CHAPTER 7
GENETICS

Definitions
Genes: are the genetic factors. A gene is made up of a group of nucleotides in a DNA.

Homologous chromosomes are similar chromosomes that carry the same traits.

Alleles: These are the alternate forms of pairs of genes, each pair expresses a specific trait; for example, tall and short is one trait carried by a pair of genes Tt (T= tall, t = short).

Homozygous: Same allelic genes (TT or tt)

Heterozygous: different allelic genes (Tt)

Monohybrid Cross: A cross of individuals that only differ by one trait.

Dihybrid Cross: A cross of individuals that differ by only two traits.

Genotype: gene combination

Phenotype: actual physical appearance

Dominant Gene: In an alternate pair of alleles, the dominant gene's trait appears and over-shadows the other non-dominant one.

Recessive Gene: The trait of a recessive gene or a non-dominant gene does not appear when the dominant allelic gene is present.

Incomplete Dominance: During the crossing of two pairs of alternate genes that carry the trait of two colors (red and white), the results produced offsprings of color in between the two colors of the parents, for example pink; this is termed incomplete dominance.

Codominance: In a pair of alleles, if neither of the alleles is dominant, then both genes exhibit their traits during inheritance.

Multiple Alleles: In some cases, more than just a pair of alleles exist for a given trait, for example, in the human blood group inheritance, there are 3 allelelic genes: A, B, and O (or I_A, I_B and I respectively), this is known as multiple allelelic inheritance.

Polygenic Inheritance: This is like incomplete dominance, but the trait is controlled by more than just a pair of alleles, as in the incomplete dominance. This is more complicated, an example is the human skin color inheritance.

Linkage: Some genes are linked such that they are always inherited together, this means that certain traits must be inherited together.

Inheritance

Gregor Mendel (1822-1884) conducted experiments to demonstrate the nature of heredity. He used 34 strains of garden peas. The plants could self-pollinate, and he could also manually cross-pollinate them. He conducted experiments to illustrate the inheritance by performing hybrid crosses of traits.

Monohybrid Cross: (cross to examine 1 trait): Green Pea (yy) x Yellow Pea (YY)
(let "YY" represent yellow color trait or a gene pair and "yy" represent green color trait or a gene pair; also yellow color gene pair is dominant. Whenever capital "Y" is present, with the small letter "y", the yellow color shows).

First obtain each gamete (egg and the sperm) gene inheritance before proceeding with the crossing (or fertilization). Gametes' genotypes are "y" and "y" from parent #1, and "Y" and "Y" also from parent #2. Place Gamete # 1genes on one arm (vertical or horizontal arm), and gamete #2 on the other arm of the square and multiply. This is seen in figure 7.1.known as a Punnett Square.

	Y	Y
y	Yy	Yy
y	Yy	Yy

Figure 7.1. Monohybrid Crossing.

All offsprings of the first generation (F1) were yellow with genotype "Yy".

Second Generation Monohybrid crossing

First obtain each gamete (egg and the sperm) gene inheritance before proceeding with the crossing (or fertilization). Gametes' genotypes are "Y" and "y" from parent #1 and "Y" and "y" also from parent #2. Place Gamete # 1genes on one arm (vertical or horizontal arm), and gamete #2 on the other arm of the square and multiply.
Yellow Pea (Yy) x Yellow Pea (Yy)

	Y	y
Y	YY	Yy
y	Yy	yy

Figure 7.2. Second generation offsprings.

F_2 Offsprings were 3/4 yellow and 1/4 green. The genotypes are "YY", "Yy", "Yy", and "yy" . Note that the green color reappeared in the second generation. He concluded that the yellow trait "Y"is dominant. From these results, Mendel came up with two principles:

Principle of Dominance and Segregation.

Principles of Dominance: In a pair of allelic genes, one gene (dominant) can mask the appearance of the other (recessive).

Principle of Segregation (or independent assortment): During gamete formation, the allelic genes segregate independently, allowing the gametes to receive each of the pair of genes.

Dihybrid Cross: Mendel also crossed parents for two traits:
Tall and Yellow Pea Plants (TTYY) x Short and Green Pea Plants (ttyy); (Tall is dominant over short and yellow is dominant over green).

Obtain the gene combinations of the gametes by making possible combinations of the genes of each parent. The gametes from parent 1 are: TY, TY, TY, and TY; the gametes from parent 2 are ty, ty, ty, and ty. Place the gametes of parent 1 on the vertical column, and those of parent 2 on the horizontal column of the Punnett Square. Multiply each set of gene in the column by all the ones on the row as follows.

	ty	ty	ty	ty
TY	TtYy	TtYy	TtYy	TtYy
TY	TtYy	TtYy	TtYy	TtYy
TY	TtYy	TtYy	TtYy	TtYy
TY	TtYy	TtYy	TtYy	TtYy

Figure 7.3. Dihybrid Crossings of two dominant genes (tall and yellow), and two recessive genes, short and green. Tall and yellow are dominant, all the offsprings in the first generation will be TtYy: tall and yellow.

Second generation dihybrid crossing: Tall yellow pea plant x Tall yellow Pea plant
Genotypes of the offsprings who are now the parents: TtYy x TtYy

To repeat the Punnett Square as in the above dihybrid crossing, you have to obtain the gametes that result from the parents' genes combinations.

Note that there are two traits, so each gamete must carry the genes representative of each trait.

Gametes' genotypes from Parent #1: TY, tY, Ty and ty; Gametes' genotype from Parent #2: TY, tY, Ty and ty

	TY	tY	Ty	ty
TY	TTYY Tall yellow	TtYY Tall yellow	TTYy Tall yellow	TtYy Tall yellow
tY	TtYY Tall yellow	ttYY Short yellow	TtYy Tall yellow	ttYy Short yellow
Ty	TTYy Tall yellow	TtYy Tall yellow	TTyy Tall green	Ttyy Tall green

ty	TtYy Tall yellow	ttYy Short yellow	Ttyy Tall green	ttyy Short green

Figure 7.4: Dihybrid crossing showing offsprings of the second filial generation

The F2 (second filial) offsprings are in the ratio of 9:3:3:1 (phenotypes).
Illustrated as follows:
Tall yellow: All offsprings with "T" and "Y" in their genotype will be tall and yellow: TTYY, TtYY, TtYy (9); Tall green: TTyy, Ttyy (3 Tall green); ttYY (3 short yellow); and ttyy (1 Short green)

*Tall is dominant, yellow is dominant also; therefore TTYYand TtYy will be tall and yellow; only ttyy will be short and green; ttYy / ttYY will be short and yellow.

Key Points

1. Alleles are alternate forms of a pair of genes. Same allelic pair of genes is termed homozygous (TT). Different allelic gene pair is termed heterozygous (Tt). The gene combination is genotype, the actual physical trait is the phenotype. In a pair of allelic genes, if one gene exhibits its physical trait, it is described as a DOMINANT GENE, the other gene that did not express itself (or that was suppressed) is RECCESSIVE GENE.
2. Gregor Mandel was the first man to conduct an experiment to demonstrate inheritance using pea plants. In his experiment, he demonstrated that if a pure green plant (gg) is crossed with a pure white plant (GG), all the offsprings will be white plants with Gg genotypes. (Refer to lecture notes or text for explanation).
3. Meiosis is a cell division in which the # of chromosomes in the daughter cell is reduced to half that of the mother cell. Meiotic cell division allows inheritance of chromosomes of parent cell by offsprings to occur without the chromosome number duplication.
4. The division occurs in 2 cycles, each cycle has four phases. The first cycle is concerned with the mixing of the genes of homologous (similar) chromosomes in the cell.
5. The first phase is PROPHASE: homologous (similar) chromosomes pair and exchange genes (crossing over of genes) through a link (a chiasma or a bridge), spindles are produced. After this, the homologous choromosomes line up in pairs in the center of the cell, this phase is METAPHASE. At ANAPHASE, these homologous chromosome separate and move to opposite ends of the pole. Cytokinesis occurs, followed by the formation of a cell plate. At TELOPHASE the cell divides producing two cells with half the number of chromosomes as the mother cells.
6. Each daughter cell begins a second cycle of cell division going through prophase, metaphase, anaphase, and telophase in process exactly like the mitotic cell division.

Study Questions

1. Make a test cross of two plants: plant #1 has blue flowers, and plant #2 has white flowers. (Note that blue is dominant over white, each parent plant flower is pure breed, that is homozygous). First state the genotype of the parents' plants, then state the possible genotypes of the first generation (F1) offsprings and phenotype of the F1 offsprings.

2. Suppose the F1offsprings of the above question #1 cross with themselves, state the genotypes of the second generation offsprings (F2) and their phenotypes.

3. Supposing from the above questions, the blue flowers were wrinkle and the white flowers were smooth, make the dihybrid crosses of the two parent plants, state both the genotype and phenotypes of the offsprings in the F1 generation. ****Note that blue and wrinkle are dominant traits.***

Hints: Choose any letter to represent the blue color (BB), white(bb), and any to represent wrinkle (WW), smooth (ww). Remember that the dominant is always a capital letter, and the recessive is always the small letter of the capitalized one.

4. Define or explain each of the following terms:
genes, homologous chromosomes, alleles, homozygous, heterozygous, monohybrid, dihybrid, genotype, phenotype, dominant gene, recessive gene, incomplete dominance, codominance, multiple alleles, polygenic inheritance, and linkage.

5. Who was Gregor Mendel?

6. State the first and second Principles of Inheritance.

7. Make a monohybrid crossing of a White Flower x a Red Flower (red color gene being the dominant gene). What will be the color of the flowers of the first generation offsprings?

8. Continue the monohybrid crossing, using the flowers obtained from #7 to do the crossing. What will be the color of flowers of the offspring in this second generation?

9. Assuming the plants that bear the red flowers are tall (tall genes and red color genes are dominant) and the ones that bear the white flowers are short (short and white color genes are recessive). What type of plants / flower color will be produced in a dihybrid cross between a tall plant with red color flower and a short plant with white color flowers?

10. Supposing a second dihybrid cross is made between the plants obtained from #9; what will be the result of this dihybrid cross plants look like?

Chapter 8
Plant Systematics

Plant systematics involves the classification and naming of plants. Carolus Linnaeus may be called the father of Binomial System of Nomenclature. This binomial system of nomenclature simplifies the naming of a plant with only two words, the first is the genus and the second is the species.

Classification of Plants

Species are organisms that can interbreed, related species can be grouped into Genera, related genera can be grouped into Families, related families are grouped into Orders, related orders are grouped into Classes.

Classes are distributed into Phyla or Divisions. Several divisions of plants form the Kingdom Planta. Below is the hierarchy of plants classification.

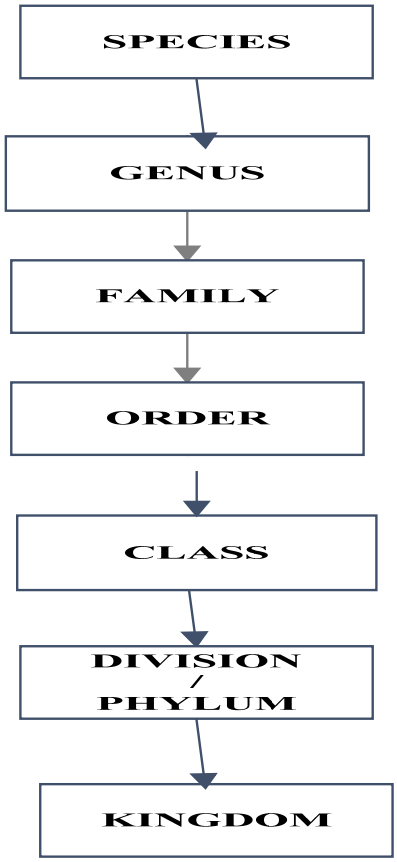

Figure 8.1: The Hierachy of classifying plants

The kingdom Planta is in the Domain Eukarya. The various plants can be classified into various divisions, classes, orders, families, genus and species. The binomial nomenclature deals with the genus and the species only.

Evolution of land plants started with the bryophytes which are nonvascular, seedless, and non-flowering plants. Bryophytes are very similar to the green algae found in pond water. They play an important ecological role in plant succession. In bryophytes the gametophytes are dominant contrary to other plants where the sporophytes are dominant. Bryophytes can grow on rocks and can tolerate drought conditions.

Following bryophytes evolved the vascular seedless plants: the ferns and their allies; there are 3 divisions: pterophyta, psilophyta and sphenophyta.

Later evolved the gymnosperms, the seed-bearing vascular plants; there are 4 divisions: cycadophyta, gnotophyta, ginkophyta and coniferophyta.

Finally evolved the angiosperms, the vascular, seed-bearing and flowering plants; there are two classes, monocotyledons and dicotyledons. There are several families and genus of flowering plants:
asteraceae –helianthus, sunflower
Brassicaceae – Brassica, broccoli
Cactaceae – Opuntia, prickly pear
Fabaceae – Pisum, garden pea
Liliaceae – Lilium, Madonna lily
Nymphaeaceae – anymphyaea, water lily
OrchidaceaeCattleya, corsage orchid
Poaceae – Saccharum, sugar cane
Rosaceae – Fragaria, strawberry
Solanaceae – Solanum, potato

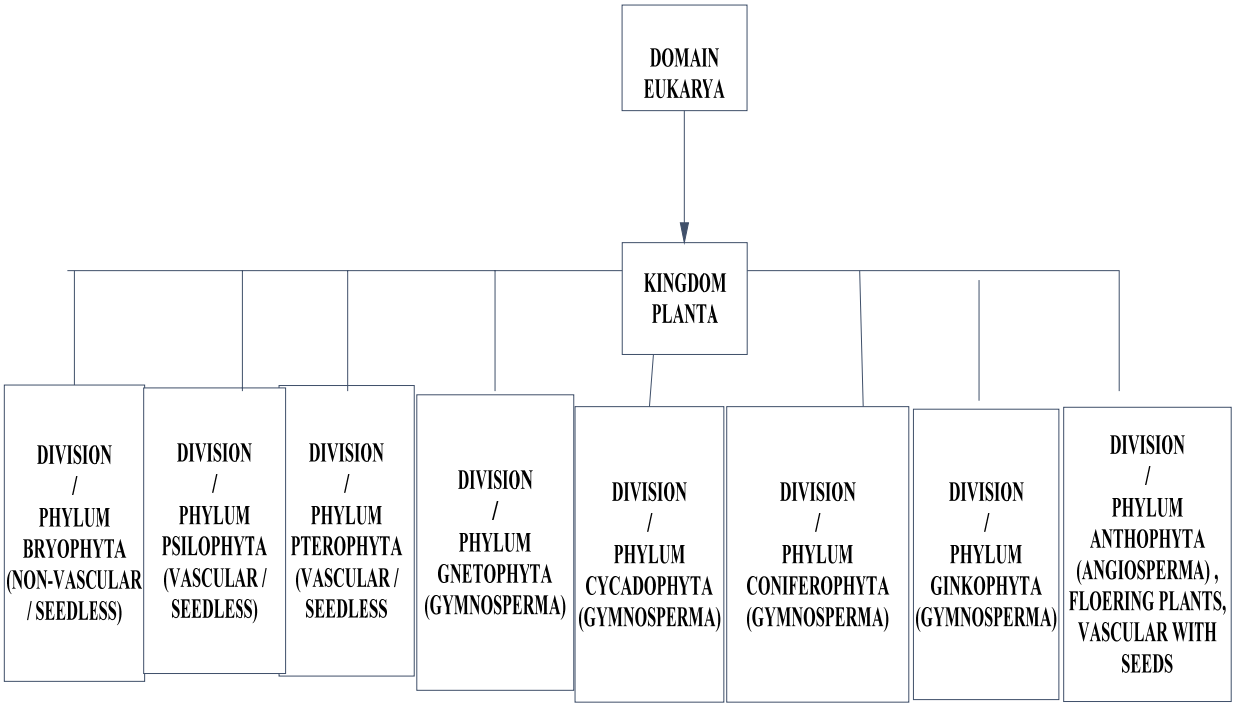

Figure 8.2: The divisions of plants.

This means that organisms are distributed into kingdoms, followed by divisions, classes, orders, families, genus and finally species. Generally an organism is recognized by the genus and the species like *Quercus rubro* (red oak).

Al organisms are divided into domains: Bacteria domain, Prokarya domain and Eukarya domain. There are 6 kingdoms that organisms are classified into: Archea, Bacteria, Protista, Planta, Animalia, and Fungi.

A species is defined as a group of organisms that can interbreed; however in plants this definition may not be exactly correct since interbreeding between different species have been established.

Darwin & the Theory of Evolution
Through the mechanism of **natural selection**, new species of an organism can evolve; this is associated with **Charles Darwin's theory of evolution**. Charles Darwin stated that species originated by means of natural selection.

According to this theory, natural selection involves 4 factors: **variation, overproduction, competition,** and **survival to reproduce.**

Variation: Members of a species exhibit differences that are inherited by their offsprings.

Overproduction: This allows the elimination of less suitable offsprings from the environment.

Competition: Within an ecosystem, individuals compete for everything, and only the ones that survive the competition remain to reproduce. These are the ones most suited to the environment.

Survival to reproduce: The most suitable individuals pass on these desirable traits to their offsprings resulting in the popularity of this desired trait.

Adaptation: For organisms to better fit to their environment, they have to be able to adapt to their environment. This means that an organism should evolve features that will enable it to adapt to its' environment; evolving such features gradually leads to changes in the organism or in the species and ultimately evolution.

Key Points

1. Diversity involves classfication of all organisms, Carolus Linnaeus brought a Binomial System of nomenclature. This involves identifying as organism with only two names, example Quercus rubio – Red Oak. Ouercus is the Genius, rubro is the species.

2. There are altogether 6 kingdoms to classify all organism into: kingdom archeobacteria / eubacteria– simple, prokaryotic cell organisms like bacteria and blue green algae. Kingdom protista includes organisms from simple to complex multicelluluar ones. This includes red, green, brown algae, sea weeds, and diatoms. Kingdom planta includes all organisms considered as plants, among them re bryophytes (mosses & liverworts), ferns and their allies, gymnosperms (confers, pines, cycads, ephedra, ginkgo) and angiosperms all flowering plants. Kingdom fungi includes all fungi (slime molds, bread models, yeasts and mushroom). The last kingdom is animalia.

Study Questions

1. State any 4 factors that are associated with Natural selection.
2. How can the theory of natural selection promote evolution?
3. What do you understand by binomial nomenclature of naming plants?
4. Who is associated with evolution and who is associated with binomial nomenclature?