

Section 5

Anatomy and Physiology of Pain Pathways

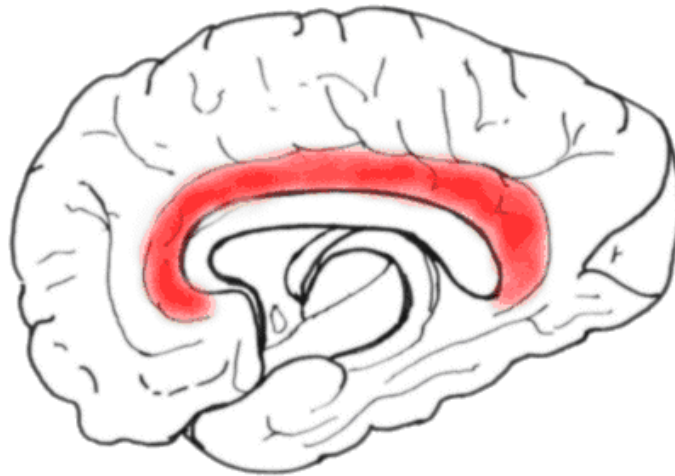
The Cortex of the Brain

The brain is devoid of nociceptive tissue, and therefore cannot experience pain. Thus, a headache is not due to stimulation of pain fibers in the brain itself. Rather, the dura mater membrane surrounding the brain and spinal cord is innervated with pain receptors, and stimulation of these dural nociceptors is thought to be involved to some extent in producing headache pain. Vasoconstriction of peripheral vessels is also another common cause of headache.

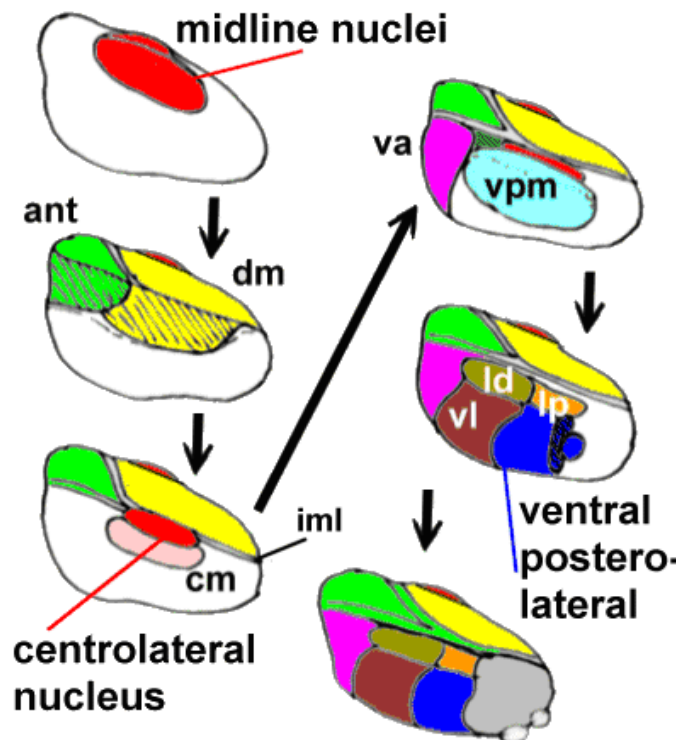
Research suggests that cortical structures are involved in the perception of pain. Connections that link higher cortical structures with pain-centered nuclei in the thalamus and brainstem include the following:

- The primary sensory cortex, S I .
- The secondary sensory cortex, S II.
- The anterior part of the insula .
- The cingulate gyrus.

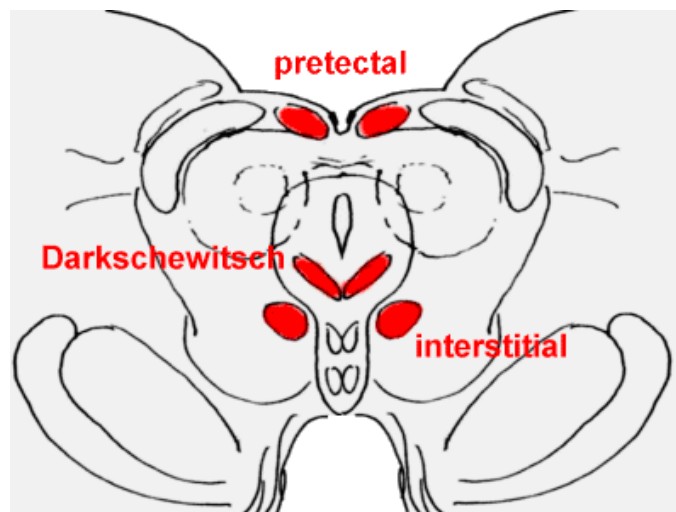
S I is concerned with the localization of pain, while the other three structures are thought to be concerned with the motivational-affective aspects of pain.



The human brain as seen from the side, showing the SI and SII sensory cortex. SI is a thin strip made up of Brodman areas 3,1 and 2 posterior to the central sulcus, while SII is found just above the lateral sulcus.¹

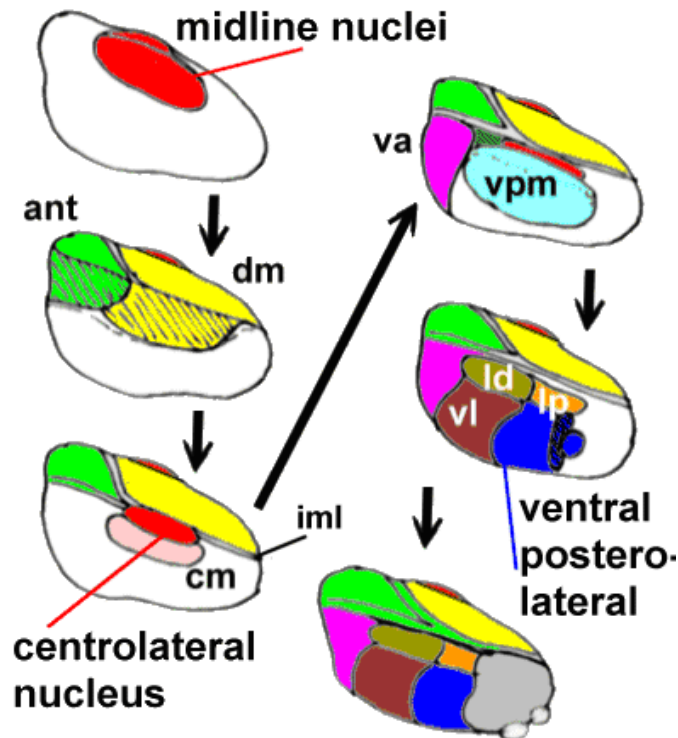


Retracted temporal lobe revealing the insula.
(the anterior portion is thought to be concerned with pain perception.)²



The picture above illustrates the medial aspect of a hemisphere, showing the cingulate gyrus.
The anterior part of the cingulate gyrus is important in the perception of 'affective' pain.

Thalamic Nuclei



The Thalamus

The thalamus has multiple nuclei that are involved with the perception of pain. The lateral nuclei deal mainly with sensory/discriminative aspects, while the medial nuclei deal with 'affective' pain. Medially is the midline nuclei. Lateral to the midline nuclei is the dorsomedial nucleus(dm) and, more anteriorly the anterior nuclei(ant) . Even further laterally we have the lateral dorsal(ld), lateral posterior(lp), ventral lateral(vl) and ventral posterolateral nuclei. The pulvinar (grey) is situated posteriorly

The internal medullary lamina bounds the dorsomedial nucleus laterally, and separates it from the anterior nuclei. Within the internal medullary lamina are the intralaminar nuclei, including the centromedian (cm) and centrolateral nuclei. Lateral to the internal medullary lamina (iml) lies the ventral posteromedial nucleus (vpm) and anterior to this is the ventral anterior nucleus (va).

A Diagram of the Thalamic nuclei. The lateral thalamus is thought to be mainly concerned with 'discriminative' pain, the medial with "affect/motivation".³

The midline nuclei include the:

- nucleus reuniens
- rhomboidal nucleus
- submedius nucleus

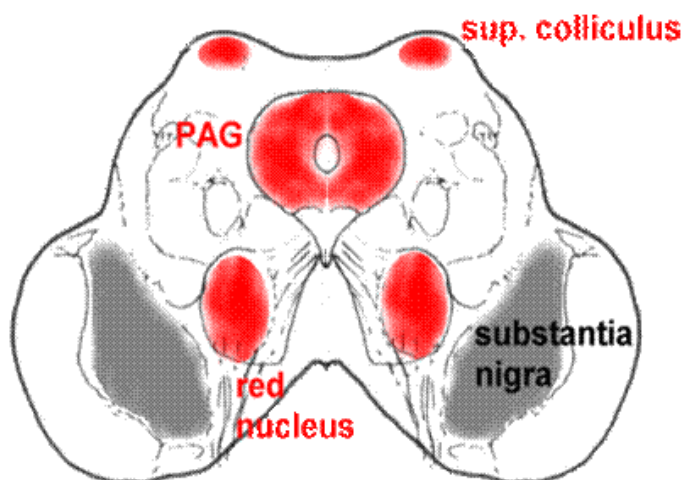
The submedius nucleus has been found to play a significant role in pain perception.

Midbrain

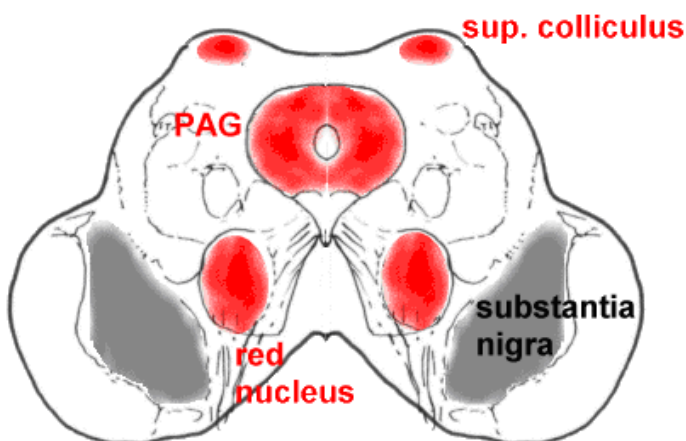
There is a host of pain-related structures in the midbrain. The midbrain is involved in 'affective' pain, with extensive connections to the reticular system of the brainstem.

Important components are:

- The peri-aqueductal grey matter (PAG)
- Deep layers of the superior colliculus
- The red nucleus
- The pre-tectal nuclei (anterior and posterior)
- The nucleus of Darkschewitsch
- the interstitial nucleus of Cajal
- The intercolliculus nucleus, nucleus cuneiformis and the Edinger-Westphal nucleus.



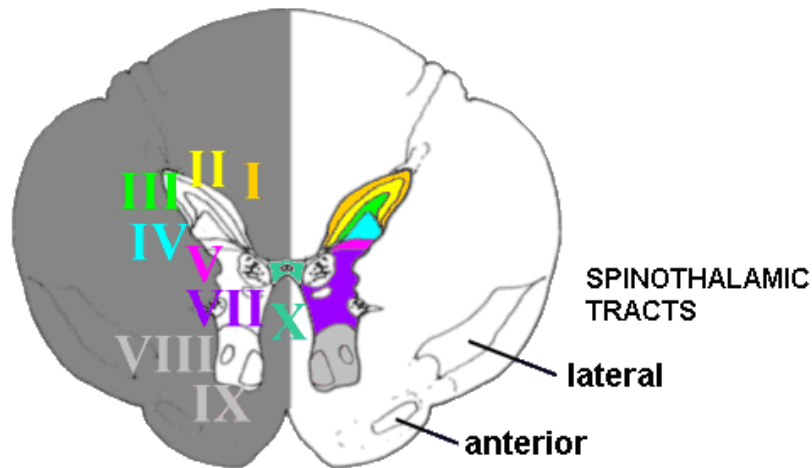
Rostral midbrain, with the anterior pretectal nucleus, interstitial nucleus of Cajal, and nucleus of Darkschewitsch in red.



A caudal section through the midbrain, showing the superior colliculus (SC), periaqueductal grey matter (PAG), and red nucleus (RN).⁴

The Pons

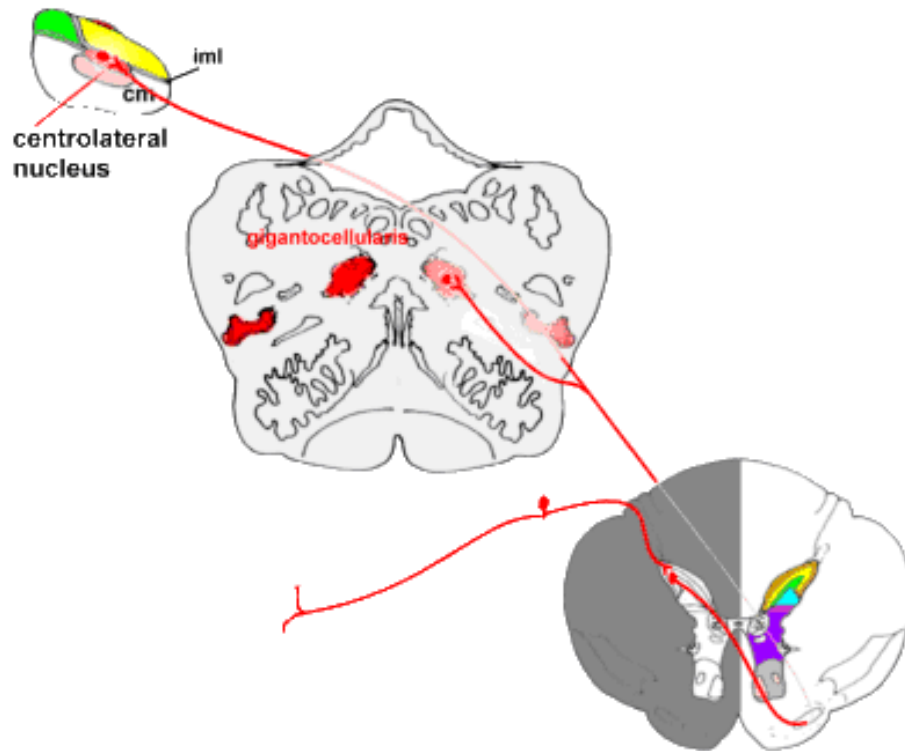
The most important pain-related nucleus in the pons is the locus coeruleus. This structure has noradrenaline-containing neurons, and projects to a variety of brainstem structures that modulate pain through pathways that descend to the spinal cord. Also, the parabrachial nuclei receive a vast number of ascending spinothalamic fibers. Both are shown in the following cross-section through the pons.



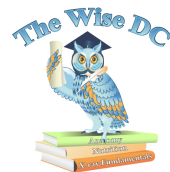
A cross-section through the pons, showing the locus coeruleus (LC) and the lateral parabrachial nucleus (PB) ⁵

The Medulla

The medulla is involved in the motivational/affective aspects of pain. Important cell groups are the nucleus gigantocellularis and related nuclei, the lateral reticular nucleus, and a variety of other nuclei. The raphe nuclei near the midline are important in the descending pathways that suppress pain.



The rostral medulla, with the nucleus gigantocellularis and lateral reticular nucleus ⁶



¹ www.aboutmind.com/brain-structure.shtml

² www.aboutmind.com/brain-structure.shtml

³ www.anaesthetist.com

⁴ www.anaesthetist.com

⁵ www.anaesthetist.com/icu/pain

⁶ www.anaesthetist.com/icu/pain