The Cerebrum

The following now refers to the cortex gray matter areas within the hemispheres. The numbers in parenthesis are indicated on the brain figure below.

Important Motor Areas

They control muscular movement and are located in the posterior part of the frontal lobe.

Primary Motor Cortex (A)

- Located in the precentral gyrus of the frontal lobe of each hemisphere. Large neurons, called pyramidal cells, allow us to consciously control the movement of our skeletal muscles. The long axons project to the spinal cord and form the massive voluntary motor tract called the corticospinal tracts.
- The entire body is represented spatially in the primary motor cortex of each hemisphere. Thus each region in here controls certain movement of the body. The body is represented upside down with the head at the infero-lateral side, the toes and feet at the medial end. Those body parts that need precise and complex motor control are represented dis-proportionally larger as more cortical area is needed to execute those movements (such as face, hands, tongue).
- The orderly mapping of the body in CNS structures is called somatotopy and the resulting "motor body" map on the cortex is termed the motor homunculus.

( Fig. 12-8, 12-9)

- Lesions in the primary motor cortex of the right hemisphere will thus paralyze the left body structures. But only voluntary control is lost; the muscles can still contract reflexively.

Important Sensory Areas

The sensory areas are brain cortex areas concerned with conscious awareness of sensation and occur in the regions behind the central sulcus.

1. Primary Somatosensory cortex (C in figure on next page)

- Resides in the postcentral gyrus of the parietal lobe, right behind the central sulcus.
- Neurons here receive information from sensory receptors (pain, temperature, touch) located in the skin and from proprioceptors (joints, muscle position) in skeletal muscle.
- It allows for spatial discrimination and identification of the body region being stimulated.
- The amount of sensory cortex devoted to a particular body region is related to how sensitive the region is, not the size of the body region. (Face, lips, fingertips are most sensitive)
- The display and mapping of the body on the primary somatosensory cortex is called the somatosensory homunculus.
2. **Primary visual area (D)**
   - located on the medial aspect of the occipital lobe
   - right eye sensory information from the retina is directed to the left visual cortex

3. **Primary auditory area (E)**
   - located in the superior margin of the temporal lobe near the lateral sulcus
   - sound energy in our ear generates impulses that are transmitted to this area

4. **Primary olfactory area**
   - located in the medial aspects of the temporal lobes; allows conscious awareness of odors

5. **Primary gustatory (taste) area (F)**
   - located at the base of the postcentral gyrus above the lateral sulcus; involved in the perception of taste

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**Association Areas**

Both primary somatosensory cortex areas and special sensory areas have nearby association areas with which they communicate and evaluate the sensations. The association areas in turn communicate with the association areas in the motor cortex to act on sensory input.

**Somatosensory association area (area 1)**
- lies just behind the primary somatosensory area
- integrates and interprets sensations based upon stored memories and past sensory experiences
- thus determines shapes, orientations by feeling touch.
- damage to this area will not allow you to recognize the object without looking at it

**Premotor Cortex (area 2)**
- Located anterior to the precentral gyrus in the frontal lobe.
- The region controls learned motor skills of a repetitious or patterned nature. It thus controls the movement of several muscle groups simultaneously and/or sequentially. Does so by sending impulses to the primary motor cortex
- It is a memory bank for skilled motor activities
Auditory association area (area 3)
• located inferior to the primary auditory area in the temporal cortex
• determines if sound is speech, music, noise
• translates words into thoughts and interprets meaning of speech

Visual association area (area 5)
• located in the occipital lobe and surrounds the primary visual area
• relates present to past visual experiences with recognition and evaluation of what we are seeing

Integration Centers / Areas

These are areas that receive information from many association areas and direct complex motor functions in response

Prefrontal cortex (area 4)
• occupies the anterior portions of the frontal lobes
• involved with intellect and complex learning abilities (cognition) and personality
• necessary to form abstract ideas, judgment, reasoning, planning
• develop slowly in children and heavily depend on feedback from one’s environment
• tumors in this area cause mental and personality disorders

Gnostic area or General interpretation area. Also called Wernicki’s area (6)
• Broad area located posteriorly in parietal and temporal lobe
• it is a common integrative area
• usually only found in the left hemisphere
• it integrates all incoming signals into a single thought or understanding of the situation
• uses this information to activate appropriate response via the prefrontal cortex and the motor areas
• injury to this area causes one to become an imbecile; ability to interpret a situation is lost

Broca’s Area (8)
• Located in the frontal lobe, just superior to the lateral sulcus and anterior to the inferior part of the premotor cortex area.
• Is involved in the translation of thoughts into speech
• Sequence of impulses are sent from this area to the premotor cortex that control the movement of larynx, pharynx and mouth while impulses reach the primary motor cortex to regulate the breathing muscles.
Diencephalon

Consist out of 3 bilateral symmetric structures that collectively enclose the third ventricle

1. Thalamus
   • Makes up 80% of the Diencephalon
   • Are paired oval masses of gray matter nuclei that make up the lateral walls of the third ventricle
   • It functions as a relay station and integration area for
     • sensory impulses that reach the cerebral cortex from the spinal cord and brain stem,
     • motor impulses that originate from the cerebellum
   • Allows for crude sensation of pain, temperature, pressure

The thalamus thus plays a key role in mediating sensation, motor activities, cortical arousal and even memory

2. Hypothalamus
   • Located below the thalamus and form the floor of the third ventricle
   • Protected by the Sella Turcica of the sphenoid bone
   • The infundibulum, a stalk of the hypothalamic tissue, connects the hypothalamus with the pituitary gland
   • The hypothalamus contains several important nuclei that are instrumental in the regulatory process of homeostasis. Despite its small size, the HT is of vital importance and few tissues in the body escape its influence.
   • The main functions of the HT are:
     • An ANS Control Center (control and integrates ANS impulses; influences blood pressure, rate and force of heart contractions, respiratory rate...)
     • A center for emotional response and behavior. Nuclei are involved in perception of pain, pleasure, fear, rage, sex drives...
     • Body temperature regulation: initiates sweating or shivering
     • Regulation of food intake: contains the so called satiety center (dependent on blood glucose and insulin levels)
     • Regulation of fluid intake: contains the thirst center (nuclei that are responsive to osmolarity of blood, they induce us to drink and also induces the release of AntiDiureticHormone)
     • Control of endocrine functions: Produces releasing hormones that for example help to induce the release of hormones form the pituitary

3. Epithalamus
   • Most dorsal part of the diencephalon, forms the roof and contains the pineal gland or body.
   • It secretes melatonin under the influence of the suprachiasmatic nuclei of the HT, and are involved in sleep-wake cycle and some mood aspects.
The Brain Stem

The brain stem is the extension from thalamus towards the spinal cord. It is a pathway for ascending and descending tracts as well as an area containing specific "primitive" (but crucial) reflex centers as well as nuclei that form the basis of our cranial nerves.

MIDBRAIN

- Massive Cerebral peduncles are located on the anterior ventral side; these are the large corticospinal tracts descending to the S.C.
- Dorsally, we find the Superior Cerebellar peduncles: these are fiber tracts that connect to the cerebellum.
- Dorsal area also contains nuclei within the white matter. They are collectively named the corpora quadrigemini:
  - Superior colliculi: reflex center for movement of eyes, neck, head to visual stimuli
  - Inferior colliculi: reflex center for head trunk movement in response to auditory stimuli
- Also contained within white matter are two pigmented gray matter nuclei:
  - Substantia nigra: controls subconscious muscle activities
  - Red nucleus: involved in relay of motor pathways that control limb flexion

PONS

- Contains mostly longitudinal conduction tracts for motor activities on ventral side (extension of the cerebral peduncles)
- Dorsal side contain lateral tracts that connect to cerebellum: middle cerebellar peduncles
- Also contain nuclei of apneustic and pneumotaxic center (aids in control of respiration)

MEDULLA OBLONGATA

- Inferior part of brain stem and blends into the spinal cord
- Ventral side contains two large corticospinal tracts descending from motor cortex: pyramids. Pyramids cross over to opposite side right above the SC (this is called the 'decussation of pyramids')
- Dorsal side contains the Inferior cerebellar peduncles: connects with cerebellum
- Within Medulla are several important regions of gray matter:
  - Cardiovascular center: regulates force and rate of heartbeat, diameter of blood vessels
  - Respiratory center: adjust basic rhythm of breathing
  - Other centers for vomiting, hiccups, coughing, swallowing, sneezing...
Cerebellum

FUNCTION

- Acts to coordinate body movements
- Continually compares the brain's intention with the body's performance
- Promotes smooth, economical voluntary movements

Cerebellar Processing:

- Voluntary motor activities initiated by motor cortex is relayed to cerebellum via Middle Cerebellar peduncles (via pons)
- Information from proprio receptors in the body and vestibular nuclei is relayed via inferior cerebellar peduncles
- After information is integrated, coordinations of the movements and the appropriate adjustments are relayed back to the motor cortex via the Superior cerebellar peduncles

Cerebellum is thus the ‘automatic’ pilot with regard to our voluntary movements

Basal Nuclei

Located deep within the white matter of each hemisphere is a group of subcortical nuclei, called the basal nuclei. The caudate nucleus (arching superiorly over the diencephalon and located medial to the internal capsule) and the lentiform nucleus (lateral to the diencephalon and lateral to the fibers of the internal capsule) form the main mass and are collectively referred to as the corpus striatum. The lentiform nucleus in itself is made up of a lateral part (the putamen) and a medial part (the globus pallidus).

The basal nuclei receive extensive inputs from the entire cerebral cortex. Via relays through the thalamus, it projects to the premotor and prefrontal areas and thus influences muscle motor movements directed by the primary motor cortex. It does not activate muscle movements directly.
Main functions

- involved in planning, initiating, maintaining and terminating motor activities
- monitor and mediate descending commands from the motor cortex
- instrumental in maintaining muscle tone and postural movements
- inhibits antagonistic movements

Their input is thus necessary for us to perform several motor activities at once. Damage in this area results in tremors and abnormal posture, walking movements (Parkinson's is a result of an overactive basal nuclei due to lack of dopamine from the substantia nigra from the midbrain or lack of dopamine receptors in basal ganglia).

Dysfunctions associated with the Basal Nuclei and Cerebellum.

The above reading tell us that the following structures are directly or indirectly involved with somatic motor functions

- Premotor Cortex of the cerebrum
- Primary motor area
- Substantia nigra and red nuclei in midbrain
- Basal nuclei
- Cerebellum

It stands to reason that lesions, tumors and/or other deviations in these areas will manifest themselves in the execution of motor functions.

Examples

Even though lesions in the basal ganglia in experimental animals have little effect, disease processes that affect the basal ganglia in humans produce marked abnormalities of motor function.

Disorders are of two general types

1. Hyperkinetic: display of excessive and abnormal movement
   - Chorea: refers to a hyperkinetic movement with rapid, involuntary "dancing" movements
   - Athetosis: Characterized by continuous, slow writhing movements
   - Ballism: involuntary movements that are intense and violent

2. Hypokinetische: display of extreme slow and rigid movements
   - Akinesia: difficulty in initiating movement and decreased spontaneous movement
   - Bradykinesia: slowness of movement
Two well known disorders can be traced back to these kinds of problems

**Parkinson's Disorder**

Under normal circumstances, *Substantia nigra* neurons inhibit the activity of the basal ganglia by releasing dopamine. Damage to the *Substantia nigra* and a loss of dopamine receptors in basal ganglia results in increased activity of the basal ganglia.

Recent evidence indicate that environmental pesticides may be involved.

Symptoms include Hyperkinesia and Hypokinesia. The hypokinetic manifestation is due to increased motor activity in both agonistic and antagonist muscles, resulting in rigidity.

**Huntington's Disorder**

An autosomal dominant inherited disease (chromosome 4). It manifests itself by a degeneration of inhibitory GABA-nergic neurons that project to the putamen. Symptoms include hyperkinetic chorea movements that gradually increase and incapacitate the patient. Dementia follows and patients die usually within 10-15 years after onset of problems.

**Cerebellum Disorders**

Damage to the Cerebellum results in poor posture, poor equilibrium and ataxia (disorders of movement coordination). The gait of a person's walking is usually widebased and drunkenlike. Voluntary movements are accompanied by intention tremor (can't move a finger in a straight line) and dysmetria (past-pointing: can't hit the object pointed at).