Human Anatomy, First Edition

McKinley & O'Loughlin

Chapter 3 Lecture Outline:
Embryology

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Embryology

- The study of the developmental events that occur during the prenatal period

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Embryology

- Begins with a single fertilized cell that divides to produce all of the cells in the body.

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The Prenatal Period

- The first 38 weeks of human development, which occurs between fertilization and birth.
- The pre-embryonic period is the first 2 weeks of development when the zygote becomes a spherical, multicellular structure.
- The embryonic period includes the third through eighth weeks of development during which all major organ systems appear.

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The Fetal Period

- Includes the remaining weeks of development prior to birth
- The fetus continues to grow
- Its organs increase in complexity

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The Stages of Embryogenesis

- Cleavage. The zygote divides by mitosis to form a multicellular structure called a blastocyst.
- Gastrulation. The blastocyst cells form three primary germ layers, which are the basic cellular structures from which all body tissues develop.
- Organogenesis. The three primary germ layers arrange themselves in ways that give rise to all the organs within the body.

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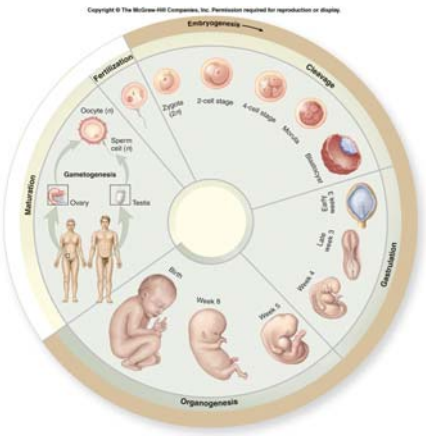

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Gametogenesis

- Following birth, an individual undergoes maturation.
  - the body grows and develops
  - the sex organs become mature
  - the sex organs then begin to produce gametes

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Chromosomes

- Human somatic cells contain 23 pairs of chromosomes for a total of 46.
- 22 pairs of autosomes and one pair of sex chromosomes.
- Autosomes contain genetic information for most human characteristics.
- A pair of similar autosomes are called homologous chromosomes.

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Diploid Cells

- A cell is said to be diploid if it contains 23 pairs of chromosomes.
- 2N = 46

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The Sex Chromosomes

- The pair of sex chromosomes determines whether an individual is female (XX) or male (XY).
- One member of each pair of chromosomes is inherited from each parent.

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Gametogenesis

- Begins with meiosis.
- Produces secondary oocytes in the female.
- Produces sperm in the male.

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Meiosis

- A type of cell division that starts off with a diploid parent cell and produces haploid daughter cells (sperm or eggs/ova).

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Meiosis I

- Meiosis results in the formation of gametes (sex cells).
- In meiosis I, homologous chromosomes are separated after synapsis and crossing over occurs.
- In meiosis II, sister chromatids are separated in a sequence of phases that resembles mitosis.

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Prophase I

- Homologous, double-stranded chromosomes in the parent cell form pairs (synapsis).
- The actual pair of homologous chromosomes is called a tetrad.
- Crossing over occurs between the maternal and paternal chromosomes.

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Metaphase I

- The homologous pairs of chromosomes line up above and along the equator of the cell.
- Forms a double line of chromosomes.
- Alignment is random with respect to maternal or paternal origin.

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Anaphase I

- Pairs of homologous chromosomes separate and are pulled to the opposite ends of the cell.

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Telophase I and Cytokinesis

- Nuclear division finishes and
- The nuclear envelopes re-form
- The cytoplasm divides
- Two new haploid cells are produced

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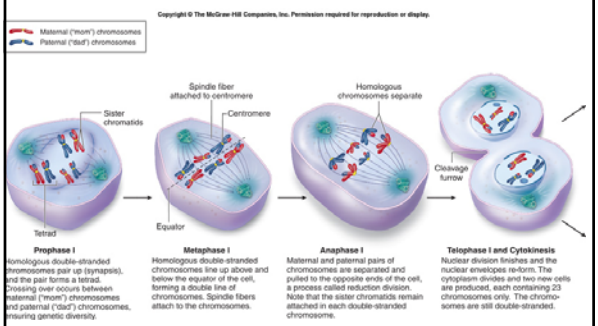

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Prophase II

- Resembles the prophase stage of mitosis.
- In each of the two new cells, the nuclear membrane breaks down, and the chromosomes collect together.
- Crossing over does not occur in this phase.

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Metaphase II

- The double-stranded chromosomes form a single line in the middle of the cell.
- Spindle fibers extend from the centrioles at the poles to the centromere of each double-stranded chromosome.

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Anaphase II

- The sister chromatids of each double-stranded chromosome are pulled apart at the centromere.
- Each chromatid (single strand) is pulled to the opposite pole of the cell.

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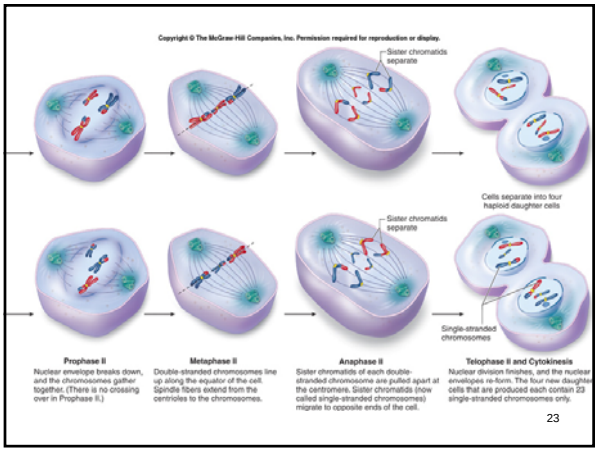

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Telophase II and Cytokinesis

- The single-stranded chromosomes arrive at opposite ends of the cell.
- A cleavage furrow forms and the cytoplasm in both cells divides, producing a total of four haploid daughter cells.
- These daughter cells mature into sperm in males or oocytes in females.

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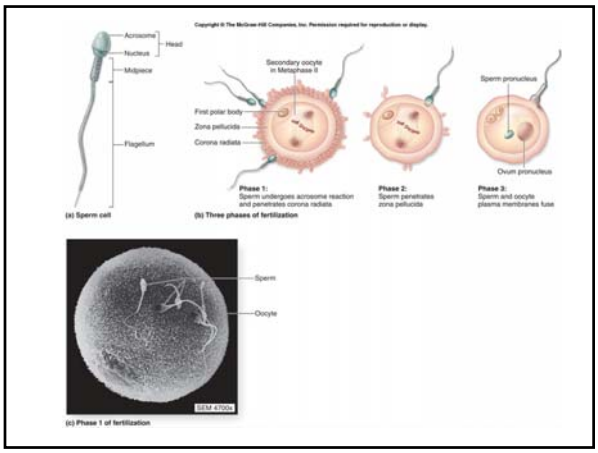

Oogenesis

- In females, the sex cell produced is called the secondary oocyte.
- This cell will have 22 autosomes and one X chromosome.

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Oogenesis

- The parent cells that produce oocytes are called oogonia and they reside in the ovaries. Oogonia are diploid cells.
- All the oogonia start the process of meiosis and form primary oocytes prior to birth.
- They are arrested in Prophase I and remain this way until the female reaches puberty.
- Each month usually only one becomes a secondary oocyte.

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Oogenesis

- When the primary oocyte completes the first meiotic division, two cells are produced.
- Division of the cytoplasm is unequal.
- The secondary oocyte receives the bulk of the cytoplasm and is the cell that is arrested in Metaphase II.
- The second cell, which receives only a tiny bit of the cytoplasm, is called a polar body.
- The polar body is a nonfunctional cell and eventually degenerates.

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Oogenesis

- Only the secondary oocyte has the potential to be fertilized.
- The secondary oocyte is ovulated
- The corona radiata and the zona pellucida form protective layers around the secondary oocyte.

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Oogenesis

- If the secondary oocyte is not fertilized, it degenerates about 24 hours after ovulation, still arrested in metaphase II.
- If the secondary oocyte is fertilized, it first finishes the process of meiosis. Two new cells are produced, and as before, the division of the cytoplasm is unequal.
- The cell that receives very little cytoplasm becomes another polar body and eventually degenerates.
- The cell that receives the majority of the cytoplasm becomes an ovum which can be fertilized.

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Oogenesis

- Typically, only one secondary oocyte is expelled (ovulated) from one of the two ovaries each month.
- The left and right ovaries alternate ovulation each month.

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Spermatogenesis

- The parent or stem cells that produce sperm are called spermatogonia.
- Spermatogonia are diploid cells that reside in the the testes.
- Each one first divides by mitosis to make an exact copy of itself called a primary spermatocyte.

3-32

Spermatogenesis

- Primary spermatocytes then undergo meiosis and produce haploid cells called spermatids.
- Spermatids contain 23 chromosomes, but they still must undergo further changes to form a sperm cell.
- In spermiogenesis, spermatids lose much of their cytoplasm and grow a long tail called a flagellum.

3-33

Spermatogenesis

- The newly formed sperm cells are haploid cells that exhibit a distinctive head, a midpiece, and a tail.
- From a single spermatocyte, four new sperm are formed.
- All sperm have 22 autosomes and either an X chromosome, or a Y chromosome.

3-34

Fertilization

- Two sex cells fuse to form a new cell containing genetic material derived from both parents.
- Restores the diploid number of chromosomes.
- Determines the sex of the organism.
- Initiates cleavage.
- Occurs in the widest part of the uterine tube (the ampulla).

3-35

Fertilization

- Millions of sperm cells are deposited in the female reproductive tract during intercourse.
- Only a few hundred have a chance at fertilization.
- Only the first sperm to enter the secondary oocyte is able to fertilize it.
- The remaining sperm are prevented from penetrating the oocyte.

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Cleavage

- Shortly after fertilization, the zygote begins to undergo a series of divisions.
- Divisions increase the number of cells in the pre-embryo, but the pre-embryo remains the same size.
- During each succeeding division, the cells are smaller and smaller.

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Cleavage

- Before the 8-cell stage, cells are not tightly bound together, but after the third cleavage division, the cells become tightly compacted into a ball called a morula.

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Implantation

- By the end of the first week after fertilization, the blastocyst enters the lumen of the uterus.
- The zona pellucida around the blastocyst begins to break down as the blastocyst prepares to invade the endometrium.
- Implantation is the process by which the blastocyst burrows into and embeds within the endometrium.

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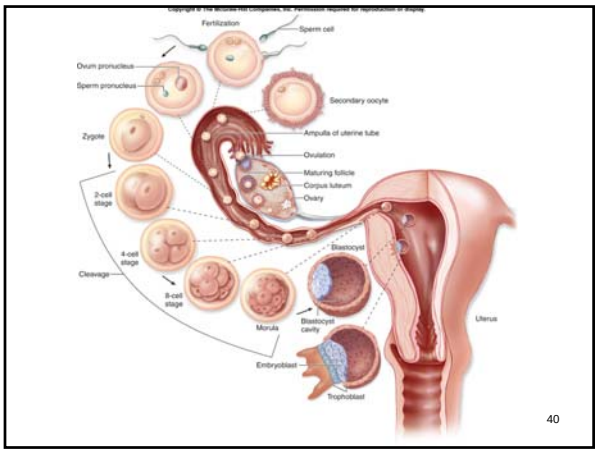

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Amnion

- Eventually encloses the entire embryo in a fluid-filled sac called the amniotic cavity to prevent desiccation.
- The amniotic membrane is specialized to secrete the amniotic fluid that bathes the embryo.

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Chorion

- The outermost extraembryonic membrane, is formed from rapidly growing cells.
- These cells blend with the functional layer of the endometrium and eventually form the placenta.

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The Placenta

- Functions in exchange of nutrients, waste products, and respiratory gases between the maternal and fetal bloodstreams.
- Transmission of maternal antibodies to the developing embryo or fetus.
- Production of hormones to maintain and build the uterine lining.

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Gastrulation

- Occurs during the third week of development immediately after implantation.
- One of the most critical periods in the development of the embryo.
- Cells of the epiblast migrate and form the three primary germ layers which are the cells from which all body tissues develop.
- The three primary germ layers are called ectoderm, mesoderm, and endoderm.

3-44

Organogenesis

- Once the three primary germ layers have formed, and the embryo has undergone folding, **organogenesis** begins.
- The upper and lower limbs attain their adult shapes, and the rudimentary forms of most organ systems have developed by week 8.
- By the end of the embryonic period, the embryo is slightly longer than 2.5 centimeters (1 inch), and yet it already has the outward appearance of a human.

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