Medical Neuroscience | Tutorial

Overview of the Thalamus

Map to Neuroscience Core Concepts[1]

NCC1. The brain is the body's most complex organ.

NCC3. Genetically determined circuits are the foundation of the nervous system.

NCC7. The human brain endows us with a natural curiosity to understand how the world works.

Learning Objectives

After study of today's learning, the student will:

1. Discuss the embryological origin of the thalamus.
2. Discuss the location of the thalamus in the human brain.
3. Characterize the role of the thalamus in brain function.

TUTORIAL OUTLINE

I. Embryological origin of the thalamus

A. the thalamus is a major part of the **diencephalon**, which is derived from the **prosencephalon** (see **Figure 22.3 and A24**[2])

1. the dorsal and posterior part of the diencephalon becomes the **thalamus**
2. the ventral and anterior part becomes the **hypothalamus**
3. thus, the thalamus is a component of the forebrain

II. Anatomical localization of the thalamus

A. with respect to the whole brain: the thalamus is near the center of the forebrain (see **Figure A14C; Appendix BoxA (Figure A)**)

B. relative to the internal capsule: the thalamus is *medial* to the posterior limb of the internal capsule (see **Figure A14B**)

C. relative to the lateral ventricle: the thalamus is the floor of the body of the lateral ventricle (see **Figure A14C**)

III. Role of the thalamus in brain function

A. general organization (see **Appendix BoxA (Figure A)**)

[1] Visit **BrainFacts.org** for *Neuroscience Core Concepts* (©2012 Society for Neuroscience) that offer fundamental principles about the brain and nervous system, the most complex living structure known in the universe.

[2] Figure references to Purves et al., *Neuroscience, 5th Ed.*, Sinauer Assoc., Inc., 2012. [click here]

1. comprised of a large number of distinct nuclei (circumscribed clusters of neurons) that are bounded by a "Y"-shaped bundle of axons
2. each nucleus sends and receives projections for a different region of the cerebral cortex:
    a. anterior group (in the crook of the "Y") projects to cingulate gyrus
    b. medial group projects to the anterior frontal lobe in front of the motor cortex (i.e., the prefrontal cortex), the insula and the medial temporal lobe
    c. lateral group projects to different regions of the remaining sensory and motor regions of the cerebral cortex in each lobe
    d. additionally, there are smaller nuclei within the fiber bundles that make up the "Y"; these intralaminar nuclei project diffusely throughout the cerebral cortex

B. principal functions (see **Appendix BoxA (Figure B)**)

1. *relay information*, in a "feed-forward" fashion, *to the cerebral cortex*
    a. sources of input to specific thalamic relay nuclei
        i. for somatic sensation, from the spinal cord and brainstem
        ii. for audition and vestibular sensation, from the brainstem
        iii. for vision, from the sensory periphery (retina)
        iv. for the modulation of movement, from the basal ganglia and the cerebellum
    b. outputs from specific thalamic relay nuclei to the cerebral cortex; these outputs to the cerebral cortex terminate densely in layer 4 thus defining unimodal, "primary" cortical areas
        i. for somatic sensation, to the postcentral gyrus
        ii. for audition, to the superior plane of the temporal gyrus
        iii. for vision, to the cortex in the banks of the calcarine sulcus (lingual and cuneus gyri)
        iv. for the modulation of movement, to the motor cortex
2. *distributer of higher-order* (more processed) *signals from one cortical area to another*
    a. some thalamic nuclei are driven primarily by cortical inputs, rather than ascending sensory or motor signals
    b. these thalamic nuclei, in turn, provide higher-order input that drives activity in other (non-primary) cortical areas
3. *modulators of cortical function*
    a. the intralaminar and midline thalamic nuclei (sometimes called the "non-specific thalamic nuclei") send diffuse projects to the cerebral cortex that terminate diffusely in upper cortical layers
    b. these diffuse projects have modulatory influences over large-scale networks of cortical neurons that could be important for attention, arousal, mood change, and transitions in sleep and wakefulness

STUDY QUESTION

What are the functions of the thalamus?

A. articulate, compound and communicate
B. relay, distribute, modulate
C. amplify, coordinate and calculate
D. advance, compute and contemplate
E. amplify, compute and communicate