

## CHAPTER 8: NEURULATION; FATE OF THE LAYERS

### 1. Neurulation

#### 1. Definition

is the process in early embryonic development that leads to the formation of the **nervous system**, which the **ectoderm** forms the **neural tube**, the precursor of the **central nervous system (CNS)** (the **brain and spinal cord**).

#### 2. Main Stages of Neurulation:

##### 2.1. Neural Plate Formation

- Signals from the **notochord** (formed from mesoderm) cause a portion of the **ectoderm** to thicken and form the **neural plate**.

##### 2.2. Shaping of the Neural Plate

- The neural plate **lengthens** and **folds at the midline** to form a groove.

##### 2.3. Neural Groove and Neural Folds

- The **neural groove** forms in the center.
- On either side of the groove, **neural folds** begin to rise.

##### 2.4. Fusion of Neural Folds

- The neural folds **move toward each other** and **fuse**, forming the **neural tube**.
- This fusion begins in the **middle** and proceeds both toward the **head (anterior)** and **tail (posterior)**.

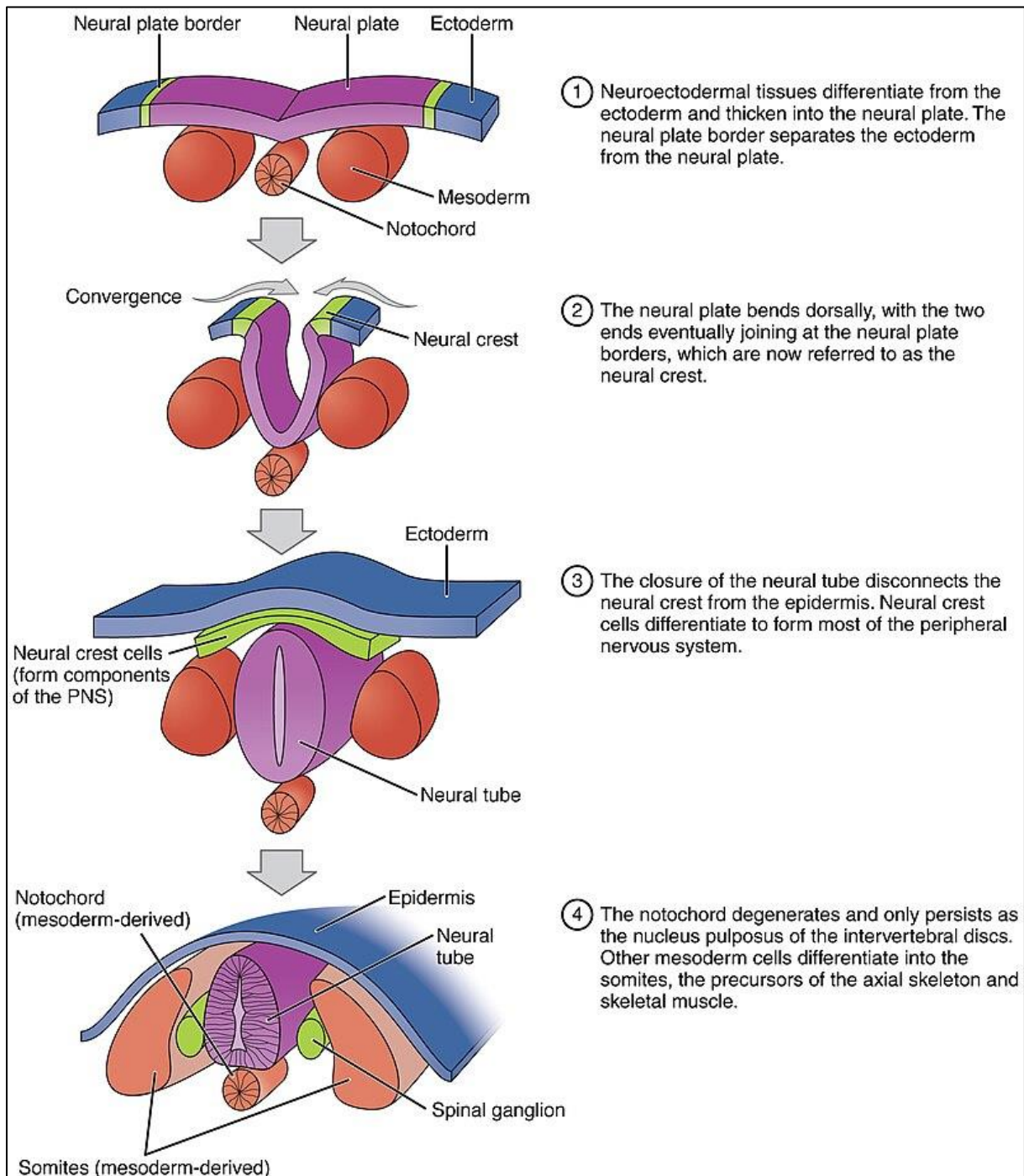
##### 2.5. Formation of Neural Crest Cells

- Some cells at the top of the neural folds become **neural crest cells**.
- These migrate to different parts of the embryo to form:
  - Peripheral nerves
  - Facial bones
  - Pigment cells

- Parts of the heart

## 2.6. Closure of the Neural Tube

- The **neural tube closes** completely.
- Failure to close properly leads to **birth defects** like **spina bifida** or **anencephaly**.



**Fig 36. The different stages of neurulation**

### 3. Results of Neurulation

By the end of **neurulation**, the embryo has laid down the **foundations of the nervous system**. Here are the key **results and outcomes**:

#### 1. Formation of the Neural Tube

- The **neural tube** is the central structure formed during neurulation.
- It gives rise to the entire **central nervous system (CNS)**:
  - **Brain** (from the anterior part of the tube)
  - **Spinal cord** (from the posterior part)

#### 2. Formation of Neural Crest Cells

- As the neural folds fuse, a special group of cells called **neural crest cells** break off.
- These **migrate** throughout the embryo and form:
  - **Peripheral nervous system (PNS)**
  - **Sensory and autonomic ganglia**
  - **Melanocytes** (pigment cells)
  - **Facial bones and cartilage**
  - **Parts of the heart (e.g. outflow tracts)**

#### 3. Separation of Ectodermal Layers

- After the neural tube forms, the overlying ectoderm **reseals**.
- This ectoderm becomes the **epidermis** (outer skin layer).

#### 4. Establishment of the Body Axis

- Neurulation contributes to defining the **dorsal (back)** side of the embryo.
- Helps orient the **anterior-posterior** (head-tail) axis more clearly.

#### 5. Preparation for Organogenesis

- After neurulation, the embryo enters the **organogenesis** stage, where specific organs and systems begin to develop from the germ layers.

## 2. Fate of the Germ Layers

### 1. Definition

Organogenesis is the stage of embryonic development where the **three germ layers** (ectoderm, mesoderm, and endoderm), formed during **gastrulation**, begin to **differentiate into organs and body systems**. It begins **after neurulation** and continues throughout the embryonic period.

In the 8<sup>th</sup> Week, the most major organs are present in basic form and after this period, the embryo is called a **fetus**, and the organs grow and mature (fetal period).

### 2. Stages / Process of Organogenesis:

#### 1. Cell Differentiation

- Cells in each germ layer become specialized for specific roles.

#### 2. Induction

- Certain cells **signal** neighboring cells to form specific tissues or organs.
- Example: notochord induces ectoderm to form the neural tube.

#### 3. Morphogenesis

- Organs take shape through **folding, budding, fusion**, and **growth** of tissues.

#### 4. Organ System Formation

- Each organ system begins to form:
  - **Nervous system** from ectoderm (neurulation)
  - **Circulatory system** from mesoderm (heart forms early)
  - **Digestive and respiratory systems** from endoderm

## 3. Fate of germ layers

### 1. Ectoderm (outer layer)

**Main fate: Skin and Nervous System**

<b>Ectoderm Derivatives</b>	<b>Description</b>
<b>Epidermis</b>	Outer layer of skin, hair, nails
<b>Central nervous system (CNS)</b>	Brain and spinal cord
<b>Peripheral nervous system (PNS)</b>	Nerves outside the CNS
<b>Sensory organs</b>	Eyes (lens, retina), ears, nose
<b>Tooth enamel</b>	Hard outer covering of teeth
<b>Mammary and sweat glands</b>	Skin-associated glands

**2. Mesoderm (middle layer)****Main fate: Muscles, Bones, Heart, Blood**

<b>Mesoderm Derivatives</b>	<b>Description</b>
<b>Muscular system</b>	Skeletal, cardiac, smooth muscle
<b>Skeletal system</b>	Bones and cartilage
<b>Circulatory system</b>	Heart, blood vessels, blood cells
<b>Excretory system</b>	Kidneys, ureters
<b>Reproductive system</b>	Gonads (ovaries, testes), uterus
<b>Dermis</b>	Inner layer of skin
<b>Notochord</b>	Precursor to the vertebral column
<b>Adrenal cortex</b>	Outer layer of adrenal glands

**3. Endoderm (inner layer)****⇨ Main fate: Digestive and Respiratory Systems**

<b>Endoderm Derivatives</b>	<b>Description</b>
<b>Lining of digestive tract</b>	From pharynx to anus
<b>Liver and pancreas</b>	Digestive glands
<b>Lining of respiratory tract</b>	Trachea, bronchi, lungs
<b>Thyroid and parathyroid glands</b>	Endocrine glands
<b>Urinary bladder and urethra</b>	Lower urinary tract
<b>Tonsils and thymus</b>	Immune system organs