From Egg to Embryo Terminology

- **Pregnancy**
  - events that occur from fertilization until the infant is born
  - usually ~ **280 days or 36-40 weeks**
  - Can survive if born premature at **27-28 weeks** but lungs are not ready

- **Gestation period**: from the last menstrual period until birth

- **Conceptus**: the developing offspring (general term)

- **Embryo**: conceptus from fertilization through week 8
  - **Preembryo** – conceptus from fertilization until it is two weeks old

- **Fetus**: conceptus from week 9 through birth
Accomplishing Fertilization

- The oocyte is viable for 12 to 24 hours
- Sperm is viable 24 to 72 hours (up to 3 days)
- For fertilization to occur, coitus (sex/intercourse) must occur no more than:
  - Three days before ovulation
  - 24 hours after ovulation
- Fertilization: when a sperm fuses with an egg to form a zygote
Sperm Transport and Capacitation

- Fates of ejaculated sperm:
  - Most will not make it — only a few thousand or 100s will make it to the uterine tube where the oocyte is located

- Sperm must undergo **capacitation** before they can penetrate the oocyte
  - **Capacitation**: membranes become fragile so that the acrosomes can release enzymes to digest outer layer of the oocyte
Acrosomal Reaction and Sperm Penetration

- An ovulated oocyte is encapsulated by:
  - The corona radiata and zona pellucida

- Sperm binds to the zona pellucida and undergoes the **acrosomal reaction**
  - Enzymes (several) are released near the oocyte
  - Hundreds of acrosomes release their enzymes to digest the zona pellucida
  - Early bird does not catch the worm!

- Once a sperm makes contact with the oocyte’s membrane: The sperm bind to specific receptors and are taken up
1. Approach: Aided by enzymes on its surface, a sperm cell weaves its way past granulosa cells of the corona radiata.

2. Acrosomal reaction: Binding of the sperm to sperm-binding receptors in the zona pellucida causes the Ca²⁺ levels within the sperm to rise, triggering the acrosomal reaction. Acrosomal enzymes from many sperm digested holes through the zona pellucida, clearing a path to the oocyte membrane.


4. Fusion: The sperm and oocyte plasma membranes fuse, allowing sperm contents to enter the oocyte.

5. Block of polyspermy: Entry of the sperm's contents causes Ca²⁺ levels in the oocyte's cytoplasm to rise, triggering the cortical reaction (exocytosis of cortical granules). As a result, the zona pellucida hardens and the sperm receptors are clipped off (slow block to polyspermy).
Blocks to Polyspermy

- Only one sperm is allowed to penetrate the oocyte
- Two mechanisms ensure **monospermy** (single sperm fertilization)
  - **Fast block to polyspermy** – membrane depolarization prevents sperm from fusing with the oocyte membrane—brought about by waves of Ca++ released from the endoplasmic reticulum—stimulates the **cortical reaction** which releases granules containing ZIPs
  - **Slow block to polyspermy** – zonal inhibiting proteins (ZIPs): Destroy sperm receptors. Cause sperm already bound to receptors to detach
- **Polyspermy**- is rare; results in cell death
Completion of Meiosis II and Fertilization

- Upon entry of sperm, the secondary oocyte:
  - Completes meiosis II-forming mature ovum
  - Casts out the second polar body
- The ovum nucleus swells, and the two nuclei approach each other
- When fully swollen, the two nuclei are called pronuclei
- **Fertilization**: when the pronuclei come together ..... produces the **Zygote**
Events Immediately Following Sperm Penetration

- Sperm
- Extracellular space
- Second meiotic division of oocyte
- Second meiotic division of first polar body
- Detached sperm tail
- Sperm pronucleus
- Ovum nucleus
- Polar bodies
- Male pronucleus
- Mitotic spindle
- Centriole
- Female pronucleus
- Zygote
- Daughter cells
- Anaphase of first cleavage division
- Sperm and ovum chromosomes
Preembryonic Development

- Zygote is formed= single diploid cell
- The first cleavage produces two daughter cells called blastomeres
- Morula –”little mulberry” small ball stage the 16 or more cell stage (72 hours old)
- By the fourth or fifth day the form structure of 100 or so cells (blastocyst)
  - **Blastocyst** : a fluid-filled hollow sphere composed of:
    - A single layer of trophoblasts-will become the **placenta**
    - An inner cell mass- will become the **embryo proper**

- zygote > blastomere >> morula >> blastocyst
Cleavage: From Zygote to Blastocyst

- (a) Zygote (fertilized egg)
- (b) 4-cell stage 2 days
- (c) Morula (a solid ball of blastomeres) 3 days
- (d) Early blastocyst (Morula hollows out, fills with fluid, and “hatches” from the zona pellucida) 4 days
- (e) Implanting blastocyst (Consists of a sphere of trophoblast cells and an eccentric cell cluster called the inner cell mass) 7 days

- Fertilization (sperm meets and enters egg)
- Oocyte (egg)
- Uterine tube
- Sperm
- Ovary
- Ovulation
- Uterus
- Endometrium
- Cavity of uterus
- Blastocyst cavity
- Trophoblast
- Inner cell mass

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Implantation

- Begins **six to seven** days after ovulation
  - the trophoblasts adhere to a properly prepared endometrium
  - corresponds to the secretory phase
- The implanted blastocyst is covered over by endometrial cells
- Implantation is completed by the 12\textsuperscript{th} day after ovulation
Implantation of the Blastocyst

- Endometrium
- Uterine endometrial epithelium
- Inner cell mass
- Trophoblast
- Blastocyst cavity
- Lumen of uterus
Implantation of the Blastocyst

- Endometrial stroma with blood vessels and glands
- Syncytiotrophoblast
- Cytotrophoblast
- Inner cell mass (future embryo)
- Lumen of uterus
Implantation

- The **corpus luteum** is maintained by **human chorionic gonadotropin (hCG)** secreted by the trophoblasts.
- hCG prompts the corpus luteum to continue to secrete progesterone and estrogen—maintains the endothelium.
- **Chorion**: developed from trophoblasts after implantation, continues production of hCG- will develop into the placenta.
- Between the second and third month, the **placenta**:
  - Assumes the role of **progesterone and estrogen** production.
  - Is providing nutrients and removing wastes.
All pregnancy tests used today are antibody tests that detect hCG in a woman’s blood or urine.

You can get a false negative (testing too soon) but you cannot get a false positive!!
Effects of Pregnancy: Anatomical Changes

- Reproductive organs become engorged with blood
  - Chadwick’s Sign
    - Vagina develops a purplish hue
  - Breast enlarge & areolae darken
  - Pigmentation of facial skin may increase (chloasma)
    - Or Melasma; aka Pregnancy Mask
- Uterus expansion
- Relaxin causes pubic symphysis to relax to ease birth
Parturition (Birth): Initiation of Labor

- Rise in estrogen
  - Increases uterine oxytocin receptors
  - Promotes formation of gap junction between uterine smooth muscle cells
  - Negates progesterone’s stability influence
- Braxton Hicks contractions (false labor)
- Rise in fetal cell oxytocin production
  - Stimulates prostaglandin release
    - uterine contraction
    - Starts thinning (effacement) & softening of cervix > stimulates oxytocin by hypothalamus
Parturition (Birth): Stages of Labor

- Dilation stage
- Expulsion stage
- Placental stage
Parturition (Birth): Stages of Labor

- Dilation stage (longest stage)
  - Further thinning (effacement) & softening of cervix
  - Cervix dilates to ~ 10cm diameter
  - Uterine contractions 15-30 mins apart lasting 10-30 sec
  - Water breaks (amnion ruptures)
  - Engagement – infant head enters true pelvis
Parturition (Birth): Stages of Labor

- **Expulsion stage**
  - Full dilation to delivery of infant
  - Uterine contractions 2-3 mins apart lasting ~ 1min
  - Crowning – largest part of baby’s head distends vulva
    - Episiotomy done here to prevent tissue tearing
  - Remainder of baby’s body delivered
  - Umbilical cord clamped and cut
Parturition (Birth): Stages of Labor

- Placental stage
  - Delivery of placenta and attached membranes (afterbirth)
  - Within 30 mins after delivery of baby
  - Uterus contracts to cause placental detachment
Lactation

- **Colostrum**
  - Clear-Yellow solution rich in vitamin A, protein, minerals, and IgA antibodies
  - Is released the first 2–3 days
  - Is followed by true milk production
- Suckling initiates positive feedback
- Oxytocin causes letdown reflex
Breast Milk

- Advantages of breast milk for the infant
  - Fats and iron are better absorbed
  - Its amino acids are metabolized more efficiently than those of cow’s milk
  - Beneficial chemicals are present
    - IgA, other immunoglobulins, complement, lysozyme, interferon, and lactoperoxidase
  - Interleukins and prostaglandins are present, which prevent overzealous inflammatory responses
  - Its natural laxatives help cleanse the bowels
Assisted Reproductive Technology

- **Artificial Insemination (AI)**
  - Sperm are placed into uterus or cervix using artificial means

- **In vitro fertilization (IVF)**
  - Oocytes & sperm are incubated in culture dishes for several days, then embryos are transferred to uterus

- **Zygote intrafallopian transfer (ZIFT)**
  - Fertilized oocytes are transferred to uterine tubes

- **Gamete intrafallopian transfer (GIFT)**
  - Sperm and harvested oocyte are transferred together into the uterine tubes
Mechanisms of Contraception

<table>
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<tr>
<th>Male</th>
<th>Event</th>
<th>Female</th>
<th>Event</th>
<th>Technique</th>
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</thead>
<tbody>
<tr>
<td>Technique</td>
<td>Production of viable sperm</td>
<td>Production of primary oocytes</td>
<td>Combination birth control pill, patch, monthly injection, or vaginal ring</td>
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<tr>
<td>Vasectomy</td>
<td>Transport down the male duct system</td>
<td>Ovulation</td>
<td>Abstinence</td>
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<tr>
<td>Abstinence</td>
<td>Sperm deposited in the vagina</td>
<td>Capture of the oocyte by the uterine tube</td>
<td>Female condom</td>
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<tr>
<td>Condom</td>
<td>Sperm move through the female's reproductive tract</td>
<td>Transport down the uterine tube</td>
<td>Tubal ligation</td>
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<tr>
<td>Coitus interruptus (high failure rate)</td>
<td>Meeting of sperm and oocyte in uterine tube</td>
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<td>Spermicides, diaphragm, cervical cap, vaginal pouch, progestin only (implant or injection)</td>
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<td>Union of sperm and ovum</td>
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<td>Morning-after pill (MAP)</td>
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<td>Implantation of blastocyst in properly prepared endometrium</td>
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<td>Intrauterine device (IUD); progestin only (minipill, implant, or injection)</td>
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