**1.** The pedigree chart below shows the blood types of three members of a family.



Which could be the blood types of individuals 1 and 2?

|  |  |  |
| --- | --- | --- |
|  | **Individual 1** | **Individual 2** |
| A. | A | AB |
| B. | AB | B |
| C. | O | B |
| D. | B | A |

(Total 1 mark)

**2.** What is the difference between the alleles of a gene?

A. Their position on the chromosome

B. Their amino acid sequence

C. Their pentose sugars

D. Their base sequence

(Total 1 mark)

**3.** The ACHOO syndrome is an inherited condition that leads to sneezing in response to bright light and is hypothesized to be inherited in an autosomal (not sex-linked) dominant fashion. The following is a pedigree chart that shows three generations from one family.



[Source: “Autosomal dominant pedigree chart. In Autosomal Dominance the chance of receiving and expressing a particular gene is 50% regardless of the sex of parent or child.” Jerome Walker. 22 July 2006.]

What evidence from the pedigree chart confirms that the ACHOO syndrome is **not** X-linked dominant?

A. Four females in the pedigree chart are affected and X-linked conditions do not affect females.

B. There is an affected male in generation II.

C. There is an affected female in generation II.

D. If the condition is X-linked dominant, the affected mother in generation II could not produce an unaffected son.

(Total 1 mark)

**4.** Rice (*Oryza sativa*) is usually intolerant to sustained submergence under water, although it grows rapidly in height for a few days before dying. This is true for one variety, *Oryza sativa japonica*. The variety *Oryza sativa indica* is much more tolerant to submergence.

Three genetically modified forms of *O. sativa japonica*, GMFA, GMFB and GMFC, were made using different fragments of DNA taken from *O. sativa indica*.

The plants were then submerged for a period of 11 days. The heights of all the plants were measured at the beginning and at the end of the submergence period.



[Adapted by permission from Macmillan Publishers Ltd, Xu et al. 2006. “Sub1A is an ethylene-response-factor-like gene that confers submergence tolerance to rice.” *Nature*. Vol 442. Pp 705–708. Copyright 2006. http://www.nature.com/]

(a) (i) State which group of rice plants were the shortest at the beginning of the experiment.

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(1)

(ii) Calculate the percentage change in height for the *O. sativa japonica* unmodified variety during the submergence period. Show your working.

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(2)

(b) Explain how the error bars can be used to compare the results for *O. sativa indica*.

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(2)

(c) Deduce the general relationship between the growth of all the *japonica* varieties and their stated tolerance level.

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(1)

(d) Outline the use of the binomial system of nomenclature in *Oryza sativa*.

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(2)

In the same experiment, the researchers 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.



[Adapted by permission from Macmillan Publishers Ltd, Xu et al. 2006. “Sub1A is an ethylene-response-factor-like gene that confers submergence tolerance to rice.” *Nature*. Vol 442. Pp 705–708. Copyright 2006. http://www.nature.com/]

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

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(1)

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

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(2)

(iii) Compare the mRNA production for the three genes during the submergence period between the two varieties.

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(2)

(f) Deduce, using all the data, which gene was used to modify GMFC.

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(2)

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

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(2)

(Total 17 marks)