MSc I Sem – Life Sciences

Course – Cell Biology

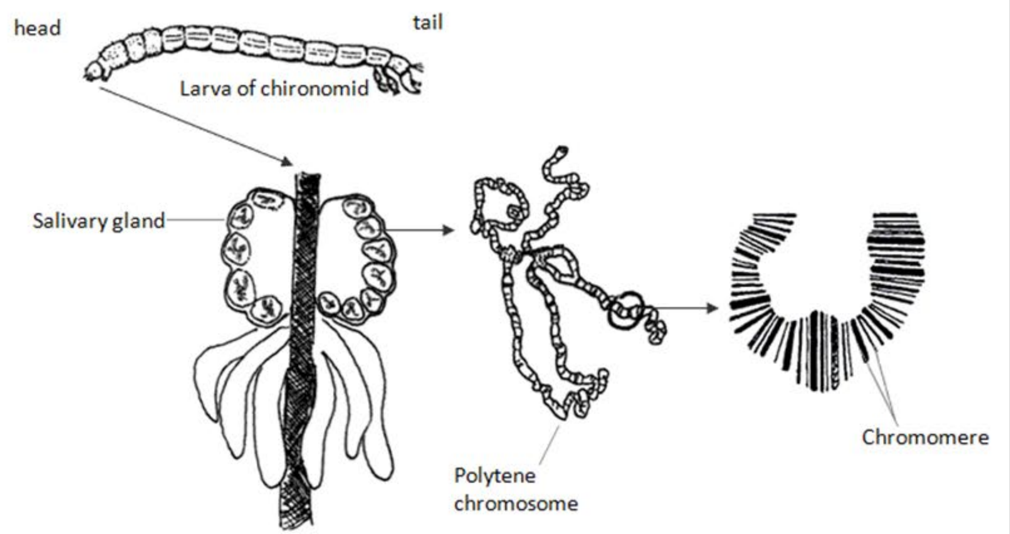
Structural Variations in Chromosomes
Or
Special Types of Chromosomes

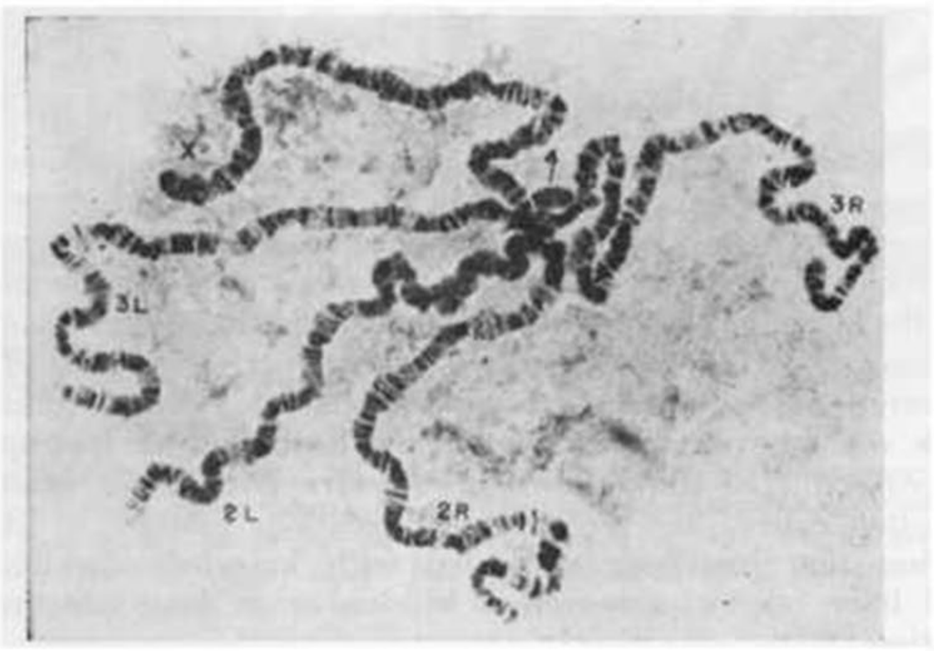
Special Types of Chromosomes

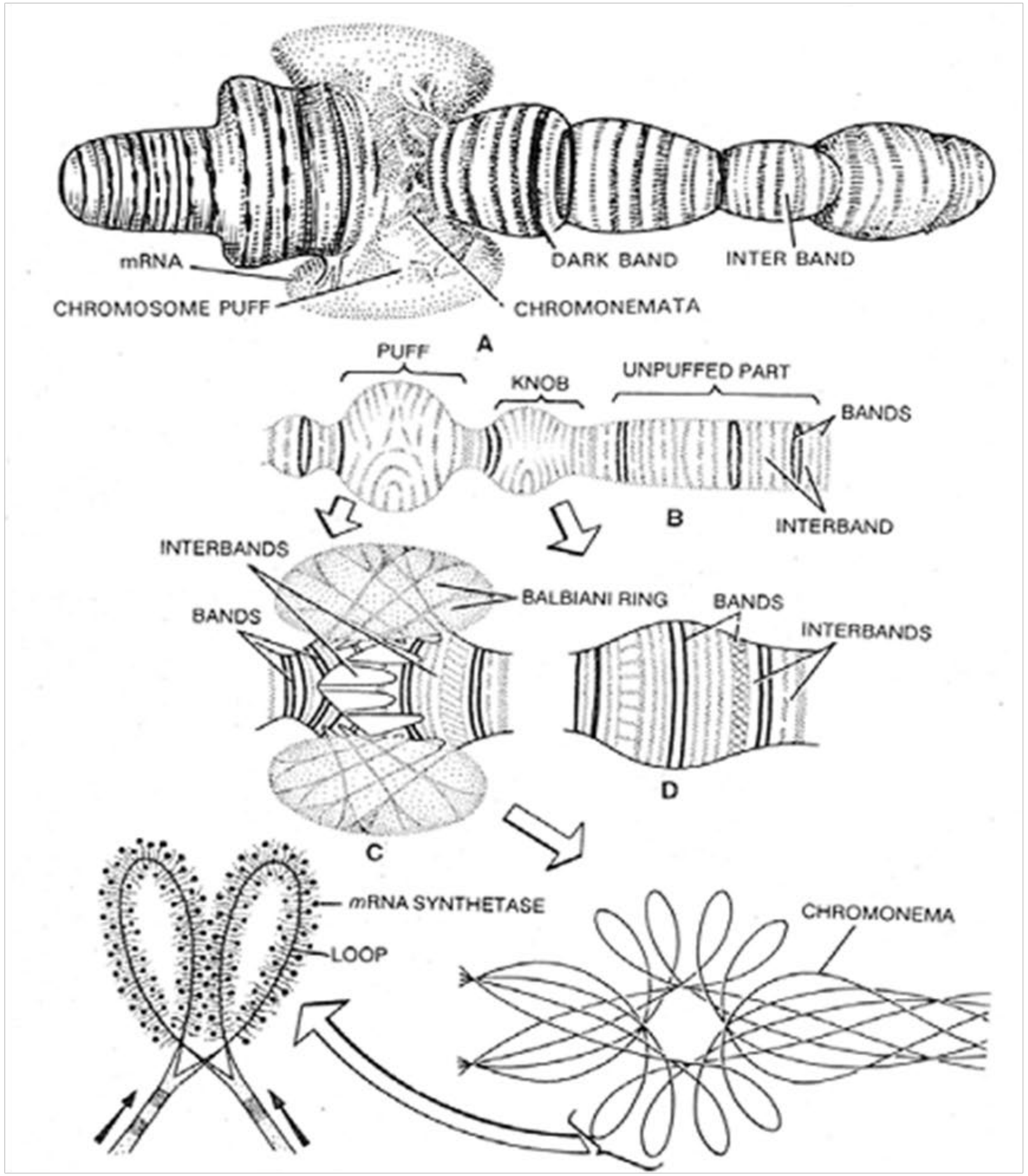
- Special with respect to shape, size and number.
- Chromosomal organization may differ.
- **Salivary gland chromosome -** Polytene chromosomes –insects and others
- **Lampbrush chromosomes** – insects and others
- Very large sized and can be visualized by light microscopy.

- **B chromosome** – super-numeric and smaller
- **L, S and E chromosome** – multiple, smaller, variable

Polytene chromosome or Salivary Gland or Giant Chromosome







- **Polytene chromosomes** are large chromosomes which have thousands of DNA strands.
- They provide a high level of function in certain tissues such as salivary glands of insects.
- Polytene chromosomes were first reported by E.G. Balbiani in 1881.
- Polytene chromosomes are found in dipteran flies: the best understood are those of *Drosophila*, *Chironomus* and *Rhynchosciara*.
- They are present in another group of arthropods of the class Collembola, a protozoan group Ciliophora, mammalian trophoblasts and antipodal, and suspensor cells in plants. In insects, they are commonly found in the salivary glands when the cells are not dividing.
- They are produced when repeated rounds of DNA replication (**endoreduplication**) without cell division forms a giant chromosome. Thus polytene chromosomes form when multiple rounds of replication produce many sister chromatids *which stay fused together*.
- Polytene chromosomes, at interphase, are seen to have distinct thick and thin banding patterns. These patterns were originally used to help map chromosomes, identify small chromosome mutations, and in taxonomic identification. They are now used to study the function of genes in transcription.

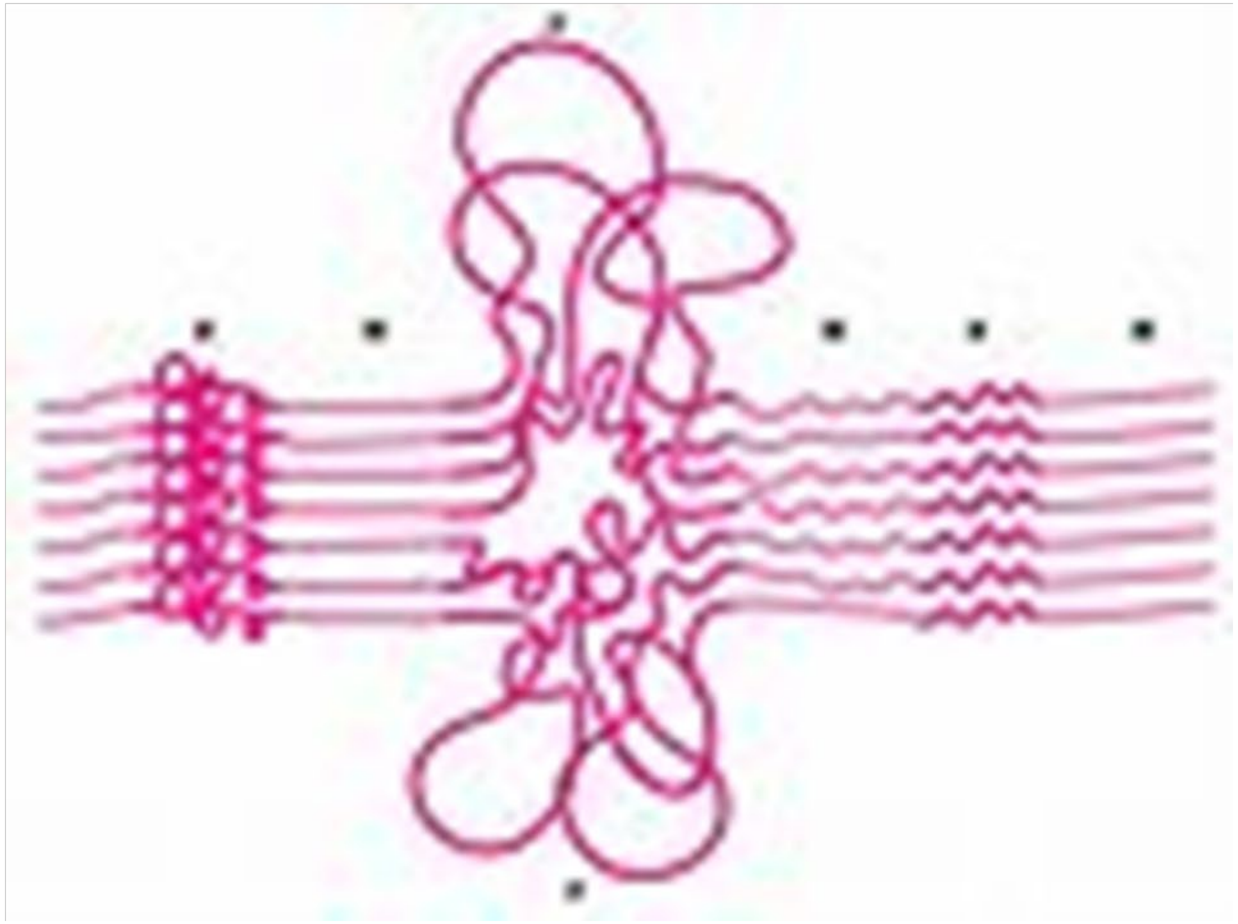
Function of Polytene Chromosomes

- In addition to increasing the volume of the cells' nuclei and causing cell expansion, polytene cells may also have a metabolic advantage as multiple copies of genes permits a high level of gene expression.
- In *Drosophila melanogaster*, the chromosomes of the larval salivary glands undergo many rounds of endoreduplication to produce large quantities of adhesive mucoprotein ("glue") 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.

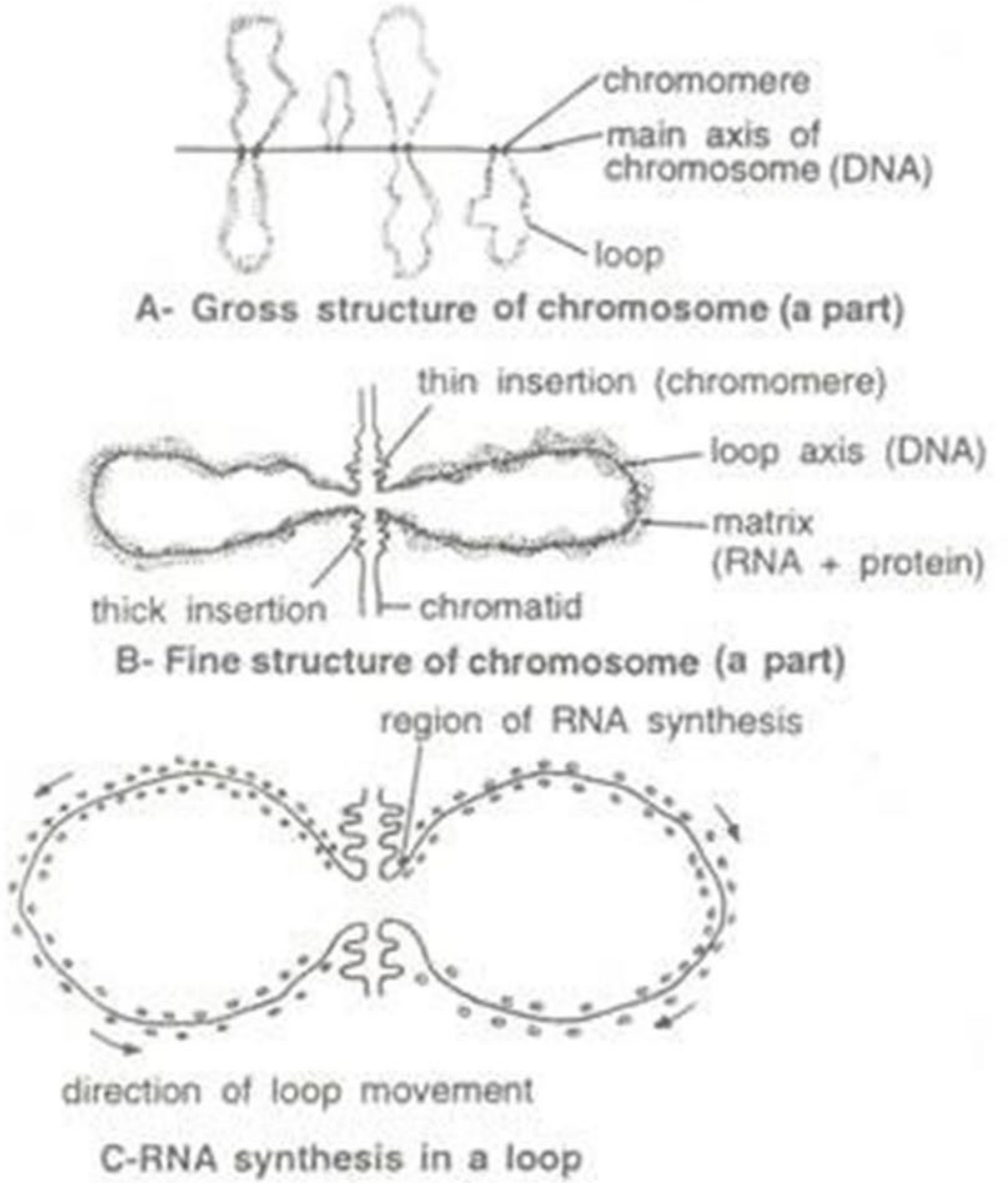
Structure of Polytene Chromosomes

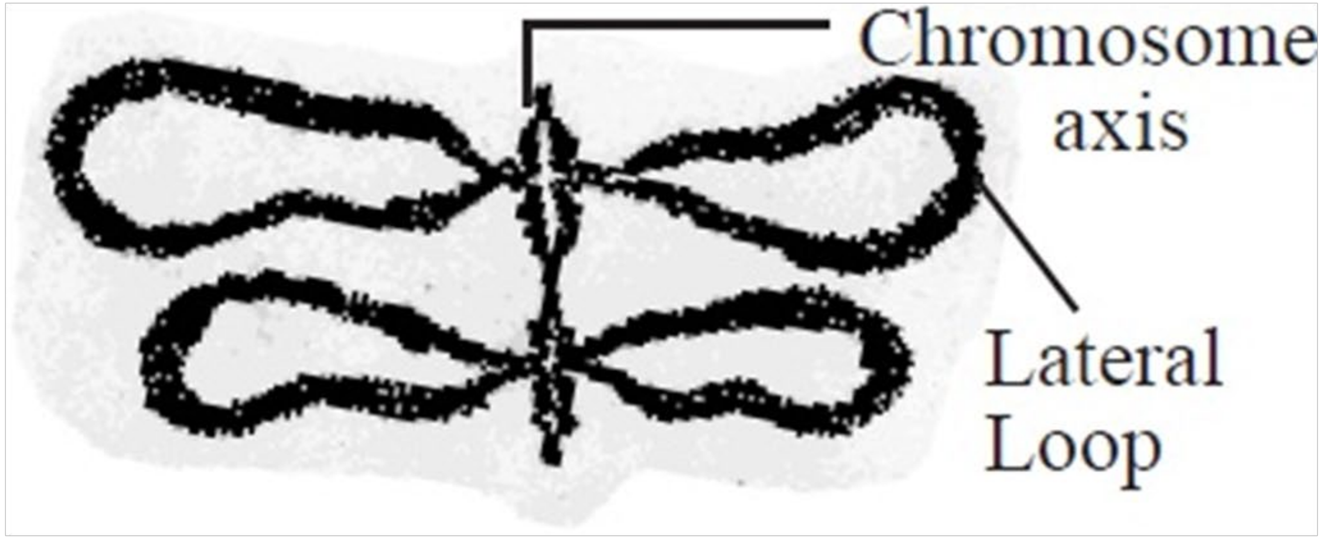
- In insects, polytene chromosomes or salivary glands chromosomes are large sized due to the presence of many longitudinal strands called chromonemata; hence the name polytene (many stranded).
- They are about 0.5 mm in length and 20 µm in diameter.
- The chromosomal strands are formed after repeated division of the chromosome in the absence of cytoplasmic division. This type of division is called endomitosis.
- The polytene chromosome contains two types of bands, dark bands and interbands. The dark bands are darkly stained and the inter bands are lightly stained with nuclear stains. The dark bands contain more DNA and less RNA. The interbands contain more RNA and less DNA. The amount of DNA in interbands ranges from 0.8 - 25%.
- The bands of polytene chromosomes become enlarged at certain times to form swellings called puffs. The formation of puffs is called puffing. In the regions of puffs, the chromonemata uncoil and open out to form many loops. The puffing is caused by the uncoiling of individual chromomeres in a band. The puffs indicate the site of active genes where mRNA synthesis takes place. The chromonemata of puffs give out a series of many loops laterally. As these loops appear as rings, they are called **Balbiani rings** after the name of the researcher who discovered them. They are formed of DNA, RNA and a few proteins. As they are the site of transcription, transcription mechanisms such as RNA polymerase and ribonucleoproteins are present.

Polytene Puff



Lampbrush Chromosomes



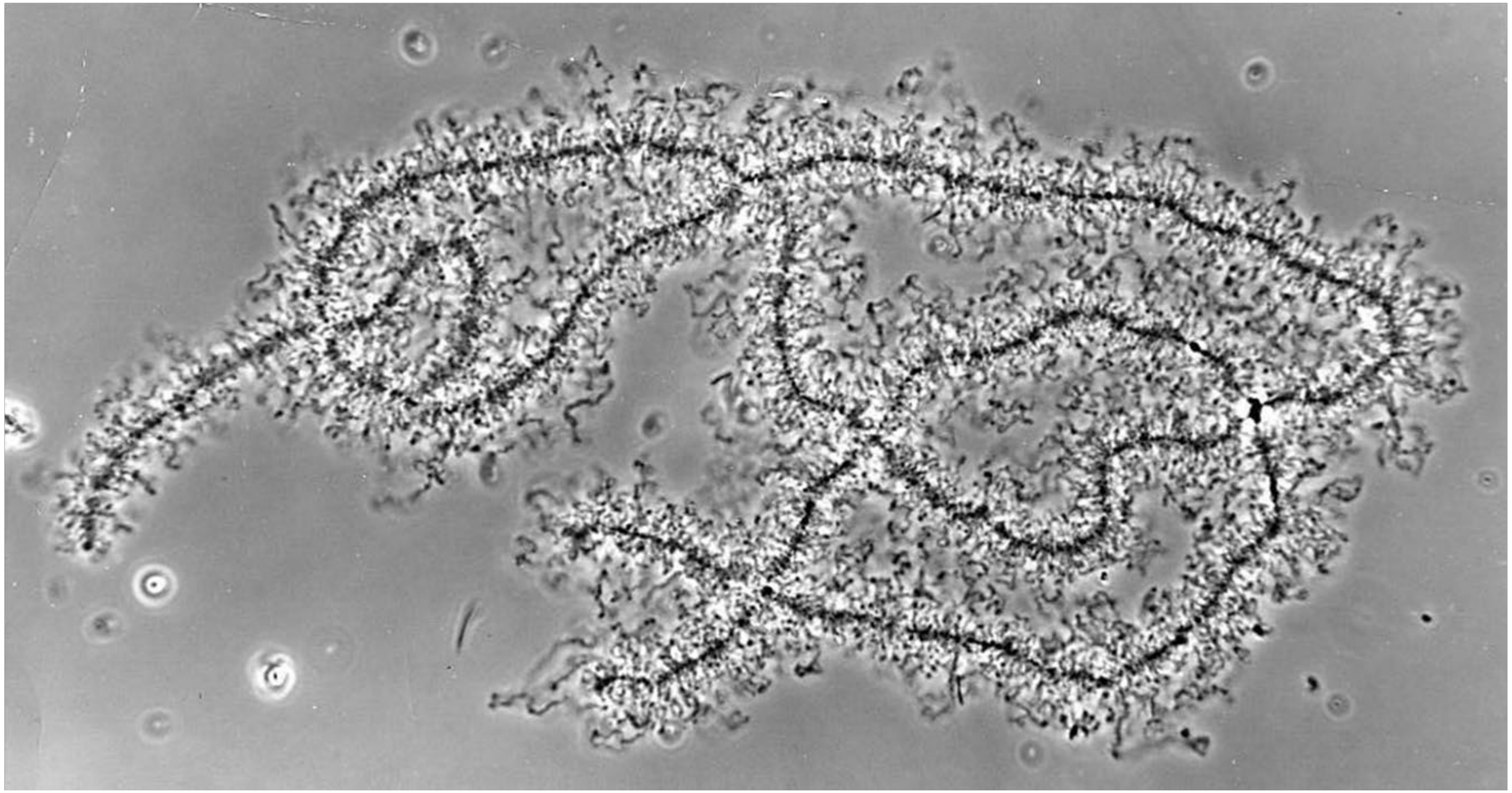


Lampbrush chromosome are found in immature eggs of most animals, except mammals.

- **Lampbrush chromosome** were first described by Walther Flemming in 1882.
- They are found in tailed and tailless amphibians, birds and insects.
- Chromosomes transform into the lampbrush 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. Lampbrush 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 lampbrush chromosomes can be microsurgically 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.
- Giant chromosomes in the lampbrush 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, lampbrush chromosomes are widely used for high-resolution mapping of DNA sequences and construction of detail cytological maps of chromosomes.

Structure of Lampbrush Chromosomes

- They are composed of a center strand (two strands of DNA) with lateral loops (one strand of DNA).
- The lateral loops are transcriptionally active.



Lampbrush chromosomes (LBCs) are transcriptionally active chromosomes found in the germinal vesicle (GV) of large oocytes of many vertebrate and invertebrate animals and also in the giant single-celled alga *Acetabularia*. These cells are all in prophase of the first meiotic division. Nevertheless, many meiotic cells do not develop LBCs, arguing that LBCs are not an essential feature of meiosis. LBCs probably represent the most active transcriptional state that can be attained by cells that must give rise to diploid progeny. Polyploidy permits cells to reach higher rates of transcription per nucleus but precludes a return to diploidy. In this sense LBCs represent a relatively *inefficient* transcriptional compromise employed by large meiotic cells. These considerations help to explain why transcriptionally active GVs develop LBCs, but they do not explain why LBCs have never been seen in somatic cells, diploid or otherwise. If LBCs are truly limited to germ cells, then some of their unusual features may reflect reprogramming of the genome. If this is the case, LBCs provide unique opportunities to study reprogramming at the level of the individual transcription unit.