9th Class Biology Notes Balochistan Board (BISE Quetta) Full Book Notes

Complete chapter-wise study notes with original practice questions for Class 9 Biology, Balochistan Textbook Board (BTBB), Quetta — for students of the Board of Intermediate and Secondary Education (BBISE), Quetta.

About these notes

These notes follow the chapters of the Balochistan Textbook Board (BTBB) Biology book for Class 9. The eleven chapters covered, in order, are:

1. **Chapter 1:** Introduction to Biology
2. **Chapter 2:** Biodiversity
3. **Chapter 3:** The Cell
4. **Chapter 4:** Cell Cycle
5. **Chapter 5:** Tissues, Organs and Organ Systems
6. **Chapter 6:** Biomolecules
7. **Chapter 7:** Enzymes
8. **Chapter 8:** Bioenergetics
9. **Chapter 9:** Plant Physiology
10. **Chapter 10:** Reproduction in Plants
11. **Chapter 11:** Biostatistics

About the paper: Under the BBISE Quetta revised Scheme of Studies for SSC-I (Class 9) from the academic session 2026 onwards, Biology carries 60 marks of theory and 15 marks of practical work, making 75 marks in total. The practical component is reported as: Practical-Based Assessment 6 marks, Favourite Practical 2 marks, and a Scientific Phenomenon-Based Project 7 marks. These figures are reproduced from third-party reports of the board's notifications; they have not been read directly off an official BBISE document. The board's own model paper is the final authority for the section-wise split of the theory paper, so students should check the current model paper on the official BBISE website, bbise.edu.pk, before their examination.

About the book and the medium: The BTBB published a new Class 9 Biology textbook in 2026. These notes are written in English, following the new book and the BBISE model papers

for 2026 onwards. Older Urdu-medium study material for Balochistan Biology also exists, and the medium of the new book could not be confirmed from an official BTBB or BBISE document at the time of writing — if your school uses the Urdu-medium edition, use these notes together with your textbook.

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CHAPTER 1

Introduction to Biology

1.1 What is Biology?

Biology is the scientific study of life and living organisms — their structure, functions, growth, origin, evolution and distribution. The word biology comes from two Greek words: *bios* (life) and *logos* (study or knowledge). A living organism shows the characteristics of life: organisation, metabolism, growth, reproduction, response to stimuli and adaptation to the environment.

1.2 Branches of Biology

Biology is divided into many branches. **Botany** is the study of plants; **zoology** is the study of animals; **microbiology** is the study of microscopic organisms such as bacteria and viruses; **anatomy** deals with the internal structure of organisms; **physiology** studies the functions of body parts; **genetics** studies heredity and variation; **ecology** studies the relations of organisms with one another and with their environment; **cell biology** studies cells; **biochemistry** studies the chemical processes of life; **biotechnology** uses living organisms to make useful products; and **marine biology** studies life in the sea.

1.3 Levels of Biological Organisation

Life is organised in a hierarchy. The smallest level is the **subatomic particle** (proton, neutron, electron), then the **atom**, then the **molecule**, then the **organelle**, then the **cell** — the basic unit of life. Cells form **tissues**, tissues form **organs**, organs form **organ systems**, organ systems form an **individual**, individuals of one kind form a **population**, populations of different species in an area form a **community**, a community with its non-living environment forms an **ecosystem**, and all ecosystems together form the **biosphere**.

1.4 Biology and Other Sciences

Biology is linked with other sciences. With **chemistry** it forms biochemistry; with **physics** it explains the movement of blood and the working of the eye; with **mathematics** it forms biostatistics; with **geography** it explains the distribution of organisms; and with **medicine** it gives the knowledge needed to treat diseases. A biologist therefore needs a basic knowledge of chemistry, physics and mathematics.

1.5 The Scientific Method and the Biological Method

Science advances by the **scientific method**, a series of steps used to solve a problem. The steps are: (1) **recognition of a problem** and observations, (2) **hypothesis** — a proposed explanation that can be tested, (3) **deductions** — the expected results if the hypothesis is true, (4) **experiments** to test the deductions, and (5) **conclusion** — the hypothesis is accepted, rejected or modified. An observation may be **qualitative** (described in words, such as the colour of a leaf) or **quantitative** (measured in numbers, such as the height of a plant).

A good experiment has a **control group** (kept unchanged) and an **experimental group** (given the treatment). The factor changed by the experimenter is the **independent variable**; the factor measured is the **dependent variable**. A **theory** is a well-tested explanation supported by much evidence, while a **law** is a statement that describes a pattern seen again and again in nature.

1.6 Malaria: An Example of the Biological Method

Malaria was a serious disease whose cause was unknown. Physicians observed that people living near marshes suffered from it. The hypothesis was formed that malaria is caused by a microorganism carried by mosquitoes. The Italian scientist Laveran observed the parasite *Plasmodium* in the blood of malaria patients, and Ronald Ross showed that the female *Anopheles* mosquito carries the parasite from one person to another. This is a classic example of the biological method in action: observation, hypothesis, experiment and conclusion.

1.7 Careers in Biology

Biology opens many careers: doctor, dentist, veterinarian, pharmacist, nurse, agriculture officer, fisheries expert, forest officer, laboratory technologist, teacher, researcher, food inspector and environmental officer. All of these serve human health, food production and the protection of nature.

> **Key point:** A hypothesis must be testable. If it cannot be tested by observation or experiment, it is not a scientific hypothesis.

Short Questions with Answers

Q1. Define biology and name its two main divisions.

Ans: Biology is the scientific study of life and living organisms. Its two main divisions are botany (study of plants) and zoology (study of animals).

Q2. What is the difference between anatomy and physiology?

Ans: Anatomy is the study of the internal structure of organisms, while physiology is the study of the functions of the parts of the body.

Q3. Write the levels of biological organisation in order, from cell to biosphere.

Ans: Cell, tissue, organ, organ system, individual, population, community, ecosystem, biosphere.

Q4. Define a hypothesis.

Ans: A hypothesis is a proposed explanation of a problem that can be tested by observation or experiment.

Q5. Name the mosquito and the parasite that cause malaria.

Ans: The female Anopheles mosquito carries the parasite Plasmodium, which causes malaria.

Long Questions with Answers

Q1. Describe the steps of the biological method, using malaria as an example.

Ans: The biological method has five steps. (1) Recognition of the problem: malaria was common near marshes. (2) Observations: patients had fever and chills; mosquitoes were common in marshy areas. (3) Hypothesis: malaria is caused by a microorganism carried by mosquitoes. (4) Deductions and experiments: Laveran found Plasmodium in the blood of patients; Ross showed that Anopheles mosquitoes carry it. (5) Conclusion: the hypothesis was confirmed — malaria is caused by Plasmodium transmitted by the female Anopheles mosquito. The same steps solve any biological problem.

Q2. Explain the levels of biological organisation with examples.

Ans: Life is organised in levels of increasing complexity. Atoms join to form molecules, such as glucose. Molecules form organelles, such as the nucleus. Organelles form the cell, the basic unit of life. Similar cells form tissues, such as muscle tissue. Different tissues form organs, such as the heart. Organs work together in organ systems, such as the circulatory system. Organ systems form an individual, such as a human being. Individuals of one species form a population; different populations form a community; a community with its environment forms an ecosystem; and all ecosystems form the biosphere.

Multiple-Choice Questions

Q1. Biology is the study of
(a) rocks and minerals (b) life and living organisms (c) the stars (d) chemicals only

Q2. The study of animals is called
(a) botany (b) microbiology (c) zoology (d) ecology

Q3. Which branch deals with heredity and variation?
(a) Anatomy (b) Genetics (c) Physiology (d) Geology

Q4. The basic unit of life is the
(a) atom (b) tissue (c) organ (d) cell

Q5. A group of similar cells performing one function is a
(a) tissue (b) organ (c) system (d) population

Q6. A testable proposed explanation is called a
(a) law (b) theory (c) hypothesis (d) fact

Q7. Malaria is caused by
(a) a virus (b) Plasmodium (c) a bacterium (d) a fungus

Q8. The female Anopheles mosquito transmits
(a) cholera (b) tuberculosis (c) malaria (d) typhoid

Q9. Biostatistics is the application of
(a) physics to biology (b) mathematics to biology (c) chemistry to biology (d) geography to biology

Q10. A well-tested explanation supported by much evidence is a
(a) hypothesis (b) deduction (c) theory (d) guess

Answer key: 1-b, 2-c, 3-b, 4-d, 5-a, 6-c, 7-b, 8-c, 9-b, 10-c

CHAPTER 2

Biodiversity

2.1 What is Biodiversity?

Biodiversity is the variety of life on Earth — the number and variety of species, genes and ecosystems. It exists at three levels: **genetic diversity** (differences among individuals of a species), **species diversity** (the number of different species) and **ecosystem diversity** (the variety of habitats such as forests, deserts and rivers). Pakistan is rich in biodiversity, with plants and animals adapted to mountains, deserts, forests and the sea coast.

2.2 Classification and Its Aims

Classification is the grouping of organisms on the basis of their similarities and differences. Its aims are to identify organisms easily, to show the relationships between them, to give each organism a single scientific name, and to make the study of millions of species possible. The science of classification is called **taxonomy**, and the science of naming organisms is called **nomenclature**.

2.3 Taxonomic Hierarchy

Organisms are arranged in a hierarchy of groups called **taxa**. From the largest to the smallest, the ranks are: **kingdom, phylum (division in plants), class, order, family, genus, species**. A **species** is a group of organisms that can interbreed and produce fertile offspring. For example, human beings belong to kingdom Animalia, phylum Chordata, class Mammalia, order Primates, family Hominidae, genus *Homo* and species *sapiens*.

2.4 Binomial Nomenclature

Carolus Linnaeus gave the system of **binomial nomenclature**, in which every species has a two-part scientific name: the **genus** name followed by the **species** name, for example *Homo sapiens* for humans and *Mangifera indica* for mango. Rules of this system are: the scientific name is written in italics (or underlined when handwritten); the genus name begins with a capital letter and the species name with a small letter; and the name is the same all over the world, so scientists everywhere understand it.

2.5 The Five-Kingdom System

Robert Whittaker proposed the five-kingdom system of classification. (1) **Monera**: unicellular prokaryotes, such as bacteria and blue-green algae; they have no true nucleus. (2) **Protista**: mostly unicellular eukaryotes, such as Amoeba, Paramecium and Euglena. (3) **Fungi**: multicellular eukaryotes that absorb food from dead matter; they have cell walls of chitin and include mushrooms and moulds. (4) **Plantae**: multicellular eukaryotes that make food by photosynthesis and have cell walls of cellulose. (5) **Animalia**: multicellular eukaryotes that feed on other organisms and have no cell wall.

Viruses do not fit in any kingdom because they are acellular — they are neither living nor non-living outside a host cell. They consist of a protein coat around a core of DNA or RNA.

Kingdom	Cell type	Cell wall	Nutrition
Monera	Prokaryotic	Present	Various
Protista	Eukaryotic	Present in some	Various
Fungi	Eukaryotic	Chitin	Absorption
Plantae	Eukaryotic	Cellulose	Photosynthesis
Animalia	Eukaryotic	Absent	Ingestion

2.6 Conservation of Biodiversity

Biodiversity is being lost because of deforestation, hunting, pollution, overgrazing and the destruction of habitats. Conservation means the protection and careful use of living resources. Methods include national parks and wildlife sanctuaries, laws against hunting, planting trees, and breeding endangered animals in zoos. In Pakistan, the markhor, the snow leopard and the Indus dolphin are protected species. Conservation is necessary because every species has a role in nature and many provide food, medicine and raw materials for human beings.

> **Key point:** A species is the smallest unit of classification. Organisms of one species can interbreed and produce fertile offspring.

Short Questions with Answers

Q1. Define biodiversity.

Ans: Biodiversity is the variety of life on Earth — the variety of species, genes and ecosystems in an area.

Q2. What are the aims of classification?

Ans: To identify organisms easily, to show relationships between them, to give each organism one scientific name, and to make the study of millions of species possible.

Q3. Write the taxonomic hierarchy from kingdom to species.

Ans: Kingdom, phylum (division), class, order, family, genus, species.

Q4. State two rules of binomial nomenclature.

Ans: The scientific name has two parts (genus + species); it is written in italics, with the genus name capitalised and the species name in small letters.

Q5. Why are viruses not placed in any kingdom?

Ans: Because viruses are acellular — they have no cell structure and are neither fully living nor non-living outside a host cell.

Long Questions with Answers

Q1. Describe the five-kingdom system of classification with one example of each kingdom.

Ans: Whittaker's five-kingdom system is: (1) Monera — unicellular prokaryotes without a true nucleus, e.g. bacteria. (2) Protista — mostly unicellular eukaryotes, e.g. Amoeba. (3) Fungi — eukaryotes with chitin cell walls that absorb food from dead matter, e.g. mushroom. (4) Plantae — multicellular eukaryotes that photosynthesise and have cellulose cell walls, e.g. mango tree. (5) Animalia — multicellular eukaryotes without cell walls that feed on other organisms, e.g. human beings. Viruses are placed in none of these kingdoms because they are acellular.

Q2. Why is conservation of biodiversity necessary, and how can it be done?

Ans: Biodiversity is necessary because species keep ecosystems in balance and provide food, medicine, timber and raw materials; losing a species can disturb the whole ecosystem. It is threatened by deforestation, hunting, pollution and habitat destruction. Conservation methods include national parks and sanctuaries, laws against hunting, tree plantation, protection of endangered species such as the markhor and the Indus dolphin, and captive breeding in zoos. Every citizen should avoid unnecessary cutting of trees and hunting.

Multiple-Choice Questions

Q1. The variety of life on Earth is called
(a) ecology (b) biodiversity (c) taxonomy (d) evolution

Q2. The science of classification is
(a) taxonomy (b) ecology (c) genetics (d) physiology

Q3. The smallest unit of classification is the
(a) genus (b) family (c) species (d) order

Q4. Binomial nomenclature was introduced by
(a) Aristotle (b) Whittaker (c) Linnaeus (d) Darwin

Q5. The scientific name of mango is
(a) Mangifera indica (b) Homo sapiens (c) Felis domesticus (d) Rosa indica

Q6. Bacteria belong to kingdom
(a) Protista (b) Fungi (c) Monera (d) Plantae

Q7. Mushroom belongs to kingdom
(a) Plantae (b) Fungi (c) Animalia (d) Monera

Q8. The cell wall of fungi is made of
(a) cellulose (b) chitin (c) pectin (d) lignin

Q9. Which of these is a protected animal of Pakistan?
(a) Markhor (b) Rabbit (c) Goat (d) Hen

Q10. Viruses are not placed in any kingdom because they are
(a) too small (b) acellular (c) too large (d) parasites only

Answer key: 1-b, 2-a, 3-c, 4-c, 5-a, 6-c, 7-b, 8-b, 9-a, 10-b

CHAPTER 3

The Cell

3.1 Discovery of the Cell and the Cell Theory

Robert Hooke first observed cells in a slice of cork in 1665 and called the small compartments "cells". Anton van Leeuwenhoek observed living cells, including bacteria, with his simple microscope. The **cell theory** states that: (1) all living organisms are made of one or more cells; (2) the cell is the basic structural and functional unit of life; and (3) all cells arise from pre-existing cells. Cells are usually small because a large surface-to-volume ratio helps them take in food and remove wastes quickly.

3.2 Prokaryotic and Eukaryotic Cells

Prokaryotic cells (bacteria) are simple: they have no true nucleus and no membrane-bound organelles; their DNA lies free in the cytoplasm. **Eukaryotic cells** (plant, animal, fungal and protist cells) have a true nucleus and membrane-bound organelles. A plant cell differs from an animal cell in having a cell wall, chloroplasts and a large central vacuole, while an animal cell has centrioles and small vacuoles, and no cell wall or chloroplasts.

3.3 Cell Organelles

The **cell membrane** is a thin, selectively permeable layer that controls what enters and leaves the cell. The **nucleus** controls all cell activities and contains DNA, the hereditary material. **Mitochondria** release energy from food by respiration and are called the powerhouse of the cell. **Ribosomes** make proteins. The **endoplasmic reticulum** (rough with ribosomes, smooth without) transports materials. The **Golgi body** packs and secretes materials. **Lysosomes** digest waste and old organelles. **Plastids** include chloroplasts (photosynthesis), chromoplasts (colour) and leucoplasts (storage). The **vacuole** stores water and sap, and is large in plant cells.

3.4 Movement of Materials Across the Membrane

Diffusion is the movement of molecules from a region of higher concentration to a region of lower concentration. **Osmosis** is the movement of water across a selectively permeable membrane from a dilute solution to a concentrated solution. When a plant cell is placed in a concentrated solution, water leaves the cell and the cytoplasm shrinks away from the cell wall — this is **plasmolysis**. When a plant cell is placed in water, it absorbs water and becomes firm; this pressure is **turgor pressure**, and it keeps the plant upright. In animal cells, too much water can cause them to burst, while loss of water shrinks them.

3.5 Microscopy

The **light microscope** uses visible light and lenses to magnify objects up to about 1500 times; living cells can be seen with it. The **electron microscope** uses a beam of electrons and magnifies up to hundreds of thousands of times, showing the fine structure of organelles, but it can only show dead specimens. The power of a microscope to show two close objects as separate is its **resolving power**; the electron microscope has a much higher resolving power than the light microscope.

Feature	Plant cell	Animal cell
Cell wall	Present (cellulose)	Absent
Chloroplasts	Present	Absent
Vacuole	Large, central	Small or absent
Centrioles	Absent (mostly)	Present

> **Key point:** The cell membrane is selectively permeable — it allows some substances to pass and blocks others, which keeps the inside of the cell in balance.

Short Questions with Answers

Q1. State the three points of the cell theory.

Ans: All living organisms are made of cells; the cell is the basic structural and functional unit of life; all cells arise from pre-existing cells.

Q2. How does a prokaryotic cell differ from a eukaryotic cell?

Ans: A prokaryotic cell has no true nucleus and no membrane-bound organelles; a eukaryotic cell has a true nucleus and membrane-bound organelles.

Q3. What is the function of mitochondria?

Ans: Mitochondria release energy from food by cellular respiration; they are called the powerhouse of the cell.

Q4. Define osmosis.

Ans: Osmosis is the movement of water across a selectively permeable membrane from a dilute solution to a concentrated solution.

Q5. What is plasmolysis?

Ans: Plasmolysis is the shrinking of the cytoplasm away from the cell wall when a plant cell loses water in a concentrated solution.

Long Questions with Answers

Q1. Compare a plant cell with an animal cell.

Ans: A plant cell has a cell wall of cellulose, chloroplasts for photosynthesis and a large central vacuole; it usually has no centrioles. An animal cell has no cell wall and no chloroplasts; it has centrioles and only small vacuoles or none. Both have a cell membrane, cytoplasm, nucleus, mitochondria, ribosomes, endoplasmic reticulum and Golgi body. The cell wall gives the plant cell a fixed shape, while the animal cell is flexible.

Q2. Describe the structure and functions of the nucleus and the mitochondria.

Ans: The nucleus is the largest organelle. It is surrounded by a nuclear membrane with pores, and it contains chromosomes made of DNA, which carry hereditary information and control all cell activities. The nucleolus inside the nucleus makes ribosomes. Mitochondria are rod-shaped organelles with a folded inner membrane. They carry out aerobic respiration, releasing energy from glucose in the form of ATP, which the cell uses for all its activities. For this reason mitochondria are called the powerhouse of the cell.

Multiple-Choice Questions

Q1. Cells were first observed by
(a) Leeuwenhoek (b) Robert Hooke (c) Schleiden (d) Schwann

Q2. The basic unit of life is the
(a) tissue (b) organ (c) cell (d) organelle

Q3. Bacteria have cells that are
(a) eukaryotic (b) prokaryotic (c) multicellular (d) acellular

Q4. The powerhouse of the cell is the
(a) nucleus (b) ribosome (c) mitochondrion (d) Golgi body

Q5. Protein synthesis takes place in the
(a) lysosome (b) ribosome (c) vacuole (d) plastid

Q6. Photosynthesis takes place in the
(a) mitochondrion (b) chloroplast (c) nucleus (d) ribosome

Q7. The cell wall of a plant cell is made of
(a) chitin (b) cellulose (c) protein (d) starch

Q8. Movement of water across a membrane is called
(a) diffusion (b) osmosis (c) plasmolysis (d) active transport

Q9. The electron microscope can show
(a) living cells only (b) dead specimens in fine detail (c) only bacteria (d) only plant cells

Q10. Which organelle digests waste material?
(a) Ribosome (b) Lysosome (c) Golgi body (d) Vacuole

Answer key: 1-b, 2-c, 3-b, 4-c, 5-b, 6-b, 7-b, 8-b, 9-b, 10-b

CHAPTER 4

Cell Cycle

4.1 The Cell Cycle

The **cell cycle** is the series of events by which a cell grows, copies its DNA and divides into two daughter cells. It has two main phases: **interphase**, the long period of growth and preparation, and the **division phase** (mitosis or meiosis). Interphase has three sub-phases: **G1** (the cell grows and makes proteins), **S** (DNA is copied), and **G2** (the cell prepares for division). Most of a cell's life is spent in interphase.

4.2 Mitosis

Mitosis is the division of a cell into two identical daughter cells, each with the same number of chromosomes as the parent cell. It has four stages. In **prophase**, chromosomes become visible and the nuclear membrane disappears. In **metaphase**, chromosomes arrange themselves at the equator of the cell. In **anaphase**, the sister chromatids separate and move to opposite poles. In **telophase**, two new nuclei form and the cytoplasm divides (**cytokinesis**). Mitosis is needed for growth, repair of damaged tissues and asexual reproduction.

4.3 Meiosis

Meiosis is the division that produces gametes (sex cells). It has two divisions: meiosis I and meiosis II. In meiosis I, homologous chromosomes pair up and exchange parts (**crossing over**), then separate, halving the chromosome number. In meiosis II, the chromatids separate like in mitosis. The result is four daughter cells, each with half the number of chromosomes. Meiosis produces variation and keeps the chromosome number constant from generation to generation.

4.4 Mitosis and Meiosis Compared

Feature	Mitosis	Meiosis
Number of divisions	One	Two
Daughter cells	Two, identical	Four, different
Chromosome number	Same as parent	Half of parent
Crossing over	Does not occur	Occurs in prophase I
Purpose	Growth and repair	Formation of gametes

4.5 Apoptosis, Necrosis and Cancer

Apoptosis is programmed cell death — an orderly process by which old or damaged cells remove themselves without harming neighbours; it shapes organs during development, for example the separation of fingers in the embryo. **Necrosis** is unplanned cell death caused by injury, infection or lack of blood supply; it damages surrounding tissue and causes inflammation. **Cancer** is uncontrolled cell division. It may be caused by mutations, radiation, certain chemicals or viruses. A tumour is a mass of abnormal cells; a malignant tumour spreads to other parts of the body and is called cancer.

> **Key point:** In humans, body (somatic) cells divide by mitosis, while gametes are formed by meiosis. A human body cell has 46 chromosomes; a gamete has 23.

Short Questions with Answers

Q1. What is the cell cycle?

Ans: The cell cycle is the series of events by which a cell grows, copies its DNA and divides into two daughter cells.

Q2. Name the three sub-phases of interphase.

Ans: G1 (growth), S (DNA synthesis) and G2 (preparation for division).

Q3. In which phase of mitosis do chromosomes line up at the equator?

Ans: In metaphase.

Q4. What is crossing over?

Ans: Crossing over is the exchange of parts between homologous chromosomes during prophase I of meiosis; it produces variation.

Q5. Define apoptosis.

Ans: Apoptosis is programmed cell death — an orderly removal of old or damaged cells without harming neighbouring cells.

Long Questions with Answers

Q1. Describe the stages of mitosis.

Ans: Mitosis has four stages. In prophase, the chromosomes shorten and become visible, the nuclear membrane disappears and the spindle forms. In metaphase, the chromosomes arrange themselves at the equator of the cell, attached to spindle fibres. In anaphase, the sister chromatids separate and move to opposite poles. In telophase, two new nuclei form, the chromosomes uncoil and the cytoplasm divides (cytokinesis), giving two identical daughter cells with the same chromosome number as the parent cell.

Q2. How does meiosis differ from mitosis, and why is meiosis important?

Ans: Mitosis has one division and produces two identical daughter cells with the same chromosome number; it is used for growth and repair. Meiosis has two divisions and produces four different daughter cells with half the chromosome number; crossing over occurs in meiosis I. Meiosis is important because it forms gametes, halves the chromosome number so that fertilisation restores the full number, and produces variation through crossing over and the independent assortment of chromosomes. Without meiosis, the chromosome number would double in every generation.

Multiple-Choice Questions

Q1. The phase in which DNA is copied is
(a) G1 (b) S (c) G2 (d) M

Q2. Mitosis produces
(a) two identical cells (b) four different cells (c) one cell (d) eight cells

Q3. Chromosomes line up at the equator in
(a) prophase (b) metaphase (c) anaphase (d) telophase

Q4. Sister chromatids separate in
(a) prophase (b) metaphase (c) anaphase (d) interphase

Q5. Meiosis produces
(a) two identical cells (b) four cells with half the chromosomes (c) two cells with double chromosomes (d) one cell

Q6. Crossing over occurs in
(a) prophase of mitosis (b) prophase I of meiosis (c) anaphase II (d) telophase

Q7. Human gametes contain
(a) 46 chromosomes (b) 23 chromosomes (c) 92 chromosomes (d) 12 chromosomes

Q8. Programmed cell death is called
(a) necrosis (b) apoptosis (c) cancer (d) mutation

Q9. Uncontrolled cell division causes
(a) diabetes (b) cancer (c) anaemia (d) rickets

Q10. Mitosis is important for
(a) growth and repair (b) formation of gametes (c) variation (d) fertilisation

Answer key: 1-b, 2-a, 3-b, 4-c, 5-b, 6-b, 7-b, 8-b, 9-b, 10-a

CHAPTER 5

Tissues, Organs and Organ Systems

5.1 Tissues

A **tissue** is a group of similar cells that work together to perform one function. In plants, **meristematic tissue** is made of young, actively dividing cells found at the tips of roots and shoots; it causes growth in length. **Permanent tissues** are made of mature cells that no longer divide. **Parenchyma** is soft tissue that stores food and carries out photosynthesis; **collenchyma** gives support to young stems; **sclerenchyma** is hard, dead tissue that gives strength. The conducting tissues are **xylem** (carries water and minerals up from the roots) and **phloem** (carries food from the leaves to all parts of the plant).

5.2 Animal Tissues

Animals have four main types of tissue. **Epithelial tissue** covers the body surfaces and lines organs, for example the skin and the lining of the stomach. **Connective tissue** binds and supports other tissues; it includes blood, bone, cartilage and fat. **Muscular tissue** contracts to produce movement; there are skeletal muscles (voluntary), smooth muscles (involuntary, in the gut and blood vessels) and cardiac muscle (in the heart). **Nervous tissue** is made of nerve cells (neurons) and carries messages around the body.

5.3 Organs and Organ Systems

Different tissues join to form an **organ**, such as the heart, leaf or stomach. Organs that work together for one purpose form an **organ system**. In flowering plants, the **root system** (roots) absorbs water and minerals, and the **shoot system** (stem, leaves, flowers) makes food and carries out reproduction. In the human body, the main systems are the digestive, respiratory, circulatory, nervous, excretory, skeletal, muscular and reproductive systems.

5.4 The Human Digestive System as an Example

The digestive system shows how organs work together. The **mouth** grinds food and mixes it with saliva. The **oesophagus** carries food to the **stomach**, where acid and enzymes begin digestion. The **small intestine** completes digestion and absorbs food into the blood through villi. The **large intestine** absorbs water, and the **liver** and **pancreas** add bile and digestive juices. Each organ has tissues suited to its work: the stomach wall has muscle tissue for churning and glandular tissue for making acid and enzymes.

5.5 Levels of Organisation Revisited

The hierarchy cell — tissue — organ — organ system — organism applies to all multicellular life. A single-celled organism such as Amoeba carries out all life processes in one cell. In a large organism, work is divided: no single cell can do everything, so tissues, organs and systems specialise. This **division of labour** makes large, complex organisms possible. Damage to one level — for example, damage to the heart muscle — affects the whole system and therefore the whole organism.

> **Key point:** Xylem carries water upwards and phloem carries food — remember "X for water up, P for food (photosynthate)".

Short Questions with Answers

Q1. Define a tissue.

Ans: A tissue is a group of similar cells that work together to perform a particular function.

Q2. What is meristematic tissue?

Ans: Meristematic tissue is made of young, actively dividing cells found at root and shoot tips; it causes growth.

Q3. Name the four main types of animal tissue.

Ans: Epithelial tissue, connective tissue, muscular tissue and nervous tissue.

Q4. What is the function of xylem?

Ans: Xylem carries water and dissolved minerals from the roots up to all parts of the plant.

Q5. Give one example each of an organ and an organ system in humans.

Ans: Organ: heart (or stomach). Organ system: the circulatory system (or digestive system).

Long Questions with Answers

Q1. Describe the plant tissues and their functions.

Ans: Plant tissues are of two kinds. Meristematic tissue consists of young dividing cells at root and shoot tips and causes growth. Permanent tissues are mature. Parenchyma stores food and carries out photosynthesis; collenchyma supports young stems; sclerenchyma is hard and gives strength to mature parts. The complex permanent tissues are xylem, which carries water and minerals upwards, and phloem, which carries food from the leaves to the rest of the plant. Together these tissues form the organs of the plant — root, stem and leaf.

Q2. Describe the four types of animal tissue with examples.

Ans: The four animal tissues are: (1) Epithelial tissue, which covers surfaces and lines organs, e.g. skin and the stomach lining. (2) Connective tissue, which binds and supports, e.g. blood, bone, cartilage and fat. (3) Muscular tissue, which contracts for movement — skeletal muscle moves bones, smooth muscle works in the gut and blood vessels, and cardiac muscle pumps the heart. (4) Nervous tissue, made of neurons, which carries messages and controls the body. Different tissues combine to form organs such as the heart and stomach.

Multiple-Choice Questions

Q1. A group of similar cells doing one job is a
(a) organ (b) tissue (c) system (d) cell

Q2. Growth in length of a plant is caused by
(a) parenchyma (b) meristematic tissue (c) sclerenchyma (d) phloem

Q3. Food is carried in plants by the
(a) xylem (b) phloem (c) collenchyma (d) parenchyma

Q4. Water is carried in plants by the
(a) phloem (b) xylem (c) cortex (d) pith

Q5. Blood is an example of
(a) epithelial tissue (b) muscular tissue (c) connective tissue (d) nervous tissue

Q6. The skin is made of
(a) epithelial tissue (b) nervous tissue (c) muscular tissue (d) bone

Q7. Cardiac muscle is found in the
(a) stomach (b) heart (c) arm (d) gut

Q8. The shoot system of a plant includes the
(a) roots (b) stem and leaves (c) root hairs (d) root cap

Q9. Neurons are the cells of
(a) muscular tissue (b) nervous tissue (c) epithelial tissue (d) connective tissue

Q10. Sclerenchyma tissue gives the plant
(a) food (b) strength (c) water (d) colour

Answer key: 1-b, 2-b, 3-b, 4-b, 5-c, 6-a, 7-b, 8-b, 9-b, 10-b

CHAPTER 6

Biomolecules

6.1 Bioelements and Biomolecules

The chemical elements found in living organisms are called **bioelements**. About 16 elements are essential; the most abundant are carbon, hydrogen, oxygen and nitrogen, with smaller amounts of calcium, phosphorus, potassium, sulphur, sodium, chlorine and magnesium. **Biomolecules** are the molecules of life. Small biomolecules (**micromolecules**) include glucose, amino acids and fatty acids; large biomolecules (**macromolecules**) include starch, proteins, lipids and nucleic acids.

6.2 Water

Water is the most abundant substance in living things (about 70% of the human body). It is a good solvent, so it carries dissolved substances in blood and sap; it takes part in chemical reactions, including photosynthesis; it has a high heat capacity, which keeps body temperature steady; and it gives turgidity to plant cells. Without water, life as we know it would be impossible.

6.3 Carbohydrates

Carbohydrates are made of carbon, hydrogen and oxygen. **Monosaccharides** are single sugars such as glucose and fructose; **disaccharides** are two sugars joined, such as sucrose (table sugar) and lactose (milk sugar); **polysaccharides** are long chains, such as starch (food storage in plants), glycogen (food storage in animals) and cellulose (the cell wall of plants). Carbohydrates are the main source of energy for the body; one gram of carbohydrate gives about 4 kilocalories of energy.

6.4 Lipids

Lipids are fats and oils. They are made of fatty acids and glycerol, and they do not dissolve in water. **Fats** are solid at room temperature and are found in animals; **oils** are liquid and are found in plants. Lipids store more energy than carbohydrates (about 9 kilocalories per gram), insulate the body against heat loss, protect organs, and form the cell membrane as **phospholipids**. Steroids, including cholesterol and some hormones, are also lipids.

6.5 Proteins

Proteins are made of **amino acids** joined by peptide bonds. There are 20 common amino acids, and the order in which they are joined decides the shape and function of the protein. Proteins have four levels of structure: primary (the sequence of amino acids), secondary (folding into helices and sheets), tertiary (the three-dimensional shape) and quaternary (several chains joined). Proteins build body tissues, act as enzymes and hormones, carry oxygen (haemoglobin), fight disease (antibodies) and provide energy when needed.

6.6 Nucleic Acids: DNA and RNA

Nucleic acids store and transmit hereditary information. They are made of **nucleotides**, each with a sugar, a phosphate group and a nitrogenous base. **DNA** (deoxyribonucleic acid) has two strands in a double helix; its bases are adenine, thymine, guanine and cytosine, and it stays in the nucleus. **RNA** (ribonucleic acid) is usually a single strand; it has uracil instead of thymine, and it carries the message from DNA to the ribosomes for protein synthesis.

Feature	DNA	RNA
Strands	Double	Usually single
Sugar	Deoxyribose	Ribose
Bases	A, T, G, C	A, U, G, C
Function	Stores information	Carries messages, makes proteins

> **Key point:** One gram of fat gives about 9 kilocalories, while one gram of carbohydrate or protein gives about 4 kilocalories. That is why fats are the best energy store.

Short Questions with Answers

Q1. What are bioelements? Name the four most abundant.

Ans: Bioelements are the chemical elements found in living organisms. The most abundant are carbon, hydrogen, oxygen and nitrogen.

Q2. Why is water important for life? Give two reasons.

Ans: Water is a good solvent that carries dissolved substances, and its high heat capacity keeps body temperature steady.

Q3. What is the difference between starch and cellulose?

Ans: Starch is the food-storage polysaccharide in plants; cellulose forms the plant cell wall and is not digested by humans.

Q4. Name the building blocks of proteins.

Ans: Proteins are built from amino acids joined by peptide bonds.

Q5. Write two differences between DNA and RNA.

Ans: DNA is double-stranded with thymine; RNA is usually single-stranded with uracil instead of thymine.

Long Questions with Answers

Q1. Describe carbohydrates: their types and functions.

Ans: Carbohydrates are made of carbon, hydrogen and oxygen. Monosaccharides are single sugars such as glucose and fructose. Disaccharides are two sugars joined, such as sucrose and lactose. Polysaccharides are long chains: starch stores food in plants, glycogen stores food in animals, and cellulose forms plant cell walls. The main function of carbohydrates is to provide energy — glucose is used in respiration, and one gram gives about 4 kilocalories. Cellulose also gives roughage, which helps digestion.

Q2. Describe the structure and functions of proteins.

Ans: Proteins are made of amino acids joined by peptide bonds. Their structure has four levels: primary (amino-acid sequence), secondary (folding), tertiary (three-dimensional shape) and quaternary (several chains). Proteins build and repair body tissues; enzymes are proteins that speed up reactions; hormones such as insulin are proteins; haemoglobin carries oxygen in blood; and antibodies defend the body against disease. A shortage of protein in the diet causes poor growth and disease.

Multiple-Choice Questions

Q1. The most abundant substance in living things is
(a) protein (b) water (c) fat (d) glucose

Q2. Glucose is a
(a) disaccharide (b) monosaccharide (c) polysaccharide (d) lipid

Q3. Table sugar is
(a) glucose (b) fructose (c) sucrose (d) lactose

Q4. Food is stored in plants as
(a) glycogen (b) starch (c) cellulose (d) fat

Q5. Food is stored in animals as
(a) starch (b) glycogen (c) cellulose (d) sucrose

Q6. One gram of fat gives about
(a) 4 kcal (b) 9 kcal (c) 2 kcal (d) 7 kcal

Q7. Proteins are made of
(a) glucose units (b) amino acids (c) fatty acids (d) nucleotides

Q8. The base found in RNA but not in DNA is
(a) adenine (b) guanine (c) uracil (d) thymine

Q9. DNA has the shape of a
(a) single strand (b) double helix (c) ring (d) sheet

Q10. Haemoglobin is a protein that
(a) fights disease (b) carries oxygen (c) digests food (d) makes hormones

Answer key: 1-b, 2-b, 3-c, 4-b, 5-b, 6-b, 7-b, 8-c, 9-b, 10-b

CHAPTER 7

Enzymes

7.1 What are Enzymes?

An **enzyme** is a biological catalyst — usually a protein — that speeds up a chemical reaction in a living organism without being used up itself. Without enzymes, the reactions of life would be far too slow. For example, the enzyme amylase in saliva begins the digestion of starch, and catalase in the liver breaks down harmful hydrogen peroxide. Each enzyme works on a particular substance, called its **substrate**, and produces a **product**.

7.2 Characteristics of Enzymes

Enzymes have several important characteristics. They are proteins and are destroyed by strong heat. They are needed only in small amounts and are not used up in the reaction, so they can be used again and again. They are specific — one enzyme usually works on one substrate only. They speed up both forward and reverse reactions. They lower the **activation energy**, which is the energy needed to start a reaction.

7.3 Mechanism of Enzyme Action

Two models explain how enzymes work. In the **lock and key model**, the substrate fits exactly into the enzyme's active site, like a key into a lock. In the **induced fit model**, the active site changes its shape slightly to fit the substrate. In both models, the enzyme and substrate form an **enzyme-substrate complex**; the reaction takes place, the product is released, and the enzyme is free to work again.

7.4 Factors Affecting Enzyme Activity

Temperature: enzyme activity increases with temperature up to an optimum (about 37°C in humans). Above the optimum, the enzyme is denatured — its shape is destroyed — and it stops working. **pH:** each enzyme works best at a particular pH; for example, pepsin works in the acid of the stomach (pH 2), while trypsin works in the alkaline intestine. **Substrate concentration:** the rate rises as more substrate is added, until all enzymes are busy, after which the rate stays constant. **Enzyme concentration:** more enzyme gives a faster rate if enough substrate is present.

7.5 Inhibitors, Cofactors and Uses of Enzymes

An **inhibitor** is a substance that slows down or stops an enzyme. A **competitive inhibitor** fits into the active site and blocks the substrate; a **non-competitive inhibitor** attaches elsewhere and changes the enzyme's shape. Some enzymes need helpers: a **cofactor** is a non-protein helper such as a metal ion, and a **coenzyme** is an organic helper such as a vitamin. Enzymes are used in industry: in washing powders to remove stains, in making bread, cheese and juices, in paper and leather making, and in medicine, where enzyme tests help diagnose disease.

> **Key point:** Heat denatures enzymes. That is why a high fever is dangerous — body enzymes begin to lose their shape and stop working properly.

Short Questions with Answers

Q1. Define an enzyme.

Ans: An enzyme is a biological catalyst, usually a protein, that speeds up a chemical reaction in a living organism without being used up.

Q2. What is a substrate?

Ans: A substrate is the substance on which an enzyme acts; the enzyme changes it into a product.

Q3. What is activation energy?

Ans: Activation energy is the energy needed to start a chemical reaction; enzymes lower it so the reaction can happen faster.

Q4. State the lock and key model in one line.

Ans: In the lock and key model, the substrate fits exactly into the enzyme's active site, like a key into a lock.

Q5. What is an inhibitor?

Ans: An inhibitor is a substance that slows down or stops the action of an enzyme.

Long Questions with Answers

Q1. Describe the factors that affect enzyme activity.

Ans: Four factors affect enzyme activity. (1) Temperature: activity rises up to an optimum (about 37°C in humans); above it, the enzyme is denatured and stops working. (2) pH: each enzyme has an optimum pH — pepsin works at pH 2 in the stomach, trypsin at alkaline pH in the intestine; wrong pH denatures the enzyme. (3) Substrate concentration: the rate rises with more substrate until all enzyme molecules are busy, then it stays constant. (4) Enzyme concentration: more enzyme gives a faster rate when enough substrate is present.

Q2. Explain the mechanism of enzyme action with the lock and key and induced fit models.

Ans: An enzyme has an active site, a pocket shaped to fit its substrate. In the lock and key model, the substrate fits the active site exactly, like a key in a lock; the enzyme-substrate complex forms, the reaction occurs and the product is released. In the induced fit model, the active site changes shape slightly to fit the substrate snugly. In both models the enzyme is not used up and can act again. Enzymes work by lowering the activation energy of the reaction, and they are specific — each enzyme usually acts on only one substrate.

Multiple-Choice Questions

Q1. An enzyme is a
(a) biological catalyst (b) substrate (c) product (d) hormone

Q2. Enzymes are mostly made of
(a) carbohydrates (b) lipids (c) proteins (d) nucleic acids

Q3. The substance an enzyme acts on is the
(a) product (b) substrate (c) cofactor (d) inhibitor

Q4. Enzymes lower the
(a) temperature (b) activation energy (c) pH (d) pressure

Q5. The optimum temperature for human enzymes is about
(a) 20°C (b) 37°C (c) 50°C (d) 0°C

Q6. High temperature destroys an enzyme by
(a) freezing it (b) denaturing it (c) dissolving it (d) diluting it

Q7. Pepsin works best at pH
(a) 2 (b) 7 (c) 9 (d) 12

Q8. A competitive inhibitor
(a) binds the active site (b) binds elsewhere (c) is a vitamin (d) is a substrate

Q9. Amylase digests
(a) protein (b) fat (c) starch (d) fibre

Q10. Catalase breaks down
(a) glucose (b) hydrogen peroxide (c) starch (d) protein

Answer key: 1-a, 2-c, 3-b, 4-b, 5-b, 6-b, 7-a, 8-a, 9-c, 10-b

CHAPTER 8

Bioenergetics

8.1 Energy and ATP

All living things need energy for growth, movement, repair and transport of substances. The energy of sunlight is trapped by plants in photosynthesis and stored in food; animals get energy by eating food. The energy currency of the cell is **ATP** (adenosine triphosphate). When ATP breaks down to ADP, energy is released for the cell's work; when energy is available, ADP is rebuilt into ATP. In this way, energy is stored and released as needed.

8.2 Photosynthesis

Photosynthesis is the process by which green plants make food from carbon dioxide and water, using sunlight and chlorophyll. The overall equation is: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$. It takes place in the **chloroplast**. In the **light reaction**, sunlight splits water, releasing oxygen, and energy is trapped as ATP. In the **dark reaction** (Calvin cycle), carbon dioxide is fixed into glucose using that energy. Factors affecting photosynthesis are light intensity, carbon dioxide concentration, temperature and the availability of water.

8.3 Cellular Respiration

Cellular respiration is the process by which cells release energy from glucose. The overall equation for aerobic respiration is: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + energy (ATP). It has three stages: **glycolysis** in the cytoplasm, which breaks glucose into pyruvate; the **Krebs cycle** in the mitochondria, which releases carbon dioxide; and the **electron transport chain**, which releases most of the ATP. Aerobic respiration gives 36 to 38 molecules of ATP from one glucose molecule.

8.4 Anaerobic Respiration (Fermentation)

When oxygen is absent, cells carry out **anaerobic respiration**. In muscle cells, glucose is broken down into lactic acid, which causes tiredness and cramp during hard exercise; this gives only 2 ATP. In yeast, glucose is broken down into alcohol and carbon dioxide — this is **alcoholic fermentation**, used in making bread and in brewing. Anaerobic respiration is quick but gives very little energy compared with aerobic respiration.

Feature	Photosynthesis	Respiration
Energy	Stores energy in food	Releases energy from food
Gas taken in	Carbon dioxide	Oxygen
Gas given out	Oxygen	Carbon dioxide
Place	Chloroplast	Mitochondrion
Occurs in	Green plants, algae	All living cells

8.5 Why Bioenergetics Matters

Photosynthesis and respiration are linked: photosynthesis stores the sun's energy in food and releases oxygen, while respiration releases that energy and gives out carbon dioxide, which plants use again. Together they keep the balance of oxygen and carbon dioxide in the air. Farmers use this knowledge — giving crops enough light, water and carbon dioxide increases photosynthesis and therefore the yield.

> **Key point:** Aerobic respiration gives 36–38 ATP per glucose; anaerobic respiration gives only 2 ATP. Oxygen makes a huge difference to energy yield.

Short Questions with Answers

Q1. What is ATP?

Ans: ATP (adenosine triphosphate) is the energy currency of the cell; its breakdown releases energy for the cell's work.

Q2. Write the overall equation of photosynthesis.

Ans: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ (in the presence of sunlight and chlorophyll).

Q3. Where does photosynthesis take place?

Ans: In the chloroplast of green plant cells, mainly in the leaves.

Q4. Name the three stages of aerobic respiration.

Ans: Glycolysis, the Krebs cycle and the electron transport chain.

Q5. What is fermentation?

Ans: Fermentation is anaerobic respiration — the breakdown of glucose without oxygen, producing lactic acid (in muscles) or alcohol and carbon dioxide (in yeast).

Long Questions with Answers

Q1. Describe the process of photosynthesis and the factors that affect it.

Ans: Photosynthesis is the process by which green plants make glucose from carbon dioxide and water using sunlight and chlorophyll, in the chloroplast. In the light reaction, sunlight splits water, oxygen is released and ATP is formed. In the dark reaction (Calvin cycle), carbon dioxide is fixed into glucose. Factors affecting the rate are: light intensity (more light, faster rate up to a limit), carbon dioxide concentration, temperature (too high denatures enzymes), and water supply (shortage closes stomata). The equation is $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$.

Q2. Describe aerobic respiration and compare it with anaerobic respiration.

Ans: Aerobic respiration uses oxygen to break down glucose completely into carbon dioxide and water, releasing 36–38 ATP. It has three stages: glycolysis in the cytoplasm, the Krebs cycle and the electron transport chain in the mitochondria. Anaerobic respiration works without oxygen; in muscles it makes lactic acid, in yeast it makes alcohol and carbon dioxide, and it gives only 2 ATP. Aerobic respiration is slow but efficient; anaerobic respiration is fast but gives little energy and leaves waste products that must be removed.

Multiple-Choice Questions

Q1. The energy currency of the cell is
(a) ADP (b) ATP (c) DNA (d) NAD

Q2. Photosynthesis takes place in the
(a) mitochondrion (b) chloroplast (c) nucleus (d) ribosome

Q3. Oxygen is released in photosynthesis from
(a) carbon dioxide (b) water (c) glucose (d) chlorophyll

Q4. The dark reaction is also called the
(a) Krebs cycle (b) Calvin cycle (c) glycolysis (d) fermentation

Q5. Aerobic respiration gives about
(a) 2 ATP (b) 10 ATP (c) 36–38 ATP (d) 100 ATP

Q6. Glycolysis takes place in the
(a) mitochondrion (b) cytoplasm (c) nucleus (d) chloroplast

Q7. The Krebs cycle takes place in the
(a) cytoplasm (b) mitochondrion (c) chloroplast (d) ribosome

Q8. Lactic acid is formed in muscles during
(a) aerobic respiration (b) anaerobic respiration (c) photosynthesis (d) digestion

Q9. Alcoholic fermentation is carried out by
(a) bacteria (b) yeast (c) virus (d) moss

Q10. Which gas is taken in during photosynthesis?
(a) Oxygen (b) Carbon dioxide (c) Nitrogen (d) Hydrogen

Answer key: 1-b, 2-b, 3-b, 4-b, 5-c, 6-b, 7-b, 8-b, 9-b, 10-b

CHAPTER 9

Plant Physiology

9.1 Plant Nutrition

Plants are **autotrophs** — they make their own food by photosynthesis. Besides carbon dioxide and water, they need **mineral nutrients** from the soil. **Macronutrients** are needed in large amounts: nitrogen (for proteins and chlorophyll), phosphorus (for DNA and ATP), potassium (for opening and closing stomata), calcium (for cell walls), magnesium (for chlorophyll) and sulphur (for proteins). **Micronutrients** are needed in small amounts: iron, zinc, manganese, boron and copper. A shortage of a nutrient causes deficiency symptoms — for example, lack of nitrogen causes yellowing of leaves, and lack of iron causes pale young leaves.

9.2 Transport of Water and Minerals

Water and minerals are absorbed by **root hairs** from the soil and carried up through the **xylem**. The main force pulling water up is **transpiration pull**: water evaporating from the leaves pulls the column of water up behind it. This works because of **cohesion** (water molecules sticking to each other) and **adhesion** (water sticking to the walls of xylem vessels). **Root pressure** also pushes water up a little. Food made in the leaves is carried to all parts of the plant through the **phloem** by **translocation**.

9.3 Transpiration and Stomata

Transpiration is the loss of water vapour from the aerial parts of a plant, mostly through the **stomata** — tiny pores on the leaves, each surrounded by two **guard cells** that open and close the pore. Transpiration is increased by bright light, high temperature, wind and low humidity; it is decreased by darkness, cold and high humidity. Transpiration is useful: it pulls water up, cools the plant and helps minerals reach the leaves. Too much transpiration can wilt the plant.

9.4 Osmosis, Turgor and Plasmolysis in Plants

Root hairs absorb water by **osmosis**: the sap inside the root hair is more concentrated than the soil water, so water moves in. **Turgor pressure** is the pressure of water pushing against the cell wall; it keeps leaves firm and stems upright. When a plant loses more water than it absorbs, turgor falls and the plant **wilts**. In a strongly concentrated solution, water leaves the cell and the cytoplasm shrinks — **plasmolysis**.

9.5 Gaseous Exchange in Plants

Plants exchange gases through the stomata on leaves and through small pores called **lenticels** on stems. During the day, photosynthesis uses carbon dioxide and releases oxygen; respiration uses oxygen and releases carbon dioxide all the time. The net exchange depends on the balance: in daylight, plants take in more carbon dioxide than they release, while at night they take in oxygen and release carbon dioxide.

> **Key point:** Transpiration pull is the main force that lifts water to the top of a tall tree — there is no pump in a plant.

Short Questions with Answers

Q1. What is an autotroph?

Ans: An autotroph is an organism that makes its own food, e.g. a green plant making food by photosynthesis.

Q2. Name two macronutrients and their functions.

Ans: Nitrogen — needed for proteins and chlorophyll. Magnesium — needed to make chlorophyll.

Q3. What is transpiration?

Ans: Transpiration is the loss of water vapour from the aerial parts of a plant, mostly through the stomata.

Q4. What are guard cells?

Ans: Guard cells are the two cells surrounding each stoma; they open and close the pore to control gas exchange and water loss.

Q5. What is transpiration pull?

Ans: Transpiration pull is the upward pull on the water column in the xylem caused by water evaporating from the leaves.

Long Questions with Answers

Q1. Describe how water is absorbed and transported to the leaves in a plant.

Ans: Water is absorbed by root hairs from the soil by osmosis, because the cell sap is more concentrated than the soil water. It passes through the root cortex into the xylem vessels. The main force moving water up is transpiration pull: water evaporating from the leaves through the stomata pulls the unbroken column of water upwards, helped by cohesion between water molecules and adhesion to the xylem walls. Root pressure gives a small upward push. The water reaches the leaves, where some is used in photosynthesis and the rest is lost by transpiration.

Q2. Explain transpiration: its mechanism, the factors affecting it, and its importance.

Ans: Transpiration is the loss of water vapour from a plant, mostly through the stomata, which are opened and closed by guard cells. It is increased by bright light (stomata open), high temperature, wind (removes humid air) and low humidity; it is decreased by darkness, cold, still air and high humidity. Transpiration is important because it creates the pull that lifts water and minerals to the leaves, it cools the plant, and it keeps the movement of water and minerals going. If transpiration exceeds absorption, the plant wilts.

Multiple-Choice Questions

Q1. Plants make their own food, so they are
(a) heterotrophs (b) autotrophs (c) parasites (d) saprophytes

Q2. Magnesium is needed for making
(a) cell walls (b) chlorophyll (c) DNA (d) starch

Q3. Lack of nitrogen causes
(a) pale young leaves (b) yellowing of leaves (c) weak stems only (d) no flowers only

Q4. Water is absorbed by the
(a) root cap (b) root hairs (c) stem (d) leaves

Q5. Food is carried in plants by the
(a) xylem (b) phloem (c) cortex (d) pith

Q6. Stomata are opened and closed by
(a) xylem (b) guard cells (c) root hairs (d) lenticels

Q7. Transpiration is increased by
(a) darkness (b) wind (c) cold (d) high humidity

Q8. Turgor pressure keeps the plant
(a) dry (b) upright and firm (c) green (d) warm

Q9. Gaseous exchange in stems takes place through
(a) stomata (b) lenticels (c) root hairs (d) xylem

Q10. The main force lifting water in a tall tree is
(a) root pressure (b) transpiration pull (c) osmosis only (d) diffusion

Answer key: 1-b, 2-b, 3-b, 4-b, 5-b, 6-b, 7-b, 8-b, 9-b, 10-b

CHAPTER 10

Reproduction in Plants

10.1 Asexual Reproduction

Asexual reproduction is reproduction from one parent without the fusion of gametes, producing offspring identical to the parent. Methods include **vegetative propagation** — new plants growing from roots, stems or leaves, for example runners in strawberry, rhizomes in ginger and bulbs in onion; **cutting** (a stem piece planted to grow roots, as in rose and sugarcane); **grafting** (joining a cutting of one plant onto the stem of another); **budding** in yeast; and **spore formation** in fungi and mosses. Asexual reproduction is fast, but it produces no variation, so the offspring are all alike and may all suffer from the same disease.

10.2 Sexual Reproduction: The Flower

Sexual reproduction involves the fusion of a male gamete with a female gamete. In flowering plants it takes place in the flower. A typical flower has four whorls: the **calyx** (sepals, which protect the bud), the **corolla** (petals, which attract insects), the **androecium** (stamens — filament and anther — which make pollen, the male gametes) and the **gynoecium** (carpels — stigma, style and ovary — which contain the ovules, the female gametes).

10.3 Pollination and Fertilisation

Pollination is the transfer of pollen from the anther to the stigma. In **self-pollination**, pollen falls on the stigma of the same flower or plant; in **cross-pollination**, pollen is carried to another plant of the same species by wind, water or insects. After pollination, the pollen grain germinates and the pollen tube grows down the style to the ovule. The male gamete fuses with the egg in the ovule — this is **fertilisation**. The fertilised egg becomes the embryo, the ovule becomes the **seed**, and the ovary becomes the **fruit**.

10.4 Seeds and Germination

A seed contains the embryo (radicle, plumule and cotyledons) and a food store. For **germination** a seed needs water, oxygen and a suitable temperature. In **epigeal germination** (for example bean), the cotyledons come above the soil; in **hypogeal germination** (for example maize), the cotyledons stay below the soil. Seeds are dispersed by wind, water, animals and by the fruit bursting open, so that new plants grow away from the parent and do not compete with it.

10.5 Importance of Plant Reproduction

Plant reproduction matters to human beings in many ways. Sexual reproduction produces variation, which helps plants adapt and lets breeders develop better varieties of crops. Asexual methods such as cutting and grafting let farmers grow many identical plants of a good variety quickly — for example, seedless grapes and good varieties of mango are grown by grafting. Reproduction also ensures the survival of species and the continuation of food supply.

> **Key point:** Pollination is the transfer of pollen; fertilisation is the fusion of gametes. They are two different steps — do not confuse them.

Short Questions with Answers

Q1. Define asexual reproduction.

Ans: Asexual reproduction is reproduction from one parent without the fusion of gametes, producing offspring identical to the parent.

Q2. Name two methods of vegetative propagation with examples.

Ans: Runners in strawberry and rhizomes in ginger; bulbs in onion and stem cuttings in rose.

Q3. Name the four whorls of a flower.

Ans: Calyx, corolla, androecium and gynoecium.

Q4. What is pollination?

Ans: Pollination is the transfer of pollen grains from the anther to the stigma of a flower.

Q5. What does the ovule become after fertilisation?

Ans: The ovule becomes the seed, and the ovary becomes the fruit.

Long Questions with Answers

Q1. Describe sexual reproduction in a flowering plant.

Ans: Sexual reproduction takes place in the flower. The anther produces pollen grains (male gametes) and the ovary contains ovules with the egg (female gamete). Pollination transfers pollen to the stigma — self-pollination within one plant, or cross-pollination to another plant by wind, water or insects. The pollen grain germinates and the pollen tube grows down the style to the ovule, where the male gamete fuses with the egg — fertilisation. The fertilised egg becomes the embryo, the ovule becomes the seed and the ovary becomes the fruit. The seed germinates when it gets water, oxygen and suitable temperature.

Q2. Compare asexual and sexual reproduction in plants.

Ans: Asexual reproduction needs one parent and no gametes; the offspring are identical to the parent, it is fast, and methods include cutting, grafting, runners and spores. Its disadvantage is no variation, so all offspring may suffer from the same disease or change in conditions. Sexual reproduction needs two gametes and fertilisation; the offspring show variation, which helps adaptation and crop improvement, but it is slower and depends on pollination. Farmers use both: sexual reproduction for new varieties and asexual methods to multiply a good variety quickly.

Multiple-Choice Questions

Q1. Reproduction without gametes is
(a) sexual (b) asexual (c) fertilisation (d) pollination

Q2. New plants from runners occur in
(a) ginger (b) strawberry (c) onion (d) potato

Q3. Grafting is used to grow
(a) seeds (b) identical plants of a good variety (c) spores (d) pollen

Q4. The male part of a flower is the
(a) gynoecium (b) androecium (c) corolla (d) calyx

Q5. Pollen is produced in the
(a) ovary (b) stigma (c) anther (d) style

Q6. The female gamete is found in the
(a) anther (b) petal (c) ovule (d) filament

Q7. Transfer of pollen to the stigma is
(a) fertilisation (b) germination (c) pollination (d) dispersal

Q8. After fertilisation, the ovary becomes the
(a) seed (b) fruit (c) flower (d) embryo

Q9. For germination a seed needs
(a) light only (b) water, oxygen and suitable temperature (c) soil only (d) fertiliser only

Q10. In epigeal germination, the cotyledons
(a) stay below the soil (b) come above the soil (c) dry up at once (d) turn into roots

Answer key: 1-b, 2-b, 3-b, 4-b, 5-c, 6-c, 7-c, 8-b, 9-b, 10-b

CHAPTER 11

Biostatistics

11.1 What is Biostatistics?

Biostatistics is the application of statistics to biology. It helps biologists collect, organise, present and interpret data from experiments and observations, and draw conclusions from them. For example, a biologist measuring the heights of plants or the number of seeds that germinate uses biostatistics to find the average and to decide whether a treatment really made a difference. Without statistics, a scientist could not tell whether a result was real or just a chance.

11.2 Data and Its Types

Data are facts or figures collected for study. **Qualitative data** describe qualities, such as the colour of a flower or the blood group of a person. **Quantitative data** are measured in numbers, such as the height of a plant or the weight of a seed; they may be **discrete** (whole numbers, such as the number of leaves) or **continuous** (measurements such as height). **Primary data** are collected directly by the researcher; **secondary data** are taken from books, reports or other sources.

11.3 Presentation of Data

Data are presented in **tables**, **bar charts** (bars showing values for different groups), **histograms** (bars for continuous data), **pie charts** (a circle divided into slices) and **line graphs** (showing change over time). A good table or graph has a clear title, labelled axes and correct units. Choosing the right method of presentation makes the results easy to understand.

11.4 Measures of Central Tendency

The **mean** (average) is found by adding all values and dividing by the number of values. Example: the heights 10, 12, 14, 16 and 18 cm have a mean of (10 + 12 + 14 + 16 + 18) ÷ 5 = 70 ÷ 5 = 14 cm. The **median** is the middle value when data are arranged in order — for 10, 12, 14, 16, 18 it is 14. The **mode** is the value that occurs most often — for 5, 7, 7, 9, 11 the mode is 7. The mean uses all values but is affected by very large or small values; the median and mode are useful when data are uneven.

11.5 Range and Simple Interpretation

The **range** is the difference between the largest and the smallest value; for 10, 12, 14, 16 and 18 it is 18 − 10 = 8. A large range shows that the data are spread out. When comparing two groups, biologists compare their means and ranges: if one group of plants given fertiliser has a higher mean height and the ranges do not overlap much, the fertiliser probably helped. Careful interpretation matters — a difference may be due to chance, small samples or poor measurement, so conclusions must be drawn with care.

> **Worked example:** Number of leaves on 5 plants: 6, 8, 8, 10, 13. Mean = (6 + 8 + 8 + 10 + 13) ÷ 5 = 45 ÷ 5 = 9. Median = 8. Mode = 8. Range = 13 − 6 = 7.

Short Questions with Answers

Q1. Define biostatistics.

Ans: Biostatistics is the application of statistics to biology — collecting, organising, presenting and interpreting biological data.

Q2. What is the difference between qualitative and quantitative data?

Ans: Qualitative data describe qualities (e.g. flower colour); quantitative data are measured in numbers (e.g. plant height).

Q3. Find the mean of 4, 6, 8, 10.

Ans: Mean = (4 + 6 + 8 + 10) ÷ 4 = 28 ÷ 4 = 7.

Q4. What is the mode of 3, 5, 5, 7, 9?

Ans: The mode is 5, because it occurs most often.

Q5. What is the range of 12, 15, 20, 25?

Ans: Range = 25 − 12 = 13.

Long Questions with Answers

Q1. Explain the measures of central tendency with examples.

Ans: The three measures of central tendency are the mean, the median and the mode. The mean is the sum of all values divided by the number of values; for 10, 12, 14, 16, 18 it is 14 cm. The median is the middle value in ordered data; for the same set it is 14. The mode is the most frequent value; for 5, 7, 7, 9, 11 it is 7. The mean uses all the data but is affected by extreme values; the median is better for uneven data, and the mode is useful for the most common value. Together they describe the centre of a set of data.

Q2. How are data collected, presented and interpreted in biology?

Ans: Data are collected as primary data (measured directly, e.g. counting germinated seeds) or taken as secondary data from books and reports. They may be qualitative (colour, blood group) or quantitative (height, weight). Data are presented in tables, bar charts, histograms, pie charts and line graphs, each with a clear title and labelled axes. They are summarised by the mean, median, mode and range. Interpretation means comparing groups — for example, comparing mean heights of plants with and without fertiliser — and deciding carefully whether the difference is real or due to chance, small samples or poor measurement.

Multiple-Choice Questions

Q1. Biostatistics is statistics applied to
(a) physics (b) biology (c) chemistry (d) mathematics only

Q2. Flower colour is an example of
(a) quantitative data (b) qualitative data (c) primary data only (d) continuous data

Q3. Plant height measured in cm is
(a) qualitative data (b) quantitative data (c) secondary data (d) a mode

Q4. The mean of 2, 4, 6, 8 is
(a) 4 (b) 5 (c) 6 (d) 10

Q5. The median of 3, 5, 7, 9, 11 is
(a) 5 (b) 7 (c) 9 (d) 3

Q6. The mode of 4, 6, 6, 8, 10 is
(a) 4 (b) 6 (c) 8 (d) 10

Q7. The range of 5, 10, 15, 20 is
(a) 5 (b) 10 (c) 15 (d) 20

Q8. Data collected directly by the researcher are
(a) secondary data (b) primary data (c) qualitative data (d) continuous data

Q9. A pie chart shows data as
(a) bars (b) slices of a circle (c) a line (d) points

Q10. Which measure uses all values in the data?
(a) Mode (b) Median (c) Mean (d) Range

Answer key: 1-b, 2-b, 3-b, 4-b, 5-b, 6-b, 7-c, 8-b, 9-b, 10-c

PRACTICAL WORK

Practical Work — Skills to Practise

Biology practical work carries 15 marks in the BBISE Quetta SSC-I scheme. The skills below are the standard practical skills for Class 9 Biology; practise them in your school laboratory under your teacher's guidance and keep a neat practical notebook.

Skills to learn

- **Using the microscope:** focus the low-power objective first, then the high-power objective; draw what you see and label it.
- **Preparing a slide:** place a thin peel (for example, onion epidermis) on a slide, add a drop of water and a stain, and lower the coverslip gently to avoid air bubbles.
- **Observing cells:** compare plant cells (with cell wall and large vacuole) and animal cells (cheek cells) under the microscope.
- **Testing food:** test for starch with iodine solution (blue-black colour), for protein with Biuret solution (purple colour), and for fats (grease spot on paper).
- **Studying osmosis:** observe a potato or plant tissue in salt solution and in water to see plasmolysis and turgor.
- **Studying leaves:** examine the structure of a leaf and its stomata; test a leaf for starch after keeping the plant in light and in darkness.
- **Recording results:** write the aim, apparatus, method, observations and conclusion for every practical, and draw labelled diagrams.

Revision checklist

- I can name all eleven chapters and their main topics.
- I can define the key terms of each chapter in my own words.
- I can draw and label a plant cell, an animal cell, a flower and the stages of mitosis.
- I can write the equations of photosynthesis and aerobic respiration.
- I can find the mean, median, mode and range of a set of data.
- I have attempted all the MCQs and checked them against the answer keys.

End of book. Good luck with your examination.