IB Biology B2.3 Cell Specialization

Worksheet 1 - Differentiation and Stem Cell Foundations

Name:	Class:	Date:
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Focus: B2.3.1-B2.3.2: zygote development, differentiation, cell signalling, and basic stem cell properties

Instructions: Answer all questions. Multiple choice questions are worth 1 mark each. For written answers, use precise biological terminology and link structure to function where possible.

Section A - Multiple choice

1. Which sequence best represents early human development after fertilization?

A. gametes -> foetus -> zygote -> embryo
B. gametes -> zygote -> embryo -> foetus -> infant
C. zygote -> gametes -> embryo -> infant
D. embryo -> zygote -> foetus -> infant

2. Differentiation is best described as

A. the fusion of gametes
B. the formation of unspecialized cells only
C. the process by which cells become specialized for particular functions
D. the division of a nucleus during mitosis

3. A body cell normally contains

A. only the genes it needs for its own function
B. all the genetic information needed to produce the organism
C. only maternal chromosomes
D. no genes after differentiation

4. Cell signalling is important in differentiation because it

A. changes the DNA sequence in every cell
B. controls which genes are expressed
C. prevents mitosis completely
D. removes chromosomes from specialized cells

5. A stem cell is defined by its ability to

A. carry oxygen and lose its nucleus
B. divide repeatedly and differentiate along different pathways
C. produce only sperm cells
D. carry nerve impulses across the whole body

6. Cancer cells are problematic because they usually show

A. slow reproduction and perfect differentiation
B. rapid reproduction with little or improper differentiation
C. no ability to reproduce
D. specialization into useful tissue

Section B - Short answer

1. Define the term zygote and state how it is formed. [2 marks]

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2. Explain why different cells in the same organism can have different structures even though they contain the same genetic information. [3 marks]

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3. State two properties that distinguish stem cells from most differentiated cells. [2 marks]

4. Explain why nerve and muscle cells may have a reduced ability to reproduce after specialization. [2 marks]

Section C - Data response / case study

Data response: gene expression in an early embryo

A researcher measured the relative concentration of a morphogen from the anterior end to the posterior end of a model embryo. The table shows arbitrary concentration units and the cell fate most commonly observed.

Distance from anterior end (%)	Morphogen concentration	Most common cell fate
0	95	Head-region cells
25	67	Anterior body cells
50	35	Middle body cells
75	12	Posterior body cells
100	3	Tail-region cells

1. Describe the trend in morphogen concentration across the embryo. [2 marks]

2. Explain how a concentration gradient could lead to different cell fates in different regions of an embryo. [3 marks]

3. Predict the likely effect of a mutation that prevents production of the morphogen at the anterior end. [2 marks]

Section D - Extended response

Extended response: Explain the relationship between cell signalling, gene expression, and differentiation in the development of a multicellular organism. [6 marks]

Answer key and marking guidance - Worksheet 1 - Differentiation and Stem Cell Foundations

Use this section for teacher marking or student self-assessment. Award credit for equivalent wording if the biological idea is accurate and clearly expressed.

- MCQ: 1 B; 2 C; 3 B; 4 B; 5 B; 6 B.

- Zygote: fertilized egg / first diploid cell (1); formed by fusion of two haploid gametes during fertilization (1).

- Different structures: all body cells contain the genome (1); different signals activate or silence different genes (1); different proteins are produced, causing different structures/functions (1).

- Stem cell properties: can self-renew/divide repeatedly/indefinitely (1); can differentiate into one or more specialized cell types (1).

- Reduced reproduction: highly specialized cells are adapted for function rather than division (1); cell-cycle activity is reduced or lost after differentiation (1).

- Data: concentration decreases from anterior to posterior (1), steep/high-to-low gradient described with values (1).

- Gradient explanation: cells detect local morphogen concentration (1); different thresholds activate different genes (1); different gene expression produces different cell fates (1).

- Mutation: anterior/head structures may fail to develop (1); posterior/tail-like structures may form at both ends or patterning becomes abnormal (1).

- Extended response marking: include cell signalling transfers information to nucleus (1); signals/morphogens form gradients (1); gene expression differs between cells/regions (1); proteins made determine structure/function (1); differentiation produces specialized tissues/organs (1); coherent sequence with example such as embryo patterning, nerve/muscle/skin (1).

General IB-style marking notes

- Do not award marks for vague statements without a clear biological link.

- For structure-function questions, award credit only when the structure is linked to the correct function.

- For data questions, accept rounded numerical answers if the working is correct.

- For extended responses, prioritize accurate terminology, logical sequence and use of relevant examples.