KRISHNAGAR ACADEMY

CELL CYCLE

&

CELL DIVISION

Biology

Class - 10

Chapter -- 1

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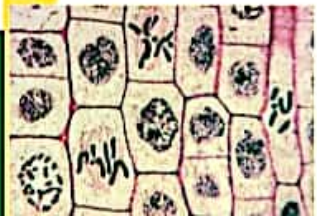
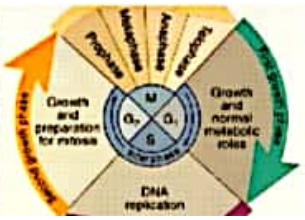
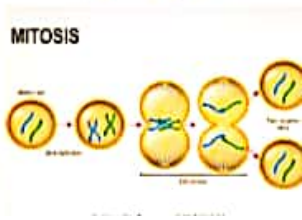






SYLLABUS

Cell Cycle and Cell Division

- *Cell cycle—Interphase (G_1, S, G_2) and M-phase.*
- *Cell Division : Mitosis and its stages. A basic understanding of Meiosis as a reduction division (stages not required). Significance and major differences between mitotic and meiotic division.*

Growth is the fundamental characteristic of all living organisms. As a cell grows the normal ratio between the volume of cytoplasm and size of its nucleus is disturbed and also surface area to volume ratio. This distortion adversely affects the cell's relationship with its environment like exchange of material between cell and its environment. The cell divides to restore the normal equilibrium.

According to cell doctrine, all cells arise from pre-existing cells. Thus, the continuity of life is mantained by cell division.

CELL CYCLE

The period from the end of one division of a cell to the end of next division is called cell cycle. The entire cell cycle is mostly of the duration of 10 to 30 hours in eukaryotes whereas for actual division only about thirty minutes to one hour is taken. Cell cycle is divided into two main phases :

(a) Interphase

(b) Division phase.

INTERPHASE

It is the growth period between two successive divisions of a cell or between end of cytokinesis of previous mitosis and beginning of prophase of new mitosis.

Interphase is completed in 3 phases in sequence :

1. G_1 Phase

RNA and protein are synthesized. The chromosome are fully uncoiled and thin and form a reticulum. This constitutes 30-40% of the entire cell cycle.

2. S phase

DNA is replicated and histone proteins are synthesized. Each chromosome is now made of two chromatids. This phase constitutes about 30-50% of the entire cell cycle.

3. G_2 phase

RNA and protein are synthesized. Cell organelle are duplicated. Proteins participate in spindle formation. This constitutes 10-20% of the entire cell cycle.

Table 1. Differences between G_1-phase and G_2-phase.

	G_1-Phase	G_2-Phase
1.	Comes before S-phase.	Comes after S-phase.
2.	Synthesis of proteins.	Synthesis of proteins takes place and duplication of organelle takes place.

M-PHASE (DIVISION PHASE)

This phase follows G_2-phase and is completed in two steps, *viz.*, karyokinesis and cytokinesis. Karyokinesis may take place by any of the following three methods :

1. Amitosis,
2. Mitosis = Somatic cell division = Equational division,
3. Meiosis = Reduction division.

AMITOSIS

Amitotic cell division does not involve spindle formation, nuclear membrane does not dissolve and genetic material may not be equally divided between daughter cells. This kind of cell division normally occurs in bacteria and cyanobacteria. Among eukaryotic cells it occurs in *Paramecium's* macronucleus, cells of embryonic membranes and mammalian chondrioblast cells.

MITOSIS = EQUATIONAL DIVISION

Mitosis was discovered by W. Flemming.

Sites of Mitosis : Mitosis commonly takes place in somatic or body cells like meristem, cambium, epithelium (stratum malpighi of skin), cells of bone marrow etc.

SIGNIFICANCE OF MITOSIS/CELL DIVISION

1. Reproduction : Unicellular organisms like *Amoeba* reproduce by dividing by mitosis after attaining optimum growth into two genetically identical cells.

2. Development : Mitosis or somatic cell division or vegetative cell division of zygote results in the development of multicellular body.

3. Growth : Mitosis results in the growth of the body from a small embryo into an adult.

4. Repair : In most tissue like epithelium, connective tissue etc., cells divide to heal up any wound in the body.

5. Regeneration : Animals like sponges and coelenterates can regenerate the entire lost part of the body. Among vertebrates salamanders have this power.

Stages of Mitosis involves karyokinesis and cytokinesis. Karyokinesis consists of four phases:

(*a*) **Prophase**—Chromatin fibres shorten and condense to form chromosomes. Each chromosome contains two chromatids (arms) connected at the centromere. The nucleolus and nuclear membrane disappear. The centrosome divides into two centrioles and move towards the opposite poles.

(*b*) **Metaphase**—The chromosomes arrange themselves upon the equator of the spindle, which arise from the centriole.

(*c*) **Anaphase**—The centromere of the chromosome divides, the sister chromatids separate and move towards opposite poles.

(*d*) **Telophase** — The chromatid when it reaches the poles lengthens to form chromatin threads, the nuclear membrane and nucleolus reappear. Spindle fibres disappear.
Karyokinesis is followed by cytokinesis.

Cytokinesis: It is the division of the cytoplasm. In an animal cell, a furrow appears at the centre of the cell membrane. The furrow deepens and splits into two daughter cells. In a plant cell, a cell plate is formed at the equatorial plane of the spindle and grows from the centre to the periphery to form two daughter cells.

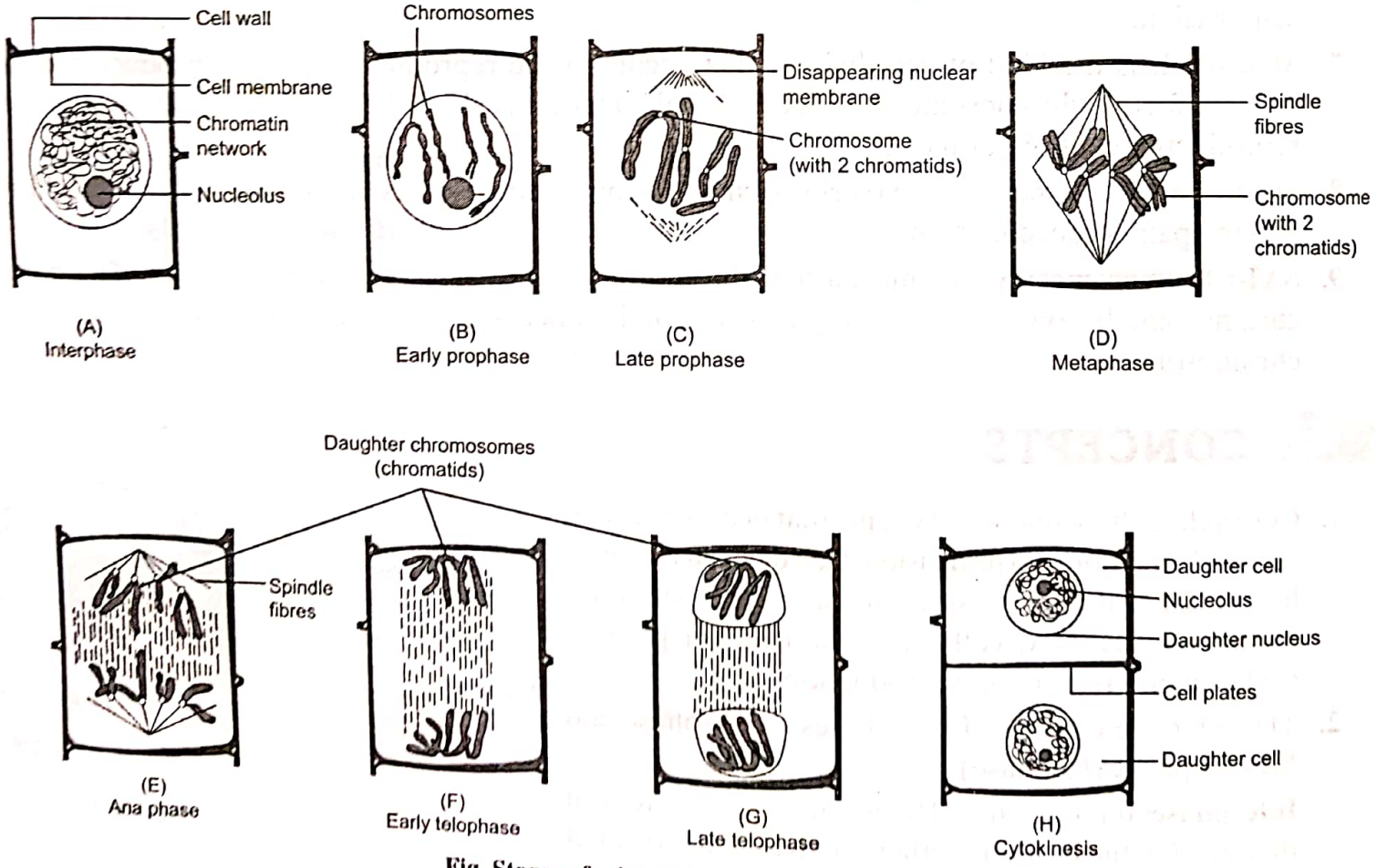


Fig. Stages of mitosis in a plant cell (A to H)

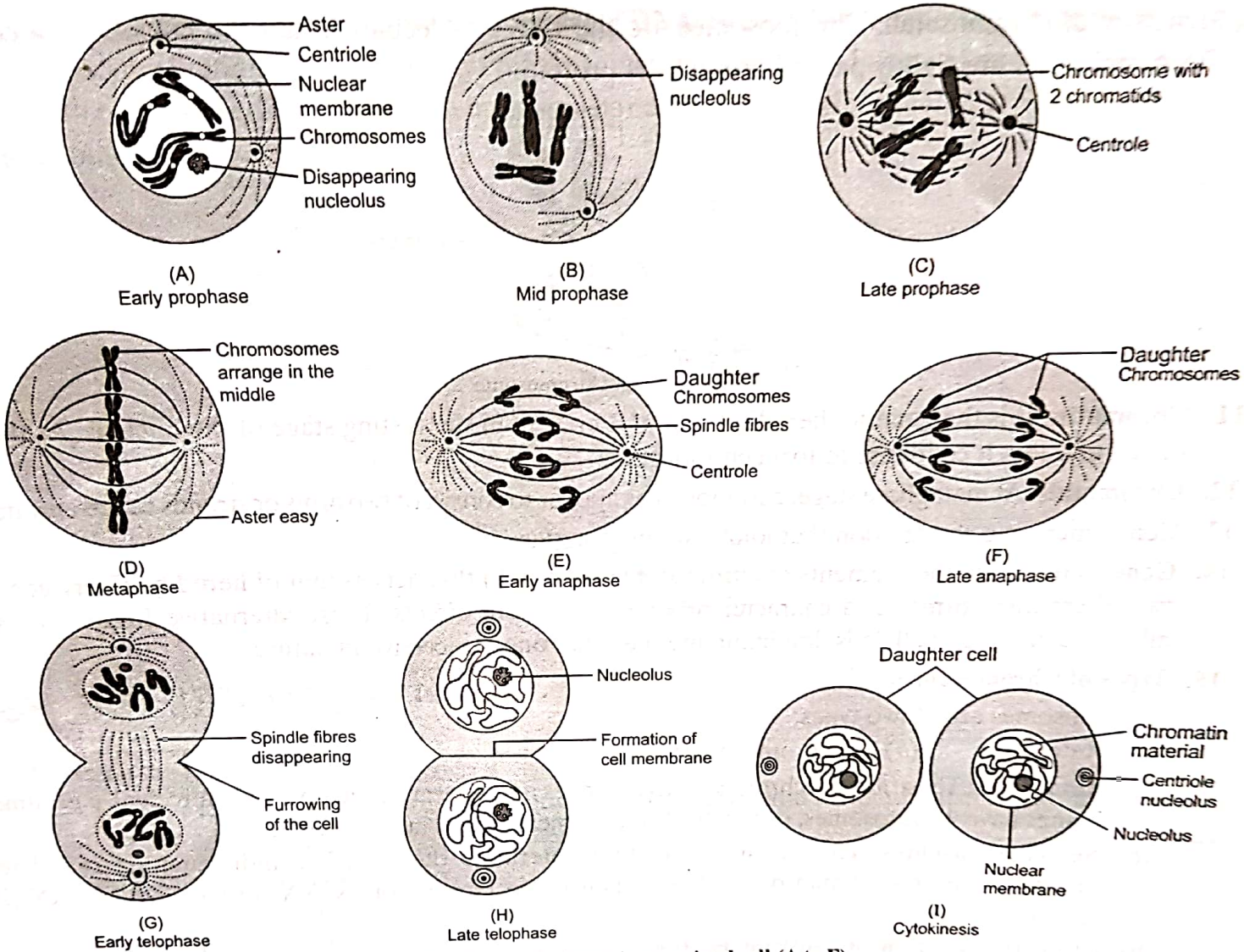


Fig. Stages of mitosis in an animal cell (A to F)

Differences in the mitosis in plant and animal cell.

Plant Mitosis	Animal Mitosis
(*a*) Asters are not formed.	(*a*) Asters are formed.
(*b*) Cytokinesis by cell plate formation.	(*b*) Cytokinesis by furrowing of cytoplasm.
(*c*) Cytokinesis is centrifugal.	(*c*) Cytokinesis is centripetal.
(*d*) Occurs in growing regions.	(*d*) Occurs in most tissues.

. Differences between Mitosis and Meiosis:

Mitosis	Meiosis
(*a*) It occurs in somatic cells.	(*a*) It occurs in reproductive cells.
(*b*) The daughter cells contain same number of chromosomes (diploid) as that of the parent cells.	(*b*) The daughter cells have half the number of chromosomes (haploid) as that of the parent cells.
(*c*) Two daughter cells are formed.	(*c*) Four daughter cells are formed.
(*d*) Only one division occurs.	(*d*) Two divisions occur.

Structure of chromosome: Chromosomes are the DNA molecules inside the nucleus of a cell. These DNA molecules are tightly packed around the protein.

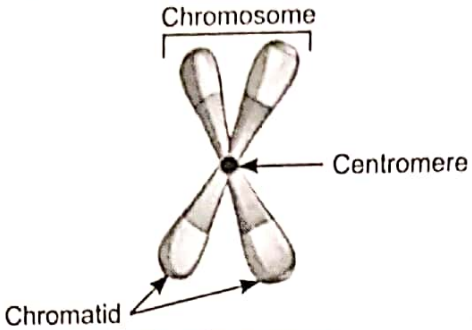


Fig. Chromosome

Chromatin: It is the genetic (heredity) material present in the resting stage of the nucleus. At the time of cell division, it condense to form chromosome.

Chromatids: At metaphase stage, chromosomes appear to consist of two arms or strands called chromatids.

Centromere is a constriction that joints two chromatids.

Genes: Genes are the segments of chromosome (or DNA) that acts as unit of heredity. Every gene has two alternative forms for a character producing different effects. These alternative forms are called alleles. Usually, one allele is dominant and the other one is recessive in nature.

Types of Chromosomes

Chromosomes are of two types:

(*a*) Autosomes (*b*) Sex chromosomes.

(*a*) **Autosomes:** These are the chromosomes that does not determine the sex of an individual. e.g. human beings have 44 autosomes, out of 46 chromosomes present in the nucleus.

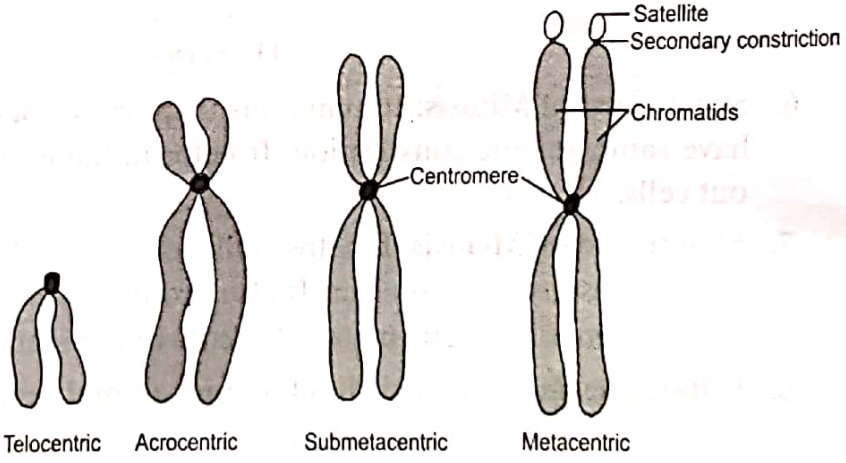
(*b*) **Sex chromosomes:** The chromosomes that determine the sex of an individual are called sex chromosomes, e.g. human beings have a pair of sex chromosomes, XX (in females) and XY (in males).

Based on the position of centromere, the chromosomes are of four types:

(*a*) **Telocentric:** Centromere is at the tip of the chromosome, it has a terminal centromere.

(*b*) **Acrocentric:** Centromere is near to one end of the chromatid where one arm is longer than the other.

(*c*) **Submetacentric:** Centromere is slightly away from the centre of the chromatid.



(*d*) **Metacentric:** Centromere is in the centre and both the arms of the chromatid are of equal length.

Structure of DNA:

- DNA forms the basis for the genetic code. It is made up of long chain of nucleotides (or polynucleotide).
- A nucleotide consists of three parts:
  - (*a*) deoxyribose (a sugar)
  - (*b*) a phosphate group
  - (*c*) 4 nitrogenous bases-adenine, guanine (called purines), cytosine and thymine (called pyrimidines).
- In a molecule of DNA, purines and pyrimidines are equal in number.
- Sugar and phosphate forms the backbone of a DNA molecule.

Watson and Crick proposed a **double helix model of DNA**. In each DNA molecule, there are two long and parallel polynucleotide chains, helically coiled around the same axis. Purine of one polynucleotide chain pairs with pyrimidine of the other with hydrogen bond. Both the chains of DNA are thus complementary to each other.

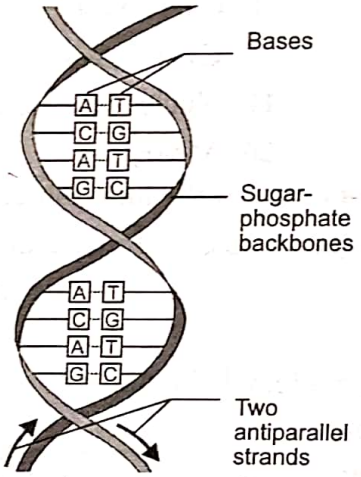


Fig. A double helical structure of DNA

MEIOSIS

Every organism has a fixed life span, it grows old and ultimately dies. But before it dies it leaves some offspring which are produced by the process of reproduction so that its species continues.

Meiosis helps in the production of gametes (gametogenesis) which are haploid since meiosis is a reduction division. Reduction means only half the number of chromosomes present in the karyotype are present in the gamete, *i.e.,* these gametes are haploid or monoploid (x or n). These gametes, on fusion during fertilization, form normal diploid zygote.

Sites of Cell Division by Meiosis : Anther and ovule in plants. Testes and ovary in animals.

Meiosis is completed in two closely coordinated divisions :

A. Meiosis I

B. Meiosis II

Meiosis I

Meiosis I shows some important changes which are as follows :

1. In a diploid cell, chromosomes are paired, half of the chromosome are of male parent and the other half of female parent.

2. Paired chromosomes carrying similar character and being similar in shape, size and structure are called homologous chromosomes.
3. Homologous chromosomes come together and arrange in pairs lengthwise. The process is synapsis. Chromosomes in pair have four strands (chromatids).
4. Chromatid of a particular chromosome are called sister chromatid whereas of homologous chromosomes are called non-sister chromatid.
5. Non-sister chromatids of homologous chromosomes wound around one another. At the point where non-sister chromatids touch each other, the segments are mutually exchanged.
6. The point of exchange is called chiasma (plural chiasmata)) and the process is called crossing over.
7. Crossing over results into recombination of genes and mixing of maternal and paternal characters.
8. Meiosis produces four daughter cells which are haploid.

Meiosis II

Meiosis II is very much like mitosis.

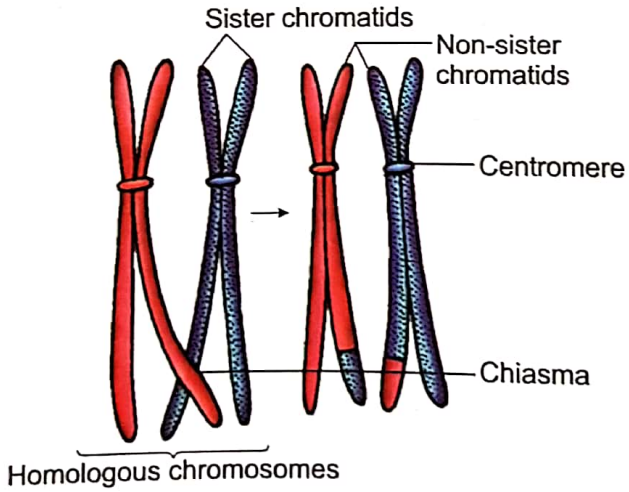
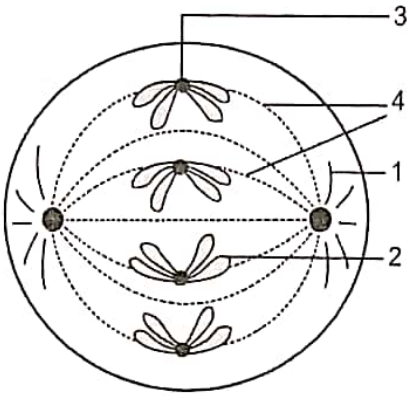


Fig. 5. Crossing over.

SUMMARY

- Cell cycle is defined as the sequence of events which take place during life cycle of a cell which includes growth and division.
- Cell cycle is divided in two major phase— interphase and M-phase.
- **Interphase** is the phase between two successive divisions.
- Cell division is of two types: mitosis and meiosis.
- Cell division helps in growth, repair, healing, regeneration, replacement of old cells and reproduction.
- The term mitosis was coined by Flemming.
- Mitosis takes place in somatic cells.
- The cells produced by mitosis are genetically similar i.e., have similar number of chromosomes.
- Mitosis is completed in four phases: Prophase, metaphase, anaphase and telophase.
  - In **prophase**, nuclear membrane and nucleolus disappear, chromatin fibres condense to form chromosomes and duplicated centrioles start moving towards opposite poles. The spindle fibres develop between them.
  - In **metaphase**, chromosomes are arranged on the equatorial plate. Each chromosome splits into two chromatids which remain joined by the centromere.
  - In **anaphase**, the centromere divides and the spindle fibres contract. The chromatids separate and move towards opposite poles.
  - In **telophase**, nuclear membrane and nucleolus reappear and chromatids uncoil to become thin chromatin fibres.
- The process of division of nucleus is called **karyokinesis**.
- The process of division of cytoplasm is called **cytokinesis**.
- Cytokinesis occurs in plant cells by cell plate formation and by furrow formation in animal cells.
- One mother cell, after mitosis, gives rise to two daughter cells which are similar to each other as well as to the mother cell.
- The term **meiosis** was given by Farmer and Moore.
- Meiosis takes place in reproductive cells during formation of gametes (sperm and ova).
- Meiosis is a very long process and is completed in two phases: meiosis I and meiosis II. Each of these phases is further divide into prophase, metaphase, anaphase and telophase.
- Meiosis results in formation of four daughter cells which are genetically different from each other as well as from the mother cell.
- The differences in daughter cells are due to crossing over.
- Crossing over is the process of exchange of parts of chromatid segments between homologous chromosomes.
- The point of crossing over looks like a cross (X). It is called **chiasma** (plural chiasmata).
- The number of chromosomes is reduced to half in daughter cells as compared to mother cell. Therefore meiosis is also called **reduction** division. Daughter cells are haploid.
- Significance of mitosis
  - It helps in healing, growth, repair, regeneration and vegetative propagation.
  - It maintains the same chromosome number and genetic constitution in all the daughter cells.
- Significance of meiosis
  - It brings about variations (differences in the members of the same species), which help in the evolution of new species.
  - It reduces the chromosome number to half in the gametes so that after fertilization, the normal diploid number of chromosomes is restored in the zygote.

There is a diagram representing a stage during mitotic cell division in an animal cell: **[2010]**



(*a*) Identify the above stage. Give a reason to support your answer.

(*b*) Name the parts labelled 1, 2, 3 and 4.

(*c*) What is the function of part 3?

(*d*) Name the stage that comes just after the stage shown in the diagram. Draw a well labelled diagram of this stage.

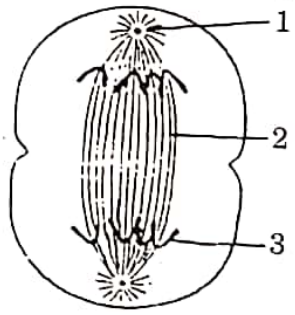
Draw a metaphase stage of mitosis showing four chromosomes in an animal cell. **[2012]**

Draw a well labelled diagram to show the anaphase stage of mitosis in a plant cell having four chromosomes. **[2013]**

(*a*) Write the names of four nitrogenous bases in a DNA molecule.

(*b*) Give reason why gametes have haploid number of chromosomes.

The diagram represents a stage during cell division. Study the same and then answer the questions that follow: **[2011]**



(*a*) Name the parts labelled 1, 2 and 3.

(*b*) Identify the above stage and give a reason to support your answer.

(*c*) Mention where in the body this type of cell division occurs.

(*d*) Name the stage prior to this stage and draw a diagram to represent the same.