Coordination and Response

Systems for coordination: Nervous system + Endocrine system

Organization of the nervous system

- Central nervous system (CNS) [brain & spinal cord] vs. Peripheral nervous system (PNS) [nerves]
- Somatic nervous system (SNS) vs. Autonomic nervous system (ANS)
- ANS: Sympathetic vs. Parasympathetic
- Neural pathways (e.g. input → processing → output)

Cerebrum

- Gray matter & white matter
- **Cerebral lobes**
  - Occipital lobe: vision
  - Frontal lobe: judgment, planning, personality, concentration, speaking, movement
  - Parietal lobe: somatosensation, integration of various senses
  - Temporal lobe: audition, olfaction, speech, declarative memory, high-level visual processing
  - Insular lobe: gustation, vestibular sensation, visceral sensation, motor control
- **Functional areas**
  - Sensory areas: conscious awareness of sensation
  - Motor areas: control voluntary movement
  - Association areas: higher mental functions (e.g. learning)
- **Cortical homunculus (in somatosensory cortex & motor cortex)**
- **Basal ganglia (nuclei):** movement, motivation

Diencephalon

- **Epithalamus:** connection between limbic system & other parts of the brain, regulation of circadian rhythms (by **pineal gland**)
- **Thalamus:** gateway (relay center) to the cortex
- **Hypothalamus:** autonomic control, endocrine control, stress response, temperature regulation, thirst & osmoregulation, sleep & wakefulness, reward center, appetite control, emotional reactions

Brainstem

- Brainstem consists of **midbrain**, **pons**, **medulla oblongata**
- Regulation of heart rate, breathing, blood pressure, swallowing, digestion
- **Reticular formation:** alertness

Cerebellum

- Adjustment in postural muscles of the body
- Programming & fine-tuning of movements

Classification of senses

- General senses: Receptors are scattered throughout the body
- Special senses: Receptors are localized at specialized areas
- Visceral Senses: Receptors are located internally

Sensory receptors: Interface between the environment & the nervous system

- Mechanoreceptors / Thermoreceptors / Photoreceptors / Chemoreceptors / Nociceptors

Sensory modalities

- Mechanoception (e.g. touch & pressure)

- Thermoception (cold vs. warm)
- Vision [stimulus: light]
- Audition [stimulus: sound waves]
- Vestibular sensation (balance)
- Gustation (taste)
- Olfaction (smell)

Excitable tissues

- Tissues that have the ability to respond to stimuli (sudden changes in the environment)
- **Nerves** and **muscles** are excitable tissues
  - composed of excitable cells (neurons and myocytes) that generate and transmit electrical impulses along the cell membrane

Synapses

- Information transfer across a chemical synapse:
  1. Action potential arrives at axon terminal
  2. Voltage-gated Ca^{2+} channels open → Ca^{2+} influx
  3. Ca^{2+} acts as a messenger
  4. Neurotransmitter is released by exocytosis
  5. Neurotransmitter diffuses across the synaptic cleft & binds to receptors → Ion influx
  6. Graded potential (EPSCs / IPSPs) is generated at postsynaptic terminal

Neuromuscular junction:

- Site where motor neuron activates the muscle to contract
- Excitation-contraction coupling

  Release of neurotransmitter **acetylcholine** (ACh) from motor neuron
  → Binding to ACh receptors on motor end-plate of muscle cells
  → Influx of Na^{+} depolarizes motor end-plate
  → **Action potentials**
  → Biochemical reactions inside muscle cells
  → **Muscle contraction**

Endocrine system: influences metabolic activities of cells via hormones

Major endocrine glands:

- Hypothalamus & pituitary
- Thyroid & parathyroid
- Adrenal glands & pancreas
- Pineal gland
- Gonads (Testes / Ovaries)

Hormones: chemical substances released from cells into blood to elicit responses at specific site(s)

- Amino acid-based hormones vs. Steroid hormones
- Mechanisms of actions:
  - Alter plasma membrane permeability
  - Stimulate protein synthesis
  - Activate or deactivate enzyme systems
  - Induce secretory activity
  - Stimulate mitosis