B.Sc. II ...

Papu II : Genetics and Biotechnology

1.) Light and electron microscopic structure of chromosome (from nucleosome to organisation of chromatids. Morphological classification of chromosomes)

Chromosome : Gk word chroma = colour
soma = body
coloured bodies रंगीन संरचनाएँ
get stained with basic dyes carotocaimine, basic fuschin
Chromosome term by **Waldeyer** (1888) वाल्डेयर 1888

Chromatin term W. Flemming 1879 फ्लेमिंग

Sutton & Boveri (1902) : Theory of chromosomal basis of heredity
आनुवांशिकी का गुणसूत्रीय आधार

Chromosomes are the physical basis of transmission of heredity traits. गुणसूत्र आनुवांशिक लक्षणों के पारगमन के भौतिक आधार है।

Prokaryotes : DNA forms single chromosome in cytoplasm
Eukaryotes : DNA is in chromosomes & are enclosed inside the nucleus.

Chromosomes are the **hereditary vehicles** that transmit the genetic information to successive generation.

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

DNA is the main genetic material of the cells carrying information in a coded form, from cell to cell & organism to organism.
Within cells DNA is not free but complexed &

proteins in a structure called chromatin

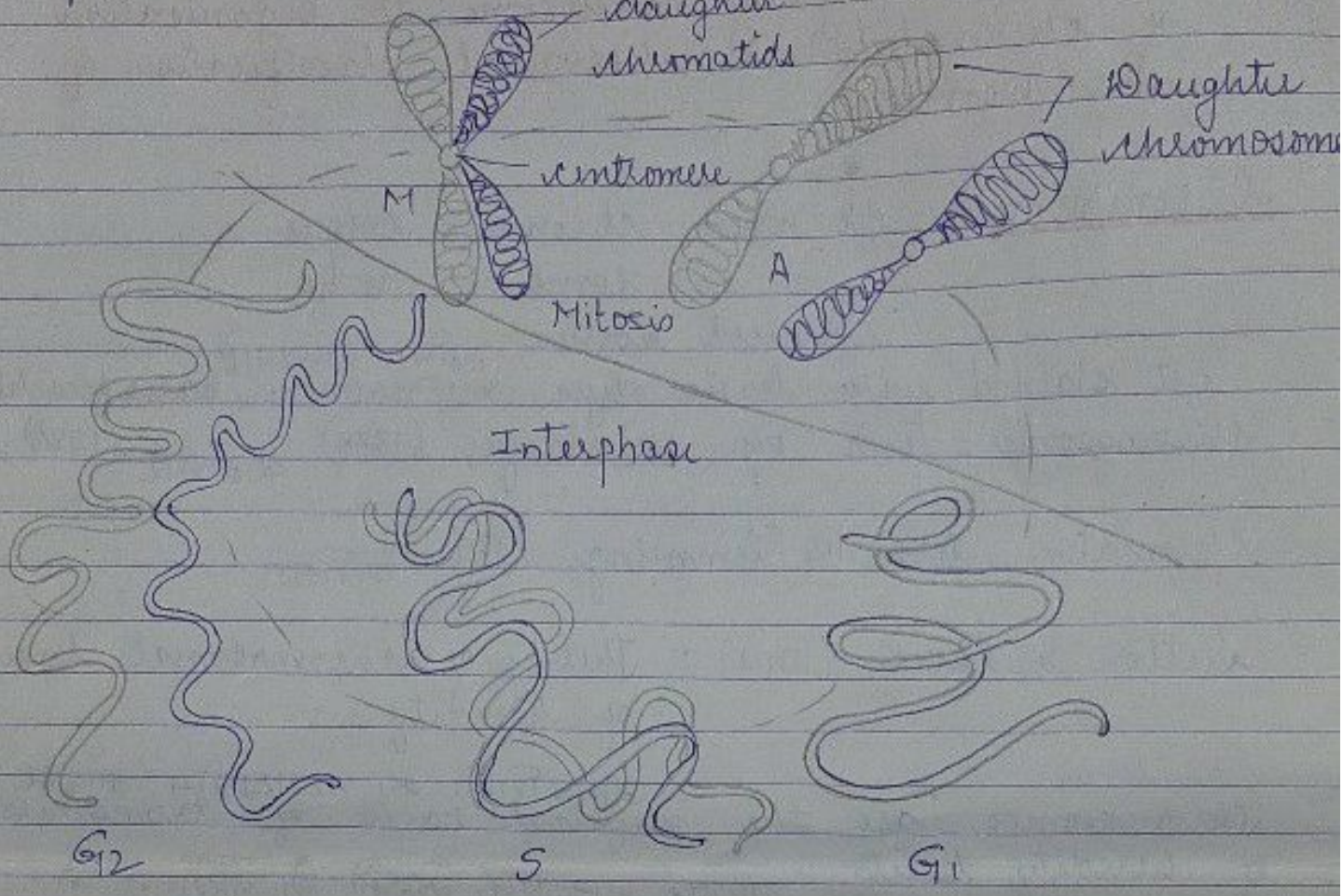


Diagram showing chromosome cycle

During cell division, the nucleus undergoes a series of complex but remarkably regular & constant changes in which the nuclear envelope & nucleolus disappear & the chromatin becomes condensed into dark staining bodies called chromosomes.

Chromosomes exhibit cyclic changes in shape & size during cell cycle. During interphase, the chromosomes form an interwoven network of fine twisted but uncoiled threads of chromatin so are invisible. As cell division proceeds, they condense into compact structure by helical coiling.

Interphase : Preparatory phase ; apparently inactive but nucleus & cytoplasm very active metabolically

& synthetically. Synthesizes & stores substances necessary of cell division.

G1 : First growth phase / Post mitotic phase.
Non-dividing cells remain in this stage.
Active protein & RNA synthesis

S : Synthesis phase. DNA replication occurs.
Varies : 6-8 hrs.

G2 : Second growth phase / Pre-mitotic phase.
Nucleus volume ↑ses.
nucleolar RNA, mRNA & rRNA synthesis

Chromatin

1. Heterochromatin	2. Euchromatin
Dark staining गाढ़ा रंजित	light stained हल्का
RNA more	DNA more
DNA less	RNA less
genetically inert निष्क्रिय	active आनुवांशिक रूप से सक्रि
Do not uncoil	Uncoils in
remain condensed	interphase

Constitutive	Facultative
अनैच्छिक	विकल्पी
Centromere	Sex chromosomes.
(Marker chromosomes)	
गुणसूत्र चिह्नक	

DIFFERENT REGIONS OF CHROMOSOMES

1. Primary constriction / Centromere प्राथमिक संकीर्णन
2. Secondary constriction / Nucleolar Organizer
3. Nucleolar Organizer Region NOR
4. Tertiary constriction
5. Telomeres
6. Chromatide अर्धगुणसूत्र
7. Chromonema & Chromomeres
   वर्णसूत्र वर्णकणिका

1. Primary Constriction and Centromere (Kinetochore)
Part of chromosome has a constriction & it is narrower than the remaining part. यह primary है
It is primary constriction
Position is constant for a given chromosome.
Feature of identification
Divides chromosome into 2 arms < short 'p' arm / long 'q' arm
Has DNA of repetitive type called as centromeric heterochromatin

Centromere : lies in the region of primary constriction
Appears like a plate-like or cup-like disc placed on pri. constriction.
Ultrastructure : In C.S. 3 layers seen
1. Outer electron dense layer : has convex outer surface. Microtubules of spindle fibres attach here & penetrate through to reach chromatin fibres. माइटोटिक तर्क यहीं रहते हैं।
2. Inner less dense layer : lies b/w chromatin fibre & outer layer.
3. Outermost fibrillar material : forms the e dense corona.

Functions : 1. Helps in attachment of microtubules of spindle fibres.
2. Helps in chromosome movement
3. Acts as a nucleation center : for polymerization of tubulin (a protein used in formation of microtubules) : helps in microtubule formation & thus spindle fibres during prometaphase & metaphase.
4. Helps in classification of chromosomes on basis of number & position of the centromere.

TYPES OF CHROMOSOMES

I. Based on number of centromeres : संख्या

1. Monocentric एककेन्द्री : most plants & animals
2. Dicentric द्विकेन्द्री : in chromosomal abnormality
3. Polycentric बहुकेन्द्री : Ascaris megalocephala
4. Acentric अकेन्द्री : Broken segments
5. Diffused : Centromere all over
   eg. insects, few plants/animals. spindle fibres attach at many points.

II. Based on position of centromere स्थिति

1. Telocentric : अन्तकेन्द्री I shaped Terminal
2. Acrocentric : अग्रबिन्दुक : sub-terminal one very small & other very long arm.
   Eg. 13, 14, 15, 21, 22, Y
3. Metacentric : मध्यकेन्द्री : at mid point. V shaped Eg. 1, 2, 3
4. Sub-metacentric : असमध्यकेन्द्री : J or L Shape 4-12 chromosome.

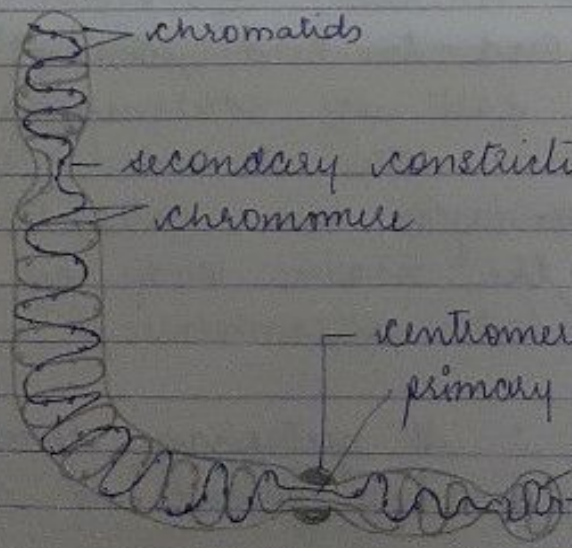


Figure: Chromosome structure during metaphase

2. Secondary Constriction or Nucliolar Organizer
Constriction other than primary
During interphase, it is sometimes associated
w nucleolus & play a role in nucleolus
formation ∴ called Nucliolar
Organizer.

3. Nucliolar Organizer Region:
Contains gene coding for
18S & 28S rRNA &
is responsible for formation
of nucleolus ∴ NOR
Lightly stained constricted
area. In humans, NOR
are located in sec^n
constriction of chrom. no.
13, 14, 15, 21, 22.

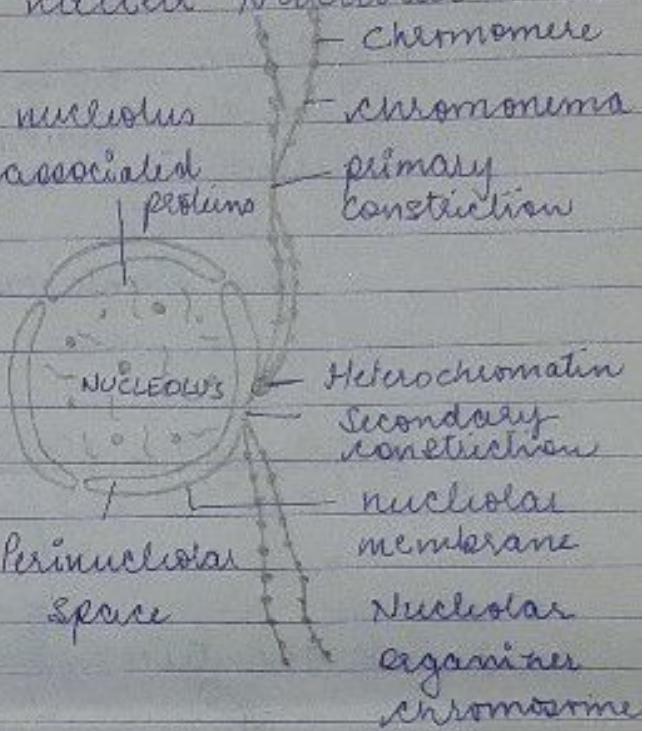


Fig: Nucliolar Organizer or Secondary constriction & its association w nucleolus.

4. Tertiary constriction:
Present in all chrom.;
function unknown.
Helps to distinguish
one chromosome from other.

5. Telomeres: Terminal part अंतिम छोर; Tips of chromosomes; rounded & sealed;
Provides stability & prevents the chromosomes from end-to-end joining.
Sometimes, Terminal part of chromosome beyond secondary constriction may rounded, elongated or knob like appendages k/a satellites. They are connected to the main body by delicate chromatin fibre. (Sat - chromosomes)

6. Chromatids अर्धगुणसूत्र: At metaphase, chromosome consists of 2 chromatids joined at centromere.
2 समान धागे जैसे रचना

At anaphase, centromere divides, each chromatid gets a centromere & becomes chromosome.

7. Chromonema & chromomeres वर्णसूत्र एवं वर्णकणिका

Chromonema : Thin & coiled fibres of chromatid
पतले व कुंडलित तंतु subunit 345 कण

Chromomere : condensed chromatin material

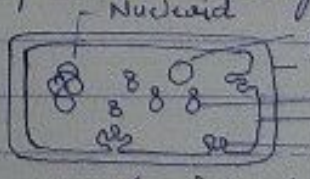
Ultrastructure of Chromosome
(परा संरचना)

Chemical composition of chromosome: (Eukaryotes)

Histone proteins	:	45-50%
DNA	:	40%
Non-histone "	:	8-9%
RNA	:	1-2%
Ions Ca^{+2}, Mg^{+2}	:	traces

Packaging of DNA in Prokaryotes:

No definite nucleus, but DNA is not scattered.
DNA is -vely charged polymer and is held by +vely charged proteins into a structure called nucloid.
DNA is arranged as large loops held by proteins called POLYAMINES
Histones are not found



Structure of Nucloid in Bacteria

Packaging of Nuclear DNA in Eukaryotes to form Chromatin, Chromatids & Chromosome

Due to DNA associated proteins occurs a more complex organisation

Histone proteins :

- Main structural proteins मुख्य संरचनात्मक प्रोटीन
- low mol. wt.
- high % of +vely charged basic A.A. - lysine & Arginine क्षारीय A.A.
- Bind the -vely charged DNA
- help in packing long DNA molecules.

Five types belong to 2 groups.

1. Nucleosomal histones

H2A, H2B, H3, H4

- Responsible for coiling DNA into nucleosome
- Form core particle or histone octamer.
- 2 of each type pr. ~~pr~~ every 200bp

2. Non-Nucleosomal

H1

- Tissue specific
- Pack DNA into 30nm
- 1 every 200 bp
- loosely associated c DNA

Non- histone proteins : 12 to 20 in number.

Not tissue specific

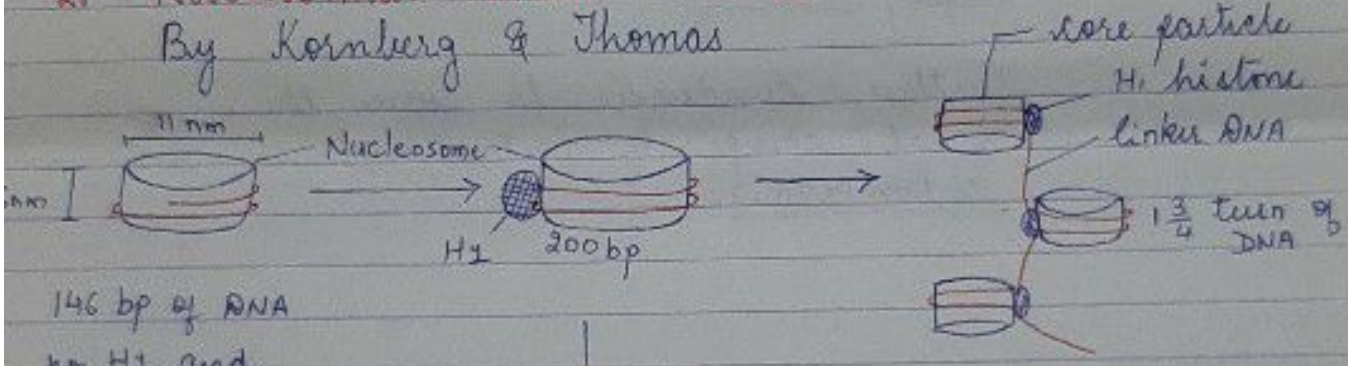
Models about Chromosome Formation

1. Folded fibre model वलित रेशा मॉडल
By Dupraw and Ris

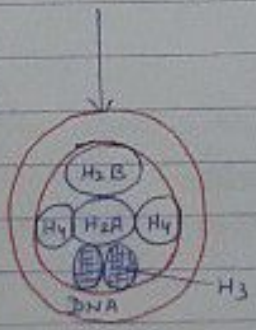
B-DNA (20 Å dia) → coils & supercoils → Type A filaments (80-110 Å) → coil & recoil → Type-B fibres (250-500 Å) → During Metaphase supercoil → Chromosomes (1200-5000 Å)

(responsible for formation of chromatin)

2. Nucleosomal Model केन्द्रिकाभ
By Kornberg & Thomas



146 bp of DNA no H1 and linker DNA



Histone Octamer

Fig. Nucleosomal fibre model

Term by P. Oudet

Nucleosomes are fundamental packing units of chromatin. Give "beads on string" appearance. Each nucleosome is 11 nm in diameter. Has a core particle and a spacer or linker DNA

Core particle or histone octamer : 8 nucleosomal histones (2 of each type). DNA strand of 146 bp is wrapped around.

cs | linker DNA : one H1 histone is present

leosome repeat after every 200 bp
man cell has 6×10^9 bp ∴ 3×10^7 nucleosomes

lenoid model :
nm nucleosomal bead on string str.
↓
nm 11nm fibre coils to form chromatin
↓ fibre (secondary structure)
nm has 6-7 nucleosome per turn
30 nm is solenoid str.

→ 30nm coils again to form super-solenoid
↓
further condenses to form the final shape of metaphase chromosomes.