Surname	Centre Number	Candidate Number
First name(s)		2

wjec cbac

GCE A LEVEL

A400U20-1

O21-A400U20-1

eduqas
Part of WJEC

FRIDAY, 15 OCTOBER 2021 – MORNING

BIOLOGY – A level component 2
Continuity of Life

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**12**	
2.	**11**	
3.	**17**	
4.	**12**	
5.	**18**	
6.	**10**	
7.	**11**	
8.	**9**	
Total	**100**	

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01

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **8**.

The quality of written communication will affect the awarding of marks.

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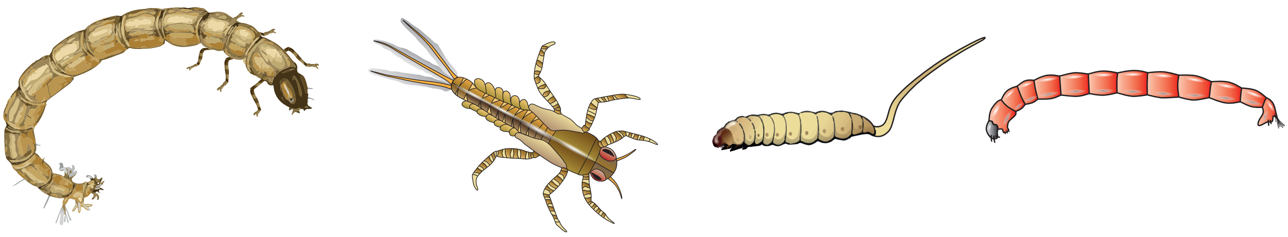
Answer **all** *questions.*

1. Many insects lay their eggs in freshwater streams and rivers. At the larval stage many insects are difficult to identify accurately below the taxon Family. **Image 1.1** shows some insect larvae (not to the same scale).

Image 1.1



(a) Suggest how protein analysis could enable ecologists to classify the larvae to the individual Species instead of the Family. [2]

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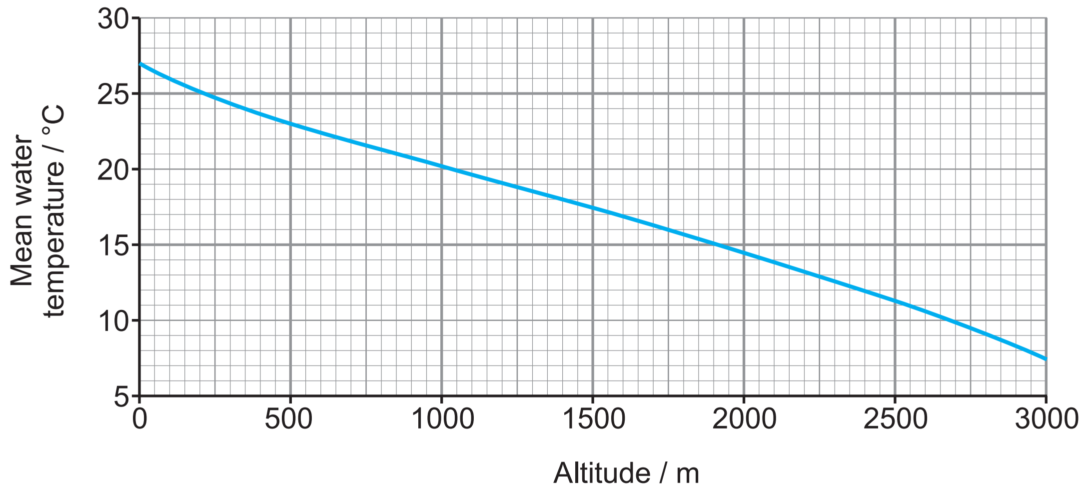
The larvae shown in **image 1.1** are aquatic and their distribution is affected by a range of environmental factors including the temperature of the water.

To investigate the effect of temperature on the biodiversity of insects with aquatic larvae, a study was carried out at three different altitudes in a mountainous region of South America. **Image 1.2** shows how mean water temperature changes with altitude.

Image 1.2



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Data were collected from shallow streams at 350 m, 2 100 m and 3 000 m above sea level, that flowed over similar rocks and had a similar pH.

Five streams were sampled at each altitude. Areas of each stream were sampled using the following kick-sampling method:

- Place a 0.5 m^2 quadrat on the stream bed in the middle of the stream.
- Place a 0.5 m wide flat-bottomed net downstream of the quadrat.
- Disturb the area of the stream bed inside the quadrat for two minutes by kicking strongly.
- Transfer the organisms caught in the net to a container.
- Group the insect larvae into Orders and record the number of Families in each Order recorded.
- Working upstream, sample a further nine areas in each stream.

(b) (i) Explain why the ecologists worked upstream from the first sample. [2]

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(ii) Suggest why the quadrats were placed in the middle of each stream. [1]

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Table 1.3 below shows the mean number of Families in the different Orders of insects per m^2 identified at each altitude tested.

Table 1.3

Order of insects	**Number of Families identified at each altitude**		
	350 m	**2 100 m**	**3 000 m**
Collembola	1	1	1
Plecoptera	1	1	1
Ephemeroptera	4	4	2
Odonata	4	1	0
Megaloptera	1	0	0
Hemiptera	4	0	0
Coleoptera	6	6	2
Trichoptera	8	9	6
Lepidoptera	1	1	0
Diptera	8	9	10

Table 1.4 shows the number of individuals of each Family found in the streams sampled at 3 000 m.

Table 1.4

Altitude = 3 000 m			
Insect Family	n	$(n–1)$	$n(n–1)$
Collembola	1	0	0
Plecoptera	1	0	0
Ephemeroptera	2	1	2
Odonata	0	–1	0
Megaloptera	0	–1	0
Hemiptera	0	–1	0
Coleoptera	2	1	2
Trichoptera	6	5	30
Lepidoptera	0	–1	0
Diptera	10	9	90
N	....	$\Sigma n(n–1)$	....
$(N–1)$	....		
$N(N–1)$	....		

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(iii) Use **table 1.4** and the formula below to calculate a Diversity Index (D) for the streams sampled at 3000 m. [3]

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$ where N = total number of insect families
n = number of families per order of insect
Σ = sum of

D = ...

(iv) The Diversity Index was calculated for the other two altitudes. These are shown below.

350 m D = 0.87
2100 m D = 0.81

Conclude and explain the effect of water temperature on the biodiversity of insects with aquatic larvae. [2]

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(v) Identify **one** *other* abiotic factor which is affected by altitude and explain why this may reduce your confidence in your conclusion. [2]

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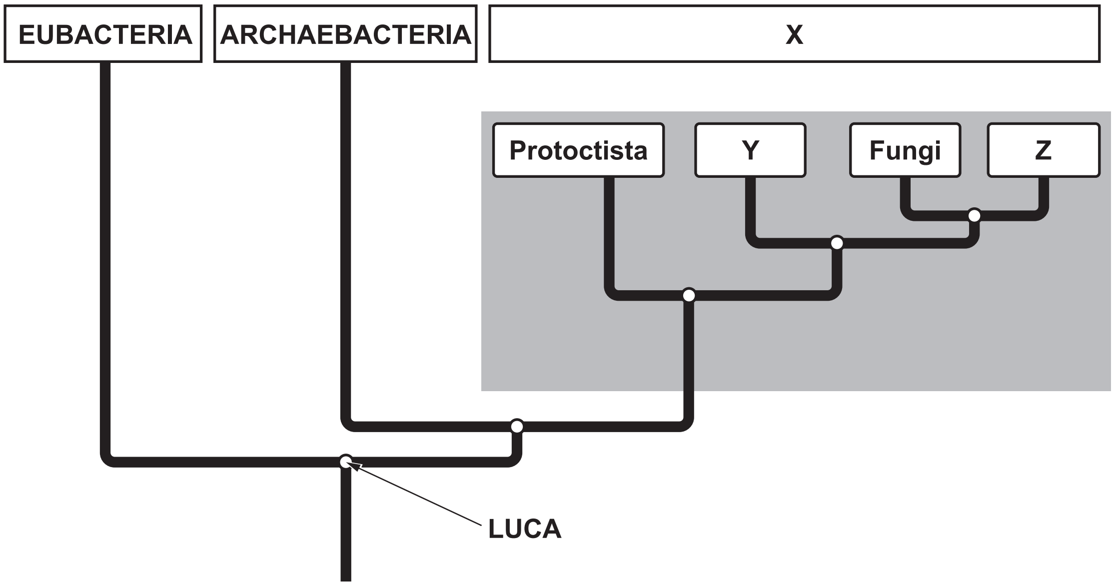
2. Humans classify organisms into groups to determine their evolutionary relationships. **Image 2.1** represents our current understanding of how organisms are related.

Image 2.1



(a) (i) Name Domain **X** shown in **image 2.1** and describe how all the organisms in this Domain are different from those in the other Domains. [2]

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(ii) Organisms in Domain **X** are classified into smaller groups of more closely related organisms: Group **Y** are all phototrophic and Group **Z** are all heterotrophic.

Using this information, state the following:

I. the **level** of classification represented by groups **Y** and **Z**; [1]

....

II. the **names** of groups **Y** and **Z**; [1]

Y ....

Z ....

III. **one** *other* distinguishing feature of groups **Y** and **Z** used to place them in these groups. [1]

Y ....

Z ....

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(b) The point labelled **LUCA** on the diagram stands for Last Universal Common Ancestor. Suggest how the role of ATP provides evidence that all organisms have evolved from this single common ancestor. [3]

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The binomial system is used to give a scientific name to all organisms on Earth. However, scientific names change. For example, one species of bluebell, *Scilla italica*, has been reclassified as *Hyacinthoides italica*.

(c) (i) State the classification **levels** (taxa) given in the binomial name of an organism. [1]

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(ii) Explain why the reclassification of *Scilla italica* as *Hyacinthoides italica* demonstrates the tentative nature of classification. Suggest why its scientific name may change again in the future. [2]

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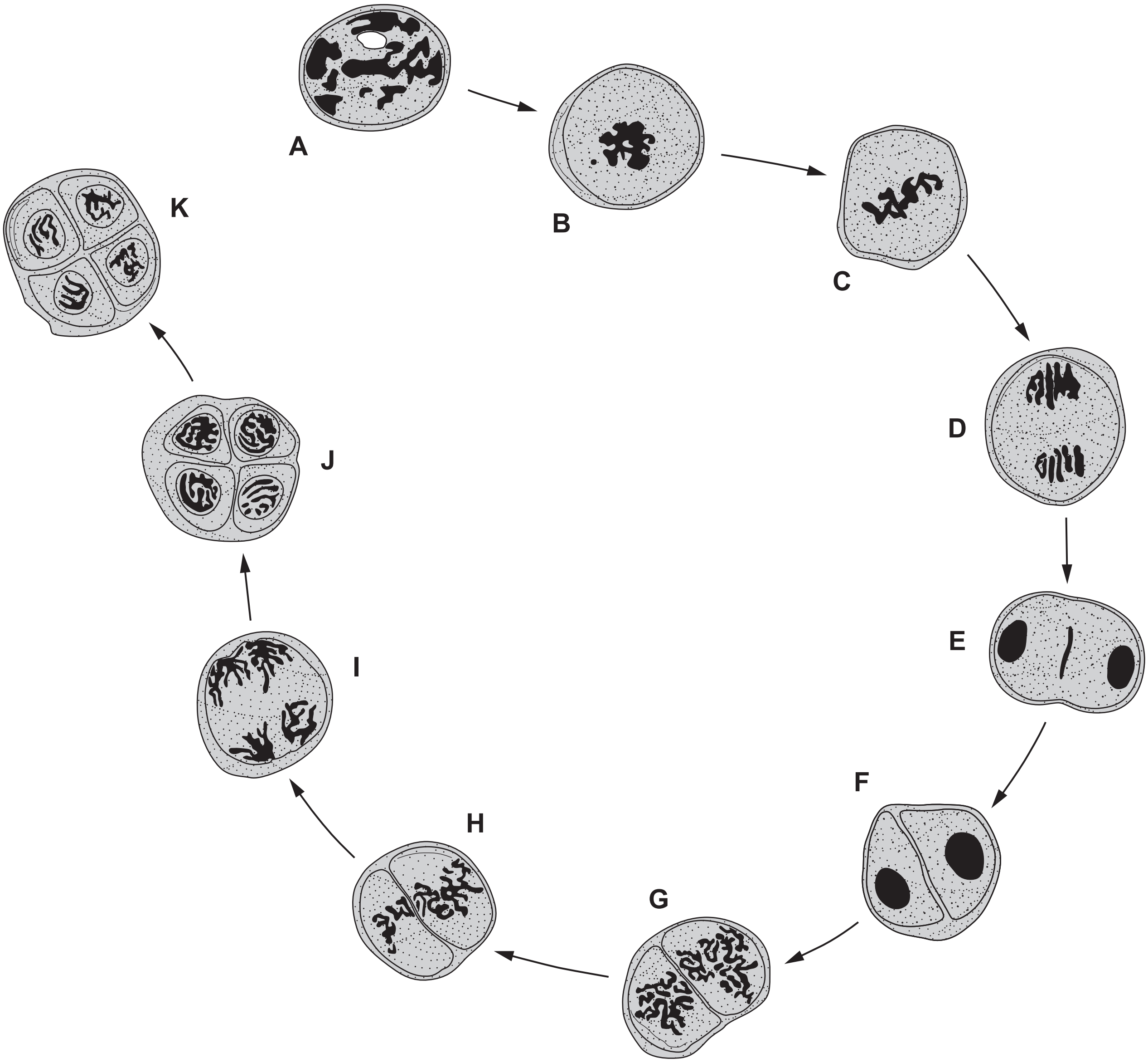
3. Pollen grain formation in flowering plants involves both mitosis and meiosis. **Image 3.1** shows stages in the formation of pollen grains in a species of lily *(Lilium sp.)* by meiosis.

Image 3.1



(a) Using your knowledge of meiosis and pollen grain formation, identify which stage labelled **A** to **K** shows the following events: [3]

I. the chromosomes from each homologous pair (composed of two chromatids) are pulled to opposite poles; ....

II. reformation of the nuclear membranes around the male gametic nuclei; ....

III. pairs of homologous chromosomes forming bivalents are arranged across the equator of the spindle apparatus. ....

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(b) Gametogenesis in male mammals follows a similar pattern to that shown in **image 3.1**.

(i) Describe **two** ways in which meiosis in an animal is different from meiosis in a plant. [2]

I. ....

....

II. ....

....

(ii) Name the cells produced in spermatogenesis in a mammal that are at the same stage of meiosis as the following stages in the formation of pollen grains in **image 3.1**. [3]

A ....

F ....

K ....

(iii) In mitosis, the cells formed during cytokinesis would re-enter the cell cycle. Explain why this does not occur following the production of sperm cells. [1]

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(c) *Lilium sp.* have a diploid number of 12 chromosomes. The number of combinations of chromosomes in the gametes of a species can differ due to independent assortment of chromosomes and can be calculated as:

$$2^n \text{ where } \mathbf{n} = \text{haploid number}$$

In addition to crossing over, independent assortment also increases genetic variation.

(i) Calculate the number of different gametes that can be produced by *Lilium sp.* due to different combinations of chromosomes alone. [2]

number of gametes = ...

(ii) Name the stage(s) of meiosis where independent assortment can occur. [1]

....

(iii) Apart from mutation, name **one** *other* source of genetic variation during sexual reproduction that does not result from meiosis. [1]

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(d) Apple trees produce pollen grains that are chemically self-incompatible with their own stigmas. To produce apples their flowers must be pollinated by pollen from a different variety of apple tree.

Flowering, including pollen production and the development of receptive stigmas, is triggered in some varieties of apple by warmer air temperatures but in others is triggered by increasing day length between March and June.

Cross-pollination often occurs between a variety in which flowering is triggered by longer day length and a variety in which flowering is triggered by warmer temperatures.

Using this information, conclude why commercial apple growers in the UK are concerned that crossing the climate change boundary could result in a lower yield of apples. [4]

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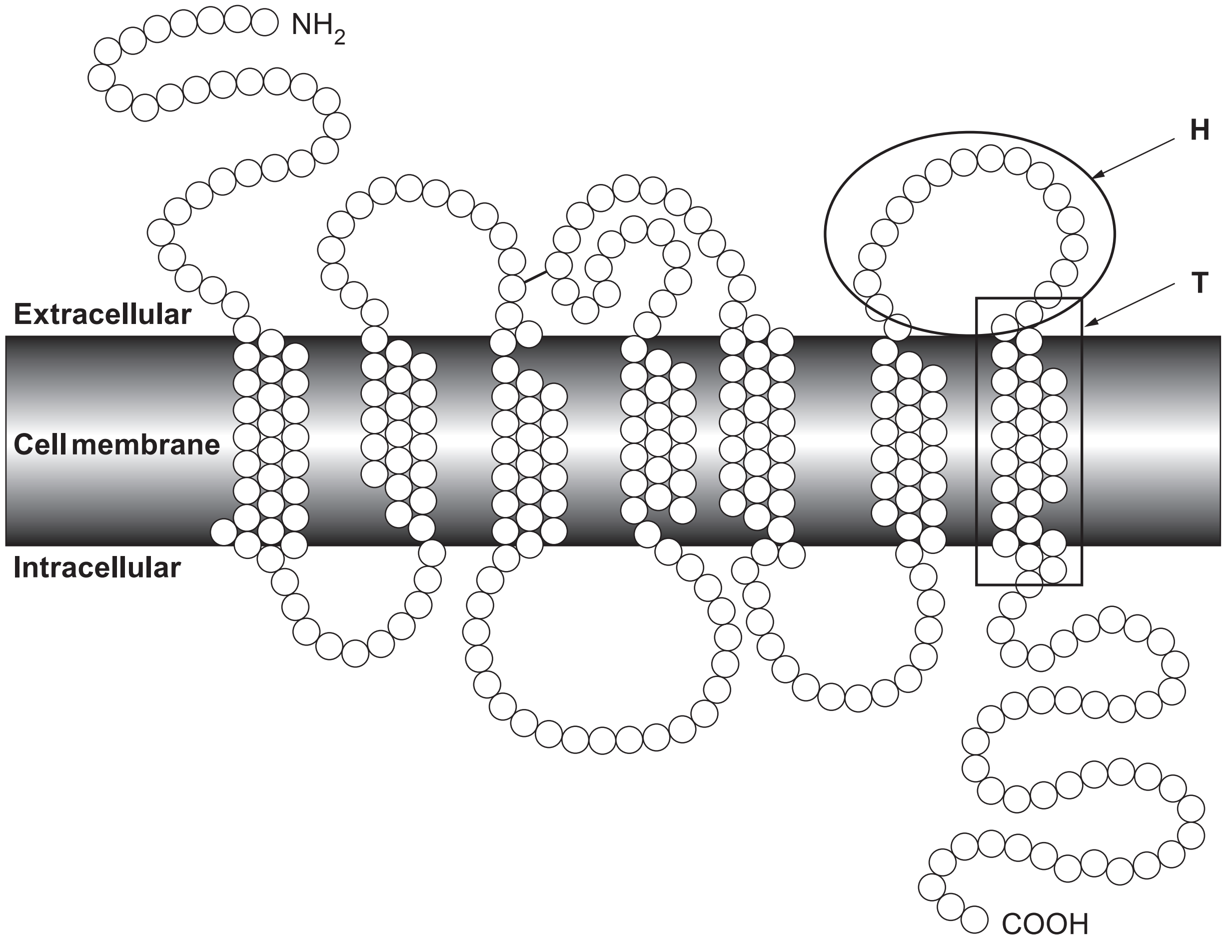
4. RhD is a glycoprotein embedded in the cell membranes of red blood cells.

Image 4.1 shows the amino acids of the RhD glycoprotein and its position in the cell membrane of red blood cells.

Image 4.1



(a) (i) One trans-membrane part of the protein, labelled **T** on **image 4.1**, is in the form of an alpha helix. State the level of protein structure present in an alpha helix and describe how this structure is maintained. [2]

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(ii) State whether the region of the protein labelled **H** on **image 4.1** contains amino acids which are hydrophobic or hydrophilic. Explain your answer. [2]

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The presence or absence of the RhD protein is controlled by a gene with two alleles:
D – the presence of RhD, and **d** – the absence of RhD.

If a woman who is rhesus negative (genotype **dd**) becomes pregnant with a child who carries a dominant allele for RhD, the mother will develop an immune response against the RhD protein from the foetus. Antibodies against RhD can cross the placenta and potentially kill the foetus.

Pre-natal testing of the foetus to determine its blood group can now be carried out by analysing the mother's blood. Some foetal DNA passes into the mother's blood and if the allele for RhD is detected doctors know that the foetus is at risk.

(b) (i) Explain why a blood test is preferable to either sampling the amniotic fluid surrounding the foetus or sampling tissue from the placenta (chorionic villus sampling). [2]

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(ii) In Europe, the proportion of the populations of both women and men who are rhesus negative is 0.16. Use the Hardy-Weinberg equations to answer the questions that follow.

$$p + q = 1$$
$$p^2 + 2pq + q^2 = 1$$

I. Determine the proportion of the population in Europe who are homozygous dominant. [2]

Proportion of population who are homozygous dominant = ...

II. Determine the proportion of the population in Europe who are heterozygous for RhD. [1]

Proportion of population who are heterozygous for RhD = ...

Examiner only

III. State the percentage of men in Europe who could not produce a rhesus positive child with a rhesus negative woman. [1]

Percentage = ...

(iii) The Hardy-Weinberg principle states that the frequencies of dominant and recessive alleles and genotypes will remain constant from one generation to the next under certain conditions which include:

- a large population;
- no selection for or against any phenotype;
- the population is isolated.

Pre-natal testing enables doctors to treat rhesus positive babies carried by rhesus negative mothers before or shortly after birth and save the lives of these children.

Using the information provided, conclude why the allele frequencies for **D** and **d** are not constant in Europe. [2]

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5. Mendel investigated the inheritance of characteristics of pea plants. He formulated two laws of inheritance:

Law of segregation	During gamete formation, the alleles for each gene segregate from each other so that each gamete carries only one allele for each gene.
Law of independent assortment	Genes for different traits can segregate independently during the formation of gametes.

Mendel found that:

- the allele for tall plants (**T**) is dominant to that for short plants (**t**)
- the allele for purple flowers (**P**) is dominant to that for red flowers (**p**).

(a) (i) Based on these laws, state the phenotypes and the ratios you would expect in the offspring following a cross between the following parent plants:

I. both plants heterozygous for height of plant – **Tt**: [1]

Phenotypes ....

Ratio ....

II. both plants heterozygous for height and flower colour – **Tt Pp**: [1]

Phenotypes ....

....

Ratio ....

(ii) State what is meant by the term *linkage* and explain why Mendel's law of independent assortment only applies if the genes are not linked. [2]

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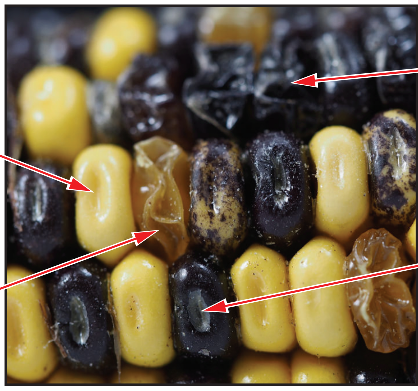
(b) Corn cobs were produced by crossing parent plants that were heterozygous for both colour and appearance of the seeds. The phenotypes in the F_1 can be seen in **image 5.1**.

Image 5.1



Key: purple **A** – dominant smooth **B** – dominant
yellow **a** – recessive wrinkled **b** – recessive

Complete the following genetic cross to show how the different genotypes resulting in these phenotypes could have been inherited. [5]

Parent phenotypes: .... × ....

Parent genotypes: .... × ....

Gametes: .... × ....

F_1 phenotypes:	purple smooth	purple wrinkled	yellow smooth	yellow wrinkled
F_1 genotypes:	....	....	....	....
	....	....	....	....
	....	....	....	....
	....	....	....	....

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(c) The phenotypes of a sample of 400 seeds were recorded as shown in **table 5.2**.

Table 5.2

phenotype	**number in sample**
purple; smooth	201
purple; wrinkled	84
yellow; smooth	81
yellow; wrinkled	34

A Chi^2 test was carried out to determine whether the results of this cross followed Mendel's law of independent assortment.

(i) State the null hypothesis for this test. [1]

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(ii) Complete the table below to calculate the Chi^2 statistic for these data. [3]

phenotype	observed numbers O	expected numbers E	$O-E$	$(O-E)^2$	$\frac{(O-E)^2}{E}$
purple; smooth	201				
purple; wrinkled	84				
yellow; smooth	81				
yellow; wrinkled	34				
Total	400				$\sum =$

$$\text{Chi}^2 = \sum \frac{(O-E)^2}{E}$$

$\text{Chi}^2 =$ ....

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The probability table for the Chi^2 statistic is shown in **table 5.3** below.

Table 5.3

Degrees of freedom	**Probability**									
	0.90	**0.80**	**0.70**	**0.50**	**0.30**	**0.20**	**0.10**	**0.05**	**0.02**	**0.01**
1	0.02	0.064	0.15	0.46	1.07	1.64	2.71	3.84	5.41	6.64
2	0.21	0.45	0.71	1.39	2.41	3.22	4.61	5.99	7.82	9.21
3	0.58	1.01	1.42	2.37	3.67	4.64	6.25	7.82	9.84	11.34
4	1.61	2.34	3.00	4.35	6.06	7.29	9.24	11.07	13.39	15.09

(iii) Based on these data the hypothesis was accepted but with low confidence. Use your calculated value of Chi^2 and data from **table 5.3** to explain this conclusion. [5]

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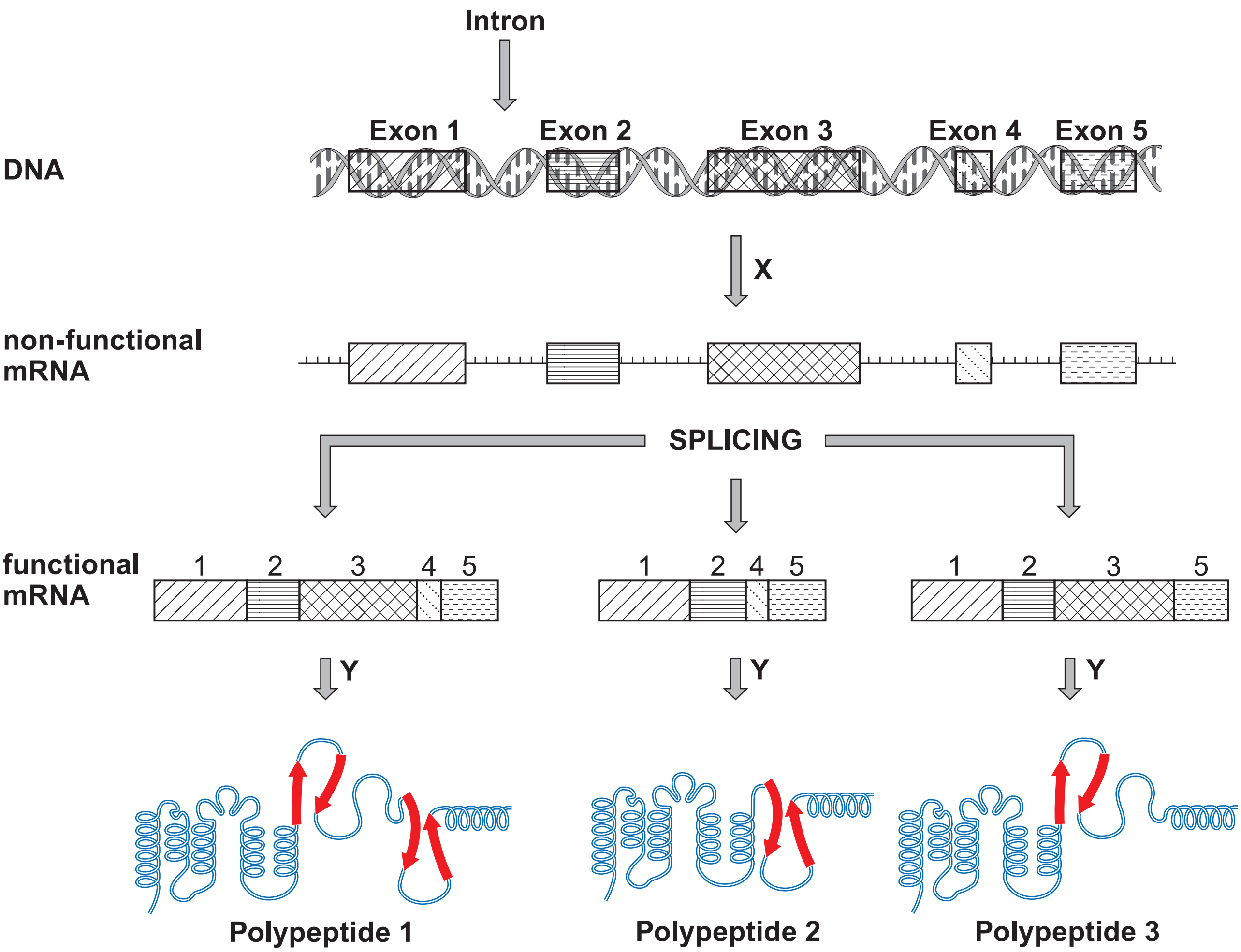
6. Most genes are made up of **exons** and **introns**. It was originally believed that the genetic code for one protein was carried by a single gene. This theory was later changed to the 'one gene – one polypeptide' hypothesis.

Image 6.1 shows the process of converting the genetic code of a single gene into polypeptides.

Image 6.1



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(a) (i) Name processes **X** and **Y** involved in the production of polypeptides **1**, **2** and **3**. [1]

X ....

Y ....

(ii) Explain how the information shown in **image 6.1** disproves the 'one gene – one polypeptide' hypothesis. [1]

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(iii) Explain why a mutation in an exon might **not** affect the primary structure of a protein. [1]

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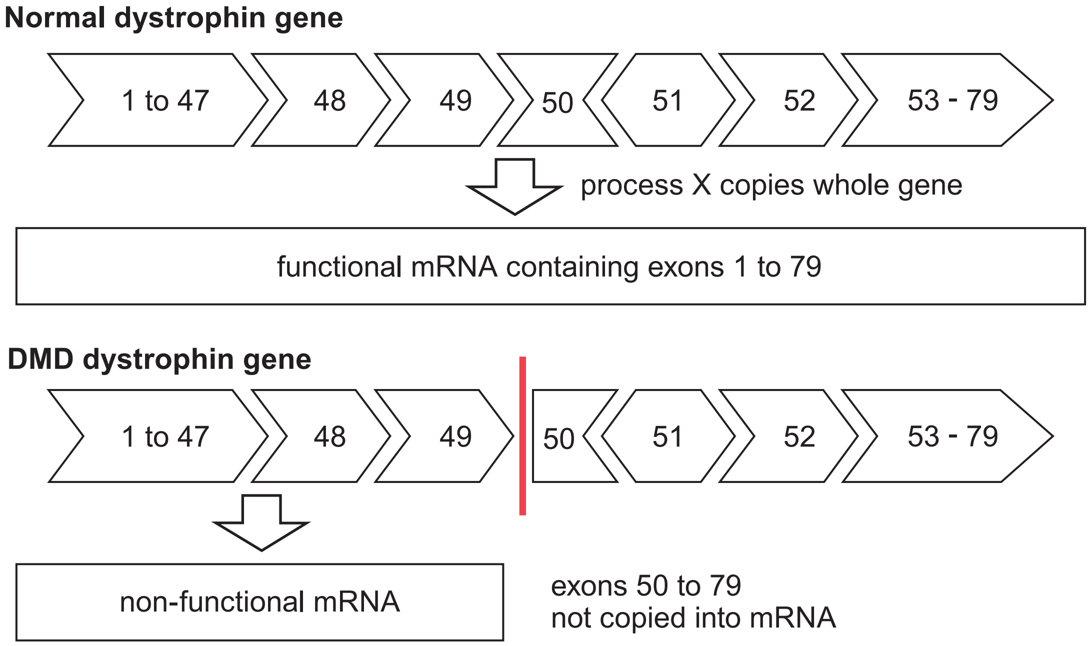
Examiner only

(b) Muscular dystrophy is caused by mutations to the gene coding for dystrophin which is found in the cell membranes of muscle cells. The dystrophin gene is the largest gene found in the human genome containing 79 exons separated by introns.

In Duchenne Muscular Dystrophy (DMD) a mutation in exon 50 prevents synthesis of the functional form of dystrophin. This is shown in **image 6.2**. Note: the shapes of the exons show whether they are able to bind to each other during splicing.

Image 6.2



Describe how functional mRNA for dystrophin is produced and suggest why the mutation to exon 50 results in a shorter form of dystrophin in a person with DMD. [5]

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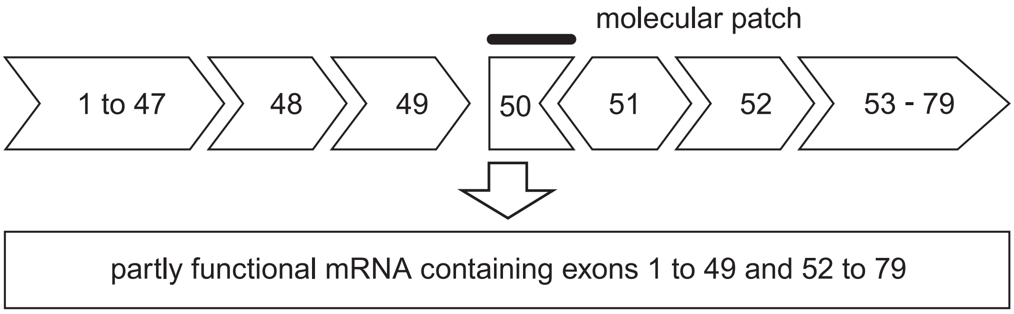
(c) One type of therapy that has been trialled is the use of a **molecular patch** that binds to exon 50. This results in the synthesis of dystrophin which is only slightly shorter than normal and is almost fully functional as shown in **image 6.3**.

Image 6.3



(i) Suggest why the mRNA produced does not contain exon 51 even though the mutation is in exon 50. [1]

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(ii) Suggest why a person treated with a molecular patch to reduce the symptoms of DMD would still be able to pass on the mutation to the next generation. [1]

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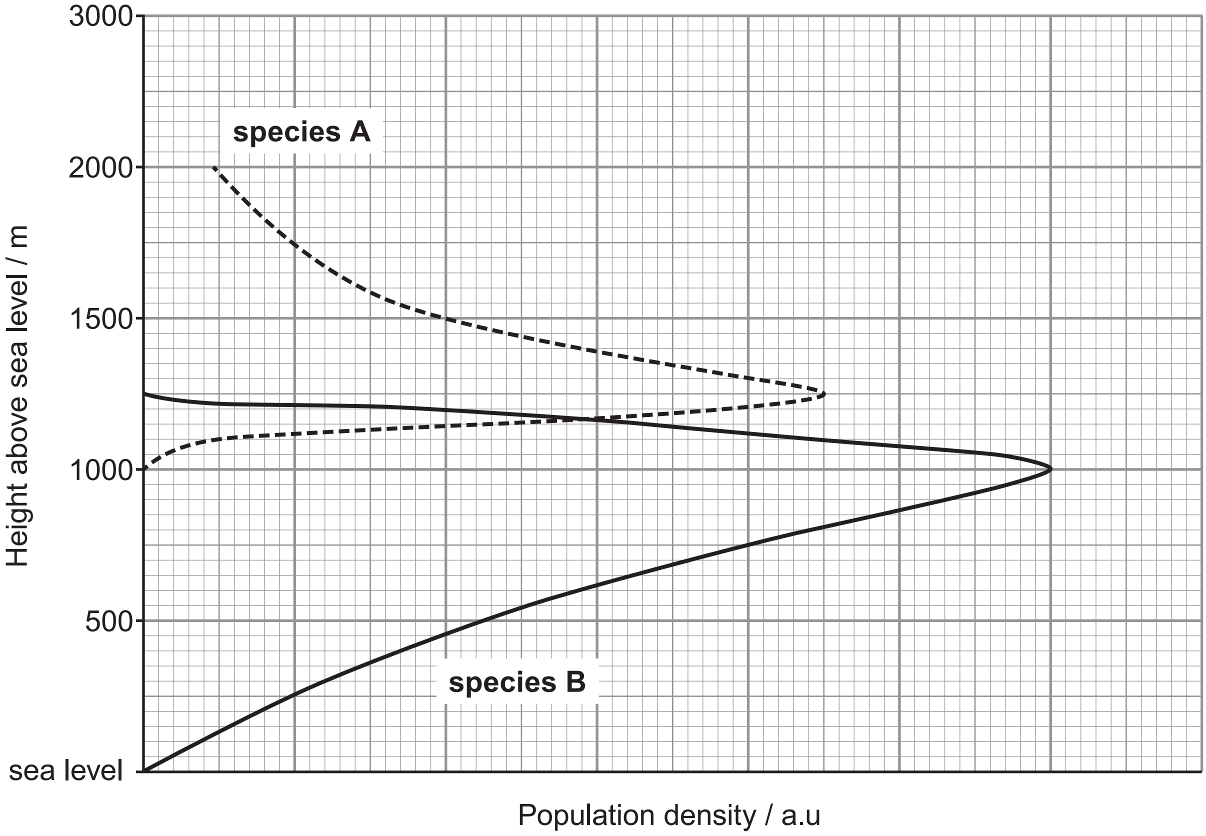
7. **Image 7.1** shows the population densities of two species of closely related birds at different heights above sea level in a mountain range in the USA.

Image 7.1



(a) (i) State the main type of competition present: [1]

I. at 800 m ....

II. between 1 000 m and 1 250 m ....

(ii) Identify **three** density dependent factors which could affect the distribution and population densities of these bird species between 1 000 m and 1 250 m above sea level. [2]

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Examiner only

(iii) Species **A** has haemoglobin with a slightly higher oxygen affinity than species **B**. Explain **one** advantage and **one** disadvantage of this to species **A**. [3]

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(b) DNA analysis of the genes which code for haemoglobin has shown that the birds evolved into different species less than 10000 years ago.

(i) Use the information given and your own knowledge to explain how **natural selection** could account for the evolution of these two species from their common ancestor. [3]

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(ii) Explain why the evolution of these two species from the same common ancestor is an example of sympatric speciation. [2]

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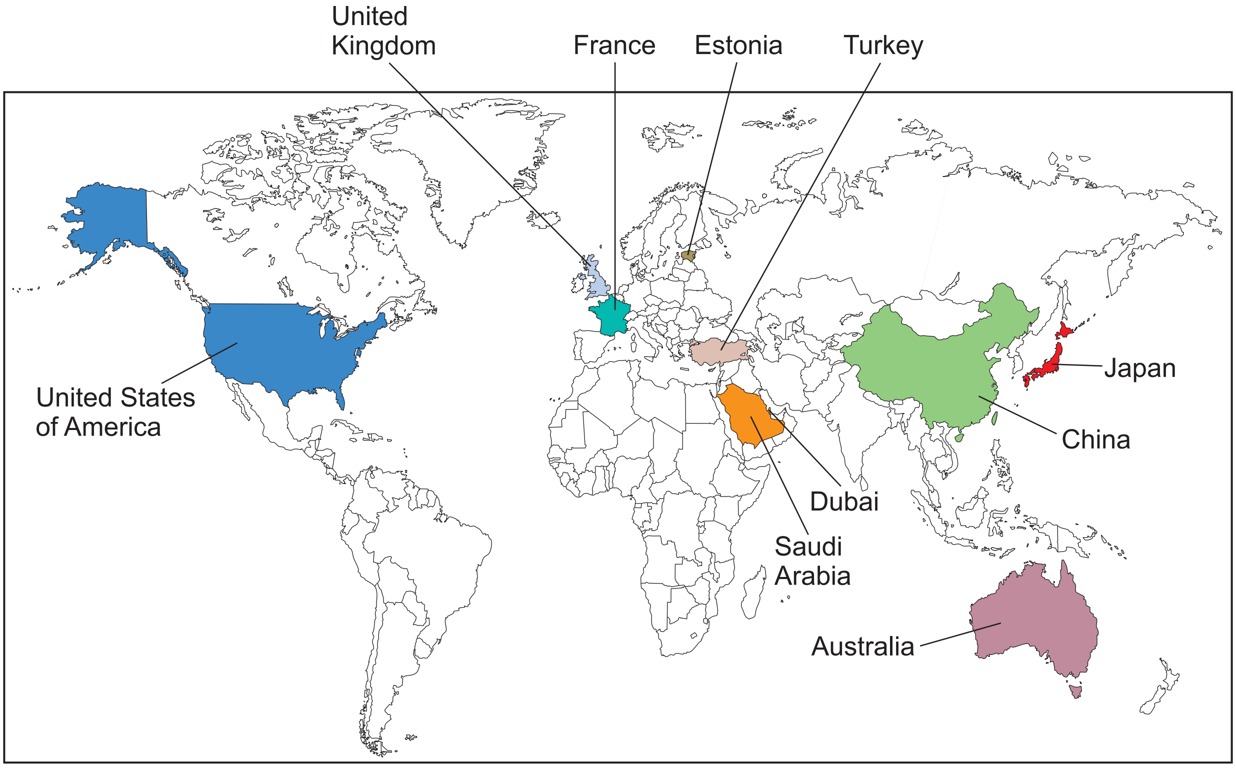
Examiner only

8. Read the passage below and then answer the questions that follow.

The purpose of the original Human Genome Project was to improve our knowledge and understanding of genetic disorders. The original study was based on the analysis of DNA from a small number of anonymous donors from Europe.

Since then, 100K projects have been set up in 10 areas around the world, as shown in **image 8.1**. These projects aim to sequence the genomes of 100 000 people with rare genetic disease or cancers.

Image 8.1



Projects have also been set up to sequence the genomes of the mosquito, *Anopheles gambiae* and the *Plasmodium* parasite that it transmits. Malaria is responsible for over a million deaths each year.

Describe how the findings of the Human Genome Project could improve the treatment of human disease and suggest why the findings of the original project may be of limited use.

Explain why the 100K projects will eventually provide more valuable information and suggest why more projects need to be set up to improve treatment of humans on a worldwide basis.

Suggest why some countries may have invested more money into sequencing the genomes of both the malaria parasite and its vector rather than funding 100K projects. [9 QER]

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END OF PAPER

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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