SEXUAL REPRODUCTION and DEVELOPMENT

Objectives

1. Define somatic cells, gametes, haploid, diploid, polyploid, aneuploid and homologous chromosomes.
2. Describe the stages of meiosis.
3. Describe spermatogenesis and oogenesis.
4. State the main stages and critical events of prenatal development.
5. Contrast the types of twins.
6. State the three main reasons why individuals are genetically different from each other.
7. Explain why dominant genetic illnesses are more common in adults than in children.

Outline

A. Ploidy
B. Meiosis
    1. Stages
        a. Prophase I
        b. Metaphase I
        c. Anaphase I
        d. Telophase I
        e. Prophase II
        f. Metaphase II
        g. Anaphase II
        h. Telophase II
    2. Gamete Maturation
        a. Spermatogenesis
        b. Oogenesis
C. Prenatal Development
    1. Fertilization
    2. Embryo
    3. Fetus
    4. Twinning
    5. Birth Defects
    6. Success Rates
D. Genetic Differences among Offspring
E. Aging

A. Ploidy

- Somatic cells
    - Diploid (2n)
    - Homologous Chromosomes
        - locus
        - allele
- Germ cells
    - Haploid cells (n)
    - Gametes
- Zygote (2n)
- Aneuploid (2n + ?)
- Polyploid
    - Triploid (3n)
    - Tetraploid (4n)

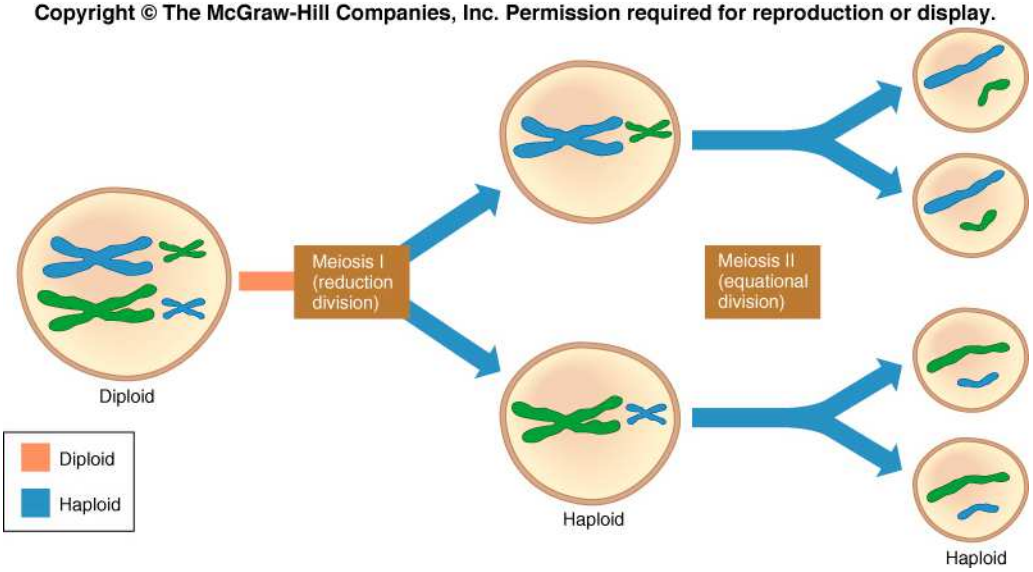
B. Meiosis

- Similar to mitosis except:
    - Number of chromosomes halved
    - Two successive divisions
        - No S phase in between
    - Synapsis during first division

    - Produces 4 haploid daughter cells
        - Daughter cells not identical
        - Daughter cells differ from mother cell

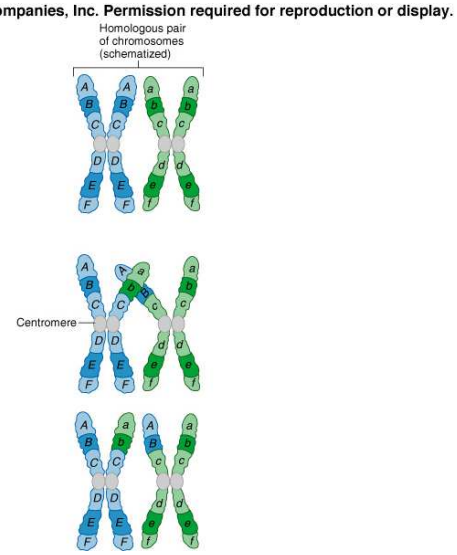
1. Stages

- Two successive cell divisions
    - Meiosis I (Reduction Division)
        - Homologous chromosomes separate
    - Meiosis II (Equational Division)
        - Chromatids split



a. Prophase I

- Nuclear membrane, nucleolus vanish
- Meiotic spindle forms
- Chromatin condenses
- **Synapsis**
    - **Homologous chromosomes pair**
    - **Tetrad**
- **Chiasmata (sing. chiasma) form**
    - **Crossing over (Recombination)**



b. Metaphase I

- Spindle attaches to centromere
- **Tetrads line up at equatorial plate**
    - **Homologous chromosomes disengage**

c. Anaphase I

- Homologous chromosomes separate
    - **Centromeres do not separate**
- Fibers pull chromosomes to poles

d. Telophase I

- Chromosomes arrive at poles
    - **Each cell has one-half**
- Spindle disappears
- Nuclear membrane, nucleoli reappear
- Cells divide
- **Second division follows**

e. Prophase II

- Chromatin condenses
- Nuclear membrane, nucleolus vanish
- Spindle forms

f. Metaphase II

- Spindle attaches to **centromeres**
- **Individual chromosomes** line up

g. Anaphase II

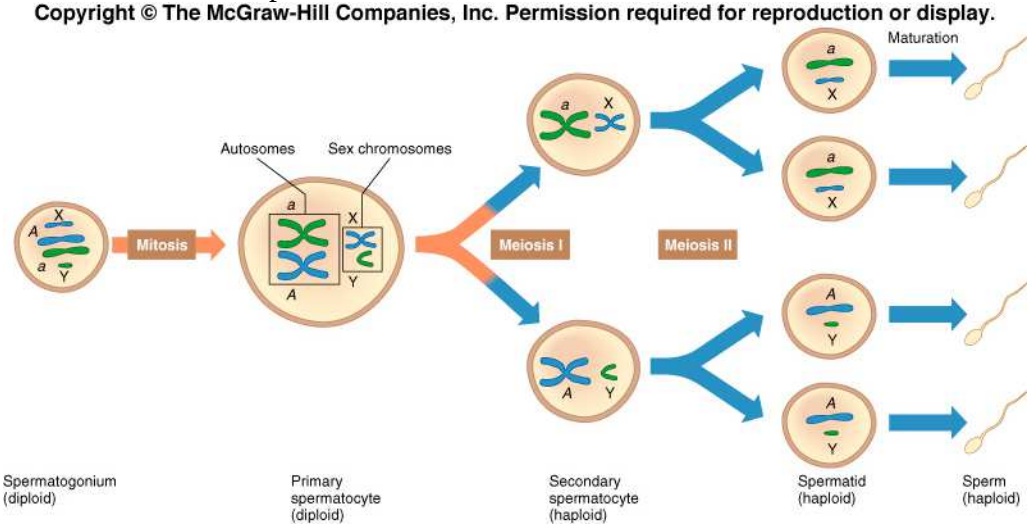
- **Centromeres divide**
    - **Chromatids separate**
- Fibers pull chromosomes to poles

h. Telophase II

- Chromosomes arrive at poles
    - Unwind into chromatin
- Spindle disappears
- Nuclear membrane, nucleoli reappear

2. Gamete Maturation
a. Spermatogenesis

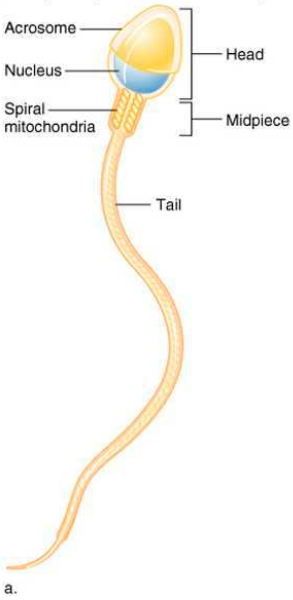
- Four functional sperm



- Spermatogonium

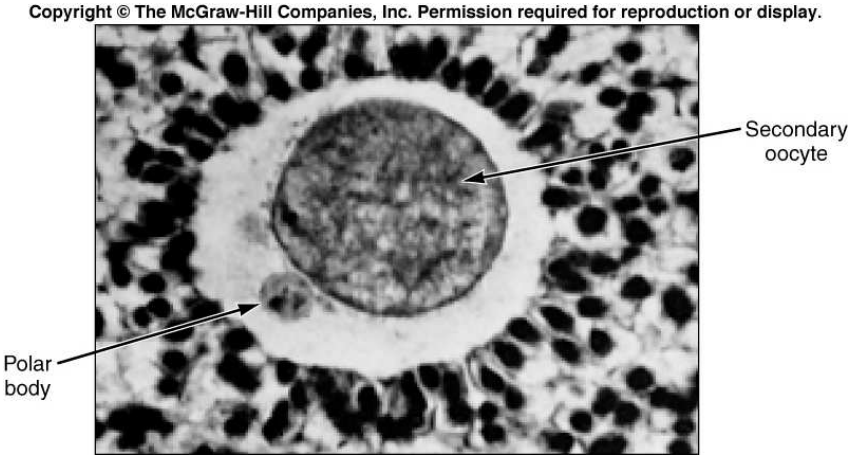
- Spermatozoan
  - Acrosome
  - Mitochondria in midpiece

- Male forms trillions over lifetime

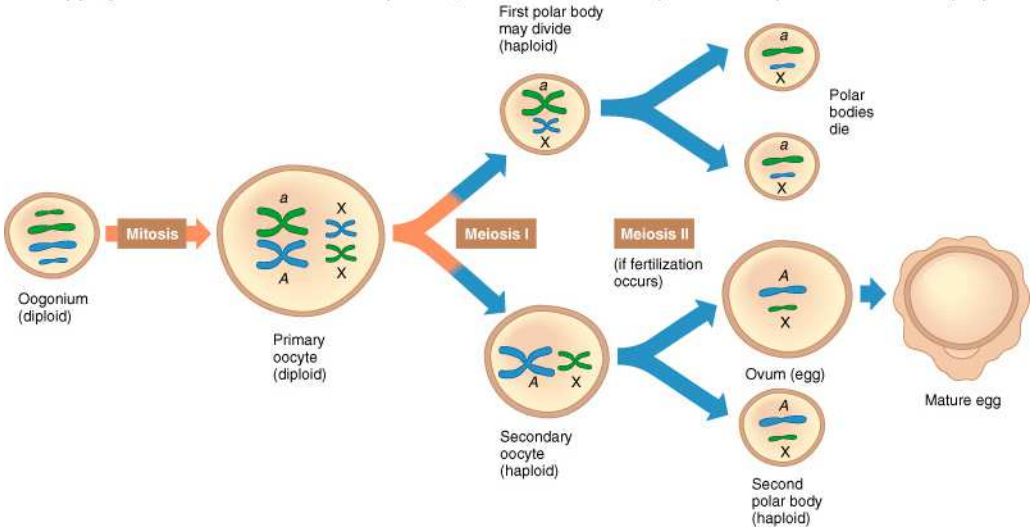


b. Oogenesis

- One functional ovum
    - Concentrates most of cytoplasm
- Three Polar Bodies
    - Discards excess chromosomes



- Primary Oocyte
    - Female forms one million at birth
        - Cycle arrests during prophase I
        - Cycle restarts at puberty



- Secondary Oocyte
    - Cycle arrests at metaphase II
    - About 400 released during lifetime
- Ovum
    - Cycle completed after fertilization
    - Provides all cytoplasmic requirements for zygote

C. Prenatal Development

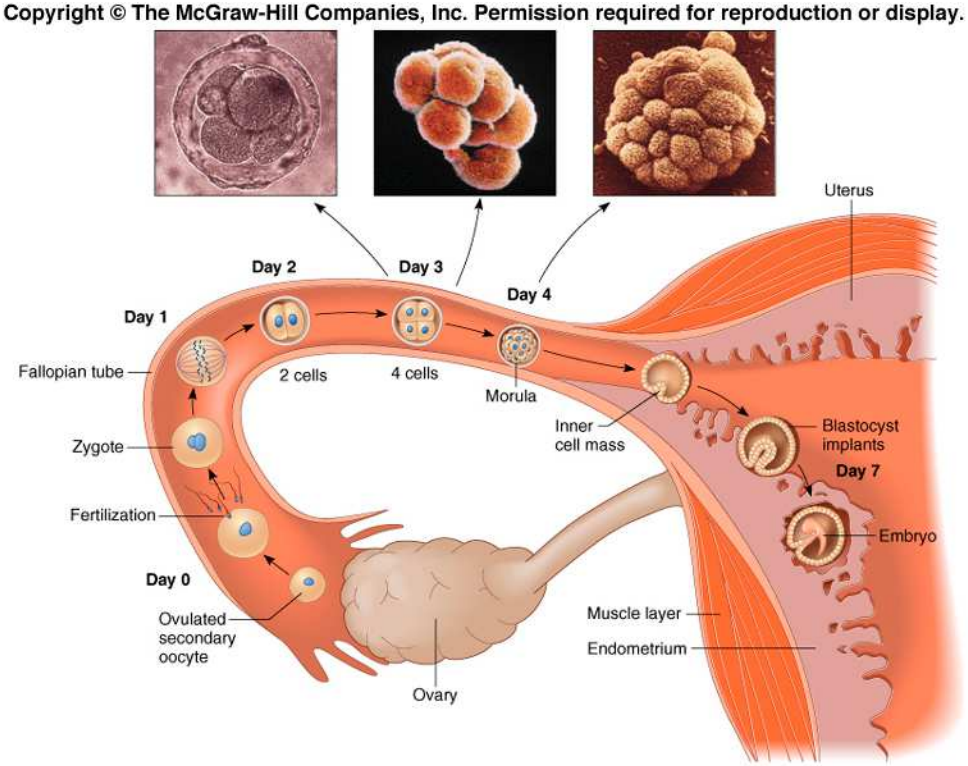
1. Fertilization

- Zygote
    - Electrical charge prevents multiple fertilizations
    - Secondary oocyte completes meiosis
    - Pronuclei fuse

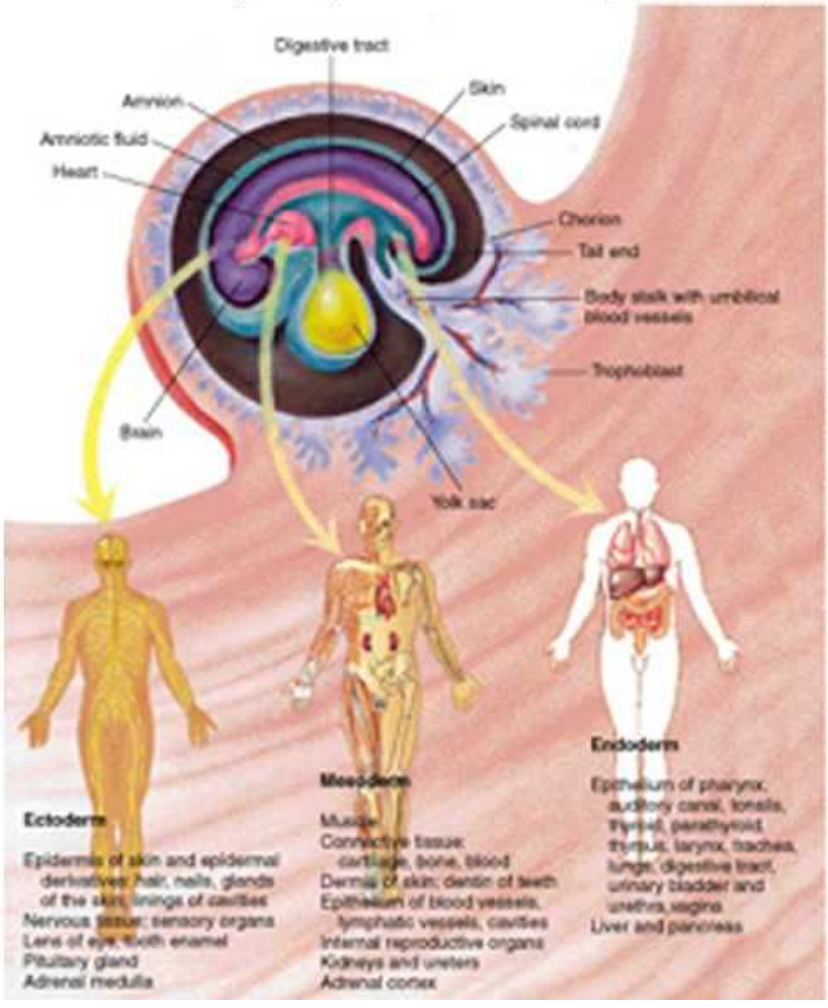
2. Embryo

- Approximately first eight weeks
    - Formation of basic bodily structures
    - Grows up to 30 mm
- Cleavage
    - Morula

- Blastocyst
  - Stage that implants into uterine wall
  - Trophoblast
    - Provides nutrients form mother
    - Forms chorion, placenta
  - Inner cell mass
    - Forms embryonic disk
    - Totipotent



- Gastrula
    - Three primary germ layers differentiate
        - Ectoderm
        - Mesoderm
        - Endoderm
    - Pluripotent



3. Fetus

- Approximately eight weeks until birth
    - Primarily growth of individual
- Many structures continue to develop
    - Bone replaces cartilage
    - Hair formed
    - Digestive and Respiratory systems develop late

- Initiation of physiological activities
    - Breathing
    - Urination and Defecation

4. Twinning

- Dizygotic (Fraternal)
    - Separate fertilizations
        - Share @ ¼ of chromosomes

        - 1 in 81
        - producing twins is partly inherited

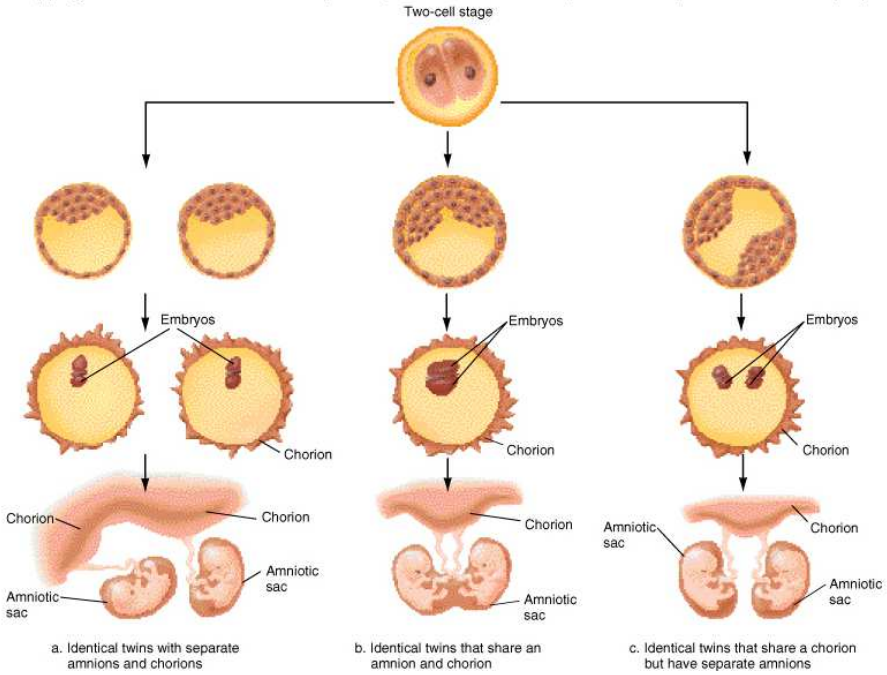
- Monozygotic (Identical)

    - Single fertilized ovum

        - Genetically identical

        - 3-4 in 1000

        - trait is not genetically inherited



a. Identical twins with separate amnions and chorions

b. Identical twins that share an amnion and chorion

c. Identical twins that share a chorion but have separate amnions

    - Types

        - Separate chorion and amniotic sac

            - Separation before day 5

            - 1/3 of cases

- Shared chorion but separate amniotic sac
    - separation between days 5 and 8
    - 2/3 of cases

- Shared chorion and amniotic sac
    - separation after day 8
    - less than 1%

- Conjoined (Siamese) twins
    - Incomplete separation of embryo
    - Twins share some tissues/organs

5. Birth Defects

- 3 in 100 births
- occasionally genetic
- generally environmental
    - due to exposure during critical period
    - teratogens
    - viruses

Table 3.3

Teratogenic Drugs

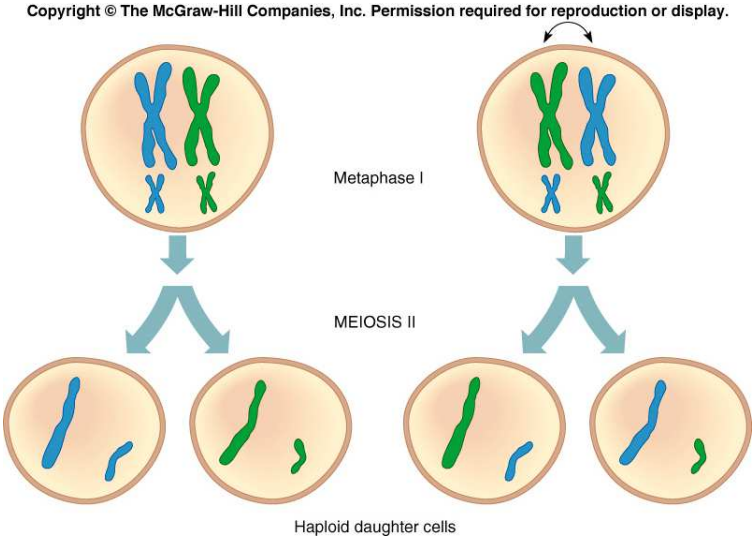
Drug	Medical Use	Risk to Fetus
Alkylating agents	Cancer chemotherapy	Growth retardation
Aminopterin, methotrexate	Cancer chemotherapy	Skeletal and brain malformations
Coumadin derivatives	Seizure disorders	Tiny nose Hearing loss Bone defects Blindness
Diethylstilbestrol (DES)	Repeat miscarriage	Vaginal cancer, vaginal adenosis Small penis
Diphenylhydantoin (Dilantin)	Seizures	Cleft lip, palate Heart defects Small head
Isotretinoin (Accutane)	Severe acne	Cleft palate Heart defects Abnormal thymus Eye defects Brain malformation
Lithium	Bipolar disorder	Heart and blood vessel defects
Penicillamine	Rheumatoid arthritis	Connective tissue abnormalities
Progesterone in birth control pills	Contraception	Heart and blood vessel defects Masculinization of female structures
Tetracycline	Antibiotic	Stained teeth
Thalidomide	Morning sickness	Limb defects

6. Success Rates

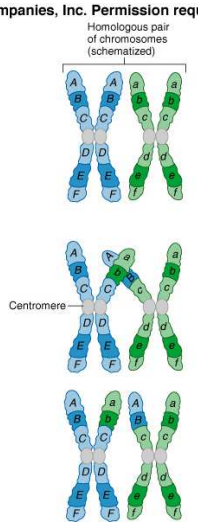
- Fertilization – 84%
- Implantation – 69%
- One week survival – 42%
- Six week survival – 37%
- Birth – 31%
- Most miscarriages due to chromosomal abnormalities

D. Genetic Differences in Offspring

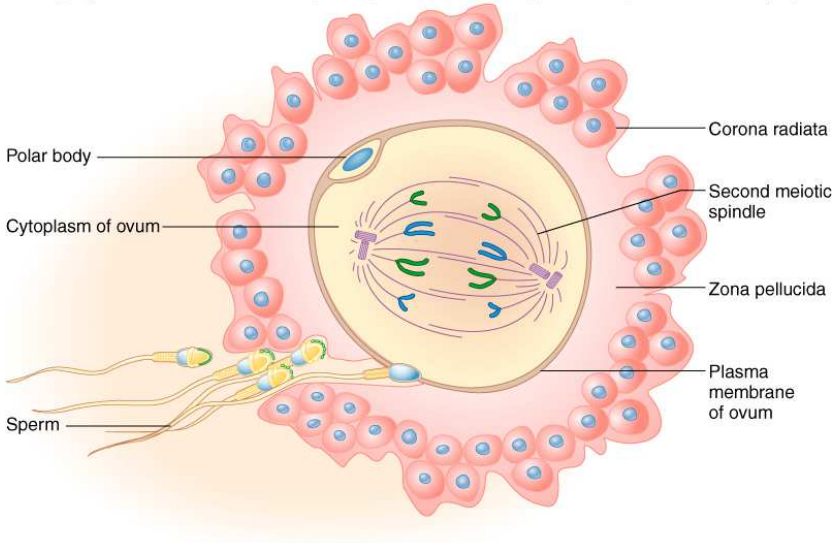
- Independent assortment of chromosomes
  - 50% chance for each chromosome
    - Chance two gametes are identical
    - 2^{23} = 8,388,608



- Crossing over (Recombination)
  - Can occur in nearly all locations



- Random fertilization



  - Identical sperms fertilize identical ova
    - $8{,}388{,}608^2$ > 1:70 trillion

D. Aging

- Longevity
  - Partially inherited
    - Twin studies
    - Chromosome 4
  - Influenced by environment
    - Genotype–Phenotype interaction
  - Negative Pleiotropy
- Genetic Illnesses
  - childhood – usually recessive
  - adulthood – dominant illnesses more common
    - 30 yrs – beginning of decline
      - DON'T I KNOW IT