Somatosensory and Motor Control
Sensory (ascending) Pathways

(a) Dorsal column-medial lemniscal system
(b) Anterolateral system
(c) Spinocerebellar system
Somatosensory Pathways

Three pathways from the spinal cord:

- **Dorsal column-medial lemniscal system**
  Transmits information about touch and proprioception to primary somatosensory cortex.

- **Anterolateral system**
  Transmits information about temperature and pain to the brainstem, reticular formation, and primary and secondary somatosensory cortices.

- **Spinocerebellar system**
  Transmits proprioceptive information to the cerebellum.
Lesions to the postcentral gyrus produce:

- Abnormally high sensory thresholds
- Impaired position sense
- Deficits in **stereognosis**, or tactile perception in the absence of visual information.
- **Afferent paresis** (a type of afferent motor aphasia) Clumsy finger movements due to lack of feedback about finger position
Tactile perception tests

(A)
1. A pattern is placed on a blindfolded subject’s palm for 5 seconds and then placed within an array.
2. The task is to identify the original pattern after handling all six patterns.

(B)
1. A duplicate of one of another group of patterns is handled by the subject.
2. The task is to identify the matching pattern in the array.
Attentional/perceptual deficits

- **Astereognosis**
  - Inability to recognize an object by touch

- **Simultaneous Extinction**
  - Two stimuli are applied simultaneously to opposite sides of the body
  - A failure to report a stimulus on one side is referred to as extinction (simultanagnosia)

- **Blind Touch (numbsense)**
  - Cannot feel stimuli, but can report their location (similar to blindsight), a form of unconscious sensing.
Attentional/perceptual deficits

- **Asomatognosia**: Loss of knowledge or sense of one’s own body
- **Anosognosia**: Unawareness or denial of illness
- **Anosodiaphoria**: Indifference to illness
- **Asymbolia for pain**: Absence of normal reactions to pain
- **Finger Agnosia**: Unable to point to the fingers or show them to the examiner
Levels of Control of Movement

- **Movement**—A change in the place or position of the body or a body part.

When the neurological control of movement is working correctly, we can walk, run, swim, tie shoelaces, play the piano, and swing a baseball bat.

When the neurological control of movement fails, the result is paralysis, or in some cases progressive movement disorders such as Parkinson’s disease, and Huntington’s disease.
Motor Planning

1. Posterior sensory cortex provides sensory information to the frontal cortex.
2. Prefrontal cortex plans movements.
3. Premotor cortex organizes movement sequences.

Motor cortex executes actions.
Sensory-Motor Feedback

(A) 1. Visual information required to locate target.
2. Frontal-lobe motor areas plan the reach and command the movement.
3. Spinal cord carries information to hand.
4. Motor neurons carry message to muscles of the hand and forearm.
5. Sensory receptors on the fingers send message to sensory cortex saying that the cup has been grasped.
7. Basal ganglia judge grasp forces, and cerebellum corrects movement errors.
8. Sensory cortex receives the message that the cup has been grasped.

(B) Motor cortex (commands)
- Basal ganglia (force)
- Cerebellum (accuracy)
- Brainstem and spinal cord (movements)
- Motor neurons
Motor (descending) pathways

- **Corticospinal tract**
  Controls fingers, hands, arms, trunk, legs, feet

- **Vestibulospinal tract**
  Plays a central role in posture

- **Tectospinal tract**
  Controls shoulder and neck movements and coordinates the visual tracking

- **Reticulospinal tract**
  Controls leg muscles

- **Rubrospinal tract**
  Controls hands, lower arms, lower legs, and feet
Motor Cortices

- **Primary Motor Cortex** - controls voluntary movement.

- **Dorsolateral prefrontal cortex** — sensorimotor integration.

- **Supplemental motor area** — Plans and sequences internally guided movements

- **Premotor cortex** — receives input mostly from the visual cortex. Plans and sequences externally guided movements.
Posterior Parietal Cortex

- Posterior parietal cortex—Integrates input from the visual, auditory, and skin senses and relays it to the dorsolateral prefrontal cortex.

- Damage to this area e.g. from a stroke results in difficulty responding to visual, auditory, or somatosensory stimuli presented to the contralateral (opposite) side of the body (contralateral neglect).
Apraxia—A movement disorder characterized by missing or inappropriate actions not caused by paralysis or any other motor impairment.

Constructional apraxia—A disorder characterized by difficulty drawing pictures or assembling objects.

Limb apraxia—An impairment in the voluntary use of a limb caused by damage to the left parietal lobe or the corpus callosum.

Apraxia of speech—A disorder characterized by difficulty speaking clearly, caused by damage limited to Broca’s area (in language it’s known as aphasia).
Mirroring Movement

- **Mirror Neurons**
  - Neurons that fire both when an animal makes a movement or when it observes the movement.
  - Imitation? Learning? Empathy? Social cognition?

Giacomo Rizzolatti
The Cerebellum

- The brain area responsible for developing rapid, coordinated responses or habits.

- Outer surface is extremely convoluted; represents 10% of the brain’s mass, but contains more than half of its neurons.

- **Ballistic movement**—A habitual, rapid, well-practiced movement that does not depend on sensory feedback; controlled by the cerebellum e.g. golf swing.
The Basal Ganglia
The Basal Ganglia

- **Basal Ganglia**—Group of structures that integrates movement and controls postural adjustments and muscle tone.

- Consists of the caudate, putamen and globes pallidus. The caudate and putamen together are known as the **striatum**.

- Integrates movement through interconnections with the primary motor cortex, the cerebellum, substantia nigra, red nucleus, and other motor centers in the brain.

- Damage to the basal ganglia results in impairments in muscle tone, postural instability, poorly integrated movements, and **difficulty performing voluntary movements** (e.g., standing and walking).
Huntington’s Disease

- **Huntington’s disease**—An inherited neurological disorder characterized by a slow, progressive deterioration of motor control, cognition, and emotion.
  
  - Caused by a dominant, defective *huntingtin* gene on the short arm of chromosome 4.
  
  - Autosomal dominant (carriers offspring have a 50% chance of developing HD phenotype).
  
  - Symptoms usually begin between the ages of 30 and 50, usually with a decline in physical activity and loss of interest in activities (apathy).
Huntington’s Disease

- Other symptoms include: involuntary movements of whole limbs or parts of a limb (Huntington’s chorea), interference of voluntary movements like walking, writing, swallowing, and speaking, and cognitive deficits (e.g., impaired storage and retrieval of information, poor abstract reasoning, and diminished cognitive flexibility).

- Characterized by progressive neuronal loss in basal ganglia neurons.

- Symptoms worsen over 15 years or so, and death eventually results from a loss of muscle control.
Parkinson’s Disease

- First signs of the disease may include a resting tremor in one hand or some stiffness in the muscles of a leg.
- Reduction in arms swing during walking; shuffling gait.
- Over time, tremors and rigidity worsen; movement becomes increasingly impaired.
- Motor disturbances are caused by the degeneration of the dopamine-producing cells of the substantia nigra that synapse with the basal ganglia.
- Many possible causes including head trauma (e.g. boxing), genetic susceptibility, and environmental toxins.
- Can strike during young age, not just in older adults.