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.

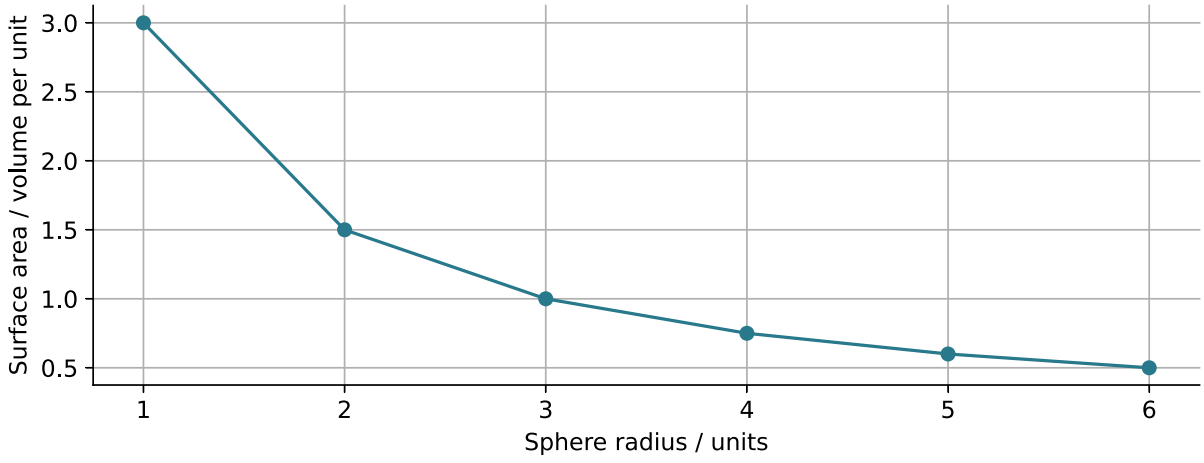
1 Key knowledge and worked examples

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]

Solutions

2.1 A Specialized cells share the same genome but express different gene sets, producing different proteins and therefore different structures. The genetic code is universal, and all these cells descend from the same zygote.

2.2 SA/V=3/r=3/6=0.5 per unit length.

2.3 True. True. 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.

2.4 differentiation. differentiation means Development of specialized cell structure and function.

3.1 Area×4, volume×8, SA/V×1/2. Exchange capacity per volume falls in the geometric model; actual cell specialization also involves shape, transport and demand.