Past-paper walk-through

Carbohydrates ▪ 1.4

eXercise

Questions in this set

- 2021 Q2

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 2

2021 ▪ Q2

Geneticists investigated the mode of inheritance of a rare disorder that alters glucose metabolism and first shows symptoms in adulthood. The geneticists studied a family in which some individuals of generations II and III are known to have the disorder. Based on the pedigree (Figure 1), the geneticists concluded that the disorder arose in individual II−2 and was caused by a mutation in mitochondrial DNA.

[Figure 1: Pedigree diagram across four generations (I, II, III, IV). Generation I: individual 1 (female without disorder) married to individual 2 (male without disorder). Generation II: their children include individual 1 (male without disorder) married to individual 2 (female with disorder), individual 3 (male without disorder) married to individual 4 (female without disorder), and individual 5 (female without disorder) married to individual 6 (male without disorder). Generation III: children of II-1×II-2 are individual 1 (male without disorder) married to individual 2 (female with disorder),

Question 2

individual 3 (female without disorder) married to individual 4 (male with disorder), individual 5 (male without disorder) married to individual 6 (female with disorder), and individual 7 (female without disorder) married to individual 8 (male with disorder); children of II-3×II-4 are individual 9 (female without disorder) and individual 10 (male without disorder) married to individual 11 (female without disorder); children of II-5×II-6 are individual 12 (male without disorder), individual 13 (female without disorder), individual 14 (female without disorder). Generation IV: child of III-1×III-2 is individual 1 (female, unknown phenotype); children of III-3×III-4 are individuals 2 and 3 (both female, unknown phenotype); children of III-5×III-6 are individuals 4 and 5 (both female, unknown phenotype); children of III-7×III-8 is individual 6 (male, unknown phenotype); children of III-10×III-11 are individual 7 (female, unknown phenotype) and individual 8 (male, unknown phenotype). Legend: open circle = female without disorder, filled circle = female with disorder, circle with "?" = female

Question 2

with unknown phenotype; open square = male without disorder, filled square = male with disorder, square with "?" = male with unknown phenotype. Caption: "Figure 1. Pedigree of a family showing individuals with the glucose metabolism disorder. A question mark indicates that the phenotype is unknown."]

TABLE 1. AVERAGE BLOOD GLUCOSE LEVELS OF INDIVIDUALS IN GENERATION IV

| Individual | Average Blood Glucose Level (mg/dL $\pm$ 2SE$_{\bar{x}}$) | |—|—| | IV−1 | 170 $\pm$ 15 | | IV−2 | 190 $\pm$ 10 | | IV−3 | 145 $\pm$ 5 | | IV−4 | 165 $\pm$ 15 | | IV−5 | 110 $\pm$ 15 | | IV−6 | 125 $\pm$ 5 | | IV−7 | 105 $\pm$ 15 | | IV−8 | 120 $\pm$ 10 |

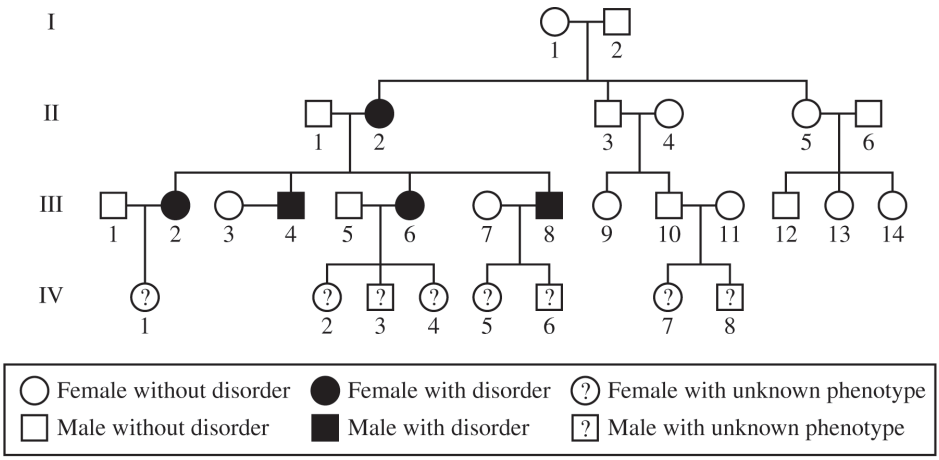
TABLE 2. PHENOTYPIC CLASSIFICATIONS BASED ON BLOOD GLUCOSE LEVELS

| Phenotype | Blood Glucose Level (mg/dL) | |—|—| | Normal | $<$ 140 mg/dL | | At risk | 140 $-$ 199 mg/dL | | Affected | $\geq$ 200 mg/dL |

Question 2

(a) The disorder alters glucose metabolism. **Describe** the atoms AND types of bonds in a glucose molecule.
(b) Using the template in the space provided for your response, **construct** an appropriately labeled graph based on the data in Table 1. **Determine** one individual who is both at risk of developing the disorder and has a significantly different blood glucose level from that of individual IV−1.
(c) Based on the pedigree, **identify** all individuals in generation IV who can pass on the mutation to their children.
(d) Based on the fact that individual II−2 is affected, a student claims that the disorder is inherited in an X-linked recessive pattern. Based on the student's claim, **predict** which individuals of generation III will be affected by the disorder. Based on the pedigree, **justify** why the data do NOT support the student's claim.

Question 2


I
II
III
IV
Female without disorder
Female with disorder
Female with unknown phenotype
Male without disorder
Male with disorder
Male with unknown phenotype

Solution 2

(a)

Mark scheme

- The atoms in a glucose molecule are carbon, hydrogen, and oxygen (C, H, and O), held together by covalent bonds.

Solution 2

(b) Mark scheme

- Construct graph (3 pts, point distribution across: axis labels; plotting in a bar graph or modified bar graph; error bars): Plot a bar graph with Individual (IV-1 through IV-8) labeled on the x-axis and Average Blood Glucose Level (mg/dL) labeled on the y-axis, one bar per individual at the height given in Table 1 (IV-1=170, IV-2=190, IV-3=145, IV-4=165, IV-5=110, IV-6=125, IV-7=105, IV-8=120), each with error bars matching its $\pm$2SE value from Table 1 (15,10,5,15,15,5,15,10 respectively). Determine (1 pt): IV-3 is both at risk (blood glucose 145 mg/dL falls in the 140-199 'at risk' range per Table 2) and has an average blood glucose level significantly different from individual IV-1 (170$\pm$15 vs 145$\pm$5 — the error bars/2SE ranges do not overlap).

Solution 2

(c)

Mark scheme

- The individuals in generation IV who can pass on the mutation to their children are IV-1, IV-2, and IV-4 (their mother, III-6, is an affected female; because the disorder is due to a mitochondrial DNA mutation transmitted maternally, all of III-6's offspring inherit and can pass on the mutation, regardless of the offspring's own phenotype/sex).

Solution 2

(d)

Mark scheme

- Predict affected individuals under the X-linked recessive claim (1 pt): III-4 and III-8 would be predicted affected in generation III. Justify why the data do NOT support the claim (1 pt): Accept either — the data do not support the claim because females III-2 and III-6 have the disorder, and under X-linked recessive inheritance they could only be affected if their father II-1 had the disorder, which he does not; or the data instead support mitochondrial inheritance, because all of the offspring of individual II-2 (affected female), not only the sons, have the disorder.