

Hypothalamus

Objectives

- To learn the general organization of the hypothalamus and the functions of the major nuclei
NTA Ch 14, pgs. 419-422
Key Figs: 14-2, 14-3
- To learn how the brain regulates neuroendocrine secretions
NTA Ch 14, pgs. 422-427
Key Figs: 14-3; 14-4,
- To learn how the hypothalamus regulates the autonomic nervous system and how brain stem and spinal lesions disrupt autonomic functions
NTA Ch 14, pgs. 427-433; 440-442
Key Figs: 14-8, 14-9
Clinical Case
#14 Menstrual irregularity; CC12-1

Note

We will not spend any time on the peripheral organization of the autonomic nervous system. That topic is covered in SPBM. Instead, we focus on the central pathways and how they control autonomic functions.

Self evaluation

- Be able to identify all structures listed in key terms and describe briefly their principal functions
- Use neuroanatomy on the web to test your understanding

G-1 Gross anatomy of hypothalamus

The ventral view of the brain. Note the relationships of the floor of the hypothalamus to the caudal edge of the chiasm and the basis pedunculi. The caudal hypothalamus lies deep to the mammillary bodies. The middle or tuberal hypothalamus lies deep to the tuber cinereum, the low protuberance extending from the mammillary bodies to the posterior chiasm.

SA03 Inferior brain view

Identify the mammillary bodies, region of other hypothalamic nuclei, and optic chiasm and tracts

SA01 Medial brain view

Identify the following landmarks and hypothalamic components: Mammillary body, region of hypothalamus, thalamus, optic nerve and chiasm, and oculomotor nerve.

hypothaltrans Hypothalamus (movie)

Key:

Hypothalamus=yellow

Ventricular system=aqua

G-3 Hypothalamic nuclei

A schematic drawing of a dissected human brain showing the major hypothalamic nuclei in parasagittal section. For landmarks, identify the fornix (a limbic system pathway memory). The fornix divides the medial and lateral hypothalamic nuclei. Find the optic chiasm (and tract) and infundibular stalk. Note also the position of the lamina terminalis, which is the rostral wall of the third ventricle.

Find the following nuclei, and for each, try and identify at least one key function: supraoptic nucleus, paraventricular nucleus, ventromedial nucleus, mammillary body (nucleus), and arcuate (infundibular) nucleus.

In the top panel, the medial hypothalamic nuclei (colored yellow in the lower portion of the figure) were not drawn, thereby revealing the lateral (purple) hypothalamic nuclei.

Note that the periventricular nuclei are not drawn on this diagram. If they had been drawn, the periventricular nuclei would form a thin sheet covering the medial (yellow) nuclei.

G-5 Ventromedial and suprachiasmatic nuclei - Nissl stain

This is a nissl-stained section, cut in an oblique coronal plane (the dorsal tissue is more caudal than the ventral tissue). For orientation, note the optic chiasm, optic tract, amygdala, third ventricle, hypothalamic sulcus, internal capsule, and subthalamic nucleus. The poorly staining circular structure just medial to the medial wing of the internal capsule is the fornix. The circumscribed ovoid structures situated ventral and medial to the fornices are the ventromedial nuclei, the largest nuclei of the hypothalamus. The small round darkly staining nuclei above the optic chiasm at the bottom of the third ventricle are the suprachiasmatic nuclei. The poorly staining region lying ventrolateral to the fornix is the lateral zone of the hypothalamus. The poor Nissl-staining in that region is due to the MFB, which occupies a considerable volume of this region.

G-4 Paraventricular and supraoptic nuclei Nissl stain

This is a Nissl-stained section through the anterior hypothalamus. Unfortunately, during the processing of this tissue, the optic chiasm and floor of the third ventricle were lost. For general orientation identify the third ventricle, internal capsule, thalamus, and amygdala. The third ventricle at this level contains two noteworthy features. First, notice the massa intermedia, an adhesion between the midline thalamic nuclei (function unknown). Second, note the indentation within the ventricular wall just ventral to the massa intermedia. This is the hypothalamic sulcus and denotes the dorsal extent of the hypothalamus. Two darkly staining nuclei are situated in the lower portions of the middle zone. These are the paraventricular nuclei. The paraventricular nucleus also has a component located in the periventricular zone. The two nuclei lying along the ventral surface of the hypothalamus are the supraoptic nuclei. These magnocellular cell groups produce oxytocin and vasopressin. The nondistinctive cellular region between these nuclei is the anterior hypothalamic area, which controls thermoregulation and the secretion of several anterior pituitary hormones. The region lying dorsal and immediately lateral to the supraoptic nucleus is the lateral hypothalamus, an amorphous cellular region that contains the MFB.

G-12 Oxytocin- and vasopressin-containing cells in the paraventricular and supraoptic nuclei of the rat

This is a coronal section showing the location of oxytocin- and vasopressin-containing neurosecretory cells within the paraventricular nucleus. Monoclonal antibodies have been used to immunohistochemically visualize each type of cell. Oxytocin cells appear as light brown (due to their labeling with diaminobenzidine), while vasopressin neurons are grayish-blue (labeled with 4-chloro-1-naphthol). Techniques designed to reveal the co-localization of several peptides within a single neuron have so far failed to find any cells which synthesize both oxytocin and vasopressin. However, both types of cells are sometimes seen to also contain corticotropin-releasing factor (CRF). (Slide courtesy of Dr. Anna Hou-Yu.)

G-13 Oxytocin- and vasopressin-containing cells in the paraventricular and supraoptic nuclei of the rat

This is a coronal section showing the location of oxytocin- and vasopressin-containing neurosecretory cells within the supraoptic nucleus. The labeling is the same as for slide G-12 (Slide courtesy of Dr. Anna Hou-Yu.)

The median eminence is located in the proximal infundibular stalk. It contains a vascular portion where the hypophyseal portal system is located.

X085 Coronal section through the infundibular stalk - myelin stain

This section cuts through the proximal portion of the infundibular stalk, which is where the median eminence is located. The median eminence contains a vascular portion where the hypophyseal portal system is located. The space overlying the stalk is the third ventricle.

G-8 Magnocellular and parvocellular neurosecretory system

This slide shows capillaries of the system in the median eminence (near #16 on slide). Parvocellular neurons release “release and release-inhibiting” factors into capillaries. These factors are carried down to the anterior pituitary, where they act directly on hormone-secreting cells.

Axons from magnocellular neurons pass through a part of the median eminence to reach the posterior pituitary. Terminals of the magnocellular neurons release oxytocin or vasopressin into systemic capillaries (e.g., located between #19 and #20 on slide).

G-8 Descending hypothalamic projections

The autonomic nervous system is under important regulation by the brain. Recently, numerous descending autonomic pathways have been identified. These pathways originate in the brain stem and the hypothalamus. The principal hypothalamic nucleus is the paraventricular nucleus. Although the pathway by which these connections are made are not well understood, some descending hypothalamic fibers may run in the dorsal longitudinal fasciculus. Other descending hypothalamic fibers course in the lateral tegmentum and do not form a discrete tract.

X020 Medulla - myelin stain

The major descending hypothalamic projection courses through the dorsolateral brain stem. In addition, the dorsal longitudinal fasciculus contains fibers that descend through the central gray of the midbrain into the periventricular gray of the medulla and pons to innervate certain cranial nerve nuclei.

Why does PICA occlusion produce Horner’s syndrome?

X-5 Spinal cord - myelin stain

After reviewing gray and white matter components, identify the intermediolateral nucleus in the thoracic cord and the approximate location of the parasympathetic nucleus in the lumbo-sacral cord. The descending hypothalamic projection is located in the lateral column where lesions produce, among other signs, Horner’s syndrome.

Key Structures and Terms

Anterior commissure
Optic tract & chiasm
Lamina terminalis
Hypothalamic sulcus
Median eminence
Pituitary
Infundibulum

HYPOTHALAMIC NUCLEI:

Periventricular zone
Paraventricular nucleus
Preoptic area
Suprachiasmatic nucleus
Supraoptic nucleus
Mammillary bodies

HYPOTHALAMIC FIBER TRACTS:

Fornix
Mammillothalamic tract
Stria terminalis
Projection from the PVN to the spinal cord

OTHER NUCLEI

Intermediolateral nucleus
Solitary nucleus