2 Structure of Chromosomes, Cell Cycle and Cell Division

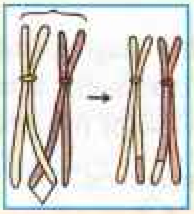
Syllabus : *Cell Cycle and Cell Division. Structure of chromosome.*

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.

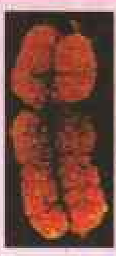
Basic structure of chromosome with elementary understanding of terms such as chromatin, chromatid, gene structure of DNA and centromere.

(Structure of chromosomes has been discussed before cell cycle and cell division for better understanding of 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. .

2 A. 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.

2.1 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. 2.1). 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.

2.2 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

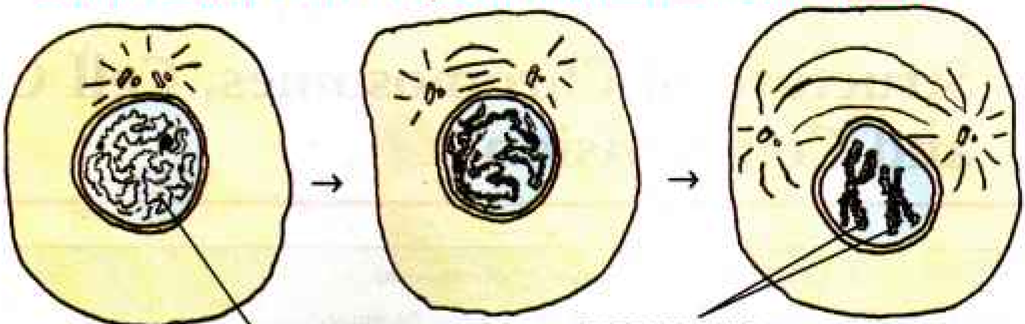


Fig. 2.1 : Condensation of chromatin fibres into chromosomes during mitotic prophase

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.

2.3 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. 2.2). 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 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. 2.9, stages D & E, page 13).

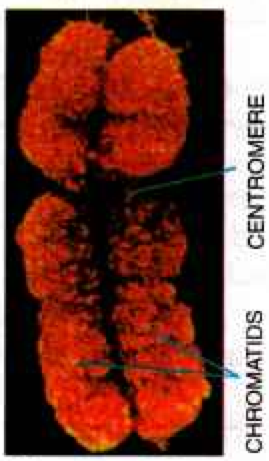


Fig. 2.2 : A human chromosome showing the chromatids and the centromere (constricted part)

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

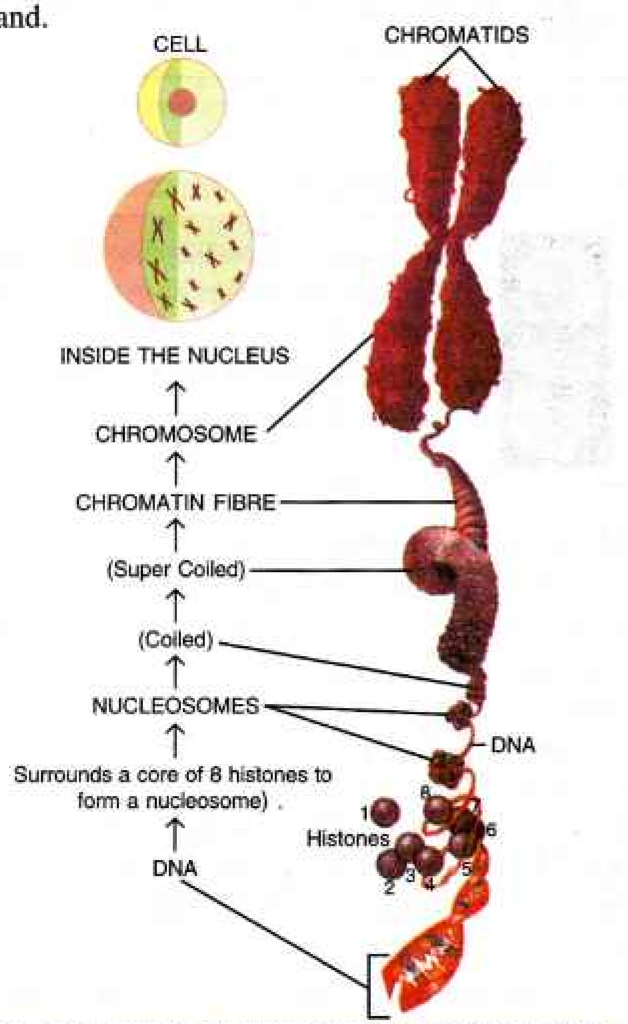


Fig. 2.3 : A highly diagrammatic representation of the structure of a chromosome, the chromatin fibre and DNA

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 super-coiled something like the coils and supercoils we see in a typical telephone cord (Fig. 2.4).

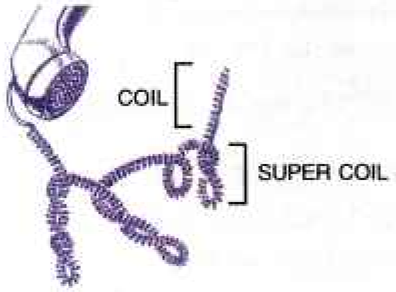


Fig. 2.4 : The concept of coiling and supercoiling as is also found in the chromatin fibre of the chromosomes

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. 2.5).

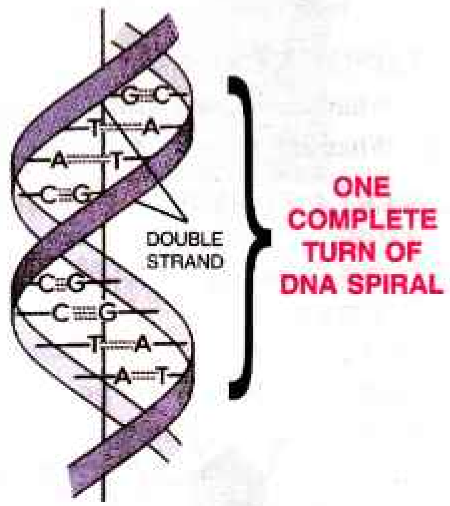


Fig. 2.5 : Schematic diagram of helical structure of DNA

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. 2.6 A) which extends to join (by a hydrogen bond) the complementary **nitrogenous base** from the other strand (Fig. 2.6B). 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). Adenine pairs with Thymine with two hydrogen bonds. Guanine pairs with Cytosine with three hydrogen bonds (Fig. 2.6 reveals the same)

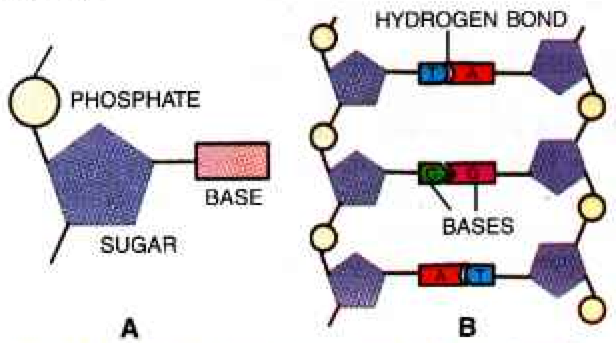


Fig. 2.6 : A – The basic structure of a nucleotide, B – Two parallel strands of a part of DNA

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. 2.7). The entire replication is a

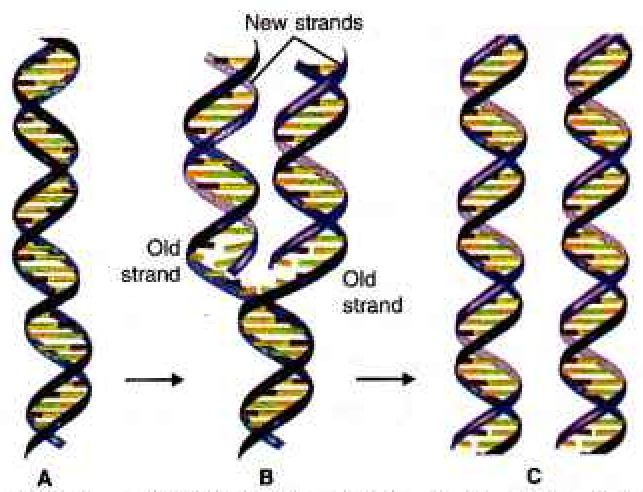


Fig. 2.7 : Replication of DNA

very complicated process which you will study in detail in higher classes.

2.4 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 ....
   (ii) The chromatids are attached to each other at ....
   (iii) DNA replicates in the .... of the cell cycle.
   (iv) Who first discovered the structure of DNA ? ....
   ....

REVIEW QUESTIONS

A. MULTIPLE CHOICE TYPE

(Choose the best option out of the four alternatives a, b, c and d)

1. The chromatin material is formed of
   (a) DNA only (b) DNA and Histones
   (c) Histones only (d) Nucleotides
2. The term "chromosomes" literally means
   (a) Inherited bodies (b) Twisted threads
   (c) Coloured bodies (d) Shining threads

B. VERY SHORT ANSWER TYPE

1. **Name** the following :
   (a) The repeating components of each DNA strand lengthwise.
   (b) The complex structure consisting of DNA strand and a core of histones.
   (c) The type of bond which joins the complementary nitrogenous bases.
   (d) The three components of a nucleotide.

C. SHORT ANSWER TYPE

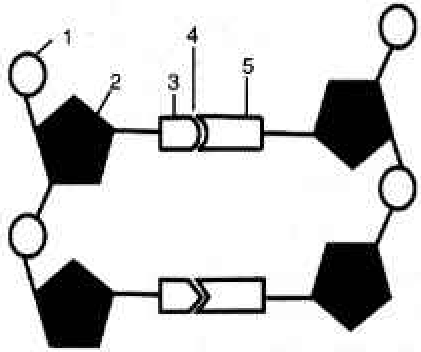
1. **What** is the difference between chromatin fibre and chromosome ?
2. **What** are the rungs of the "DNA ladder" made of?
3. Correct the following statements if there is any mistake.
   (a) The four nitrogenous bases in the DNA are Guanine, Thiamine, Adrenaline and Cytosine.
   (b) Genes are specific sequences of bases on a chromosome.
   (c) A nucleotide is composed of a sulphate, a sugar (pentose) and a nitrogenous base.
   (d) Nucleosomes are groups of cysteine molecules surrounded by DNA strands.
   (e) If there are 46 chromosomes in a cell, there will be 23 chromatin fibres inside the nucleus during interphase.

D. LONG ANSWER TYPE

1. **What** are nucleosomes ?
2. **What** are genes ?

E. STRUCTURED/APPLICATION/SKILL TYPE

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



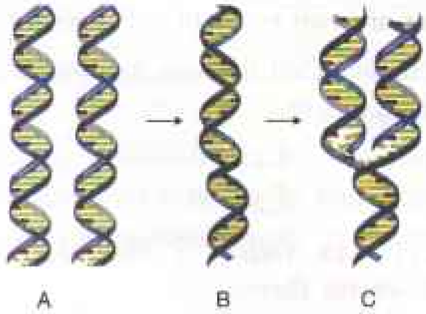
(a) **How many** strands are shown in the diagram?

(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 ? ....



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

2.5 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. 2.8 : A 4-day-old human embryo containing 16 cells, resulting from four cell divisions [1 × 2 = 2; 2 × 2 = 4; 4 × 2 = 8; 8 × 2 = 16]. 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 higher forms, as in humans, or in the banyan tree, special cells in the reproductive organs undergo a special kind of cell division (***meiosis***) to produce sperms and eggs. The 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	*Chromosomes* in WOMAN
(a) **Body cells**	= 46 (23 pairs) (2*n*)	46 (23 pairs) (2*n*)
(b) **Sex cells** (sperms and eggs) =	23 (single) (*n*) ↘	23 (single) ↙ (*n*)
Fertilised egg	(from sperm) 23 + 23 (from egg)	
	New baby = 46 (23 pairs) (2*n*)	

2.6 TYPES OF CELL DIVISION

There are two types of cell division :-

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

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

MITOSIS is the cell division in which one parent cell divides into two identical daughter cells.

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, the nucleus prepares for this change and doubles the quantity of DNA (the chromosome substance). This is the **interphase** (Fig. 2.9), 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 — Karyokinesis

Karyokinesis of 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 2.9 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 and is termed **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 duplicated **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. 14)]

(ii) Metaphase (*meta* : after) (Fig. 2.9 C)

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

(iii) Anaphase (*ana* : up, back) (Fig. 2.9 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.

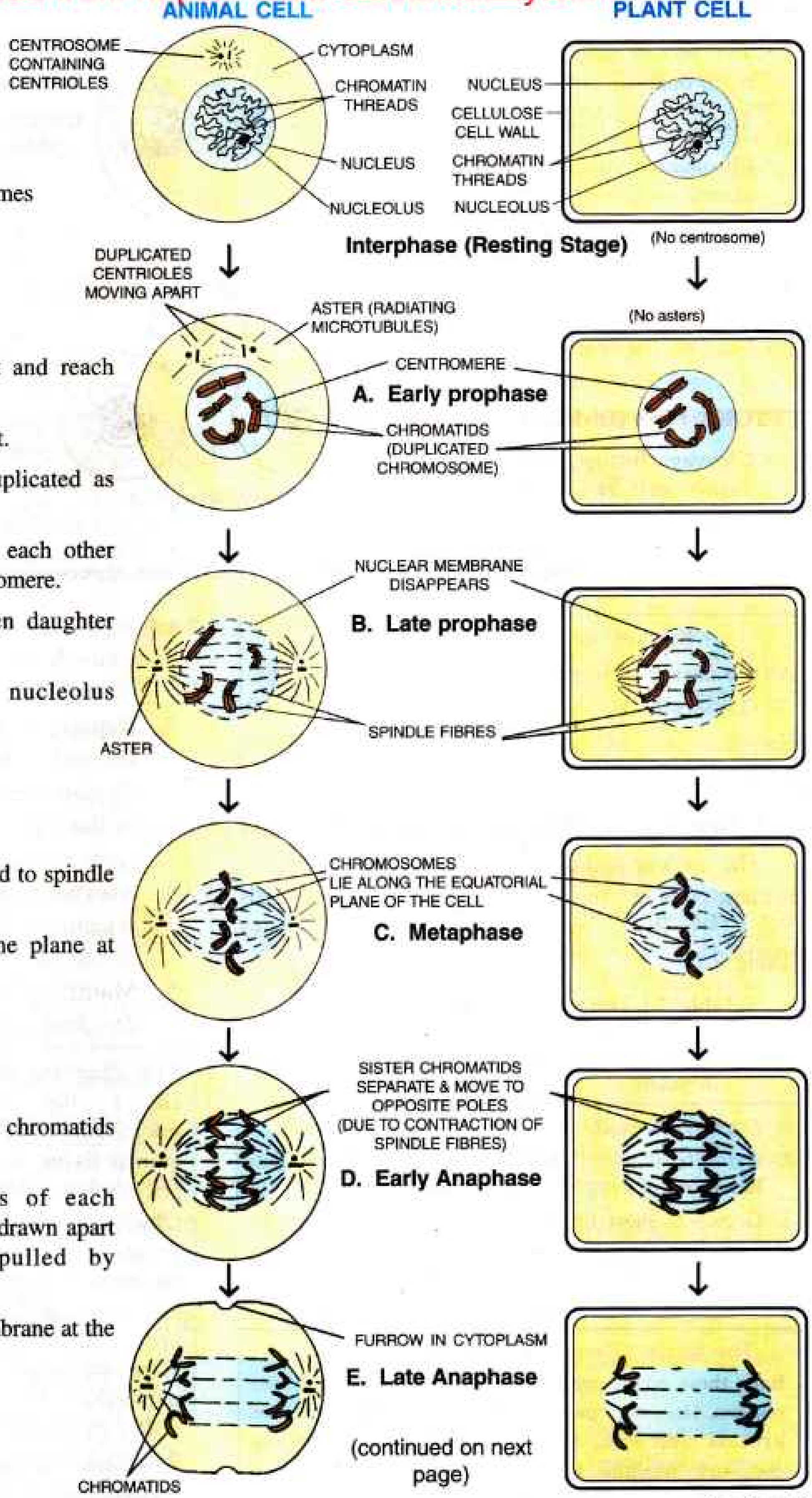
(iv) Telophase (*telo :* end) (Fig. 2.9 F)

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. 2.9).



INTERPHASE (resting phase)

No visible change in chromosomes but active synthesis of DNA

(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.

(ii) METAPHASE (C)

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

(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.

(continued on next page)

Fig. 2.9 : 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.

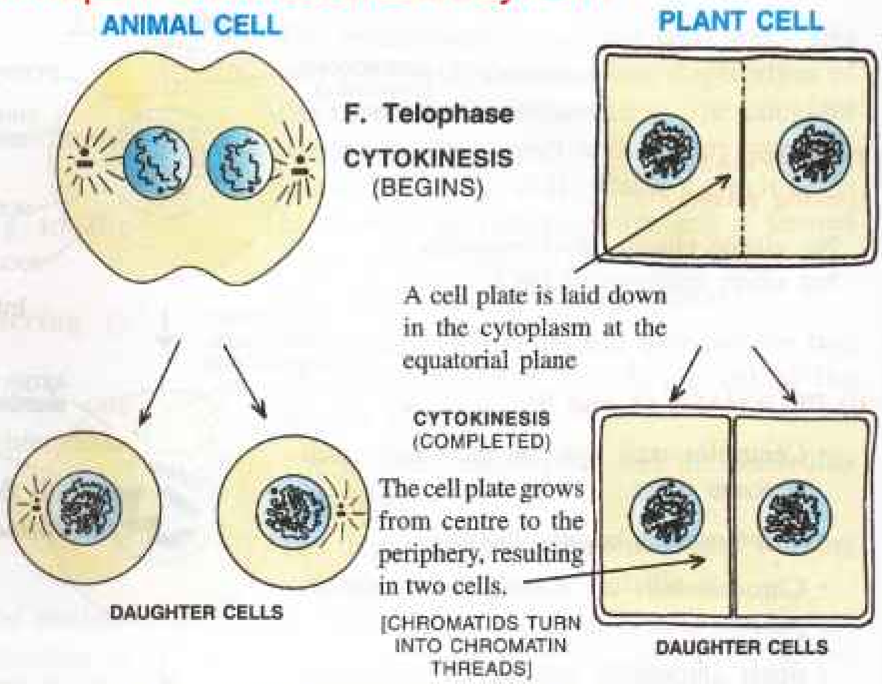


Fig. 2.9 (Continued) : Mitosis (In a cell where chromosome number is 4)

> **Karyokinesis and Cytokinesis**
>
> All the nuclear changes that occur during cell division are collectively termed **karyokinesis** (**karyo** : nucleus)
>
> Karyokinesis is followed by the division of cytoplasm (**cytokinesis**).

2.6.2 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. 2.9). 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 loses its identity in the process and two, the "daughter" cells are not necessarily feminine. However, these two expressions are being used conventionally.**

2.6.3 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.

> **1** — Cell in interphase stage
>
> **2** — Cell in prophase stage : Advancing condensation of chromatin network into chromosomes.

3 — Cell in metaphase stage : Chromosomes arranged at "equator" (as if seen from the polar end above).

4 — Cell in anaphase stage : Chromosomes start getting pulled to the poles.

5 — Cell in telophase stage : Chromosomes reach the "poles" and nucleus is being formed.

6 — Young cells formed 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.

2.7 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) **first growth phase,** (ii) **synthesis phase** and (iii) **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).

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

(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.

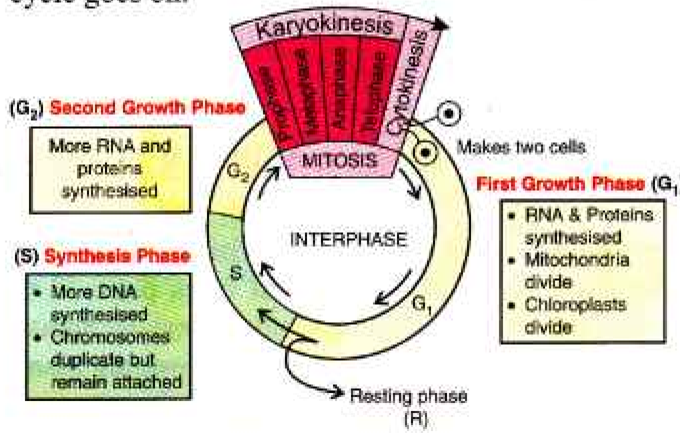


Fig. 2.10 : Cell cycle

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.

Downloaded from https:// www.studiestoday.com

- 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.

2.8 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. 2.11) [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 meiosis I and meiosis II, the first is the **reduction division** and the second is **mitotic division** (Fig. 2.11).

EXTRA **NOT IN SYLLABUS**

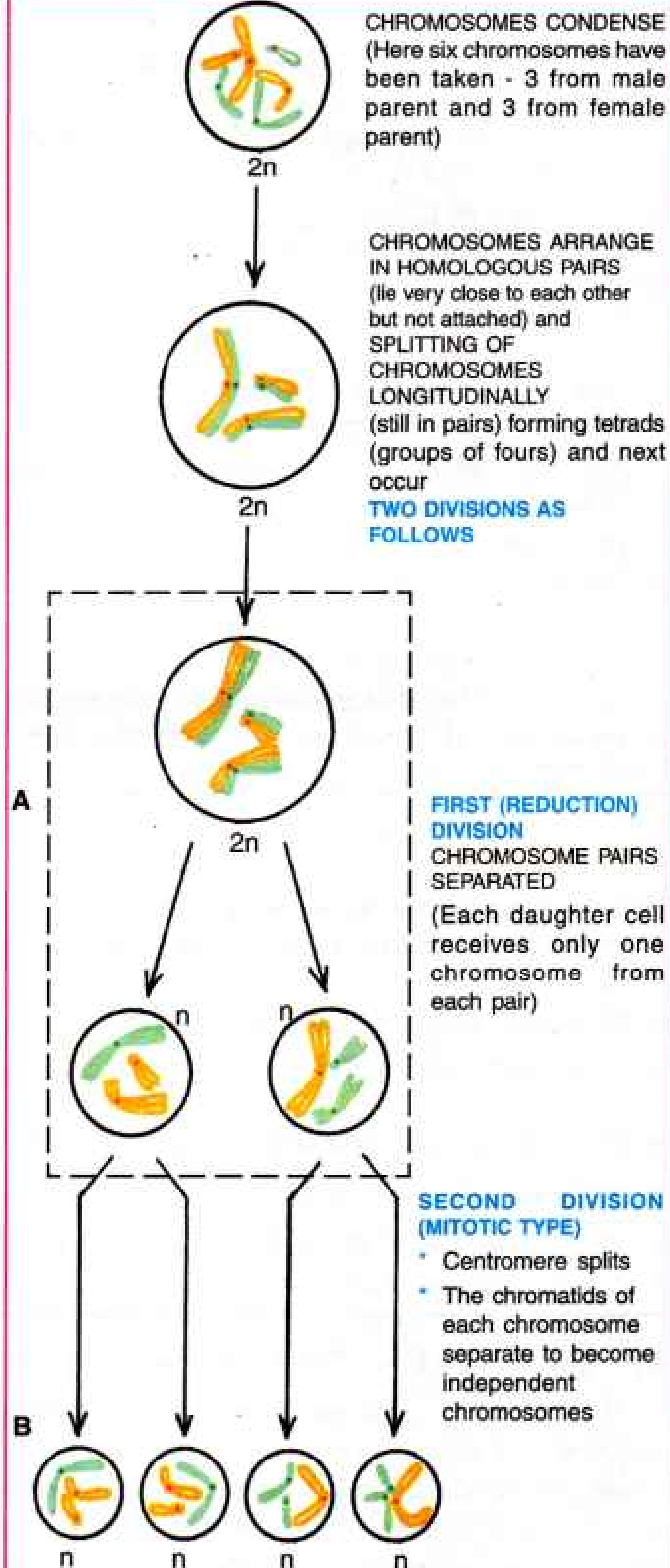


Fig. 2.11 : The behaviour of chromosomes shown during nuclear divisions in meiosis. Chromosome number taken is 6 (=3 pairs). We may imagine that the hollow outlined yellow chromosomes are paternal (having been received from male parent) and the solid green ones maternal (from the female parent).

2.8.1 Significance of Meiosis

1. **Chromosome number is halved** in gametes (sex cells), so that on fertilization, the normal number (2*n*) 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. 2.12) resulting in genetic recombination.

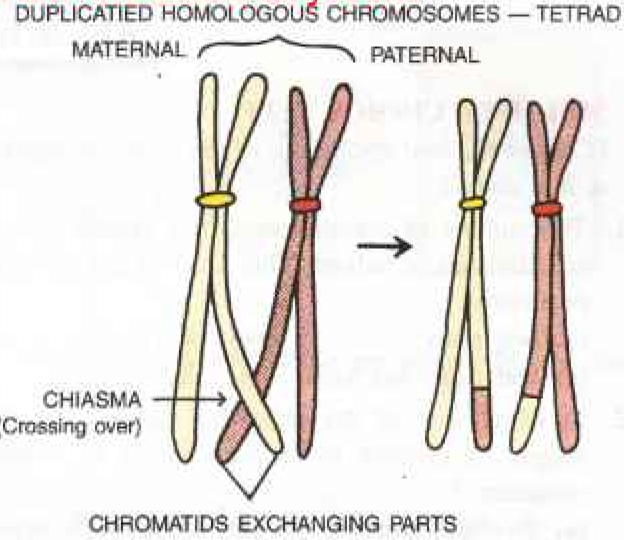


Fig. 2.12 : Crossing over between maternal and paternal chromatids during meiosis to produce a new combination of genes — having split at the chiasma

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.	**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.

EXTRA — **STEM CELLS** — **Not in syllabus**

[Stem cells mean undifferentiated cells which can undergo unlimited divisions and give rise to one or several different types of cells.]

The term **"stem cells"** is very much in the news these days, and specially so in connection with the treatment of certain human diseases.
The term **"stem"** though more familiar with respect to plants, has a wider sense meaning **"branch off"**. The plant stem bears unspecialised cells that can differentiate into leaves, flowers, fruits, seeds, *etc.*
In animals, there are embryonic cells which differentiate into different tissues and organs. Embryonic stem cells take different development directions. *For example*, some become nerve stem cells, some become specialised to produce blood cells and so on. These tissue specific stem cells persist throughout life even in adults.

REVIEW QUESTIONS

A. MULTIPLE CHOICE TYPE

(Choose the best option out of the four alternatives a, b, c and d)

1. The number of chromosomes in a certain type of cell division is halved. This kind of cell division occurs in
   (a) only testis (b) only ovary
   (c) both ovary and testis (d) all body cells
2. In which one of the following options the two stages of mitosis have been given in correct sequence ?
   (a) Prophase, anaphase (b) Metaphase, telophase
   (c) Anaphase, telophase (d) Telophase, anaphase
3. Synthesis phase in the cell cycle is called so for the synthesis of more of
   (a) RNA (b) RNA and proteins
   (c) DNA (d) Glucose

B. VERY SHORT ANSWER TYPE

1. Imagine one cell (A) has undergone one mitotic division and another cell (B) has completed its meiotic division. How many cells would the two produce?
   Cell A : ....
   Cell B : ....
2. **Match** the events given in column A with the phase in mitotic cell division in Column B

Column 'A'	Column 'B'
(a) Chromosomes get arranged in a horizontal plane at the equator.	Anaphase
(b) Daughter chromosomes move to the opposite poles of a spindle.	Prophase
(c) Chromosomes become visible as fine long threads.	Telophase
(d) Chromosomes lose their distinctiveness and gradually become transformed into a chromatin network.	Metaphase

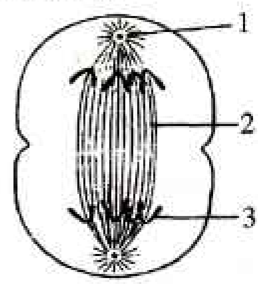
3. Fill in the blanks
   (a) Mitosis occurs in our .... cells.
   (b) Mitosis produces two daughter cells whereas meiosis produces .... daughter cells.
   (c) Meiosis occurs only in .... cells.
   (d) Modern humans have 46 chromosomes. Their sperms and eggs will have .... chromosomes each.
   (e) During the pairing of chromosomes in meiosis, the .... chromosomes come to lie side by side.
   (f) The .... (s) are surrounded by radiating rays and termed as aster.

C. SHORT ANSWER TYPE

1. **State** the difference between :
   (a) Chromosome and chromatid,
   (b) Centrosome and centromere,
   (c) Aster and spindle fibres.
   (d) Haploid and diploid
2. "First meiotic division is the reduction division". **What** does the word 'reduction' refer to in this statement?
3. "Gametes must be produced by meiosis for sexual reproduction". **Why** is it so?
4. Mention whether the following statements are ***true*** **(T)** or ***false*** **(F)**. Give reason in support of your answer.
   (a) As you grow from childhood to adulthood, your skin cells divide only to replace such cells that are lost from the surface. (T/F)
   (b) The unfertilised human egg has half the number of chromosomes of the body cells. (T/F)
   (c) Nuclear membrane in a mitotically dividing cell remains intact up to the metaphase and disappears only in the telophase. (T/F)
   (d) Mitotic cell division can be a mode of reproduction. (T/F)
   (e) Crossing-over between chromatids can occur only between homologous chromosomes. (T/F)

D. STRUCTURED/APPLICATION/SKILL TYPE

1. The diagram below represents a stage during cell division. Study the same and then answer the questions that follow:



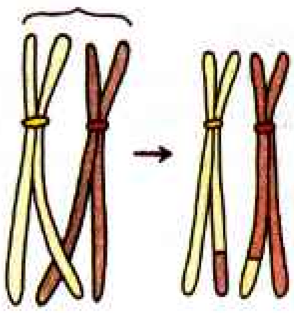
   (a) **Name** the parts labelled 1, 2 and 3.
   (b) **Identify** the above stage and give a reason to support your answer.

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

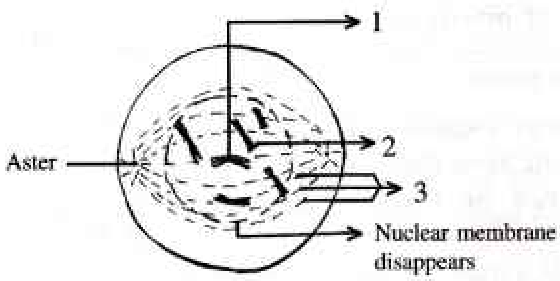
(d) **Name** the stage prior to this stage and draw a diagram to represent the same.

2. **Draw** a labelled diagram to show the metaphase stage of mitosis in an animal cell having '6' chromosomes.

3. The diagram given below represents a certain phenomenon which occurs during meiosis. **Name** and **explain** the phenomenon by using the terms — **homologous chromosomes, chromatids, crossing-over**.



4. Given below is a diagram representing a stage during mitotic cell division in an animal cell. **Examine** it carefully and **answer** the questions which follow.



(a) **Identify** the stage. Give one reason in support of your answer.

(b) **Name** the cell organelle that forms the 'aster'.

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

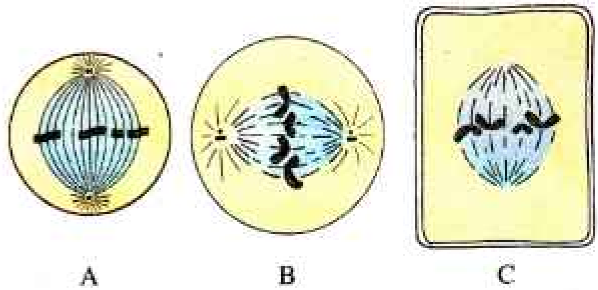
(d) **Name** the stage that follows the one shown here. How is that stage identified?

(e) **Mention** two differences between mitosis and meiosis with regard to :
  (i) The number of daughter cells produced.
  (ii) The chromosome number in the daughter cells.

5. Given ahead are three diagrammatic sketches (A, B and C) of one and the same particular phase during **mitotic type of cell division**.

(a) Identify the phase ....

(b) What is the diploid number of chromosomes shown in them ? ....



(c) Identify whether these are animal cells or plant cells ?

A ....,

B ....,

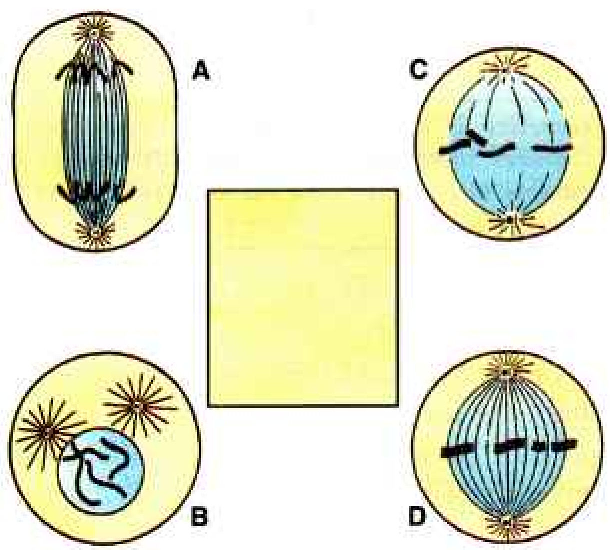
C ....,

(d) Which of these is/are shown in correct direction ? (Tick mark the correct answer).

(i) Only A (ii) Only B

(iii) Only A and C (iv) All the three

6. Shown below are four stages (A, B, C, D) (not in sequence) of a certain kind of cell division.



(a) **Is it** a plant cell or an animal cell? Give two reasons. ....

(b) **Is it** undergoing mitosis or meiosis?

....

(c) **What** should be the correct sequence of these four stages among themselves?

....

(d) **Name** the stage that should precede the earliest of these stages............................

(e) **Draw** the stage named above inside the blank space provided.

Downloaded from https:// www.studiestoday.com