GIANT CHROMOSOMES

The following points highlights the five special types of chromosomes. The types are: 1. Polytene Chromosome or Giant Chromosome 2. B-Chromosome or Supernumerary Chromosome 3. Chimaera 4. SAT-Chromosome.

Special Types of Chromosomes:

Chromosomes which significantly differ in structure and function from normal chromosomes are known as special chromosomes. Special chromosomes include lampbrush chromosome, polytene chromosome and B chromosome.

i. Lampbrush Chromosome:

These are special types of chromosomes in which large number of loops are projected out from the chromatin axis giving a lampbrush appearance. Such chromosomes are called lampbrush chromosomes. They are found in oocyte nuclei of both vertebrates and invertebrates and spermatocyte nuclei of Drosophila during diplotene stage. These chromosomes have three main features.

a. Extra Ordinary Length:

Lampbrush chromosomes have remarkable length. They are sometimes larger than polytene chromosomes. The length has been recorded up to 1 mm in urodele amphibian.

b. Large Number of Loops:

Lampbrush chromosomes have large number of loops. Loops are projected in pair from the chromomere (Fig. 4.3). One to nine loops may arise from a single chromomere. The chromomere are connected by inter- chromomere fibres.

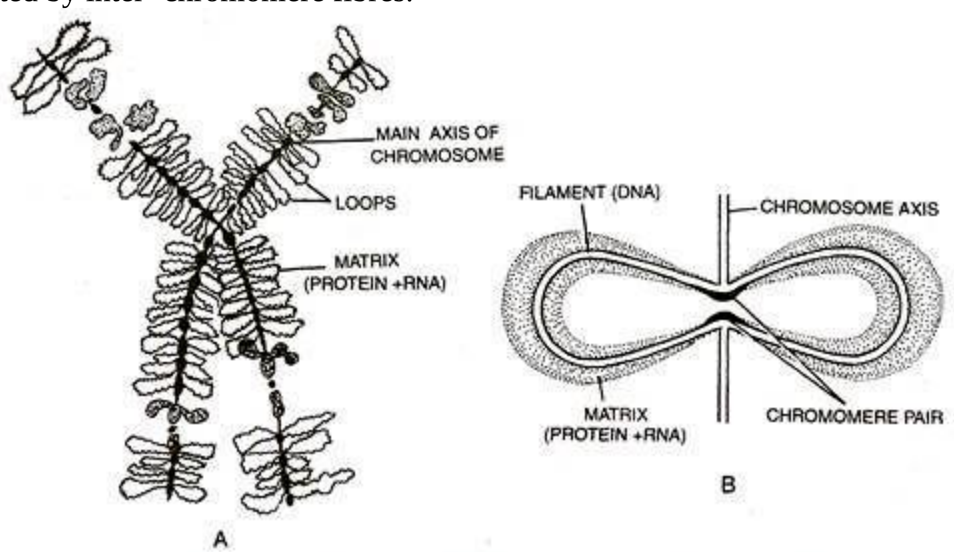

Fig. 8.58. Lampbrush chromosome . A, Enlarged view of a part of lampbrush chromosome. B, One loop of a lampbrush chromosome.

c. Lamp-Brush Appearance:

Projection of large number of pairs of loops from chromomeres leads to lampbrush appearance. The loops increase gradually in numbers, reach maximum in diplotene and gradually decline after diplotene and ultimately disappear.

In diplotene stage, lampbrush chromosomes consist of two homologous chromosomes which are in contact only at certain points, called chiasmata. Each chromosome of the pair consists of two chromatids which lie together and form the chromosome axis or main axis.

The axis is differentiated into chromomeres (dark colour) and loops (light colour). Loops are formed on both sides of chromosomal axis. Each chromatid has one chromomere. The chromosomal axis, the chromomere and the loop axis all are made up of DNA and have hereditary function or are considered regions of genetic activity.

ii. Polytene or Giant Chromosomes:

The multiple replicates of the same chromosome holding together in a parallel fashion resulting in very thick chromosome are known as polytene chromosomes and such condition is referred to as polyteny. They were first reported by Balbiani (1881) in salivary glands of dipteran insects.

Later on they were reported in salivary glands of Drosophila and several other insects. Since these chromosomes are generally found in salivary gland, they are also known as salivary gland chromosomes.

These chromosomes have three main features as given below:

a. Bands:

The strips which are found in these chromosomes are known as bands. Some of the bands are visible in a swollen or expanded form which is known as puffs (Fig 4.4). When a puff becomes very much enlarged it is called a Balbiani ring.

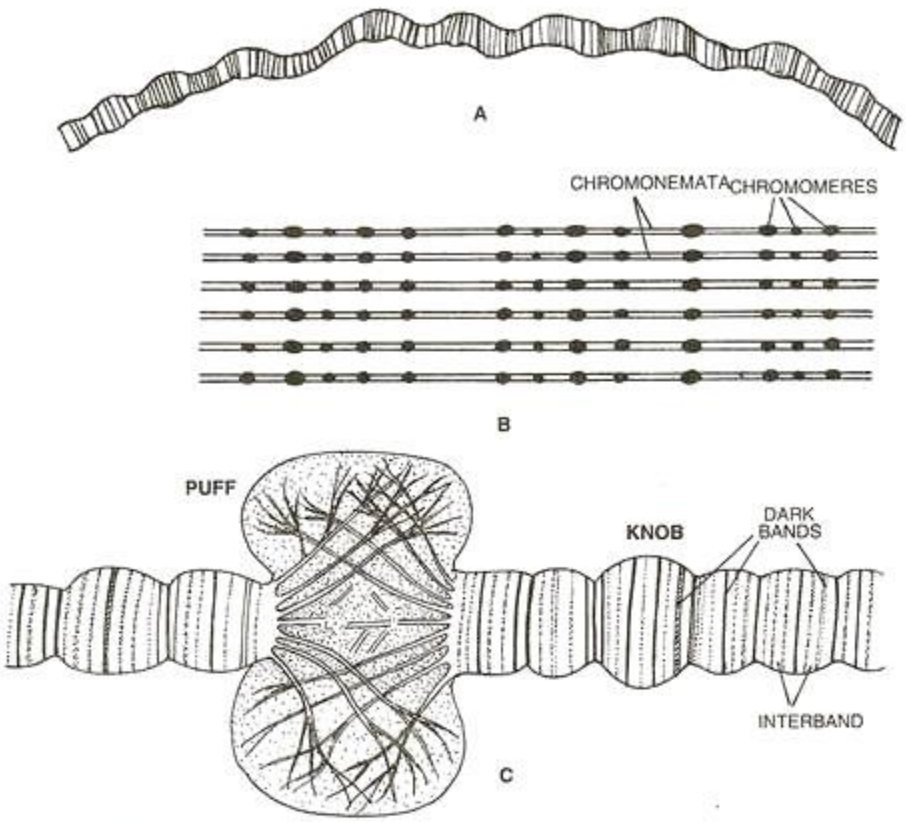

Fig. 8.57. Polytene chromosome. A, a typical polytene chromosome. B, schematic representation of formation of a polytene chromosome and its dark bands by coming together of a number of chromonemata and their chromomeres. C, an enlarged portion of polytene chromosome showing a puff.

b. Puffs:

The swollen regions are known as chromosome puffs or Balbiani rings. The puffs are reversible and considered as regions of genetic activity. Recently it has been found in Drosophila that each band contains the genetic material of a single gene.

Origin of Puffs:

Puffs originate from single band and are involved in RNA synthesis. The process of puff formation at different sites of polytene chromosomes is referred to as puffing. The first sign of puffing is the accumulation of an acidic protein at the pre-puff site followed by an increase in the rate of RNA synthesis at that site.

There is a characteristic puffing in different tissues and at different time during larval development. The presence of a specific puff is related with the appearance of a specific protein, for example, salivary proteins were found to be associated with a particular puff.

Significance of Puffs:

The puffs represent sites of DNA synthesis, i.e., gene transcription. Transcription also occurs in the bands, but to a very small extent. The accumulation of ribonucleo protein has been demonstrated in the region of puff. Inhibitors of transcription such as actinomycin D and alpha aminitin prevent puff formation and lead to some amount of reduction of existing puffs.

There is an increase in puffing during those stages of larval development when moulting hormone ecdysone is released from the prothorasic gland. This has also been shown experimentally by injection of ecdysone into fourth instar larvae which responds by increased formation of puffs.

c. Giant Size:

Polytene chromosomes have giant size. The size may be observed up to 200 times or more than the normal chromosomes. Because of their giant size, they are also referred to as giant chromosomes. These chromosomes are somatically paired and their number in the salivary gland cells always appears to be half of the normal somatic cells.

Now these chromosomes have also been reported in malpighian tubes, larval fat bodies, debte gut epithelia, etc. These chromosomes can be easily studied in the salivary gland of Drosophila. For this purpose, the salivary glands are dissected out from third instar larvae and squashed in aceto-carmine. The slides can be viewed under light microscope.

1. Functions of Lampbrush chromosomes,

(a) Synthesis of RNA:

Functions of lampbrush chromosomes involve synthesis of RNA and protein by their loops. RNA is synthesized only at the thin insertion and then carried around the loops to the thick insertion. There it may be either destroyed or released into nucleus.

(b) Formation of yolk material:

There are some probabilities that lampbrush chromosomes help in the formation of certain amount of yolk material for the egg.

II Polytene chromosomes:

These are also giant chromosomes but relatively smaller than lampbrush chromosomes, found in the larvae of certain dipterans. Such banded chromosomes occur in the larval salivary glands, midgut epithelium, and rectum and Malpighian tubules of various genera (Drosophila, Sciara, Rhynchosciara, and Chironomus). In these larvae the salivary glands contain salivary cells so large in size that they can easily be seen with the lens power of a dissecting microscope.

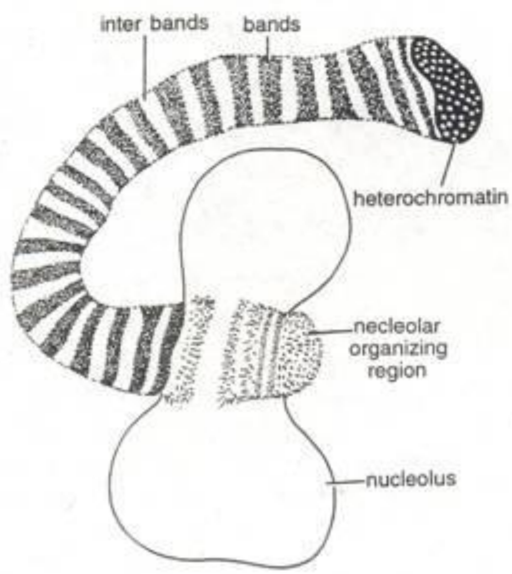

Fig. 12. Structure of a polytene chromosome of *Cecidomyia serotinae* showing nucleolar part.

Nuclei of these cells are much larger than those of ordinary cells being generally about 25µ in diameter, and chromosomes in nuclei are so large that they are 50 to 200 times as large as chromosomes in other body cells of the organism.

They were first observed in 1881 by E.G. Balbiani in Chironomus and were studied by Korschelt (1884) and Corney (1884). Heitz and Bauer in 1933 studied these giant chromosomes in Bibio hortulanus larvae, while Painter (1933) described them in salivary glands of Drosophila.

Because of their large size showing numerous strands these are named as polytene chromosomes (name suggested by Kollar) or commonly salivary gland chromosomes. The latter term is a misnomer as these chromosomes may occur in other somatic cells of body besides salivary gland cells.

Polytene Function

(1) Main function of the polytene chromosome is to carry genes which ultimately control physiology of an organism. These genes are formed of DNA molecules.

(2) Shifting of heterochromatin in respect to euchromatin produces giant changes called position effects. These effects cause mutations in animals as well.

(3) Heterochromatic regions contain fewer genes than euchromatic parts. Production of nucleolar material is entirely done by heterochromatin.

(4) Chromosomes also help in protein synthesis indirectly. Nucleolus contains RNA, and this RNA serves as a means of transmission of genetic information to the cytoplasm, leading to the formation of specific protein.