Lecture 8

Derivatives of mesoderm

Objectives

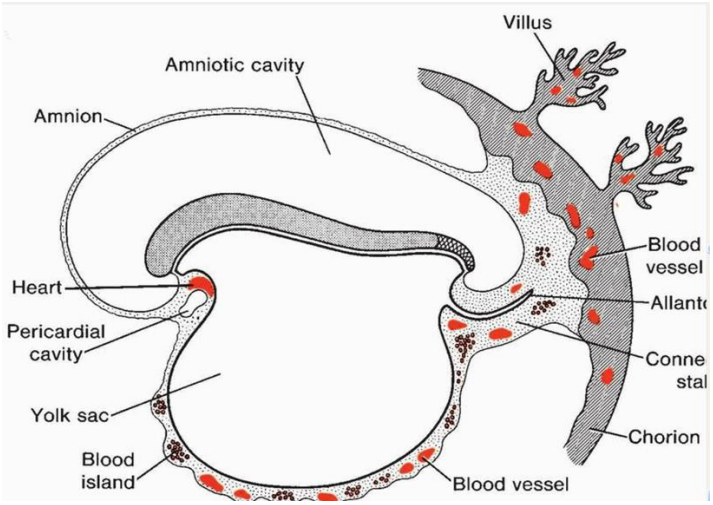
1. **Enumerate the embryological steps of blood vessel formation.**
2. **Explain the process of gut formation.**
3. **Define full term placenta.**
4. **List the main function of placenta.**

Blood and Blood Vessels

Blood cells and blood vessels also arise from mesoderm. Blood vessels form in two ways:

- vasculogenesis, whereby vessels arise from blood islands
- angiogenesis, which entails sprouting from existing vessels.

The first blood islands appear in mesoderm surrounding the wall of the yolk sac at 3 weeks of development and slightly later in lateral plate mesoderm and other regions. These islands arise from mesoderm cells that are induced to form hemangioblasts (common precursor for vessel and blood cell formation).



Although the first blood cells arise in blood islands in the wall of the yolk sac, this population is transitory. The definitive hematopoietic stem cells are derived from mesoderm surrounding the aorta in a site near the developing mesonephric kidney called the aorta gonad- mesonephros region (AGM). These cells colonize the liver, which becomes the major hematopoietic organ of the embryo and fetus from second to seven months. Stem cells from liver colonize the bone marrow, the definitive blood forming tissue in the seven month of gestation, and thereafter, the liver loses its blood-forming function.

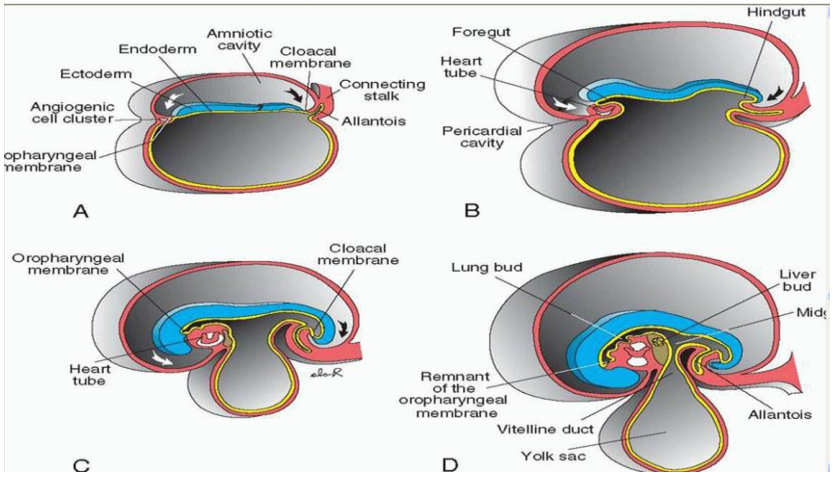
Yolk sac → liver → bone marrow

Endodermal derivatives

The gastrointestinal tract is the main organ system derived from the endodermal germ layer. This germ layer covers the ventral surface of the embryo and forms the roof of the yolk sac. With development and growth of the brain vesicles, however, the embryonic disc begins to bulge into the amniotic cavity. Lengthening of the neural tube now causes the embryo to curve into the fetal position as the head and tail regions (folds) move ventrally. Simultaneously, two lateral body wall folds form

and also move ventrally to close the ventral body wall. As the head and tail and two lateral folds move ventrally, they pull the amnion down with them, such that the embryo lies within the amniotic cavity. The ventral body wall closes completely except for the umbilical region where the connecting stalk and yolk sac duct remain attached. Failure of the lateral body folds to close the body wall results in ventral body wall defects.

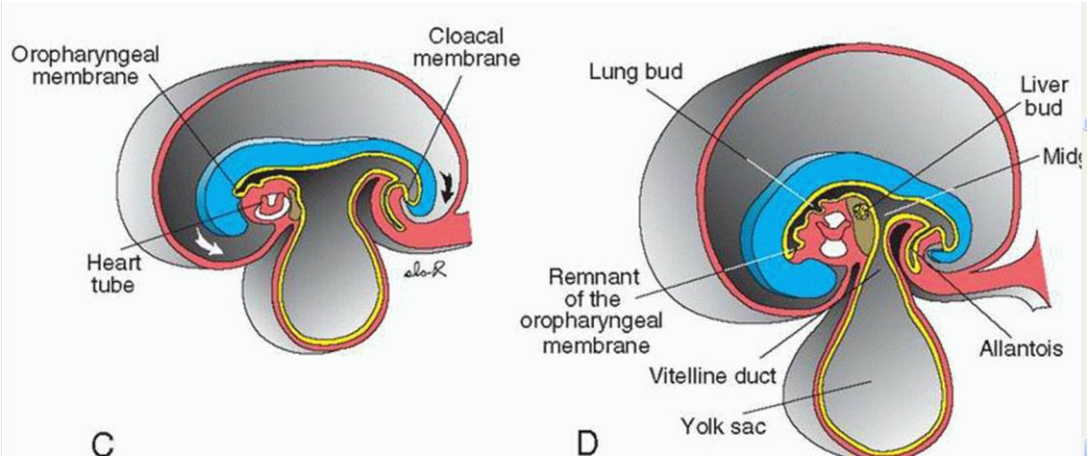
Ventral body wall abnormalities ?

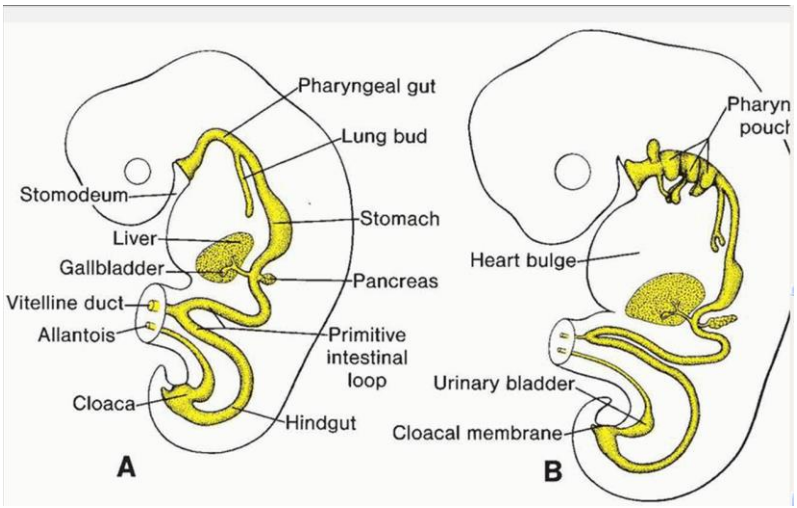


As a result of cephalocaudal growth and closure of the lateral body wall folds, a continuously larger portion of the endodermal germ layer is incorporated into the body of the embryo to form the gut tube. The tube is divided into three regions: **the foregut, midgut, and hindgut**.

- **The midgut** communicates with the yolk sac by way of a broad stalk, the vitelline (yolk sac) duct. This duct is wide initially, but with further growth of the embryo, it becomes narrow and much longer.

- **The foregut** is temporarily bounded by the oropharyngeal membrane. In the 4th week: the oropharngeal membrane ruptures, establishing an open connection between the oral cavity and the primitive gut
- **The hindgut** also terminates temporarily at the cloacal membrane. This membrane separates the upper part of the anal canal (derived from endoderm) from the lower part called the proctoderm that is formed by ectoderm. The membrane breaks down in the 7th week to create the opening for the anus.





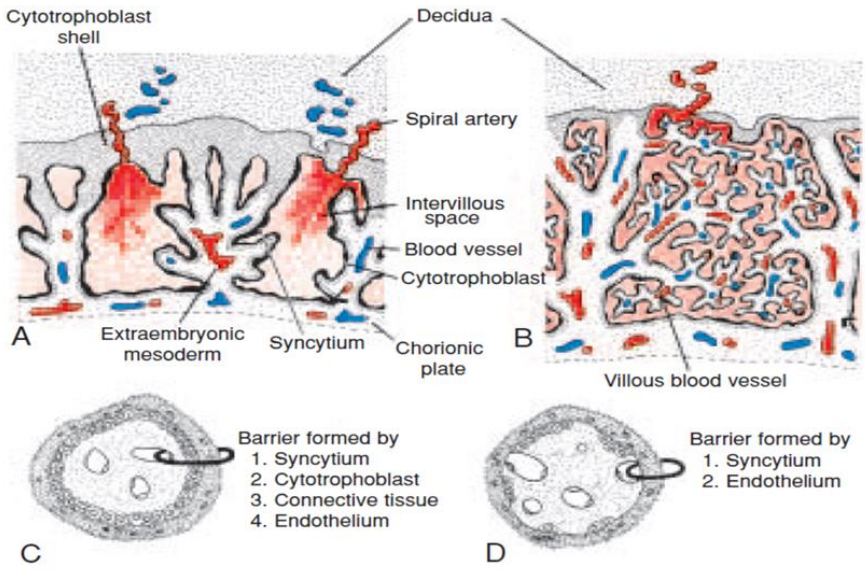
The endoderm initially forms:

The epithelial lining of the primitive gut and the intraembryonic portions of the allantois and vitelline duct. During further development, endoderm gives rise to:

- The epithelial lining of the respiratory tract.
- The parenchyma of the thyroid, parathyroids, liver, and pancreas.
- The reticular stroma of the tonsils and thymus.
- The epithelial lining of the urinary bladder and urethra.
- The epithelial lining of the tympanic cavity and auditory tube.

Changes in trophoblast

By the beginning of the second month, the trophoblast is characterized by a great number of secondary and tertiary villi that give it a radial appearance. The surface of the villi is formed by the syncytium, resting on a layer of cytotrophoblastic cells that in turn cover a core of vascular mesoderm. The capillary system developing in the core of the villous stems soon comes in contact with capillaries of the chorionic plate and connecting stalk, thus giving rise to the extraembryonic vascular system. During the following months, numerous small extensions sprout from existing villous stems into the surrounding lacunar or intervillous spaces. Initially these newly formed villi are primitive, but by the beginning of the fourth month, cytotrophoblastic cells and some connective tissue cells disappear. The syncytium and endothelial wall of the blood vessels are then the only layers that separate the maternal and fetal circulations.



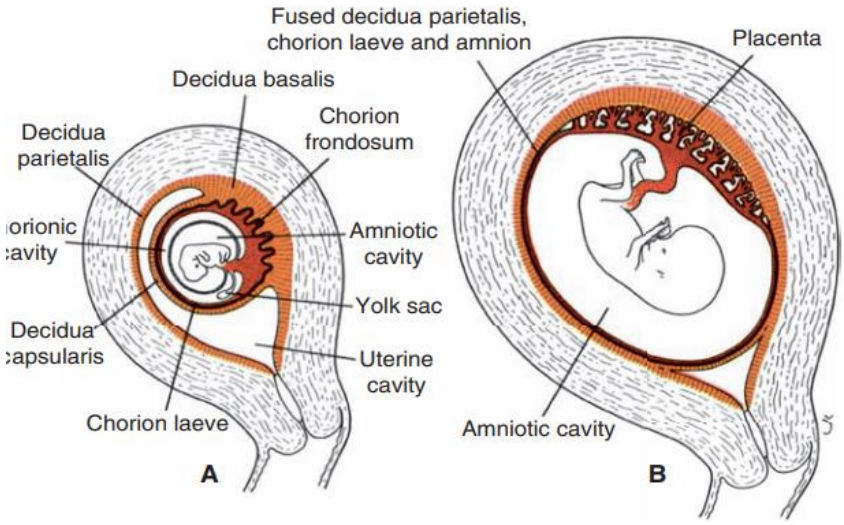
Chorion frondosum and decidua basalis

In the early weeks of development, villi cover the entire surface of the chorion. As pregnancy advances, villi on the embryonic pole continue to grow and expand, giving rise to the chorion frondosum (bushy chorion). Villi on the abembryonic pole degenerate and by the third month this side of the chorion, now known as the chorion laeve, is smooth. The difference between the embryonic and abembryonic poles of the chorion **is also reflected in the structure of the decidua**, the functional layer of the endometrium, which is shed during parturition:

- **The decidua over the chorion frondosum, the decidua basalis,** consists of a compact layer of large cells, decidual cells, with abundant amounts of lipids and glycogen. This layer, the decidual plate, is tightly connected to the chorion.
- **The decidual layer over the abembryonic pole is the decidua capsularis**. With growth of the chorionic vesicle, this layer becomes stretched and degenerates. Subsequently, the chorion laeve comes into contact with the

uterine wall (decidua parietalis) on the opposite side of the uterus and the two fuse obliterating the uterine lumen.

Hence, the only portion of the chorion participating in the exchange process is the chorion frondosum, which, together with the decidua basalis, makes up the placenta. Similarly, fusion of the amnion and chorion to form the amniochorionic membrane obliterates the chorionic cavity. It is this membrane that ruptures during labor.



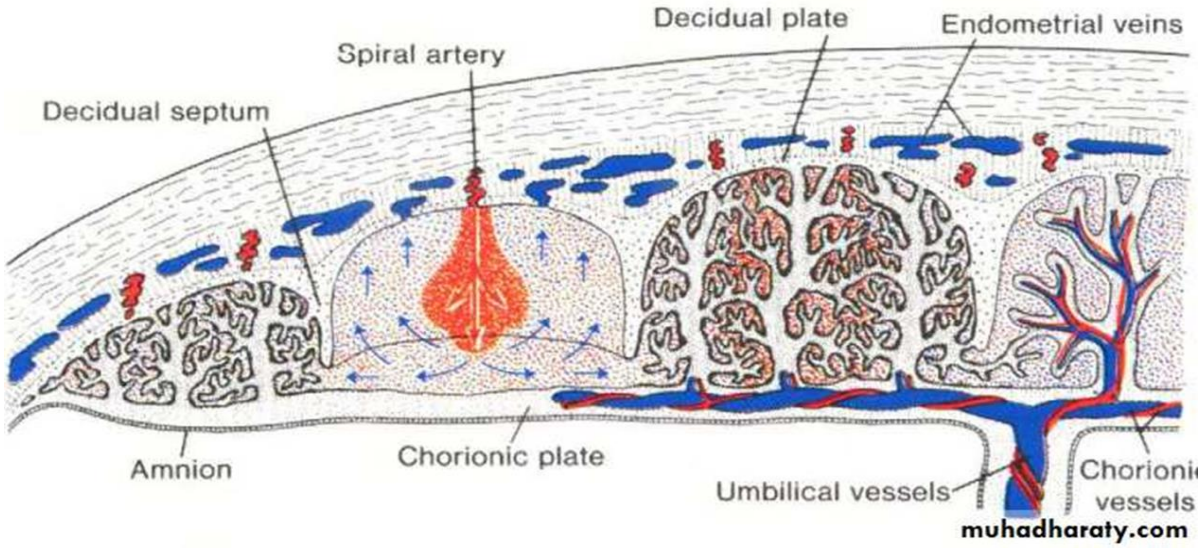
Structure of the Placenta

By the beginning of the fourth month, the placenta has two components:

- a fetal portion, formed by the chorion frondosum.
- a maternal portion, formed by the decidua basalis.

On the fetal side, the placenta is bordered by the chorionic plate; on its maternal side, it is bordered by the decidua basalis, of which the decidual plate is most intimately incorporated into the placenta. During the fourth and fifth months the decidua forms a number of decidual septa, which project into intervillous spaces but do not reach the chorionic plate. These septa have a core of maternal tissue, but their

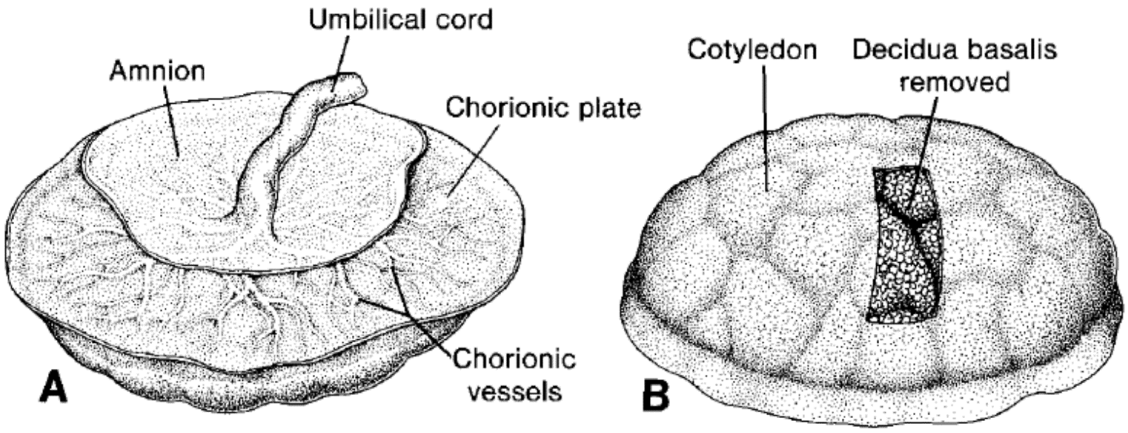
surface is covered by a layer of syncytial cells, so that at all times a syncytial layer separates maternal blood in intervillous lakes from fetal tissue of the villi. As a result of this septum formation, the placenta is divided into a number of compartments, or cotyledons. Since the decidual septa do not reach the chorionic plate, contact between intervillous spaces in the various cotyledons is maintained.



Full term placenta

At full term, the placenta is discoid with a diameter of 15 to 25 cm, is approximately 3 cm thick, and weighs about 500 to 600 g. At birth, it is torn from the uterine wall and, approximately 30 minutes after birth of the child, is expelled from the uterine cavity. After birth, when the placenta is viewed from the maternal side, 15 to 20 slightly bulging areas, the cotyledons, covered by a thin layer of decidua basalis, are clearly recognizable. Grooves between the cotyledons are formed by decidual septa. The fetal surface of the placenta is covered entirely by the chorionic plate. A number of large arteries and veins, the chorionic vessels, converge toward the umbilical cord. The chorion, in turn, is covered by the amnion. Attachment of the umbilical cord is

usually eccentric and occasionally even marginal. Rarely, however, does it insert into the chorionic membranes outside the placenta (velamentous insertion).



Function of placenta

Main functions of the placenta are

(1) exchange of metabolic and gaseous products between maternal and fetal bloodstreams.

(2) production of hormones.

Functions:

- Exchange of Gases.
- Exchange of Nutrients and Electrolytes.
- Transmission of Maternal Antibodies (Ig G).
- Hormone Production (progesterone, estrogens, hCG, somatomamotropin (placental lactogen)).
- Detoxification of some drugs.

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