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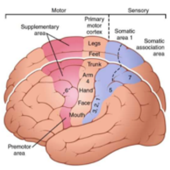
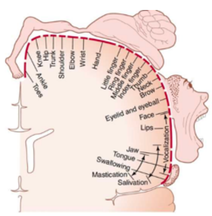
# Control of body movements

## Motor cortex



- We said before that the **motor function** will **activate or inhibit** the **effector c**ells ( like the glands and muscles – skeletal, smooth or cardiac)
- We will **only talk about skeletal muscles** which is a **voluntary action** so the **integral function** would be **in** the **cerebral cortex called** the **motor cortex**
- **Areas** in the **motor cortex**:
  - We have a **primary motor area** which is **very close** to the **primary somatosensory area**
    - The primary motor area has a **distorted representation** of the body parts – **motor homunculus**
      - **Most representation** is in the **hands** and **mouth** ( **tongue**)
      - The **representation** in the **somatosensory area depended** on the **density of sensory receptors** while **here** in the **motor area** it is **based** on **how detailed and fine movement** is **required** (so most in fingers and hands and the fine movement in the speech)
        - **Hands and speech represents more than 50%** of the **primary motor area**
  - We also have a **premotor area** and a **supplementary area** ( some books regard them as one area)
  - There area **association areas** for the **motor function**



- We also have a **memory motor function** which is **important** so that **not every time we plan** a **movement we have to restart from the beginning** and **make it from scratch**, **so** I **store this information that I need for later** so that **when I need it I can quickly give** it to the **primary cortex**, this is how we learn
- **Most voluntary movements initiated** by the **cerebral cortex** are **achieved when** the **cortex activates patterns** of **function stored** in **lower brain areas**: the **cord**, **brain stem**, **basal ganglia**, and **cerebellum**.
- These **lower centers**, in turn, **send specific control signals** to the **muscles**.
- For a **few types of movements**, however, the **cortex has almost a direct pathway** to the **anterior motor neurons** of the **cord**, **bypassing some motor centers on the way**.
- This is **especially true** for **control** of the **fine dexterous movements** of the **fingers and hands.**

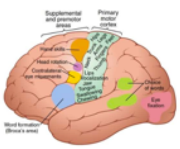
## Primary motor cortex

- The **execution** of the **function** of **the skeletal muscles** ( movement) **occurs by this area**

- **more than half of** the **entire primary motor cortex** is **concerned** with **controlling the muscles of the hands** and the **muscles of speech**.
- **excitation** of a **single motor cortex neuron usually excites** a **specific movement rather** than **one specific muscle**.

## Premotor area

- Here the **planning of movement** occurs **which then goes to the primary motor area** for **execution**
- The **most anterior part** of the **premotor area first develops** a "**motor image**" of the **total muscle movement** that is to be **performed**.



- Then, in the **posterior premotor cortex**, this **image excites** each **successive pattern** of **muscle activity required** to **achieve the image**.
- it **sends signals either directly** to **the primary motor cortex** or to **the basal ganglia** and **thalamus back** to the **primary motor cortex**.
- **A special class of neurons called mirror neurons becomes active when a person performs** a **specific motor task** or **when he or she observes** the **same task performed** by **others**.
    - **So basically they imitate the movement and then are stored in these associated areas**
- Thus, the **activity of these neurons** "**mirrors**" the **behavior of another person** as though the **observer was performing the specific motor task**.
- **important** for **understanding the actions** of **other people and** for **learning new skills** by **imitation**.

## Supplementary area

- **Contractions elicited** by **stimulating this area** are **often bilateral rather than unilateral**.
- In **general**, this **area functions** in **concert with the premotor area** to **provide body-wide attitudinal movements**, **fixation movements** of the **different segments** of the **body**, **positional movements** of the **head and eyes**, and so forth, as **background for the finer motor control of the arms** and **hands by the premotor area and primary motor cortex**.
- So both the **premotor area and the supplementary area play** an **important** role in **attidunal movements** which **controls the position of the eyes** and **these complex things**
- There are other areas in the cerebral cortex which also controls movements like
    - the **broca area**
    - **voluntary eye movement**
    - **head rotation movement**
    - **hand skills movement**

## Broca's

- **Word forming area**
- Normally **how a person learns a language**
    - First you have to **get the sensory information** from **either auditory** or **visual sensation**
    - **Auditory** will **go** to the **primary auditory cortex** and there **we have analysis** for **frequency** and **loudness** and are **analyzed via the Wernicke's area** ( so this mean I understood the language and comprehended it and now I have to react to it by speaking which requires a motor area- the Broca area)
    - After it is analyzed it is **sent to the Broca area** which **allows the movement of the vocal cords** and **muscles required for speaking**
- **Damage to it does not prevent a person** from **vocalizing** but **makes it impossible** for the **person to speak whole words**.
    - **This is called expressive aphasia – the patient cant formulate words so he cant express himself**
- A **closely associated cortical area also causes appropriate respiratory activation** of the **vocal cords that occur simultaneously** with the **movements of the mouth and tongue during speech**.
- Thus, the **premotor neuronal activities related to speech are highly complex**.

## Voluntary eye movement area

- **Allows** a **person to voluntarily move the eyes toward different objects**.
- **When damaged**, the **eyes tend to lock involuntarily onto specific objects**, an **effect controlled** by **signals from the occipital visual cortex**.
    - **It would cause eye fixation**
- This **area also controls eyelid movements** such as **blinking**.

## Head rotation area

- This **area** is **closely associated** with the **eye movement field**; it **directs the head toward different objects.**
    - **Its synergistically ( hand in hand) with the eye movement**

## Hand skills area

- **destruction** in **this area causes hand movements** to **become uncoordinated** and **non-purposeful**, a **condition called motor apraxia**.

## Frontal Cortex

- the frontal cortex **plays a role** in the **motor control** in which its **function is its important to tell you** the **appropriation of certain movements** and at **what time it should be** done
- so it basically **makes judgements** and **decides whether** to **perform this movement or not** at specific time

## Columns in motor cortex

- **most important layer is layer 5 since it contains the neuronal cells which causes the descending pathways to occur**
- **Each column of cells functions** as a **unit, usually stimulating** a **group of synergistic muscles**, or **just a single muscle.**
- Also, **each column** has **six distinct layers of cells**, as is **true throughout nearly all the cerebral cortex**.
- The **pyramidal cells** that give **rise to the corticospinal fibers** all **lie in the 5th layer**.
  - Start the **corticospinal tract**
- The **neurons of each column operate** as an **integrative processing system**, **using information** from **multiple input sources** to **determine the output response from the column.**
- In addition, **each column** can **function as an amplifying system** to **stimulate large numbers** of **pyramidal fibers** to the **same muscle** or to **synergistic muscles simultaneously**.
  - I have to **stimulate within 50-100 cells** so that the **movement can occur**
- This **ability** is **important because stimulation** of a **single pyramidal cell seldom excites** a **muscle**.
- We have **two types of pyramidal** cells, **dynamic and static**

## Dynamic vs static signals

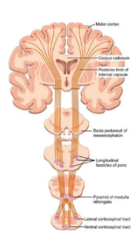
- **each column of cells excites two populations** of **pyramidal cell neurons**, **one called dynamic neurons** and the **other static neurons**.
- The **dynamic neurons** are **excited at a high rate** for a **short period at the beginning** of a **contraction**, causing the **initial rapid development of force**.
- The **static neurons** then **fire at a much slower rate**, but **they continue firing** at this slow **rate** to **maintain the force of contraction** as **long as the contraction is required**.

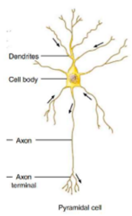
## Motor pathways

- **Motor signals** are **transmitted directly from the cortex** to the **spinal cord through** the **corticospinal tract** and **indirectly through multiple accessory pathways** that **involve the basal ganglia**, **cerebellum**, and **various nuclei of the brain stem**
  - **In the brain stem the most important structures are the red nucleus and reticular nuclei and the vestibular nuclei**
- In general, the **direct pathways are concerned** with **discrete and detailed movements**, **especially** of the **distal segments** of the **limbs**, **particularly the hands and fingers**.

## Corticospinal tract

- The **most important output pathway** from the **motor cortex** is the **corticospinal tract**, also called the **pyramidal tract.**



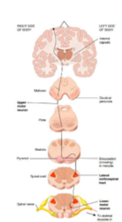



- **Giant pyramidal cells**, called **Betz cells**, have the **most rapid rate of transmission** of any **signals from the brain to the cord.**
    - These **giant cells** are **important to ensure rapid conduction velocity**
    - Fastest rate of conduction veolcity in our body
- **Direct motor pathways**, also known as the **pyramidal pathways**.
- **Pyramidal cells** are **upper motor neurons** that have **pyramid-shaped cell bodies**. They are the **main output cells** of the **cerebral cortex**.
- The **direct motor pathways consist** of **corticospinal pathways and** the **corticobulbar pathway**
- **Axons of UMNs** in the **cerebral cortex form** the **corticospinal tracts**, **which descend through** the **internal capsule** of the **cerebrum and the cerebral peduncle** of the **midbrain**.
- In the **medulla oblongata**, the **axon bundles** of the **corticospinal tracts form** the **ventral bulges known as the pyramids.**
- **About 90% of the corticospinal axons decussate** to the **contralateral side** in the **medulla oblongata** and then **descend into the spinal cord** where **they synapse with a local circuit** neuron or a **lower motor neuron**.
    - **These are the lateral corticospinal tract**
- The **10% that remain on the ipsilateral side eventually decussate** at the **spinal cord levels** where they **synapse with a local circuit neuron or lower motor neuron**.
    - These are the **anterior corticospinal tract**
- Thus, the **right cerebral cortex controls most of the muscles on the left side** of the **body**, and the **left cerebral cortex controls most of the muscles on the right side of the body**.
- There are **two types of corticospinal tracts**: the **lateral corticospinal tract** and the **anterior corticospinal tract**

## Lateral corticospinal tract

- **Corticospinal axons** that **decussate in the medulla form** the **lateral corticospinal tract** in the **lateral white column of the spinal cord**.
- **These axons synapse** with **local circuit neurons** or **lower motor neurons in the anterior gray horn** of the **spinal cord.**
- **Axons** of **these lower motor neurons exit** the **cord in the anterior roots of spinal nerves** and **terminate** in **skeletal muscles** that **control movements** of the **distal parts of the limbs**.
- The **distal muscles** are **responsible for precise, agile,** and **highly skilled movements** of the **hands** and **feet.**
- **Because** the **muscles** of the **hand and feet are very important to control**, we have a **backup pathway** known as the **rubrospinal pathway**

Lateral corticospinal tract



## Anterior corticospinal tract

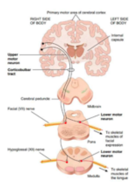
Anterior corticospinal tract

- **Corticospinal axons that do not decussate** in the **medulla form the anterior corticospinal tract** in the **anterior white column of the spinal cord.**
- At **each spinal cord level**, **some of these axons decussate via the anterior white commissure**. Then, **they synapse with local circuit neurons** or **lower motor neurons in** the **anterior gray horn**.
- **Axons of these lower motor neurons exit** the **cord in the anterior roots of spinal nerves**.
- They **terminate in skeletal muscles** that **control movements** of **the trunk and proximal parts** of the **limbs**
    - **For posture mainly**

## Corticobulbar tract

- **Conducts impulses** for the **control of skeletal muscles in the head**.
- **Axons of upper motor neurons** from the **cerebral cortex form the corticobulbar tract**, which **descends along with the corticospinal tracts through the internal capsule** of the **cerebrum** and **cerebral peduncle of the midbrain**.

Corticobulbar tract



- **Some** of the **axons** of the **corticobulbar tract decussate**; **others do not.**
- The **axons terminate in** the **motor nuclei of 9 pairs** of **cranial nerves in** the **brain stem: the oculomotor (III), trochlear (IV), trigeminal (V), abducens (VI), facial (VII), glossopharyngeal (IX), vagus (X), accessory (XI), and hypoglossal (XII).**
    - **The other 3 are sensory ( olfactory, optic and vestibulocochlear)**
- The **lower motor neurons** of **the cranial nerves convey impulses that control precise**, **voluntary movements** of the **eyes, tongue, and neck**, **plus chewing**, **facial expression**, **speech**, and **swallowing**.

## Other pathways from motor cortex

- The **motor cortex gives rise** to **large numbers of additional**, **mainly small fibers** that **go to deep regions** in the **cerebrum and brain stem.**

## Incoming sensory pathways to motor cortex

- The **functions of the motor cortex** are **controlled mainly by nerve signals from** the **sensory system**.
- **Once the sensory information** is **received**, the **motor cortex operates in association** with the **basal ganglia** and **cerebellum to excite appropriate motor actions**.
- The **most important incoming fiber pathways** to **the motor cortex are**:
    - **fibers** from **adjacent regions of the cerebral cortex**.
    - **fibers** that arrive **through the corpus callosum** from the **opposite cerebral hemisphere.**
    - **Fibers from different thalamic nuclei**