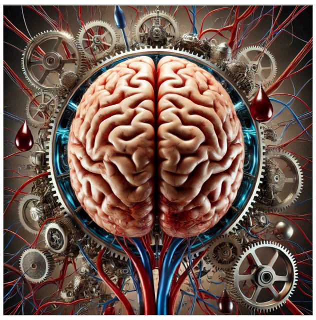
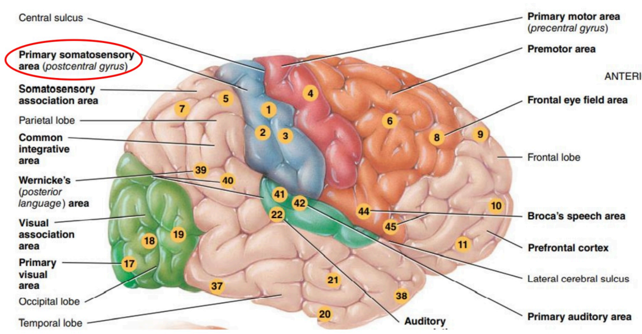


CNS—physiology~3
Written by: Dr.Ali Abujammil.

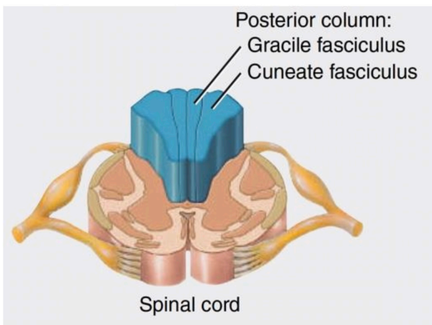
I have explained many things and clicked on the details only for the purposes of understanding.

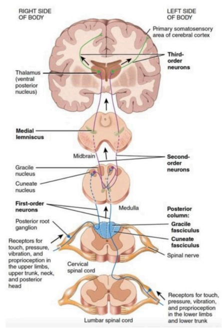
Cerebral cortex



The image is a diagram illustrating the Cerebral Cortex and its different parts. The red circle encloses the Primary Somatosensory Area located in the Parietal Lobe. This area is responsible for processing sensory information from the body, such as touch, temperature, pressure, and pain. It is located immediately behind the Central Sulcus. The diagram also shows other areas of the brain, such as the Frontal Lobe responsible for executive functions, the Temporal Lobe responsible for hearing and memory, and the Occipital Lobe responsible for vision. The diagram also shows other important areas such as Broca's Area responsible for speech production, and Wernicke's Area responsible for speech comprehension.

Posterior (Dorsal) Column- Medial Lemniscus Pathway



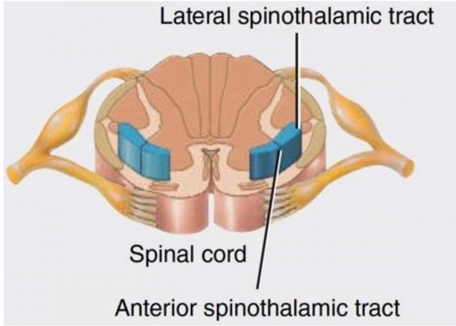


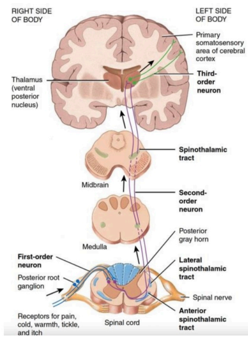
The image depicts the Posterior Column-Medial Lemniscus Pathway in the nervous system. This pathway is responsible for transmitting sensory information, such as fine touch, vibration, pressure, and proprioception, from the body to the brain.The diagram shows two main parts:

The Spinal Cord: The diagram shows a cross-section of the spinal cord, focusing on the Posterior Column which contains two main bundles of nerve fibers: Gracile Fasciculus Transmits sensory information from the lower half of the body and Cuneate Fasciculus Transmits sensory information from the upper half of the body.

The Ascending Pathway to the Brain: The diagram shows how sensory signals travel from the spinal cord to the brainstem (specifically the medulla oblongata), where the nerve fibers cross over (decussation) and continue ascending to the thalamus and then to the somatosensory cortex in the parietal lobe of the brain, where sensory information is processed.

Antero-Lateral Spinothalamic Pathways





The image shows the Antero-Lateral Spinothalamic Pathways. These pathways are responsible for transmitting sensory information related to pain, temperature, crude touch, and itch from the body to the brain.The diagram shows:

The Spinal Cord: The diagram shows a cross-section of the spinal cord, highlighting the Anterior Spinothalamic Tract and the Lateral Spinothalamic Tract. These tracts are located in the gray matter of the spinal cord.

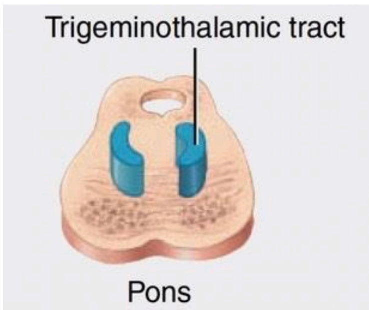
The Anterior Spinothalamic Tract: Transmits sensory information related to crude touch and pressure.

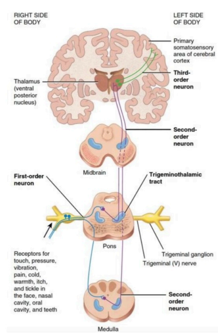
The Lateral Spinothalamic Tract: Transmits sensory information related to pain, temperature, and itch.

The Thalamus: The image shows how sensory signals from the spinal cord reach the thalamus, a major relay station in the brain for processing sensory information before it reaches the cerebral cortex.

The Cerebral Cortex: The image shows how sensory signals from the thalamus reach the cerebral cortex, where sensory information is fully processed. It is noted that signals from the right side of the body reach the left side of the brain, and vice versa, due to the decussation of nerve fibers in the spinal cord.

Trigeminothalamic Pathway





The image shows a diagram of the Trigeminothalamic Pathway. This pathway is responsible for transmitting sensory information from the face to the brain. The diagram shows:

The Trigeminal Nerve: The diagram shows the trigeminal nerve fibers carrying sensory information (touch, pressure, pain, temperature) from the face to the brainstem.

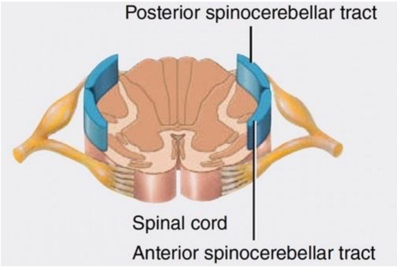
The Trigeminal Ganglion: This is a cluster of sensory neuron cell bodies of the trigeminal nerve.

The Pons: The diagram shows the entry of trigeminal nerve fibers into the pons in the brainstem.

The Thalamus: The image shows how sensory signals from the pons travel to the thalamus, a major relay station for processing sensory information before it reaches the cerebral cortex.

The Cerebral Cortex: The image shows how sensory signals from the thalamus reach the cerebral cortex, where sensory information is fully processed. It is noted that signals from one side of the face reach the opposite side of the brain.

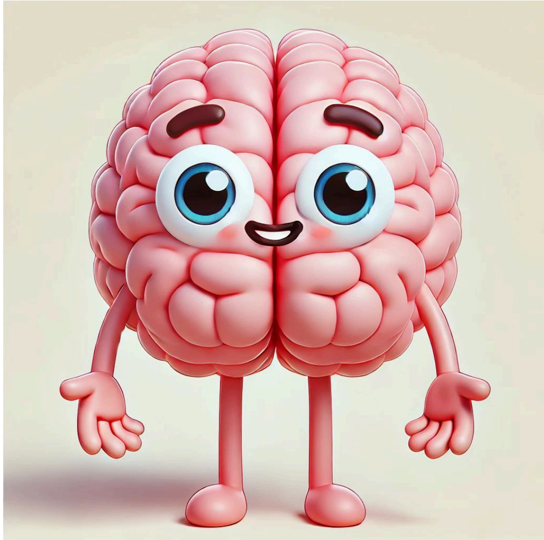
Anterior and Posterior Spinocerebellar Pathways



The image shows a diagram illustrating the Anterior and Posterior Spinocerebellar Pathways. These pathways transmit proprioceptive sensory information from the spinal cord to the cerebellum. The cerebellum plays a crucial role in motor coordination, balance, and posture control.The diagram shows:

The Posterior Spinocerebellar Tract: this tract carries proprioceptive sensory information from nerve receptors in muscles, joints, and tendons from the lower half of the body. This information is used to determine the body's position in space. Note that this tract does not decussate (cross to the opposite side of the spinal cord) before reaching the cerebellum.

The Anterior Spinocerebellar Tract: this tract carries proprioceptive sensory information from nerve receptors in muscles, joints, and tendons from the entire body. Unlike the posterior tract, this tract decussates in the spinal cord before it again decussates before reaching the cerebellum. This means information from one side of the body reaches the same side of the cerebellum.



Somatic sensory pathways are essential in the nervous system for transmitting sensory information from sensory receptors such as those in the skin, muscles, and joints to the brain for interpretation. These pathways consist of a series of neurons that convey the sensory signals across multiple stages to ensure accurate processing in the brain.

1. First-order (Primary) Neurons: These are the first sensory neurons in the somatic sensory pathway, responsible for transmitting signals from the sensory receptors to the central nervous system (CNS), specifically to the brainstem or spinal cord, They carry sensory information like pain, pressure, temperature, and muscle tension from the periphery (skin, muscles, joints) to the CNS; The impulses travel via the spinal or cranial nerves, which carry the

sensory information from the body or face to the brainstem or spinal cord; The cell bodies of first-order neurons are located in sensory ganglia near the spinal cord or within cranial nerve ganglia.

2. Second-order (Secondary) Neurons: These neurons conduct impulses from the brainstem or spinal cord to the thalamus, a major relay station in the brain; Second-order neurons handle the processing and routing of sensory signals before they are sent to the thalamus. They cross to the opposite side (decussation) as they pass through the brainstem or spinal cord, which is important for the processing of sensations on the opposite side of the body; These neurons reside in the brainstem or spinal cord, and their axons travel toward the thalamus, crossing to the opposite side during their path.

Decussation: The crossing of nerve fibers in second-order neurons ensures that sensory information from one side of the body is processed in the opposite hemisphere of the brain. For example, a sensation of pain in the right hand will be processed in the left hemisphere of the brain.

3. Third-order (Tertiary) Neurons: These neurons conduct impulses from the thalamus to the primary somatosensory area of the brain; They carry the final sensory signals to the primary somatosensory cortex where the conscious perception of sensations occurs. This is where the brain interprets touch, pain, temperature, and proprioception; The cell bodies of third-order neurons are located in the thalamus. Their axons project to the primary somatosensory cortex located in the postcentral gyrus of the parietal lobe.

Sensory Interpretation: The sensory information from one side of the body is perceived in the sensory cortex of the opposite hemisphere of the brain. This allows for conscious awareness of sensations, such as recognizing the temperature of an object you touch.

Additional Example with More Detail- Let's say you touch a very hot surface:

1. First-order Neurons: The sensory receptors in your skin detect the high temperature and send a signal through the sensory nerves to the spinal cord.

2. Second-order Neurons: The signal travels up the spinal cord to the brainstem. Here, it crosses to the opposite side (decussates) and ascends to the thalamus.

3. Third-order Neurons: The signal is then transmitted from the thalamus to the primary somatosensory cortex in the brain, where the sensation of pain and heat is perceived.

The posterior column-medial lemniscus pathway is one of the most important sensory pathways in the nervous system, responsible for transmitting fine touch, vibration, pressure, and proprioception from the limbs, trunk, neck, and posterior head to the primary somatosensory cortex in the brain. This pathway plays a vital role in enabling the body to interpret and interact with the environment precisely.

The Neural Pathway :

1. First-order Neurons: This pathway starts at sensory receptors (such as those in the skin, muscles, and joints) in the limbs (hands, feet, legs, arms), trunk, neck, and posterior head;

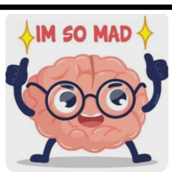
These receptors detect environmental stimuli such as touch, pressure, vibration, and temperature. They convert these stimuli into electrical signals that are carried by the first-order sensory neurons; The signals travel via sensory nerves to the spinal cord or cranial nerves if originating from the head; The cell bodies of these neurons are located in sensory ganglia near the spinal cord or cranial nerve ganglia.

2. Second-order Neurons: These neurons are found in the medulla oblongata in the brainstem or the spinal cord; The second-order neurons carry sensory signals to the thalamus, where they undergo decussation (crossing over) to the opposite side of the body. This ensures that sensory information from one side of the body is processed in the opposite side of the brain; These neurons carry the signals to the thalamus, crossing to the opposite side in the medulla.

3. Third-order Neurons: These neurons are located in the thalamus, which is a key relay station in the brain; The third-order neurons transmit the signals from the thalamus to the primary somatosensory cortex in the brain, located in the postcentral gyrus of the parietal lobe; Upon reaching the somatosensory cortex, the brain processes the sensory signals, resulting in conscious awareness of touch, pain, temperature, or any other sensation. The brain can also pinpoint the location of the sensation on the body.

The Pathway Steps: first Receptors in Sensory Organs, The sensory signals begin in receptors located in the skin, muscles, or joints, detecting stimuli such as touch, pressure, or vibration then a First-order Neuron Transmission, The sensory neurons carry the signals to the spinal cord or brainstem and we have Decussation in the Medulla, In the medulla oblongata, the nerve fibers cross over to the opposite side of the brain then Transmission to the Thalamus, The sensory signals continue to the medial lemniscus in the brainstem and then ascend to the thalamus, The signals reach the primary somatosensory cortex, where conscious perception of sensations occurs.

Integration of Sensory Functions: Fine Touch-Ability to sense detailed features of objects through touch and Vibration-Ability to detect oscillations or vibrations in objects and Pressure-The sensation of force applied to the skin or underlying tissues and Proprioception-Ability to perceive the position and movement of body parts in space.



You will find me repeating the explanation of neural pathways in detail and my goal of this is to facilitate memorization, Please focus on the differences.

The anterolateral spinothalamic pathway is an essential sensory pathway in the nervous system, responsible for transmitting sensations such as pain, temperature, itch, and tickle from various parts of the body (such as limbs, trunk, neck, and posterior head) to the primary somatosensory cortex in the brain.

Details of the Neural Pathway:

1. First-order Neurons: This pathway begins at sensory receptors located in the skin or other tissues that respond to stimuli like pain, temperature, itch, or tickle. The sensory receptors detect environmental stimuli and convert them into electrical signals (nerve impulses). These

signals are carried by sensory neurons to the spinal cord; cell bodies of these neurons are located in sensory ganglia, which are near the spinal cord.

2. Second-order Neurons: These neurons begin in the spinal cord at the dorsal horn, which is part of the gray matter of the spinal cord and transmit the sensory signals to the thalamus. Decussation or crossing over occurs at the spinal cord level, where the nerve fibers cross to the opposite side.

3. Third-order Neurons: These neurons are located in the thalamus, a key relay station for sensory information in the brain and carry the signals from the thalamus to the primary somatosensory cortex in the parietal lobe; Finally, the primary somatosensory cortex interprets the sensory signal consciously, allowing the person to experience sensations such as pain, temperature, itch, or tickle.

Steps of Signal Transmission: at the first Sensory Receptors-signal starts at the sensory receptors in the skin or tissues then First-order Neurons-The signal travels via sensory nerves to the spinal cord, After this the Second-order Neurons-The signal crosses over at the spinal cord (decussation) and heads toward the thalamus, and finally Third-order Neurons-The signal travels from the thalamus to the sensory cortex in the brain.

Sensory Functions Transmitted by the Pathway: Pain-sensation of discomfort caused by harmful stimuli such as injuries or inflammation and Temperature- sensation of different temperatures, whether hot or cold and Itch- sensation that triggers the urge to scratch, often due to allergic reactions and Tickle- sensation caused by light stimulation of the skin, usually felt on areas like the feet or underarms.

The trigeminothalamic pathway is a critical sensory pathway that transmits sensations from the face and head to the brain. It is similar to the spinothalamic pathway but is specialized for sensations from the face, oral cavity, nasal cavity, and parts of the scalp. This pathway carries information about pain, temperature, fine touch, pressure, and proprioception to the primary somatosensory cortex.

Pathway Details:

1. First-order Neurons: The cell bodies are located in the Trigeminal Ganglion, similar to the sensory ganglia in spinal pathways; Transmit sensory information from the face, oral cavity, nasal cavity, teeth, parts of the scalp, and deeper structures of the head; The sensory fibers enter the brainstem via the Trigeminal Nerve (CN V).

2. Second-order Neurons: Located in the Trigeminal Sensory Nucleus, which spans the medulla and pons and Receive sensory input from first-order neurons and process it; The fibers cross to the opposite side of the brainstem-Decussation, meaning sensory information from the right side of the face is processed in the left hemisphere; After crossing over, the fibers travel to the Thalamus via the trigeminothalamic tract.

3. Third-order Neurons: Begin in the Thalamus, the brain's major sensory relay center; Transmit signals to the Primary Somatosensory Cortex in the Parietal Lobe; sensory signal is then consciously perceived as pain, touch, or temperature.

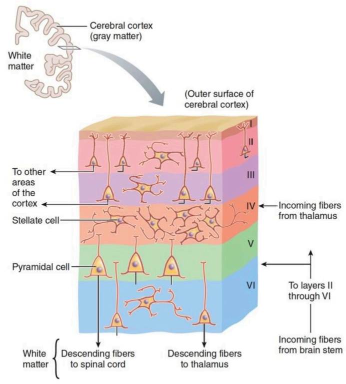
Subdivisions of the Trigeminothalamic Pathway:

1. Principal Sensory Pathway: Transmits fine touch, pressure, and vibration; Passes through the Principal Sensory Nucleus of the Trigeminal Nerve in the pons and After decussation, travels to the thalamus and then the somatosensory cortex.

2. Spinal Trigeminal Pathway: Transmits pain, temperature, and crude touch; Fibers enter the medulla and pass through the Spinal Trigeminal Nucleus, Cross over to the opposite side and travel to the thalamus and then the somatosensory cortex.

3. Mesencephalic Pathway: Responsible for proprioception from jaw muscles; Passes through the Mesencephalic Nucleus without decussation.(It's nice to know this extra information)

Sensory Functions Processed by This Pathway: Pain- Perceived from facial injuries or toothaches and Temperature- Detecting hot or cold sensations on the face and Touch- Detecting light or deep pressure on the face and Proprioception- Awareness of jaw position during chewing or speaking.



The image shows a cross-section of the somatosensory cortex, focusing on its layered organization and neural pathways. The somatosensory cortex consists of six distinct layers, each with a specific function in processing sensory information from the body.

Layer I: A superficial layer containing few neurons, primarily consisting of branching nerve fibers from deeper layers. It plays a role in regulating and integrating between neurons in other layers.

Layer II: Contains small stellate cells, responsible for processing initial sensory information and passing it to deeper layers.

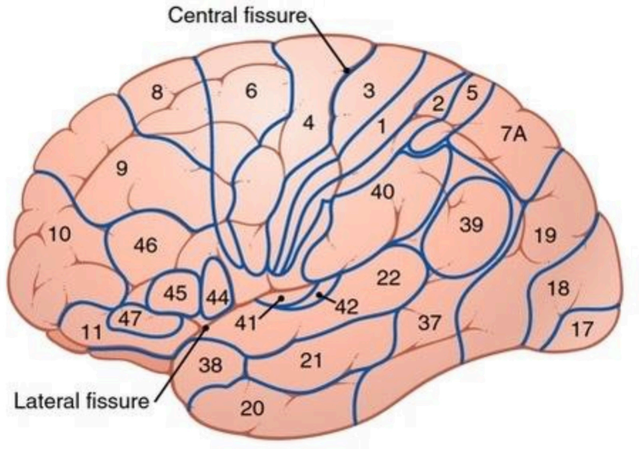
Layer III: Contains medium-sized pyramidal cells, responsible for processing more complex sensory information and sending it to other brain areas.

Layer IV: The main layer for receiving sensory information coming from the thalamus. It contains stellate and small pyramidal cells, processing initial sensory information before sending it to upper layers.

Layer V: Contains large pyramidal cells, responsible for sending sensory information to other brain areas, including the spinal cord via descending fibers.

Layer VI: Contains medium-sized pyramidal cells, responsible for sending sensory information to the thalamus via descending fibers.

The diagram also shows neural pathways coming from the thalamus and coming from the brainstem, those projecting to other areas of the cerebral cortex, and descending fibers to the spinal cord and to the thalamus, These pathways facilitate the integration of sensory information from different sources and regulate motor responses.



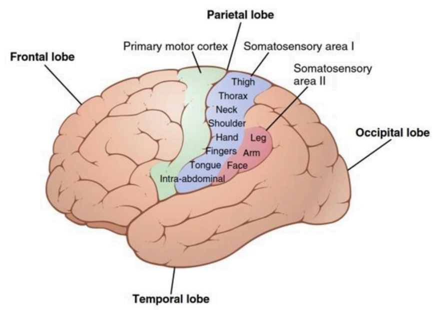
The image show:

Central fissure: This is the deep groove that separates the Frontal Lobe from the Parietal Lobe. This fissure is an important landmark in determining the locations of sensory and motor areas in the brain.

Lateral fissure: Another groove that separates the Temporal Lobe from the Frontal and Parietal Lobes.

Numbered areas (Areas 1-47): These represent Brodmann areas, which are functionally defined regions in the cerebral cortex. Each area has a specific function in processing sensory or motor information.

The image is a simplified diagram of the cerebral cortex, focusing on the Parietal Lobe which contains the Primary Somatosensory Cortex. The diagram shows how different parts of the body are represented in this area, with larger areas dedicated to more sensitive body parts such as fingers and face and smaller areas to less sensitive parts such as the leg, also shows other lobes of the brain: the Frontal Lobe, the Temporal Lobe, and the Occipital Lobe.



We will do a quick review and implement the difference between the tracks.

The Left Cerebral Hemisphere Receives Sensory Input from the Right Side of the Body.

The human nervous system is organized in a crossed fashion, meaning that sensory information from the right side of the body is processed in the left cerebral hemisphere, and vice versa, This happens due to the decussation (crossing over) of sensory fibers at different points along the pathway to the brain.

Main Sensory Pathways That Transmit Information to the Opposite Hemisphere:

1. Posterior Column-Medial Lemniscus Pathway:

Conveys: Fine touch, Vibration sense, Proprioception (body position awareness)

Decussation point: Sensory fibers enter the spinal cord through the dorsal roots, They ascend through the posterior columns of the spinal cord without crossing and When they reach the medulla oblongata, they cross over via the medial lemniscus then They continue to the thalamus and finally reach the primary somatosensory cortex in the left hemisphere Thus, sensations from the right side are perceived in the left cerebral hemisphere.

2. Spinothalamic Pathway:

Conveys: Pain, Temperature, Crude touch

Decussation point: Sensory fibers enter the spinal cord through the dorsal roots, They cross over immediately within the spinal cord at the level where they enter They ascend through the lateral spinothalamic tract toward the thalamus and then reach the primary somatosensory cortex in the left hemisphere, Thus, pain and temperature sensations from the right side are processed in the left cerebral hemisphere.

3. Trigeminothalamic Pathway (For the Face and Head):

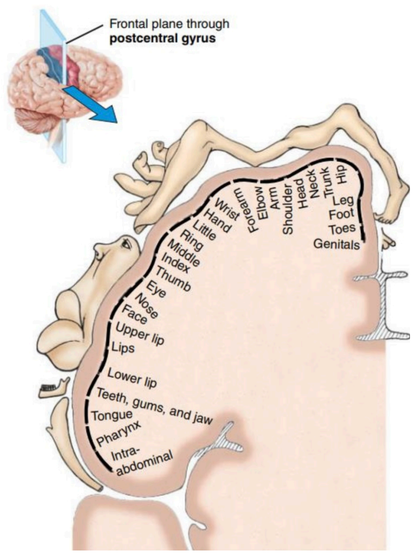
Conveys: Pain, temperature, and touch from the face and head

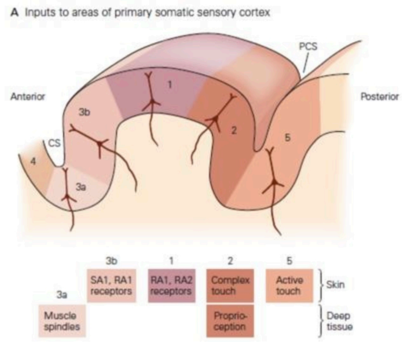
Decussation point: Sensory fibers enter the brainstem via the Trigeminal Nerve (CN V) They cross over within the brainstem (medulla and pons) and They ascend to the thalamus, then to the primary somatosensory cortex in the left hemisphere Thus, sensory input from the right side of the face is processed in the left hemisphere.

Why Does Decussation Happen?

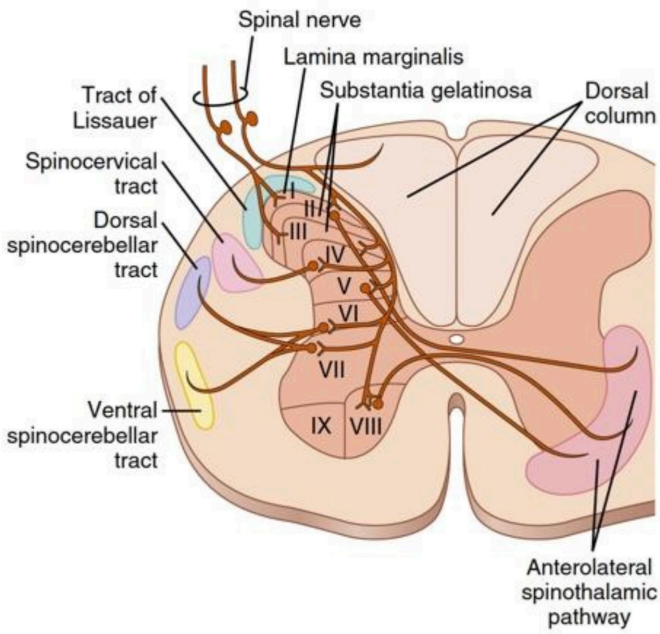
Crossed organization in the nervous system is thought to provide better coordination and control of movement and sensation. Since the left hemisphere also controls motor functions of the right side of the body, having sensory input from the right side processed in the same hemisphere allows for more efficient sensorimotor integration.

The image shows a diagram representing the somatotopic organization of the primary somatosensory cortex. It illustrates how different parts of the body are mapped onto specific areas of the somatosensory cortex, with the size of the area corresponding to the sensitivity of that body part. More sensitive areas, like the hands and face, are represented by larger areas, while less sensitive areas, like the legs, are represented by smaller areas. This representation is known as a sensory homunculus because the representation is not proportional to the actual size of the body parts. The top part of the diagram shows a cross-section of the brain indicating the location of the somatosensory cortex.





The image is a diagram showing the inputs to different areas of the primary somatosensory cortex in the brain. The cortex is divided into numbered areas (1, 2, 3a, 3b, 5), each receiving sensory input from different types of receptors. For example, area 3a receives input from muscle spindles, while areas 1 and 2 receive input from complex touch and proprioception receptors. Area 5 receives input from active touch. The diagram also shows that these areas receive input from the skin and deep tissue. In short, the diagram illustrates how different sensory information from the body is processed in specific areas of the somatosensory cortex.



This is from me, and I am giving a brief overview. The image shows a diagram of a cross-section of the spinal cord, illustrating different ascending neural pathways. The diagram shows the dorsal column and the different layers of the gray matter, numbered I through IX. It also shows the main ascending tracts, including:

Dorsal Spinocerebellar Tract: Transmits proprioceptive sensory information from the body to the cerebellum.

Ventral Spinocerebellar Tract: Also transmits proprioceptive sensory information to the cerebellum.

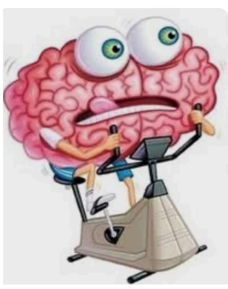
Spinocervical Tract: Transmits sensory information from the neck and upper body.

Tract of Lissauer: A small tract transmitting sensory information.

Anterolateral Spinothalamic Pathway: Transmits sensory information about pain, temperature, and light touch.

Lamina Marginalis: A layer of gray matter.

Substantia Gelatinosa: An area in the gray matter that plays a role in pain processing.



Be as precise as a scalpel, as knowledgeable as the mind, and as patient as the pulse of life.