Answer all questions in the spaces provided on the examination paper
The marks available for each question are indicated on the paper
A calculator will be provided
Answer all questions in the spaces provided

1. a) What developmental abnormality results in an atrial septal defect, and why would an atrial septal defect with blood flowing from right to left atrium be classed as cyanotic? (3 marks)

   An atrial septal defect occurs when the foramen ovale fails to close after birth (1). The deoxygenated blood in the right atrium would mix with the oxygenated blood in the left atrium (1) and this would lower the oxygen concentration of the circulating blood (1)

   Answered well. Some answers did not give the name of the structure (foramen ovale), but many received full marks

b) A patient has contracted bacterial endocarditis, which has damaged their aortic valve, preventing it from closing properly. How will this affect blood flow in the heart and what will be the consequences of aortic valve dysfunction? (2 marks)

   Blood will leak back into the left ventricle (from the aorta) during diastole (1). This would result in a lower cardiac output and therefore the heart will have to work harder to pump the same amount of blood (1).

   Some answers lost marks for not being specific enough (i.e. needed to state both the aorta and left ventricle). Many answers stated that blood volume would be reduced without stating the consequence of this. It is unlikely that a slightly reduced blood volume would cause damage/ lack of oxygen to tissues, instead the heart would work harder to compensate which would be problematic long term

   This question addresses the following LOs
   LO1: Using examples, discuss the concept of disease.
   LO2: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.

2. a) Describe an experiment which provided evidence for definitive haematopoietic stem cells arising from the embryo, rather than the yolk sac. (3 marks)
Quail-chick transplantation chimeras (quail embryo grafted onto chick yolk sac after removal of chick embryo) (1). The origin of mature circulating cells was determined using cell markers (1) which showed these cells to be quail in origin (1).

Many good answers to this question. Some did not mention that the origin of the mature cells would need to be determined (e.g. by identifying cell surface markers, or other sensible suggestion).

b) How does hypoxia stimulate angiogenesis in the embryo? (2 marks)

Low oxygen activates hypoxia inducible factor (HIF) (1) which increases the expression of vascular endothelial growth factor (VEGF) (1) which causes angiogenesis.

Mostly answered well. Many answers attracted full marks.

This question addresses the following LO
LO2: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.

3. Describe the pharmacological rationale behind the use of beta blockers in the treatment of angina. (3 marks)

β1-adrenoceptors are found in heart. Must state β1 (1 mark). Adrenaline and Noradrenaline act on these receptors to increase heart rate (1 mark). Beta blockers compete with Adr/NA for binding sites but since they have no efficacy do not elicit a response. Therefore they act to reduce heart rate (1 mark).

LO1: Using examples, discuss the concept of disease.
LO2: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.

Not answered well. Many answers were vague and/or students did not discuss pharmacology. Some students failed to mention B1 receptors, while many did not mention role of adrenaline/noradrenaline.
4. a) Outline the primary somatosensory cortex in the diagram below. (1 mark)

Diagram below shows the answer. The student should not encroach the primary motor cortex for the mark to be awarded.

Mostly answered well. A number of students labelled primary visual cortex or temporal cortex. A few labelled primary motor cortex.

b) What is the main determinant of the resting membrane potential? (1 mark)

Movement of K+ ions out of the cell. Students must indicate both K+ ions and movement out of cell.

Mostly answered well. Some students did not mention direction of ions.

c) If action potentials are generated in response to a person pressing their finger on a table, from which subdivision of the thalamus does this neuron receive synaptic input? (1 mark)

Ventral posterior nucleus

Mostly answered well

d) In which part a neuron is the action potential generated? What
property of this part of the neuron facilitates this action potential generation? (1 mark)

Axon initial segment (1/2 mark)
Highest density of Na+ channels (1/2 mark)

Mostly answered well. Marks were awarded if reason given that this area is unmyelinated. Some students said axon hillock which is what you were taught at A-level but lectures were explicit that it occurred at AIS.

The diagram below shows transmembrane currents generated in response to prolonged depolarisation.

![Diagram showing transmembrane currents](image)

e) Identify the ions responsible for the generation of the currents labelled (i) and (ii). (1 mark)

(i) K+ (1/2 mark)
(ii) Na+ (1/2 mark)

A number of students had this the wrong way round

f) What properties of the ion channels are responsible for these currents? (2 marks)

Both activated by depolarisation (1/2 mark) but voltage-gated K+ channels open slower (1/2 mark)
Voltage-gated Na+ channels have inactivation gate that causes transient inward current (1/2 mark), whereas voltage-gated K+ channels do not
inactivate so get prolonged current (1/2 mark).
Students generally answered this well although many did not mention K+ channels opening slower.

**LO3: Describe the organisation of the nervous system and how neurons communicate.**

5. The diagram below shows postsynaptic potentials recorded from a neuron located in the brain area most associated with poor impulse control in teenagers. Postsynaptic potentials were recorded in the absence (Control) or presence of TTX (+TTX) – a blocker of voltage-gated Na+ channels. The mean amplitude (height) of the postsynaptic potentials is shown on the right.

![Diagram](image)

a) In which brain area were the postsynaptic potentials recorded? (1 mark)

**Orbitofrontal cortex**

Students answered correctly but many answered PFC.

b) Which neurotransmitter was likely responsible for the postsynaptic potentials? Explain your reasoning. (1 mark)

**GABA** (1/2 mark). A mark is not awarded for glycine due to location of neuron.
**IPSP** is generated by this transmitter (1/2 mark)

Not very well answered. Many students thought this was related to catecholamines, which were not discussed in relation to IPSPs/EPSPS.
Many students did not recognise this as an IPSP (despite downward potential)

c) Provide an interpretation of the data shown above. You should assume that there is nothing wrong with the TTX. (2 marks)

The postsynaptic potentials are not being generated from action potentials (1 mark).
Since action potentials require the opening of voltage-gated Na+ channels (1 mark).

The first mark above will also be awarded for a comments about TTX-insensitive Na+ channels although students have not been taught about this.

This was deliberately challenging. A few students answered this correctly. Most students did not recognise that postsynaptic potentials are generated by action potentials and considered movement of Na+ through postsynaptic receptor.

d) Provide a hypothesis on what you would expect to happen to these postsynaptic potentials in the presence of amphetamine. Provide an explanation. (2 marks)

Decreased frequency/amplitude or completely gone (1 mark). The students have not been taught about mini-IPSCs and so this question is based more on interpretation given their understanding of amphetamine mechanism of action.
Because amphetamine decreases uptake of neurotransmitter into vesicles (1 mark)

Generally answered well. Marks were awarded if students hypothesised different effect (e.g. increase) if logic was sound.

LO3: Describe the organisation of the nervous system and how neurons communicate.

6. a) The sympathetic nervous system promotes arousal, defence, and
escape. The parasympathetic nervous system promotes eating and procreation. Outline four other differences between the sympathetic and parasympathetic nervous systems. \(4 \text{ marks}\)

To be awarded mark, student must get both parts correct
(1) In PNS, pre- and post-ganglionic neurons both release acetylcholine. In SNS, pre-ganglionic neurons release acetylcholine, whereas post-ganglionic neurons both release adrenaline.
(2) In PNS, ganglia lie close to end-organs. In SNS, ganglia lie close to spinal cord.
(3) PNS ganglia generally innervate single end-organs. SNS ganglia innervate many target organs.
(4) PNS originate from the brainstem (CNIII, VII, IX, X) or spinal cord segments S2 -> S4. SNS preganglionic neurons arise only from the spinal cord (segments T1 – T12, L1 – L3)

Generally answered well but a number of students were too vague in their answers.

b) The image below shows an ECG trace from a healthy girl and a girl with Rett syndrome. Which girl has been diagnosed with Rett syndrome? Explain your reasoning. \(1 \text{ mark}\)

Girl (i), because there is prolonged Q-T interval, a common feature of Rett syndrome. Only 1 mark because student cannot be awarded mark for guessing correctly.

Not very well answered.

LO1: Using examples, discuss the concept of disease.
LO2: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.

LO3: Describe the organisation of the nervous system and how neurons communicate.

7. Maternal insulin resistance occurs in normal pregnancies during the 3rd trimester. What is the relevance of this?  (2 marks)

A decrease in insulin sensitivity results in reduced glucose uptake into maternal cells (1) so more glucose is available for the growing foetus (1)

Mostly answered well. Many answers attracted full marks

This question addresses the following LO
LO2: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.

8. a) How does the placenta help to protect the foetus from infection?  (2 marks)

The placenta allows some maternal antibodies to cross into the foetus (1). The placenta also acts as a barrier to the passage of some microbes from mother to foetus (1).

Many received full marks for this question. Some answers lost marks for stating that the placenta produces antibodies, rather than mainly allowing passage of maternal antibodies

b) Which placental hormone is traditionally detected in a urine dipstick pregnancy test and what is its function?  (3 mark)

Human chorionic gonadotropin or hCG (1). hCG ensures maintenance of the corpus luteum so progesterone is secreted (1) which maintains the endometrial lining (1)

Those that correctly identified the hormone, often received full marks. Some answers failed to mention that it is progesterone needed to maintain the endometrial lining (instead stating that HCG was the hormone responsible)
This question addresses the following LO
LO2: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.

9. Describe how luteinising hormone (LH) and follicle-stimulating hormone (FSH) stimulate human spermatogenesis. (4 marks)

Leydig cells produce testosterone in response to LH (1). Testosterone (1) and FSH act on Sertoli cells (1), which in turn promote spermatogenesis (1).

LO2: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.

Many answers were awarded full marks. Some confusions with the female system. Several answers did not mention that testosterone acts on Sertoli cells.

10. a) What are the main characteristics of the human cleavage stage of development before compaction? (2 marks)

A series of cell divisions (1) that are not associated with overall growth of the embryo, resulting in successively smaller cells (1).

Many good answers. Some students may have stated that the cells stay the same size, not the embryo.

b) Describe two approaches of determining the sex of a cleavage stage embryo. (2 marks)

Amplification of part of the Y chromosome by PCR (1)
FISH with probes detecting the Y and/or X chromosomes (1)

Most students mentioned PCR and FISH, but some answers did not explain what would be detected with these methods. Some answers only stated that the Y chromosome can be detected, without giving further details.

LO2: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.
11. How have researchers exploited the pharmacology of the estrogen receptor to create inducible knockout mice. (4 marks)

Cre recombinase is fused to the ligand-binding domain of the estrogen receptor (1 mark).
The resulting protein, CreER, is confined to the cytoplasm (1 mark).
In the presence of tamoxifen, CreER is translocated to the nucleus (1 mark), where it catalyzes recombination of the target DNA sequences flanked by loxP sites (1 mark).

On average, students received 2 marks for this question. A number of students did not attempt to answer question or addressed this question from the point of view of how tamoxifen affects ER processing. Some confusion that Cre is fused to ligand binding domain of ER.

LO1: Using examples, discuss the concept of disease.
LO2: Describe basic aspects of human anatomy and the function and regulation of the major physiological systems in the healthy human body.