Citation Key
for more information see: http://open.umich.edu/wiki/CitationPolicy

Use + Share + Adapt
{ Content the copyright holder, author, or law permits you to use, share and adapt. }

Public Domain – Government: Works that are produced by the U.S. Government. (USC 17 § 105)
Public Domain – Expired: Works that are no longer protected due to an expired copyright term.
Public Domain – Self Dedicated: Works that a copyright holder has dedicated to the public domain.
Creative Commons – Zero Waiver
Creative Commons – Attribution License
Creative Commons – Attribution Share Alike License
Creative Commons – Attribution Noncommercial License
Creative Commons – Attribution Noncommercial Share Alike License
GNU – Free Documentation License

Make Your Own Assessment
{ Content Open.Michigan believes can be used, shared, and adapted because it is ineligible for copyright. }

Public Domain – Ineligible: Works that are ineligible for copyright protection in the U.S. (USC 17 § 102(b)) *laws in your jurisdiction may differ

{ Content Open.Michigan has used under a Fair Use determination. }

Fair Use: Use of works that is determined to be Fair consistent with the U.S. Copyright Act. (USC 17 § 107) *laws in your jurisdiction may differ

Our determination DOES NOT mean that all uses of this 3rd-party content are Fair Uses and we DO NOT guarantee that your use of the content is Fair.

To use this content you should do your own independent analysis to determine whether or not your use will be Fair.
Hypothalamus

M1 CNS Head and Neck
March 18, 2009
Lecture Outline

• Hypothalamus, localization and adjacent structures (Brief)
• Development
• Regional organization of nuclei
  – Preoptic
  – Supraoptic
  – Tuberal
  – Mammillary
• Functionally related nuclei
  – Endocrine
  – Autonomic
  – Behavioral
• Hypothalamus and its connections to other brain areas and systems
• Blood Supply
Important Terms

• Diencephalon
• Thalamus
• Third Ventricle
• Internal Capsule
• Optic Chiasm
• Anterior Pituitary
• Posterior Pituitary
• Medial Zone
• Lateral Zone
• Medial Preoptic Area
• Lateral Preoptic Area
• Paraventricular Nuc.
• Supraoptic Nuc.
• Suprachiasmatic Nuc.
• Periventricular Nuc.
• Arcuate Nuc.
• Mammillary Bodies
• Medial Forebrain Bundle
• Fornix
• Stria Terminalis
• Mammillothalamic Tract
• Dorsal Longitudinal Fasciculus
• Hypothalamo-hypophyseal Tract
• Tubero-infundibular Tract
Hypothalamus
Essential Functions

Control of the pituitary gland (Endocrine)

Control of the autonomic nervous system

Control of a variety of behaviors that are essential for survival (of the individual and of the species): eating, drinking, sleep, sexual behavior, parental behavior, and aggression.
In the adult brain the diencephalon is completely surrounded by the telencephalon. Together they form the “forebrain.”

Regions of the Diencephalon:

A. Epithalamus (pineal gland and habenula)
B. Dorsal Thalamus
C. Hypothalamus
D. Ventral thalamus (or subthalamus)  
(not visible in this midline section)
E. Posterior pituitary

mi. massa intermedia - adhesion between dorsal thalami
The Hypothalamus

A unique area of the brain that sends and receives hormonal and other molecular signals via the vascular system, as well as neural signals.

About 4gm of the 1500gm mass of the brain

Major functions:

• Control of the pituitary gland (both anterior and posterior)

• Control of the autonomic nervous system

• Control of a variety of behaviors that are essential for survival (of the individual and of the species): eating, drinking, sleep, sexual behavior, parental behavior, and aggression.
Development

Hypothalamus
Part of prosencephalon
Continuous with alar plate

Pituitary

Posterior Lobe (Pars nervosa) Arises from the floor of the developing diencephalon.

Anterior Lobe (Adenohypophysis) Arises from the roof of the developing oral cavity = Rathke’s pouch
The hypothalamus is a matrix of nuclei.

It is described as four areas (preoptic, supraoptic, tuberal, mamillary) each with nuclei that have distinctive functions.
The Preoptic Area

MPOA (medial preoptic area) regulates:
- male sexual behavior
- parental behavior

MPOA neurons
- express estrogen & androgen receptors
- controlled by endocrine feedback from testes, ovaries, and adrenals

LPOA (lateral preoptic area)
- important in thermoregulation, both behavioral (panting) and autonomic heat dissipation; vasodilation, sweating
The Supraoptic Area

The paraventricular and supraoptic nuclei contain magnocellular neurons that produce oxytocin and vasopressin. Their axons release these peptides onto the capillaries of the posterior pituitary.

Netter’s image of supraoptic area removed
The Supraoptic Area

Cells in the suprachiasmatic nuclei are circadian oscillators that entrain endocrine functions and behaviors to the 24-hour light-dark cycle.
Periventricular and Arcuate neurons express receptors for a variety of hormones and provide feedback regulation through a portal venous system to the trophic-hormone-producing cells of the anterior pituitary.

(list of factors to follow)

unlike many other endocrine tissues, the ant. pit. is so dependent on the hypothal that it is not transplantable
The Tuberal Area

Ventromedial nucleus

- neurons express estrogen, androgen and progesterone receptors
- control female sexual behavior and aggression.
The Mammillary Area

The mammillary bodies receive input from the hippocampus via the fornix. They project to the anterior nucleus of the thalamus through the mammillothalamic tract.

Damage to the mammillary bodies and their connections with the hippocampus produces anterograde amnesia (as seen in Korsakoff’s syndrome).

Mammillary nuclei (bodies) part of limbic system
The Lateral Hypothalamic Area (LHA)
Sympathetic autonomic function: Lateral and posterior hypothalamus
Parasympathetic autonomic function: Medial and anterior hypothalamus

The MFB
- runs through the LHA
- contains both ascending and descending fibers.
- connects limbic areas, hypothalamus, and brain stem (includes parasympathetic connections)
- some fibers reach spinal cord sympathetic neurons

Netter’s image of hypothalamus removed
Real Sections

Supraoptic

Tuberal

Mammillary

Haines, *Fundamental Neuroscience for Basic and Clinical Applications*, Elsevier
Hypothalamus:

**Endocrine Function**

Paraventricular and supraoptic nuclei: regulate water balance, produce Antidiuretic Hormone (ADH, a.k.a. vasopressin) and oxytocin. Destruction causes Diabetes Insipidis

Preoptic Nuclei: Contain sexually dimorphic nuclei, regulate release of gonadotropin hormone

Arcuate Nuclei (Tuberal Nuclei): produce hypothalamic releasing factors, contains dopaminergic neurons that inhibit prolactin release, contains beta endorphin – a role in opiate analgesia

Haines, Fundamental Neuroscience for Basic and Clinical Applications, 3rd edition, 2005, Fig. 30-5
ENOCRINE FUNCTION

1. **DIRECT:** From supraoptic and paraventricular nuclei via hypothalamo-hypophyseal tract - secretion of neuroendocrine products (OXYTOCIN, VASOPRESSIN) into general circulation via vasculature of posterior pituitary.

2. **INDIRECT:** From Tuberal nuclei (arcuate) via tuberoinfundibular tract - Secretion of releasing hormones (e.g. GHRF, LRF) into portal plexus which influences release (of other substances -GH, LH, TSH, ACTH, FSH, PROLACTIN,) by anterior pituitary.
<table>
<thead>
<tr>
<th>Nucleus</th>
<th>Releasing Hormone</th>
<th>Pituitary Hormone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>Growth hormone-releasing inhibitor h.</td>
<td>Inhibits release of Growth Hormone</td>
</tr>
<tr>
<td>Supraoptic</td>
<td>Corticotrophin-releasing h.</td>
<td>Oxytocin and Vasopressin Corticotropin</td>
</tr>
<tr>
<td>Ventromedial</td>
<td>Growth hormone-releasing h.</td>
<td>Growth Hormone</td>
</tr>
<tr>
<td>Dorsomedial</td>
<td>Growth hormone-releasing h. Thyrotropin-releasing h.</td>
<td>Growth Hormone Thyrotropin</td>
</tr>
<tr>
<td>Arcuate</td>
<td>Gonadotropin-releasing h. Growth hormone-releasing h. Prolactin-releasing inhibition h.</td>
<td>Gonadotropins Growth Hormone Prolactin Inhibition</td>
</tr>
<tr>
<td>Lateral Hypothalamic Zone</td>
<td>Thyrotropin-releasing h. Growth hormone-releasing h. Growth hormone-releasing inhibitor h.</td>
<td>Thyrotropin Growth Hormone Inhibits release of Growth Hormone</td>
</tr>
</tbody>
</table>
Hypothalamus:

**Autonomic Function:**

**Anterior Nucleus:** thermal regulation (dissipation), stimulation of parasympathetic NS, destruction results in hyperthermia

**Posterior Nucleus:** thermal regulation (conservation of heat) stimulation of sympathetic NS, destruction results in inability to thermoregulate

**Suprachiasmatic Nucleus:** receives input from retina, mediates circadian rhythms

Haines, Fundamental Neuroscience for Basic and Clinical Applications, 3rd edition, 2005, Fig. 30-5
AUTONOMIC FUNCTION

"Head Ganglion" of autonomic system: Regulates almost all autonomic functions such as: body temperature (preoptic area), heart rate, blood pressure, bladder contraction, hunger (paraventricular).

Connections to reticular system and raphe nuclei of brainstem – Dorsal Longitudinal Fasciculus.
Limbic Function:

**Dorsomedial nucleus:** emotional behavior, stimulation results in obesity and savage behavior (sham rage).

**Ventromedial nucleus:** satiety center, destruction results in obesity and savage behavior, stimulation inhibits feeding.

**Lateral nucleus:** feeding center, stimulation induces eating. Destruction results in loss of appetite, anorexia, starvation.

**Mammillary nucleus:** input from hippocampal formation, lesions result in memory deficits. Projects to anterior nucleus of the thalamus.
LIMBIC FUNCTION:
Regulation of emotional behavior (anger, rage, sexual activity, etc.).
Pathways to and from parts of limbic system parallel each other:

1. AMYGDALA via stria terminalis

2. HIPPOCAMPUS & SUBICULUM via fornix (to and from mammillary bodies)

3. SEPTAL NUCLEI, Olfactory Cortex, SUBICULUM via medial forebrain bundle (MFB)

4. THALAMUS - Mammillo-thalamic tract

Haines, Fundamental Neuroscience for Basic and Clinical Applications, 3rd edition, 2005, Fig. 30-8
MAJOR CONNECTIONS OF HYPOTHALAMUS

I. LIMBIC SYSTEM

1. MEDIAL FOREBRAIN BUNDLE
   septal nuclei, olfactory regions ↔ HYPOTHALAMUS & brain stem

2. FORNIX
   Hippocampal Complex ↔ Mammillary Bodies of Hypothalamus

3. STRIA TERMINALIS
   Amygdala ↔ Hypothalamus

4. MAMMILLOTHALAMIC TRACT
   Hypothalamus ↔ Thalamus (anterior nucleus
AUTONOMIC CONNECTION

5. DORSAL (posterior) LONGITUDINAL FASCICULUS

Hypothalamus ← → Brain Stem Reticular Formation
Hypothalamus ← → Brain Stem Nuc (e.g. vagus)
          ← → Intermediolateral Cell Column

ENDOCRINE CONNECTIONS

6. Hypothalamo-Hypophyseal TRACT

Hypothalamus ← → Neurohypophysis

7. Tubero-infundibular Tract

Tuberal Nuclei ← → Sinusoids, Portal Veins ← → Adenohypophysis
Paraventricular and supraoptic nuclei
- regulate water balance
- produce ADH and oxytocin
- destruction causes diabetes insipidus
- paraventricular nucleus projects to autonomic nuclei of brain stem and spinal cord

Anterior nucleus
- thermal regulation (dissipation of heat)
- stimulates parasympathetic NS
- destruction results in hyperthermia

Preoptic area
- contains sexual dimorphic nucleus
- regulates release of gonadotropic hormones

Suprachiasmatic nucleus
- receives input from retina
- controls circadian rhythms

Dorsomedial nucleus
- stimulation results in obesity and savage behavior

Posterior nucleus
- thermal regulation (conservation of heat)
- destruction results in inability to thermoregulate
- stimulates the sympathetic NS

Lateral nucleus
- stimulation induces eating
- destruction results in starvation

Mamillary body
- receives input from hippocampal formation via fornix
- projects to anterior nucleus of thalamus
- contains hemorrhagic lesions in Wernicke's encephalopathy

Ventromedial nucleus
- satiety center
- destruction results in obesity and savage behavior

Arcuate nucleus
- produces hypothalamic releasing factors
- contains DOPA-ergic neurons that inhibit prolactin release
The **hypothalamus** is supplied with blood by small branches of the Circle of Willis.
Additional Source Information

for more information see: http://open.umich.edu/wiki/CitationPolicy

Slide 3: The Anatomy of the Nervous System: From the Standpoint of Development and Function, SW Ranson
Slide 7: The Anatomy of the Nervous System: From the Standpoint of Development and Function, SW Ranson
Slide 9: Haines, Fundamental Neuroscience for Basic and Clinical Applications, Elsevier
Slide 12: Source Undetermined
Slide 13: Source Undetermined
Slide 14: Source Undetermined
Slide 18: Haines, Fundamental Neuroscience for Basic and Clinical Applications, Elsevier
Slide 19: Haines, Fundamental Neuroscience for Basic and Clinical Applications, 3rd edition, 2005, Fig. 30-5
Slide 20: Source Undetermined
Slide 22: Haines, Fundamental Neuroscience for Basic and Clinical Applications, 3rd edition, 2005, Fig. 30-5
Slide 23: Haines, Fundamental Neuroscience for Basic and Clinical Applications, 3rd edition, 2005, Fig. 30-5
Slide 24: Haines, Fundamental Neuroscience for Basic and Clinical Applications, 3rd edition, 2005, Fig. 30-9
Slide 25: Haines, Fundamental Neuroscience for Basic and Clinical Applications, 3rd edition, 2005, Fig. 30-9
Slide 26: Haines, Fundamental Neuroscience for Basic and Clinical Applications, 3rd edition, 2005, Fig. 30-8
Slide 29: Source Undetermined
Slide 30: Haines, Fundamental Neuroscience for Basic and Clinical Applications, 3rd edition, 2005, Fig. 30-7