14.1 Specialized cells: structure linked to function

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS differentiation • gene expression

Objective

Specialized cells: structure linked to function. Original classroom practice for IB HL; not an official IB paper.

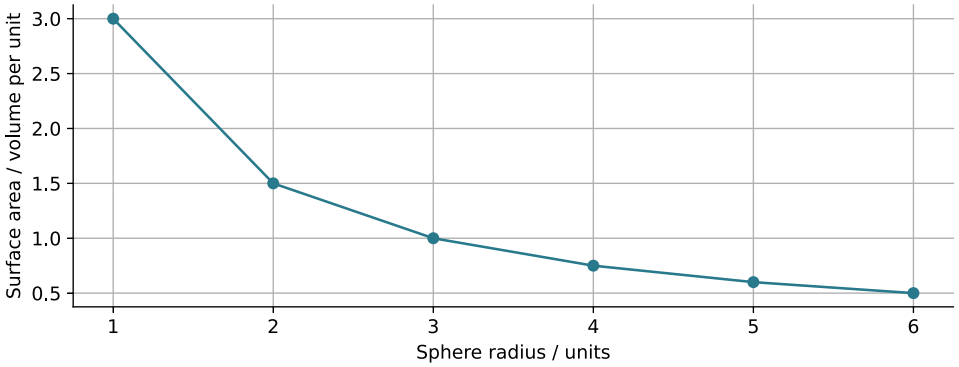
1 Key knowledge and worked examples

What would explain this observation?

- A root-hair cell and a red blood cell have different shapes because their functions impose different demands.

Build the model

- **Differentiation** produces specialized cells through different patterns of **gene expression** .
- A root-hair extension increases exchange area.
- A mammalian red blood cell lacks a nucleus at maturity and contains haemoglobin; this is a specific adaptation, not a rule for all animal cells.
- differentiation: Development of specialized cell structure and function.
- gene expression: Use of genetic information to produce a functional product.



Choose evidence that can test it

- Link a named feature to a mechanism and then to the function.
- Increased area can support exchange, but membrane proteins, gradients and metabolic demand also matter.
- Stem cells retain different degrees of developmental potential.

In the lab: Compare scaled drawings of named cells. Label the structure, state the function and explain the causal link. Use tissue-specific examples rather than saying every specialized cell has every adaptation.

Work from known quantities

- Known: a spherical model cell has radius 2 units.
- Surface area/volume = 3/r = 1.5 per unit.
- A radius of 4 gives 0.75 per unit.
- Doubling radius halves this ratio, even though total area increases.

Your turn: For a sphere, surface area/volume = 3/r. Find this ratio when r = 6 units.

Check the conclusion and its limits

- Specialization does not usually require a cell to lose most of its genes.
- The spherical calculation models geometry; it does not describe every actual cell shape.

Not true: All mature animal cells lack a nucleus. Most mature animal cells keep their full genome and nucleus; only a few exceptions, such as mammalian red blood cells, lose the nucleus. Specialization comes from gene expression, not gene loss.

Key:

- Differentiation produces specialized cells through different patterns of gene expression.
- Link a named feature to a mechanism and then to the function.
- Watch for: specialization does not usually require a cell to lose most of its genes.

Write from a surface-to-volume ratio of 0.30

- A spherical model cell has radius 10 units. Use surface area over volume = 3 over r.
- Find the ratio. Doubling the radius halves this ratio.

2 Practice

2.1 What best explains many differences between specialized cells? Choose one answer.

- **A** They express different sets of genes
- **B** Every cell has a different genetic code
- **C** They have no shared ancestry [1]

2.2 For a sphere, surface area/volume = 3/r. Find this ratio when r = 6 units. Show the relation, substitution and units. [2]

2.3 Decide whether this claim is true and justify: Most mature animal cells keep their full genome and nucleus; only a few exceptions, such as mammalian red blood cells, lose the nucleus. [2]

2.4 Development of specialized cell structure and function: write the technical term. [1]

3 Exam-style questions

3.1 A spherical cell doubles radius. Compare area, volume and SA/V factors; explain why total area increasing does not remove exchange constraints. [4]