Model Answers: Medium

1a

a) The term *n* indicates that...

Any **two** of the following:

- Cells (at this stage of the life cycle) are haploid; [1 mark]
- The cells have half the normal number of chromosomes; [1 mark]
- The cells have undergone meiosis; [1 mark]

[Total: 2 marks]

The term 'gamete' has been used in Fig. 1 so there are no marks available for identifying the *n* cells as gametes.

1b

b) The processes taking place at the stages marked **A** and **B** are...

- **A** = meiosis; [1 mark]
- **B** = mitosis; [1 mark]

[Total: 2 marks]

Stage **A** shows a transition between a *2n* stage and an *n* stage, showing a halving of the chromosome number; this must therefore be meiosis.

Stage **B** shows a transition between a *2n* stage and another *2n* stage; the chromosome number is the same but more cells are present, so this must be mitosis.

1c

c) The events taking place at stage **C** involve...

Any **one** of the following:

- Fertilisation; [1 mark]
- The fusion of two (gamete) nuclei; [1 mark]

[Total: 1 mark]

1d

d) The importance of the process taking place at **A** (meiosis) is...

- It results in haploid cells / cells with half the number of chromosomes (compared to a body/somatic cell) / **OR** it is reduction division; [1 mark]
- It ensures that fertilisation results in / zygotes are diploid cells **OR** it ensures that zygotes are viable / have the correct number of chromosomes **OR** it prevents a doubling of the chromosome number with each generation; [1 mark]
- It generates genetic variation / genetically different gametes; [1 mark]

[Total: 3 marks]

2a

a) The stages of meiosis shown in Fig.1 are...

- **A** = metaphase II; [1 mark]
- **B** = anaphase II; [1 mark]
- **C** = prophase II; [1 mark]
- **D** = telophase II; [1 mark]

[Total: 4 marks]

If the cells were in meiosis I there would only be one cell present for prophase, metaphase, and anaphase and there would be two cells present in telophase.

2b

b) The process (crossing over) shown in Fig. 2 involves...

Any **two** of the following:

- Homologous chromosomes pair up / are very close together; [1 mark]
- Sections of the chromosomes/non-sister chromatids overlap/cross over/become entangled; [1 mark]
- Stress is placed on the DNA at the crossing points/chiasmata; [1 mark]
- The DNA breaks and rejoins / sections of DNA are exchanged / the positions of the alleles are switched; [1 mark]

[Total: 2 marks]

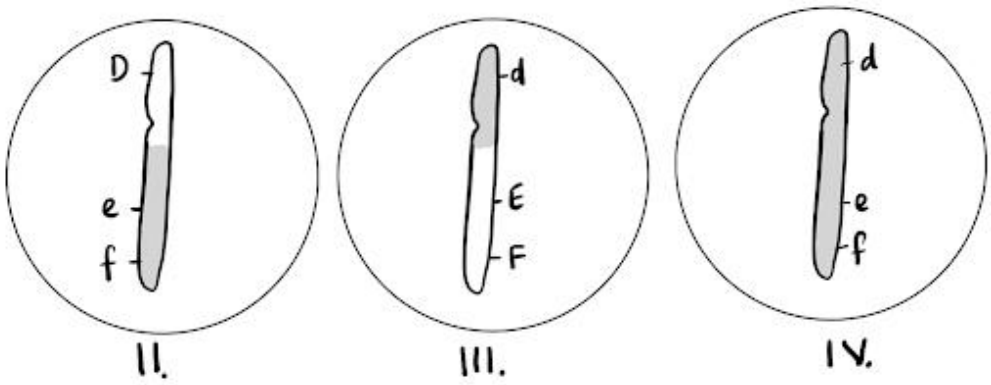
2c

c) The chromosomes would have the following allele combinations...

- **II** = short arm of chromosome - D **AND** long arm of chromosome - e and f; [1 mark]
- **III** = short arm of chromosome - d **AND** long arm of chromosome - E and F; [1 mark]
- **IV** = short arm of chromosome - d **AND** long arm of chromosome - e and f; [1 mark]

[Total: 3 marks]

It is important to ensure that the letters representing the genes are appropriately located on the chromosome (that is, the D/d gene is on the short arm and E/e & F/f are on the long arm). Note that no marks are awarded for the shading of the chromosomes as the question asks only for the allele combinations.



2d

d) Genetic variation is important for the survival of *D. melanogaster* as a species because...

Any **two** of the following:

- Different individuals will have different phenotypes / different phenotypes will exist within a population; [1 mark]
- Some individuals will survive if the environment changes / a new selection pressure arises; [1 mark]
- Natural selection can act on their population/species / the population/species will be able to evolve/adapt by natural selection; [1 mark]

[Total: 2 marks]

Genetic variation is the essential starting point for natural selection, as genetic variation gives rise to phenotypic variation. A species with little or no phenotypic variation will be unable to

evolve by natural selection (as there will be no individuals with advantageous characteristics) so if their environment changes the species will be at risk of extinction.

3a

a) i) The type of cell division shown in Fig.1 is...

- Meiosis; [1 mark]

a) ii) The events taking place include...

- The homologous pairs / bivalents line up along the middle/equator of the cell; [1 mark]
- Spindle fibres/microtubules attach to centromeres; [1 mark]

[Total: 3 marks]

Mitosis does not involve the lining up of homologous pairs of chromosomes, so this identifies the cell division in Fig. 1 as meiosis.

Fig. 1 shows metaphase (I), so shows the lining up of homologous pairs and their attachment to the spindle in preparation for anaphase.

3b

b) The process shown in Fig. 1 contributes to genetic variation by...

Any **two** of the following:

- Independent assortment/segregation occurs; [1 mark]
- Chromosomes randomly align / line up independently of each other; [1 mark]
- The way in which the chromosomes align/line up determines which chromosome ends up in which daughter cell; [1 mark]

[Total: 2 marks]

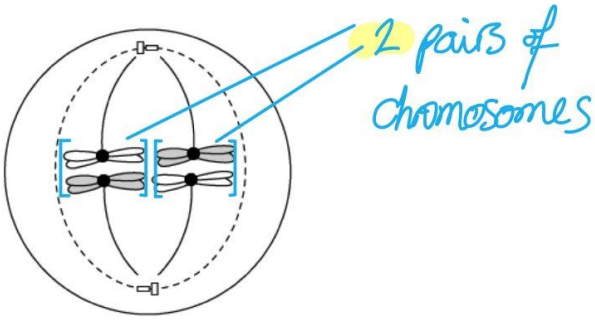
3c

c) The number of possible chromosome combinations that could be generated by the cell shown in Fig.1 is...

- 2^2; [1 mark]
- 4; [1 mark]

Full marks can be awarded for the correct answer in the absence of other calculations.

[Total: 2 marks]



Equation for calculating possible no. of chromosome combinations:

2^n — number of pairs of chromosomes

substitute numbers into equation:

$2^2 = 4$ possible combinations

[1 mark] [1 mark]

3d

d) i) The stage of cell division shown in Fig. 2 is...

- Anaphase I; [1 mark]

d) ii) The reasons for this include...

It is anaphase because...

Any **one** of the following:

- Chromosomes are being pulled apart to the poles of the cell; [1 mark]
- Spindle/microtubule fibres are shortening; [1 mark]

It is the first division of meiosis because...

- The homologous pairs are separating (as opposed to the sister chromatids, as would be the case in meiosis II or mitosis); [1 mark]

[Total: 3 marks]

For the first mark here you need to identify the stage of meiosis as well as which division is taking place.

The chromosomes are pulled apart as the spindle fibres shorten in anaphase, and in the first division of meiosis it is the pairs of chromosomes that are separated. During the second division of meiosis or during mitosis the sister chromatids are separated when the centromere breaks.

4

b) The behaviour of chromosomes during meiosis involves...

Any **eight** of the following:

Meiosis I

- Chromosomes condense; [1 mark]
- Homologous chromosomes pair up / bivalents form; [1 mark]
- Crossing over occurs / chiasmata form; [1 mark]
- Spindle fibres/microtubules attach to centromeres; [1 mark]
- Bivalents/pairs line up on equator of cell; [1 mark]
- Independent assortment (of homologous pairs); [1 mark]
- Chromosomes are pulled to opposite poles; [1 mark]
- Chromosome number is halved / cell becomes haploid; [1 mark]

Meiosis II

- (Individual) chromosomes line up on equator; [1 mark]
- Chromosomes line up at right-angles to the equator from meiosis I; [1 mark]
- Centromeres break/divide; [1 mark]
- (Sister) chromatids separate; [1 mark]

Accept *general statements such as "meiosis halves the chromosome number / produces haploid cells" without the specific context of meiosis I for marking point 8.*

Reject *statements that suggest that the halving of the chromosome number occurs specifically during meiosis II.*

[Total: 8 marks]

This question refers specifically to the **behaviour of chromosomes**, so descriptions of other cell components such as nuclear membranes and centrioles will not be credited.

Make sure that you are confident at distinguishing between **bivalents**, **single chromosomes**, and **chromatids**:

- Bivalent = a homologous **pair** of chromosomes
- Chromosome = a **single** chromosome. Until anaphase of meiosis II this will consist of **two sister chromatids** joined at the centromere and will have an 'X-shaped' appearance.
- Chromatid = one of the two identical halves of a chromosome formed during DNA replication in preparation for cell division. Joined chromatids are referred to as 'sister chromatids' or 'a chromosome'. As soon as the sister chromatids are separated during meiosis II they become chromosomes in their own right.

Note that cells **become haploid** at the end of **meiosis I** when the **bivalents** are separated. At the end of meiosis II the **amount of DNA** in the cell halves when the chromatids are separated but the ploidy of the cell does not change. It is still correct to say that 'meiosis produces haploid cells', but not to say that 'meiosis II halves the chromosome number'.