IB Biology B2.3 Cell Specialization

Worksheet 2 - Morphogens, Gradients, and Early Development

Name:	Class:	Date:
_____	_____	_____

Focus: B2.3.1: impact of gradients on gene expression within an early-stage embryo

Instructions: Answer all questions. HL-style questions are included where application and evaluation are required.

Section A - Multiple choice

1. A morphogen is a

A. structural protein that forms the cytoskeleton
B. signal molecule that controls cell differentiation
C. digestive enzyme in lysosomes
D. cell-surface channel for ions

2. A gradient means that a substance

A. has the same concentration everywhere
B. exists only inside the nucleus
C. has concentration differences across a region
D. is not able to move

3. In a fruit fly embryo, defective bicoid genes would most likely affect

A. anterior-posterior patterning
B. oxygen binding by haemoglobin
C. surfactant secretion
D. sperm motility

4. Which process transfers information from the cell surface to the nucleus?

A. cell signalling
B. phagocytosis
C. exocytosis
D. surface area-to-volume ratio

5. Differentiation depends most directly on

A. which genes are expressed
B. whether all cells are the same size
C. the removal of DNA
D. the permanent loss of the plasma membrane

6. The first cells produced by the zygote are initially

A. specialized muscle fibres
B. unspecialized
C. red blood cells
D. type II pneumocytes

Section B - Short answer

1. Outline the role of bicoid as an example of a morphogen. [3 marks]

_____

_____

_____

_____

2. Explain why the same signal molecule may produce different outcomes in two regions of an embryo. [3 marks]

_____

_____

_____

_____

3. State one reason why models of early embryonic development are useful in biology. [2 marks]

4. Describe one difference between an embryo and a foetus in human development. [2 marks]

Section C - Data response / case study

Case study: threshold response to a morphogen

Cells in an embryo express different genes depending on the concentration of morphogen X. Gene A switches on above 70 units, Gene B between 30 and 70 units, and Gene C below 30 units.

Cell position	Morphogen X (units)	Predicted gene expression
1	82	
2	61	
3	43	
4	22	
5	8	

1. Complete the predicted gene expression column for positions 1-5. [3 marks]

2. Suggest how the embryo would be affected if the morphogen spread evenly throughout the embryo at 45 units. [2 marks]

3. Explain why mutation in a morphogen gene can have large effects on body plan development. [3 marks]

Section D - Extended response

Extended response: Discuss why regulation of gene expression is essential for the development of a complex multicellular organism from one zygote. [6 marks]

Answer key and marking guidance - Worksheet 2 - Morphogens, Gradients, and Early Development

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 A; 4 A; 5 A; 6 B.

- Bicoid: signal/morphogen protein (1); highest near anterior/head end (1); controls gene expression and anterior structure development (1).

- Different outcomes: cells receive different concentrations (1); thresholds activate different genes (1); cells may also be at different developmental stages or have different receptors (1).

- Models: simplify complex systems (1); allow predictions/testing of how gradients influence patterning (1).

- Embryo/foetus: embryo is early stage before body structures appear, about up to ninth week in humans (1); foetus is from body-structure appearance to birth (1).

- Data completion: position 1 Gene A; positions 2 and 3 Gene B; positions 4 and 5 Gene C. Award 3 for all correct, 2 for 3-4 correct, 1 for 1-2 correct.

- Even 45 units: most/all cells would express Gene B (1); normal regional differences/body patterning would be reduced or abnormal (1).

- Mutation effects: morphogens act early (1); they control expression of many downstream genes (1); many cells/regions are affected, causing major body-plan changes (1).

- Extended response marking: zygote divides to produce many cells (1); cells contain same genome (1); selective gene expression creates different proteins (1); signals/morphogen gradients control expression (1); specialized tissues/organs require different cell types (1); uses accurate example and logical development sequence (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.