

Biology
Higher level
Paper 2

Wednesday 6 May 2015 (morning)

Candidate session number

2 hours 15 minutes

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Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer two questions.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[72 marks]**.

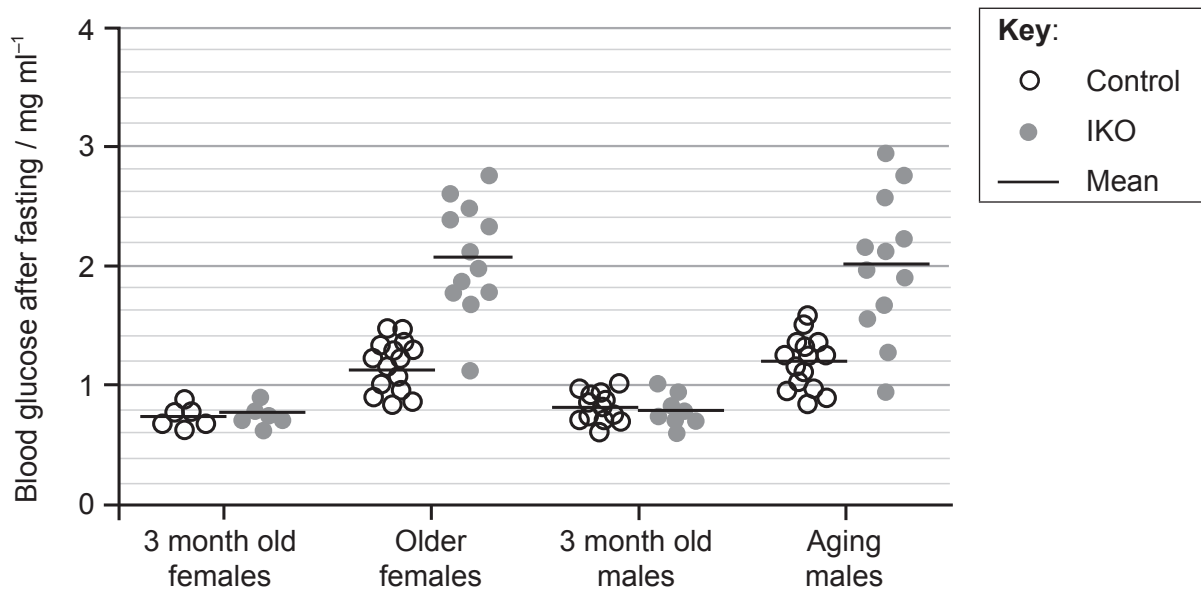


Section A

Answer **all** questions. Write your answers in the boxes provided.

1. Diabetes is often associated with the failure of the β (beta) cells in the pancreas, but it is unclear what actually causes this failure. FoxO1 is a protein which acts as a transcription factor to regulate the expression of genes involved in cell growth. FoxO1 also regulates increase in number and differentiation in cells such as pancreatic β cells.

A study was conducted using mice lacking the gene for FoxO1 in β cells (IKO) as well as normal (control) mice. Blood glucose levels after fasting were compared for four groups of mice: young (3 months old) male mice, young (3 months old) female mice, older females (who have had several pregnancies) and aging males (16–20 months).



[Source: Chutima Talchai, Shouhong Xuan, Hua V. Lin, Lori Sussel, Domenico Accili, "Pancreatic β Cell Dedifferentiation as a Mechanism of Diabetic β Cell Failure", *Cell*, Volume 150, Issue 6, 14 September 2012, Pages 1223–1234]

- (a) Compare blood glucose levels after fasting in young control mice and young IKO mice without FoxO1. [2]

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(Question 1 continued)

- (b) Aging and having pregnancies are considered to be physiological stresses. Deduce the effect of stress on blood glucose levels. [2]

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- (c) Outline the relationship between blood glucose levels after fasting and lack of FoxO1 in the mice studied. [2]

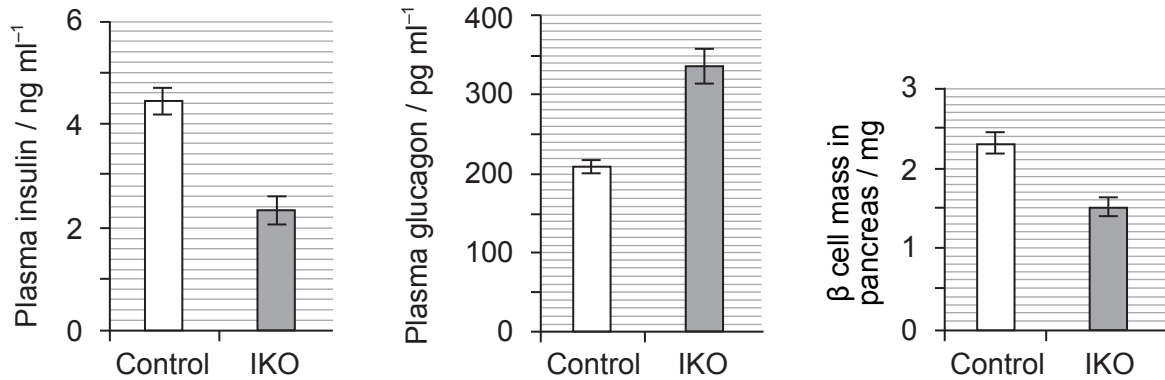
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(Question 1 continued)

The levels of pancreatic hormones and β cell mass in older female control mice and older female IKO mice lacking FoxO1 were then investigated.



[Source: Chutima Talchai, Shouhong Xuan, Hua V. Lin, Lori Sussel, Domenico Accili, "Pancreatic β Cell Dedifferentiation as a Mechanism of Diabetic β Cell Failure", *Cell*, Volume 150, Issue 6, 14 September 2012, Pages 1223–1234]

- (d) Calculate the percentage difference in β cell mass of the IKO mice compared to the control mice. [2]

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- (e) State the correlation between lack of FoxO1 and pancreatic hormones in mice. [1]

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Answers written on this page
will not be marked.



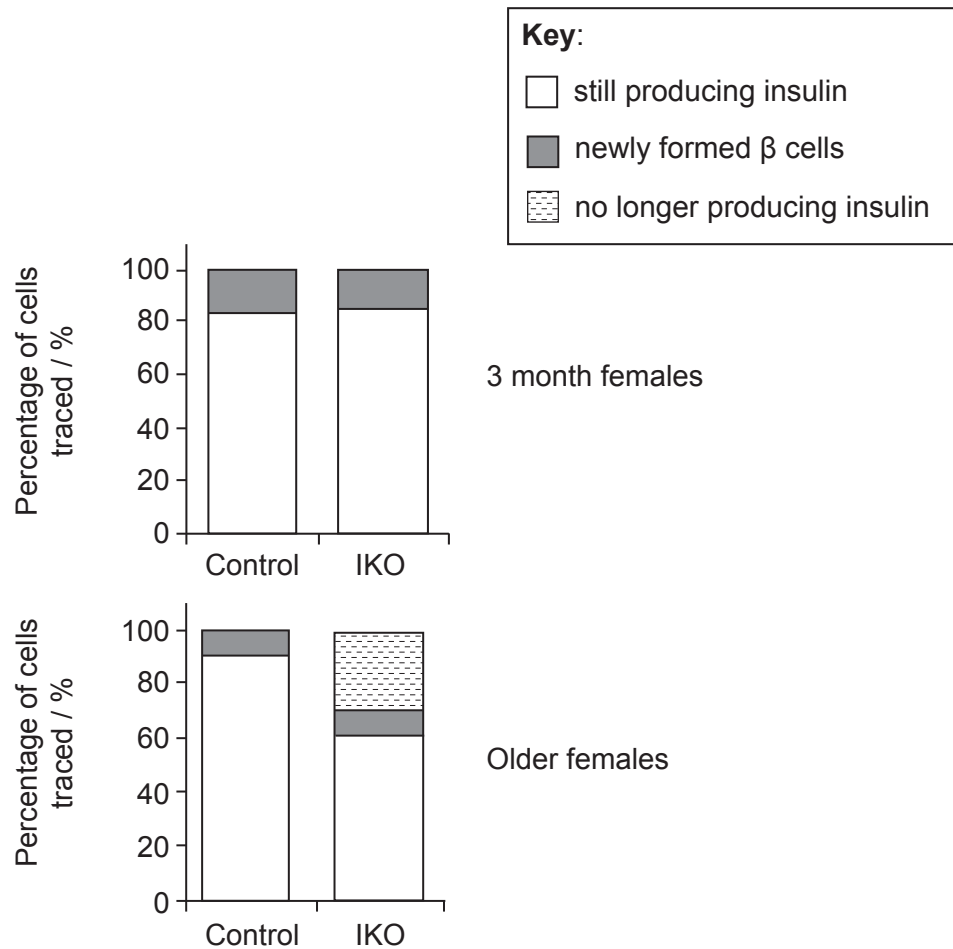
20EP05

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(Question 1 continued)

To examine whether the changes observed were due to lack of β cell function or change in β cell number, investigators traced marked cells. They were able to determine if cells were:

- still producing insulin
- newly formed β cells
- no longer producing insulin.



[Source: Chutima Talchai, Shouhong Xuan, Hua V. Lin, Lori Sussel, Domenico Accili, "Pancreatic β Cell Dedifferentiation as a Mechanism of Diabetic β Cell Failure", *Cell*, Volume 150, Issue 6, 14 September 2012, Pages 1223–1234]

(f) State which group of cells showed the least change in the mice studied.

[1]

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(Question 1 continued)

(g) Deduce the effects of aging on the distribution of cell types in mice. [2]

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A hypothesis has been suggested that diabetes is caused by β cells losing their ability to act as β cells, not by the death of β cells. In other words they dedifferentiate.

(h) Using all the information provided, discuss whether the data support this hypothesis. [2]

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(i) When there are high blood glucose levels, more FoxO1 is found in the nucleus of the cell than in the cytoplasm. Suggest a role of FoxO1 considering this and the data. [2]

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2. A study of 600 adolescents in Sweden showed that milk consumption has a positive effect on height which shows continuous variation. However, milk contains lactose which some people can digest but some cannot.

(a) (i) State the pattern of inheritance that contributes to continuous variation. [1]

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(ii) Explain the production of lactose-free milk. [3]

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(Question 2 continued)

(b) The diagram below shows the structure of lactase.



[Source: Kindly provided by RL Miesfeld, The University of Arizona, Tucson, AZ USA]

(i) Identify the protein structures indicated by I and II. [1]

I:
II:

(ii) Describe how structure I is held together. [2]

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(Question 2 continued)

- (iii) This protein is described as a globular protein. Distinguish between globular and fibrous proteins. [2]

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3. The diagram below shows a plant of the *Solanum* genus.



(a) (i) State whether this plant is dicotyledonous or monocotyledonous. [1]

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(ii) State **two** features visible in the diagram above that indicate this. [2]

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(Question 3 continued)

- (b) (i) Label the diagram of *Solanum* on page 12 to show the name of a structure specialised for food storage. [1]

- (ii) Outline the transport of products of photosynthesis to the storage structure. [3]

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Section B

Answer **two** questions. Up to two additional marks are available for the construction of your answers. Write your answers in the boxes provided.

4. (a) Draw a labelled diagram of the human adult male reproductive system. [5]
- (b) Compare the processes of spermatogenesis and oogenesis. [8]
- (c) Describe the consequences of the potential overproduction of offspring. [5]
5. (a) Outline the processes that occur during the first division of meiosis. [6]
- (b) Prior to cell division, chromosomes replicate. Explain the process of DNA replication in prokaryotes. [8]
- (c) Outline outcomes of the human genome project. [4]
6. (a) Draw a labelled diagram to show the structure of a motor neuron. [4]
- (b) Explain how skeletal muscle contracts. [8]
- (c) Active skeletal muscle requires a good supply of oxygen. Outline the mechanism of ventilation in the lungs. [6]
7. (a) Draw a labelled diagram to show the structure of the plasma membrane. [5]
- (b) The light-dependent reactions in photosynthesis take place on the thylakoid membranes. Explain the light-dependent reactions. [8]
- (c) Outline **two** factors that affect the rate of photosynthesis. [5]



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