TOPIC V: NERVOUS SYSTEM III – INTEGRATION & CONTROL (BRAIN + SPINAL CORD)

Learning Outcomes: Upon completion of Topic V (5), you should be able to

a) Define the term reflex.
b) Describe reflex responses in terms of major structural and functional components of a reflex arc.
c) Distinguish between each of the following pairs of reflexes: somatic versus visceral, monosynaptic versus polysynaptic, and ipsilateral versus contralateral.
d) Describe the following reflexes (giving examples) and name all components of each reflex arc: stretch reflex, flexor (withdrawal) reflex, and crossed-extensor reflex.
e) Describe reciprocal inhibition and how it relates to reflexes.
f) Describe the micturition reflex as an example of a visceral spinal reflex.
g) Describe the general functions of the cerebrum.
h) Describe the general functions of the brainstem, including the midbrain, pons and medulla oblongata.
i) Describe the major functions of the hypothalamus.

A) Overview

- sensory (afferent) division "inputs" info into brain + spinal cord (control centres)
- brain + spinal cord integrate info and control effectors through motor (efferent) division ("output")

B) Spinal Cord

1) Reflexes

- rapid, automatic response to stimuli.
- stimulus always causes the same motor response
- usually protective
- involve 2 or more neurons
- Reflex pathway or arc = pathway of impulses

stimulus ⇝ R ⇒ CNS ⇒ E (effector)

- reflexes are categorized according to:
    a) effector
        i) somatic reflex = effector is skeletal muscle
        ii) visceral (autonomic) reflex = effector is smooth muscle, cardiac muscle or glands
    b) which sides of the body the sensory + motor neurons are located
        i) ipsilateral reflex = sensory + motor neurons are on same side
        ii) contralateral = sensory + motor neurons are on opposite sides
    c) number of synapses (+ neurons) in arc

i) monosynaptic reflex = one synapse between 1 sensory + 1 motor neuron
ii) polysynaptic reflex = 2 or more synapses between 3 or more neurons

- examples:
  a) Somatic Spinal Reflexes:
    i) Stretch Reflex
      e.g. knee jerk reflex
        - extensor muscle contracts
        - stimulus = tapping patellar ligament, which stretches the quadriceps femoris muscle
        - receptor = muscle spindle (in quad.)
        - effector = skeletal muscle (quad.) - it contracts
        - ipsilateral, monosynaptic
    ii) Flexor (Withdrawal) Reflex
      - e.g. in leg
        - stimulus = stepping on nail
        - receptor = touch, pressure, pain
        - effector = hamstrings (= flexors) → contract
        - ipsilateral, polysynaptic
    iii) Crossed Extensor Reflex
      e.g. in leg
        - stimulus = stepping on nail
        - receptor = touch, pressure, pain
        - effector = quadriceps femoris in the opposite leg (=extensor) → contracts
        - contralateral, polysynaptic
        - keeps you from falling down when ii) occurs

    § Reciprocal Inhibition
      - skeletal muscle (or group) contracts (= agonist)
      - at same time, antagonist prevented from contracting (inhibitory interneurons firing)
      - e.g. in stretch reflex
        - quadriceps femoris (agonist) contracts
        - hamstrings (antagonists) contraction inhibited

  b) Autonomic Spinal Reflexes
    - Effector = smooth m., cardiac m., or glands
      e.g. Micturition Reflex - urinary bladder
        - stimulus = stretch of the bladder
        - receptor = stretch receptors in bladder wall
        - CNS = sacral segment of spinal cord (PSNS)
        - effector = detrusor muscle (wall of bladder) contracts & internal urethral sphincter opens (both are smooth

muscle)

C) <u>Brain</u>

1) <u>Cerebrum</u>:
- interpreting sensory info from general and special senses
- initiating & controlling skeletal muscle movement (motor areas and basal nuclei)
- memory, intellect etc.
- relaying info between different parts of the brain and/or spinal cord (association, commissural + projection tracts)

2) <u>Brain Stem</u>:
- controls life-sustaining processes e.g. breathing, circulation
- if brain stem functional but higher centres damaged → alive but not aware, no conscious control
- parts:

a) Midbrain
- auditory and visual reflexes → movement of eyes (vision), head and neck in response to visual/auditory stimuli

b) Pons
- functions with medulla to regulate breathing (pontine respiratory centres)

c) Medulla oblongata

functional regions:

i) decussation (crossing) of sensory + motor tracts
- e.g. left brain controls right skel. muscles, receives sensory input from right side

ii) autonomic vital reflex centres

① Respiratory Area
- drives breathing rate

② Cardiovascular Centre
- cardiac area - modifies heart rate
- vasomotor area - controls blood vessel diameter

iii) other, non-vital areas – control swallowing, vomiting, coughing, sneezing, etc

3) <u>Hypothalamus</u>

Major Functions:

a) Regulates ANS (smooth & cardiac muscle, glands)
b) Regulates parts of endocrine system
c) Regulates temperature - “thermostat cells”
d) Regulates food + water intake, body fluid conc.

e) Part of limbic system (cerebrum, thalamus, hypothalamus) = emotional brain
    - basic emotions regulated here (e.g. fear)

f) Part of the reticular activating system (RAS), with the reticular formation in brain stem, cortex + thalamus
    - RAS
        - alerting function when awake
        - receives sensory input for awakening → sets sleep/wake cycles

§ All major homeostatic functions! → damage = loss of homeostasis