International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

# A Deep Insight on Structure and Organization of Chromosomes and their Genetic Significance in Living Organisms - An Informative Article

**Sure Naveen**

Research Associate (Plant Breeding), Agricultural Research Station (ARS), Chinapavani, India
E mail: *naveensure23[at]gmail.com*

**Abstract:** ***Chromosomes are thread - like structures located inside the nucleus of animal and plant cells. Each chromosome is made of protein and a single molecule of deoxyribonucleic acid (DNA). Passed from parents to offspring, DNA contains the specific instructions that make each type of living creature unique. The term chromosome comes from two Greek words; Chroma (color) and soma (body). Scientists gave this name to chromosomes because they are cell structures, or bodies, that are strongly stained by some colorful dyes used in research. Strasburger first discovered chromosomes in 1875, and the term chromosome was coined by waldeyer in 1888. They have been considered as the physical bases of heredity because they have a special organization, individuality, functions and are capable of self - reproduction. When, the chromosomes of a species are arranged according to their size, shape and structure, then this representation is called karyotype. In this article, let us have a deep insight on the structure and organization of chromosomes, classification of chromosomes, karyotype and idiogram.***

**Keywords:** DNA, Chromosome, Heredity, Karyotype and Idiogram

## 1. Introduction

Chromosomes are normally referred as physical bases of inheritance as chromosomes have a special structural organization, specific functions to perform and possess integrity and individuality and have potential for self - reproduction. DNA is the main chemical constitution, which is responsible for the transmission of genetic blue print of parents from one generation to the next. Organization and number of DNA are varied to each living being.

The chromatin fibers are the basic unit of chromosome structure. The organization of this chromatin fiber into a chromosome was proposed by different models out of which the familiar models were:

1) The folded fiber model by **DuPraw** in 1965.
2) Nucleosome - Solenoid model by **Kornberg** and **Thomas** in 1974. Among the two models, Nucleosome - Solenoid model was the most accepte

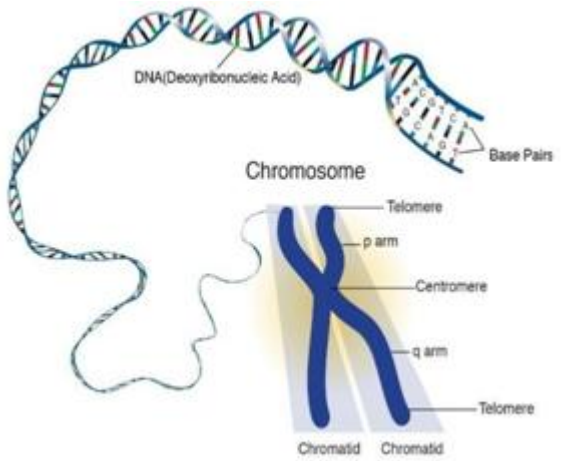


**Figure 1:** Chromosomes

They are present in all living beings in a specific number and organization and usually fall into following categories:

**(a) Prokaryotic Chromosomes**

The prokaryotes consist of a single, giant, double - stranded DNA molecule, circular chromosome in each of their nucleoids, but has no protein and RNA unlike eukaryotes. Size of the chromosome varies from species to species. Thus, the bacterium *Escherichia coli* has 100 long chromosomes.

**(b) Eukaryotic Chromosomes**

Eukaryotes like plants and animals contain more genetic information, if we compare to viruses and prokaryotes. DNA may not be present as a single unit, but, as many units together called as chromosomes. Number of chromosomes are specific to the type of organisms.


Licensed Under Creative Commons Attribution CC BY

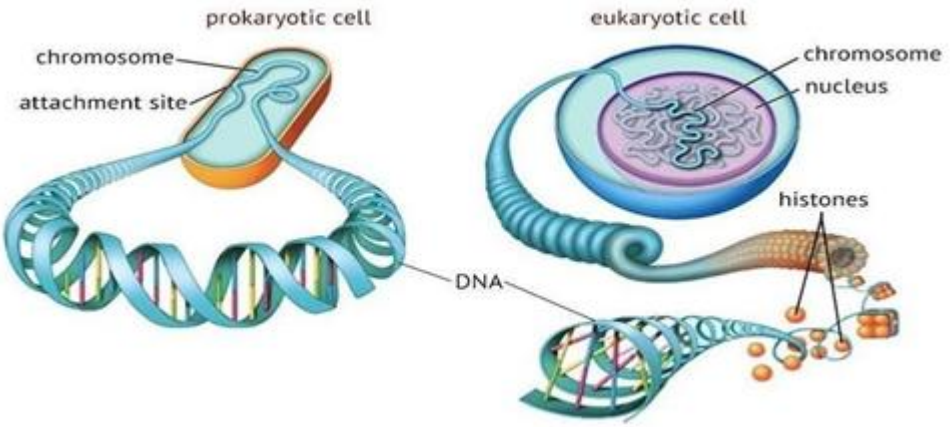


**Figure 2:** Chromosome Structure in Prokaryotes and Eukaryotic Cells

**(c) Viral Chromosomes**

They occur singly and chemically may contain either RNA or DNA. Chromosomes are linear or circular in shape, in case of, viral species containing DNA (e. g., T2, T3, T4, Bacteriophages) and on the other hand, they may be linear in shape with single - stranded RNA molecule and occur in some animal viruses (e. g., poliomyelitis virus, influenza virus) and most plant viruses (e. g., TMV). All viral chromosomes are either tightly packed within capsids or occur freely inside the host cell

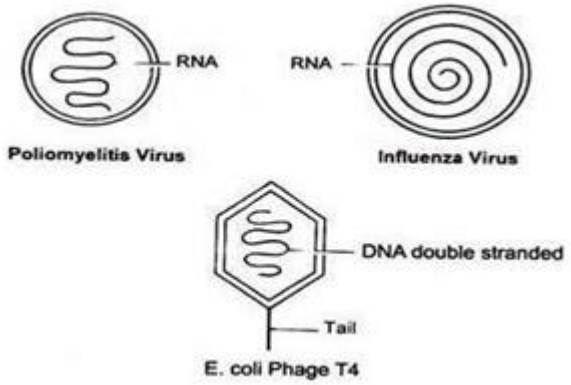


**Figure 3:** Viral Chromosomes

**Organization of DNA into a Chromosome:**

Usually eukaryotic chromosomes contains a single giant molecule of DNA that moves from one end of the chromosome to the other end through the centromere. Chromatin in interphase is held in a negatively super coiled series by histone packaging (Nucleosome). The super - coiled nucleosome fiber is called Solenoid. Each solenoid linked to other by linker DNA. Such that a molecule of DNA (146bp) is packed as a unit of nucleosome and many nucleosomes combines to form chromatin fiber. Then, these chromatin fibers in turn coiled into highly condensed structures visible under light microscope. This model of organization of DNA into chromosome is called as Nucleosome - Solenoid model.

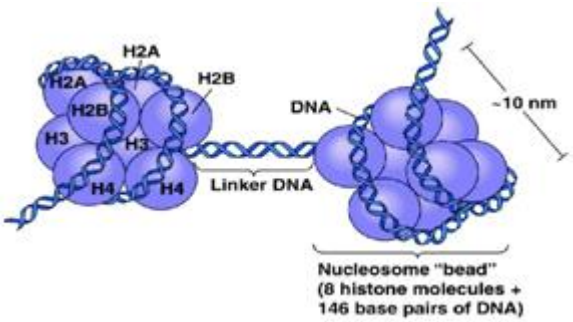


**Figure 4:** Typical Nucleosome Structure

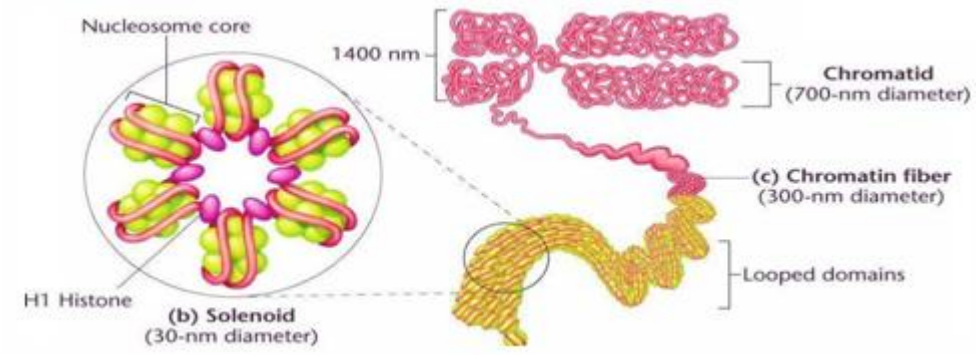


**Figure 5:** Nucleosome - Solenoid Model

**Structure of Chromosome**

The typical chromosomal structure is studied well by using mitotic metaphase chromosome under light microscope. A typical chromosome consists of the following parts:

1) Centromere
2) Chromatid Chromomeres
3) Chromonema
4) Euchromatic region


Licensed Under Creative Commons Attribution CC BY

5) Heterochromatic region
6) Matrix
7) Pellicle
8) Satellite
9) Secondary constriction
10) Telomere

**Centromere:**
The region of chromosome at which the spindle fibers are attached during metaphase is known as centromere or primary constriction or kinetochore. Centromere is associated with the movement of chromosomes at anaphase, called as kinetochore. Based on the position of the centromere the shape of the respective chromosome will change.

**Chromatid:**
The sub - units of each chromosome or each longitudinal arms of a chromosome is called chromatid. These sub - units get separated at mitotic anaphase and at second meiotic anaphase. During replication of chromatin in s - phase, chromatids arise and still attached to the same chromosome are called sister chromatids. After centromere division each chromatid develop as a chromosome.

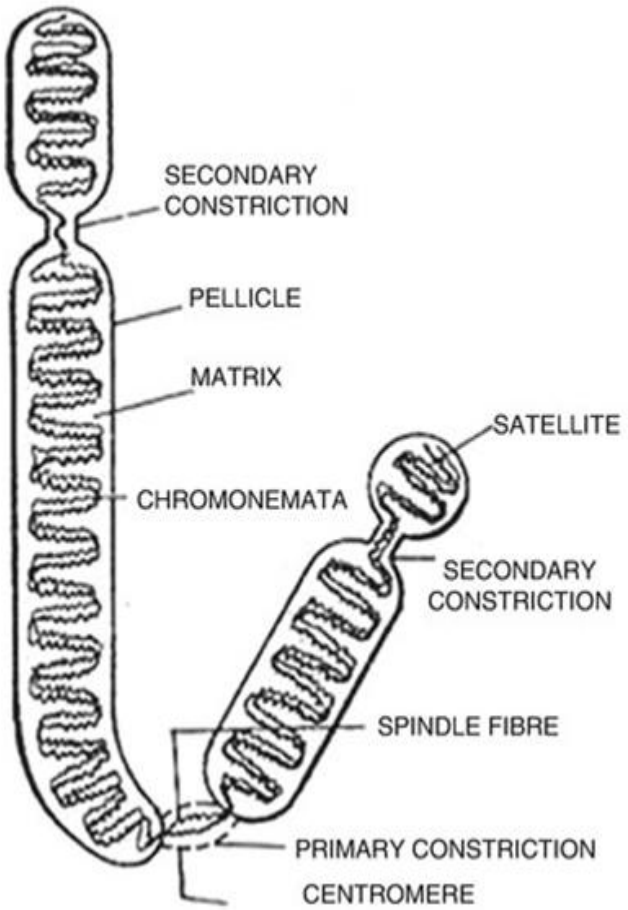


**Figure 6:** Typical Chromosome Structure

**Chromomeres:**
These are linearly arranged bead like structures found on the chromosomes are called as chromomeres. One can observe them clearly in polytene chromosomes. Usually, they represent a unit of DNA replication, chromosome coiling, RNA synthesis and RNA processing.

**Chromonema:**
Thread like coiled structures found in chromosomes are called chromonema. They are associated with duplication of chromosome and gene holding portion of chromosome.

**Euchromatin Region:**
Transcriptionally active region of chromosome that shows relatively uncoiled chromonema and shows staining behavior to chromosomal complements.

**Heterochromatic Region:**
Region composed of highly repetitive DNA and highly condensed part of the chromosome appearing during interphase stage. This region is usually transcriptionally inactive.

**Matrix:**
It is called as achromatic region of chromosome where the chromonema is embedded.

**Pellicle:**
Pellicle is referred as sheath which encloses the matrix of a chromosome. Represents the non - genetic material of chromosome.

**Satellite:**
A segment of chromosome present outside the main chromosome body which is associated with the nucleolar organizer. Chromosome consists of secondary constriction or satelliteS are called as satellite chromosome or sat chromosome.

**Secondary Constriction:**
Constricted region found in the short arm of a chromosome, which is far from the centromere is called as secondary constriction. It has a fixed position and thus, used as a marker.

**Telomere:**
The terminal portion of a chromosome on both ends is known as telomere. Generally, telomere of one chromosome cannot unite with telomere of other due to polarity effect. It maintains the structural integrity of the chromosomes.

**Classification of Chromosomes**
The chromosomes are classified on many ways such as:

**Based on Position of Centromere:**
1) **Metacentric Chromosome:** Centromere is located at the middle, which makes two equal arms in length and assumes 'V' shape at anaphase.
2) **Sub - metacentric Chromosome:** Centromere is located slightly away from the center of the chromosome and assume 'J' shape at anaphase.
3) **Acrocentric Chromosome:** Centromere is located at one end or sub - terminal portion and assumes 'J' shape at anaphase.
4) **Telocentric Chromosome:** Centromere is located at the terminal end of the chromosome and assumes a rod shape during anaphase.


Licensed Under Creative Commons Attribution CC BY

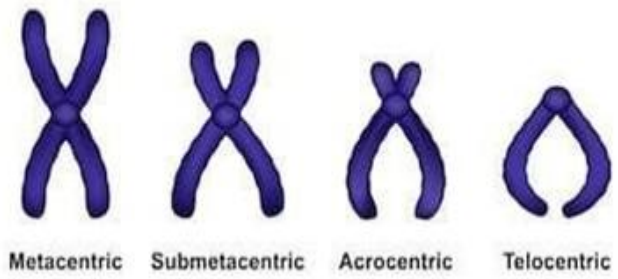


**Figure 7:** Types of chromosomes based on position if centromere

**Based on the Number of Centromeres:**

1) **Acentric Chromosome:** A chromosome without centromere. They remain as laggard or slow to move during cell division and is eventually lost.
2) **Monocentric Chromosome:** A chromosome with one centromere. This is normal type of chromosome.
3) **Dicentric Chromosome:** A chromosome having two centromeres. Such chromosomes make dicentric bridges at anaphase. These are normally produced due to inversions and translocations.
4) **Polycentric Chromosome:** More than one localized centromere. Usually, they the result of chromosome mutation and rarely through nuclear differentiation.

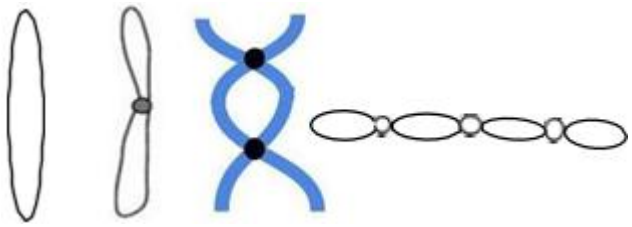

**Figure 8:** (a) Acentric (b) Monocentric (c) Dicentric (d) Polycentric

**Based on Role of Sex Determination:**

1) **Autosomes:** Chromosomes which are not differ in morphology and in number in male and female sex or the chromosomes other than sex chromosomes are called autosomes.
2) **Allosomes:** Chromosomes which differ in morphology and in number in male and female sex and contain sex determining genes e. g., X and Y, Z and W chromosomes.

**Chemical Structure of Chromosomes**

Eukaryotic chromosomes are composed of DNA, RNA, histone and non - histone proteins and some ions. Some of the most common enzymatic proteins are DNA polymerase, RNA - polymerase, DPN - pyrophosphorylase, Phosphoprotiens and nucleoside triphosphatase. Includes Ca+2 and Mg+2 as metal ions to maintain structural integrity of chromosomes.

**Karyotype**

Generally used for cytological studies, when the chromosomes of a species are arranged according to their size, shape and structure, then this representation is called karyotype.

**Idiogram**

When the karyotype of a species are represented by the diagram then such diagrams are called idiograms.

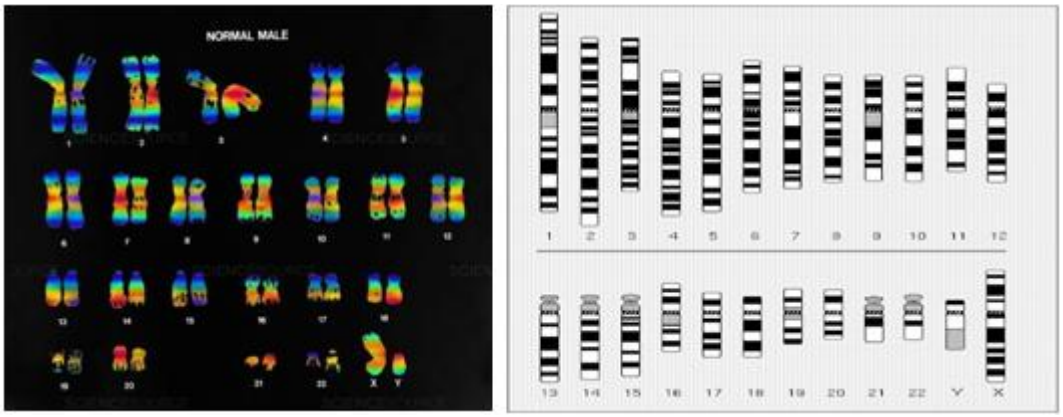


**Figure 9: (**a) Human Karyotype (b) Human Idiogram

**Genetic Significance of Chromosomes**

Chromosomes are normally considered as the organs of heredity as:

1) They form the only link between two generations.
2) The genetic material is localized in the chromosome and its contents are relatively constant from generation to generation.
3) A diploid chromosome set consist two morphologically similar sets, one is derived from mother and another from father at fertilization.
4) The chromosomes maintain and replicate the genetic information contained in their DNA molecule and this information is transcribed at the right time in proper sequence into specific types of RNA molecules which directs the synthesis of different types of proteins to form a body form like the parents.

**Conflict of Interest:** NO


Licensed Under Creative Commons Attribution CC BY

## References

[1] Abuelo, J, G. Moore, D. E.1969. Journal of Cell Biology, **41**: 73.
[2] Atkin, N. B., Ohno, S.1967. *Chromosoma*; **29**: 365.
[3] McClintock, B.1941. *Genetics* **25:** 234.
[4] Watson JD, Crick FH. Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid. *Nature.1*953 Apr 25; **171** (4356): 737 - 8.
[5] Makalowski W. The Human genome structure organization. *Acta Biochim. Pol*.2001; **48** (3): 586 - 98.
[6] Van der Horst A, Lens SM. Cell division: Control of the chromosomal passenger complex in time and space. *Chromosoma*.2014 Mar; **123** (1 - 2): 25 - 42.
[7] Morgan, T. H. (1910) Chromosomes and heredity. Amer. Nat.4**4**, 449 - 496.
[8] Hentschel, C. C. & Birnstiel, M. L. (1981). The organization and expression of histone gene families. *Cell* **25**, 301313.
[9] Finnegan, D. J. (1989) Eukaryotic transposable elements and geneome evolution. *Trends Genetics*; **5,** 103 - 107.
[10] Woodcock CL, Dimitrov S. Higher - order structure of chromatin and chromosomes. *Curr Opin Genet Dev*.2001; **11**: 130–135.
[11] Wolffe AP, Guschin D: Chromatin structural features and targets that regulate transcription. *J Struct Biol* 2000, **129**: 102 - 122.


Licensed Under Creative Commons Attribution CC BY