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International

CRAWFORD INTERNATIONAL
PRELIMINARY EXAMINATION 2024
LIFE SCIENCES PAPER 1

GRADE	12	DATE	21 AUGUST 2024
TIME	3 HOURS	TOTAL	200

NAME		SURNAME	
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PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 42 pages. Please check that your question paper is complete.
2. This question paper consists of four questions.
3. **Answer ALL the questions on the question paper and hand it in at the end of the examination. Remember to write your NAME in the space provided.**
4. Read the questions carefully.
5. Use the total marks that can be awarded for each of the questions as an indication of the detail required.
5. It is in your own interest to write legibly and to present your work neatly.
6. TWO additional pages (pages 41 and 42) are included at the end of the paper. If you run out of space for an answer, use these pages. Clearly indicate the number of your answer should you use this extra space.

FOR OFFICE USE ONLY: MARKER TO ENTER MARKS

Q1	Q2	Q3	Q4	TOTAL	%
80	40	40	40	200	

QUESTION 1

- 1.1 Select the term in Column B that best matches the description in Column A. Write the letter of the term in the corresponding space provided between the brackets. Each letter may be used only once.

COLUMN A**COLUMN B**

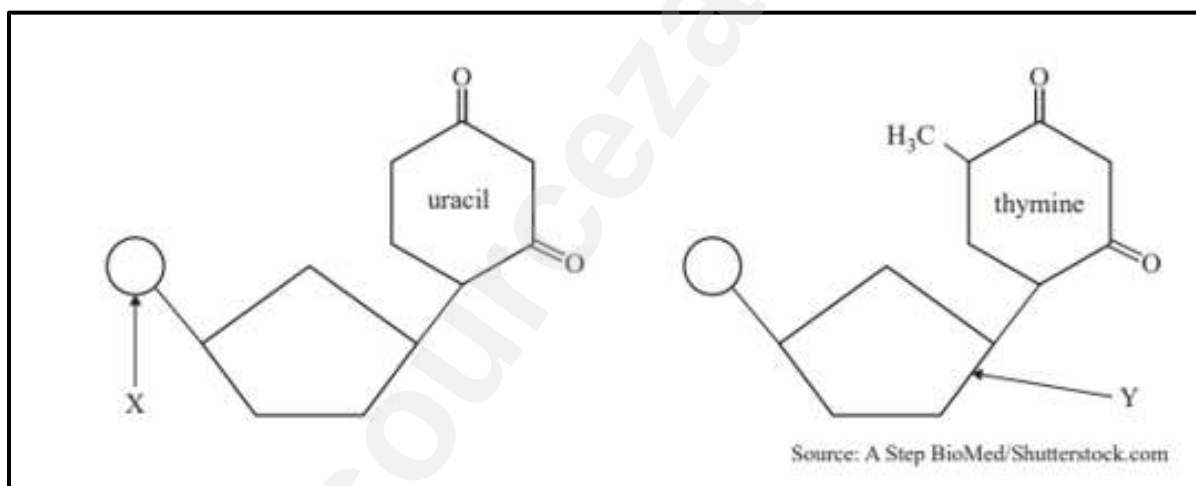
- | | |
|--|----------------------------------|
| [] A diagrammatic representation showing possible evolutionary relationships between organisms. | A Adaptive radiation |
| [] Structures in different organisms that have similar characteristics suggesting that they arose from a common ancestor. | B Artificial selection |
| [] Divergence from a single ancestor to give rise to many new species. | C Cladogram |
| [] Selective process driven by the environment. | D Different breeding seasons |
| [] Unrelated species evolve to have similar kinds of traits for a particular function. | E Analogous structures |
| [] Process of evolution in which there are long periods during which no change in the species occurs. | F Convergent evolution |
| [] An example of reproductive isolation. | G Natural selection |
| [] Selective process driven by human choices. | H Punctuated equilibrium |
| [] An example of <i>Australopithecus africanus</i> . | I Taung child |
| [] Used to trace the migration of early <i>Homo</i> species. | J Inbreeding |
| | K Homologous structures |
| | L mtDNA |

(10)

- 1.2 Nine multiple-choice questions are given below. Choose the most correct option for each question and write the letter of your choice in the space provided in the table below.

Question	1.2.1	1.2.2 (2)	1.2.3	1.2.4	1.2.5	1.2.6 (2)	1.2.7	1.2.8	1.2.9
Answer									

- 1.2.1 The basic structure of two nucleotides is shown below. Each nucleotide has three subunits.

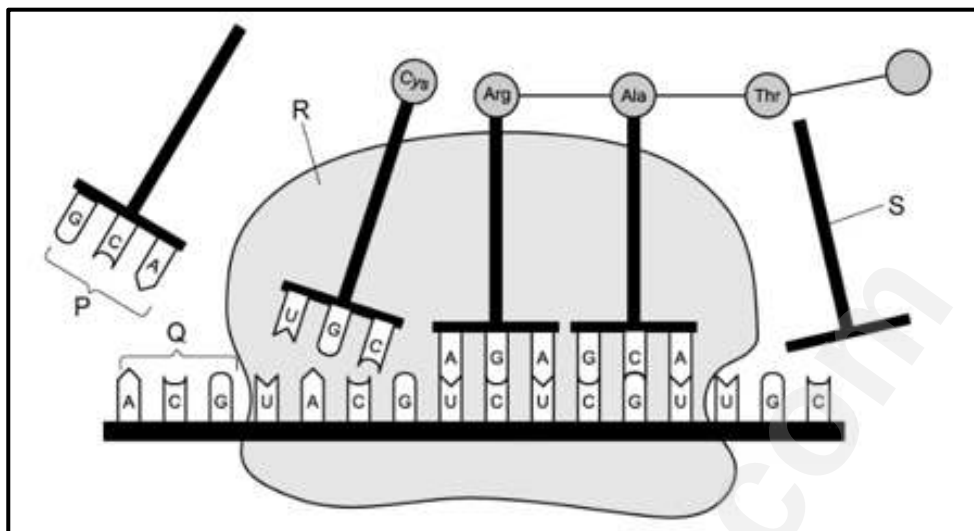


It can be concluded that the ...

- A Subunit labelled X is a nitrogen base.
- B Subunit labelled Y is ribose sugar.
- C Nucleotide with the subunit labelled uracil can be found in DNA.
- D Nucleotide with the subunit labelled thymine will have a pentose sugar subunit.

(1)

Use the following diagram showing the process of translation to answer the questions 1.2.2 and 1.2.3.



[Adapted: <https://commons.wikimedia.org>]

1.2.2 Which row of the following table correctly identifies the labelled components?

	P	Q	R	S
A	Anticodon	Codon	Ribosome	mRNA
B	Codon	Anticodon	Ribosome	tRNA
C	Anticodon	Codon	Ribosome	tRNA
D	Codon	Anticodon	mRNA	Ribosome

(2)

1.2.3 A section of a DNA molecule contains the following base sequences:

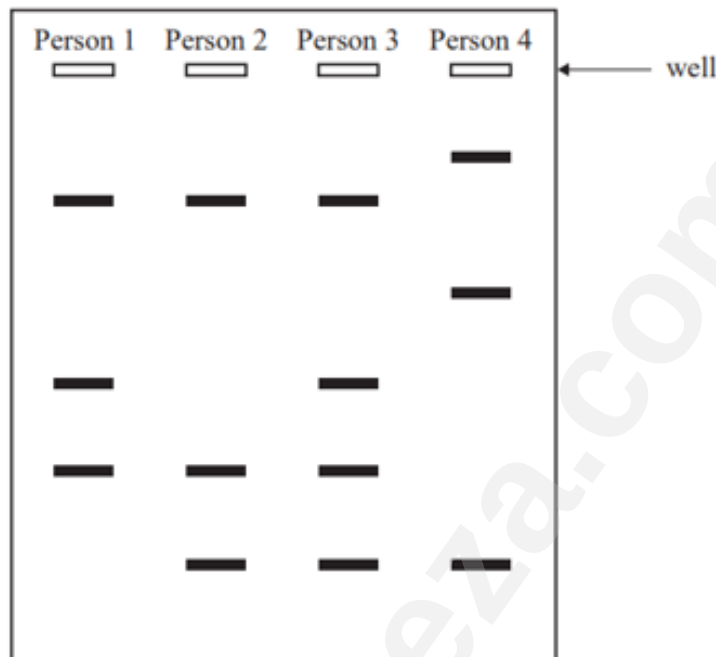
ATA CCT GCA

Which of the following would represent the base sequences of the codons on the mRNA molecule after transcription?

- A ATA CCT GCA
- B AUA CCU GCA
- C TAT GGA CGT
- D UAU GGA CGU

(1)

- 1.2.4 The amplified DNA fragments were separated using gel electrophoresis. The results are shown below:



Which of the following conclusions can be made based on the results shown?

- A Person 4 could be the father of Person 1.
- B Person 2 could be the mother of Person 3.
- C Person 4 and Person 2 are identical twins.
- D Person 1 is not biological brother of Person 3.

(1)

- 1.2.5 Which of the following is not an example of natural selection?

- A DDT resistance in mosquitos
- B Breeding cows to increase milk production
- C Antibiotic resistance in bacteria
- D Development of a different species of Galapagos finch

(1)

- 1.2.6 A wildlife researcher conducted a study on a savanna reserve using mark-recapture to estimate the zebra population. In the first capture, 80 zebras were captured and marked with ear tags.

Two weeks later, a second capture was conducted, where 64 zebras were caught. Among these, 32 zebras were identified to have ear tags.

What is the estimated size of the zebra population?

- A 120
- B 128
- C 160
- D 168

(2)

- 1.2.7 A pelican uses its large beak to catch fish. The reason that Lamarck would have provided for the large beak of the pelican is that ...

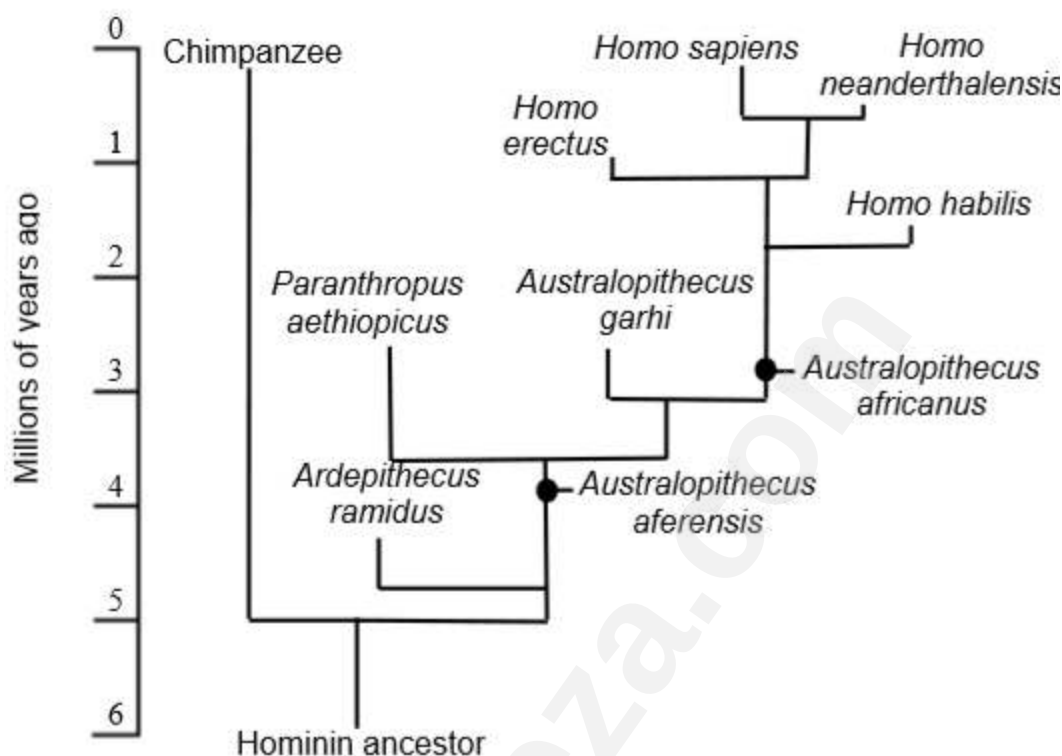


[Sourced from: <https://www.britannica.com/animal/pelican>]

- A Pelicans with smaller beaks were better suited for survival.
- B There was variation in the beak size and thus some pelican's beaks were better suited to catch fish.
- C The more the pelican used its beak, the larger the beak grew.
- D All pelicans had exactly the same sized beaks.

(1)

1.2.8 Study the diagram below.



[Source: Secondary School Improvement Programme 2020]

What conclusion can be drawn from the above diagram?

- A *Homo sapiens* is a direct descendant of *Ardipithecus ramidus*.
- B *Homo sapiens* evolved from chimpanzees.
- C *Australopithecus africanus* is a common ancestor of all *Homo* species.
- D *Homo sapiens* and *Homo erectus* have the most recent common ancestor.

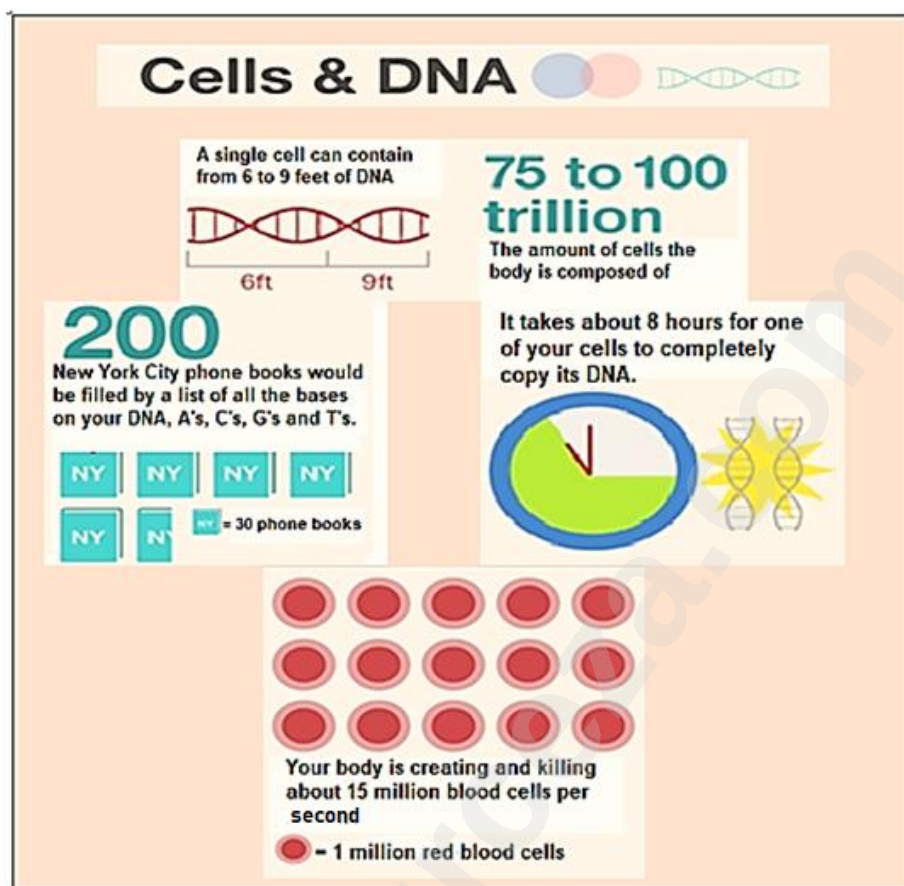
(1)

1.2.9 Biogeography is ...

- A the study of fossils in order to learn about the earlier forms of life.
- B the theory that worldwide disasters have caused the extinction of species.
- C the theory that that Earth and all living things have been created in their present forms and are unchangeable.
- D the observed patterns of distribution of species.

(1)

1.3 Study the infographic below cells and DNA and answer the questions that follow.



[Adapted from <https://www.infographicszone.com/science/top-5-dna-infographics>]

The five statements in the table below refer to the information from the infographic on cells and DNA. For each statement, decide whether:

- A the statement is supported by the information in the infographic
- B the statement is contradicted by the information in the infographic
- C the statement is neither supported nor contradicted by the information in the infographic

	STATEMENT	A, B or C
1.3.1	DNA has a double helix shape.	
1.3.2	The discovery of the DNA structure was made possible by Rosalind Franklin.	
1.3.3	The human body can consist of 82 trillion cells.	
1.3.4	DNA consists of nucleotides.	
1.3.5	15 billion red blood cells are killed every minute.	

(5)

- 1.4 Study the images of a ladybird and an aphid [Figure 1] below and a graph [Figure 2] that shows their relationship.

Ladybird feeding on an Aphid

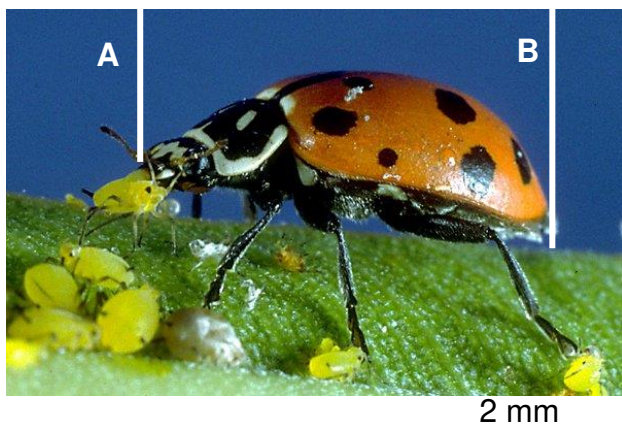


Figure 1

[Source: <https://www.cirrusimage.com>]

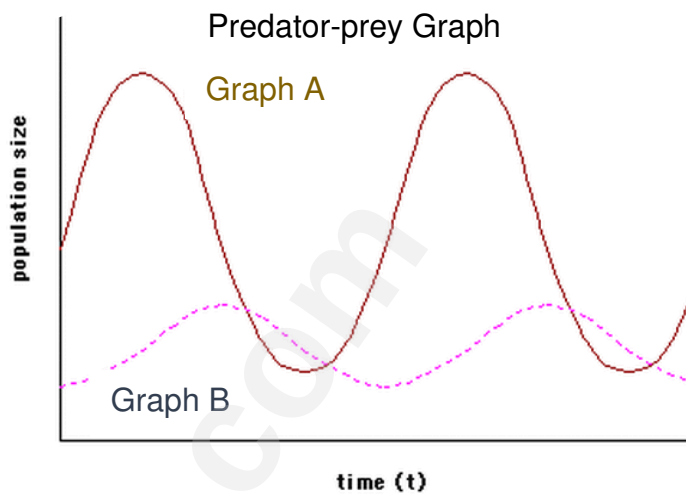


Figure 2

[Source: <https://eisdesert.weebly.com/uploads/3/7/8/3/37839065/771834502.gif?615>]

- 1.4.1 In the example above the Ladybird is the predator and the aphid the prey. Mention **three** ways in which predators play a role in maintaining diversity in an ecosystem.

(3)

- 1.4.2 Study Figure 2 and indicate which line would represent the ladybird, Graph A or Graph B.

(1)

- 1.4.3 Provide reasoning for your answer in question 1.4.2.

(2)

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- 1.4.4 Explain how the introduction of Ladybirds to a farm will be beneficial to the environment.

(2)

- 1.4.5 Use the scale line in Figure 1 to calculate the actual length of the Ladybird from A to B.

Show all working.

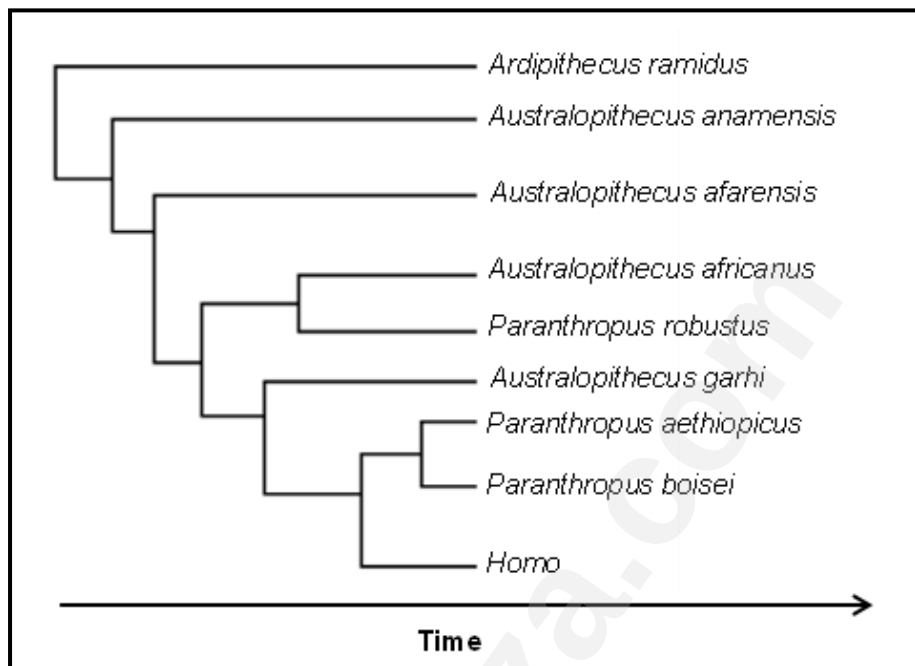


(3)

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TURN OVER

1.5 Refer to the diagram below and answer the questions that follow.



[Adapted from <http://tolweb.org/tree>]

1.5.1 State the number of genera shown in the diagram above.

_____ (1)

1.5.2 According to this diagram, which:

A Genus is most recently evolved?

_____ (1)

B Genus is the oldest?

_____ (1)

C Hominid shares a common ancestor with *Australopithecus africanus*?

_____ (1)

1.5.3 Name two *Homo* species, excluding *Homo sapiens*, that were discovered in Africa.

(2)

- 1.5.4 *Australopithecus sediba* is not shown in the diagram above but plays an important role in the trend in hominid development.

Why is *Australopithecus sediba* considered as an important discovery?

(2)

- 1.6 Between 1972 and 1980, biologists Peter and Rosemary Grant from Princeton University, USA studied finch populations in the Galapagos Archipelago.

The table below shows their data for one finch population on one island (Daphne Major), for a period of 7 years.

Year	1974	1975	1976	1977	1978	1979	1980
Rainfall (mm)	-	-	130	20	130	70	50
Number of finches	1 200	1 400	1 200	150	350	300	200
Small seeds (mg/m ²)	-	800	600	90	300	70	50

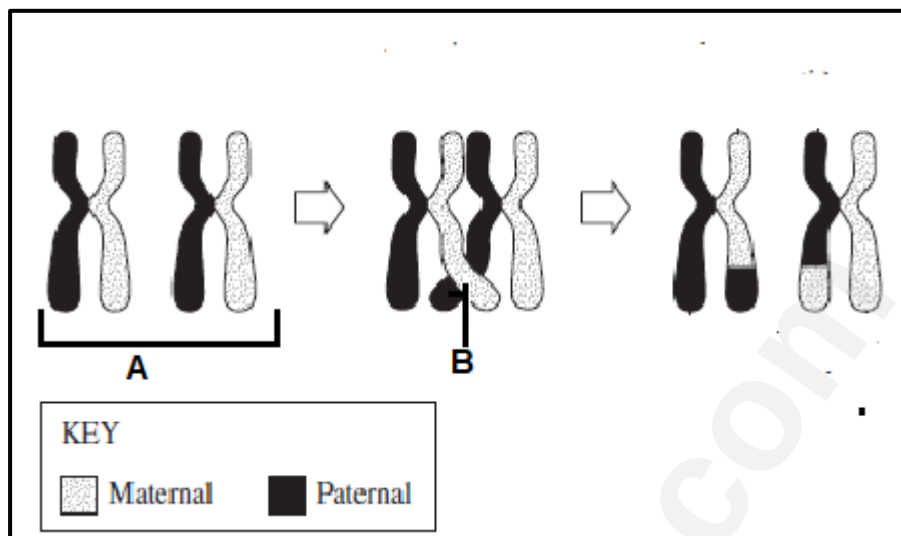
- 1.6.1 In which year did they record the largest drop in rainfall, number of seeds and number of finches?

(1)

- 1.6.2 Explain how the three events mentioned in QUESTION 1.6.1. are related to each other.

(3)

- 1.7 During a test a student drew a diagram to show a process occurring during meiosis as shown below. Study the diagram and answer the questions that follow.



[Adapted from <https://educationstandards.nsw.edu.au>]

- 1.7.1 Identify label A.

_____ (1)

- 1.7.2 Study the part of the diagram labeled A carefully and explain the critical mistake made by the student when drawing the diagram.

 _____ (2)

- 1.7.3 Study the diagram with the label B and answer the following questions.

A Identify (name) the process taking place at label B.

_____ (1)

B Discuss the importance of the process taking place at B.

 _____ (2)

C Name the contact point labelled B.

_____ (1)

D During which phase of meiosis does this process take place?

_____ (1)

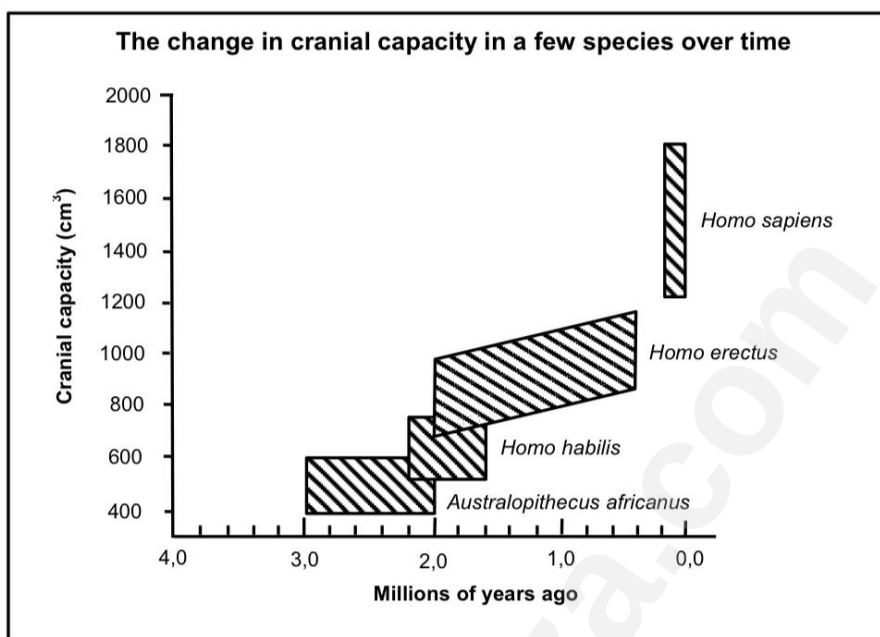
1.8 Indicate whether each of the descriptions in COLUMN I apply to A ONLY, B ONLY, BOTH A AND B or NONE of the items in COLUMN II. Write 'A only', 'B only', 'both A and B' or 'none' in the answer column.

	COLUMN I	COLUMN II	ANSWER
1.8.1	Humans select the characteristics when breeding organisms.	A: Artificial selection B: Natural selection	
1.8.2	Law of inheritance of acquired characteristics.	A: Darwinism B: Modification by descent	
1.8.3	A testable statement that may be accepted or rejected.	A: Theory B: Hypothesis	
1.8.4	Discovered the fossil of <i>Australopithecus sediba</i> .	A: Raymond Dart B: Ron Clark	
1.8.5	Pronounced brow ridges.	A: African apes B: <i>Homo sapiens</i>	
1.8.6	Similarity between humans and African apes.	A: Opposable thumb B: A short and wide pelvis	
1.8.7	Divergence from a single lineage to give rise to many new species from a single ancestor.	A: Genetic drift B: Adaptive radiation	
1.8.8	A change in gene frequency within a population.	A: Macroevolution B: Microevolution	

[Adapted from GCE Biology A2 2019]

(8)

- 1.9 Study the graph below on the change in cranial capacity of hominins over time and answer the questions that follow.



[Adapted from: Trinity 2021 Prelim]

- 1.9.1 Name the species which represents the hominin with the smallest cranial capacity.

_____ (1)

- 1.9.2 What is the largest cranial capacity (in cm³) of *Homo erectus*?

_____ (1)

- 1.9.3 When did *Homo habilis* become extinct?

_____ (1)

- 1.9.4 Which of the organisms represented above has the greatest **range** in cranial capacity?

_____ (1)

- 1.9.5 Name two *Australopithecus* fossils found in South Africa.

 _____ (2)

- 1.10 Read the article on the wolves at Yellowstone Park and then answer the questions that follow.

Researchers find adverse effects of apex predator reintroduction: 'The conservation message is don't lose them in the first place'

"When you disturb ecosystems by changing the makeup of a food web, it can lead to lasting changes that are not quickly fixed."

A 20-year study on the effects of reintroducing wolves into Yellowstone National Park found that removing the apex predators has caused far more damage than expected to the park's ecosystem. Colorado State University researchers launched the study in 2001 to determine if bringing grey wolves, grizzly bears, and cougars back to Yellowstone's northern range would help its food web and ecosystem recover. The large carnivores had been eradicated from the park by the 1920s in an attempt by the U.S. government to control the predators' populations. However, without predators to keep the ecosystem balanced, elk numbers skyrocketed to unsustainable levels, which led to the decimation of willow and aspen trees along small streams. In turn, beavers that used willows as a food and shelter source left the area, which meant the trees' root systems no longer benefited from the flooding caused by beaver dams.

Scientists thought the reintroduction of wolves to the park in 1995 would allow the animals and plants to recover from the cascading effects of losing apex predators, but they found it wasn't that simple. While cougars and grizzlies have made a comeback, bison herds have replaced many elk. Since they share the elks' food sources, willow and aspen trees remain threatened.

[Adapted from: <https://www.thecooldown.com/outdoors/yellowstone-national-park-wolves-study-ecosystem/>]

- 1.10.1 Why did the author of the article state that "When you disturb ecosystems by changing the makeup of a food web, it can lead to lasting changes that are not quickly fixed." By referring to the examples in the article, explain what he meant.

(2)

- 1.10.2 Explain why the elk numbers increased drastically when the wolves had been removed from the ecosystem, but decreased rapidly after the wolves had been reintroduced. Give two reasons for their decline in population numbers.

(3)

- 1.10.3 If the number of elk have decreased, why have the aspen and willow populations not recovered as expected?

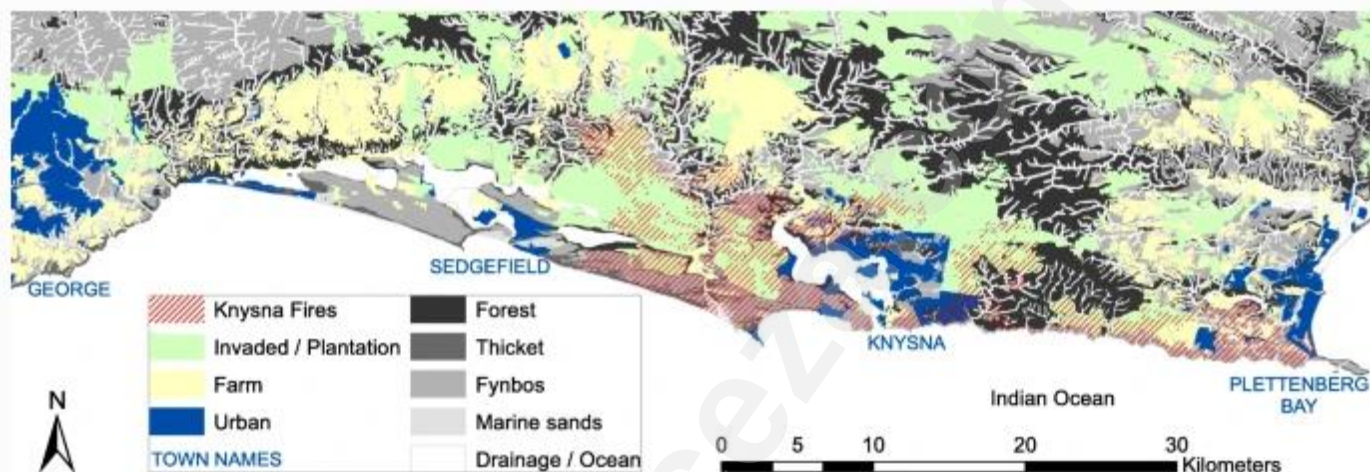
(1)

QUESTION 2

2.1 Read the passage on the Knysna fires of June 2017 and answer the questions that follow:

In June 2017, devastating wildfires swept through the town of Knysna in the Western Cape, South Africa. These fires razed over 15,000 hectares of land, including more than 800 buildings and vast expanses of forest plantations. Tragically, the fires claimed the lives of seven people. This event stands as one of the most severe wildfires on record in the region.

Map of the study area showing the extent of the 2017 Knysna Fires



An analysis of the burned area, to determine if any factors affected the severity of the fire, revealed that a significant portion was comprised of natural vegetation, particularly fynbos shrublands. However, over half of the affected area consisted of invasive alien pine tree plantations or natural vegetation invaded by alien species. Satellite imagery was used to assess burn severity across different land cover types, showing that biomass consumption was notably higher in areas with invasive alien trees.

The Knysna wildfires were influenced by several factors. The severity of the wildfires was worsened by invasive species, historical fire suppression, and residential development in fire-prone areas. This underscores the need for controlling invasive plants, regulating development, and promoting fire-wise practices.

[Adapted from: <https://fireecology.springeropen.com/articles/10.1186/s42408-018-0001-0#:~:text=The%202017%20Knysna%20Fires%20burned,of%20the%20total%20area%20burned>]

2.1.1 What was the aim of the investigation conducted after the Knysna Fires?

(2)

2.1.2 Identify the independent and dependent variables.

A Independent: _____ (1)

B Dependent: _____ (1)

2.1.3 Provide a conclusion for their investigation.

(2)

2.1.4 Propose a comprehensive plan for mitigating wildfire risks in Knysna based on the conclusions drawn from the study.

(3)

2.1.5 Assess the limitations of using satellite imagery to measure burn severity in different land cover types.

(2)

The photographs below show images taken after the Knysna fire.



[source: <https://www.google.com/imgres?q=fires+in+Knysna+and+the+ecology&imgurl=https>

2.1.6 Identify the type of succession that will result due to the fires in the Knysna forest.

(1)

2.1.7 Write down a reason to explain your answer in question 2.1.6.

(2)

2.1.8 What are the first plants that colonise the bare soil called?

(1)

2.1.9 Explain briefly what ecological succession is.

(2)

2.2 Read the text below and answer the questions that follow.

Lion, *Panthera leo*, large, powerfully built cat (family Felidae) that is second in size only to the tiger, it is a famous apex predator.

Lions are unique among cats in that they live in a group, or pride. The members of a pride typically spend the day in several scattered groups that may unite to hunt or share a meal. A pride consists of several generations of lionesses, some of which are related, a smaller number of breeding males, and their cubs. The group may consist of as few as 4 or as many as 37 members, but about 15 is the average size.



There are a number of competing evolutionary explanations for why lions form groups. The relative importance of these factors is debated, and it is not clear which was responsible for the establishment of group life and which are secondary benefits.

Lions prey on a large variety of animals ranging in size from rodents and baboons to Cape (or African) buffalo and hippopotamuses, but they predominantly hunt medium- to large-sized hoofed animals such as wildebeests, zebras, and antelopes.

[Adapted from: lion. (2024). Retrieved from <https://www.britannica.com/animal/lion>]

2.2.1 What is meant by the term apex predator?

(1)

2.2.2 It is uncommon for cats to live in groups. Discuss the advantages lions have by living and hunting in prides.

(3)

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- 2.2.3 Name the type of competition that exists **within** a pride of lions and explain the reason for your answer.

(2)

- 2.2.4 Lions are not the only predators in the Savanna. Explain how lions and leopards can co-exist.

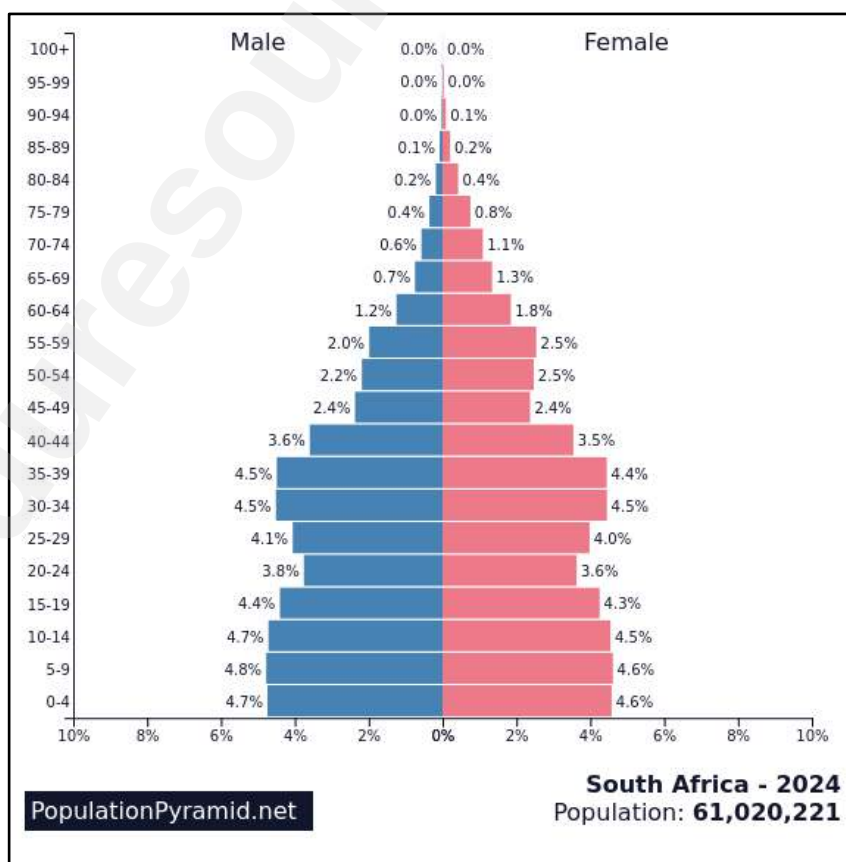
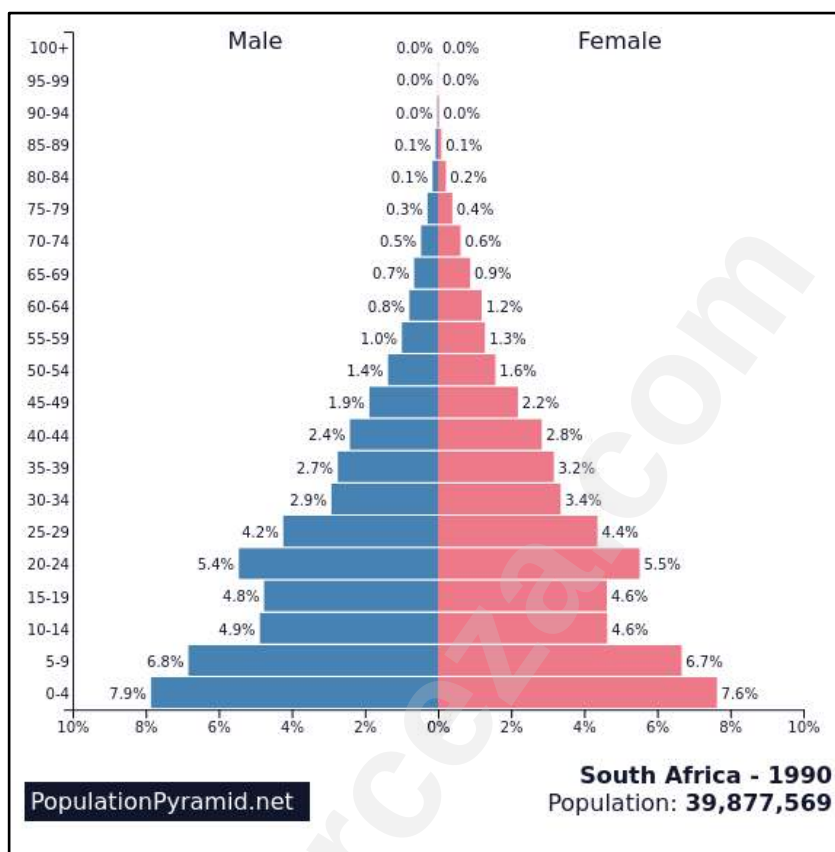
(3)

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2.3 Study the graphs depicting the human population of South Africa in 1990 and 2024 below and answer the questions that follow.



[Source: Population Pyramids of the World from 1950 to 2100. (n.d.). Retrieved from <https://www.populationpyramid.net/south-africa/1990/>]

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TURN OVER

- 2.3.1 Identify whether the 1990 graph represents the population from a more-developed country or a less-developed country. Provide **TWO** reasons to explain your answer.

(3)

- 2.3.2 Compare the population pyramids of South Africa in the images above. Suggest what might have caused the changes that have occurred over the years?

(2)

- 2.3.3 Based on the 2024 Population Pyramid, what advice would you give to the government on investment in facilities that will be needed in the next 10 years?

(2)

- 2.3.4 Would you have given the same advice in 1990? Explain your answer.

(2)

- 2.3.5 In 1990 the percentage of the human population in the 20 to 24-year-old category was higher than the preceding 10 years (ages 10 to 19 years). What percentage of the total population was aged between 20 to 24 years in 1990?

(1)

- 2.3.6 Do people in South Africa in 2024, have a longer life expectancy than in 1990? Give a reason for your answer.

(2)

- 2.3.7 How would an aging population affect the future of the human population in South Africa?

(2)

[40]

QUESTION 3

- 3.1 Patau syndrome is a serious condition caused by a mutation affecting the chromosome number. This severely disrupts normal development and, in many cases, results in miscarriage, stillbirth or the baby dying shortly after birth.

Babies with Patau's syndrome can have a wide range of health problems. Their growth in the womb is often restricted, resulting in a low birth weight, and 8 out of 10 will be born with severe heart defects. The brain often does not divide into 2 halves. This is known as holoprosencephaly. When this happens, it can affect facial features and cause defects such as:

- cleft lip and palate
- an abnormally small eye or eyes (microphthalmia)
- absence of 1 or both eyes (anophthalmia)

Other abnormalities of the face and head include smaller than normal head size (microcephaly) and ear malformations and deafness

Patau's syndrome affects about 1 in every 4,000 births. The risk of having a baby with the syndrome increases with the mother's age. More than 9 out of 10 children born with Patau's syndrome die during the first year.

Babies with Patau's syndrome can have a wide range of health problems.

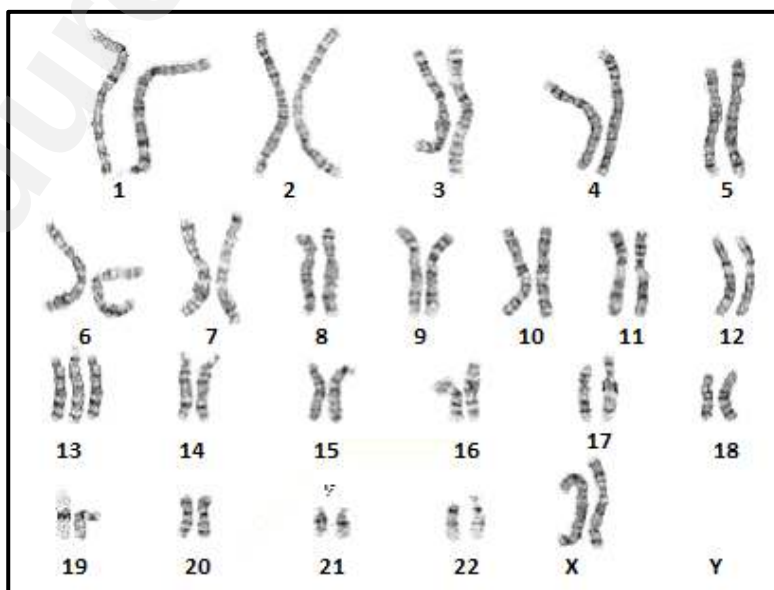
Their growth in the womb is often restricted, resulting in a low birth weight, and 8 out of 10 will be born with severe heart defects.

The brain often does not divide into 2 halves. This is known as holoprosencephaly.

Adapted from: [<https://www.nhs.uk/conditions/pataus-syndrome/#:~:text=There's%20no%20specific%20treatment%20for,baby%20is%20able%20to%20feed>]

[<https://my.clevelandclinic.org/health/diseases/24647-trisomy-13-patau-syndrome>]

The figure below shows the arrangement of chromosomes from an individual who has Patau syndrome.



[Source: <https://www.learningaboutelectronics.com/images/Pataus-syndrome-trisomy-13-karyotype.png>]

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3.1.1 What is the arrangement of the chromosomes illustrated in the diagram on the previous page called?

(1)

3.1.2 Explain how this chromosome arrangement differs from a person without Patau syndrome.

(2)

3.1.3 Name the type of mutation that resulted in this condition.

(1)

3.1.4 Explain the cause of this mutation and suggest exactly when it could have taken place.

(2)

3.1.5 Briefly discuss the impact this mutation would have on the phenotype of the individual suffering from this mutation.

(2)

3.1.6 If your baby was shown to have Patau syndrome when an amniocentesis test was performed at 16 weeks of pregnancy, would you terminate the pregnancy or not. Give reasons for your answer.

(2)

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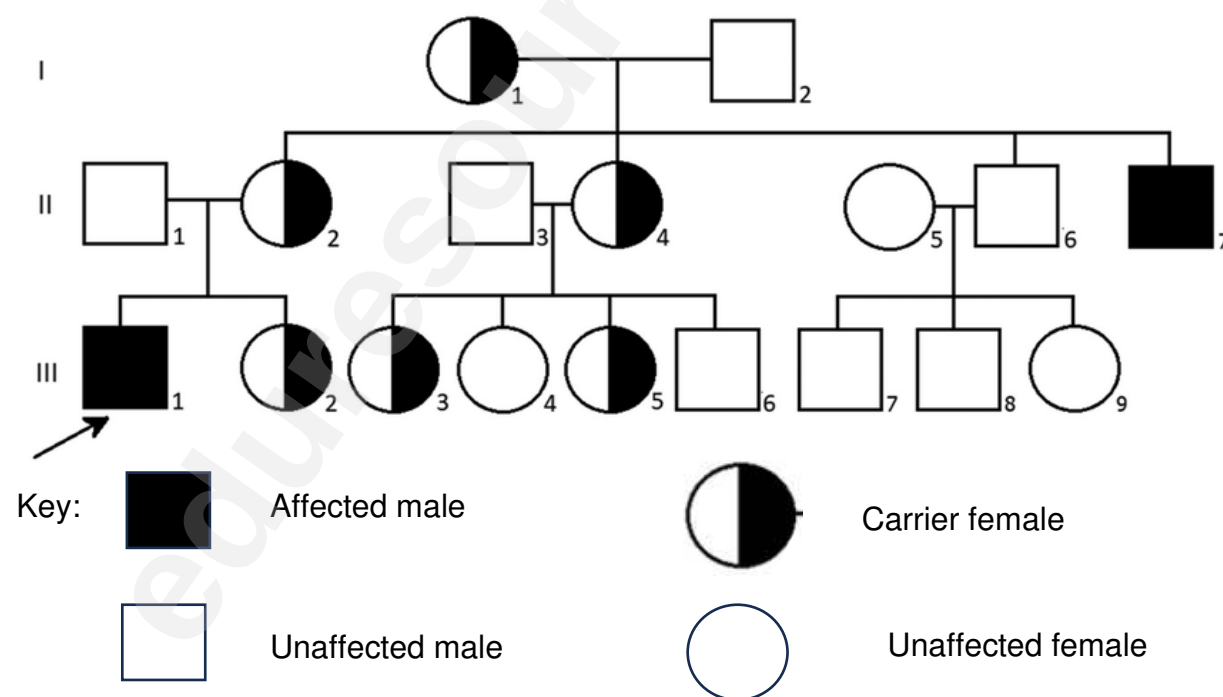
3.2 Sex-linked Diseases: the Case of Duchenne Muscular Dystrophy (DMD)

DMD is a fatal neuromuscular disorder caused by a recessive mutation on the **X chromosome**.

The DMD gene encodes dystrophin, a huge muscle **protein** with about 4,000 amino acids that plays an integral role in maintaining the structural integrity of muscle cells. Cells with mutated DMD genes cannot make normal dystrophin, which means that they are unable to function appropriately. The deleterious effect of this lack of dystrophin becomes apparent early in life, although usually not immediately. Most babies with DMD appear normal at birth and don't start showing their first symptoms, muscle weakness, until between the ages of three and five years. Affected children then experience increasing difficulty in performing daily tasks, such as climbing stairs and playing with their peers. Most DMD patients rely on the use of a wheelchair by their early teens, with their muscles becoming progressively weaker and more atrophied. Patients usually die from heart or respiratory problems by their twenties or thirties, if not before.

[Adapted from: <https://www.nature.com/scitable/topicpage/sex-linked-diseases-the-case-of-duchenne-800/>]

The Pedigree diagram below shows the family tree of a family affected by muscular dystrophy (DMD)



[Adapted from:

<https://www.researchgate.net/publication/336149065/figure/fig1/AS:809106554224641@1569917443347/Duchenne-muscular-dystrophy-patient-NAs-family-tree-III-1-proband-Duchenne.ppm>]

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- 3.2.1 In the family tree shown on the previous page, there are no females affected by DMD, only males, why is that so?

(2)

- 3.2.2 Is it possible for females to be affected by DMD? Explain your answer.

(2)

- 3.2.3 Is individual 1 in row I homozygous or heterozygous? Explain your answer.

(2)

- 3.2.4 Would the age of the female parent have any effect on the probability of a child inheriting DMD? Discuss your answer.

(2)

Write down the genotypes of individual 1 and 4 in row III.

1 _____

4 _____ (2)

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- 3.2.5 Use the symbol X^D to show the chromosome which is not carrying the mutation for DMD and draw a diagram in the space below to show the genetic cross between individuals 1 and 2 in row I.

Include the following in your answer:

- Parental genotypes
- A genetic cross or Punnett diagram.
- The probable genotypic and phenotypic ratios of the offspring.

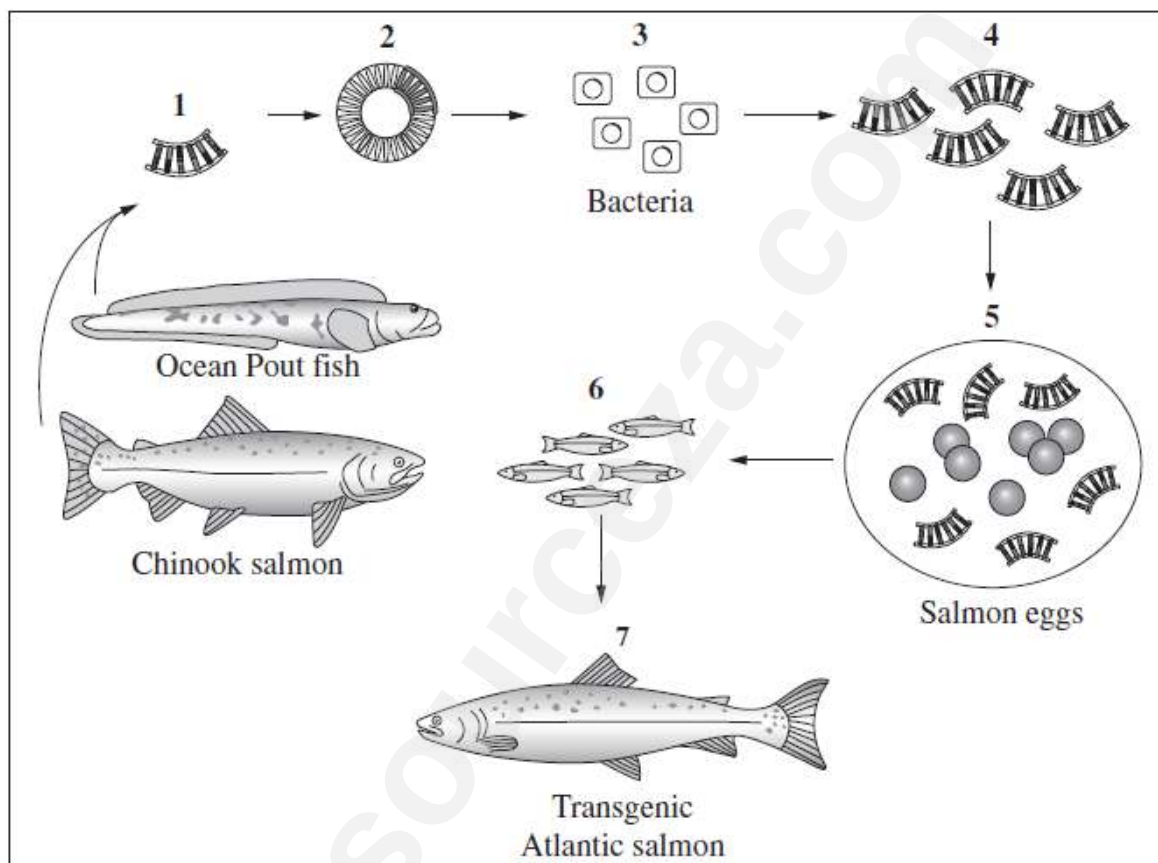
(6)



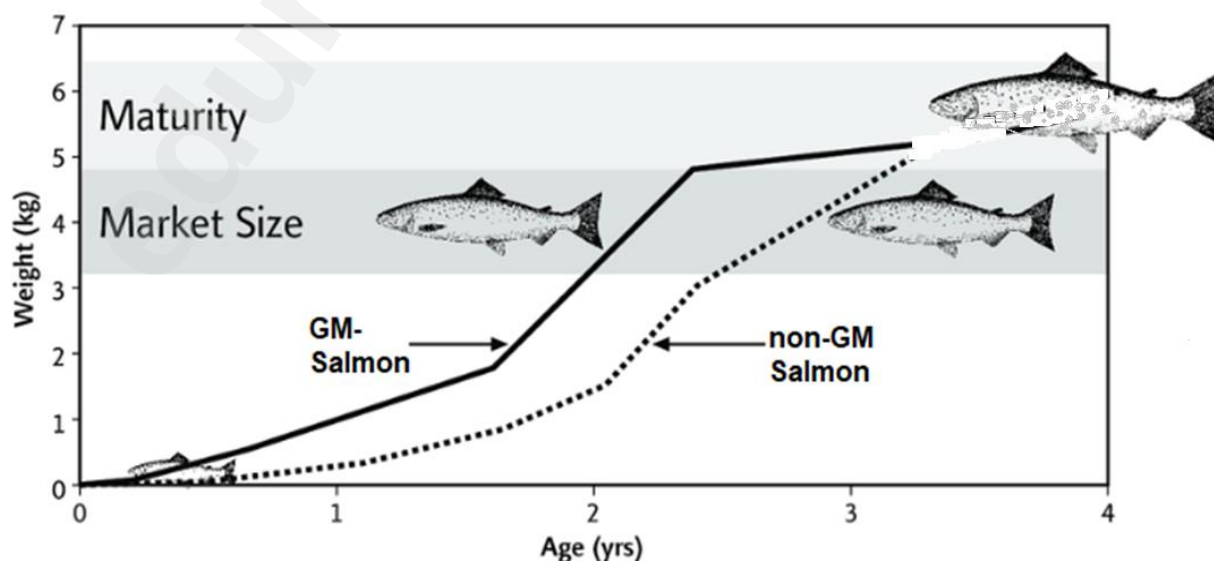
- 3.3 Genetically engineered Atlantic salmon have been produced and approved for aquaculture in the USA. These salmon have a transgene that includes a protein-coding sequence from a Chinook salmon's **growth hormone gene** and the promoter region of an Ocean Pout's **antifreeze protein gene**.

Study the information below and answer the questions that follow.

The flow-diagram below provides an overview of the production of the transgenic salmon.



The graph below shows the results of the investigation.



[Adapted: <<https://researchgate.net>>]

- 3.3.1 Although two transgenes were inserted into the eggs of the Atlantic salmon, only one would benefit the fish industry financially.

State the purpose of this investigation.

(2)

- 3.3.2 Define the term transgenic.

(1)

- 3.3.3 Study the flow-diagram carefully and explain the process as depicted in steps 1 to 4.

(4)

- 3.3.4 Provide a reason for inserting the antifreeze gene into the salmon.

(2)

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- 3.3.5 Briefly explain the beneficial characteristics acquired by the GM-salmon with special mention to the economic value of the genetically modified salmon. Support your answer with data from the graph.

(3)

- 3.3.6 Many people might be against the creation and release of the GM Atlantic salmon. Discuss two objections people may have against this project.

(2)

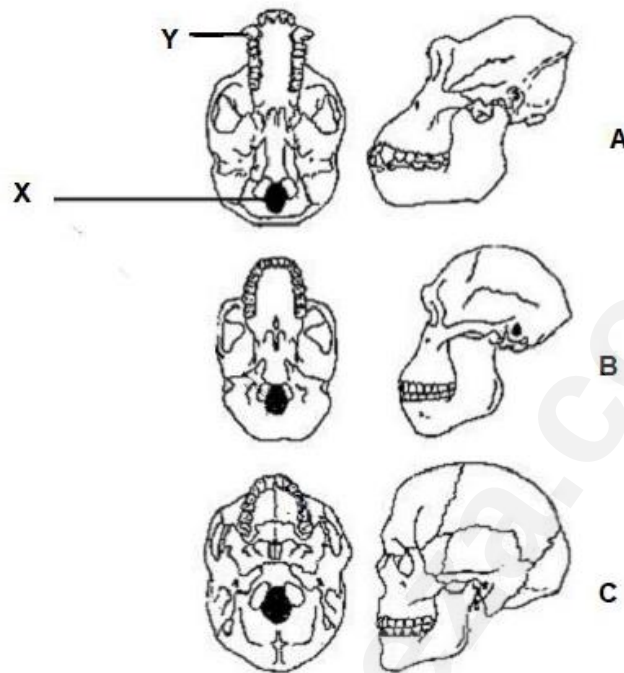
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TURN OVER

QUESTION 4

- 4.1 The diagram below shows the skulls of three organisms. Study the diagrams and answer the questions that follow.



[Source: GDE; September 2019]

- 4.1.1 Write down the correct term for the part labeled X and for the type of teeth labeled Y.

X _____

Y _____

(2)

- 4.1.2 Explain the significance of the location of part labeled X in Organism C.

(2)

- 4.1.3 Which of the skulls, A, B or C belongs to:

A. An australopithecine _____ (1)

B. A quadrupedal primate _____ (1)

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- 4.1.4 Explain how the change in the skull from **B** to **C** could indicate a change in intelligence.

(2)

- 4.1.5 How would you expect the shape of the spine of organism A to differ from organism C?

(2)

- 4.1.6 Bipedalism was obviously an advantageous characteristic in the development of the hominids. List two advantages of bipedalism.

(2)

- 4.1.7 Currently, there are two hypotheses on how modern humans spread around the world. Discuss the difference between the Out of Africa hypothesis and the Multiregional hypothesis.

(4)

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4.2 Read the text below and then answer the questions that follow.

Losing their tails provided our ape ancestors with an evolutionary advantage, but we're still paying the price.

One of the more obvious differences between us and many primate relatives is that we don't have a tail. The loss of the tail happened around 25 million years ago (for comparison our common ancestor with chimps was about 6 million years ago). We still have the coccyx as an evolutionary hangover from this tail-bearing ancestry.

Tail loss occurred in our ape ancestors at the same time as the evolution of a more erect back and, in turn, a tendency to use only two of the four limbs to support the body. While we can speculate on why these evolutionary changes may be coupled, that doesn't address the problem of how (rather than why) tail-loss evolved: what were the underlying genetic changes?

The recent study looked at just that question. It identified an intriguing genetic mechanism. Many genes combine to enable the development of the tail in mammals. The team identified that primates without a tail had one additional "jumping gene" sequence of DNA that can transfer to new areas of a genome. In this case called a tail-determining gene, TBXT.

Evolutionary cost

What was unusual was the effect that this new addition had. The team also identified that the same primates also had an older but similar jumping gene just a little bit of a distance away in the DNA also embedded within the TBXT gene. The effect of these two in close proximity was to alter the processing of the resulting TBXT messenger. The two jumping genes can stick to each other in the RNA, causing the block of RNA between them to be excluded from the RNA that gets coded into protein, resulting in a shorter protein.

To see the effect of this unusual exclusion, the team genetically mimicked this situation in mice by making a version of the mouse TBXT gene that was also missing the excluded section. If you make a mouse with only the form of the TBXT gene with the section excluded, they were missing a tail and they can develop a condition that closely resembles the human condition spina bifida (when the spine and spinal cord fail to develop properly in the womb, causing a gap in the spine).

The team suggest that just as the coccyx is an evolutionary hangover of the evolution of being tailless that we all have, so too spina bifida may be a rare hangover resulting from the disruption to the gene that underpins our lack of a tail. Being tailless, they suggest, was a large advantage, and so an increase in incidences of spina bifida was still worth it.

[Adapted from: <https://www.nature.com/articles/s41586-024-07095-8>]

Some of the consequences of being born with spina bifida or: that specific parts of the body formation, e.g. bowel and/or bladder problems like constipation and incontinence, back pain and muscle weakness.

[Adapted from: <https://my.clevelandclinic.org>]

Most babies born with spina bifida go on to live normal, active lives, especially when given proper treatment and care.

[Adapted from: <https://kidshealth.org>]

- 4.2.1 Is it true to state that we (humans) lost our tails after our ancestors broke away from our common ancestors with chimpanzees? Discuss your answer.

(2)

- 4.2.2 Our coccyx is a remnant of a tail found in our ancestral form. What is such a remnant of a once useful organ called?

(1)

- 4.2.3 When we lost our tail, there was an unintentional consequence caused by the same chance mutation. What was that consequence?

(1)

- 4.2.4 If the mutation occurred 25 million years ago, why are humans still being born with this (question 4.2.3) consequence?

(2)

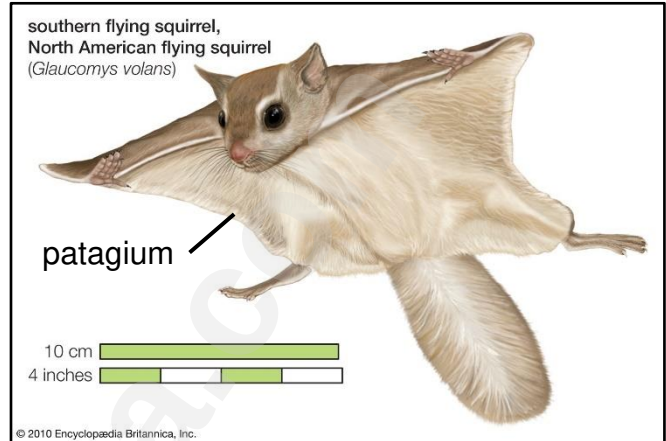
- 4.2.5 When organisms evolve, natural selection should favour beneficial mutations. Why would our ancestors have become tail-less at the cost of harmful mutations?

(2)

4.3 Flying squirrels

Unlike other squirrels, flying squirrels are nocturnal. They have large black eyes, rounded ears, and long whiskers. They den (sleep) in tree cavities, grottoes or rock crevices on cliffs, and cave ledges. Some also build nests high in trees where branches join the trunk.

Flying squirrels are long-limbed and slender with a long, bushy tail which may be cylindrical or flattened. Their dense fur is soft and long and either silky or woolly in texture. Flying squirrels are characterized by their gliding membrane, a furred patagium which attaches to the forelimbs via the styli-form cartilage at the wrist and extends down to the heel of the hindlimbs. Additionally, flying squirrels have the longest limbs relative to body size of all squirrels. These squirrels are not capable of true flight, instead they use a specialized membrane, the patagium to glide from one place to another after they jump from a height.



[Source: <https://cdn.britannica.com/90/81290-050-80E5B060/flying-squirrel-North-American-mammal.jpg>]

[Adapted from: Animal Diversity Web]

4.3.1 Using your knowledge of Darwin's theory of natural selection, explain how and why patagia would have been selected for, in squirrels.

(5)

4.3.2 Other than patagia, name **and** describe one structural adaptation of the flying squirrel for its mode of life.

(2)

- 4.3.3 There are normal squirrels living in the same forests as the flying squirrels, yet they evolved into a different species. What is this type of speciation called?

(1)

- 4.3.4 Name **two** mechanisms of reproductive isolation that could have prevented interbreeding between the normal squirrels and flying squirrels.

(2)

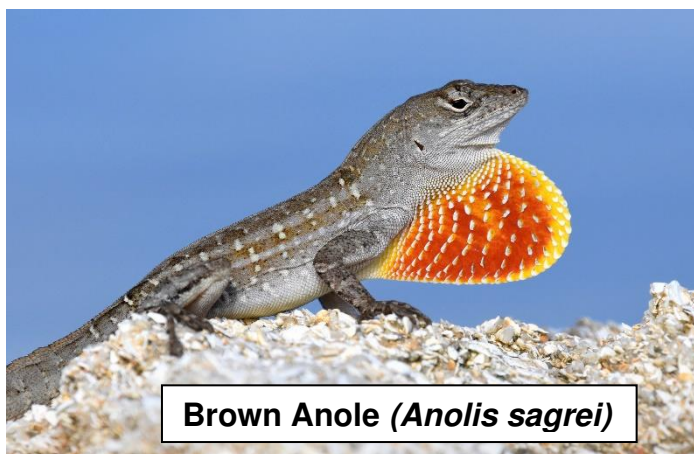
- 4.4 Read the article about the brown anole lizard below and then answer the questions that follow.

Lizards Released and Stranded on Islands Show Evolution at Work

Jason Kolbe, a biologist at the University of Rhode Island led a study to determine how much of the evolutionary divergence in separated populations is due to the founder effect and how much is from natural selection.

To answer this question Kolbe and his team randomly selected male-female pairs of brown anole (*Anolis sagrei*) lizards from Iron Cay (near the Bahamas, south of Florida, USA) and released them on seven smaller islands in 2005. The smaller islands, whose lizard populations had been wiped out by a recent hurricane, are very similar to one another, populated by the same types of insects, birds and vegetation (short scrubs, i.e small woody trees) but very different from Iron Cay, which is forested.

Previous research has shown that forest anoles have longer hind limbs than their scrub cousins, which allow lizards to move quicker across thick branches. Short limbs give lizards the stability they need to walk along narrow perches.



Brown Anole (*Anolis sagrei*)

[Source: <https://inaturalist-open-data.s3.amazonaws.com/photos/22869683/original.jpg>]

The researchers predicted that over time, the lizards in their experiment would develop shorter hind limbs than those of the lizards on Iron Cay, but they did not know what role the founder effect would play in the matter.

Over the next four years, Kolbe and his team measured the limb lengths and analyzed the genetic material of tissue samples from the brown anole lizards on Iron Cay, the seven experimental islands and 12 nearby islands. The 12 nearby islands served as controls.

After the first year of the study, the researchers immediately noticed that the offspring of the original lizards on the experimental islands had less genetic variability than the Iron Cay lizards. Kolbe also observed a significant difference in hind-limb length among the islands. Since the founder effect is a random process independent of the environment, there was no pattern to the length of the lizards' hind limbs and apparently, no relationship between limb length and perch diameter, he explained.

Over the next few years, however, a pattern did emerge for the lizards on the experimental islands. With each generation, their hind limbs got shorter, making them better suited for their environment. Shorter limbs enable them to move more easily through the tree branches, therefore surviving their predators. However, the founder effect was not completely snuffed out: Lizard populations with the longest limbs in 2006 still had the longest limbs three years later.

"Both processes seem to be important here," Kolbe said. "Original differences were created that were random, and then the environment decreased their mean hind-limb length."

[Adapted from: <https://www.livescience.com/18276-lizards-show-evolution.html>]

4.4.1 Explain the founder effect.

(2)

4.4.2 Explain why the offspring of the original lizards on the experimental islands had less genetic variability than the Iron Cay lizards.

(2)

4.4.3 Why did the hind limbs of the lizards on the experimental islands become shorter?

(2)

[40]

Total: 200 marks

**REMEMBER TO CLEARLY INDICATE AT THE QUESTION THAT YOU USED THE
ADDITIONAL SPACE TO ENSURE THAT ALL ANSWERS ARE MARKED.**

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