(i) **Q-banding :** It is obtained when chromosomes are stained with **quinacrine mustard .** It stains A-T rich areas (developed by **casperson** for Y chromosomes) .

(ii) **G-banding :** chromosomes are stained with Giemsa. It stains sulphur rich protein parts.
A variety of different bands obtained by the modification of Q-banding andG-banding like C, T and N-bands. Q, C, G and R banding used for animal karyotypes while **cand Nbanding** used in plants.

(iii) **C-banding : -** It is used to stain constitutive **heterochromatin,** usually in centromeric region of the chromosome. The process involves denaturation of chromosomeby heat or trisodium citrate and then apply giemsa stain.

(iv) **R-banding: -** The process involved incubation of the chromosomes ina buffer at high temperature followed by use of Glemsa stain. This brings about the visualization of sulphur deficient region of chromosomes thus named as **reverse giemsa**.

NEW TECHNOQUES IDIOGRAM PREPARATION

Modern techniques used in karyotype preparation are **ISH, FISH (Fluorescence in Situ Hybridisation) , Mc FISH (Multicolour fluorescence in situ Hybridisation) and flow cytometey.**

Idiogram: -Diagrammatic representation of Kaeyotype . In idigogram of Drosophila sex chromosomes are placed firt. Idiogram is specific for every species.

USE OF KARYOTYPING OR IDIOGRAM

(i) It suggests primitive of advanced features of an organism. If karyotype shows a large size difference between the smallest and largest chromosomes of the set and having fewer metacentric chromosomes then it is called **asymmetric karyotype,** which is a reatively advance feature . Symmetric karyotype is primitive feature.

(ii) He karyotype of different species are compared and similarities in them represent the evolutionary relationships.

(iii) Karyotype is helpful in detection of chromosomal abberrations and polyploidy.

(iv) In research of **medical genetics Forensic science cytogenetics and Antthropoenetics.**

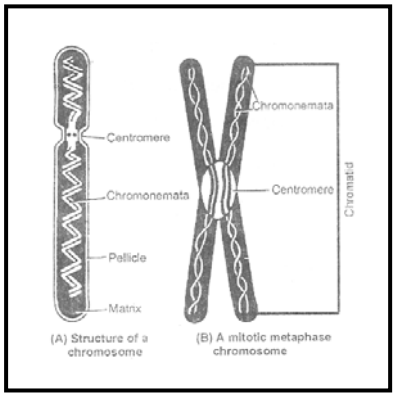
1. **In situ Hybridization (FISH) :** Using DNA probe labelled with radioactive molecule to locate the position of DNA sequence on chromosome.
2. **Fluorescence in Situ Hybridization (FISH) :** DNA may also be labelled with fluorochrome to locate the position of DNA sequence on chromosome.
3. **Multicolour Fluourescene in Situ Hybridization (Mc FISH) :** More fluorochrome colour of locate the position of DNA sequence on chromosome.
4. **Flow cytometry:** This is recent technique . in this technique a suspension of many thousands of chromosomes is made and the suspended chromosomeare stained with a DNA binding flurochrome.

- These chromosomepass through the cytometer the fluorescence for individual chromosome and the result is represented in the form of **histogram.**
- Each peak in this histogram represent or a group of chromosome of same size.
- This technique allow detection of difference as small as 1. 5 to 4. 0 Mega base pair.
- This technique allow detection of aneuploidy/duplication or deletion.

STRUCTURE OF CHROMOSOME (Parts which appears in metaphase chromosome) .

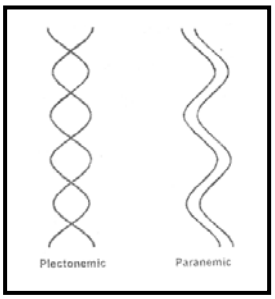
1. **Pellicle-** This is outermost , thin proteinaceous or sheath of chromosome.
2. **Matris-**This is a liquid nongenetic achromatic ground substance of chromosome , which has different type of enzymes, minerals, water, Proteins.

3. **Chromonema (singular chromonemata)** → Term by **Vejdovsky.** This is an important , genetical, highlycoiled thread, throughout the length of a chromosome or chromatid , It was called **Chromonema**. Chromonema lie embeded in an achromatic matrix.



- ☞ Each. Chromonema is consist of single long threas of DNA associated with histone.
- ☞ Sometimes bead like structure are seen on . Chromonema fibres, which are called as . Chromomeres.

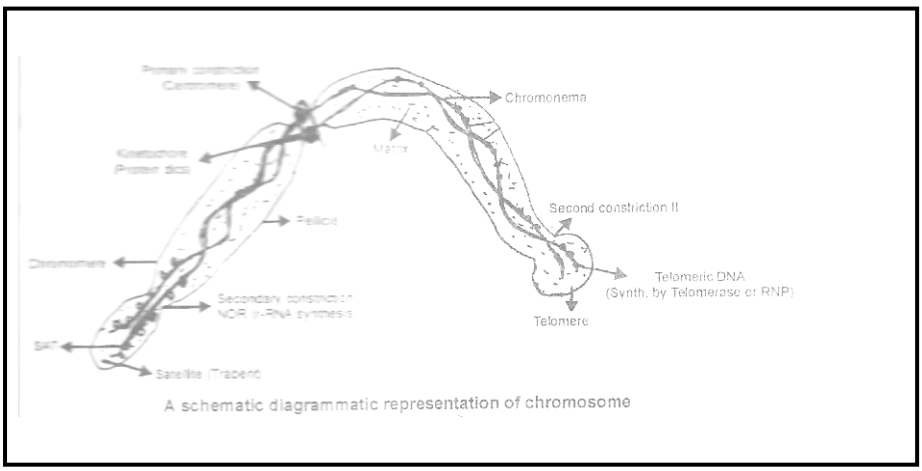
- ☞ Types of coiling in . Chromonema-
  - (i) **Plectonemic- coiling : -** When both the . Chromonema are inter twined and can not be seperated eadily. (in mitotic prophase chromosomes)
  - (ii) **Plectonemic- coiling : - Plectonemic- coiling : -**When both chromonema can be easily seperable. (In meiotic prophase)



4. **Centromere/Kinetochore: -** (Primay constriction)
- ☞ Each chromosome (at metaphase) is consist of two half chromosome or two chromatids, Both the chromatids of a chromosome are joined or connected by a tructure called **Centrocmere.** At this point or centromere two protein discs are present which is called **kinetochore**.
- ☞ **Kinetochores** constitute the actual site of attachment of spindles to chromosomes during cell division. Centromeric DNA is called as **alphoid DNA.**
- ☞ At the region of centromere the chromosome is comparativelt narrower than remaining part of chromosome. Thus it is termed as **Primary constriction.**

5. **Chromatid –**At metaphase stage each chromosome is consist of two cylindrical strucres – called **chromatids.** Both sister chromatids or longitudnal half chromosome are joined together by a common **centromere,** A chromosome, may have single chromatid (inAnaphase or Telophase) or two chromatid . (as in metaphase.)

6. **Secondary constricion:** Besides primary constrictions one or two , other constriction may also occurs on some chromosome, which are known as cecondary constriction.
- ☞ Secondary constriction is also known as **NOR (Nucleolar organizer region)** (13, 14, 15, 21, 22 chromosome in human)



7. **Satellite :** part of chromosome remains after the NOR is known as chromosomes **satellite/Trabent.**

☞ Chromosomes with satellite part are called as **SAT chromosome (**SAT=Sine Acid Thymonucleinico**)**

8. Telomere: chromosomes have polarity and polar ends of chromosomes is known as

☞ Telomere. Telomere prevents fusion of one chromosomes to other chromosome . Telomere rich in Guanine base.

☞ **Enzyme Telomerease** presents in telomere part of chromosome, which is a **Ribonucleopotein.**

TYES OF CHROMOSOMES ON THE BASIS OF POSITION OF CENTROMERE

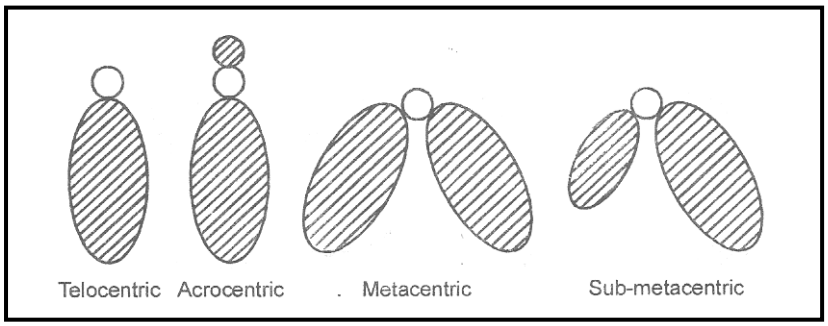
(i) Telocentric: - When centromere is terminal or located at tip of chromosome.

(ii) Acrocentric: -When the centromere is sub- terminal or located neat the tip .

(iii) Metacentric: -When the centromere is located at mid of the chromosome.

(iv) Sub metacentric: -When the centromere located near centre or mid point of chromosome.

☞ The ratio of length of the long arm to the short arm of a chromosome is called **arm ratio,** Aem ratio is masimum in acrocenteric chromosome.



TYPES OF CHROMOSOMES ON THE BASIS OF NUMBER OF CENTROMERE

(i) Acentric ;- Chromosome without centromere.

(ii) Monocentric: - Chromosome with one centromere.

(iii) Dicentric: -When the number of centromere is two .

(iv) Polycentric chromosome: -When the number of centromere is more than two & diffused in throughout chromosome length.

ULTRA STRUCTURE OF FINE STRUCTURE OR THE CHROMOSOME

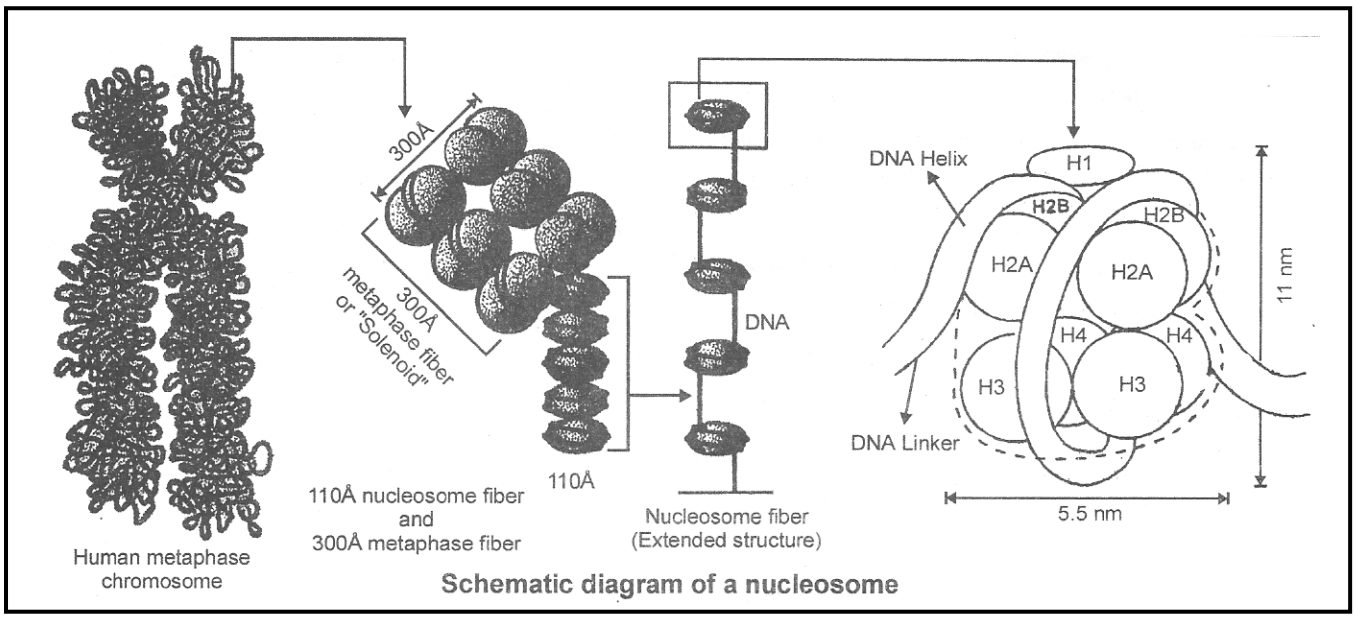
Following theories was given for structure of chromosome: -

(i) Multstranded (Multineme) model: -This model was proposed by steffenson. According to him each chromatid of chromosomeos consist of 16 DNA chains.

(ii) Singel strand models: - (Supported by crossing over)

(a) Uninemal model : - Given by Ris. According to this model each chromatid of chromosome is consist of **one DNA molecule.**

(b) Foldedfibre model: -Proposed by Du Praw. According to this model , chromosome is consist of highly folded **single DNA molecule.**



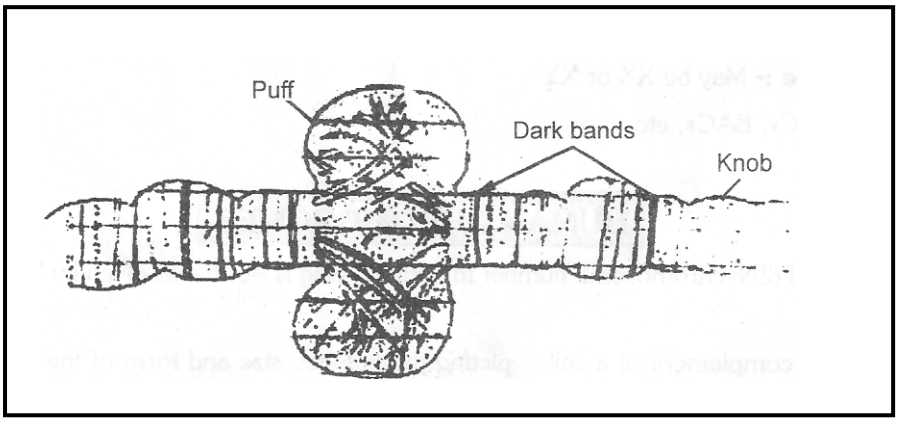
(c) **Nucleosome model: -**Bead like structure in chromatin was first observed by Olin's etal This model was proposed by **Kornberg & Thomas** in 1974, which is most important and universally accepted model for the structure of chromosome . This model explain that how giant DNA molecule & histone (Chromatin) packaged in a chromosome. Term **nucleosome** was given by **P, Oudet** in 1975 . " Nucleosome is a unit of chromatin (chromosome) which is composed of about 200 base of the DNA and an Octamer (Core particle) of four types (H2A, H2B, H3 & H4) of histone proleins " Nucleosome is also known as Nu-budy or γ - particle.

Nucleosome =Binding DNA (146bp) + Octamer + Linker DNA +H 1 Histone
(H2A, H2B, H3 , H4 × 2)

- 6 Nuclesome unit united (or super coiling) to forma **Solenoid** structure. (by klug -1982)
- H_1 histone protein (**sealing histone**) joined the turns of binding DNA in nucleosome .
- Nucleosome unit have 1. 75 or $1\frac{3}{4}$ turns of binding DNA .

SPECIAL TYPE OF CHROMOSOMES

1. **Salivary gland chromosome : -** This type of chromosome was discovered by E. G. Balbiani , in Chironomous larva of insect. Size of this chromosome may upto 2000 micron (2mm) and number of chomatids reach. 512 to many thousands. Thus , this type of chromosome also known as **Giant chromosome.**

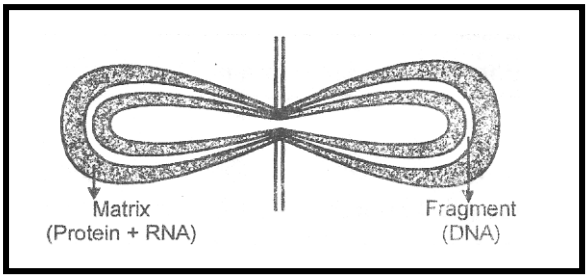


- **Koller** named it as **Polytene chromosome** , because number of chromatids is very high.

- Swollen areas present at some places in polytene chromosome , which are called as **Baibiani rings or puffs.** These puffs helps in synthesis of RNA & proteins.
- Salivary gland chromosome concerns with **metamorphosis** and **moulting** process of insect larva. (This chromosome is related to a moulting hormone -Ecdyson)

2. **Lamp brush chromosome**-Discovered by **Flemming and Ruckert** form oocyes of **vertebeates (Amphibia)** during diplotene stage of cell division . These chromosomes look like lamp-brush , thuscalled as **lamp brush chromosome**.
Size of these chromosome may upto 500 micron, and also called as **giant chromosome.**

- Axis of lamp –brush chromosome is consist of DNA, which matrix is consist of RNA & proteins.
- Lamp brush chromosome is concerned with "**Vitellogenesis**" (Yolk formation)



3. **B- Chromosome/Accessory chromosome/Superunemerary chromosome: -**

- Discovered by Wilson in Metapodian Insect. Name suprtniemerary chromosome was given by **D. Jones** 1975.
- These are heteochromatic & small sized chromosome. Thus , no phenotpic effects are know.
  (Morphological control)
- B- chromosomes also present in plants cells (Maize)
- They are supposed to be involved in **Ecological** adaptaion of organisms.

4. **Mega chromosome: -**

- Found in Hybrid species of Tobacco.

5. **Isochromosome**: -

- When the both arms of the chromosomes are identical or genetically similar. Then chromosomes called as **isochromosomes**. If are of a telocentric chromosomeorid splitted upto centromere then a metacentric chromosome with two identical arms is formed . such chromosome is called **isochromosome**. **Ring chromosome: -** Prokaryotic chromosome are ring chromosome or consists of circular fokded DNA without histone.

7. **Sex chromosome**: - May be XX or XY

8. HACs , MACs , YACs , BACs etc.

HUMAN CHROMOSOMES

- The normal diploid (2N) chromosome number in human being is 46. It was given by **T. H. Tijo** and **A. Levan** in 1956.

- The chromosome complement of a cell depicting the number , size and form of the chromosome as seen in metaphase of mitosis is called **karyotype** and diagrammatic representation of karyotype is known as **Idiogram orKaryogram. .**

- The chromosomes are morphologically numbered in to **7 groups**. (size and poditon of centromere) by Denver and **Colorado** (1960)
  - **Group (A) :** 1-3 chromosomes of largest size and submetacentric or **metacentic** centromere.
  - **Group (B) :** 4-5 chromosomes with less larger **, submetacentric**
  - **Group (C) :** 6-12 chromosomes with medium sized and **submetacentric** centromere.
  - **Group (D) :** 13-15 chromosomes, shorter than group 'C' with centromere near the end (**Acrometaceteric) .** They are SAT chromosomes or satellite.
  - **Group (E) :** 16-18 chromosomes, short sized , with medial **(Metacenteric)** or submedian centromere **(Submetataceteric)**
  - **Group (F) :** 19-20 s, short sized with **median centromere**.
  - **Group (G) :** 21-22 chromosomes, smallest in size, Acrocentric and are also posess satellites.
- X chromosome is placed in 'C' group due to its larger size and submedian centromere.
- Y- chromosome is placed in group 'G' due to its short size but satellite absent and is Acrocentric type.