MEIOSIS & SEXUAL REPRODUCTION

10.1 HALVING THE CHROMOSOME NUMBER

Interphase

- **Meiosis:** type of nuclear division that occurs in sexually reproducing organisms.
    - Reduces chromosome number from **diploid** (**2n**) to **haploid** (**n**) number.
- **Gamete:** reproductive cell (sperm & egg).
- **Zygote:** formed by fusion of gametes; always has diploid (2n) number of chromosomes.
- **Sexual reproduction:** gametes & zygote formation.

Homologous Pairs of Chromosomes

- In diploid body cells, chromosomes occur as pairs.
- Each set of chromosomes is a **homologous** pair; each member is a **homologous chromosome** or **homologue.**
- Homologues look alike; have same length & centromere position.
- A location on 1 homologue contains gene for the same trait that occurs at this locus on the other homologue, although genes may code for different variations of that trait.
- **Alleles:** alternate forms of a gene.

Overview of Meiosis

- **Meiosis** involves 2 nuclear divisions & produces four haploid daughter cells.
- Each daughter cell has half the n^{o} of chromosomes found in diploid parent nucleus.

- **Meiosis I**:
  - Prior to meiosis I, DNA replication occurs, each chromosome has 2 sister chromatids.
  - During meiosis I, homologous chromosomes pair – **synapsis.**
  - During synapsis, the 2 sets of paired chromosomes lay alongside each other as a **bivalent**.

- **Meiosis II**: centromeres divide & daughter chromosomes (derived as sister chromatids) separate.
  - Chromosomes in the 4 daughter cells have only 1 chromatid.
  - In animal life cycle, daughter cells become gametes that fuse during fertilization.

10.2 GENETIC VARIATION

Genetic Recombination

- Occurs as *crossing-over* & *independent assortment*.
- Due to GR, offspring have a different combination of genes than their parents.
- In prokaryotes, variation occurs only due to **mutation**.

Crossing-over

- **Crossing-over:** exchange of genetic material b/w non-sister chromatids of a bivalent during meiosis I.
- At **synapsis**, homologous chromosomes are held in position by **nucleoprotein lattice** (***synaptonemal complex***).
  - After crossing-over, lattice of synaptonemal complex breaks down, but homologues are temporarily held together by *chiasmata*.
  - Homologues separate and are distributed to daughter cells.
- **Chiasmata:** regions where non-sister chromatids are attached due to crossing-over.

Independent Assortment (metaphase I)

- Homologues align independently (in a random manner) at metaphase plate.
- In a cell with 3 pairs of chromosomes: ^{23} or 8 combinations**.**

10.3 PHASES OF MEIOSIS

A. Prophase I

- Nucleolus disappears; nuclear envelope fragments; centrosomes migrate away from each other; & spindle fibers assemble.
- Homologous chromosomes undergo synapsis to form bivalents; crossing-over occurs.
- Chromatin condenses & chromosomes become visible.

B. Metaphase I

- Fully formed spindle
- Bivalents held together by chiasmata align independently at the metaphase plate at equator of spindle.
- Kinetochores attach to *kinetochore spindle fibers*.
- Maternal & paternal homologues of each bivalent may be oriented towards either pole.

C. Anaphase I

- Homologues of each bivalent separate & move toward opposite poles.
- Each chromosome still has 2 chromatids.

D. Telophase I

- Nuclear envelope reforms & nucleoli reappear.
- May or may not be accompanied by cytokinesis.

E. Interkinesis

- Similar to interphase but no DNA replication.

F. Meiosis II and Gamete Formation

- **Metaphase II**: haploid number of chromosomes align at metaphase plate.
- **Anaphase II**: sister chromatids separate at centromeres; 2 *daughter chromosomes* move toward poles.
- Due to crossing-over, each gamete contains chromosomes with different types of genes.
- At the end of **telophase II** & cytokinesis, there are 4 haploid cells.
  - In animals, haploid cells mature & develop into gametes.
  - In plants, daughter cells become **spores** & divide to produce haploid generation; these haploid cells fuse to become a zygote that develops into a diploid generation.

10.4 MEIOSIS COMPARED TO MITOSIS

Mitosis	Meiosis
1 nuclear division	2 nuclear divisions
produces 2 daughter cells	produces 4 daughter cells
daughter cells are diploid	daughter cells are haploid
genetically identical	daughter cells not genetically identical to each other or parental cell
occurs in all tissues for growth & repair	occurs at certain time in sexually reproducing organisms

Meiosis I Compared to Mitosis

- DNA is replicated only once before both mitosis and meiosis.
- 1 nuclear division in mitosis; 2 nuclear divisions in meiosis.

- **Prophase I of meiosis:** homologous chromosomes pair & undergo crossing-over.
- **Metaphase I of meiosis:** bivalents align at metaphase plate; in **mitosis** individual chromosomes align.
- **Anaphase I in meiosis:** homologous chromosomes (with centromeres) separate & move to opposite poles; in **mitosis**, sister chromatids separate & move to opposite poles.

10.5 HUMAN LIFE CYCLE

- **Life cycle:** all reproductive events between 1 generation & next.
- In plants, there are 2 adult stages: diploid (**sporophyte**) & haploid (**gametophyte**).
- In human males, meiosis is part of **spermatogenesis** (production of sperm) in *testes*.
- In human females, meiosis is part of **oogenesis** (production of eggs) in *ovaries*.
- After birth, mitotic cell division is involved in growth & tissue regeneration of somatic tissue.

Spermatogenesis and Oogenesis

Spermatogenesis

- In the testes of males, **primary spermatocytes** with 46 chromosomes undergo meiosis I to form 2 **secondary spermatocytes,** each with 23 duplicated chromosomes.
- Secondary spermatocytes divide (meiosis II) to produce 4 **spermatids,** with 23 daughter chromosomes.
- Spermatids differentiate into **sperm** (**spermatozoa**).
- Meiotic cell division in males always results in 4 cells that become sperm.

Oogenesis

- In ovaries of human females, **primary oocytes** with 46 chromosomes undergo meiosis I to form 2 cells, each with 23 duplicated chromosomes.
- 1 of the cells, **secondary oocyte**, receives almost all the cytoplasm; other cell (**polar body**) disintegrates or divides again.
- Secondary oocyte begins meiosis II & then stops at metaphase II.
- At ovulation, secondary oocyte leaves ovary & enters oviduct where it meets a sperm.
- If a sperm enters secondary oocyte, oocyte is activated to continue meiosis II to completion.
    - Result is mature egg & another polar body, each with 23 daughter chromosomes.
- Meiosis produces 1 egg & 3 polar bodies; polar bodies serve to discard unnecessary chromosomes & retain most of the cytoplasm in egg.
- **Cytoplasm**: source of nutrients for developing embryo.