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 trilaminal layers

As the zygote is formed after fertilization it divides by mitosis into two daughter cells. These cells further divide repeatedly, until a mulberry like mass of cells, morula is formed. The inner layers of the cells from the embryo are called embryoblasts, and the outer layer nourishes the embryo is called trophoblast.

After about 1 week of fertilization a cleft appears in embryoblasts that widens into the amniotic cavity. The base of this cavity consists of columnar cells which represents embryonic ectoderm. Beneath the layer of ectoderm, a layer of cuboidal cells develops, called endoderm. The free ends of this layer approach each other and fuse forming bilaminar embryonic disc.

One week later cells of ectoderm migrate along the primitive streak between the ectoderm and endoderm and form a middle layer called mesoderm. Thus trilaminar embryonic disc is formed.

All groups of tissues develop from trilaminal germ layers.

Our Complex Central Nervous System Emerges From the Neural Tube

Imagine you're in the amniotic cavity and you look down on the ectoderm. At around the 19th day, you would see the **primitive streak** at the caudal end and the **primitive node** slightly more cranially (runs for about only 1/5 of the distance towards the cranial end). Above the node, the **neural plate** is formed through neural cell compaction, the first phase of neurulation.

This happens under **the influence of the notochord**, which lies ventral to the resulting plate and centrally within the mesoderm. One distinguishes between the **caudal** and **cranial neural plate**. The caudal portion lies centrally in the middle third of the embryonic disc, and it spreads along 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 in the cranial direction. The **brain** develops from this portion. Ectoderm lying lateral to the neural plate is called **lateral surface ectoderm** at this stage, and can thus be distinguished from neuroectoderm (neural plate, and all of the structures arising from it).
Four nodular compactions form between the cranial neural plate and the surface ectoderm. They are the 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 the 20th day, they begin to merge from the middle, forming a **neural tube**. This continues to close up in cranial and caudal directions, initially allowing the **cranial neuropore** and **caudal neuropore** to remain open (delayed closure).

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

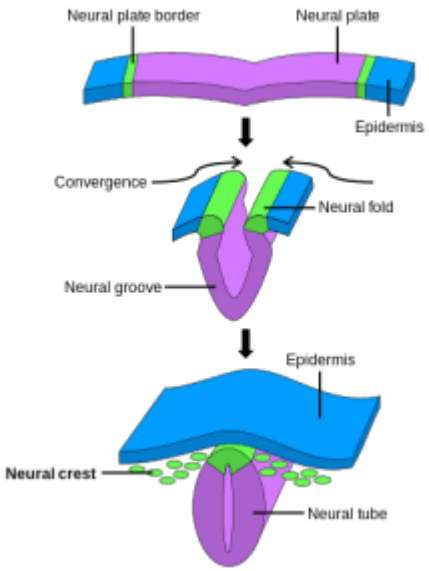


Image: “Neural crest formation during neurulation” by NikNaks. License: CC BY-SA 3.0

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 are characterized by **high migration ability**. They initially form to the left and right of the neural tube into paired neural crests before they fan out and specialize into various cell types:

- Sympathetic and parasympathetic ganglia
- Dorsal root ganglia + their mantle cells, partially ganglia of the cranial nerves V, VII, IX, 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)
- Septum and outflow tracts of the heart

Somitogenesis: The Segmentation of the Body Starts Early

Through **induction processes** of the notochord, compactions lateral to it, and within the mesoderm, form cell densities which extend in the craniocaudal direction in a chain-like fashion. They are described as **paraxial mesoderm**, while the laterally adjacent portions are called **intermediate mesoderm** (middle) and **lateral plate mesoderm**. Beyond the lateral portion, the mesoderm becomes thinner.

Through **oscillating** expressions of segmentation genes, the paraxial strands are divided into paired, nodular consolidations called **somites**. From cranial to caudal end, mesodermal cells are thus turned into **epithelial spheres with a central cavity**.

After complete epithelialization of the segments, the somite spheres of the neuro- and

surface ectoderm are, under the influence of the notochord, divided into:

- Ventromedial portion = **sclerotome cells**: migration in medial direction and fusion with cells on the opposite side; resulting mesenchymal clasps are precursor structures of the vertebral column
- Dorsolateral portion = **dermomyotome**: precursor of skin cells and myoblasts

The First Body Cavity as a Product of the Lateral Folding

Two cavities are present at the trigeminal germ disk stage. The **amniotic cavity** is adjacent to the ectoderm and the **yolk sac** is adjacent to the endoderm. While these lie extraembryonically, an inner body cavity begins to develop. The embryo **folds laterally** and simultaneously with somitogenesis (in caudal direction). Here, the amniotic cavity enlarges and “embraces” the embryonic disc. This pushes back the yolk sac which is now shrinking, not only across, but also in the longitudinal axis through **cranio-caudal folding**.

In the lateral plate mesoderm, columns open up, and their walls are described with two terms: The side facing the ectoderm is called **somatopleural mesoderm**. The side facing the endoderm is the **splanchnopleural mesoderm** (at this point, has nothing to do with the final pleura!). Through lateral folding, the **gaps** formed on both sides move closer and eventually merge to form the **intraembryonic celom** (often just called celom). This is the first, initially unified body cavity. At the beginning, the gaps laterally have a direct connection to the chorionic cavity, which is then lost through lateral folding.

The endoderm is also compressed during this process. The edges approach each other, so that they eventually merge and form the **gut tube**. This extends from the caudal to the cranial end, in which an opening to the yolk sac remains centrally – the **ductus omphaloentericus** or **vitelline duct**.

The Diaphragm Separates the Chest and Abdomen

In the region between heart and liver precursors, a mesenchymal plate forms ventrally within the celom. This **septum transversum** does not yet divide the body cavity completely but leaves constrictions free on either side of the intestinal tube (now an esophageal precursor). They are named **pericardioperitoneal canals** (connects pericardium and peritoneum).

Posteriorly, two **plicae pleuroperitoneales** are elevated through the growth of liver and mesonephros. The canals come even closer to each other in the process, forming what’s called 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.

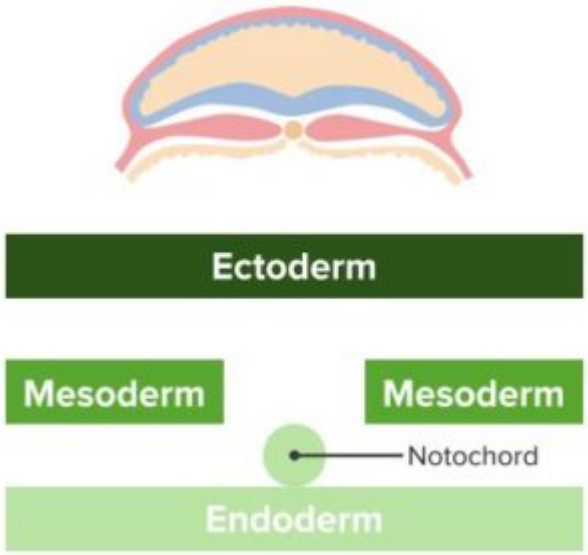
In the 7th week of development, the individual components combine; at the end of the 8th week, the first cavity separation is complete. With the continued growth of the entire embryo, the cervically placed diaphragm moves inferiorly to its thoracic location. With it, it takes the nerve branches from C3 – C5 (= branches of the phrenic nerve).

Division of Thoracic Space into Pleural and Pericardial Cavities

The **primitive pericardial cavity** is formed over the cardiac precursor, above the septum transversum. At the level of pericardioperitoneal canals, lung buds grow from the dorsomedial aspect. They lead to the anterior and lateral expansion of the channel (the buds push between the intestinal tube and the pericardial cavity).

From the dorsolateral aspect, **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 then also anteriorly, so that the heart in the pericardial cavity becomes replaced by the ventral body wall and is pushed inwards/dorsally.

Each layer gives rise to different tissue or organ and tissues of the same system may have origin from different embryonic layer.



"Derivatives of the germ layers" Image created by Lecturio

ECTODERMAL LAYER- gives rise to the nervous system, the epidermis of skin and its appendages, salivary glands, mucosa of nasal cavity, paranasal sinuses, pituitary gland etc.

ENDODERMAL LAYER- gives rise to the epithelial lining of gastrointestinal tract, liver, gallbladder, pancreas, epithelial lining of respiratory tract, mucous membrane of urinary bladder, urethra, bulbourethral and great vestibular glands etc.

MESODERMAL LAYER- Bones, cartilages, muscles, cardiovascular tissue, kidneys, suprarenal glands, gonads, spleen, most of the genital tract, mesothelial lining of pericardial, pleural and peritoneal cavity etc.

References

Stauber, Weyerstahl, Gynäkologie und Geburtshilfe, 2. Auflage

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

Correct answers: 1A, 2B, 3B

Notes