CHAPTER 3

Chromosomes

Q.1. Write an essay on chromosomal aberrations.

Ans. Chromosomal Aberrations

Since the development of chromosome techniques in human beings, chromosomes of patients in the hospitals are routinely analysed. As a result of such examination, a number of abnormalities could be attributed to chromosomal aberrations.

I. Triploidy

A solitary case of triploid human being (2n = 69) was reported in 1960 by **Brook** and **Santesson.** This triploid individual had three complete sets of autosomes and XXY chromosomes. Consequently, it was a male individual and showed abnormalities in cerebral development, had syndactyly of hands and feet and was small jawed obese. This triploid individual survived only upto birth.

II. Aneuploidy and structural changes

Trisomics (2n + 1 = 47) and monosomics (2n - 1 = 45) are known in human beings. Trisomy or monosomy may involve a sex chromosome or an autosome.

1. Aneuploidy involving sex chromosomes : Aneuploid chromosome numbers involving X-chromosome and the resulting phenotypes are listed in Table I.

Table I. Chromosome constitution, sex and phenotypes of some aneuploids known in human beings.

Sex chromosomes	Sex	Phenotypes
XO (monosomic)	female	Turner's syndrome
XX (disomic)	female	normal
XXX (trisomic)	female	superfemale
XXXX (tetrasomic)	female	(mental abnormalities)
XXXXX (pentasomic)	female	(mental abnormalities)
XY (disomic)	male	normal
XYY (trisomic)	male	normal
XXY (trisomic)	Male	Klinefelter's syndrome
XXYY (tetrasomic	Male	
XXXY (tetrasomic)	Male	extreme Klinefelter's
XXXXY (pentasinic)	Male	

(a) Turner's syndrome : Turner's syndromes are characterized by **monosomy of XO** type. These are immature females (sterile) with webbed neck.

(b) Klinefelter's syndrome : Klinefelter's syndromes were characterized by trisomy (XXY). These are male individuals, who are phenotypically fairly normal but have a very low sperm count and, are therefore sterile. Chromosome constitutions of other Klinefelter's syndromes are given in Table.

2. Autosomal aneuploidy : Trisomy for different autosomes is known, which includes the following : (i) **trisomy 21,** (ii) **trisomy 17,** (iii) **trisomy 18** and (iv) **trisomy D** (13-15). Most frequent autosomal trisomics are those for chromosome 21, perhaps because chromosome 21 is a small chromosome and its addition does not cause lethality. Before trisomy was known, syndromes were described in 1866 by **Langdon-Down** of England and were popularly called mongolian idiots or Down's syndromes. Phenotypic abnormalities associated with these syndromes included slant of eyes, thick tongue, sagging mouth, unusual palm and feet, obesity and slow mental growth. The life expectancy of these idiots is about 8 to 12 years.

The trisomy for chromosome 17 or for 13—15 (D group) has more serious effect and is, therefore, rarer. Trisomy 17 and trisomy 18 had effects like small mouth, low-set-ears, heart defect, flexion anomaly of fingers and toes and sometimes also syndactyly, malformed chest and webbed neck. The trisomic for D group (13—15) has heart defect, polydactyly, mental retardation, harelip, cleft palate and severely defective eyes.

3. Structural changes : In certain cases of chromosomal aberrations, the chromosome number does not change and remains 2n = 46, but there may be structural changes involved. One of these structural changes may lead to Down's syndrome. In some such cases, it was discovered that extra chromosome 21 (in trisomy 21) was attached to another perhaps acrocentric chromosome of the D group or the G group, so that although it is a trisomic in chromatin content but has a chromosome number 2n = 46. Another translocation 13—22 gives rise to 2n = 45 and leads to delayed development of speech and to a low I.Q.

☛ **Q.2. Discuss the role of X and Y chromosomes in the determination of sex in man.**

Ans. **Role of X and Y-Chromosomes**

In man X-chromosome is female determining and Y-chromosome is male determining.

Sex anomalies found in human race support the role of X-and Y-chromosomes in determining sex in human beings.

1. Klinefelter's syn- drome (2n=47 or 44 + XXY) : This is caused by presence of an extra X-chromosome in males. Such males prossess 47 chromosomes (44 autosomes +XXY sex chromosomes). Mor- phologically, these are sterile males with underdeveloped genitalia, sparse body hair and some degree of breast development. These exhibit mental retardation and limited

intelligence. Klinefelter's syndrome is seen in one out of every 500 male births. It arises by the non-disjunction of XX-chromosomes.

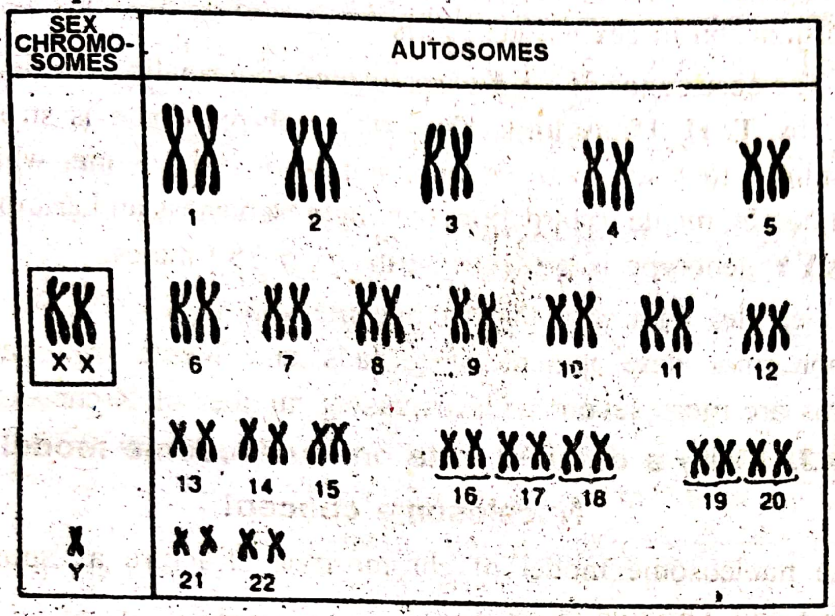


Fig. Chromosome compliment of a person suffering from Kilnefalter syndroms.

2. Turner's syndrome (2n = 45 or 44 + X) : It is caused by the absence of one X-chromosome in female. Such females possess 45 chromosomes (one less than the normal 46). These are sterile females with poorly developed ovaries and underdeveloped breasts. They have webbed neck and broad chest. One in every 25,000 birth suffers from Turner's syndrome.

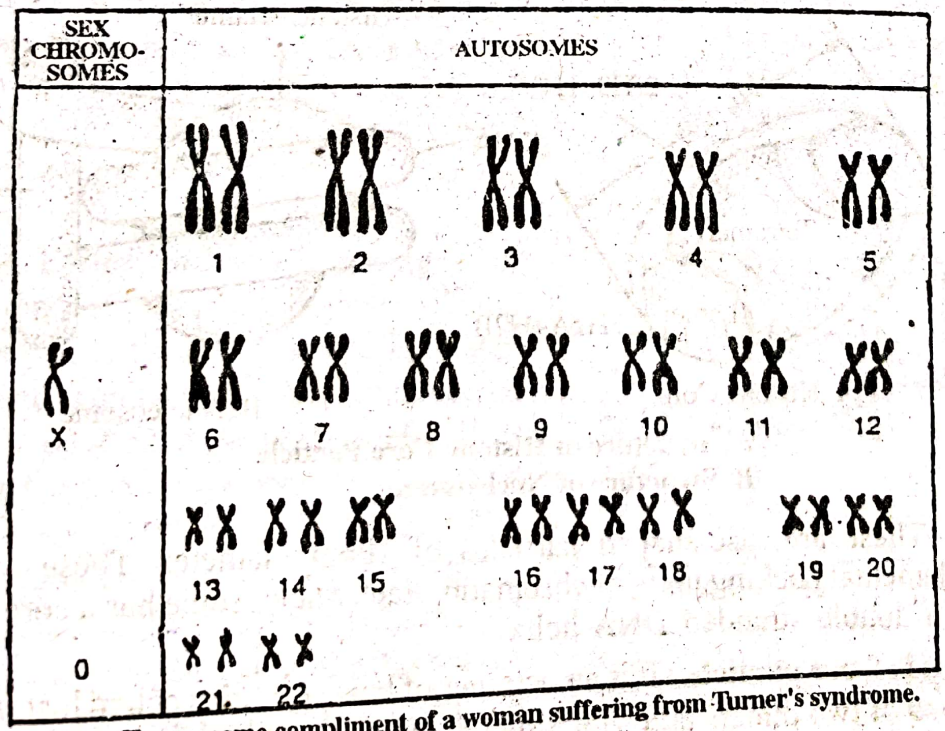


Fig. Chromosome compliment of a woman suffering from Turner's syndrome.

3. **Males with XXY (diplo-X), XXXY (triplo-X), XXXXY** (tetra X) and **XXXXXY** chromosomes were observed. In all these, extra **X** arises as a result of nondisjunction of sex chromosomes.

4. The occurrence of **XYY** chromosome abnormality was first observed in 1962 by **T. H. Hauschka.** The extra Y-chromosome is strongly male determining and leads to overproduction of male hormone, which causes unusual height, mental retardation, over aggressiveness and criminal bent of mind. **XYY** genotype is present one in every 300 males.

5. Females with extra X-chromosome (XXX, XXXX, OR XXXXX) show abnormal development of gonads and mental retardation. The symptoms are more severe with increasing number of X-chromosomes.

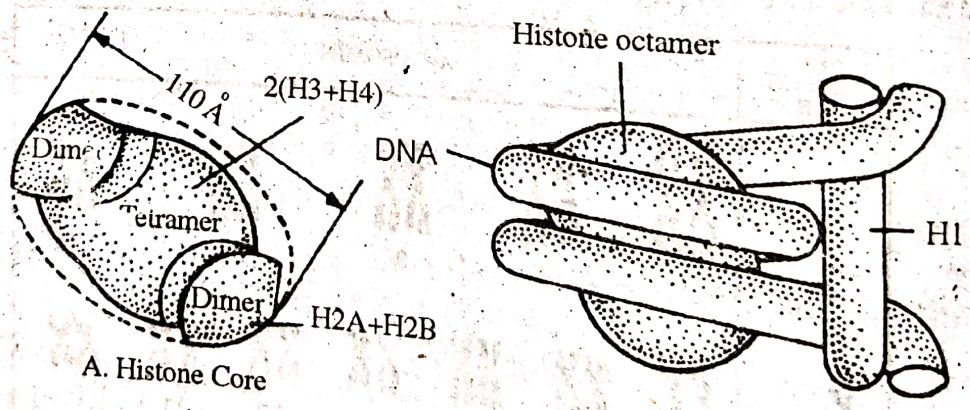
☛ **Q.3. Write a detailed note on Nucleosome model.**

Ans. **Nucelosome concept**

The nucleosome model of chromosome structure as sponsered by **Kornberg** and **Thomas** in 1974.

In interphase nucleus, the nucleoprotein fibre of each chromosome is formed of repeated units of **nucleosomes.** These are arranged like **'beads on a string'**. This beaded string has a diameter of 30nm or 300. It is called **300nm chromatin fibres.** The beads are like nucleosomes and these are connected by **linker DNA.**

Nucleosomes



A. Structure of Histone Core Particle
B. Structure of Nucleosome

These are disc-shaped particles of 10nm diameter. These represent fundamental packing units of chromatin. Each nucleosome has a core particle and a double stranded DNA helix.

(1) Core particle : It is an octomer of basic proteins called histones. It is formed of two dimers and a tetramer. Each dimer is formed of one copy each

of two histones H2A and H2B, the tetramer consists of two molecules each of H3 and H4. The core particle is 11 nm in diameter and 6nm in height.

(2) DNA helix : It is a segment of DNA, molecule it is formed of about 200 nucleotide pairs. Each coil consists of 83 base pairs.

One unit of H1 histone is associated with one nucleosome. It seals the two coils of DNA on the core particle.

Supersolenoid structure of Nucleoprotein Fibre (Levels of Packaging)

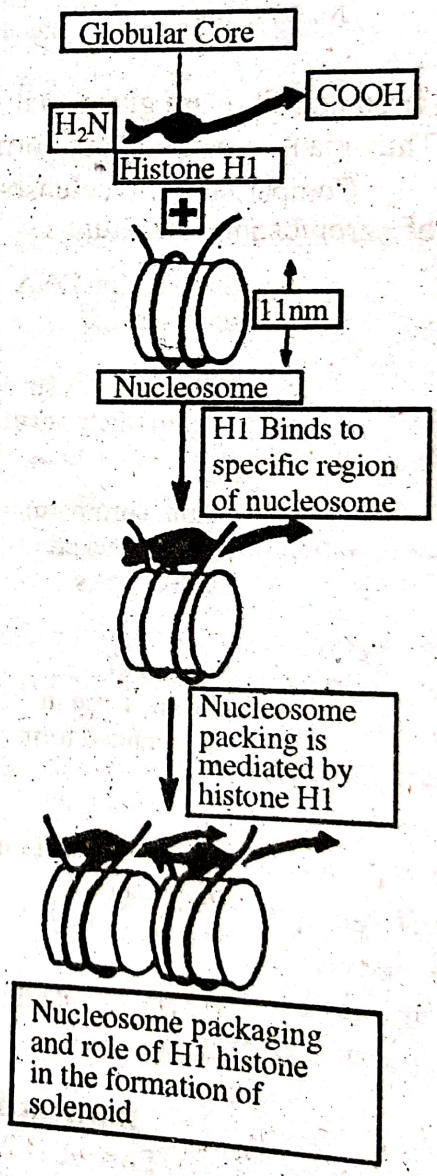
1. Primary packaging or formation of 10nm nucleoprotein fibre : 20 or 2nm Coiling of DNA around histone core to form 11nm nucleosome is called **primary packaging** of chromatin. It reduces length of DNA by 1/7 times. As a result of this, the chromating fibre has a diameter of about 11nm and is described as 10nm or 11nm fibre. It is seen in interphase nucleus.

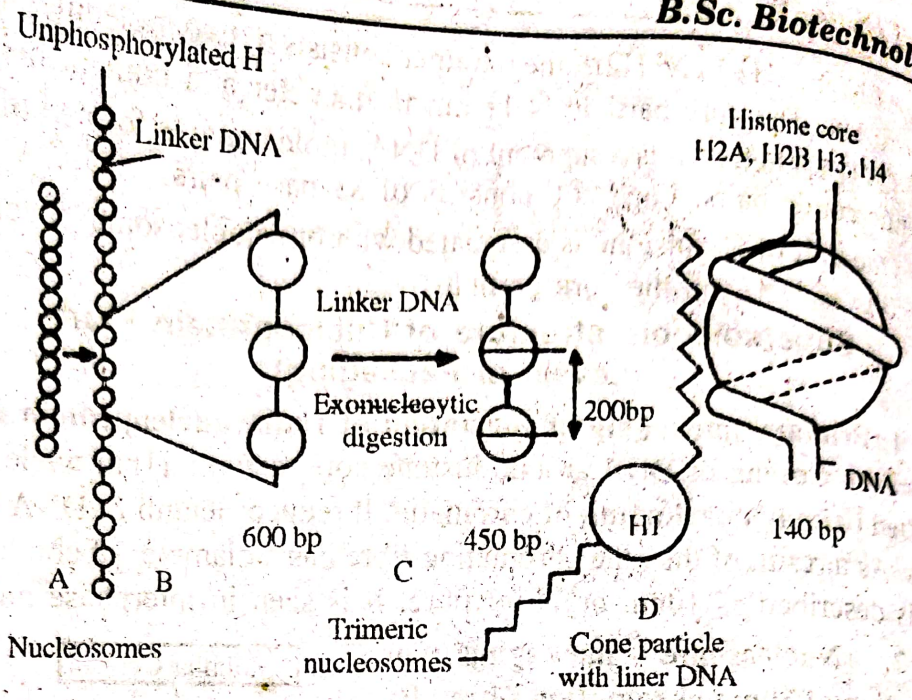
2. Nucleosome packaging or formation of 30nm chromation fibre : By the spiral coiling of 10nm chromatin fiber and packaging of nucleosome 30nm thick chromatin fibre is formed. One spiral has 6 nucleosomes packed together.

H1 histone molecules are associated for the packaging of nucleosomes and supercoiling associated.

H1 molecule has a globular central region with two arms in opposite direction. The central portion associated to a specific location in the nucleosome, while its one arm covers the linker DNA near the bead and other arm associated with next histone core.

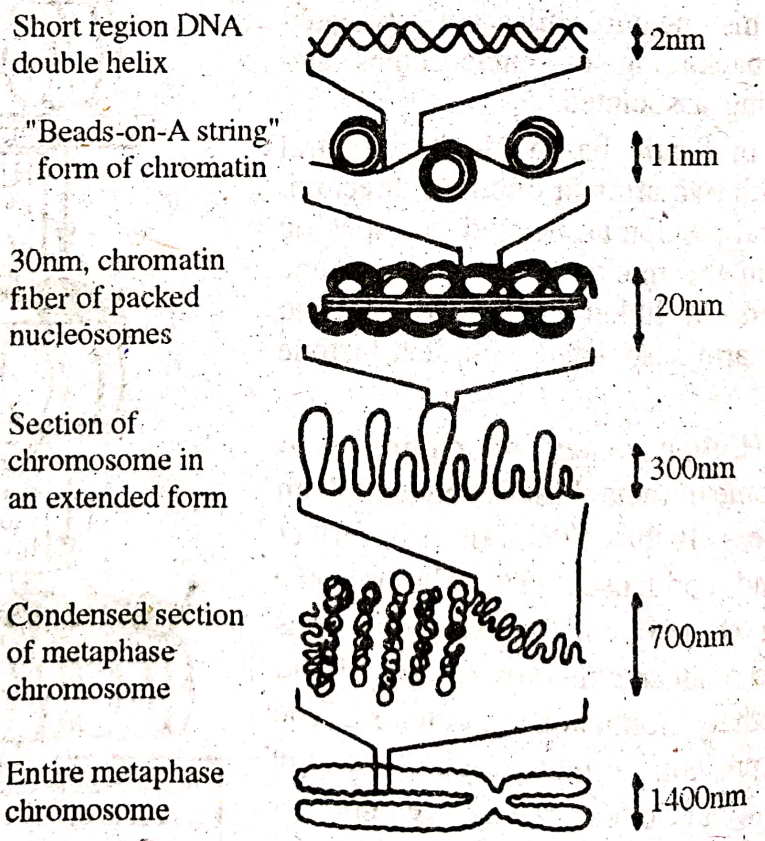
3. Higher order of coiling : A chromosome of metaphase is about 1400nm in thickness. It thus 30nm fibre is further coiled and condensed. The chromosome consist a **central core** or **scaffold.** It is composed of an enzyme ***topoisomerase*** and 12-20 other nonhistone proteins. The scaffold presents a main regions for the attachment of coils. These regions of attachment are called **scaffold attachment regions (SARs)** each. Scaffold is in the form of spiral. The loops of 30 nm





chromatin fibre are glued to its SARs and project laterally from the scaffo
Thus giant supercoils are formed.

Comparison of Nucleosome Model with DuPraw's Folded Fibre Mo
of chromosome Structure :



Different degrees of coiling of nucleoprotein fibre of 11 NM thickness to form chromosome, nucleosome

The nucleosome model is better and more accepted than DuPraw's folded fibre model because :

1. According to **DuPraw's unineme model,** the DNA molecule is spirally coiled and packed in protein to form nucleoprotein fibril nucleosomes are absent. According to **nucleosome model of chromatin,** DNA is wrapped around histone cores to forms nucleosomes.
2. Nucleosomes are the fundamental packing units but according to DuPraw No such units are present.
3. According to **DuPraw** did not describe any specific order of packaging but according to nucleasome model presents formation of solenoid, and supersolenoids and their attachment with **topoisomerase scaffold** for higher levels of coiling.
4. The nucleosome model is supported and proved by biochemical and cytological techniques. DuPraw's model is not supported by these observations.

Q.4. Describe the structure of chromosome ?

Or

Describe structure and ultrastructure of chromosome.

Strasfurger

Ans.

Chromosomes are the filamentous structure found inside the karyolymph of nucleus. The name chromosomes was first given by in 1875. The chromosomes bears gene and play a main role in heredity. During reproduction these chromosomes are passed on to next generation through gametes. The physicochemical composition of these is such that they have specific and profound effect upon the course of development and hence upon organism's character.

The chromosome may be found as a nuclear component having special organisation, individuality and function. This is maintaining its morphology and physiological properties through successive cell division they may be very thin and delicate in some phases and may be thick and compact in other phases of cell division.

Number of Chromosomes

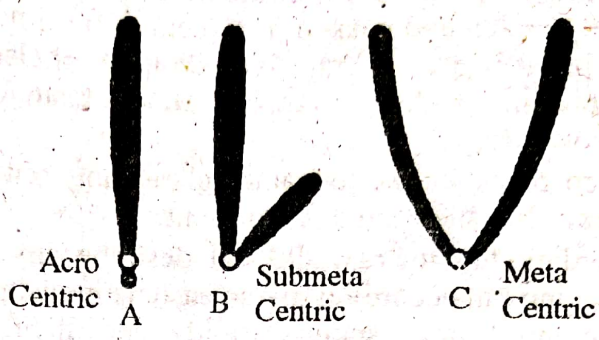
The number is variable in different species of plant and animals. The number of chromosomes in a species is constant but. The lowest number of chromosome have been recorded in *Ascaris mengalocephala* (n = 1) and the largest number in some protozoan, as in *Radiolarians* n = 800. The haploid set of chromosomes is called *genome.*

MORPHOLOGY

Size and Shape

The chromosomes usually appear as cylindrical bodies which vary form 0.1μ to about 30μ in length and from 0.2μ to 2μ in diameter. The

chromosomes depending upon the position of centromere they may be of many types—



(1) Acrontric Chromosomes : Rod like chromosomes having a very small arm.

(2) Sub-metacentric Chromosomes : Chromosomes having unequal arms and resembling in shape.

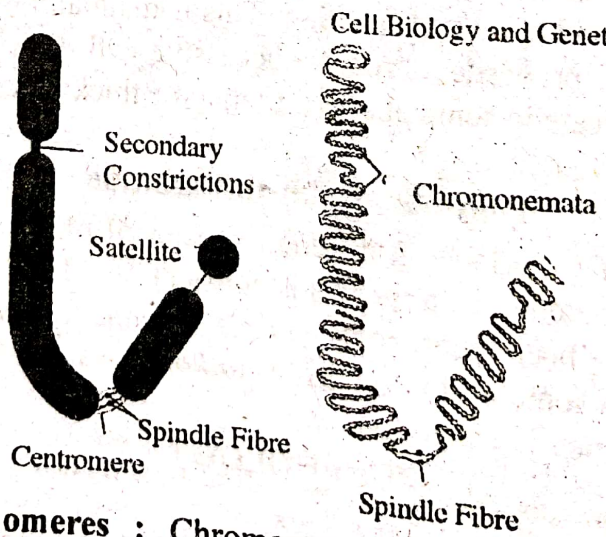
(3) Metacentric Chromosomes : V-shaped chromosomes having equal arms.

Structure

A chromosomes have many parts :

(1) Pellicle and Matrix : Pellicle is the outermost membrane of the chromosomes. Pellicle is made up of a very then and acronematic or material of without gene. The structure and function of matrix are not fully known.

(2) Chromatids : During metaphase stage, chromosomes appears to possess two threads called chromatids. The two chromatids are held together at a point along their length and which is called centromere or primary constrictions. These chromatids are spirally coiled *chromonemas* at metaphase.



(3) Chromomeres : Chromonemata is a long thread occurring throughout the chromosomes. These chromonemas possess numerous bead like bodies called *chromomeres.*

(4) Satellite bodies : Besides the primary constructions in chromosomes, the secondary constrictions also be found. The starting part of secondary constriction of chromosomes is called *satellite.*

(5) Centromere : Some non-staining gaps appear as constriction in the chromosomes and is generally called *kinetochore* or *centromere.* It is identified as the part of the chromosome, to which the spindle fibres are connected during cell division. Generally one centromere is located in one chromosome (monocentric) but there can be two (dicentric) or more (polycentric) in a chromosome.

Fine Structure of Chromosomes :

Fibril is the smallest visible unit of the chromosomes, which is nearly 100 in thickness. This fibril contain 2DNA double helixes separated. A completed chromatid thus consists of two half chromatid thus with 16 double DNA helix. A chromosome consists of two chromatids *i.e.,* have 32 DNA helix and is nearly 1600 thick before duplication.

Q.5. Give a brief account of lampbrush and polytene Chromosome.

Or

Describe the structure of salivary gland chromosome and its importance.

Ans. **Lampbrush Chromosome**

Lampbrush chromosomes are grant sized chromosomes found in oocytic nucleicy these vertebrate which have large yalk eggs. These can bee seen by the naked eye. Gall and Chalan 1974 gave their detailed structure and functions. Lampbrush chromosomes found in *Sharks, Amphibiane* reptiles and birds which produce large and yalky egg.

A lampbrush chromosome (in diplatene stage) consist of two homologous chromosome which are in contact only at certain point. Each chrmosome of pair is formed of two sister chromatids, which lie parallel and form chromosomal axis or main axis. Main axis is made up of DNA and protein. Loop axis is surrounded with matrix compared of RNA and proteins. This gives fuzzy appearance to lateral loop. At the base of the loop, chromosomal axis appears as coiled due to stained chromosomers. On the

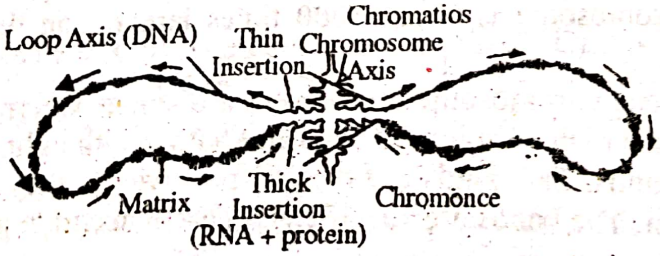


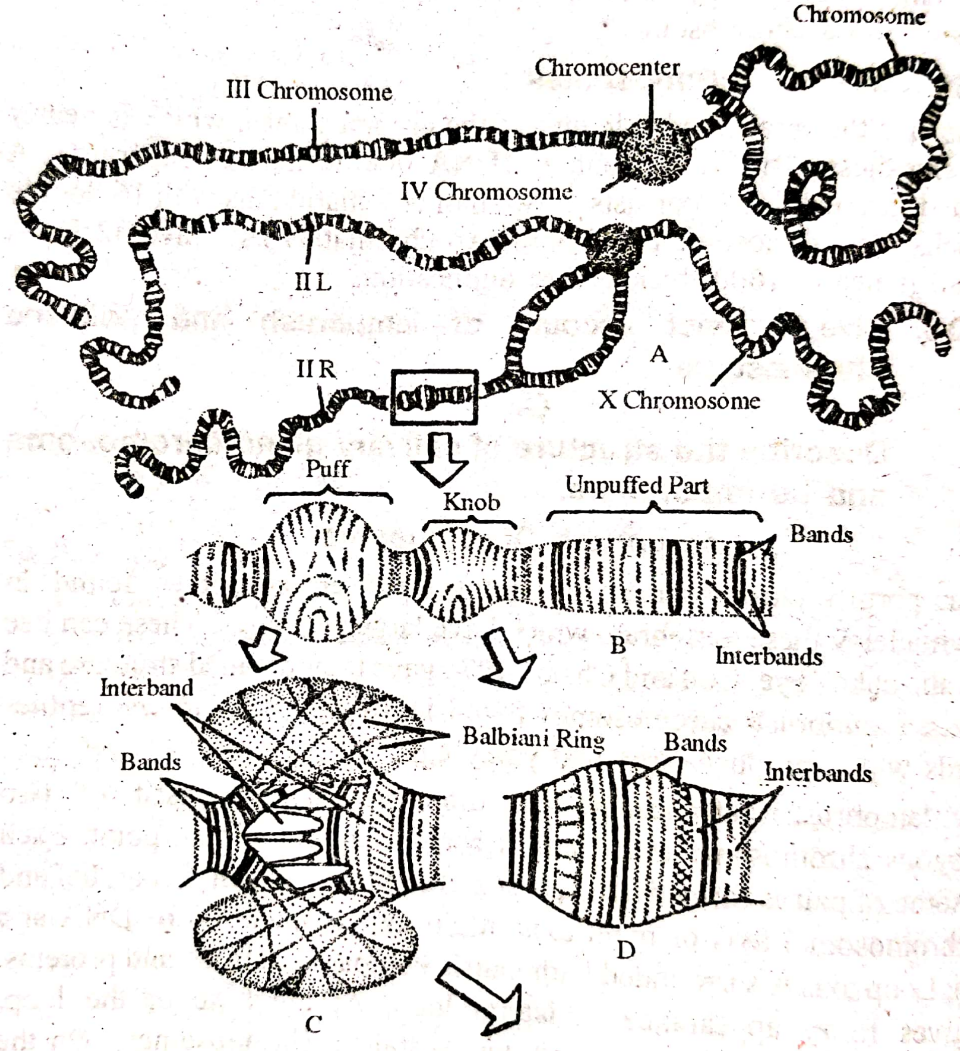
Fig. A part of main axis with a pair of lateral loops of a lampbrushchrmosome showing synthesis of RNA

point, at one side matrix becomes thick and formed a thick insertion, other side become thin and formation of thin unsertion.

The function of Lamp brush chromosomes is producing RNA and protein are related to the function of yolk in the growing egg.

Polytene Chromosome

The polytene chromosome occur in the nuclei of Salivary gland, Malphighian tubules, epithelial lining of guilt of *Drosophila* and some fat bodies



of the larvel stage of certain Diptera. In *Drosophilla* melanogester the volume of polytene chromosome is about 1000 times larger than that of somatic chromosomes.

The polytene chromosome are present a distinct pattern of transverse banding. It consist of dark-coloured band alternating with light coloured band area, the interbands. The bands are fuclgen positive *i.e.* they are formed of heterochromatin. The bands are specific and permit accurate mapping of the chromosome.

Polytene chromosome is formed by endomitosis.

☛ **Q.6. Write a note on Chromosome and Chromatid.**

Ans. **Chromosome and Chromatid**

The chromosomes are thread-like bodies consisting largely of DNA and protein which found in the nucleus of every animal. They occur in pairs in somatic cells of animals and higher plants. The two members of every pair are identical in appearance, and are said to be homologous. These are capable of self duplication and maintaining their morpho- logical and physiological characteristic division after division.

The chromatids are two strands, which finally from duplication of a chromosome at S-shape. These are visible during prophase and metaphase of all division. They separate at anaphase and are then known as daughter chromosomes. ●

☛ **Q.7. Write a short note on B-chromosome.**

Ans. **B-chromosome or Supernumery chromosome :** Certain plant and animal cells have one or more additional chromosome in addition to the normal number. Such accessory chromosome are very small and genetically inert.

There are composed of heterochromatin. Normally their presence in the nucleus does not effect phenatype but if these are too many, they reduce fertility and vigour. ●

☛ **Q.8. What is amniocentesis ? How it can be used in knowing the sex of foetus ?**

Ans. Amniocentesis is technique for the diagnosis of some of the genetic abnormalities during the foetal or intrauterine life of foetus. This has increased the possibility of preventing or alleviating the effects of a genetic disorder if it can be detected as early as possible. Amniocentesis is also used to determine the sex of unbron.

In amniocentesis, a sample of amniotic fluid is obtained from the amniotic cavity around the foetus by inserting a needle through the lower abdomen of pregnant woman and through the wall of uterus. The amniotic fluid is now centrigufed. The cells form a sediment and removed. These cells are transferred to the slides, fixed and stained. These are then studied for the study of karyotype, determination of sex, sex abnormalities and chromosomal abnormalities. ●

☛ **Q.9. What is synaptonemal complex ? Describe its structure and function.**

Ans. **Synaptonemal complex (SC) and its significance in meiosis**

Moses in 1956 first discovered synaptonemal complex (SC), a feature of meiotic prophase synaptonemal complexes are seen at zygotene in the

region of pairing. At pachynema these complexes are even more conspicuous.

Structure of synaptonemal complex

It is composed to three parallel (Fig. III). The two **lateral elements** seem to be composed of fibres that are slightly wider than 10 nm and are called **synaptomeres. central element is a ladder like configuration.** The transverse element are electron dense filament that inter connected central element with the lateral element. Cytochemical studies have demonstrated that the lateral elements are rich in **DNA, RNA and proteins, but that the central element contains mainly RNA, protein and little DNA.**

Function of synaptonemal complex : The appearance and disappearance of the synaptonemal complex coincide with the stages of meiosis in which pairing and recombination occur. In meiosis pairing and recombination are most important phenomenona of synaptonemal complex. This comple is slowely-2 disappear in Diplatene.

☛ **Q.10.Write notes on the gynandromorphs.**

Ans. Gynandromorphs : Some *Drosophila individuals were occured to possess half of the body of male and half of female. They are called* **gynandromorphs.** As many as three types of **gynanders** or gynandromorphs canbe differentiated into :

(1) Bilateral gynanders : Here the half lateral side is of male and the other half of female.

(2) Antero-posterior gynanders : Here the anterior end of the animal is of one sex and the posterior of the other.

(3) Sex piebalds : Here the female fly has irregularly scattered spots of male tissue.

Morgan and Bridges, 1919 explained the formation of gynandromorphs on the basis of chromosome theory of sex determination. In *Drosophila* the zygote developing into a female has two X-chromosomes. Due to loss or disappearance of one X-chromosome during cleavage of the fertilized egg, a gynandromorph is made. While the derivatives with only one X-chromosome develop themale tissue, the other with two X-chromosomes gives rise to female tissue. Hence half of the body shows male characteristics, the other half is female. In silk worms some eggs contain two nuclei. It is possible that both the nuclei are fertilized by different antherozoids. If one nucleus contains X-chromosome and the other has a Y-chromosome, the half body of the insect develops into female, the other half forms the male.

☛ **Q.11.Write short note on duplicate genes.**

Ans. Duplicate Gene Interaction (15 : 1 ratio) : When two pairs of indetical alleles are present, either of which is able to produce the character in questions, are said to be duplicate factors. **Shull** found in Shepher'd purse that there are two types of seed pods (i) triangular, (ii) elongated. These when crossed give triangular and elongated pods in the ratio of 15 : 1 in F_2

		Female Gametes			
		TD	Td	tD	td
Male Gametes.	TD	TTDD	TTDd	TtDD	TtDd
	Td	TTDd	TTdd	TtDd	Ttdd
	tD	TtDD	TtDd	ttDD	ttDd

Triangular TTDD × Elongated ttdd

Symbol Triangular TtDd

Triangular T-D 9	Triangular T-dd 3	Triangular tt D– 3	Triangular ttdd 1

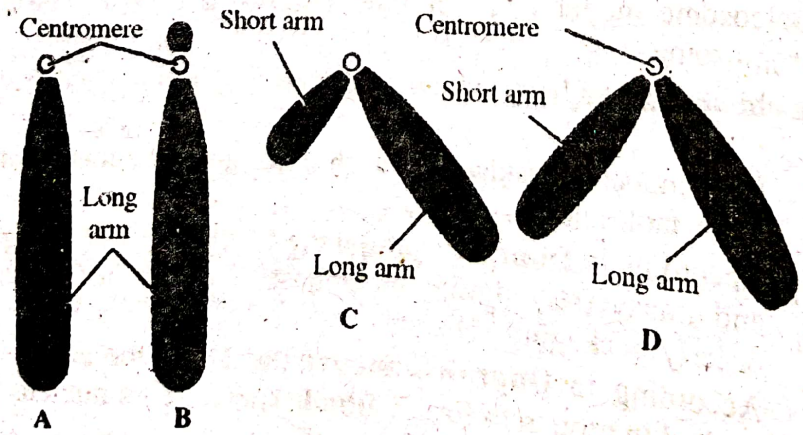
Gametes: TD, Td, tD, td

tD	TtDD	TtDd	ttDD	ttDd

Fig. The results of a cross between triangular and elongated pods in shepherd's purse showing inheritance of duplicate factors.

Q.12. Differentiate between Metacentric acrocentric chromosomes. Or Depending upon the position of centrommere there can be how many types of chromosomes ?

Ans. Corresponding to different positions of centromere, chromosomes would be called :



(i) acrocentric or telocentric, having terminal centromere,

(ii) submetacentric having sub-terminal centromere

and (iii) matacentric having median centromere.

☛ **Q.13. Write short notes on : (i) Kinetochore, (ii) Nucleolar organizer in chromosome, (iii) Telomere.**

Ans. (i) **Kinetochores :** It is a disc shaped structure those appears on centromere of chromosomes. During late prophase of cell division, two **kinetochores develop** on two opposite faces of the centromere.

A kinetochore is a disc shaped structure and contains RNA and protein. It is a trilainar structure and has a dense outer protein layer a middle layer of low density, and a dense inner layer hose remains tightly attached to centromeric DNA. During late prophase of cell division some microtubules become attacked with the kinetochores. Kinetochores attach the chromatids with the spindles and the microtubules provide force for chromosomal movement during cell division.

(ii) Nucleolar organizes in chromosomes : DNA in certain secondary constrictions contains genes which code for 18S and 28S ribosomal RNAs and induce the formation of nucleoli. These secondary constrictions act as nucleolar organizers. In man nucleolar organizers are located in the secondary constrictions of chromosomes 13, 14, 15, 21 and 22.

(iii) Telomere : The ends or the tips of the chromosomes are called telomeres. It has special properties. When chromosomes are broken, the broken ends become **'sticky'**, and fuse with other borken parts of chromosomes. In contrast the telomeric ends of chromosomes are stable. They do not fuse with any other parts of chromosomes.

Ultrastructure of telomere : The telomeric ends of DNA molecules contain many repetitions of 5 to 8 nucleotides. In man, the nucleotide sequence, TTAAGG, is repeated 250 to 1000 times. This sequence is common in all vertebrates and unicellular **Trypanosoma**. This guanine rich DNA strand of telomere remains single stranded. It forms a hair pin like fold. There is G=G pairing at the the tip of telomere.

☛ **Q.14. "Nucleosome model is better than Dupraw's folded fibre model of chromosome." Discuss it ?**

Ans. Nucleosome model is better than Dupraw's folded fiber model of chromosome.

The above fact can be proved by comparing the main points of the two models.

1. Both models consider that a chromosome contains a single large DNA molecule.
2. According to **Dupraw's model** the fibril folds both longitudinally and transversely during metaphase. He has not described any orderly packaging scheme.
3. According to **Dupraw's model** the DNA molecule is spirally packed in protein to form a **fibril**. There are no nucleosoines. The

nucleosome model states that the DNA is wrapped around the histone cores. This is a cytologically observed fact.

4. **Duparaw's model** is not supported by biochemical or cytological observations asn ahs been rejected.

Q.15. Write note on banding pattern in human chromosomes.

Ans.

Banding Technique

Many regions of individual chromosomes can be identified through recently developed bending techniques. These techniques were introduced by **Caspersons** *et al* (1968-71), **Arrighi** and **Hsu** (1971) and **Sumer** *et al* (1971). These techniques include staining the chromosomes with fluorescent dyes after many treatements. The staining gives different patterns of stained and unstained regions along the length of chromosome. The banding pattern of a particular chromosome remains constant for a particular treatment. The main banding patterns are known as Q, G, C, R, T, F and N banding patterns.

1. Q-Banding : The Q-bands are fluorescent bands on human chromosome if human chromosomes are stained with **quinacrine mustard (QM),** a fluorescent dye. The flurorescent bands are known as **Q-bands** and the intercalary non-fluorcescent dark bands are called **R-band** or **reverse bands.**

2. G-Banding : The G-bands appear if human chromosomes are stained with Giesma stain. With G-banding three major types of chromatin can be recognized – **euchromatin, centromeric** and **heterochromatin.**

3. C-Banding : If the human chromosomes are stained with **Giesma in highly alkaline medium,** the chromatids stain blue and centromeres appear magenta. Geisma stains the constitutive heterochromatin.

4. T-Banding : T-banding stains telomeres of chromosomes.

5. R-Banding : The R-bands are reverse of the Q and G-bands. These lie between the fluroescent Q bands. With acridine orange staining, R-bands appear as green, brightly fluorescent bands between Q or G-bands.

6. F-Banding : This technique uses the Feulgen stain (F-bands).

7. N-Banding : The N-bands are present in the satellite of chromosomes 13, 14, 15, 21 and 22. This stain stains the nucleolar region specifically.

Clinical importance : In case of a large number of chromosomal abnormalities like loss of a very small part, insertion of additional segment or addition of whole chromosome can be easily recognised by banding techniques e.g., Down's Syndrome, Cat's-Cry syndrome.

Q.16. Write note on difference between euchromatin and heterochromatin.

Ans.

Difference between Euchromatin and Heterochromatin

1. Chromatin makes up the nucleus. It is made up of DNA protein.
2. Chromatin has two forms : Euchromatin and heterochromatin.

3. When stained and observed under an optical microscope, euchromatins are the light-colored bands while heterochromatins are the dark-colored bands.
4. Darker staining indicates tighter DNA packaging. Heterochromatins thus have tighter DNA packaging than euchromatins.
5. Heterochromatins are compactly coiled regions while euchromatins are loosely coiled regions.
6. Euchromatin contains less DNA while heterochromatin contains more DNA.
7. Euchromatin is early replicative while heterochromatin is late replicative.
8. Euchromatin is found in eukaryotes, cells with nuclei and prokaryotes, cells without nuclei.
9. Heterochromatin is only found in eukaryotes.
10. The functions of euchromatin and heterochromatin are gene expression, gene repression and DNA transcription.

☛ **Q.17.Write short note on cytosol.**

Ans.

Cytosol

The cytosol or intracellular fluid (ICF) or cytoplasmic matrix is the liquid found inside cells. It is separated into compartments by membranes. For example, the mitochondrial matrix separates the mitochondrion into compartments.

In the eukaryotic cell, the cytosol is within the cell membrane and is part of the cytoplasm, which also comprises the mitochondria, plastids and other organelles (but not their internal fluids and structures); the cell nucleus is separate. In prokaryotes, most of the chemical reactions of metabolism take place in the cytosol, while a few take place in membranes or in the periplasmic space. In eukaryotes, while many metabolic pathways still occur in the cytosol, others are contained within organelles.

The cytosol is a complex mixture of substances dissolved in water. Although water forms the large majority of the cytosol, its structure and properties within cells is not well understood. The concentrations of ions such as sodium and potassium are different in the cytosol than in the extracellular fluid; these differences in ion levels are important in processes such as osmoregulation and cell signaling. The cytosol also contains large amounts of macromolecules, which can alter how molecules behave, through macromolecular crowding.

Although once thought to be a simple solution of molecules, multiple levels of organization exist in the cytosol. These include concentration gradients of small molecules such as calcium, large complexes of enzymes that act together to carry out metabolic pathways and protein complexes such as proteasomes and carboxysomes that enclose and separate parts of the cytosol.