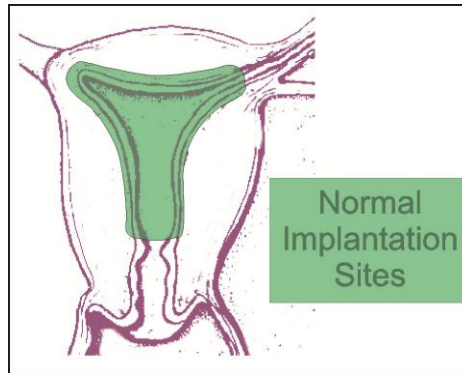




Early Development: The Blastocyst, Implantation & Extraembryonic Membranes

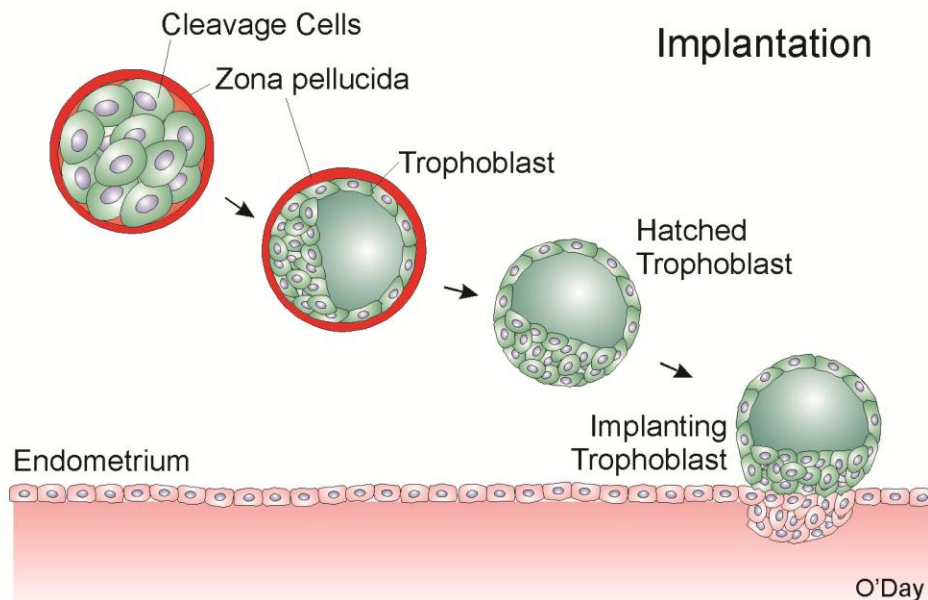
Implantation of the Embryo

- Complex interaction between embryo and uterine tissues
- Occurs ~6-7d after fertilization
- Hormones have prepared uterus to accept embryo
- Embryo binds to uterine epithelium then penetrates
- These events transform the embryo into a fetus



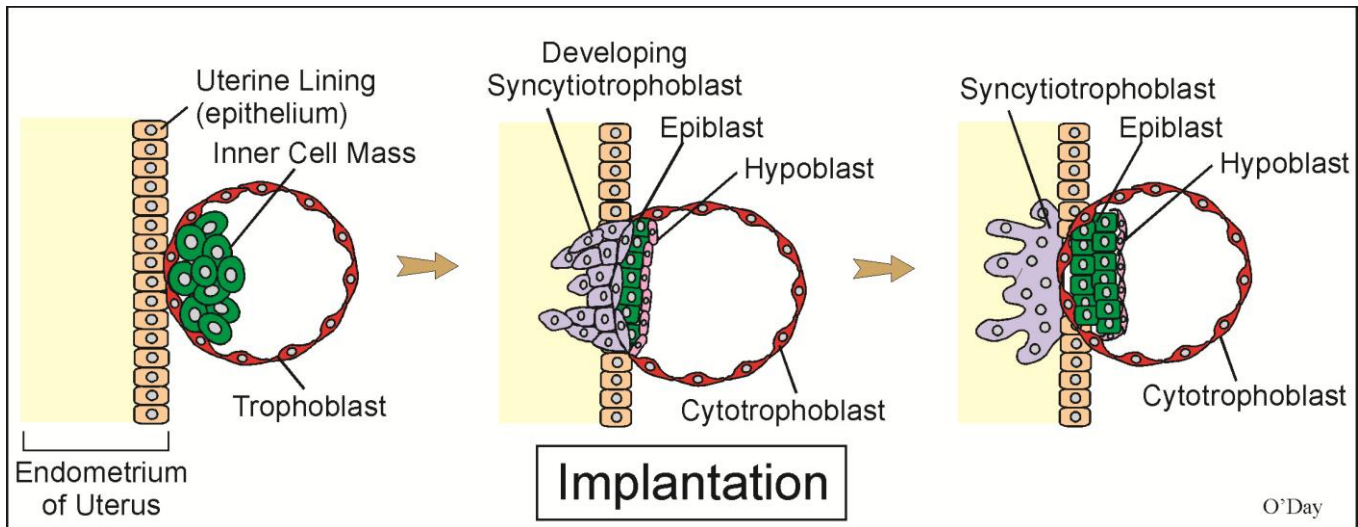
Implantation: The Sequence of Events

The following figure shows the sequence of events from the morula to the trophoblast followed by to the start of implantation in the uterus after trophoblast hatching.



Blastocyst, Implantation & Extraembryonic Membranes

The following diagram shows the initial sequence of events during implantation. The specific processes that are occurring are detailed below.



1. **Apposition:** of blastocyst to endometrial epithelium
2. **Adherence:** via cell adhesion molecules (e.g., L-selectin; trophinin)
3. **Formation of Syncytiotrophoblast:** Fusion of cytotrophoblast cells results in giant multinucleate cell that will surround complete embryo
4. **Penetration:** Syncytiotrophoblast is invasive and works way into uterine tissue ultimately making contact with maternal blood vessels
5. **Decidual Reaction:** Uterine tissue responds to embryonic invasion by setting up an immunological barrier, the decidua; thus the decidua is derived from maternal tissues

Cell Adhesion Molecules & Implantation

Two cell adhesion molecules have been shown to function during embryo implantation: L-selectin and trophinin.

L-selectin (Lymphocyte selectin)

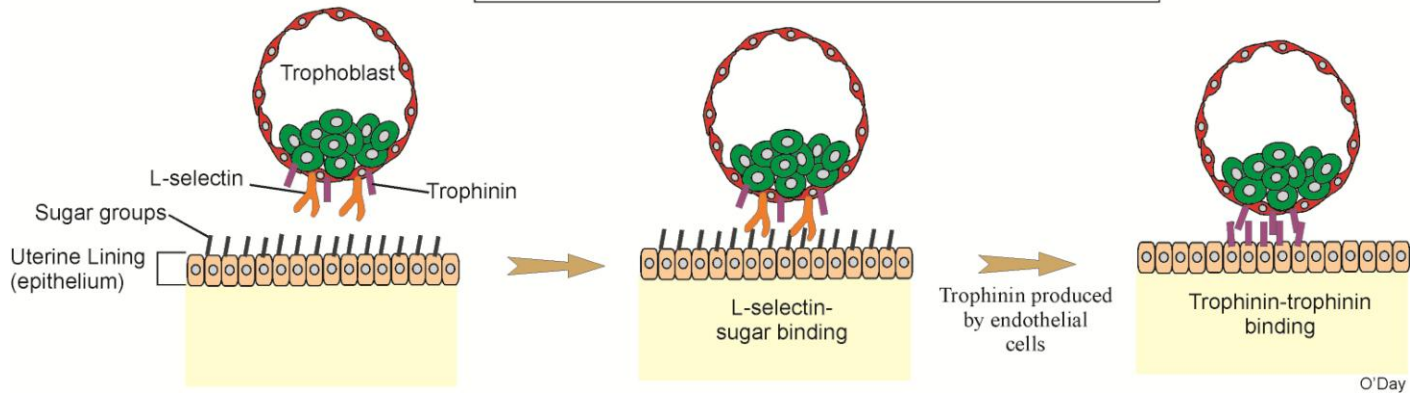
- a lectin (binds carbohydrate groups) cell adhesion molecule
- present in cells of blastocyst
- binds to sugar groups on extracellular matrix of endometrial cells
- weak adhesion; involved in initial adherence
- initiates events leading to trophinin expression by maternal cells

Trophinin

- homophilic cell adhesion molecule
- once trophinin molecules appear on endometrial cells, trophinin-trophinin binding occurs
- strong adhesion event

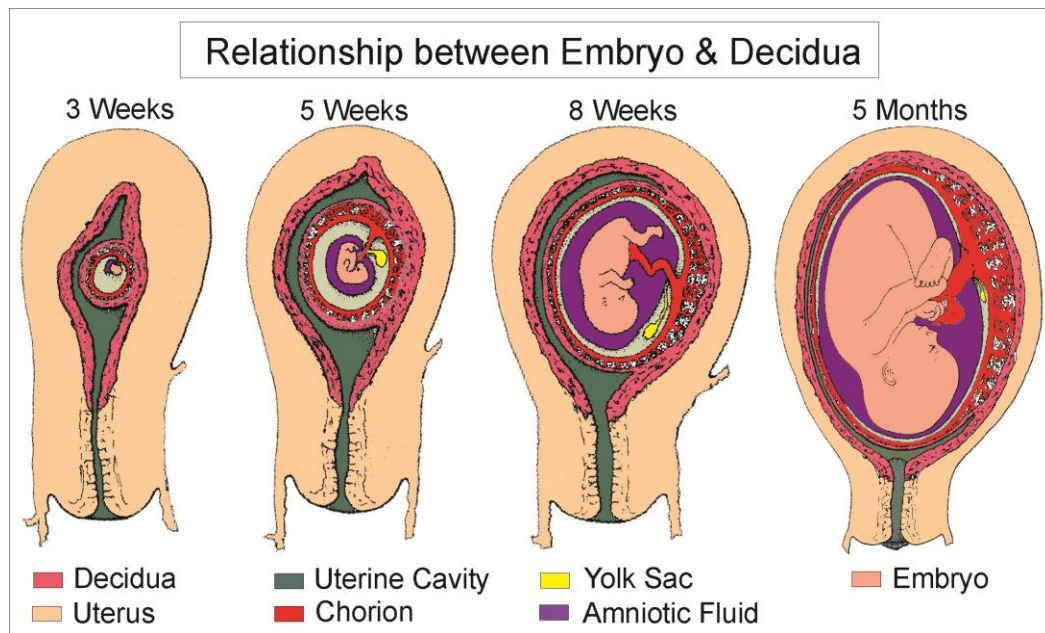
These events are summarized in the following graphic.

Cell Adhesion Molecules & Implantation



The Fetal/Maternal Interface

- The maternal body supplies nutrients, oxygen and protection to developing fetus
- Because the fetus has a different genetic makeup than the mother, it is recognized a foreign tissue
- There is a need to avoid immune response by the mother's body which would lead to rejection (natural abortion) of the fetus
- The Placenta & chorion provide this function
- The Chorion is one of a group of extraembryonic membranes while the placenta is a combination of maternal and extraembryonic tissues
- An early step in this avoidance is the formation of the decidua (see above) by maternal tissues
- The syncytiotrophoblast and other extraembryonic tissues (including changes in the chorion and amnion) interact with the decidua in a complex series of events to form the fully developed placenta as indicated in the following figure.



The Blastocyst: Origin of the Cell Lineages

To understand the origin of the cell lineages that give rise to the embryo and to the extraembryonic tissues, we need to take a step back to the blastocyst stage.

Blastocyst, Implantation & Extraembryonic Membranes

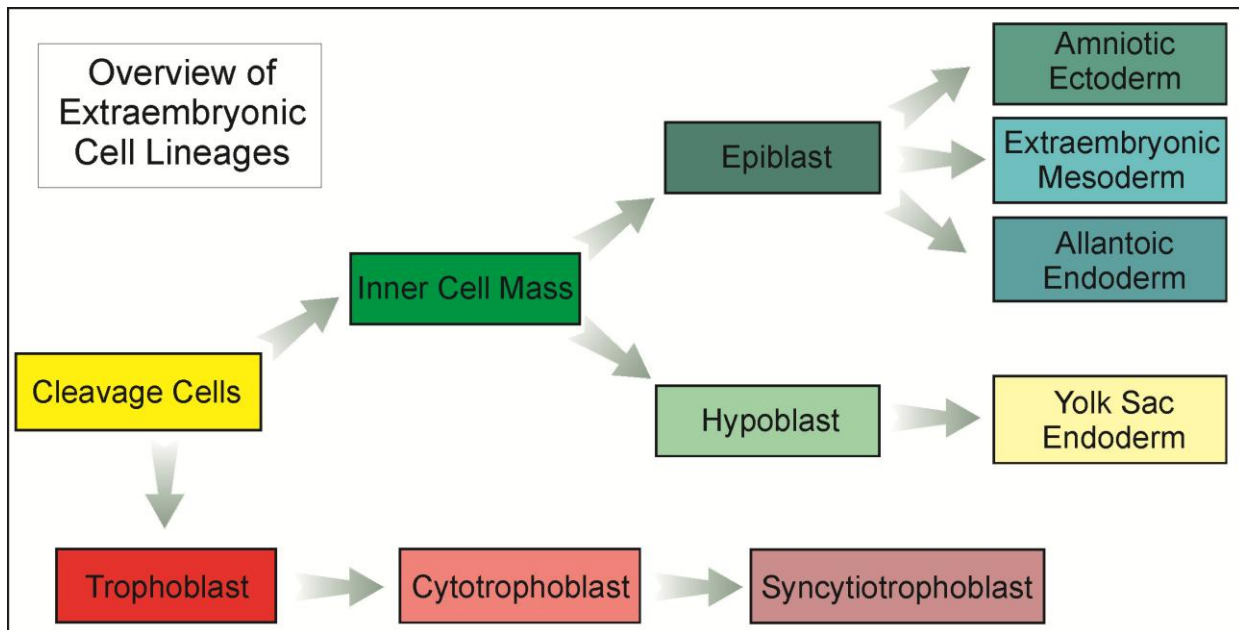
Blastocyst: Two cell types exist as specific groups of cells

- ICM = Inner Cell Mass; forms embryo plus some extraembryonic membranes
- Trophoblast forms only extraembryonic membranes

Cell Lineages: These groups (ICM & Trophoblast cells) represent two specific "Cell Lineages"; they will give rise to specific extraembryonic and embryonic tissues as the fetus develops

Extraembryonic Cell Lineages

The following figure reveals the origin of each of the extraembryonic membranes.



Thus cleavage results in the blastocyst in which two groups of cells are discernable each of which will contribute to extraembryonic tissues. These thus represent two cell lineages: the inner cell mass which will form cells of the amnion, yolk sac and the allantois. (Of course, the ICM will also contribute to the embryo which will be the focus of the rest of the course and detailed later). Here we'll summarize some basic information about some of the extraembryonic tissues.

Extraembryonic Membranes

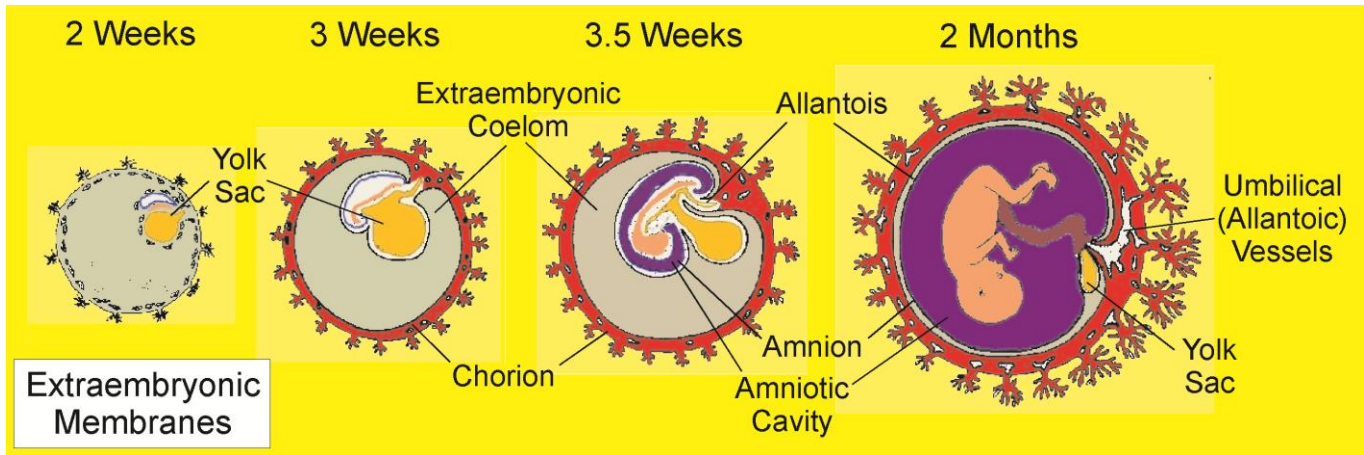
Chorion: covers fetus & other membranes

Amnion: forms protective, fluid filled sac around embryo

Yolk Sac: originally held yolk (lower animals)

Allantois: used for waste removal

Blastocyst, Implantation & Extraembryonic Membranes



Functions of the Yolk Sac

- Lower vertebrates: contains yolk; function lost in humans
- Source of PGCs (endodermal lining) as they migrate through it; not where they originate (epiblast)
- forms blood islands (embryonic hematopoiesis)
- some blood vessels remain (gut of adult)

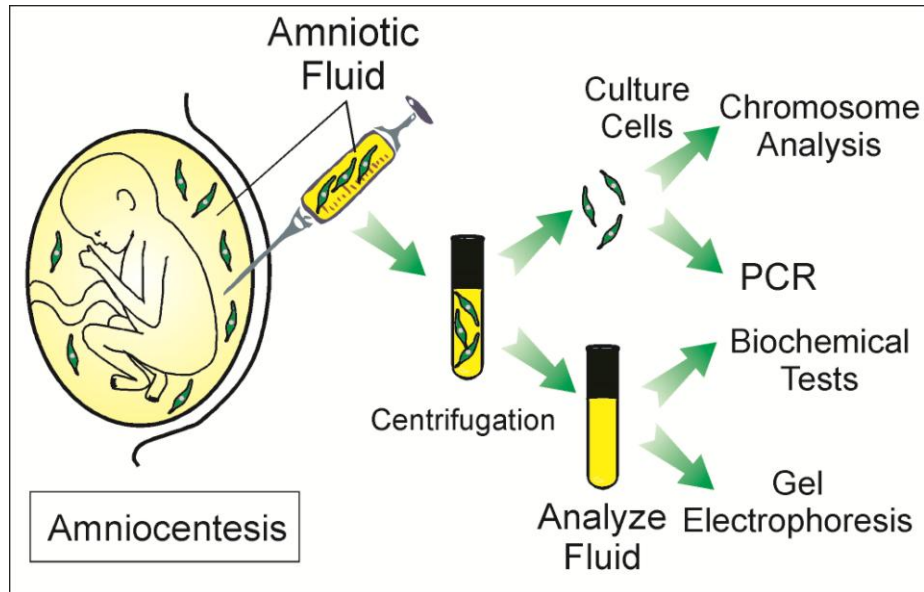
Functions of Amnion

- "surrounds embryo like a fluid filled balloon"
- suspends embryo in amniotic fluid that: a. protects against mechanical injury/shock and adhesions, and b. allows for fetal growth and movement
- amniotic fluid contains 200 proteins: used for assessing status of mother & fetus
- Amniotic fluid contains cells from embryo: used in genetic analysis (e.g., sex, anomalies)

Amniocentesis

Amniocentesis is carried out when there are medical concerns of one nature or another. Thus, depending on the genetic background of the parents, amniocentesis may be carried out to generated cells and amniotic fluid for the detection of, for example, Tay Sachs disease. A couple may want to know the sex of their child and a simple chromosomal analysis will reveal this. Such tests can also reveal problems such as trisomy. Let's look at the diagram showing how this procedure is carried out and then list some more information about it.

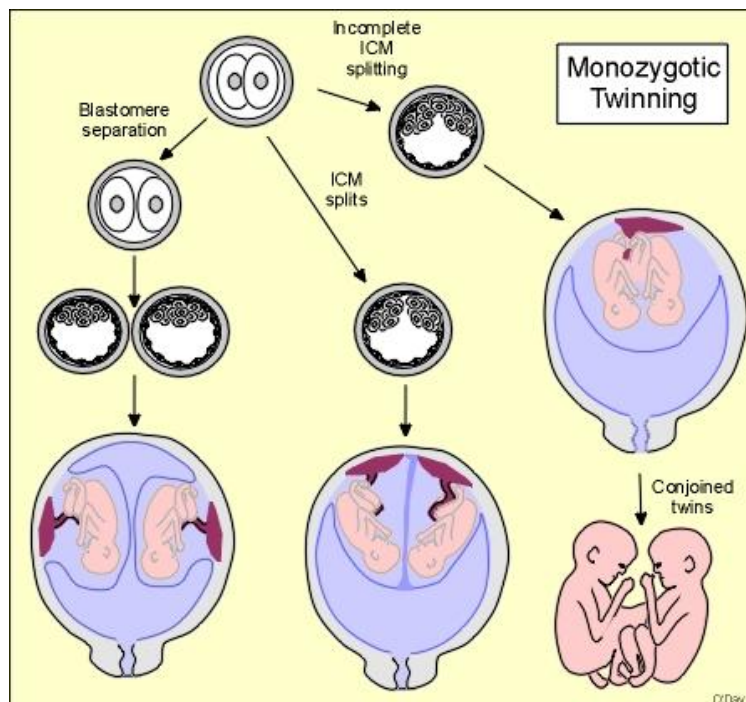
Blastocyst, Implantation & Extraembryonic Membranes



- Removal of small amount of amniotic fluid via needle
- Not done before 13-14wks (not enough fluid)
- Amniotic fluid contains cells that have been sloughed from embryo
- Fluid: examine proteins present (e.g., alpha-fetoprotein signals neural tube defects)
- Cells: sex (e.g., X chromosome; trisomy) or genetic defects (e.g., PCR/enzymes for Tay Sachs)

Twinning & the Blastocyst

Twinning occurs in many ways. If two different eggs are fertilized at the same time (obviously by different sperm) then fraternal (non-identical) twins result. The formation of identical twins can occur in different ways and is related to certain developmental defects (e.g., conjoined twins).



Final Comments

- The development of the fetal/maternal interface is a critical step
- The embryo and the fetus interact to construct the placental relationship
- The hypoblast & inner cell mass each form specific extraembryonic membranes
- The extraembryonic membranes serve many critical functions
- The amniotic fluid provides a window into the development of the fetus

References

Fukida, M. & K. Sugihara, 2008. An integrated view of L-selectin and trophinin function in human embryo implantation, J. Obstet. Gynaecol. Res. 34: 129-136.

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