Outline

I. Central Nervous System vs Peripheral Nervous System

II. Peripheral Nervous System
   A. Somatic Nervous System
   B. Autonomic Nervous System

III. Autonomic Nervous System
   A. Parasympathetic Nervous System
   B. Sympathetic Nervous System

IV. Reflex Actions

V. Central Nervous System
   A. Protection of CNS
   B. Spinal Cord
   C. Brain
Two Parts of the Nervous System

- **Central Nervous System (CNS)**
  - Brain and Spinal Cord

- **Peripheral Nervous System (PNS)**
  - Nervous tissue outside brain and spine
  - Sensory organs
**Peripheral Nervous System**

- **Somatic nervous system** – division of PNS that controls **voluntary** functions.
  - Responsible for movement, controls skeletal muscles

- **Autonomic nervous system** – division of PNS that controls **involuntary** functions.
  - Controls cardiac and smooth muscles, and glands
Autonomic Nervous System is divided into two systems:

- **Parasympathetic division** – “rest and digest”

- **Sympathetic division** – stimulatory stress responses…
  - “flight or fight”
Figure 8.1 The nervous system

Central nervous system
Brain and spinal cord

Peripheral nervous system

Sensory Input
- Input from sensory receptors responding to external stimuli
- Input from sensory receptors in skin, muscles and joints
- Input from sensory receptors in internal organs

Motor Output

Somatic nervous system
Directs voluntary movements

Autonomic nervous system
Regulates involuntary bodily activities, such as heart rate and breathing rate

Parasympathetic nervous system
Governs bodily activities during restful conditions

Sympathetic nervous system
Prepares body for stressful or emergency situations
Parasympathetic Nervous System

- Constricts pupil
- Increases salivation
- Decreases breathing rate
- Slows heart rate
- Widens blood vessels
- Increases digestive activity
- Increases digestive activity
- Contracts bladder muscles
- Stimulates defecation

Synapse between neurons

(Cranial and sacral regions of spinal cord)
Parasympathetic – Rest and Digest

- Constricts eye pupils
- Stimulates salivation
- Slows heart rate
- Constricts breathing
- Dilates blood vessels
- Stimulates digestion
- Constricts bladder
- Stimulates sex organs
**PNS – Sympathetic Nervous System**

Sympathetic Nervous System
(Thoracic and lumbar regions of spinal cord)

- Dilates pupil
- Decreases salivation
- Increases breathing rate
- Increases heart rate
- Narrows blood vessels
- Slows digestive activity
- Slows digestive activity
- Stimulates secretion of epinephrine and norepinephrine
- Causes salt and water retention
- Relaxes bladder muscles
- Inhibits defecation
- **Ganglion**
Sympathetic – Fight or Flight

- Dilates eye pupils
- Inhibits salivation
- Accelerates heart rate
- Facilitates breathing
- Stimulates secretion of epinephrine and norepinephrine
- Stimulates release of free glucose
- Inhibits digestion
- Relaxes bladder
- Inhibits sex organs
Reflex Actions

- Sometime the body requires a very fast response, such as reacting to a hot stove.
  - We may not have time to send the message all the way up to the brain to process the information.

- The spinal cord can process the information and send a response back to the motor nerves.
Reflex Arc

- The pathway consisting of a sensory receptor, a sensory neuron, interneurons, a motor neuron, and an effector (muscle or target organ).
Which division of your PNS controls voluntary functions?

1. Autonomic
2. Somatic
This division of your PNS inhibits digestion:

1. Parasympathetic
2. Sympathetic
This division of your PNS slows heart rate and lowers blood pressure:

1. Sympathetic
2. Parasympathetic
Protection of the CNS

The CNS consists of the brain and spinal cord, which are vulnerable structures!

The CNS is protected by:

1. Bone (skull and vertebral column)
2. Meninges
3. Cerebrospinal fluid
4. Blood-brain barrier
Protection of the CNS

The bones of the skull and vertebral column are hard cases that protect the brain and spinal cord.

The meninges are three membranes that protect the brain and spinal cord.

Cerebrospinal fluid cushions the brain and spinal cord.
Meninges

- **Meninges** are protective membranes (connective tissue) that cover the brain and spinal cord.

- There are three layers of the meninges:
  1. **Dura mater** – outer layer
     - Tough, thick, and leathery
  2. **Arachnoid mater** – middle layer
     - Contains thin, spider web-like extensions connecting to the pia mater
  3. **Pia mater** – inner layer
     - Delicate, molded closely along the surface of the CNS
Meningitis

- **Meningitis** – inflammation of the meninges.

- It is caused by many forms of bacteria and viruses.

- If the infection spreads to the underlying brain tissue, it can lead to **encephalitis**, an inflammation of the brain.
  - This is a VERY serious condition!
Cerebrospinal Fluid (CSF)

- Fluid produced in the ventricles of the brain.
- CSF fills:
  - Ventricles
  - In-between the meninges
  - Central canal of the spinal cord.

- **Functions:**
  1. Shock absorption
  2. Support the weight of the brain
  3. Nourishment and waste removal
Blood-Brain Barrier

- Formed by the **tight junctions** between the cells lining the blood vessels of the brain.

- Permits certain substances to enter the brain, while inhibiting others from entering.

- It inhibits many drugs that are not lipid-soluble from reaching brain tissue.
The innermost layer of the meninges is the:

1. Pia mater
2. Dura mater
3. Arachnoid mater
Where is CSF found?

1. Central canal of spinal cord
2. Ventricles
3. Between meninges
4. All of the above!
The blood-brain barrier is formed by which kind of junctions?

1. Adhesion
2. Gap
3. Tight
Spinal Cord

- Spinal cord extends from the base of the brain down the back, and transmits messages between the brain and the rest of the body.

- There is cerebrospinal fluid located in a central canal in the spinal cord.
If you look at a cross section of the spinal cord you will see “white matter” and “gray matter”.

- The white matter is myelinated axons.

- Gray matter is mainly cell bodies and non-myelinated axons.
Spinal Cord

(a) View from front of body

White matter
Gray matter
Dorsal root
Dorsal-root ganglion
Ventral root
Pair of spinal nerves
A Tour of the Brain…

- Cerebrum
  - Cerebral cortex
  - Hippocampus
  - Amygdala
- Hypothalamus
- Thalamus
- Cerebellum
- Brain stem – midbrain, pons, medulla oblongata
- (Pineal gland and pituitary gland are in the brain, but they are part of the endocrine system.)
The Brain

- The brain is the control center of the body!
- Weighs less than 3 pounds, and yet is responsible for all the unconscious functioning of the body, as well as the conscious thought.
- The cerebral cortex of the cerebrum is the thinking, conscious part of the brain.
Cerebrum

- Contains:
  - Cerebral cortex
  - Hippocampus
  - Amygdala

- Functions:
  - Sensory area for touch, vision, hearing, and olfaction
  - Motor area for voluntary movement
  - Association area for sensation interpretation, language, thinking, decision-making, self-awareness, creativity, and memory storage
Cerebral cortex – thin outer layer of the cerebrum where most of the higher thinking and processing takes place.

- Contains sensory areas
- Prefrontal region of the cerebral cortex is responsible for decision making
- Folding increases surface area
Cerebrum – Cerebral Cortex

Longitudinal fissure

Right hemisphere

Left hemisphere
Beneath the cortex is white matter, which looks white due to the high density of myelinated axons.

- **Corpus callosum** – band of white matter that connects the two cerebral hemispheres.
Cerebrum and Corpus Callosum

**Cerebrum**
- Contains sensory areas for skin senses, vision, hearing, olfaction
- Motor areas for voluntary control of movement
- Association areas for interpreting sensations, language, thinking, decision making, self-awareness, creativity, and storage of memories

**Corpus callosum**
- Allows left and right cerebral hemispheres to communicate with one another
Gray matter consists of interneurons, cell bodies, and unmyelinated axons that integrate information.

White matter consists of myelinated axons that allow communication over long distances.

The corpus callosum is a band of white matter that allows communication between the cerebral hemispheres.
Cerebrum

- **Hippocampus** – important in long-term memory.

- **Amygdala** – important in remembering fear and responding to it.
Memory (the Limbic System)
Thalamus

- **Thalamus** – processes sensory information (except smell) and relays it to other areas of the brain.
Hypothalamus

- **Functions:**

1. Maintains homeostasis: controls heart rate, blood pressure, breathing rate, body temperature
2. Regulates drives such as hunger
3. Controls the pituitary gland
The Brain

Figure 8.3 (2 of 2)

**Thalamus**
- Processes all sensory information (except olfaction)
- Relays information to appropriate higher brain centers

**Hypothalamus**
- Controls heart rate, blood pressure, breathing rate, body temperature, food intake
- Is a center for emotions
- Serves as “master biological clock”
Cerebellum – maintains balance and coordination, refines motor skills, helps learn new motor skills.
Cerebellum

- Coordinates sensory–motor voluntary movement
- Stores memory of learned motor patterns
Brain Stem

- Contains:
  - Medulla oblongata
  - Midbrain
  - Pons
Brain Stem – Medulla Oblongata

- **Functions:**
  - Controls many vital involuntary functions including breathing, heart rate, and blood pressure
Brain Stem – Pons

- Functions:
  - Assists the medulla oblongata to control involuntary breathing
  - Relays messages between the spinal cord/cerebellum, and the cerebrum, thalamus, and hypothalamus
Brain Stem - Midbrain

Functions:

- Important in voluntary muscle control
- Relay station for auditory and visual information
- Relays information between the cerebellum/spinal cord and the cerebrum
- Controls eye movement
The Brain

Brainstem

**Midbrain**
- Relays information between the cerebellum or spinal cord and the cerebrum
- Integrates sensory input

**Pons**
- A bridge between higher and lower brain centers

**Medulla oblongata**
- Contains autonomic centers for heart rate and digestive activities
- Relays sensory information to thalamus
Glands

- Pituitary gland and pineal gland are part of the brain but will be covered as part of the endocrine system!
Which region of the brain is the region where most of the higher thinking and processing takes place?

1. Amygdala
2. Hippocampus
3. Cerebral cortex
4. Hypothalamus
Which region of the brain is the region important in long-term memory?

1. Amygdala
2. Hippocampus
3. Cerebral cortex
4. Hypothalamus
Which region of the brain regulates drives including hunger, maintains homeostasis, controls the pituitary gland?

1. Amygdala
2. Hippocampus
3. Cerebral cortex
4. Hypothalamus
Which region of the brain is important in remembering fear and responding to it?

1. Amygdala
2. Hippocampus
3. Cerebral cortex
4. Hypothalamus

Amygdala
Hippocampus
Cerebral cortex
Hypothalamus

25% 25% 25% 25%
Important Concepts

- Read Chapter 8

- What are the somatic nervous system and autonomic nervous system, and what do they each control?

- What are reflex actions?

- What are the parasympathetic and the sympathetic divisions of the autonomic nervous system?
  - What specifically do they control (increase heart rate, increase respiration, etc.)?
Important Concepts

- What protects the CNS
- What are the three layers of the meninges?
  - Be able to describe them and their locations (which is the inner, middle, or outer layer.)
- What is meningitis and what is the cause? What is encephalitis?
- What are the functions of cerebrospinal fluid?
- What is the function of the blood-brain barrier, and what does it allow to pass?
Important Concepts

- Major regions of the brain and their functions: cerebrum (including the cerebral cortex, hippocampus, and amygdala), hypothalamus, thalamus, cerebellum, brain stem (including the midbrain, pons, and medulla oblongata)

- Which parts of the brain are in the cerebrum and which parts are in the brain stem?

- What is the corpus callosum, and what is its function?
Definitions

- Long-term memory, somatic nervous system, autonomic nervous system, voluntary, involuntary, reflex arc, constrict, dilate, inhibit, accelerate, facilitate, stimulate, relax, white matter, gray matter, prefrontal region