DESCENDING TRACTS OF SPINAL CORD

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GRAY MATTER OF SPINAL CORD

Gray matter of spinal cord is a collection of nerve cell bodies, dendrites and parts of axons. It is placed centrally in the form of wings of butterfly and it resembles the letter ‘H’. Exactly in the center of gray matter is a canal called the Spinal canal.
Central canal

**Dorsal horn** (cell bodies of interneurons on which afferent neurons terminate)

**Lateral horn** (cell bodies of autonomic efferent nerve fibers)

**Ventral horn** (cell bodies of somatic efferent neurons)
ANTERIOR GRAY HORN:
contains the nuclei of anterior motor neurons, involved in motor function.

There are 3 types of anterior motor neurons present:

1. **ALPHA MOTOR NEURONS**: give rise to large A-alpha fibers (14 micrometers) that innervate large skeletal muscle “Motor units”.

2. **GAMMA MOTOR NEURONS**: transmit through A-gamma fibers (5 micrometers) that innervate small special skeletal muscle fibers called “Intrafusal fibers”.

3. **RENSHAW CELLS**: are inhibitory neurons that carry out “Lateral Inhibition” at the spinal cord.

4. **INTERNEURONS**: are present in all areas of the cord gray matter. Small and highly excitable neurons. All types of neuronal circuits (*diverging, converging & repetitive discharge*) are found in the inter-neuronal pool.
What are Descending Tracts or Motor Tracts?
From the various regions of brain to the skeletal muscles, the information is relayed through the **DESCENDING TRACTS**

These are pathways that carry action potentials from **multiple** regions of the brain to the Lower Motor Neurons in the brainstem or spinal cord, where they make an NMJ with the motor end plate.
Why do we mention both spinal cord and brainstem when we mention the termination of the Lower motor neurons?

Skeletal (striated) muscle contraction is initiated by “lower” motor neurons in the spinal cord and brainstem. The cell bodies of the lower motor neurons are located in the ventral horn of the spinal cord gray matter and in the motor nuclei of the cranial nerves in the brainstem.
Descending motor pathways innervate alpha motor neurons, gamma motor neurons, and interneurons. The motor neurons are topographically organized in the anterior horn of the spinal cord according to two rules: the flexor-extensor rule and the proximal-distal rule.

**Flexor-extensor rule:** motor neurons that innervate flexor muscles are located posteriorly to motor neurons that innervate extensor muscles.

**Proximal-distal rule:** motor neurons that innervate distal muscles (e.g., hand muscles) are located lateral to motor neurons that innervate proximal muscles (e.g., trunk muscles).
Also, if there are lower motor neurons, there should be Upper motor neurons....
What do you understand by the Upper motor neurons and Lower motor neurons?
Upper vs Lower Motor Neurons

**UPPER MOTOR NEURONS**

- **Upper motor neurons (UMNs)** are motor neurons that synapse on the lower motor neurons (either directly or via interneurons).
- These neurons arise from the cerebral cortex and the brainstem.
- They usually form the First Order Neurons of the Descending Tracts.

**LOWER MOTOR NEURONS**

- **Lower motor neurons (LMNs)** are motor neurons that directly innervate skeletal muscle.
- The cell bodies of these neurons are located within the anterior (ventral) horns of the spinal cord (spinal nerves) and within brainstem motor nuclei (cranial nerves).
THE FINAL COMMON PATHWAY

• A name given to the alpha motor neuron (& the gamma motor neuron).
• Numerous nervous input converge including:
  - Descending pathways comprising the axons of “upper” motor neurons modulate the activity of lower motor neurons. The cell bodies of upper motor neurons are located either in the cortex or in brainstem centers, such as the vestibular nucleus, the superior colliculus, and the reticular formation.
  - Direct input from sensory neurons, thus mediating important sensory motor reflexes that operate at the level of the brainstem and spinal cord.
• Lower motor neurons, therefore, are the final common pathway for transmitting neural information from a variety of sources to the skeletal muscles.
Name the different Descending Tracts?
DESCENDING TRACTS

Divided into:

PYRAMIDAL TRACTS/ DIRECT PATHWAYS
- Muscle Tone
- Movements with skill and precision
- Movements of the distal parts of the limbs

EXTRAPYRAMIDAL TRACTS/ INDIRECT PATHWAYS
- Posture, Equilibrium & overall body co-ordination.
- Movements of the proximal parts of the limbs and trunk
<table>
<thead>
<tr>
<th>Type</th>
<th>Tract</th>
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<tbody>
<tr>
<td>Pyramidal tracts</td>
<td>1. Anterior corticospinal tract</td>
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<tr>
<td></td>
<td>2. Lateral corticospinal tract</td>
</tr>
<tr>
<td>Extrapyramidal tracts</td>
<td>1. Medial longitudinal fasciculus</td>
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<tr>
<td></td>
<td>2. Anterior vestibulospinal tract</td>
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<td></td>
<td>3. Lateral vestibulospinal tract</td>
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<td></td>
<td>4. Reticulospinal tract</td>
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<td></td>
<td>5. Tectospinal tract</td>
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<td></td>
<td>6. Rubrospinal tract</td>
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<td></td>
<td>7. Olivospinal tract</td>
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</table>
Descending tracts have 3 neurons

- **1st order neurons (UMN)**: Cell bodies are in the cerebral cortex & other supra spinal areas

- **2nd order neurons**: Short & situated in the anterior grey column of the spinal cord

- **3rd order neuron (LMN)**: Situated in the anterior grey column & innervate the skeletal muscles through anterior roots of the spinal nerves
PYRAMIDAL TRACTS

- Also called Direct Pathways.
- Aggregations of upper motor neuron fibers that travel from the cerebral cortex and terminate directly on the Lower motor neurons of either the brainstem (corticobulbar) or spinal cord (corticospinal) and control motor functions of the Face and distal parts of the limbs of the body.

- They include:

1. Corticospinal Tract (Anterior & Lateral): The lateral corticospinal tract is responsible for the control of the distal musculature and the anterior corticospinal tract is responsible for the control of the proximal musculature. A particularly important function of the lateral corticospinal tract is the fine control of the digits of the hand.

The **corticospinal system** controls motor neurons and interneurons in the spinal cord.
The **corticobulbar system** controls brainstem nuclei that innervate cranial muscles.
CORTICOSPINAL TRACT

- Thalamus, Basal Ganglia & Cerebellum
- Somato sensory Cortex, Frontal, Visual & Auditory Cortex
- Corpus Callosum (input from the opp. Cerebral Cortex)

INCOMING PATHWAYS TO THE MOTOR CORTEX

MOTOR CORTEX

CORTICOSPINAL TRACT
30% Primary Motor Cortex + 30% Premotor Cortex & Supplementary Cortex + 40% Somatosensory Cortex

3% fibers from 
BETZ Cells, 
Size: 60µm, 
Speed: 70 m/sec

30% Primary Motor Cortex + 30% Premotor Cortex & Supplementary Cortex + 40% Somatosensory Cortex

Corticospinal Tract

↓

Posterior Limb of the Internal Capsule

↓

Brainstem

(From here the **Corticobulbar Tract** goes to the muscles of the face & the rest of the tract cont.)

↓

Pyramids of the Medulla Oblongata (thus, called Pyramidal tracts)

↓

80% fibers cross over in the **Pyramidal Decussation**

↓

LATERAL CORTICOSPINAL TRACT
(descends in the lateral white column)

↓

Interneurons

↓

Alpha motor neurons of all levels of the body.

20% Fibers stay uncrossed

↓

ANTERIOR CORTICOSPINAL TRACT
(descends in the anterior white column)

↓

Interneurons

↓

Alpha motor neurons of neck and upper limbs.
Both the lateral and anterior corticospinal tracts are crossed pathways; they cross the midline at different locations, however.
Figure 4-15  Simple form of the descending motor pathway from the cerebral cortex to the skeletal muscle. Note the three neurons involved.
**THE CORTICOSPINAL TRACT**

Interneurons run directly from the motor cortex to their synapses with somatic motor neurons. Most corticospinal neurons cross the midline at the pyramids.

- **Primary motor cortex of left cerebral hemisphere**
- **Cranial nerves to selected skeletal muscles**
- **Most corticospinal pathways cross to the opposite side of the body at the pyramids.**
- **Somatic motor neurons to skeletal muscles**
EXTRAPYRAMIDAL PATHWAYS
or INDIRECT PATHWAYS

The **Indirect pathways** originate in the brainstem & they are concerned with the involuntary movements of the body.

They do not pass through the pyramids, therefore, are also called **Extrapyramidal Tracts**.

1. Rubrospinal Tract
2. Reticulospinal Tract
3. Vestibulospinal Tract
4. Tectospinal Tract

These pathways are also called the **Medial Descending Pathways** and they innervate the proximal or axial muscles of the body. Thus, this system is concerned with maintenance of tone, posture and equilibrium (involuntary movements) in the proximal group of muscles.
### VESTIBULOSPINAL TRACT
- Originates from the Vestibular nuclei.
- **Medial and lateral vestibular tracts.**
- They are activated during postural movements, balance and head movements.

### RETICULOSPINAL TRACT
- Originates from the pontine & medullary reticular formation.
- Regulates posture and muscle tone by stimulation of the gamma motor neurons.
- Pontine reticulospinal tract is excitatory in nature & will increase the gamma discharge.
- Medullary reticulospinal tract is inhibitory & will reduce the gamma discharge.
- If damaged, leads to rigidity as loss of inhibitory influence.

### TECTOSPINAL TRACT
- Also called the Colliculospinal Tract.
- Originates in the superior colliculus of the midbrain.
- Control head & eye movements, in response to visual & auditory stimuli.

### RUBROSPINAL TRACT
- Part of the corticorubrospinal tract.
- Fibers arise from the large meganocellular cells of Red nucleus of the midbrain.
- Synapse on the alpha motor neurons along with the lateral corticospinal tract.
- Controls movements of the distal group of muscles, and plays a role in velocity of movements.
- Brings input from cerebellum.
CORTICORUBROSPINAL TRACT

- The **red nucleus** is a structure in the rostral midbrain & is involved in motor coordination.
- Red Nucleus contain large cells called **Magnocellular nuclei**.
- Has a homunculus.
- Accessory route for discrete movements.
- They then descend with the Lateral Corticospinal Tract.
- Those fibers that originate in the Red Nucleus form the **Rubrospinal Tract** & together with the **corticospinal tract** are called the **Corticorubrospinal Tract**.
- The corticospinal and rubrospinal tracts are also called the **LATERAL MOTOR SYSTEM** of the cord. They control fine motor movements of the distal parts of the limbs. However, the Rubrospinal Tract is an Extrapyramidal Tract.
Descending Motor Pathways

Cortex
- Internal capsule (posterior limb)
- Midbrain
  - Basis pedunculi
  - Pons
    - Basis pontis
    - Rostral medulla
      - Pyramid
        - Cervicomedullary junction (decussation)
      - Pyramid decussation
    - Spinal Cord
      - Lateral corticospinal tract

Cortex
- Midbrain
  - Red nucleus (magnocellular division)
- Pons
- Rostral medulla
  - Caudal medulla
- Spinal Cord
  - Lateral intermediate zone and lateral motor nuclei

Rubrospinal tract
  - Lateral column
Descending Motor Pathways

Cortex
- Internal capsule (posterior limb)
- Midbrain
  - Basis pedunculi
  - Pons
  - Medulla
    - Pyramid
  - Spinal Cord
    - Anterior corticospinal tract
      - Medial intermediate zone and medial motor nuclei
      - Ventral column

Cortex
- Midbrain
  - Pons
    - Rostral medulla
      - Lateral vestibular nucleus
        - Lateral vestibulospinal tract
      - Medial vestibular nucleus
        - Medial vestibulospinal tracts
    - Cervical Spinal Cord
      - Medial intermediate zone and medial motor nuclei

Vestibulospinal tracts
What is the difference between Upper and Lower Motor Neuron Lesions?

While lower motor neuron lesion is fairly simple, Upper motor neuron lesion means the lesion can occur at any of the 3 locations:

1. Descending tracts
2. Alpha motor neurons
3. Cerebrum

(To understand signs and symptoms of damage to the Upper and Lower motor neurons, it is important to understand that motor system is not a serial organization but a parallel one!)
Lower motor neurone lesions

Upper motor neurone lesion (i.e. cerebral infarction)

Upper motor neurone lesion (i.e. corticospinal tract)

Synapse

Lower motor neurone lesion (i.e. of peripheral nerve)

Lower motor neurone lesion (i.e. at nerve root)
<table>
<thead>
<tr>
<th>UPPER MOTOR NEURON LESION</th>
<th>LOWER MOTOR NEURON LESION</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Muscle groups affected diffusely, NEVER individually.</td>
</tr>
<tr>
<td>2</td>
<td>Muscular Atrophy is not seen and if seen, it is very slight.</td>
</tr>
<tr>
<td>3</td>
<td>Muscle Tone Increased.</td>
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<tr>
<td>4</td>
<td>Spasticity after an initial flaccidity.</td>
</tr>
<tr>
<td>5</td>
<td>Tendon reflexes first lost, later exaggerated.</td>
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<tr>
<td>6</td>
<td>Clonus present.</td>
</tr>
<tr>
<td>7</td>
<td>Babinski’s Positive</td>
</tr>
<tr>
<td>8</td>
<td>Fasciculations not seen.</td>
</tr>
<tr>
<td>9</td>
<td>Weakness of muscles/ Paresis.</td>
</tr>
<tr>
<td>10</td>
<td>Stroke, Cord section.</td>
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</tbody>
</table>