Prenatal Development: Three Stages

- **Germinal stage**
  - Zygote
- **Embryonic stage**
  - Embryo
- **Fetal stage**
  - Fetus

**Principles of development:**
- Cephalocaudal*
- Proximodistal*

- Germinal stage: first 2 weeks after fertilization.
- Embryonic stage: from about 2 weeks to 8 weeks. Organs and major body systems develop rapidly.
- Fetal: 8 weeks to final stage of gestation.
- Cephalocaudal: dictates that development proceeds from the head to the lower part of the trunk.
- Proximodistal: development proceeds from parts near the center of the body to the outer ones. Example: head and trunk develop before the limbs and the arms and legs, before the fingers and the toes.
Germinal Stage

- Fertilization to 2 weeks
- Zygote divides
  - Mitosis
  - Within 24 hours, 64 cells
  - Travels down the fallopian tube, approximately 3 – 4 days
  - Changes to a blastocyst
  - Cell differentiation begins
    - Embryonic disk
      - Differentiates into two layers
        » Ectoderm: outer layer of skin, nails, hair, teeth, sensory organs, nervous system, including brain and spinal cord
        » Endoderm: digestive system, liver, pancreas, salivary glands, respiratory system
      - Later a middle layer, mesoderm, will develop into skin, muscles, skeleton, excretory and circulatory systems
    - Implants about the 6\textsuperscript{th} day after fertilization
    - Only 10% - 20% of fertilized ova complete the task of implantation
- 800 billion or more specialized cells that make up the human body.
- the zygote divides and becomes more complex and is implanted in the wall of the uterus. Within 36 hours after fertilization, the zygote enters a period of rapid cell division and duplication= mitosis
- Blastocyst: fluid filled sphere, which floats freely in the uterus until the 6\textsuperscript{th} day after fertilization.
- Embryonic disk: is a thickened cell mass in which the embryo begins to develop.
Germinal Stage (cont)

• Blastocyst begins to develop into organs that will nurture and protect:
  – Amniotic cavity or Amniotic sac, with its outer layers, amnion and chorion, the placenta and umbilical cord.
  – Placenta allows oxygen, nourishment, and wastes to pass between mother and baby
    • Maternal and embryonic tissue
    • Placenta filters some infections
    • Produces hormones
      – To support pregnancy
      – Prepares mother’s breasts for lactation
      – Signals contractions for labor
  – Umbilical cord is connected to embryo
    • Mother’s circulatory system not directly connected to embryo system, no blood transfers

Amniotic sac is a fluid filled membrane that encases the developing baby, giving it room to move.
Embryonic Stage: 2 – 8 weeks

• Second stage of gestation
• Organs and major body systems develop rapidly
  – Respiratory, digestive, nervous
  – Critical period!*
    • Embryo most vulnerable to destructive influences in prenatal environment
Embryonic Stage (cont)

• Most severely defective embryos usually do not survive beyond first trimester
  – 3-month period

• Spontaneous abortion (miscarriage) occurs
  – 1 in 4 pregnancies end in miscarriage
    • May possibly be as high as 1 in 2
    • 3 out of 4 spontaneous abortions occur during first trimester
    • Most miscarriages result from abnormal pregnancies
      – 50% - 70% abnormal chromosomes
  – Males more likely to spontaneously abort or be stillborn
<table>
<thead>
<tr>
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<th>Conception</th>
<th>Birth</th>
<th>Life</th>
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<td>96</td>
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Fetal Stage: 8 Weeks - Birth

• Final Stage of gestation
• Presence of bone cells signals fetal stage*
• Not a passive passenger
  – Breathe, kick, turn, flex, somersault, squint, swallow, make a fist, hiccup, suck their thumbs
• Fetuses can feel pain third trimester
• Ultrasound detects outline of fetus
• Significant changes between 28 – 32 weeks that explain why premature infants at this age have better outcomes
• Males more active during gestation
  – Inborn
Fetal Stage (cont)

- Olfactory system begins to develop 14 weeks
- Fetus responds to mother’s voice, heartbeat, and vibrations of her body
  - Hear, touch
  - Begins about 26 weeks of gestation, plateaus at 32 weeks
- “Learn” and “remember”
  - Newborn prefers mother’s voice
  - Newborn prefers mother’s native language

- Olfactory system which controls the sense of smell and taste
- In fact 3 day infants sucked more on the nipple that activated a recording of a story that their mother frequently read aloud during the last 6 weeks of pregnancy than the nipple that activated two other stories
Prenatal Development: Environmental Influences

• **Maternal factors**
  – Nutrition and maternal weight
  – Malnutrition
  – Physical activity and strenuous work
  – Drug intake
    • Medical drugs
    • Alcohol
    • Nicotine
    • Marijuana, cocaine, methamphetamine
  – HIV/AIDS
  – Maternal illnesses
  – Stress
  – Age
  – Outside environmental hazards
Prenatal Development: Environmental Influences (cont)

- **Maternal factors**
  - Nutrition and maternal weight
    - Need 300 – 500 more calories a day
    - Need extra protein
    - Weight gain of 25 – 35 pounds less likely to have birth complications
  - Overweight before pregnancy
    - Highest risk of stillbirth or losing baby during first week of life
    - Higher neural-tube defects
    - Higher heart defects
    - More birth defects
    - Complications of pregnancy higher: miscarriage, difficulty inducing labor, higher cesarean
  - Underweight more likely to have dangerously small babies
  - What woman eats is important
    - Fish is brain food
      - High mercury levels
    - Folic acid
      - Prevents anencephaly and spina bifida
      - Now in grain products in US since 1998
      - Childbearing age women encouraged to take folate supplements daily
Prenatal Development: Environmental Influences (cont)

- Maternal factors
  - Malnutrition
    - More likely to die in early adulthood
    - Increase stroke rates in middle age
    - Developing brain
      - Antisocial personality disorders at age 18
    - Low vitamin D in mothers children have low bone mineral content at age 9
    - Link between fetal undernutrition and schizophrenia
  - Dietary supplements help
Maternal factors

- Physical activity and strenuous work
  - Moderate exercise doesn’t endanger fetus of healthy woman
  - Regular exercise helps prevent constipation, improves respiration, circulation, muscle tone, and skin elasticity
    - Keep heart rate under 150
  - Employment is not harmful
    - Unless long hours, strenuous work, occupational fatigue
Prenatal Development: Environmental Influences (cont)

• Maternal factors
  – Drug intake (everything makes its way to the fetus)
    • Medical drugs
      – DES
        » Taken from late 1940’s to early 1950’s for prevention of miscarriage
        » Daughters in puberty got cervical cancer, vaginal cancer
        » In midlife, twice the risk of breast cancer
        » Sons have had malformations in genital tract
      – Prozac
        » Infants have disrupted neurobehavioral activity, increased risk of severe respiratory failure
Prenatal Development: Environmental Influences (cont)

• Maternal factors
  – Drug intake
    • Medical drugs
      – Thalidomide
        » Taken from 1957 to 1960’s for morning sickness
        » 10,000 – 20,000 children born in 46 countries
        » 100,000 miscarried
        » Predominantly Germany and Great Britain

*American Academy of Pediatrics committee on Drugs, 1994: No medication be prescribed for a pregnant or breast-feeding woman unless it is essential for her health or the child’s*
Prenatal Development: Environmental Influences (cont)

• Maternal factors
  – Drug intake
    • Alcohol
      – Fetal alcohol syndrome (FAS)
      – 5 in 1000 born in the US
      – Retarded growth
      – Facial and bodily malformations
      – Disorders of the central nervous system
        » Short attention span, learning disabilities, memory problems
        » Slow reaction time
        » Distractibility
        » Restlessness
        » Hyperactivity
      – FAS and FAE occur 1 in 100 US births
      – Most common cause of mental retardation*
      – Leading preventable cause of birth defects in US*
      – No known safe amount of alcohol
Fig. A: Fetal Alcohol Syndrome, Diagnosis, Epidemiology, Prevention, and Treatment. (Institute of Medicine, 1996).

Fig. B: Reprinted with permission from Clarens & Smith, (1978). Copyright 1978 by the New England Journal of Medicine, Massachusetts Medical Society.

Figs. C and D: Reprinted with permission from Jones et al. (1973). Copyright 1973 by the Lancet Ltd.

small eyes (distance from A to B)

Discriminating Features
- short palpebral fissures
- flat midface
- short nose
- indistinct philtrum
- thin upper lip

In the Young Child

Associated Features
- epicranial folds
- low nasal bridge
- minor ear anomalies
- micrognathia
smooth philtrum — thin upper lip

fetal alcohol syndrome

philtrum groove — upper lip

Normal philtrum and upper lip

FASD: Brain Regions Affected

- The corpus callosum
- The cerebral cortex
- The hippocampus and cerebellum

Matsen, et al., 1994

FAS Facial Characteristics

Small Eye Openings
Smooth Philtrum
Thin Upper Lip

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Prenatal Development: Environmental Influences (cont)

• Maternal factors
  – Drug intake
    • Nicotine
      – Single most important factor in low birth weight in developed countries *
      – Increased miscarriage
      – Growth retardation
      – Stillbirth
      – Small head circumference
      – SIDS
      – Colic
      – Hyperkinetic disorder
      – Long-term respiratory
      – Neurological, cognitive and behavioral problems
      – Males with reproductive problems
      – Offspring with diabetes
      – School age: poor attention span, hyperactivity, anxiety, learning and behavior problems, perceptual-motor and linguistic problems, poor IQ scores, low grade placement, neurological problems
Prenatal Development: Environmental Influences (cont)

• Maternal factors
  – Drug intake
    • Caffeine
      – 4 or more cups coffee day increased SIDS
      – 8 or more cups coffee day dramatically increased fetal death
    • Marijuana
      – Mixed studies
      – Heavy use can lead to birth defects, LBW, withdrawal-like symptoms at birth, increased attention disorders, learning problems later in life
        » Possibly suggests problems with the frontal lobe
    • Cocaine
      – Associated with spontaneous abortion, delayed growth, premature labor, LBW, small head size, birth defects, impaired neurological development
      – High exposure, childhood behavior problems
      – Studies controversial, as are laws charging pregnant women
    • Methamphetamine
      – LBW, SGA
Prenatal Development: Environmental Influences (cont)

– HIV/AIDS
  • Virus may cross placenta during pregnancy, labor/delivery, or breast milk
  • Biggest risk: if she doesn’t know she is HIV +
  • Significant decrease as a result of AZT, now <2%

– Maternal illnesses
  • Colds, flu, urinary tract and vaginal infections, STIs
  • Screened for thyroid functioning (cognitive functioning)
  • Rubella before 11th week: deafness, heart defects
  • Diabetes in mother: 2 – 5 times more likely to develop birth defects: heart and spinal cord
  • Toxoplasmosis, parasite infection from cattle, sheep, pigs, cats
    – Especially in second and third trimesters
    – Brain damage in fetus, vision impairment/blindness, seizures, miscarriage, stillbirth, death of fetus
    – 9 out of 10 appear normal at birth
    – Avoid raw meat or very rare, wash hands and surfaces of raw meat, peel and wash raw fruits and vegetables, avoid cat feces and areas of cat feces, wear gloves
Prenatal Development: Environmental Influences (cont)

- Maternal factors
  - Stress
    - Unusual stress during pregnancy at elevated risk of malformations: cleft lip, cleft palate, heart malformations
  - Major stress during 24th – 28th week may influence development of autism
  - Age
    - Miscarriage and stillbirth rises with age
      - 90% of pregnancies in women over 45 end in miscarriage
      - Donated ova to older women have younger outcomes
      - Down syndrome increases as do other chromosomal abnormalities
Prenatal Development: Environmental Influences (cont)

• Maternal factors
  – Outside environmental hazards
    • Air pollution
    • Chemicals
    • Radiation particularly between 8 – 15 weeks
    • Extreme heat and humidity
    • Chemicals in manufacturing semi-conductor chips
    • Exposure to DDT
    • Insecticides
      – Chlorpyrifos and diazinon cause stunting of prenatal growth
    • Hazardous waste sites
    • Lead, mercury, dioxin, nicotine, ethanol: asthma, allergies, autoimmune disorders such as lupus
    • Chemically contaminated ground water and home pesticide use: childhood cancers, leukemia
    • Routine dental x-rays triple risk of LBW
Prenatal Development: Environmental Influences (cont)

- Paternal factors
  - Abnormal or poor quality sperm:
    - Lead
    - Marijuana
    - Tobacco smoke
    - Large amounts of alcohol
    - Radiation
    - DES
    - Pesticides
    - High ozone levels
  - Male occupations
    - Oil: Prader Willi (same gene contributed by mother on same chromosome = Angelman syndrome)
  - Smoking contributes to secondhand smoke, linked with low birthweight, infant respiratory infections, SIDS, cancer, reduction in head circumference
  - Age
    - Dwarfism
    - Schizophrenia
    - Autism
Monitoring and Promoting Prenatal Development

• Ultrasound (sonogram): noninvasive
  – No known risk

• Amniocentesis: invasive
  – Performed after 15 weeks
  – Results take 1 – 2 weeks
  – Small added risk of fetal loss or injury

• Chorionic villus sampling (CVS): invasive
  – Performed 10 weeks
  – Additional risk of fetal loss or injury than amnio

• Maternal blood test (AFP): noninvasive
  – No known risk
  – False negatives/false positives
Proportion of U.S. Mothers with Late or No Prenatal Care, According to Race or Ethnicity, 2004.

- All Races: 3.6%
- Cuban: 2.9%
- American Asian or Pacific Islander: 3.0%
- White: 2.2%
- Puerto Rican: 3.9%
- Central and South American: 5.1%
- Mexican American: 5.5%
- Black or African American: 5.7%
- American Indian or Alaskan Native: 7.9%
Every hour of every day is an unspeakably perfect miracle.
-- Walt Whitman