Chapters 11: Introduction to the Nervous System and Nervous Tissue

**Nervous system** – controls our perception and experience of world
  - Directs __________ movement
  - Seat of consciousness, personality, learning, and memory
  - Regulates __________

→ **Module 11.1: Overview of the Nervous System**

**Anatomical Divisions of the Nervous System**

[2 Anatomical Div. = CNS, PNS]

1. ________ – includes **brain** and **spinal cord**

2. ________ – consists of all **nerves** in body outside protection of skull and vertebral column (cranial nerves, spinal nerves)

**Functional Divisions of the Nervous System**

[3 Functional Div. = Sensory, Integrative, Motor]

1.
   - **sensory receptors** gather information about internal and external environments
     - **afferent division** carries information toward CNS
       a. __________ sensory division
          - signals from ____________, bones, joints, and skin;
       - **special sensory div.** (vision, hearing, taste, smell, and balance)
       b. __________ sensory division
          - signals from __________ (organs)

2. __________ functions – analyze and interpret incoming sensory information and determine response
3. ___________ functions

– actions performed in response to integration

- ___________ division carries information away from CNS
  a. ___________ nervous system – info to skeletal muscle
  b. ___________ nervous system (ANS) – information to smooth muscle, cardiac muscle, glands

Module 11.2: Nervous Tissue

Neurons

Neurons – excitable cell type responsible for sending and receiving signals in form of action potentials (AP)

A. Structure of neurons

1.

nucleus, cytoplasm with organelles, ___________ (RER, gray color)

2. Cytoplasmic extensions (processes):

___________ – receive information from other neurons, conduct impulse toward soma

___________ (nerve fiber) – conducts impulse away from soma, includes axon hillock, axon terminals (synaptic knobs)

Poliovirus and Retrograde Axonal Transport

• ___________ – caused by poliovirus; infection that impacts CNS (especially SC) → deformity and paralysis

• No cure exists, but prevented by vaccination

• Virus accesses CNS by entering muscle cells → motor neurons at NMJ → retrograde axonal transport until reaching SC

• Other viruses (herpes simplex, rabies) and toxins (tetanus) can to invade via this method
Classification of Neurons

- **Structural:**
  - ___________ neurons – single axon and multiple dendrites, > 99% of all neurons (motor)
  - ___________ neurons – one axon, one dendrite, and cell body between them; found in eye and olfactory epithelium (sensory)
  - ___________ neurons – have only one fused axon that extends from cell body and divides into two processes (sensory)

- **Functional:**
  - ___________ (afferent neurons) – carry information toward CNS; pseudounipolar or bipolar
  - ___________ (association neurons) – relay information within CNS between sensory and motor neurons; make up most of neurons in body; multipolar
  - ___________ (efferent neurons) – carry information away from cell body in CNS to muscles and glands; multipolar

**Neurons**

- Specific neuron components group together:

  **CNS:**
  - ___________ – clusters of neuron cell bodies
  - ___________ – bundles of axons

  **PNS:**
  - ___________ – clusters of neuron cell bodies
  - ___________ – bundles of axons
Neuroglia

- ____________ – provide support and protection for neurons, maintain their environment, divide and fill space when a neuron dies

- CNS:
  - Oligodendrocytes
  - Ependymal cells
- PNS:
  - Schwann cells

- CNS:
  ____________ – large star-shaped cells

Facilitate transport of nutrients and gases between blood vessels and neurons; form blood-brain barrier (BBB)

- ____________ – form myelin in CNS
- ____________ – activated by injury into phagocytic cells
- ____________cells – ciliated cells that manufacture and circulate CSF

- PNS:
  - ____________cells – produce myelin
  - ____________cells – supportive functions

The Myelin Sheath

___________ = repeating layers of phospholipid plasma membrane, insulation

Nodes of Ranvier = gaps between myelin sheaths

___________ = myelinated axons

___________ = neuron cell bodies, unmyelinated processes
Regeneration of Nervous Tissue

Regeneration nearly nonexistent in CNS and is limited in PNS

- **Regeneration** steps:
  1. Degeneration of axon and myelin sheath **distal** to injury (*Wallerian degeneration*)
  2. _________ _________ from proximal end of axon
  3. Schwann cells form **regeneration tube**
  4. **Single growth process grows** into regeneration tube
  5. **New axon is** ____________ to its target cell

Gliomas and Astrocytomas

- **Primary brain tumors** – originate in brain; most are ____________ (caused by abnormally high rate of division of glial cells)
- **Predisposing conditions** – exposure to ionizing radiation and certain diseases
- Most commonly affected cell is ____________ → tumor is called ____________

  Range in severity from mild with good prognosis to highly aggressive with very poor prognosis

  **Treatment** – varies with tumor type, age, and health of patient; usually involves surgical removal of mass with chemotherapy and perhaps radiation therapy

→ Module 11.3: Electrophysiology of Neurons

**Introduction to Electrophysiology of Neurons**

- All neurons are excitable or responsive to stimuli (chemical, electrical, and mechanical)
- Stimuli generate electrical changes across plasma membrane (PM)
  - ____________potentials – travel short distances
  - ____________potentials – travel entire length of axon; begin at trigger zone →
  → axon terminal
• Ion channels – ions must rely on specific protein channels for diffusion

• Resting Membrane Potential (RMP) = -__________

due to difference in distribution of ions across PM

Principles of Electrophysiology: Types of Ion Channels

__________ - Ions follow conc. gradient
__________ - Open in response to specific chemical binding
__________ - Open or close due to changes in voltage across PM
__________ - Open or close due to mech. stim. (stretch, press., vibration)

Principles of Electrophysiology

RMP =

Cell is polarized (positive on outside, negative on inside of PM)

Diffusion of ions across PM determined by Electrochemical Gradient:

• Electrical gradient:
  __________ on ____________, __________ on __________ of plasma membrane

• Chemical Gradient:
  ______ outside > Na+ inside
  ______ inside > K+ outside

How Do Positive Ions Create a Negative Resting Membrane Potential

• A neuron that has no membrane potential; charges are distributed equally across plasma membrane

• Now, imagine that a potassium ion diffuses out of cytosol down concentration gradient through a leak channel…

• Six positive charges are now outside membrane and four positive charges inside; makes overall charge inside cytosol −1 and in extracellular fluid +1—a membrane potential has been created
• Imagine that many thousands of potassium ions exit through leak channels; causes membrane potential to become progressively more negative

**Changes in Resting Membrane Potential: Ion Movements:**

• ___________ – Na+ channels open, Na+ flow into cell; membrane potential becomes more positive

• ___________ – K+ ion channels open; K+ flow out of cell; cell becomes more negative, returning to RMP

• ___________ – cell becomes more negative than normal RMP due to efflux of K+ plus influx of Cl-

---

**Local Potentials**

__________ potentials – serve as triggers for long-distance AP

• May cause:

__________ – positive charges enter cytosol and make membrane potential less negative (−70 to −60 mV)

__________ – either positive charges exit or negative charges enter cytosol; makes membrane potential more negative (−70 to −80 mV)

• Sometimes called ____________ potentials because vary greatly in size

---

**Action Potentials**

• Events in an Action Potential:

1. Local potential must be able to depolarize axon strongly enough to reach ____________ (usually −55 mV)

2. **Depolarization** – sodium ions rush in (___________)

3. ____________ – potassium ions rush out (___________)

4. **Hyperpolarization** may occur
Local Anesthetic Drugs

- **Local anesthetics** – (like ____________) commonly administered agents for surgical or dental procedures; produce temporary numbness in specific area

- Block voltage-gated sodium channels of neurons in treated area; prohibits depolarization and therefore action potentials relaying pain are not transmitted to CNS

- Nonselective; also affect sodium channels in muscles of area; causes temporary paralysis; reason for crooked smiles and drooling following dental work

**Refractory Period**

- ___________ period – period of time, after neuron has generated an AP, when neuron cannot be stimulated to generate another AP

- ___________ refractory period – when no additional stimulus (no matter how strong) is able to produce additional AP

- ___________ refractory period – immediately after absolute refractory period; only a strong stimulus can produce AP

**Local and Action Potentials Compared**

Graded local potentials produce variable changes in membrane potentials

___________ potentials cause a maximum _____________ to +30 mV

- **All-or-none principle** – AP that either happens completely or not at all

If a neuron does not depolarize to threshold then no AP will occur

AP are not dependent on strength, frequency, or length of stimulus like local potentials

**Propagation of Action Potentials**

APs **conducted** (___________) along entire length of axon =

- unidirectional

- Each AP triggers next section of axon, usually starting at trigger zone and ending at axon terminals
Conduction speed – influenced by both axon diameter and presence or absence of myelination

– Presence or absence of ____________ gives rise to 2 types of conduction:
  – ____________ conduction – myelinated processes exhibit “jumping” type of conduction, ____________ rate
  – ____________ conduction – unmyelinated processes, _______ rate of conduction

Saltatory conduction –myelinated axons increase speed of conduction; AP only depolarize nodes of Ranvier and “jump over” ____________

Continuous conduction – in unmyelinated axons every section of axolemma from trigger zone to axon terminal must propagate AP; slower conduction speed

• Classification of Axons by Conduction Speed:

Type A fibers – ______ diameter (120 m/sec or 250 mi/h); (5–20 µm) and ____________; sensory and motor axons associated with skeletal muscle and joints

Type B fibers – ____________ diameter, slower conduction speeds (15 m/sec or 32 mi/hr); mostly ____________ with intermediate diameter axons (2–3 µm); ANS efferent fibers, some sensory

Type C fibers – ____________ diameter, slowest conduction speeds (0.5–2 m/sec or 1–5 mi/hr); (0.5–1.5 µm); ____________ ANS efferent fibers and sensory axons (transmit pain, temperature, and pressure)

Multiple Sclerosis

• Multiple sclerosis (MS) – certain cells of immune system attack myelin sheaths within CNS; type of ____________ ____________ (patient’s own immune system attacks part of body)

• Causes progressive loss of myelin sheath; in turn causes loss of current from neurons
• **Symptoms** – result from progressive slowing of AP propagation; symptoms depend on region of CNS affected; most exhibit changes in sensation (e.g., numbness), alterations in behavior and cognitive abilities, and motor dysfunction, including paralysis

→ **Module 11.4: Neuronal Synapsis**

**Overview of Neuronal Synapses**

- _____ _____ – where a neuron meets its target cell (in this case another neuron) is called a **neuronal synapse**
  - electrical (gap junctions) – breathing, cardiac & SMC
  - _____ _____ – most synapses
    - can occur between an axon of one neuron and another part of another neuron (dendrite, soma, axon)
    - Presynaptic neuron → _____ _____ → Postsynaptic neuron

**Chemical Synapses**

- **Events at a Chemical Synapse:**
  - multiple neurons secreting many different types of excitatory or inhibitory neurotransmitters

  1. AP in presynaptic neuron triggers ________ **ion channels** in axon terminal to open
  2. _____ _____ of calcium ions causes synaptic vesicles to release neurotransmitter into synaptic cleft
  3. Neurotransmitters **bind to** _____ _____ on postsynaptic neuron
  4. **Ion channels open, leading to a local potential and possibly an AP if threshold is reached**

**Postsynaptic potentials** – can be **Excitatory** or **Inhibitory**:

  a. **Excitatory postsynaptic potential (EPSP)** = Membrane potential moves _____ _____ to threshold
  b. **Inhibitory postsynaptic potential (IPSP)** = Membrane potential moves _____ _____ away from threshold
Arthropod Venom

- **Venomous arthropods** (in United States) include spiders and scorpions; many of their venoms affect neuronal synapses; termed **neurotoxins**
  - ___________ (Latrodectus mactans) – toxin causes massive release of neurotransmitter leading to repetitive stimulation of postsynaptic neuron
  - ___________ – most lethal of 40 species in United States; venom prevents postsynaptic sodium channels from closing; membrane remains polarized and continues to fire action potentials

- Mechanisms are different but result is similar; both lead to overstimulation of postsynaptic neuron;
- **Common symptoms** – muscle hyperexcitability, sweating, nausea and vomiting, and difficulty breathing
- **Treatment and prognosis** – depends on amount of venom received and availability of medical care; severe cases usually require ___________ to block effects of toxin

---

**Neural Integration**

- Neurons receive input, both inhibitory and excitatory, from multiple neurons, each of which influences whether an action potential is generated
- ___________ ___________ – process in which postsynaptic neuron integrates all incoming information into a single effect

→ **Module 11.5: Neurotransmitters**

**Neurotransmitters**

- Over 100 known neurotransmitters

4 groups:

1. ___________ (acetycholine)- E [___________]
2. Biogenic amines: E

   Catecholamines (NE, Epi (adrenaline), dopamine) [___________]

   Serotonin

3. Amino acids: (Glutamate – E; GABA - Inhib.)

4. Neuropeptides: E and I (endorphins)

**Psychiatric Disorders and Treatments**

- **Psychiatric disorders** affect thought processes; generally treated by modifying synaptic transmission to change how neurons communicate

- **Psychopharmacology** (study of drugs that affect higher brain functions) targets either AP generation or some aspect of neurotransmitter physiology:

  ___________ – repetitive **psychotic episodes** (periods during which patient is unable to appropriately test beliefs and perceptions against reality); thought to result from excessive release of dopamine; management involves blocking postsynaptic dopamine receptors

  ___________ disorders – marked by disturbances in mood; decreased levels of serotonin, norepinephrine, and/or dopamine; most widely used antidepressants are **selective serotonin reuptake inhibitors (SSRIs)**

  ___________ – characterized by exaggerated and inappropriate fear responses; abnormalities in norepinephrine, serotonin, and GABA transmission; drugs for treatment include antidepressants, GABA activity enhancers

  ___________ – characterized by episodes of abnormal elevated mood (mania) followed by depression; treatments involve decreasing ease of AP generation
Module 11.6: Functional Groups of Neurons

**Neuronal Pools**
- Groups of interneurons within CNS:
  - Composed of neuroglial cells, dendrites, and axons in one location and cell bodies in another location
  - Connections between pools allow for complex mental activity (planned movement, cognition, and personality)

**Neuronal Circuits**
- **Neural circuits** – patterns of synaptic connection between neural pools
  - _________ circuits
    - one neuron sends impulses to multiple postsynaptic neurons
    - incoming sensory information sent from SC to different neuronal pools in brain for processing
  - _________ circuits
    - axon terminals from multiple neurons converge onto a single postsynaptic neuron
    - respond to sensory information
Chapter 12: The Central Nervous System

CNS =
- involved in movement, interpreting sensory, maintaining homeostasis, and functions relating to mind

→ Module 12.1: Overview of the Central Nervous System

Overview of CNS Functions

- Functions of nervous system:
  - ___________ functions muscles contract, glands secrete (PNS)
  - ___________ functions – sensations in and outside body (PNS)
  - ___________ functions – include decision-making processes (CNS)
    - Interpretation of sensory information
    - Planning and monitoring movement
    - Maintenance of homeostasis
    - Higher mental functions such as language and learning

Basic Structure of the Brain and SC

- Brain – soft, whitish-gray organ in cranial cavity, continuous with SC
  - mostly nervous tissue; some epithelial and CT
    - ___________ filled with cerebrospinal fluid (___________)
    - ~20% of cardiac output; requires large amounts of O₂, glucose, and nutrients

4 divisions of brain:
- ___________
  - left and right hemispheres
  - higher mental functions, sensory & motor
• ____________ - deep to hemispheres
  - process, integrate & relay; homeostasis; bio rhythms
• ____________ - inferior to occipital lobe
  - voluntary motor activities
• ____________ = midbrain, pons, medulla oblongata
  - reflexes, homeostasis, relay information

__________ – located in **vertebral cavity**
  - Extends from foramen magnum to L1 & L2
  - Length ~ 45 cm (17–18 inches)
  - Diameter 0.65–1.25 cm (0.25–0.5 inches)
  - ____________ – CSF filled cavity within SC, continuous with brain’s ventricles

**White matter** – found in both brain and SC; (___________ axons)

__________ = bundles of white matter (processes in CNS)

__________ = clusters of cell bodies and dendrites (gray matter)

__________ **matter** – found in both brain and SC;
  - (cell bodies, dendrites, and unmyelinated axons)
    1. Cerebral cortex is gray matter
    2. Center H (butterfly)-shape of SC

➔ **Module 12.2: The Brain**

**The Cerebrum**

• ____________ – shallow grooves on surface of cerebrum
• ____________ - elevated ridges found between sulci
• **Corpus callosum** – connects right & left hemispheres
• **fissure** – deep groove that separates left and right cerebral hemispheres
• **Transverse fissure** – separates occipital lobe from cerebellum
• _________ – CSF-filled cavities, one in each hemisphere

Five lobes are found in each hemisphere:

- **Frontal lobe** (motor, complex mental fcn.)
- **Parietal lobe** (__________)
- **Temporal lobe** (__________)
- **Occipital lobe** (__________)
- **Insula** (__________)

**Cerebral Cortex** = gray matter, covers cerebral hemispheres
- All neurons in cortex are interneurons
- Functions of neocortex (most recently evolved part of brain) include conscious processes as planning **movement**, interpreting incoming **sensory** information, and **complex higher functions**

**Gray Matter: Cerebral Cortex:**
- Neocortex is divided into three areas: [Motor, Sensory, Association]

1. **motor cortex** – plans and executes movement
   - located in frontal lobe (pre-central gyrus)
     - **cortex** – anterior to primary motor cortex, plan and carry out movement
     - **eye fields** - back and forth eye movements as in reading

2. **Primary sensory cortices** – receive and process sensory input
   - Somatosensory areas – in postcentral gyrus of parietal lobe; cutaneous (temp. & touch)
   - Visual areas –
   - Auditory areas –
- Gustatory cortex – insula and parietal
- Olfactory cortex –

3. **Association areas** integrate different types of information
   - ____________ – produce speech sounds
   - **Prefrontal cortex** – most of frontal lobe, fcn. in behavior, personality, learning, memory
   - **Parietal & temporal association cortices** – integrate sensory info, attention

• **Basal nuclei**
  - masses of gray matter deep within each hemisphere
  - Caudate nuclei
  - Putamen
  - Globus pallidus

• **Limbic system**
  - includes limbic lobe, hippocampus, amygdala
  - connect these regions of gray matter with rest of brain
  - Found only within mammalian brains

**The Diencephalon**

**Diencephalon** – located in center of brain between hemispheres above brainstem
- 4 parts: Thalamus, Hypothalamus, Epithalamus, Subthalamus
Gateway for sensory info. to cerebral cortex

Receives all sensory (except smell)

- Regulation of ANS, sleep/wake cycle, thirst and hunger, and body temperature

Secretes hormones that reg. pituitary & other glands

- ____________ – superior to thalamus; includes endocrine gland called **pineal gland** that secretes **melatonin**; hormone involved in sleep/wake cycle

- ____________ – inferior to thalamus; functionally connected with basal nuclei; together, they control movement

**Cerebellum**

- located inferior to occipital lobe

- - arbor vitae

**Brainstem**

- vital to our immediate survival

- Includes midbrain, pons, medulla oblongata

- surrounds **cerebral aqueduct** (connects third and fourth ventricles)

- **Superior** and **inferior ____________**: involved in visual and auditory reflexes respectively

- **Substantia nigra** – works with basal nuclei to control movement; produces dopamine

- ____________ – inferior to midbrain
- Regulation of movement, breathing, reflexes, and complex functions associated with sleep and arousal

• ______________ ____________ – most inferior structure of brainstem

- Regulation of breathing, and other vital activities

→ Module 12.3: Protection of the Brain

**Brain Protection**

Three features protect delicate brain tissue:

1. ______________ ____________ – three layers of membranes that surround brain

2. **Cerebrospinal fluid (CSF)** – fluid that bathes brain and fills cavities

3. **Blood-brain barrier** – prevents many substances from entering brain and its cells from blood

• **Cranial meninges**
  
  – composed of three layers:

  superficial to deep:

  epidural space

  a.

  subdural space

  b. (weblike)

  subarachnoid space (CSF filled)

  c. (in contact with brain tissue)

**The Ventricles and Cerebrospinal Fluid**

• **Four ventricles** within brain (1\textsuperscript{st} & 2\textsuperscript{nd} = lateral ventricles, 3\textsuperscript{rd} and 4\textsuperscript{th} ventricle connected via cerebral aqueduct)

  continuous with central canal of spinal cord

Lined with ______________ cells

Filled with ______________

• **CSF** (similar to plasma)
Produced by _______________ ____________

Reabsorbed by arachnoid villi (granulations)

~800ml produced daily, only 150ml at any time

Cushions brain, maintains temp., removes wastes, provides buoyancy

Infectious Meningitis

• Potentially life-threatening infection of meninges in subarachnoid space; inflammation occurs, causing classic signs: headache, lethargy, stiff neck, fever

• Diagnosis – examination of CSF for infectious agents and white blood cells (cells of immune system); bacteria and viruses are most common causative agents:

___________ – generally mild; resolves in 1–2 weeks

___________ – can rapidly progress to brain involvement and death; aggressive antibiotic treatment necessary; some most common forms are preventable with vaccines

→ Module 12.4: The Spinal Cord

The Spinal Cord

• ____________ – composed primarily of nervous tissue; responsible for both relaying and processing information (reflexes)

• Spinal Meninges (similar to cranial meninges)

___________ space – space between meningeal dura and walls of vertebral foramina; filled with veins and adipose tissue; cushions and protects spinal cord

___________ space – between arachnoid and pia mater; filled with CSF; base of spinal cord contains a large volume of CSF useful site for withdrawing samples laboratory testing

Epidural Anesthesia and Lumbar Punctures
• **Epidural (spinal) anesthesia** – local anesthetic medication is injected into epidural space through an inserted needle
  - Causes “numbing” (inability to transmit motor or sensory impulses) of nerves extending off spinal cord below level of injection
  - Commonly given during childbirth and other surgical procedures
• **_________ _________** (spinal tap) – needle inserted into subarachnoid space between L4 and L5; avoids possibility of injuring SC
  - CSF is withdrawn for analysis; used to assess conditions like meningitis, encephalitis and multiple sclerosis

**External Spinal Cord Anatomy**

- ___________ – extends from between L1 and L2 to coccyx
  - composed of spinal pia mater
- ___________ = bundle of spinal nerves contained in vertebral canal
- **Spinal nerves** (PNS); carry sensory and motor impulses to and from SC
  - Posterior (dorsal) nerve root –
  - Anterior (ventral) nerve root -

**Internal Spinal Cord Anatomy**

- Butterfly (H)-shaped spinal _______ matter is surrounded by tracts of white matter; ___________ – filled with CSF; seen in center of spinal cord
- **Anterior (ventral) horn** – motor neurons to skeletal muscle
- **Posterior (dorsal) horn** – sensory information
- **Lateral horn** – motor, visceral efferent (ANS)

→ **Module 12.5: Role of the CNS in Sensation**

**General Somatic Senses**

- **Role of Cerebral Cortex in Sensation, S1 and Somatotopy:**
  - ___________ relays most incoming information to **primary somatosensory cortex (S1)** in postcentral gyrus
Each part of body is represented by a specific region of S1, a type of organization called ____________

More S1 space is dedicated to hands and face; represents importance of manual dexterity, facial expression, and speech to human existence

**Phantom Limb Pain**

- **Phantom limb** – occurs after amputation of limb, digit, or even breast; patients perceive body part is still present and functional in absence of sensory input; small percentage develop **phantom pain** (burning, tingling, or severe pain) in missing part

- Difficult to treat due to complex way CNS processes pain; supports idea that S1 has “map” of body that exists independently of PNS

- Over time, map generally rearranges itself so body is represented accurately; phantom sensations decrease

→ **Module 12.6: Role of the CNS in Voluntary Movement**

**Role of Brain in Voluntary Movement**

- **Role of Cerebral Cortex** in Voluntary Movement:

  Primary motor cortex is organized somatotopically; certain body regions have disproportionately more cortical area devoted to them (especially lips, tongue, and hands); signifies importance of vocalization and manual dexterity to human survival

**Parkinson's Disease**

- One of most common movement disorders

- **Hypokinetic** = movement is difficult to initiate and once started, difficult to terminate

- **Symptoms** – minimal facial expression, shuffling gait, no arm swing, resting tremor

- **Cause** – degeneration of ____________ -secreting neurons of substantia nigra; genetics suspected in ~10% of cases

- **Treatment** – medications that increase level of dopamine
Module 12.7: Role of the CNS in Maintenance of Homeostasis

**Role of CNS in Maintenance of Homeostasis**

__________ is defined as maintenance of a relatively stable internal environment in face of ever-changing conditions

- **Homeostatic functions** include maintaining fluid, electrolyte, and acid-base balance; BP; BG and [O₂]; biological rhythms; and body temperature

Endocrine system secretes ____________ into blood; regulates functions of other cells (long term)

Nervous system sends ____________ ____________; excite or inhibit target cells (immediate)

**Homeostasis of Vital Functions**

- **Autonomic nervous system (______)**
  - Maintain vital functions (HR, BP, digestion)
  - Although ANS is a component of PNS, mainly controlled by hypothalamus

- ____________ is one of few vital functions not under ANS control; regulated by Pons and Medulla

- **Body Temperature** – reg. by ____________

**Fever**

- Elevation of body temperature can accompany variety of infectious and noninfectious conditions

- Due to ____________ (chemicals) secreted by cells of immune system and by certain bacteria; cross BBB and interact with hypothalamus (control temp.)

- Pyrogens increase hypothalamic set point to higher temperature; feedback loop triggers shivering and muscle aches due to increased muscle tone; VC of blood vessels to skin

- ____________ (acetaminophen and aspirin)- work by blocking formation of pyrogens; hypothalamus returns to normal set point
Dementia

• Patients with dementia exhibit a progressive loss of recent memory, degeneration of cognitive functions, and changes in personality

• No proven method for prevention or cure of dementia exists; some drugs may slow progression of Alzheimer’s disease in certain patients but do not reverse changes that already exist; ineffective in other forms of dementia

• Common (most to least) forms of dementia include:
  • Neurofibrillary tangles (aggregates of proteins in neurons), senile plaques (extracellular deposits of specific protein around neurons)
  • Vascular dementia
  • Lewy body dementia
  • Pick’s disease

Learning and Memory

Two basic types of memory:

1. ___________ (fact) – readily available to consciousness
   ex. – phone number, a quote, or pathway of corticospinal tracts

2. ___________ (procedural or skills) – unconscious association
   ex. – how to enter phone number on a phone, how to move your mouth to speak, and how to read this chapter

• Declarative and nondeclarative memory classified by length of storage time
  ___________ memory – stored only for a few seconds; is critical for carrying out normal conversation, reading, and daily tasks
  ___________ (working) memory – stored for several minutes; allows you to remember and manipulate information with a general behavioral goal in mind
  ___________ memory – a more permanent form of storage for days, weeks, or even a lifetime
Chapter 13: The Peripheral Nervous System

PNS:
1. ___________ (Afferent)
   a. Somatic Sensory Div. (special senses, skin, skeletal muscle)
   b. Visceral Sensory Div. (viscera)
2. ___________ (Efferent)
   a. Somatic Motor Div. (to skeletal muscle)
   b. Visceral Motor Div. (ANS)

Module 13.1: Overview of the Peripheral Nervous System

Overview of Peripheral Nerves and Associated

- **Peripheral nerves** = axons of many neurons bound together by CT
  ___________ nerves – contain both sensory and motor neurons

  Sensory nerves –
  Motor nerves -

- 2 types of nerves:
  Spinal nerves (___________)
  Cranial nerves (___________)

- **Spinal nerves**
  ___________ (ventral) root - motor neurons from anterior horn
  ___________ (dorsal) root - sensory neurons from posterior horn

  ___________ ____________ - collection of cell bodies of sensory neurons

- **Structures associated with spinal nerves:** Epineurium – outermost layer of CT, holds motor and sensory axons together
  ___________ – CT that surrounds fascicles (bundles of axons)
  ___________ – CT surrounds individual axon
Module 13.2: The Cranial Nerves

**The Sensory Cranial Nerves**

- Sensory only cranial nerves:

  ________(I)
  ________(II)
  ________(VIII)

**The Motor Cranial Nerves**

Oculomotor (III) – 4 of extraocular muscles, pupil constriction, opens eyelid, lens shape

___________ (IV) – 1 of extraocular muscles (sup. oblique)

___________ (VI) – 1 of extraocular muscles (lat. rectus)

Accessory (XI) – larynx, trapezius, SCM

Hypoglossal (XII) – tongue muscles

**The Mixed Cranial Nerves**

___________ (V) – supplies skin of face, muscles of mastication

___________ (VII) – facial expressions, taste ant. 2/3 tongue

Glossopharyngeal (IX) – taste post. 1/3 tongue, BP changes, swallowing, salivary glands

___________ (X) – thoracic and abdominal viscera, main nerve of PSN

---

**Trigeminal Neuralgia (tic douloureux)**

- Chronic pain syndrome

- Involves one or more branches of trigeminal nerve (CN V)
  
  - Certain stimuli may trigger attacks (chewing, light touch, vibrations)
  
  - Cause: idiopathic

  - Treatment: pain medications, sever nerve
Bell’s Palsy

Facial nerve (CN VII)

- Cause: virus, tumor, trauma, or idiopathic
- Weakness or complete paralysis of facial muscles (unilateral)

**Treatment** - anti-inflammatory medication, antiviral medication, PT, and surgery; even without treatment,

Many individuals recover function of paralyzed muscles in about 3 weeks

→ Module 13.3: The Spinal Nerves

*Structure of Spinal Nerves and Spinal Nerve Plexuses*

Cervical Plexus

- 

Brachial Plexus

- 
- 
- Musculocutaneous n.
- Median n.
- 

Lumbar Plexus

- Obturator n.
- 

Sacral Plexus

-
A Hiccup Cure That Really Works

- **Hiccups** – spasms of diaphragm that cause a forceful inhalation of air

- **Phrenic nerve remedy:**
  - Place fingers ~ 1 cm lateral to vertebral column level of C3-C5
  - Apply firm pressure to muscles of neck that overlie phrenic nerve until hiccups stop, in about 5–10 seconds

**Lumbar Plexus**

- Left and right **lumbar plexuses** are derived from anterior rami of L₁–L₅; anterior to vertebrae; embedded deep within psoas muscle; branches innervate pelvic structures and lower extremity after splitting into 2 divisions

→ **Module 13.4: Role of PNS in Sensation**

**Classification of Sensory Receptors**

- Based on location of stimuli they detect:
  - ____________ – detect stimuli originating from outside body (thermoreceptors, chemoreceptors, photoreceptors)
  - ____________ – detect stimuli originating from within body itself (chemoreceptors)
  - ____________ - depolarize in response to anything that mechanically deforms tissue (vibration, light touch, stretch, and pressure)

- **Merkel cell fibers**
  - Found in epidermal ridges of especially fingertips
  - Detect discriminative touch stimuli (object form and texture)

- **Tactile corpuscles (___________ corpuscles)**
  - Dermal papillae

- **Ruffini endings**
• Lamellated corpuscles (____________ corpuscles)

➔ Module 13.6: Reflex Arcs: Integration of Sensory and Motor Function

Reflex Arcs

• Reflexes – pre-programmed, automatic responses to stimuli; ____________ arc; usually protective negative feedback loops

Reflexes begin with a sensory stimulus and finish with a rapid motor response.

Neural integration between sensory stimulus and motor response occurs in CNS, at spinal cord or brainstem.

Types of Reflexes

• Reflexes can be classified by at least two criteria:

  Number of synapses that occur between neurons involved in arc

  Type of organ in which reflex takes place, either visceral or somatic

• Simplest reflex arcs (__________ reflexes) involve only a single synapse within spinal cord between a sensory and motor neuron; more complicated types of reflex arcs (__________ reflexes) involve multiple synapses

  Simple stretch reflex

  Body’s reflexive response to stretching of muscle to shorten it back to within its “set” optimal length

  Flexion (withdrawal) reflex:
Amyotrophic Lateral Sclerosis

- degeneration of cell bodies of motor neurons in anterior horn of SC, upper motor neurons in cerebral cortex; cause of degeneration is unknown at present; many factors likely play a role

- Most common early feature of disease is muscle weakness, particularly in distal muscles of limbs and hands; over time weakness spreads to other muscle groups; upper motor neuron symptoms also develop

- Death usually in ~5 years of disease’s onset

- Although intensive research efforts are ongoing, at this time there is no cure or treatment that prevents disease progression
Chapter 14: The Autonomic Nervous System and Homeostasis

**ANS** = involuntary arm of **PNS**  
- two divisions:  
  - __________ (SNS)  
  - __________ (PSN)  
- maintain **homeostasis**

→ **Module 14.1: Overview of the Autonomic Nervous System**

**Comparison of Somatic and Autonomic Nervous Systems**

- Motor divisions of PNS:
  - __________ _________ division → **skeletal muscle** (conscious control)
  - __________ motor division → **smooth** muscle, **cardiac** muscle, and glands (involuntary)
- ANS motor neurons require a two-neuron circuit:
  1. Preganglionic neuron –
  2. Postganglionic neuron –

**Divisions of the ANS**

Main structural and functional differences between **SNS** and **PSN**:

- __________ nervous system – preganglionic axons are usually short and postganglionic axons are usually long

- __________ nervous system – preganglionic parasympathetic axons are long while postganglionic axons are short

**Sympathetic nervous** (SNS)

- **thoracolumbar division**
- **Sympathetic ganglia** located near SC
- “__________________” division of ANS; prepares body for emergency situations
Parasympathetic nervous system

- Craniosacral division
- Cranial nerves → head and neck, thoracic viscera, and most abdominal viscera
- “_________________” division; role in digestion and maintain body’s homeostasis at rest
- Postganglionic neurons located near target organ; requires only a short axon to connect

Module 14.2: The Sympathetic Nervous System

Effects of SNS on Target Cells

Effects of SNS on target cells:
- directed at ensuring survival and maintenance of homeostasis during time of physical or emotional stress
  - Cardiac muscle cells → Increase _______ and force of contraction
  - _______ of blood vessels → digestive, urinary, & integumentary
  - Dilation of ____________
  - _______ to skeletal & cardiac muscle
  - Constriction of sphincters → urinary & digestive
  - Relaxation of smooth muscle of digestive tract
  - Dilation of ____________
  - ____________ sweating

Module 14.3: The Parasympathetic Nervous System

Gross and Microscopic Anatomy PSN

“_________________” division of ANS
- Role in maintenance functions - digestion and urine formation
- Craniosacral divison
• PSN cranial nerves – oculomotor (CN III), facial (CN VII), glossopharyngeal (CN IX), and vagus (CN X) nerves

**Effects of PSN on Target Cells**

• Cardiac muscle cells - ____________ HR & BP

• SMC contraction along digestive tract – increased ____________

• ________ of digestive and urinary sphincters → promotes urination and defecation

Engorgement of penis or clitoris

__________ salivation, lacrimation, and digestive enz.

→ Module 14.4: PNS Maintenance of Homeostasis

**Interactions of Autonomic Divisions**

• Sympathetic and parasympathetic divisions work together to keep many of body’s functions within their normal homeostatic ranges

**dual innervation**

Dual innervation allows **SNS** to become dominant and trigger effects that maintain homeostasis during physically demanding periods

**PSN** division regulates same organs, preserving homeostasis between periods of increased physical activity

![Real World]

**Postural Orthostatic Tachycardia Syndrome (POTS)**

- Increase in heart rate (known as **tachycardia**) when an individual moves from lying or sitting down to standing up; VD → BP drop due to drop due to gravity

**Symptoms** (from low blood pressure)

- include dizziness and lightheadedness

- fatigue and thirst

- shortness of breath, chest pain, cold extremities, and muscle weakness
**Cause:** excessive SNS activity

**Treatment:** dietary modifications such as increasing water and salt intake