

**Department of biology**

**Zoology**

**First stage**

**(6)**

**Genes and Heredity**

**By**

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**The physical basis of heredity**

When **Gregor Mendel** formulated his laws of heredity, he postulated a particulate nature for the units of inheritance. What exactly these particles were he did not know. Today scientists understand not only the physical location of hereditary units (i.e., the genes) but their molecular composition as well. The unraveling of the physical basis of heredity makes up one of the most fascinating chapters in the history of biology.

Perhaps the most fundamental property of all living things is the **ability to reproduce**. All organisms **inherit** the genetic information specifying their structure and function from their parents. Likewise, all cells arise from preexisting cells, so the genetic material must be replicated and passed from parent to **progeny** cell at each cell division. How genetic information is replicated and transmitted from cell to cell and organism to organism thus represents a question that is central to all of biology. Consequently, elucidation of the mechanisms of genetic transmission and identification of the genetic material as DNA were discoveries that formed the foundation of our current understanding of biology at the molecular level.

**Genes and Chromosomes**

The main relationship between DNA, genes, and chromosomes is that genes are made up of segments of coiled DNA, and chromosomes are long supercoiled chains composed of various genes. In humans, a single gene can contain about 1 million base pairs of DNA and a chromosome can contain about 1,000 such genes, and a single cell has 46 of such chromosomes.

DNA, Genes, and Chromosomes are the three important concepts that are needed in understanding the principles of genetics along with inheritance and variation.

**What is a Gene?**

A gene is a part of a long polynucleotide sequence of the DNA that codes for various proteins that can express a particular genetic trait in the living body.

A gene is basically the physical and functional unit of heredity that stores a particular genetic trait.

Genes can vary in size from having the DNA polynucleotide chain with a few hundred DNA bases to more than 2 million bases.

Genes are part of the chromosomes, which are present in the cell nucleus. A single chromosome can contain hundreds to thousands of genes. Genes are the controller of the inheritance of genetic traits.

Alleles are forms of the same gene with small differences in their sequence of DNA bases and controls the variation in a living body. These small differences contribute to each person‘s unique physical features. Just like the gene for height can have the allele of being tall or short if expressed.

**Genes and Chromosomes**

Each individual in a sexually reproducing species inherits two alleles for each gene, one from each parent. Furthermore, when such an individual forms sex cells, each of the resultant **gametes** receives one member of each allelic pair. The formation of gametes occurs through a process of cell division called meiosis. When gametes unite in fertilization, the double dose of hereditary material is restored, and a new individual is created. This individual, consisting at first of only one cell, grows via mitosis, a process of repeated cell divisions. Mitosis differs from meiosis in that each daughter cell receives a full copy of all the hereditary material found in the parent cell.

It is apparent that the genes must physically reside in cellular structures that meet two criteria. First, these structures must be replicated and passed on to each generation of daughter cells during mitosis. Second, they must be organized into homologous pairs, one member of which is parceled out to each gamete formed during meiosis.

As early as 1848, biologists had observed that cell nuclei resolve themselves into small rodlike bodies during mitosis; later these structures were found to absorb certain dyes and so came to be called chromosomes (coloured bodies). During the early years of the 20th century, cellular studies using ordinary light microscopes clarified the behaviour of chromosomes during mitosis and meiosis, which led to the conclusion that chromosomes are the carriers of genes.

**What is a Chromosome?**

In the nucleus of each cell, the DNA molecule is the chemical unit of inheritance, and a long polymer of DNA forms a gene, and when many of such genes get packaged (supercoiled/coiled) into a bigger thread-like structure forms a chromosome.

Each chromosome is made up of DNA tightly coiled many times around proteins called histones that support its structure.

DNA is so compressible that a DNA helix with a diameter of 2nm (2 x 10-9 m) can be supercoiled to become a chromatid of 700nm (700 x 10-9 m) diameter or so. A chromosome consists of two chromatids attached together.

**Relationships Between DNA, Genes, And Chromosomes**

**1.** DNA is the chemical unit of genetic inheritance which is the part of genes and many of such genes together constitute the structure of a chromosome.

**2.** A single DNA is a Double Helix Structure of two nucleotide strands. A polymer of many nucleotides forms a gene. Various such genes form a chromosome.

**3.** DNA contains the chemical structure to code for a few proteins. Genes contain a long polymer of DNA to code for a lot of multiple proteins. And, a chromosome contains various genes that code for a multiple of multiples of proteins.

**4.** A single DNA nucleotide cannot express a genetic trait. A gene with a huge polynucleotide of DNA can express a specific genetic trait. And, a chromosome that contains a lot of genes can express various genetic traits as a whole.

**5.** DNA has the ability to coil and supercoil. It‘s a way of the packaging itself to fit inside the nucleus of the cell. And in doing so, DNA makes genes and genes subsequently make chromosomes.

**6.** DNA is the chemical unit of hereditary, Gene is the functional unit of hereditary, and Chromosome as a whole is the carrier of hereditary information from generation to generation.

**7.** DNA Topoisomerases are universal enzymes found in all cell types. These enzymes act on DNA Helix to coil it to make a gene which further coils to make a nucleosome. Various nucleosomes coil further using that same enzyme to form a Chromosome. That‘s how DNA is coiled and supercoiled to form a chromosome.

**8.** Chromosomes are the carrier of both genes and DNA because it contains both. In reality, the chromosome is not other than the supercoiled structure of DNA itself.

**9.** DNA takes part in replication and transcription for a particular gene and also for the overall chromosome to form various proteins. It‘s only the DNA in the genes and chromosomes that take part in replication and transcription and thus forming proteins.

**10.** Genes are those chunks of DNA that contains the information of how, when, and why to code for proteins. It has the information to stop or start DNA replication, transcription, and further the translation process.

**11.** Genes are the chunks of DNA that pass from the parents to offspring. Genes are just like the processor and motherboard of the genetic information.

**12.** The activity of the whole chromosome is controlled by the various genes present in it. And, the gens are directly dependent on the structure of the DNA present in it

