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**HUMAN BIOLOGY**

**UNITS 3 & 4**

**2024**

**Marking Guide**

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Teacher: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Time allowed for this paper**

Reading time before commencing work: ten minutes

Working time: three hours

**Materials required/recommended for this paper**

***To be provided by the supervisor***

This Question/Answer booklet

Multiple-choice answer sheet

***To be provided by the candidate***

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: up to three calculators, which do not have the capacity to create or store programmes or text, are permitted in this ATAR course examination

**Important note to candidates**

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised material. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

**Section One: Multiple-choice 30% (30 Marks)**

|  |  |
| --- | --- |
| **Question Number** | **Solution** |
| **1** | **C** |
| **2** | **D** |
| **3** | **D** |
| **4** | **A** |
| **5** | **C** |
| **6** | **B** |
| **7** | **B** |
| **8** | **B** |
| **9** | **C** |
| **10** | **C** |
| **11** | **C** |
| **12** | **D** |
| **13** | **D** |
| **14** | **D** |
| **15** | **A** |
| **16** | **A** |
| **17** | **D** |
| **18** | **D** |
| **19** | **C** |
| **20** | **B** |
| **21** | **D** |
| **22** | **C** |
| **23** | **A** |
| **24** | **B** |
| **25** | **A** |
| **26** | **A** |
| **27** | **A** |
| **28** | **D** |
| **29** | **B** |
| **30** | **B** |

**Section One: Multiple-choice 30% (30 Marks)**

This section has **30** questions. Answer **all** questions on the separate Multiple-choice answer sheet provided. For each question shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. Do not use erasable or gel pens. If you make a mistake, place a cross through that square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 40 minutes.

Questions 1, 2 and 3 refer to the diagram below which shows a type of locomotion in a primate.

A monkey from a rope

Description automatically generated

1. What is the best name for this type of movement?

(a) knucklewalking

(b) bipedal locomotion

(c) brachiation

(d) arboreal clinging and leaping

2. Which of the following adaptions is found in an organism that moves in this way?

(a) having claws instead of nails

(b) legs being longer than arms

(c) long thumbs

(d) broad thorax

3. Compared to *Homo sapiens*, this organism would have

(a) more forward-facing eyes.

(b) shorter fingers.

(c) a larger cerebral cortex.

(d) a stronger degree of prognathism.

Questions 4, 5 and 6 refer to the image below showing glands of the human body.

A diagram of a human body

Description automatically generated

4. An underproduction of hormone from Structure B

(a) would result in an intolerance to cold.

(b) is called hyperthyroidism.

(c) would cause a decrease in the release of TSH.

(d) can be treated by removing all or part of the gland.

5. Structure A does **not**

(a) regulate sleep patterns.

(b) release its hormones from the posterior pituitary.

(c) produce parathyroid hormone (PTH).

(d) control hunger and thirst.

6. Structure C

(a) is an exocrine gland.

(b) produces hormones.

(c) is involved in a hormone cascade for regulating body temperature.

(d) produces TSH.

7. The table below shows the half-life of a number of different radioisotope techniques. Which of these isotopes would be most useful in dating *Australopithecus afarensis*?

|  |  |
| --- | --- |
| **Technique** | **Half life** |
| Carbon 14 | 5730 years |
| Uranium 238 | 4.51 x 109 years |
| Strontium 90 | 28 years |
| Iodine 131 | 8.05 days |

(a)

(b)

(c)

(d)

8. A kitchen midden was excavated in the Middle East. Lower levels contained fish bones and crustacean shells. Middle layers contained spores from ferns, plants and frog skeletons. Upper layers contained egg shells, bones from lizards and skeletons of small mammals. While this area has been occupied, the evidence suggests

(a) the site was not occupied continuously throughout history.

(b) the climate of the area was becoming drier.

(c) tools used for hunting were changing.

(d) the size of the population living there was decreasing.

9. An isotope has a half-life of 4 x 106 years. In 8 x 106 years,

(a) half of the original amount of isotope will be present.

(b) twice as much of the original amount of isotope will be present.

(c) one quarter of the original amount of isotope will be present.

(d) all of the isotope will be present.

10. Scientists have continued to classify and reclassify hominin specimens as more information and fossils comes to light. *Homo heidelbergensis* and *Homo neanderthalensis* were classified as different species, but now they are classified as the same species, *Homo neanderthalensis*, in Europe. These organisms must

(a) have looked enough alike to be thought to be one species.

(b) have been separated by a geographical barrier.

(c) be able to interbreed in nature.

(d) be able to survive in the same habitat.

11. Which of the following correctly lists the cultural advances from earliest to most recent?

(a) use of fire, art, hand axes, spiritual beliefs

(b) painting, burial of the dead, use of fire, pebble tools

(c) pebble tools, use of fire, hafting, burin

(d) hand axes, burin, hafting, spiritual beliefs

Questions 12, 13 and 14 refer to the information below.

The incidence of diabetes is rising at approximately 3% per year. Some have suggested that

early exposure to complex proteins in powdered formula milk is contributing to this increase.

Scientists testing this idea randomly allocated 10 newborn babies to each group, one group

only breastfed up to 6 months of age and one group given any type or amount of formula milk

from 2 months onwards. For the next 15 years, every September, the parents were surveyed

and asked whether their child had been diagnosed with diabetes.

12. Which of the following could not **be** a hypothesis the scientists could have been testing?

(a) Proteins in formula milk increase the occurrence of diabetes.

(b) The incidence of diabetes decreases if only breastmilk is given to babies under 6 months.

(c) Proteins in formula milk do not affect the incidence of diabetes.

(d) The incidence of diabetes is affected by the proteins in formula milk.

13. Which of the following is correct for this investigation?

|  |  |  |
| --- | --- | --- |
| **Controlled variable** | **Dependent variable** | **Uncontrolled variable** |
| Newborns | Proteins in formula | Other dietary proteins |
| Surveyed | Incidence of diabetes | Amount of formula |
| Amount of formula | Survey | Incidence of diabetes |
| Newborns | Incidence of diabetes | Other dietary proteins |

(a)

(b)

(c)

(d)

14. Which of the following could be improvements the scientists could make to their methodology?

(a) increase the number of babies in each group to improve validity

(b) increase the number of babies in each group to improve accuracy

(c) decrease the amount of proteins in the formula milk given to half the babies so they do not get diabetes

(d) decrease the number of uncontrolled variables to improve validity

Question 15 refers to the information and table below.

The original DNA base sequence of ATA GGT CTC TCT is mutated to ATT GGA GTG TCT.

The amino acids formed by different DNA codons are shown in the table.

|  |  |
| --- | --- |
| **DNA codons** | **Amino acid formed** |
| GGT, GGC, GGA, GGG | Gly |
| GTT, GTA, GTG, GTC | Val |
| ATC, ATT, ATA | Ile |
| TCC, TCT, TCA, TCG | Ser |
| CTC, CTT, CTA, CTG | Leu |

15. Which of the following statements would be correct with regard to the mutated DNA strand?

(a) This mutation will change the amino acid sequence.

(b) This mutation is a due to a translocation.

(c) The amino acid sequence of the mutated strand would be Ile, Gly, Ser, Val.

(d) This mutation would reduce variation in the population.

Question 16 refers to the three photos below of different primate jaws.

**A jaw bone with teeth

Description automatically generatedA skeleton of a human body

Description automatically generated with medium confidenceA model of a human jaw

Description automatically generated**

Jaw R Jaw S Jaw T

16. Which of the following correctly matches the jaw and the species to which it belongs?

|  |  |  |
| --- | --- | --- |
| **Gorilla** | **Human** | **Australopithecine** |
| Jaw S | Jaw R | Jaw T |
| Jaw S | Jaw T | Jaw R |
| Jaw T | Jaw R | Jaw S |
| Jaw T | Jaw S | Jaw R |

(a)

(b)

(c)

(d)

17. For efficient bipedal locomotion, the pelvis should be

(a) long and narrow.

(b) long and broad.

(c) short and narrow.

(d) short and broad.

18. All of the following are items found at archaeological digs.

1. Burnt remains in a fireplace hearth
2. *Homo habilis* cranium
3. Hand axe
4. Wooden spear
5. Tooth from the jaw of *Homo sapiens* (Cro Magnon)

Which of these would be able to be dated using radiocarbon dating?

(a) (i), (ii), (iii), (iv) and (v)

(b) (ii), (iv) and (v) only

(c) (i), (ii), (iii) and (iv) only

(d) (i), (iv) and (v) only

Question 19 refers to the image below which shows the relationships between a number of species.

A diagram of a tree

Description automatically generated with medium confidence

19. This image suggests that

(a) *P. boisei* is more closely related to *P. robustus* than to *P. aethiopicus*.

(b) the common ancestor of *P. aethiopicus* and *P. boisei* is also the common ancestor of *Homo*.

(c) *Homo* is more closely related to *A. africanus* than it is to *A. afarensis*.

(d) *A. afarensis* is least like the Outgroup.

20. Fever

(a) resets the medulla oblongata to higher temperature.

(b) can kill bacteria or prevent them from dividing.

(c) begins with sweating and is followed by chills.

(d) is stimulated by the release of heparin.

Questions 21 and 22 refer to the image below.

A diagram of blood cells

Description automatically generated

21. The image above shows

(a) a lipid soluble hormone as it forms a hormone receptor complex on the cell membrane.

(b) Cell B as the target cell for this hormone.

(c) a hormone that can alter gene activity.

(d) two target cells, one of whom is more sensitive to this hormone than the other.

22. If inflammation occurred at this site,

(a) the blood vessel would vasoconstrict to reduce blood flow to the area.

(b) pyrogens would be released.

(c) histamine would allow more fluid to exit the blood and enter the intercellular fluid.

(d) phagocytes would be opsonised by activated T cells.

23. Which of the following statements is **incorrect**?

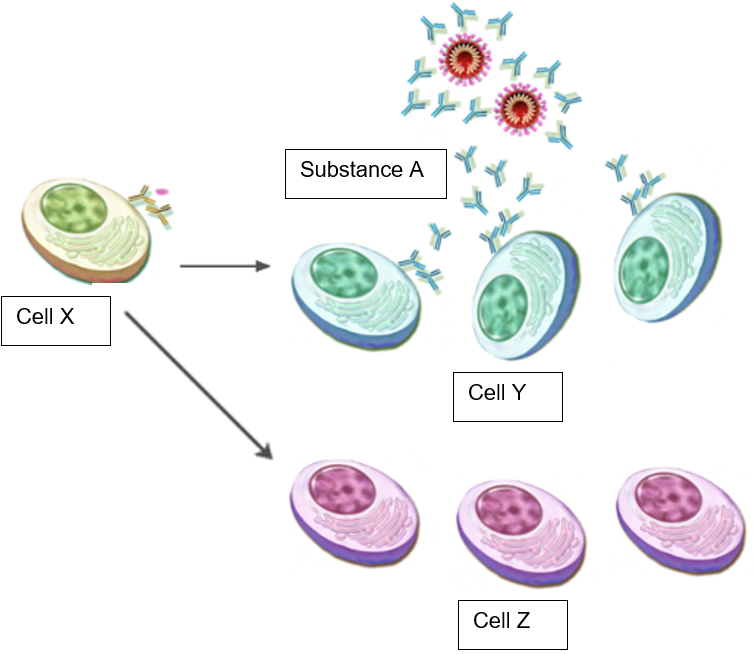
(a) Sympathetic nerve impulses cause blood vessels to the gut to vasodilate.

(b) Somatic nerve impulses cause skeletal muscles to contract.

(c) Autonomic nerve impulses are both excitatory and inhibitory.

(d) There are two neurons in the parasympathetic nerve pathway.

Questions 24 and 25 refer to the image below.



24. Which of the following statements is correct?

(a) Cell X is a T lymphocyte which has recognised an antigen.

(b) Cell Z will be able to produce a stronger faster response to this antigen in the future.

(c) Cell Y is a B lymphocyte which has not been activated or sensitised.

(d) Cells X, Y and Z are all part of the body’s non-specific internal immunity.

25. Substance A can act in a variety of ways. Which of the following ways is **incorrect**?

(a) phagocytosis

(b) agglutination

(c) makes soluble substances insoluble

(d) dissolves organisms

26. Trypanosomiasis is a disease caused by a parasite that can be transmitted by the saliva of the Tsetse fly, the bite or faeces of the reduviid bug that inhabits poorly constructed huts made of mud and thatch or by blood transfusions. In this instance,

(a) the acid of the stomach would provide external non-specific immune defences.

(b) the most common form of transmission would be through contaminated food.

(c) blood transfusions would provide indirect contact with the parasite.

(d) the parasite would be considered a vector.

27. Which of the following about index fossils is **incorrect**?

(a) They should be found over a long period of time.

(b) They may be pollen grains or trilobites.

(c) They should be easily recognisable.

(d) They can be found widespread geographically.

28. Gene flow between two groups would

(a) increase if adjoining populations spoke different languages.

(b) increase if both populations were separated by a large mountain range.

(c) decrease if migration from one population to the other often occurred.

(d) decrease if people only married within their own cultural group.

Questions 29 and 30 refer to the image of an action potential shown below.

A diagram of a red line

Description automatically generated

29. At stage C,

(a) sodium gated channels are closed and potassium gated channels are open.

(b) the action potential will climb to a membrane potential of +30mV at point D.

(c) sodium potassium pumps are operating to pump 3 sodium out and 2 potassium in.

(d) the inside of the neuron is becoming more negative and the outside more positive.

30. For this action potential to occur in a myelinated neuron,

(a) an all or nothing effect can only occur beneath a Schwann cell.

(b) a refractory period must occur within the nodes of Ranvier.

(c) no stimulus is required as myelin acts as an insulator.

(d) all ions enter between the Schwann cells and exit through the myelin sheath.

**End of Section One**

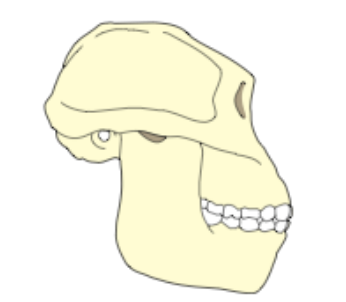
**Section Two: Short answer 50% (110 Marks)**

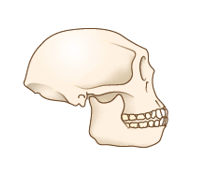
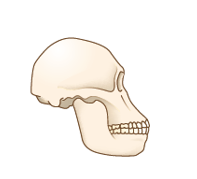
This section has **seven** questions. Answer **all** questions. Write your answers in the spaces provided.

Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 90 minutes.

**Question 31 (13 marks)**

At Piluo in China, a number of tools and fossilised skulls were found. Due to a typhoon approaching, the specimens were quickly placed in a box and returned to the museum for studying in the future. Unfortunately, specimen boxes from different areas were opened at the same time and placed on the bench without appropriate labelling. The three skulls shown below were all on the bench.



Skull A Skull B Skull C

(a) Explain which skull/s could **not** have been found in Piluo. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Skull B and C | 1 |
| Only found in Africa / did not leave Africa | 1 |
| **Total** | **2** |

(b) Name the species to which Skull A belongs and state one identifying characteristic in the image to justify your decision. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| *Homo erectus* | 1 |
| Has a sagittal keel | 1 |
| **Total** | **2** |

(c) Name the species to which Skull C belongs and state one identifying characteristic in the image to justify your decision. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| *Paranthropus robustus* | 1 |
| Sagittal crest | 1 |
| **Total** | **2** |

(d) The species depicted by Skull C is herbivorous. Use the image to justify this decision.

(1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Large molars and premolars | 1 |
| Long ramus in mandible |
| **Total** | **1** |

A black and white drawing of a person

Description automatically generatedThe following tools (not shown to scale) were found at different sites in the Middle East.

A group of stone arrows

Description automatically generated

Tool Kit A Tool B

(e) The specimens shown in Tool Kit A were all removed from a rock core. What are these pieces of rock called and what species was the first to create tools of this kind?

(2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Flakes | 1 |
| *Homo neanderthalensis* | 1 |
| **Total** | **2** |

(f) (i) What would Tool B have been made out of? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| bone | 1 |
| tusk |
| antler |
| **Total** | **1** |

(ii) What species would have been the first to make tools of this kind? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Homo sapiens | 1 |
| Cro Magnon |
| **Total** | **1** |

(g) Besides tools, state one cultural feature *Homo neanderthalensis* and *Homo sapiens* (Cro Magnon) were each believed to have first demonstrated. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Homo neanderthalensis – burying dead / spiritual beliefs | 1 |
| Homo sapiens – art / murals | 1 |
| **Total** | **2** |

**Question 32 (11 marks)**

Alzheimer’s is a non-reversible brain disorder that develops over a number of years. Yaramul is a small village high up in the Andes mountain range in South America that has the highest frequency of the genetic mutation for early onset Alzheimer’s in the world and has been traced back to an ancestor from the 17th century.

(a) Explain how this frequency could have come about. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The village formed a small isolated population | 1 |
| Due to geographical barriers | 1 |
| People could only breed within the village / no gene flow | 1 |
| Due to random genetic drift / founder effect | 1 |
| **Total** | **4** |

(b) (i) State the neurotransmitter involved in the formation of Alzheimer’s disease.

(1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Acetylcholine | 1 |
| **Total** | **1** |

(ii) What substance enters the axon terminal and initiates the release of neurotransmitters? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Calcium | 1 |
| **Total** | **1** |

(iii) Name the process that allows neurotransmitters to be released into the synapse. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Exocytosis | 1 |
| **Total** | **1** |

(iv) By what process do neurotransmitters move across the synapse? (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Diffusion | 1 |
| **Total** | **1** |

(c) Some drugs used to treat Alzheimer’s disease are injected into the cerebrospinal fluid. Describe the functions of cerebrospinal fluid and suggest why drugs might be given in this way. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Shock absorbing | 1-2 |
| Provide nutrients to the CNS tissues |
| Remove waste from the CNS tissues |
| Improve access to brain cells | 1 |
| **Total** | **3** |

**Question 33 (15 marks)**

A diagram of a person using a spray can

Description automatically generated

(a) Identify the labels in the image above: (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| 2 – nocireceptors / pain receptors / thermoreceptors | 1 |
| 4 – effectors | 1 |
| 5 – grey matter | 1 |
| **Total** | **3** |

(b) Identify Structure 6 in the image above and state what would be found there. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Dorsal / posterior root ganglion | 1 |
| Cell bodies of sensory neurons | 1 |
| **Total** | **2** |

(c) State one structural and one functional characteristic most reflex arcs share. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Structural – made of 3 neurons / contains sensory, connector and motor neurons | 1 |
| Functional – fast / autonomic / stereotyped / does not involve the brain in determining a response / require a stimulus | 1 |
| **Total** | **2** |

A diagram of a brain

Description automatically generated

(d) Describe how Structure B varies between great apes and humans and suggest an advantage of such a variation to humans. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Smaller cerebrum / less cerebral cortex in great apes compared to humans | 1 |
| Allows humans to learn / communicate / think / reason / remember / process information more quickly/easily | 1 |
| **Total** | **2** |

(e) Suggest how Structures A and D are similar. (1 mark)

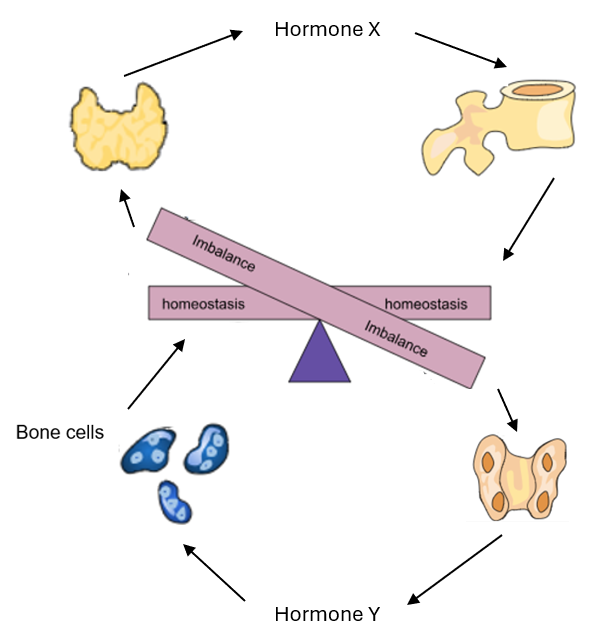
|  |  |
| --- | --- |
| **Description** | **Marks** |
| Both contain white matter / connect parts of the CNS with each other | 1 |
| **Total** | **1** |

(f) Explain the role of Structure C in decreasing carbon dioxide concentrations in the blood. (5 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Chemoreceptors in the aortic and carotid bodies / respiratory centre of the medulla oblongata detect high carbon dioxide levels in the blood | 1 |
| And pass nervous impulses / action potentials to the respiratory centre in the medulla oblongata | 1 |
| Which sends nerve impulses via the phrenic and intercostal nerves | 1 |
| To cause the diaphragm and intercostal muscles | 1 |
| To contract and relax faster | 1 |
| **Total** | **5** |

**Question 34 (15 marks)**

The mechanism of homeostasis of blood calcium levels is shown in the image below.



(a) Define homeostasis. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The maintenance of a relatively constant internal environment | 1 |
| For the body’s optimal functioning | 1 |
| **Total** | **2** |

(b) Name hormones X and Y. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| X – calcitonin | 1 |
| Y – PTH / parathyroid hormone | 1 |
| **Total** | **2** |

(c) State the effect of Hormone X on bone. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Stores calcium in bone tissue | 1 |
| **Total** | **1** |

(d) Besides involvement in managing blood calcium levels, the thyroid is also involved in temperature regulation. Explain how the thyroid regulates body temperature.

(2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Thyroid produces thyroxine which affects all body cells | 1 |
| Increasing the rate of cell respiration / metabolism which creates heat | 1 |
| **Total** | **2** |

(e) (i) The body can regulate temperature using nervous control as well as hormonal

control. Explain how two nervous communications would help to regulate body temperature. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Any 2 of the following points, named and explained** |  |
| Shivering – generates heat | 1-2 |
| Sweating – loses heat through evaporation | 1-2 |
| Vasodilation – loses heat through conduction / convection / radiation | 1-2 |
| Vasoconstriction – reduces heat loss through conduction / convection / radiation | 1-2 |
| **Total** | **4** |

(ii) State the division of the nervous system that these nervous communications would pass through and explain your choice. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Any 1 of the following points, named and explained** |  |
| Efferent – the message is travelling from the CNS to the body | 1-2 |
| Autonomic – the message is unconscious | 1-2 |
| **Total** | **2** |

(iii) Explain **two** ways in which behaviour could help to regulate body temperature. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **Any 2 of the following points, explained** |  |
| Put on clothes / sit in front of a heater / huddle / exercise / hot shower etc | 1 |
| Reduce heat loss / generate heat (must match behaviour) |
| Take off clothes / sit in air conditioning / spread out / don’t move / swim etc | 1 |
| Increase heat loss / generate less heat (must match behaviour) |
| **Total** | **2** |

**Question 35 (22 marks)**

(a) A variety of dating techniques can be used to determine the age of different fossils. Complete the table below to differentiate between carbon 14 dating and stratigraphy. (8 marks)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Description** | | | **Marks** | |
|  | **Carbon 14 dating** | **Stratigraphy** | |  |
| Identify whether this technique is a form of relative or absolute dating | Absolute | Relative | | 1-2 |
| Type of material dated using this technique | Organic | Organic or inorganic | | 1-2 |
| Time limit associated with this technique | Less than 70,000 years | Unlimited | | 1-2 |
| One weakness associated with this technique | At least 3 g of material is required /  C14:C12 ratio is not the same through history / C14:C12 ratio is not the same everywhere in the world | Geological faults / folding / disturbances / deliberate burial disrupt the layers | | 1-2 |
| **Total** | | | | **8** |

(b) State **two** conditions required for fossilisation to take place and **two** reasons why fossils may not be found. (4 marks)

Conditions required for fossilisation to take place:

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Quick burial / presence of hard body parts / absence of decay organisms / long period of stability / alkaline soil / sedimentary soils / lack of oxygen | 1-2 |
| **Total** | **2** |

Reasons why fossils may not be found:

|  |  |
| --- | --- |
| **Description** | **Marks** |
| We don’t look in the right places / buried too deep / inaccessible / destroyed by human activity / don’t recognise them as fossils | 1-2 |
| **Total** | **2** |

(c) DNA extracted from fossils can be used to determine the relationships between organisms and patterns of migration. Give **two** reasons why mitochondrial DNA might be used rather than nuclear DNA to determine these relationships. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Higher rate of mutation than nuclear DNA / large amounts of it is present in cells / more easily accessible in cells | 1-2 |
| **Total** | **2** |

The DNA of three species, *Homo habilis*, *Homo erectus* and *Australopithecus africanus* were compared and are shown below:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Species 1 | T | G | A | C | T | T | A | A | C |
| Species 2 | T | C | A | C | A | C | C | G | C |
| Species 3 | T | G | T | C | T | T | G | A | C |

(d) Which of the three species, Species 1, 2 or 3, would belong to *Australopithecus africanus*? Give a reason for your decision. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Species 2 | 1 |
| It has the most / 5 and 6 differences to the other species as it is in a different genus | 1 |
| **Total** | **2** |

(e) Complete the table below by contrasting the skeletal structures of the hands and feet between *Australopithecus afarensis* and *Homo erectus* and suggest an advantage of these adaptations for each species. (6 marks)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Description** | | | | **Marks** |
|  | | ***Australopithecus afarensis*** | ***Homo erectus*** |
| Hands | | short thumbs  long fingers  curved finger bones | long thumb  short fingers  straight finger bones | 1-2 |
| Feet | | Long toes  Curved toe bones | Short toes  Straight toe bones | 1-2 |
| Advantage | | Able to climb trees | More efficient weight transfer / more energy efficient striding locomotion | 1-2 |
| **Total** | | | **6** |

**Question 36 (16 marks)**

Severe Combined Immunodeficiency Disease (SCID) is a severe inherited disease where people have no immunity as T cells do not develop. Researchers studying this disease carried out a trial using gene therapy on the stem cells of affected children taken from the children’s umbilical cord blood.

(a) What is gene therapy? (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The replacement of an affected gene with a healthy gene | 1 |
| In order to treat single gene disorders | 1 |
| **Total** | **2** |

(b) Explain why the researchers believed that gene therapy on the stem cells would provide better outcomes than stem cell replacement therapy alone. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Stem cells from the children will contain the same genetic disorder | 1 |
| Gene therapy will give them a healthy gene | 1 |
| **Total** | **2** |

(c) Describe three ways in which the researchers could have conducted their research in an ethical manner. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Confidential / anonymous / informed written consent / right to withdraw / minimised harm / voluntary participation | 1-3 |
| **Total** | **3** |

The researchers conducted their investigation on three children and collected the following

data.

|  |  |  |  |
| --- | --- | --- | --- |
| Time (weeks) | Average Number of T cells in the blood (mg/mL) | | |
| No treatment | Cell replacement therapy only | Cell replacement and gene therapy |
| 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 10 |
| 3 | 0 | 0 | 25 |
| 4 | 0 | 0 | 75 |

(d) State an appropriate title for their table of results. (1 mark)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The effect of cell replacement and gene therapy on average number of T cells in the blood of children with SCID | 1 |
| **Total** | **1** |

(e) Explain why no treatment was given to some children. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| They were the control | 1 |
| As a means for comparison to the treatment groups | 1 |
| **Total** | **2** |

(f) Explain which type of graph they should use to represent their data. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Line graph | 1 |
| As the data is continuous | 1 |
| **Total** | **2** |

(g) In their analysis, the researchers suggested that future study should increase the reliability. Describe how and why they should do this given the opportunity.

(2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Increase the number of children used / repeat the experiment | 1 |
| So that they can identify outliers / ensure the data is consistent in the same population | 1 |
| **Total** | **2** |

(h) Children with SCID must have numerous injections to provide them with the immunity their own body can’t provide. Explain what type of immunity they are being given.

(2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Artificial passive | 1 |
| They are being injected with antibodies | 1 |
| **Total** | **2** |

**Question 37 (18 marks)**

Historically, diabetes was seen as a single disease, until 1936, when Harry Himsworth published a paper in *The Lancet* suggesting that it was actually two different diseases. The World Health Organisation (WHO) officially recognised two distinct types of diabetes in 1980.

(a) Weight loss and being overweight are a symptom of each of the different types of diabetes. State which condition is associated with each type of diabetes and explain why these symptoms are associated with each disease. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Weight loss is associated with Type 1 | 1 |
| As cells are not able to bring glucose in, fat cells break down fat / do lipogenolysis to provide glucose to cells / gluconeogenesis | 1 |
| Being overweight is associated with Type 2 | 1 |
| Due to named lifestyle factors / eating too much / not exercising enough | 1 |
| **Total** | **4** |

(b) Differentiate between the treatment for Type 1 and Type 2 diabetes. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Type 1 – insulin pump / insulin injections | 1 |
| Type 2 – increase exercise / lose weight / modify diet / eat less simple carbohydrate / modify lifestyle | 1 |
| **Total** | **2** |

Recently “Type 1.5 diabetes” or ‘double diabetes’ has been identified where sufferers show symptoms of both conditions. Researchers are racing to find appropriate management strategies and causes for this.

(c) Mutations in the HLA-DR3 and HLA-DR4 genes are linked to the incidence of Type 1 diabetes. Explain whether this mutation is somatic or germline in nature. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Germline | 1 |
| Type 1 diabetes can be inherited / passed on to offspring | 1 |
| **Total** | **2** |

(d) Researchers have used gel electrophoresis and PCR to study the HLA-DR3 and HLA-DR4 genes. Explain why each of these processes would have been used in the study. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| PCR – to make multiple copies of the HLA-DR3 and HLA-DR4 genes | 1 |
| Electrophoresis – to determine whether people with diabetes have either of these genes | 1 |
| **Total** | **2** |

In 1923 Banting, Best and Macleod received the Nobel Prize in Medicine for their work in

processing insulin from cattle and pig pancreas and it wasn’t until 1982 that Eli Lilly produced

the first commercially available biosynthetic insulin.

(e) Give **two** reasons why biosynthetic insulin is a better option than that produced

from cattle and pigs. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| No contamination from other organisms or proteins / can be made in larger quantities / does not require the death of animals / does not pass on other diseases / will not cause an immune response | 1-2 |
| **Total** | **2** |

The biosynthetic production of insulin is shown below.

A diagram of a cell cycle

Description automatically generated

(f) (i) Give **two** reasons why Cell A is used in this process over other types of cells.

(2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Available in large numbers / reproduces quickly / only requires a small amount of space / has been well studied / reproduces plasmids | 1-2 |
| **Total** | **2** |

**Question 37** (continued)

(ii) Identify Substance C and Substance D and explain why they are used in this process. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Substance C – restriction enzyme | 1 |
| Cuts open DNA leaving sticky ends | 1 |
| Substance D – DNA ligase | 1 |
| Binds sticky ends of DNA back together | 1 |
| **Total** | **4** |

**End of Section Two**

**Question 38 (20 marks)**

(a) Using aldosterone and antidiuretic hormone (ADH), explain how the hypothalamus communicates with the pituitary gland. (10 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Hypothalamus produces ADH | 1-5 |
| And passes it down axons in vesicles |
| To store it in the axon terminals in the posterior pituitary |
| Hypothalamus then passes a nerve impulse down to posterior pituitary |
| in order to release ADH |
| Hypothalamus releases ACTH releasing factors which are hormones | 1-5 |
| Into the local capillary network |
| Which passes to the anterior pituitary |
| And causes it to release ACTH into the bloodstream |
| ACTH causes the adrenal cortex to release aldosterone |
| **Total** | **10** |

(b) Aldosterone and antidiuretic hormones belong to different categories of hormone. Explain why hormones would be used rather than nervous messages in the control of body fluid homeostasis and why the effects of these two hormones are different. (10 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Hormones would be used rather than nervous messages as they:  Have a longer duration / can act for longer  Have low specificity / can target a number of different types of cells | 1-2 |
| Aldosterone is lipid soluble | 1-4 |
| Lipid soluble hormones can enter cells |
| And form hormone receptor complexes inside the nucleus / on genes |
| Which alters protein synthesis / transcription / translation |
| Which has a more long-lasting effect |
| ADH is water soluble | 1-4 |
| Water soluble hormones cannot enter cells |
| They form hormone receptor complexes on the cell membrane |
| And stimulate the release of a secondary messenger |
| Which alters the enzyme activity in the cytoplasm |
| **Total** | **10** |

**Question 39 (20 marks)**

A toxin produced by diphtheria, a bacterial disease, can be used in mice to kill B cells in order to study treatments for autoimmune diseases.

(a) Describe the characteristics of bacterial cells and suggest how the diphtheria vaccine could provide immunity to this disease. (8 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Bacterial cells have a cell wall / slime layer / plasmids / no nucleus / one strand of DNA in the cytoplasm / no membrane bound organelles / seen using a light microscope / one cell big | 1-3 |
| When injected into the body, the diphtheria toxin is seen as an antigen | 1-5 |
| B cells will become activated, sensitised, enlarge and divide |
| Dividing to form plasma cells and memory cells |
| The plasma cells will produce antibodies |
| Antibodies will destroy the antigen |
| The memory cells will remember the antigen for the future |
| So they can provide a faster stronger response |
| **Total** | **8** |

(b) State whether antibiotics or antivirals would be used to treat diphtheria, explain your choice and describe how they act to treat the disease. (8 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Antibiotics | 1 |
| As diphtheria is a bacteria / antivirals only work on viruses | 1 |
| Bacteriocides | 1 |
| Which kill the bacteria | 1 |
| By changing the structure of the cell wall / cell membrane | 1 |
| By disrupting essential enzymes |
| Bacteriostatics | 1 |
| Which stop the bacteria from reproducing | 1 |
| By disrupting protein synthesis | 1 |
| **Total** | **8** |

(c) Diphtheria is part of the Australian National Immunisation Program Schedule which begins when babies are 2 months of age. Give reasons why parents might choose to vaccinate their child against diphtheria. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Easy access / peers are vaccinating / requirement for childcare / free / high level of maternal education / they themselves were vaccinated / believe it will protect their child against the disease / | 1-4 |
| **Total** | **4** |

**Question 40 (20 marks)**

Recent research indicates that the genetic variant linked to the risk of multiple sclerosis was brought to Europe about 5000 years ago by a migration of the Yamnaya people, a group of herders from the Pontic Steppe in the Balkans and Western Asia. Scientists studied the DNA of 317 ancient skeletons and teeth and compared it to 410,000 specimens in the UK biobank.

(a) Explain how DNA sequencing, comparative biochemistry and bioinformatics would have been used in this research. (8 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| **DNA sequencing** |  |
| Investigators would have collected DNA samples from each of the Yamnaya specimens | 1-2 |
| Then determined the nitrogen base sequence for the DNA of each specimen |
| **Comparative biochemistry** |  |
| DNA sequences from the Yamnaya would have been compared to the UK specimens who had multiple sclerosis (MS) | 1-3 |
| In order to see whether the Yamnaya carried the MS gene |
| The more similar the DNA sequences the more closely related the Yamnaya were to the UK population |
| And the more recent their common ancestors |
| **Bioinformatics** |  |
| The amount of data required to be compared for all the genomes is extremely large | 1-3 |
| So the DNA data would be held and compared using computer technology |
| Which would more accurately be able to identify similarities and differences in the DNA sequences |
| **Total** | **8** |

(b) Multiple sclerosis is an autoimmune disease, where the immune system has a strong response to the body’s own cells. There is a suggestion this may have protected the Yamnaya from diseases found in the animals they herded. Using the research about multiple sclerosis, explain how this demonstrates natural selection. (12 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| The Yamnaya show variation in having the gene/s for MS | 1 |
| More Yamnaya are born than survive to maturity | 1 |
| The Yamnaya usually maintain its numbers over time | 1 |
| The MS gene is adaptive and aids survival of the Yamnaya | 1 |
| The gene/s are selective forces | 1 |
| So a struggle for existence between the Yamnaya occurs | 1 |
| Those with the gene/s for MS survive | 1 |
| as they are not adversely affected by the diseases infecting their animals | 1 |
| Those without the gene for MS die from the diseases of their animals | 1 |
| The well adapted individuals reproduce | 1 |
| And pass the gene/s for MS on to their offspring | 1 |
| Over time the frequency for the gen/s for MS increases in the Yamnaya population | 1 |
| **Total** | **12** |

**Question 41 (20 marks)**

Sickle cell disease is due to a mutation that causes the amino acid glutamic acid to be changed to valine on the beta chain of haemoglobin. It provides carriers with the capacity to withstand infections by malarial parasites.

(a) Define mutation, name the specific type of mutation that is caused by sickle cell and describe how mutations can come about. (8 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Mutations are any change in the DNA | 1 |
| Sickle cell is caused by a point mutation | 1 |
| **Mutations can come about by:** |  |
| During DNA replication | 1 |
| Substitutions – when a different nitrogen base/s is/are inserted instead | 1 |
| Deletions – when a nitrogen base is removed |
| Point mutation – when one nitrogen base is changed |
| Frameshift – when the DNA becomes unreadable / incomplete |
| During cell division | 1 |
| Inversions – a segment is reversed | 1 |
| Translocations – a piece of DNA is placed onto another chromosome |
| Non-disjunctions – homologous chromosomes fail to separate |
| Due to damage through mutagens | 1 |
| Such as mustard gas / UV light / X rays / cosmic rays / radioactive waste / antibiotics / formaldehyde / sulfur dioxide / nuclear explosions | 1 |
| Trigger DNA replication errors / cause DNA to break / lengthen / block replication / allow mutated cells to multiply |
| **Total** | **8** |

(b) Suggest how different selection pressures and founder effects could account for the incidence of sickle cell in different countries. (12 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Those with sickle cell trait are heterozygotes and do not die from sickle cell as only half their red blood cells are affected | 1 |
| Heterozygotes have a resistance to malaria | 1 |
| In countries where malaria is present, malaria would be the selection pressure | 1 |
| Those without sickle cell trait are more likely to die of malaria | 1 |
| Those with sickle cell trait have a survival advantage | 1 |
| And are more likely to survive to reproductive maturity | 1 |
| And pass on the sickle cell allele | 1 |
| Resulting in the frequency of the sickle cell allele becoming more common in these countries | 1 |
| If malaria is not present, the frequency of the sickle cell allele would vary as there is no advantage to it being present | 1 |
| Founder effect occurs when a small group leaves their large population and begins again somewhere else | 1 |
| By chance, this small group may not contain all the alleles of the original population | 1 |
| If someone did contain the sickle cell allele, over time it may become more common through random genetic drift regardless of whether malaria was present or not | 1 |
| **Total** | **12** |