Pregnancy and Human Development
Dr. Gary Mumaugh

From Egg to Embryo
- Pregnancy – events that occur from fertilization until the infant is born
- Conceptus – the developing offspring
- Gestation period – from the last menstrual period until birth
- Preembryo – conceptus from fertilization until it is two weeks old
- Embryo – conceptus during the third through the eighth week
- Fetus – conceptus from the ninth week through birth

Relative Size of Human Conceptus

Accomplishing Fertilization
- The oocyte is viable for 12 to 24 hours
- Sperm is viable 24 to 72 hours
- For fertilization to occur, coitus 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
- Fates of ejaculated sperm
  - Leak out of the vagina immediately after deposition
  - Destroyed by the acidic vaginal environment
  - Fail to make it through the cervix
  - Dispersed in the uterine cavity or destroyed by phagocytic leukocytes
  - Reach the uterine tubes
Implantation

- Begins six to seven days after ovulation when the trophoblasts adhere to a properly prepared endometrium
- The trophoblasts then proliferate and form two distinct layers
- Implantation is completed by the fourteenth day after ovulation

Placentation

- The placenta is fully formed and functional by the end of the third month
- The placenta also secretes other hormones
  - Human placental lactogen, human chorionic thyrotropin, and relaxin

Primary Germ Layers

- Serve as primitive tissues from which all body organs will derive
- Ectoderm – forms structures of the nervous system and skin epidermis
- Endoderm – forms epithelial linings of the digestive, respiratory, and urogenital systems
- Mesoderm – forms all other tissues
- Endoderm and ectoderm are securely joined and are considered epithelia

Organogenesis

- By the 8th week all organ systems are recognizable

Development of Fetal Circulation

- By the end of the 3rd week:
  - The embryo has a system of paired vessels
  - The vessels forming the heart have fused
Unique vascular modifications seen in prenatal development include umbilical arteries and veins, and three vascular shunts (occluded at birth)
- Ductus venosus – venous shunt that bypasses the liver
- Foramen ovale – opening in the interatrial septa to bypass pulmonary circulation
- Ductus arteriosus – transfers blood from the right ventricle to the aorta

Effects of Pregnancy: Anatomical Changes
- Chadwick’s sign – the vagina develops a purplish hue
- Breasts enlarge and their areolae darken
- The uterus expands, occupying most of the abdominal cavity
- Lordosis is common due to the change of the body’s center of gravity
- Relaxin causes pelvic ligaments and the pubic symphysis to relax
- Typical weight gain is about 29 pounds
- Relative Uterus Size During Pregnancy
Effects of Pregnancy: Metabolic Changes
- The placenta secretes human placental lactogen (hPL), also called human chorionic somatomammotropin (hCS), which stimulates the maturation of the breasts
- hPL promotes growth of the fetus and exerts a maternal glucose-sparing effect
- Human chorionic thyrotropin (hCT) increases maternal metabolism
- Parathyroid hormone levels are high, ensuring a positive calcium balance

Effects of Pregnancy: Physiological Changes
- GI tract – morning sickness occurs due to elevated levels of estrogen and progesterone
- Urinary system – urine production increases to handle the additional fetal wastes
- Respiratory system – edematous and nasal congestion may occur
- Dyspnea (difficult breathing) may develop late in pregnancy
- Cardiovascular system – blood volume increases 25-40%
  - Venous pressure from lower limbs is impaired, resulting in varicose veins

Parturition: Initiation of Labor
- Estrogen reaches a peak during the last weeks of pregnancy causing myometrial weakness and irritability
- Weak Braxton Hicks contractions may take place
- As birth nears, oxytocin and prostaglandins cause uterine contractions
- Emotional and physical stress:
  - Activates the hypothalamus
  - Sets up a positive feedback mechanism, releasing more oxytocin
Stages of Labor: Dilation Stage
- From the onset of labor until the cervix is fully dilated (10 cm)
- Initial contractions are 15–30 minutes apart and 10–30 seconds in duration
- The cervix effaces and dilates
- The amnion ruptures, releasing amniotic fluid (breaking of the water)
- Engagement occurs as the infant’s head enters the true pelvis

Stages of Labor: Expulsion Stage
- From full dilation to delivery of the infant
- Strong contractions occur every 2–3 minutes and last about 1 minute
- The urge to push increases in labor without local anesthesia
- Crowning occurs when the largest dimension of the head is distending the vulva
- The delivery of the placenta is accomplished within 30 minutes of birth
- Afterbirth – the placenta and its attached fetal membranes
- All placenta fragments must be removed to prevent postpartum bleeding

Extrauterine Life
- At 1-5 minutes after birth, the infant’s physical status is assessed based on five signs: heart rate, respiration, color, muscle tone, and reflexes
- Each observation is given a score of 0 to 2
- Apgar score – the total score of the above assessments
  - 8-10 indicates a healthy baby - Lower scores reveal problems
### APGAR SCORING SYSTEM

<table>
<thead>
<tr>
<th></th>
<th>0 Points</th>
<th>1 Point</th>
<th>2 Points</th>
<th>Points totaled</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity</strong></td>
<td>Absent</td>
<td>Arms and legs</td>
<td>Active movement</td>
<td></td>
</tr>
<tr>
<td>(muscle tone)</td>
<td></td>
<td>flexed</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pulse</strong></td>
<td>Absent</td>
<td>Below 100 bpm</td>
<td>Over 100 bpm</td>
<td></td>
</tr>
<tr>
<td><strong>Grinace</strong></td>
<td>Flaccid</td>
<td>Some flexion of</td>
<td>Active motion (sneeze, cough,</td>
<td></td>
</tr>
<tr>
<td>(reflex irritability)</td>
<td></td>
<td>Extremities</td>
<td>pull away)</td>
<td></td>
</tr>
<tr>
<td><strong>Appearance</strong></td>
<td>Blue, pale</td>
<td>Body pink,</td>
<td>Completely pink</td>
<td></td>
</tr>
<tr>
<td>(skin color)</td>
<td></td>
<td>Extremities blue</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Respiration</strong></td>
<td>Absent</td>
<td>Slow, irregular</td>
<td>Vigorous cry</td>
<td></td>
</tr>
</tbody>
</table>

- **Severely depressed** 0-3
- **Moderately depressed** 4-6
- **Excellent condition** 7-10

The Apgar score rates:

- Respiration, crying
- Reflexes, irritability
- Pulse, heart rate
- Skin color of body and extremities
- Muscle tone
**First Breath**
- Once carbon dioxide is no longer removed by the placenta, central acidosis occurs
- This excites the respiratory centers to trigger the first inspiration
- This requires tremendous effort – airways are tiny and the lungs are collapsed
- Once the lungs inflate, surfactant in alveolar fluid helps reduce surface tension

**Transitional Period**
- Unstable period lasting 6-8 hours after birth
- The first 30 minutes the baby is alert and active
  - Heart rate increases (120-160 beats/min.)
  - Respiration is rapid and irregular
  - Temperature falls
- Activity then diminishes and the infant sleeps about three hours
- A second active stage follows in which the baby regurgitates mucus and debris
- After this, the infant sleeps, with waking periods occurring every 3-4 hours

**Lactation**
- The production of milk by the mammary glands
- Estrogens, progesterone, and lactogen stimulate the hypothalamus to release prolactin-releasing hormone (PRH)
- The anterior pituitary responds by releasing prolactin
- Colostrum
  - Solution rich in vitamin A, protein, minerals, and IgA antibodies
  - Is released the first 2–3 days
  - Is followed by true milk production

**Lactation and Milk Let-down Reflex**
- After birth, milk production is stimulated by the sucking infant
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 of meconium

Prenatal Stages
- Germinal period: Days 1-14
  - Implantation: One-half are successful
  - Miscarriage: 15% to 50%
- Embryonic period: 3rd to 8th week
  - Organogenesis, Sexual differentiation
  - Brain development starts at 3-4 weeks
- Fetal period: 9th week – birth
  - Proliferation, Migration
  - Ends in tremendous brain development
  - Age of viability at 23 weeks (5 ½ months)

Stages of Life
Infancy
- From the end of the 4th week to one year
- The growth rate is high
- The teeth begin to erupt
- The muscular and nervous systems mature
- Communication begins
Childhood
- From one year to puberty
- The growth rate is high
- Permanent teeth appear
- Muscular control is achieved
- Bladder and bowel controls are established
- Intellectual abilities mature

Adolescence
- From puberty to adulthood
- The person becomes reproductively functional and emotionally more mature
- Growth spurts occur
- Motor skills continue to develop
- Intellectual abilities continue to mature

Adulthood
- Adolescence to old age
- The person remains relatively unchanged anatomically and physiologically
- Degenerative changes begin

Senescence
- Old age to death
- Degenerative changes continue
- The body becomes less able to cope with the demands placed on it
- Death results from various conditions and diseases
### Table 23.10 | Aging-Related Changes

<table>
<thead>
<tr>
<th>Organ System</th>
<th>Aging-Related Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integumentary</td>
<td>Degenerative loss of collagenous and elastic fibers in dermis; decreased production of pigment in hair follicles; reduced activity of sweat and sebaceous glands; skin thins, wrinkles, and dries out; hair turns gray and then white</td>
</tr>
<tr>
<td>Skeletal system</td>
<td>Degenerative loss of bone matrix; bones become thinner, less dense, and more likely to fracture; stature may shorten due to compression of intervertebral discs and vertebrae</td>
</tr>
<tr>
<td>Muscular system</td>
<td>Loss of skeletal muscle fibers; degenerative changes in neuromuscular junctions; loss of muscular strength</td>
</tr>
<tr>
<td>Nervous system</td>
<td>Degenerative changes in neurons; loss of dendrites and synaptic connections; accumulation of lipofuscin in neurons; decreases in sensation; decreasing efficiency in processing and recalling information; decreasing ability to communicate; diminished senses of smell and taste; loss of elasticity of lenses and consequent loss of ability to accommodate for close vision</td>
</tr>
<tr>
<td>Endocrine system</td>
<td>Reduced hormonal secretions; decreased metabolic rate; reduced ability to cope with stress; reduced ability to maintain homeostasis</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>Degenerative changes in cardiac muscle; decrease in lumen diameters of arteries and arterioles; decreased cardiac output; increased resistance to blood flow; increased blood pressure</td>
</tr>
<tr>
<td>Lymphatic system</td>
<td>Decrease in efficiency of immune system; increased incidence of infections and neoplastic diseases; increased incidence of autoimmune diseases</td>
</tr>
<tr>
<td>Digestive system</td>
<td>Decreased motility in gastrointestinal tract; reduced secretion of digestive juices; reduced efficiency of digestion</td>
</tr>
<tr>
<td>Respiratory system</td>
<td>Degenerative loss of elastic fibers in lungs; fewer alveoli; reduced vital capacity; increase in dead air space; reduced ability to clear airways by coughing</td>
</tr>
<tr>
<td>Urinary system</td>
<td>Degenerative changes in kidneys; fewer functional nephrons; reductions in filtration rate, tubular secretion, and tubular reabsorption</td>
</tr>
</tbody>
</table>
| Reproductive systems | Male
                       | Reduced secretion of sex hormones; enlargement of prostate gland; decrease in sexual energy                                                                                                                          |
|                   | Female
                       | Degenerative changes in ovaries; decrease in secretion of sex hormones; menopause; regression of secondary sex characteristics                                                                               |

### Table 23.11 | The Ten Leading Causes of Death in the United States, 2004

<table>
<thead>
<tr>
<th>Cause</th>
<th>% of total 2,397,615 deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Heart disease</td>
<td>27.2</td>
</tr>
<tr>
<td>2. Cancer</td>
<td>23.1</td>
</tr>
<tr>
<td>3. Stroke</td>
<td>6.2</td>
</tr>
<tr>
<td>4. Chronic obstructive pulmonary disease (COPD)</td>
<td>0.5</td>
</tr>
<tr>
<td>5. Injuries</td>
<td>0.4</td>
</tr>
<tr>
<td>6. Diabetes mellitus</td>
<td>0.3</td>
</tr>
<tr>
<td>7. Alzheimer disease</td>
<td>0.3</td>
</tr>
<tr>
<td>8. Influenza and pneumonia</td>
<td>0.2</td>
</tr>
<tr>
<td>9. Kidney disease</td>
<td>0.2</td>
</tr>
<tr>
<td>10. Infection (septicemia)</td>
<td>0.1</td>
</tr>
</tbody>
</table>
**Teratogen**

- Any disease, drug or environmental agent that can harm a developing fetus
- 15% of newborns have minor problems
- 5% of newborns have significant problems
- Generalizations about the effects of teratogens
  - Critical period is worse in organogenesis
  - Dosage and duration
  - Genetic make-up of mom determines susceptibility

![Figure 4.5 The critical periods of prenatal development. Each organ or structure has a critical period when it is most sensitive to damage from teratogens. Dark band indicates the most sensitive periods. Light band indicates the time that each organ or structure is somewhat less sensitive to teratogens, although damage may still occur. ADAPTED FROM MOORE & PERSAUD, 1993.](image-url)
Teratogens: Drugs
- Thalidomide
  - For morning sickness in the 1950s
  - All or parts of limbs missing
- Tobacco
  - Miscarriage, low birth weight, SIDS, slows fetal growth
- Alcohol: FAS
  - Small, facial deformities, retardation
- Cocaine
  - Processing difficulties

Teratogens - Diseases
- Rubella (German Measles)
  - Blind, deaf, heart, brain
- Syphilis
  - Miscarriage, blind, deaf, heart, brain
- AIDS: Mothers transmit to babies
  - Without treatment 15%-35% of infected babies will become HIV positive
  - Even those infected, 75% are alive at age 5

Teratogens: Environmental Hazards
- Radiation
  - MR, leukemia, cancer, mutations, spontaneous abortions, etc.
  - Avoid X-rays when pregnant
- Pollutants
  - In air and water
  - Lead: MR (also postnatally)
    - 1 in 4 children live in homes with lead paint
- One estimate is that there are 70,000 synthetic chemicals are available for exposure, and only 20% have been tested for toxicity
<table>
<thead>
<tr>
<th>Other Maternal Conditions or Diseases</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken pox</td>
<td>Chicken pox can cause spontaneous abortion, premature delivery, and slow growth, although fewer than 2% of exposed fetuses develop limb, facial, or skeletal malformations.</td>
</tr>
<tr>
<td>Cytomegalovirus</td>
<td>This common infection shows mild flu-like symptoms in adults. About 25% of infected newborns develop hearing or vision loss, mental retardation, or other impairments, and 10% develop severe neurological problems or even die.</td>
</tr>
<tr>
<td>Influenza (flu)</td>
<td>The more powerful strains can cause spontaneous abortions or neural abnormalities early in pregnancy.</td>
</tr>
<tr>
<td>Rubella</td>
<td>Rubella may cause vision and hearing loss, mental retardation, heart defects, cerebral palsy, and microcephaly (see main text).</td>
</tr>
<tr>
<td>Toxemia</td>
<td>Affecting about 5% of mothers in the third trimester, its mildest form, preeclampsia, causes high blood pressure and rapid weight gain in the mother. Untreated, preeclampsia may become eclampsia and cause maternal convulsions, coma, and death of the mother, the unborn child, or both. Surviving infants may be brain damaged.</td>
</tr>
<tr>
<td>Toxoplasmosis</td>
<td>This illness, caused by a parasite in raw meat and cat feces, leads to blindness, deafness, and mental retardation in approximately 40% of infants born to infected mothers.</td>
</tr>
<tr>
<td>DRUG</td>
<td>EFFECTS</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Alcohol</td>
<td>Results include a small head, facial abnormalities, heart defects, low birth weight, and intellectual retardation (see main text).</td>
</tr>
<tr>
<td>Antiepileptic drugs</td>
<td>Drugs such as Dilantin, Luminal, and Teqretol, used to treat seizures, increase the incidence of cleft lip and palate, neural tube defects, kidney disease and restricted growth (Kothare &amp; Kaleyias, 2007).</td>
</tr>
<tr>
<td>Aspirin and nonsteroidal and anti-inflammatory drugs</td>
<td>An occasional low dose is OK, but used in large quantities, such drugs may cause neonatal bleeding and anti-inflammatory drugs gastrointestinal discomfort. Large amounts of these over-the-counter pain killers (e.g., Advil) have been associated with low birth weight and increased risk of miscarriage (Li, Liu, &amp; Odouli, 2003).</td>
</tr>
<tr>
<td>Chemotherapy drugs</td>
<td>Such drugs cross the placenta and attack rapidly dividing cells. They can increase malformations and lead to miscarriage.</td>
</tr>
<tr>
<td>Marijuana</td>
<td>Heavy use of marijuana has been linked to premature birth, low birth weight, and mild behavioral abnormalities such as irritability at birth.</td>
</tr>
<tr>
<td>Narcotics</td>
<td>Addiction to heroin, codeine, methadone, or morphine increases the risk of premature delivery and low birth weight. The newborn is often addicted and experiences potentially fatal withdrawal symptoms (e.g., vomiting and convulsions). Longer-term cognitive deficits are sometimes evident.</td>
</tr>
<tr>
<td>Sex hormones</td>
<td>Birth control pills containing female hormones have been known to produce heart defects and cardiovascular problems, but today’s pill formulas are safer. Progesterone in drugs used to prevent miscarriage may masculinize the fetus. Diethylstilbestrol, once prescribed to prevent miscarriage, increased the risk of cervical cancer and created infertility and pregnancy problems in exposed daughters (DESAAction, 2007; Kaufman et al., 2000).</td>
</tr>
<tr>
<td>Stimulants</td>
<td>Heavy caffeine use has been linked to miscarriages, higher heart rates, and abnormal reflexes and irritability at birth, but it does not seem to have long-lasting effects on development (Barr &amp; Streissguth, 1991). Cocaine use can cause premature delivery, spontaneous abortion, and low birth weight, and it may result in later learning and behavioral problems (see main text). Amphetamine use has been linked to aggressive behavior and low school achievement (Billing et al., 1994).</td>
</tr>
<tr>
<td>Tobacco</td>
<td>Babies of smokers tend to be small and premature, have respiratory problems, and sometimes show intellectual deficits or behavioral problems later in development (see main text). Sons whose mothers smoked during their pregnancy may later have fertility problems (Storgaard et al., 2003). Secondhand smoke in the pregnant woman’s environment can increase her risk of miscarriage (George et al., 2006).</td>
</tr>
</tbody>
</table>