Thalamus and Sensory Functions of Cerebral Cortex
Objectives

I: To describe the functional divisions of thalamus.

II: To state the functions of thalamus and the thalamic syndrome.

III: To define the somatic sensory cortical areas.

IV: To list the functions and the dysfunctions of the somatic sensory cortical areas.
THE THALAMUS

The two thalami are large ovoid masses of gray matter situated at the lateral walls of the third ventricle, one on each side. They are interconnected by a short communicating bar of white matter (Massa intermedia) which traverses the third ventricle.

Thalamus operates in close association with cerebral cortex, so both are sometimes called thalamo-cortical system.

All the nervous signals which go to the cerebral cortex pass first through and relay in the thalamus. That is why the thalamus is sometimes called the "secretary of the cerebral cortex".
ANATOMICAL DIVISIONS OF THE THALAMUS

In each thalamus there are 5 groups of nuclei:
FUNCTIONAL DIVISIONS OF THE THALAMUS

Functionally, the thalamic nuclei could be classified into four categories:

[I] Specific projection nuclei (cortical relay nuclei):

a. Ventral posterolateral nucleus (VPL), which is the site of relay of the somatic sensory pathways from the trunk and limbs.
b. Ventral posteromedial nucleus (VPM), which is the site of relay of the trigeminal sensory pathway from the head.
c. Medial geniculate body (MGB); site of relay of the auditory pathway.
d. Lateral geniculate body (LGB): site of relay of the visual pathway.

AFFERENT CONNECTIONS: From the medial, spinal and trigeminal lemnisci, optic tract, auditory pathways.

EFFERENT CONNECTIONS: Specific thalamic projection system to specific points in the somatic audio and visual sensory areas of the cerebral cortex.
[II] Nonspecific projection nuclei:
  a. Intralaminar and midline nuclei.
  b. Ventoanterior nucleus.
  c. Anterior nuclei.

AFFERENT CONNECTIONS: From the ascending reticular activating system (ARAS), and the paleospinothalamic tracts.
EFFERENT CONNECTIONS: Nonspecific thalamic projection fibers to all parts of the cerebral cortex. The anterior nuclei are connected to the hypothalamus and limbic system.

[III] Association nuclei:
  a. Dorsolateral nucleus.
  b. Posterolateral nucleus.
AFFERENT CONNECTIONS: From other thalamic nuclei
EFFERENT CONNECTIONS: Dorsomedial nucleus projects to prefrontal cortical area, while the dorsolateral nucleus projects to the cortical association areas.
[IV] Motor nuclei:
The most important of these is the ventrolateral nucleus VL.

AFFERENT CONNECTIONS: From the basal ganglia and cerebellum.
EFFERENT CONNECTIONS: The motor cortex.

Fig. 6-1 Thalamic nuclei
FUNCTIONS OF THE THALAMUS

1. It is a relay station for all the sensory pathways in their way to the cerebral cortex except olfaction.
2. It acts as a final sensory center for conscious perception of some sensations: i.e. slow pain, high or low grades of temperature and crude touch.
3. Facilitation of the cerebral cortex, raising its excitability up to the level necessary to do all cerebral functions.
4. Identification of the stimulus affect (pleasant or unpleasant), and controlling the emotional and motor reactions to it.
5. It is part of the limbic circuit which is concerned with recent memory and memory search.
6. It is part of the caudate and putamen circuits which control the motor activity.
7. It is involved in control of high intellectual cortical functions and the behavior and personality through its connections with the cortical association areas and with the prefrontal cortical areas respectively.
THE THALAMIC SYNDROME
(The thalamic hyperesthetic anesthesia)

The most common cause of this syndrome is thrombosis of the thalamogeniculate artery which is a branch of the posterior cerebral artery.
This leads to degeneration of the posterior and ventral parts of the thalamus.
The manifestations which appear on the contralateral side of the lesion include:

MOTOR EFFECTS

The damage of the ventrolateral nucleus (main motor nucleus) leads to loss of cerebellar and basal ganglion control on the motor cortical areas. There is hemiparesis (weakness of the muscles), hemiataxia and choreoathetoid movements.
There is complete hemi anesthesia at the onset of the disease except the upper part of face sensation is retained.

Few weeks later protopathic sensation (primitive sensations which include crude touch, slow pain and high or low temperatures) are recovered.

Epicritic sensations (fine sensations, which include fine touch, proprioceptive sensations and intermediate grades of temperature) are permanently and irreversibly lost.

The threshold of pain is elevated but once reached it gives very unpleasant severe agonizing pain.
There are three somatic sensory areas in the cerebral cortex:

1. **THE PRIMARY SOMATIC SENSORY AREA (SI):**
   This area is located in the post central gyrus of the parietal lobe (Fig. 6-1). It receives projection fibers from the ventrobasal complex of the thalamus (VPLN and VPMN).

**BODY REPRESENTATION:**

- a. It is crossed and inverted representation (Fig. 6-2). The upper half of the face is bilaterally represented.
- b. The area of representation is proportional to the number of receptors in this part, not to its size.
- c. Modality representation is included within the topographic representation.
- d. Topographic areas of representation are changeable and modified.
Figure 6-2: Brodmann areas of the cerebral cortex.

Figure 6 - 3: Body representation in the postcentral sensory gyrus
FUNCTIONS:
The primary somatic sensory area is essential for the perception of:

1. **Fine touch sensation**, i.e. tactile localization and discrimination.

2. **Localization of pain and temperature sensations**, SI is not essential for their perception; it is only needed for their accurate localization.

3. **Intensity discrimination** of different stimuli.

4. **Texture of material**.

5. **Proprioception**; static and dynamic.
THE SECONDARY SOMATIC SENSORY AREA (SII)

LOCATION:
In the supramarginal gyrus, behind the lower part of SI.

BODY REPRESENTATION:
Bilateral representation with poor topographic representation. The head area is generally in the anterior part and the leg area in the posterior part. SII receives connection fibers which convey input signals from SI, the visual and auditory cortical sensory areas, and the thalamic nuclei on both sides of the body.

FUNCTIONS:
SII is a potentiator of SI. And it cannot work independent of SI. So, SI can work without SII, but the opposite is not true.
SOMATIC SENSORY ASSOCIATION AREA
(SOMATIC INTERPRETATIVE AREA)

LOCATION:
This area is located in the posterior parietal cortex, behind SI and above SII.

CONNECTIONS:
It receives sensory signals from SI, SII, and the thalamus.

FUNCTIONS:
1. It combines all sensory signals to give meaning to the complex sensory input.
2. Stereognosis. This area is the center of stereognosis.
3. Spatial orientation of the body with its surroundings.
4. Memory. This area is the memory store of previous sensory experience. Stimulation of this area produces sensory hallucinations.
DYSFUNCTION:

A lesion in the somatic sensory association area results in:

1. **Astereognosis**, i.e. inability to identify objects by their touch, shape, weight and texture.

2. **Autotopagnosia**, loss of recognition of part or whole contralateral side of the body. The patient does not acknowledge the existence of the affected part and fails to include it in planning of voluntary movement.

3. Impaired memory and decreased intelligence.