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CHROMOSOMAL ORGANIZATION

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CHROMOSOMAL ORGANIZATION

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INTRODUCTION

▪Chromosomes are clearly visible as distinct bodies during the stages of cell division only and their number can be counted with relative ease only during mitotic metaphase.

▪ Chromosomes are composed of thin chromatin threads these were earlier called chromanemata but are now termed as chromatin fibers.

▪ Some tissue of certain organisms contain chromosomes which differ significantly from normal chromosomes in terms of either morphology or function.

▪ the following types of chromosomes may be included under this category –(1) Giant chromosome [Lampbrush, Polytene] (2)Sex chromosome

▪ One micron of a metaphase chromosome contains about 8000 μ of DNA double helix.

▪ Each species has a definite and generally, a constant somatic and gametic chromosome number & their size depending upon the stage of cell division.

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HISTORY

1842	Karl Nagli	Observed rod like chromosomes in the nuclei of plant cells.
1887	Benden & bovery	Reported that the no. of chromosomes for each species was constant.
1888	W.Waldeyer	Gave the present name of chromosome.
1948	Kaufmann	Described the morphology of chromosome.
1974	R.D. Kornberg	Proposed the nucleosome model of the basic chromatin material.

RESEARCHES ARE CONTINUIG TILL DATE..

CHROMOSOMAL ORGAIZATION

DEFINITION

The chromosomes are the nuclear components of special organization, individuality and function. They are capable of self reproduction & play a vital role in heredity, mutation, variation & evolutionary development of the species.

Chromosomes are the rod shaped, dark stained bodies seen during metaphase stage of mitosis when cells are stained with a suitable basic dye and viewed under a light microscope.

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TYPES

GIANT CHROMOSOME

some cells at particular stages contain large nuclei with giant or large sized chromosomes, called giant chromosome. The giant chromosomes divided into two types:

- POLYTENE CHROMOSOME
- LAMPBRUSH CHROMOSOME

SEX CHROMOSOME

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TYPES

LAMPBRUSH

- During the prolonged diplotene stage of oocytes these chromosomes are the most observable.
- During deplotene a lampbrush chromosome consists of two homologous chromosomes that are in contact with each other at several points(chiasmata).
- From each chromosome a pair of loops emerged in opposite directions vertical to the main chromosome axis.
- These lateral loops give these chromosomes the appearance of a lampbrush, which is the reason for their name lampbrush chromosomes.

POLYTENE

- They were 1st discovered by **balbiaini in 1881** in dipterans salivary glands, giving them the commonly used name salivary gland chromosome.
- Polytene chromosomes contain several dark staining regions, called bands, separated by relatively light or non staining interband regions.
- Each chromosome is composed of numerous strands, each strands representing one chromatid. Therefore, these chromosomes are also known as polytene chromosomes.
- The present name polytene chromosomes was suggested by **KOLLAR** due to the occurrence of many chromonemata in them.

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SEX CHROMOSOME

♣ In **1902, McClung** discovered the accessory or X chromosome of grasshopper & postulated that this chromosome was involved in sex determination.

♣ This was the first demonstration that a character (in this case sex) was associated with a specific chromosome.

♣ It may be argued that like any other character, sex is also governed by genes.

♣ Since a specific chromosome is involved in sex development, the genes governing this trait may be located in the X chromosome.

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MORPHOLOGY

In mitotic metaphase chromosomes, the following structural features can be see under the light microscope:

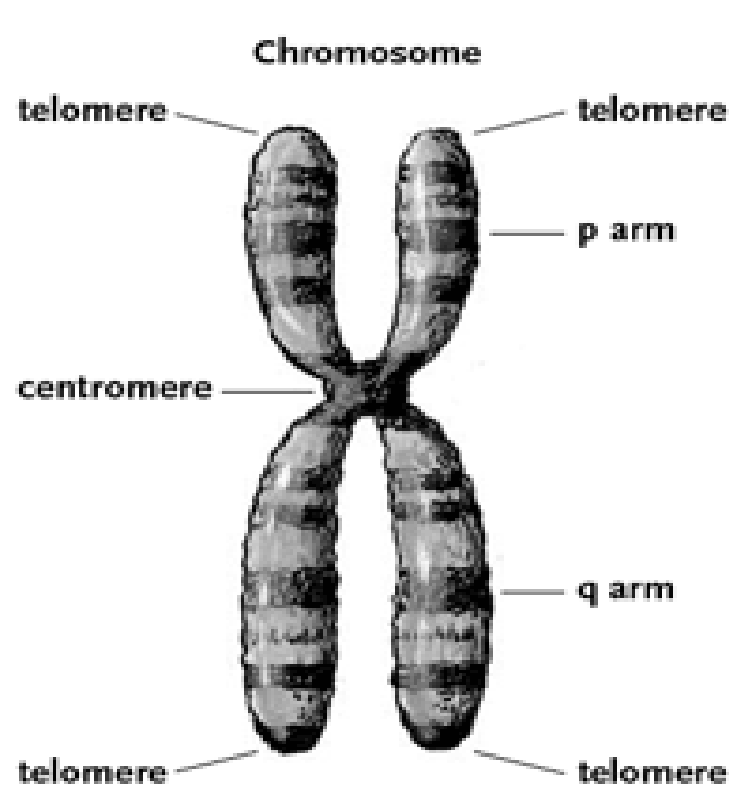

Fig no. -1 (chromosome)

- ***CHROMATID***
- ***CENTROMERE***
- ***TELOMERE***
- ***SECONDARY CONSTRICTION***
- ***CHROMOMERE***
- ***CHROMATIN***

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MORPHOLOGY

CHROMATID

At mitotic metaphase each chromosome consists of 2 symmetrical structures, called chromatid.

Each chomatid contains a single DNA molecule.

Both chromatids are attached to each other only by the centromere and become separated at the beginning of anaphase,

When the sister chromatids of a chromosome migrate to the opposite poles.

CENTROMERE

The region where the two sister chromatids of a chromosome appear to be joined or held together during mitotic metaphase is known as centromere.

Under light microscope, centromere generally appears as a constriction in the chromosome(primary constriction).

During cell division spindle fibers attach to centromeres. as a result, centromeres are the first parts of chromosomes to be seen moving towards the opposite poles during anaphase.

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MORPHOLOGY

CENTROMERE

Metacentric Chromosome- The centromere is located in the centre of chromosome.

Submetacentric Chromosome- Centromere is located on one side of the central point.

Acrocentric Chromosome- Centromeres are located close to one end of the chromosome.

Telocentric Chromosome- The centromere appears to be located at one end of the chromosome.

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TELOMERE

- The 2 ends of a chromosome are known as telomeres.
- Telomeres are highly stable and they not fuse or unite with telomeres of other chromosomes.
- The structural integrity and individuality of chromosomes is maintained due to the telomeres.

SECONDARY CONSTRICTION

- In some chromosomes, a second constriction, in addition to that due to centromere, is also present;
- This additional constriction is known as secondary constriction.
- The region between the secondary constriction & the nearest telomere, is known as satellite.
- Therefore, chromosome having secondary constrictions are called satellite chromosomes.

CHROMOMERE

- The chromomeres are bead like accumulation of chromatin material that are sometimes visible along interphase chromosomes.
- Chromomere bearing has an appearance of necklace in which several beads occur on a string.
- Chromomeres become especially clear in the polytene chromosome at metaphase chromosomes are tightly coiled and the chromomeres are no longer visible.

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MORPHOLOGY

CHROMATIN

The material of which chromosomes are composed is called chromatin.

Depending on their staining properties, the following two types of chromatin may be distinguished in the interphase nucleus:

HETEROCHROMATIN

- **In the dark staining regions, the chromatin remains in the condensed state & is called heterochromatin.**
- **Heterochromatin is characterized by the especially high content of repetitive DNA sequences & contains very few, if any, structural genes.**
- **It is late replicating & is not transcribed.**

EUCHROMATIN

- **Portions of chromosomes that stain lightly are only partially condensed; this chromatin is termed euchromatin.**
- **Euchromatin contains structural genes which replicate and transcribe during G1 & S phase of interphase.**
- **The euchromatin is considered genetically active chromatin, it has a role in the phenotype expression of the genes.**

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HETEROCHROMAITN

There are 2 types of heterochromatin:-

CONSTITUTIVE

in it DNA is permanently inactive & remains in the condensed state throughout the cell cycle.

this most common type of heterochromatin occurs around the centromere, in the telomeres & in the c-bands of the chromaosomes.

FACULTATIVE

such type of heterochromatin is not permanently maintained in the condensed state; instead it udergoes periodic dispersal &durig this time this transcriptionaly active.

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SATELLITE DNA

- Constitutive heterochromatin contains short repeated sequences of DNA called satellite DNA, because upon ultracentrifugation it separates from the main component of DNA.
- Satellite DNA may have a higher or lower G+C content than the main fraction.
- e.g. the mouse satellite DNA is a 240 base pair sequence that is repeated about 10000,000 times in the mouse genome, constituting 10% of the total mouse DNA.

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NUCLEOSOME-SOLENOID MODEL

NUCLEOSOME-SOLENOID MODEL

This model was proposed by KORNBERG and THOMAS in 1974 and is universally accepted. according to this model chromatin is composed of a repeating unit called nucleosome. A nucleosome contains an average of ~200 bp DNA. one complete nucleosome, a complete disc of 11 nm diameter and 6 nm height, consists of:

1. **NUCLEOSOME CORE- It consists of a histone octamer composed of two molecules each of histones H2a,H2b H3 & H4. in addition, a 146 bp long DNA molecules is wound round this histone octame, in.... turns .the structure of nucleosome core is essentially invariable in all the eukaryotes.**

2. **LINKER DNA- This DNA forms the string part of the heads-on-a-string structure seen on isolation of chromatin fiber, and is nuclease susceptible, the beads are due to the nucleosome cores.**

3. **H1 HISTONE- Each nucleosome contains on an average, one molecule of H1 histone. Complete removal of H1 histone does not affect the structure of nucleosome core, indicating that H1 is located outside the nucleosome core. H1 is more likely located at the linker DNA and could seal the DNA in the nucleosome by binding at the sites where DNA enters and leaves the nucleosome.**

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NUCLEOSOME-SOLENOID MODEL

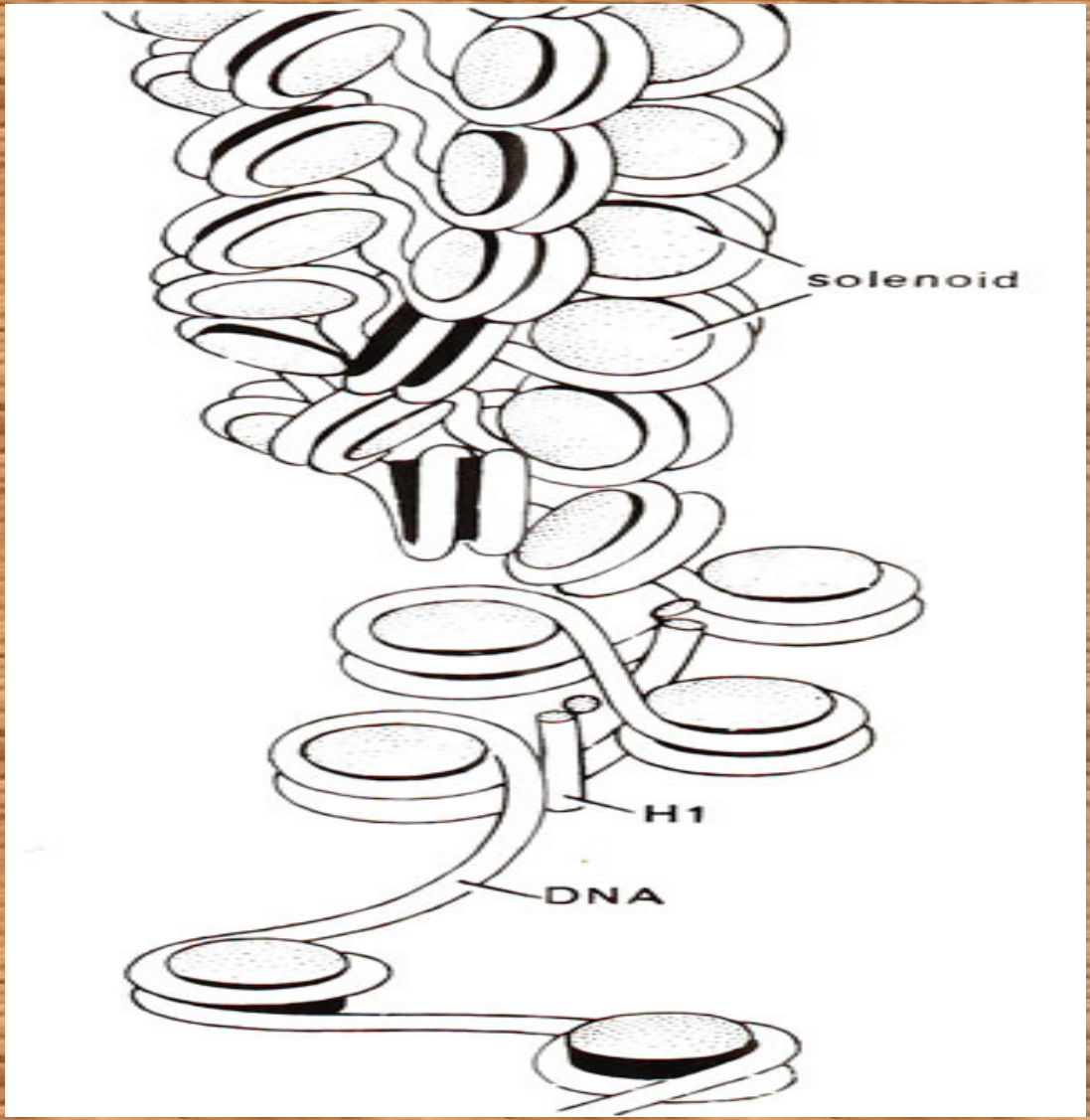

Fig no. -2 (NUCLEOSOME-SOLENOID MODEL)

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CHEMICAL COMPOSITION

Metaphase chromosomes contains on an average 15-20 % DNA, 10-15 % RNA & 65-70 % protein.

RNA

- Purified interphase chromatin contains upto 10 % RNA, while in metaphase chromosomes RNA constitutes 10-15% of the dry weight.
- RNA associated with chromosomes is ribosomal, messenger & transfer RNA.

DNA

- It plays the central role of controlling heredity.
- The DNA found in chromosomes is mainly of 2 types:

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TYPES OF DNA

UNIQUE DNA

- Consists of those DNA segments their base sequences are not repeated in the genome.
- It is rare unique DNA to be over 2×10 9 bp.
- The length of unique component of DNA tends to increase with overall genome size to up to 3×10 9 bp.
- The amount of unique DNA increases with the relative complexity of the organism.

REPITITIVE DNA

- Consists of DNA nucleotide or base sequences, are present in several to a million copies per genome.
- The proportion of repetitive DNA in the genome varies from one species to the other:
- Human genome has only 30 % repetitive DNA .

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PROTIENS

HISTONES

- Histones are very basic proteins because they are enriched I the amino acids arginine & lysine.
- Histones bind tightly to DNA which is an acidic.
- Histoes constitute about 80% of the total chromosomal protein.
- They are present in an almost 1:1 with DNA.
- Total molecular weight histones ranges from 10,000 to 30,000.
- There are 2 types of histoens in eukaryotic chromosomes, namely H1,H2A,H2B,H3 & H4.

NON-HISTONES

- Make up about 20% of the total chromosome mass, they are mainly acidic in nature.
- There may be a large no. of different types of non histone proteins.
- These proteins show variation from one to the other species.
- This class of proteins includes many enzymes, such as DNA and RNA polymerases & transcription factors.

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APPLICATION

•**KARYOTYPE**-Arranging chromosomes of a species according their size,shape and structure is called karyotype .

Karyotype is a systematized array of chromosomes of a single cell prepared either by photography or by drawing.

•**IDIOGRAM**-A representation of a species in the form of a diagram is called idiogram.it is the enlarged photographs of stained chromosomes.

Idiogram helps in proper identification & numbering of chromosomes.

•**CHROMOSOMAL ANOMALIS & HUMAN DISORDERS:-**

1.Autosomal Anomalis-The autosomal aneuploids are produced by the non disjunction between the chromosomes of any one of the 22 pairs of autosomes.

2.Anomalies in sex chromosomes-The genes for these characters are known to be carried on X-chromosome. there are also other characters like hairs on the ears, which are carried on Y-chromosome.

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SUMMARY

Chromosomes are composed of thin chromatin threads these were earlier called chromanemata but are now termed as chromatin fibers.

In mitotic metaphase chromosomes, the following structural features can be see under the light microscope:
Chromatid, cetromere, telomere, sec.constriction, chromomere & chromatin.

According to SOLENOID MODEL chromatin is composed of a repeating unit called nucleosome.

Metaphase chromosomes contains on an average 15-20 % DNA, 10-15 % RNA & 65-70 % protein.

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CONCLUSION

Chromosome provides the genetic information for various cellular functions essential for survival, growth, development, reprodountion etc. of organisms.

Chromosome protects the genetic material (DNA) from being damaged duing cell division.

Chromosomes are participate in regulation of gene action in eukaryotes.

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THANK YOU!