Pregnancy, Growth, and Development

**Pregnancy (gestation)** is the presence of a developing offspring in the uterus
- About 38-42 weeks (9 months) in length
- Divided into trimesters (about 3 months each)
- Called the ‘prenatal’ (before birth) stage of development

**Growth** is an increase in size. Involves increases in cell numbers (hyperplasia) and cell sizes (hypertrophy)

**Development** is the continuous process by which an individual changes from one life phase to another
- Prenatal (development in utero)
- Neonatal (first 28 days after birth)
- Postnatal (from birth until maturity)
- Aging and death
**Prenatal Terminology and Times**

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<th>Embryological (week 1 to 8)</th>
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**Date of conception** – add 14 days to the date of the onset of the last menstrual period

**Due Date** – add 266 days to the date of conception (about 280 days from the onset of the last menstrual period)

(Rule of thumb from onset of last menstrual period: Subtract 3 months from the month of the last period, then add 4 days unless pregnancy covers an entire month of February, then add 7 days)

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**Major Events in Each Trimester**

- **First trimester** (weeks 1-12)
  - Most critical period (most vulnerable to drugs, alcohol)
  - Embryological and early fetal development
  - Rudiments of all major organ systems appear
- **Second trimester** (weeks 13-24)
  - Development of organs and organ systems (almost complete by end of sixth month)
  - At end of trimester, fetus looks human
- **Third trimester** (weeks 25 to birth)
  - Rapid fetal growth
  - Deposition of adipose tissue
  - Major organ systems become functional
  - At 35 weeks (~2.5 Kg), fetus can usually survive if born early (twins typically born during this time)

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**Steps in Fertilization**

- Sperm cell reaches corona radiata of egg
- Acrosome releases enzymes
- Sperm cell penetrates zona pellucida
- Sperm cell’s membrane fuses with egg cell’s membrane

Fertilization by more than one sperm (polyspermy) is prevented by a fast block and a slow block.
Implantation

- begins about the 6th day of development
- trophoblast will help form the placenta
- trophoblast secretes hCG - suppresses menstruation by maintaining the corpus luteum

Summary of Stages and Events of Early Human Prenatal Development

- fertilized ovum
  - 12-24 hours after ovulation
  - zygote forms
- cleavage
  - 30 hours to third day
  - mitosis increases cell number
- morula
  - third to fourth day
  - solid ball of cells
- blastocyst
  - fifth day through second week
  - trophoblast and inner cell mass form
- gastrula
  - end of second week
  - primary germ layers form
Early Embryonic Stage

- Three primary germ layers form
- Gastrula stage
- Germ layers of embryonic disc
- 2 weeks (~2mm long)

Primary Germ Layers

- Ectoderm
- Mesoderm
- Endoderm

Changes During Embryonic Development

- 2 weeks (~2mm long)
- 5 weeks
Changes During Embryonic Development

End of eighth week marks end of embryological period

Embryonic Membranes

As amnion develops, it surrounds the embryo, and the umbilical cord begins to form from structures in the connecting stalk

Functions of the Placenta

<table>
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<tr>
<td>Nutritional roles</td>
<td>Transport nutrients such as glucose, amino acids, fatty acids, minerals, and vitamins from the maternal blood to the fetal blood</td>
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<tr>
<td>Excretory roles</td>
<td>Transport metabolic waste products such as urea, bilirubin, and excess water and minerals from the fetal blood to the maternal blood</td>
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<tr>
<td>Respiratory roles</td>
<td>Exchange of gases between maternal and fetal blood</td>
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<tr>
<td>Endocrine roles</td>
<td>Synthesis of hormones, such as estrogen, progesterone, relaxin, and human chorionic gonadotropin, and production of glucose for energy, and other hormones such as corticotropin-releasing factor, growth hormone, and adrenocorticotropic hormone, to regulate fetal growth and development</td>
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Mnemonic for placental functions: 
IRENE

Immune
Respiratory
Endocrine
Nutritional
Excretory

Table from: Saladin, Anatomy & Physiology, McGraw Hill, 2007
Placenta

Placental membrane consists of:
- epithelial wall of an embryonic capillary
- epithelial wall of a chorionic villus

Placenta at Seventh Week

Consists of an embryonic portion and a maternal portion

Overview of Fetal Circulation

Gases and nutrients are exchanged with the fetus through the placenta.

Breathing and digestion are carried out by the mother for the fetus.

Besides the umbilical vessels, the major differences in fetal circulation are due to the fact that:
1. Fetal lungs are collapsed; fetus is not breathing air
2. There is nothing to digest; fetus is not eating
1. Foramen ovale – allows blood returning to right atrium to bypass right ventricle and pass directly into left atrium (then to left ventricle, then aorta)
2. Ductus arteriosus – allows blood from right ventricle to bypass pulmonary trunk and pass directly into the aorta

1. Ductus venosus – allows about 50% of blood returning to fetus through the umbilical vein to bypass the liver and empty directly into the inferior vena cava (then back to right atrium of heart)
Hormonal Changes During Pregnancy

Mechanism that preserves uterine lining during early pregnancy

- Placental cells secrete hCG
- hCG maintains corpus luteum
- Corpus luteum continues to secrete estrogen and progesterone
- Estrogen and progesterone promote growth, development, and maintenance of uterine wall

hCG helps prevent spontaneous abortion

Relative concentrations of three hormones in maternal blood during pregnancy

- Secreted mainly by placenta after about 12 weeks
### Hormonal Changes During Pregnancy

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### The Fetus and Mother at Term

- Figure from: Martini, *Anatomy & Physiology*, Prentice Hall, 2001

Factors Contributing to Onset of Labor

• as birth approaches, progesterone levels decrease (allowing increase in uterine contractions); estradiol continues to rise
• prostaglandins synthesized which may initiate labor
• stretching uterine tissue stimulates release of oxytocin
• oxytocin stimulates uterine contractions
• fetal head stretches uterus, cervix, vagina, and vulva
• positive feedback results in stronger and stronger contractions and greater release of oxytocin

Birth Process

A positive feedback mechanism propels the birth process

Stages of Labor

Parturition = process of giving birth

Stages of labor:
1. Dilation
2. Expulsion
3. Placental

Normal position of fetus just prior to delivery (cephalic, vertex presentation)
Breech presentation is bottom first
Stages in Birth

• **dilation (1st) stage**
  - onset of true labor
  - variable in length (8 hrs. or more)
  - contraction up to ½ minute every 10-30 min
  - Rupture of amniotic membrane (“water breaks”) late in process

Cervix dilates and effaces, and fetus begins moving toward cervical canal

Figure from: Martini, Anatomy & Physiology, Prentice Hall, 2001

Stages in Birth

• **expulsion (2nd) stage**
  - usually less than 2 hrs
  - contractions at max intensity (lasting for 1 min, every 2-3 min)

Cervix is pushed open by approaching fetus (positive feedback cycle) and baby’s head enters vagina

Figure from: Martini, Anatomy & Physiology, Prentice Hall, 2001

Stages in Birth

• **placental (3rd) stage**
  - afterbirth
  - usually within an hour after delivery

Figure from: Martini, Anatomy & Physiology, Prentice Hall, 2001
**Milk Production**

- placental estrogens and progesterone stimulate further breast development
- estrogens cause ductile system to grow
- progesterone causes alveolar glands to develop
- placental lactogen (HCS) also produces changes in breast
  - prolactin is released about the 5th week of pregnancy
  - milk production does not begin until after birth

**Milk-Letdown Reflex**

Recall that oxytocin (OT) is a stimulus for smooth muscle contraction and is secreted by the neurohypophysis

OT stimulates myoepithelial cells in the walls of the lactiferous ducts and sinuses

Know this pathway

**Ejection of Milk**

- Nipple or areola of breast is mechanically stimulated
- Nerve impulses travel to hypothalamus
- Hypothalamus signals posterior lobe of pituitary gland to release oxytocin
- Oxytocin causes myoepithelial cells surrounding alveolar glands to contract
- Milk is ejected from ductile system through nipple
Human Colostrum, Breast Milk, and Cow’s Milk

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Human Colostrum</th>
<th>Human Milk</th>
<th>Cow’s Milk</th>
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<tr>
<td>Total Protein (g/L)</td>
<td>22.9</td>
<td>10.6</td>
<td>30.9</td>
</tr>
<tr>
<td>Lactalbumin (g/L)</td>
<td>3.7</td>
<td>25.0</td>
<td></td>
</tr>
<tr>
<td>Casein (g/L)</td>
<td>3.6</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Immunoglobulins (g/L)</td>
<td>16.4</td>
<td>0.19</td>
<td>0.6</td>
</tr>
<tr>
<td>Fats (g/L)</td>
<td>20.0</td>
<td>15.1</td>
<td>35.0</td>
</tr>
<tr>
<td>Lactose (g/L)</td>
<td>57</td>
<td>71</td>
<td>47</td>
</tr>
<tr>
<td>Calcium (mg/L)</td>
<td>641</td>
<td>344</td>
<td>1370</td>
</tr>
<tr>
<td>Phosphorus (mg/L)</td>
<td>103</td>
<td>141</td>
<td>910</td>
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*Colostrum data are for the first day postpartum, and human milk data are for "mature milk" at about 55 days postpartum.

Postnatal Period

Neonatal period
- birth to end of 6th week
- newborn begins to carry on respiration, obtain nutrients
- ingest nutrients, excrete wastes, regulate body temperature, and make cardiovascular adjustments

Infancy
- 5th week to one year
- growth rate is high
- teeth begin to erupt
- muscular and nervous systems mature
- communication begins

First 6 weeks postpartum = puerperium (return of mother to normal physiology)

Childhood
- one year to puberty
- growth rate is high
- permanent teeth appear
- muscular control is achieved
- bladder and bowel controls are established
- intellectual abilities mature

Adolescence
- puberty to adulthood
- person becomes reproductively functional and emotionally more mature
- growth spurts occur
- motor skills continue to develop
- intellectual abilities continue to mature
Postnatal Period

Adulthood
- adolescence to old age
- person remains relatively unchanged anatomically and physiologically
- degenerative changes begin

Senescence
- old age to death
- degenerative changes continue
- body becomes less able to cope with demands placed on it
- death results from various conditions and diseases

THE END!!!!

Review

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Know this slide and the terms on it.

- Postnatal (from birth until maturity)
- Neonatal (first 28 days after birth)
- Infancy (end of 4th week to one year)
- Childhood (1 year of age to puberty)
- Adolescence (puberty to adulthood)
- Senescence (decline of sex hormones; old age to death)
Review

• First trimester
  – Critical period (most vulnerable)
  – Embryological and early fetal development
  – Rudiments of all major organ systems appear

• Second trimester
  – Development of organs and organ systems (almost complete by end of sixth month)
  – At end of trimester, fetus looks human

• Third trimester
  – Rapid fetal growth
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