Thalamus

Sits on top of brainstem
Near center of brain
Nerve fibers project in all directions

Difficult to map connections
Organized in 3D
Cortex is organized in 2D
Plus layers

Surrounds 3rd ventricle
Each half is shape & size of walnut

Relays sensory & motor signals
Regulation of consciousness
Sleep, and alertness

Lots of information from cortex
Lots of info to other brain parts
Multi-function switchboard
Every sense but smell

Vision
Lateral geniculate nucleus (LGN)
Pre-process and relay

Audition
Medial geniculate nucleus (MGN)
Auditory connection
From inferior colliculus to primary auditory cortex

Impacts sleep & wake
Reciprocal connections w/ cortex
Thalamo-cortical-talamic circuits

Provides channels
From basal ganglia & cerebellum
To cortical motor areas
Impacts antisaccade eye-movement

Damage
Korsakoff’s Syndrome
Can be caused by damage to thalamus
Fatal Familial Insomnia
Hereditary disease
degeneration of thalamus
gradual loss of ability to sleep
Leads to total insomnia & death

Thalamic Syndrome
Caused by stroke
One-sided burning sensation
Mood swings

Four parts
Ventral thalamus
Dorsal thalamus
Epithalamus
Hypothalamus

1. Ventral thalamus
   reticular nucleus
   GABAergic cells
   inhibit relay cells
   flush against lateral surface of dorsal thalamus

2. Dorsal thalamus
   Bundle of 15 relay nuclei
   Send signals to cortex

3. Epithalamus
   Interconnecting fibers to pineal gland and limbic system
   Secretion of melatonin (pineal)
   Emotion (basal ganglia)

4. Hypothalamus

Hypothalamus
Large dog barks at you, body reacts
   Neural response
   Hormonal response

Impacts
Triggers adrenal glands to release adrenaline and cortisol
Adrenaline (epinephrine)
   Increase heart rate
   Elevates blood pressure
**Cortisol**

- Primary stress hormone
- Increases blood glucose
- Improves brain’s use of glucose
- Increases availability of tissue repair substances
- Shut down nonessential functions
  - Anything not needed in fight-flight
  - Alters immune system
  - Suppresses digestive system
- Once Perceived Threat Is Gone
  - Resets
  - Unless it’s consistent threat
  - Depressed immune system, more likely:
    - Digestive problems
    - Sleep problems
    - Heart disease
    - Obesity

**Located below thalamus**

- About the size of an almond

**Contains small nuclei**

- Each with different functions
- Links nervous & endocrine sys

**Secretes hormones**

- stimulate or inhibit secretion by pituitary

**Controls**

- body temp, hunger, thirst, sleep, circadian rhythm and fatigue

**Three parts**

- Anterior
- Tuberal
- Posterior

1. **Anterior**
   
   **Medial**
   
   - Medial preoptic nucleus
     - Regulates release of gonadotropic hormones
   - Sexually dimorphic nucleus
     - releases GnRH
       - differential development of sexes
       - in-utero testosterone levels
Anterior Hypothalamic Nucleus
  panting, sweating
Suprachiasmatic Nucleus
  Circadian rhythms

Lateral
  Thirst & hunger

2. Tuberal
   Medial
     Dorsomedial Hypothalamic Nucleus
       Blood pressure & heart rate
     Growth hormone-releasing hormone (GHRH)
   Lateral
     Thirst & hunger

3. Posterior
   Medial
     Memory
       Blood pressure, pupil dilation, shivering
   Lateral
     Hunger
       Damage to this area
         reduced food intake
       Stimulating
         causes a desire to eat
     Blood sugar level drops
       Receptors in blood signal lateral hypothalamus
       Brain areas fire in unison
         creating the sensation of hunger
     Blood sugar level increases
       Signals ventro-medial hypothalamus
   Two structures
     lateral hypothalamic area
       Hunger
     Lateral preoptic nucleus
       Non-REM sleep
   Damage
     Frolich’s Syndrome
       decreased levels in GnRH
       defects of feeding centers of hypothalamus
         increase food and calorie intake
     It is characterized by:
       Affects males mostly
       No endocrine problems
Mature normally after puberty
It is characterized by:
  Growth retardation
  Atrophy of gonads
  Altered secondary sexual characteristics

**Other names**
- Babinski-Fröhlich syndrome
- Hypothalamic Infantilism-Obesity
- Launois-Cleret Syndrome
- Sexual Infantilism

**Hypothalamus & Sex**

**Differences to brain structure**
- **No cause-effect summary**
  - Differences in gender
  - Difference in sexual orientation

**Suprachiasmatic Nucleus (SCN)**
- **Internal clock**
  - Largest in heterosexual men
  - Smaller in homosexual men
  - Smallest in women

**Sexually Dimorphic Nucleus (SDN)**
- **In anterior hypothalamus**
  - twice as large in heterosexual men as and homosexual women, in terms of volume but not number of neurons.
- **Responds to smelling common odors**
  - scent of testosterone found in male sweat
    - homosexual men and heterosexual women
  - scent of estrogen found in female urine
    - heterosexual men and homosexual women

**Pituitary gland**

**Protrusion at bottom of hypothalamus**
- **Size of a pea**
- **Connects to hypothalamus**
  - Thin tube called pituitary stalk or infundibular stem

**“Master” endocrine gland**
- **Impacts other glands**
- **But controlled by hypothalamus**
Two parts
1. Anterior
   adenohypophysis
   parvocellular neurons (small)
   Secretes growth hormone (GH or HGH)
       Also called somatotropin
       $ by GHRH (from hypothal.)
       Growth hormone releasing hormone
       Inhibited by somatostatin
       From hypothal.
   Secretes TSH
       Thyroid-stimulating hormone
   Secretes ACTH
       Adrenocorticotropic hormone
   Secretes FSH (follicle-$ hormone)
   Secretes LH (lutropin)
   Secretes Prolactin (PRL)
   Secretes Beta-endorphin
   Secretes LTH (luteotropic)

2. Posterior
   neurohypophysis
   magnocellular neurons (large)
   Secretes Oxytocin
   Secretes ADH (antidiuretic hormone)
       Also called vasopressin

Function
Secretes hormones to control:
   Growth & metabolism
   Pregnancy & sex organs
   Thyroid gland
   Water regulation
   Temperature
   Endorphin

Diseases
Acromegaly
   too much growth hormone
Cushing’s
   Too much adrenocorticotropic hormone
Growth hormone deficiency
   Too little growth hormone
Syndrome of inappropriate antidiuretic hormone
  Too much vasopressin
Diabetes insipidus
  too little vasopressin
Sheehan syndrome
  Too little of any of the pituitary hormones
Pickardt-Fahlbusch syndrome
  Too little of any of the pituitary hormones
  Too much prolactin
Hyperpituitarism (adenoma)
  Too much of any of the pituitary hormones
Hypppituitarism
  Too little TSH (thyroid hormone)
  Vasopressin
Hyperthyroidism
  Too much TSH
  Almost always a pituitary adenoma

Limbic System
  Thalamus
  Hypothalamus
  Pituitary
  Basal ganglia

Basal ganglia
  In PNS = ganglia
  In CNS = nuclei
How they work
  Disinhibition principle
    If no input = steady fire at high rates

Distinct masses of gray matter
  deep in brain
  not far from thalamus
  Left-right sides mirror each other

Group of nuclei
  Work together as functional unit
  Interact with cortex, thalamus, etc

Neurotransmitters
  Inputs use Glutamate
  Outputs use GABA
  Internal connections use Dopamine or ACh
4 structures
- Striatum
- Pallidum (w 2 nuclei)
- Substantia nigra (2 parts)
- Subthalamic nucleus

Two large parts
- Striatum & Pallidum

Two smaller parts (& farther back)
- Substantia Nigra & Subthalamic

1. Striatum
- Largest
- Looks striped
- Large & small bundles of fibers
- White matter
- Looks like two blobs of gray separated by large white stripe
- Complex internal organization
- Vast majority of neurons (96%?)
  - lots of dendritic spines
  - small cell bodies
- Medium spiny
  - GABAergic
  - Inhibitors
- Two types of medium spiny
  - Substance P & dopamine D1
    - Direct pathway
  - Enkephalin & dopamine D2
    - Indirect pathway
- Organized in 3D
- Cortex is layered; organized 2D

Basal ganglia impacts
- Voluntary motor control
- Inhibits motor systems

Procedural learning
- Eye movements
- Habits

Rewards?
- Internal connections use dopamine
- VTA→NA dopamine connection
Increase effectiveness of signal
   Cocaine
   Nicotine
   Amphetamines
   Overactive in schizophrenia?

Eye movements
   Lots of brain regions at work
   Superior Colliculus
      layered structure
      2D retinal maps
      Gets inhibitory effect from basal ganglia (SNr)
      Pause their inhibition when eyes

Action selection?
   Which behavior to do when
   Parkinson's disease
      Major loss of dopaminergic cells in the substantia nigra
      Gradual loss of the ability to initiate movement
      Motivation
         Can do components of movement
         Hunger fails to initiate movements
         Not switched on: “paralysis of will”
         kinesia paradoxica
            Moves easily in emergency
            Immobile after issue passed

Motivation
   VTA to NA reward system
      Animals with $ electrodes
         Bar-pressing
      Humans show increased action
         addictive drugs
         good-tasting food
         Sex
      Animal with severe basal ganglia damage won’t move toward food
         Even if placed within inches
         Chew & swallow if put in mouth

Huntington's disease
   Major loss of medium spiny neurons in striatum
      inability to prevent parts of the body from moving unintentionally
**Hemiballismus**

Damage to the subthalamic nucleus
uncontrollable flinging movements of arms and legs

**Cerebral palsy**

Damage to basal ganglia during 2\textsuperscript{nd} and 3\textsuperscript{rd} trimester

**Foreign accent syndrome**

Some combination of problems in cerebellum, Broca’s area & basal ganglion
Caused by stroke or injury
Mispronunciation of words
Listener’s hear it as accent
speaking native with accent
Not new vocabulary
Sufferer’s may imitate other aspects of accent to normalize the syndrome