CHAPTER 3
Fetal Development
DNA and nucleus control cell function

- The genes and chromosomes in the DNA determine individual traits

Each contains 46 chromosomes

- 22 pairs of autosomes
- 1 pair of sex chromosomes

Biological development influenced by

- External environment (teratogens)
- Drug use
- Undernutrition

Smoking
Cell Division and Gametogenesis (p. 31)

- **Mitosis**
  - Continuous process
  - Body grows, develops, and dead cells are replaced
  - Each daughter cell contains same number of chromosomes as parent cell—called *diploid*
  - Process of mitosis for sperm is spermatogenesis
  - Process of mitosis for ovum is oogenesis
Cell Division and Gametogenesis (p. 31)

• Meiosis
  – Reproductive cells undergo two sequential divisions
  – Number of chromosomes is 23 per cell with only one sex chromosome—called haploid
  – At fertilization, the new cell contains 23 chromosomes from the sperm and 23 chromosomes from the ova
  – Formation of gametes by this type of cell division is gametogenesis
Cell Division and Gametogenesis

SPERMATOGENESIS

- Testis
  - Spermatogonium 46, XY
  - Primary spermatocyte 46, XY
    - First meiotic division
      - Secondary spermatocytes
        - 23, X
        - 23, Y
        - Spermatids SPERMIOGENESIS
          - 23, X
          - 23, Y
          - Normal sperms

- OOGENESIS
  - Ovary
  - Primary oocyte 46, XX in primary follicle
  - Follicular cells
    - Primary oocyte 46, XX in growing follicle
    - Zona pellucida
      - Antrum
        - Secondary oocyte 23, X in mature follicle
        - First polar body
          - Corona radiata
            - Sperm
              - Fertilized oocyte 46, XX or 46, XY
              - Second polar body
Fertilization (p. 33)

• Occurs when a sperm penetrates an ovum and they unite
• Takes place in the outer third of the fallopian tube, near the ovary
• As soon as it occurs, a chemical change in the membrane around the fertilized ovum prevents further sperm from penetrating the ovum
Nursing Tip (p. 33)

• During sexual counseling, the nurse should emphasize that the survival time of sperm ejaculated into the area of the cervix may be up to 5 days and that pregnancy can occur with intercourse as long as 5 days before ovulation.
Sex Determination (p. 33)

- Sperm can carry either an X or a Y chromosome
- Male determines the gender of the fetus
- pH of female reproductive tract influences survival rate of the X- and Y-bearing sperm, including speed of motility
- XX results in female
- XY results in male
Sex Determination (p. 33)

• The gender of a baby is determined by the father’s sperm.
• The conception and birth of a child of a certain sex is a source of concern to some families.
Inheritance (p. 34)

• Each gene is coded for inheritance
  – Genes carry instruction for dominant and recessive traits
  – Dominant usually overpower recessive
  – Passed on to offspring
Tubal Transport of the Zygote (p. 34)

- Zygote is formed by union of sperm and ovum
- Transported through fallopian tube into uterus
- During transport, zygote undergoes rapid mitotic division (known as cleavage)
- Size of zygote does not increase, individual cells become smaller as they divide, then form a solid ball (known as a morula)
Maternal-Fetal Circulation (p. 35)
Morula (p. 33)

- Enters uterus on third day
  - Floats for another 2 to 4 days
  - Cells form a cavity
  - Two distinct layers evolve
    - Inner layer is a solid mass of cells called blastocyst
    - Develops into embryo and embryonic membranes
    - Outer layer—trophoblast
    - Develops into embryonic membrane—chorion
Implantation of the Zygote (p. 35)

• Usually in upper section of posterior uterine wall
  – Cells burrow into prepared lining—endometrium
  – Endometrium now called decidua
  – Area under blastocyst is decidua basalis
    • Becomes maternal part of the placenta
Development (p. 35)

• Cell differentiation
  – Occurs after implantation
  – Special functions
    • Chorion
    • Amnion
    • Yolk sac
    • Primary germ layers
Chorion (p. 35)

- Develops from trophoblast
- Envelops amnion, embryo, and yolk sac
- Thick membrane has projections called villi
- Villi extend into decidua basalis on uterine wall
- Form the embryonic/fetal portion of placenta
Amnion (p. 35)

• Second membrane
• Thin structure that envelops and protects embryo
• Together, chorion and amnion form an amniotic sac filled with fluid (bag of waters)
• Amniotic fluid is clear, mild odor, may contain bits of vernix or lanugo
• Volume of fluid steadily increases from ~30 mL at 10 weeks to 350 mL at 20 weeks; at 37 weeks, fluid is ~1000 mL
Functions of Amniotic Fluid (p. 35)

• Maintains an even temperature
• Prevents the amniotic sac from adhering to the fetal skin
• Allows symmetrical growth of fetus
• Allows buoyancy and fetal movement
• Acts as a cushion to protect the fetus and umbilical cord from injury
Yolk Sac (p. 35)

- A cavity develops on the ninth day after fertilization
- Functions only during embryonic life
- Initiates production of red blood cells
- Continues until fetal liver takes over around 6 weeks
- Umbilical cord encompasses yolk sac which then degenerates
Germ Layers (p. 35)

- Zygote in blastocyst stage transforms into three primary germ layers
  - Ectoderm
  - Mesoderm
  - Endoderm
Ectoderm (p. 35)

- Outer layer of skin
- Oil glands and hair follicles of skin
- Nails and hair
- External sense organs
- Mucous membrane of mouth and anus
Mesoderm (p. 35)

- True skin
- Skeleton
- Bone and cartilage
- Connective tissue
- Muscles
- Blood and blood vessels
- Kidneys and gonads
Endoderm (p. 35)

- Lining of trachea, pharynx, and bronchi
- Lining of digestive tract
- Lining of bladder and urethra
Three Stages of Prenatal Development (pp. 35-37)

- Zygote: cell formed by union of sperm and ovum
- Embryo: second to eighth week of development
  - By third week heart will pump blood
- Fetus: ninth week until birth
- Age of viability: 20 weeks of gestation but requires NICU care to survive
Nutritional Consideration

• Folic Acid Supplements can help prevent most neural tube defects...which can help with prevention of spina bifida

• It is important that mother start with supplements in the first days of the embryo.
Prenatal Development (pp. 36-37)

• Embryo at 3, 4, 6, and 8 weeks and by 9th week able to see sex organs on Ultra sound
Prenatal Development (cont.) (pp. 36-38)

- Embryo at 17 - leg movement and weeks, bones ossified; eye movement occurs
- Embryo at 25 - eyes are open, now viable, vernix caseosa and lanugo on skin, brown fat formed, lungs begin to secrete surfactant
Prenatal Development (cont.) (pp. 36-38)

• Embryo at 29 and 36 weeks
Accessory Structures of Pregnancy (p. 38)

- Placenta
- Umbilical cord
- Fetal circulation
  - Supports fetus
Placenta (p. 38)

• Organ for fetal respiration, nutrition, and excretion

• Produces four hormones
  – Progesterone
  – Estrogen
  – Human chorionic gonadotropin (hCG)
  – Human placental lactogen (hPL)
Placental Transfer (p. 38)

• Fetal deoxygenated blood and waste products leave the fetus through two umbilical arteries

• Fetal and maternal blood do not normally mix

• Oxygenated, nutrient-rich blood from mother spurts into intervillous space from spiral arteries in the decidua

• Fetal blood releases carbon dioxide and waste products
Placental Transfer (pp. 38-39)

• Fetal blood takes oxygen and nutrients before returning to fetus through umbilical vein

• Many harmful substances can be transferred to fetus
  – Drugs, nicotine, viral infectious agents
  – May cause fetal drug addiction, congenital anomalies, and fetal infection
Placental Hormones (p. 39)

• Progesterone

• Functions during pregnancy
  – Maintains uterine lining for implantation of the zygote
  – Reduces uterine contractions to prevent spontaneous abortion
  – Prepares the glands of the breasts for lactation
  – Stimulates testes to produce testosterone, which aids the male fetus in developing the reproductive tract
Placental Hormones (p. 39)

- Estrogen
  - Stimulates uterine growth
    - Increases the blood flow to uterine vessels
    - Stimulates development of the breast ducts to prepare for lactation
  - Effects of estrogen, not related to pregnancy
    - Increased skin pigmentation
    - Vascular changes in the skin and mucous membranes of nose and mouth
    - Increased salivation
Human Chorionic Gonadotropin (hCG) (p. 39)

- Causes the corpus luteum to persist and continue production of estrogen and progesterone to sustain pregnancy
- hCG is detectable in maternal blood as soon as implantation occurs (usually 7 to 9 days after fertilization)
Human Placental Lactogen (hPL) (p. 39)

• Also known as *human chorionic somatomammotropin* (hCS)

• hPL causes decreased insulin sensitivity and utilization of glucose by mother
  – Helps to make more glucose available to fetus to meet growth needs
Umbilical Cord (p. 39)

- Lifeline between mother and fetus
- Two arteries carry blood away from fetus
- One vein returns blood to the fetus
- Wharton’s jelly covers and cushions cord vessels
- Normal length is 55 cm (22 inches)
- The umbilical cord usually protrudes near the center of the placenta
Memory Jogger (p. 39)

• An easy way to remember the number and type of umbilical cord vessels is the woman’s name “AVA,” which stands for “Artery-Vein-Artery”
Maternal-Fetal Circulation (p. 39)
Fetal Circulatory Shunts (p. 40)

- Foramen ovale-diverts most blood from right atrium to left atrium
- Ductus arteriosus-diverts most blood from the pulmonary artery into the aorta
- Ductus venosus-diverts some blood away from the liver as it returns from the placenta
Circulation Before Birth (p. 40)

- Blood enters fetal body through umbilical vein
- About half goes to the liver, remainder enters inferior vena cava through the ductus venosus, then goes through foramen ovale, then ductus arteriosus
- Blood containing waste products is returned to placenta through umbilical arteries
Circulation After Birth (p. 40)

- Foramen ovale closes within 2 hours after birth (permanently by age 3 months)
- Ductus arteriosus closes within 15 hours (permanently in about 3 weeks)
- Ductus venosus closes functionally when cord is cut (permanently in about 1 week)
- If newborn has untreated respiratory distress it can cause the foramen ovale to reopen the increased resistance to blood flow
- After permanent closure, the ductus arteriosus and ductus venosus become ligaments
Impaired Prenatal Development (pp. 40-41)

• Undernutrition
  – Can result in permanent changes in fetal structure, physiology, and metabolism
  – Can influence development of conditions such as heart disease and stroke in adulthood
  – Exposure to toxins in utero
  – Can also influence health in later life
Impaired Prenatal Development (pp. 40-41)

• Intrauterine growth restriction may reduce number of cells in organs
  – Can predispose to the development of specific diseases later in life

• Fetal growth best assessed when weight, length of gestation, placental size, and newborn head and abdominal circumference are considered

• Fetal growth limited by nutrients and oxygen received from mother—for instance monozygotic twins

• A healthy mother can produce a healthy child who is less prone to illness
Impaired Prenatal Development and Subsequent Illness (pp. 40-41)

• Undernutrition in utero can result in:
  – Permanent changes in fetal structure, physiology, metabolism
  – Development of chronic conditions later in life

• To prevent illness of the next generation, this generation must focus on their own health practices
Multifetal Pregnancy (pp. 41-42)

- Twins occur once in every 90 pregnancies
- When hormones are used to assist with ovulation, twinning and other multifetal pregnancies occur
- Monozygotic twins are from a single fertilized ovum (identical)
- Dizygotic twins are from two separate fertilized ovum (fraternal) so will have separate chorions
  - Usually a familial tendency
Multifetal Pregnancy (cont.) (pp. 41-42)