ANATOMY

EMBRYOLOGY

EMBRYOLOGY

Development of Nervous System

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Following fertilisation, the **Nervous System** begins to form in the 3rd week of development. It continues after birth and for many years into the future.

Structurally, the nervous system is divided into two parts:

- **Central nervous system** – consists of the brain and the spinal cord.
- **Peripheral nervous system** – consists of cranial and spinal nerves, ganglia, plexuses, and sensory receptors.

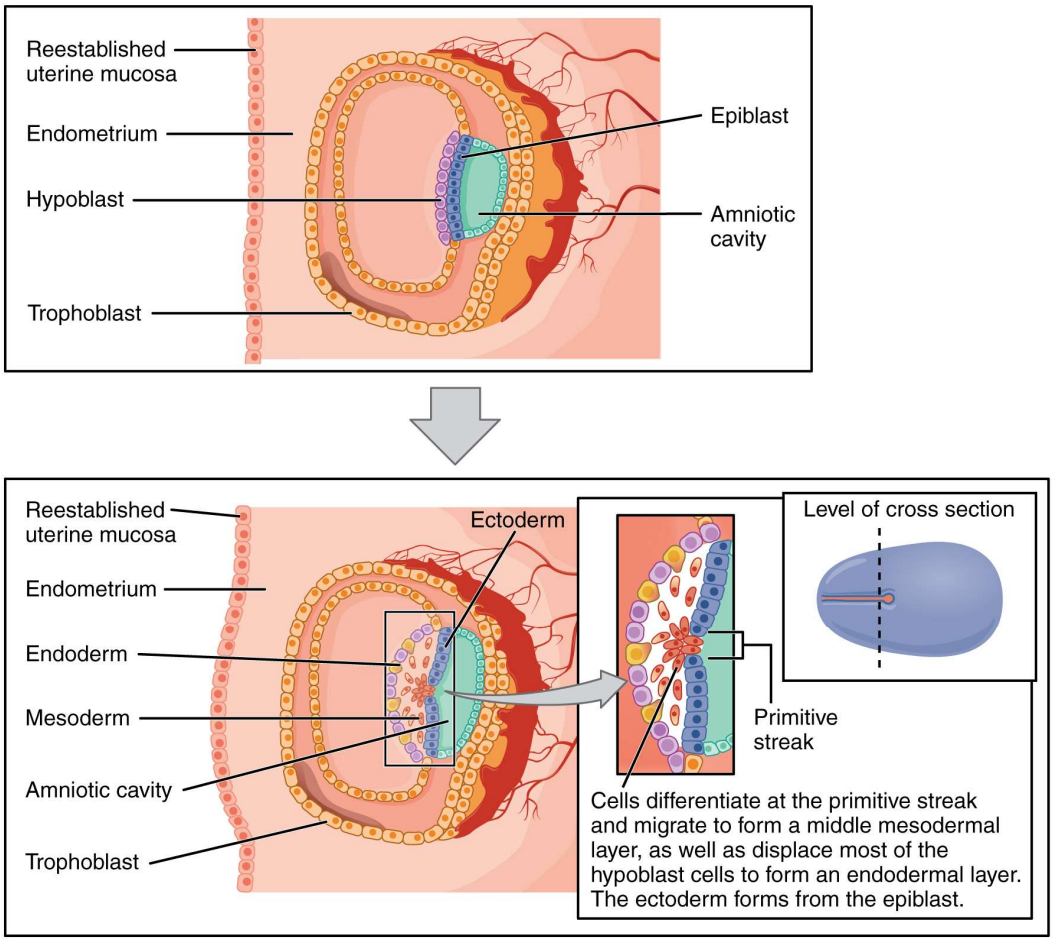
Development of CNS

Early Stages

- At the end of week two, a structure called the **primitive streak** appears as a groove in the epiblast layer of the bilaminar disk.
- Cells within the epiblast migrate downward through the primitive streak, giving rise to three layers from the initial two. These three germinal layers form the **trilaminar embryonic disk**:
- **Endoderm** – innermost layer
- **Mesoderm** – middle layer
- **Ectoderm** – outermost layer
- The nervous system is derived from the **ectoderm**, which is the outermost layer of the embryonic disc. For more details, check out our article on early embryonic development.

Development of CNS

Germ layers



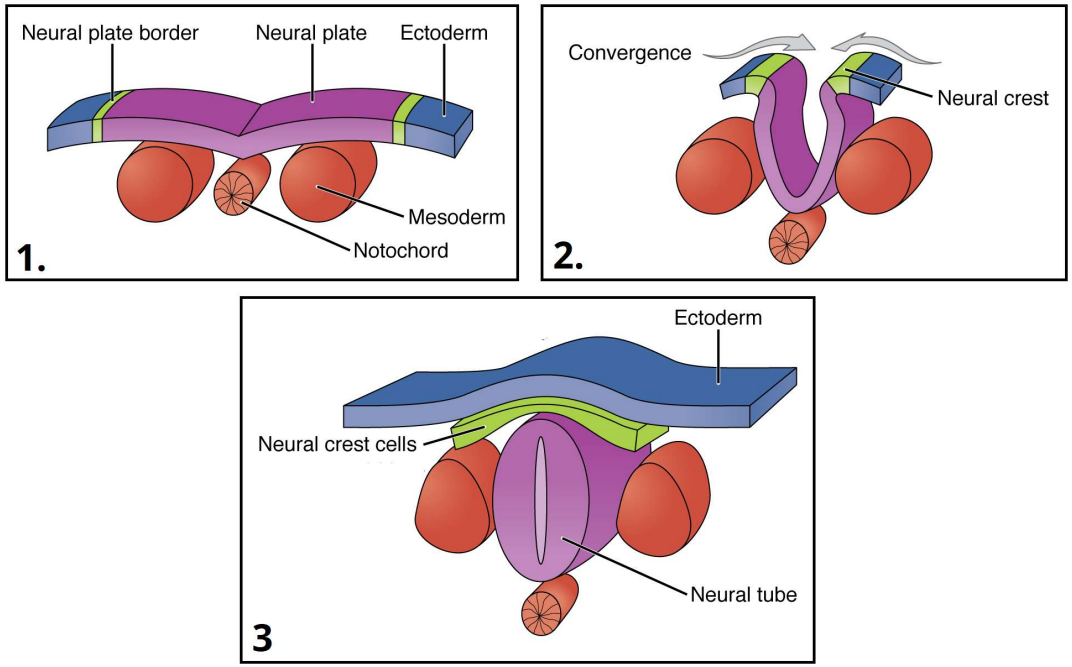
Development of CNS

Neurulation

- In the third week of development, the **notochord** appears in the mesoderm. The notochord secretes growth factors which stimulate the differentiation of the overlying ectoderm into neuroectoderm – forming a thickened structure known as the neural plate.
- The lateral edges of the neural plate then rise to form neural folds. The neural folds move towards each other and meet in the midline, fusing to form the **neural tube** (precursor to the brain and spinal cord).
- During fusion of the neural folds, some cells within the folds migrate to form a distinct cell population – known as the **neural crest**. They give rise to a diverse cell lineage – including melanocytes, craniofacial cartilage and bone, smooth muscle, peripheral and enteric neurons and glia

Development of CNS

Neurulation



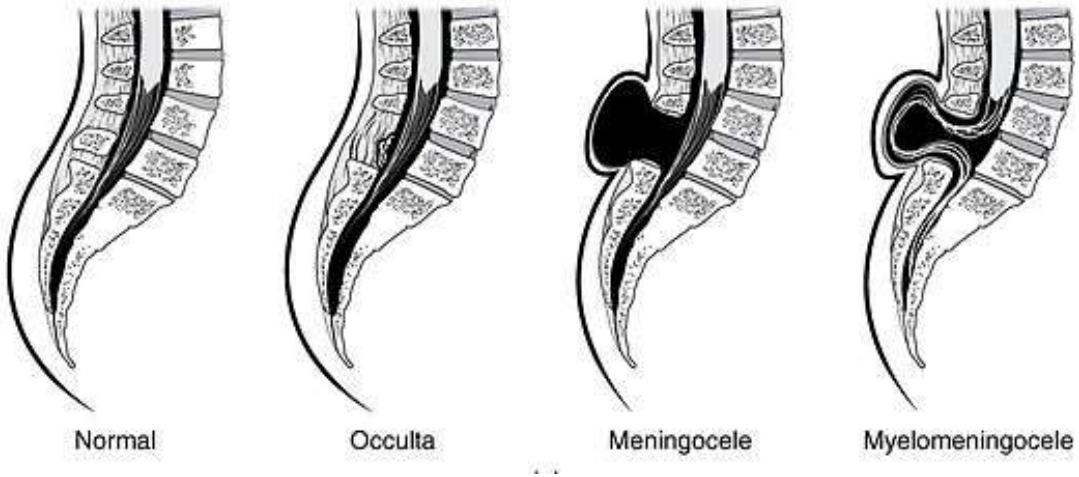
Development of CNS

Clinical Relevance: Defects in Neural Tube Formation

- **Anencephaly** results from failure of the neural tube to close at the cephalic end, leading to the partial absence of the brain and skull. The lack of crucial brain structures mean that this is a lethal condition, and new-borns with this congenital abnormality typically do not survive longer than a few hours or days after birth.
- **Spina bifida** results from incomplete closure of the neural tube at the caudal end (most commonly in the lumbar region). There are three main types of spina bifida, of increasing severity:
- **Spina bifida occulta** – the mildest form, is characterised by an incomplete closure of the vertebrae, without protrusion of the spinal cord. Most people with this form of spina bifida are unaware of having it, and its discovery is often incidental.
- **Meningocele** (meningeal cyst) – where the meninges protrude between the vertebrae posteriorly, but the spinal cord is undamaged.
- **Myelomeningocele** – the most severe form, where a portion of the spinal cord remains unfused and protrudes posteriorly through an opening between the vertebrae, in a sac formed by the meninges. This is associated with severe disability.

Development of CNS

Clinical Relevance



Development of CNS

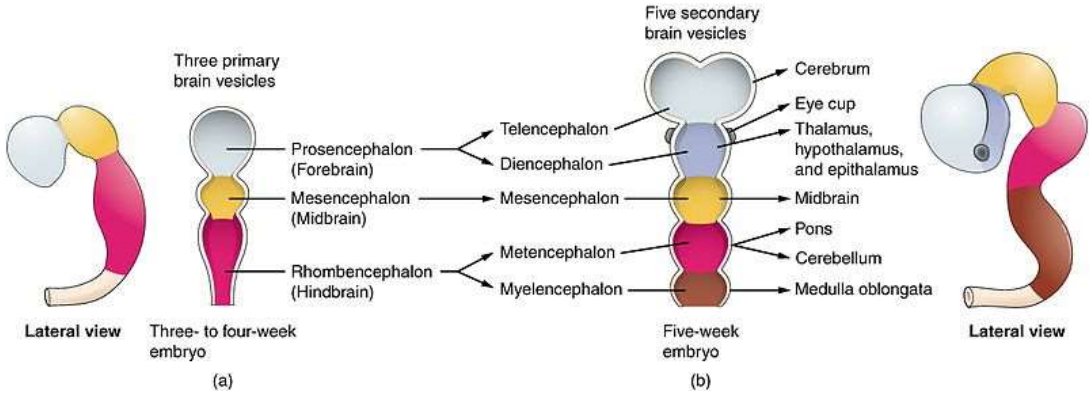
Brain and Cerebellum

- In the fifth week of development, swellings appear at the cranial end of the neural tube. Three **primitive vesicles** appear first, and subsequently these develop into five secondary vesicles.
- These vesicles will give rise to all the structures of the brain and cerebellum, as well as the ventricular system shown in the table below:

Primary Vesicles	**Secondary Vesicles**	**Neural Derivatives**	**Cavity Derivatives**
Prosencephalon	Telencephalon	Cerebral hemispheres and globus pallidus	Lateral ventricle
	Diencephalon	Thalamus, hypothalamus, and epithalamus	Third Ventricle
Mesencephalon	Mesencephalon	Midbrain	Cerebral aqueduct
Rhombencephalon	Metencephalon	Pons and cerebellum	Upper part of 4th ventricle
	Myelencephalon	Medulla	Lower part of 4th ventricle/central canal

Development of CNS

Brain Vesicles and their derivatives



Development of CNS

Meanwhile, Neuroderm cells begin to differentiate into neurones and glial cells. **Neurones** migrate throughout the brain, and once they have reached their final destination they develop axons and dendrites, forming synapses.

Spinal Cord

- Whilst the cranial end of the neural tube forms the brain and cerebellum, the caudal end develops to form the **spinal cord**.
- Cells on the dorsal side form the alar plate, which subsequently becomes the **dorsal horn**(posterior). Cells at the ventral end form the basal plate, which then becomes the ventral horn (anterior).

Development of CNS

After Birth

- Development of the central nervous system continues for many years after birth. Synapses form and new connections appear, increasing in number throughout childhood and into adulthood.
- Only synapses and pathways that are used survive into adulthood; the process of **synaptic pruning** allows unused synapses to be eliminated.