II. NEURO-EMBRYOLOGY

DEVELOPMENT OF NEURAL TUBE

- **Neural Plate**: thickening of embryonic ectoderm, Day 18.
- **Notochord**: Just ventral to the neural plate. It induces formation of the **Neural Tube**.
- **Neural Folds** are formed on the Neural Plate. Next, they begin to move toward each other, forming a **Neural Groove**.
- **NEURAL TUBE**: Is formed from the primitive Neural Groove. *This occurs first in the midsection of the embryo and then proceeds rostrally and caudally.*
  - **Rostral Neuropore** and **Caudal Neuropore** are the open ends of the Neural Tube.
- **NEURAL TUBE DEFECTS**:
  - **SPINA BIFIDA**: Failed closure of the caudal part of the Neural Tube. But, the nervous system continues to develop normally.
  - **Meningoceles** (outpocketings of meninges) and **Meningomyeloceles** (outpocketings of meninges + nervous tissue) will result.
  - **ANENCEPHALY**: Failure of rostral closure of neural tube and subsequent differentiation.

**NEURAL CREST CELLS**: Lie on either side of the Neural Groove and are pinched off by closure of the Neural Tube. They form a number of important structures.

- **Dorsal Root Ganglia** and portions of sensory ganglia that are like the Dorsal Root (V, VII, VIII, IX, X)
- **Sympathetic Ganglia**
- **Parasympathetic (Enteric) Ganglia**
- **Pia and Arachnoid Mater**
- **Schwann Cells**
- **Melanocytes Proliferation in Neural Tube**: Cells start connected both to the internal and external limiting membranes of the neural tube, but ultimately remain connected only to the internal limiting membrane.
- **NEURAL BIRTHDAY**: Occurs when a cell-line has had its last division and remains in the same structure terminally thereafter. Neurons from the same structure tend to have the same Neural Birthdays.
- **THREE LAYERS of Proliferating Tube**:
  - **Ventricular Layer**: Contains dividing cells.
  - **Mantle Layer**: Postmitotic neuronal cells bodies (after their birthday)
  - **Marginal Layer**: Axoplasmic extensions of the mantle layer.
● NEURAL VESICLES: At 3 weeks, three distinct outpocketings can be made out. These are the classical three vesicles out of which entire nervous system grows:

- **Rhombencephalon** (Hindbrain)
- **Mesencephalon** (Midbrain) ------- Midbrain
- **Proencephalon** (Forebrain) ------- Diencephalon + Telencephalon
  - Thalamus
  - Epithalamus
  - Hypothalamus
  - Subthalamus

● VENTRICLES will arise from the Central Canal of the Neural Tube.

● FLEXURES: Characteristic flexures create the shape of the CNS
  - 26 Days: Mesencephalic and Cervical Flexures.
  - 35-50 Days: Pontine Flexure brings the Cerebellum to lie dorsal to the Pons.

GROSS BRAIN DEVELOPMENT
- **Prosencephalon** (Forebrain) -> Diencephalon + Telencephalon
  - (1) Telencephalon -> Cerebral Hemispheres
  - (2) Diencephalon

- **Mesencephalon** (Midbrain) -> (3) Midbrain

- **Rhombencephalon** (Hindbrain)
  - Metencephalon -> (4) Pons, Cerebellum
  - Myelencephalon -> (5) Medulla Oblongata

**SPINAL CORD DEVELOPMENT**
- **Sulcus Limitans**: It appears along the Neural Tube, and separates dorsal and ventral regions of the spinal cord.
  - **ALAR (DORSAL) PLATE**: Neurons become specialized for sensory.
  - **BASAL (VENTRAL) PLATE**: Neurons become specialized for motor.

**BRAINSTEM / CEREBELLUM DEVELOPMENT**
- **MEDULLA**
  - CN NUCLEI are arranged in *Columns* in the medulla.
  - CLOSED MEDULLA:
    - OPEN MEDULLA: *The Alar Plate is displaced laterally*. So, sensory stuff is now lateral to motor stuff, which tends to be more medial.

- **PONS**: It maintains the alar / basal plate distinction between sensory / motor.
- **CEREBELLUM**: Formed from the *Rhombic Lips* of the Alar Plate of the Pons.
  - These lips fold medially to cover the Pons, so that Pons is ventral to Cerebellum.
  - There are two proliferative zones present during development:

  **TELENCEPHALON**: The neurons develop in an “inside-out” fashion. The earliest neuronal birthdays occur closest to the medullary center, then neurons migrate beyond that.

**CELLULAR EVENTS IN DEVELOPMENT**
- **Making Neuronal Connections**:
  - Sometimes a neuron will ***reel out*** its axon as it grows.
  - At other times, a neuron will use physical or chemical (**chemotaxis**) cues to grow toward a target.

- **Synaptic Plasticity**: Modifications to neuronal connections made after development is complete.
  - They can be made as an alternative pathway following damage to a connection.
  - They can be made in the process of “learning.”

- **Programmed Cell Death**: More neurons than are needed are made during development.
  - Neurons that are unsuccessful at making their connections are then lost (killed, DEAD) by a pre-programmed neuronal cell death.