


BGDA Lecture - Development of the Nervous System

Introduction

	<p>Neural development is a complex and ongoing process that commences in week 3 and continues through into the postnatal period. This lecture will introduce concepts about the timing, origin and abnormalities of the nervous system.</p> <p>Final lecture content will be added to this current page, the linked online textbook chapters are available as pre-reading for this lecture.</p>
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Aim

To develop an understanding of the development of the nervous system and the consequences of abnormal development.

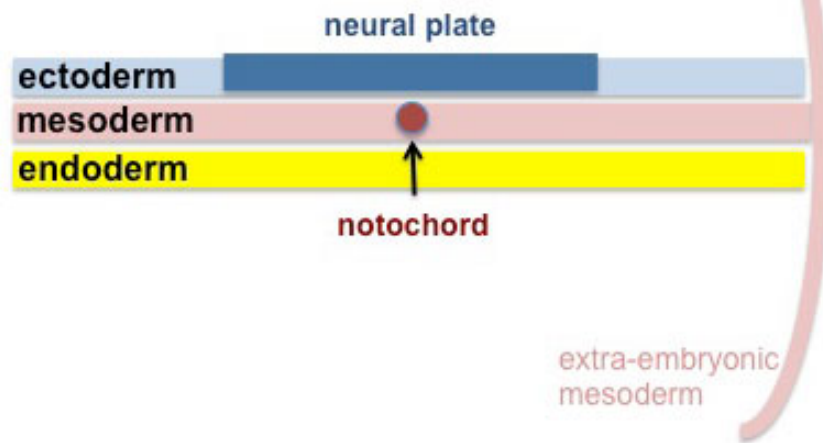
Textbooks

Textbooks	[Expand]
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Week 3

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Trilaminar Embryo (transverse section)



Week 3 Movies [Expand]

Ectoderm

- neural plate - midline (columnar cells)
 - neural crest - outside lateral edges of neural plate
- surface ectoderm - lateral (cuboidal cells)
 - head - sensory and anterior pituitary (placodes)
 - integument - epidermis of skin, hair, glands, teeth enamel

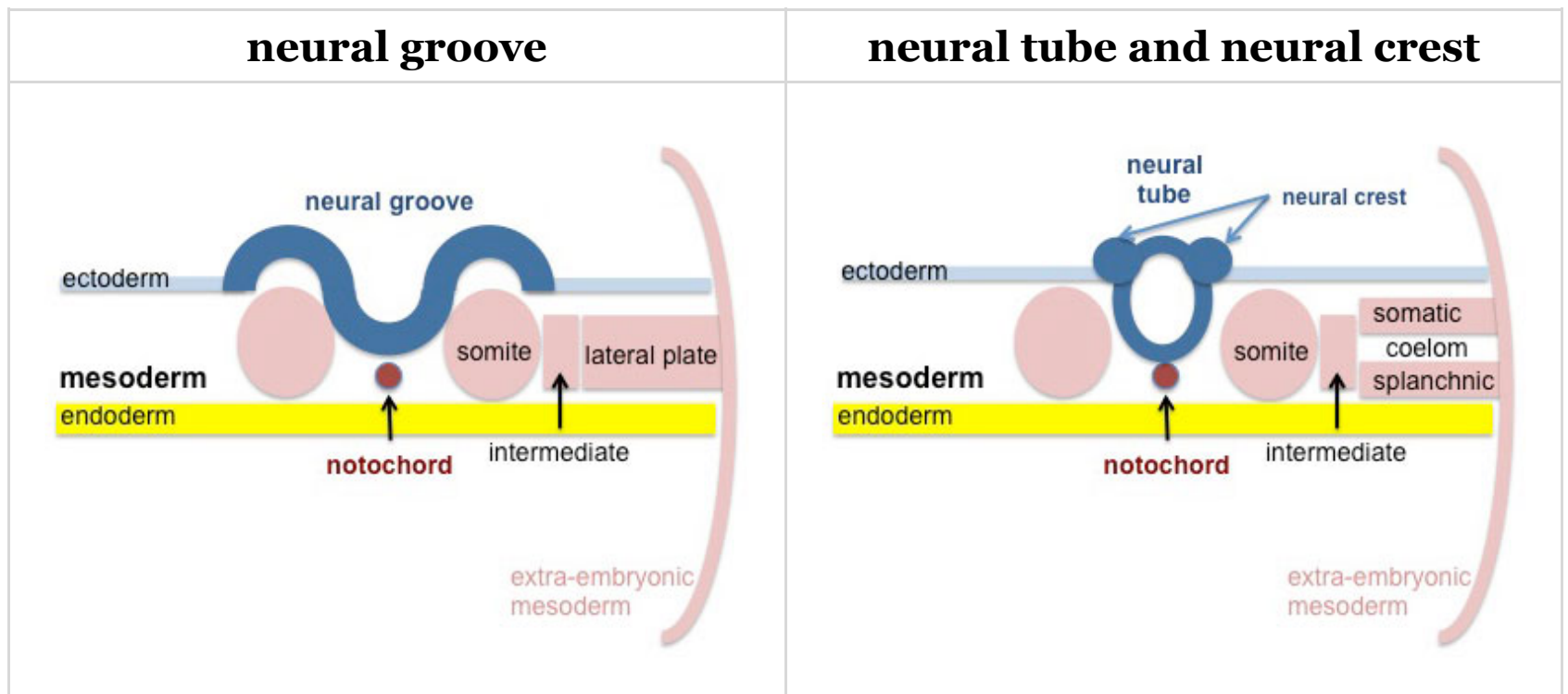
Neural Plate

- extends from **buccopharyngeal membrane** (oral membrane) to **primitive node** (Hensen's node)
- forms above notochord and paraxial mesoderm
- neuroectodermal cells - neural plate, [neural crest](#)

- rostrocaudal width
 - broad - brain plate
 - narrow - [spinal cord](#)

Week 4

Neural Tube



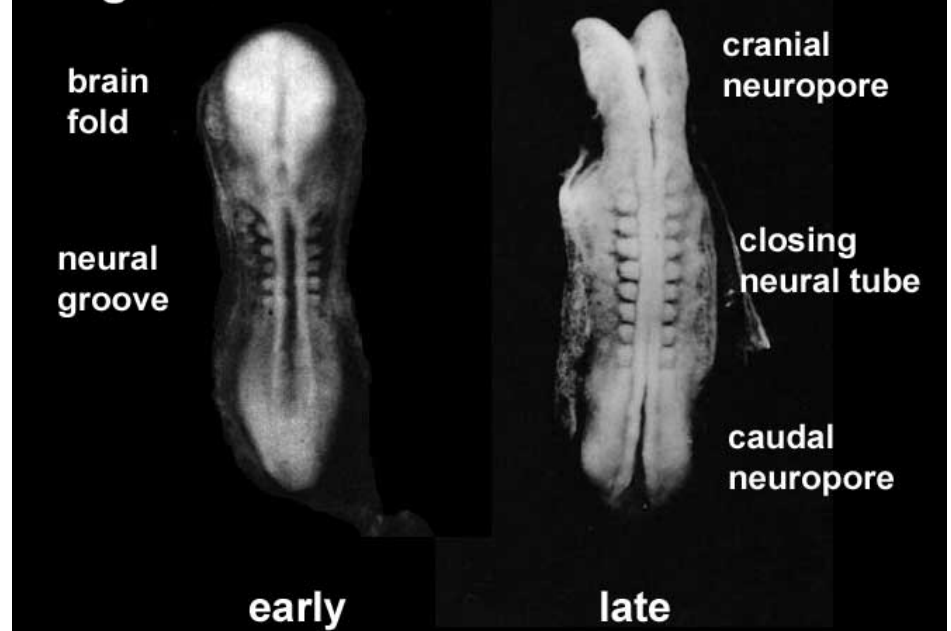
Stage 10 - Dorsal View



[Mobile](#) | [Desktop](#) | [Original](#)

[Stage 10](#) | [Embryo Slides](#)

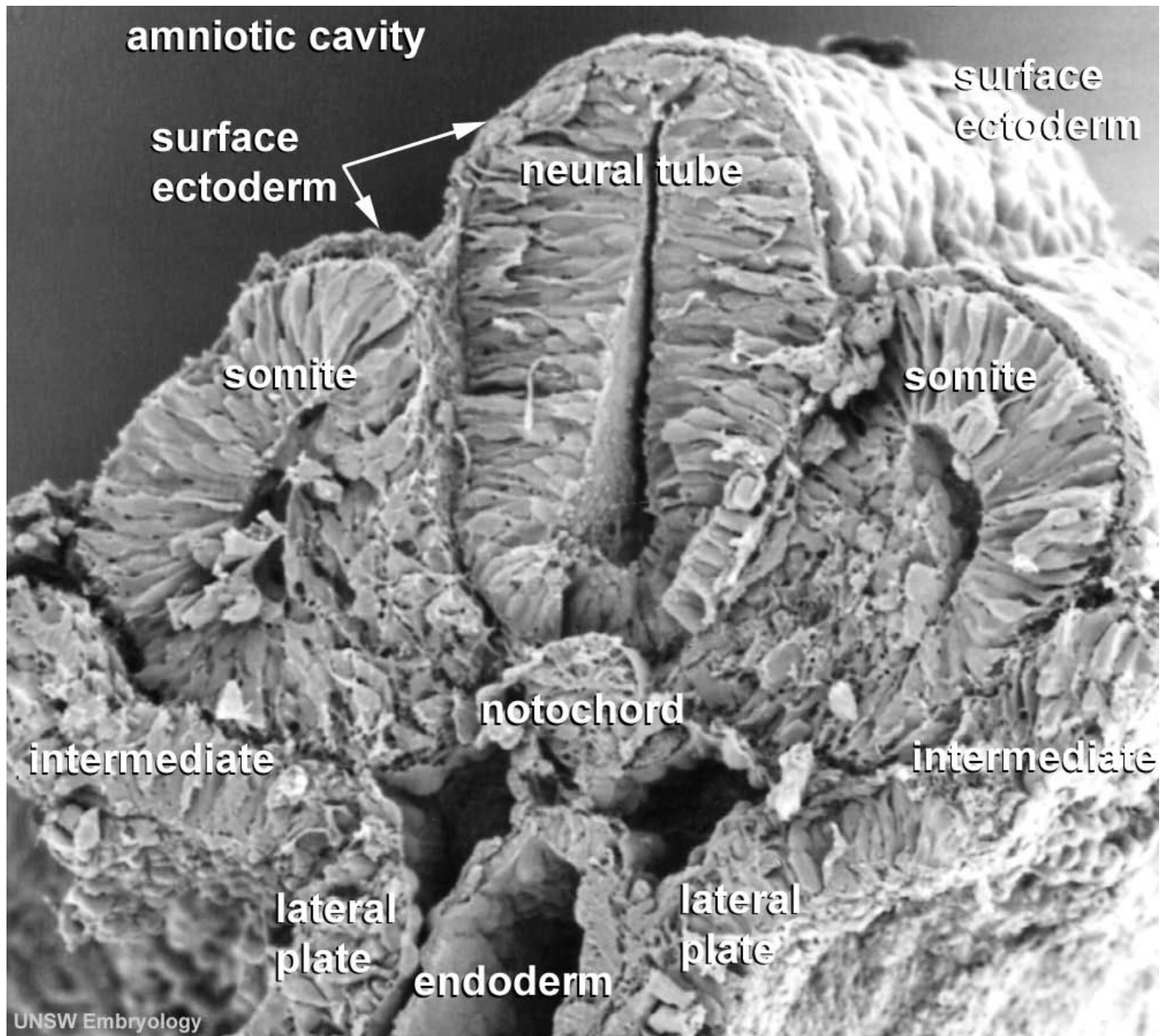
stage 10



Week 4 Movies [\[Expand\]](#)

- Stage [10](#) (22 - 23 days)
-

- Stage [10](#) (22 - 23 days)
- 23 day, 11 somite pairs
- Stage [11](#) (23 - 26 days)



Neuropores

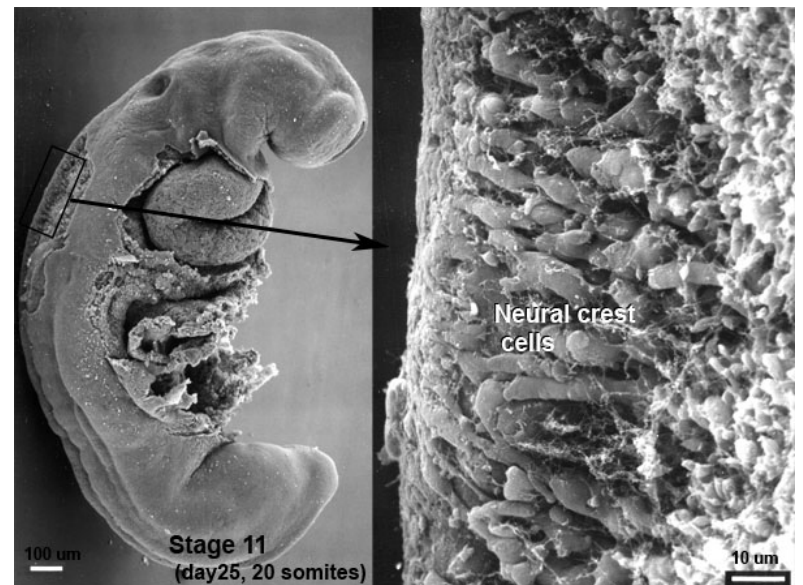
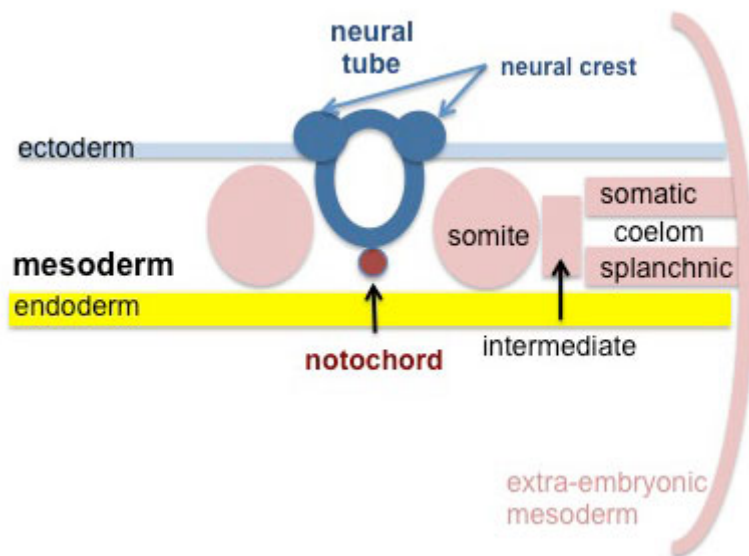
Cranial neuropore (cephalic, rostral or anterior) closes about 24 days post-fertilization.

- [11](#) Anterior Neuropore
- [11](#) Posterior Neuropore

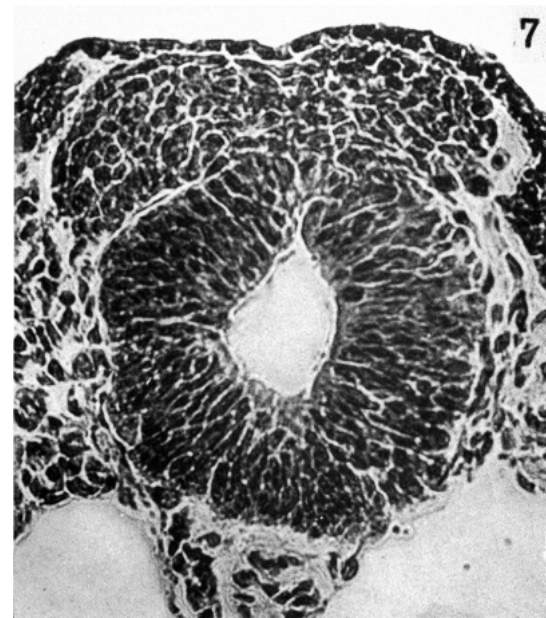
Caudal neuropore (posterior) closes about 28 days post-fertilization.

- Stage [12](#) (26 - 30 days)
- Stage [12](#) (26 - 30 days)
- Common sites of neural tube defects.

Neural Crest



Human embryo neural crest cells
([Week 4](#), Stage [11](#))



Neural crest (acoustico-facial
primordium)

Chicken neural crest cell migration into pharyngeal arches.

Cartoon shows example of some neural crest medial migration and structures formed at the level of the body.

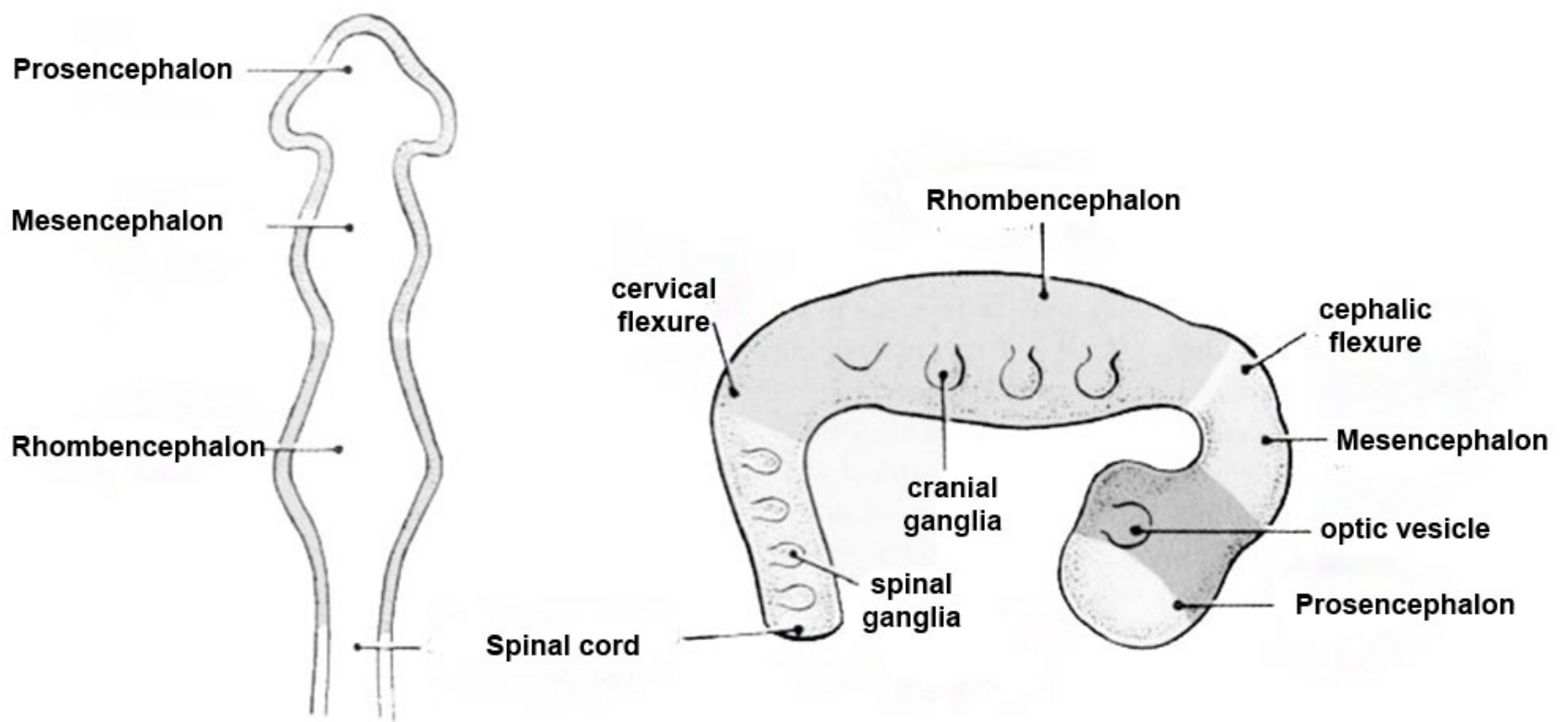
- Cells staying dorsal to neural tube - dorsal root ganglia (DRG)
- Cells migrating ventral to neural tube - sympathetic ganglia
- Cells migrating peritoneal cavity wall - [adrenal](#) medulla
- Cells migrate into GIT wall - [enteric nervous system](#)

Neural Crest Origin	
System	Cell Type
Peripheral Nervous System (PNS)	<p>Neurons - sensory ganglia, sympathetic and parasympathetic ganglia, enteric nervous system, and plexuses</p> <p>Neuroglial cells, olfactory ensheathing cells^[1]</p> <p>Schwann cells^[2]</p>
Endocrine	<p>Adrenal medulla</p> <p>Calcitonin-secreting cells</p> <p>Carotid body type I cells</p>
Integumentary	Epidermal pigment cells
Facial cartilage and bone	Facial and anterior ventral skull cartilage and bones
Sensory	Inner ear, corneal endothelium and stroma
Connective tissue	<p>Tooth papillae</p> <p>smooth muscle, and adipose tissue of skin of head and neck</p> <p>Connective tissue of meninges, salivary, lachrymal, thymus, thyroid, and pituitary glands</p> <p>Connective tissue and smooth muscle in arteries of aortic arch origin</p>
Links: Neural Crest Development Category:Neural Crest Neural Crest collapsible table	

[neural crest](#)

Primary Brain Vesicles

Traditional vesicle description (simplified name and alternate neuromere description in brackets)

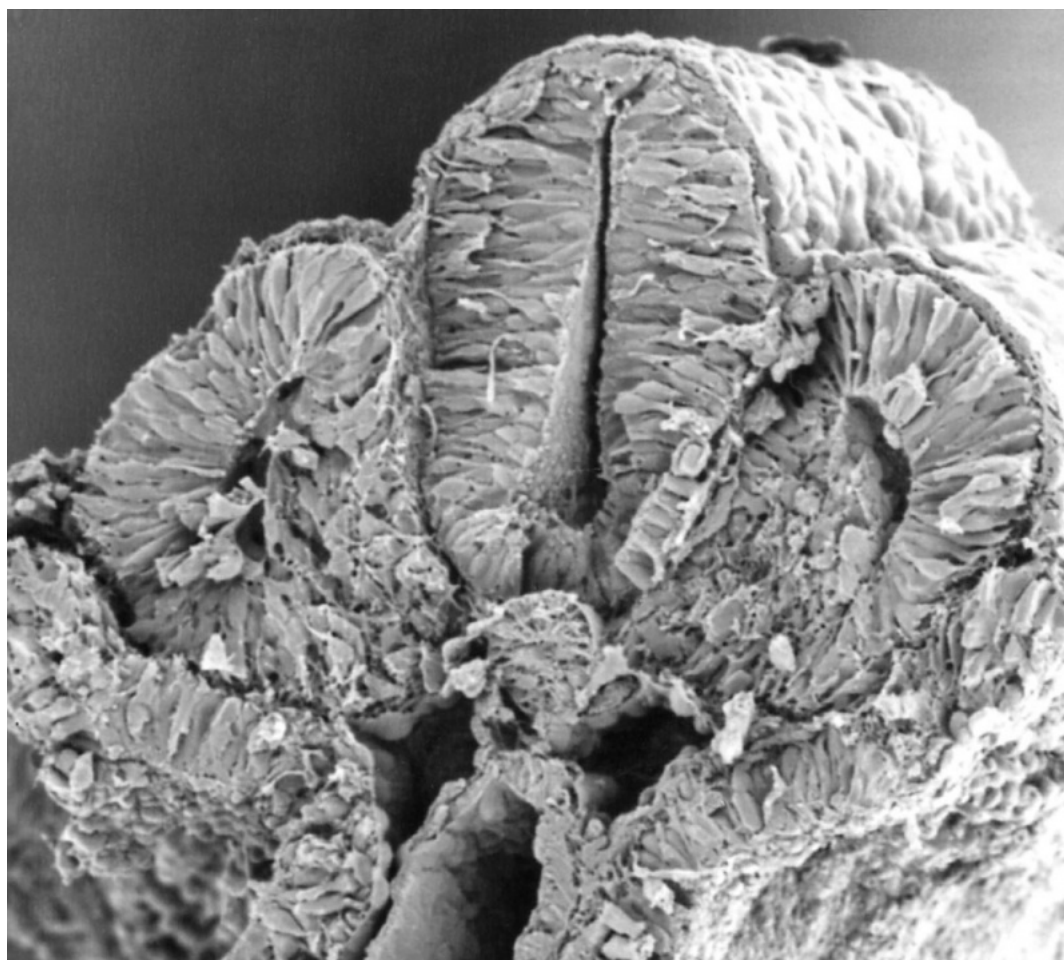


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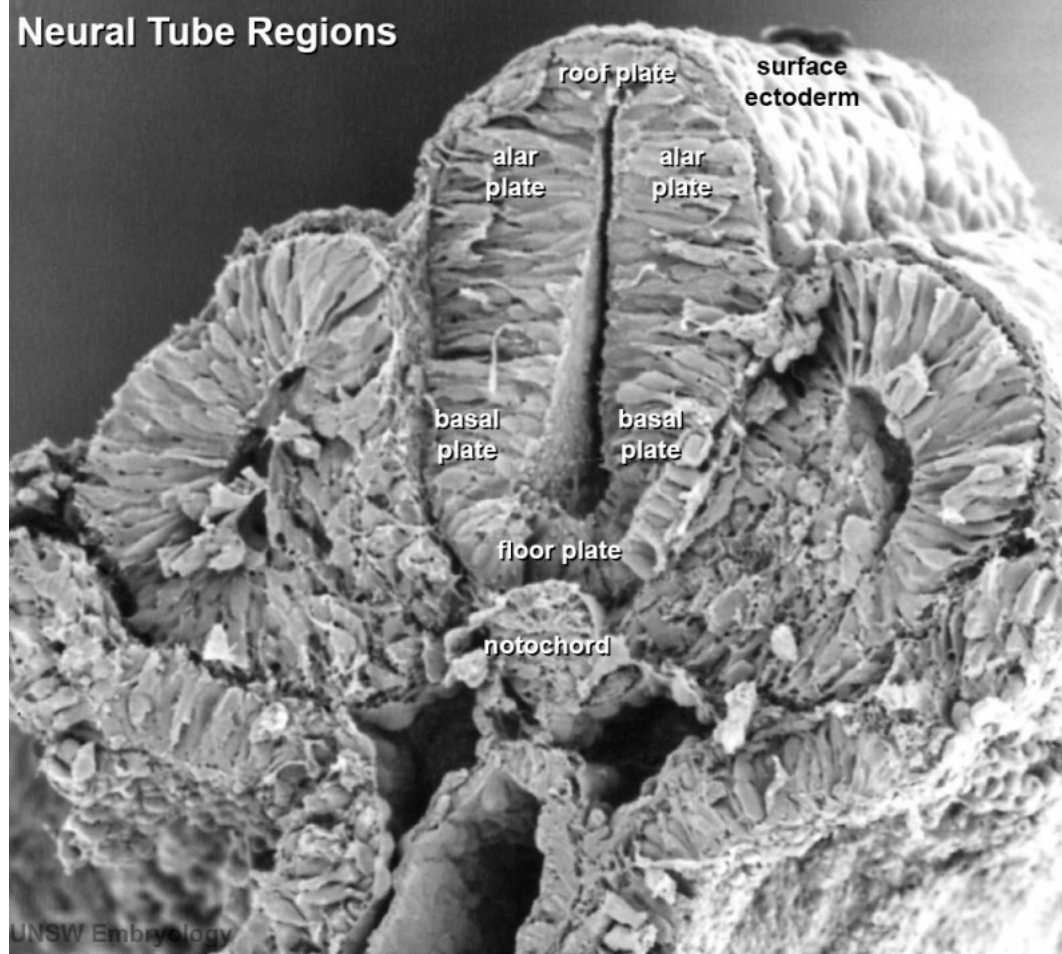
Brain

1. [Prosencephalon](#) (forebrain, prosomeres)
2. [Mesencephalon](#) (midbrain, mesomeres)
3. [Rhombencephalon](#) (hindbrain, rhombomeres)

Spinal Cord



Neural Tube Regions



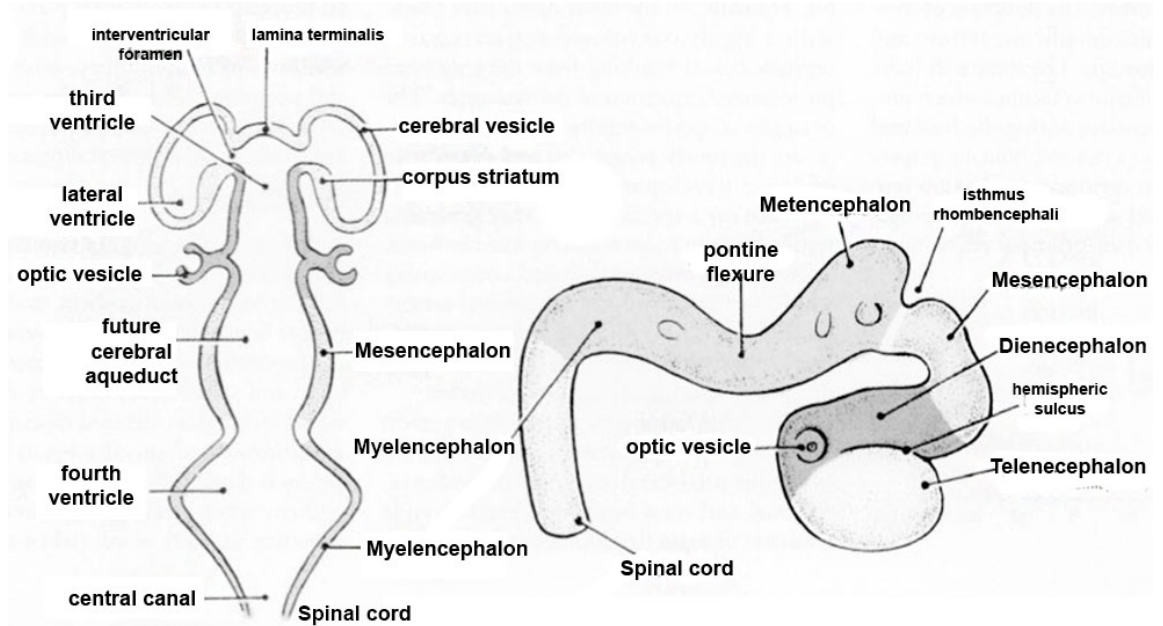
Neural Tube Regions [Expand]

Links: [Spinal Cord](#)

Week 5

Secondary Brain Vesicles

1. [Telencephalon](#)
2. [Diencephalon](#)
3. [Mesencephalon](#)
4. [Metencephalon](#)
5. [Myelencephalon](#)

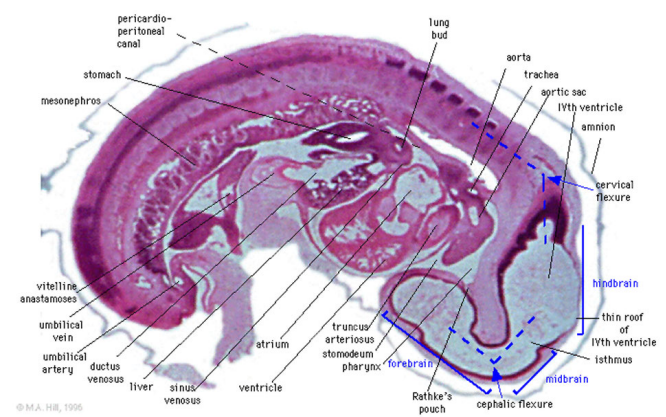


Brain Flexures

Rapid growth folds the neural tube forming

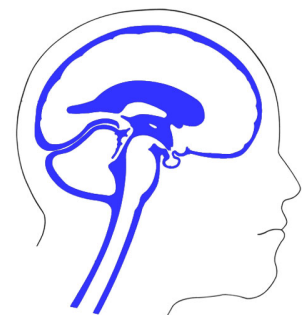
3 brain flexures (cranial to caudal)

- **cephalic flexure** - (mesencephalic) pushes mesencephalon upwards
- **pontine flexure** - generates 4th ventricle (cerebellum will grow into this space)
- **cervical flexure** - between brain stem and spinal cord



Ventricles

- cavity within neural tube will form the contiguous space of the ventricles of the brain and central canal of spinal cord
- space is filled initially with amniotic fluid, later with **CerebroSpinal Fluid (CSF)**
- CSF is secreted by
 - **chorioid plexus** modified vascular structures lying within the ventricles
 - floor of lateral ventricle and roof of the third and fourth ventricles
 - **ventricular ependymal cells** and cells lining the subarachnoid space
- CSF also fills the subarachnoid space (between arachnoid mater and pia mater).



CSF in ventricles and meninges

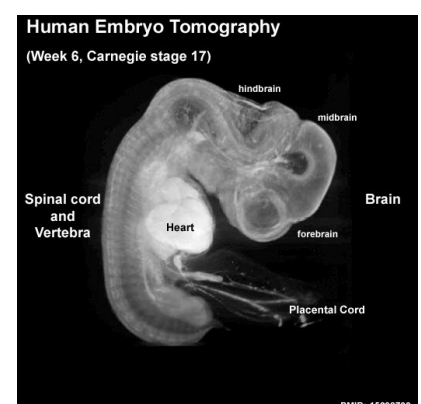
CSF-filled spaces in adult brain.

Adult Ventricular Structures [Expand]

Adult Meninges Layers [Expand]

Links: [Neural - Ventricular System Development](#)

Week 6



Note the shape and

<p>Movie</p>	<p>size of the different regions of the brain and spinal cord.</p> <ul style="list-style-type: none"> • Telencephalon (cerebrum) has begun to expand and will eventually cover the midbrain region. • Dorsal root ganglia are visible outside the spinal cord.
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Week 8

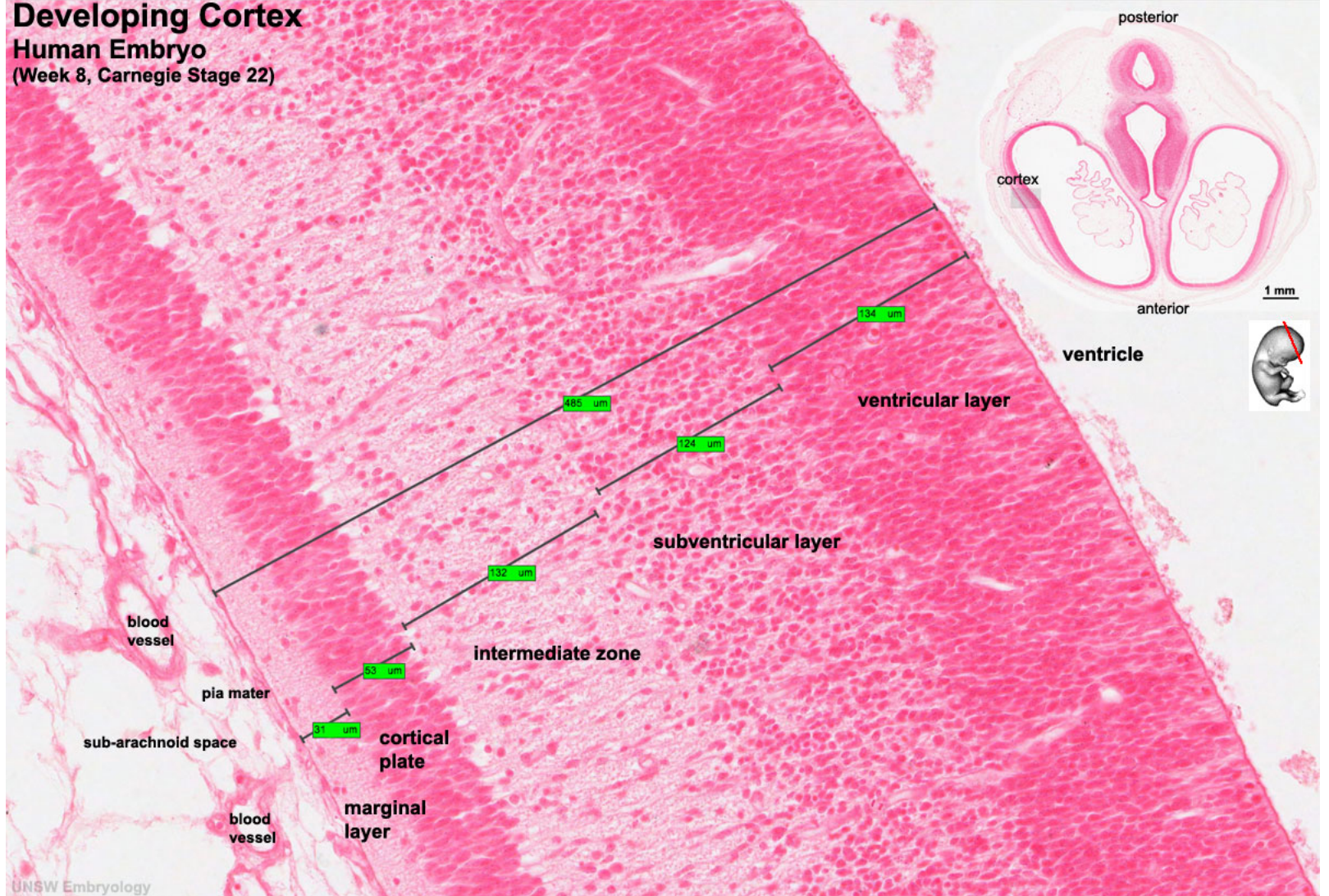
The human MRI movie below (head, sagittal plane, left to right) shows the central nervous system (CNS) development at the end of the embryonic period (week 8; [GA](#) week 10).

Cortex

Developing Cortex

Human Embryo

(Week 8, Carnegie Stage 22)



Week 8 Developing Cortex [Expand]

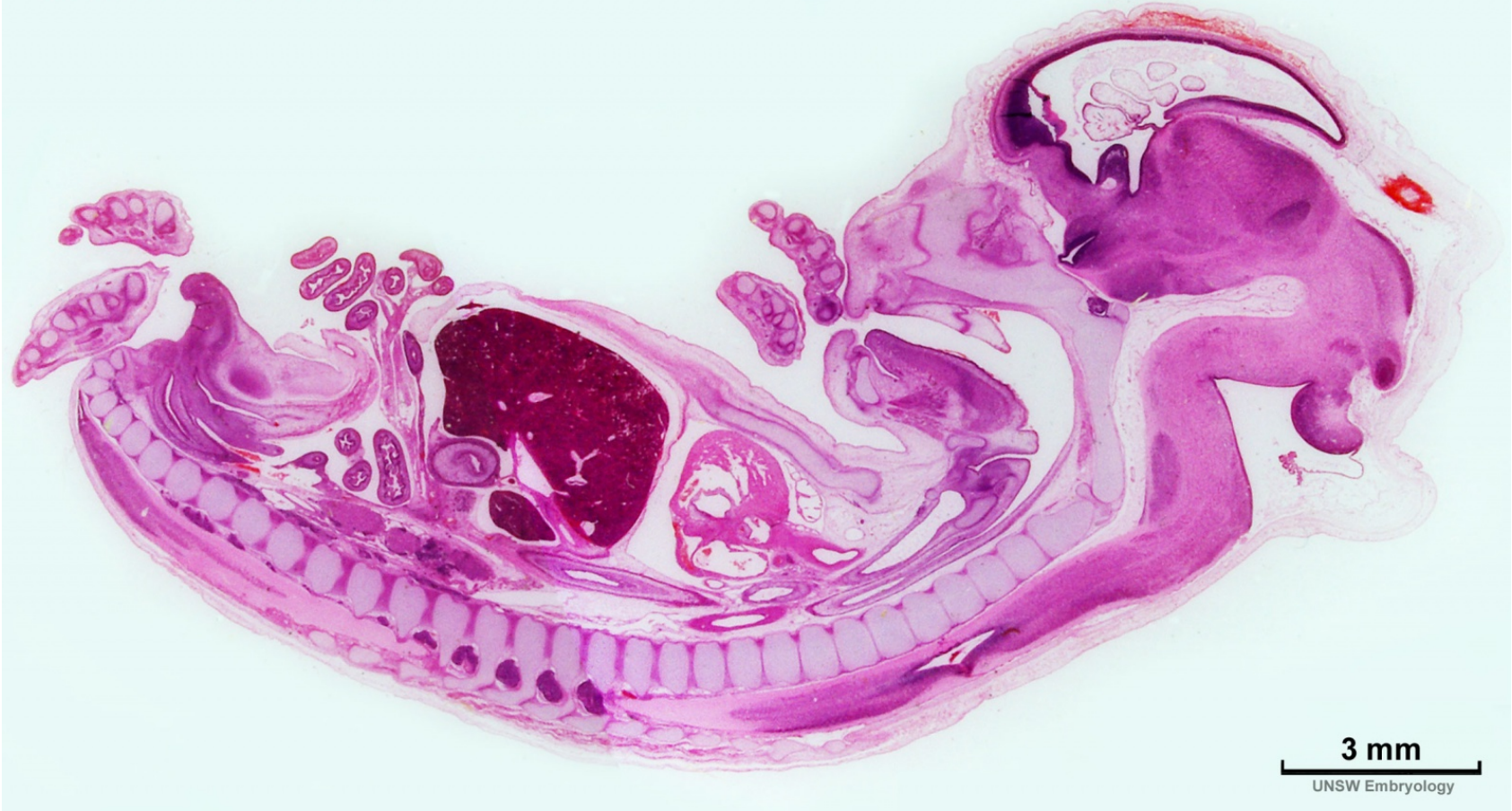
Spinal Cord



[Expand]

Second Trimester

Human Fetus (10 week)

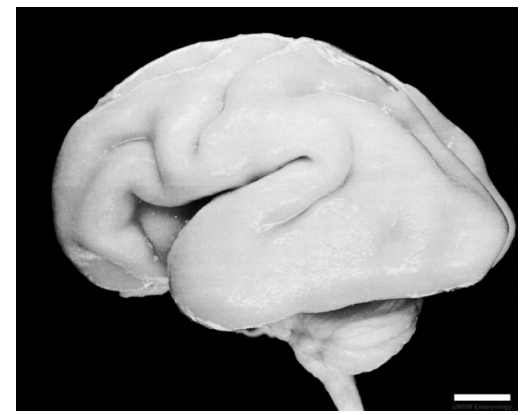
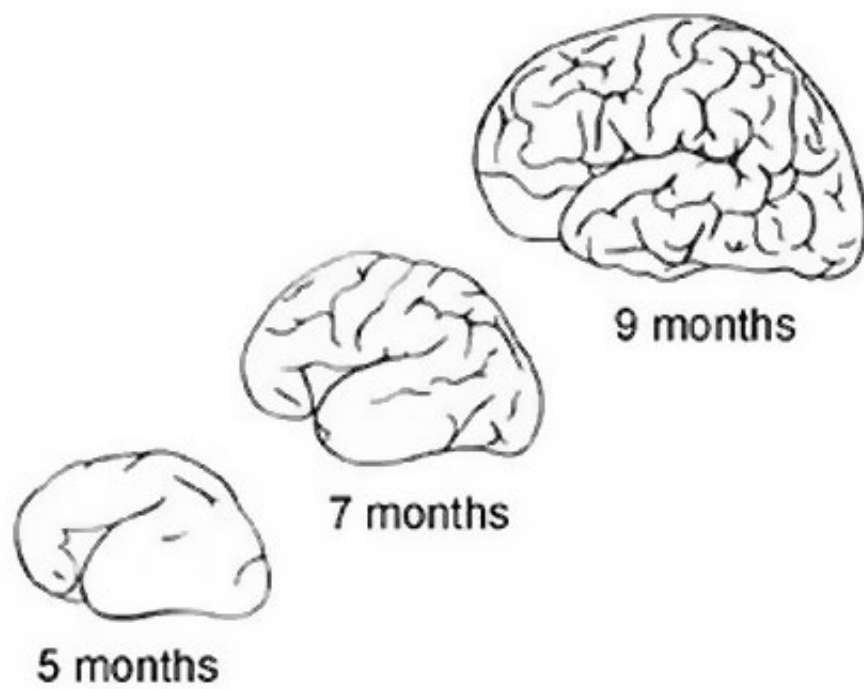


Human week 10 fetus

Brain and Ventricular Development ^[4]	Brain Fissure Development ^[4]
Sylvian Fissure Development [Expand]	

Third Trimester

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Human Fetus (CRL 240mm) Brain

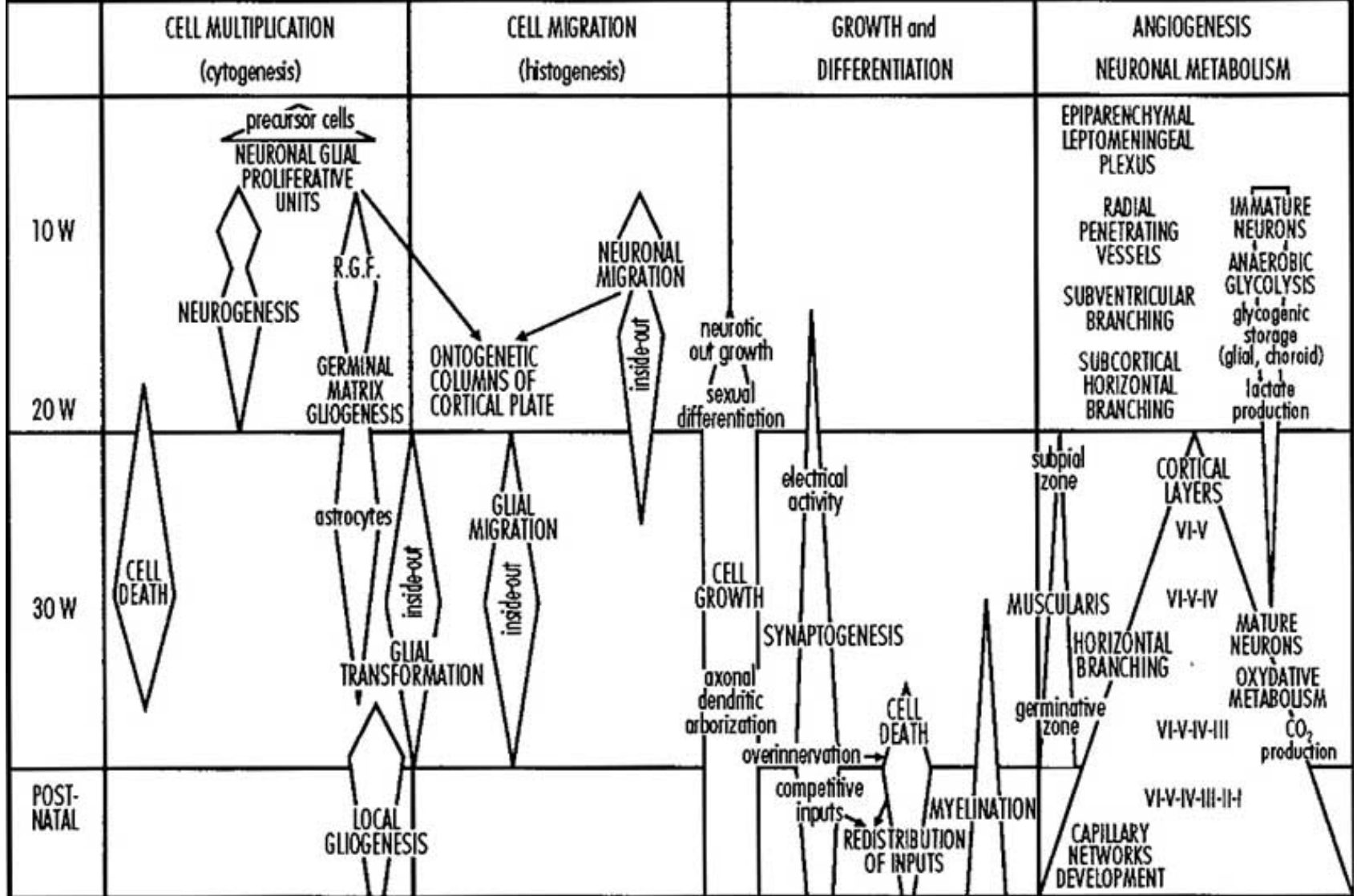
The brain goes from a smooth surface to begin to fold.

- Folds occur as millions of cells push into the cortex, increasing the surface area.
- **groove** - fissure (plural, fissures).
- **fold** - gyrus (plural, gyri).

Human Brain Growth

[\[Expand\]](#)

Fetal Timeline

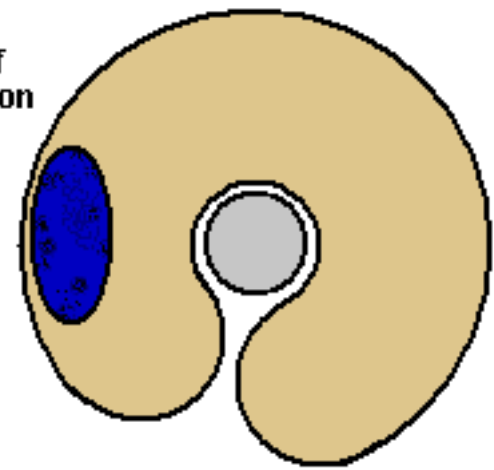


Electrical Activity

- Cerebral cortex has no neuronal connections at end of first trimester [GA](#) 12 weeks.
- Electroencephalogram (EEG) activity first seen in third trimester [GA](#) 7 months.

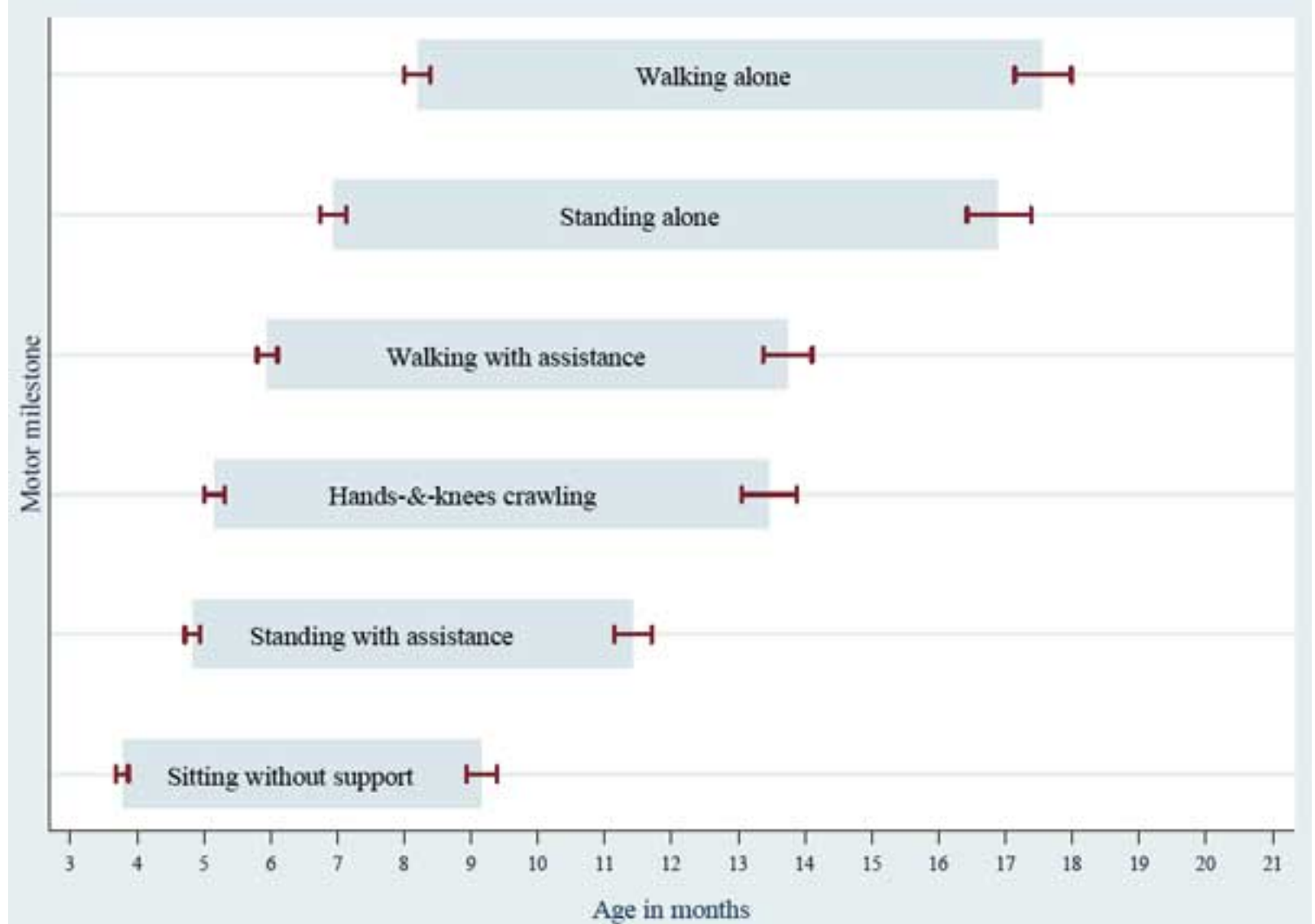
Myelination

Myelination of a peripheral axon



Myelination process occurs both in the CNS (from neural tube glia) and also in peripheral nerves (from neural crest Schwann cells).

Postnatal



[Neural Exam Movies](#)

Movies

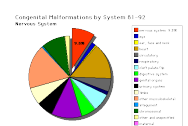
All Neural Movies [Expand]

Abnormalities

There are a large number of different neural abnormalities associated with genetic, environmental and unknown causes. These can also involve several different systems including: neural tube, neural crest, sensory development, ventricular and vascular system development.

It would be difficult to cover all in this current lecture so a few examples are given and students should explore the topic more widely themselves.

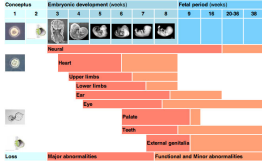
Links: [neural abnormalities](#) | [Neural Crest Abnormalities](#) | [Ventricular Abnormalities](#)



- spina bifida and anencephaly

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-
-
- Congenital hydrocephalus (MRI)
- Dandy Walker malformation (MRI)
- Intestinal aganglionosis

Environmental



The long time course of neural development (week 3 through to postnatal) also means that a large number of different environmental factors, including dietary deficiency, can impact upon its development and also have a range of different effects.

- [folate](#)
- [iodine deficiency](#)
- [Infections](#)
- [Fetal Alcohol Syndrome](#)

[Postnatal Neural Assessment](#) - there are several basic clinical motor assessments that can identify normal and abnormal development.

Abnormality Links
[Expand]

Terms

Neural Terms
[Expand]

Other Terms Lists
[Expand]

- ↑ Barraud P, Seferiadis AA, Tyson LD, Zwart MF, Szabo-Rogers HL, Ruhrberg C, Liu KJ & Baker CV. (2010). Neural crest origin of olfactory ensheathing glia. *Proc. Natl. Acad. Sci. U.S.A.* , 107, 21040-5. PMID: [21078992](#) [DOI](#).
- ↑ Woodhoo A & Sommer L. (2008). Development of the Schwann cell lineage: from the neural crest to the myelinated nerve. *Glia* , 56, 1481-

90. PMID: [18803317](#) DOI.

3. ↑ . (1970). Embryonic vertebrate central nervous system: revised terminology. The Boulder Committee. *Anat. Rec.* , 166, 257-61. PMID: [5414696](#) DOI.
4. ↑ ^{4.0} ^{4.1} Huang H, Xue R, Zhang J, Ren T, Richards LJ, Yarowsky P, Miller MI & Mori S. (2009). Anatomical characterization of human fetal brain development with diffusion tensor magnetic resonance imaging. *J. Neurosci.* , 29, 4263-73. PMID: [19339620](#) DOI.



BGDA: [Lecture 1](#) | [Lecture 2](#) | [Practical 3](#) | [Practical 6](#) | [Practical 12](#) | **Lecture Neural** | [Practical 14](#) | *Histology Support* - [Female](#) | [Male](#) | [Tutorial](#)

Glossary Links

[Glossary:](#) [A](#) | [B](#) | [C](#) | [D](#) | [E](#) | [F](#) | [G](#) | [H](#) | [I](#) | [J](#) | [K](#) | [L](#) | [M](#) | [N](#) | [O](#) | [P](#) | [Q](#) | [R](#) | [S](#) | [T](#) | [U](#) | [V](#) | [W](#) | [X](#) | [Y](#) | [Z](#) | [Numbers](#) | [Symbols](#)

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[What Links Here?](#)

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