M.Sc Zoology
Semester I
Paper CC3

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Chromosome

Introduction And History

- Definition:-Chromosomes are the rod-shaped, dark-stained bodies seen during metaphase stage of mitosis.
- Strausberger discovered chromosome in 1875.
- The term chromosome was coined by Waldeyer in 1888.
- Term initiated as (Chroma=Colour and Soma=Body).

Chromosome

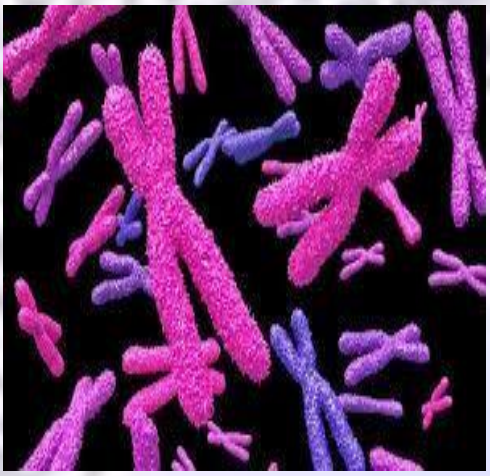
- Chromosome are composed of DNA and associated proteins.
  - Viral genomic DNA is associated withcapsid proteins
  - Prokaryotic DNAis associated with proteins in the nucleotide
  - Eukaryotic DNA ia organized with proteins into a complex structure

Chromosomes in eukaryotes and prokaryotes are different

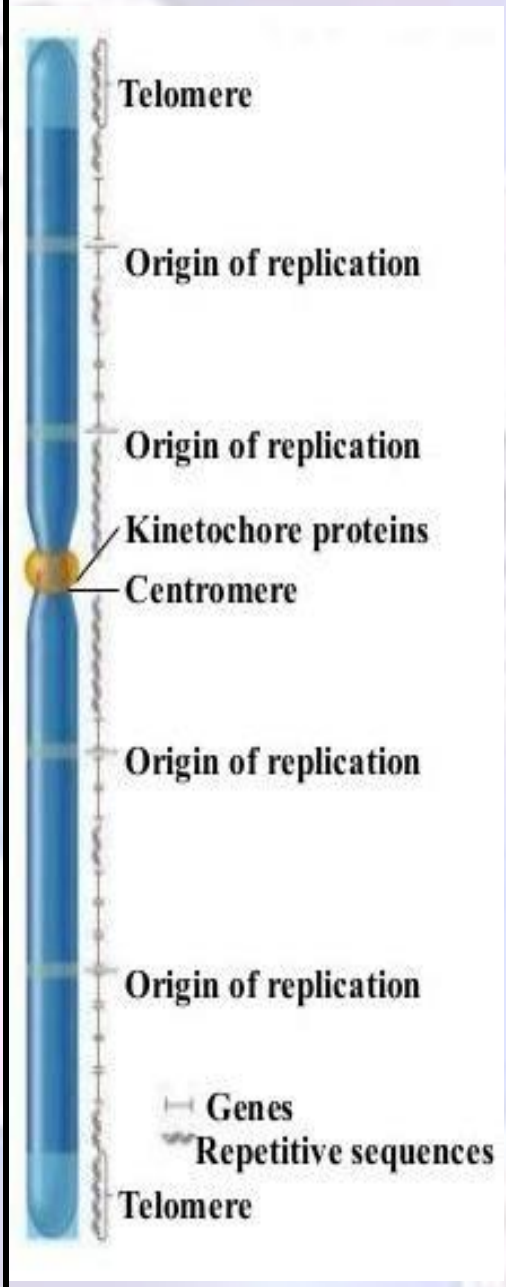
PROKARYOTES	EUKARYOTES
Single chromosome plus plasmids	Many cgromosomes
Circular chromosome	Linear chromosomes
Made only of DNA	Made of chromatin, a nuclear protein(DNA coiled around histone proteins)
Found in cytoplasm	Found in nucleus
Copies its chromosome and divides immediately afterwards	Copies chromosomes, then the cell grows, then goes through mitosis to organize chromosomes in two equal groups.

Eukaryotic Chromosomes

- Found in the nucleus.
- Condensed and visible during cell division.
- At the begining of mitosis they can be seen to consists of two threads(sister chromatids)joined by a centromere.



- The sister chromatids are identical copies.
- During mitosis the sister chromatids separate and are placed into two nuclei.
- Eukaryotic species contain one or more sets of chromosomes(ploidy level).
- DNA amount in eukaryotic species is greater than that in bacteria.



Key Features:

Eukaryotic chromosomes are usually linear.

A typical chromosome is ten of millions to hundreds of millions of basepairs in length.

Eukaryotic chromosomes are occur in set.

Many species are diploid, that means somatic cell contains 2 set of Chromosomes.

Genes are interspersed throughout the chromosome.

A typical ChromosomeContains between a few and several thousand different genes.

Each chromosome contains a centromere that forms arecognition site for kinetochore proteins.

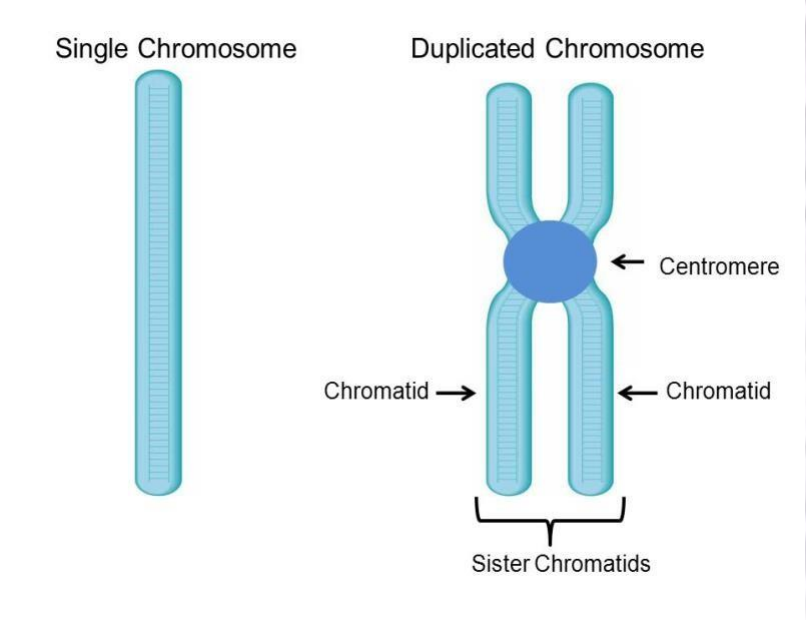
Telomere contains specialized sequence located at ends of the linear chromosome.

Repetitive sequences are commonly found near

Chromosome Organisation

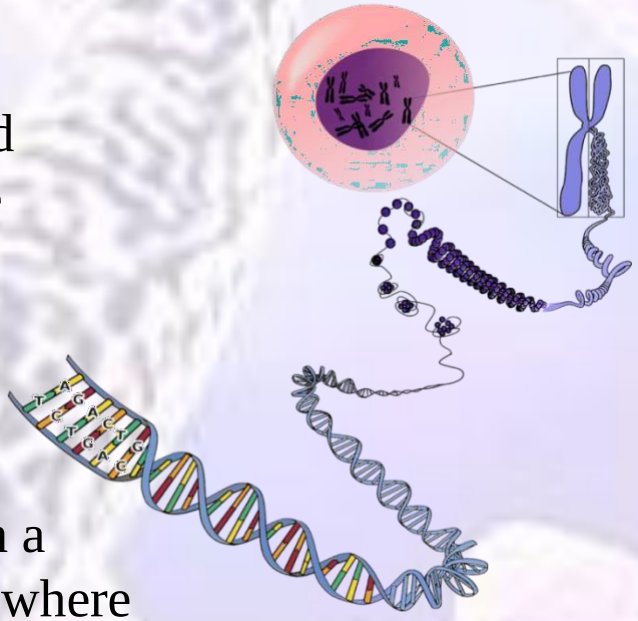
- Genes located between centromere and telomeres
  - Hundred to thousands of genes are present
  - In lower eukaryotes (i.e. yeast)
    - Genes are relatively small
    - Very few introns
  - In higher eukaryotes(i.e. mammals)
    - Genes are long
    - Have many introns
- Non gene sequences
  - Repetitive DNA
    - Telomere
    - Centromere
    - Satellite

Chromosome structure



- **Sister chromatid**

  – One of two attached members of a duplicated eukaryotic chromosome



- **Centromere**

  – Constricted region in a eukaryotic chromosome where sister chromatids are attached

Important Structural Elements of the Eukaryotic Chromosome

- **Centromeres**

  - Centromere are the primary constrictions along eukaryotic chromosomes.It mediate chromosomal migration during mitosis and meiosis.

  - Functions of centromeres

    - It functions in cell division; where the two daughterchromosomes are held tohether Mitosis(after DNA replication but before cell division)

    - Mitotic segregation of chromosomes.

    - Direct the formation of kinetochore (an elaborate protein complex) essential for chromosome segregation.

- **Telomeres**

  - Telomeres cap the ends of linear chromosomes and are needed for successful cell division.

  - Functions of telomeres

    - Protect the ends of linear DNA molecules from deoxyribonuclease

    - Prevent fusion of chromosomes

    - Fciliate complete replication of the ends of linear DNA molecules

  - Most telomere contains **repetitive sequences** and a distinct structure.

Repetitive Sequences

- Sequence complexity refers to the number of times a particular base sequence appears in the genome
- Eukaryotic chromosomes contain repetitive DNA (15 to 18%), Human(~50%)

- 3 main types of sequences
  - Non-repetitive
  - Moderately repetitive
  - Highly repetitive(low complexity)

- **Unique or non-repetitive sequences**
  - Found once or a few times in the genome
  - Includes structural genes as well as intergenic areas

- **Moderately repetitive**
  - Found a few hundred to a few thousand times
  - Includes
    - Genes for rRNA and histones
    - Origin of replications
    - Transposable elements

- **Highly repetitive**
  - Found tens of thousands to million of times
  - Each copy is relatively short(a few nucleotides to several hundred in length)
  - Some sequences are interspersed through out the genome
    - Example: *Alu* family in humans
  - Other sequences are clustered togrther in tandem arrays
    - Example:AATAT and AATATAT sequences in Dorsophilla
    - These are commonly found in the centromeric regions

Chromosome structure changes as eukaryotic cells divides

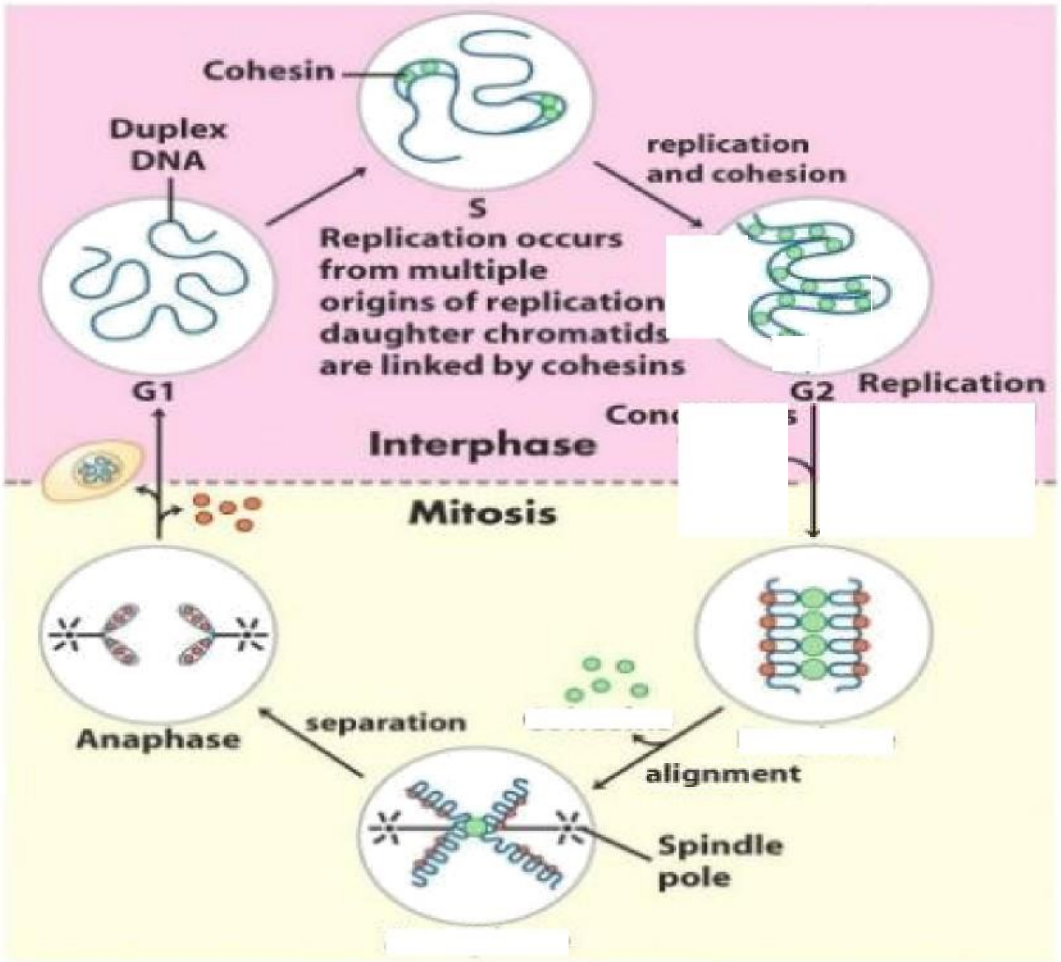
M phase: condensed state, completely disentangled from each other

G1, S, G2 phase: diffused, significantly less Compact. The structure of chromosome Changes,

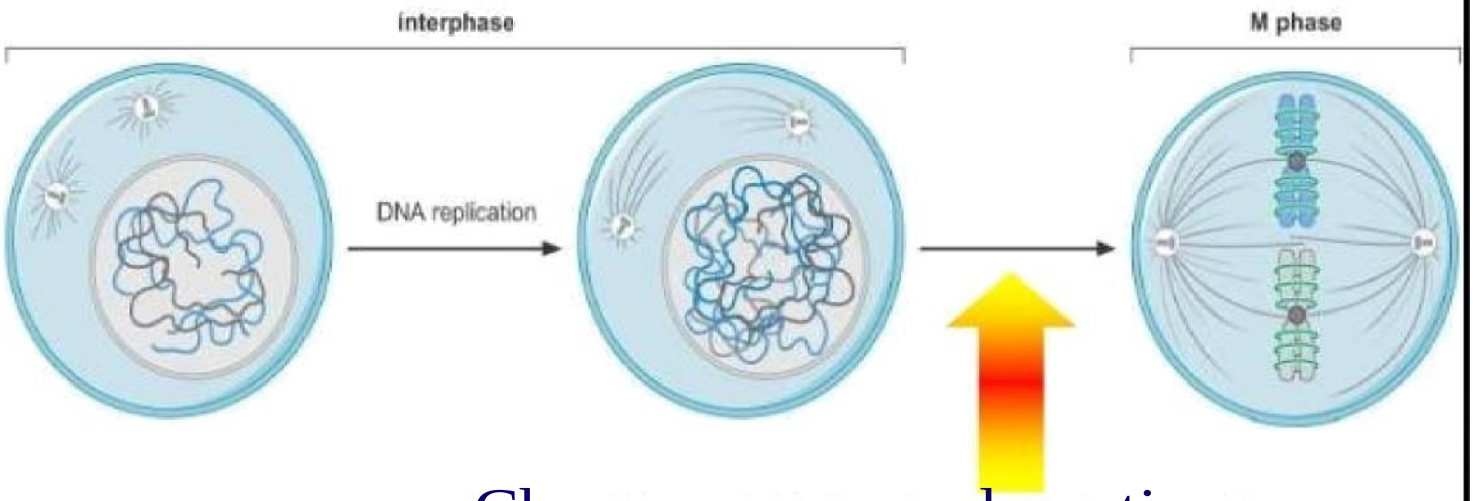
e.g.

DNA replication requires the nearly complete Disassembly and reassembly of the proteins associated with each chromosome

Changes in chwrnosome structure during lhe cek cycle

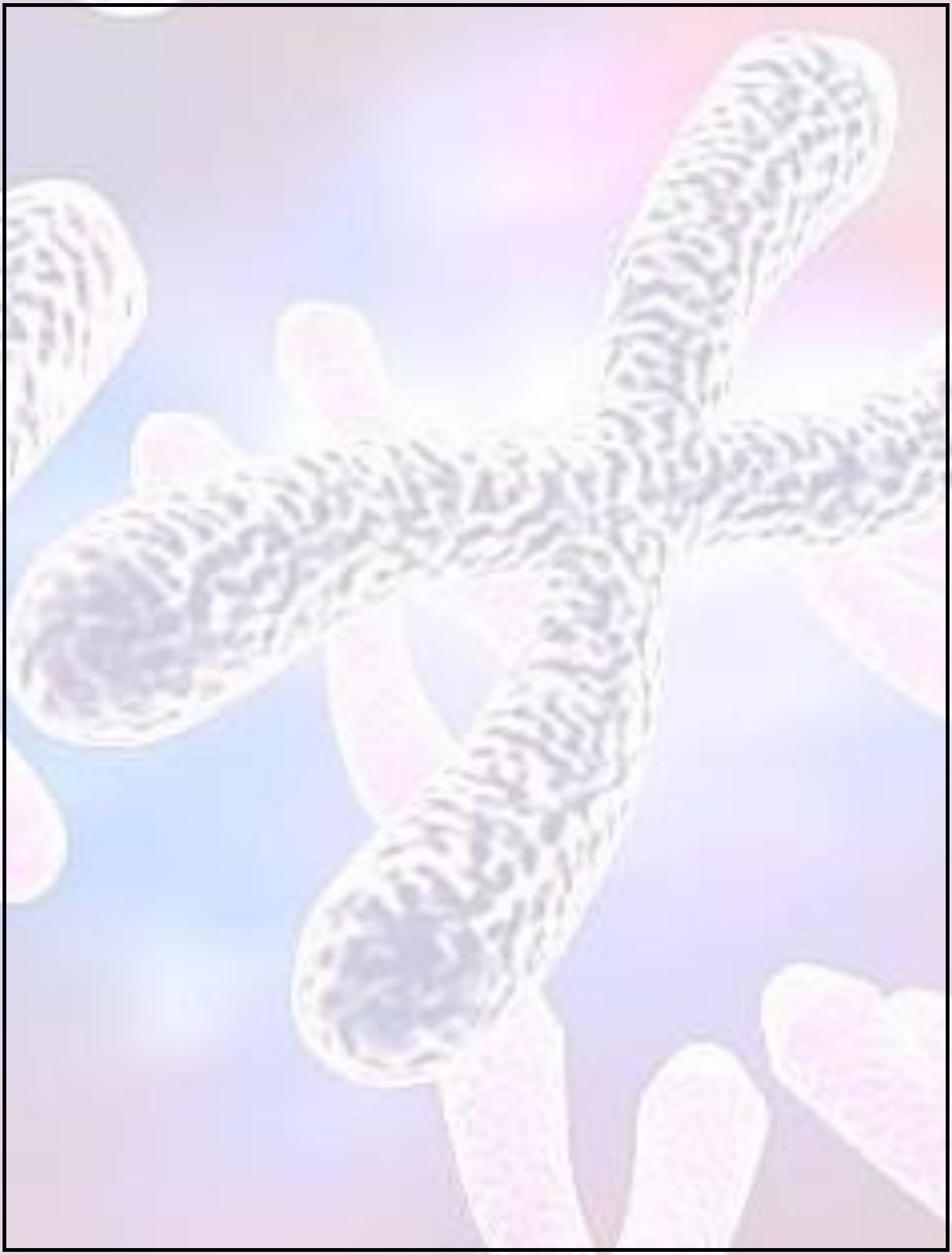


Changes in chroinatin structure



Chromosome condensation

REMEMBER: chromosome is a consistently changing structure (dynamics)



Numbers of chromosomes

- A eukaryotic cell's DNA is divided into a characteristic number of chromosomes.
- Constant for each cell in n the body (except sex cells which only have half sets).
- Costant throughout the life of an indivisual (you don't lose or gain chromosomes).
- Constant for all members of a species.
- **Chromosome number**
  - Sum of all chromosomes in a cell of a given type.
  - A human body has 23 pairs of chromosomes.
- **Diploid**
  - The cell havi g two set of chromosome(2n chromosome).
  - e.g. Human muscle cell or say blood cell[46 number of chromosome: 2n (2x23=46)]

- **Haploid**
  - The cell having one set of chromosome (n number of chromosome).
  - e.g. Human sperm cell/ Ova cell (23 number of chromosome: n)

Examples of chromosome number	
Species no.	Chromosome

Fruit fly	8
Amoeba	13
Frog	26
Cat	38
Human	46
Cow	60
Dog	78
Vizacha rat	102
Horse tail	216
Adder's tongue ferm	1200

Types of chromosomes

- There are two types of eukaryotic chromosomes: autosomes and sex chromosomes.

- **Autosomes**
  - Paired chromosomes with the same length, shape, centromere location, and genes.

– Any chromosome other than a sex chromosome

- **Sex chromosomes**
  – Members of a pair of chromosomes that differ between male and females.

Other types of Eukaryotic chromosomes

- Polytene chromosome

- Lampbrush chromosome

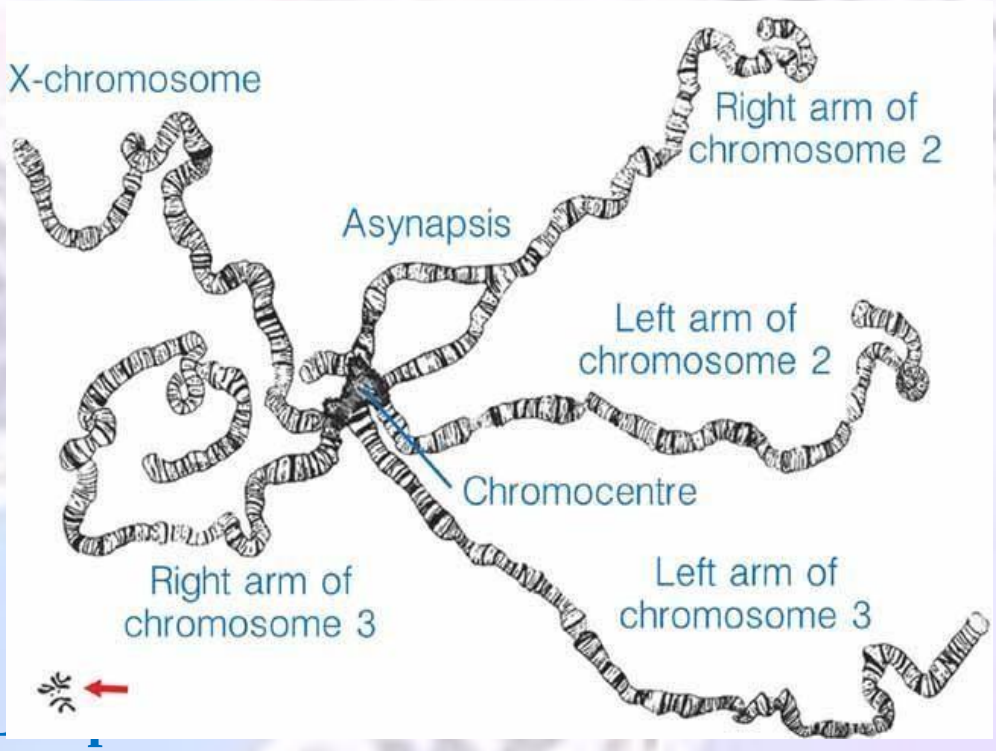
Both these chromosome increases transcriptional activity of gene.

Polytene chromosomes and **lampbrush chromosomes** are very large and can be visualized by light microscopy.

- **Polytene chromosomes:**

– have distinctive banding patterns
– represent paired homologous
– are composed of many DNA strands

polytene chromosomes have puff regions where the DNA has uncoiled and are visible manifestation of a high level of gene activity.

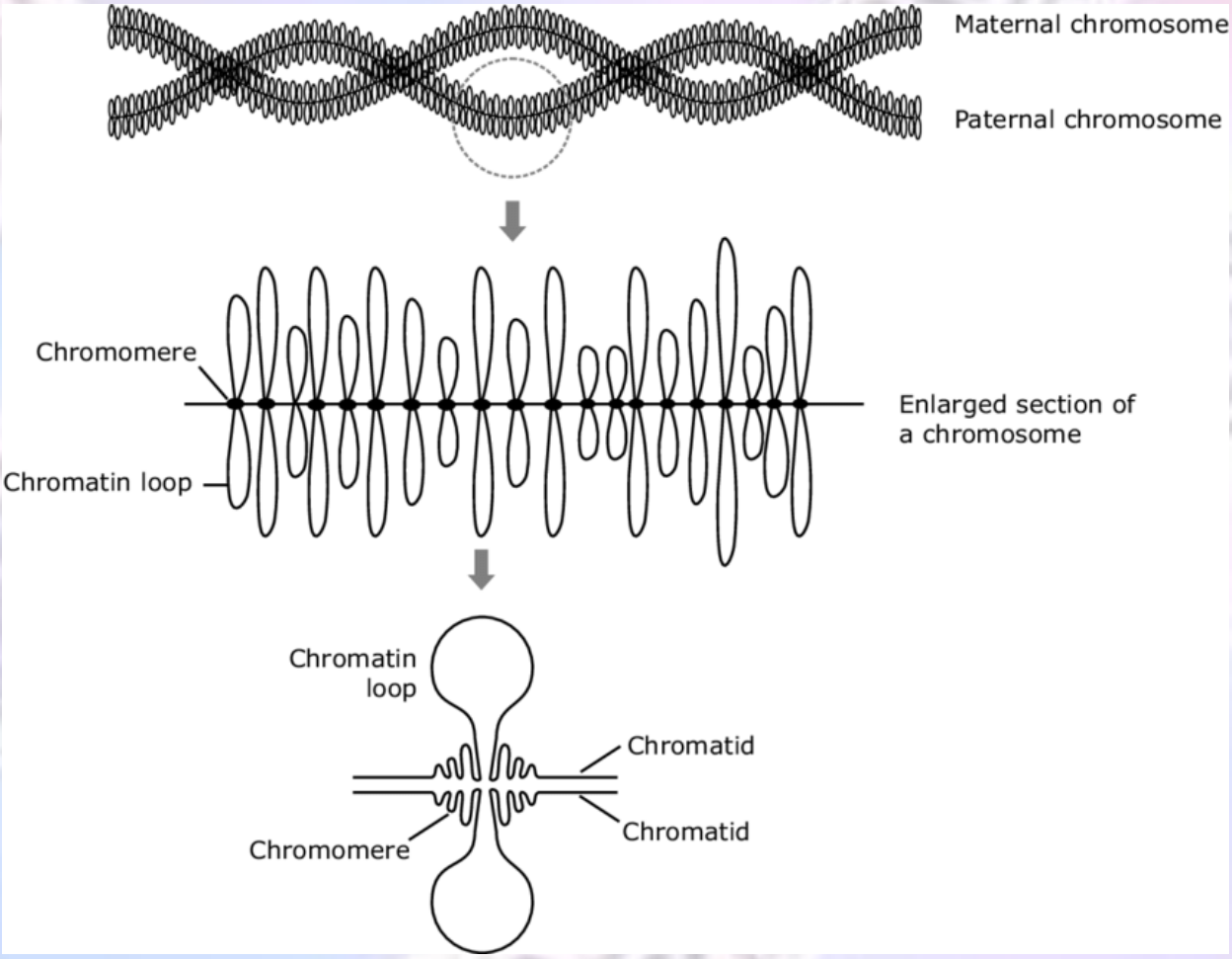


- **L**

– large and have extensive DNA looping.

– Formed through DNA replication without separation or cell division.

– Found in oocytes in the diplotene stage of meiosis.

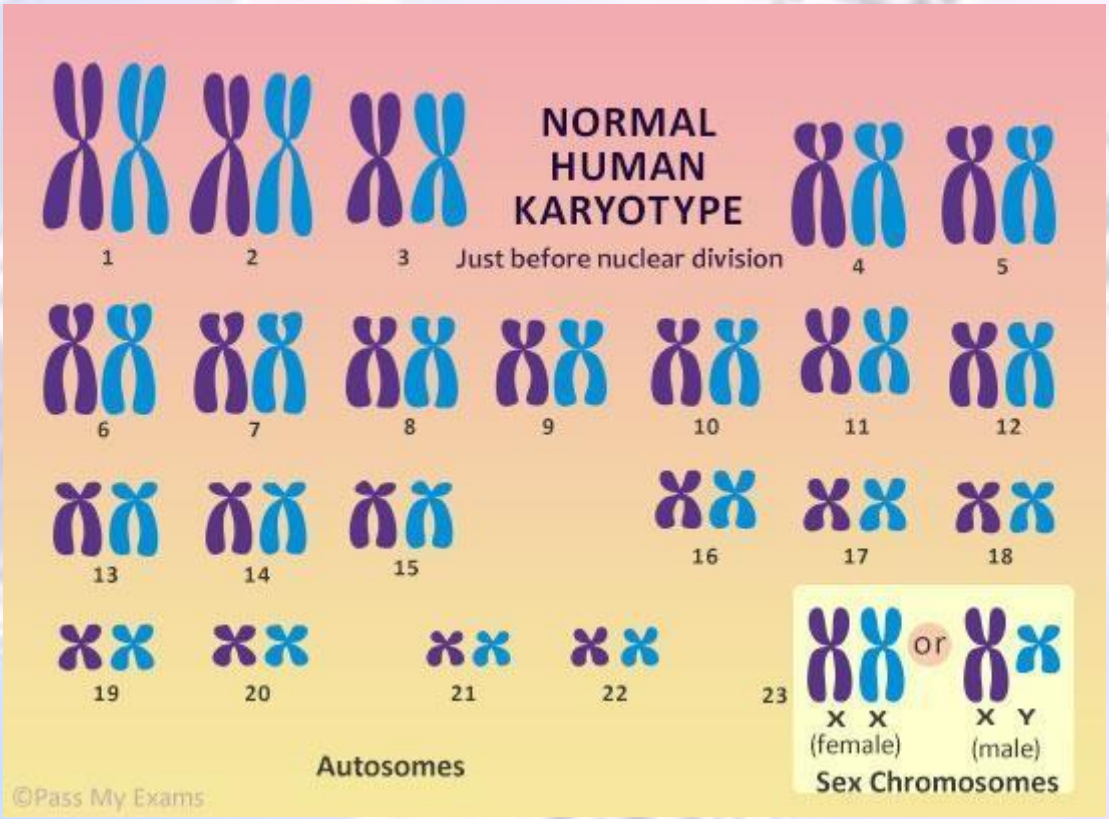


Karyotypes

- A display of 46 chromosome of an indivisual.
- Chromosomes are photographed while visible in *metaphase.*

- Arranged by size and centromere location.

- Eac h chromosome has a twin that resembles it in size and shape (except sex chromosome in males).



Proteins in chromosome

Half of the molecular mass of eukaryotic chromosome is **protein .**Two types of proteins are associated with DNA in eukaryotes:

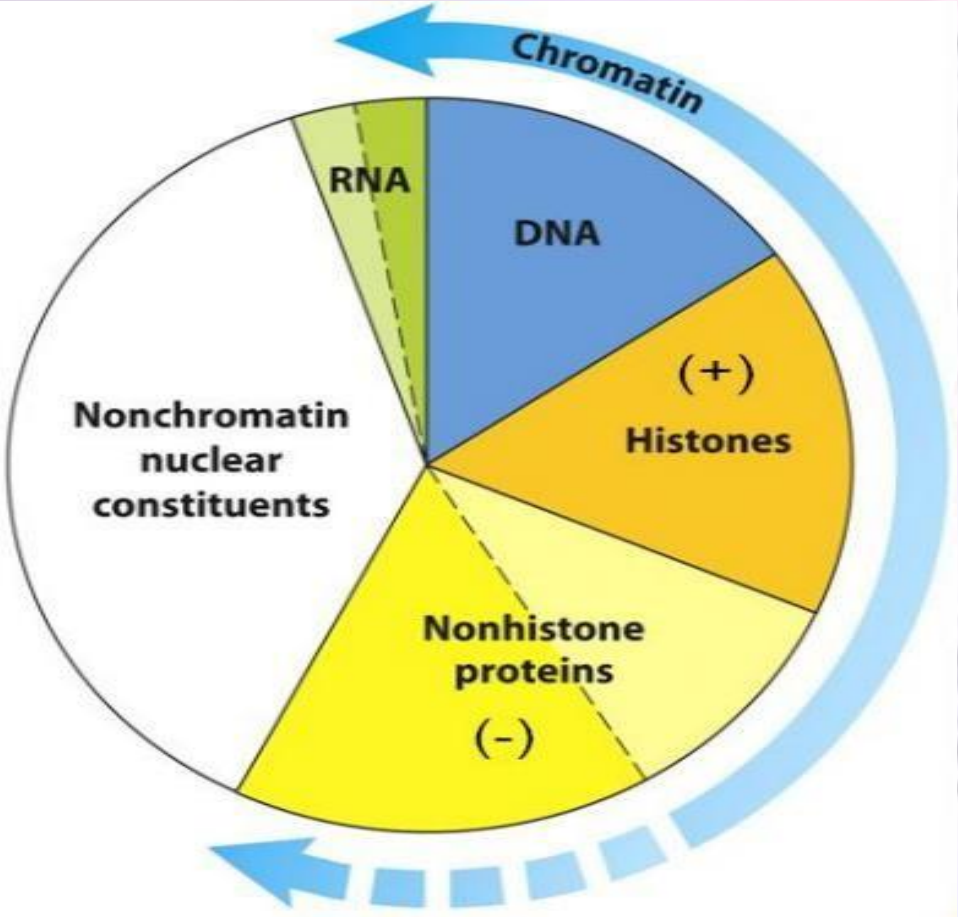
1. Histones
2.Non-histones

Chromosome along with these proteins called chromatin.

Chromatin is formed through end to end non-covalent attachment of chromosomes.

- The majority of the associate proteins are small, basic proteins called histones.

- Other proteins associated with the chromosome are reffered to as non-histone proteins, including numerous DNA binding proteins that regulate the transcription, translation, repair and recombination of DNA.



Histones:

H1, H2a, H2b, H3, H4
(Protamines in sperm)
Structural

Nonhistone proteins:

Non structural
Regulation

Nucleosomes: DNA + histones except H1