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TOTAL MARKS

INTERNATIONAL SECONDARY CERTIFICATE EXAMINATION
NOVEMBER 2023

BIOLOGY: PAPER I

EXAMINATION NUMBER

Time: 3 hours

200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 36 pages. Please check that your question paper is complete.
2. Read the questions carefully and make sure that you answer all parts of all the questions.
3. **Questions must be answered on the question paper in the spaces provided. Write your examination number in the blocks above.**
4. Use the total marks that can be awarded for each question and the space provided 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 blank pages (pages 35–36) are included at the end of the question paper. If you run out of space for an answer, use these pages. Should you use this extra space, number the answers exactly as the questions are numbered.

FOR MARKERS' USE ONLY

Question	1	2	3	4	**Total**
Marks	80	40	40	40	**200**
Marked					
Moderated					

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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 space between the brackets. Each letter may be used only once.

	COLUMN A		COLUMN B
[ ]	The observable physical characteristics of an organism.	A	Recessive
[ ]	The alternative form of a gene.	B	Dominant
[ ]	The gene that is expressed in a heterozygous organism.	C	Locus
[ ]	The two strands that make up a chromosome after DNA replication.	D	Gene
[ ]	The chromosome number in a somatic cell.	E	Allele
[ ]	All the thread-like structures composed of DNA and histone proteins in the nucleus of a cell.	F	Haploid
[ ]	A unit of inheritance composed of DNA.	G	Phenotype
[ ]	The ploidy of a gamete.	H	Diploid
[ ]	The position of a gene on a chromosome.	I	Nucleotide
[ ]	The gene that is not expressed in a heterozygous organism.	J	Chromatin
		K	Homologous
		L	Chromatids

(10)

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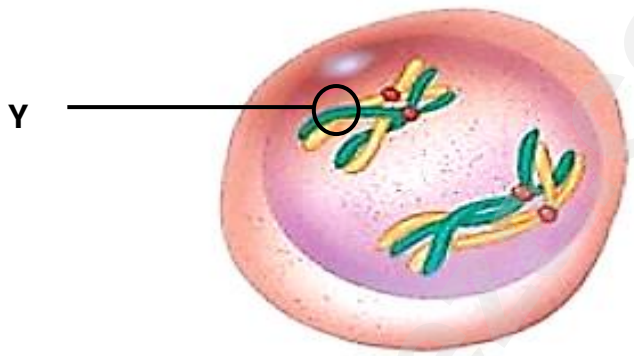
1.2 Six multiple-choice questions are given below. Choose the most correct option for each question and write the letter of your choice in the grid below.

Question	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.2.6
Answer						

Questions 1.2.1 to 1.2.3 refer to the figure shown below.

Figure 1.2 – A cell undergoing meiosis



[Adapted from: <https://uoitbio2013.wordpress.com/mitosis-vs-meiosis/meiosis/>]

1.2.1 Which row in the table below indicates the phase of meiosis shown in **Figure 1.2**?

	Phase of meiosis	**Reason**
A	Telophase II	Four gametes present.
B	Interphase	A copy of each chromosome has been made.
C	Prophase I	Crossing over of chromatids.
D	Anaphase I	Homologous chromosomes do not separate.

(2)

1.2.2 Provide the term for the place at which chromatids touch at Y.

A Spindle fibre
B Centromere
C Centriole
D Chiasma

(1)

1.2.3 How many homologous pairs are evident in **Figure 1.2**?

A 2
B 4
C 1
D 8

(1)

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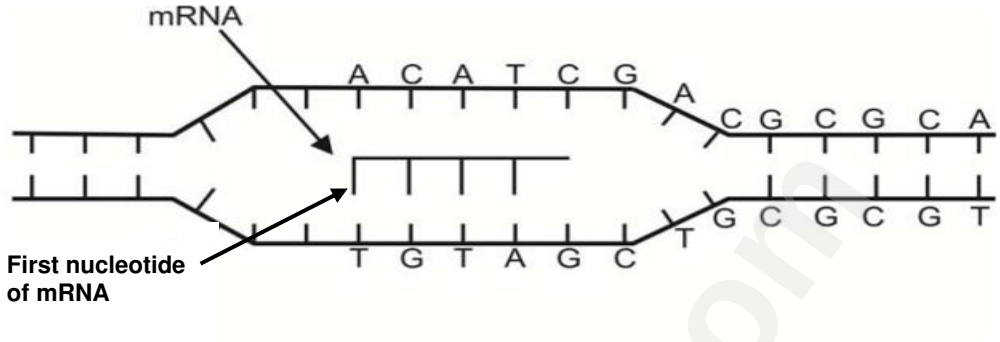
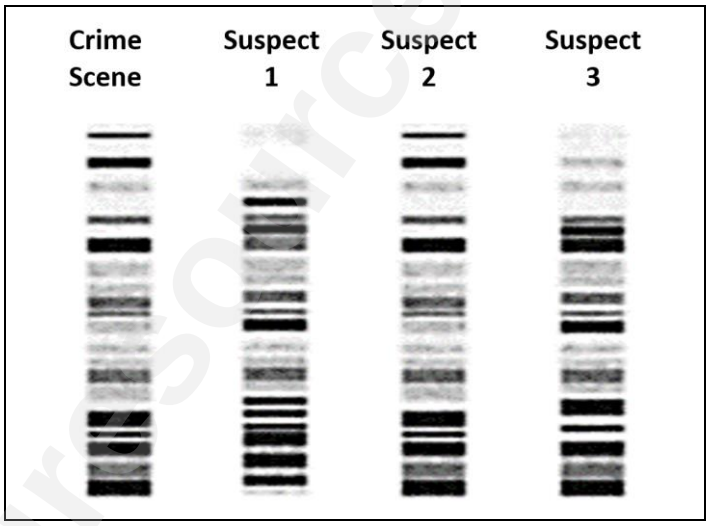
1.2.4 The following diagram shows a section of a DNA molecule during transcription. Which of the following options shows the correct sequence of the first four nucleotides in the mRNA?



A ACAT
B ACAU
C TGTA
D UGUA (2)

1.2.5 The DNA profiles below show a DNA sample taken from a crime scene and from three suspects who might have been involved in the crime.



[Adapted from: <https://evolution.berkeley.edu/evo-news/evolution-at-the-scene-of-the-crime/>]

From the information provided, which of the suspects was likely to have been involved in the crime?

A Only suspect 1 was at the crime scene.
B Only suspect 2 was at the crime scene.
C Suspects 1 and 2 were at the crime scene.
D Suspects 1 and 3 were at the crime scene. (2)

1.2.6 A single DNA molecule has 8 000 nucleotides of which 28% are thymine and 22% are guanine. How many cytosine bases would be present in this DNA molecule?

A 2 240
B 4 000
C 1 760
D 6 240 (2)

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1.3 Study the information below. Use this information, your own knowledge and **Figure 1.3** on page 6 to answer the questions that follow.

Cassava is a staple food in many African countries. It is an ideal crop to grow because it uses nutrients from the soil efficiently and is resilient to poor environmental conditions. The yield of cassava, however, has become very low due to the deadly cassava mosaic virus (CMV). The CMV inserts its genetic material into the DNA of the cassava plant. This alters a specific gene within the cassava plant that leads to yellowing and wrinkling of the cassava leaves, among other effects as seen in Table 1.3 below. This then limits the growth of the cassava tuber which is the starchy food storage organ of the plant.

After many years of research and working together with scientists from around the world, scientists from Uganda and Kenya have managed to produce a disease-resistant cassava variety using CRISPR. This collaborative research began in 2006 between the Donald Danforth Plant Science Centre in the United States of America, the National Crops Resources Research Institute in Uganda and the Kenya Agricultural and Livestock Research Organisation.

Cassava plant affected by CMV as seen by the yellowing of the leaf

Tubers of the genetically modified cassava plant

[Source: <https://geneticliteracyproject.org/2020/06/30/>]
[Source: <https://www.foodbusinessafrica.com/kenya-set-to-have-a-new-genetically-modified-cassava-variety-subject-to-safety-review/]

Table 1.3 – The effects of CMV on the cassava plant

Disease name	Effects on the cassava plant	Gene affected by CMV that leads to disease	Genes that provide resistance to CMV
Cassava mosaic virus	- Severe stunting of plant growth - Leaf wrinkling - Yellow mosaic pattern on the leaf - Rotting of roots - Weak plant stem - Reduced growth of the tuber	EACMV-K201	- CMD1 - CMD2 - CMD3

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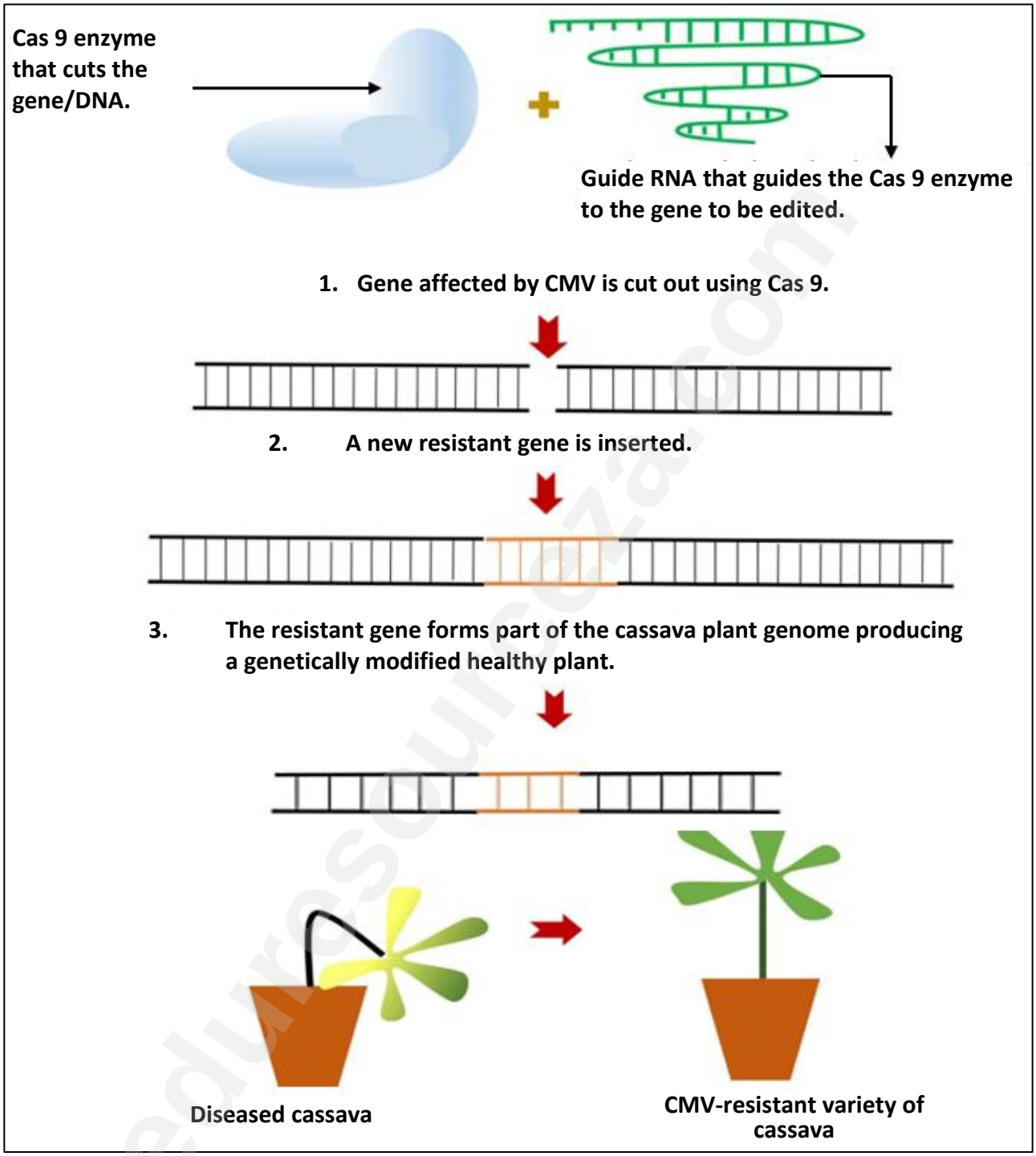
Figure 1.3 – The process of CRISPR to produce disease-resistant cassava.



[Source: <https://www.frontiersin.org/articles/10.3389/fpls.2018.02008/full>]

1.3.1 Provide the correct scientific term from **Figure 1.3** for the following:

(a) The process used for the editing genes: _____

_____

(b) The cassava plant with an altered genome: _____

_____ (2)

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1.3.2 Complete the table below using the information provided on pages 5–6.

Steps in Figure 1.3	Answer
Name the enzyme used in step 1.	
Name the gene cut out in step 1.	
Name the guide molecule.	
Identify ONE gene that might have been added in step 2.	

(4)

1.3.3 Using the sources provided as well as your own knowledge, explain how the CMV reduces the size of cassava tubers.

_____

_____

_____

(2)

1.3.4 Suggest how collaboration with scientists from the United States of America might be advantageous to African countries.

_____

_____

_____

_____

(2)

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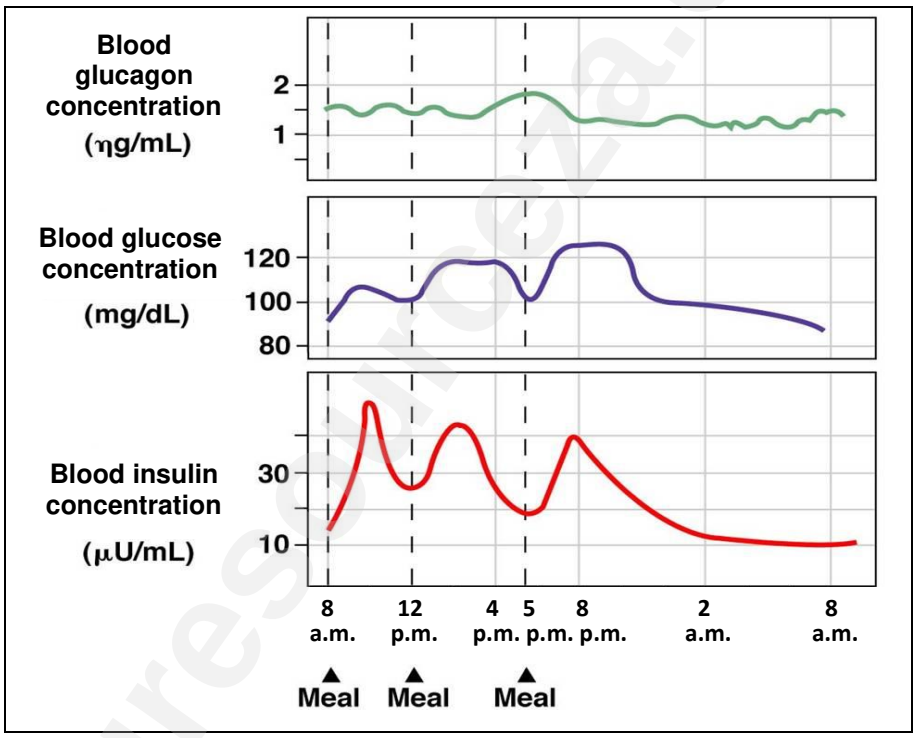
1.4 Study the information shown below and answer the questions that follow.

The occurrence of diabetes in sub-Saharan Africa is rapidly rising. In 2015, the International Diabetes Federation (IDF) estimated that there were 14,2 million people with diabetes in sub-Saharan Africa. It is not known how many of these African people have Type 1 or Type 2 diabetes. Prevalence is highly varied between countries. There is also great variability in rural versus urban occurrence with urban areas having a higher occurrence. Africa is the region with the highest percentage of undiagnosed people – 70% of people with diabetes do not know that they have it. Diabetes caused about 312 000 deaths in 2017, and 73% of these deaths were people under the age of 60.

[Source:<https://www.openaccessgovernment.org/diabetes-african-region/73153/>]

Figure 1.4 – Graphs showing the blood glucagon, glucose and insulin concentrations in an individual over 24 hours.



[Source: <https://www.austincc.edu/apreview/EmphasisItems/Glucose_regulation.html>]

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Consider the statements in the table below and for each statement decide whether:

A **The statement is supported by the information provided above.**

B **The statement is contradicted by the information provided above.**

C **The statement is neither supported nor contradicted by the information provided.**

	STATEMENT	A, B OR C
1.4.1	Urban areas in sub-Saharan Africa have a higher prevalence of diabetes.	
1.4.2	At 5 p.m., glucagon is high because blood glucose concentration is low.	
1.4.3	Insulin concentration increases when the blood glucose concentration is low.	
1.4.4	14,2 million people in sub-Saharan Africa have Type 2 diabetes.	
1.4.5	The 8 a.m. meal caused the blood glucose concentration to rise the most.	
1.4.6	The highest blood glucose concentration between 12 p.m. and 5 p.m. is 120 mg/dL.	
1.4.7	70% of people in Africa know they have diabetes.	
1.4.8	Rural areas have a lower occurrence of diabetes because most people are not diagnosed.	
1.4.9	Treatment for diabetes is improving in sub-Saharan Africa.	
1.4.10	Obesity is the biggest cause of Type 2 diabetes in Africa.	

(10)

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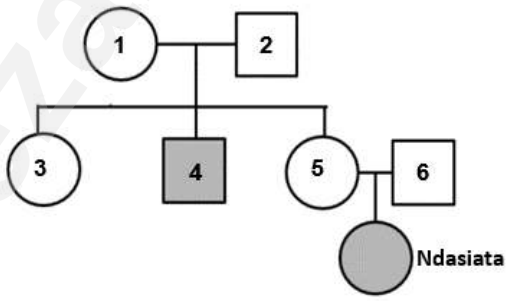
1.5 Study the information given below to answer the questions that follow.

Albinism is an autosomal recessive genetic disorder that occurs in humans and animals. In animals, the disorder results in whitish-pink fur and eyes with red pupils. This condition is caused by a genetic point mutation in the TYR gene. The TYR gene contains 1587 nucleotides. This gene provides instructions for the synthesis of the tyrosinase enzyme in cells. This enzyme produces a pigment called melanin that is responsible for eye and fur colour in animals.

A rare albino zebra, named Ndasiata, with no black stripes has been spotted in the Serengeti National Park in Tanzania. She is covered mostly in white fur, with only a few faint black lines on her neck, head and body and she has very poor eyesight.

Fig. 1.5.1 – Ndasiata, the albino zebra, has easily integrated with other zebras in the park	**Fig. 1.5.2 – Pattern of inheritance of albinism in Ndasiata's family**
	

[Source: <https://www.ndtv.com/offbeat/rare-albino-zebra-spotted-in-tanzania-has-internet-stunned-2816902>]

[Source: <https://www.indiatimes.com/trending/environment/rare-albino-zebra-tanzania-without-stripes-564027>]

[Source: <https://www.ndtv.com/offbeat/rare-albino-zebra-spotted-in-tanzania-has-internet-stunned-2816902>]

1.5.1 From the source, provide the correct biological term for 'the building blocks' that make up the TYR gene.

_____ (1)

1.5.2 Discuss ONE piece of evidence from **Figure 1.5.2** that shows that albinism follows an autosomal recessive pattern of inheritance.

_____

_____

_____ (2)

1.5.3 State the genotypes of the following zebras shown on **Figure 1.5.2.** above.
Use the following symbols: A = normal melanin; a = albinism

(a) Zebra 1 _____

(b) Zebra 4 _____ (2)

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1.5.4 How many amino acids make up the tyrosinase enzyme coded for by the TYR gene? Show all working.

(2)

1.5.5 Explain how a point mutation occurs and how it results in a different protein being made.

(4)

1.5.6 Refer to the text on page 10 and explain TWO disadvantages that Ndasiata faces in her environment due to her albinism.

(4)

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1.6 Study the information below on reproduction in elephants. Elephants are mammals and therefore have similar reproductive hormones to humans. Use this information and your own knowledge to answer the questions that follow.

Bull behaviour

1. The male examines the female's urine for the presence of sex hormones. When high levels of sex hormones are detected, the male approaches the female.
2. Each male comes into musth at a specific time every year; this varies from male to male. Musth refers to the period during which male elephants are ready to mate. During this time, they display the 'musth walk', which is when secretions are produced from swollen glands on their faces and urine dribbles constantly from their penises making them take on a green colour. Frequent mating calls are made.

Cow behaviour

1. Females that are ready to mate signal their location to bulls that may be a few kilometres away with a series of loud, very-low-frequency calls.
2. The menstrual cycle of the cow is unusually long; for example, the development and presence of the corpus luteum lasts about twelve weeks, whereas in humans it lasts two weeks.
3. Gestation lasts for 22 months and usually one calf is born at a time; twins are rare. The calf is entirely dependent on the mother, indicating a high level of parental care.

[Source: <https://ielc.libguides.com/sdzg/factsheets/african_elephant/reproduction>]

1.6.1 Provide a meaning for 'courtship behaviour'.

_____

_____

(2)

1.6.2 Describe ONE courtship behaviour displayed by male elephants.

_____

_____

_____

(2)

1.6.3 Name the hormone secreted by the corpus luteum.

_____

(1)

1.6.4 Do elephants display *r*-strategy or *K*-strategy survivorship? Provide evidence from the text to support your answer.

_____

_____

(2)

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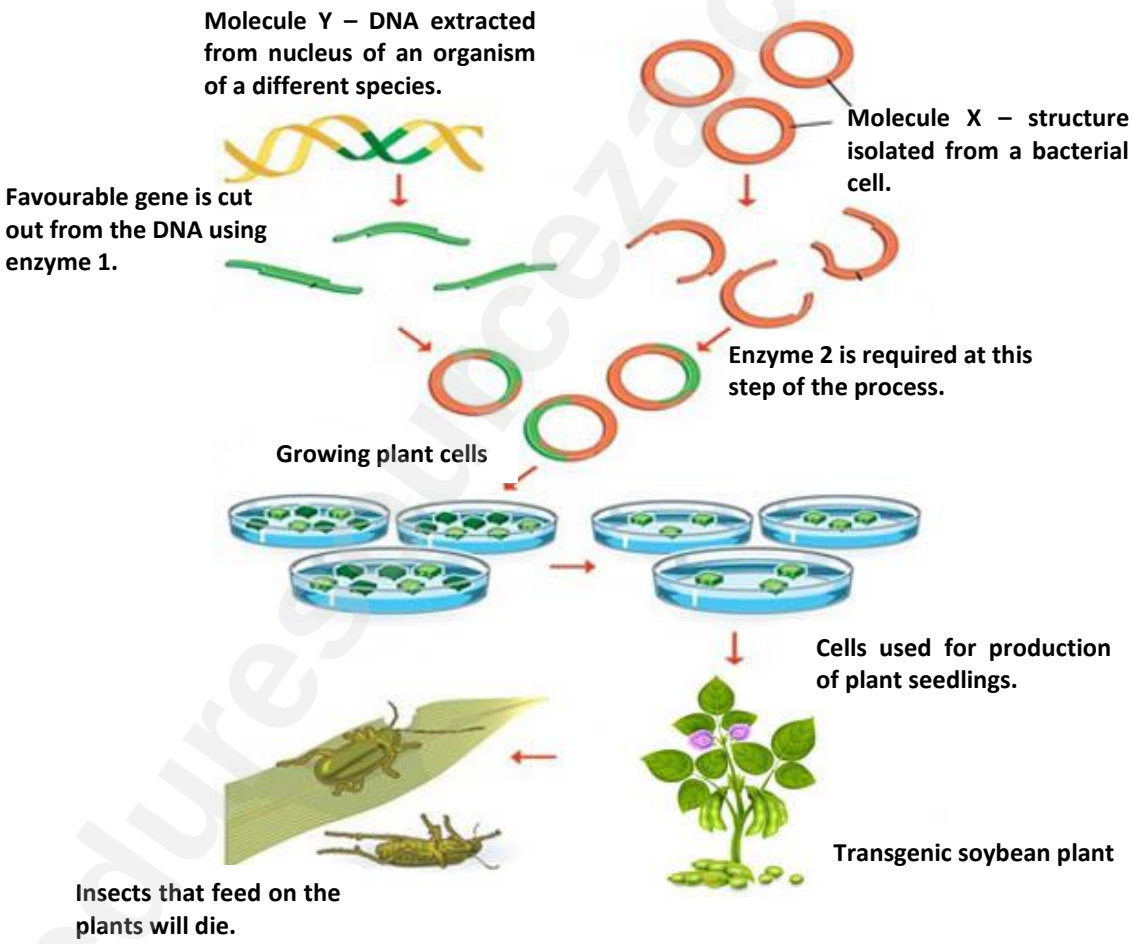
1.7 1.7.1 Study the information provided below. Use this information and your own knowledge to answer the questions that follow.

Soybean is an important crop in Ghana because it has multiples uses. Soybean is a good source of fatty acids, minerals like calcium and phosphorus, and vitamins A, B, C and D. Soybean crops in Ghana face many challenges, such as low yields and poor seed quality, and they are susceptible to pests and diseases. One way to produce high-yielding varieties of soybean is to create genetically engineered pest-resistant soybean crops. This can increase the yield by up to 33%. However, the release of transgenic crops into the environment is an ethical concern for many people in Ghana.

[Source: <https://scialert.net/>]

Figure 1.7.1 – Process of genetically engineering pest-resistant soybean plants using recombinant DNA technology



[Source: <https://www.britannica.com/science/genetically-modified-organism>]

(a) Explain why the new variety of genetically engineered soybean plant is referred to as being transgenic.

_____

_____

(2)

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(b) What is the 'new favourable characteristic' in the gene?

_____ (1)

(c) Name enzyme 1.

_____ (1)

(d) Provide the function of enzyme 2.

_____ (1)

(e) Describe ONE difference in structure between molecule X and molecule Y.

_____

_____

_____ (2)

(f) Identify ONE nutritional mineral found in soybean plants.

_____ (1)

(g) State ONE advantage of producing transgenic soybean crops in Ghana.

_____

_____ (1)

(h) Provide TWO possible ethical concerns that people may have with genetically engineered soybean plants.

_____

_____

_____

_____ (2)

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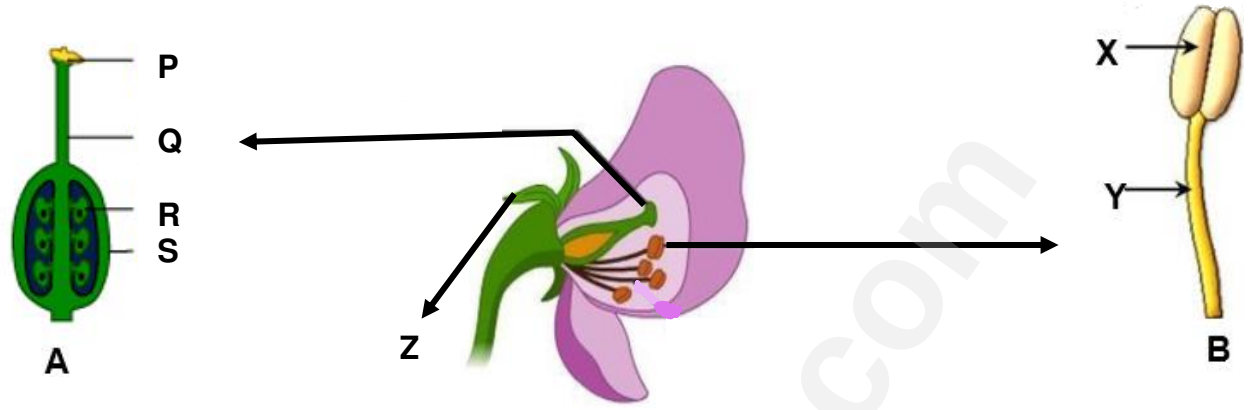
1.7.2 Study the structure of the soybean flower below and answer the questions that follow.

Figure 1.7.2 – Structure of the soybean flower



[Source: <https://static.sciencelearn.org.nz/images/images/000/002/477/embed/>]

(a) Which structure, **A** or **B**, represents the male part of the flower?

_____ (1)

(b) Provide the letter of the part in structure **B** where meiosis occurs.

_____ (1)

(c) (i) Identify the structure labelled **Z**.

_____ (1)

(ii) Provide a function of structure **Z**.

_____ (1)

(d) Describe ONE way in which part **P** is structurally adapted to carry out its function.

_____

_____ (2)

(e) Provide the letter of the part in structure **A** that forms the soybean seed after fertilisation?

_____ (1)

[80]

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QUESTION 2

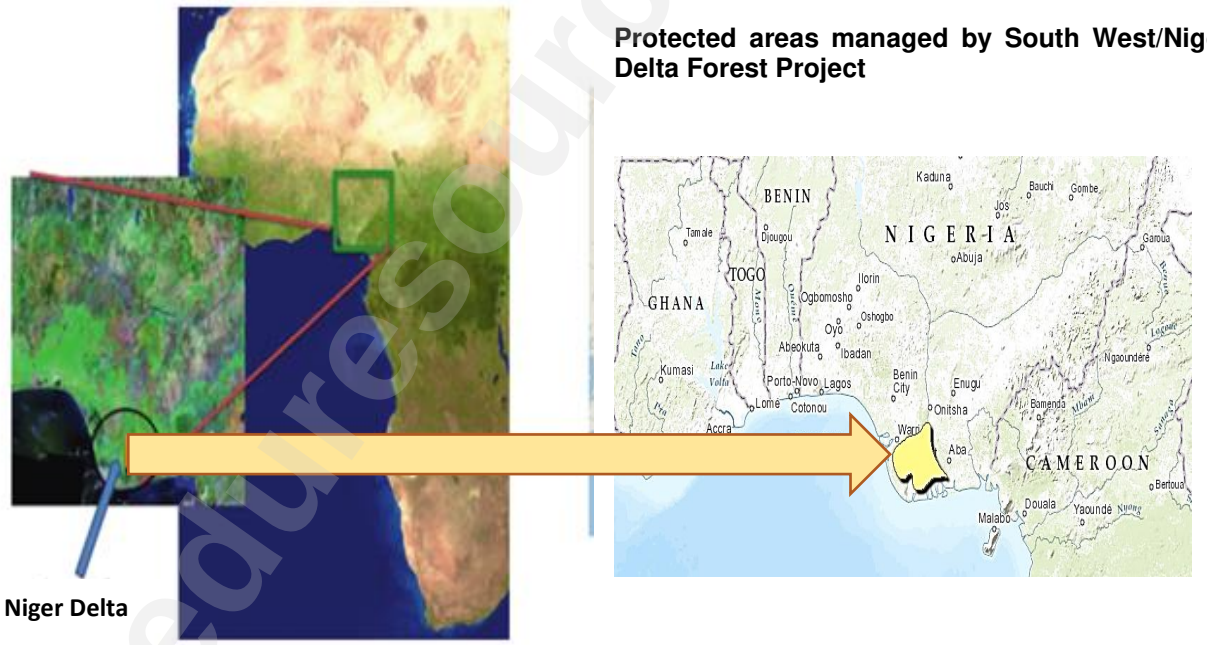
2.1 Read the source below and use this information and your own knowledge to answer the questions that follow.

Discovery channel is an American TV channel owned by Warner Brothers. It has introduced a new initiative called *Change Drivers*, which highlights people who dedicate their lives to making a difference in the world. Each person is tackling a different problem that today's society is facing. These videos have been aired on DStv® and YouTube®.

One such person is Rachel Ikemeh, a Nigerian conservationist, whose goals have been to protect highly threatened forest habitats and primate populations in southern Nigeria. Her efforts have helped bring back a species from the brink of extinction – the critically endangered Niger Delta red colobus monkey (*Piliocolobus epieni*). Another species that is critically endangered in this habitat is the Niger Delta pygmy hippopotamus (*Choeropsis liberiensis*). These two species feed on plant leaves and fruit. The monkeys forage in the trees, while the hippos feed at ground level.

The Niger Delta forest is a large ecosystem in Nigeria made up of many different plant and animal species. In recent years, the biodiversity of this ecosystem has been threatened by increased human activity that has resulted in the death of many of the red colobus monkeys.

Figure 2.1 – Map showing the location of the Niger Delta forest in Nigeria



Ikemeh is the founder of the Southwestern Niger Delta Forest Project, a conservation initiative that has been dedicated to the protection of fragile wildlife populations and habitats across Africa's most-populated nation, Nigeria. She is also committed to promoting the need to increase conservation leadership amongst African females.

The project sites are located in dangerous areas. Criminals involved in poaching, illegal marijuana farming and illegal oil mining use the forests as a hideout to carry out their operations. Ikemeh and her team are constantly surrounded by threats, but this has not stopped her working to reach her goals.

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Rachel Ikemeh received the National Geographic / Buffet Award for Leadership in Conservation in 2022

The Niger Delta red colobus monkey

Many indigenous tribes can also be found living in the Niger Delta forest, one of them being the Ijaw people. The Delta is considered their ancestral land. They are one of the largest tribes living in the Delta and make up 10% of the Nigerian population. The Ijaw people mostly work as fishermen and farmers. Their local foods include fish, yams and plantains. Their land is rich in oil and their oil exploration has led to further ecological disturbances in the forest.

The Ijaw people and their culture

[Source: <https://www.researchgate.net/publication/338513875_The_Impact_of_Landscape_Reclamation_on_Mangrove_Forest_and_Coastal_Areas_in_the_Niger_Delta_Nigeria>]
[Source:<https://swnigerdeltaforestproject.org.ng/>]
[Source: <https://explorer-directory.nationalgeographic.org/rachel-a-ikemeh>]
[Source: <https://www.academia.edu/12655230/Assessing_the_Population_Status_of_the_Critically_Endangered_Niger_Delta_Red_Colobus_Piliocolobus_epieni_>]
[Source: <https://theculturetrip.com/africa/nigeria/articles/a-guide-to-the-indigenous-people-of-nigeria/>]

2.1.1 Provide the scientific term from the text for the following definitions:

	Definition	Biological term
(a)	The variety of plant and animal life in the Niger Delta forest.	
(b)	The red colobus monkey faces a high risk of extinction.	
(c)	A group of pygmy hippos of the same species living in a given area in the Niger Delta forest.	
(d)	The natural home of the red colobus monkey in the Niger Delta forest.	

(4)

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2.1.2 Explain how animals that have the same diet, like the pygmy hippo and the red colobus monkey, co-exist in the same area.

_____

_____

_____

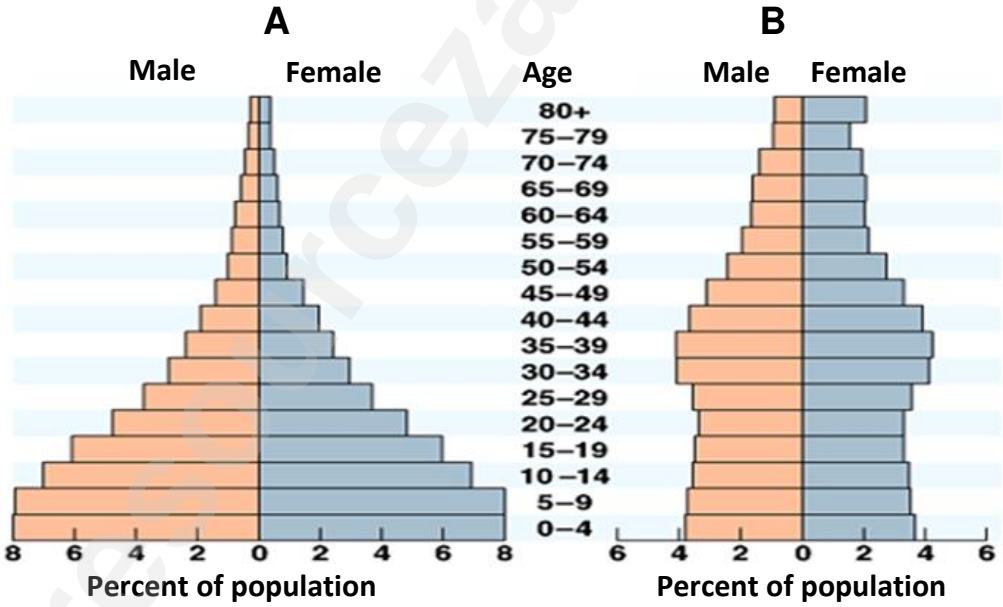
(2)

2.1.3 Identify the type of competition that exists between members of the red colobus monkeys for the same resources.

_____

(1)

2.1.4 The Nigerian population follows the demographics of a developing nation.



[Source: <https://faculty.uca.edu/johnc/population_ecology.htm>]

Which graph, **A** or **B**, indicates the population of Nigeria? Give a reason for your answer.

_____

_____

_____

(2)

2.1.5 Identify ONE human activity that results in the destruction of the forest ecosystem.

_____

(1)

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2.1.6 Do you think it is worth the effort for Ikemeh and her team to risk their lives to achieve their goals? Explain your answer.

(2)

2.1.7 Explain why the destruction of the red colobus monkeys' habitat can be regarded as a density-independent factor?

(2)

2.1.8 Identify the population parameter that caused the decline of the monkey population.

(1)

2.1.9 Do you think *Change Drivers* is getting sufficient publicity for the project to be successful? Justify your answer.

(2)

2.1.10 (a) Besides the focus on conservation, what other goal does Ikemeh promote?

(1)

(b) Suggest why this goal is an important one in Africa.

(1)

2.1.11 Explain how the actions of the Ijaw people may undermine Ikemeh's conservation efforts.

(2)

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2.2 Read the source below and use this information as well as your own knowledge to answer the questions that follow.

Vultures are one of the most important scavengers that exist; they can strip a carcass (dead body of an animal) in a matter of minutes. The vulture population is fast declining and could possibly become extinct in the near future. Across Africa, there are many factors that have led to the decline in vulture populations.

Figure 2.2.1 – A vulture stripping a carcass

[Source: <https://sonoranimages.wordpress.com/2019/11/01/vultures-doing-what-they-do-best/>]

Impact of Poaching on Vulture Populations

One of the greatest threats to vulture numbers is the poaching of other animals. Vultures die after eating poisoned animals left behind by poachers. Poachers poison the carcass so that the vultures die, and law enforcement cannot see them flying above the poached animals as they fly in to eat the carcasses. In July 2013 in Namibia, researchers came across a horrific scene: 500 dead vultures surrounded an elephant carcass that was poisoned. In May 2021, an article published in the journal *Global Ecology and Conservation*, noted a sudden spike in intentional vulture poisoning and poaching of other animals.

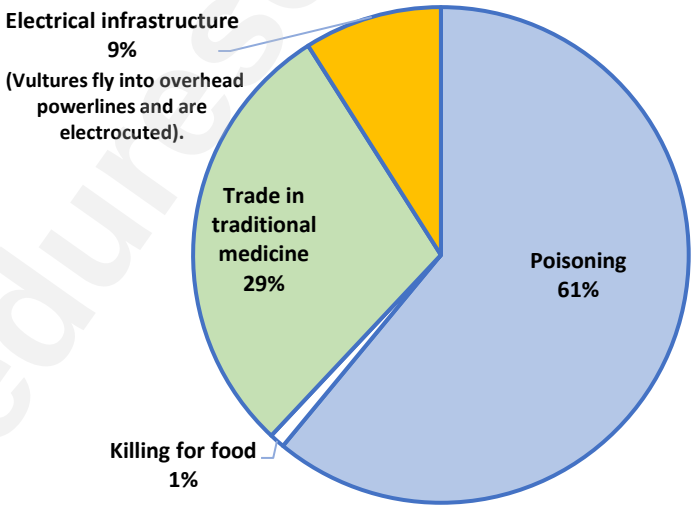
The Endangered Lappet-faced Vulture in KwaZulu-Natal

Conservationists in KwaZulu-Natal noticed a significant decline in nesting sites of the lappet-faced vulture. The lappet-faced vulture is the largest vulture on the African continent and is listed as endangered on the IUCN* Red List. After intensive aerial surveys in September 2021, it was noticed that nest counts for the lappet-faced vulture in KZN dropped from 15 active nests in 2020 to only six active nests in 2021.

[Source: <https://www.nationalgeographic.com/animals/article/150731>]

*IUCN – International Union for Conservation of Nature

Figure 2.2.2 – Some factors that have led to the decline in vulture populations



[Source: <https://www.researchgate.net/figure/Major-threats-to-vulture-populations-Four-quantitative-factors-constituted-a-serious_fig1_278675705>]

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2.2.1 From the options given below, choose the most correct definition of *a vulture species*. **Circle the letter of the correct answer**.

A All the species of vultures that live in the KZN conservation area.
B All the lappet-faced vultures that share similar traits and can breed with one another and produce fertile offspring.
C All the birds that live in KZN, their interactions with each other and with their non-living environment. (2)

2.2.2 Refer to the information provided and your own knowledge to explain why vultures are so important to an ecosystem.

_____

_____

_____
(2)

2.2.3 Calculate the percentage decrease in the number of active nests in KZN between 2020 and 2021. Show all working.

_____

_____

_____
(3)

2.2.4 Was a direct method or an indirect method used to estimate the number of active vulture nests in 2021? Explain your answer.

_____

_____
(2)

2.2.5 Provide ONE advantage and ONE disadvantage of the sampling method used to determine the number of vulture nests as mentioned in 2.2.4 above.

Advantage _____

_____

Disadvantage _____

_____
(2)

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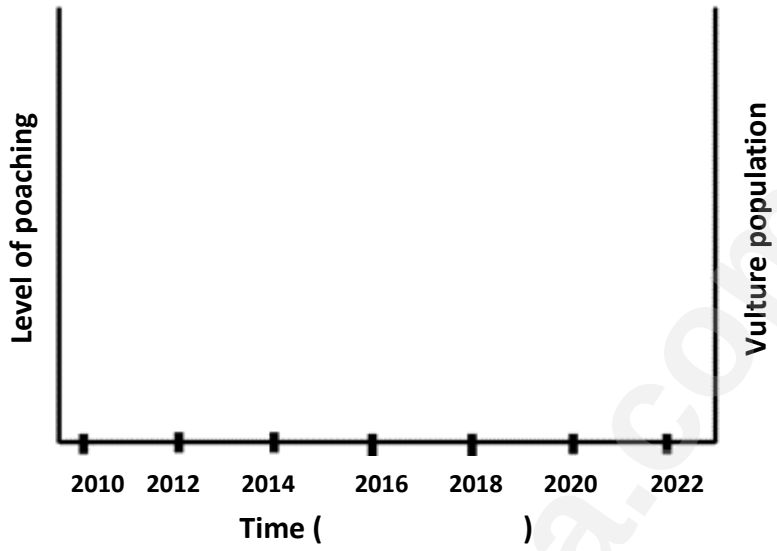
2.2.6 Complete the graph below that shows the impact of poaching of other animals on the vulture population over time.



In order to complete the graph, add the following on to the graph:

(a) A graph line to represent the change in the vulture population over time. (1)

(b) A different graph line to indicate the increase in poaching over time. (1)

(c) A key to differentiate between the vulture population and the poaching graph lines. (1)

(d) A unit on the X-axis. (1)

2.2.7 Refer to **Figure 2.2.2** on page 20 and determine the combined total percentage of vultures that die due to electrical infrastructure **and** trade in traditional medicine? Show all working.

_____

(2)

2.2.8 Conservationists have started installing solar-powered GPS tracking units on all the lappet-faced vulture chicks to monitor their movements.

Do you think this is a suitable method of monitoring the size of vulture populations? Justify your answer.

_____

_____

_____

(2)

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[40]

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QUESTION 3

3.1 Read the information below and use this and your own knowledge to answer the questions that follow.

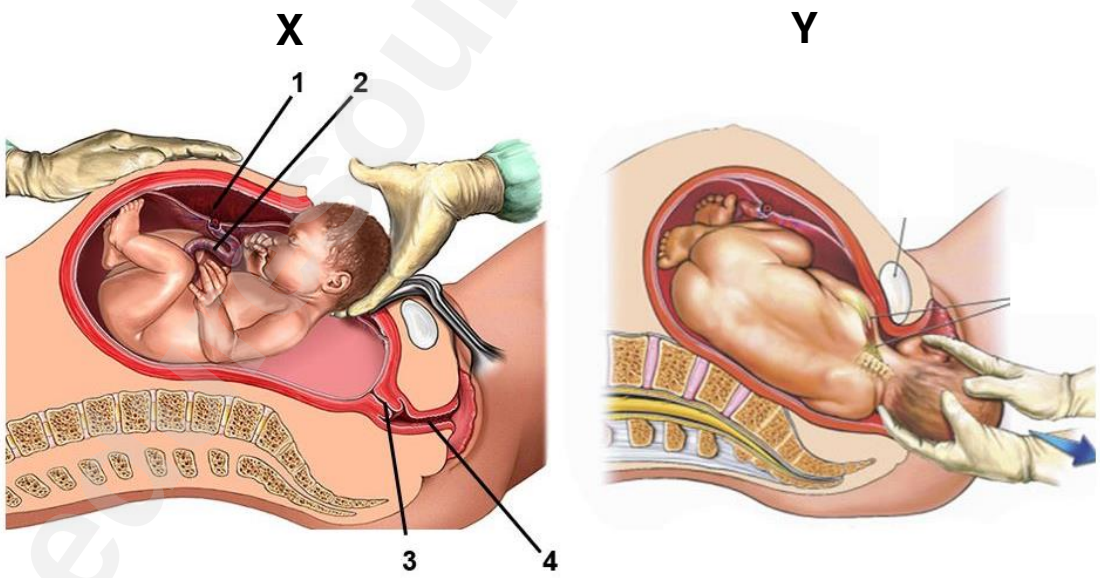
In 2017, sub-Saharan Africa accounted for approximately 66% of global maternal deaths during birth. Maternal deaths can be reduced if African countries had access to delivery by caesarean section (C-section). A C-section is a surgical procedure in which a baby is born through a cut made in the mother's abdominal wall and uterus. This type of delivery is often carried out when natural birth (vaginal delivery) would put the mother or baby at risk due to complications during labour.

In other countries where at least 10% of women have a C-section, the number of maternal deaths is significantly decreased. Africa has the lowest C-section rate in the world and only about 2% of mothers have access to safe C-sections. One of the factors contributing to this low percentage is a lack of trained obstetricians (doctors that specialise in delivering babies).

A study conducted in Tanzania and Ethiopia showed that C-sections are vital in sub-Saharan Africa where complications such as difficult labour, history of prior C-section, foetal distress, uterine rupture and bleeding are common.

[Source:<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8442509/>]

Figure 3.1 – The TWO types of deliveries used when giving birth



[Source:<https://www.babydestination.com/c-section-versus-natural-delivery-risks-and-benefits>]

3.1.1 From **Figure 3.1**, provide the letter (X or Y) that identifies the following:

(a) Natural birth: _____

(b) Caesarean section: _____

(2)

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3.1.2 Provide labels for the following structures shown in **Figure 3.1**.

3: _____

4: _____

(2)

3.1.3 Besides the lack of trained obstetricians in sub-Saharan Africa, suggest TWO reasons why so many females give birth naturally and do not have a C-section?

_____

_____

_____

(2)

3.1.4 Using the information provided, draw a table in the space below comparing TWO differences between the two types of deliveries when giving birth. Provide a heading for the table.

(6)

3.1.5 The following events, not given in the correct order, occur during natural childbirth.

1. Stronger contractions push the baby through the vagina.
2. The placenta and umbilical cord are expelled from the uterus.
3. The mucus plug is released from the cervix.
4. The umbilical cord is cut and clamped.
5. Mild contractions cause the 'waters to break' (amnion ruptures).
6. The cervix starts to dilate.

Place the events in the correct order by writing the numbers in the boxes below.

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(6)

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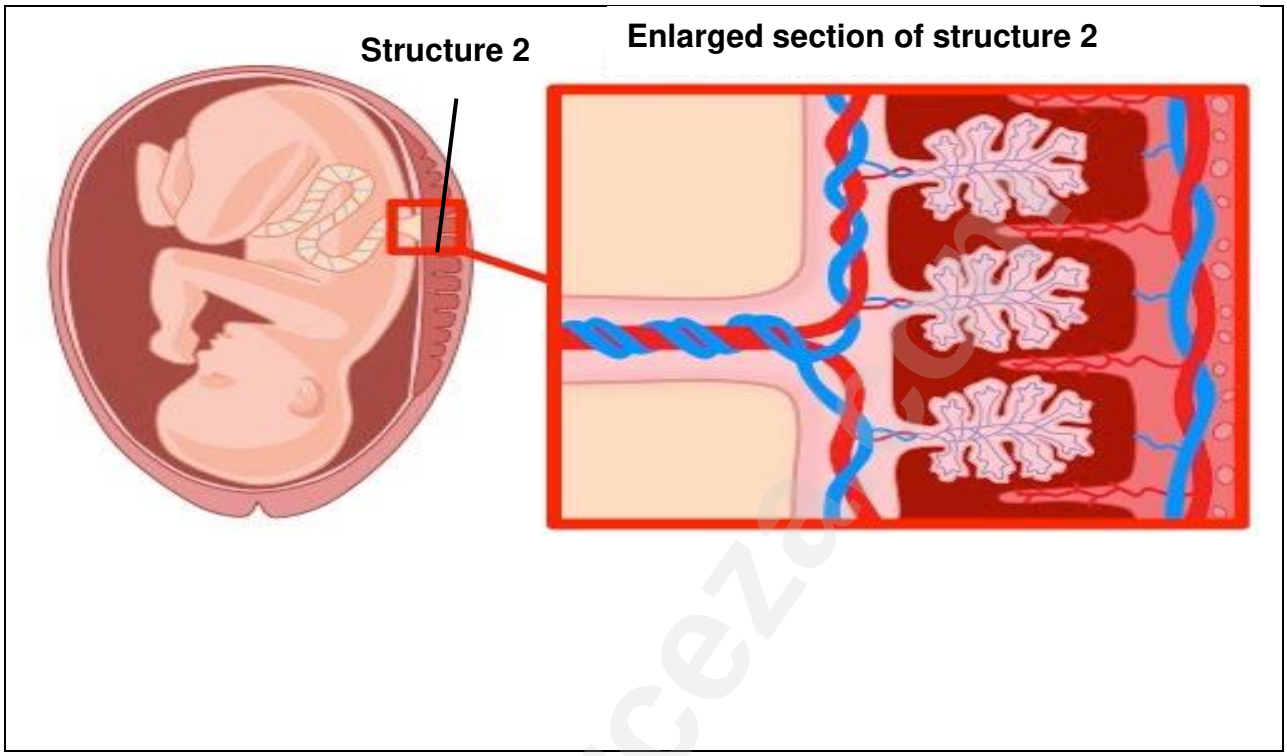
3.2 Study the figure below to answer the questions that follow.

Figure 3.2 – Structure of the umbilical cord and placenta



[Source:<https://ib.bioninja.com.au/higher-level/topic-11-animal-physiology/114-sexual-reproduction/placenta.html>]

3.2.1 On the diagram above showing the enlarged section of structure 2, clearly label the following:

(a) An umbilical artery
(b) An umbilical vein
(c) A chorionic villus
(d) A maternal blood vessel (4)

3.2.2 Name ONE substance found in each of the following blood vessels in the umbilical cord:

Umbilical artery: _____

Umbilical vein: _____

(2)

3.2.3 Describe TWO functions of structure 2.

_____

_____

_____

_____

(4)

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3.3 Read the information below and use this and your own knowledge to answer the questions that follow.

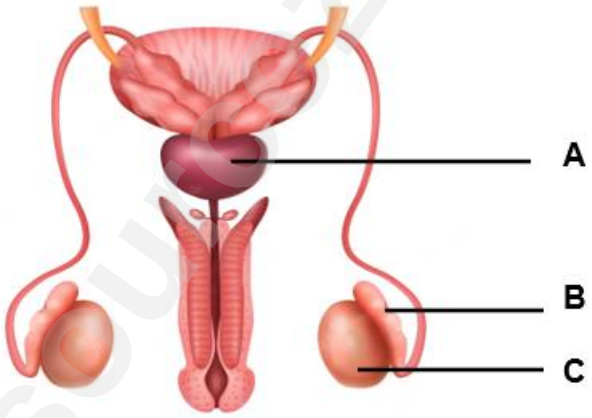
A vasectomy, or male sterilisation, is one of the few fertility control methods that allows men to take responsibility for contraception. In many parts of the world, family planning is still considered a woman's responsibility. Globally, only 2,2% of men have vasectomies, while 18,9% of women are sterilised.

Countries with the highest vasectomy rates include Canada (22%), the United Kingdom (21%), New Zealand (19,5%) and the United States (11%). In Africa only 0,1% of men have undergone vasectomies, mostly due to lack of awareness.

On the African continent, vasectomies could be one of the most effective male birth-control methods; it is inexpensive, a simple procedure, and very effective.

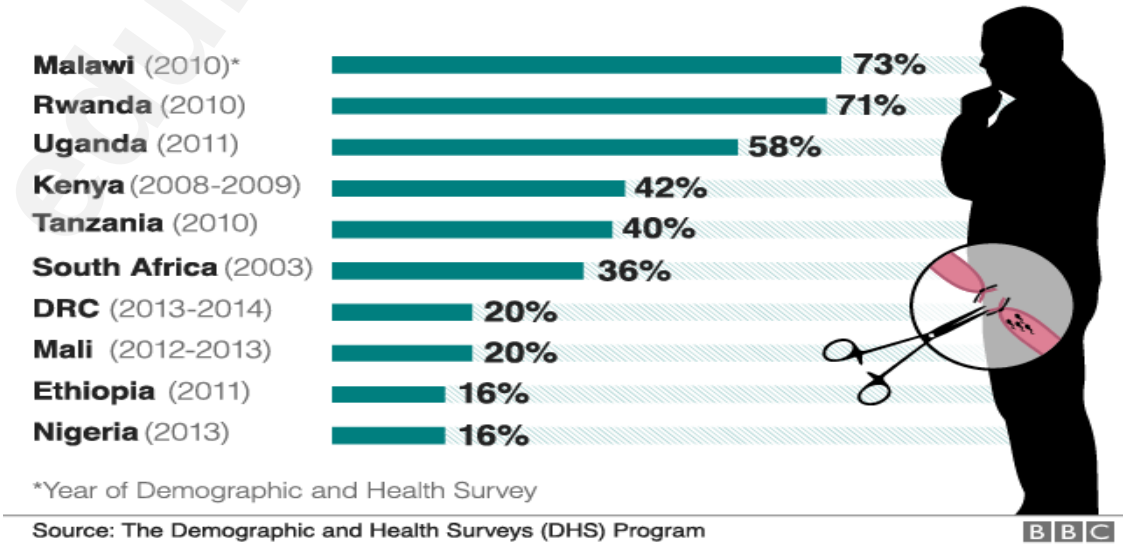
[Source: <https://theconversation.com/myths-and-misconceptions-stop-african-men-from-going-for-a-vasectomy-51879>]

Figure 3.3.1 – Front view of male reproductive system



[Source: <https://thebiologynotes.com/male-reproductive-system/>]

Figure 3.3.2 – Awareness levels of vasectomies as a family-planning method in different African countries, according to a health survey.



[Source:<https://www.bbc.com/news/world-africa-44632151>]

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3.3.1 Refer to **Figure 3.3.1** on page 26 to answer the following questions.

(a) Provide labels for structures **A** and **B**.

A _____

B _____

(2)

(b) Name the biological process that takes place in structure **C** that produces gametes.

_____

(1)

(c) Name the hormone secreted by structure **C**.

_____

(1)

(d) On **Figure 3.3.1** on page 26, indicate with an **X** where a vasectomy is performed to sterilise a male. (2)

3.3.2 Name the structure where a tubal ligation is performed in females.

_____

(1)

3.3.3 Provide ONE advantage of having a vasectomy.

_____

(1)

3.3.4 Suggest a reason why so few African men have vasectomies?

_____

_____

(1)

3.3.5 What is the difference in the vasectomy rate between Canada and Africa? Show working.

_____

(1)

3.3.6 Refer to **Figure 3.3.2** on page 26 to answer the following questions.

(a) Which country has **twice** the awareness level of vasectomies of the DRC?

_____

(1)

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(b) Provide ONE reason why the results of the health survey may be seen as being scientifically unreliable.

_____

_____

_____

(1)
[40]

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QUESTION 4

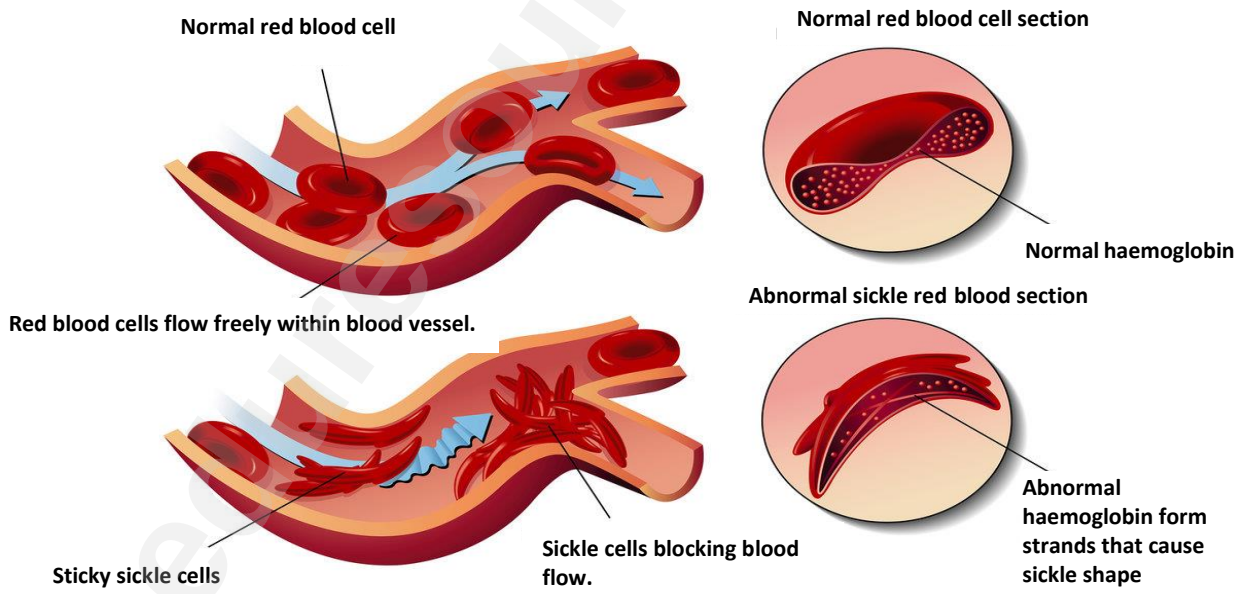
Read the source below and use this information as well as your own knowledge to answer the questions that follow.

Sickle cell anaemia is an autosomal recessive inherited disorder that affects the shape of red blood cells in humans. Haemoglobin is a protein molecule found in red blood cells. The haemoglobin molecule transports oxygen in the blood. A mutation in the gene coding for haemoglobin results in sickle cell anaemia.

Red blood cells are usually round and flexible, so they move easily through blood vessels. In sickle cell anaemia, some red blood cells are shaped like sickles (half-moon shaped). These sickle cells become rigid and sticky, which can slow or block blood flow. Individuals with this disease suffer from anaemia, periodic episodes of pain, swollen hands and feet, and frequent infections.

Nearly 90% of the world's sickle cell population lives in three countries: Nigeria, India, and the Democratic Republic of Congo. It has been estimated that at least 150 000 babies are born with sickle cell anaemia in Nigeria annually. About 7 million babies are born in Nigeria every year. Lack of new-born genetic screening in Nigeria means that these babies might not be diagnosed and could die by the age of five.

Figure 4.1 – Diagram showing normal red blood cells and sickle cells



[Source:<https://www.mayoclinic.org/diseases-conditions/sickle-cell-anemia/symptoms-causes/syc-20355876>]
[Source: <https://www.tamingthesru.com/blog/intern-diagnostics/laboratory-evaluation-of-sickle-cell-disease-in-the-ed>]

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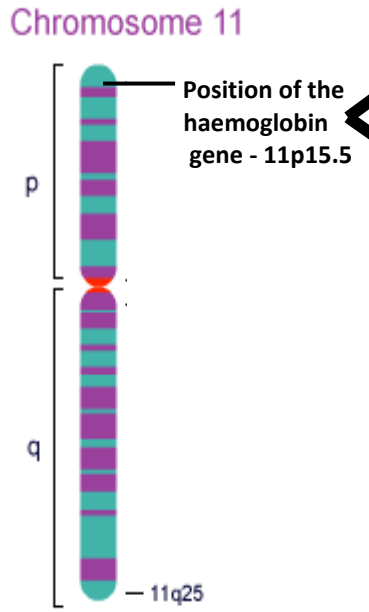
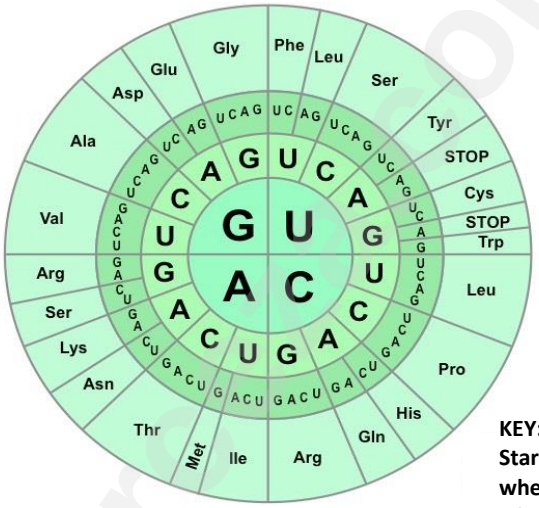
Figure 4.2 – Chromosome 11 showing position of haemoglobin gene



Section of normal haemoglobin gene:
GGA CTC CTC

Section of the abnormal gene after the mutation has occurred:
GGA CAC CTC

mRNA codon wheel



KEY:
Start with 4 central nucleotides when reading the mRNA codon wheel.

[Source: <https://sicklecelldiseasebiology.weebly.com/genetic-cause.html>]
[Source: <https://www.medicalhomeportal.org/diagnoses-and-conditions/sickle-cell-disease>]
[Source: <https://ib.bioninja.com.au/standard-level/topic-2-molecular-biology/27-dna-replication-transcri/genetic-code.html>]

4.1 Decide whether the statements in the table below are true or false. Write TRUE or FALSE in the second column. If false, correct the statement by writing the correct term for the underlined word in the third column.

STATEMENT	TRUE / FALSE	CORRECT WORD
4.1.1 A child that is homozygous recessive for the condition will be <u>unaffected.</u>		
4.1.2 The point mutation resulting in sickle cell anaemia is a <u>deletion</u> mutation.		
4.1.3 Sickle cell anaemia is an <u>autosomal</u> condition because the mutation is on chromosome 11.		
4.1.4 Haemoglobin is produced during the process of <u>protein synthesis</u>.		
4.1.5 CCU on the mRNA strand codes for the amino acid <u>proline (Pro)</u>		

(7)

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4.2 Use the information provided to describe ONE difference between a normal red blood cell and a sickle red blood cell.

(2)

4.3 Refer to the section of the normal red blood cell in **Figure 4.1** on page 29. Is this blood cell cut in a cross-section or a longitudinal section?

(1)

4.4 What percentage of Nigeria's babies born every year will be diagnosed with sickle cell anaemia? Show all working.

(2)

4.5 Identify the locus of the haemoglobin gene.

(1)

4.6 Identify ONE difference between a nucleotide of a DNA molecule and a nucleotide of an RNA molecule.

(2)

4.7 Refer to the portion of the normal haemoglobin gene shown in **Figure 4.2** on page 30. Using the normal DNA strand, write the corresponding mRNA sequence below.

(3)

4.8 Refer to the information provided in **Figure 4.2** and the mRNA codon wheel to explain how the mutation in the haemoglobin gene occurs and how this leads to the formation of sickle cells.

(4)

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4.9 Draw a flow diagram to show the steps involved in the process of **transcription** that is required for the synthesis of a haemoglobin molecule. Provide a heading for the flow diagram.

(7)

4.10 Name the organelle where translation of the haemoglobin molecule takes place.

_____

(1)

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4.11 A married couple are thinking of having a child. They are both heterozygous for sickle cell anaemia and consult a genetic counsellor.

(a) (i) Draw a genetic cross/Punnett square to determine the probability of the couple having a child with sickle cell anaemia.

Use the following key:
D – normal
d – sickle-cell

(3)

(ii) Show all genotypic and phenotypic ratios that arise from the cross.

_____

_____

_____

(2)

(iii) State the probability of a child being homozygous for sickle cell anaemia.

_____

(1)

(b) Suggest what advice the genetic counsellor would give the couple about having a baby based on the results from the Punnett square you have drawn and your own knowledge.

_____

_____

_____

_____

(2)

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4.12 Refer to the text and suggest a strategy for African countries to reduce the number of children dying from sickle cell anaemia.

_____

_____

_____

(2)
[40]

Total: 200 marks

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ADDITIONAL SPACE (ALL QUESTIONS)

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

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