DO NOT WRITE ON THIS BOOKLET BEFORE THE EXAM BEGINS
DO NOT TURN OVER THIS PAGE UNTIL INSTRUCTED TO DO SO BY AN INVIGILATOR
Answer all questions in the spaces provided

1. The SNARE hypothesis explains how the specificity of membrane traffic in eukaryotic cells is achieved. Outline its key features.  
   (4 marks)

2. Provide experimental evidence demonstrating that molecular machinery required for membrane traffic in eukaryotic cells is evolutionarily conserved.  
   (3 marks)

3. a) Provide a piece of evidence that indicates a close relationship between Choanoflagellates and animals.  
   (1 mark)

   b) Provide a piece evidence that indicates cell-to-cell signalling predates the evolution of multicellularity.  
   (1 mark)
4.  
   a) How does the mosaic theory of animal development conflict with the principle of nuclear equivalence? (2 marks)

   b) Briefly describe an experiment that supports the principle of nuclear equivalence during animal development. (2 marks)

5.  
   a) Describe how the ras protein functions as a self-regulating molecular switch? (2 marks)

   b) How does activation of the raf enzyme lead to changes in gene transcription? (3 marks)
6. You have identified a novel protein closely related to nodal in the frog Xenopus. How would you investigate if this protein can function as a morphogen? (2 marks)

7. Compare and contrast how cortisol and retinoic acid signalling lead to activation of gene transcription. (4 marks)

8. a) What are the three main classes of cis-regulatory elements? (3 marks)
   i) 
   ii) 
   iii)
b) What are the functions associated with general transcription factors and where within the cis-regulatory regions of protein coding genes do they bind?  

(3 marks)

c) With reference to a specific example, describe how trans-acting factors are able to regulate cell lineage.  

(5 marks)
9. Briefly explain how you could test the ability of haematopoietic stem cells to differentiate into red blood cells (erythrocytes). (4 marks)

the space above this line should be sufficient for your answer
10. An experiment was set up to determine changes in protein expression during the cell cycle. Epidermal stem cells were grown in Petri dishes in culture medium that was supplemented with serum to generate sufficient cells for the experiment. Serum contains many growth factors and cytokines to promote cell division. At 24 hours before the start of the experiment, the epidermal stem cells were switched to a culture medium without serum.

The serum was then replaced and protein samples were taken from the epidermal stem cells every 2 hours for 14 hours. The protein samples were analysed by SDS-PAGE and are shown in the figure below.

![Image of SDS-PAGE gel](image_url)

Figure legend: SDS-PAGE analysis of protein expression in epidermal stem cells during the cell cycle. After 24 hours of serum-starvation, serum was added back to the cell cultures and protein extracted every 2 hours for 14 hours and loaded onto the gel (lanes 1-7). The gel was stained to allow visualisation of the different sized proteins.

a) Where are epidermal stem cells normally located in the body? (1 mark)
b) Why was serum first removed from the epidermal stem cells for 24 hours and then added back at the start of the experiment? (2 marks)

c) The SDS-PAGE analysis suggests that the expression levels of one protein clearly changes as the cells progress through the cell cycle. On the figure above, label this protein as “Protein A” with an arrow. (1 mark)

d) In the cell cycle of epidermal stem cells, it is known that M phase lasts about 1 hour, the G1 phase lasts approximately 3-4 hours, S phase lasts approximately 7-8 hours and G2 around 4-6 hours. Referring to the SDS-PAGE results, what can you deduce about the expression of Protein A in these epidermal stem cells during the cell cycle? (4 marks)
11. Using three examples, compare and contrast endochondral and intramembranous ossification.  

(3 marks)

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