

# BGDA Lecture - Development of the Nervous System

## Introduction



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.

Final lecture content will be added to this current page, the linked online textbook chapters are available as pre-reading for this lecture.

[2017 Lecture PDF](#)

## Aim

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

Draft Lecture Timetable - Monday 29 May 2017 09:00 AM - 10:00 AM  
Development of the nervous system Kensington - Rex Vowels Theatre

## Textbooks

## Week 3

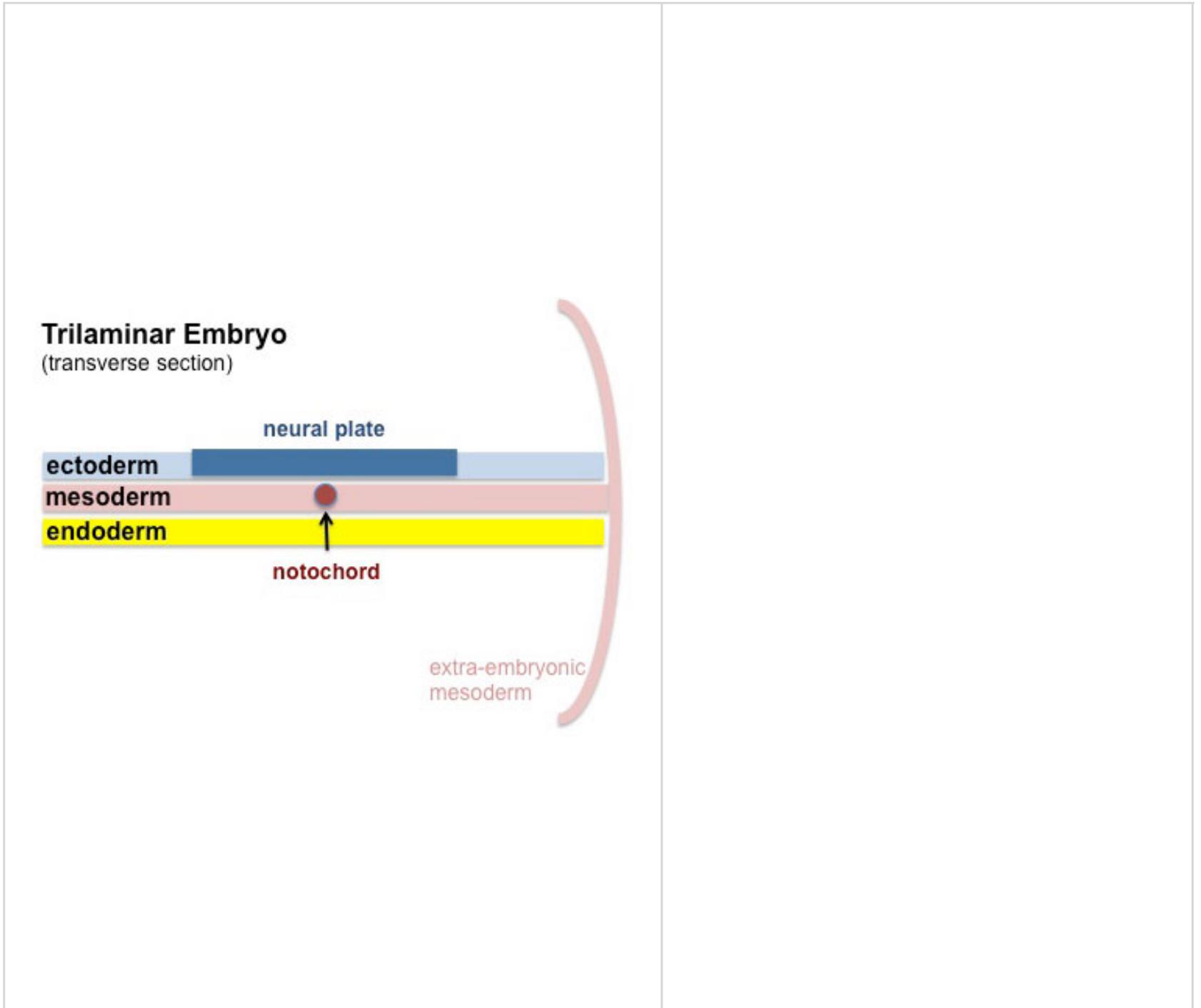
### Ectoderm

- 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)

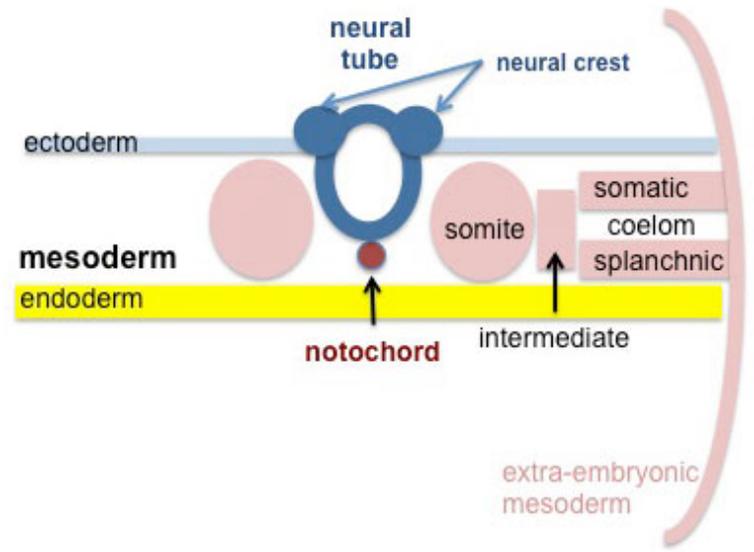
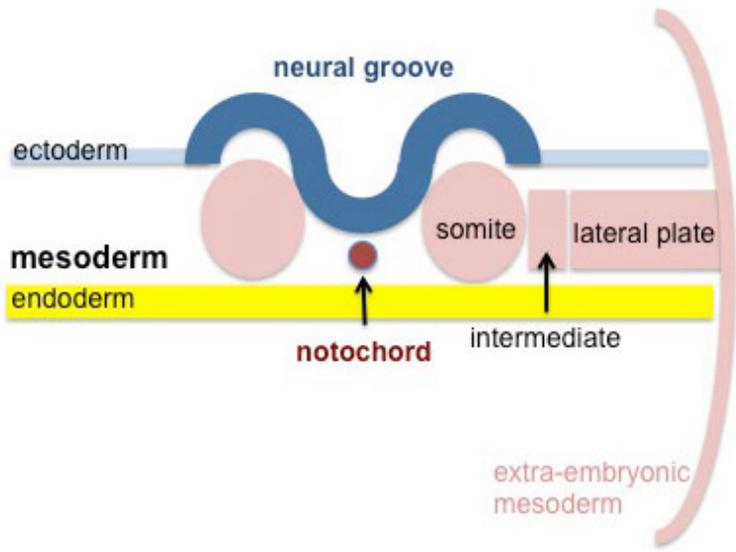
- forms above notochord and paraxial mesoderm
- neuroectodermal cells - neural plate, neural crest
- rostrocaudal width
  - brain plate (broad)
  - spinal cord (narrow)



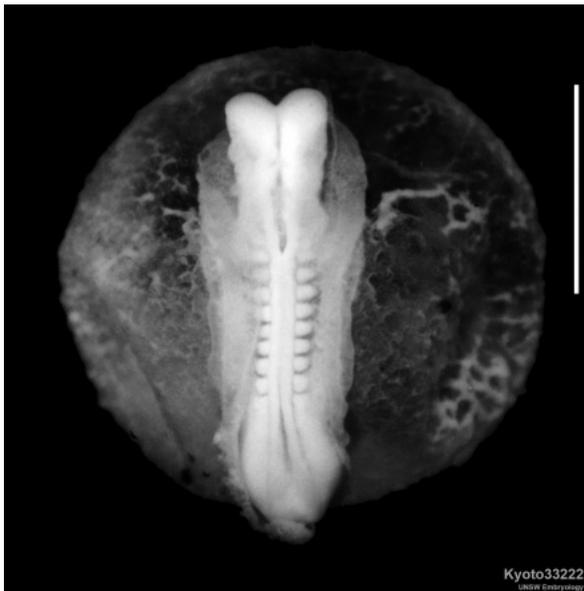
## Week 4

### Neural Tube

neural groove	neural tube and neural crest



## Stage 10 - Dorsal View



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

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

## stage 10

brain fold

neural groove



early

cranial neuropore

closing neural tube

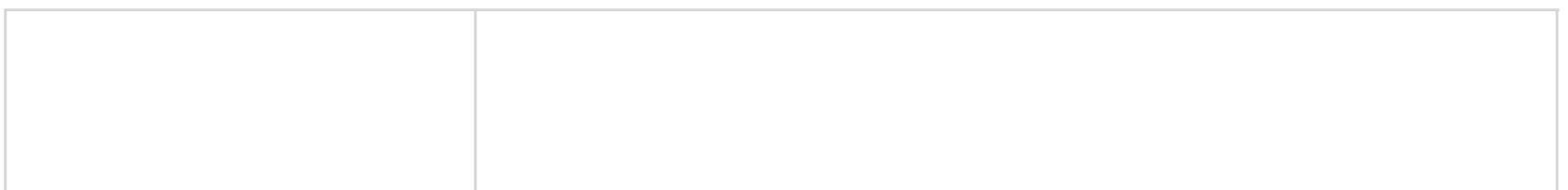
caudal neuropore

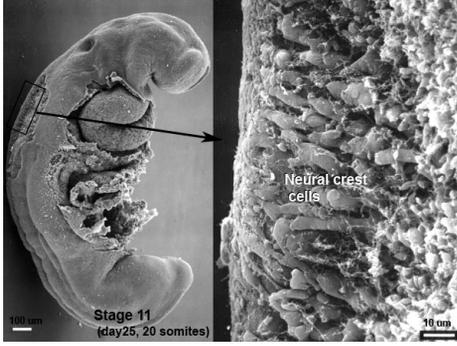


late

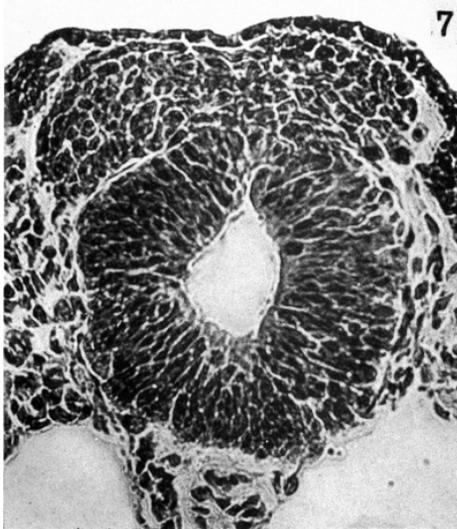
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## Neural Crest





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



Chicken neural crest cell migration into pharyngeal arches.

Neural crest (acoustico-facial primordium)

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
<a href="#">Peripheral Nervous System (PNS)</a>	Neurons - sensory ganglia, sympathetic and parasympathetic ganglia, <a href="#">enteric nervous system</a> , and plexuses  Neuroglial cells  <a href="#">Schwann cells</a>
<a href="#">Endocrine</a>	<a href="#">Adrenal medulla</a> <a href="#">Calcitonin-secreting cells</a> Carotid body type I cells
<a href="#">Integumentary</a>	<a href="#">Epidermal pigment cells</a>
<a href="#">Facial cartilage and bone</a>	<a href="#">Facial and anterior ventral skull cartilage and bones</a>
<a href="#">Sensory</a>	<a href="#">Inner ear, corneal endothelium and stroma</a>
	<a href="#">Tooth papillae</a>

smooth muscle, and adipose tissue of skin of head and neck

## Connective tissue

Connective tissue of meninges, salivary, lachrymal, thymus, thyroid, and pituitary glands

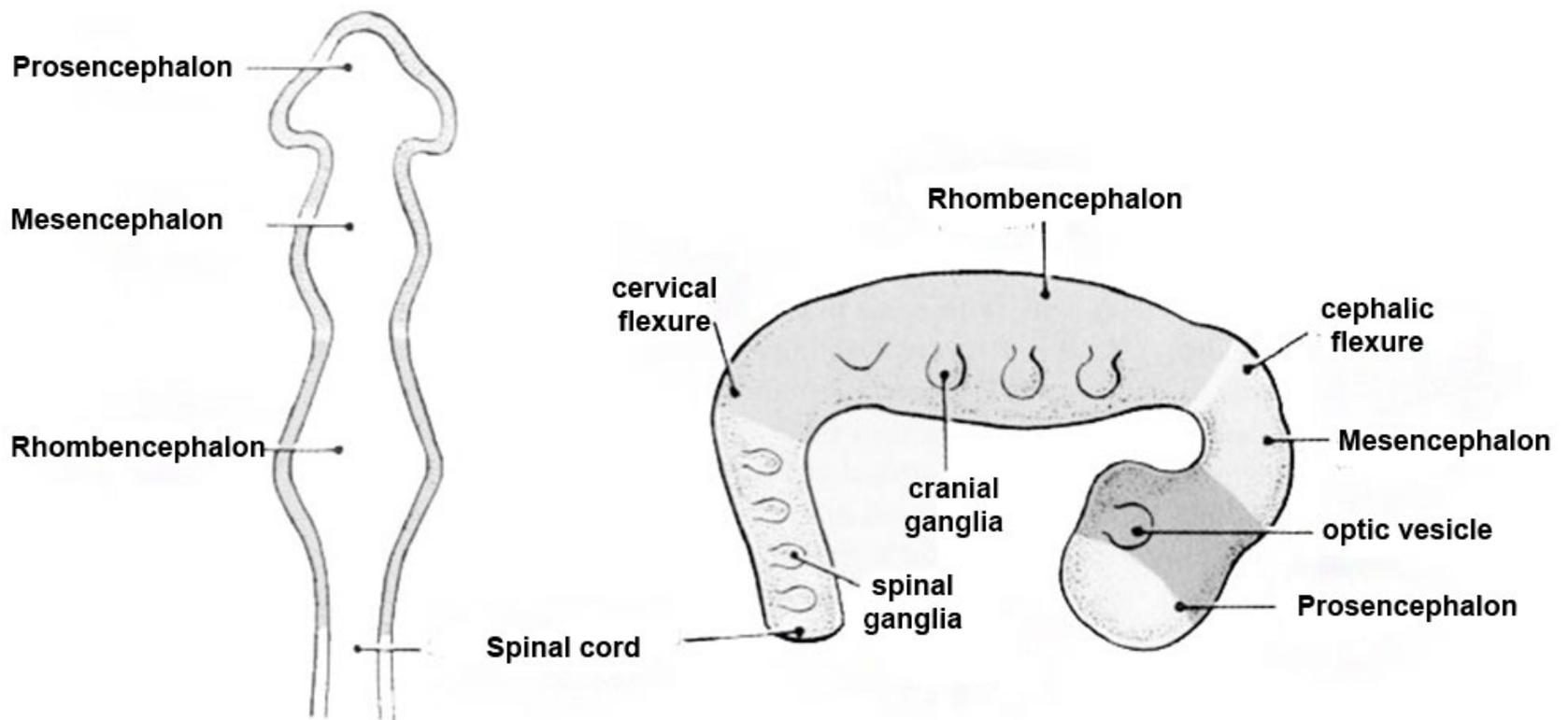
Connective tissue and smooth muscle in arteries of aortic arch origin

**Links:** [Neural Crest Development](#) | [Category:Neural Crest](#) | [Neural Crest collapsible table](#)

## Neural Crest Development

### **Primary Brain Vesicles**

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

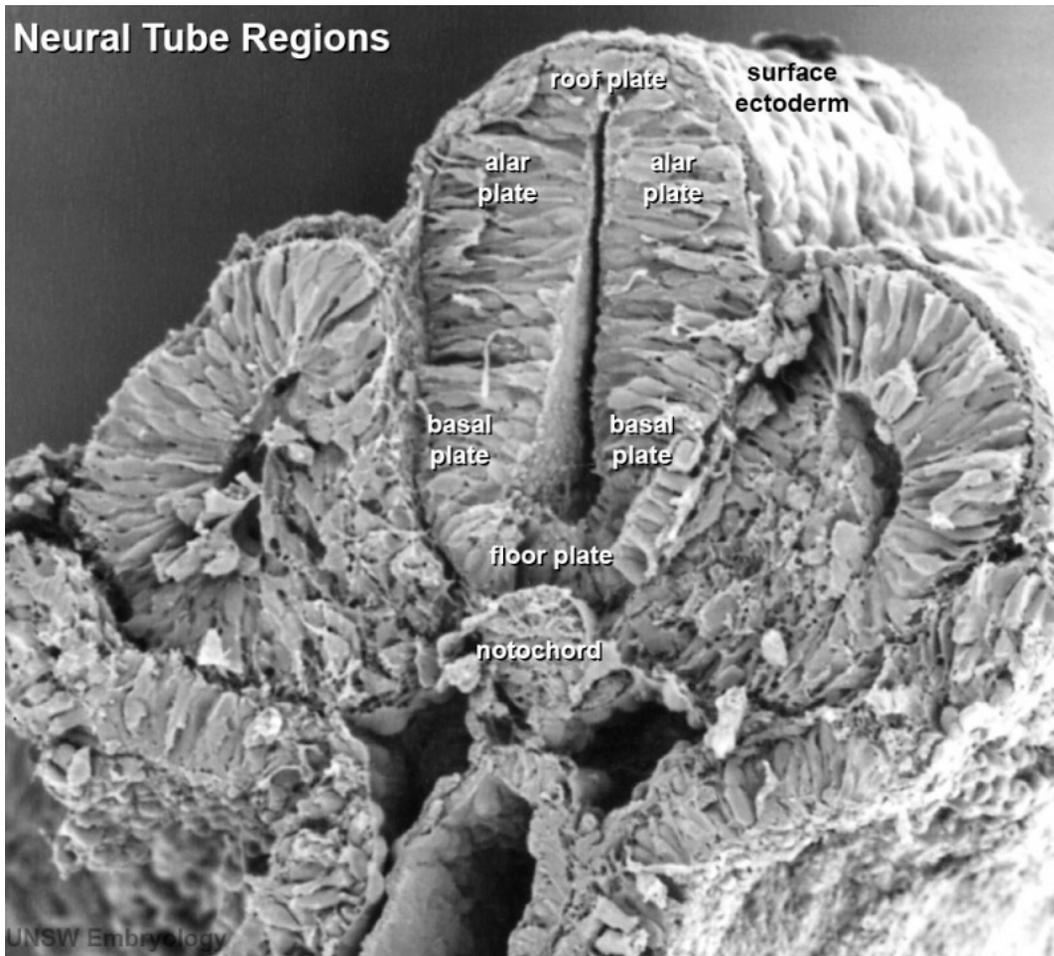
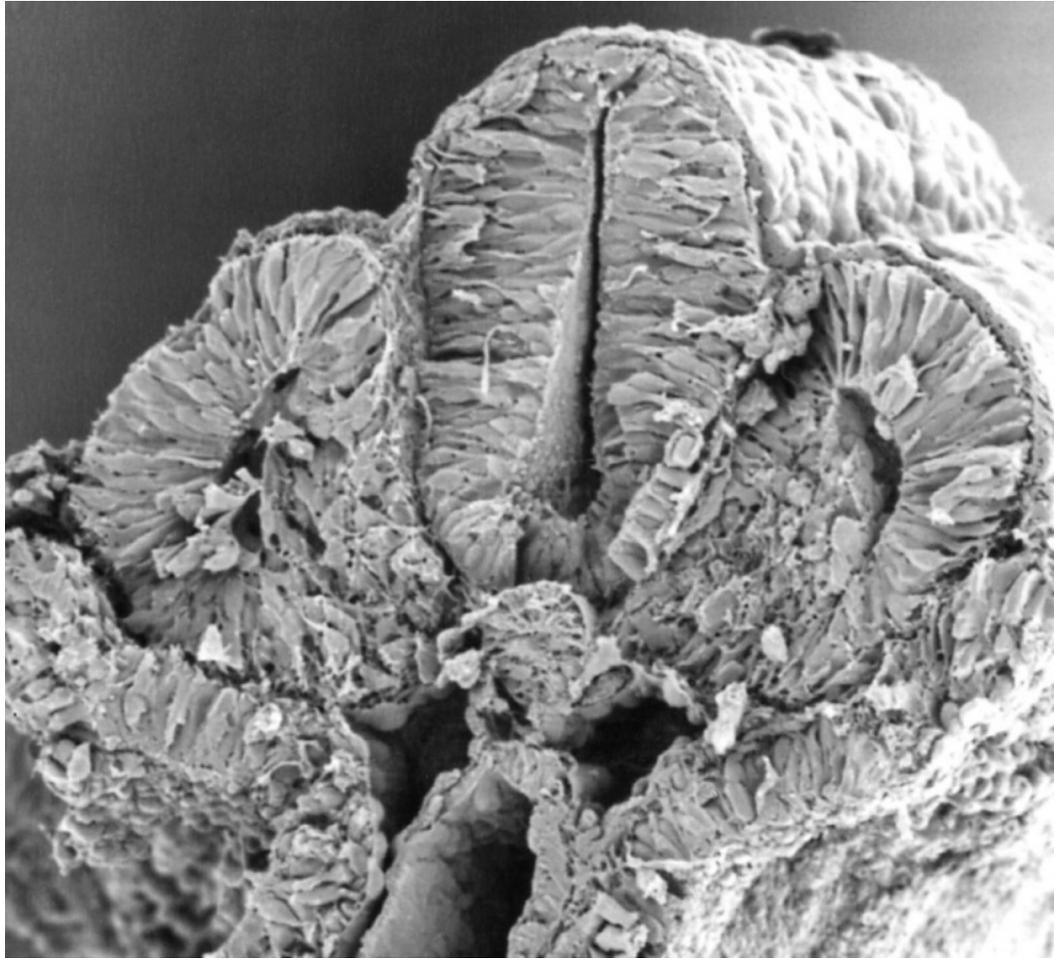


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## **Brain**

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

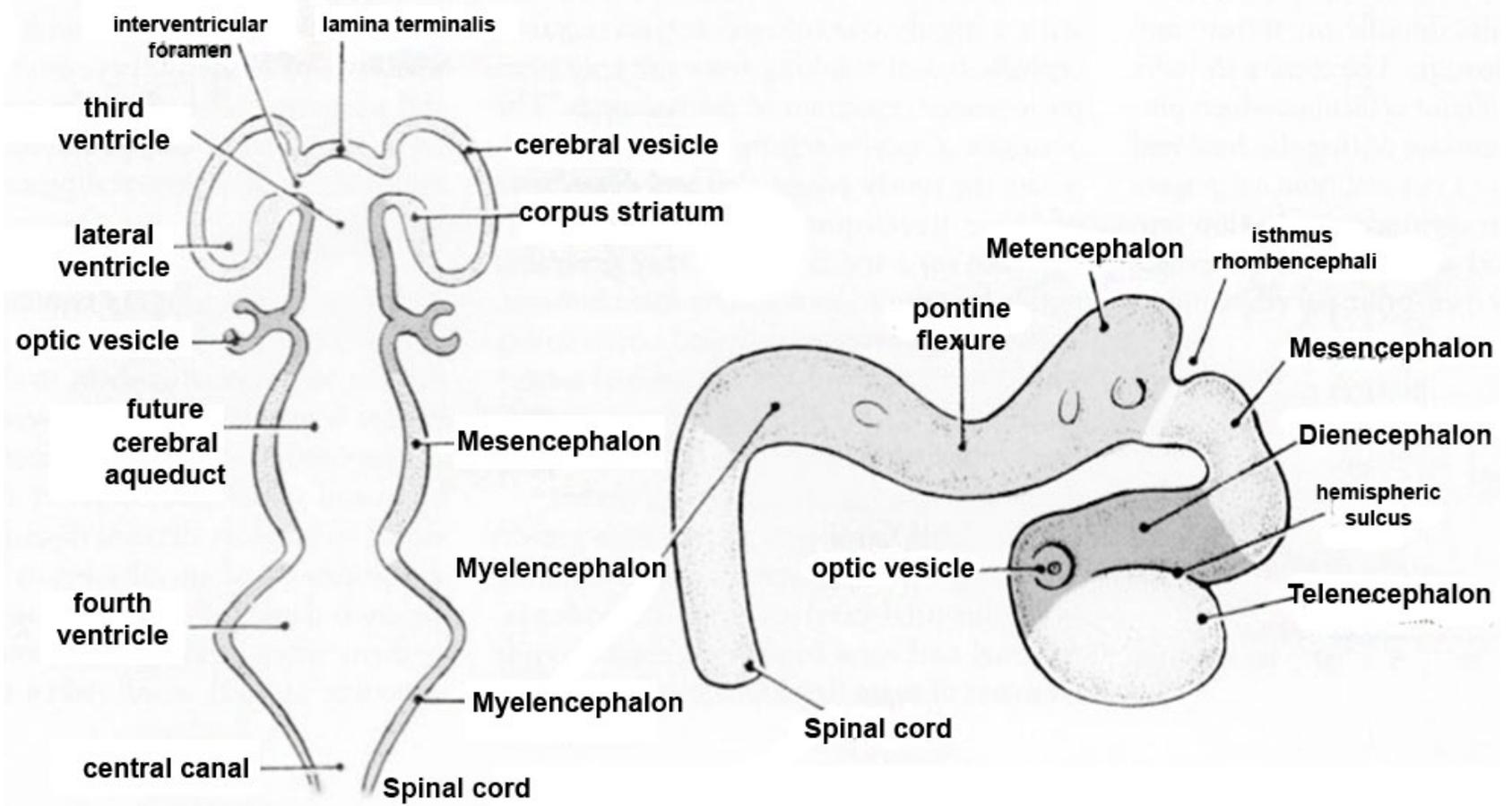
# Spinal Cord



Links: [Spinal Cord](#)

**Week 5**

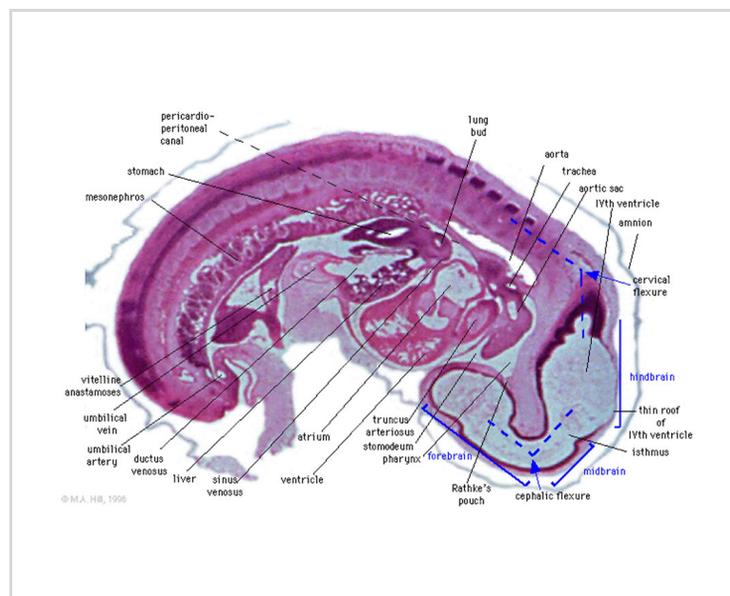
**Secondary Brain Vesicles**



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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)

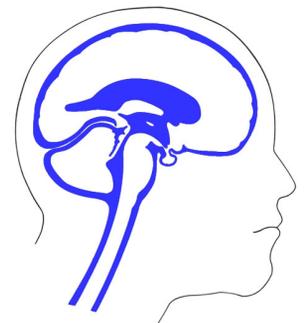
- **cephalic flexure** - (mesencephalic) pushes mesencephalon upwards
- **pontine flexure** - generates 4th ventricle (cerebellum will grow into this space)
- **cervical flexure** - between brain stem and spinal cord

## 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).



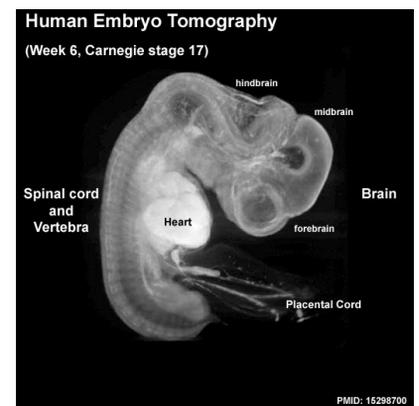
CSF in ventricles and meninges

CSF-filled spaces in adult brain.

**Adult Ventricular Structures** [Expand]

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

## Week 6



Note the shape and size of the different regions of the brain and spinal cord.

- Telencephalon (cerebrum) has begun to expand and will eventually cover the midbrain region.
- Dorsal root ganglia are visible outside the spinal cord.

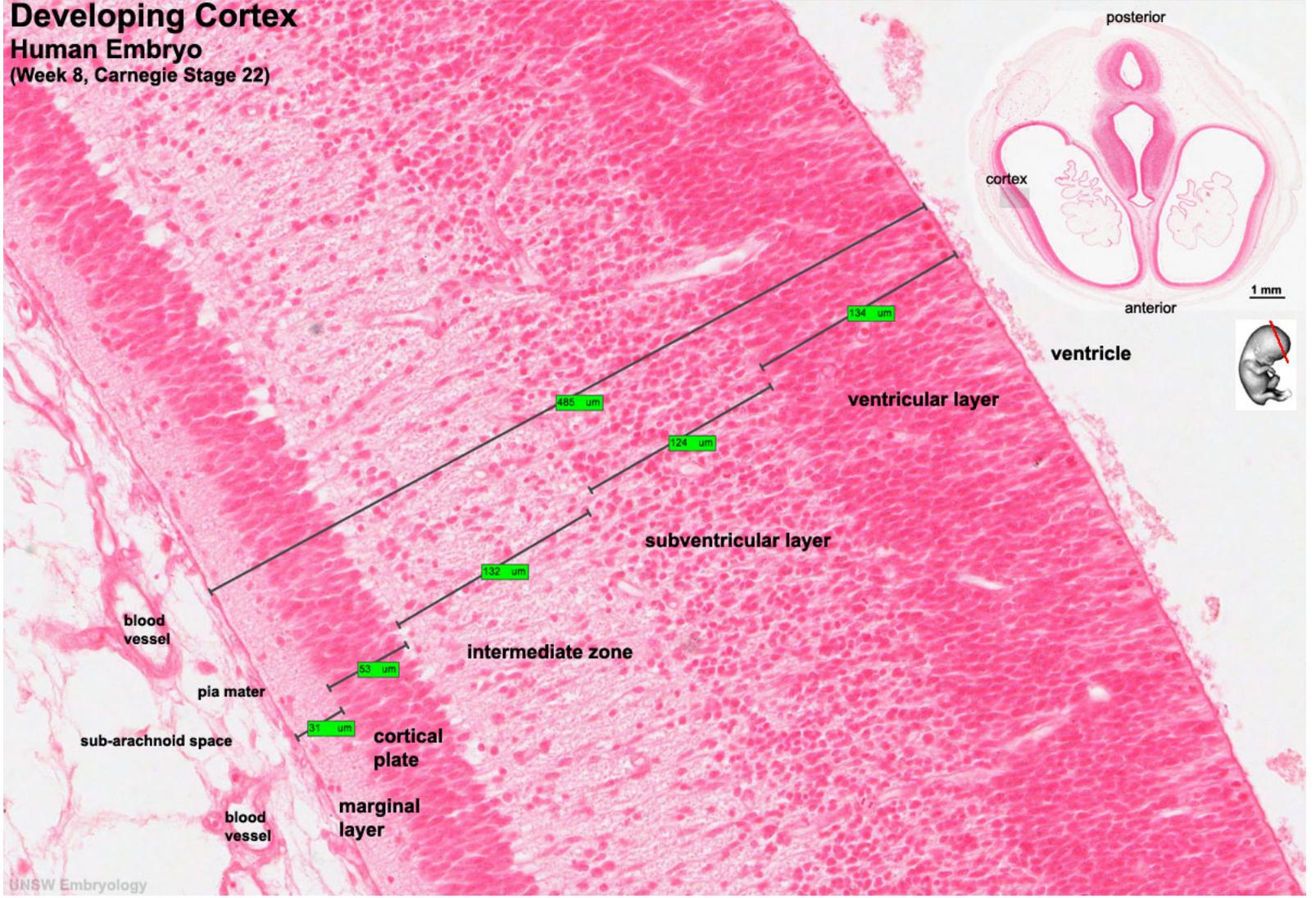
[Movie](#)

## **Week 8**

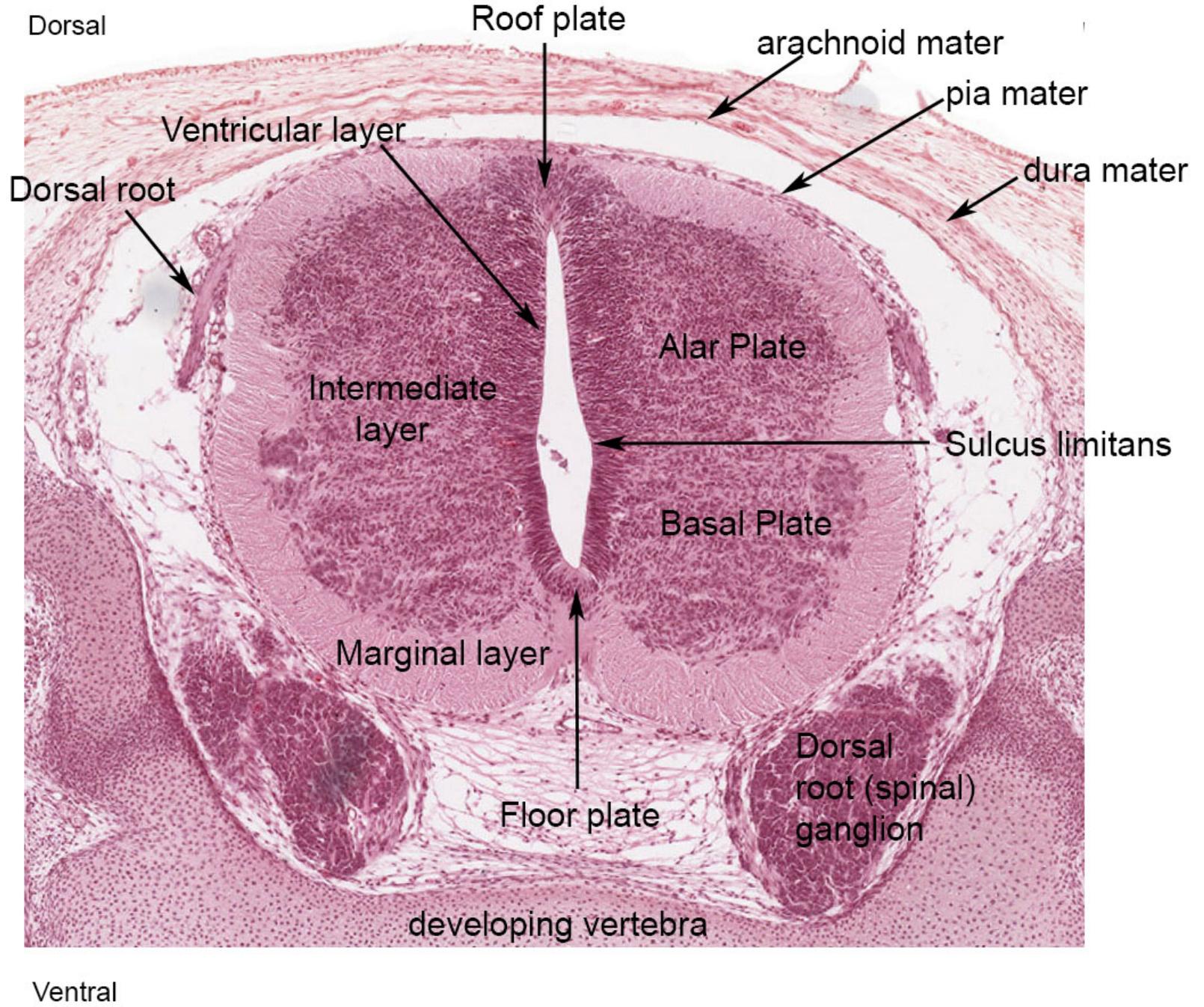
The human MRI movie below (head, sagittal plane, left to right) shows the central nervous system (CNS) development at the end of the embryonic period (week 8; [GA](#) week 10).

**Cortex**

# Developing Cortex Human Embryo (Week 8, Carnegie Stage 22)



## Spinal Cord



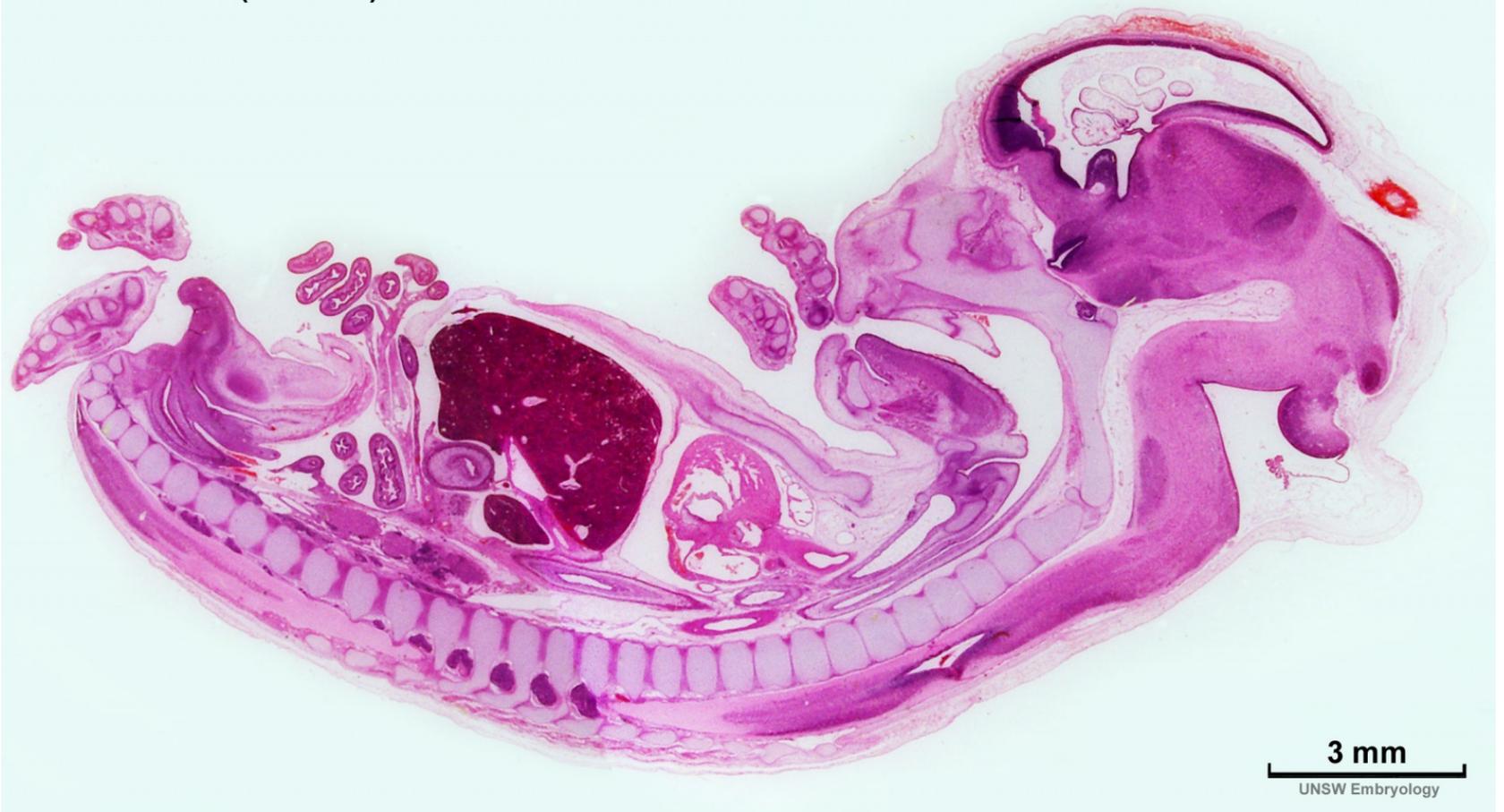
**Week 8 Developing Spinal Cord (virtual slide)**

[Expand]

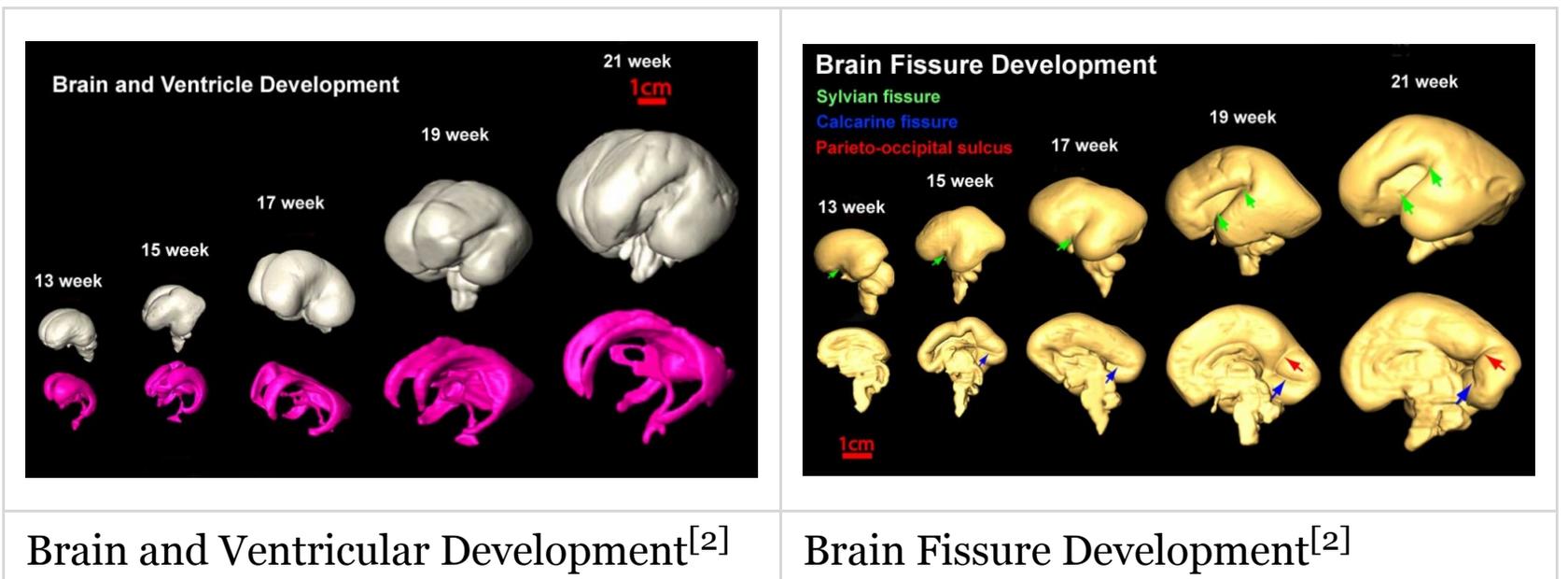
**Fetal**

**Second Trimester**

Human Fetus (10 week)



Human week 10 fetus

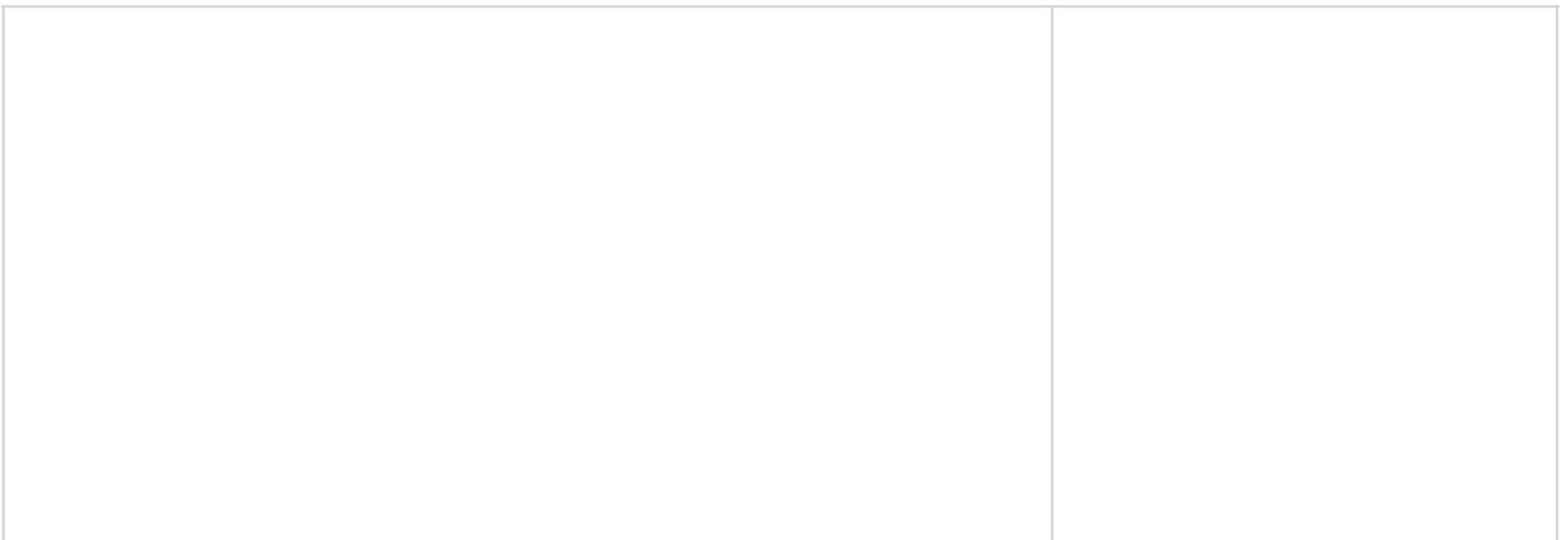


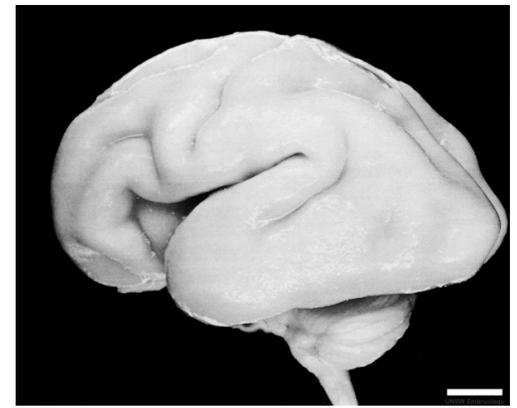
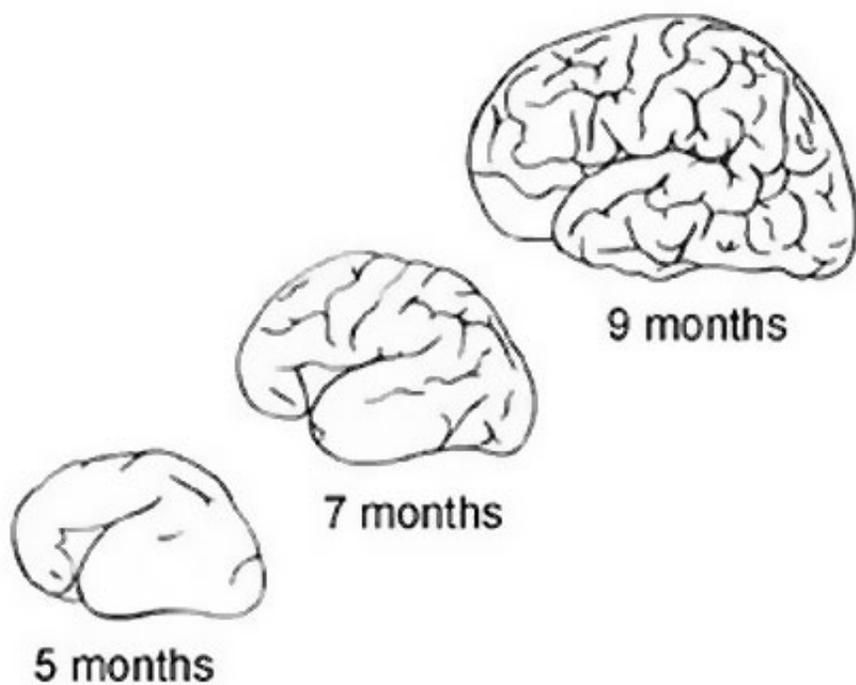
Brain and Ventricular Development<sup>[2]</sup>

Brain Fissure Development<sup>[2]</sup>

**Sylvian Fissure Development** [Expand]

## Third Trimester



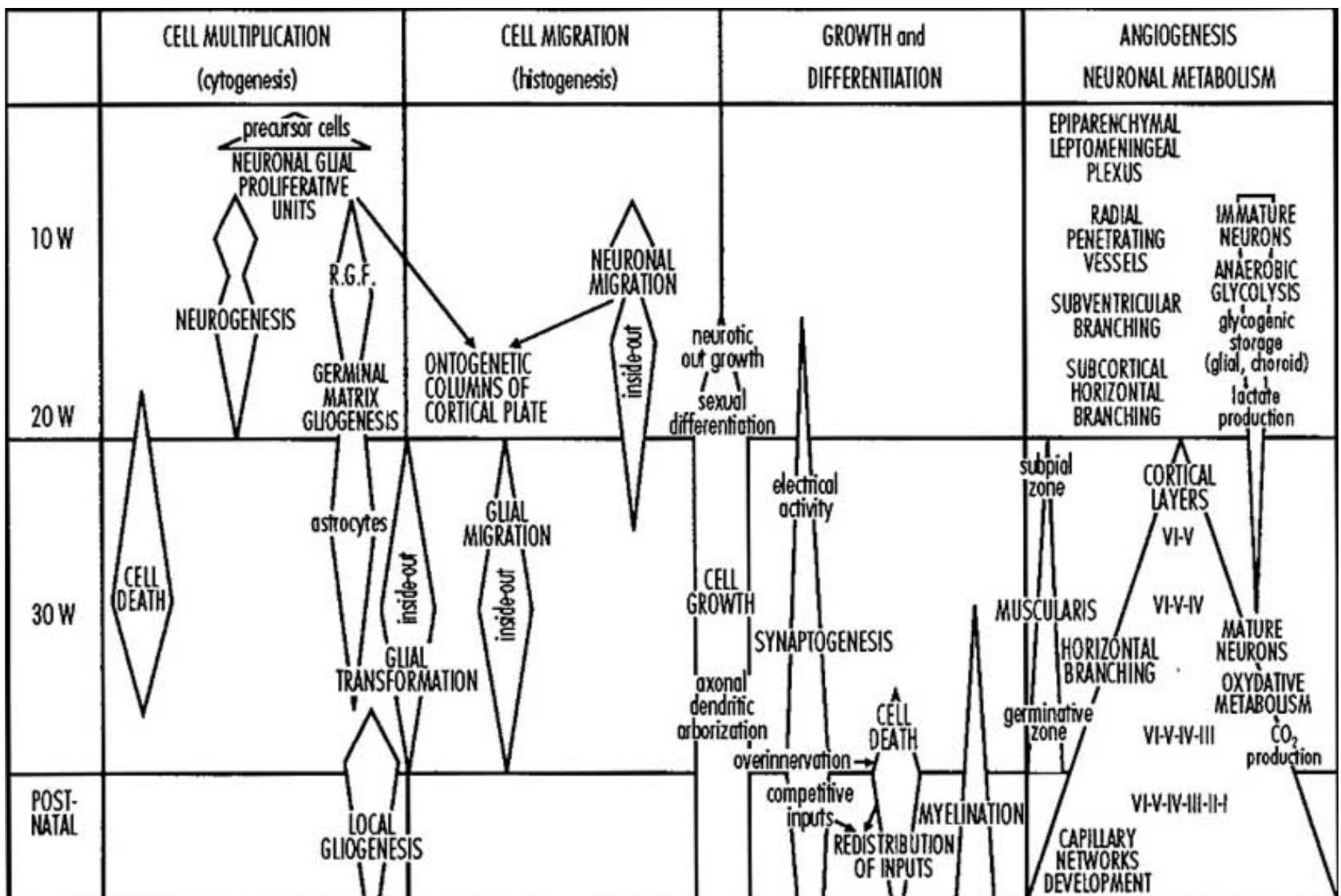


Human Fetus (CRL 240mm) Brain

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

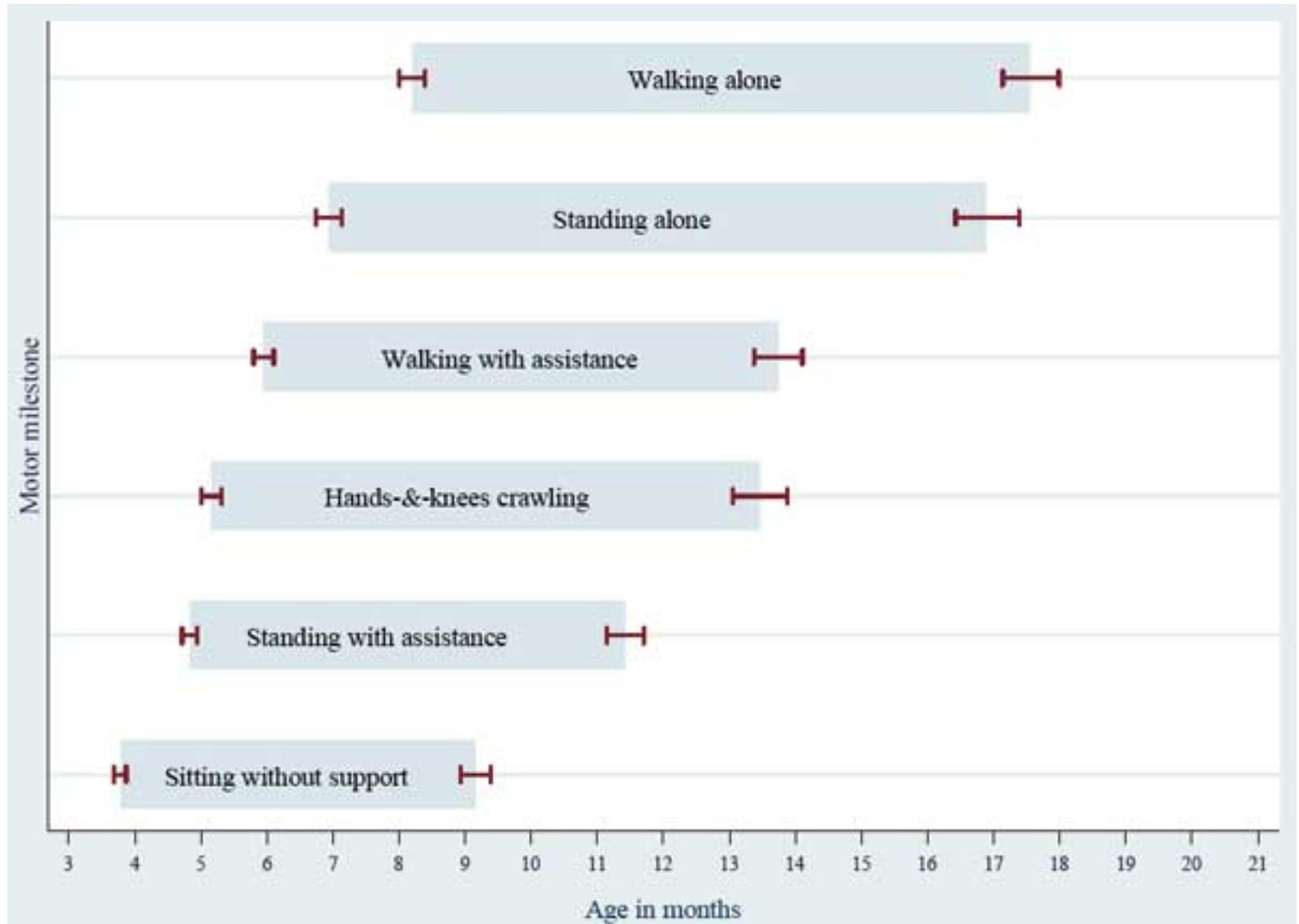
- Folds occur as millions of cells push into the cortex, increasing the surface area.
- **groove** - fissure (plural, fissures).
- **fold** - gyrus (plural, gyri).

## Fetal Timeline



- 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.

## Postnatal



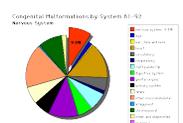
## [Neural Exam Movies](#)

## Movies

## 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.

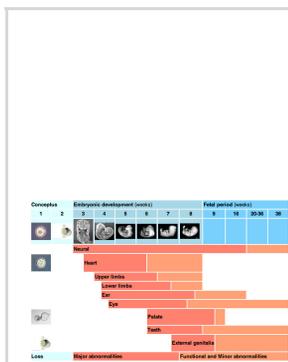
It would be difficult to cover all in this current lecture so a few examples are given and students should explore the topic more widely themselves.



**Links:** [Neural System - Abnormalities](#) | [Neural Crest](#)

- spina bifida and anencephaly
- 
- 
- 
- 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.

- [Infections](#)
- [Folate](#)
- [Iodine](#)
- [Alcohol](#)

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

## Terms

1. ↑ **Embryonic vertebrate central nervous system: revised terminology. The Boulder Committee.** Anat. Rec.: 1970, 166(2);257-61 [PubMed 5414696](#)
2. ↑ <sup>2.0</sup> <sup>2.1</sup> Hao Huang, Rong Xue, Jianguang Zhang, Tianbo Ren, Linda J Richards, Paul Yarowsky, Michael I Miller, Susumu Mori **Anatomical characterization of human fetal brain development with diffusion tensor magnetic resonance imaging.** J. Neurosci.: 2009, 29(13);4263-73 [PubMed 19339620](#) |



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

## Glossary Links

[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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