Lecture 15: Pregnancy

- Gestational Development
- Early development and the placenta
- Maternal/fetal conflict
- The Physiology of Pregnancy
- Pica eating
- Pregnancy Sickness
Exercise during Pregnancy and Miscarriage

![Graph showing frequency of miscarriage with exercise and non-exercise](chart)

Stages of Development

- Conceptus (morula & blastocyte)
- Embryo
- Fetus
- Embryogenesis
- Embryonic Phase
- Fetal Phase

Embryogenesis

- Conceptus (morula & blastocyte)
- First 14-16 days = formation of an embryo
- Histiotropic nutrition - relies on uterine secretions for oxygen and metabolic substrates
- Differentiation into embryonic (inner cell mass) and extra-embryonic tissue (trophoblast)
Implantation: Actions of Blastocyte

• (1) Blastocyte establishes physical and nutritional contact with maternal endometrium

Establishment of the Placenta

• Digestion of maternal tissue to release metabolic substrates
• Primary Decidualization Reaction

Implantation: Actions of Blastocyte

• (2) Trophoblast starts to produce HCG (Human Chorionic Gonadotrophin) to keep corpus luteum alive

Expression of HCG during human pregnancy

Species Differences in Placentas

- Human (discoid)
- Mouse, rabbit, bat
- Cat, seal, elephant, horse (zonary)
- Cow, sheep, giraffe (cotyledonal)
- Horse, whale, kangaroo (diffuse)
Embryonic Phase
*(Weeks 3-8)*

- Formation of basic body plan
- Development of all major organ systems

Fetal Phase
*(Weeks 9-38)*

- Growth and further development of body tissues and organs.
Corpus Luteum

- Produces increasing amounts of progesterone
- Helps maintain early pregnancy
- Synthesizes estrogen
- Important for production until 6-7 weeks of pregnancy
- If embryo can’t maintain hormone production often results in miscarriage at this time.

The Role of the Fetus

The Placenta - “baby side”

The Placenta - “mother side”

Human Haemomonochorial Placenta

- Extra-embryonic tissue, containing fetal blood vessels, penetrates deep into maternal tissue
Human Haemomonochorial Placenta - Terminal villus

- Tips of capillaries form tortuous loops -- slowing blood flow and allowing for exchange of metabolites with maternal blood.

Human Haemomonochorial Placenta

- Maternal spiral artery ejects blood into ‘maternal blood space’

Pregnancy Conflicts

Hamilton’s Rule

You are related to yourself by 100%, to your children your siblings and your parents by 50%, etc.
Pregnancy “Conflicts”

- Paternal genes will be selected to increase the transfer of nutrients to the fetus.
- Maternal genes will be selected to limit transfers in excess of some maternal optimum.

Monogenetic Mouse Embryos

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<thead>
<tr>
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<th>Embryo</th>
<th>Yolk Sac</th>
<th>Trophoblast</th>
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Supporting Evidence

- Trophoblast invades maternal endometrium and remolds the spiral arteries so they are unable to constrict.
  - Fetus gains access to mother’s arterial blood & mother can’t change nutrient content of blood.
  - Volume of blood reaching placenta not under maternal control.

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  - Placenta is able to release hormones directly into maternal circulation.
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  - Fetus gains access to mother’s arterial blood & mother can’t change nutrient content of blood
  - Volume of blood reaching placenta not under maternal control
  - Placenta is able to release hormones directly into maternal circulation
- High HCG levels

**Trend toward increased hormone production?**

*Increase in number of genes responsible for hormonal production in Humans*

- Increase from 1 \( \text{CG} \beta \) gene in Anthropoid Ancestor to \( \text{CG} \beta \) in human
- Increase from 1 \( \text{O} \)-linked sugar chain in Anthropoid Ancestor to \( \text{O} \)-linked sugar chain in human
- Increase from 1 CRE element in Ancestral \( \alpha \) promoter to 2 in human

**Hormonal Production in the Placenta**

- Estrogen
- Progesterone
- HCG (Human Chorionic Gonadotropin)
- HPL (Human Placental Lactogen)

**Fetoplacental Unit**

- Placenta converts androgens from the adrenal gland of the fetus (as well as the mother) into estrogen.

**Fetal Adrenal Glands**

- Fetal adrenal is the largest organ in the baby’s body (adult size) and produces 10 times the amount of hormones as an adult.

**Estrogens and the Fetoplacental Unit**

- Placenta converts androgens from the adrenal gland of the fetus (as well as the mother) into estrogen.
Estrogen & the Fetoplacental Unit

- Placenta converts androgens from the adrenal gland of the fetus (as well as the mother) into estrogen.
- Estrogen causes changes in the uterus, cervix, vagina and breasts and affects metabolism.

The Placenta: Progesterone

- Takes over progesterone production from the Corpus Luteum
- Levels are 10 times as high as before fertilization
- Keeps uterus from contracting

The Placenta: HCG

- Keeps Corpus Luteum from shrinking.
The Placenta: HCG

- Keeps Corpus Luteum from shrinking.
- Production rises steeply after implantation.

The Placenta: HPL (Human Placental Lactogen)

- Alters mother’s metabolism to make sugar and proteins more available to fetus.

The Placenta: HPL

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- Stimulates alveoli in mother’s breasts to develop and prepare for lactation.

Hormonal changes during Pregnancy

Species Differences in Pregnancy Hormones

Hominoid Pregnancy Hormones
Changes in the mother

Changes in Uterus

- Uterus grows to 500-1000 times in size
- New muscles fibers are produced.

Changes in Uterus

Changes in Skeleton

- Increased spinal curvature
- Loosening of joints

Changes in Skeleton

Digestive System

- Uterus pushes intestines & stomach up to the side
Digestive System

- Uterus pushes intestines & stomach up to the side
- Shift in stomach causes change in angle of esophagus—heartburn

- High progesterone-increased transit time

Urinary Tract Changes

- Kidneys process 50% increase in waste

- Slower transit time (smooth muscle slowed down by progesterone)

- Urinary Tract Infections

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- Urinary Tract Infections

- Compression of bladder
Changes during Pregnancy

- Gums may bleed — blood vessel stimulation caused by high estrogen

Heart Changes

- Heart works harder. Pulse increases by 10-15 beat/min

Lung Changes

- Lungs compressed

- Rib cage flares up and out

Changes during Pregnancy

- Gums may bleed — blood vessel stimulation caused by high estrogen

- Hemorrhoids and varicose veins may develop

Heart Changes

- Heart works harder. Pulse increases by 10-15 beat/min

- Total cardiac output increased by 30%

Lung Changes

- Lungs compressed
Lung Changes
- Lungs compressed
- Rib cage flares up and out
- Lungs bring in 40% more air.

Changes During Pregnancy
- Separation of rectus abdominus muscle (diastesis)

Immune System
- Placenta keeps baby’s cells from entering blood stream
- Progesterone slows down antibody production
- Baby produces surface repellent molecules that cross placenta and coat mother’s lymphocytes

Immune System
- Placenta keeps baby’s cells from entering blood stream

Breast Changes
- Increased engorgement caused by estrogen and progesterone
  - Tenderness
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- Size increase
- Alveoli increase
- Striae visible

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- Striae visible
- Areola darkens

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- Colostrum production
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<tr>
<th>The Vagina</th>
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<td>• Blood vessels in uterus, vagina and pelvic area enlarge and increase in number</td>
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<td>• Increases blood vessels and mucous glands</td>
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<td>• Formation of mucous plug</td>
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Changes in Sexuality

- Increased blood flow may result in increased sexual arousal
- May be more easily aroused
- May have multiple orgasms

Changes in Pigmentation

- High levels of melanocyte stimulating hormone
- Progesterone and estrogen stimulate pigment cells
- “Linea nigra”
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Changes in Blood Volume
- Blood volume increases by 50-100%

Changes in Blood Volume
- Blood volume increases by 50-100%
  - Fills blood reservoir of uterus
  - Protects baby from drop in b.p.
  - Prepare mother for childbirth
  - Estrogen causes increase in blood clotting factors
Sources of Weight Gain

Studies of Pregnancy Sickness (NVP, Nausea and Vomiting during Pregnancy)

Pregnancy Sickness and Hormonal Levels
- Higher levels of HCG associated with increased nausea, vomiting, food aversion and smell aversion
- HCG peaks at 8-10 weeks — parallels pregnancy sickness

Increased Estrogen/Decreased Progesterone ratio: Increased food avoidance, smell aversion
Pregnancy Sickness and Hormonal Levels

- Higher levels of HCG associated with increased nausea, vomiting, food aversion and smell aversion
- HCG peaks at 8-10 weeks — parallels pregnancy sickness
- Increased Estrogen/Decreased Progesterone ratio: Increased food avoidance, smell aversion
- Ratio not related to nausea or vomiting

Pregnancy Sickness Hypothesis

- Food aversions, nausea and vomiting of pregnancy sickness protect embryo against maternal ingestion of teratogens and abortifacients that are abundant in natural foods.

Pregnancy Sickness

- Foods that are safely ingested by adults contain compounds that induce fetal malformations

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- Pregnancy sickness begins when the embryo becomes vulnerable to toxins
- Olfactory system changes during pregnancy in ways that promote selective avoidance
- Women with pregnancy sickness have better pregnancy outcomes

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- Foods that are safely ingested by adults contain compounds that induce fetal malformations
- Women with pregnancy sickness avoid foods that emit cues associated with toxicity
- Pregnancy sickness begins when the embryo becomes vulnerable to toxins
- Olfactory system changes during pregnancy in ways that promote selective avoidance
- Pregnancy sickness is cross-cultural

Test of Profet Hypothesis

Does morning sickness protect the embryo by causing pregnant women to physically expel and subsequently avoid foods that contain teratogenic and abortifacient chemicals?

Test of Profet Hypothesis

- Symptoms peak when embryonic organogenesis is most susceptible to chemical disruption (weeks 6-18)
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- Women who experience morning sickness are significantly less likely to miscarry than women who do not (9 of 9 studies)
- Women who vomit suffer fewer miscarriages than those who experience nausea alone
- Many pregnant women have aversions to alcoholic and nonalcoholic (mostly caffeinated) beverages and strong-tasting vegetables, especially during the first trimester.

(Flaxman & Sherman, 2000)

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- Many pregnant women have aversions to alcoholic and nonalcoholic (mostly caffeinated) beverages and strong-tasting vegetables, especially during the first trimester.
- However, greatest aversions are to meat, fish, poultry and eggs.

(Flaxman & Sherman, 2000)

Cross-Cultural Survey of Morning Sickness Incidence

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<thead>
<tr>
<th>Number of Societies</th>
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<tr>
<td>NVP Observed</td>
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<td>NVP Never Observed</td>
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(Flaxman & Sherman, 2000)

Pregnancy Sickness and Avoidance of Food Borne Pathogens

- Pregnant women are immunosuppressed and thus more vulnerable to serious infections.
- Thus, pregnancy sickness evolved to avoid food borne parasites and pathogens that might be dangerous.
- Differs from Profet by (1) focusing on toxins in meat not teratogens in plants (2) avoidance of infection not birth defects

(Flaxman & Sherman, 2000)
Next Time…

- Energetics of pregnancy
- Birth
- Evolution of human birth
- Birth practices in other cultures