5.3 Application of Enzymes in Daily Life

Enzymes have long been widely used in the commercial sector and for everyday use. The enzymes used are extracted from natural resources such as bacteria or are produced synthetically.

Immobilized enzymes are enzymes that combine with inert and insoluble substances to increase the resistance of enzymes towards change in factors such as pH and temperature. With this method, the enzyme molecules will remain in the same position throughout the catalytic reaction and then be separated easily from its product. This technology is known as **immobilized enzyme technology**. This technology is used in various industrial applications (Photograph 5.1).

Formative Practice 5.2

1. How are enzymes produced?
2. How does immobilized enzyme technology help to accelerate the enzyme reaction?
3. Give examples of industries that use enzymes in the manufacturing of products.

Digestive enzymes are used in the medical sector

Pectinase and cellulase enzymes are used in juice production

Lactose enzymes are used in lactose-free milk

Amylase, lipase, protease and cellulase enzymes in bio detergent

Trypsin enzyme extracts fur from animal hide to make leather products

Protease enzyme separates the fish skin

PHOTOGRAPH 5.1 Enzyme immobilization technology is used in various industrial application

5.3.1

Summary

METABOLISM AND ENZYMES

Metabolism

- Anabolism
- Catabolism

Enzyme

- Enzyme nomenclature: adding *-ase* to the substrate
- General characteristics of enzymes
- Intracellular and extracellular enzymes
- Enzyme action mechanism—'lock and key' hypothesis
- Factors that influence the enzyme action
  - Temperature
  - pH
  - Substrate concentration
  - Enzyme concentration

Application of Enzymes in Daily Life

- Digestive enzymes
- Lactose-free milk and fruit juice
- Bio detergent
- Leather product (separate fur from animal hide)

Self Reflection

Have you mastered the following important concepts?

- Types of metabolism
- General characteristics of enzymes
- Mechanism of enzyme action
- Factors that influence the mechanism of enzyme action
- Application of enzymes in daily life

Summative Practice 5

1 Some chefs sometimes wrap meat in papaya leaves and the meat is marinated for 5 hours before it is cooked. What is the purpose of wrapping with papaya leaves?

2 Why are apples that have been boiled after they are peeled, do not change colour to brown?

3 (a) Enzymes are used in industries and everyday life. Explain the use of enzymes to extract agar-agar from seaweed.
(b) State one function of lipase in the food industry.

4 (a) State two characteristics of enzymes.
(b) Explain why only certain substrate can combine with enzymes.
(c) (i) What is the hypothesis that is used to explain the mechanism of enzyme action? In this hypothesis, what represents the structure of enzymes and the structure of the substrate?
(ii) Which characteristics of enzymes can explain this hypothesis?

Essay Questions

5 (a) If you are a food entrepreneur, suggest an enzyme that you can use to process meat and fish. State the function of this enzyme.
(b) Discuss how the characteristics of the enzymes can influence its action.

Enrichment

6 The enzymes that exist in the bacteria strain which live in hot spring areas can be extracted and added to laundry detergent. Suggest why enzymes from these bacteria are suitable to be used as laundry detergent.

7 Why does cyanide poisoning cause immediate death?

8 Fresh fruits can be processed to produce juice. Fruits are crushed and squeezed before the juice is extracted. Plant cells contain strong cellulose walls. However, if enzymes that contain pectinase enzymes are used, more juice can be extracted. Based on this information, suggest one laboratory experiment that can extract more fruit juice than the pressing method.

Complete answers are available by scanning the QR code provided

CHAPTER

6 Cell Division

Can identical organisms be produced?

Do You KNOW...

- How does growth happen?
- How does an organism produce new cells?
- How is genetic variation created?

6.1 Cell Division

6.1.1 Describe:
- karyokinesis (nuclear division)
- cytokinesis (cytoplasmic division)

6.1.2 Describe the terms haploid, diploid, chromatin, homologous chromosomes, paternal chromosome and maternal chromosome.

6.2 Cell Cycle and Mitosis

6.2.1 Describe the phases in a cell cycle:
- interphase
- G_1 phase
- S phase
- G_2 phase
- M phase
- mitosis
- cytokinesis

6.2.2 Arrange the stages of mitosis in the correct order.

6.2.3 Communicate about the cell structure of each stage of mitosis and cytokinesis by using labelled diagrams.

6.2.4 Compare and contrast mitosis and cytokinesis in animal and plant cells

6.2.5 Discuss the necessity of mitosis in:
- development of embryo
- growth of organisms
- healing of wounds on the skin
- regeneration
- asexual reproduction

6.3 Meiosis

6.3.1 State the meaning of meiosis.

6.3.2 Identify types of cells that undergo meiosis.

6.3.3 State the necessity of meiosis in:
- the formation of gametes (gametogenesis).
- producing genetic variation
- maintaining diploid chromosomal numbers from one generation to another.

6.3.4 Explain the stages of meiosis in the correct order:
- meiosis I
- meiosis II

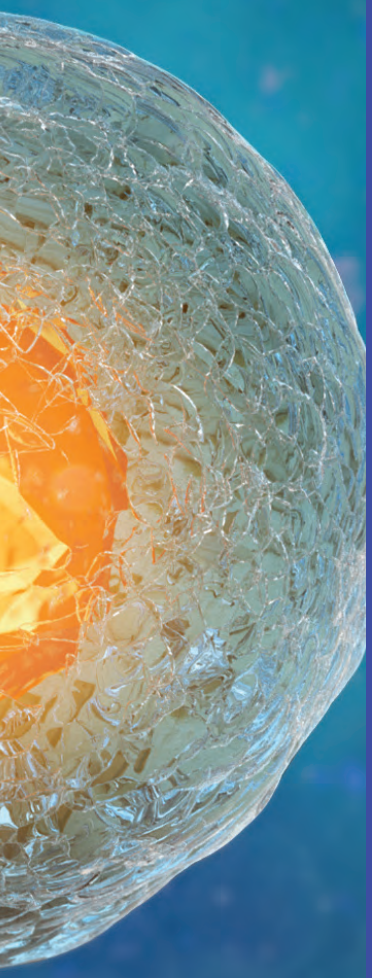
6.3.5 Draw and label the cell structure in each stage of meiosis I, meiosis II and cytokinesis.

6.3.6 Compare and contrast meiosis and mitosis.

6.4 Issues of Cell Division on Human Health

6.4.1 Explain the effects of abnormal mitosis on human health:
- tumour
- cancer

6.4.2 Evaluate the effects of abnormal meiosis on Down syndrome individuals.



6.1 Cell Division

Cells in our body always grow, divide and die. As such, the dead cells must be replaced with new cells. Cells in the body produce new cells through the cell division process. Cell division involves two stages, that is karyokinesis and cytokinesis.

- **Karyokinesis** involves the division of the nucleus.
- **Cytokinesis** involves the division of the cytoplasm.

The organism's body cells are divided into **somatic cells** and **reproductive cells** or **gametes**.

Brainstorm!

What happens when cells cannot undergo cell division?

ORGANISM CELL

SOMATIC CELL	GAMETE
• Body cells apart from gametes. • Somatic cells are produced through the mitosis process. • It contains a **diploid** number of chromosomes, that is, each cell contains two sets of chromosomes or 2n. In human somatic cells, 2n = 46.	• Gametes are reproductive cells. • Gametes are produced through the meiosis process. • It contains a **haploid** number of chromosomes, that is, each cell contains one set of chromosomes or n. In human gametes, n = 23.

In diploid cells, one set of chromosomes originate from the male parent or **paternal chromosomes** and another set is from the female parent or **maternal chromosomes**. Both paternal and maternal chromosomes have the same structural characteristics. This pair of chromosomes are called **homologous chromosomes** (Figure 6.1). **Chromatin** is a chromosome that looks like a long thread.

ICT 6.1
Importance of cell division (Accessed on 21 August 2019)

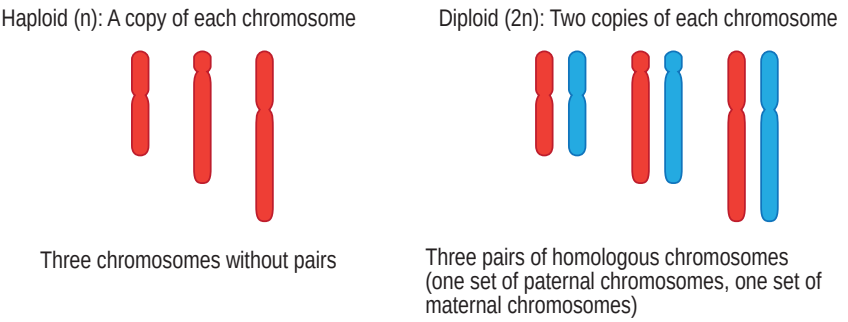


FIGURE 6.1 Haploid and diploid chromosomes

Formative Practice 6.1

1 Give the definition of the following terms:
(a) karyokinesis (c) chromatin
(b) cytokinesis (d) homologous chromosomes

2 Predict what will happen if the cells in the reproductive organs of humans are unable to produce haploid cells.

6.1.1 6.1.2

6.2 Cell Cycle and Mitosis

What is a cell cycle?

The **cell cycle** refers to the sequence of events that involves DNA multiplication and cell division to produce two daughter cells. The cell cycle consists of **interphase** and **M phase**. **Interphase** is the longest phase in the cell cycle. This phase is made up of the **G_1**, **S** and **G_2** phase.

G_1 PHASE

1 Cells grow. Cell components such as mitochondrion and endoplasmic reticulum are produced at this stage. Proteins used in the cell cycle are also synthesised during this time. At this stage, the nucleus looks big and the chromosome is in the form of chromatin.

S PHASE

2 DNA synthesis occurs in the S phase. The DNA in the nucleus is replicated. Each chromosome multiplies into two identical chromosomes known as sister chromatids. Both chromatids contain the same copy of the DNA molecule. Both chromatids are joined at the centromeres.

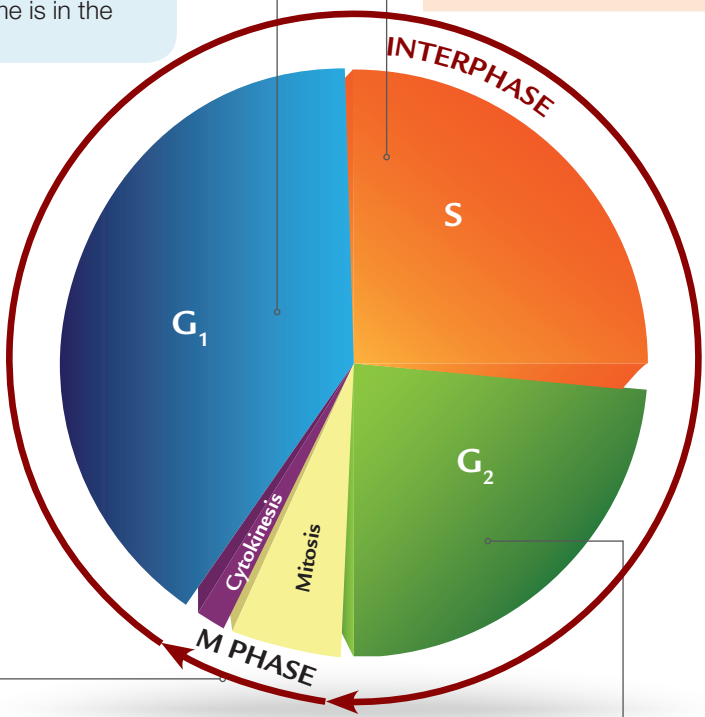


FIGURE 6.2 Cell cycle

M PHASE

4 M phase is made up of **mitosis** and **cytokinesis**. Mitosis involves prophase, metaphase, anaphase and telophase.

G_2 PHASE

3 The cells will continue to grow and remain active metabolically during the G_2 phase. Cells gather energy and make final arrangements to enter the next stage of cell division. After the interphase stage, the cell will enter the M phase.

Mitosis

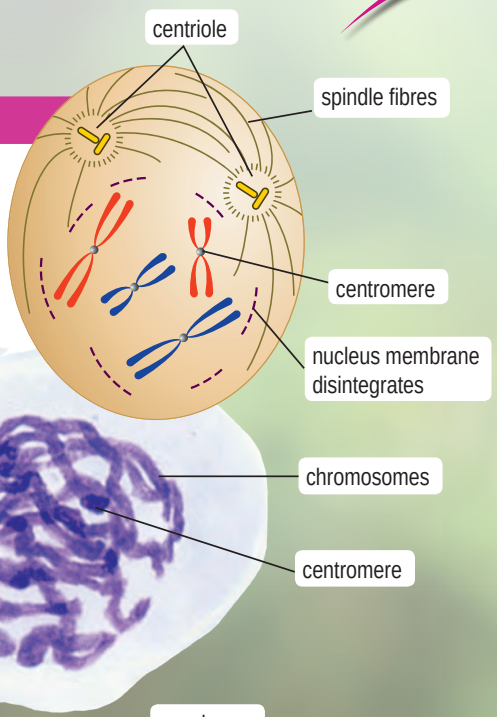
Mitosis is defined as the division of the nucleus of parent cell into two nuclei (Photograph 6.1). Each nucleus contains the same number of chromosomes and genetic content with the nucleus of parent cell.

Our World of Biology

The failure of mitotic division in somatic cells will not be inherited by the next generation.

PROPHASE

- In the nucleus, chromatin starts to shorten and thicken to form a chromosome structure that can be seen through a light microscope.
- The chromosome is seen to be made up of two identical threads called **sister chromatids**.
- Both sister chromatids are joined at the **centromere**.
- The nucleus membrane disintegrates, the nucleolus disappears, the centriole moves to the opposite poles and spindle fibres start to form.



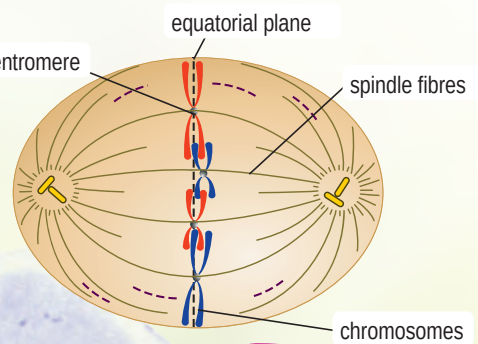
ICT 6.2

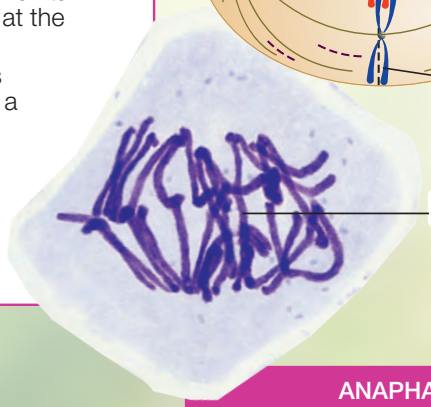
Activity: Design three dimensional models of the mitotic stages

PHOTOGRAPH 6.1 Mitosis at the tip of the plant root

METAPHASE

- Centrioles are at the opposite poles of the cell.
- The spindle fibres maintain the chromosomes at the equatorial plane.
- The chromosomes become aligned in a single row on the equatorial plane.
- Metaphase ends when the centromere begins to divide.





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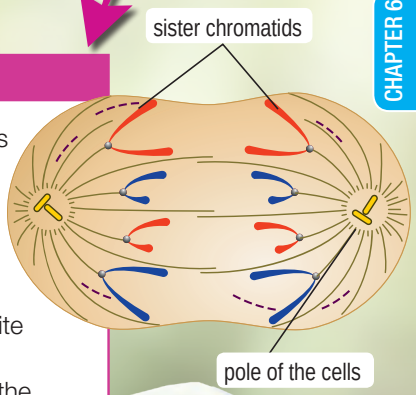
ANAPHASE

- The centromere divides into two and the sister chromatids separate.
- Spindle fibres shorten, contract and the sister chromatids are attracted to the opposite pole cells.
- Anaphase ends when the chromatid arrives at the pole of the cell.



TELOPHASE

- When the chromatids are at the opposite poles, they are now called the daughter chromosome.
- Each pole contains one set of complete and identical chromosomes.
- Chromosomes are shaped again as fine chromatin threads.
- Nucleoli are formed again.
- Spindle fibres disappear.
- A new nucleus membrane is formed.
- The telophase stage is followed by cytokinesis.

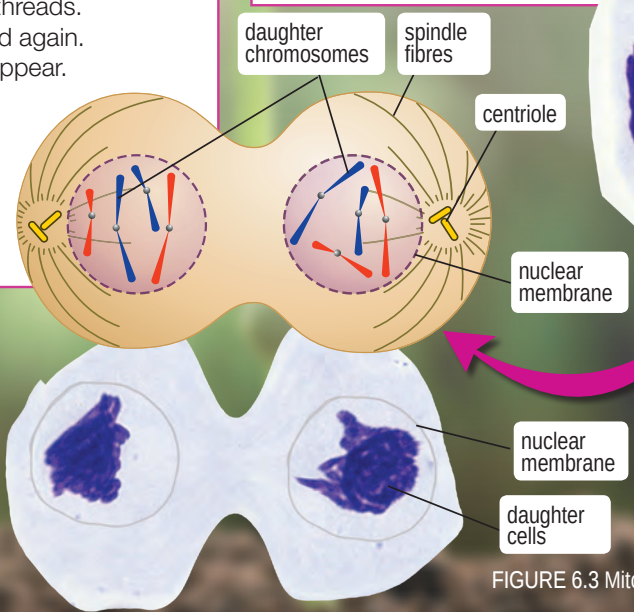


FIGURE 6.3 Mitosis

6.2.2 6.2.3

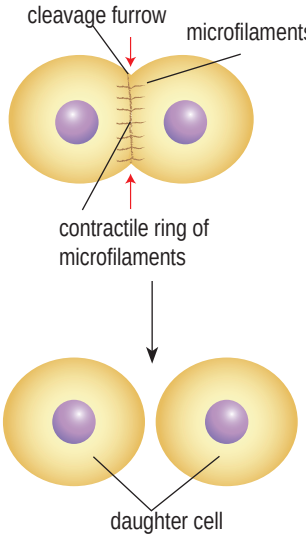


FIGURE 6.4 Cytokinesis in animal cells

The differences between mitosis and cytokinesis in animal cells and plant cells

Plant cells do not contain centrioles. However, plant cells can still form spindle fibres during mitosis.

Cytokinesis is different between animal cells and plant cells. Cytokinesis is the division of cytoplasm that happens immediately after the nucleus is formed, that is, at the end of telophase. Cytokinesis occurs in animal cells when the plasma membrane constricts in the middle of the cell between the two nuclei (Figure 6.4). Microfilaments at the point of constriction will contract, causing the cell to constrict until it splits to form two daughter cells.

Cytokinesis in plant cells also begins when the formed vesicles combine to form cell plates at the centre of the cell (Figure 6.5). The cell plates are surrounded by a new plasma membrane and a new cell wall substance is formed among the spaces of the cell plates. The cell plates expand outwards until they combine with the plasma membranes. At the end of cytokinesis, cellulose fibres are produced by the cells to strengthen the new cell walls. Two daughter cells are formed. Each cell has a diploid condition.

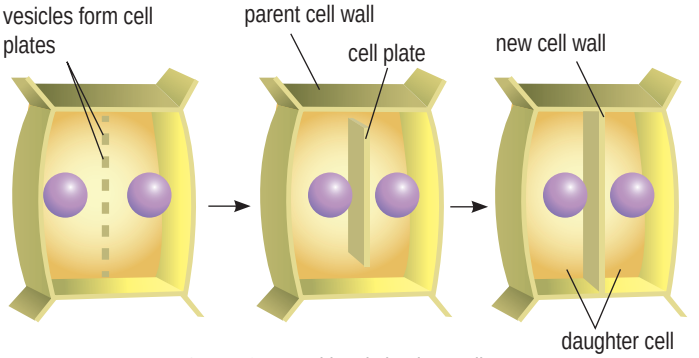


FIGURE 6.5 Cytokinesis in plant cells

The necessity of mitosis

Mitosis is important for the following life processes.

For embryo development and organism growth, mitosis ensures that rapid cell growth occurs.

Through the mitosis process, the lizard is able to grow a new tail (regeneration) if the tail breaks.

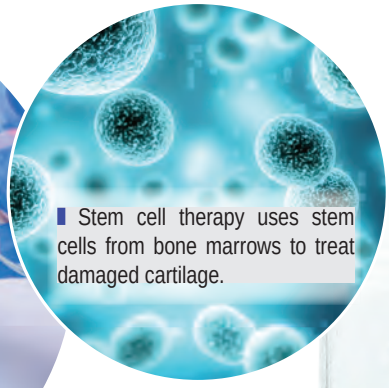
When the body is injured, mitosis will produce new cells to replace cells that are dead or damaged.

Mitosis aids organisms such as hydra to produce new individuals through the formation of new buds.

PHOTOGRAPH 6.2 The necessity of mitosis for living organisms

6.2.4 6.2.5

The culturing technique uses stem cells from animals which are then cultured in laboratories to produce meat.



Stem cell therapy uses stem cells from bone marrows to treat damaged cartilage.

In agriculture, the technique of culturing plant tissues is used to produce young plants through the culturing of parent cells without going through the fertilisation process.

PHOTOGRAPH 6.3 The application of mitosis in the fields of medicine and agriculture

Formative Practice 6.2

1 State the application of mitosis in the field of agriculture.

2 Explain the process that occurs during the S phase.

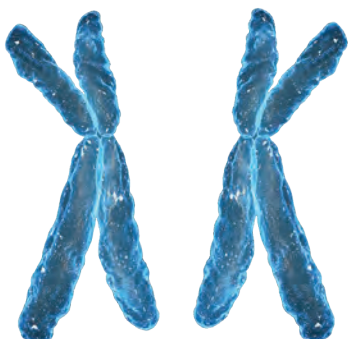
3 Predict what will happen if the spindle fibres fail to develop.

4 Explain the necessity of mitosis for life processes.

6.3 Meiosis

Meiosis is the process of cell division that occurs in reproductive organs to produce gametes that contain half the number of chromosomes (haploid) of the parent cells (diploid). Meiosis occurs in the testis (male) and ovary (female) for animals and humans.

The need for meiosis

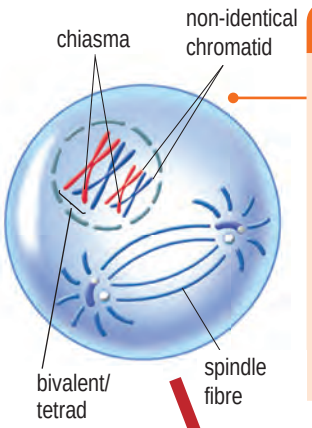


PHOTOGRAPH 6.4
Homologous chromosome

Meiosis forms gametes through the process of **gametogenesis** and ensures that **the diploid chromosome number** of organisms that carry out sex reproduction is always maintained from one generation to the next. Meiosis also produces **genetic variation** in the same species. Meiosis is divided into two stages of cell division, that is **meiosis I** and **meiosis II** (Figure 6.6).

a. Meiosis I comprises of **prophase I**, **metaphase I**, **anaphase I** and **telophase I**.
b. Meiosis II comprises of **prophase II**, **metaphase II**, **anaphase II** and **telophase II**.

6.3.1 6.3.2 6.3.3



PROPHASE I

- Chromatin **shortens**, **thickens** and forms visible chromosomes. The pairing of homologous chromosomes (**synapsis**) forms **bivalent** (or known as a **tetrad,** that is four chromatids for each homologous chromosome).
- The **crossing over** process that is an exchange of genetic material between non-identical chromatids takes place. Crossing over produces a **combination of genes** that are **new** in chromosomes. The point where the chromatids cross over is called **chiasma**. At the end of prophase I, the nucleus membrane and nucleoli will start to disappear. Both centrioles will move towards the opposite pole cells. Spindle fibres are formed among the centrioles.

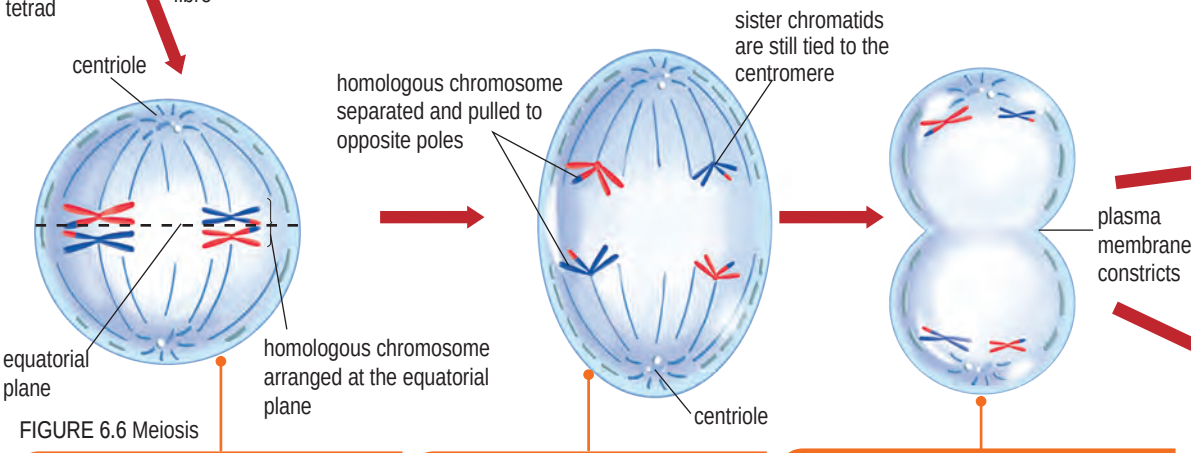


FIGURE 6.6 Meiosis

METAPHASE I

- The homologous chromosomes are arranged at the **equatorial plane**.
- One chromosome from each pair of the homologous chromosome is tied to the spindle fibres from one pole cell and its homologous is tied to the spindle fibres from the opposite pole cell.
- The sister chromatids are still tied together because the centromere has not separated.

ANAPHASE I

- The spindle fibres contract and cause each homologous chromosome to separate from its homologous pair and be pulled to the opposite poles.
- Each chromosome is still made up of a pair of sister chromatids tied to a centromere and move as one unit.

TELOPHASE I

- The chromosomes arrive at the opposite pole cells.
- Each polar cell contains a number of haploid chromosomes that are made up of one set of chromosomes only.
- The spindle fibres will then disappear.
- Nucleoli will reappear and the nuclear membrane is formed.

- Telophase I is succeeded by the cytokinesis process that produces two daughter cells.
- Both daughter cells produced are in the **haploid** condition.
- The interphase for meiosis I is usually short and the DNA does not replicate.

AR

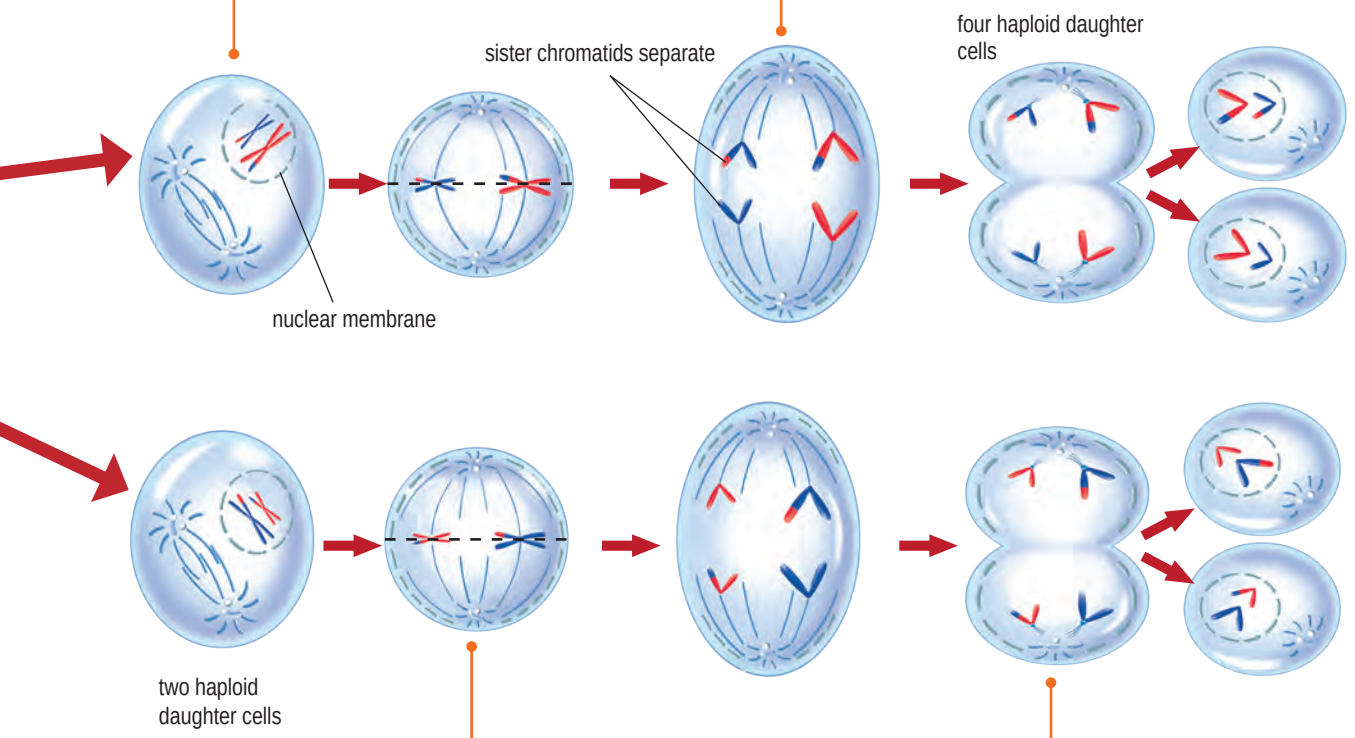
6.3.4 6.3.5

PROPHASE II

- The nucleoli and the nuclear membrane disappear.
- Each chromosome is made up of sister chromatids that are joined at the centromere.
- The spindle fibres start to form in both daughter cells.

ANAPHASE II

- The sister chromatid centromere starts to separate.
- The **sister chromatid** pair separates and moves towards the opposite poles led by the centromere.
- Each chromatid at this stage is known as a **chromosome**.



METAPHASE II

- **Chromosomes** are arranged at random on the equatorial plane for each daughter cell.
- Each chromatid is tied to the spindle fibres at the **centromere**.
- Metaphase II ends when the centromere separates.

TELOPHASE II

- Chromosomes arrive at the pole of the cell.
- Spindle fibres disappear. The nuclear membrane and the nucleoli are reconstructed.
- The number of chromosome for each daughter cell is half the number of parent chromosomes.
- Telophase II ends with the process of **cytokinesis** that produces **four daughter cells** that are **haploid**.
- Each haploid cell contains **half the number of parent cell** chromosomes. The genetic content is also different from the diploid parent cell. The haploid cells develop into gametes.

6.3.4 6.3.5

Activity Zone

Build a thinking tool to compare and contrast:
(a) meiosis I and meiosis II
(b) meiosis and mitosis

Comparison and contrast between meiosis and mitosis

You have learned about two types of cell divisions, that is the mitosis and meiosis. What is the main event that differentiates mitosis and meiosis and between meiosis I and meiosis II? Compare and contrast the two types of cell division.

Formative Practice 6.3

1 State the most obvious difference between meiosis I and meiosis II.

2 Explain how meiosis I can reduce the number of chromosomes in the daughter cell.

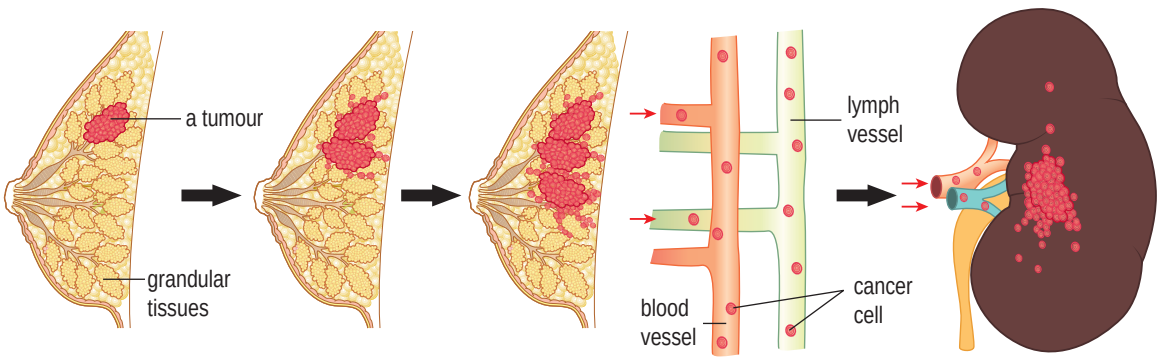
6.4 Issues of Cell Division on Human Health

The cell cycle is controlled by a special control system at each G_1, S, G_2 and M phase to ensure proper division of the cells. However, uncontrolled cell division sometimes can lead to the formation of tumours.

ICT 6.3

Video: Cancer
(Accessed on 21 August 2019)

Tumour is divided into two types which are **benign tumour** and **malignant tumour**. A benign tumour is not dangerous and can be removed surgically. A malignant tumour is also called **cancer**. Cancer is caused by several factors such as radiation (x-ray, gamma rays and ultraviolet rays), chemical substances (such as tar in tobacco), carcinogens (such as formaldehyde and benzene), genetic factors, and also bacteria and viruses. This will cause the cells to divide continuously and develop into a tumour. The cancer cells will spread and destroy normal cells around them. This condition will affect the functions of the tissues around them. Cancer that is not identified at the early stage can cause damage to the organs and finally death (Figure 6.7).



The tumour grows from a single cell.

Cancer cells compete to get nutrients from other tissues around them.

The cancer cells spread through the lymph vessels and blood vessels to other parts of the body.

A new tumour develops on other organs.

FIGURE 6.7 The development of breast cancer

6.3.6 6.4.1

PHOTOGRAPH 6.5
A child with Down syndrome displays certain characteristics such as stunted body growth and mental retardation

Any abnormality during the division of meiosis can also cause genetic diseases such as Down syndrome. This happens because the spindle fibres fail to function during anaphase I or anaphase II. As a result, the chromosome fails to separate (nondisjunction). Gametes will have an abnormal number of chromosomes (22 or 24 chromosomes). If fertilisation between a normal gamete (23 chromosomes) and an abnormal chromosome (24 chromosomes) occurs, the zygote will carry 47 chromosomes which is an abnormal condition (Figure 6.8).

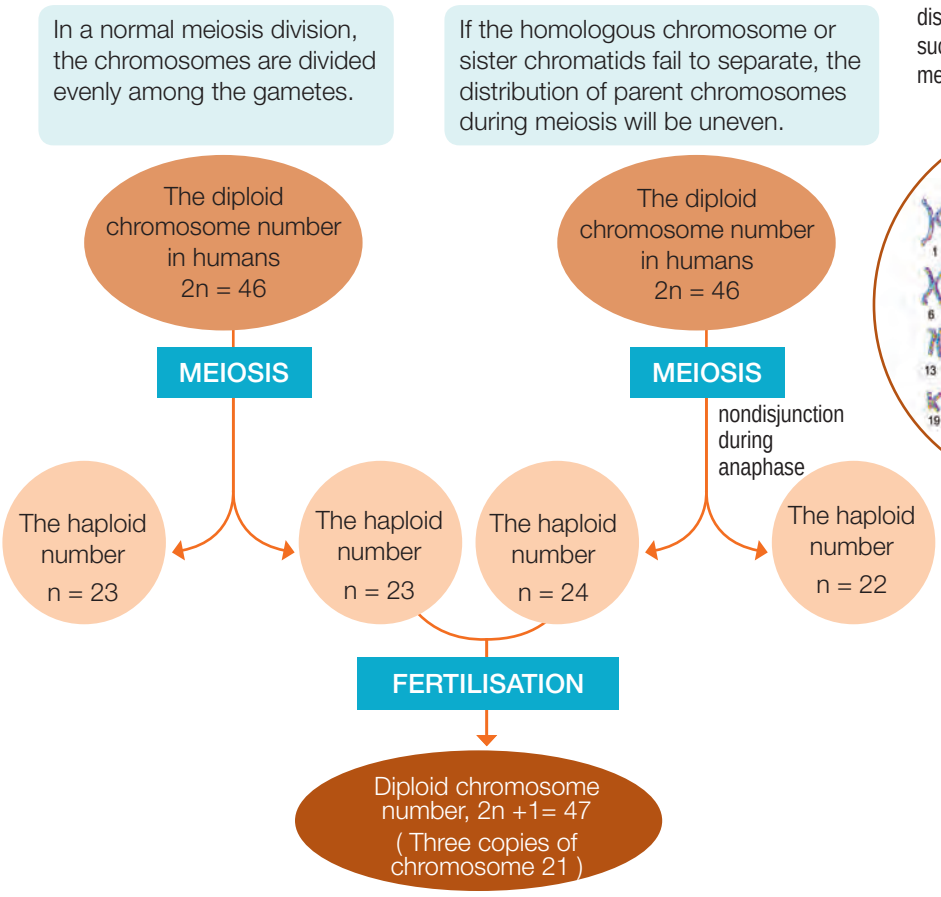
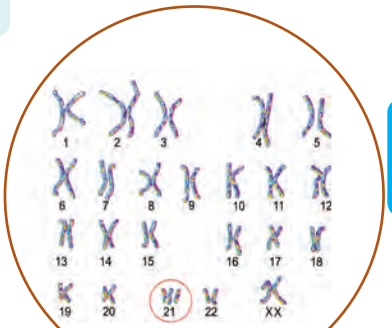


FIGURE 6.8 Formation of trisomy 21



PHOTOGRAPH 6.6
The complete chromosome set of an individual with Down syndrome

CHAPTER 6

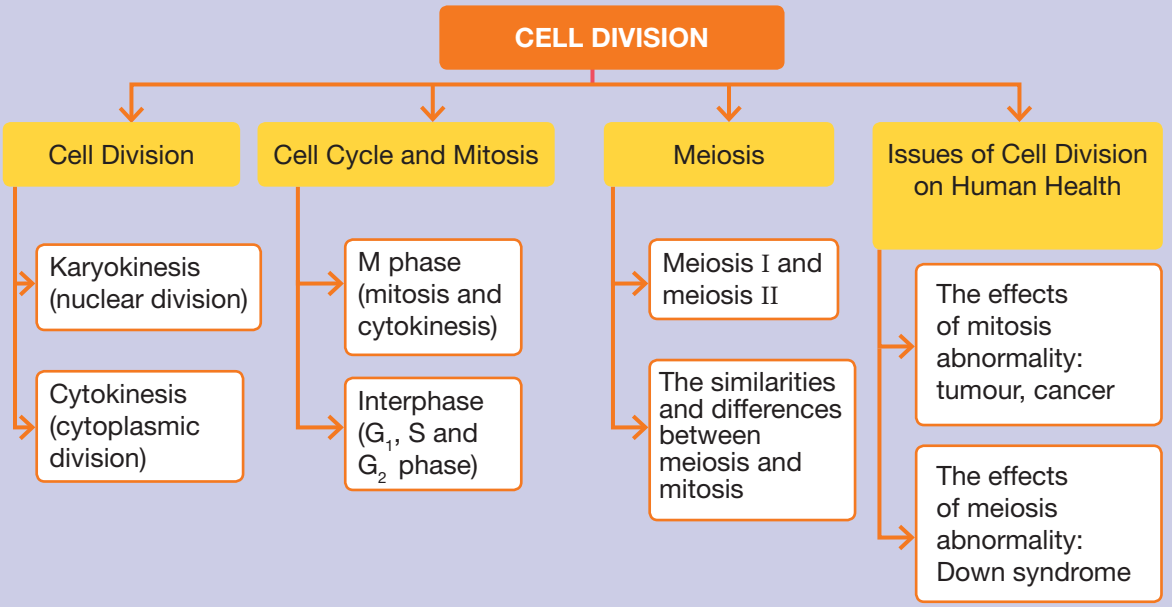
An individual with Down syndrome has 47 chromosomes, which is an extra chromosome at the 21st set. This condition is known as **trisomy 21**. This syndrome can cause mental retardation, slanted eyes and a slightly protruding tongue.

Formative Practice 6.4

1 Explain why radiotherapy is used to control or stop the growth of cancer cells.

2 Nondisjunction conditions in humans can cause genetic diseases such as Down syndrome. State the number of chromosomes and the characteristics that are found in an individual with Down syndrome.

Summary



Self Reflection

Have you mastered the following important concepts?

- Definitions of karyokinesis, cytokinesis, haploid, diploid, chromatin, homologous chromosomes, paternal and maternal chromosomes
- Cell cycle
- Stages of mitosis
- The differences between mitosis and cytokinesis between animal cells and plant cells
- Stages of meiosis
- Differences and similarities between meiosis and mitosis
- The need for mitosis and meiosis
- The effects of mitosis and meiosis abnormality towards human health

Summative Practice 6

1 Name the sequences in the mitosis process.

2 What is the function of the centriole in the division of animal cells?

3 State one difference between mitosis metaphase and meiosis metaphase I.

4 (a) Explain the importance of cell division that happens at the tip of a plant root.

(b) A farmer wants to plant a large number of quality breed mango trees in a short time for commercial purposes. State and explain the techniques that can be used by the farmer.

5 Figure 1 shows a cell at stage M in a cell cycle. Draw both cells that will be formed if the P chromosome does not separate.

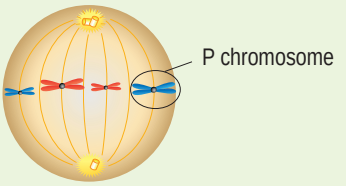


FIGURE 1

Essay Questions

6 Figure 2 shows the complete set of chromosomes of an individual.

(a) State the genetic disorder this individual has.

(b) Explain how this individual is born with this genetic disorder.

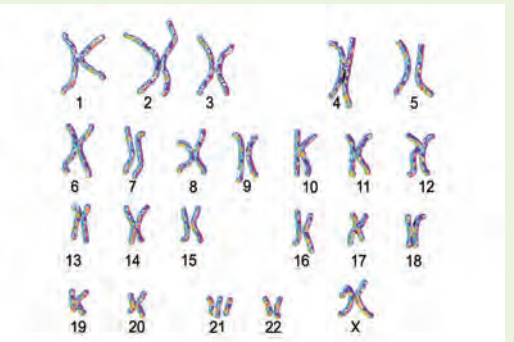


FIGURE 2

7 Cancer cells are formed after normal cells are exposed to factor Y.

(a) Explain the formation of cancer cells.

(b) State two examples of factor Y that causes the formation of cancer cells.

(c) State two ways to avoid the development of cancer cells.

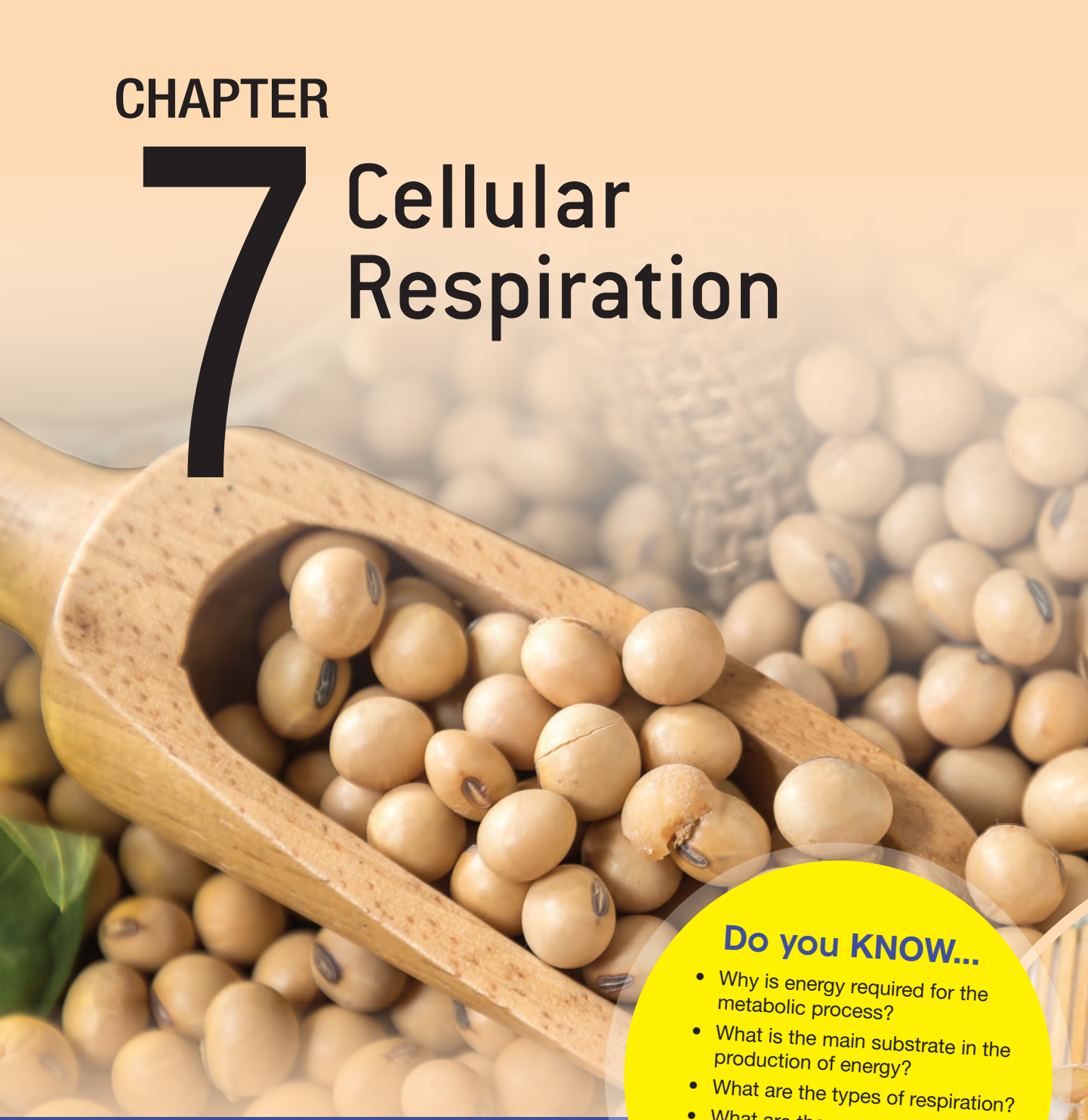
Enrichment

8 The development of plant tissue culture has allowed scientists to improve the quality and quantity of a crop. Scientists in Malaysia have succeeded in patenting a product that can be sprayed on orchid plants to overcome infections caused by a virus. This branch of biotechnology is called *RNA interference* technology. In your opinion, can the spray technology be used for all organisms as protection against infections?

Complete answers are available by scanning the QR code provided

CHAPTER

7 Cellular Respiration



Do you KNOW...

- Why is energy required for the metabolic process?
- What is the main substrate in the production of energy?
- What are the types of respiration?
- What are the processes that occur in aerobic respiration and fermentation?

How is tempe processed?

7.1 Production of energy through cellular respiration

- **7.1.1** Justify the necessity of energy in metabolic processes.
- **7.1.2** Identify the main substrate used in energy production.
- **7.1.3** List the types of cellular respiration:
  - aerobic respiration
  - anaerobic respiration
  - fermentation

7.2 Aerobic respiration

- **7.2.1** Conceptualise energy production from glucose during aerobic respiration in cells.
- **7.2.2** Write a word equation for aerobic respiration in cells.
- **7.2.3** Conduct an experiment to study aerobic respiration.

7.3 Fermentation

- **7.3.1** State the factors that cause fermentation to occur in cells.
- **7.3.2** Explain by using examples of energy production from glucose during fermentation in:
  - human muscle cells
  - *Lactobacillus*
  - yeast
  - plants such as paddy
- **7.3.3** Write and explain word equations for:
  - lactic acid fermentation
  - alcohol fermentation
- **7.3.4** Conduct an experiment to study fermentation in yeast.
- **7.3.5** Compare and contrast aerobic respiration and fermentation.

7.1 Production of energy through cellular respiration

In Chapter 5, you have learned about two types of metabolic reaction, which are **anabolism** and **catabolism**. Both of these reactions involve energy.

- The catabolism process releases energy.
- The anabolism process uses energy.

Without energy, the anabolic processes such as protein formation which is the basic muscle substance will not occur.

Activity Zone

Conduct a group discussion about the energy requirements in the metabolic process.

The main substrate in energy production

Cellular respiration is carried out to generate the energy needed by all living cells. **Cellular respiration** is the oxidation process of organic molecules through several stages to release energy. The main substrate for cellular respiration is **glucose**. Chemical energy found in glucose is released to produce energy required by cells. In humans and animals, glucose is obtained through the digestion of carbohydrates from the food eaten.

In green plants, light energy can be trapped by chlorophyll for the photosynthesis process to produce glucose.

Types of cellular respiration

There are two types of cellular respiration, which are aerobic and anaerobic respiration. **Aerobic respiration** occurs in the presence of oxygen. **Anaerobic respiration** occurs in the absence of oxygen. **Fermentation** is an alternative pathway of obtaining energy besides cellular respiration. In fermentation, the breakdown of glucose is incomplete in conditions of limited oxygen or without oxygen. This chapter focuses only on aerobic respiration and fermentation.

Formative Practice 7.1

1 Give five examples of the necessity of energy in a metabolic process.

2 State the main substrate in the production of energy.

3 State the meaning of cellular respiration and the types of cellular respiration.

4 Explain how humans, animals and plants acquire glucose to produce energy.

7.1.1 7.1.2 7.1.3

7.2 Aerobic Respiration

Aerobic respiration is the breakdown of glucose involving oxygen to produce chemical energy. Oxygen is used to oxidise glucose to produce carbon dioxide, water and energy.

The aerobic respiration process begins with the glycolysis process. **Glycolysis** means the breakdown of glucose by enzymes. This process occurs in the cytoplasm. One glucose molecule is broken down into two pyruvate molecules.

The following process occurs in the mitochondrion. Pyruvate produced from glycolysis is then oxidised through a series of reactions to produce **carbon dioxide**, **water** and **energy**. A large amount of this energy is used to produce **adenosine triphosphate (ATP)** molecules.

ICT 7.1

Video: Aerobic respiration
(Accessed on 21 August 2019)

Brainstorm!

The number of mitochondrion in the muscle cells of an athlete increases after intensive training. Explain how this contributes to the achievement of the athlete as compared with those who do not undergo intensive training.

Glycolysis
Glucose → Pyruvate
(Occurs in the cytoplasm)

Oxidation of Pyruvate
Carbon dioxide + water + energy
(Occurs in the mitochondrion)

The aerobic respiration is simplified as follows.

- ATP molecules are produced when a group of non-organic phosphate is added to adenosine diphosphate (ADP).

$$\text{ADP + phosphate} \xrightarrow{\text{energy}} \text{ATP}$$

- ATP molecules have weak phosphate links.
- When the phosphate links on ATP molecules are broken, the energy released is supplied to cells to help us carry out our daily activities.

$$\text{ATP} \xrightarrow{\text{energy}} \text{ADP + phosphate}$$

The complete process of glucose oxidation is simplified as follows:

Word equation:

Glucose + oxygen → Carbon dioxide + water + energy (2898 kJ)

CHAPTER 7

7.2.1 7.2.2

Activity 7.1 To study aerobic respiration

Experiment

Problem statement
Do living organisms carry out aerobic respiration?

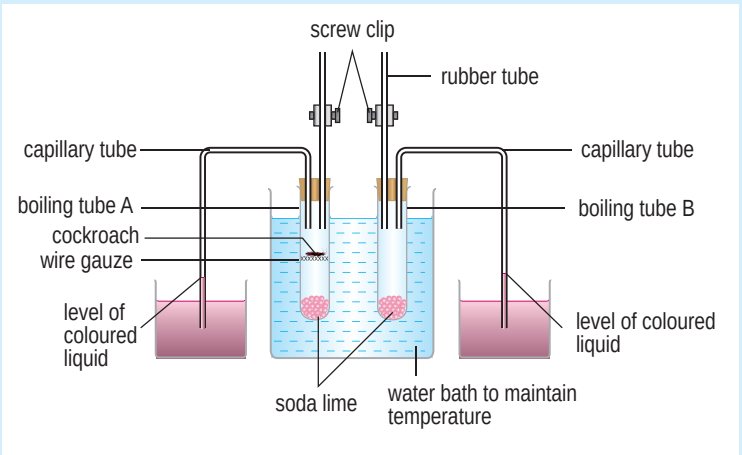
Hypothesis
Living organisms use oxygen and release carbon dioxide during aerobic respiration.

Take Note!
Wipe all connectors with petroleum jelly to ensure that the apparatus prepared is airtight.

Variable
Manipulated: Presence of living organisms
Responding: Increase in the level of coloured liquid
Fixed: Initial level of coloured liquid

Materials
Water, coloured liquid, soda lime, living organism (cockroach) and petroleum jelly

Apparatus
Boiling tubes, screw clip, wire gauze, 250 ml beaker, capillary tube, ruler, rubber tube and water bath



Apparatus set-up to study aerobic respiration process

Biological Lens
The apparatus set-up is called a respirometer. It is used to measure the rate of respiration of an organism by estimating the rate of oxygen used.

Procedure
1. Prepare the apparatus as shown in the figure above.
2. Prepare two boiling tubes labelled A and B.
3. Fill both boiling tubes with 10 g soda lime.
4. Put the wire gauze in the middle of boiling tube A.
5. Put a cockroach on the wire gauze in boiling tube A while the boiling tube B is left empty.
6. Wipe all connections of the apparatus with petroleum jelly.
7. Close the screw clip and mark the height of the initial level of the coloured liquid in the capillary tube for both boiling tubes.
8. Leave the apparatus for an hour.
9. Measure and record the final height of the coloured liquid in both capillary tubes after an hour with a ruler.
10. Record your observations in the following table.

Results

Boiling tube	Initial level (cm)	Final level (cm)	Difference in levels (cm)
A			
B			

Discussion

1 What is the purpose of preparing boiling tube B?

2 What is the function of soda lime in the boiling tube?

3 Is there a change in the level of coloured liquid in capillary tube A? Explain your answer.

Conclusion

Is the hypothesis accepted? Suggest a suitable conclusion.

Formative Practice 7.2

1 State the meaning of aerobic respiration.

2 Suggest another substrate apart from glucose that can be used by cells for cellular respiration.

3 State the word equation for aerobic respiration.

4 Describe the processes involved in aerobic respiration to produce energy.

7.3 Fermentation

Fermentation is the incomplete breakdown of glucose in conditions of limited oxygen or without oxygen. Fermentation is different from aerobic respiration in its metabolic pathway after the glycolysis stage. After glycolysis, the pyruvate produced will undergo either **alcohol fermentation** or **lactic acid fermentation**.

7.3.1

ICT 7.2

Video: Anaerobic respiration
(Accessed on 21 August 2019)

FERMENTATION

The incomplete breakdown of glucose in limited or no oxygen conditions.

ALCOHOL FERMENTATION

The incomplete breakdown of glucose to ethanol, carbon dioxide and energy.

Glucose → Ethanol + carbon dioxide + energy (210 kJ)

YEAST

- Ethanol is used in the making of beer and wine.
- The released carbon dioxide makes bread dough rise.

PLANTS

- Paddy plants that grow in waterlogged areas with less oxygen are able to carry out **alcohol fermentation**.
- Ethanol produced in the tissues during the fermentation process is toxic to most plants but the cells of paddy plants have a higher tolerance for ethanol compared to other species.
- Paddy plants produce plenty of alcohol dehydrogenase enzymes that can break down ethanol molecules into non-toxic carbon dioxide.

Activity 7.2 Produce and market food products produced through fermentation

Project

Procedure

1. Your teacher will divide your class into a few groups.
2. Each group will choose one food product that is produced through the fermentation process and market that product in school. Examples of products are tapai, yoghurt or bread.
3. Each group needs to prepare a proposal before starting the project. The proposal must contain:
   - introduction of the project including the objectives
   - execution cost
   - production and marketing plan
   - expected outcome
4. If necessary, get advice from your teacher or parents to ensure the smooth delivery of the project.
5. Conduct the project as planned.
6. At the end of the project, each group must prepare a complete report.

LACTIC ACID FERMENTATION

The breakdown of glucose into lactic acid and energy.

Glucose → Lactic acid + energy

LACTOBACILLUS

- The bacteria *Lactobacillus* carries out milk **fermentation** to produce **yoghurt**.
- *Lactobacillus* acts on the lactose (milk sugar) and turns it into lactic acid.
- The lactic acid will then coagulate casein (milk protein) to produce yoghurt.
- Lactic acid is the source of a sour taste in yoghurt.

Brainstorm!

Some bacteria can only survive in anaerobic conditions. Predict what can happen to this type of bacteria when oxygen is supplied.

HUMAN MUSCLE CELLS

- This process is carried out by the muscle cells during vigorous training.
- During vigorous training, the rate of oxygen used exceeds the oxygen supplied by the blood circulatory system.
- The muscle is in an oxygen-deficiency state and is said to undergo **oxygen debt**.
- During this process, glucose cannot break down completely. For each glucose molecule that is broken down, only two ATP molecules or 150 kJ energy will be produced.
- The produced lactic acid accumulates until it reaches a level of concentration that can cause fatigue and muscle cramps.
- Once the vigorous activity stops, the intake of excess oxygen will oxidise the lactic acid into carbon dioxide, water and energy. When all the lactic acid has been expelled, the **oxygen debt** is **repaid**.
  - Figure 7.1 shows a lack of oxygen in muscles and oxygen debt is repaid.

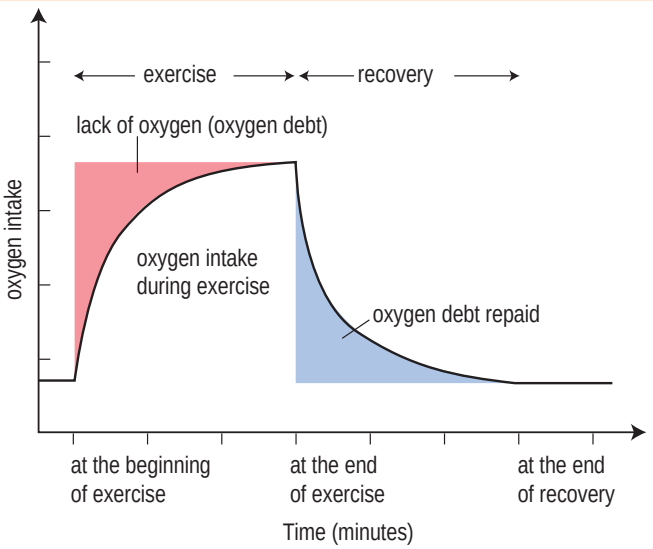


FIGURE 7.1 Lack of oxygen in muscles and oxygen debt repaid

7.3.2 7.3.3

CHAPTER 7