2 CELL CYCLE, CELL DIVISION AND STRUCTURE OF CHROMOSOMES

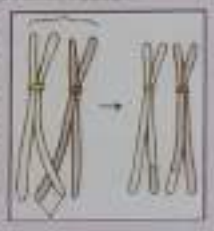
***Syllabus** : Cell Cycle and Cell Division, Structure of chromosome.*

***Scope of Syllabus** :* 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.

Basic structure of chromosome with elementary understanding of terms such as chromatin, chromatid, gene structure of DNA and centromere.

[Cell cycle can be understood better after knowing about cell division and hence we are first describing the cell division]



Cell division is one of the most fundamental characteristics of life. This is the method which enables life to perpetuate generation after generation. This is equally true in the case of the simplest organisms like amoeba as is in the highly complex ones such as ourselves, the giant sized elephants or the tall coconut tree. Some of the details of cell division are slightly difficult to understand, but we have tried to make it as simple as possible.

2A. CELL DIVISION – NEW CELLS FROM THE EXISTING ONES

2.1 NEW CELLS NEED TO BE PRODUCED

New cells need to be produced for (1) growth, (2) replacement, (3) repair and (4) reproduction.

1. ***For growth*** : Every organism, be it a plant or an animal, begins its life as a single cell (the fertilized egg). This cell divides repeatedly to form a cluster of cells which start shaping for different functions to form tissues and organs. Thus, cell division is essential for ***growth***.

Fig. 2.1 : A 4-day-old human embryo containing 16 cells, resulting from four cell divisions. As they multiply, they specialise to form the tissues and organs of the body

2. ***For replacement*** : There is always a wear and tear of cells during the normal body functions. *For example*, 20 million red blood cells in our body are destroyed every minute. These are ***replaced*** by new cells formed through a division of their parent cells in the bone marrow. In plants, the old and dried leaves fall off and new ones grow out.

3. ***For repair*** : Apart from normal wear and tear of the tissues in the body, there may be accidental injuries. One may get cuts in the skin or fractures in the bone. ***Repair*** of such injuries is again through cells which divide, cover up the gaps and join the broken ends.

REMEMBER

In cell divisions for growth, replacement and repair, the number of chromosomes remains the same at each division. The chromosomes duplicate and distribute equally in the daughter cells. This kind of division which occurs in all body cells except in the egg producing oocytes (in ovaries) and sperm producing spermatocytes (in testes), is known as ***mitosis***.

4. *For reproduction* : Reproduction is also through the activity of the dividing cells. Amoeba or bacteria just divide to produce two similar independent cells by mitosis. In larger forms, as in humans or in the banyan tree, special cells in the reproductive organs undergo a special cell division (***meiosis***) to produce sperms and eggs. These sperms and eggs receive only half the number of chromosomes of their parent cells, *i.e.*, one chromosome from each pair. This reduction in chromosome number is very significant.

Look at the following example in humans :

Kind of cells	*Chromosomes*	
	in **MAN**	*in* **WOMAN**
Body cells =	46 (23 pairs) ($2n$)	46 (23 pairs) ($2n$)
Sex cells (sperms and eggs) =	23 (single) (n)	23 (single) (n)
Fertilised egg	(from sperm) 23 + 23 (from egg)	
	New baby = 46 (23 pairs) ($2n$)	

2.2 TYPES OF CELL DIVISION

There are two types of cell division :-

1. *Mitosis* : Cell division leading to growth and development. take place in body cells
2. *Meiosis* : Cell division leading to the production of gametes (sex cells). take place in sex cells

2.2.1 MITOSIS (*mitos* : thread, referring to chromatin thread)

MITOSIS is the cell division in which two identical daughter cells are produced by the division of one parent cell.

The most important aspect of mitosis is that **the same normal chromosome number is maintained at each cell division.**

Just before the division of the cell, it prepares for this change and doubles the quantity of DNA (the chromosome substance). This is the **interphase** (Fig. 2.2), apparently the resting phase, since no change in chromosomes is visible externally, but actually it is quite active in synthesising the DNA.

Phases of mitosis

Mitosis occurs in four main phases although each of these phases merges into the next phase thereby making it a continuous process. The four phases of mitosis are :

(i) **Prophase** (ii) **Metaphase**
(iii) **Anaphase** (iv) **Telophase**

By and large, the four phases of mitosis are similar in both animal and plant cells. However, we are first describing the mitotic stages in an animal cell. Figure 2.2 illustrates these stages in animal and plant cells side by side. Two major differences in the mitosis of plant and animal cells have been listed in Table 2.1.

(i) Prophase (*pro* : first) (Fig 2.2 A & B)

(1) The **chromosomes** have become short and thick and are clearly visible inside the nucleus.
(2) Each chromosome has already duplicated (having made its copy), to form two **chromatids**.
(3) The two sister chromatids remain attached to each other at a small region called **centromere**.
(4) The **centrosome** (in animal cell) splits into two along with simultaneous duplication of the centrioles contained in it. The daughter centrioles move apart and occupy opposite "poles" of the cell. Each centriole is surrounded by radiating rays called **aster** (*aster* : star). (The animal cells may have either one or two centrioles).
(5) A number of fibres appear between the two daughter centrioles, which are called the **spindle fibres**.
(6) The **nuclear membrane** and the **nucleolus disappear**.
(7) The **chromosomes start moving towards the "equator"** of the cell.

[*Note* : "Poles" mean the extremities of an axis, and "equator" means the middle plane dividing the cell into two similar halves. The naturally occurring cells may be oriented in all possible directions (Figure in Box p. 11)]

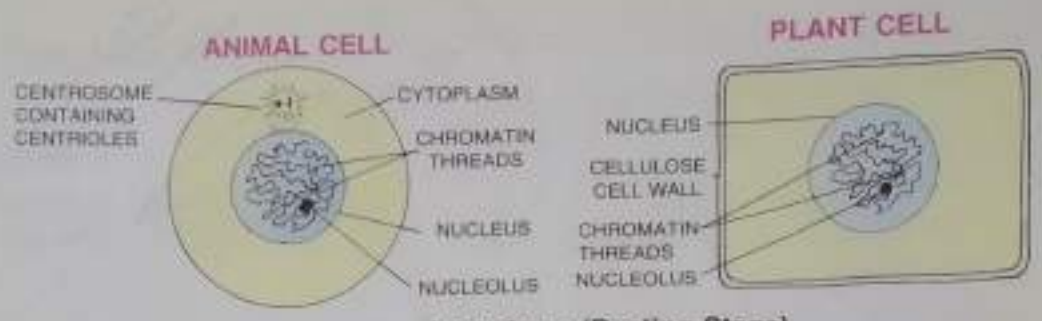
(ii) Metaphase (*meta* : after) (Fig. 2.2 C)

The chromosomes arrange on the equatorial plane. Each chromosome gets attached to a spindle fibre by its centromere.

(iii) Anaphase (*ana* : up, back) (Fig. 2.2 D & E)

The centromere attaching the two chromatids divides and the two sister chromatids of each chromosome separate and are drawn apart towards opposite poles. The drawing action is performed by the contraction of spindle fibres.

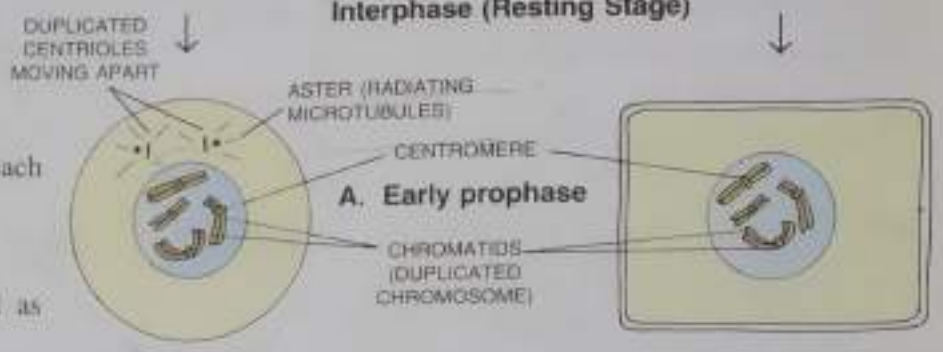
INTERPHASE
(resting phase)



Interphase (Resting Stage)

(i) PROPHASE (A and B)

- Centrioles start moving apart and reach opposite poles.
- Chromosomes become distinct.
- Chromosomes are already duplicated as paired chromatids.
- Sister chromatids attached to each other at a small region called centromere.
- Spindle fibres appear between daughter centrioles.
- Nuclear membrane and nucleolus disappear.

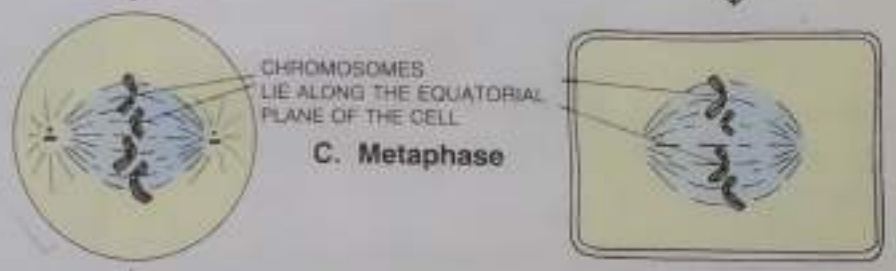


A. Early prophase

B. Late prophase

(ii) METAPHASE (C)

- Each chromosome gets attached to spindle by its centromere.
- Chromosomes lined up in one plane at equator.

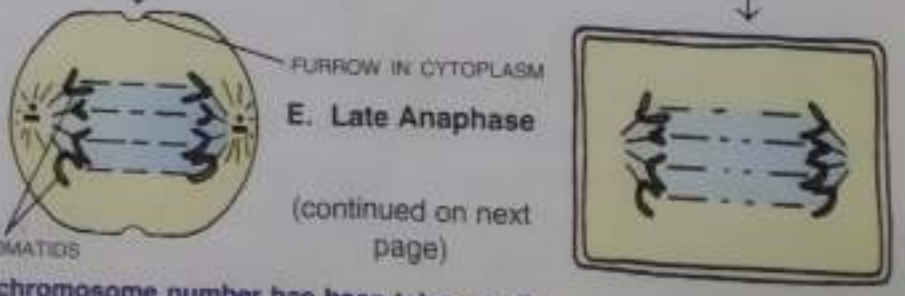


C. Metaphase

(iii) ANAPHASE (D and E)

- Centromere attaching the two chromatids divides.
- The two sister chromatids of each chromosome separate and are drawn apart towards opposite poles pulled by shortening of spindle fibres.
- A furrow starts in the cell membrane at the middle in animal cell.

D. Early Anaphase



E. Late Anaphase

(continued on next page)

Fig. 2.2 : Mitosis (in a cell where the chromosome number has been taken as 4)

(continued)

(iv) TELOPHASE (F)

- Two sets of daughter chromosomes reach opposite poles.
- Spindle fibres disappear.
- Chromatids thin out in the form of chromatin fibres.
- Nuclear membrane is formed.
- The cleavage furrow starts deepening in the animal cell.
- Nucleoli reappear.

CYTOKINESIS (Division of cytoplasm)

- Cleavage furrow deepens totally in animal cell and separates the two daughter cells.

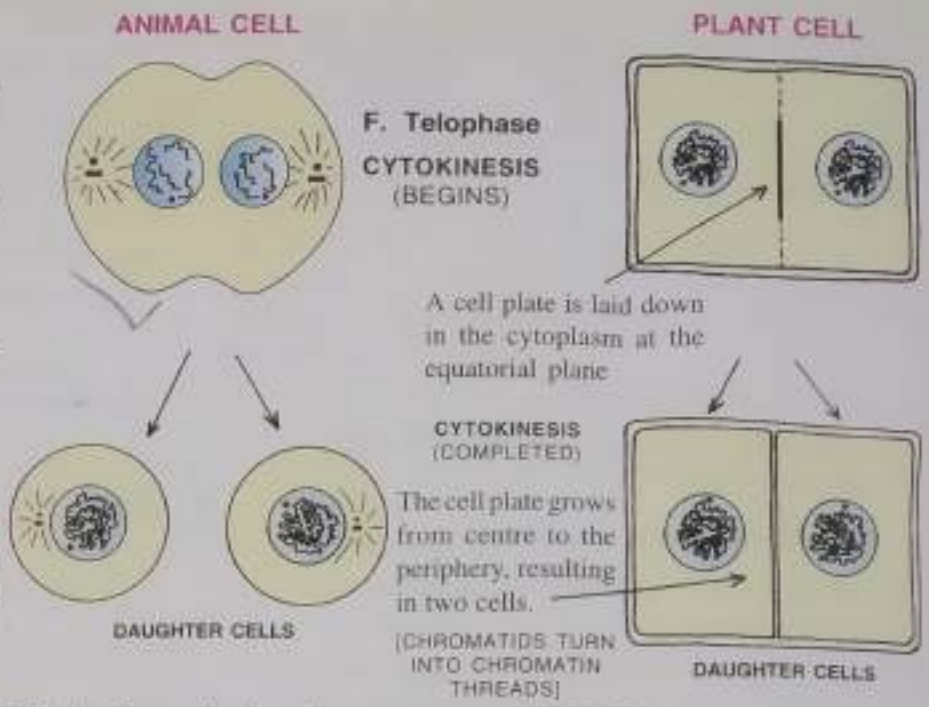


Fig. 2.2 (Continued) : Mitosis (in a cell where chromosome number is 4)

(iv) Telophase (*telo* : end) (Fig. 2.2 F)

1. Each chromatid or the daughter chromosome lengthens, becomes thinner and turns into a network of chromatin threads.
2. Nuclear membrane reappears.
3. Nucleolus reappears in each daughter nucleus.

All the contents of the cytoplasm including the mitochondria and also the chloroplasts in plant cell are randomly distributed in the daughter cells during karyokinesis.

Cytokinesis (Division of cytoplasm)

At the end of telophase, a furrow appears in the cell membrane in the middle, which deepens and finally splits the cytoplasm into two, thus producing two new cells (Fig. 2.2). Division of Nucleus

Karyokinesis and Cytokinesis Division of cytoplasm

All the nuclear changes that occur during cell division are collectively termed karyokinesis (**karyo** : nucleus)

Karyokinesis is followed by the division of cytoplasm (**cytokinesis**).

2.2.2 Differences in Mitosis in Animal and Plant cells

The nuclear and chromosomal events of mitosis in plant cells are the same as those in animal cells (Fig. 2.2). But some differences are as follows (Table 2.1) :-

Table 2.1 Differences between mitosis in animal and plant cell

Animals	Plants
1. Asters are formed.	1. Asters are not formed.
2. Cytokinesis **by furrowing** of cytoplasm.	2. Cytokinesis **by cell plate** formation.
3. Occurs in most tissues throughout the body (for growth and replacement.)	3. Occurs mainly at the growing tips (for lengthening) and sides (for increase in girth)

The terms "Parent" and "Daughter" cells !

Both these terms are actually inappropriate for two reasons. One, the "parent" cell disappears in the process and two, the "daughter" cells are not necessarily feminine. However, these two expressions are being used conventionally.

2.2.3 Significance of Mitosis

1. **Growth** or increase in the body size due to formation of new cells in the tissues.
2. **Repair** of damaged and wounded tissues by renewal of the lost cells.
3. **Replacement** of the old and dead cells such as the replacement of the blood cells and the epidermal cells of the skin.
4. **Asexual** reproduction in which the unicellular organisms, such as amoeba or the yeast cell, divide into two.

5. Maintains **same chromosome number** in daughter cells.

The diagram alongside shows the sectional microscopic view of an animal tissue undergoing active mitotic cell division. Observe carefully that such naturally occurring cells are oriented in all possible directions, and also they are in different phases. Note the stages of cells numbered 1-6.

Stage 1 : Interphase

Stage 2 : Prophase : Advancing condensation of chromatin network into chromosomes.

Stage 3 : Metaphase : Chromosomes arranged at "equator" (as if seen from the polar end above).

Stage 4 : Anaphase : Chromosomes start getting pulled up.

Stage 5 : Telophase : Chromosomes reaching the "poles".

Stage 6 : Cells after division.

THE MITOCHONDRIA AND CHLOROPLASTS IN CELL DIVISION

- Both mitochondria and chloroplasts have their **own DNA** (containing certain genes).
- They also contain their own **Ribosomes** which help in producing the particular proteins of these two organelles.
- Both these **divide of their own** by simple fission, just splitting into two and are partitioned between the two daughter cells produced by mitosis.
- Mitochondrial division is also guided by the genes in the nucleus and through the cytoplasmic ribosomes.

HOW OLD ARE SOME OF OUR BODY CELLS ?

- Cells of the **eye lens, nerve cells** of the cerebral cortex and most **muscle cells** last a life time but once dead are not replaced.
- **Skin cells** are replaced every two weeks or so.
- **Red blood cells** last for about 120 days and are replaced.
- **Bone cells** are replaced every 10 years or so in adults.
- **Epithelial cells** lining the gut last only 5 days.
- Average life of **other gut cells** is about 15 years.
- **Liver cells** are replaced every 300–500 days. 1½ year

2.3 CELL CYCLE — *"Divide, grow and redivide"*

The new cells at the end of mitosis are relatively small, with a full sized nucleus but relatively little cytoplasm. Now, they enter **interphase** during which they prepare for the next cell division and grow to the same size as their mother cell. The interphase itself has *three* phases — (i) **the first growth phase,** (ii) **synthesis phase** and (iii) **the second growth phase.**

(i) First Growth Phase (G_1) — RNA and proteins are synthesised, the volume of cytoplasm increases. Mitochondria (in all cells) and chloroplasts (in plant cells) divide – these two organelles have their own DNA. In late G_1 phase, all cells must follow one of the two paths. They may *either* withdraw from the cell cycle and enter a resting phase (R) *or* start preparing for the next division by entering the next synthesis phase (S). (10 hours)

(ii) Synthesis Phase (S) – More DNA is synthesised, the chromosomes are duplicated. (8 hours)

(iii) Second Growth Phase (G_2) – This is a shorter growth phase, in which RNA and proteins necessary for cell division continue to be synthesised. Now the cell is ready to start next cell division and thus the cell cycle goes on. (5 hours)

Mitosis: (1 hour)

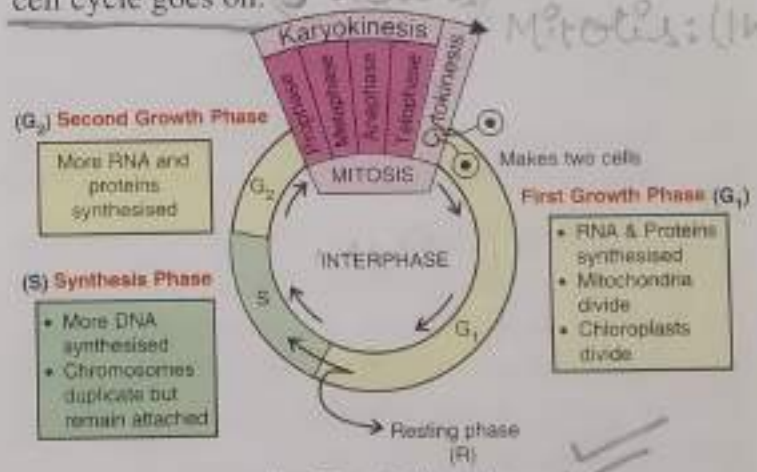


Fig. 2.3 : Cell cycle

Can the cell cycle go on endlessly ?

No. At some places it stops **permanently**, at some places **temporarily** and at others **till it is needed**. There is a regulatory mechanism for cell cycles.

- **Brain** and other **nerve cells**, once formed in the embryo do not divide further. Once dead, they are not replaced.
- **Liver cells** may divide only once every one to two years to replace damaged or destroyed cells.

- **Surface skin** cells are continuously lost and replaced by the underlying cells. A large portion of household dust contains human skin cells. The powdery material that comes off from your skin on scratching or on hard rubbing while bathing contains same dead cells.
- In plants, the cells at the growing points **(meristems)** divide very rapidly and produce new leaves, buds and flowers, etc.
- Specialised **germinal cells** in the ovary and testis in animals and in the ovary and anthers in plants undergo the other type of cell division called meiosis to produce sex cells.
- Uncontrolled non-stop cell cycles may lead to **tumours that may or may not be cancerous.**

Cell production and cell death

- As **children** we grow, because new cells are continously being produced and they outnumber the dying cells.
- When we are **adults**, our cell population stays constant. The number of new cells produced equals the number of cells dying.
- As we grow **old**, the number of new cells produced runs short of those that are dying.

2.4 MEIOSIS (Reduction division producing gametes)

Meiosis is the kind of cell division that produces the sex cells or the gametes. It takes place in the reproductive organs (**testis** and **ovary**) in humans to produce ***sperms*** and ***ova***. In the flowering plants, it takes place in the **anthers** and the **ovary** to produce ***pollen grains*** and ***ovules***.

The most significant aspect of meiosis (*meiosis* : diminution) is that the **number of chromosomes** in the sex cells is halved. *For example*, out of the 23 pairs of chromosomes in humans, only single chromosomes *i.e.* one member of each pair **(haploid)** are passed on to the sex cells. This is essential because when the male and female gametes fuse during fertilisation, the normal double **(diploid)** number of chromosomes (in pairs) is reacquired. The diploid number, as a rule, is expressed as **"2n"** and the haploid number as **"n"**.

Stages in meiosis (Fig. 2.4) [As per scope of syllabus, the **stages of meiosis are not required**]. However, just to know the basic about it, meiosis is completed in two divisions, the first is the **reduction division** and the second is **mitotic division** (Fig. 2.4).

2.4.1 Significance of Meiosis

1. **Chromosome number is halved** in gametes (sex cells), so that on fertilization, the normal number ($2n$) is restored.
2. It provides for **mixing up of genes** which occurs in two ways :
   (i) **The maternal and paternal chromosomes get mixed up** during the first (reduction) division as they separate from the homologous pairs.
   (ii) **Cross joining.** While the maternal and paternal chromosomes are separating, the chromatid material very often gets exchanged between the two members of a homologous pair (as shown in Fig. 2.5) resulting in genetic recombination.

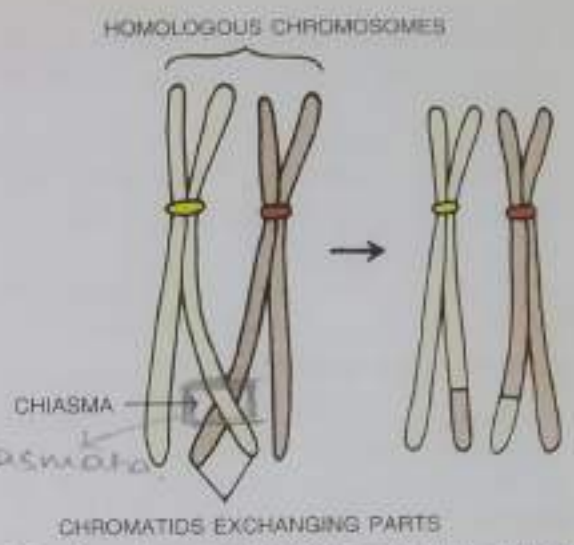


Fig. 2.5 : Crossing over between maternal and paternal chromatids during meiosis to produce a new combination of genes

Both these permutations and combinations provide for the innumerable variations in the progeny. That is how the children of the same parents, howsoever similar, are different from each other in certain respects. The variations often contribute in evolution.

Table 2.2 : Differences between Mitosis and Meiosis

	Mitosis	Meiosis
1. *Where it occurs*	in the **somatic** (body) **cells**.	in **reproductive cells**.
2. *What for*	to provide **for growth and replacement**.	only **for gamete formation**.
3. *When it occurs*	continuously **throughout life**.	only in **reproductively active age**.
4. *Number of daughter cells produced*	**two daughter cells**.	**four daughter cells**.
5. *Number of chromosomes passed on to each daughter cell*	**full set of chromosomes** is passed on to each daughter cell. This is the **diploid** (2n) number of chromosomes.	Only **half the number of chromosomes** is (Only one member from each pair). This is the **haploid** (n) number of chromosomes.
6. *Number of nuclear divisions*	**a single nuclear division** after chromosome duplication.	followed by **two nuclear divisions** after chromosome duplication.
7. *Identity of chromosomes and genes in daughter cell*	**identical**.	**randomly assorted** between the gametes produced. This results in genetic variations.

CHECK POINT 01

1. Cell cycle consists of how many phases?
2. DNA replication occurs in which phase of cell cycle?
3. Which phase of cell cycle is known as pre-mitotic phase?
4. Which phase of cell cycle is actual phase of division?
5. Give example of cells which undergo continuous cell cycle and cell division.

CHECK POINT 02

1. In which cell mitosis occurs?
2. ..... is a longest and most complex stage of mitosis.
3. In which stage of mitosis spindle fibres get disappeared?
4. In which phase of mitosis nuclear membrane reforms?
5. What is the difference between cytokinesis in animal and plant cell?
6. Mitosis helps in the replacement of old or dead cells. True or false?

CHECK POINT 03

1. Which division is also called reductional division?
2. In which type of cells meiosis occurs?
3. Why meiosis-II is called homotypic division?
4. Name four stages similar in mitosis and meiosis.
5. Give difference between mitosis and meiosis on the basis of number of daughter cells produced.

2 B. STRUCTURE OF CHROMOSOMES

You have learnt earlier that the most conspicuous events occurring during cell divisions are all related to chromosomes. The duplicated chromosomes get evenly distributed into the daughter cells during mitosis. Thus, all body cells that are the result of a long chain of repeated mitotic divisions, have the same type of chromosomes in the same number. This ensures the normal functioning of the cells and through that, the life of the organism.

2.5 WHAT ARE CHROMOSOMES?

When a normal unstained living cell is observed under a light microscope, its nucleus may not appear to contain any particular thing inside. But when the same cell is stained with suitable dyes, several structures become noticeable in the nucleus. In all probability, you may be looking at a non-dividing stage (interphase) of the cell, although depending upon the part of the body from where the cell has been taken, it may as well show some division stages too.

In the interphase, the nucleus shows a network of very long extremely thin dark-staining fibres called *chromatin fibres*. As the cell begins to enter the first stage (prophase) of cell division, the **chromatin fibres condense** to form chromosomes (Fig. 2.6). The chromosomes readily pick up certain dyes and get coloured, hence the name chromosomes (*chroma:* coloured, *soma* : body).

Chromosomes are the highly condensed coiled chromatin fibres.

2.6 DISCOVERY OF CHROMOSOMES

Chromosomes were first discovered in 1882 by a German Scientist, Walther Fleming. He noticed these in the rapidly dividing cells of the larvae of salamander (an amphibian). The microscope he used was of old type and through it, he saw minute threads that appeared to be dividing lengthwise. Fleming called their division *mitosis* (literally meaning "thread"). Subsequently, with the help of more powerful microscopes and by using special techniques, the chromosomes and their constituents have been studied in great detail.

2.7 STRUCTURE OF CHROMOSOMES

Each chromosome in its condensed form as visible during the start of cell division, consists of two chromatids joined at some point along the length. This point of attachment is called **centromere**, and it appears as a small constricted region (Fig. 2.7). The centromere also serves to attach to the spindle fibre during cell division. Each chromosome's centromere is located at a particular site. As the spindle

Fig. 2.7 : A human chromosome showing the chromatids and the centromere (constricted part)

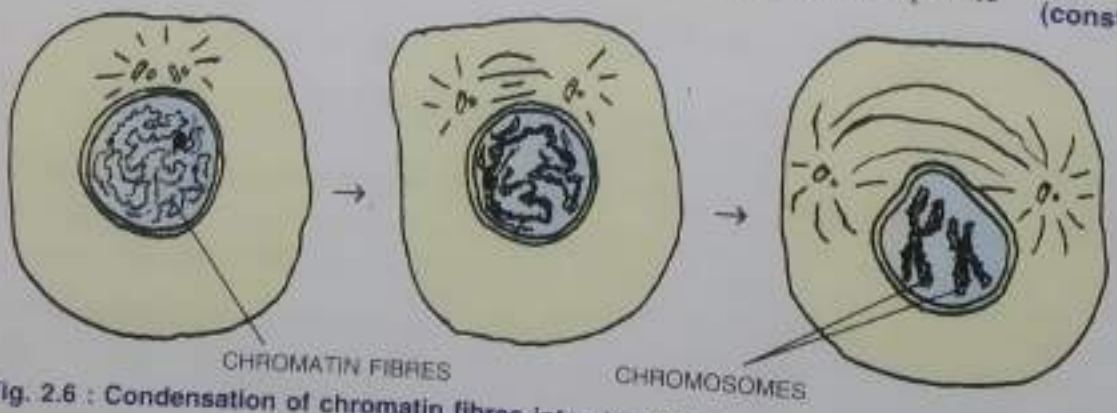


Fig. 2.6 : Condensation of chromatin fibres into chromosomes during mitotic prophase

fibre contracts, the sister chromatids are separated at the centromere, and each is pulled away from the other towards the two poles of the dividing cell (see Fig. 2.2, stages D & E, page 9).

After the completion of cell division, the chromatids (now called chromosomes) decondense and revert to their very long and fine thread-like chromatin fibres. There would be as many chromatin fibres inside the nucleus as the number of chromosomes that appear during cell division.

Chromatin : The chromatin material that constitutes the fibre is formed of two substances :

1. **DNA** (deoxyribonucleic acid) — about 40%.
2. **Histones** (a particular type of proteins) — about 60%.

Figure 2.8 given below is a highly diagrammatic representation of the structure of chromatin fibres showing the sequentially enlarged view of the DNA strand.

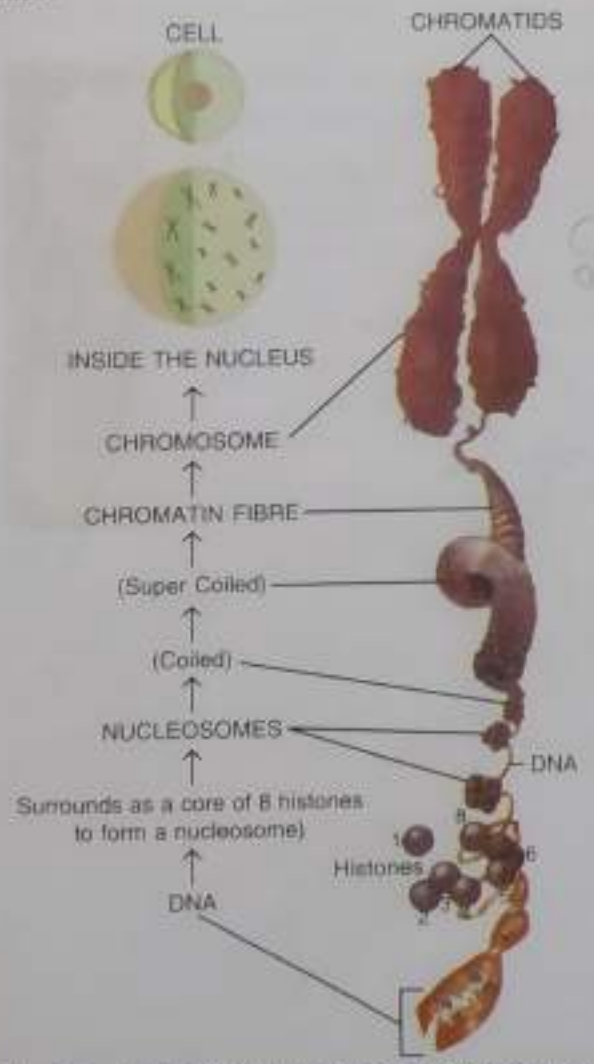


Fig. 2.8 : A highly diagrammatic representation of the structure of a chromosome, the chromatin fibre and DNA

The DNA strand winds around a core of *eight histone* molecules. This core can be imagined like a football, around which a long rope is wound with one or two loops. Each such complex is called ***nucleosome***.

A single human chromosome may have about a million nucleosomes!

The entire chromatin fibre is coiled and supercoiled something like the coils and supercoils we see in a typical telephone cord (Fig. 2.9).

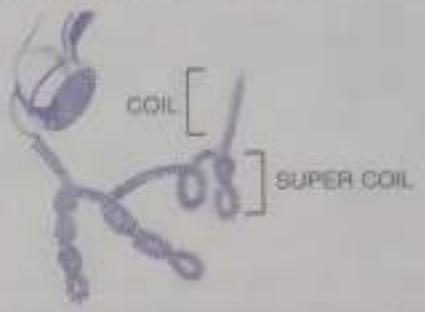


Fig. 2.9 : The concept of coiling and supercoiling as is also found in the chromatin fibre of the chromosomes

Structure of DNA

[The shape of the DNA molecule was studied by Rosalind Franklin in 1953 and the structure was finally worked out by Watson and Crick in the same year.]

The DNA is a very large single molecule, and hence it is described as a **macromolecule**. It is composed of two complementary strands wound around each other in a double helix (Fig. 2.10).

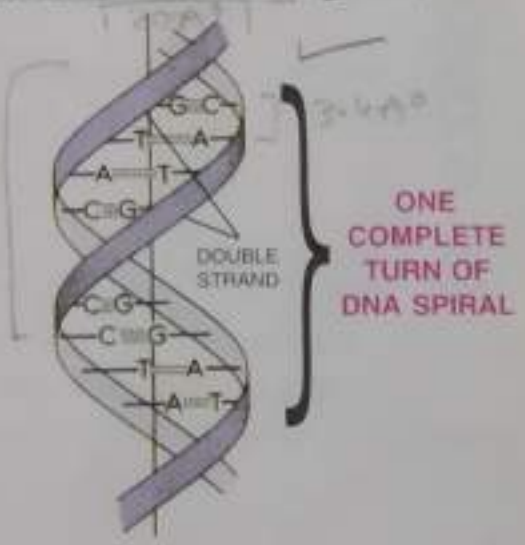


Fig. 2.10 : Schematic diagram of helical structure of DNA

Each single DNA strand is composed of repeating **nucleotides** which are made of three components, ***phosphate***, ***sugar*** (pentose) arranged lengthwise and

a **nitrogenous base** attached to the sugar inwards (Fig. 2.11 A) which extends to join (by a hydrogen bond) the complementary nitrogenous base from the other strand (Fig. 2.11B). Thus the two strands together make a ladder-like arrangement, with the nitrogenous bases forming the "rungs" of the ladder. The bases are – Adenine (A), Guanine (G), Cytosine (C) and Thymine (T).

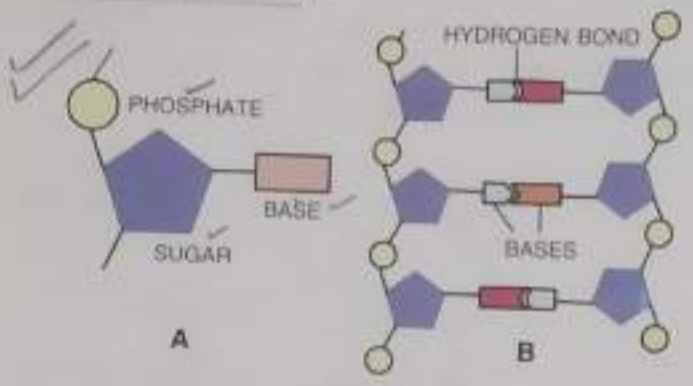


Fig. 2.11 : A – The basic structure of a nucleotide, B – Two paralleled strands

Formation of the new DNA. During the interphase of cell cycle, each DNA molecule (*i.e.* the chromosome) duplicates in readiness for their equitable distribution in the two daughter cells during mitosis. For replication, the DNA double helix opens at one end, making the two strands free to which **new strands begin to form** and the process continues in a sequence for the whole length of the DNA (Fig. 2.12). The entire replication is a very complicated process which you will study in detail in higher classes.

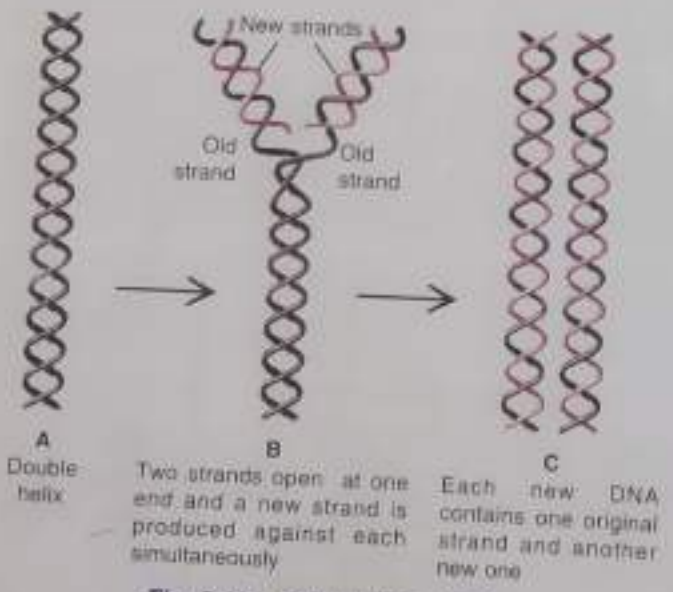


Fig. 2.12 : Replication of DNA

2.8 WHAT ARE GENES ?

***Genes* are specific sequences of nucleotides on a chromosome, that encode particular proteins which express in the form of some particular feature of the body.**

Extra | **DNA FINGERPRINTING** | **Not in syllabus**

Lots of regions in between genes are just non-functional. Such areas (about 99 percent of the total DNA) show tremendous variations from person to person and help in identification of the individual by what is popularly known as **DNA fingerprinting** but better called **DNA profiling**. DNA fingerprinting is useful in establishing paternity and maternity in criminal cases. Blood or semen stains, hair, or items of clothing found at the site of crime provide biological evidence through DNA fingerprinting.

?

PROGRESS CHECK

1. Fill in the blanks :

(i) Chromatin fibre is made up of DNA and Histones

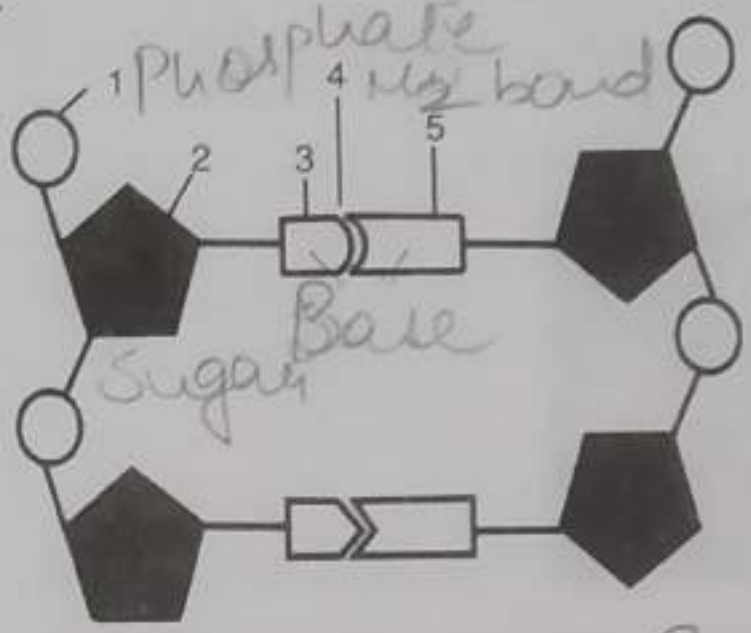
(ii) The chromatids are attached to each other at Centromere

(iii) DNA replicates in the Interphase of the cell cycle.

(iv) Who first discovered the structure of DNA ? Rosalind Franklin

E. STRUCTURED/APPLICATION/SKILL TYPE

1. Given below is a schematic diagram of a portion of DNA.



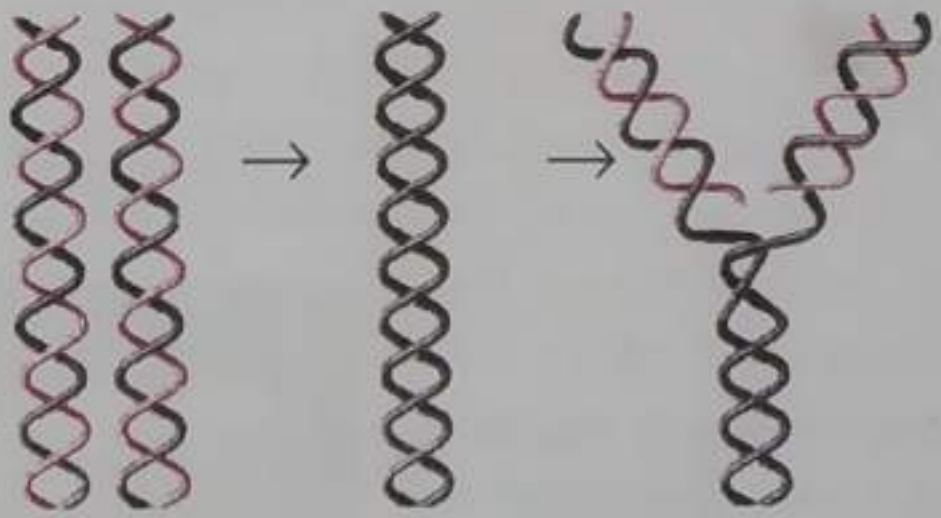
(a) **How many** strands it is showing?

(b) **How many** nucleotides have been shown in each strand?

(c) **Name** the parts numbered 1, 2, 3, 4 and 5 respectively.

(d) **Name** the DNA unit constituted by the parts 1, 2 and 3 collectively.

2. The three sketches given below (A, B and C) are intended to represent the replication of DNA. **What** should be their correct sequence starting with the first and ending with the last ? .....



CHECK POINT 04

1. What are centromeres?
2. Name the thread-like structure found in a resting state of nucleus.
3. Name the chromosome in which centromere is present at the terminal end.
4. Who proposed the double helix structure of DNA?
5. Write the nitrogenous bases found in DNA.

SUMMARY

- **Cell** is the basic structural, functional and biological unit of all living organisms.
- **Cell cycle** involves a series of changes in a cell and cell division. It is the process of formation of new cells from the pre-existing cells.
- Cell cycle consists of two main phases; **Interphase** or non-dividing phase and **Mitotic phase** or M-phase.
- **Interphase** is further divided into three main stages on the basis of its synthetic activities. These are **G_1-phase** first growth phase (synthesis of RNA and proteins), **S-phase** or synthesis phase (DNA replication) and **G_2-phase** or second growth phase (synthesis of RNA and proteins).
- The **M-phase** is the actual phase of division. It occurs in two steps; i.e. **Karyokinesis** and **Cytokinesis**.
- **Cell division** is the process by which life perpetuates. It is of two types; mitosis and meiosis.
- **Mitosis** leads to the production of two identical daughter cells with the same number of chromosomes.
- **Meiosis** is a special type of cell division taking place in sex cells or gametes. In this cell division, a cell undergoes two successive divisions to produce four daughter cells. Each cell contains half the number of chromosomes as compared to the parent cell.
- **Chromosomes** are highly condensed and coiled chromatin fibres. They possess genes which are responsible for the transfer of traits from one generation to the next generation.
- **Chromatins** are the thread-like form of chromosomes. These are present in nucleus during resting state of the cells.
- On the basis of the position of the centromere, chromosomes are of four types; Metacentric, Sub-metacentric, Acrocentric and Telocentric.
- **Genes** are segments of DNA.
- The DNA molecule consists of two helical strands which are unbranched and are twisted around a common axis.
- Each deoxyribonucleotide unit consists of 3 basic molecules namely phosphate group, ribose sugar and nitrogenous base.

NOTES

Chapter :Introduction to Cell, Cell Cycle, Cell Division and Structure of Chromosome

CELL

. Cell is the structural and functional unit of life.

. All organisms including humans are made up of microscopic cells.

. All cells arise from preexisting cells which undergo repeated divisions to form a large mass of cells (Cell theory given by Schleiden and Schwann) .

. Each and every cell in an organism possess three essential parts which are cell membrane, cytoplasm and nucleus.

Cell Cycle

It is an orderly sequence of events taking place in a cell leading to its division. It is also known as a period between the growth of the cell and its division into daughter cells. The cell cycle is divided into two main phases such as:

1. Interphase

2. M-Phase

(diagram of cell cycle)

1. It is the period between two successive cell divisions. It is also known as the resting phase. Interphase itself is divided further into three main stages which are first growth phase, synthesis phase and second growth phase.

In first growth phase synthesis of RNA and protein takes place.

In synthesis phase DNA replication takes place.

In second growth phase only RNA and Protein synthesis continues.

2. Following the interface, cell enters into the M-phase. It starts with the division of nucleus which is also called karyokinesis and usually ends with the division of cytoplasm which is also termed as cytokinesis.

Cell Division

It is one of the most fundamental characteristic of all living organisms. It is essential for maintaining life of the organisms on the earth. It forms new cells for growth ,repair, replacement and reproduction.

There are two types of cell division :

1. Mitosis

2. Meiosis

(diagram of plant and animal cells showing different stages of Mitosis)

1. Mitosis

It is a type of cell division in which one parent cell divides into two identical daughter cells. It is also known as somatic cell division as it takes place only in somatic cells. Chromosomes in mitosis are replicated and are distributed equally into the two daughter nuclei. In mitosis both parent cell and the daughter cells have equal number of chromosomes at the end of division. Therefore, it is also known as equational division. Mitosis is broadly divided into two stages

a. Karyokinesis that is division of nucleus.

b. Cytokinesis that is division of cytoplasm.

Following events take place during karyokinesis: -

. Prophase

. Metaphase

. Anaphase

. Telophase

In cytokinesis cytoplasm division takes place

. In animal cells cytokinesis takes place by cell furrow method.

. In plant cells cytokinesis takes place by cell plate formation.

CHROMOSOMES

. Chromosome can be seen only in metaphase and anaphase stage of cell division.

. In non dividing cells they are seen as a network of thread like structures called chromatin reticulum.

. Chromosome number remains constant in the cells of each species.

. On the basis of number of chromosomes , the cells are said to be haploid or diploid.

. The character and complexity of an individual does not depend on the number of chromosome rather it depend upon the types of genes present on the chromosomes.

. Parts of chromosome are: - chromatid, centromere, chromonema and chromomeres.

. Chromosomes which determines sex of an individual are called sex chromosomes or allosomes.

. Chromosomes other than sex chromosomes are called autosomes.

NUCLEIC ACID

. Nucleic acid are macromolecules which are composed of many small units called nucleotide.

. Nucleic acids are of following two types: -

1.DNA

2.RNA

. DNA is a double stranded helix made of many nucleotides. Nucleotides are linked with one another and make a polynucleotide chain.

. Watson and Crick proposed the molecular model of DNA by which physical , chemical and biological properties of DNA become clear.

Worksheet

1. **DRAW THE FOLLOWING DIAGRAMS IN YOUR NOTEBOOK (INTERLEAF)**
- CELL CYCLE.
- MITOSIS IN PLANT AND ANIMAL CELL.
- STRUCTURE OF DNA.
- STRUCTURE OF CHROMOSOME.
2. **WRITE ALL THE NOTES (GIVEN IN PDF) IN YOUR NOTEBOOK.**
3. **SOLVE THE QUESTIONS GIVEN AFTER EVERY TOPIC AND WRITE IT IN YOUR NOTEBOOK.**