Trilaminar Germ Disk

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From the trilaminar germ disk, cells join up to form organ systems and to differentiate further. Early on, precursor structures of the central nervous system already develop. At the same time, segmentation of the embryo takes place. This article elucidates the most important steps and also explains the division of body cavities into pericardial, pleural and peritoneal cavities.

Formation of trilaminar layers

The zygote formed after fertilization divides into 2 daughter cells via mitosis. These cells further divide repeatedly, into a morula, which is a mulberry-like mass of cells. The inner layer of cells lining the embryo are called embryoblasts, and the outer layer nourishing the embryo is known as trophoblasts.

After nearly a week of fertilization, a cleft in the embryoblasts widens into the amniotic cavity. The base of this cavity is lined by columnar cells, which represent the embryonic ectoderm. A layer of cuboidal cells known as endoderm develops beneath the ectoderm. The free ends of this layer approach each other and fuse forming a bilaminar embryonic disc.

A week later, the cells of ectoderm migrate along with the primitive streak between the ectoderm and endoderm and form a middle layer known as mesoderm. Thus, a trilaminar embryonic disk (trilaminar embryo or trilaminary blastoderm) is formed.

All groups of tissues develop from the trilaminal germ layers.

The Complex Central Nervous System Emerges From the Neural Tube

In the amniotic cavity, around day 19, a **primitive streak** forms at the caudal end and the **primitive node** slightly more cranially (extending approx. 1/5th of the distance towards the cranial end). Above the node, the **neural plate** is formed via neural cell compaction, the first phase of neurulation occurring under **the influence of the notochord**, which lies ventral to the resulting plate and centrally within the mesoderm. The **caudal** and **cranial neural plates** can be distinguished. The caudal portion lies centrally in the middle third of the embryonic disc, and extends as a thick band from caudal to cranial end. It represents the origin of the **spinal cord**.

The cranial neural plate is rather round and teardrop-shaped, widening cranially. The **brain** develops from the cranial neural plate. The ectoderm lying lateral to the neural plate is called **lateral surface ectoderm** at this stage, which is thus distinguished from neuroectoderm (neural plate, and its structural derivatives).

Four nodular compactions form between the cranial neural plate and the surface ectoderm: olfactory, otic, lens and trigeminal **placodes**.

Similar to the notochord, the edges of the neural plate thicken to become **neural folds** and form a **neural groove**. The groove deepens, as the folds move closer to each other. On day 20, the neural folds begin to merge from the middle, forming a **neural tube**. This process continues to close up in the cranial and caudal directions, initially allowing the **cranial** and **caudal neuropores** to remain open (delayed closure).

The Neural Crest is More Than Just the Origin of the Peripheral Nervous System

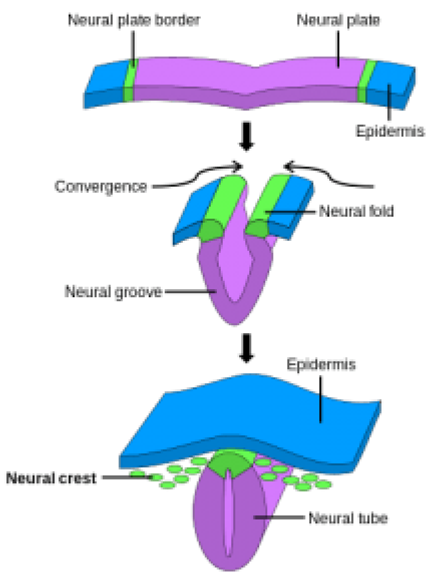

Image: Neural crest formation during neurulation. By NikNaks, License: CC BY-SA 3.0

The cells at the edge of the neural groove become the cells of the so-called **neural crest**.

After the closure of the tube, they merge dorsally between the neural tube and the **surface ectoderm**, which merges over it. The cells exhibit **increased migration**. They initially form paired neural crests to the left and the right of the neural tube before spreading out and specializing into various cell types:

- Sympathetic and parasympathetic ganglia
- Dorsal root ganglia and their mantle cells, partial ganglia of the cranial nerves V, VII, IX, and X
- Enteric nervous system
- Pia mater, arachnoid layer
- Connective and supporting tissues of the head, odontoblasts (teeth)
- Dermis and subcutaneous tissue of the head
- Skin melanocytes
- Adrenal medulla (cortex of mesodermal origin)
- Schwann cells (form myelin sheaths of the peripheral nervous system)
- C cells in the thyroid gland (= parafollicular cells)
- Cardiac septum and outflow tracts

Somitogenesis: Early Segmentation of the Body

Cell densities are formed via induction of the notochord, its lateral compactions, and within the mesoderm, extending in the craniocaudal direction in a chain-like fashion. They are described as **paraxial mesoderm**, while the lateral and adjacent portions are known as **intermediate mesoderm** (middle) and **lateral plate mesoderm**. Beyond the lateral portion, the mesoderm becomes thinner.

The paraxial strands are divided into paired, nodular consolidations called **somites** via oscillating expression of segmentation genes. The mesodermal cells are thus transformed into **epithelial spheres with a central cavity,** along the cranial to caudal end.

After complete epithelialization of the segments, the somite spheres of the neuroectoderm and surface ectoderm, under the influence of the notochord, are divided into:

- Ventromedial portion = **sclerotome cells,** which migrate in the medial direction followed by fusion with cells on the opposite side; resulting in mesenchymal clasps, which are precursors of the vertebral column
- Dorsolateral portion = **dermomyotome,** which is a precursor of skin cells and myoblasts

The First Body Cavity Generated Via Lateral Folding

Two cavities are found at the trigeminal germ disk stage. The **amniotic cavity** is adjacent to the ectoderm and the **yolk-sac** is adjacent to the endoderm. In addition to these extraembryonic structures, an inner body cavity begins to develop. The embryo **folds laterally** and simultaneously during somitogenesis (in the caudal direction) as the amniotic cavity enlarges and ‘embraces’ the embryonic disc. This process pushes back the shrinking yolk-sac due to **craniocaudal folding**.

In the lateral plate mesoderm, the columns open up, and their walls are characterized by a **somatopleural mesoderm**, which is the side facing the ectoderm, and a

splanchnopleural mesoderm, which is the side facing the endoderm. The **gaps** formed on both sides move closer via lateral folding, and eventually merge to form the **intraembryonic celom,** representing the first, initially unified body cavity. Initially, the gaps are connected directly to the chorionic cavity laterally, which is then lost upon lateral folding.

The endoderm is also compressed during this process. The edges approach each other and eventually merge to form the **gut tube,** which extends from the caudal to the cranial end. The gut tube carries an opening to the yolk-sac centrally: the **ductus omphaloentericus** or **vitelline duct**.

The Diaphragm Separates the Chest from Abdomen

In the region separating heart and liver precursors, a mesenchymal plate forms ventrally within the celom. This **transverse septum** does not divide the body cavity completely but leaves constrictions known as **pericardioperitoneal canals** (connecting pericardium and peritoneum) free on either side of the intestinal tube, which is now an esophageal precursor.

Posteriorly, 2 **plicae pleuroperitoneales** are elevated through the growth of liver and mesonephros. The canals are close to each other in the process, forming the **hiatus pleuroperitoneales**. Plicae and the septum grow wider. Myogenic precursor cells migrate from somites C3–C5 and colonize the majority of the resulting diaphragm. Other parts originate from the esophageal precursor and perivascular mesenchyme.

During week 7 of development, the individual components combine, and at the end of week 8, the first cavity separates completely. Following the continued growth of the entire embryo, the cervical diaphragm moves below its thoracic location and is innervated by the branches of the phrenic nerve (C3–C5).

Division of Thoracic Space into Pleural and Pericardial Cavities

The **primitive pericardial cavity** is formed above the cardiac precursor, above the septum transversum. At the level of pericardioperitoneal canals, lung buds grow dorsomedially, leading to the anterior and lateral expansions of the channel between the intestinal tube and the pericardial cavity.

Dorsolaterally, the **plicae pleuropericardiales** in turn push between lung buds and the primitive pericardial cavity. First, a **hiatus pleuropericardialis** persists between the folds, which then fuse, forming the **membrana pleuropericardialis**. The separation is complete. The lungs expand even further laterally and anteriorly so that the heart in the pericardial cavity is replaced by the ventral body wall and is pushed inward dorsally.

Each layer gives rise to different tissues or organs, and tissues in the same system may originate in a different embryonic layer.

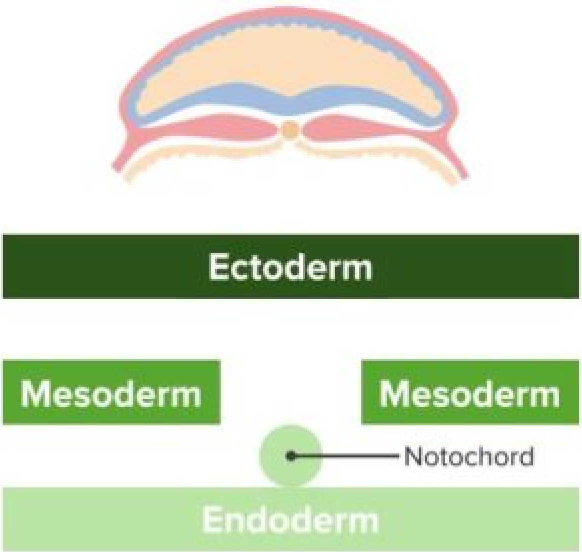

Image: Derivatives of the germ layers. By Lecturio

Ectodermal layer forms the nervous system, and structures such as the epidermis of the skin and its appendages, salivary glands, mucosa of the nasal cavity, paranasal sinuses, and pituitary gland.

Endodermal layer forms structures such as the epithelial lining of the gastrointestinal tract, liver, gallbladder, and pancreas; the epithelial lining of the respiratory tract; the mucous membrane of the urinary bladder, urethra, and bulbourethral and great vestibular glands.

Mesodermal layer forms structures such as bones, cartilages, muscles, cardiovascular tissue, kidneys, suprarenal glands, gonads, spleen, most of the genital tract, along with the mesothelial lining of pericardial, pleural and peritoneal cavities.

References

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Gätje et al., Kurzlehrbuch Gynäkologie und Geburtshilfe, 2. Auflage

Correct answers: 1A, 2B, 3B

Notes