2.5 Plant cell structure, xylem and phloem

Name: _____ Class: _____ Date: _____ **Total: 18 marks**

KEY WORDS microfibril • secondary thickening • xylem • phloem • sieve plate

Objective

Practise statements 4.1-4.6 with Core Practicals 7-8: plant cell structure, cellulose and lignin, xylem and phloem structure, and their distribution in root, stem and leaf.

1 Key knowledge and worked examples

■ Two polysaccharides, two jobs

Starch (α-glucose, helical amylose + branched amylopectin) stores energy. Cellulose (β-glucose, every other unit inverted) gives straight chains that hydrogen-bond into **microfibrils** – tensile strength like steel wire per gram. **Secondary thickening** deposits lignin in spirals or rings, waterproofing and resisting collapse.

■ Xylem and phloem side by side

	Xylem	Phloem
Cells	dead, hollow, end walls lost	living sieve-tube elements + companion cells
Wall	lignified (except pits)	cellulose, with sieve plates
Transport	water + minerals, upward, no energy	sugars, both directions, energy-requiring
Extra role	support	–

Root: xylem forms a central star, phloem between its arms. Stem: vascular bundles in a ring, phloem outside xylem. Leaf: midrib and veins, xylem above phloem.

■ Worked example: potometer arithmetic

A potometer loses 0.9 cm^3 in 30 minutes with one leafy shoot whose mass is 12 g. Uptake per gram per hour $= 0.9/12 \times 2 = 0.15$ cm^3 g^{-1} h^{-1}. Assume water uptake $\approx$ transpiration only over short runs; cut the shoot underwater to keep the column unbroken.

2 Practice

2.1 Explain how cellulose microfibrils give a plant cell wall its strength. [2]

2.2 State two structural differences between xylem vessels and phloem sieve tubes. [2]

2.3 Name the tissue between the xylem and the root's outer layers that transports sugars. [1]

3 Exam-style questions

3.1 Explain how the structure of xylem vessels suits the transport of water from root to leaf, referring to four structural features and the function each serves. [4]

3.2 The photograph shows a transverse section of a sunflower stem stained to show lignin. Describe where you would find the xylem and phloem in this section, and explain why lignin is absent from the walls of companion cells. [4]

3.3 A student uses a potometer to compare water uptake of a plant in still air and in a fan's airflow. The bubble moves 12 mm in 5 minutes in still air and 46 mm in 5 minutes in the fan. Calculate the ratio of uptake rates, suggest why the fan increases uptake, and state one variable that must be kept the same for the comparison to be valid. [5]

Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 Many cellulose chains lie parallel, cross-linked by hydrogen bonds, bundling into microfibrils layered in different directions, which resists stretching in every direction.

2.2 Any two: xylem cells are dead with no cytoplasm, phloem's are living; xylem walls lignified, phloem's cellulose with sieve plates; xylem hollow continuous tubes, phloem has pores in sieve plates.

2.3 Phloem.

3.1 Any four pairs: dead hollow cells form a continuous low-resistance tube; lignified walls waterproof and stop collapse under tension; loss of end walls removes barriers; pits allow lateral water movement into surrounding tissue; narrow bore holds the water column by cohesion.

3.2 Xylem inside each vascular bundle toward the centre, stained red by lignin; phloem outside the xylem toward the epidermis. Companion cells are metabolically active cells of the phloem that load sugars into sieve tubes; lignin would kill them and block the plasmodesmata they use – lignified cells are dead.

3.3 Ratio $46/12 \approx 3.8 : 1$. The airflow removes the humid boundary layer around the leaves, steepening the water-vapour gradient and raising transpiration. Keep the same plant, temperature/light and water temperature (any one, B1).