HL Paper 2

a.i. Nucleosomes help to regulate transcription in eukaryotes. [1]

State the components of a nucleosome.

a.ii. Nucleosomes help to regulate transcription in eukaryotes. [1]

State a chemical modification of a nucleosome that could impact gene expression.

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a. Distinguish between RNA and DNA. [3]

b. Explain the process of DNA replication. [8]

c. Outline how enzymes catalyse reactions. [7]

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a. Outline the action of enzymes. [4]

b. Explain the roles of specific enzymes in prokaryote DNA replication. [7]

c. Many genetic diseases are due to recessive alleles of autosomal genes that code for an enzyme. Using a Punnett grid, explain how parents who do not show signs of such a disease can produce a child with the disease. [4]

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a. Outline the structure and functions of nucleosomes. [4]

b. Explain how DNA is used to pass on genetic information to offspring accurately but also produce variation in species. [8]

c. Accurate transmission of base sequences to offspring depends on successful gamete production. Describe how spermatogenesis occurs in humans. [6]

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a. Describe the relationship between genes, polypeptides and enzymes. [4]

b. Outline control of metabolic pathways. [6]

In the red squirrel (*Tamiasciurus hudsonicus*), the allele for grey fur colour (G) is dominant to the allele for red fur colour (g) and the allele for a fluffy tail (F) is dominant to hairless tail (f).

a. The genes described above form a linkage group. Define *linkage group*. [1]

b. A cross is made between squirrels of the following genotypes. [2]

$$\frac{G\ F}{g\ f} \times \frac{g\ f}{g\ f}$$

Using a similar format, identify the genotypes of offspring which are recombinants.

c. Explain how the recombinants are formed during meiosis. [3]

d. Explain the role of transfer RNA (tRNA) in the process of translation. [2]

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a. Draw a labelled diagram of the ultrastructure of a prokaryote. [4]

b. Explain the process of DNA replication. [8]

c. Outline how the structure of the ribosome is related to its function in translation. [6]

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a. Draw a labelled diagram showing **two** different complementary pairs of nucleotides in a molecule of DNA. [4]

b. Outline the structure of nucleosomes. [2]

c. Explain primary structures and tertiary structures of an enzyme. [3]

Angiospermophyta are vascular flowering plants.

a. Describe the transport of organic compounds in vascular plants. [4]

b. The flowers of angiospermophyta are used for sexual reproduction. Outline **three** processes required for successful reproduction of angiospermophyta. [3]

c. Growth in living organisms includes replication of DNA. Explain DNA replication. [8]

a. Outline the structure of a ribosome. [4]

b. Distinguish between fibrous and globular proteins with reference to **one** example of each protein type. [6]

c. Auxin is a protein. Explain its role in phototropism. [8]

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b. Outline, with an example, the process of exocytosis. [5]

c. Translation occurs in living cells. Explain how translation is carried out, from the initiation stage onwards. [9]

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a. State **four** functions of proteins, giving a **named** example of each. [4]

b. Outline the structure of ribosomes. [6]

c. Explain the process of transcription leading to the formation of mRNA. [8]

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a. Outline the processes that occur during the first division of meiosis. [6]

b. Prior to cell division, chromosomes replicate. Explain the process of DNA replication in prokaryotes. [8]

c. Outline outcomes of the human genome project. [4]

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a. Most of the DNA of a human cell is contained in the nucleus. Distinguish between unique and highly repetitive sequences in nuclear DNA. [5]

b. Draw a labelled diagram to show **four** DNA nucleotides, each with a different base, linked together in **two** strands. [5]

c. Explain the methods and aims of DNA profiling. [8]

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a. Draw a labelled diagram of *Escherichia coli* as an example of a prokaryote. [4]

b. Explain the process of transcription in prokaryotes. [8]

c. Some prokaryotes cause infectious diseases which stimulate the body's immune system. Outline the principles that form the basis of immunity. [6]

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a. Nitrogen is part of many important substances in living organisms. [3]

Draw labelled diagrams to show a condensation reaction between two amino acids.

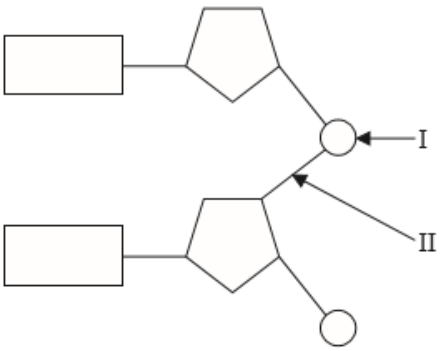
b. Nitrogen is part of many important substances in living organisms. [4]

Distinguish between transcription and translation.

c. Nitrogen is part of many important substances in living organisms. [8]

Explain how insects excrete nitrogenous wastes.

The diagram below shows two nucleotides linked together to form a dinucleotide.



a (i). Identify the chemical group labelled I. [1]

a (ii). State the type of bond labelled II. [1]

b. Distinguish between the sense and antisense strands of DNA during transcription. [1]

c. Compare the DNA found in prokaryotic cells and eukaryotic cells. [2]

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a. Draw a labelled diagram showing the ultra-structure of a liver cell. [4]

b. Distinguish between prokaryotic cells and eukaryotic cells. [6]

c. Explain prokaryotic DNA replication. [8]

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a. Define the terms *chromosome*, *gene*, *allele* and *genome*. [4]

b. Compare the genetic material of prokaryotes and eukaryotes. [6]

c. Explain the process of DNA replication. [8]

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a. Draw molecular diagrams to show the condensation reaction between two amino acids to form a dipeptide. [4]

b. Outline the roles of the different binding sites for tRNA on ribosomes during translation. [4]

c. Explain the production of antibodies. [7]

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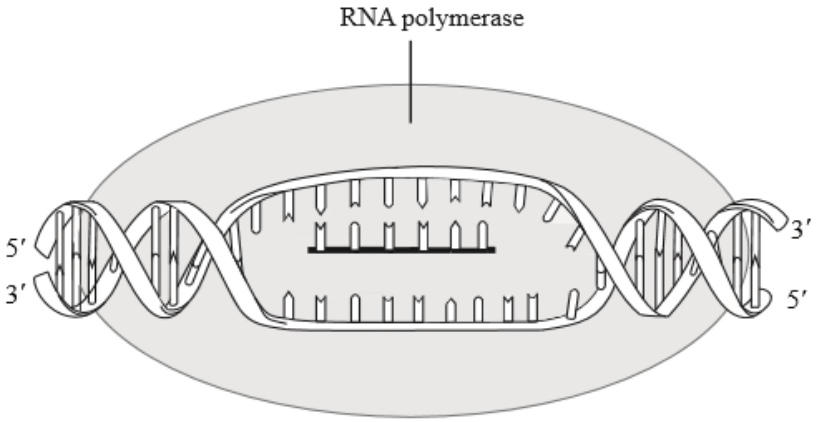
a. Cells go through a repeating cycle of events in growth regions such as plant root tips and animal embryos. Outline this cell cycle. [4]

b. Draw a labelled diagram of the formation of a chiasma by crossing over. [3]

c. Explain the control of gene expression in eukaryotes. [8]

The diagram below shows the process of transcription.



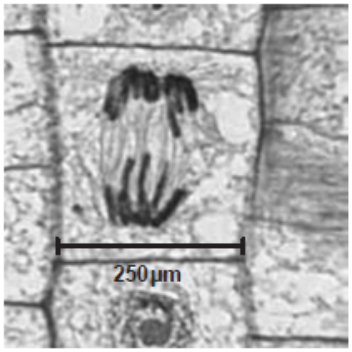
a. DNA replication involves a number of enzymes including DNA polymerase. Identify **one** other enzyme involved in DNA replication. [1]

b. Explain the role of Okazaki fragments in DNA replication. [2]

c (i) Label the sense and antisense strands. [1]

c (ii) Draw an arrow on the diagram to show where the next nucleotide will be added to the growing mRNA strand. [1]

The micrograph shows a cell from the root of an onion (*Allium cepa*) during mitosis.



[Source: adapted from http://img.ehowcdn.com]

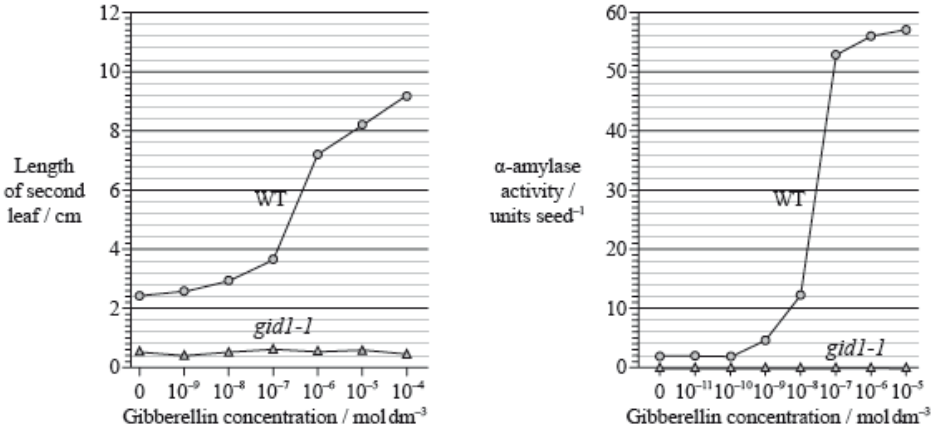
a(i). Calculate the magnification of the image. [1]

a(ii) Deduce the stage of mitosis shown in the micrograph. [1]

a(iii) The onion (*Allium cepa)* is an angiospermophyte. The honey bee (*Apis mellifera*) is an arthropod. State **three** structural differences between the cells of an onion and a honey bee. [2]

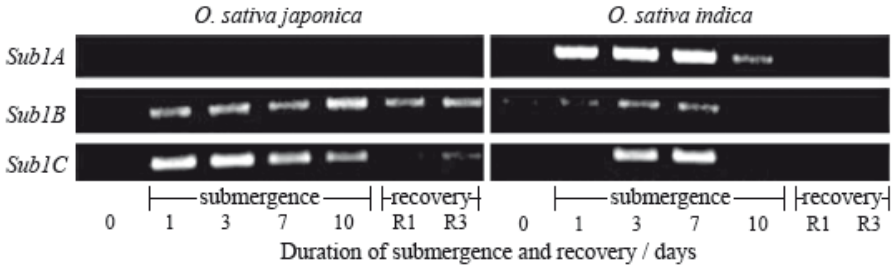
b. State what is indicated by the presence of polysomes in a cell. [1]

Gibberellin promotes both seed germination and plant growth. Researchers hypothesize that the gene *GID1* in rice (*Oryza sativa*) codes for the production of a cell receptor for gibberellin. The mutant variety *gid1-1* for that gene leads to rice plants with a severe dwarf phenotype and infertile flowers when homozygous recessive. It is suspected that homozygous recessive *gid1-1* plants fail to degrade the protein SLR1 which, when present, inhibits the action of gibberellin. The graphs show the action of gibberellin on the leaves and α-amylase activity of wild-type rice plants (WT) and their *gid1-1* mutants.



[Source: adapted from M. Ueguchi-Tanaka et al. (2005) 'Gibberellin-insensitive dwarf1 encodes a soluble receptor for gibberellin'. Nature, 437, pp. 693—698. Adapted by permission from Macmillan Publishers Ltd (c) 2005.]

Most rice varieties are intolerant to sustained submergence under water and will usually die within a week. Researchers have hypothesized that the capacity to survive when submerged is related to the presence of three genes very close to each other on rice chromosome number 9; these genes were named *Sub1A*, *Sub1B* and *Sub1C*. The photograph below of part of a gel shows relative amounts of messenger RNA produced from these three genes by the submergence-intolerant variety, *O. sativa japonica*, and by the submergence-tolerant variety, *O. sativa indica*, at different times of a submergence period, followed by a recovery period out of water.

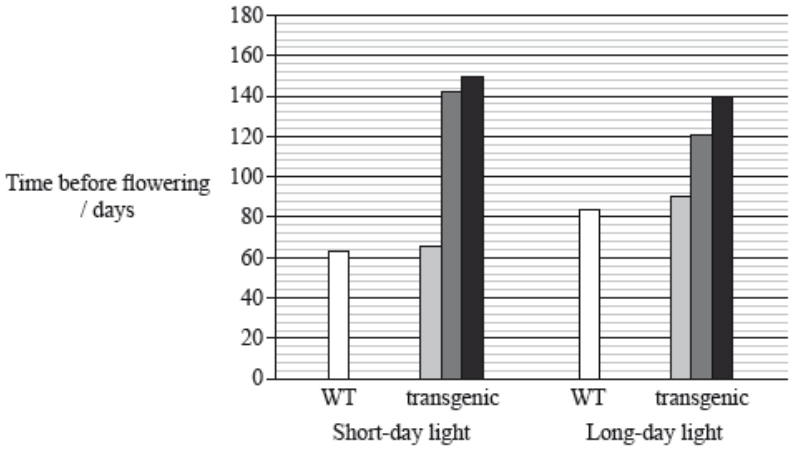


[Source: Adapted from "Sub1A is an ethylene-response-factor-like gene that confers submergence tolerance to rice" (2006) Kenong Xu, Xia Xu, Takeshi Fukao, Patrick Canlas, Reycel Maghirang-Rodriguez et al. Nature, 442, pp. 705—708. Adapted by permission from Macmillan Publishers Ltd (c) 2006.]

The *OsGI* gene causes long-day flowering and the effect of its overexpression has been observed in a transgenic variety of rice. Some wild-type rice (WT) and transgenic plants were exposed to long days (14 hours of light per day) and others to short days (9 hours of light per day).

The shades of grey represent the genotypes of the transgenic plants, where:

- –/– do not have the overexpressed *OsGI* gene
- +/– are heterozygous for the overexpressed *OsGI* gene
- +/+ are homozygous for the overexpressed *OsGI* gene.



[Source: adapted from R. Hayama, S. Yokoi, S. Tamaki, M. Yano and K. Shimamoto (2003) 'Adaptation of photoperiodic control pathways produces short-day flowering in rice.' Nature, 422, pp. 719—722. Adapted by permission from Macmillan Publishers Ltd (c) 2003.]

a(i). State which variety of rice fails to respond to gibberellin treatment. [1]

a(ii). The activity of α-amylase was tested at successive concentrations of gibberellin. Determine the increment in gibberellin concentration that produces the greatest change in α-amylase activity in wild-type rice plants (WT). [1]

b. Discuss the consequence of crossing *gid1-1* heterozygous rice plants amongst themselves for food production. [3]

c(i). Determine which gene produced the most mRNA on the first day of the submergence period for variety *O. sativa japonica*. [1]

c(ii). Outline the difference in mRNA production for the three genes during the submergence period for variety *O. sativa indica*. [2]

d. Using only this data, deduce which gene confers submersion resistance to rice plants. [2]

e(i). State the overall effect of overexpression of the *OsGI* gene in plants treated with short-day light. [1]

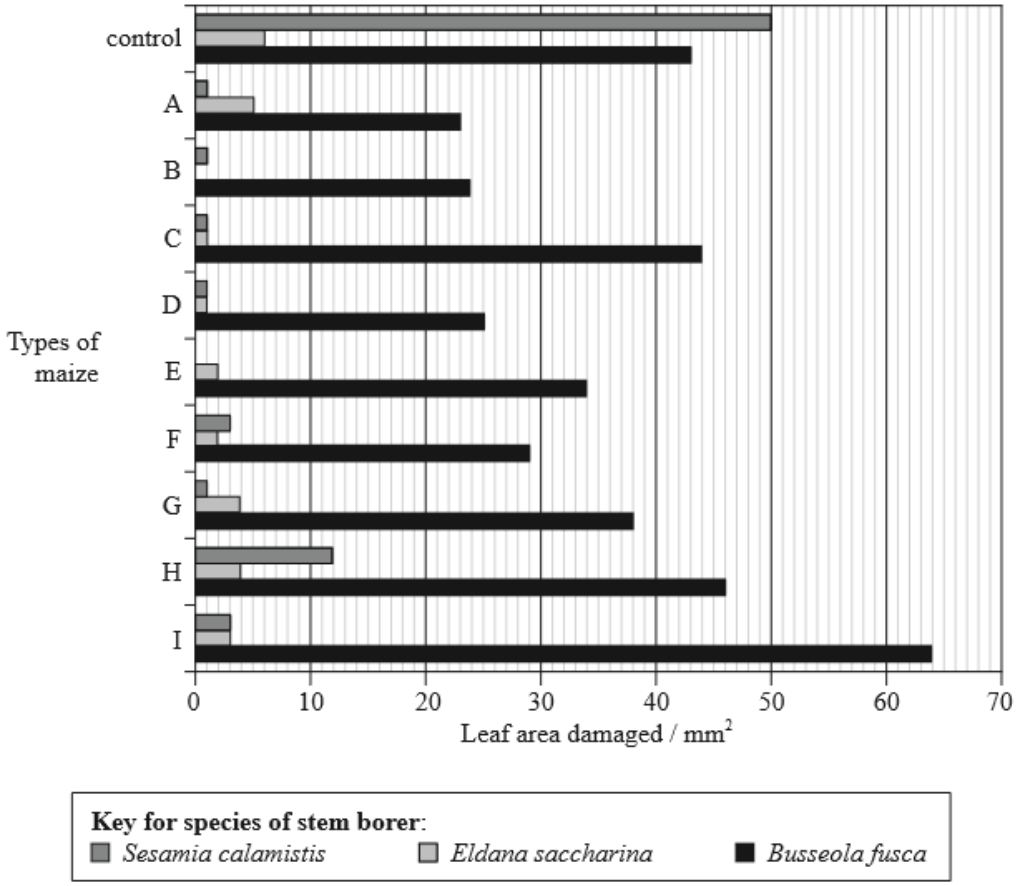
e(ii). Compare the results between the plants treated with short-day light and the plants treated with long-day light. [2]

e(iii). State, giving **one** reason taken from the data opposite, if unmodified rice is a short-day plant **or** a long-day plant. [1]

g. Evaluate, using all the data, how modified varieties of rice could be used to overcome food shortages in some countries. [2]

Genetic engineering allows genes for resistance to pest organisms to be inserted into various crop plants. Bacteria such as *Bacillus thuringiensis* (Bt) produce proteins that are highly toxic to specific pests.

Stem borers are insects that cause damage to maize crops. In Kenya, a study was carried out to see which types of Bt genes and their protein products would be most efficient against three species of stem borer. The stem borers were allowed to feed on nine types of maize (A–I), modified with Bt genes. The graph below shows the leaf areas damaged by the stem borers after feeding on maize leaves for five days.

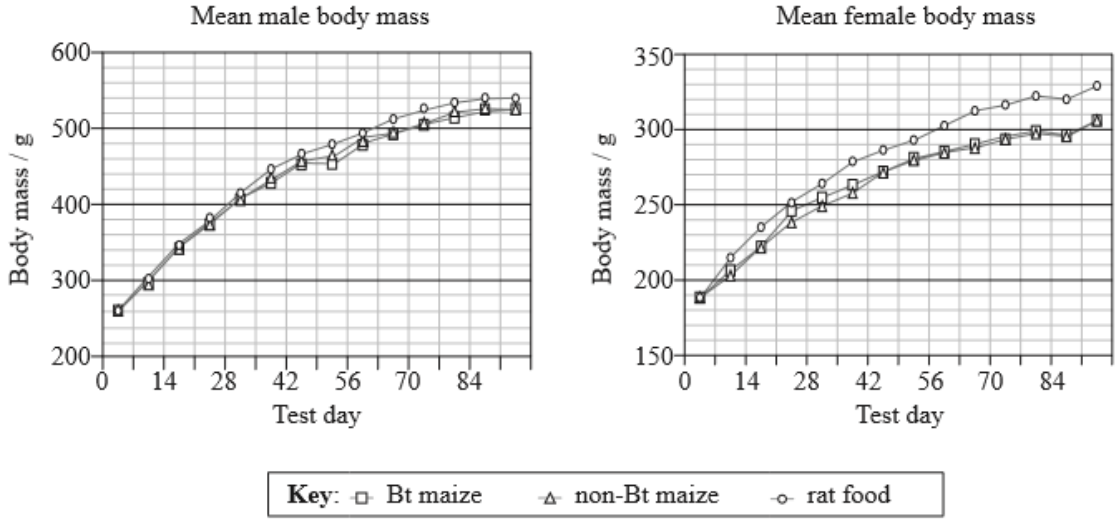


[Source: adapted from S Mugo, *et al.*, (2005), *African Journal of Biotechnology*, **4** (13), pages 1490–1504]

Before the use of genetically modified maize as a food source, risk assessment must be carried out. A 90-day study was carried out in which adult male and female rats were fed either:

- seeds from a Bt maize variety
- seeds from the original non-Bt maize variety
- commercially prepared rat food.

All the diets had similar nutritional qualities.



[Source: adapted from L A Malley, *et al.*, (2007), *Food and Chemical Toxicology*, **45**, pages 1277–1292]

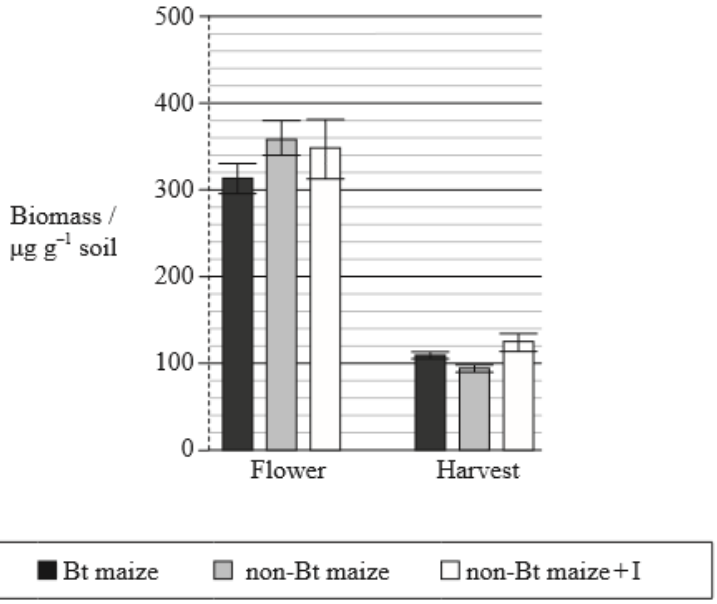
Studies have shown that Bt proteins are released by plant roots and remain in the soil. One study looked at the biomass of microorganisms in soil surrounding the roots of:

• Bt maize

• non-Bt maize

• non-Bt maize with an insecticide (I).

The graph below shows the biomass of microorganisms at two different times in the growth cycle of the plants (Flower and Harvest). Error bars represent standard error of the mean.



[Source: adapted from M Devare, *et al.*, (2007), *Soil Biology and Biochemistry*, **39**, pages 2038–2047]

Bt proteins act as toxins to insects, primarily by destroying epithelial cells in the insect's digestive system. Below is the three-dimensional structure of one such protein.

[Source: M Soberon, *et al.*, (2007), *Toxicon*, **49**, pages 597–600]

a. Calculate the percentage difference in leaf area damaged by *Sesamia calamistis* between the control and maize type H. Show your working. [2]

b. Discuss which species of stem borer was most successfully controlled by the genetic engineering of the maize plants. [3]

c. Calculate the change in mean mass of male and of female rats fed on Bt maize from day 14 to 42. [2]

d. Evaluate the use of Bt maize as a food source on the growth of the rats. [2]

e. Comment on the use of Bt maize as a food source compared to the other diets tested. [1]

g. Compare the biomass of microbes in the soils surrounding the roots of Bt maize and non-Bt maize. [2]

h. The researchers' original hypothesis stated that microorganisms would be negatively affected by the Bt protein released by the plant roots. [2]

Discuss whether the data supports the hypothesis.

i (i). State the type of structure shown in the region marked A in the diagram above. [1]

i (ii). Outline how this structure is held together. [2]

i (iii). Region A inserts into the membrane. Deduce, with a reason, the nature of the amino acids that would be expected to be found in this region. [2]