Chapter 11: Introduction to Genetics

Class	Biology

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11.1 — The Work of Gregor Mendel

Mendel’s Experiments

Genetics: study of heredity

- **Heredity:** the delivery of characteristics from parent to offspring
- What makes organisms unique

Gregor Mendel (Austrian monk) studied peas.

- Easy to work with
- Quickly-growing

The Role of Fertilization

Male part of a flower → sperm (pollen)

Female part of a flower → eggs

Fertilization → male and female reproductive cells join

- Produces a new cell (develops into am embryo)
- **Trait:** a specific characteristic of an individual (ex. color, height, size)

Pea plants are self-pollinating (both male and female reproductive organs).

- Mendel cross-pollinated plants to see genetic differences

Hybrids: offspring of crosses between parents with different traits

Genes & Alleles

P (Parental Generation) → original pair of plants

F_1 (First Filial Generation) → offspring of the *P generation*

- Hybrid pea plants only had traits from one parent

Genes: factors that are passed from one parental generation to the next

- Pea plants showed different forms of a trait (ex. tall, short)
  - **Alleles:** different forms of a gene

Dominant & Recessive Alleles

Principle of Dominance: some alleles are dominant and some are recessive

- At least one dominance allele exhibits the dominant trait
- No dominant alleles exhibit the recessive trait

Segregation

F_2 Generation (Second Filial Generation) → offspring of the *F_1 generation*

The F_1 Cross

Recessive alleles reappeared in the F_2 plants.

Segregation: separation of alleles

Gametes: sex cells

- Dominant and recessive alleles segregate when *gametes* form

Gamete Formation

> Each gamete contains only one allele for a gene.

- F_2 generation → new combinations of alleles

11.2 — Applying Mendel's Principles

Probability & Punnett Squares

Dominant → **T**

Recessive → **t**

Crosses: **Tt** X **Tt** → **TT**, **Tt**, **Tt**, **tt**

- 1/4 are recessive (probability)

Probability: the likelihood that a certain event will occur

- Past outcomes don't affect future results

Using Segregation to Predict Outcomes

Probability of having *tt* allele → 1/4

- 1/4 of offspring will show recessive trait

Homozygous → two identical alleles for a gene (*TT* or *tt*)

Heterozygous → two different alleles for the same gene (*Tt*)

Averages get closer to predicted values from probability with more cases (more offspring).

Genotype & Phenotype

Genotype: genetic makeup (ex. *TT*, *Tt*, *tt*)

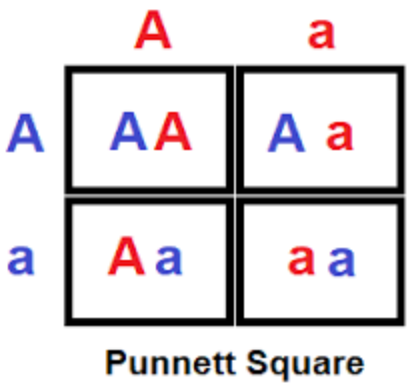
Phenotype: physical traits (ex. *tall*, *short*)

Genotype → Phenotype

Using Punnett Squares

Punnett Square: diagram of a genetic cross

- Mathematical probabilities
- Predict genotype and phenotype combinations



Punnett Square

Monohybrid Cross: 2×2 punnett square

- One trait

Dihybrid Cross: 2×2 punnett square

- Two traits

	YR	YR	YR	YR
yr	YyRr	YyRr	YyRr	YyRr
yr	YyRr	YyRr	YyRr	YyRr
yr	YyRr	YyRr	YyRr	YyRr
yr	YyRr	YyRr	YyRr	YyRr

Independent Assortment

Principle of Independent Assortment → genes for different traits can segregate independently during gamete formation

- Accounts for genetic variation in organisms

Mendel's Principles

1. The inheritance of biological characteristics is determined by individual units called genes that are passed from parent to offspring.

2. When two or more forms of a gene exist, some may be dominant and some may be recessive.
3. In most sexually-reproducing organisms, each adult has two copies of a gene - one from each parent. The genes segregate from each other when gametes are formed.
4. Alleles for different genes segregate independently of each other.

11.3 — Other Patterns of Inheritance

Beyond Dominant and Recessive Alleles

Incomplete Dominance: cases in which one allele is not completely dominant over another

- Some alleles are neither dominant nor recessive.

Codominance: phenotypes of multiple alleles are clearly expressed (ex. human blood)

Multiple Alleles → more than two alleles of a gene

Polygenic Traits: traits controlled by multiple genes (interaction of several genes)

- Wide range of phenotypes

Non-Mendelian Inheritance

- Doesn’t follow Mendel’s principles

Maternal Inheritance: only traits from the mother are expressed

- Chloroplasts and mitochondria contains there own genes (from the egg cell)

Genetic Imprinting: chemical modification of genes

Genes and the Environment

An organism’s characteristics are not only affected by its genetic makeup.

- Also affected by the environment

> Environmental conditions can affect gene expression and influence genetically-determined traits.

11.4 — Meiosis

Chromosome Numbers

Mendel's principles require two events to occur:

- Organisms inherit a single copy of a gene from each parent
- Sets of genes must be separated so that gametes contain one set of genes

Gametes: sex cells

- Chromosomes are the carriers of genes

Diploid and Haploid Cells

Homologous Chromosomes: 8 chromosomes (4 from each parent)

- **Diploid** → 2 sets of homologous chromosomes (2N)
- **Haploid** → 1 set of homologous chromosomes (N)

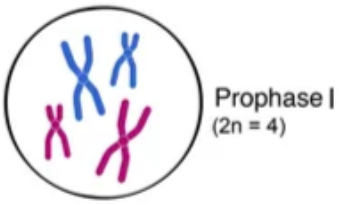
Phases of Meiosis

Meiosis → cuts the number of chromosomes in half

- Diploid cell → 4 haploid cells

Meiosis I

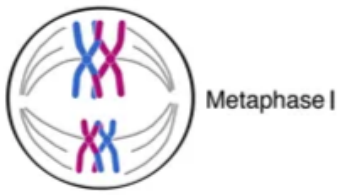
- Chromosomes replicate beforehand
    - Replicated chromosome = 2 identical chromatids joined



- Chromosomes pair up

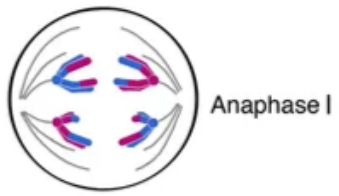
Tetrads (pairing of homologous chromosomes - 4 chromatids) form

Crossing Over: a process for chromosomes to exchange linked genes (chromosomes switch some of their genes)

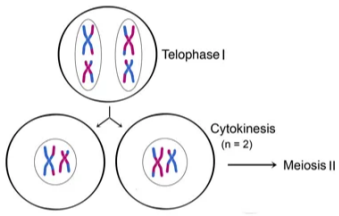


Paired homologous chromosomes align themselves in the center of the cell

- Spindle fibers pull them



Spindle fibers pull each homologous chromosome pair to opposite ends of the cell



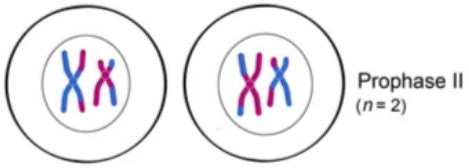
- Nuclear membrane reforms around chromosomes

Cytokinesis → splits the cell to form two new cells

Chromosome pairs are shuffled and different

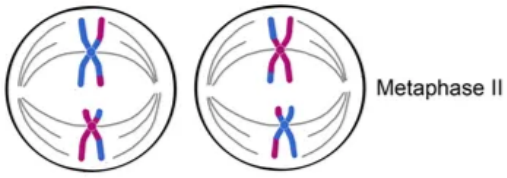
Meiosis II

- No chromosome replication
- Another round of division



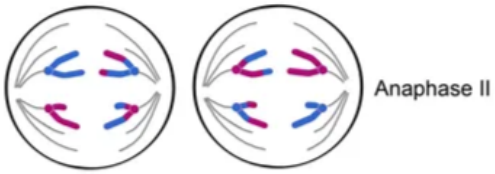
- Chromosomes become visible

Homologous pairs are already separated (from *Meiosis I*)



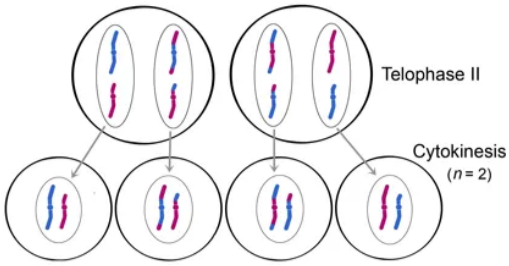
Chromosomes are lined up in the middle of the cell

- Spindle fibers align them



Paired chromatids separate

- Brought to opposite ends of the cell



Cells finally divide and separate

- Nuclear envelope reforms

Ending Result: 4 Haploid Cells

Gametes & Zygotes

Male gametes → **sperm**

Female gametes → **eggs**

Sperm + egg = *fertilized egg* (**zygote**)

- Undergoes cell division to form a new organism

Meiosis vs. Mitosis

Allele Separation: separated in *meiosis*, but not mitosis

Chromosome Number: halved in *meiosis*, but not mitosis

Number of Cell Divisions: 2 in *meiosis*, but not mitosis

Gene Linkage & Gene Mapping

Gene Linkage

- Genes on the same chromosome are regularly expressed together
    - “Linked” on the same chromosome
- Linkage groups → different genes commonly expressed together

Gene Mapping

Alfred Sturtevant → student at Columbia University

- Made a theory on gene locations

↑ Distance between genes on a chromosome = ↑ Probability of genes crossing over

- Figured out distance between genes