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Chapter 13: The Peripheral Nervous System and Reflex Activity

Part 1 Sensory Receptors and Sensation

13.1 Sensory Receptors are Activated by Changes in the Internal or External Environment

a) Classify general sensory receptors by stimulus detected, body location, and structure.

We can classify stimulus following different characteristics:

1. Stimulus Type:

-Mechanoreceptors: This type responds to mechanical force. For example touch, pressure, vibration, or stretch.

-Thermoreceptors: As their name indicates, they respond to temperature changes.

-Photoreceptors: They respond to light

-Chemoreceptors: They respond to chemicals in solution, such as molecules smelled or tasted, or changes in blood or interstitial fluid chemistry

-Nociceptors: They respond to damaging stimuli that could result in pain. For example searing heat, extreme cold, or excessive pressure. They stimulate other receptors such as thermoreceptors, mechanoreceptors, or chemoreceptors.

2. Location

-Exteroceptors: Located usually near or at the body surface. Exteroceptors are sensitive to touch, pressure, pain, and temperature. They are also receptors of special senses, such as vision, hearing, equilibrium, smell, and taste.

-Interoceptors (aka visceroceptors): Located inside the body and respond to stimuli within the body, such as from the internal viscera and blood vessels. They are diverse, including chemical changes, tissue stretch, and temperature. They can also cause us to feel pain, discomfort, hunger, or thirst.

-Proprioceptors: They also respond to internal stimuli, but they have a more specific location. They are situated in skeletal muscles, tendons, joints, and ligaments and in connective tissue coverings of bones and muscles. They are very active; they advise the brain of our body movements by monitoring how much the organs containing these receptors are stretched.

3. Structure: They are divided into 2 main groups:
    a. <u>Nonencapsulated Nerve Endings:</u>

        -Free nerve endings of sensory neurons: Located in most body tissues. Based on location, they can be exteroceptors, interoceptors, and proprioceptors. Regarding to stimulus type, they can be thermoreceptors, chemoreceptors, mechanoreceptors, or nociceptors.

        -Epithelial tactile complexes: Located in the basal layer of the epidermis. Based on the location they are exteroceptors, and according to the stimulus type they are mechanoreceptors.

        -Hair follicle receptors: As their name indicates, they surround hair follicles. Based on location, they are exteroceptors. While according to the stimulus type they react, they are mechanoreceptors. Although epithelial tactile complexes and

hair follicle receptors are both mechanoreceptors, epithelial complexes are slowly adapting, while hair follicle receptors rapidly adapting.

b. Encapsulated Nerve Endings: They are all mechanoreceptors

- **Tactile corpuscles (Meissner's corpuscles):** They are exteroceptors located in the dermal papillae of hairless skin, nipples, external genitalia, fingertips, soles of feet, or eyelids.
- **Lamellar Corpuscles (Pacinian):** They are exteroceptors, interoceptors, and some proprioceptors. They are located in the dermis and hypodermis, periostea, mesentery, tendons, or ligaments, among other parts.
- **Bulbous corpuscles (Ruffini endings):** Their body location is in the dermis and hypodermis, and joint capsules. They are exteroceptors and proprioceptors, based on their locations.
- **Muscle spindles:** They are proprioceptors located in skeletal muscles, especially in the extremities.
- **Tendon organs:** Proprioceptors located in tendons
- **Joint kinesthetic receptors:** Proprioceptors located in joint capsules of synovial joints. They can be mechanoreceptors and nociceptors.

13.2 How is sensory information processed? Receptors, Ascending Pathways, and Cerebral Cortex Process Sensory Information

a) Outline the events that lead to sensation and perception.

SENSATION

1. Receptor level: Sensory Receptors
    a. Processing at the Receptor Level:

        i. Generating a Signal
        ii. Adaptation
            1. Phasic receptors
            2. Tonic receptors
2. Processing at the Circuit Level: Processing in ascending pathways
3. Processing at the Perceptual level: Processing in cortical sensory areas
    a. Perceptual detection
    b. Magnitude estimation
    c. Spatial discrimination
    d. Feature abstraction
    e. Quality discrimination
    f. Pattern recognition

PERCEPTION

1. Pain tolerance
2. Visceral and Referred Pain

b) Describe receptor and generator potentials and sensory adaptation.

Generator potentials: graded potential produced when the receptor region is part of a sensory neuron, therefore, it generates action potentials in sensory neurons.

Receptor potential: Graded potential that occurs in a separate cell. This potential changes the amount of neurotransmitter released by the receptor cell onto the sensory neuron.

Sensory adaptation: Some sensory receptors exhibit adaptation, which is a change in sensitivity in the presence of a constant stimulus.

c) Describe the main aspects of sensory perception.

Part 2 Transmission Lines: Nerves and Their Structure and Repair

13.3 Nerves and associated ganglia. Nerves are Cordlike Bundles of Axons that Conduct Sensory and Motor Impulses

a) Describe the general structure of a nerve.

A nerve is a cordlike organ that belongs to the PNS. They possess axons, which are surrounded by endoneurium. The perineurium binds groups of axons into bundles called fascicles. The epineurium, a tough fibrous sheath, encloses all the fascicles to form the nerve.

b) Define ganglion and indicate the general body location of ganglia.

A ganglion is a neuron cell body associated with nerves in the PNS. Ganglia, which is a collection of the ganglion is located in the PNS.

c) Follow the process of nerve regeneration.

1. The axon fragments
2. Schwann cells and macrophages clean out the dead axon distal to the injury
3. Axon filaments grow through a regeneration tube.
4. The axon regenerates and a new myelin sheat forms.

13.4 Cranial nerves. There are 12 Pairs of Cranial Nerves

1. Name the 12 pairs of cranial nerves; indicate the body region and structures innervated by each.

Cranial nerve I: OLfactory: Located in the nasal mucosa to synapse with the olfactory bulbs.

Cranial nerve II: Optic: It is a brain tract because it develops as an outgrowth of the brain.

Cranial nerve III: Oculomotor (eye mover): This nerve supplies four of the six extrinsic muscles that move the eyeball in the orbit. Do not possess a sensory function

Cranial nerve IV: Tochlear: Innervates an extrinsic eye muscle that loops through a pulley-shaped ligament in the orbit. Do not possess a sensory function.

Cranial nerve V: Trigeminal. General sensation. Supplies sensory fibers to the face and motor fibers to the chewing muscles.

Cranial nerve VI: Abducens Do not possess sensory function. Controls extrinsic eye muscle that abducts the eyeball.

Cranial nerve VII: Facial: Sense of taste. Innervates muscles of facial expression.

Cranial nerve VIII: Vestibulocochlear: Sense of hearing and balance.

Cranial nerve IX: Glossopharyngeal (means tongue and pharynx): Sense of taste. Its structure helps to innervate.

Cranial nerve X: Vagus: Sense of taste. It is the only cranial nerve to extend beyond the head and neck to the thorax and abdomen.

Cranial nerve XI: Accessory: Do not possess sensory function. Considered as part of the vagus nerve.

Cranial nerve XII:Hypoglossal: Do not possess sensory function. This nerve runs inferior to the tongue and innervates the tongue muscles.

13.5 Spinal nerves. 31 Pairs of Spinal Nerves Innervate the Body

a) Describe the general structure of a spinal nerve and the general distribution of its rami.

Each spinal nerve is connected to the spinal cord by a dorsal root (sensory fibers) that conduct impulses from peripheral receptors to the spinal cord; and a ventral root (motor fibers) that innervate the skeletal muscles.

Distribution of rami: Small dorsal ramus, a larger ventral ramus, and a tiny meningeal branch. Besides they possess special rami called rami communicates, which contain autonomic nerve fibers attached to the base of ventral rami of the thoracic spinal nerves.

b) Define plexus. Name the major plexuses and describe the distribution and function of the peripheral nerves arising from each plexus.

Plexuses are interlacing nerve networks located in the cervical, brachial, lumbar, and sacral regions, and they serve the limbs.

1. **Cervical Plexus and Neck**

- **Cutaneous Branches:** Lesser occipital (C2 (C3)), greater auricular (C2,C3), transverse cervical (C2, C3), supraclavicular (C3, C4)
- **Motor Branches:** Ansa cervicalis (C1-C3), segmental and other muscular branches (C1-C5), phrenic (C3-C5).

2. **Brachial plexus:** Musculocutaneous, median, ulnar, radial, axillary, dorsal scapular, long thoracic, subscapular, suprascapular, pectoral.
3. **Lumbar plexus**: Femoral, obturator, lateral femoral cutaneous, iliohypogastric, ilioinguinal, genitofemoral.

<u>Part 3 Motor Endings and Motor Activity</u>

13.6 Motor endings. Peripheral Motor Endings Connect Nerves to their Effectors

a) Compare and contrast the motor endings of somatic and autonomic nerve fibers.

Motor endings of somatic nerve fibers form neuromuscular junctions with their effector cells, the skeletal muscle cells.

Anatomic nerve fibers, or anatomic motor endings, varicosities, are more simple than motor endings nerve fibers. They are beaded terminals that innervate smooth muscle and glands. They contain Ach or norepinephrine as a neurotransmitter.

13.7 How does motor activity come about? There are Three Levels of Motor Control

a) Outline the three levels of the motor hierarchy.

Segmental level: Consist of reflexes and spinal cord circuits that control automatic movements. These circuits are called Central Pattern Generators (CPGs).

Projection level: COnsists of neurons acting through the direct and indirect motor pathways. Upper motor neurons (direct pathways) and brain stem motor nuclei (indirect pathways).

Precommand level: Controls the outputs of the cortex and brain stem motor centers andpossess the highest level of the motor hierarchy. The key center is the cerebellum.

b) Compare the roles of the cerebellum and basal nuclei in controlling motor activity.

The cells in the basal nuclei, as well as those in the cerebellum, are involved in unconscious movements. However, the cerebellum lacks direct connections to the spinal cord. It acts on motor pathways through the projection areas of the brain stem and on the motor cortex via the thalamus to fine-tune motor activity. The basal nuclei receive inputs from all cortical areas and send their output back mainly to premotor and prefrontal cortical areas via the thalamus. Compared to the cerebellum, the basal nuclei appear to be involved in more complex aspects of motor control.

Part 4 Reflex Activity Nerves and Their Structure and Repair

13.8 The Reflex Arc Enables Rapid and Predictable Responses

a) Name the components of a reflex arc and distinguish between autonomic and somatic reflexes.

The reflex arc is composed of five components: receptor, sensory neuron, integration center, motor neuron, and effector.

Reflexes are classified based on the function. They can be: SOmatic reflexes: They activate skeletal musclesç or Automatic reflexes, they activate visceral effectors: smooth or cardiac muscles or glands.

13.9 Spinal reflexes. Spinal Reflexes are Somatic Reflexes Mediated by the Spinal Cord

a) Compare and contrast stretch, flexor, crossed-extensor, and tendon reflexes.

The **stretch reflex** makes sure that the muscle stays at that length; such as the patellar or knee-jerk reflex. They all involve a single synapse and motor activity on the same side of the body, therefore, they are monosynaptic and ipsilateral.

Tendon reflexes produce muscles to relax and lengthen in response to tension.

Flexor reflexes are initiated by a painful stimulus.

Crossed-extensor reflex usually accompanies the flexor reflex in weight-bearing limbs and plays an important role in maintaining balance.

b) Describe two superficial reflexes.

Superficial reflexes are activated by gentle cutaneous stimulation.

Abdominal reflexes: When stroking the skin of the lateral abdomen a contraction is produced in which the umbilicus moves toward the stimulated site, either above, lateral or below the umbilicus. By doing so, these reflexes check the integrity of the spinal cord and ventral rami from T8 to T12.

Plantar Reflex: IT tests the integrity of the spinal cord from the lumbar vertebrae L4 to the Sacral vertebrae S2. It indirectly tests if the corticospinal tract is functioning the way it should. Its normal response is the toes flexing downward.