Fertilization to Gastrulation: Days 1-20

RECOMMENDED READING:

William J. Larsen “Human Embryology” 3rd ed., pages 1-21, 37-44 and 53-56, figures & legends 3-6 and 3-7.
http://cna.uc.edu/embryology/ - this site is good for animations and glossary for each book chapter.

LEARNING OBJECTIVES:

1. Understand the location within the mother’s reproductive tract where fertilization and the initial divisions of the fertilized egg occur.
2. Understand the maturation events that must occur in the sperm within the woman's reproductive track to make them capable of fertilizing an egg.
3. Understand the significance of compaction, the segregation of the blastomeres and formation of the blastocyst.
4. Distinguish between the descendents of the trophoblasts and the inner cell mass.
5. Understand the concepts of potency and differentiation.
6. Understand the role played by hypoblast and the primitive node.
7. Understand how the three germ layers are established by cellular movements through the primitive streak and primitive node.
8. Understand the concepts of induction and competence.

GLOSSARY:

General terminology

Conceptual age - counts the age of the embryo from the time of fertilization.
Embryo - refers to developing organism up to ~ 9th week post-conception.
Fetus - refers to the developing organism from 9th week post-conception to birth.
Neonatal - post-birth period.

Fertilization

Acrosome reaction: a regulated exocytotic event in which an apical vesicle (acrosome) in the sperm head fuses with the sperm's plasma membrane. The reaction is treiggered by "egg factors".
Capacitation: the process by which the sperm becomes capable of fertilizing an egg (ovum).
Concepsis - includes embryonic and extraembryonic tissue during the preimplantation period.
Fallopian tube: oviduct of the human, site of fertilization and initial cleavage divisions.
Ovum: female germ cell from ovary. Held in first meiotic prophase until ovulation
Polar body: There are aymmetrical meioses during egg maturation. The smaller "daughters" bear this name.

Sperm: male germ cell from testes. Has completed meiosis and is terminally differentiated at ejaculation.
Zona Pellucida: made by ovum and is composed of proteins and glycoproteins that are instrumental in preventing multiple sperm from entering egg.
Zygote: fertilized egg (ovum).

Cleavage period

Blastomeres: cells produced by cleavage divisions of the zygote.
Blastocyst: formed from the blastomeres. Has a central fluid-filled cavity (blastocoel) and is divided into outer trophoblasts and an inner cell mass.
Cleavage divisions: non-synchronous mitotic divisions following fertilization. No growth between cell division cycles. Result in cells (blastomeres) of approximately equal size.
Compaction: a key event at ~8cell stage when the blastomeres express cell adhesion molecules on their cell surface, become polarized and form a solid cluster.
Epiblast: The inner cell mass forms a two layered embryo. The epiblast is the top layer (facing the placenta) and gives rise to the embryo proper and the amniotic membrane.
Hypoblast: Bottom layer (facing the blastocoel) of the 2 layered embryo. Plays a role in establishing polarity but does not contribute cells to the embryo.
Inner cell mass: will give rise to the epiblast and hypoblast. Also called embryoblast in the text.
Trophoblasts: derived from the outer cells of the blastocyst, forms the embryonic/fetal component of the placenta**.**

Implantation

Amnioblasts: These cells differentiate from the epiblast at the end of the first week to form the amnioblast layer of the amniotic membrane.
Amnion: The amniotic cavity is filled with amniotic fluid, which provides protection and space for growth of the embryo and fetus.
Bilaminar germ disc: After the epiblast and hypoblast differentiate from each other in the embryoblast, the embryo is called a bilaminar (two-layered) germ disc.
Chorion: the outermost fetal membrane that surrounds the chorionic cavity. It is synonymous with "chorionic sac" and "chorionic plate" and consists of three kinds of tissues: syncytiotrophoblast, cytotrophoblast, and extraembryonic somatopleuric mesoderm and their derivatives.
Chorionic cavity: The chorionic cavity appears during the second week of development as vacuoles (see movie at Larsen web site).
Cytotrophoblast - enclose the blastocyst cavity and form the inner layer of placental villi.
Endometrium: The endometrium refers to the epithelial lining of the uterus into which the embryo implants.
Extraembryonic endoderm: This general term describes the lining of the primary and secondary yolk sacs.
Extraembryonic mesoderm: derived during gastrulation and forms the core of maturing placental villi.
Maternal sinusoids: Expanded maternal capillaries become connected to the trophoblastic lacunae to establish the uteroplacental circulation.

Stem villus: The stem villi are differentiations of the chorionic plate. On about day 11, they can be described as simple evaginations of the chorionic plate. By day 16 the primary stem villi acquire an innermost core of extraembryonic mesoderm (secondary stem villi). By day 21, extraembryonic mesoderm within the villus core, differentiates into blood vessels and blood cells within the yolk sac, connecting stalk and core of the secondary villi, thus converting the secondary stem villi into tertiary stem villi.
Syncytiotrophoblast: A highly invasive syncytium is produced by mitoses within cells of the cytotrophoblast on about day 6. This tissue grows by additions from this proliferating population of cytotrophoblastic cells and as implantation continues, the syncytiotrophoblast invests the entire blastocyst. The secretion of hydrolytic enzymes by the syncytiotrophoblast contributes to its invasive capacity. The trophoblastic lacunae form as cavities within the syncytiotrophoblast on about the 11th day of development and thus the syncytiotrophoblast eventually comes to line the tertiary stem villi that protrude into the maternal lakes formed by the trophoblastic lacunae.
Yolk sac: The primary yolk sac (primitive yolk sac or exocoelomic cavity) is formed by transformation of the blastocyst cavity as extraembryonic endoderm (also called Heuser's membrane) migrates out from the edge of the hypoblast to form an inner lining of the cytotrophoblast. This structure is pushed away after the formation of an outer lining of extraembryonic mesoderm and subsequent to a second wave of proliferation and migration of extraembryonic endoderm. This second transformation of the blastocyst cavity produces the secondary (definitive) yolk sac and results in degradation of the exocoelomic cavity after their breakup into exocoelomic vesicles.

Gastrulation

Chordamesoderm: axial (midline) mesoderm which gives rise to the notochord.
Competence: the ability to respond to an inductive signal. Once a competent cell responds to an inductive signal, it becomes specified.
Committed: the time point when a cell's fate to a particular lineage is fixed. This does not imply final phenotypic differentiation.
Germ layers: ectoderm, mesoderm and endoderm.
Hypoblast (anterior visceral endoderm) - signaling center for orientation of the primitive streak and for induction of anterior structures.
Induction: the change in a cell or tissues fate due to a signal from another tissue or cell.
Notochord: midline (axial) mesoderm.
Prechordal plate: a portion of axial mesoderm just cranial to the notochord, will give rise to mesoderm of the head and is also an important signaling center.
Primitive node: most anterior (cranial) aspect of the primitive streak with a role in inducing structures of the trunk.
Primitive streak: site of cell movements from epiblast to form other germ layers.