BSc Degree Examinations 2018-9

Department:
BIOLOGY

Title of Exam:
Introduction to Biomedical Sciences Part II

Time Allowed:
1.5 hours

Marking Scheme:
Total marks available for this paper: 50
The marks available for each question are indicated on the paper

Instructions:
Answer all questions in the spaces provided on the examination paper

For marker use only:

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DO NOT WRITE ON THIS BOOKLET BEFORE THE EXAM BEGINS
DO NOT TURN OVER THIS PAGE UNTIL INSTRUCTED TO DO SO BY AN INVIGILATOR
1. The velocity of blood flow is slowest in the capillaries. How is this achieved and why is this important? (4 marks)

The main vessels responsible for slowing blood flow through a capillary bed are the arterioles (1). Contraction of smooth muscle in the vessel wall reduces vessel diameter which therefore increases resistance and slows blood flow before entering the capillaries (1). This is important to allow sufficient time for exchange (1) and to prevent damage to the delicate capillaries (1).

LO: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.

Most answers attracted some marks for this question, although not many achieved full marks. I did also accept that velocity is slow in capillaries due to their small lumen/ excessive capillary branching. However, the arterioles needed to be mentioned as they are the key vessel for controlling blood flow through a capillary bed. Some stated that blood flow is slow as they are further from the heart - I did not accept this because veins are even further from the heart but velocity of blood flow is faster in these vessels.

2. Explain why blood in the coronary sinus drains into the right atrium. (3 marks)

Blood in the coronary sinus returns deoxygenated blood (1) from coronary veins (1) back into the circulation. It returns blood to the right atrium because this goes to the lungs to be oxygenated. If it returned to the left atrium this would then lower the oxygen content of the systemic circulation (1)

LO: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.

Mostly answered well. Some marks lost for missing out details e.g. blood is deoxygenated, or that the blood in the coronary sinus has come from the coronary veins.

3. Explain why mice that are negative for the Scl gene die in utero. (3 marks)

The Scl gene codes for a transcription factor (1) responsible for the formation of angioblasts (1). Mice negative for this gene die due to failed blood vessel formation (1)
If you correctly identified the role of Scl, full marks were often achieved. Most marks were lost for stating an incorrect role (e.g. stating that Scl is involved in cardiac development).

4. Why are beta blockers such as propranolol contraindicated in individuals with asthma or Chronic Obstructive Pulmonary Disease (COPD)? (2 marks)

Propanolol is non-selective for different β-adrenoceptors (1). Activation of β2-adrenoceptors will contract smooth muscle in the lung (1).

LO: Using examples, discuss the concept of disease.

LO: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.

This was answered well. Marks were not awarded if it was unclear whether student understood that Propanolol was antagonizing the action of Adrenaline.

5.

a) Rett syndrome is caused by mutations in the gene encoding which protein? (1 mark)

MeCP2

Most students got this correct

b) Draw an ECG trace that you would expect to record from a healthy girl and an ECG trace you would expect to record from a girl with Rett syndrome who also presents with long QT syndrome. Label the different ECG waves. (2 marks)
1 mark awarded for correct labelling (see model answer figure above)
1 mark awarded if there is a clear extension of QT interval

This was answered well. Marks were not awarded if PQRST were not correctly labelled or if it was not clear that an ECG was drawn.

c) Describe how DNA methylation changes across postnatal development in neurons.  

(mC typically occurs in the CG context (1 mark)
But in neurons non-CG methylation increases during development (1 mark) to become most abundant type of methylation in neurons (1 mark).

Students generally did well on this. Some students did not mention CG methylation. Many students did not get final mark. A mark was awarded if student mentioned that increased non-CG methylation coincided with symptom presentation.

LO: Using examples, discuss the concept of disease.

LO: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.

6.
a) Shade and label the diagram below to highlight the brain region where alpha waves appear upon eye closing.  

(1 mark)
Most students got this correct. Mark was awarded for ‘occipital lobe’. No mark was awarded if region was shaded only.

b) Shade the thalamus in the diagram below. State the subdivision of the thalamus that sends axons to the brain region mentioned in a) above.

(2 marks)
Lateral Geniculate Nucleus

Mostly answered well. Mark not award if student only stated LGN or missed out the word lateral.

LO: Describe the organisation of the nervous system and how neurons communicate.

7. You record electrical activity between an electrode inserted in a neuron and an electrode in the conducting fluid outside.

a) The figure below shows changes in membrane potential in response to a 0.5 mA current injection before (A) and after the addition of the mitochondrial inhibitor cyanide (B). Explain the effect of cyanide. (4 marks)
The RMP is generated by movement of K+ ions out of the cell down concentration gradient (1 mark).
This concentration gradient is maintained by Na-K-ATPase, which requires the hydrolysis of ATP (1 mark).
With no source of ATP the ion concentration gradients would dissipate (1 mark)
With no RMP or concentration gradients, action potentials cannot be generated (1 mark).

This was a selective question. A number of students received full marks. Some students thought that this response was related to synaptic transmission rather than direct excitation of the neuron.

b) The figure below shows a separate experiment whereby you record Na+ currents (I Na, blue lines) in response to a voltage step (purple lines) before (A) and after the addition of pronase (a protease, B). Describe the effect of pronase treatment on I Na, and provide the molecular basis for this effect. (4 marks)

Before pronase I Na increases after depolarization as the channels activate (1 mark). Then, I Na decreases rapidly as inactivation occurs (1 mark)
After pronase treatment, inactivation does not occur (1 mark) due to loss of ball and chain mechanism (1 mark).

This was a selective question. A number of students received full marks. Most answers were vague or did not realise that the question related to inactivation.

LO: Describe the organisation of the nervous system and how neurons communicate.
LO: Acquire, analyse, interpret and write up/present experimental data.

8. Explain the consequence of a mutation resulting in a non-functional testosterone receptor on gonad and external genitalia development in XY
The gonads would develop as testes (1) due to the presence of the Y chromosome and SRY gene (1). As Leydig cells develop (in the testes), they would synthesise and secrete testosterone, but the non-functional testosterone receptor would not recognise the testosterone (1). Therefore, without testosterone, female external genitalia would develop (1).

Some answers stated that both the gonads and the external genitalia would be female (which is incorrect as the development of the gonads is independent of testosterone). Some marks lost for missing details (e.g. SRY is required for testes development).

9. A study was performed to determine if there is a link between serum progesterone concentration and risk of spontaneous miscarriage. Describe the data in the table below and explain the role of progesterone during pregnancy. (3 marks)

<table>
<thead>
<tr>
<th>Serum progesterone (ng/ml)</th>
<th>Percentage of pregnancies that ended in spontaneous miscarriage</th>
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<tbody>
<tr>
<td>0–4.9</td>
<td>85.5 %</td>
</tr>
<tr>
<td>5.0–9.9</td>
<td>65.8 %</td>
</tr>
<tr>
<td>10.0–14.9</td>
<td>31.3 %</td>
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<tr>
<td>15.0–19.9</td>
<td>9.8 %</td>
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<tr>
<td>20.0–24.9</td>
<td>7.7 %</td>
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</tbody>
</table>

The data shows that the risk of spontaneous miscarriage is higher with lower serum concentrations of progesterone (1). Progesterone is needed to maintain the endometrial lining (1) and encourage placental development (1).

LO: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.

LO: Acquire, analyse, interpret and write up/present experimental data.

Most answers described the data appropriately. Some marks were lost for not providing enough detail regarding the function of progesterone (did also accept that
progesterone maintains a quiescent uterus), but generally, this question was answered well.

10. A male patient is affected by an X-linked dominant disease for which the causative genetic mutation has not been identified. His female partner does not suffer from the disease. Explain which preimplantation genetic diagnosis approach(es) would be suitable to ensure that the child of the couple is not affected by the X-linked dominant disease. Consider both the biopsy approach and the genetic testing method. (5 marks)

A blastomere biopsy would be suitable (1), whereas a polar body biopsy would not, because it only provides information on genetic material inherited from the mother, but not the father (1). To ensure that the child is not affected by the disease, the sex of the embryo can be determined, and only male embryos chosen for transfer into the uterus (1). To determine the sex of the embryo, PCR can be used to amplify part of the Y chromosome (1), or FISH with probes that detect the Y and/or X chromosomes (1).

LO: Using examples, discuss the concept of disease.
LO: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.

Most students correctly identified a suitable biopsy approach (a mark was awarded for suggesting blastocyst stage biopsies), but some answers did not explain why a polar body biopsy would not be suitable. Some answers were awarded full marks, but many answers only provided a general description of PCR and FISH, without mentioning that sexing of the embryo should be done, or which genomic regions or chromosomes should be amplified or tested for. Several answers described how a known mutation could be tested for.

11. Explain why only one follicle reaches full maturity during the follicular phase of a menstrual cycle. (5 marks)

During the early follicular phase, gonadotrophin levels are high enough to support the development of several follicles (1). The developing follicles produce increasing amounts of oestrogens (1), which have an inhibitory effect on gonadotropin (especially FSH) production (1). Towards the end of the follicular phase, only the biggest follicle has acquired enough granulosa cells with enough FSH receptors to still receive sufficient FSH signals for survival (1), whereas for smaller follicles, the reduced FSH levels are insufficient to support further development (1).
LO: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.

Some good answers, but several answers did not contain enough detail, and some answers described the different stages of follicle development rather than explain why only one follicle reaches full maturity.

12. Is Tamoxifen an agonist or antagonist at estrogen receptors? (4 marks)

Both. In breast (at least for first 10 years), Tamoxifen causes ER to translocate to nucleus, bind EREs and recruit co-repressors the repress gene transcription (1). In this way, Tamoxifen is antagonising the action of estrogen in the breast (1). In bone, uterus or after 10 years of treatment in breast, Tamoxifen recruits co-activators at EREs, enhancing gene transcription (1). In this way, estrogen acts like an agonist at ERs (1).

Most students received full marks for this question with a good understanding of why Tamoxifen is both. Some students were confused between agonist and antagonist properties.

LO: Using examples, discuss the concept of disease.

LO: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.