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CHAPTER NOTES

Tissues in Action Class 9 Notes | CBSE Science Chapter 3

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Ask me anything from this chapter. A concept, a numerical, or that one doubt you did not want to raise in class. Pick one to start:

Explain Tissues in Action simply

What can the board exam ask?

Most important formulas

Quiz me on this chapter

Ask Ira anything...



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Tissues in Action Class 9 Notes | CBSE Science Chapter 3

Tissues in Action is Chapter 3 of CBSE Class 9 Science (Exploration, 2026-27). It explains how cells of similar structure group into tissues, and how the structure of each tissue suits its job. The plant half covers meristems (apical, lateral and intercalary), permanent tissues such as the epidermis, parenchyma, collenchyma, sclerenchyma, xylem and phloem, and the three plant tissue systems. The animal half covers epithelial, connective, muscular and nervous tissues, then the musculoskeletal system, the four types of joints, the skeleton and totipotency in plant cells.

School exams test this chapter through comparisons and reasoning: parenchyma versus collenchyma versus sclerenchyma, xylem versus phloem, tendon versus ligament, the three kinds of muscle, and matching an epithelium to its function. Case and data questions use the onion root tip activity, annual rings of a teak tree and Steward's carrot culture. The same tissues return in Class 10 biology when you study

Quick Answer - Tissues in Action

A tissue is a group of similar cells work through meristems: apical (length), lateral (width), and intercalary (thickness). They differentiate into permanent tissues: epidermis (protects), parenchyma (fills), collenchyma (flexibility), sclerenchyma (support), xylem (water transport), and phloem (food transport). Animals have four types of tissues: epithelial (covering), connective (support), muscular (movement), and nervous (communication). Tendons join muscle to bone, ligaments connect bones at ball and socket, hinge, pivot and



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All Key Terms at a Glance

Term	Meaning	Example or location
Apical meristem	Dividing cells that increase length	Root and shoot tips
Lateral meristem	Ring of dividing cells that increases girth	Along the circumference of the stem
Intercalary meristem	Dividing cells that allow regrowth	Base of internode or just above the node (grasses)
Parenchyma	Living, thin-walled, stores food	Air spaces in aquatic plants
Collenchyma	Living, corners thickened with pectin, flexible	Stems and tendrils
Sclerenchyma	Mostly dead, thick lignin, hard	
Xylem and phloem	Complex tissues for transport of water and food	
Epithelial tissue	Closely packed cells covering organs and lining	
Tendon and ligament	Muscle to bone; bone to bone	
Neuron	Cell that receives, transmits messages	
Totipotency	A mature plant cell that can grow into a whole plant	



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Key Concepts

1. Tissues, Levels of Organisation and Division of Labour

Life begins when a single cell divides many times. The cells formed give rise to skin (protection), muscles (movement), bones (support), nerves (control and coordination) and all other organs.

A **tissue** is a group of cells, similar in structure, that work together to perform a specific function. In a unicellular organism such as amoeba, one cell performs all the functions of life. In multicellular organisms like plants and animals, different groups of cells perform different functions.

Hierarchy of organisation in a multicellular organism:

Cell → Tissue → Organ → Organ system → Organism

- Cells of a similar type performing a similar function form a **tissue**.
- More than one type of tissue forms an **organ**.
- Different organs form an **organ system**.
- Organ systems together form the **organism**.

Division of labour: when different tissues perform different functions and can carry out complex life processes. For example, in plants, xylem transports water and minerals, while phloem transports food.

Why are plant and animal tissues different?

Feature	Plants
Movement	Most are fixed in one place and need support to stay firm and upright.
Cell wall	Rigid cell wall gives rigidity and strength.
Nutrition	Tissues use solar energy to make food by photosynthesis.



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The idea running through the chapter: **the structure of a tissue matches its function**. A thin layer suits exchange, a thick wall suits support, a long fibre suits carrying messages.

2. Meristematic Tissues: How Plants Grow

Plants grow in three ways:

- increase in **length** (height of stem and depth of roots),
- increase in **girth** (thickness of stem), and
- **regrowth** after branches are cut or after grazing.

All three need actively dividing cells. A tissue made of such cells is called a **meristematic tissue** (meristem). There are three types.

(a) Apical meristem: growth in length

Activity 3.1 (onion roots): two onion bulbs are placed in two jars. Root lengths are measured on days 1, 2 and 3. One jar has roots about 1 cm. Root lengths in both jars are the same.

Observation: roots in Jar A keep growing and roots in Jar B are cut.

Conclusion: roots grow only from their tip continuously. Shoot tips also contain actively dividing cells. Roots and shoots are the **apical meristems**.

(b) Lateral meristem: growth in girth

Stems of dicot plants grow in diameter over the years. These are called **annual growth rings**. Some rings are formed under unfavourable growth conditions in a particular year. By studying the age of a tree and learn about the climate of that year.

The increase in girth is caused by actively dividing cells. These cells divide and produce new cells inside the stem. The girth of the stem increases. This tissue is the **lateral meristem**.



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Going further (cork cambium): a young plant is covered by a single-layered epidermis. As the plant grows older, some cells below the epidermis of the stem gain the ability to divide, act as lateral meristematic cells and form the **cork cambium**. Its cells divide to form **cork cells**, which are dead, compactly arranged and contain a substance that makes them impermeable to water and gases. Cork forms the **bark** of the tree.

(c) Intercalary meristem: regrowth after cutting

If the tip of a young stem is cut, the stem stops growing in length, but new branches arise from the **nodes**. A node is the point on a stem where branches or leaves arise. The part of the stem between two nodes is the **internode**. A trimmed garden hedge becomes bushy, and mowed or grazed grass grows back. This happens because of the **intercalary meristem**, located at the base of the internode or just above the node.

Meristem	Location	Result
Apical	Tips of roots and shoots	
Lateral	Along the circumference (stem)	
Intercalary	Base of the internode or example, in grasses)	

Features of meristematic cells

- Small cells with **thin cell walls**.
- A **large, prominent nucleus**.
- **Dense cytoplasm** with many organelles
- **Vacuoles are generally absent**.
- Tightly packed, with little or no intercellular space

These features allow continuous and rapid growth.

Differentiation

Meristems keep adding new cells. Some of these cells have the ability to divide, change in structure and function to become specialised for support, transport or storage. The process by which a cell specialised to perform specific functions is called **differentiation**.



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3. Permanent Tissues in Plants

A T.S. of a sunflower stem under a microscope shows many kinds of cells, each group specialised for a particular job. These are **permanent tissues**. They are of two kinds:

- **Simple permanent tissue:** made of only one type of cell (parenchyma, collenchyma, sclerenchyma).
- **Complex permanent tissue:** made of more than one type of cell working together (xylem, phloem).

The textbook groups plant tissues by function into protective, supporting and conducting tissues.

(i) Protective tissue: epidermis

The epidermis is the outermost layer of the plant body and protects all parts of the plant. It is a **tightly packed, single layer of flat, rectangular cells**.

- **Cuticle:** epidermal cells are covered by a thin layer of cutin. In dry habitats may have a thick cuticle, with stomata. The cuticle also protects against water loss.
- **Root hairs:** hair-like projections of epidermal cells that absorb water and minerals from the soil.
- **Stomata:** pores in the epidermis of leaves through which **transpiration**, the evaporation of water, occurs. It creates a **transpiration pull** in the xylem, which helps in the upward movement of water and minerals from the plant body.

(ii) Supporting tissues: simple permanent



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Tissue	Cells	Wall	Functions and examples
Parenchyma	Living, loosely packed with intercellular spaces	Thin	Mainly stores food; photosynthesis in green parts; specialised parenchyma forms air spaces that help aquatic plants float
Collenchyma	Living	Unevenly thickened at the corners due to deposition of pectin (a chemical that gives rubber-like flexibility)	Support with flexibility, so stems and tendrils bend without breaking
Sclerenchyma	Mostly dead		



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(iii) Conducting tissues: complex p

Xylem transports water and minerals from plant strength. It has four components:

- **Tracheids** and **vessels**: tubular and thick
- **Xylem parenchyma**: the **only living** component
- **Xylem fibres**.

Tracheids, vessels and xylem fibres are present in

Phloem transports food from the leaves to the rest of the plant. It is **mostly made of living cells**. It has four components:

- **Sieve tubes**: long, tubular cells joined end to end

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- **Companion cells:** specialised parenchyma cells that regulate the cellular functions of sieve tube cells. Their main function is to monitor the loading and unloading of sugars in sieve tubes.
- **Phloem parenchyma:** stores food materials, and resin, tannins and latex.
- **Phloem fibres:** primarily sclerenchymatous; they support the sieve tubes and give strength.

Point	Xylem	Phloem
Carries	Water and minerals	Food
Direction	From roots to other parts	From leaves to other parts
Living or dead	Mostly sclerenchymatous; only xylem parenchyma is living	Mostly living cells
Components	Tracheids, vessels, xylem parenchyma, xylem fibres	Sieve tubes, companion cells



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Plant tissue systems

Plant tissues are organised into three tissue systems.

1. **Dermal tissue system:** the outer covering of the plant body. It prevents water loss.
2. **Ground tissue system:** the main body of the plant. It includes parenchyma, collenchyma, and sclerenchyma.
3. **Vascular tissue system:** the conducting tissue. It includes xylem and phloem.

4. Epithelial Tissues: Coverings and linings

Animal tissues are mainly of four types: epithelial, connective, muscle, and nervous.

Epithelial tissue forms the outer covering of the body and lines internal organs like the mouth, lungs, blood vessels and intestine. It acts as a barrier **between them**. This prevents the entry of pathogens and the secretion and movement of substances.

Different epithelia are built for different jobs (textbook Table 3.2):

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Function	Structure	Location
Exchange: rapid diffusion of liquids and gases	Single layer of thin, flat cells	Lining of blood vessels and lungs
Protection: against mechanical injury, friction and entry of microbes	Many layers of cells; outer cells flat and tightly packed	Skin, mouth and oesophagus
Secretion: mucus, enzymes, hormones, sweat, saliva	Cells specialised to produce and release substances; may be cuboidal or columnar	Salivary glands, sweat glands, stomach lining
Sensory: smell, taste, sound and balance	Specialised receptor cells with hair-like cilia	Nostrils, taste buds, inner ear
Absorption: efficient uptake of nutrients and water	Single layer of cuboidal cells, often with microvilli	Small intestine

Structure and function: where materials move through one thin layer, so the distance is short. Where there are many layers, so damaged outer cells can be replaced. Where food must be absorbed (small intestine) surface.

5. Connective Tissues: Blood, Bone

A tissue that connects and supports other parts by transporting nutrients, gases and hormones from head to toe. Both are connective tissues, y... in the **matrix**: watery, soft and jelly-like in

Blood

Blood has a fluid part, **plasma** (about 55% of total volume): red blood cells, white blood cells and platelets to blood:



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Experience	Observation	Explanation
A small cut on the skin	Red blood oozes out; a clot forms after some time	The red colour is due to haemoglobin , an iron-rich protein in RBCs. Platelets help blood clot at the site of injury.
A skin infection	The area turns red and may swell; there may be fever	White blood cells collect at infected areas, causing inflammation (redness and swelling) and possible pus formation.
Exercise or running	Faster breathing; face may turn red	Muscles need more oxygen, so breathing becomes faster and blood flow increases.

RBCs live for about **4 months** and are replaced regularly.

Bone, cartilage, tendon and ligament

Action	Experience
Touch your elbow gently	Hard, rigid structure
Press and fold your ear, or press your nose and stop	Soft, flexible, returns to shape
Touch forearm muscles and wiggle your fingers	Movement felt in forearm though fingers are far away
Sit and raise your leg as far as the knee allows	The joint does not move beyond a limit


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- **Bone:** rigid matrix with **calcium and phosphorus**
- **Cartilage:** soft, jelly-like matrix; gives flexibility

- **Tendon:** connects **muscle to bone**.
- **Ligament:** connects **bone to bone** and prevents excessive movement.

Going further (stem cells): stem cells in the bone marrow can divide and make new cells. In a bone marrow transplant, stem cells from a healthy person are given to patients with blood cancers like leukemia or disorders such as thalassemia.

6. Muscular and Nervous Tissues

Muscular tissue

Movements under our conscious control, such as running, writing or lifting objects, are **voluntary movements**. Movements that happen automatically, such as food moving through the intestine or the heart beating, are **involuntary movements**. Three kinds of muscle carry out these movements.

Feature	Skeletal muscle
Control	Voluntary
Location	Attached to the skeleton
Cell shape	Long, cylindrical fibres, unbranched
Nuclei	Many (multinucleate)
Striations	Striated (light and dark bands)
Typical work	Running, writing, lifting

Skeletal muscle is made of bundles of **mu**

Nervous tissue



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Pulling your hand away from something hot is controlled by **nervous tissue**, the body's control and coordination network. The **brain** is the control centre, coordinating activities, memory and responses. Muscles, voluntary and involuntary, cannot work on their own; they receive instructions from nervous tissue. During exercise, for example, the brain signals the heart to beat faster to meet the higher demand for oxygen.

The cells of nervous tissue are **neurons** (nerve cells), specialised to receive, process and transmit messages. A neuron has three main parts:

1. **Cell body**: contains the nucleus and controls the cell's activities.
2. **Dendrites**: receive signals from other neurons.
3. **Axon**: a long fibre that carries messages away from the cell body and ends in **axon terminals**, which pass the message to other cells.

Direction of a message: **dendrites → cell body → axon → axon terminals → next cell**. The long axon suits carrying messages over long distances in the body.

7. The Musculoskeletal System and Movement

The **musculoskeletal system** is made of bones and ligaments. It helps us stand upright, move, and perform activities under the control of the nervous system.

How movement happens: muscles **pull** on bones by means of bands called tendons. When a muscle contracts, movement occurs at a joint. A **joint** is a junction where two bones meet. It allows movement but cannot move bones on their own.

Body weight from bones and muscles: bones make up about 12 to 15 per cent of body weight, though this varies. The textbook gives average muscle as about 40 per cent for adult males and 35 per cent for adult females.

Types of joints



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Joint	Example	How it is built	Movement allowed
Ball and socket	Shoulder	Rounded top of the upper arm bone fits into a shallow hollow of the shoulder bone	Forward, backward, sideways and circular movements
Hinge	Elbow, knee	Bends and straightens like a door hinge; a small bone, the kneecap, protects the knee joint	In one direction only
Pivot	Skull on the backbone (neck)	Allows the head to turn like a doorknob in its socket	Side to side turning of the head, as in shaking it for "no"
Fixed	Bones of the skull	Flat bones joined together	No movement; keeps

The shoulder, together with the collarbone is part of the skeleton.

The skeletal system

The skeletal system is a framework of bones and organs. It includes the **skull**, **vertebral column**, **rib cage** and **limbs**.

- **Vertebral column (backbone, spine):** a series of small bones called **vertebrae**. It supports the **spinal cord**. A **disc** between vertebrae acts as a cushion for the spinal cord.
- **Rib cage:** formed by **12 pairs of ribs**. It protects the heart and lungs. Ribs are attached to the spine at the back and to the sternum at the front by flexible cartilage. This lets the chest expand and contract, changing the space in the chest so air can move in and out. Breathing is painful and difficult.



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8. Totipotency, Tissue Culture and Applications

In 1958, **F. C. Steward** showed that single cells from the phloem of carrot can regenerate whole plants. His team grew phloem cells in a nutrient medium with simple sugars and hormones under suitable conditions. The cells divided to form a mass of cells, which gradually divided and differentiated into a complete plant.

- **Dedifferentiation:** the specialised phloem cells regained the ability to divide and formed an undifferentiated mass of unspecialised cells.
- **Redifferentiation:** under suitable conditions, with nutrients and growth chemicals, this mass divided further and formed roots, shoot and finally a complete plant.
- **Totipotency:** the ability of some mature plant cells to undifferentiate, divide and redifferentiate into a new plant under specific conditions. Such cells are **totipotent**. This is similar to the way a zygote divides and differentiates into a whole organism.

Steward also compared combinations of light, air and nutrient medium (textbook Table 3.6). With a solid medium and nutrients the fresh weight of the plantlets was 20% more than those grown in liquid medium with nutrients: one gave a 20% increase in fresh weight. The number of plantlets per medium was the same in these two rows,

Crown gall disease: tumour-like swellings on the stem of a plant. It is caused by the bacterium **Agrobacterium tumefaciens**. It transfers its genetic material into plant cells to produce valuable phytochemicals, improve the quality of the plant.

Key Terms Sheet

The chapter has no formulas, so this sheet is not applicable.



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Term or fact	What to write
Meristems	Apical (length), lateral (girth), intercalary (regrowth)
Wall materials	Cuticle: cutin; collenchyma corners: pectin; sclerenchyma: lignin
Blood composition	Plasma about 55%, formed elements about 45% of total volume
RBC life span	About 4 months
Ribs	12 pairs, attached to spine and sternum, joined by flexible cartilage
Skeleton share of body weight	About 12 to 15 per cent in adults
Bone or muscle mass estimate	Estimate
Totipotency	F. C. St
Crown gall	<i>Agroba</i>



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Important Definitions

Term	Definition
Tissue	A group of cells, similar in structure, that work together to perform a specific function.
Meristematic tissue	A tissue made of actively dividing cells, responsible for growth in plants.
Differentiation	The process by which meristematic tissue becomes specialised to perform specific functions, forming permanent tissue.
Permanent tissue	Tissue formed from cells that have lost the ability to divide and are specialised for a function. Simple: one type of cell. Complex: more than one type of cell.
Epithelial tissue	Tissue of closely packed cells covering the outer surface of organs and lining internal cavities.
Connective tissue	Tissue that connects different parts of the body, such as bone, cartilage, and blood.
Tendon	Connective tissue that connects muscle to bone.
Ligament	Connective tissue that connects bone to bone.
Neuron	A cell of nervous tissue that carries electrical messages.
Totipotency	The ability of some cells to differentiate into all cell types of the body.



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Solved Examples (NCERT)

Example 1: Cutting the onion root

Question: Two onion bulbs grow roots in jars. In one jar, the roots are cut to about 1 cm. Predict the growth of roots in both jars from day 4 onwards and explain.

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Answer:

1. Roots in Jar A keep increasing in length because their tips are intact.
2. Roots in Jar B stop growing in length after the tips are cut.
3. Reason: root tips contain the apical meristem, whose cells divide continuously. Removing the tip removes the dividing cells.
4. Conclusion: roots grow in length only from their tips. Jar A is the control; Jar B is the test.

Example 2: Teak tree growth data (NCERT Exercise 7)

Data: age (years), diameter at breast height (cm), annual rings: 5, 4, 5; 10, 8, 10; 20, 24, 20; 25, 28, 25; 30, 32, 30; 40, 40, 40.

(i) Analyse the graph in terms of the diameter of the stem over time.

- The diameter rises at every age in the tree.
- Increase per year: 5 to 10 years, $4/5 = 0.8$ cm; 10 to 20 years, $8/10 = 0.8$ cm; 20 to 25 years, $4/5 = 0.8$ cm; 25 to 30 years, $4/5 = 0.8$ cm; 30 to 40 years, 0.8 cm each.
- Growth in girth was fastest between 10 and 20 years, 0.8 cm per year.

(ii) What is the relation between the diameter and the number of annual rings equals the age of the tree?
The diameter also increases, so both rise together. The diameter increases by the same amount per ring, because ring width is constant.

(iii) Which specialised tissue is responsible for the increase in diameter?
The lateral meristem, a ring of actively dividing cells.

Example 3: Estimating bone and muscle mass

Question: An adult man weighs 70 kg. Using the following data, estimate the mass of bone and muscle in his body. Assume that, on average, adult male muscle about 40 to 50 per cent of body weight.

Solution:

- Bone: $70 \times 12/100 = 8.4$ kg; $70 \times 15/100 = 10.5$ kg
- Muscle: $70 \times 40/100 = 28$ kg; $70 \times 50/100 = 35$ kg

Actual values vary with age, gender and body composition.



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Example 4: Coconut husk and coriander stalk (NCERT Pause and Ponder 1)

Question: You may have noticed that fibres of coconut husk are hard and brittle, whereas the leaf stalks of coriander are soft and flexible. Find out the reason.

Answer: Coconut husk fibres are made of **sclerenchyma**. Their cells have thick walls with lignin and are mostly dead, so they are hard and strong but cannot bend. Coriander leaf stalks have **collenchyma**, which is living, with walls thickened only at the corners by pectin. Pectin gives rubber-like flexibility, so the stalk bends without breaking.

Example 5: Thick cuticle in desert and water plants (NCERT Pause and Ponder 2)

Question: Why do you think that a thick cuticle on the outer wall of epidermis is advantageous for a plant living in the desert but disadvantageous for a plant living underwater?

Answer: The cuticle is a waxy layer of cutin that reduces water loss. In the desert, water is scarce, so a thick cuticle reduces loss by evaporation. In water, there is no shortage of water, and a thick cuticle prevents the uptake of water and substances with the surrounding water.

Example 6: Assertion-Reason set

Options: (i) Both (A) and (R) are true, and (R) is the correct explanation of (A). (ii) Both (A) and (R) are true, but (R) is not the correct explanation of (A). (iii) (A) is false, but (R) is true.

1. **A:** Epithelium is well-suited for gas exchange. **R:** Epithelium has tall cells that slow down diffusion. **Answer:** (i) Both (A) and (R) are true, and (R) is the correct explanation of (A). Epithelium consists of a single layer of thin, flat cells for rapid diffusion.
2. **A:** Cardiac muscle can contract continuously. **R:** Cardiac muscle has a high number of mitochondria and an abundant blood supply. **Answer:** (i) Both (A) and (R) are true, and (R) is the correct explanation of (A). In this chapter (cardiac muscle works with many mitochondria or the heart's blood supply to provide energy to the cell. A steady energy supply is required for continuous contraction).
3. **A:** Tendons connect bone to bone and ligaments connect muscle to bone. **R:** Ligaments are made of dense connective tissue that transmits force from muscle to bone; ligaments connect bone to bone. **Answer:** (ii) Both (A) and (R) are true, but (R) is not the correct explanation of (A). Ligaments connect bone to bone, while tendons connect muscle to bone.
4. **A:** In a hinge joint, movement occurs primarily in one plane. **R:** In a ball and socket joint, movement occurs in all directions. **Answer:** (i) Both (A) and (R) are true, and (R) is the correct explanation of (A). A hinge joint allows movement in one plane only, while a ball and socket joint allows movement in all directions.



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Example 7: The mango sapling in monsoon winds (NCERT Exercise 9)

Question: Aamrapali observed that a young mango sapling's stem bends flexibly during monsoon winds and does not break. Which tissue is responsible for this flexibility? Predict and provide your explanation of the impact if the existing tissue was replaced by sclerenchyma.

Answer: **Collenchyma** gives the flexibility. Its cells are living and their walls are thickened unevenly at the corners by pectin, which gives support with rubber-like flexibility. If collenchyma were replaced by sclerenchyma, the stem would become hard and rigid because sclerenchyma walls are thick with lignin and the cells are mostly dead. A rigid young stem could not bend with strong winds, so it would be more likely to snap.

Example 8: Sugarcane cuttings (NCERT Exercise 10)

Question: Sohan grew sugarcane from two types of cuttings, A and B. After a few weeks, type B cuttings sprouted and grew into plants, while type A did not. (i) Why were the type 'B' cuttings able to grow as sugarcane but type 'A' could not? (ii) What difference was present in type 'B' compared to type 'A'? (iii) What observation did you make about the effect of this change? (iv) What parameters did you consider to ensure a fair comparison?

Answer: the cuttings are shown in textbook. Reasoned from the result. Check them again.



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1. The chapter says new branches arise from the node. Type B had a node with dividing meristems. Confirm this from the figure before writing.
2. The likely difference is that type B cutting had a node with dividing meristems. Confirm this from the figure before writing.
3. Whether each cutting sprouted and developed (type B had a node with dividing meristems sprouting).
4. Same length and thickness of cutting, same observation period.

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Competency-Based Questions (with answers)

1. Case-based: The school lawn

Mowed grass on the school lawn grows back within days. A neem sapling whose top shoot was eaten by a goat stopped growing taller but developed two new side branches.

(a) Which meristem helps the grass grow back? **(b)** Why did the sapling stop growing taller? **(c)** From where did the new branches arise?

Answer: (a) The intercalary meristem at the nodes of the grass stem. (b) The goat removed the shoot tip, which carries the apical meristem responsible for growth in length. (c) From the nodes of the stem, where intercalary meristem is present.

2. Case-based: Injury on the football field

Riya twisted her knee. The band joining her thigh bone to her calf muscle was torn. The band joining her calf muscle to her heel bone was also torn.

(a) Name the two bands. **(b)** Which type of joint is present between the thigh bone and the calf bone? **(c)** What is the normal limit of movement of this joint? **(d)** Why is the movement beyond its normal limit?

Answer: (a) The torn band is a ligament (knee joint). (b) Hinge joint. (c) Ligaments give strength to the joint. With the ligament torn, that limit is lost.

3. Source-based: Steward's carrot

"He observed that these phloem cells divide and differentiate into a complete plant."

(a) What property of the carrot cells does this demonstrate? **(b)** What is the process called? **(c)** Which natural cell shows a similar property?

Answer: (a) Totipotency. (b) Dedifferentiation. (c) The zygote, which divides and differentiates into a complete plant.



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4. Assertion-Reason

Assertion (A): Xylem parenchyma is the only living component of xylem. **Reason (R):** Tracheids, vessels and xylem fibres are primarily sclerenchymatous.

Answer: Both A and R are true, and R is the correct explanation of A. The other three components are sclerenchymatous, which leaves xylem parenchyma as the living part.

5. Assertion-Reason

Assertion (A): Meristematic cells divide continuously and rapidly. **Reason (R):** Meristematic cells have thick walls and large vacuoles.

Answer: A is true, but R is false. Meristematic cells have thin walls, a large prominent nucleus, dense cytoplasm, and vacuoles are generally absent.

6. Assertion-Reason

Assertion (A): The ribs can move during breathing. **Reason (R):** The ribs are attached to the cartilage.

Answer: Both A and R are true, and R is the correct explanation of A. The ribs can move during breathing, and the rib cage expands and contracts, changing the volume of the thoracic cavity.

7. Case-based: The debarked tree

An elephant severely debarked a tree in a forest.

(i) Which function(s) of the tree is/are hampered by further damage to the tree trunk? How would be hampered if the tissues beneath the bark are removed? What assumptions are you making to answer the question? How would your assumptions be changed if the bark is removed from a small part of the tree trunk?

Answer: (i) Protection: bark is made of cork cells. Its loss exposes the trunk to water loss, infection, and insect attack. Transport of food from the leaves (phloem) and water/minerals (xylem), and growth in girth (lateral meristems) would be hampered. If the tissues beneath the bark are removed, the tree would die. Assumptions: The tree is a dicot. The bark is made of cork cells. The tissues beneath the bark are phloem, xylem, and lateral meristems. If the bark is removed from a small part of the tree trunk, the tree might survive.



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deeper all round the trunk, phloem could no longer carry food from the leaves to the roots, and the harm would be far greater.

8. Competency MCQ: Identify the muscle

A tissue sample under the microscope shows cylindrical, branched cells, each with a single nucleus and faint striations. Which organ did it come from? (a) Biceps (b) Stomach (c) Heart (d) Intestine

Answer: (c) Heart. Branched cells with one nucleus and faint striations are cardiac muscle, found only in the heart.

Important Questions for Exams

1-Mark Questions

1. If a plant is unable to transport food from leaves to roots, which tissue is most likely damaged? (i) Xylem (ii) Phloem (iii) Epidermis (iv) Sclerenchyma
2. Meristematic tissues divide repeatedly. (i) They have thick walls for protection. (ii) They have thin walls, dense cytoplasm, and a prominent nucleus. (iii) They have thin walls, dense cytoplasm, and functionally differentiated cells. (iv) They have thick walls, dense cytoplasm, and a prominent nucleus.
3. Why are the epithelial tissues that line the gut wall thick? (i) To store food efficiently. (ii) To facilitate exchange of materials across them. (iii) To provide structural support. (iv) To prevent materials from passing through.
4. Which type of joint is involved when you bend your arm? (i) Ball and socket joint. (ii) Hinge joint. (iii) Pivot joint. (iv) Saddle joint.
5. Name the chemical deposited in the walls of cartilage.

2-Mark Questions

1. Differentiate between a tendon and a ligament. (i) A tendon transmits the force of muscle contraction. (ii) A ligament gives stability, limits movement and helps in joint movement.



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2. **Write two functions each of stomata and root hairs.** Stomata: gaseous exchange; transpiration, which creates a transpiration pull in xylem and helps eliminate wastes. Root hairs: increase surface area; absorb water and minerals from the soil.
3. **A plant cell and an animal cell are of the same size. (i) Which cell will have a larger vacuole? Give reasons. (ii) What assumptions are you making to answer the question above?** (i) The plant cell. As learnt in Chapter 2, a mature plant cell usually has one large central vacuole that stores water, minerals, sugars and wastes; in animal cells vacuoles are only sometimes present and are much smaller. (ii) That both are mature, non-dividing cells. A meristematic plant cell generally lacks vacuoles, so the answer would change.
4. **Why does the skull have fixed joints while the shoulder has a ball and socket joint?** The skull protects the brain, eyes and ears, so its flat bones are joined firmly and cannot move. The shoulder must move the arm freely forward, backward, sideways and in circles, which a rounded bone end in a shallow hollow allows.

3-Mark Questions

1. **Compare parenchyma, collenchyma and sclerenchyma on the basis of their functions.** Parenchyma: thin walls, living cells, spaces for floating in aquatic plants. Collenchyma: thickened corners, living, support with flexibility. Sclerenchyma: thick walls, dead, strength (coconut husk, walnut shell).
2. **Coconut husk fibres are used for mats and ropes. Sclerenchyma couldn't serve the same purpose.** Sclerenchyma is thick and strong. Parenchyma has thin walls suited to storage and photosynthesis, and if it were thick it would be weak.
3. **Vibha claims to her friend Neha that, "Apical meristems are at the tips of the shoot and root to help her understand further if the stem grows from the tips or from the sides." What do you think about her claim?** Apical meristems are at the tips, but there are also lateral meristems on the sides of the stem, and the intercalary meristems at the base of the internodes. Neha can ask: "If meristems were only at the tips, how does grass grow back after mowing?"
4. **Draw up a table comparing skeletal, cartilaginous and smooth muscle tissues.** Skeletal: long, cylindrical, unbranched, striated; single nucleus; no striations. Cartilaginous: short, rounded, unbranched, non-striated; multiple nuclei; no striations. Smooth: spindle-shaped, unbranched, non-striated; single nucleus; no striations.



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5-Mark Questions

- 1. Describe the three types of meristems with their location and role. List the features of meristematic cells and explain differentiation.** Apical meristem at root and shoot tips: growth in length (onion root tips stop growing when cut). Lateral meristem, a ring of cells along the circumference of the stem: divides to give cells inside and outside, so girth increases; the annual growth rings in a cut trunk record this growth year by year. Intercalary meristem at the base of the internode or just above the node: regrowth after cutting, as in grass and hedges. Features: small cells, thin walls, large prominent nucleus, dense cytoplasm, vacuoles generally absent, tightly packed. Differentiation: some new cells lose the ability to divide, change in structure and function, and become permanent tissues specialised for support, transport or storage.
- 2. Explain the structure and functions of xylem and phloem. Why are they called complex permanent tissues?** Xylem: tracheids and vessels (tubular, thick-walled), xylem parenchyma (the only living part) and xylem fibres; carries water and minerals from roots to other parts and gives strength. Phloem: sieve tubes (long cells joined end to end by perforated walls, carry food), companion cells (specialise to monitor loading and unloading of sugar in latex) and phloem fibres (strength); most are complex because each has more than one function. Both are complex because each has more than one function. Both have differentiated.
- 3. During the discussion in class, Rohan said, "Simple tissues but little different in case of view of the discussion in class. Simple cell doing one job, which fits Rohan's statement. Different cell types (tracheids, vessels, companion cells) working together for one overall function. Simple cells are not all similar, but they share a common function."**



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Common Mistakes and Explanations

- 1. Swapping tendon and ligament.** Tendon connects muscle to bone, while ligament connects bone to bone. Tendon is made of collagen fibers, while ligament is made of elastic fibers.
- 2. Saying meristems are only at the tips.** Apical meristems are at the tips, but lateral meristems are along the sides of the stem, and intercalary meristems are at the nodes.
- 3. Giving meristematic cells large vacuoles.** Meristematic cells are small, have thin walls, and lack large vacuoles. They have a large prominent nucleus, dense cytoplasm, and vacuoles are generally absent.

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4. **Mixing up pectin and lignin.** Pectin at the corners of collenchyma gives flexibility; lignin in sclerenchyma walls gives hardness.
5. **Calling sclerenchyma living.** Most sclerenchyma cells are dead. Parenchyma and collenchyma are living.
6. **Calling all of xylem dead.** Xylem parenchyma is its only living component. Phloem is mostly living.
7. **Reversing the direction of transport.** Xylem: water and minerals from roots to other parts. Phloem: food from leaves to other parts.
8. **Writing "lungs have thick, many-layered epithelium".** Exchange needs a single layer of thin, flat cells. Many layers are for protection (skin, mouth, oesophagus).
9. **Muscle feature errors.** Only skeletal muscle is multinucleate. Cardiac muscle is branched with faint striations. Smooth muscle has no striations.
10. **Neuron direction.** Dendrites receive; the axon carries the message away and passes it on at the axon terminals.
11. **Joint examples.** Shoulder: ball and socket joint. Skull bones: fixed.
12. **Rushing assertion-reason items.** Judge whether R explains A.

Quick Revision Points

- Cell → tissue → organ → organ system → organism
- Apical meristem (root and shoot tips): let the plant grow
- Intercalary meristem (at nodes): regrow after damage
- Meristematic cells: thin walls, large nuclei, cytoplasm tightly packed.
- Epidermis: single layer of flat cells with cuticle to prevent water loss and gases and transpire.
- Parenchyma: living, thin walls, stores food
- Collenchyma: living, corners thickened for extra support
- Sclerenchyma: thick lignified walls, most dead



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- Xylem: tracheids, vessels, xylem parenchyma (only living part), fibres; water and minerals up from roots.
- Phloem: sieve tubes, companion cells, phloem parenchyma, fibres; mostly living; food from leaves.
- Epithelium: closely packed cells; thin single layer for exchange, many layers for protection, tall cells for absorption.
- Blood: plasma about 55%, formed elements about 45%; haemoglobin in RBCs, platelets clot, WBCs collect at infected areas; RBCs live about 4 months.
- Bone: rigid matrix of calcium and phosphorus compounds. Cartilage: soft, jelly-like, cushions.
- Skeletal muscle: voluntary, multinucleate, striated. Smooth: involuntary, spindle, no striations. Cardiac: involuntary, branched, faint striations, no fatigue.
- Neuron: cell body, dendrites, axon, axon terminals; the brain is the control centre.
- Joints: ball and socket (shoulder), hinge (elbow, knee), pivot (neck), fixed (skull).
- 12 pairs of ribs joined by flexible cartilage. Cartilage makes up 12 to 15 per cent of adult body weight.
- Totipotency: Steward (1958) grew whole plantlets from a single cell. *Tomato tumefaciens* causes crown gall and is used in genetic engineering.



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Weightage and Exam Pattern

Class 9 has no board exam. This chapter is important for internal assessment (term and annual papers), and the NCERT source for definitions, comparisons and structure-function.

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Question type	What this chapter typically supplies
MCQ, one-word and assertion-reason	Identifying a tissue from its features, naming a joint, pectin versus lignin, tendon versus ligament
Short answer	Types of meristems, simple permanent tissues compared, muscle types compared, parts of a neuron
Long answer	Xylem and phloem in detail, meristems with differentiation, joints and the musculoskeletal system
Case-based and data-based	Onion root tips, teak tree rings, debarked trees, sugarcane cuttings, carrot tissue culture, sports injuries

This chapter is the foundation for Class 10 biology. Xylem, phloem, stomata and transpiration return when you study transport in plants, and the nervous system when you study the nervous system.



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