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 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 $\mu$m) 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 $\mu$m); 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 $\mu$m); ________ 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**

• ____________ – 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. ______________ (acetylecholine)- 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:
  o **Frontal lobe** (motor, complex mental fcn.)
  o **Parietal lobe**
  o **Temporal lobe**
  o **Occipital lobe**
  o **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:**
  o 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

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**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**

Cerebellum

- located inferior to occipital lobe

- arbor vitae

**The Brainstem**

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 (1st & 2nd = lateral ventricles, 3rd and 4th 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

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**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 -

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**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)

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**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 the 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

- **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

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**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

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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 \( \rightarrow \) **skeletal muscle** (conscious control)
  
  ____________ **motor division** \( \rightarrow \) **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 division
• 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

**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