AS PER THE LATEST ICSE SYLLABUS

Revised and Updated

LIVING SCIENCE BIOLOGY

D K RAO • J J KAUR

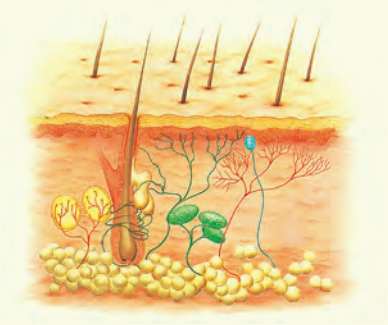
CLASS 10

Ratna Sagar

Based on the latest syllabus prescribed by the Council for the Indian School Certificate Examinations

LIVING SCIENCE BIOLOGY

CLASS 10



D K RAO
MPhil, PhD

J J KAUR
MPhil, PhD

Consulting Editors

Akhilesh Kumar Srivastava
MSc, BEd, MPhil
Head of the Department, Biology
La Martiniere College, Lucknow

Shyam Ganguly
Former Sr Science Master
Doon School
Dehra Dun

Illustrations by Sunil Dutt

Ratna Sagar

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Virat Bhavan, Commercial Complex, Mukherjee Nagar, Delhi 110009
PHONE: (011)47038000 ◆ **FAX:** (011)47038099

rsagar@ratnasagar.com ◆ ratnasagar.com ◆ ratnasagar.co.in

SHOWROOM: 4808/24 Bharat Ram Road, Darya Ganj, New Delhi 110002
PHONE: (011)43028000 ◆ **FAX:** (011)45166099

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Preface

Living Science 'Biology' for Class X conforms to the latest ICSE syllabus of the Council for the Indian School Certificate Examinations. The book contains all the material which is a part of the core syllabus.

Biology is about understanding how living organisms work. During the last couple of centuries, our knowledge of Biology has grown at a staggering rate.

We have written this book to give you a thorough introduction to Biology at the Secondary level. We have presented the various scientific concepts as vital, compelling and meaningful which might otherwise seem dull. Each part of this book has been carefully planned to make it student friendly and present Biology in an interesting, understandable and enjoyable manner. We have tried to stress the applications of what you are learning so that you can relate the facts to the living world.

THE 'GUIDED TOUR'

Before you start using this book, let us familiarize you with its major features.

Course Divided into Themes and Chapters

The book is divided into different chapters based on four themes. The continuity from one theme to another and one chapter to another is step by step, clear and methodical.

- Theme 1: **Basic Biology**
- Theme 2: **Plant Physiology**
- Theme 3: **Animal Study (with reference to humans only)**
- Theme 4: **Health: Diseases and Hygiene**

Learning Objectives

Learning becomes easy and purposeful if one is aware of the goals and targets. Thus, 'Learning Objectives' have been given in the beginning of each chapter to guide the learner about the concepts to be studied step by step. The Learning Objectives also provide an overview of the entire chapter.

The Text

Learning proceeds from concrete to abstract. One learns about the difficult unknown concepts from simple facts which are quite familiar to him/her. The main text introduces ideas from scratch. A lucid introduction to the chapter has been given to stimulate the interest of the learner in the respective topics. Informal and interactive style has been used throughout the text, which is divided into units and sub-units.

Self-Test Assignments

Each section is followed by a self-test assignment in the form of 'Check your progress' to reinforce the concept. Each chapter contains several such assignments which students will find valuable to obtain feedback about their progress.

Text and Illustration Coordination

A large number of figures have been used to enhance effectiveness of the text. Simple and clear illustrations have been designed keeping the needs of the reader in mind. The text and illustrations together teach the content better and in an interesting manner.

Use of Tables, Graphs and Flowcharts

The tables and graphs used in the text are capable of standing on their own (self-explanatory). In addition, important processes are explained in the form of flowcharts which are in coordination with the text.

Feature Boxes

The feature boxes contain topics of special interest—practical techniques or modern applications of science. Interesting facts related to the topics have been included at appropriate places as box material. These boxes will give you an indepth knowledge to help you understand the concept better.

Summary

The main text of each chapter has been summarized at the end of the chapter which lists the main points of the text. The summary is excellent for revision and to gain an overview of the topics covered in the chapters.

Terminal Exercises

Terminal exercises at the end of each chapter focus on the application of the subject matter and contain questions which give the opportunity to practice key skills. These exercises provide a full dress rehearsal for examination. They include a variety of questions to facilitate the integration of different concepts taught and test the grasp of the complete chapter. These will be highly helpful for examination purpose and to identify strengths and weaknesses in understanding the concepts.

Glossary and Sample Question Paper

A glossary of technical terms has been provided at the end of the book for quick reference. In addition, to provide a practice on the types of questions asked in the examination a sample question paper has also been provided. The sample question paper will be very useful for examination purposes.

We wish to express our sincere thanks to Mr S Sarkar for his valuable suggestions.

We sincerely hope that this book will meet the aspirations of the students as well as the teachers. Your valuable suggestions for further improvement of the book shall be appreciated and gratefully acknowledged.

Delhi

D K Rao
J J Kaur
University of Delhi
Delhi

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SYLLABUS
Cell cycle and cell division

SCOPE OF SYLLABUS
Cell cycle—Interphase (G_1, S, G_2) and M. Phase.
Cell Division: Mitosis and its stages. A basic understanding of meosis as a reduction division (stages not required). Significance and major differences between mitotic and meiotic division.

1 Cell Division

In Class IX you have studied about cells. A cell is the structural and functional unit of life. New cells arise from the pre-existing cells by the process of **cell division**.

Cell division is an important phenomenon that occurs in all living organisms. In unicellular organisms, cell division directly produces two individuals thus, it is a means of reproduction. In multicellular organisms, there are two types of cells—the somatic cells or the body cells (which form the body of the organism) and the reproductive cells (gamete-producing cells). In multicellular organisms, life begins from a single cell, the zygote, which divides and redivides into a number of cells to form a complete organism.

WHY CELLS DIVIDE?

The cells divide to produce new cells. The new cells are produced for:

- **growth:** Cell division produces new cells which grow and form a cluster of similar cells to form tissues and organs. This is essential for the growth of an organism.
- **replacement of dead cells:** The existing cells in our body are destroyed regularly. These cells should be replaced by the new cells for the normal functioning of the body. Cell division helps in the replacement of dead cells.
- **repair of tissues:** In case of injuries or normal wear and tear of tissues, cells divide and new cells fill up the broken cut ends to heal wounds. Thus, cell division is essential for the repair of the tissues.
- **reproduction:** New cells arise from pre-existing cells. The sex cells (sperms and eggs) are formed because of cell division (meiosis). These sex cells form zygote after fertilization. Thus, cell division is essential for reproduction.

TYPES OF CELL DIVISION

Two types of cell division occur in organisms—mitosis and meiosis.

Mitosis occurs in somatic cells (as well as reproductive cells such as in spermatogonia and oogonia before entering meiotic cycle) leading to growth and development.

Meiosis occurs in reproductive cells leading to gamete formation.

LEARNING OBJECTIVES

After completing this chapter, you will be able to:

- explain the need for cell division;
- describe the two types of cell division and list their phases;
- draw diagrams to explain the sequence of events in the two types of cell divisions;
- tabulate the differences between mitosis and meiosis;
- state the significance of mitosis and meiosis;
- explain how chromosome number is maintained during mitosis while it is halved during meiosis.

Karyokinesis and cytokinesis

The cell division includes two events—**nuclear division** or **karyokinesis** leading to division of parent nucleus into daughter nuclei; followed by the division of cytoplasm or **cytokinesis** leading to the division of the parent cell into daughter cells.

MITOSIS (GK. MITOS: THREAD)

Mitosis is an **equational division** in which **one parent cell divides to form two daughter cells**. The daughter cells formed are identical to each other and also to the parent cell in every respect. In **mitosis, the same normal chromosome number of the parent cell is maintained at each division of the cell** and hence it is referred as equational division.

Interphase

Interphase is the growth period between two successive divisions of a cell. Thus, it is a phase just before the cell starts dividing. This stage is said to be a **resting phase** because no external change in chromosomes is visible. However, the cell is metabolically most active and prepares itself for the division.

The following events take place during interphase:

- Synthesis of RNA and proteins required for normal life of the cell (energy production, growth, repair, etc.) occurs.
- Synthesis of new genetic material required for division occurs, i.e. DNA molecules duplicate.
- Volume of cytoplasm and nucleus increases.
- Chromosomes are not yet distinguished.

Phases of mitosis

Mitosis occurs in four phases namely,

- Prophase
- Metaphase
- Anaphase
- Telophase

The various phases of mitosis are nearly similar in

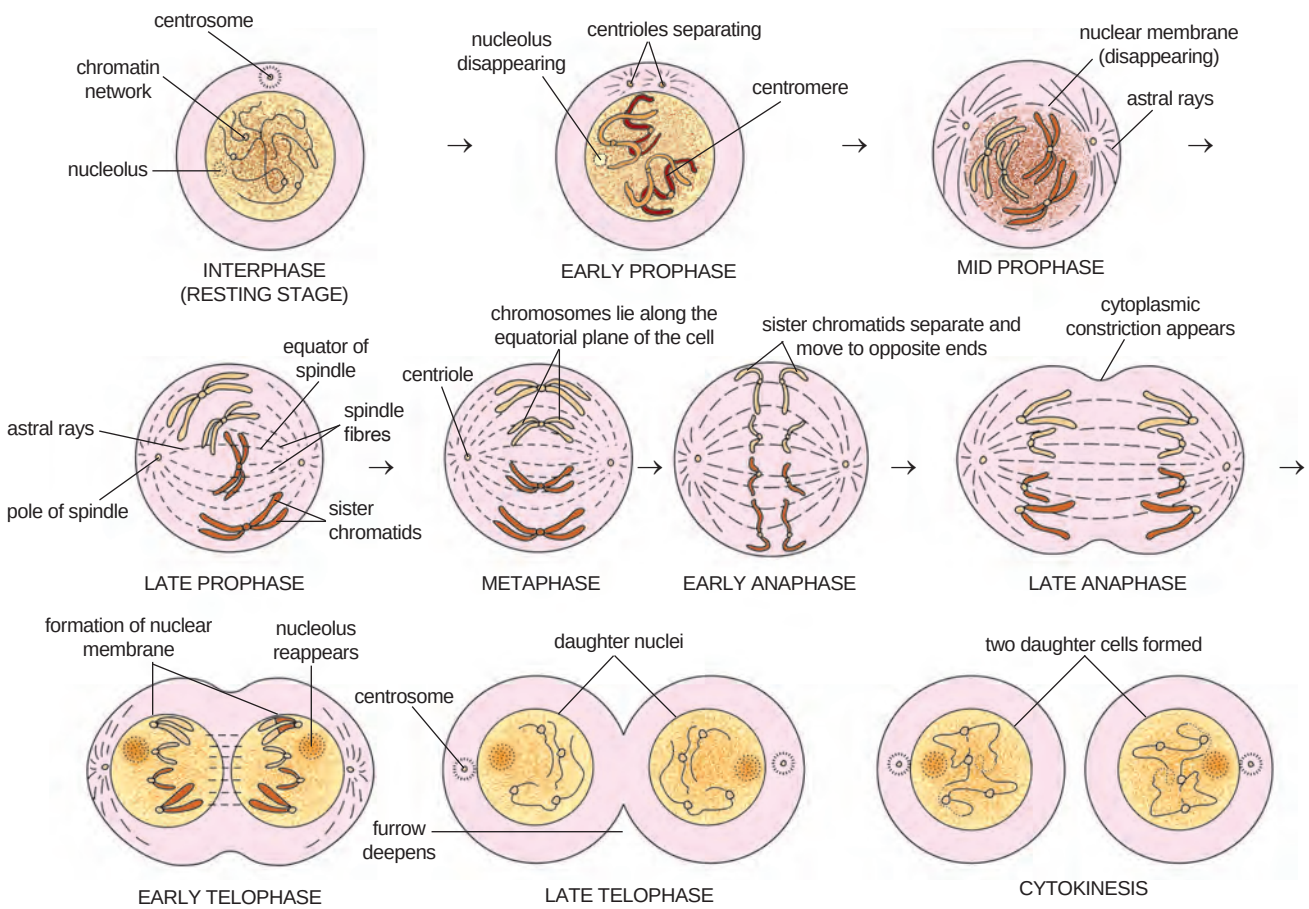


Fig. 1.1 Stages of mitosis in an animal cell

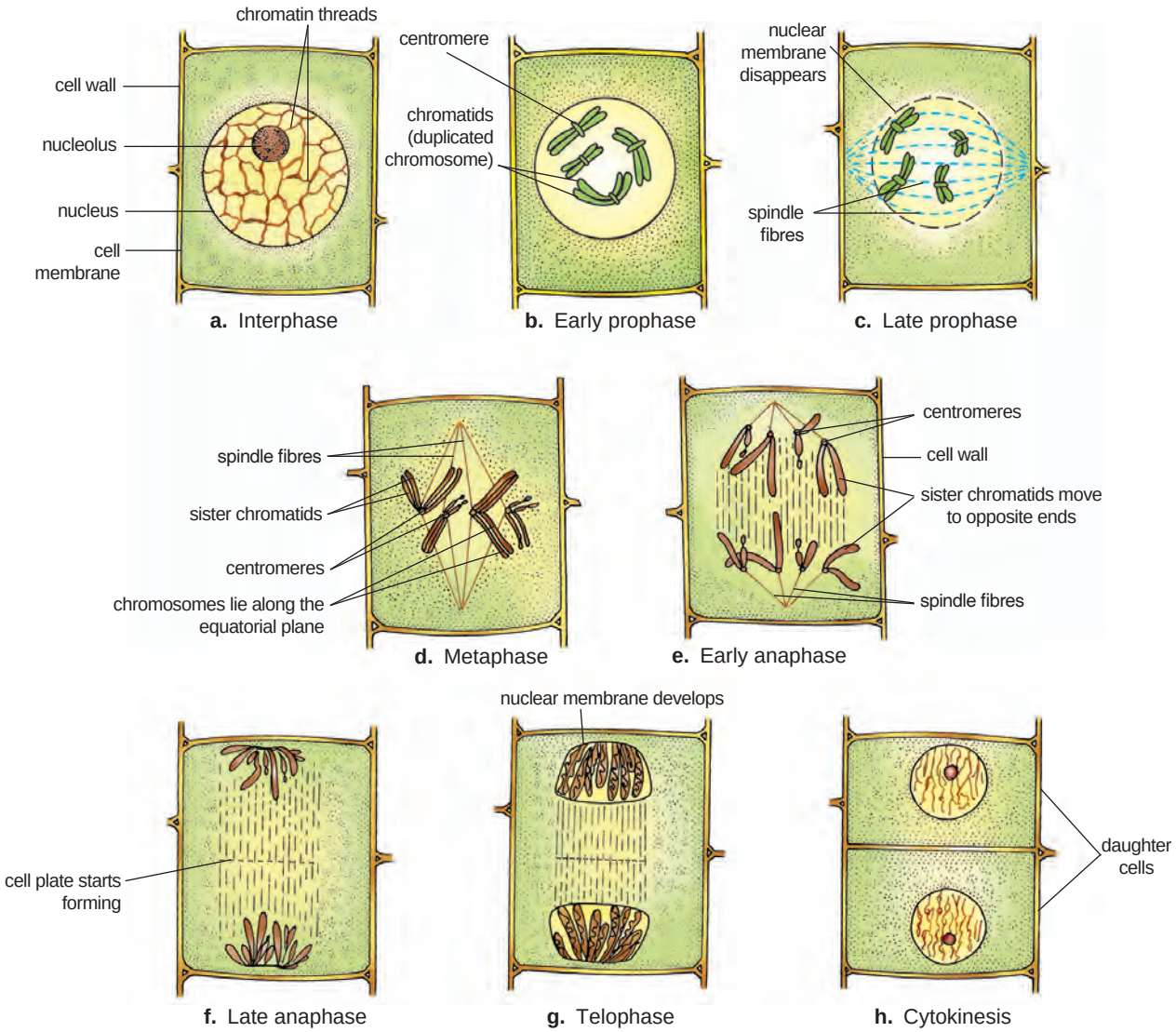


Fig. 1.2 Mitosis in a plant cell

both animal and plant cells. For better understanding, the mitosis in animal cells is described here and wherever variation occurs, the mitosis in plant cell is also described.

(I) Prophase (Gk. *Pro:* before, *phasis:* stage)

1. This is the **first and longest phase of mitosis**.
2. The chromatin material undergoes condensation (becomes short and thick) and changes into thread-like structures called **chromosomes**.
3. Each chromosome has two thread-like structures called **sister chromatids**, which lie close to each other and remain attached at a point called **centromere**.
4. As prophase advances, the chromosomes become shorter and condensed (thickened).
5. In animal cells, the centrosome initiates and regulate the cell division. The **centrosome** splits into two small round bodies called centrioles. The two **centrioles** of the centrosome migrate to the opposite sides (poles) of the cell.
6. Soon two star-like structures with radiating fibres known as **asters** are formed around the centriole at each pole. Between the separating centrioles, spindle fibres are formed by the aster.
7. Towards the end of the prophase, the nucleolus and the nuclear membrane disappear.

(II) Metaphase (Gk. *Meta:* between, *phasis:* stage)

1. Chromosomes become still shorter and thicker due to condensation.

2. The chromosomes arrange themselves on the equatorial plane in such a way that their centromeres lie on the equator and arms face towards the poles.
3. Centromere of each chromosome is attached by a spindle fibre.

(III) Anaphase (Gk. *Ana:* back, *phasis:* stage)

1. **This is the shortest phase of mitosis**.
2. The centromere of each chromosome divides into two halves (sister chromatids) so that each chromatid has its own centromere.
3. The sister chromatids separate and begin to move towards the opposite poles due to the contraction of the spindle fibres, and due to the repelling force developed between them.
4. Depending on the position of the centromere, the chromosomes appear as U, V or J-shaped.
5. The anaphase ends when all the chromatids (now behaving like chromosomes) reach the opposite poles.

(IV) Telophase (Gk. *Telo:* end, *phasis:* stage)

1. This is the last phase in karyokinesis (nuclear division). The events of prophase occur in reverse sequence during telophase.
2. The chromatids (daughter chromosomes) uncoil, elongate and change into network of chromatin threads.
3. The nuclear membrane reappears around the chromatin network at each pole.
4. Nucleolus reappears in each daughter nucleus and spindle fibres disappear.
5. In animal cells, centrosome organizes itself above the nucleus, thus making the completion of karyokinesis.

The karyokinesis (mitosis proper) is followed by the division of the cytoplasm known as cytokinesis.

Cytokinesis (Gk. *Cyto:* cell, *kinesis:* movement)
It is the division of cytoplasm to form two daughter cells. It begins during late anaphase and is completed soon after telophase. It is different in animal and plant cells.

How is cytokinesis different in animal and plant cells?

1. In **animal cells**, a constriction (or furrow) appears in the plasma membrane. This constriction deepens by the end of the telophase, finally completing the division of cytoplasm.

   In **plant cells**, a cell plate is formed in the centre of the cell at the end of the anaphase. The cell plate extends on either side until it completely divides the cell into two daughter cells.
2. In animal cells, cytokinesis starts from the periphery and proceeds towards the centre, but in plant cells, cytokinesis starts from the centre due to cell plate formation, and extends towards the periphery.
3. In plant cells, no centrosome (centriole) is there and asters are not formed. However, spindle formation still occurs and are formed by microtubules (cytoplasmic strands).

Significance of mitosis

- Mitosis maintains the **same number of chromosomes** in all the cells of an individual.

  In other words, **mitosis is an equational division** in which **two daughter cells produced are identical to each other** and even to their parent cell. This type of cell division usually takes place in the somatic cell such as tips of roots, stem, etc.
- It plays a significant role in wound healing, replacement of cells lost during wear and tear.
- It is responsible for the growth of an organism. A fertilized cell develops into an embryo and finally into an adult as a result of mitotic cell division.
- Mitosis helps the cells maintain the proper size.
- It is a method of asexual reproduction in unicellular organisms.
- If mitotic cell division becomes uncontrolled, it may cause tumours or cancerous growth.

CHECK YOUR PROGRESS 1

A. Answer these questions.

1. Name the two kinds of cell division found in living beings.
2. What is the significance of mitosis? Give three points.

B. Name the stage of mitotic cell division showing following events.

1. The chromatin material undergoes condensation and changes into thread-like structures called chromosomes.
2. The spindle fibres attach themselves to the centromere of the chromosomes.

3. The sister chromatids separate and begin to move towards opposite poles due to contraction of spindle fibres.
4. Cytoplasm divides to form two daughter cells.

C. Name the kind of cell division that takes place in

1. formation of sperms in animals.
2. repair of wound and replacement of cell during wear and tear.
3. growth of an organism.

THE CELL CYCLE

Till now you have studied about mitosis. But mitosis is only one phase of the cell cycle. A cell cycle starts from the time a new cell is formed and it ends when it completes its own division. Then the cell cycle starts again for each new daughter cell formed.

A cell cycle may be defined as the **"events in a cell by which there is an increase in the mass and cytoplasmic components of the cell; duplication of DNA; and then division of nucleus and cytoplasm of the cell. Thus, a cell cycle extends from the time a cell is formed till the time it completes division."**

Interphase

The cell cycle starts with the interphase during which a cell prepares itself for cell division. The interphase is the longest phase of cell cycle. It is metabolically the most active phase of the cell cycle. It has three sub-phases:

1. **G1 or first growth phase:** This is the first 'Gap' (interval) phase of cell growth and functioning before DNA replication. During this phase:
   - RNA and proteins are synthesized and volume of cytoplasm increases to almost double.
   - Mitochondria (in plant and animal cells) and chloroplasts (in plant cells) divide.
   - Now the cell either enters the resting phase (R phase) or a synthetic phase (S phase).
2. **S or synthesis phase:** This is the phase of DNA replication. The DNA is synthesized and chromosomes are duplicated during this phase.
3. **G2 or second growth phase:** It is the second 'Gap' phase after DNA replication. It is a shorter phase in which RNA and proteins necessary for cell division continue to be synthesized. Now the cell becomes ready for next cell division, i.e. mitosis.

Mitosis

It has nuclear division (prophase, metaphase, anaphase and telophase) usually followed by cytoplasmic division. The various phases of cell cycle are given in Figure 1.3.

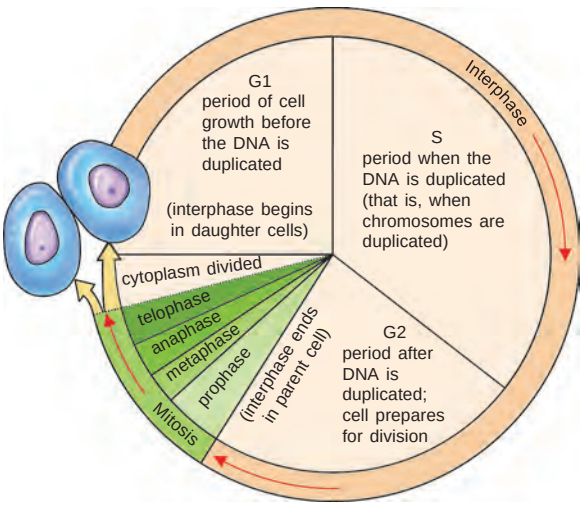


Fig. 1.3 Eukaryotic cell cycle, generalized. The length of each part differs among different cell types.

The cell cycle does not go endlessly. It stops permanently at some point of time. Its duration differs from one cell type to another cell type. For example, **nerve cells** (neurons) in our brain once formed in embryo do not divide further. All **blood cells** form and replace the worn-out cells at an average rate of 2–3 million each second. **Surface skin cells** are continuously replaced by underlying cells. **Liver cells** divide once every 1–2 years to replace damaged cells.

MEIOSIS (GK. MEIOMUM: TO DIMINISH)

Meiosis takes place in the reproductive cells that produce gametes. Meiosis is a modified mitosis in which **chromosomes divide once and the nucleus divides twice**, after which the number of chromosomes are reduced to half. Thus, the four cells resulting from a meiotic division have a haploid number of chromosomes. It means that the **number of chromosomes becomes half in each sex cell**. This is because when the male and female gametes fuse during fertilization, the **diploid** (double) number of chromosome pairs are re-established. **Meiosis is a reductional division**.

Stages of meiosis

(**As per syllabus, it is not necessary to study the stages of meiosis. However, it is useful to know**). Meiosis includes two nuclear divisions:

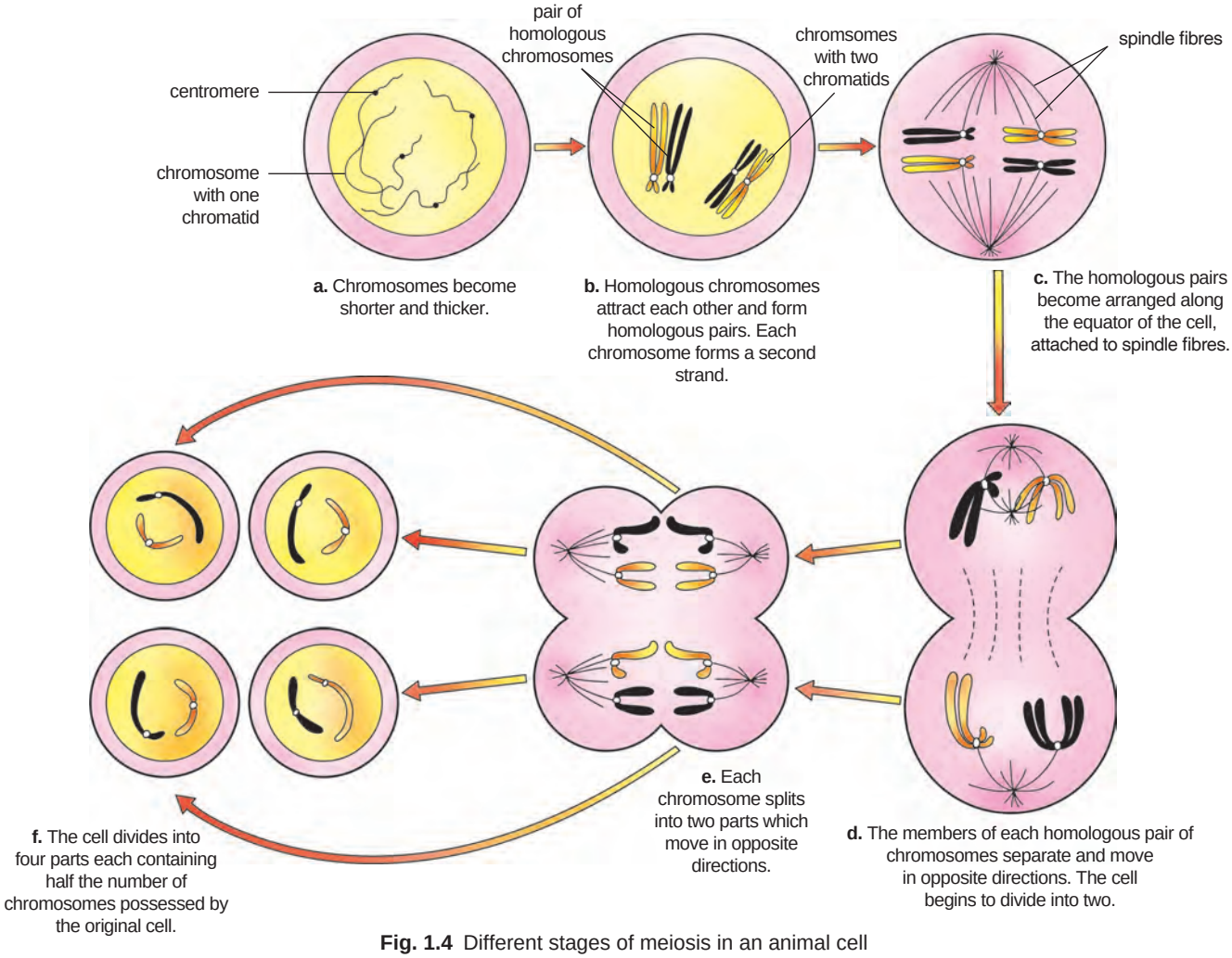


Fig. 1.4 Different stages of meiosis in an animal cell

- first meiotic division (reduction division), and
- second meiotic division (mitotic division/ equational division)

Thus, in meiotic cell division, all the stages, i.e. prophase, metaphase, anaphase and telophase are repeated twice.

(A) FIRST MEIOTIC DIVISION

In this division, homologous chromosomes come together (associate) and subsequently segregate into daughter cells. Thus, the number of chromosomes are reduced from diploid (double) to the haploid (single) state. That is why it is known as reduction division.

The following events take place during this division.

(I) Chromosomes pair and separate

1. The chromatin network undergoes condensation and shortening and changes into chromosomes.
2. The **homologous chromosomes** (one received from father and one received from mother) attract each other and come to lie in pairs. The pairing of homologous chromosomes is known as **synapsis** and the pair is known as **bivalent**.

(II) Chiasmata formation

1. Chromosome continues to shorten and thicken. Each chromosome splits lengthwise into two chromatids so that each homologous pair now has four chromatids and is termed as **tetrad**.
2. The non-sister chromatids of a tetrad break open and rejoin each other. This is known as **crossing over** or **chiasmata** (singular: chiasma) **formation**.
3. Exchange of some genes or portions of chromatids takes place between two non-sister chromatids of homologous chromosomes during this stage.

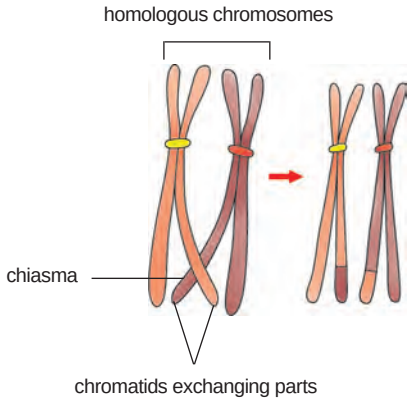


Fig. 1.5 Crossing over between maternal and paternal chromatids

- Due to crossing over of homologous chromosomes, chromosomes separate out. Nucleolus and nuclear membrane disappear.
- The members of homologous chromosomes completely separate from each other and move towards the opposite poles. Nuclear membrane reappears leading to the formation of two daughter nuclei.

Each daughter nucleus, thus formed at the end of the Meiosis I, has half the number of chromosomes as compared to the parent cell.

(B) SECOND MEIOTIC DIVISION

It is similar to mitosis. During this the two chromatids of each chromosome separate and move to opposite poles. Nuclear membrane reappears and four cells are formed. Finally each cell formed has haploid (n), half the number of chromosomes of the original cell (diploid, 2n).

Significance of meiosis

- The **number of chromosomes are reduced to half** in the daughter cells.
- It results in the formation of haploid sex cells (sperms and ova), which after fertilization restore the diploid number of chromosomes in the zygote.
- During crossing over which occurs in meiosis, part of chromatids are exchanged between homologous chromosomes which **bring about variations in the offsprings**.
- The four chromatids of a homologous pair of chromosomes are passed on to four different daughter cells. This also causes gametic variation.
- It avoids the multiplication of chromosomes, and thus maintains the stability of species.

Differences between mitosis and meiosis

The major differences between mitosis and meiosis are given in Table 1.1.

Table 1.1 Differences between mitosis and meiosis

MITOSIS	MEIOSIS
1. It occurs in both the somatic and reproductive cells.	1. It occurs in reproductive cells only at the time of gamete formation.
2. It involves a single division resulting in the formation of two daughter cells.	2. It involves two successive divisions resulting in the formation of four daughter cells.
3. The number of chromosomes remain the same in the daughter cells.	3. The number of chromosomes are reduced to half in the daughter cells.
4. Daughter cells produced have the genetic make up identical to parent cells.	4. Daughter cells produced have genetic make up different from the parent cells.
5. Chromosome duplication is followed by a single nuclear division.	5. Chromosome duplication is followed by two nuclear divisions.
6. It is of a short duration.	6. It is of a longer duration.
7. No chiasmata formation or crossing over takes place.	7. Chiasmata formation or crossing over takes place.
8. The exchange of genetic material does not take place between homologous chromosomes.	8. The exchange of genetic material takes place between homologous chromosomes.

CHECK YOUR PROGRESS 2

A. State whether following statements are True or False.

1. In meiosis, chromosomes divide twice and nucleus divides once.
2. Meiosis is a reductional division.
3. The first meiotic division is a homotypic division.
4. The breakup and rejoining of non-sister chromatids of a tetrad around each other is known as chiasmata formation.
5. Each daughter nucleus formed at the end of meiosis I, has half the number of chromosomes as compared to the parent cell.
6. Meiosis results in the formation of haploid sex cells.

SUMMARY

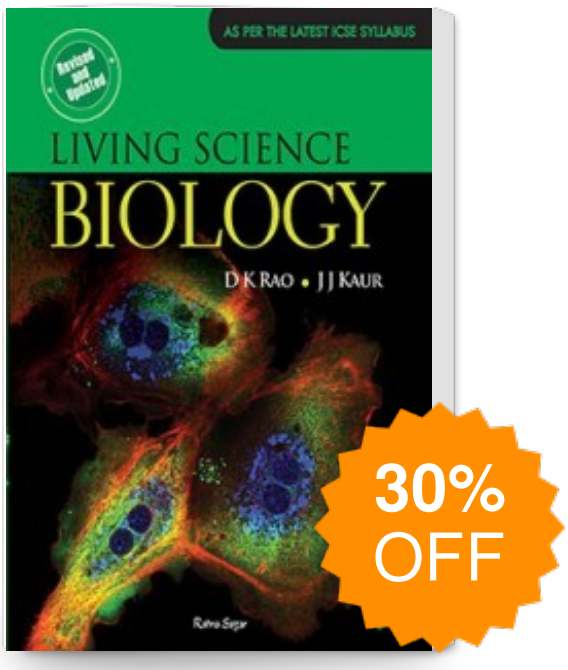
- A parent cell provides each daughter cell with the hereditary material and cytoplasm through cell division.
- Cell division is necessary for growth, replacement of dead cells, healing of wounds and reproduction.
- There are two types of cell divisions—mitosis and meiosis.
- Mitosis is an equational division required for growth and development. A diploid cell divides to form two genetically identical diploid cells in mitosis.
- Meiosis is a special type of cell division which produces sex cells or gametes. It is known as reduction division. One diploid cell divides to produce four genetically different haploid cells as a result of meiosis.
- A cell division starts when a new cell forms. It proceeds through interphase and ends when the cell reproduces by mitosis and cytokinesis. The cell prepares itself for division during interphase.
- Mitosis has four phases—prophase, metaphase, anaphase and telophase.
- Meiosis has two nuclear divisions—first meiotic division and second meiotic division.
- The cell cycle has following four phases—interphase, growth phase (G1), synthesis phase (S) and second growth phase (G2).

EXERCISES

A. Differentiate between mitosis and meiosis with respect to the following features.

FEATURES	MITOSIS	MEIOSIS
1. occurrence	_____	_____
2. number of daughter cells formed at the end of division	_____	_____
3. number of chromosomes in daughter cells (haploid/diploid)	_____	_____
4. exchange of genetic material between homologous chromosomes	_____	_____

ICSE Living Science Biology Class X



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