Development & Inheritance

Fertilization

- Sperm is viable for about 48 hrs and secondary oocyte about 24 hrs, therefore there is a 3 day window for fertilization
- Sperm movement toward egg enhanced by:
  - Contractions of uterus due to prostaglandins in semen
  - Possible chemical attractant from oocyte
- Capacitation – takes about 7 hrs
  - Increased flagellar activity
  - Changed cell membrane around acrosome (removal of cholesterol, glycoproteins and proteins)
- Entering sperm must penetrate corona radiata and zona pellucida (presence of glycoprotein (ZP3)) which binds sperm head and initiates release of acrosomal contents (enzymes)
- Upon penetration, oocyte membrane depolarizes, triggers intracellular release of Ca\(^{2+}\), followed by exocytosis of ZP3 inactivator and zona pellucida hardening
  - prevents polyspermy
- Secondary oocyte completes meiosis II division, another polar body formed
- Nuclei fuse becoming zygote
- Dizygotic vs monozygotic twins
  - Monozygotic embryos separate before 8 days after fertilization
  - If after 8 days, usually conjoined twins

Oocyte Fertilization (graphic)

Early Stages

- Cleavage - early mitotic cell division of zygote without increase in size
- First division - about 30 hrs after fertilization
- After 4 days, solid mass of cells - morula
- On day 5, a fluid filled cavity forms (blastocyst cavity or blastocele) adjacent to inner cell mass – blastocyst
  - Endometrium secreted fluid is glycogen-rich uterine milk
  - Outer layer (trophoblast) and portion of inner layer - primary fetal component for placenta

Zygote Early Development (graphic)

Stages of Early Development (graphic)

Implantation

- On or about the 6th day
- Zona pellucida breaks down, blastocyst increases in size and finally attaches to endometrium in posterior wall, inner cell mass towards wall
- Trophoblast cells form two layers - become part of chorion
Syncytiotrophoblast - outer portion secretes enzymes to burrow into endometrium and has diffuse cell structure
Cytotrophoblast - discrete cell structure
Trophoblast also secretes human chorionic gonadotropin (hCG) - maintains corpus luteum and its production of estrogens and progesterone until about 9th week when placenta produces estrogens and progesterone

Abnormal implantation - ectopic pregnancy in uterine tube, abdominal cavity or cervix
  Twice as likely in smokers – limited cilia movement

Implantation in Endometrium (graphic)

Hormonal Changes in Pregnancy (graphic)

Embryonic Development
  First 2 months (embryonic period) - primordial organs, membranes, & placenta form
  Gastrulation - 2 → 3 germinal layers
    At day 8, formation of amnion (from cytotrophoblast) and cavity
    At day 12 endoderm expands to enclose yolk sac
    At day 15 mesoderm appears as distinct layer
    Differentiation of 3 germinal layers at embryonic disc
    Provide foundation for organ structures (Table 29.1)

Formation of Yolk Sac (graphic)

Formation of 3 Germinal Layers (graphic)

Embryonic Membranes
  Form outside of developing embryo
  Yolk sac - early site of blood formation and source of cells for primitive germ (sex) cells
  Amnion - grows to cover all of embryo and space containing amniotic fluid
    Fluid includes maternal blood filtrate, embryonic urine and cell matter
    Provides physical and temperature protection
    Amniocentesis
  Chorion - derived from trophoblast and portion of mesoderm to surround embryo (outside of amnion)
    Embryo portion of placenta
    Produces hCG
  Allantois - important in embryonic blood formation and vessels in umbilical cord

Embryonic Regions (graphic)

Amniocentesis Procedure (graphic)

Placenta
  Partial placental development (complete by month 3)
  Function
    Exchange of gases, nutrients and wastes
– Isolation barrier to microbes (except AIDS, German measles, chicken pox, measles, poliomyelitis)
– Storage of certain nutrients - carbs, proteins, calcium and iron
– Drugs pass freely
– Transcytosis of some maternal antibodies
– Hormone production - human chorionic gonadotropin, estrogen & progesterone (responsibility from corpus luteum), relaxin, human chorionic somatomammotropin (hCS)(also human placental lactogen), corticotropin-releasing hormone (CRH) - Fig. 29.16
  • hCG in urine detectable at 8 days after fertilization - pregnancy test (peaks at 9 wks)
  • Typical cause of morning sickness

• Maternal portion derived from stratum functionalis of endometrium - decidua basalis
• Chorion villi extend into endometrium, ultimately with allantois derived vessels extending into regions of maternal blood (intervillous spaces)
  – Chorionic villi sampling (CVS) – earlier testing, faster results, but more risky than amniocentesis
• Remains of placenta are “afterbirth”

**Hormones from the Placenta (graphic)**
**Tissues of the Placenta (graphic)**
**Placental Structure (graphic)**
**CVS Procedure (graphic)**

**Gestational Changes**
• Uterine enlargement in abdomino-pelvic cavity
• Increased stroke volume by 30%
• Increase cardiac output by 20-30%
• Increased heart rate by 10-15%
• Increased blood volume by 30-50%
• Increased tidal volume by 30-40%
• Decreased expiratory reserve by 40%
• Decreased residual capacity by 25%
• Decrease in airway resistance by 36%
• Increased O₂ consumption by 10-20%
• Pressure on stomach and bladder
• Increased renal plasma flow by 35%
• Increased glomerular filtration rate by 40%

**Labor**
• Labor initiated by hormonal changes
  – Maternal estrogen levels increase (source from altered fetal secretions) superceding the effect of progesterone which inhibits uterine contraction
– Estrogen increases uterine muscle receptors for oxytocin and gap junctions
– Stretching of uterine wall increases release of oxytocin from posterior pituitary (via hypothalamus)

Hormonal Changes in Pregnancy (graphic)

Stages of Labor
• Dilation stage - from beginning of regular contractions, rupturing of amniotic sac, to full dilation of cervix
• Expulsion state - from dilation to completed delivery
• Placental stage - from delivery to expulsion of placenta

Stages of Labor (graphic)

On Your Own
• Newborn physiological changes
  – Particularly cardiovascular
• Lactation

Inheritance
• Genotype vs. phenotype
  – Genetic makeup vs. visual appearance
  – Homozygous vs. heterozygous
  – Dominant/recessive alleles
  – Incomplete dominance – sickle-cell anemia
• Autosomal vs. sex-linked traits
  – R-G color blindness, hemophilia and others
• Punnett square
• Multiple-allele inheritance and codominance
  – Blood groups
• Polygenic inheritance
  – Skin color
• Nondisjunction
  – Trisomy of chromosome 21 – Down syndrome
• Translocation
  – Crossing-over of non-homologues
  – When related to portion of chromosome 21 – another form of Down syndrome

Human Chromosomes (graphic)
Simple Dominance - PKU (graphic)
Incomplete Dominance (graphic)
Sex Linkage (graphic)
Multiple Allele and Co-dominance (graphic)