurons of the sympathetic nervous system originate in the intermediolateral gray matter of the spinal cord
      (ii) Axons travel through the ventral roots
      (iii) Synapse with lower motor neurons in the sympathetic chain
   (b) Parasympathetic
      (i) Preganglionic neurons in brainstem nuclei and sacral area of the spinal cord
      (ii) Axons travel through cranial nerves and nerves of the sacral spinal cord
      (iii) Their axons travel farther before synapsing with the parasympathetic ganglia
which are typically right next to the target organ

5) ANS innervates 3 types of tissues
(a) Glands
(b) Smooth muscle
(c) Cardiac muscle

6) Sympathetic and parasympathetic ANS have opposing functions.
(a) CNS circuitry inhibits activity in one system while the other is active

D) The enteric division innervates the digestive system and receives input from the ANS

E) Central control of the ANS is largely mediated through the nucleus of the solitary tract which integrates sensory info from the internal organs and coordinates the output of autonomic brain stem nuclei.

IV) NEUROTRANSMITTERS AND THE PHARMACOLOGY OF AUTONOMIC FUNCTION

A) Preganglionic neurotransmitters
1) ACh is main transmitter
2) ACh binds with nAChRs
3) Opens voltage-gated channels that evoke EPSPs that tend to trigger postganglionic action potentials
4) Repeated stimulation results in the release of
   (a) NPY (neuropeptide Y)
   (b) Vasoactive intestinal polypeptide (VIP)

B) Postganglionic neurotransmitters

V) THE DIFFUSE MODULATORY SYSTEM OF THE BRAIN

A) Intro
1) Modulatory systems have widely dispersed & diffuse connections
2) They regulate large collections of neurons
   (a) Change excitability
   (b) Synchronize or desynchronize activity

B) Anatomy and functions of the diffuse modulatory system
1) Typically the core of each system has a small set of neurons
2) They typically arise in the central core of the brain (usu. the brainstem)
3) Wide projections from each neuron with axons contacting more than 100,000 postsynaptic neurons scattered throughout the brain.
4) Synapses designed to release transmitters into the extracellular fluid so that they can diffuse to many neurons

C) The Noradrenergic Locus Coeruleus
1) Uses NE
2) Widespread connections throughout the brain
Chemical Control of Behavior and Brain

(a) Cortex
(b) Thalamus
(c) Hypothalamus

3) Functions: most active when exposed to novel nonpainful sensory stimuli and least active when relaxing; probably makes the brain more responsive thereby increasing speed of processing
(a) Attention
(b) Arousal
(c) Sleep-wake cycles
(d) Learning
(e) Memory
(f) Anxiety
(g) Pain
(h) Mood
(i) Brain metabolism

D) Serotonergic raphe nuclei
1) Structure: it helps to form the ascending reticular activating system along with the locus coeruleus
2) Functions
   (a) Sleep-wake cycle
   (b) Involved in stages of sleep
   (c) Emotion and mood

E) Dopaminergic substantia nigra and ventral tegmental area
1) Two systems
   (a) Substantia nigral projections to the striatum
      (i) Facilitates the initiation of voluntary motor response to environmental stimuli
      (ii) These pathways are destroyed in Parkinson’s disease.
   (b) Ventral tegmental projections – the mesocorticolimbic pathways project from here to the frontal cortex and the limbic system.
      (i) Reward center (which will cover in chapter 18)
      (ii) Implicated in some psychiatric disorders (covered in chapter 21)

F) Cholinergic basal forebrain and brainstem complexes
1) Two major cholinergic systems
   (a) Basal forebrain complex
      (i) Medial septal nuclei which innervate the hippocampus
      (ii) Basal nucleus of Meynert
      (iii) Function unknown but probably involved in learning and memory
      • First cells affected by Alzheimer’s disease
• Probably involved in sleep-wake cycle and arousal

(b) Pontomesencephalotegmental complex
  (i) Operates mostly on the dorsal thalamus
  (ii) In conjunction with NE & 5-HT regulates the excitability of sensory relay nuclei
  (iii) Links the brainstem and basal forebrain complexes

G) Drugs
  1) Most drugs of abuse act upon the diffuse modulatory systems, especially NE, DA and 5-HT
  2) Hallucinogens
     (a) LSD is a 5-HT agonist in presynaptic raphe neurons.
        (i) It inhibits neuron firing.
        (ii) Decreased raphe activity is associated dreamlike state
        (iii) Raphe destruction does not mimic LSD though and these animals still respond to LSD.
        (iv) LSD probably works by interfering with 5-HT in the cortex where perception and
             interpretation normally occur

3) Stimulants
   (a) Cocaine and amphetamines work on the DA & NE systems
      (i) Increase alertness
      (ii) Increase self-confidence
      (iii) Increase exhilaration & euphoria
      (iv) Sympathomimetic
   (b) Block reuptake
      (i) Cocaine blocks reuptake of DA more specifically
      (ii) Amphetamines block the reuptake of both DA and NE
           • Also release DA
      (iii) Inhibiting the production of catecholamines blocks the effects of cocaine and
            amphetamines
      (iv) Addiction effect through stimulation of the mesocorticolimbic DA system