Chapter 18
Lecture Outline

See separate PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.
Human Development and Aging
Points to ponder

• What is fertilization?
• Describe the steps in fertilization.
• What is cleavage? Growth? Morphogenesis? Differentiation?
• What are the four extraembryonic membranes?
• Be familiar with what happens during pre-embryonic development, fetal development, and development after birth.
• Follow the path of fetal circulation.
• What determines the sex of an individual? Be sure to understand the three hormones involved and the SRY gene.
Points to ponder

• What are two conditions in which sex determination is ambiguous, and two conditions in which the sex organs do not develop normally?
• What are the three stages of birth?
• What can you do to help prevent birth defects?
• What are the hypotheses of aging?
• What are the effects of aging on the body?
Fertilization

• Fertilization is the union of the sperm and egg to form a zygote.

• Egg is surrounded by an outer matrix called the zona pellucida.

• Outside this matrix it has a few layers of follicular cells collectively called the corona radiata.
Fertilization

• Steps of fertilization
  1. Several sperm penetrate the corona radiata.
  2. Acrosomal enzymes digest a portion of the zona pellucida.
  3. Sperm binds to and fuses with the egg’s plasma membrane.
  4. Sperm nucleus enters the egg.
  5. Sperm and egg nuclei fuse.
1. Sperm makes its way through the corona radiata.

2. Acrosomal enzymes digest a portion of zona pellucida.

3. Sperm binds to and fuses with egg plasma membrane.

4. Sperm nucleus enters cytoplasm of oocyte.

5. Cortical granules release enzymes; zona pellucida becomes fertilization membrane.

6. Sperm and egg pronuclei are enclosed in a nuclear envelope.

Figure 18.1 The steps in the fertilization of an egg.
What prevents more than one sperm from entering?

- The egg’s plasma membrane changes to prevent other sperm from binding.

- Vesicles within the egg release enzymes that cause the zona pellucida to become impenetrable and sperm cannot bind.
What are the main processes of development?

- **Cleavage** – cells undergo division without the embryo increasing in size
- **Growth** – cells undergo division as well as increase in size
- **Morphogenesis** – the embryo begins to take shape as cells migrate
- **Differentiation** – when cells take on specific structure and function (the nervous system is the first visible system)
What are the functions of the extraembryonic membranes in humans?

- **Chorion** – fetal half of the **placenta**, the organ that provides the embryo with nourishment and gets rid of wastes
- **Allantois** – gives rise to the bladder and the blood vessels of the umbilical cord that carry blood to and from the fetus
- **Yolk sac** – contains many blood vessels and where blood cells first form (there is little yolk in humans)
- **Amnion** – contains amniotic fluid that cushions and protects the embryo
Figure 18.3 The extraembryonic membranes.
What are the stages of development?

1. **Pre-embryonic development** - 1\textsuperscript{st} week of development after fertilization

2. **Embryonic development** – 2\textsuperscript{nd} week after fertilization until the end of the 2\textsuperscript{nd} month

3. **Fetal development** – the 3\textsuperscript{rd} through the 9\textsuperscript{th} months of development

4. **Development after birth** – stages of life including infancy, childhood, adolescence, and adulthood
1. Pre-embryonic development

- **Cleavage** – cell division that increases the number of cells
- **Morula** – compact ball of embryonic cells
- **Early blastocyst** – inner cell mass that becomes the embryo, covered by a layer of cells that becomes the chorion
- **Implantation** – embryo embeds into the uterus around day six
1. Pre-embryonic development: Week 1

Figure 18.2 The stages of pre-embryonic development.
2. Embryonic development: Week 2

- Pregnancy begins after implantation.
- **Human chorionic gonadotropin** (HCG) is secreted, maintaining the corpus luteum and the endometrium.
- HCG is the basis for a pregnancy test.
- The inner cell mass detaches itself and becomes the embryonic disk that will go through **gastrulation** to become three primary germ layers (ectoderm, mesoderm, and endoderm).
2. Embryonic development: Week 2

Figure 18.4a The stages of embryonic development.

- amniotic cavity
- embryonic disk
- yolk sac
- chorionic villi
- chorion

a. 18 days
18.2 Pre-Embryonic and Embryonic Development

3 primary germ layers

Figure 18.5  The embryonic germ layers.

<table>
<thead>
<tr>
<th>Primary Germ Layer</th>
<th>Human Adult Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ectoderm (outer layer)</td>
<td>Epidermis of skin; epithelial lining of oral cavity and rectum; nervous system</td>
</tr>
<tr>
<td>Mesoderm (middle layer)</td>
<td>Skeleton; muscular system; dermis of skin; cardio vascular system; urinary system; reproductive system; outer layers of respiratory and digestive systems</td>
</tr>
<tr>
<td>Endoderm (inner layer)</td>
<td>Epithelial lining of digestive tract and respiratory tract; associated glands of these systems; epithelial lining of urinary bladder</td>
</tr>
</tbody>
</table>
2. Embryonic development: Week 3

- Nervous system begins to develop.

- The posterior neural tube will become the spinal cord and brain.

- Development of the heart begins.

Figure 18.4b The stages of embryonic development.
2. Embryonic development: Weeks 4 and 5

• 4th week
  – The embryo is slightly larger than the height of the print in your book.
  – Chorionic villi form.
  – The umbilical cord forms.
  – Limb buds form (later develop into legs and arms).
  – Hands and feet are apparent.

• 5th week
  – The head enlarges.
  – Eyes, ears, and nose become prominent.
Figure 18.4c-d The stages of embryonic development.
Figure 18.6 The human embryo after five weeks of development.
2. Embryonic development: Weeks 6-8

- The embryo begins to look like a human being.
- Reflex actions occur.
- All organ systems have been established.
- The embryo is 38 mm by the end of this period and weighs about the same as an aspirin tablet.
3. Fetal development: Months 3 and 4

- Hair develops.
- The head slows in growth so that the body size can catch up.
- Cartilage begins to be replaced by bone.
- It is possible to distinguish female from male (month 3).
- The heartbeat can be heard with a stethoscope (month 4).
- By the end of this period, the fetus is ~6 inches and ~6 ounces.
3. Fetal development: Months 5-7

- Fetal movement can be felt by the mother.
- Fetus is in fetal position.
- Eyelids are fully open.
- Fetus size has increased to ~12 inches and ~3 pounds.

Figure 18.8 A five- to seven-month-old fetus.
3. Fetal development: Months 8 and 9

- Weight gain is about a pound per week.

- Fetus rotates so the head is pointed toward the cervix.

- At the end of fetal development, the fetus weighs ~7.5 pounds and ~20.5 inches.
Preventing birth defects

• Get physical exams by a trained doctor.

• Have good health habits: proper nutrition and adequate sleep and exercise.

• Avoid smoking, alcohol, and drug abuse.

• Avoid having X-rays.

• Avoid certain medications and supplements.

• Avoid sexually transmitted diseases or know if you have one.
Note: Fetal and maternal blood do not mix because exchange of materials between the two occurs at the chorionic villi.
Development of the sex organs

• Sex of an individual is determined at conception (XX is female and XY is male).

• If the SRY (the sex-determining region on the Y chromosome) gene is present at week 6 then the embryo develops into a male.

• Anti-Müllerian hormone secreted by the testes prevents the development of female sex organs.
Development of the sex organs

- At 14 weeks, primitive testes and ovaries are already developing.

- The development of the external organs is dependent on the presence or absence of dihydrotestosterone (DHT) produced by the testes.
Development of the sex organs

18.3 Fetal Development

Figure 18.9 Development of the internal sex organs.

Figure 18.10 Development of the external sex organs.
Abnormal development of the sex organs

• **XY female syndrome** - an individual develops into a male because a piece of the Y chromosome containing the SRY gene is missing

• **XX male syndrome** – an individual develops into a male because the same small piece of the Y containing the SRY gene is present on an X chromosome
Ambiguous sex determination

- Results from the absence of testosterone, anti-Müllerian hormone and/or DHT
  - Androgen insensitivity syndrome: all hormones are made, but testosterone receptors on cells are ineffective; thus the individual has testes that do not descend and outwardly appears to be female
  - Male pseudo-hermaphroditism: an individual appears female until puberty when anti-Müllerian hormone is produced, but the testes never produce testosterone or DHT
Androgen insensitivity syndrome

Figure 18.11 Androgen insensitivity affects sexual development.

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What changes occur in the mother’s body?

- Nausea and vomiting are common symptoms early on (morning sickness).
- Some mothers report an overall increase in energy levels and sense of well-being.
- Acid reflux and constipation are common problems.
- There is an increase in vital capacity.
- Edema and varicose veins can result.
- **Incontinence** is not uncommon.
- The placenta produces peptide hormones that make cells resistant to insulin, so diabetes can result.
-Stretch marks are common.
- Melanocyte activity increases in some areas.
Birth

• True labor is characterized by uterine contractions that occur every 15-20 minutes and last for at least 40 seconds each.

• Three stages
  – Stage 1
    • Effacement occurs, in which the cervical canal slowly disappears and the baby’s head acts as a wedge to cause cervical dilation.
Birth

– **Stage 2**
  - Uterine contractions occur every 1-2 minutes, lasting for 1 minute each.
  - An incision (episiotomy) is made to the opening to help the baby as its head reaches the exterior.
  - Once the baby is born, the umbilical cord is cut and tied.

– **Stage 3**
  - The afterbirth is delivered, usually about 15 minutes after the birth of the baby.
Birth

a. First stage of birth: Cervix dilates.

b. Second stage of birth: Baby emerges.

d. Third stage of birth: Afterbirth is expelled.

Figure 18.13 The stages of birth.
Aging

- Stages of life: infancy, childhood, adolescence, and adulthood

- Hypotheses of aging
  - **Cellular aging**: there may be hormonal and genetic influences on aging; mitochondrial activity and caloric intake may be involved
  - **Damage accumulation**: aging may result from the accumulation of damage—some avoidable, some unavoidable—over time
What are the effects of age on body systems?

- Skin becomes thinner, less elastic, and dry.
- Less adipose tissue in the skin, so one feels cold more easily.
- Decrease in melanocytes leading to gray hair, while some of the remaining cells are larger leaving “age spots” (dark spots on the skin).
- Heart shrinks and arteries become more rigid.
- Reaction time slows and senses are muted.
What are the effects of age on body systems?

- Lenses in the eyes lose ability to accommodate.
- Blood pressure usually increases.
- Bone density declines.
- Muscle mass decreases.
- Weight gain results from a decrease in metabolism and an increase in inactivity.
- Females undergo menopause and males andropause.
Think about how you might prevent aging

Figure 17.15 What steps can an individual take to increase health span?

Note: Although many changes occur in the body as we age, some of them can be tempered or even reversed by understanding what extrinsic factors can be controlled to decrease these changes.