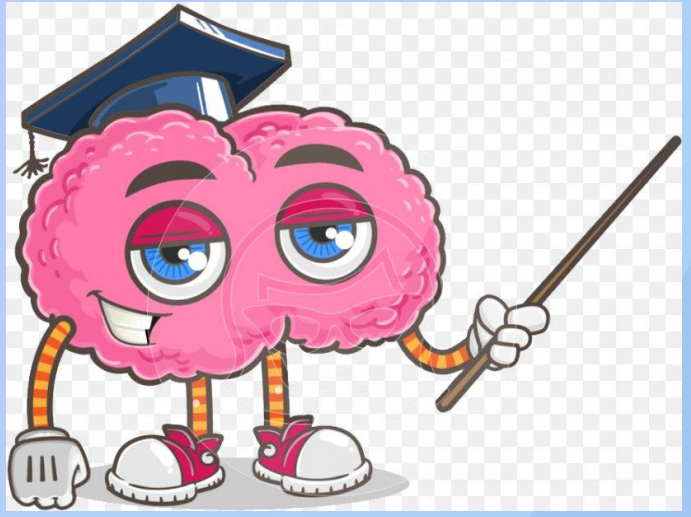
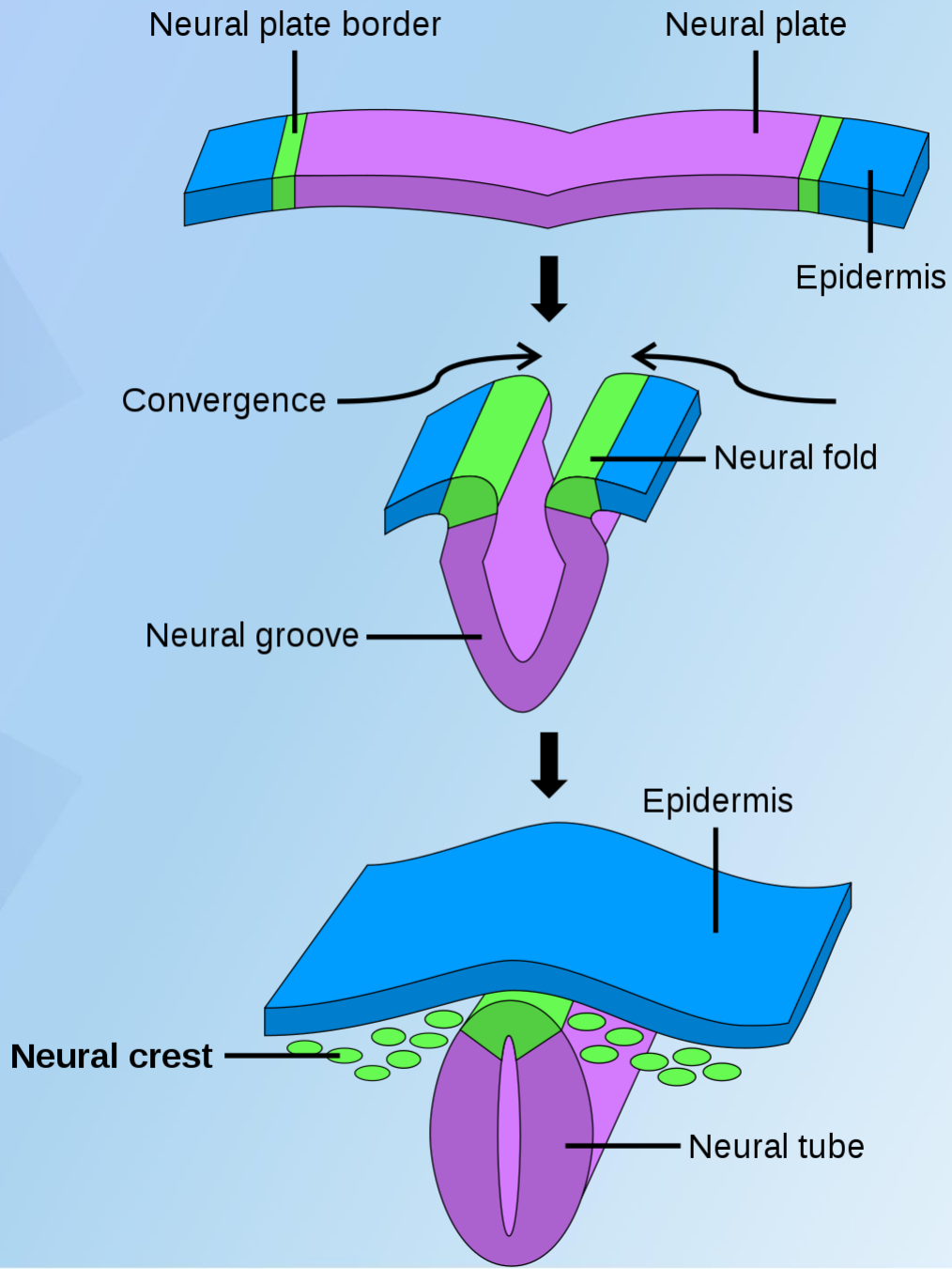


Brain Development, Telencephalon, Diencephalon

Kuba Chyla
5/6 MD
13.2.2020

Neurulation

- First signs of brain development appear during **3rd/**4th week (**neurulation**)
- **Neural plate** and **neural groove** develop on the posterior aspect of the **tri**laminar embryo
- How does this happen? Thanks to some **FAT SIGNALING >>>> Notochord** and **paraaxial mesoderm** induce overlying **surface ectoderm** to differentiate into **neural plate**
  - **F:** Fibroblast Growth Factor
  - **A:** Activin
  - **T:** TGF-beta


Neural plate border
Neural plate
Epidermis
Convergence
Neural fold
Neural groove
Epidermis
Neural crest
Neural tube

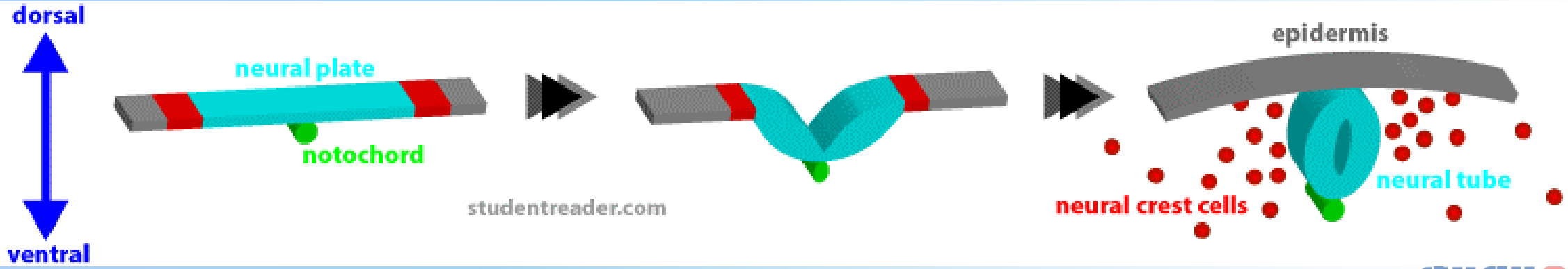
The **neural tube** then differentiates into the CNS (brain including forebrain, midbrain, hindbrain, and spinal cord)

and

The **neural crest** gives rise to all cells of PNS and ANS (cranial, spinal and autonomic ganglia)

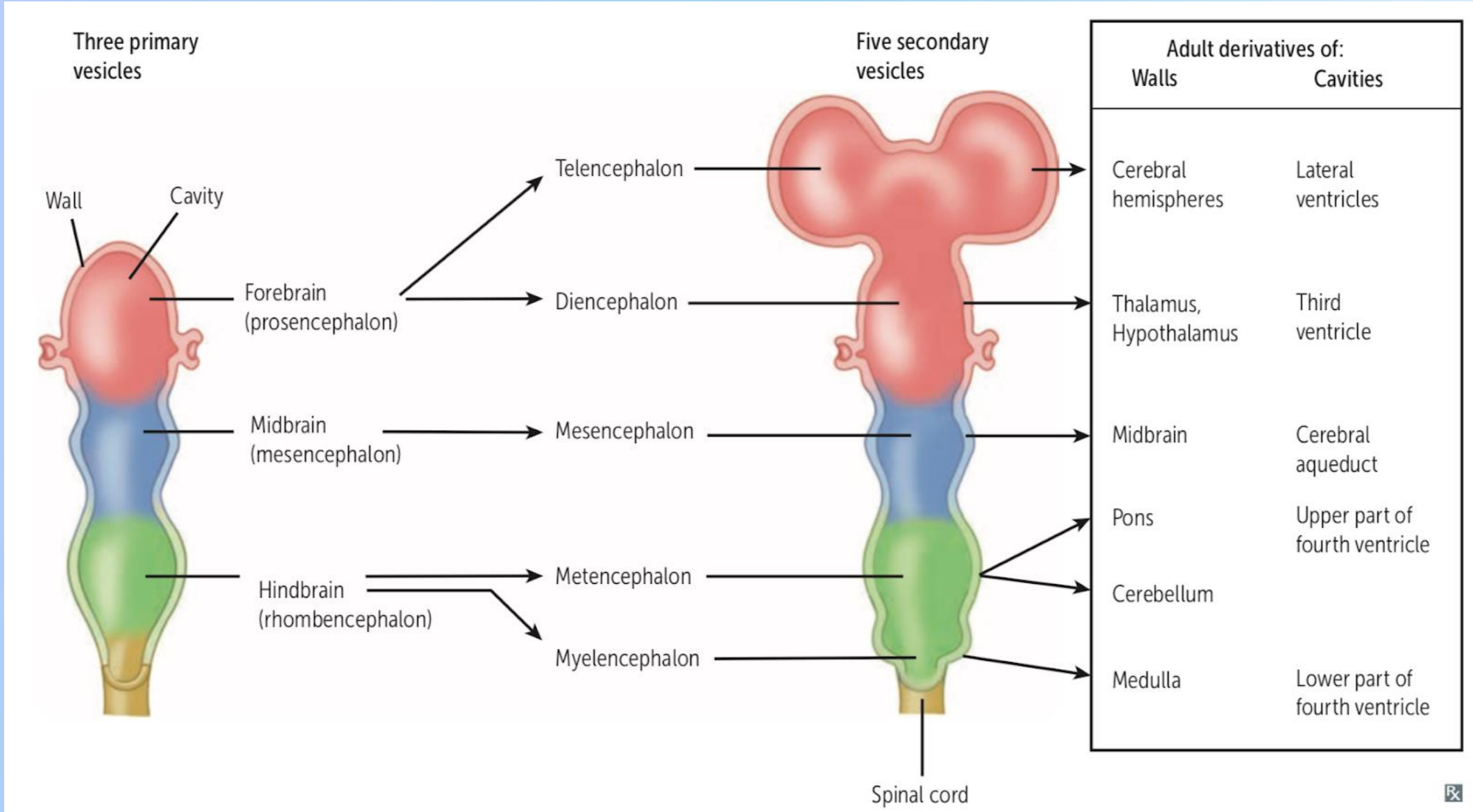
while

The **notochord** becomes the vertebral column



Key embryonic divisions:

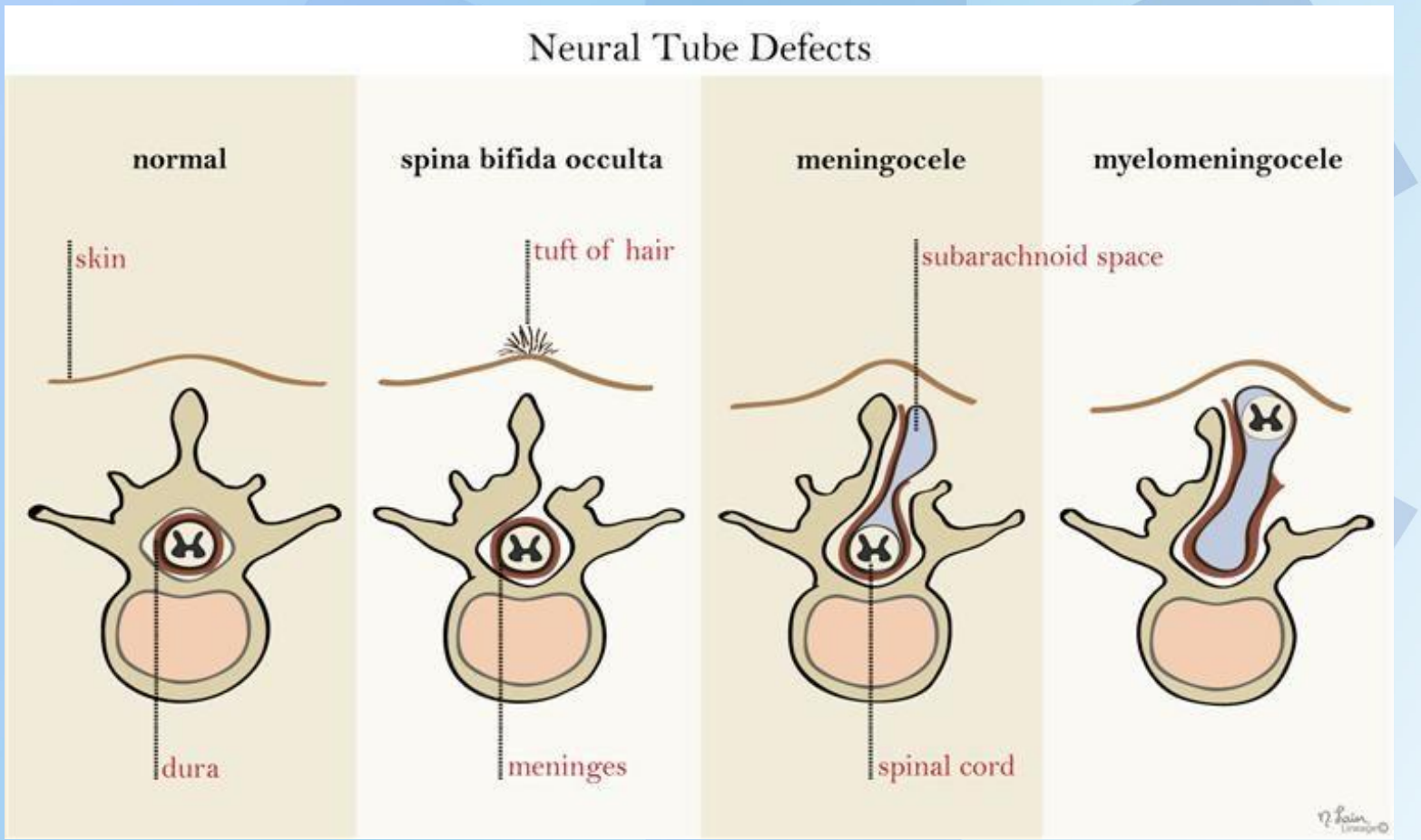
- **3 primary** brain vesicles
  - **Prosencephalon**
  - **Mesencephalon**
  - **Rhombencephalon**
- **5 secondary** brain vesicles:
  - **Telencephalon >>** cerebral cortex, white matter, basal ganglia
  - **Diencephalon >>** epithalamus (pineal gland), thalamus, subthalamus, hypothalamus
  - **Mesencephalon >>** tectum, tegmentum, cerebral peduncles
  - **Metencephalon >>** pons, cerebellum
  - **Myelencephalon >>** medulla oblongota


Three primary vesicles
Five secondary vesicles
Wall
Cavity
Forebrain (prosencephalon)
Midbrain (mesencephalon)
Hindbrain (rhombencephalon)
Telencephalon
Diencephalon
Mesencephalon
Metencephalon
Myelencephalon
Spinal cord
Adult derivatives of:
Walls
Cavities
Cerebral hemispheres
Lateral ventricles
Thalamus, Hypothalamus
Third ventricle
Midbrain
Cerebral aqueduct
Pons
Upper part of fourth ventricle
Cerebellum
Medulla
Lower part of fourth ventricle

BRAIN DEVELOPMENT: Other high-yield facts

- **CSF production** is believed to begin during the 5th week
- **Glioblasts** differentiate from neuroepithelial cells lining the neural tube, giving rise to **astrocytes** (from astroblasts) and **oligodendrocytes** (oligodendroblasts). After producing neuroblasts and glioblasts, they **differentiate into ependymal cells**- forming the ependyma (epithelium like lining of the ventricular system of the brain and the central canal of the spinal cord). **Microglia** develops from **mesenchymal cells**.
- Alar plate (dorsal part) has afferent activity while the basal plate (ventral part) has efferent activity

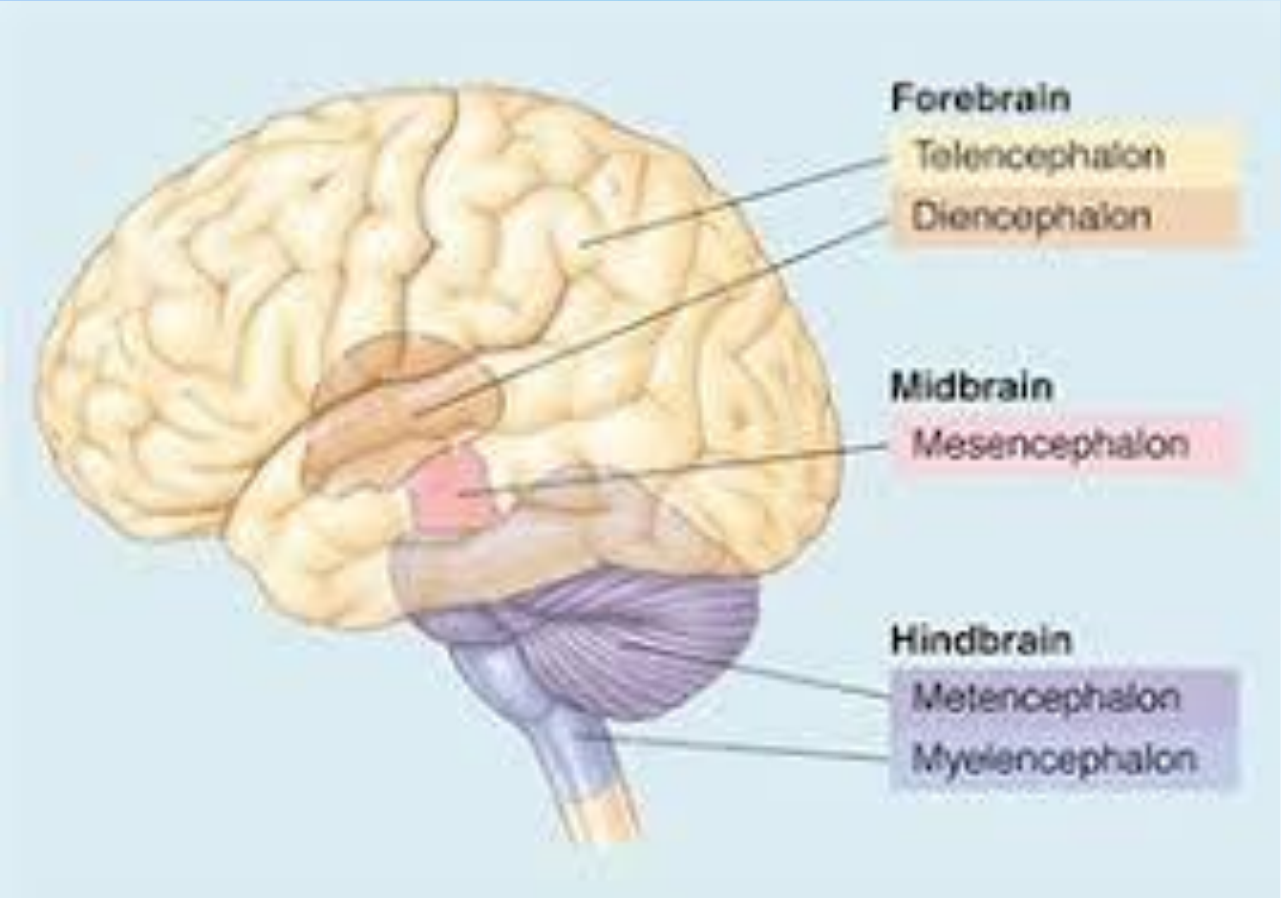
Neural Tube Defects: Clinical Correlation



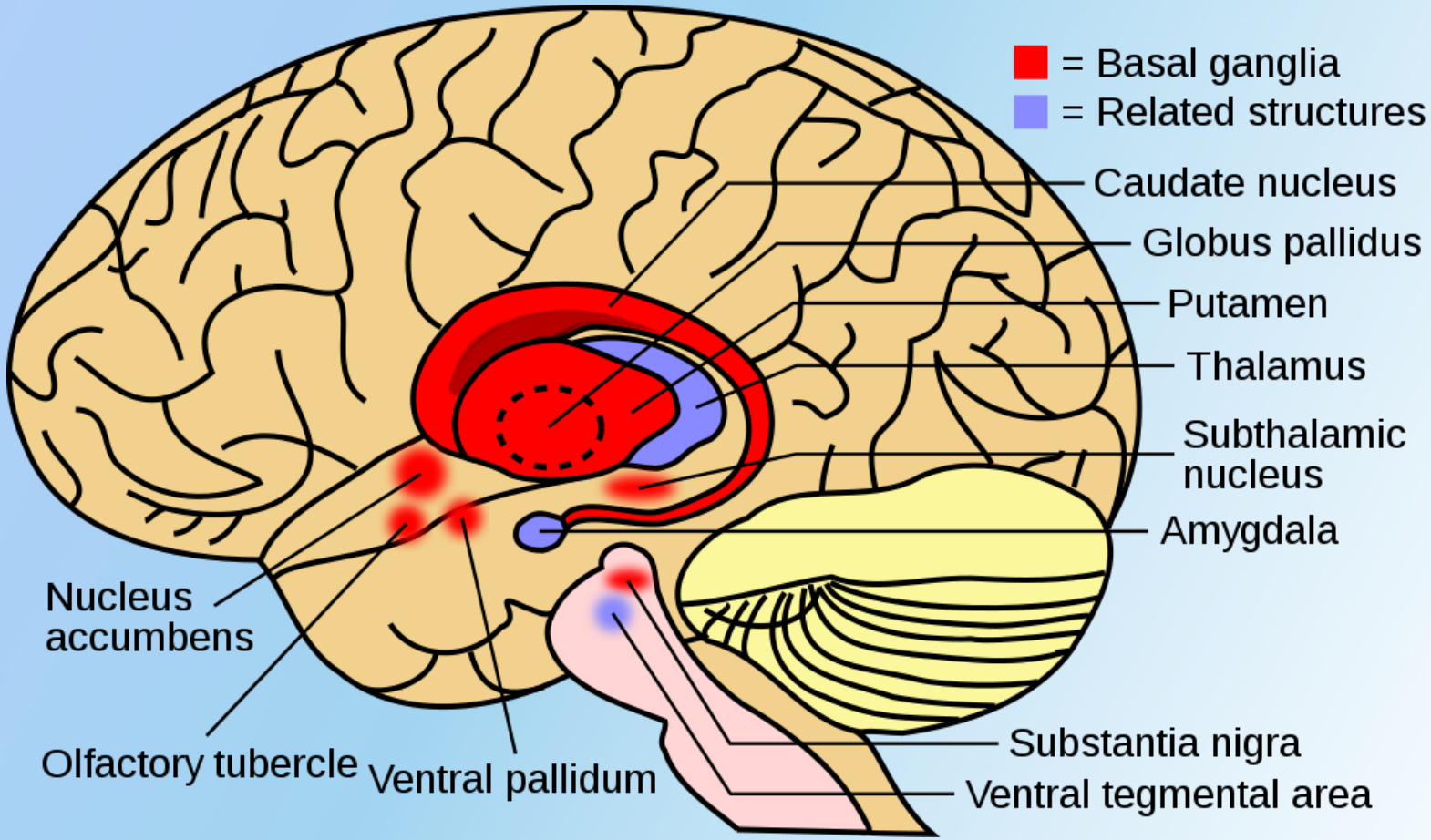
- Spina bifida occulta – result of the failure of one or more neural arches to fuse in the median plane, occurs in the L5 or S1 vertebrae in approx. 10 %
- Spina bifida with meningocele – protrusion of the spinal cord through these defects in the vertebral arches, cyst contains meninges and CSF
- Spina bifida with meningomyelocele – more common and more severe than spina bifida with meningocele. In reality could occur anywhere, but most common in lumbar and sacral segment – also associated with craniolacunia (defective development of the calvaria – skullcap).
- Rachischisis – rostral neuropore fails to close by the 27th day, resulting in a spinal cord which is exposed, permanent paralysis or weakness of the lower limb.
- Meningoencephalocele – neural tube defect characterized by a sac-like protrusion, containing brain tissue and meninges
- Meningocele – sac-like protrusion containing meninges
- Meningohydro-encephalocele – includes brain tissue, meninges and CSF (ventricular system)

TELENCEPHALON

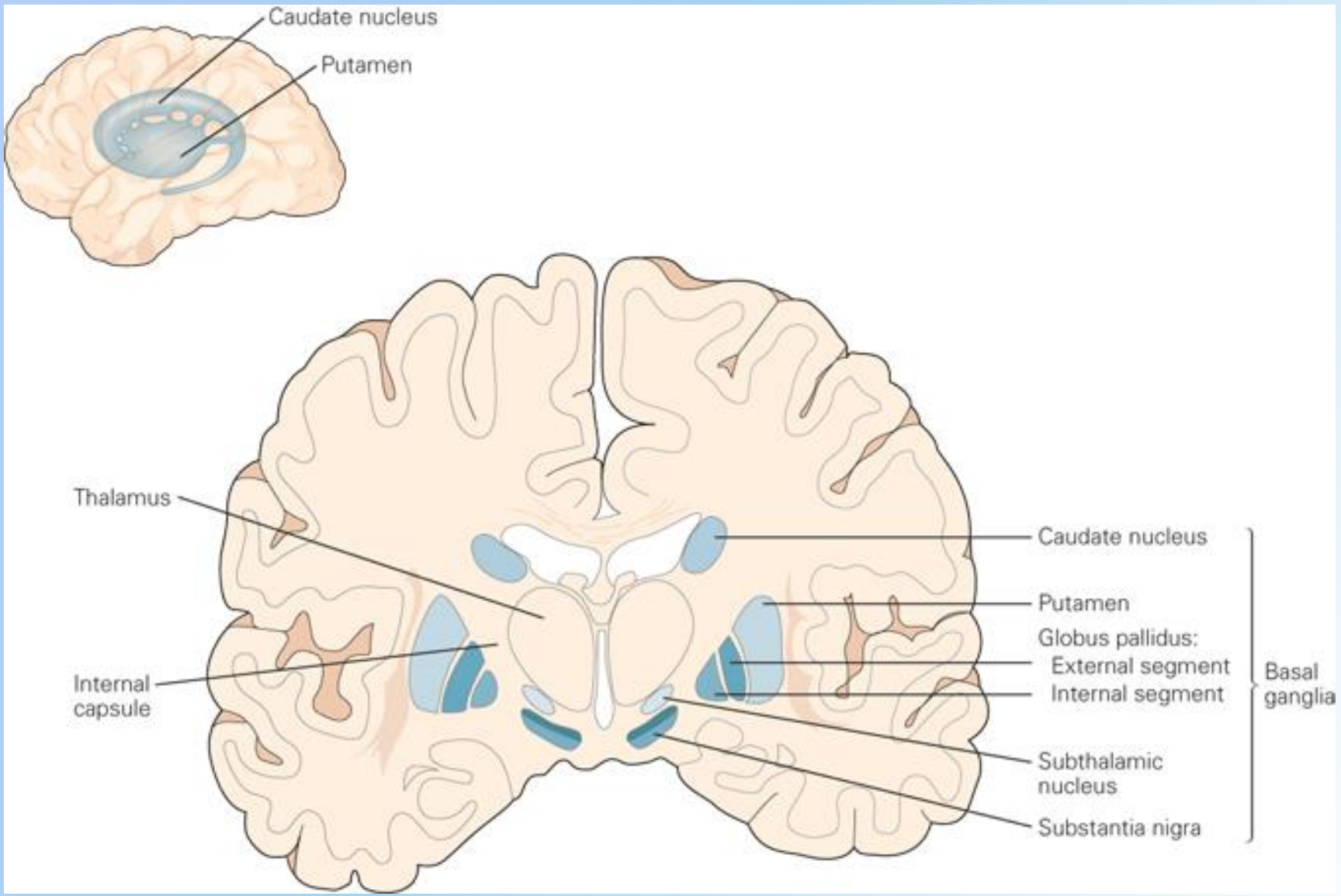
- Development: Prosencephalon > Telencephalon > Cerebrum, White Matter, Basal Ganglia



Basal Ganglia



- **Basal ganglia:** interconnected system of nuclei w/ various functions including **control of voluntary movements, cognition, and emotion,** as well as **procedural learning** and **eye movements**
- Include:
  - Striatum (both dorsal including caudate nucleus and putamen + ventral including nucleus accumbens and olfactory tubercle)
  - Globus pallidus
  - Ventral pallidum
  - Substantia nigra
  - Subthalamic nucleus

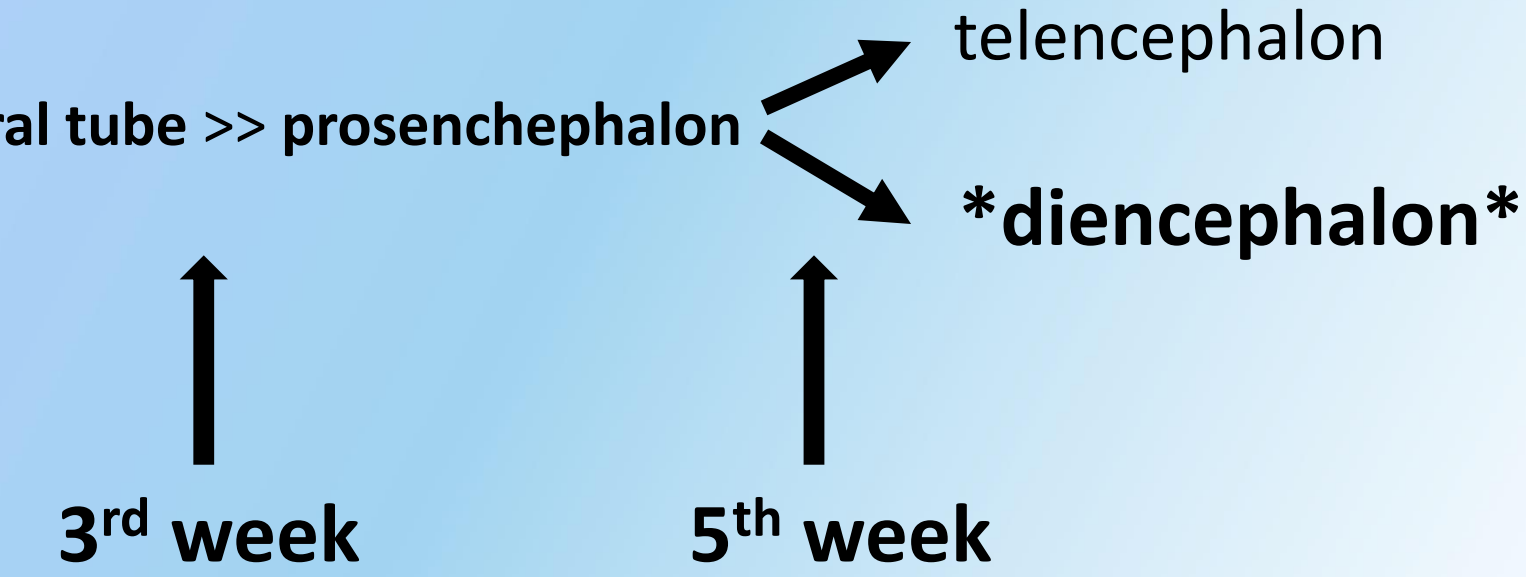

Caudate nucleus
Putamen
Thalamus
Internal capsule
Caudate nucleus
Putamen
Globus pallidus:
External segment
Internal segment
Subthalamic nucleus
Substantia nigra
Basal ganglia

Clinical Correlation

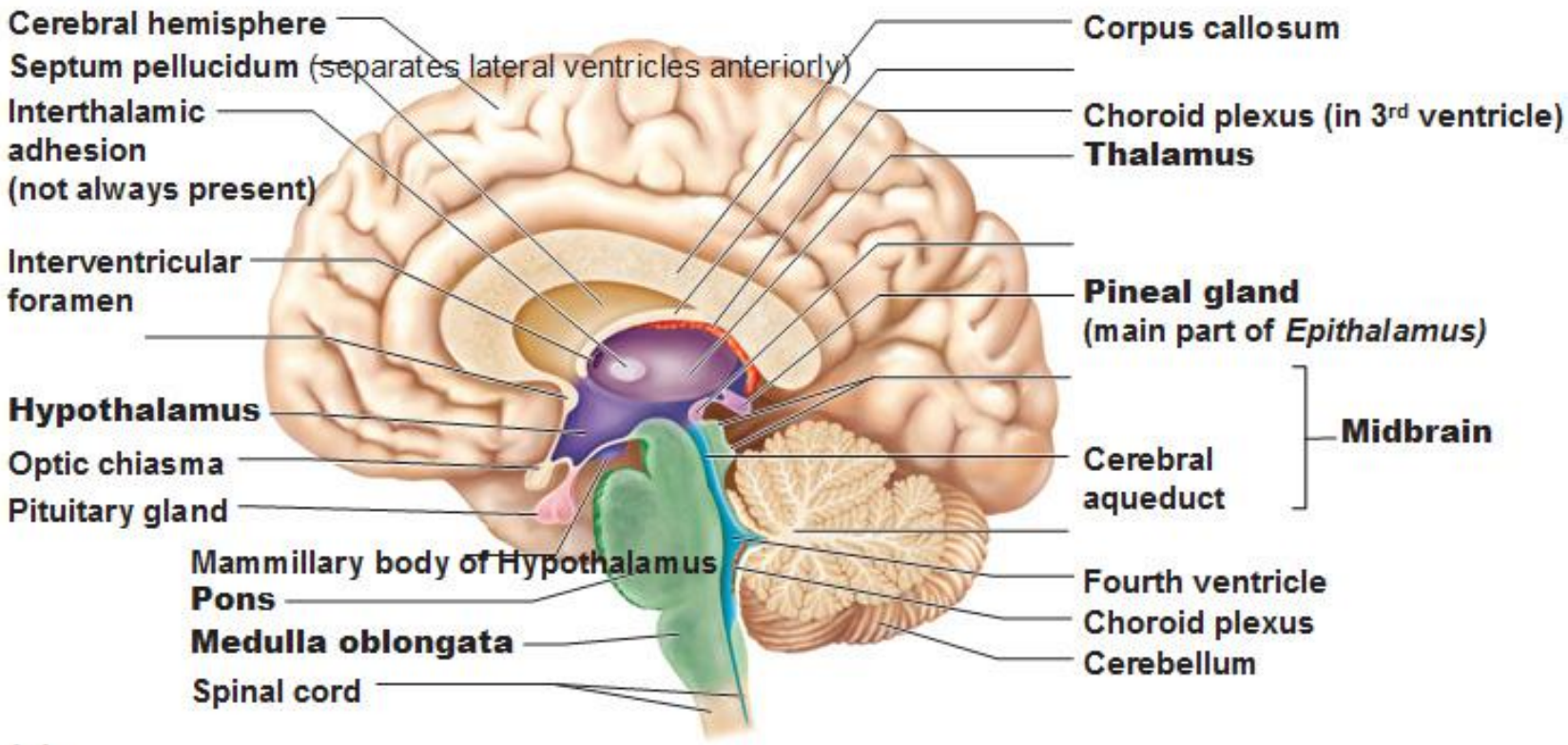
- Tourette syndrome, OCD, addiction, Huntington disease, Parkinson disease have all been primarily linked to dysfunction within different regions of the basal ganglia.
- Cocaine and amphetamine increase the dopamine signal within the mesolimbic and mesocortical pathways of the basal ganglia.

DIENCEPHALON

- What does it consist of?
  - Most importantly, **thalamus, hypothalamus, third ventricle**
  - But also **epithalamus** and **subthalamus** (more on these later)
- Precursor?



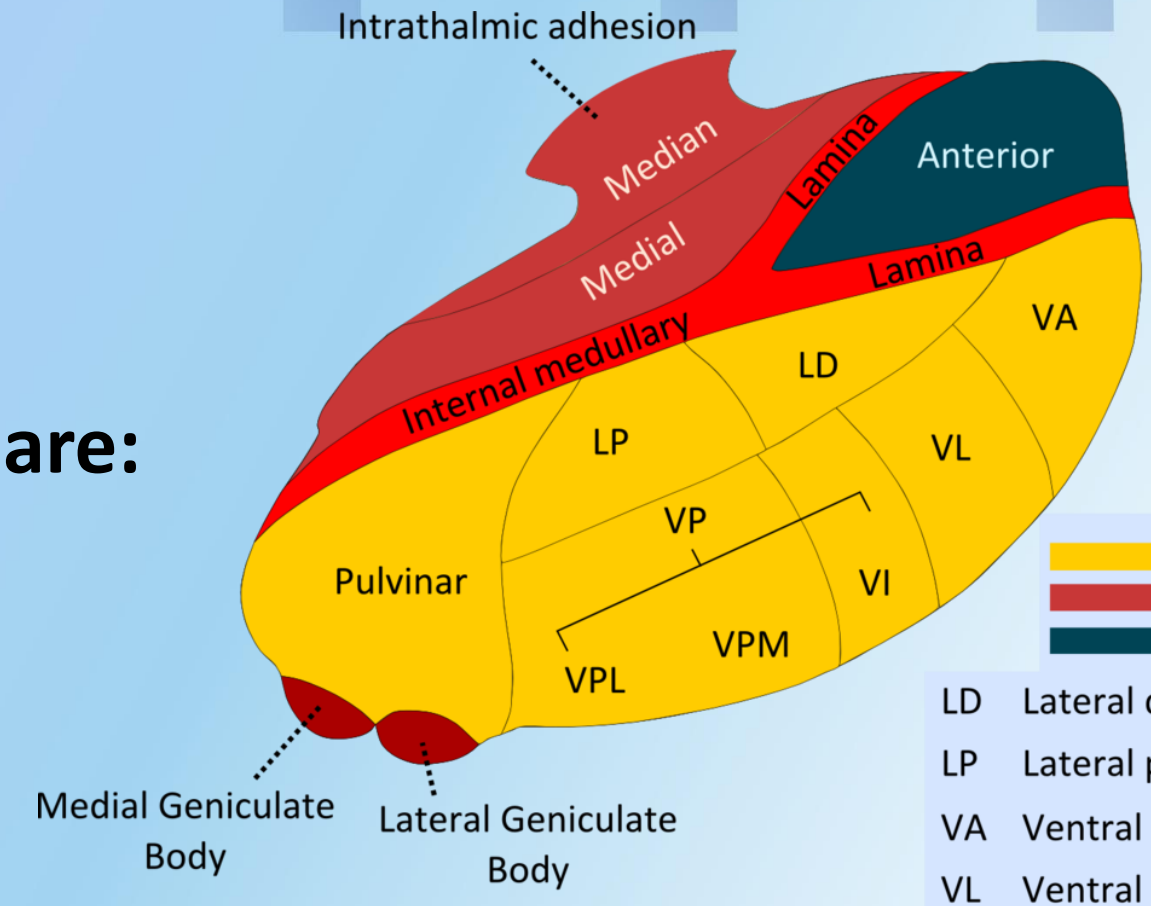
The Diencephalon (and Brainstem)



(a)

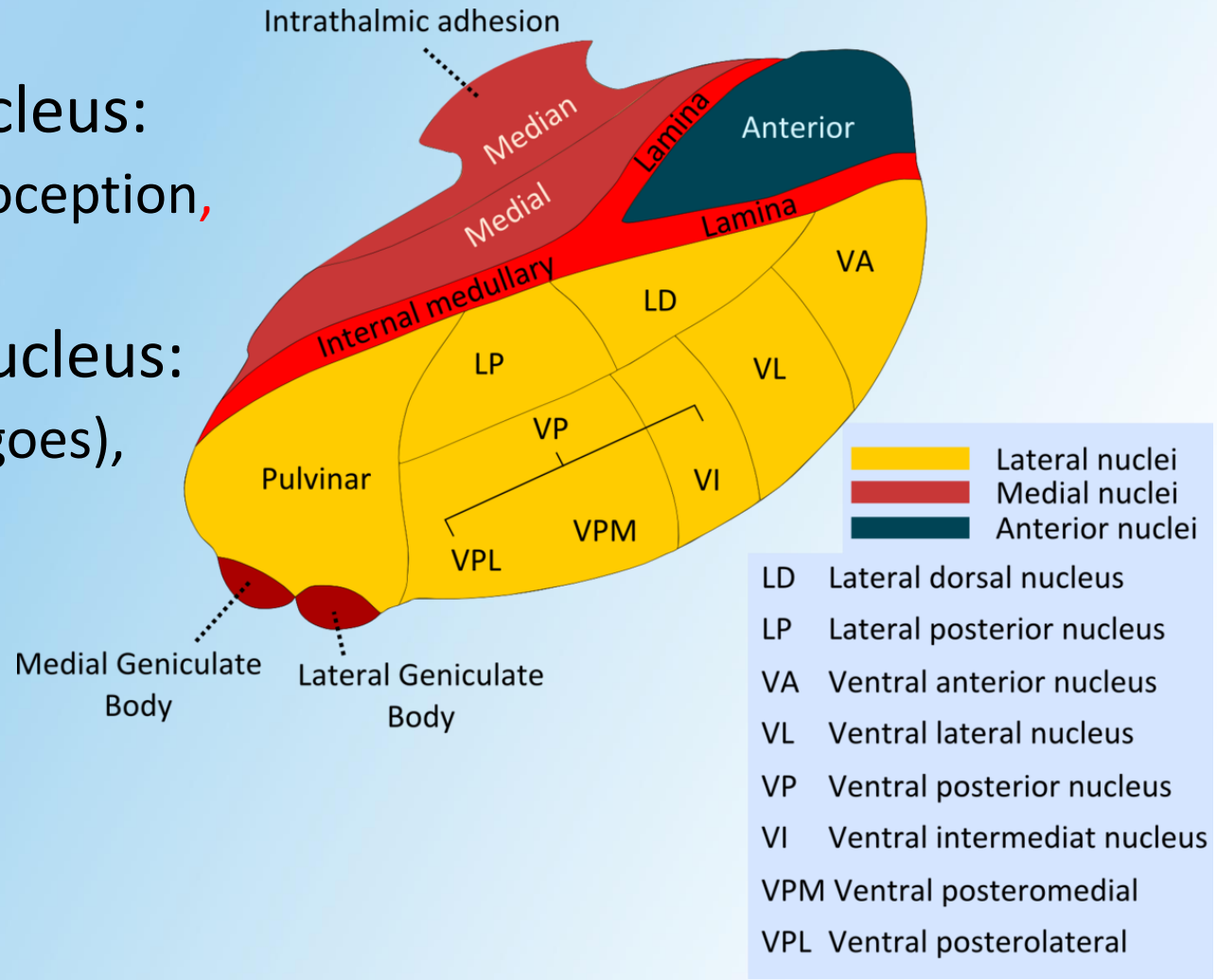
Thalamus

- **MANY nuclei**
- **The most high-yield are:**
  - **VPL**
  - **VPM**
  - **VL**
  - **LGB**
  - **MGB**



Thalamic Nuclei

- VPL: Ventral PosteroLateral Nucleus:
  - Vibration, Pain, Pressure, Proprioception, Light Touch, Temperature
- VPM: Ventral PosteroMedial Nucleus:
  - Face sensation (where Makeup goes), taste (YUMMM)
- Ventral Lateral Nucleus:
  - Motor
- Lateral Geniculate Body
  - Vision: “Lateral = Light”
- Medial Geniculate Body
  - Hearing: “Medial = Music”



The thalamus receives sensory stimuli from everywhere except?

I really hope someone NOSE the answer…

OLFACTION is <u>NOT</u> relayed through the thalamus

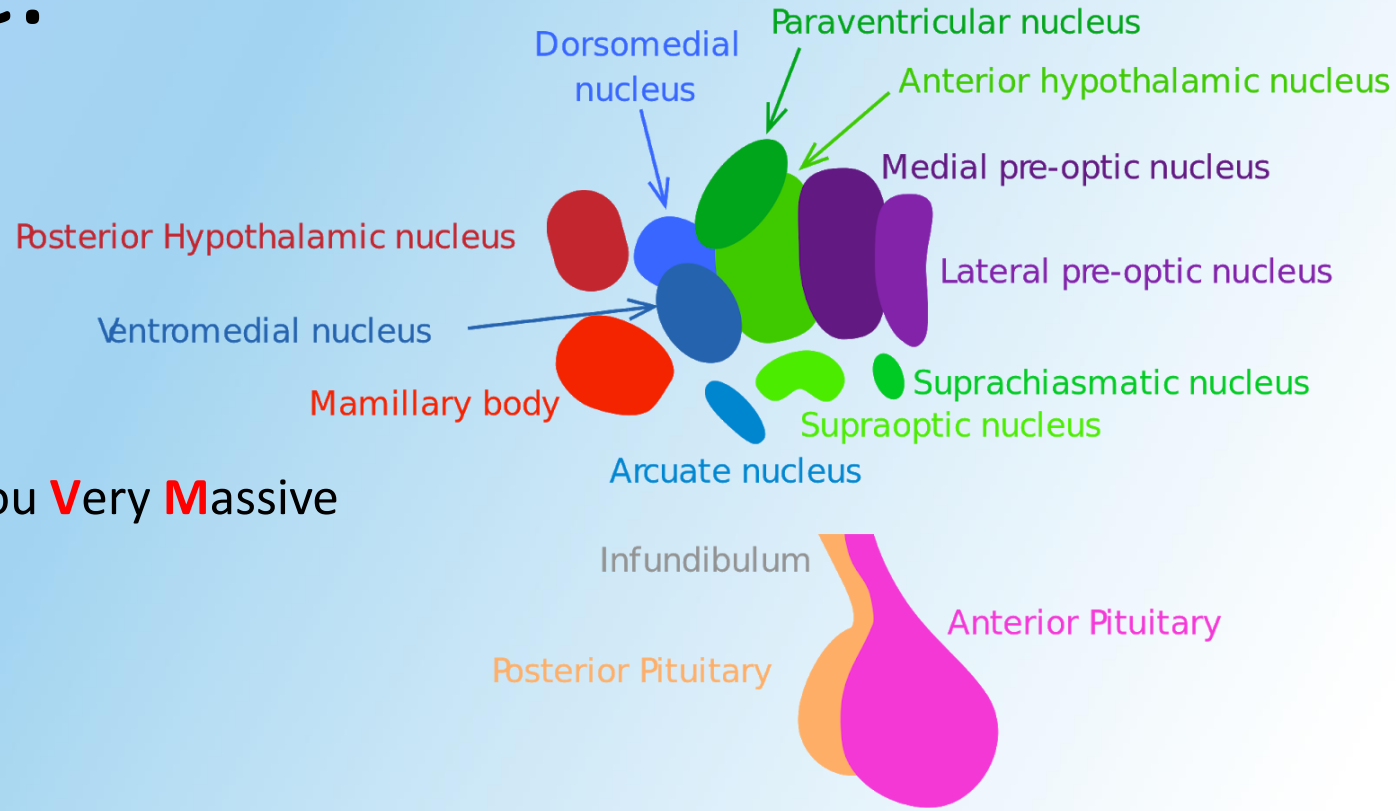
Hypothalamus

Random, right? Well no, because the hypothalamus is responsible for TAN HATS:

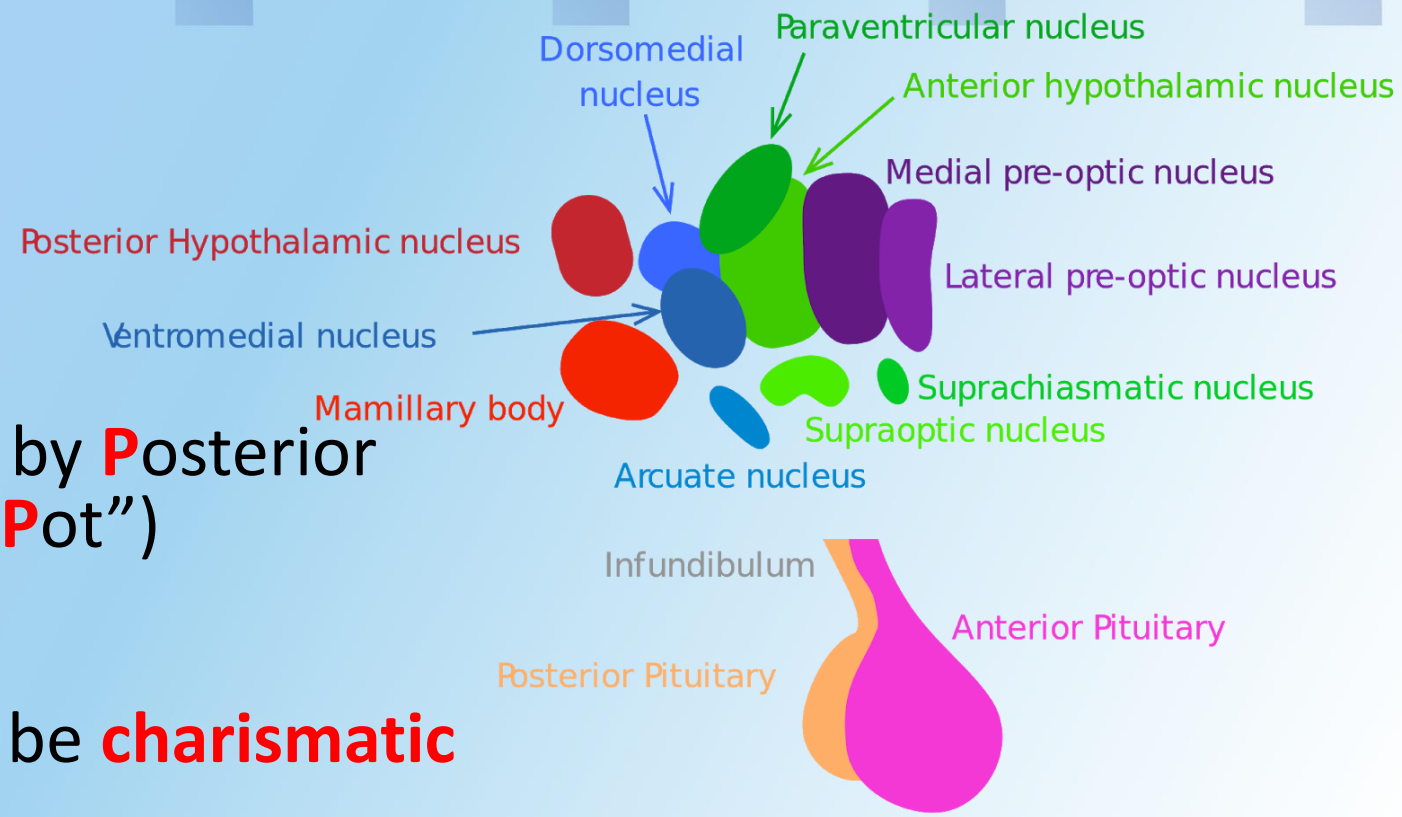
- Thirst and water balance
- Adenohypophysis
- Neurohypophysis
- Hunger
- Autonomic nervous system
- Temperature
- Sexual urges

Hypothalamus also contains many nuclei. The most important are:

- **L**ateral nucleus
  - Hunger
    - **L**ateral injury makes you **L**ean
- **V**entro**M**edial nucleus
  - Satiety
    - **V**entro**M**edial injury makes you **V**ery **M**assive
- **A**nterior nucleus
  - **C**ooling, parasympathetic
- **A**/**C** = **a**nterior **c**ooling



- **P**osterior nucleus
  - **H**eating, sympathetic.
    - **H**eating is controlled by **P**osterior hypothalamus (“**H**ot **P**ot”)
- Suprachiasmatic nucleus
  - Circadian rhythm
    - You need to **sleep** to be **charismatic** (chiasmatic)
- Supraoptic and paraventricular nuclei
  - Synthesize ADH and oxytocin
- Preoptic nucleus
  - Thermoregulation, sexual behavior



A few words on the epithalamus and subthalamus

- **Subthalamus**:
  - Helps control **motor activity**
  - Consists of the cranial ends of the **substantia nigra** and **red nucleus**
- **Epithalamus:**
  - **Habenular nuclei:** regulate various **CNS neurotransmitters**
  - **Pineal gland:** where **melatonin** is produced

REVIEW

In which of the following are the 3 **primary** and 5 **secondary** vesicles paired correctly?

A. Prosencephalon>>Diencephalon
Mesencephalon>>Mesencephalon, Telencephalon
Rhombencephalon>>Myelencephalon, Metencephalon

B. Prosencephalon>>Telencephalon, Diencephalon, Metencephalon
Mesencephalon>>Mesencephalon
Rhombencephalon>>Myelencephalon

C. Prosencephalon>>Telencephalon, Diencephalon
Mesencephalon>>Mesencephalon
Rhombencephalon>>Metencephalon, Myelencephalon

In which of the following are the 3 **primary** and 5 **secondary** vesicles paired correctly?

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B. Prosencephalon>>Telencephalon, Diencephalon, Metencephalon
Mesencephalon>>Mesencephalon
Rhombencephalon>>Myelencephalon

C. **Prosencephalon>>Telencephalon, Diencephalon**
Mesencephalon>>Mesencephalon
Rhombencephalon>>Metencephalon, Myelencephalon

In which of the following weeks can you see the first signs of brain development?

A. 2-3 weeks
B. 3-4 weeks
C. 4-5 weeks
D. 5-6 weeks
E. 6-7 weeks

In which of the following weeks can you see the first signs of brain development?

A. 2-3 weeks
B. **3-4 weeks**
C. 4-5 weeks
D. 5-6 weeks
E. 6-7 weeks

CSF begins to form during week _____ of development:

A. 7
B. 8
C. 4
D. 5
E. 6
F. 3
G. 9

CSF begins to form during week _____ of development:

A. 7
B. 8
C. 4
D. **5**
E. 6
F. 3
G. 9

True/False:

Meningocele and myelomeningocele are associated with a tuft of hair

FALSE! SPINA BIFIDA OCCULTA IS

One last interesting clinical correlation

- This very sad example of **cyclopia** is the most extreme presentation of **holoprosenchephaly**, which is due to failure of the **prosencephalon** to separate into two cerebral hemispheres (**telencephalon**) which usually occurs during weeks 5-6.
    1. Can you guess what the more mild form of holoprosencephaly would look like?
    2. Do you know any specific **trisomies** or other syndromes which can present with holoprosencephaly?

1. Cleft lip/palate
2. Trisomy 13, Fetal Alcohol Syndrome

QUESTIONS?

THANK YOU VERY MUCH

BEST OF LUCK ;)

SPECIAL THANKS TO EIRIK KRAGER