Course - M.Sc. Botany, Part-II Paper-VII

Topic-Gaint Chromosomes (Cell Biology)

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Giant chromosome are large chromosome which have thousands of DNA strands. There are two types – Lambrush chromosome and polytene chromosomes

Lambrush Chromosomes

Lambrush chromosomes were first discovered by Flemming in 1882 on amphibian oocytes. IT has is a special type of chromosome it is big in size this is the reason it is known as giant chromosome. A detailed study of the lambrush chromosomes was made by J. Ruckert in 1892 on the oocyte of the shark.

Lambrush chromosomes occure at the diplotene of meiotic prophase in oocytes of all are not as large as those of animal species and which produce a lot of RNA. However, the lambrush chromosomes of invertebrates are not as large as those of vertebrates, but they have the characteristic hairy appearance. The lambrush chromosomes have also been reported in plants

In many animals lambrush chromosome may be more than 1000µ in length and 20 µ in width during early prophase I. In some salamander oocytes the lambrush chromosomes may reach a length of 5900 µ.However, towards the end of prophase I (diakinesis) try, the chromosomes contract and are greatly reduced in size .they may contract still further during metaphase I. Lambrush chromosomes are very elastic and can be stretched up to about two times before they break.

Structure: Lambrush chromosomes have many fine lateral projections , giving them the characteristic "hairy" appearance .They are best visualized in salamander oocytes because they have a high DNA content and therefore very large chromosomes.

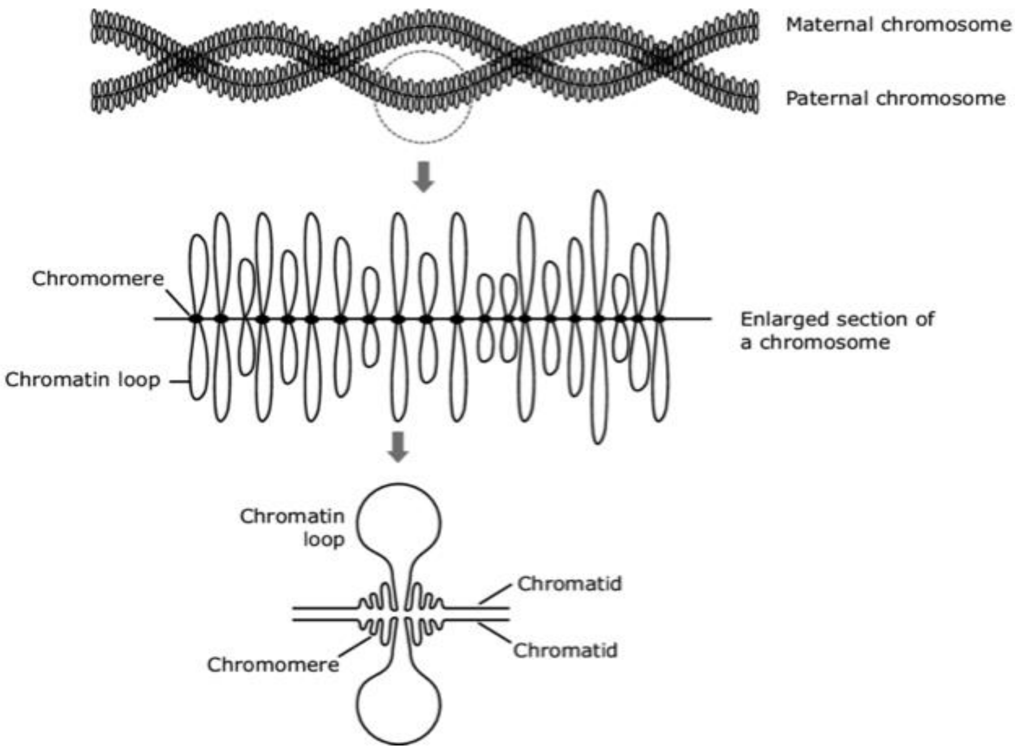
Lambrush chromosomes of tailed and tailless amphibians, birds and insects are described best of all. Chromosomes transform into the lambrush form during the diplotene stage of meiotic prophase I due to an active transcription of many genes. They are highly extended meiotic half-bivalents, each consisting of 2 sister chromatids. Lambrush chromosomes are clearly visible even in the light microscope, where they are seen to be organized into a series of chromomeres with large chromatin loops extended laterally. Amphibian and avian lambrush chromosomes can be micro surgically isolated from oocyte nucleus (germinal vesicle) with either forceps or needles.

Each lateral loop contains one or several transcription units with polarized RNP-matrix coating the DNA axis of the loop.

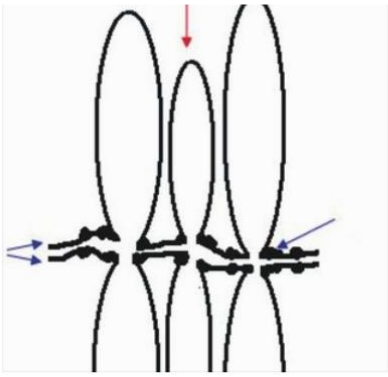
Chromosomal axis: Each chromosome consists of two chromatids which are represented by axil filament. Thus, a pair of homologous chromosomes has four filaments in all. The loops represent lateral extension of the axial filaments .at the end of the axil filaments are small swelling without loops .These are telomere. It also contains region called centromere, which is loop free.

Chromomeres: At certain point along with their length the axial filaments become tightly coild .These point are called chromomeres. The chromomeres are found in pairs, one chromomere for each filament. They correspond to hetrochromatin.

Loops: Loops are of two main type – typical and special. Most of the loops are typical .Each typical loop consists of a central axis from which are given off RNA fibrils of progressively increasing lengths. This makes the loop markedly thicker on one side .The special loops have a marked asymmetry and have granules at the end of the fibrils.

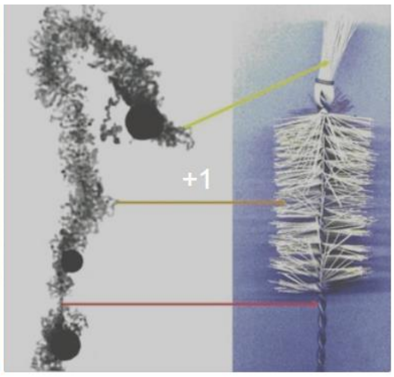


Lambrush chromosome



Schematic (a) and detailed (b) lampbrush chromosome structure (Katarzyna Andraszek)

The second goose lampbrush chromosome with a magnification of its distinctive structures. A 2…



A lampbrush chromosome and the " original item " . The arrows indicate analogous structures; a…

Function

Giant chromosomes in the lambrush form are useful model for studying chromosome organization, genome function and gene expression during meiotic prophase, since they allow the individual transcription units to be visualized. Moreover, lambrush chromosomes are widely used for high-resolution mapping of DNA sequences and construction of detail cytological maps of individual chromosomes.

A hypothesis about lambrush chromosome function is proposed which takes into account several aspects of their morphology and behaviour. It is suggested that in lambrush loops, alterations of the deoxyribonucleo protein fibre take place which reprogram the chromosome for development. Such reprogramming could involve exchange or enzymatic modification of regulatory molecules (i.e., non-histone proteins). Since inhibition of RNA synthesis causes the loops to collapse, it is possible that transcription largely occurs to generate and maintain the loop, allowing the DNP fibre to “enter” the nucleoplasm. Lambrush chromosomes are also involved in the production of “masked” mRNAs for early development. The giant granular loops could either be the sites where such mRNAs are packaged or they could be sites where specific alterations of the deoxyribonucleo protein fibre take place.

Lampbrush chromosomes in cytogenetics and genomics

Lampbrush chromosomes of various species have a very similar structure and perform the same function. Comparative studies of LBCs in various species have shown that the side loops seem to be much longer in species with higher C-values (genome size refers to the haploid set of chromosomes). This regularity explicitly reflects differences in the organisation of genome sequences. One explanation of the effect of genome size on the loop length is based on the existence of substantial differences in the length and distribution of transcribed sequences in relation to chromomere sequences in variously sized genomes (Macgregor, 1980; Gregory, 2002). Another theory suggests that the total increase in the length of loop transcription units' results from so called "over-transcription" of longer intergenic segments present in larger genomes.

Polytene Chromosome

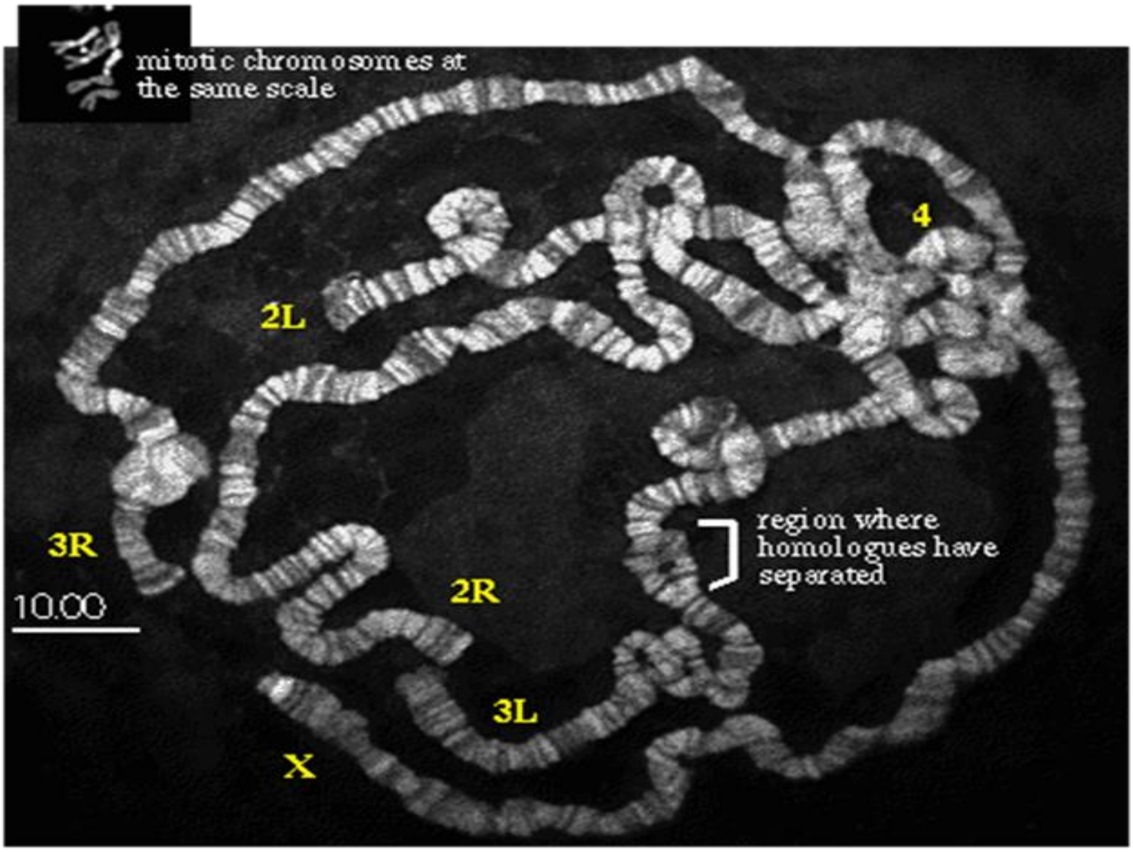
Polytene chromosomes, normally chromosomes are not visible during interphase. It was first observed by Balblni (1881) in the salivary gland of the midge Chironomous and hence are called salivary gland chromosomes.

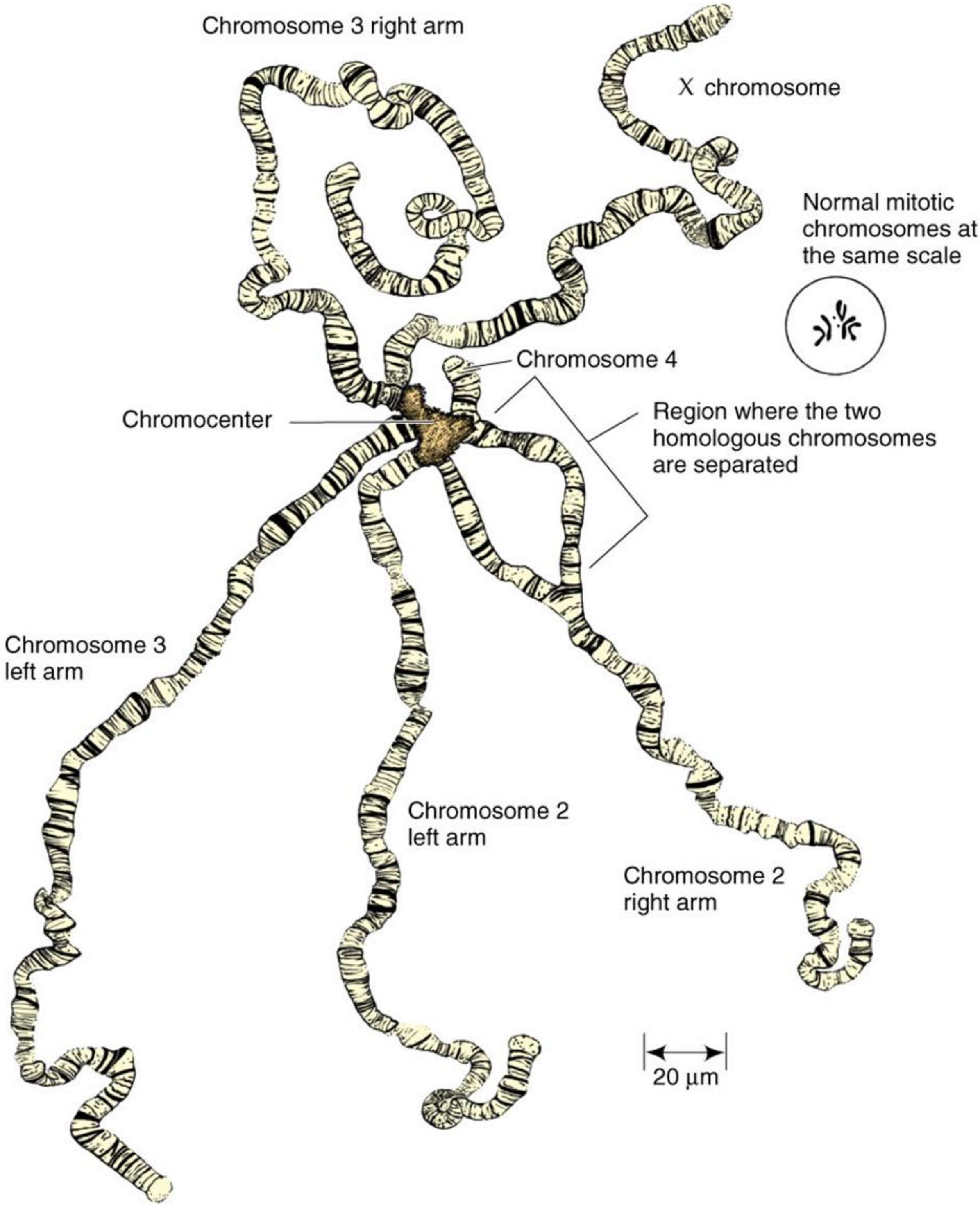
Polytene chromosomes, also known as giant chromosomes, are unusual chromosomes. They were discovered to be located in the nuclei of cells in the salivary gland, in third instar larvae, of two-winged (dipteran) flies and other specific tissues in Diptera. These special chromosomes are found in the two-winged (dipteran) fruit fly (Drosophila).

Polytene chromosomes are formed by the repeated replication of homologous chromosomes, in which the replicated individual sister chromatid strands do not separate. Polytene chromosomes is formed by approximately 1000 to 4000 unit chromatids (chromonemata). Each unit chromatid consist of a single identical DNA molecules associated with protein. The DNA fibres are continuous from one end of the chromosome to the other. They are tightly folded in the band and relatively extended in the inter bands. Which are all perfectly aligned laterally within the structure. Found to be formed in the "terminal cells" of the larva, these Polytene structures are abnormal chromosomes. These terminal cells are removed when the dipteran move into the next stage of their life cycle: the formation of the pupa. The terminal cells cannot divide and hence, they are eliminated.

Chromosome puffs: The bands of polytene chromosomes become enlarged at certain times to form swelling which are called chromosomes puffs or Balbiani rings. According to Beerman and Bahr (1954), chromosome puffs are region where the tightly coiled chromosomal fibres open out to form many loops. Thus, puffing is due to unfolding or uncoiling of individual chromosomes in a band. The puffs are active genes and represent sites of RNA synthesis

The polytene chromosomes have been proven very useful in developing cytological study. These cytological study are in-depth and very detailed. They are produced when the chromosomes are stained and viewed under a light microscope, making visible alternating dark bands and light inter bands. The dark bands are due to the side-by-side arrangement of tightly folded regions of chromatin strands. These are often seen in mitotic and meiotic chromosomes as chromomeres. The light bands are known as the inter bands or euchromatin and more DNA is found within the bands rather than in the inter bands and dark band is known as hetrochromatin.





Polytene chromosomes in *Drosophila* (2n = 4)

Function:

Polytene chromosomes increasing the volume of the cells's nuclei and causing cell expansion, It is also have a metabolic advantage as multiple copies of genes permits a high level of gene expression. In Drosophila melanogaster, for example, the chromosomes of the larval salivary glands undergo many rounds of endoduplication to produce large quantities of adhesive mucoprotein before pupation. Another example within the fly itself is the tandem duplication of various polytene bands located near the centromere of the X chromosome which results in the Bar phenotype of kidney-shaped eyes.

The interbands are involved in the interaction with the active chromatin proteins, nucleosome remodeling, and origin recognition complexes. Their primary functions are: to act as binding sites for RNA pol II, to initiate replication and, to start nucleosome remodeling of short fragments of DNA.