1. Diencephalon – regional organization and internal structure:
   ✓ thalamus – topographic and nuclear organization
   ✓ metathalamus – the geniculate bodies
   ✓ epithalamus – pineal gland and habenula
   ✓ subthalamus (ventral thalamus)
   ✓ hypothalamus – divisions, nuclei and connections

2. Third ventricle

3. Brainstem reticular formation
Embryologic development

- Embryonic origin:
  - side walls of the *prosencephalon* (forebrain)

- Location – at the midline of the brain:
  - caudally – *mesencephalon*
  - cranially – *telencephalon*

- Functions:
  - relay system between sensory input neurons and other parts of the brain
  - works in tandem with the limbic system
Diencephalon – gross structure and parts

- Pineal gland
- Caudate nucleus
- Thalamus
- Amygdala
- Pituitary gland
- Hypothalamus
- Hippocampus
- Corpus callosum
- Septum pellucidum
- Interthalamic adhesion
- Anterior commissure
- Hypothalamus
- Frontal lobe
- Mammillary body
- Optic chiasm
- Pituitary gland
- Fornix
- Choroid plexus in third ventricle
- Thalamus
- Habenular nucleus
- Pineal gland
- Part of the corpora quadrigemina
- Mesencephalic aqueduct
- Infundibulum
- Cerebellum
- Fourth ventricle

5 parts:
1. THALAMUS
2. HYPOTHALAMUS
3. EPITHALAMUS
4. SUBTHALAMUS
5. METATHALAMUS
Thalamus – external features

- two egg-shaped lobes of grey matter
  - third ventricle medially
  - hypothalamus ⇒ hypothalamic sulcus

- nuclear complex – 2% of the total brain
  - about 80%
    - of diencephalic mass
      - ~30 mm long
      - ~20 mm wide
      - ~20 mm tall

Gr. θάλαμος = room, chamber

- Thalamus dorsalis:
  - rostral pole = tuberculum anterius thalami
  - caudal pole = pulvinar thalami (“cushioned seat”)
  - interthalamic adhesion
  - lamina affixa
  - stria terminalis thalami
Thalamus – internal structure

- internal medullary lamina (medial) – Y-shaped:
  - anterior
  - medial
  - lateral nuclear groups

- external medullary lamina (lateral):
  - reticular nucleus of the thalamus
Thalamus – nuclear organization

- 50-60 distinct nuclei
- 5 functional nuclear groups:
  - sensory relay nuclei
  - motor relay nuclei
  - reticular system relay nuclei
  - limbic system relay nuclei
  - association relay nuclei
- 8 main anatomic nuclear groups:
  - intralaminar
  - ventral – anterior, lateral, posterior
  - lateral dorsal
  - medial
  - midline
  - anterior
  - posterior
  - reticular
Thalamic nuclei

- in internal medullary lamina:
  - intralaminar nuclear group:
    - rostral intralaminar nuclei:
      - central lateral nucleus, *nucleus centralis lateralis*
      - central medial nucleus, *nucleus centralis medialis*
      - paracentral nucleus, *nucleus paracentralis*
    - caudal intralaminar nuclei:
      - centromedian nucleus, *nucleus centromedianus*
      - parafascicular nucleus, *nucleus parafascicularis*
  - laterally from internal medullary lamina:
    - ventral nuclear group:
      - ventral anterior nucleus, *nucleus ventralis anterior*
      - ventral lateral nucleus, *nucleus ventralis lateralis*
      - ventrobasal nuclei, *nuclei ventrobasales*:
        - ventral posterior, *nucleus ventralis posterolateralis*
        - ventral posteromedial, *nucleus ventralis posteromedialis*
        - ventral posterior inferior, *nucleus ventralis posterior inferior*
Thalamic nuclei

- **medial nuclear group:**
  - (mediodorsal complex)
    - mediodorsal nucleus, *nucleus mediodorsalis* (magnocellular portion)
      - affects, emotion, behaviour
    - medioventral nucleus (parvicellular portion)
      - *nucleus medioventralis*

- **midline nuclear group:**
  - paratenial and paraventricular nuclei
    - limbic system
    - memory, awake and alert state

- **lateral nuclear group:**
  - lateral dorsal, *nucleus dorsalis lateralis*
  - lateral posterior, *nucleus lateralis posterior*
  - pulvinar, *nuclei pulvinares*
Thalamic nuclei

- **anterior nuclear group:**
  - limbic system
  - *nucleus anterodorsalis*
  - *nucleus anteroventralis*
  - *nucleus anteromedialis*

- **posterior nuclear group:** (in ventral pulvinar)
  - posterior nucleus, *nucleus posterior*
  - suprageniculate nucleus
  - limitans nucleus

- **reticular nucleus of thalamus**

- **geniculate nuclear group:**
  - medial geniculate nucleus
  - lateral geniculate nucleus
- **Medial geniculate body**: subcortical acoustic center (thalamic relay)
  - inferior colliculi \(\rightarrow\) inferior brachium
  - acoustic radiation \(\rightarrow\) auditory cortex

- **Lateral geniculate body**: primary processing center for visual information
  - superior colliculi \(\rightarrow\) brachium of superior colliculus
  - optic radiation \(\rightarrow\) visual (striate) cortex
- **stria medullaris thalami**
- **habenular trigone:**
  - habenular nuclei, medial and lateral
- **habenula**
  - habenular commissure
- **pineal gland, corpus pineale (epiphysis)**
- **posterior commissure**
  - subfornical organ (circumventricular organs)
Subthalamus (ventral thalamus)

- subthalamic nucleus (corpus Luysi): basal ganglia
  ✔ extrapyramidal motor system
- zona incerta – GABAergic neurons
- nuclei campi perizonales (H₁- and H₂-fields of Forel)
- ansa lenticularis and lenticular fasciculus
Hypothalamus – gross anatomy

Gr. ήποθαλαμός = hypo-, cognate to Latin sub- "under"
✓ most ventral portion of the diencephalon
✓ weight 4-5 g – less than 1% of the total human brain volume
- preoptic area, area preoptica
- optic chiasm, chiasma opticum
- tuber cinereum, median eminence
- infundibular tract, infundibulum ⇒ hypophysis cerebri
- mammillary bodies, corpora mammillaria
Optic chiasm and tract

- part of the visual system
- Gr. χίασμα, "crossing", from the Greek χιαζω 'to mark with an X', after the Greek letter 'X', chi
- the part where CN II partially cross
- allows for parts of both eyes that attend to the right visual field to be processed in the left visual system in the brain, and vice versa
Mammillary bodies

- incorporated into the limbic system – part of the ‘Papez circuit’
- fasciculus mammillothalamicus (tract of Vicq d’Azyr)
- fasciculus mammillotegmentalis
- involved with the processing of recognition memory
Hypothalamic divisions

- hypothalamic areas and zones:
  - rostral
  - dorsal
  - intermediate zone
  - lateral zone
  - medial zone
  - posterior
Hypothalamic nuclei

- **preoptic region:**
  - preoptic periventricular nucleus
  - medial preoptic nucleus
  - lateral preoptic nucleus

- **anterior hypothalamic region:**
  - supraoptic nucleus
    - \(\Rightarrow\) *oxytocin, vasopressin* (ADH)
  - paraventricular nucleus
  - anterior hypothalamic nucleus
  - suprachiasmatic nucleus
    - \(\Rightarrow\) *endogenic brain clock* (circadian rhythms)
Hypothalamic nuclei

- **intermediate hypothalamic region:**
  - dorsomedial nucleus
  - ventromedial nucleus
  - tuberal nuclei, incl.
    - arcuate (infundibular) nucleus: A₁₂

- **posterior hypothalamic region:**
  - medial mammillary nucleus
  - lateral mammillary nucleus
  - intermediate mammillary nucleus
  - (intercalated nucleus of *Le Gros Clark*)
  - posterior hypothalamic nucleus
Hypothalamus – functional significance

- 0.5% of the total volume of human brain
- main function – homeostasis (maintaining the body's status quo)
- central control of:
  - visceral functions
  - endocrine effects – release/inhibiting factors
- neurosecretion:
  - pituitary hormones – oxytocin, vasopressin
- temperature regulation – dual thermostat
- instinctive and cyclic behaviors:
  - regulation of food (appetite) and water intake
  - control of sexual behavior and reproduction
  - biological clock (sleep-waking cycle)
  - expression of emotion, fear, rage, aversion, pleasure and reward
Hypothalamus – clinical significance

- numerous functional considerations in injury:
  - sleepiness
  - obesity
  - diabetes insipidus
  - adiposogenital dystrophy
  - libido loss
  - dysregulation of body temperature
Diencephalic syndrome

- Synonyms: diencephalic syndrome of emaciation, Russell’s syndrome:

  ✓ hypothalamic tumors
  ✓ postnatal failure to thrive
  ✓ progressive emaciation (abnormal thinness)
  ✓ unusual eye position and sometimes blindness
  ✓ intense sleepiness
  ✓ amnesia
  ✓ euphoric appearance
  ✓ emesis (vomiting)
Hypothalamic connections

- **Afferent connections:**
  - corticohypothalamic fibers
  - limbic system –
    - hippocampo-hypothalamic afferents
    - amygdalo-hypothalamic fibers
    - septal region
    - piriform lobe
  - thalamus – periventricular nucleus, zona incerta
  - brainstem reticular formation –
    - dorsal longitudinal fasciculus (of Schütz)
    - mammillary peduncle

- **Efferent connections:**
  - medial forebrain bundle
  - hypothalamo-hypophysial – neurohypophysis
  - mammillary efferent fibers – fasciculus mammillaris princeps:
    - fasciculus mammillothalamicus
    - fasciculus mammillotegmentalisis
  - descending hypothalamic projections:
    - n. tractus solitarii, n. dorsalis n. vagi
    - laminae I and II of the spinal cord
Third ventricle

- embryonic origin – prosencephalon
- location – between the two thalami (lateral walls) and hypothalamus
Third ventricle

- **anterior boundary** – *lamina terminalis*  
  anterior commissure

- **posterior boundary** –  
  posterior commissure
  - pineal recess ⇔ pineal gland
  - cerebral aqueduct

- **floor** – parts of the hypothalamus  
  (optic chiasma, tuber cinereum, infundibulum)
  - optic recess
  - infundibular recess

- **roof** – layer of ependyma, covered by  
  the *tela choroidea ventriculi tertii* ⇔  
  choroid plexus of the third ventricle

- **communication with:**
  - fourth ventricle –  
    cerebral aqueduct (of *Sylvius*)
  - lateral ventricles –  
    interventricular foramina (of *Monro*)
Why is the reticular formation a reticular formation? Because their fibers indeed build a net.

NB: reticulum means netlike structure
Reticular formation (RF) – general considerations

1. Brainstem RF proper
2. Spinal RF
3. Other RF-related brainstem areas
   ✓ periaqueductal grey matter (PAG)
   ✓ reticular activating system (RAS)
   ✓ locus coeruleus

✓ Widespread distribution and extensive collateralization of reticular axons

✓ Typical neurons of the reticular formation – mostly interneurons
**Brainstem RF proper – (>100 small) nuclei**

- **Median (midline) column of reticular nuclei – raphe nuclei** (serotonergic and peptidergic – enkephalin and β-endorphin):
  - *nucleus raphes obscurus et pallidus* in medulla
  - *nucleus raphes magnus* in pons (peptidergic)
  - *nucleus raphes centralis superior* and
  - *nucleus raphes dorsalis* in midbrain

- **Medial (paramedian) column – magnocellular (efferent and motor):**
  - medullary gigantocellular (magnocellular) nucleus
  - pontine gigantocellular nucleus
  - *nucleus tegmenti pontis*
  - *nucleus pontis caudalis*
  - *nucleus pontis oralis*
  - *nucleus cuneiformis*
  - *nucleus subcuneiformis*

- **Lateral column – parvocellular (afferent and sensory):**
  - *nucleus pontis centralis*
  - *nuclei parabrachiales*
  - *nucleus tegmentalis pedunculopontinus*
Reticular formation – functions

- controls ~25 specific behaviors:
  - sleep
  - walking
  - eating
  - urination & defecation
  - sexual activity

- additional functions:
  - arousal
  - attention
  - cardiac reflexes
  - motor functions
  - regulates awareness
  - relays nerve signals to the cerebral cortex

- one of the phylogenetically oldest portions of the brain
“Everything we thought we knew about the hypothalamus was wrong! Wrong, wrong, wrong!”