CNS
Brain and spinal cord

Brain = two cerebral hemispheres, brainstem, cerebellum,

Diencephalon = thalamus/hypothalamus/pituitary

Spinal cord = ascending and descending axons, interneurons, autonomic neurons, sensory neurons

Cerebral hemispheres divided into lobes; connected by a layer of axons called the corpus callosum; takes care of collection and integration of sensory input, regulation of mood and behavior, and higher order thought processes

Brainstem divided based on development into areas called the midbrain, the pons and the medulla; regulates basic functions such as breathing, heart rate, and digestion
Cerebrum

Association areas = integration and direction of voluntary behaviors
Fields = areas where sensory information comes in and is integrated into perception
Limbic system

• Amygdala – emotion and memory
  • NMDA receptors
• Hippocampus – learning and memory
  • NMDA receptors
  • GABA receptors
• Basal ganglia (corpus striatum) – control of movement
  • GABA receptors
The **NMDA receptor complex**. Activation (i.e., excitation) occurs when either glutamate (Glu) or N-methyl-d-aspartate (NMDA) and glycine (Gly) bind to the receptor molecule. A channel within the receptor complex enables molecules to cross the cell membrane. Magnesium (Mg) blocks this channel. When Mg is removed from the channel and the receptor is activated, calcium (Ca++) and sodium (Na+) ions enter the cell and potassium ions (K+) leave.

These cells can stay depolarized for long periods of time (up to days in some receptors). This is the basis of memory formation and is termed **long term potentiation**.
Diencephalon

- Thalamus – relay station for sensory information to limbic system, cortex, cerebellum
  - GABA, serotonin, and dopamine receptors and neurons
- Hypothalamus – centers for behavioral drives, biological clock, key in homeostasis mechanisms
Cerebellum

- Interprets sensory information and produces appropriate coordinated movement
- Norepinephrine is major neurotransmitter
Brainstem

- Divided into three main parts: medulla oblongata, pons, mesencephalon (midbrain)
- Cranial nerves emerge from this area; sensory and motor information to/from the head and neck, as well as the *vagus* nerve that innervates and receives information from many internal organs
- Medulla = cross-over of information; control centers for blood pressure, breathing, swallowing, vomiting
- Pons – relay station for information going between cerebellum and cerebrum
- Mesencephalon – controls eye movement; relays for auditory and visual cortex

Reticular formation runs through the brainstem – arousal/sleep, muscle tone, modulation of pain
• Function in cerebral hemispheres is not identical; “right brain-left brain”

• Hemispheres communicate with one another through a large set of myelinated axons called the corpus callosum

**What generalization can you make about right brain function? Left brain function?**

**Which side would be “dominant” in right handed people?**
Sensory stimuli

Cerebral cortex: integration occurs within the association areas of this part of the brain

Integrated information passed on to the Limbic system creates emotion

Feedback creates awareness of emotions

Hypothalamus and brain stem initiate

Somatic motor responses (voluntary and unconscious)

Autonomic responses

Endocrine responses

Immune responses

KEY:
- Yellow: Stimulus
- Red: Integrating center
- Green: Systemic response
Muscle tension/length, blood pressure, pH/O2 content of blood, pH of CSF, lung inflation, osmolarity of body fluids, blood glucose, distention of gut

Types of Sensory Receptors:

- Chemoreceptors
  Examples:

- Mechanoreceptors
  Examples:

- Thermoreceptors
  Examples:

- Photoreceptors
  Examples:

- Nociceptors
  Examples:
• Receptors can be free nerve endings or more complex receptors covering the nerve endings.
• Axons can be either myelinated or unmyelinated
• Heat, cold, pain, touch, pressure, proprioception
• *Conscious* perception of information
Special Senses

- Highly specialized receptors; some are neural in origin and morphology, many are non-neural in origin and morphology
  - Non neural = taste buds (epithelial cells), photoreceptors
  - Neural = smell
Characteristics of Sensory Neurons

- **Receptive fields**: convergence results in a larger perceived receptive field
- Stimuli converted into graded potentials or change in membrane potential
- Threshold is the minimum stimulus required to activate a receptor
- Coding and processing of stimuli allows us to determine the stimulus type, intensity, location, and duration
  - **Type** determined by the cortex in response to where the input comes from; 1:1 association between type of receptor and sensation is called *labeled line coding*
  - **Location** determined by which group of neurons in the cortex is activated; topographical organization of the sensory areas of the cortex; *lateral inhibition* is also used

- **Intensity** of stimulus – *population coding* and *frequency coding*
- Duration of stimulus – duration of action potentials; some neurons turn off after a certain amount of time (*adaptation*)
  - Tonic receptors – slow to adapt
  - Phasic receptors – adapt rapidly
Lateral Inhibition helps in determining location
Intensity and duration of stimulus are frequency coded
Autonomic Nervous System

- Often work in opposition
- Cooperate to fine-tune homeostasis
- Both may fire tonically; dominant system produces effect
- Regulated by the brain; hypothalamus, pons and medulla
- Can also be regulated by spinal reflexes; no higher order input
- Pathways both consist of a two neuron system

Preganglionic neuron → autonomic ganglion → postganglionic neuron → target
from CNS outside CNS
Parasympathetic

- Sometimes called the “cranio-sacral division
- Long preganglionic neurons; short postganglionic neurons (often in the target organ)
- Preganglionic neurons secrete Ach on to nicotinic receptors
- Postganglionic neurons secrete Ach on to muscarinic receptors
- Target tissues are smooth muscle, cardiac muscle, exocrine glands, brown fat
Sympathetic

- Sometimes called the “thoraco-lumbar” division
- Short preganglionic neurons; long postganglionic neurons; ganglia are called the chain ganglia
- Preganglionic neurons secrete Ach onto nicotinic receptors
- Postganglionic neurons secrete NE on to α or β receptors
- Target tissues are smooth muscle, cardiac muscle, endocrine glands, brown fat
B1 found on heart muscle and in certain cells of the kidney

B2 found in certain blood vessels, smooth muscle of airways; found where sympathetic neurons ARE NOT

A1 receptors are found most commonly in sympathetic target tissues

A2 receptors are found in the GI tract and pancreas (relaxation)
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<td>Uterus</td>
<td>Depends on stage of cycle</td>
<td>Depends on stage of cycle</td>
<td>α β2</td>
</tr>
</tbody>
</table>

*Hormonal epinephrine only
Sympathetic nerve endings also activate the release of NE and E from the adrenal medulla

Enhances effects of NE from sympathetic nerve endings

Adds the effects of E to the overall arousal ("fight or flight") pattern