A-Level
BIOLOGY

Genetics, Populations, Control of Gene Expression

Total number of marks: 48

| 0 8 . 2 | Scientists investigated the genetic diversity between several species of sweet potato. They studied non-coding multiple repeats of base sequences.

Define 'non-coding base sequences' and describe where the non-coding multiple repeats are positioned in the genome.

Non-coding base sequences do not code for amino acids. Non-coding **[2 marks]**
multiple repeats can be found in between genes.

The percentage similarities in the non-coding multiple repeats of base sequences of four species of sweet potato are shown in **Table 3**.

Table 3

Species of sweet potato	Percentage similarity between non-coding multiple repeat base sequences			
	C	L	R	T
C		53.5	25.7	59.7
L	53.5		33.4	53.7
R	25.7	33.4		36.6
T	59.7	53.7	36.6	

| 0 8 . 3 | Use the information in **Table 3** to complete the phylogenetic tree shown in **Figure 8**.

Write the letter that represents the correct species into each box.

[1 mark]

Figure 8
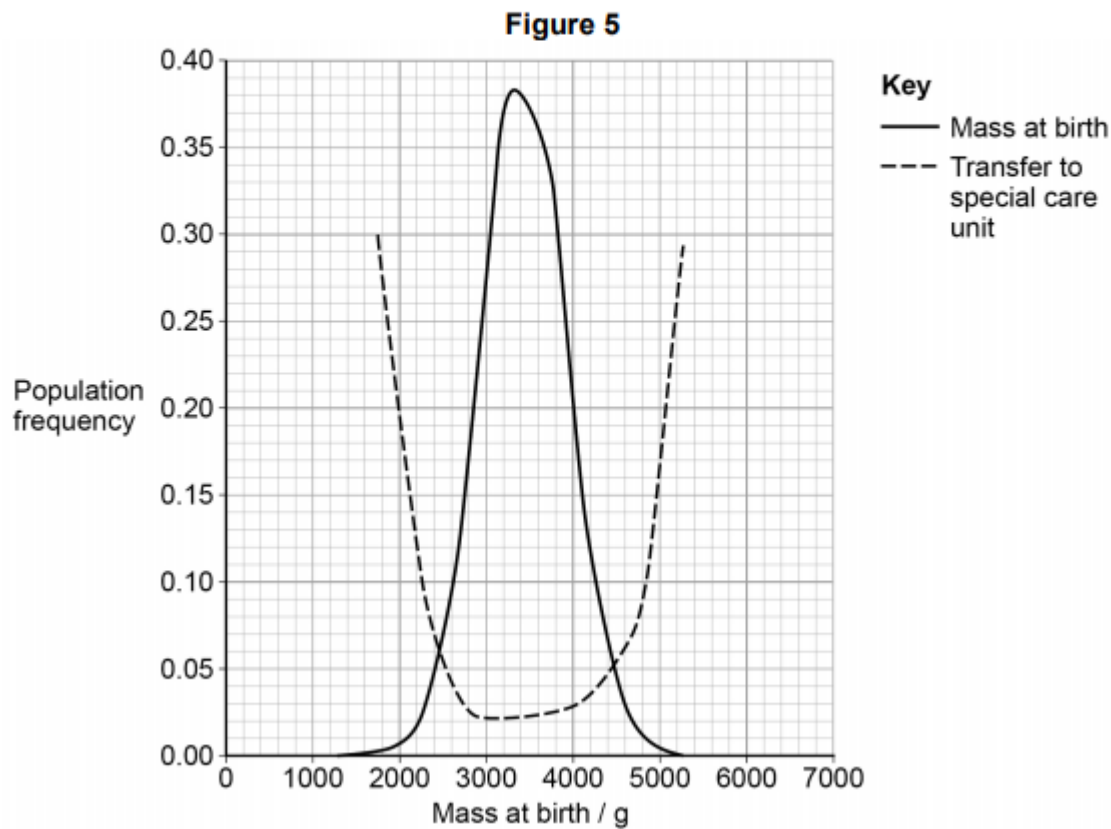

Historical time,
years before present
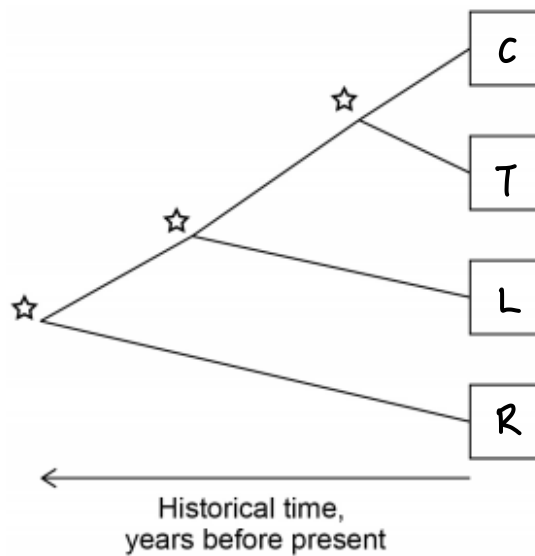
Key

☆ Common ancestor of
the species to the right

Scientists collected data on 800 000 human births. The data showed the mass of each baby at birth and whether the baby needed to be transferred to a special care unit for very ill babies.

Their results are shown in **Figure 5**.

Figure 5

Key
— Mass at birth
--- Transfer to special care unit

Population frequency (y-axis)
Mass at birth / g (x-axis)

| 0 4 |.| 1 | Use **Figure 5** to explain how human mass at birth is affected by stabilising selection.
[3 marks]

Stabilising selection selects against very low birth mass and very high birth mass. For babies with a mass below 3000g or above 4000g, there is a high population frequency of those transferred to special care unit. They have a lower chance of survival so it is less likely that their alleles will be passed on. Therefore the alleles for very low/very high birth mass will have a low frequency in the population.

| 0 | 4 | . | 2 | The scientists studied the effect of one form, *KIR2DS1*, of the human *KIR* gene on mass at birth.

In the following passage the numbered spaces can be filled with biological terms.

KIR2DS1 is an _____(1)_____ of the *KIR* gene, found at a _____(2)_____ on chromosome 19. *KIR2DS1* is 14 021 bases long and is _____(3)_____ into mRNA that is 1101 bases long. This mRNA is then _____(4)_____ into a polypeptide 304 amino acids long. The polypeptide is then modified in the organelle,_____(5)_____, before forming its functional _____(6)_____ protein structure.

Write the correct biological term beside each number below, that matches the space in the passage.

[3 marks]

(1) __allele__

(2) __locus__

(3) __transcribed__

(4) __translated__

(5) __Golgi apparatus__

(6) __tertiary__

Table 1 shows mRNA codons and the amino acids coded for by each codon. It also shows some properties of the R group of each amino acid.

Table 1

1st base	2nd base				3rd base
	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
					C
	Leu		Stop	Stop	A
				Trp	G
C	Leu	Pro	His	Arg	U
					C
			Gln		A
					G
A	Ile	Thr	Asn	Ser	U
					C
			Lys	Arg	A
	Met				G
G	Val	Ala	Asp	Gly	U
					C
			Glu		A
					G

Key to the properties of the R group of each amino acid

- No overall charge
- Positively charged
- Negatively charged

0 5 . 2 The genetic code is described as degenerate.

What is meant by this? Use an example from **Table 1** to illustrate your answer.

[2 marks]

The same amino acid is coded by different codons. For example, cysteine can be coded by UGU and UGC.

1 0 . 1 Describe how mRNA is formed by transcription in eukaryotes.

[5 marks]

(see next page)

1 0 . 3 Define 'gene mutation' and explain how a gene mutation can have:

- no effect on an individual
- a positive effect on an individual.

[4 marks]

A gene mutation is when there is a change in DNA nucleotide sequence. This can be a substitution, insertion or deletion.

Gene mutation can have no effects when it is in the non-coding region or when a substituted base sequence still codes for the same amino acid.

Gene mutation can also lead to the production of a different protein which helps the organism to survive better.

10.1 In the nucleus, DNA unwinds to form a transcription bubble with exposed bases. The hydrogen bonds between complementary bases were broken. Free RNA nucleotides form hydrogen bonds with their complementary bases on the template strand. RNA polymerase joins the nucleotides by forming the sugar-phosphate backbone. Hydrogen bonds between mRNA and the template strand are broken at the end of transcription and the DNA molecule reforms into a double helix. mRNA is transported out of the nucleus via nuclear pores.

In women, the first division of meiosis produces one daughter cell that has almost all of the cytoplasm. The other daughter cell consists of a nucleus surrounded by a very small amount of cytoplasm and a cell-surface membrane. This very small daughter cell is called a polar body. Polar bodies do not usually divide. The same process occurs in the second division of meiosis, resulting in one egg cell and two polar bodies.

The diagram in **Figure 3** shows the formation of an egg cell and two polar bodies during meiosis. It also shows what happens to one pair of homologous chromosomes. This pair carries two alleles of gene A.

Figure 3
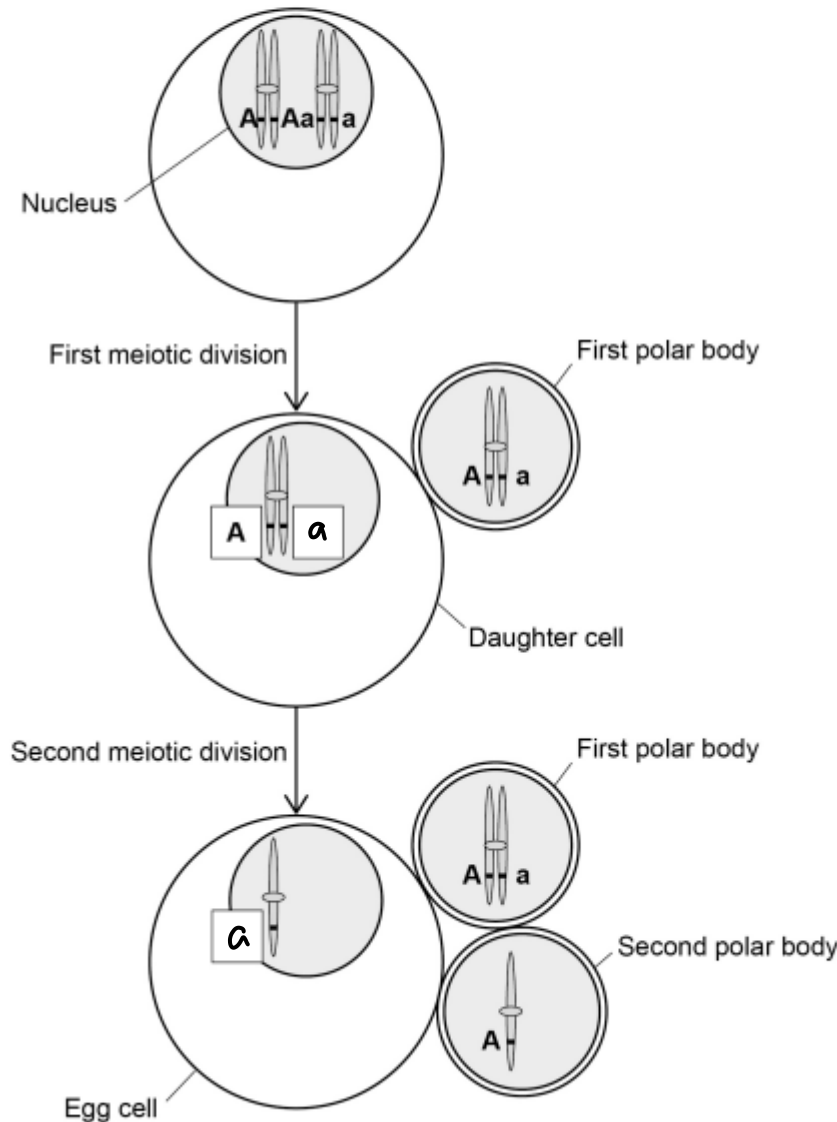
Not to scale

0 3 . 1 Complete **Figure 3** by putting **A** or **a** in the boxes. One box has been completed for you with **A**.

[1 mark]

0 3 . 2 Put a tick (✔) in the box next to the name of the process that produced the combination of alleles on the chromosome in the first polar body in **Figure 3**.

[1 mark]

Anaphase ☐

Crossing over ✔

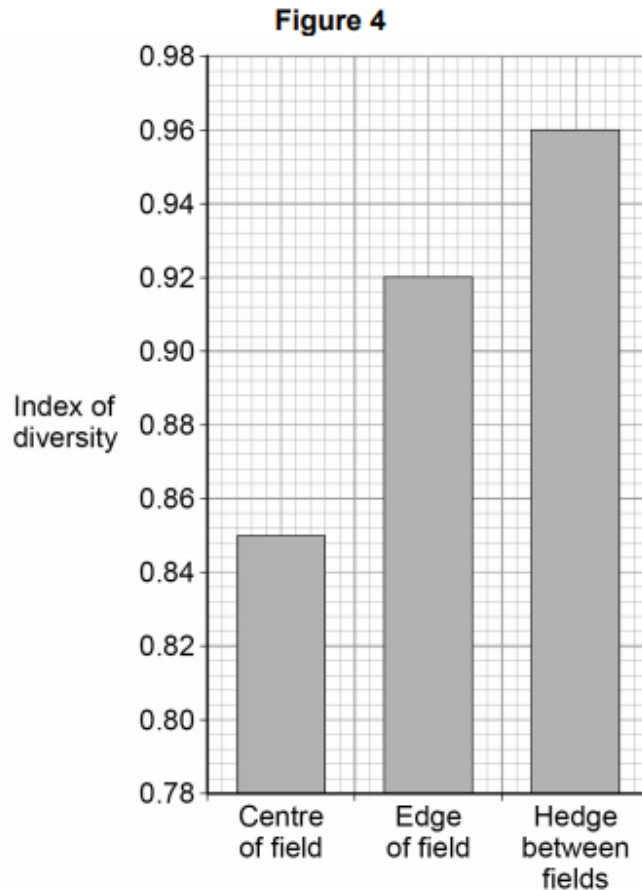Independent assortment ☐

Semi-conservative replication ☐

0 3 A group of students investigated biodiversity of different areas of farmland.
They collected data in each of these habitats:

- the centre of a field
- the edge of a field
- a hedge between fields.

Their results are shown in **Figure 4**.

Figure 4

0 3 . 1 What data would the students need to collect to calculate their index of diversity in each habitat?

Do **not** include apparatus used for species sampling in your answer.
[1 mark]

Total number of organisms in the community and number of organisms for a single species.

0 3 . 2 Give **two** ways the students would have ensured their index of diversity was representative of each habitat.
[2 marks]

use random sampling and collect data from more areas.

0 3 . 3 Modern farming techniques have led to larger fields and the removal of hedges between fields.

Use **Figure 4** to suggest why biodiversity decreases when farmers use larger fields.
[1 mark]

The centre of the field, which has low biodiversity, will account for a greater area. Hedges between fields, which have high biodiversity are removed, so overall the biodiversity decreases.

0 3 . 4 Farmers are now being encouraged to replant hedges on their land.

Suggest and explain **one** advantage and **one** disadvantage to a farmer of replanting hedges on her farmland.

Advantage: biodiversity increases as there is a larger area for different species to grow

[2 marks]

Disadvantage : there might be more weed which competes with the crop, so yield decreases.
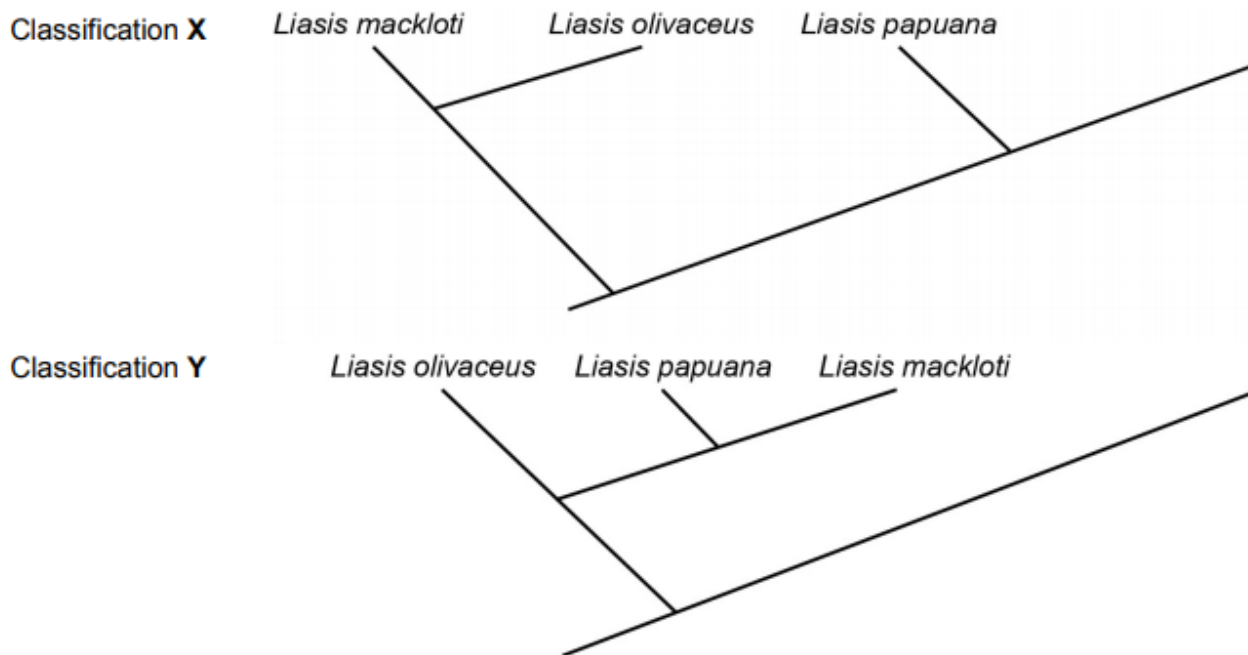
0 8 **Figure 3** shows two different ways of classifying the same three species of snake.

- Classification **X** is based on the frequency of observable characteristics
- Classification **Y** is based on other comparisons of genetic characteristics.

All three species of snake belong to the Python family.

Figure 3

Classification **X**   *Liasis mackloti*   *Liasis olivaceus*   *Liasis papuana*

Classification **Y**   *Liasis olivaceus*   *Liasis papuana*   *Liasis mackloti*

0 8 . 1 What do these classifications suggest about the evolutionary relationships between these species of snake?

[2 marks]

Classification X suggests that based on observable characteristics, Liasis mackloti and Liasis olivaceus has a more recent common ancestor.

Classification Y suggests that based on genetic analysis Liasis olivaceus and Liasis papuana has a more recent common ancestor.

0 8 . 2 Complete **Table 4** below to show the missing names of the taxa when classifying these snakes.

[1 mark]

Table 4

Taxon (hierarchical order)	Name
Domain	Eukaryote
Kingdom	Animal
Phylum	Chordata
Class	Reptilia
Order	Squamata
Family	Python

0 8 . 3 There is a debate about the name of one of these species of snake. Some scientists name it *Liasis papuana* and other scientists name it *Apodora papuana*.

Give the name of the taxon about which the scientists disagree.

[1 mark]

genus

In a species of flowering plant, the **T** allele for tallness is dominant to the **t** allele for dwarfness. In the same species, two alleles **C^R** (red) and **C^W** (white) code for the colour of flowers. When homozygous red-flowered plants were crossed with homozygous white-flowered plants, all the offspring had pink flowers.

0 6 . 2 Name the relationship between the two alleles that code for flower colour.
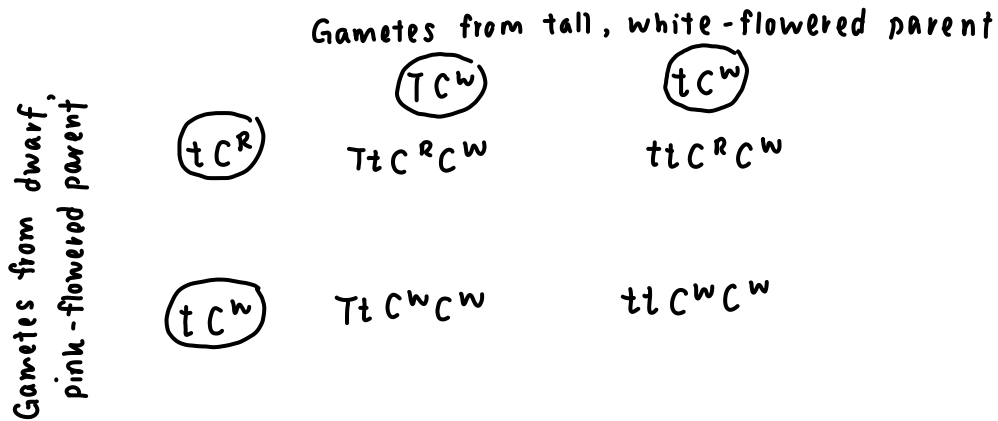
[1 mark]

codominant

0 6 . 3 A dwarf, pink-flowered plant was crossed with a heterozygous tall,
white-flowered plant.

Complete the genetic diagram to show all the possible genotypes and the ratio of
phenotypes expected in the offspring of this cross.

[3 marks]

Phenotypes of parents: Dwarf, pink-flowered   ×   Tall, white-flowered

Genotypes of parents: $tt\,C^R C^W$ $Tt\,C^W C^W$

Gametes from tall, white-flowered parent

$(T C^W)$ $(t C^W)$

Gametes from dwarf, pink-flowered parent

$(t C^R)$ $Tt\,C^R C^W$ $tt\,C^R C^W$

$(t C^W)$ $Tt\,C^W C^W$ $tt\,C^W C^W$

Genotypes of offspring: $Tt\,C^R C^W$, $tt\,C^R C^W$, $Tt\,C^W C^W$, $tt\,C^W C^W$

Phenotypes of offspring: tall & pink-flowered   , dwarfed & pink-flowered ,

tall & white-flowered , dwarfed & white flowered

Ratio of phenotypes: 1   :   1   :   1   :   1

0 1 . 1 Describe how a **non-competitive** inhibitor can reduce the rate of an
enzyme-controlled reaction. Non-competitive inhibitors bind to an alternative site on the
enzyme and changes its active site shape so that it is no longer complementary to the substrate.
[3 marks]

0 9 A scientist produced transgenic zebrafish. This prevents substrate binding & ES complexes
forming. Increasing substrate concentration does
not remove inhibition.

She obtained a gene from silverside fish. The gene codes for a
growth hormone (GH).

She inserted copies of this *GH* gene into plasmids. She then microinjected these
recombinant plasmids into fertilised egg cells of zebrafish.

0 9 . 1 Describe how enzymes could be used to insert the *GH* gene into a plasmid.
[2 marks]
Restriction enzymes are used to create sticky ends
on the GH gene. Ligase enzymes joins the GH gene, marker gene
and plasmid to form the recombinant plasmid.

0 9 . 2 Microinjection of DNA into fertilised egg cells is a frequent method of producing transgenic fish. However, the insertion of the transferred gene into nuclear DNA may be delayed. Consequently, the offspring of transgenic fish may not possess the desired characteristic.

Suggest and explain how delayed insertion of the *GH* gene could produce offspring of transgenic fish without the desired characteristic.

[2 marks]

The fertilised egg cells might have already divided by mitosis before the transferred gene is inserted. Not all cells will carry the transferred gene.

The scientist investigated whether the transferred *GH* gene increased the growth of transgenic zebrafish. She microinjected 2000 fertilised egg cells with the *GH* plasmid and left 2000 fertilised egg cells untreated. After 12 months, she determined the mean mass of the transgenic and non-transgenic fish.

The results the scientist obtained are shown in **Table 3**.

Table 3

A value of ±2 × SD from the mean includes over 95% of the data.

Type of zebrafish	Mean mass of zebrafish / g (± 2 × SD)
Transgenic	1.79 (± 0.37)
Non-transgenic	0.68 (± 0.13)

0 9 . 3 Using **Table 3**, what can you conclude about the effectiveness of the *GH* gene on the growth of zebrafish?

[2 marks]

The mean mass of transgenic zebrafish is 1.11g higher than non-transgenic zebrafish. The standard deviations do not overlap suggesting that the difference is significant and the GH gene is effective in promoting growth of the zebra fish

0 9 . 4 Explain how **two** features of the design of this investigation helped to ensure the validity of any conclusions obtained.

Do **not** include calculating the mean or SD in your answer.

[2 marks]

A large number of fertilised egg cells (2000) were used in each group. The mean mass was only measured after 12 months so there is more time for the effects of the gene to be shown.