**Chapter 4: Heredity**

**Section 1: Mendel and His Peas**

**Heredity** – passing of traits from parents to offspring.

In the mid-1800’s, **Gregor Mendel** performed many important experiments with pea plants that led to important discoveries about heredity.

Gregor Mendel was born in 1822 in Austria. Entered a monastery when he was 21 to teach science. Unable to pass exams to become a teacher, so returned to monastery to experiment with plants.

Mendel knew patterns of inheritance were not clear. Traits could skip generations or seem to disappear altogether.

Garden peas were a good choice for his research. Why?

* Quick growth
* Many varieties
* Capable of **self pollination** (has both male and female reproductive structures). Pollen from one flower can fertilize ovule of the same flower. Also capable of **cross-pollination**, which means pollen from one flower can fertilize ovule of a different flower. Pollen can travel via insects, wind, etc.

Thus, Mendel was able to grow **true breeding** plants. When a true-breeding plant self-pollinates, all of the offspring are identical to the parent.

Mendel studied just one **characteristic** at a time. A characteristic is a feature that has different forms in the population. The different forms of each characteristic are called **traits**.

* The characteristic of seed shape has two traits – round or wrinkled
* The characteristic of plant height has two traits – tall or short
* The characteristic of flower color has two traits – white or purple

Mendel crossed true-breeding pea plants to study 7 different characteristics. Each plant was true breeding for different traits of each characteristic. The offspring from such a cross are called **first generation** plants (or **F1** which means first filial). All of the F1 plants had the same trait that one of the parents had. This trait is called the **dominant** trait. Mendel called the trait that did not appear in the F1 generation the **recessive** trait.

* For example, when Mendel crossed a true-breeding white flowered plant with a true-breeding purple flowered plant, all of the F1 offspring had purple flowers. Thus, Mendel concluded that purple flowers were dominant and white flowers were recessive.

Mendel then allowed the F1 plants to self-pollinate. He found that the recessive trait appeared again in the **F2** (second filial) generation.

Mendel began counting the ratio of dominant traits to recessive traits in the F2 generation and found that the ratio was consistently 3:1 for the dominant trait: recessive trait for each of the 7 characteristics he studied.

Mendel realized that his results could only be explained if each plant had 2 sets of instructions for each characteristic. Mendel’s ideas were published in 1865, but it wasn’t until 30 years after his death that the importance of his findings was finally recognized.

**Section 2: Traits and Inheritance**

Scientists now call the instructions for an inherited trait **genes**. The different forms of a gene are called **alleles**. Dominant alleles are shown with a capital letter and recessive alleles are shown with a lowercase letter.

**Phenotype** – organism’s appearance (ex. Purple or white flower color)

**Genotype** – both inherited alleles together

* Homozygous = *true breeding* with two of the same allele for a gene (ex. PP or pp)
* Heterozygous = two different alleles for a gene(ex. Pp)

**Punnett Squares** are used to organize all possible combinations of offspring from 2 particular parents. Alleles from one parent are written across the top of the grid, while alleles from the other parent are written along the side. All possible combinations are shown in the grid.

***Try this!*** Cross a true breeding purple flowered plant (PP) with a true-breeding white flowered plant (pp). What are the genotypic and phenotypic F1 results? Cross 2 F1 plants to create the F2 generation. What are the genotypic and phenotypic F2 results? Does this help explain Mendel’s findings?

Each parent has 2 alleles for each gene. If the alleles are the same, then all offspring will receive the same one. If the alleles are different there is a 50% chance that their sex cells will receive one or the other. The mathematical chance that something will happen is called **probability**.

***Try this!*** *Toss a coin. What are the chances it will be heads or tails? (1/2) What are the chances that it will be heads 2 times in a row? Just multiply the probability of each event together to calculate the probability of both events (1/2 x ½ = ¼). So, there is a 25% chance of getting heads 2 times in a row. The same principle applies to inheritance!*

**Exceptions to Mendelian Inheritance**

**Incomplete Dominance** – when one trait is not completely dominant over the other. Heterozygous individuals appear to have a blend of the 2 traits. For example, snapdragons show incomplete dominance with flower color: a red snapdragon crossed with a white snapdragon produces a pink snapdragon.

**One gene, many traits** – sometimes one gene influences many traits. For example, the gene for albinism in humans causes loss of pigmentation in hair, skin, and eyes.

**Many genes, one trait (polygenic trait)** – many of our traits like hair, eye and skin color or height are controlled by many genes.

**Environmental influence** – traits are expressed as a result of both genetic *and* environmental influence. For example, certain breeds of horses have a gene for long hair but those who live where the summer is long shed their long hair for a time, in colder climates they keep it.

**Section 3 – Meiosis**

**Asexual reproduction** – only one parent cell needed. Cell divides by mitosis (eukaryotic cells) or binary fission (prokaryotic cells).

**Sexual reproduction** – sex cells from 2 parents join together to produce offspring. Sex cells are haploid (have only 1 set of chromosomes). Each sex cell has 1 chromosome from each homologous pair.

**Meiosis** – process of making sex cells (egg and sperm).

After rediscovering Mendel’s work, a graduate student named Walter Sutton was studying sperm cells in insects. After some time, he proposed an important hypothesis that is still widely accepted: **Genes are located on chromosomes**. He knew that understanding meiosis was critical to finding the location of genes.

**Steps of Meiosis**

* **Interphase**  - chromosomes are copied
* **Prophase I –** chromosomes condense, nuclear membrane breaks down
* **Metaphase I ­– homologous pairs align**
* **Anaphase I – homologous pairs separate**
* **Telophase I** – cell pinches into 2 identical cells
* **Prophase II – chromosomes not copied again. Each cell contains 1 copy, made up of 2 sister chromatids, from each homologous pair**
* **Metaphase II** – chromosomes align along midline of cell
* **Anaphase II**  - sister chromatids (half of a chromosome) separated
* **Telophase II – four new cells, each with half the number of chromosomes present in the original cell**

**Sex Chromosomes**

Human females have 2 X chromosomes while males have an X an a Y chromosome. The Y chromosome does not have the same genes as the X, so males have only one copy of certain genes found on the X chromosome while females have 2.

**Sex-linked disorders**

Because females have 2 X chromosomes, they have a backup gene if one is damaged. Males have only one X, so if the gene on their X is damaged, they will have certain disorders. Sex-linked disorders are much more common in males for this reason.

* Colorblindness
* Hemophilia

**Recessive disorders**

Some disorders are inherited as a result of 2 recessive alleles, one from each parent.

* Cystic fibrosis
* Tay sachs disease

**Genetic Counseling**

If a family has a history of genetic disorders and are worried about passing a disease on to their offspring, they can consult with a genetic counselor. The counselor can use a diagram called a **pedigree** to trace a trait through generations of a family and predict whether a person is a carrier of a hereditary disease.

The picture below shows the pedigree of Queen Victoria’s family. She was a carrier for a sex-linked disorder called hemophilia. The pedigree shows how the disorder was passed on from generation to generation from mother to son.

