Model Answer

B Sc I sem. Examination 2014

LZC-102: Cell biology

Section A

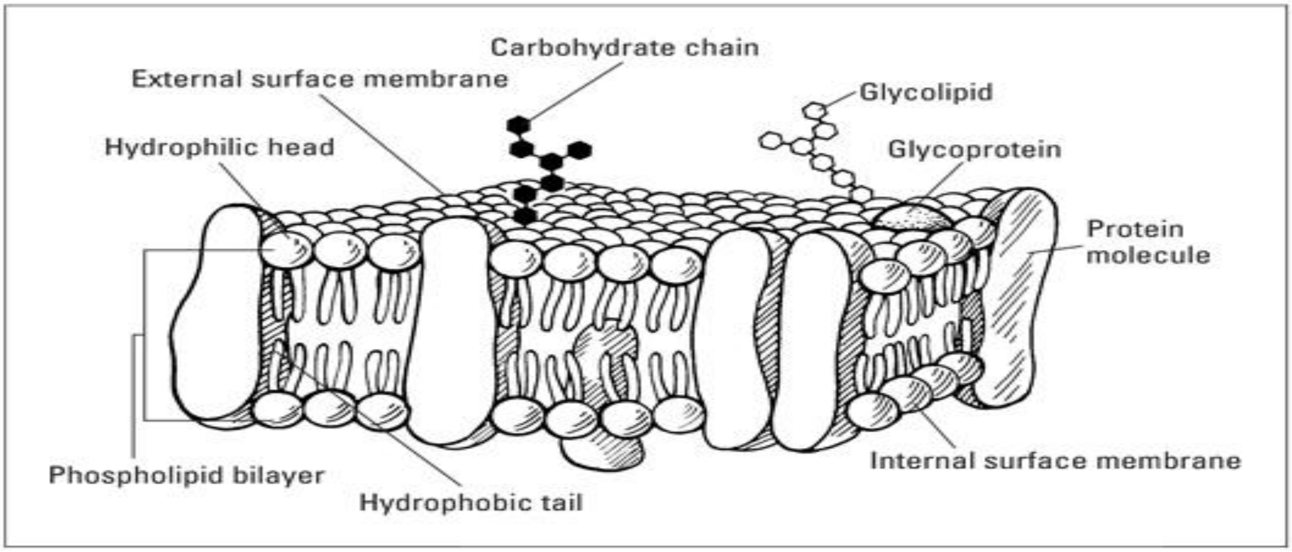
i)	**a**	**ii)**	**a**
iii)	**b**	**iv)**	**a**
v)	**b**	**vi)**	**b**
vii)	**c**	**viii)**	**a**
ix)	**b**	**x)**	**b**

Answer No. 1: Fluid-Mosaic Model of the Cell Plasma Membrane

Plasma membrane can be defined as a biological membrane or an outer membrane of a cell, which is composed of two layers of phospholipids and embedded with proteins. It is a thin semi permeable membrane layer, which surrounds the cytoplasm and other constituents of the cell. The biological membrane, which is present in both eukaryotic and prokaryotic cell. It is also called as cell membrane as it is works as a barrier between the inner and outer surface of a cell. In animal cells, the plasma membrane is present in the outer most layer of the cell and in plant cell it is present just beneath the cell wall.. The plasma membrane that surrounds these cells has two layers (a bilayer) of phospholipids (fats with phosphorous attached), which at body temperature are like oil (fluid).

Each phospholipid molecule has a head that is attracted to water (hydrophilic: hydro = water; philic = loving) and a tail that repels water (hydrophobic: hydro = water; phobic = fearing). Both layers of the plasma membrane have the hydrophilic heads pointing toward the outside; the hydrophobic tails form the inside of the bilayer.

Because cells reside in a watery solution (extracellular fluid), and they contain a watery solution inside of them (cytoplasm), the plasma membrane forms a circle around each cell so that the water-loving heads are in contact with the fluid, and the water-fearing tails are protected on the inside.



Function of Plasma Membrane

1. It separates the contents of the cell from its outside environment and it regulates what enters and exits the cell.
2. Plasma membrane plays a vital role in protecting the integrity of the interior of the cell by allowing only selected substances into the cell and keeping other substances out.
3. It also serves as a base of attachment for the cytoskeleton in some organisms and the cell wall in others. Thus the cell membrane supports the cell and helps in maintaining the shape of the cell.
4. The cell membrane is primarily composed of proteins and lipids. While lipids help to give membranes their flexibility and proteins monitor and maintain the cell's chemical climate and assist in the transfer of molecules across the membrane.
5. The lipid bilayer is semi-permeable, which allows only selected molecules to diffuse across the membrane.

Answer No. 2: Spindle apparatus refers to the subcellular structure that segregates chromosomes between daughter cells duringcell division. It is also referred to as the mitotic spindle during mitosis or the meiotic spindle during meiosis

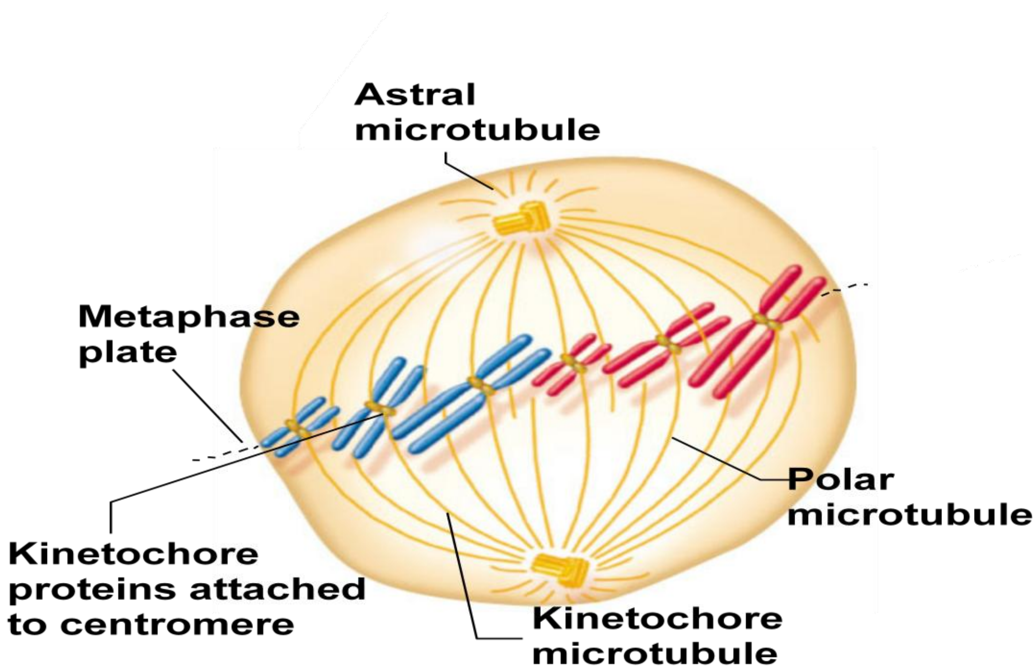
While the spindle apparatus is composed of hundreds upon hundreds of proteins, the fundamental machinery are the spindlemicrotubules. Attachment of microtubules to chromosomes is mediated by kinetochores, which actively monitor spindle formation and prevent premature anaphase onset. Microtubule polymerization and depolymerization dynamics drive chromosome congression. Depolymerization of microtubules generates tension at kinetochores, bipolar attachment of sister kinetochores to microtubules emanating from opposite cell poles couples opposing tension forces, aligning chromosomes at the cell equator and poising them for segregation to daughter cells. Once every chromosome is bi-oriented, anaphase commences and cohesin, which couples sister chromatids, is severed, permitting the transit of the sister chromatids to opposite poles.

The cellular spindle apparatus includes the spindle microtubules, associated proteins, and any centrosomesor asters present at the spindle poles.[3] The spindle apparatus is vaguely ellipsoid in cross section and tapers at the ends. In the wide middle portion, known as the spindle midzone, antiparallel microtubules are bundled by kinesins.

Composed of microtubules originated from centrioles .Microtubules are formed polymerization of tubulin proteins

3 types of spindle microtubules

- Aster microtubules
  - Important for positioning of the spindle apparatus
- Polar microtubules
  - Help to "push" the poles away from each other
- Kinetochore microtubules
  - Attach to kinetochore , at the centromere



Answer No. 3:

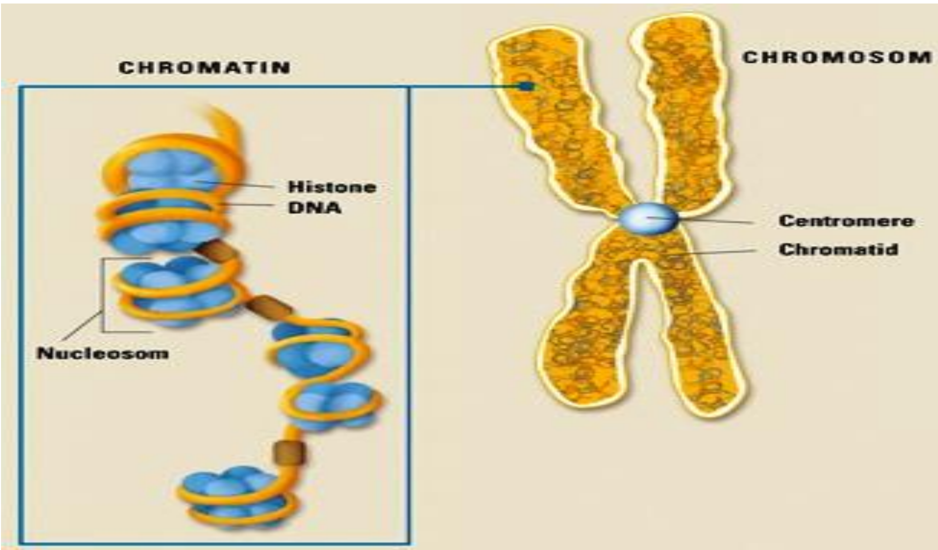
A chromosome is packaged and organized chromatin, a complex of macromolecules found in cells, consisting of DNA, protein and RNA. The main information-carrying macromolecule is a single piece of coiled double-stranded DNA, containing many genes,regulatory elements and other non-coding DNA. The DNA-bound macromolecules are proteins, which serve to package the DNA and control its functions. Chromosomes vary widely between different organisms. Some species also contain plasmids or otherextrachromosomal DNA.

Compaction of the duplicated chromosomes during mitosis and meiosis results either in a four-arm structure (pictured to the right) if the centromere is located in the middle of the chromosome or a two-arm structure if the centromere is located near one of the ends. Chromosomal recombination during meiosis plays a vital role in genetic diversity. If these structures are manipulated incorrectly, through processes known as chromosomal instability and translocation, the cell may undergo mitotic catastrophe and die, or it may unexpectedly evade apoptosis leading to the progression of cancer.

The chromosomes vary widely between different organisms. Eukaryotic cells have large number of linear chromosomes and cells of prokaryotes have smaller and circular DNA. Cells may contain more than one type of chromosome, like in most eukaryotic cells, the mitochondria and the chloroplasts in plant cells possess their own set of chromosomes.

Bacterial Chromosome Structure
Prokaryotic cells (bacteria) contain their chromosome as **circular DNA.** Usually the entire genome is a single circle, but often there are extra circles called **plasmids.** The DNA is packaged by **DNA-binding proteins**. The bacterial DNA is packaged in loops back and forth. The bundled DNA is called the **nucleoid**. It concentrates the DNA in part of the cell, but it is not separated by a nuclear membrane

Eukaryotic Chromosome Structure **Eukaryotic cells** contain their DNA within the **nuclear membrane**. The DNA double helix is bound to proteins called **histones**. The histones have positively charged (basic) amino acids to bind the negatively charged (acidic) DNA. The DNA is wrapped around the histone core of eight protein subunits, forming the **nucleosome**. The nucleosome is clamped by histone H1. About 200 base pairs (bp) of DNA coil around one histone.



Functions:

Genetic Code Storage: Chromosome contains the genetic material that is required by the organism to develop and grow. DNA molecules are made of chain of units called genes. Genes are those sections of the DNA which code for specific proteins required by the cell for its proper functioning.

Sex Determination: Humans have 23 pairs of chromosomes out of which one pair is the sex chromosome. Females have two X chromosomes and males have one X and one Y chromosome. The sex of the child is determined by the chromosome passed down by the male. If X chromosome is passed out of XY chromosome, the child will be a female and if a Y chromosome is passed, a male child develops.

Control of Cell Division: Chromosomes check successful division of cells during the process of mitosis. The chromosomes of the parent cells insure that the correct information is passed on to the daughter cells required by the cell to grow and develop correctly.

Formation of Proteins and Storage: Proteins are essential for the activity of a cell. The chromosomes direct the sequences of proteins formed in our body and also maintain the order of DNA. The proteins are also stored in the coiled structure of the chromosomes. These proteins bound to the DNA help in proper packaging of the DNA.

Answer No. 4:

The cell cycle, or **cell-division cycle**, is the series of events that take place in a cell leading to its division and duplication (replication) that produces two daughter cells. In cells without a nucleus (prokaryotic), the cell cycle occurs via a process termed binary fission. In cells with a nucleus (eukaryotes), the cell cycle can be divided in three periods: interphase, the mitotic (M) phase, and cytokinesis.

Phases of the cell cycle

The division cycle of most eukaryotic cells is divided into four discrete phases:

M, G_1, S, and G_2. M phase (mitosis) is usually followed by cytokinesis. S phase is the period during which DNA replication occurs. Before a cell can enter cell division, it needs to take in nutrients. All of the preparations are done during interphase. Interphase is a series of changes that takes place in a newly formed cell and its nucleus, before it becomes capable of division again. It is also called preparatory phase or intermitosis. Previously it was called resting stage because there is no apparent activity related to cell division.Typically interphase lasts for at least 90% of the total time required for the cell cycle.

Interphase proceeds in three stages, G_1, S, and G_2, preceded by the previous cycle of mitosis and cytokinesis. The cells nuclear chromosomes are duplicated during S phase.

G_1 Phase

The first phase within interphase, from the end of the previous M phase until the beginning of DNA synthesis, is called G_1 (G indicating *gap*). It is also called the growth phase. During this phase the biosynthetic activities of the cell, which are considerably slowed down during M phase, resume at a high rate. The duration of G_1 is highly variable, even among different cells of the same species. In this phase, cell increases its supply of proteins, increases the number of organelles (such as mitochondria, ribosomes), and grows in size.

S Phase

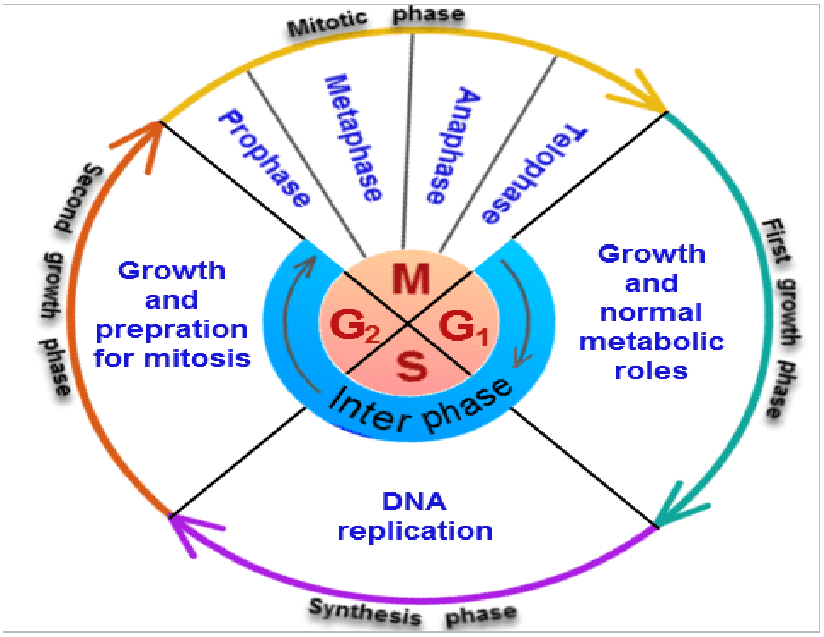
The ensuing S phase starts when DNA replication commences; when it is complete, all of the chromosomes have been replicated, i.e., each chromosome has two (sister) chromatids. Thus, during this phase, the amount of DNA in the cell has effectively doubled, though the ploidy of the cell remains the same. During this phase, synthesis is completed as quickly as possible due to the exposed base pairs being sensitive to harmful external factors such as mutagens.

G_2 phase

The completion of DNA synthesis is followed by the G_2 phase (gap 2), during which cell growth continues and proteins are synthesized in preparation for mitosis.

M Phase

The relatively brief *M phase* consists of nuclear division (karyokinesis). It is a relatively short period of the cell cycle. M phase is complex and highly regulated. The sequence of events is divided into phases, corresponding to the completion of one set of activities and the start of the next. These phases are sequentially known as: prophase, metaphase, anaphase, telophase, cytokinesis



Answer No. 5:

A type of cellular reproduction in which the number of chromosomes are reduced by half through the separation of homologous chromosomes, producing two haploid cells. This process occurs in all sexually reproducing eukaryotes (both single-celled and multicellular) Humans, animals, plants, fungi.

Stages of Meiosis 1

- The first meiotic phase is **prophase 1**. As in mitosis, the nuclear membrane dissolves, chromosomes develop from the chromatin, and the centrosomes push apart, creating the spindle apparatus. Homologous (similar) chromosomes from both parents pair up and exchange DNA in a process known as crossing over. It has following stages:

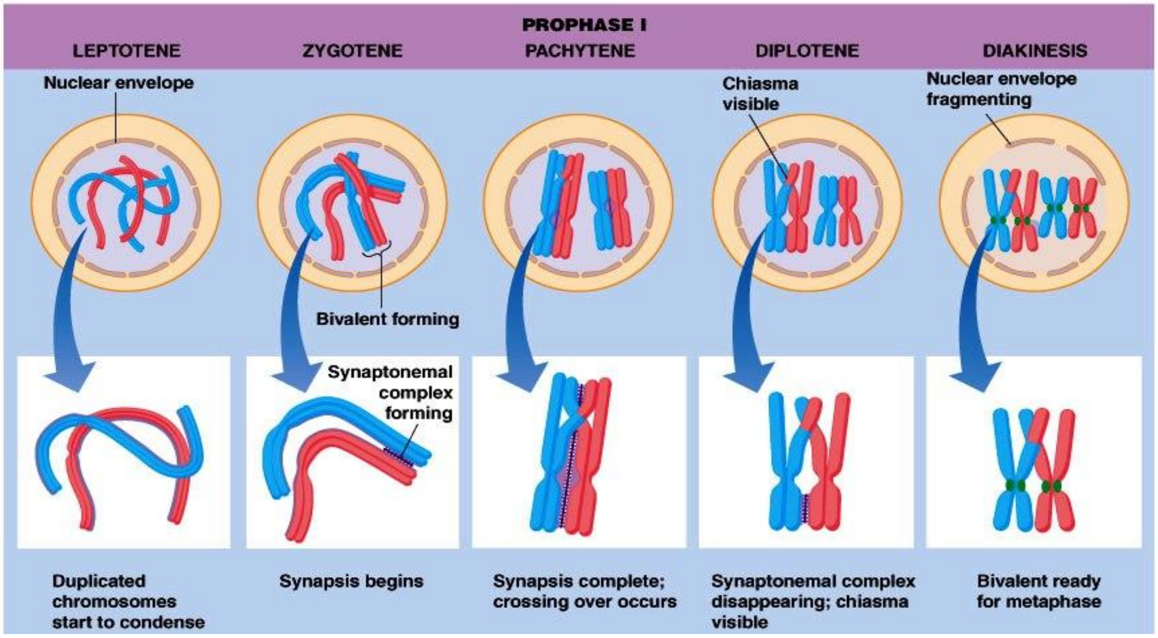
Leptotene: The first stage of prophase I is the *leptotene* stage, also known as *leptonema*, from Greek words meaning "thin threads". In this stage of prophase I, individual chromosomes—each consisting of two sister chromatids—condense from the diffuse interphase conformation into visible strands within the nucleus. During leptotene, lateral elements of the synaptonemal complex assemble.

zygoten*e* :The *zygotene* stage, also known as *zygonema*, from Greek words meaning "paired threads",occurs as the chromosomes approximately line up with each other into homologous chromosome pairs. At this stage, the synapsis (pairing/coming together) of homologous chromosomes takes place, facilitated by assembly of central element of the synaptonemal complex. he paired chromosomes are called bivalent or tetrad chromosomes.

***pachytene* :** The *pachytene* (pronounced stage, also known as *pachynema*, from Greek words meaning "thick threads is the stage when chromosomal crossover(crossing over) occurs. Sex chromosomes, however, are not wholly identical, and only exchange information over a small region of homology. At the sites where exchange happens, chiasmata form.

Diplotene: During the *diplotene* stage, also known as *diplonema*, from Greek words meaning "two threads, the synaptonemal complex degrades and homologous chromosomes separate from one another a little. The chromosomes themselves uncoil a bit, allowing some transcription of DNA. After prophase I cells enter to the following stages for complete reductional division.

Metaphase 1, some of the spindle fibers attach to the chromosomes' centromeres. The fibers pull the tetrads into a vertical line along the center of the cell.**Anaphase 1** is when the tetrads are pulled apart from each other, with half the pairs going to one side of the cell and the other half going to the opposite side. It is important to understand that whole chromosomes are moving in this process, not chromatids, as is the case in mitosis. **Telophase 1** where cytokinesis begins splitting the cell into two daughter cells. In telophase 1, The spindle apparatus dissolves, and nuclear membranes develop around the chromosomes that are now found at opposite sides of the parent cell / new cells.



Answer No. 6:

Cancer is a class of diseases characterized by out-of-control cell growth. There are over 100 different types of cancer, and each is classified by the type of cell that is initially affected.

Cancer harms the body when damaged cells divide uncontrollably to form lumps or masses of tissue called tumors (except in the case of leukemia where cancer prohibits normal blood function by abnormal cell division in the blood stream). Tumors can grow and interfere with the digestive, nervous, and circulatory systems, and they can release hormones that alter body function. Tumors that stay in one spot and demonstrate limited growth are generally considered to be benign.

More dangerous, or malignant, tumors form when two things occur:

1. a cancerous cell manages to move throughout the body using the blood or lymph systems, destroying healthy tissue in a process called invasion
2. that cell manages to divide and grow, making new blood vessels to feed itself in a process called angiogenesis.

When a tumor successfully spreads to other parts of the body and grows, invading and destroying other healthy tissues, it is said to have metastasized. This process itself is called metastasis, and the result is a serious condition that is very difficult to treat.

Causes : Cancer is ultimately the result of cells that uncontrollably grow and do not die. Normal cells in the body follow an orderly path of growth, division, and death. Programmed cell death is called apoptosis, and when this process breaks down, cancer begins to form. Unlike regular cells, cancer cells do not experience programmatic death and instead continue to grow and divide. This leads to a mass of abnormal cells that grows out of control.

Carcinogens : Carcinogens are a class of substances that are directly responsible for damaging DNA, promoting or aiding cancer. Tobacco, asbestos, arsenic, radiation such as gamma and x-rays, the sun, and compounds in car exhaust fumes are all examples of carcinogens. When our bodies are exposed to carcinogens, free radicals are formed that try to steal electrons from other molecules in the body. Theses free radicals damage cells and affect their ability to function normally.

There are five broad groups that are used to classify cancer.

1. Carcinomas are characterized by cells that cover internal and external parts of the body such as lung, breast, and colon cancer.,
2. Sarcomas are characterized by cells that are located in bone, cartilage, fat, connective tissue, muscle, and other supportive tissues.
3. Lymphomas are cancers that begin in the lymph nodes and immune system tissues.
4. Leukemias are cancers that begin in the bone marrow and often accumulate in the bloodstream.

Answer No. 7:

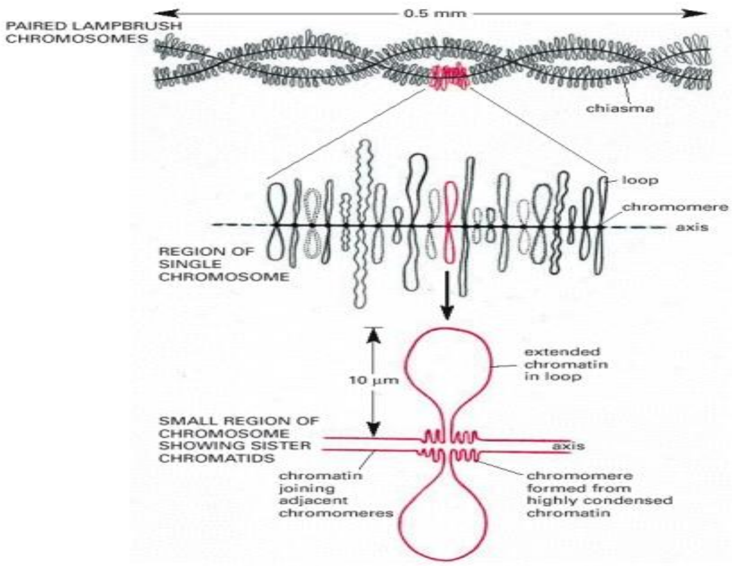
Lampbrush chromosomes :

These chromosomes occur in the oocytes (germ cells in the ovary) of amphibians and in fishes, reptiles ,birds and in some insects.They are extremely large synapsed homologous chromosomes,seen in the diplotene stage of prophase-I in meiosis. They measure about 1500 to 2000 micrometer in length as opposed to 15–20 µm during later stages of meiosis. They were first discovered by Flemming in 1882

The amphibian oocyte (immature egg) has certain periods of very active RNA synthesis. This stage can last several months.Lampbrush chromosomes are extended chromosome bivalents . Lampbrush chromosomes are highly active in

RNA synthesis, and they form unusually stiff and extended chromatin loops that are covered with newly transcribed RNA packed into dense RNAprotein complexes

The paired chromosomes of oocytes in meiosis consist of numerous chromatin loops arranged along an axis . Chiasma formation is visible at various locations.Each segment of a lampbrush chromosome consists of aseries of chromatin loops, originating from an axis and a condensed structure, the chromomere along the axis .



Polytene chromosomes :

Polytene chromosomes were discovered by Balbiani (1881) in larval salivary glands, Malpighian tubules, intestine,hypoderm and muscles of Chironomus plumosus as a cylindrical cord that repeatedly unravelled and filled the nucleus.

Polytene chromosomes have characteristic light and dark banding patterns that can be used to identify chromosomal rearrangements and deletions. Dark banding frequently corresponds to inactive chromatin, whereas light banding is usually found at areas with higher transcriptional activity. The banding patterns of the chromosomes are especially helpful in research, as they provide an excellent visualization of transcriptionally active chromatin and general chromatin structure. For example, the polytene chromosomes in *Drosophila* have been used to support the theory of genomic equivalence, which states that all of the cells in the body maintain the same genome. **Chromosome puffs** are diffused uncoiled regions of the polytene chromosome that are sites of RNAtranscription. A **Balbiani ring** is a large chromosome puff. Polytene chromosomes are about 200 µm in length. The chromonema of these chromosomes divide but do not separate. Therefore, they remain together to become large in size. Another form of chromosomal enlargement that provides for increased transcription is the lampbrush chromosome.