Lectures (46-47)
Third week of development

By

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Learning objectives

After this lecture, student should be able to:

- Know Gastrulation (formation of embryonic mesoderm and endoderm).
- Know formation of the Notochord.
- Describe the further development of the trophoblast.

Content of the lecture

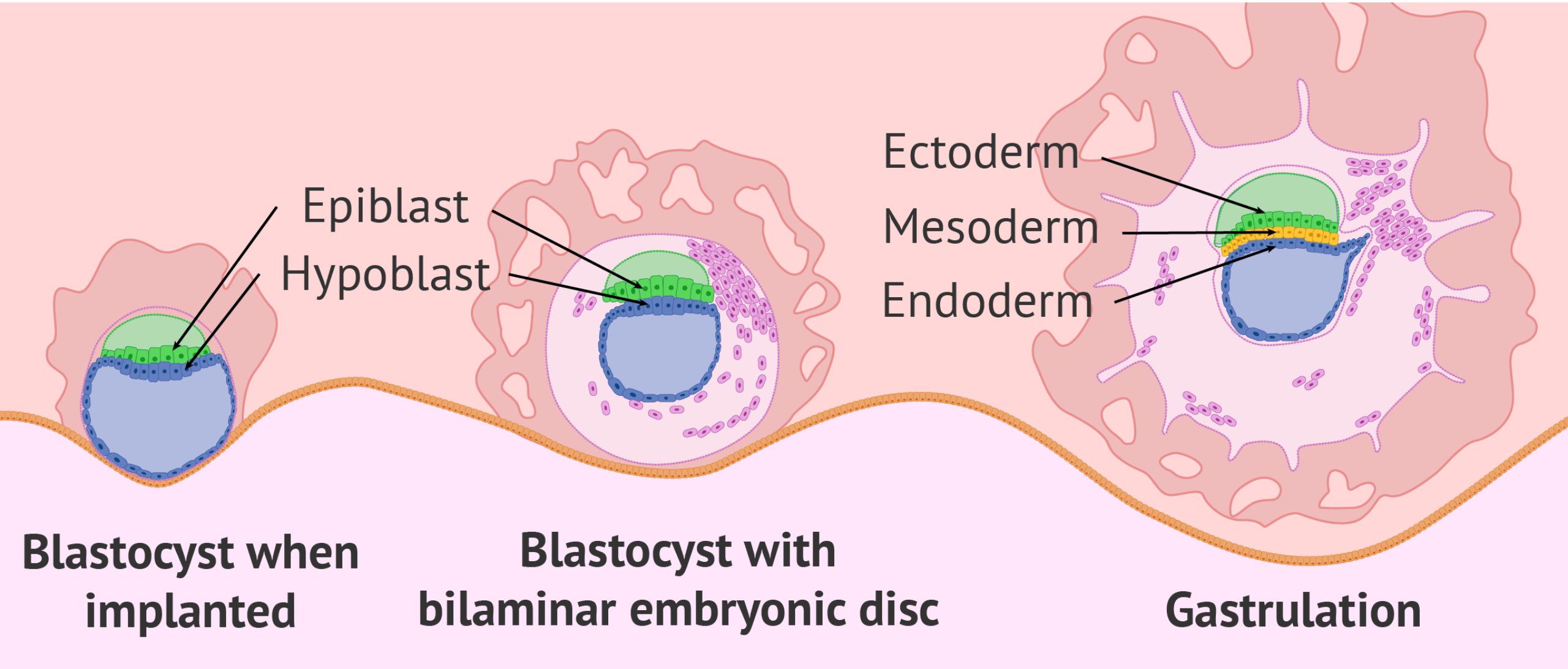
- Formation of the trilaminar germ disc.
- Formation of the Notochord.
- Further development of the trophoblast and development of a villus.

Gastrulation

The most characteristic event occurring during the third week of gestation is **gastrulation**.

-**Definition of gastrulation**: It is the process that establishes all three germ layers (ectoderm, mesoderm, and endoderm) in the embryo.

-**Evidence of gastrulation** is the appearance of primitive streak.


Epiblast
Hypoblast
Ectoderm
Mesoderm
Endoderm
Blastocyst when implanted
Blastocyst with bilaminar embryonic disc
Gastrulation

-Steps of Gastrulation

1- First , the ***Primitive streak appears as*** vaguely defined groove on the on the surface of the epiblast .

2- Later on, it is clearly visible as a narrow groove with slightly bulging regions on either side. The cephalic end of the streak, **the primitive node,** consists of a slightly elevated area surrounding the small **primitive pit .**

3- Cells of the epiblast migrate toward the primitive streak. Upon arrival in the region of the streak, they become flask-shaped, detach from the epiblast, and slip beneath it. This inward movement is known as ***invagination.***

4-Once the cells have invaginated, some displace the hypoblast, creating the **embryonic endoderm**, and others come to lie between the epiblast and newly created endoderm to form **mesoderm**.

5-Cells remaining in the epiblast then form **ectoderm**. **Thus, the epiblast, through the process of gastrulation, is the source of all of the germ layers, and cells in these layers will give rise to all of the tissues and organs in the embryo.**

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6- More and more cells move between the epiblast and hypoblast layers; they begin to spread laterally and cranially and migrate beyond the margin of the disc to become in contact with the extraembryonic mesoderm covering the yolk sac and amnion.

7- In the cephalic direction, they pass on each side of the **prechordal plate.**

What is the prechordal plate ?

-It is the region between the tip of the notochord and the oropharyngeal membrane and is derived **from some of the first cells that migrate through the node in the midline and move in a cephalic direction**.

What is the importance of prechordal plate?

the prechordal plate is important for induction

of the forebrain formation.

The oropharyngeal membrane at the cranial end of the disc consists of a small region of tightly adherent ectoderm and endoderm cells that represents the future opening of the oral cavity.

The cloacal membrane is formed at the caudal end of the embryonic disc . This membrane, which is similar in structure to the oropharyngeal membrane, consists of tightly adherent ectoderm and endoderm cells with no intervening mesoderm.

The allantoenteric diverticulum, or allantois, appears as extension of posterior wall of yolk sac into the connecting stalk. This structure is rudimentary in human.

Notochord

The **notochord** (**axial mesoderm, notochordal process, chorda dorsalis)** is the important structure forming in all chordate embryos. It is an early forming midline structure in the trilaminar embryo mesoderm layer.

-*This is a transient embryonic anatomy structure, not existing in the adult, required for patterning the surrounding tissues.*

Formation of notochord:

1-Prenotochordal cells firstly invaginating in the primitive node move forward cranially in the midline until they reach the region of prechordal plate by Instructive signals from the primitive streak region induce notochordal precursor cells to form the **notochord** . These **prenotochordal cells** become intercalated (inserted)in the hypoblast so that the midline of the embryo consists of two cell layers that form the **notochordal plate .**

2-The cells of the notochordal plate proliferate and detach from the endoderm. They then form a solid cord of cells, the **definitive notochord, which underlies the neural tube and serves as the basis for the axial skeleton.**

3-The notochord and prenotochordal cells **extend cranially to the prechordal plate (an area just caudal to the oropharyngeal membrane) and caudally to the primitive pit.**

4-The primitive pit forms an indentation in the epiblast, **the neurenteric canal temporarily connects the amniotic and yolk sac cavities, later on closed.**

N.B. The elongation of the notochord is a dynamic process, the cranial end forms first, and caudal regions are added after that.

Function of notochord:

1-The notochord defines the primordial longitudinal axis of the embryo and gives it some rigidity

2-Provides signals that are necessary for the development of axial musculoskeletal structures and the central nervous system

3-Contributes to the intervertebral discs

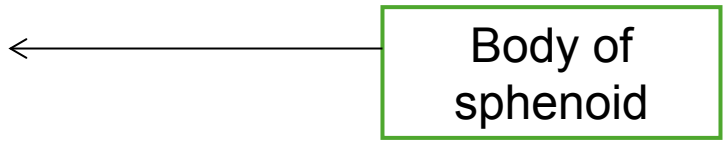
Fate of notochord:

The notochord disappears with the exception of a part that will form the followings:

1- Apical ligament of the skull.

2- Part of bones of skull base.

3- Nucleus pulposus of intervertebral disc.



Tumors of notochord:

Chordoma

-Rare type of bone cancer arising from remnants of the embryonic notochord

The embryonic disc

-Initially flat and almost round. Gradually becomes elongated, with a broad cephalic and a narrow caudal end.

-Expansion of the embryonic disc occurs mainly in the cephalic region; the region of the primitive streak remains the same size. growth and elongation of the cephalic part of the disc that is caused by a continuous migration of cells from the primitive streak region in a cephalic direction.

By the middle of the third week, intraembryonic mesoderm separates the ectoderm and endoderm everywhere **except:**

1-At the oropharyngeal membrane cranially

2-In the median plane cranial to the primitive node, where the notochordal process is located

3-At the cloacal membrane caudally

The primitive streak shows regressive changes at the **end of fourth week ,** rapidly shrinks, and disappears. In the **cephalic part of embryonic disc**, germ layers begin their differentiation by **the middle of the third week** while the differentiation of the **caudal part begins by the end of fourth week**.

Teratogenesis Associated With Gastrulation

Caudal dysgenesis (sirenomelia): insufficient mesoderm is formed in the caudal most region of the embryo. Because this mesoderm contributes to formation of the lower limbs, urogenital system (intermediate mesoderm), and lumbosacral vertebrae, abnormalities in these structures occur. Affected individuals exhibit a variable range of defects, including hypoplasia and fusion of the lower limbs, vertebral abnormalities, renal agenesis, imperforate anus, and anomalies of the genital organs.

Tumors Associated With Gastrulation

Sacrococcygeal teratoma: tumors result from remnants the primitive streak that persist in the sacrococcygeal region commonly contain tissues derived from all germ layers.

Further development of trophoblast:

1-At the beginning of third week, the trophoblast contains **primary villi** which are composed of cytotrophoblastic core surrounded by syncytiotrophoblastic shell.

2- During further development, mesodermal cells derived from extraembryonic mesoderm penetrate into the core of the primary villi. The newly formed structure is called **secondary chorionic villus**.

3-By the end of the third week, mesodermal cells in the core of the villus begin to differentiate into blood cells and small blood vessels, forming the villous capillary system. The villus is now known as **a tertiary villus or a definitive placental villus.**

4-Capillaries in tertiary villi make contact with **capillaries developing in the mesoderm of the chorionic plate and in the connecting stalk**.

4-These vessels, in turn, establish contact with the intraembryonic circulatory system, connecting the placenta and the embryo. When the heart begins to **beat in the fourth week of development**, the villous system is ready to supply the embryo proper with essential nutrients and oxygen.

5- **Cytotrophoblastic cells in the villi** penetrate progressively into the overlying syncytium until they reach the maternal endometrium.

6-The cytotrophoblastic cells establish contact with extensions of neighboring villous stems, forming a thin outer cytotrophoblast shell. This shell gradually surrounds the trophoblast entirely and attaches the chorionic sac firmly to the maternal endometrial tissue .

7-Villi that extend from the **chorionic plate to the decidua basalis are called stem or anchoring villi**. Those that branch from the sides of stem villi are **free (terminal) villi,** through which exchange of nutrients and other factors will occur.

cytotrophobla
st

The chorionic cavity, meanwhile, becomes larger, and by the 19th or 20th day, the embryo is attached to its trophoblastic shell by a narrow **connecting stalk.**

The connecting stalk later develops into the **umbilical cord**, which forms the connection between placenta and embryo.