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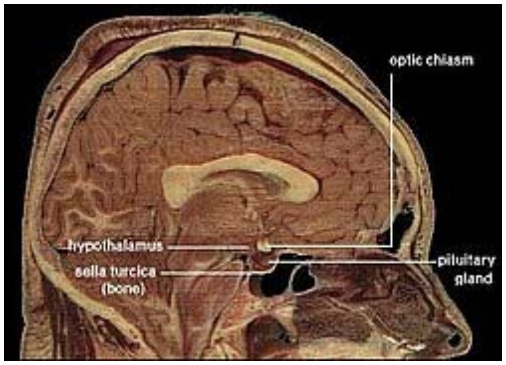
Hypothalamus

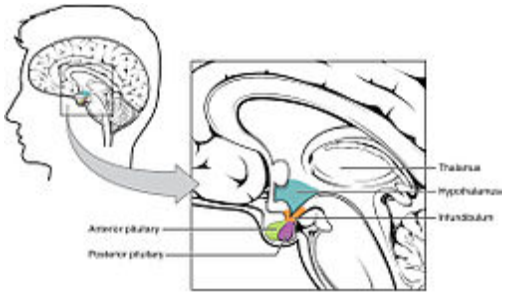
The **hypothalamus** is a portion of the brain that contains a number of small nuclei with a variety of functions. One of the most important functions of the hypothalamus is to link the nervous system to the endocrine system via the pituitary gland. The hypothalamus is located below the thalamus and is part of the limbic system.[1] In the terminology of neuroanatomy, it forms the ventral part of the diencephalon. All vertebrate brains contain a hypothalamus. In humans, it is the size of an almond. The hypothalamus is responsible for the regulation of certain metabolic processes and other activities of the autonomic nervous system. It synthesizes and secretes certain neurohormones, called releasing hormones or hypothalamic hormones, and these in turn stimulate or inhibit the secretion of hormones from the pituitary gland. The hypothalamus controls body temperature, hunger, important aspects of parenting and attachment behaviours, thirst,[2] fatigue, sleep, and circadian rhythms. The hypothalamus derives its name from Greek ὑπό, *under* and θάλαμος, *chamber*.

Contents

Hypothalamus



Location of the human hypothalamus



Location of the hypothalamus (*blue*) in relation to the pituitary and to the rest of the brain

Details	
Part of	Brain
Identifiers	
Latin	*hypothalamus*
MeSH	D007031 (https://meshb.nlm.nih.gov/record/ui?ui=D007031)
NeuroLex ID	birnlex_734 (http://www.neurolex.org/wiki/birnlex_734)
TA	A14.1.08.401 (http://www.unifr.ch/ifaa/Public/EntryPage/TA98%20Tree/Entity%20TA98%20EN/14.1.08.401%20Entity%20TA98%20EN.htm) A14.1.08.901 (http://www.unifr.ch/ifaa/Public/EntryPag

Structure

The hypothalamus is a brain structure made up of distinct nuclei as well as less anatomically distinct areas. It is found in all vertebrate nervous systems. In mammals, magnocellular neurosecretory cells in the paraventricular nucleus and the supraoptic nucleus of the hypothalamus produce neurohypophysial hormones, oxytocin and vasopressin. These hormones are released into the blood in the posterior pituitary.[3] Much smaller parvocellular neurosecretory cells, neurons of the paraventricular nucleus, release corticotropin-releasing hormone and other hormones into the hypophyseal portal system, where these hormones diffuse to the anterior pituitary.

	e/TA98%20Tree/Entity%20TA98%20EN/14.1.08.901%20Entity%20TA98%20EN.htm)
FMA	62008 (https://bioportal.bioontology.org/ontologies/FMA/?p=classes&conceptid=http%3A%2F%2Fpurl.org%2Fsig%2Font%2Ffma%2Ffma62008)
Anatomical terms of neuroanatomy	

Nuclei

The hypothalamic nuclei include the following:[4][5][6]

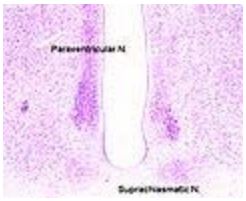
Human hypothalamus (shown in red)

List of nuclei, their functions, and the neurotransmitters, neuropeptides, or hormones that they utilize

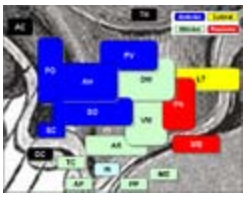
Region	Area	Nucleus	Function[7]
Anterior	Preoptic	Preoptic nucleus	▪ Thermoregulation
	Medial	Medial preoptic nucleus	▪ Regulates the release of gonadotropic hormones from the adenohypophysis ▪ Contains the sexually dimorphic nucleus, which releases GnRH, differential development between sexes is based upon in utero testosterone levels ▪ Thermoregulation[8]
		Supraoptic nucleus	▪ Vasopressin release ▪ Oxytocin release
		Paraventricular nucleus	▪ thyrotropin-releasing hormone release ▪ corticotropin-releasing hormone release ▪ oxytocin release ▪ vasopressin release ▪ somatostatin release
		Anterior hypothalamic nucleus	▪ thermoregulation ▪ panting ▪ sweating ▪ thyrotropin inhibition
		Suprachiasmatic nucleus	▪ Circadian rhythms
	Lateral	Lateral nucleus	See Lateral hypothalamus § Function – primary source of orexin neurons that project throughout the brain and spinal cord
Tuberal	Medial	Dorsomedial hypothalamic nucleus	▪ blood pressure ▪ heart rate ▪ GI stimulation
		Ventromedial nucleus	▪ satiety ▪ neuroendocrine control
		Arcuate nucleus	▪ Growth hormone-releasing hormone (GHRH) ▪ feeding ▪ Dopamine-mediated prolactin inhibition
	Lateral	Lateral nucleus	See Lateral hypothalamus § Function – primary source of orexin neurons that project throughout the brain and spinal cord
		Lateral tuberal nuclei	
Posterior	Medial	Mammillary nuclei (part of mammillary bodies)	▪ memory

		Posterior nucleus	■ Increase blood pressure ■ pupillary dilation ■ shivering ■ vasopressin release
	Lateral	Lateral nucleus	See Lateral hypothalamus § Function – primary source of orexin neurons that project throughout the brain and spinal cord
		Tuberomammillary nucleus[9]	■ arousal (wakefulness and attention) ■ feeding and energy balance ■ learning ■ memory ■ sleep

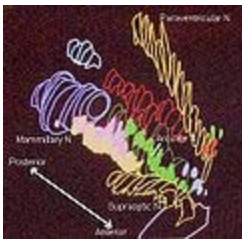
See also: ventrolateral preoptic nucleus, periventricular nucleus.



A cross section of the monkey hypothalamus displays 2 of the major hypothalamic nuclei on either side of the fluid-filled 3rd ventricle.



Hypothalamic nuclei Symbols: AC: anterior commissure PO: preoptic nucleus SC: suprachiasmatic nucleus OC: optic chiasma TC: tuber cinereum AP: anterior pituitary IN: infundibulum PP: posterior pituitary ME: median eminence AH: anterior hypothalamic nucleus SO: supraoptic nucleus TH: thalamus PV: paraventricular nucleus (not to be confused with periventricular nucleus, which is not shown) DM: dorsomedial nucleus VM: ventromedial nucleus AR: arcuate nucleus (associated with periventricular nucleus, which is not shown) LT: lateral nucleus PN: posterior nucleus MB: mamillary body



Hypothalamic nuclei on one side of the hypothalamus, shown in a 3-D computer reconstruction[10]

Connections

The hypothalamus is highly interconnected with other parts of the central nervous system, in particular the brainstem and its reticular formation. As part of the limbic system, it has connections to other limbic structures including the amygdala and septum, and is also connected with areas of the autonomous nervous system.

The hypothalamus receives many inputs from the brainstem, the most notable from the nucleus of the solitary tract, the

locus coeruleus, and the ventrolateral medulla.

Most nerve fibres within the hypothalamus run in two ways (bidirectional).

- Projections to areas caudal to the hypothalamus go through the medial forebrain bundle, the mammillotegmental tract and the dorsal longitudinal fasciculus.
- Projections to areas rostral to the hypothalamus are carried by the mammillothalamic tract, the fornix and terminal stria.
- Projections to areas of the sympathetic motor system (lateral horn spinal segments T1-L2/L3) are carried by the hypothalamospinal tract and they activate the sympathetic motor pathway.

Sexual dimorphism

Several hypothalamic nuclei are sexually dimorphic; i.e., there are clear differences in both structure and function between males and females.[11] Some differences are apparent even in gross neuroanatomy: most notable is the sexually dimorphic nucleus within the preoptic area,[11] in which the differences are subtle changes in the connectivity and chemical sensitivity of particular sets of neurons. The importance of these changes can be recognized by functional differences between males and females. For instance, males of most species prefer the odor and appearance of females over males, which is instrumental in stimulating male sexual behavior. If the sexually dimorphic nucleus is lesioned, this preference for females by males diminishes. Also, the pattern of secretion of growth hormone is sexually dimorphic;[12] this is why in many species, adult males are visibly distinguishable from females.

Responsiveness to ovarian steroids

Other striking functional dimorphisms are in the behavioral responses to ovarian steroids of the adult. Males and females respond to ovarian steroids in different ways, partly because the expression of estrogen-sensitive neurons in the hypothalamus is sexually dimorphic; i.e., estrogen receptors are expressed in different sets of neurons.

Estrogen and progesterone can influence gene expression in particular neurons or induce changes in cell membrane potential and kinase activation, leading to diverse non-genomic cellular functions. Estrogen and progesterone bind to their cognate nuclear hormone receptors, which translocate to the cell nucleus and interact with regions of DNA known as hormone response elements (HREs) or get tethered to another transcription factor's binding site. Estrogen receptor (ER) has been shown to transactivate other transcription factors in this manner, despite the absence of an estrogen response element (ERE) in the proximal promoter region of the gene. In general, ERs and progesterone receptors (PRs) are gene activators, with increased mRNA and subsequent protein synthesis following hormone exposure.

Male and female brains differ in the distribution of estrogen receptors, and this difference is an irreversible consequence of neonatal steroid exposure. Estrogen receptors (and progesterone receptors) are found mainly in neurons in the anterior and mediobasal hypothalamus, notably:

- the preoptic area (where LHRH neurons are located, regulating dopamine responses and maternal behavior;[13]
- the periventricular nucleus where somatostatin neurons are located, regulating stress levels;[14]
- the ventromedial hypothalamus which regulates hunger and sexual arousal.

Development

In neonatal life, gonadal steroids influence the development of the neuroendocrine hypothalamus. For instance, they determine the ability of females to exhibit a normal reproductive cycle, and of males and females to display appropriate reproductive behaviors in adult life.