Fertilization, Development, & Birth

No Reading Assignments:

However, much of the info., the images & videos shown can be found at:
http://biology.kenyon.edu/courses/biol114/Chap13/Chapter_13B.html

**Fertilization** = Union of egg and sperm to form a zygote.

- Sperm has a long journey through reproductive tract (from vagina, uterus, to fallopian tubes.
- Once at egg, sperm compete for entry.
- The egg is a fortress of barriers to sperm entry.
1. Fertilization

The egg is a fortress of barriers to sperm entry.

**Layers of the ovulated secondary oocyte (egg):**
1. **Corona radiata** = outermost layer of follicular cells.
2. **Zona pellucida (ZP)** = layer having receptors for sperm binding.
3. **Perivitalline space** = space above egg plasma membrane.
4. **Egg plasma membrane** = innermost layer directly over egg. This is place where egg & sperm fuse together.

**Acrosome** = cap of digestive enzymes on head of sperm.

**Acrosome Reaction** = reaction of sperm acrosome when binds to ZP of egg. Enzymes released from acrosome digest egg plasma membrane allowing sperm entry into cell.
Question?
Why can ONLY one sperm enter (fertilize) an egg?

Extra chromosome cause problems in zygote → spontaneous miscarriage

**Polyspermy** = When more than 1 sperm enters an egg. **BAD!**

There are 2 ways that polyspermy is prevented
Polyspermy = When more than 1 sperm enters an egg. BAD!

There are 2 ways that polyspermy is blocked:

1. Fast block = occurs within 2-3 sec of 1st sperm entering, change in egg plasma membrane electrical potential from -70 mV to +20 mV.

2. Slow block = occurs within 10 sec of 1st sperm entering.
   A. Fusion of sperm w/plasma membrane causes a calcium wave to spread through egg.

   B. Calcium wave triggers a cortical reaction = cortical granules released from egg causes water to fill perivitalline space. Water lifts ZP off egg and makes it stiff. No other sperm can enter now.
1. Fast Block to Polyspermy:

Before the addition of sperm, the potential difference across the egg cell membrane is about -70 mV.

Within 1–3 seconds after the fertilizing sperm enters the egg, the potential shifts in a positive direction.

= initiate the calcium wave

2. Slow Block: A. Calcium Wave
2. Slow Block: B. Cortical Reaction

Source: http://biology.kenyon.edu/courses/biol114/Chap13/Chapter_13B.html

[Diagram showing the process of the cortical reaction during fertilization.]
2. Development

Divided into 3 Classifications:
1. **Pre-embryonic period** = 1st week of development.

2. **Embryonic period** = 2nd week up to 2 months of development.

3. **Fetal period** = from months 3 – 9 of development.

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**Pre-embryonic period** = 1st week after single cell zygote created.

Single celled zygote differentiates into several cells:
2 cell → 4 cell → 8 cell → 16 cell (**Morula**) → **Blastocyst**

**Morula** = compact ball of ~16 cells.

**Blastocyst** = ball of cells that secretes hCG (& rescues CL).

separated into:
- a) **inner cell mass** (this will become the embryo)
- b) **trophoblast** (this will become the chorion)
Pre-embryonic period (1st week)

1. **Fertilization**
   - Egg nucleus + Sperm nucleus = Zygote

2. **Ovulation**
   - Egg travels through **uterine tube** to **amniotic sac**

3. **Cleavage**
   - Single celled zygote creates 2 cell, 4 cell, 8 cell, Morula (compact ball of ~16 cells), Blastocyst (ball of cells)

   - **Morula**
   - **Blastocyst**

4. **Implantation**
   - Amniochorionic fluid surrounds embryo/fetus

5. **Amnion** = Sac around embryo

- **Amnion fluid** = fluid surrounding embryo/fetus, held within amniotic sac

- **Chorion** = structure that becomes fetal placenta

- **Chorionic villi** = small projections that burrow into endometrium & become umbilical cord

- **Allantois** = becomes fetal blood vessels

- **Inner Cell Mass** (will become the embryo)

- **Trophoblast** (will become the chorion)

- **Chorion**

- **Amnion**

- **Umbilical Cord**

- **Placenta**
Pre-embryonic period (1st week)

**Implantation**

What is this? What does it become?

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>inner cell mass</td>
<td>trophoblast</td>
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</table>

**Question:** What are the 2 divisions of this blastocyst?
- A = inner cell mass
- B = trophoblast

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Embryonic period (2nd week to 2nd month)

**Week 2:**
- **Implantation** = embryo implants into endometrium by burrowing its chorionic villi into tissue.
- **Gastrulation** = embryonic tissues divide into 3 “germ layers”:
  1. **endoderm** = layer that becomes gastrointestinal & lungs.
  2. **mesoderm** = layer becomes skeleton, muscles, heart, blood vessels, urinary & reprod. system.
  3. **ectoderm** = layer becomes nervous system, skin, eyes, hair.
- Symptoms of pregnancy begin
- Blood test positive for hCG.
## Embryonic period (2nd week to 2nd month)

### Week 3:
- Miss period.
- Urine tests positive for hCG.
- Placenta well formed (attachment between endometrium & embryo)
- Placenta produces progesterone for remainder of pregnancy.
- **Allantois develops into umbilical cord.**

### Week 4:
Heart beats can be heard. Limb buds form. Cartilaginous skeleton.

### Week 8 (2 months & end of embryonic period):
Start to “show” pregnancy (embryo only 1½ inches! (____________)
Organ systems form.
Bony skeleton starts.
Nose, ears, fingers & toes.
Sex differentiation starts
Embryonic period (2nd week to 2nd month)

Fig. 8.4

Germ layers:
- Amniotic fluid
- embryo
- Yolk sac

Amniotic Fluid

Trophoblast

Chorionic villi

Chorion

Yolk sac

Umbilical cord

2 weeks

2 ½ weeks

3 weeks

5 weeks +

2 weeks

2 ½ weeks

3 weeks

5 weeks +

6 in, 6 oz

4 days

3 weeks

4 months

5 weeks

4 days

3 weeks

5 weeks

4 months
5 weeks

Actual embryo size

Fig. 8.2

The Fetus, Uterus & Placenta

Muscle layer of uterine wall
Uterine cavity
Lining of uterus (endometrium)
Amnion
Chorion
Placenta
Umbilical cord
Amniotic cavity filled with amniotic fluid
Mucus plug
Cervix
Vagina (birth canal)

Maternal blood collects
Umbilical vein
Umbilical arteries
Chorionic villi

Maternal endometrial vein
Maternal endometrial artery
Fetal period (3\textsuperscript{rd} to 9\textsuperscript{th} month)

Month 3 (end of 1\textsuperscript{st} trimester):
Best time to determine gender by \textit{ultrasound}. Uterus size of grapefruit.

Month 4 (start of 2\textsuperscript{nd} trimester):
Organ systems become more developed. Fetal movement felt.
Minimum time fetus needs to survive outside of womb (90\% survival @26 – 28 weeks).

Month 5:
Fetus covered by protective cheesy coating called \textit{vernix caseosa}.

Month 6 (end of 2\textsuperscript{nd} trimester):
Fetus covered by fine hairs called \textit{lanugo}. Mom’s breasts swell.
Fetal period (3rd to 9th month)

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Best time to determine gender by ultrasound. Uterus size of grapefruit.

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Month 6 (end of 2nd trimester):
Fetus covered by fine hairs called “lanugo”. Mom’s breasts swell.

Month 7 (start of 3rd trimester):
Male fetus testes descend into scrotal sac. Most organ systems fully formed. Eyes open. Fetus gains in size & weight. SO DOES MOM! She gets “striae” (stretch marks)

Month 8:
Baby’s body turns head down facing cervix. Baby gains ~1 lb /week.

Striae
= Stretch marks.
Effects of Placental Hormones on Mom:

The placenta actually makes several hormones that affect mother:

1. **Progesterone**
   - A) keeps uterus pregnancy-friendly.
   - B) suppresses mom’s immune system to ↓ chance it will attack fetus.

2. **Estrogen**
   - A) causes ↑ salt & water retention in mom.
   - B) this causes ↑ blood pressure. = hypertension.

3. **Peptide hormone** – causes insulin-resistance in mom (mom’s tissues take up less blood glucose and fetus diverts glucose to itself)
   - \( \text{Type 2 diabetes in pregnant women} \)
   - \( \text{g} \text{estational diabetes} \)
Effects of Placental Hormones on Mom:

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**Gestational hypertension** = high blood pressure in pregnant women due to high placental estrogen. May endanger mom – and BP drugs during pregnancy complicated.

**Gestational diabetes** = increased blood glucose in pregnant women due to placental peptide hormone. Can also cause problems.

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**Question:**
What is an ultrasound?

= sound waves emitted by device that bounce back from structures in uterus to produce a visible image.

Sonogram (ultrasound) at 4 ½ months
**Pre-natal testing** = genetic & other testing done on fetal cells to look for problems in development.

**Ex. A**) **Amniocentesis** = insert long needle (carefully!) into amniotic sac to withdraw fluid (and fetal cells) for analysis.

**Pre-natal testing** = genetic & other testing done on fetal cells to look for problems in development.

**Ex. B**) **Chorionic villi sampling** = insert catheter into vagina, cervix, uterus, and suctioning some chorionic villi (of placenta) for analysis.

*Safer but more expensive than amnio.*
Fetal period (3rd to 9th month)

Month 9 (end of 3rd trimester):
Fetus ready for birth
Fetus controls events of start of labor!

Events at Start of Labor:
> fetus releases cortisol (stress hormone) at losing room in uterus.
> fetal cortisol causes mom’s pituitary to release oxytocin.
> Oxytocin causes strong uterine contractions.
> Uterine contractions squeeze fetus more.
> Fetus releases more cortisol, causes more oxytocin release.
> Fetus head pressed against cervix, causes more oxytocin release.
> cycle repeats until fetus out!
**3. Birth**

**Parturition** = the process of giving birth.

**Has 3 stages:**

**Stage 1: (can last 1 – 20 hrs or more!)

- Baby’s head presses on cervix causing oxytocin release by mom’s brain.
- Uterine contractions push baby against cervix more.
- **Mucus plug** of cervix breaks free.
- Baby’s head enters cervix & amniotic sac ruptures (**water breaks**)
- Cervix dilates up to 10 cm
- **Epidural** can be given (catheter placed in spinal lumbar epidural space to give anesthetic).

\[
\text{to lessen pain of childbirth.}
\]

**Epidural**
3. Birth

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Stage 2:
- Baby is delivered (leaving out a lot of excitement in between here!)
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- **Episiotomy**, if needed, performed here.

**Stage 3:**
- Placenta expelled (afterbirth)
- **Uterine involution** starts (uterus returns to normal shape)
  
  [Breast feeding helps uterine involution – it causes oxytocin release & tightening of uterus!]

**Parturition** = the process of giving birth.
Parturition = the process of giving birth.

Dystocia = problems during birth.

Breech birth = baby is positioned upside down for birth (butt or feet first)

External cephalic version = doctor physically reaches in & turns baby’s body into right position (head down).
   > Can cause bleeding of mom that can lead to blood mixing w/fetus. (see Rh disease later)
Dystocia = problems during birth.

Sometimes, dystocia requires Cesarean section (C-section)
- Major surgery!
- Done if mom or baby’s life in danger.
- Risky for mom and baby.
- ↑ chance of mom’s blood mixing w/fetal blood. (see Rh disease later)

C-Section
### Pros and Cons of Breast Feeding:

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
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<tbody>
<tr>
<td>Breast milk has antibodies (protect)</td>
<td>Some babies allergic to milk</td>
</tr>
<tr>
<td>Lactation / nursing is energy expensive! (lose baby weight)</td>
<td>Only mom can do it, or else pump milk &amp; store.</td>
</tr>
<tr>
<td>Bonding mom &amp; baby</td>
<td>Time consuming</td>
</tr>
<tr>
<td>Helps uterine involution</td>
<td>Can inflame the nipples</td>
</tr>
<tr>
<td>Baby more healthy</td>
<td>Can develop mastitis (inflamed mammary glands &amp; need antibiotics)</td>
</tr>
<tr>
<td>Breast milk is FREE!</td>
<td>Can pass some diseases thru breast milk</td>
</tr>
<tr>
<td>↓ lifetime risk of breast cancer</td>
<td>If mom needs medication &amp; it passes thru Breast milk??</td>
</tr>
<tr>
<td>↓ lifetime risk of ovarian cancer</td>
<td>Public breast feeding still controversial</td>
</tr>
<tr>
<td>Nursing suppresses ovulation (not the best birth control though)</td>
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### Pros and Cons of Breast Feeding:

<table>
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<tr>
<td>uterine involution (nursing &amp; oxytocin release cause uterine contraction)</td>
<td>Big energy expenditure for mom (lactating mom's metabolism 4X normal).</td>
</tr>
<tr>
<td>Better nutrition &amp; antibodies for baby</td>
<td>Mom is the source of milk - stay close.</td>
</tr>
<tr>
<td>Free nutrition</td>
<td>(unless pumps milk into bottles)</td>
</tr>
<tr>
<td>Bonding experience</td>
<td>Mastitis = inflamed mammary tissues.</td>
</tr>
<tr>
<td>Breast tissue matures after pregnancy &amp; has ↓ risk breast cancer.</td>
<td>Mom needs good nutrition &amp; has to be careful about taking medication.</td>
</tr>
<tr>
<td>Lose weight because breastfeeding uses a lot energy.</td>
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Birth Defects:

Many!!!

**Spina bifida** = fetal spinal cord protrudes through back. Requires surgical repair.

**Ancephaly** = abnormal head & brain development.
- > serious disorder
- > usually leads to miscarriage.
Birth Defects: Many!!!

**Spina bifida** = fetal spinal cord protrudes through back. Requires surgical repair.

**Ancephaly** = abnormal head & brain development.
- > serious disorder
- > usually leads to **miscarriage**.

**Miscarriage** = body spontaneously aborts an embryo or fetus due to abnormalities. *Fact: approximately 33% of all pregnancies end in miscarriage (often before mom know’s she’s pregnant).*
Fetal Alcohol Syndrome

Mom drinks heavily regularly during pregnancy, especially during 1st trimester (organ developing)

Baby born w/ alcohol withdrawal, developmental delays, underweight, classic facial features (see pic above)

Rh incompatibility in pregnancy

Rh = an antigen on some red blood cells.

If Rh- woman pregnant from Rh+ man – 50% chance baby is Rh+

Risk of exposure of mom’s blood stream to fetal RBCs with Rh+ antigens.
(Ex. During miscarriage or tissue tearing during birth or C-section)
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If Rh- woman pregnant from Rh+ man – 50% chance baby is Rh+

Risk of exposure of mom’s blood stream to fetal RBCs with Rh+ antigens. (Ex. During miscarriage or tissue tearing during birth or C-section)

- **IF Baby’s blood cells (with Rh+) get into mom’s body**
  - Mom’s immune system would develop anti-Rh antibodies within 2 weeks of exposure.
  - During her **next pregnancy** if baby Rh+, maternal antibodies cross placenta
  - Maternal antibodies attack (hemolyze) fetal RBCs
  - “autoimmune hemolytic anemia” = immune destruction of RBCs in baby from mom’s antibodies

**Prevention:** Coomb’s test to confirm autoimmune hemolytic anemia in newborn

> If doctor suspects exposure to Rh+ blood in mom’s first pregnancy.
> Give injection of anti-Rh antibodies to mom
> antibodies destroy and fetal Rh+ fetal RBCs in mom’s Body BEFORE her immune system detects & makes own antibodies.