| Surname | Date | Tutor |
|---|---|---|
| First name(s) | | |

BioWelsh

# GCE A LEVEL

BW-A2-4.3-W1

## TOPIC WORKSHEET 1 – 4.3 INHERITANCE

## BIOLOGY – A2 unit 4

### Variation, Inheritance and Options

Suggested time: 3 hours 15 minutes

**For Tutor's use only**

| Question | Maximum Mark | Mark Awarded | Question | Maximum Mark | Mark Awarded |
|---|---|---|---|---|---|
| 1. | 9 | | 9. | 10 | |
| 2. | 10 | | 10. | 9 | |
| 3. | 10 | | 11. | 10 | |
| 4. | 9 | | 12. | 9 | |
| 5. | 10 | | 13. | 11 | |
| 6. | 10 | | 14. | 9 | |
| 7. | 11 | | 15. | 9 | |
| 8. | 9 | | Total | 145 | |



**ADDITIONAL MATERIALS**

In addition to this worksheet, you will require a calculator and a ruler.

**INSTRUCTIONS TO CANDIDATES**

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name and the date in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you are working on screen, write your answers on paper and number each one clearly.

**INFORMATION FOR CANDIDATES**

The number of marks is given in brackets at the end of each question or part-question. The worksheet is out of **145** marks.

The assessment of the quality of extended response (QER) will take place in question **15**.

The quality of written communication will affect the awarding of marks.

This worksheet is written by BioWelsh in the style of the WJEC A level Biology examination, following the WJEC specification (topic 4.3). It is not an official WJEC paper.

Tutor only

Answer **all** questions.

**1.** In the fruit fly *Drosophila melanogaster*, a gene for body colour has two alleles. The allele for a grey body, **E**, is dominant to the allele for a black (ebony) body, **e**. **Image 1.1** shows a pair of homologous chromosomes from a body cell of one fly, with the alleles of three of its genes shown on the chromosomes.

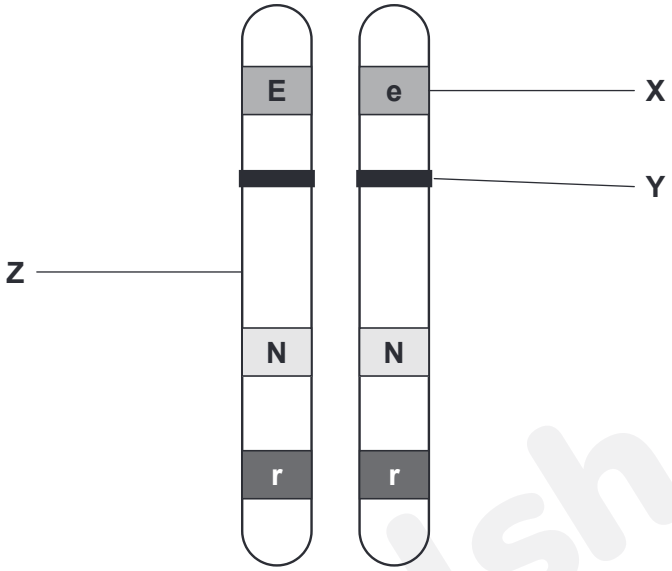



**Image 1.1**

(a) Identify the structures or regions labelled **X**, **Y** and **Z**. [3]

X .....

Y .....

Z .....

(b) Define the term **allele**. [1]

.....

.....

Tutor only

(c) Complete **Table 1.2** to show the genotype of this fly for each gene, and whether it is homozygous or heterozygous for that gene. [2]

**Table 1.2**

| Gene | Genotype | Homozygous or heterozygous |
|---|---|---|
| body colour | ..... | ..... |
| gene N | ..... | ..... |
| gene R | ..... | ..... |

(d) This fly is crossed with a fly that has a black body. Draw a genetic diagram to show the genotypes and phenotypes of the offspring you would expect, and state the expected phenotype ratio. [3]



9

Tutor only

**2.** In Andalusian chickens, feather colour is controlled by one gene with two codominant alleles, $C^B$ and $C^W$. Birds that are $C^BC^B$ have black feathers, birds that are $C^WC^W$ are white with a few dark flecks (called splash), and birds with both alleles have blue-grey feathers and are called blue. A breeder mated blue birds with each other. **Table 2.1** shows the chicks that hatched.

**Table 2.1**

| Feather colour of chicks | Number of chicks |
|---|---|
| black | 23 |
| blue | 51 |
| splash | 26 |

(a) Explain what is meant by codominant alleles, using the blue chickens as an example. [2]

.....

.....

.....

.....

(b) Draw a genetic diagram to show why the breeder obtained the results in **Table 2.1**. [3]

(c) Use **Table 2.1** to state the ratio of black to blue to splash chicks, as a whole-number ratio. [1]

.....

.....

(d) Explain why the breeder can never obtain a flock in which all the offspring of blue parents are blue. [2]

.....

.....

Tutor only

.....

.....

(e) Suggest which birds the breeder should mate to obtain only blue chicks. Explain your answer. [2]

.....

.....

.....

.....



10





Turn over.

Tutor only

**3.** Manx cats have no tail. Taillessness is caused by a dominant allele, **M**. Embryos that are homozygous **MM** die early in development, so no **MM** kittens are born. Cats that are **mm** have a normal tail. **Table 3.1** shows the total number of kittens born in several litters from matings between two Manx cats.

**Table 3.1**

| Phenotype of kittens | Number of kittens |
|---|---|
| tailless (Manx) | 58 |
| tailed | 31 |
| total | 89 |

(a) State the genotype of every Manx cat that is born. Give a reason for your answer. [1]

.....

(b) Draw a genetic diagram to predict the phenotype ratio of kittens born when two Manx cats are mated. [3]

A student wrongly expected a ratio of 3 tailless : 1 tailed and used a chi-squared test on the results in **Table 3.1**, using the formula:

$$\chi^2 = \Sigma (O - E)^2 \div E$$

(c) (i) Calculate the value of $\chi^2$ for the student's hypothesis. Show your working. [3]

$\chi^2$ = .....

Tutor only

(ii) The critical value of $\chi^2$ for 1 degree of freedom at p = 0.05 is 3.84. State **and** explain what the value of $\chi^2$ shows about the student's hypothesis. [2]

.....

.....

.....

.....

(iii) Explain how the results in **Table 3.1** support the idea that **MM** embryos die. [1]

.....

.....



10

Tutor only

**4.** **Image 4.1** shows a cell from an animal during meiosis. The cell has the genotype AaBb, and the two genes are on different chromosomes.

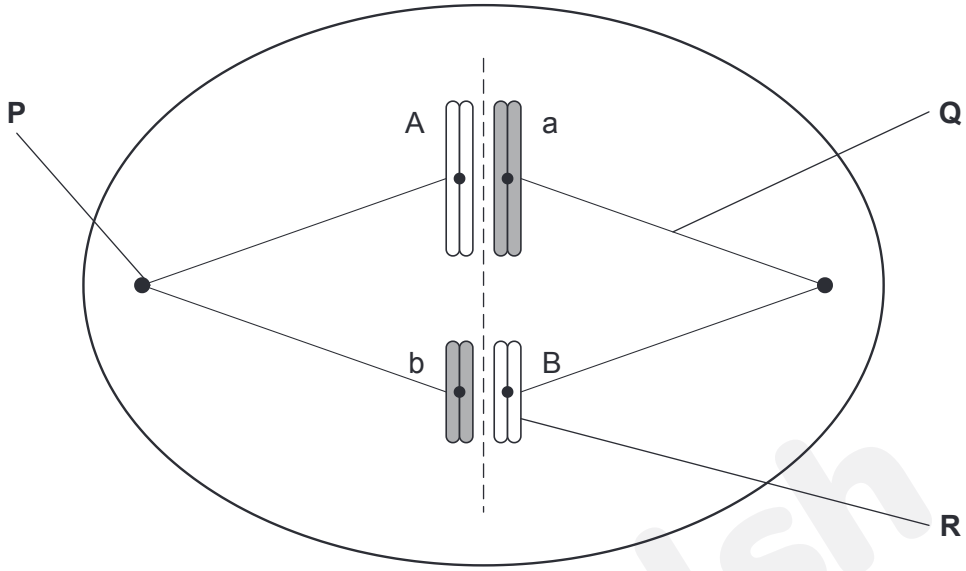



**Image 4.1**

(a) Name the stage of meiosis shown in **Image 4.1**. Give a reason for your answer. [2]

.....

.....

.....

.....

(b) Identify the structures labelled **P**, **Q** and **R**. [2]

P .....

Q .....

R .....

(c) State the genotypes of the gametes that will be produced from the arrangement shown in **Image 4.1**. [1]

.....

(d) Explain how this animal is able to produce four genetically different types of gamete in equal numbers. [3]

.....

.....

Tutor only

.....

.....

.....

.....

(e) The body cells of this animal have 8 chromosomes. Calculate the number of different combinations of chromosomes that are possible in its gametes as a result of independent assortment alone. [1]

Number of combinations = .....



9

Tutor only

**5.** In *Drosophila melanogaster*, a grey body (**E**) is dominant to an ebony body (**e**), and normal wings (**V**) are dominant to vestigial wings (**v**). The two genes are on different chromosomes. Flies that were heterozygous for both genes were crossed with each other. **Table 5.1** shows the offspring.

**Table 5.1**

| Phenotype | Number of flies |
|---|---|
| grey body, normal wings | 290 |
| grey body, vestigial wings | 101 |
| ebony body, normal wings | 92 |
| ebony body, vestigial wings | 37 |
| total | 520 |

(a) State the genotypes of the gametes produced by one of the heterozygous parent flies. [1]

.....

(b) State the phenotype ratio expected in the offspring, and explain why this ratio is expected. [2]

.....

.....

.....

.....

The null hypothesis was that there is no significant difference between the observed numbers and the numbers expected from this ratio.

(c) (i) Complete **Table 5.2** and calculate $\chi^2$. [3]

**Table 5.2**

| Phenotype | Observed (O) | Expected (E) | $(O - E)^2 \div E$ |
|---|---|---|---|
| grey, normal | 290 | 292.5 | 0.02 |
| grey, vestigial | 101 | ..... | 0.13 |
| ebony, normal | 92 | 97.5 | ..... |
| ebony, vestigial | 37 | ..... | ..... |
| | | $\chi^2$ = | ..... |

Tutor only

**Table 5.3** shows critical values of $\chi^2$ at p = 0.05.

**Table 5.3**

| Degrees of freedom | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **Critical value** | 3.84 | 5.99 | 7.82 | 9.49 |

(ii) State the number of degrees of freedom, and use **Table 5.3** to explain whether the null hypothesis should be accepted or rejected. [3]

.....

.....

.....

.....

.....

.....

(d) Explain why the test is more reliable when a large number of flies is counted. [1]

.....

.....

10

Tutor only

**6.** In sweet peas (*Lathyrus odoratus*), purple flowers (**P**) are dominant to red flowers (**p**), and long pollen grains (**L**) are dominant to round pollen grains (**l**). Early in the twentieth century, geneticists crossed plants that were heterozygous for both genes, and obtained the offspring shown in **Table 6.1**.

**Table 6.1**

| Phenotype | Number of plants |
|---|---|
| purple flowers, long pollen | 4831 |
| purple flowers, round pollen | 390 |
| red flowers, long pollen | 393 |
| red flowers, round pollen | 1338 |
| total | 6952 |

(a) Calculate the number of plants with purple flowers and long pollen that would be expected if the ratio were 9 : 3 : 3 : 1. [1]

Expected number = .....

(b) The value of $\chi^2$ for these results, tested against 9 : 3 : 3 : 1, is 3372. The critical value at $p = 0.05$ is 7.82. State the number of degrees of freedom and what this value of $\chi^2$ shows. [3]

.....

.....

.....

.....

.....

.....

(c) Explain why many more plants had purple flowers with long pollen, and red flowers with round pollen, than a 9 : 3 : 3 : 1 ratio predicts. [3]

.....

.....

.....

Tutor only

.....

.....

.....

(d) Explain how the plants with purple flowers and round pollen, and with red flowers and long pollen, were produced. [2]

.....

.....

.....

.....

(e) Suggest what the small number of these plants shows about the positions of the two genes on the chromosome. [1]

.....

.....



10





Turn over.

Tutor only

**7.** Tobacco seeds were collected from a plant that was heterozygous for a gene needed to make chlorophyll. The allele for chlorophyll production, **G**, is dominant to the allele **g**; seedlings that are **gg** are albino (white). The plant had been self-pollinated. Students placed 55 seeds on damp filter paper in each of five Petri dishes, kept them in the light at 25 °C and counted the seedlings after 10 days. **Table 7.1** shows their results.

**Table 7.1**

| Dish | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| **Green seedlings** | 38 | 41 | 36 | 40 | 37 | 192 |
| **Albino seedlings** | 14 | 12 | 15 | 11 | 16 | 68 |

(a) Explain why the dishes were kept in the light. [2]

.....

.....

.....

.....

(b) Suggest **two** variables, other than light and temperature, that should be kept the same in each dish. [2]

.....

.....

.....

.....

The students used this formula:

$$\chi^2 = \Sigma (O - E)^2 \div E$$

(c) Use the totals in **Table 7.1** to calculate $\chi^2$ for a ratio of 3 green : 1 albino. [3]

$\chi^2$ = .....

Tutor only

(d) The critical value of $\chi^2$ for 1 degree of freedom at p = 0.05 is 3.84. State the conclusion the students should make. [2]

.....

.....

.....

.....

(e) The students counted the seedlings again after three weeks and found far fewer albino seedlings. Explain why. [2]

.....

.....

.....

.....



11

Tutor only

**8.** **Image 8.1** shows the chromosomes from a body cell of a man, photographed and arranged in pairs.

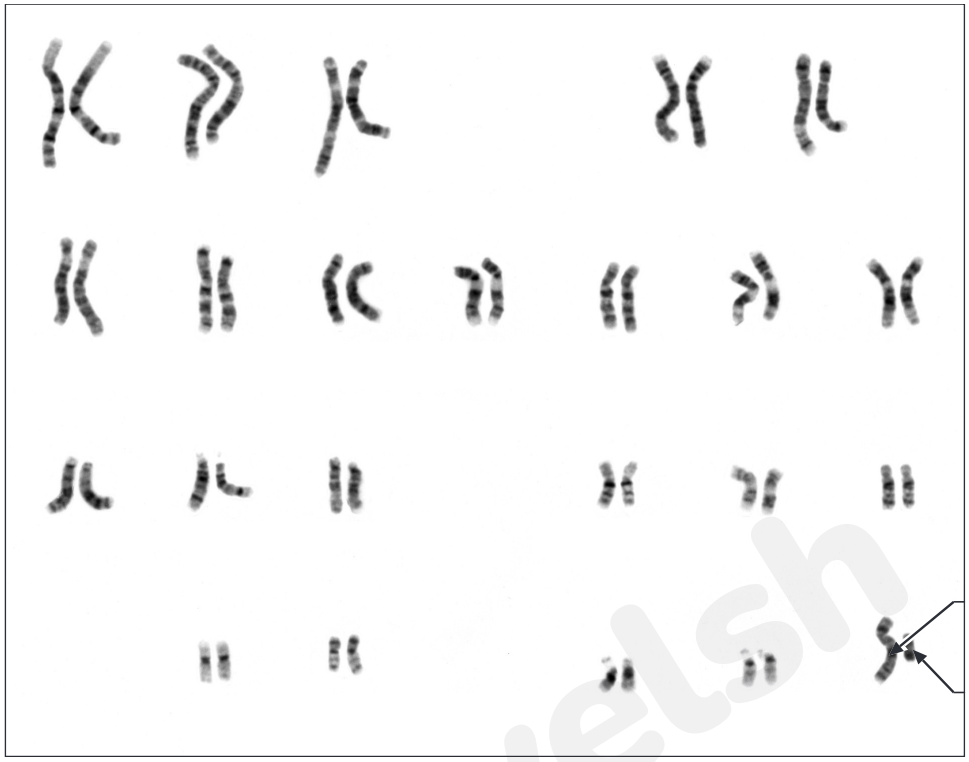



**Image 8.1**

(a) State the number of autosomes in this cell. [1]

.....

(b) Identify chromosomes **T** and **U**, and explain how they show that the cell came from a male. [2]

.....

.....

.....

.....

(c) Explain why the father, and not the mother, determines the sex of a child. [2]

.....

.....

.....

.....

Tutor only

Red-green colour blindness is caused by a recessive allele, $X^b$, of a gene on the X chromosome. The normal allele is $X^B$. A woman with normal vision, whose father was colour blind, has children with a man with normal vision.

(d) (i) Explain why the woman must be a carrier. [1]

.....

.....

(ii) Draw a genetic diagram to find the probability that one of their sons is colour blind. [3]



9

Tutor only

**9.** Haemophilia A is caused by a recessive allele of a gene for a blood clotting protein on the X chromosome. **Image 9.1** shows the inheritance of haemophilia A in one family.

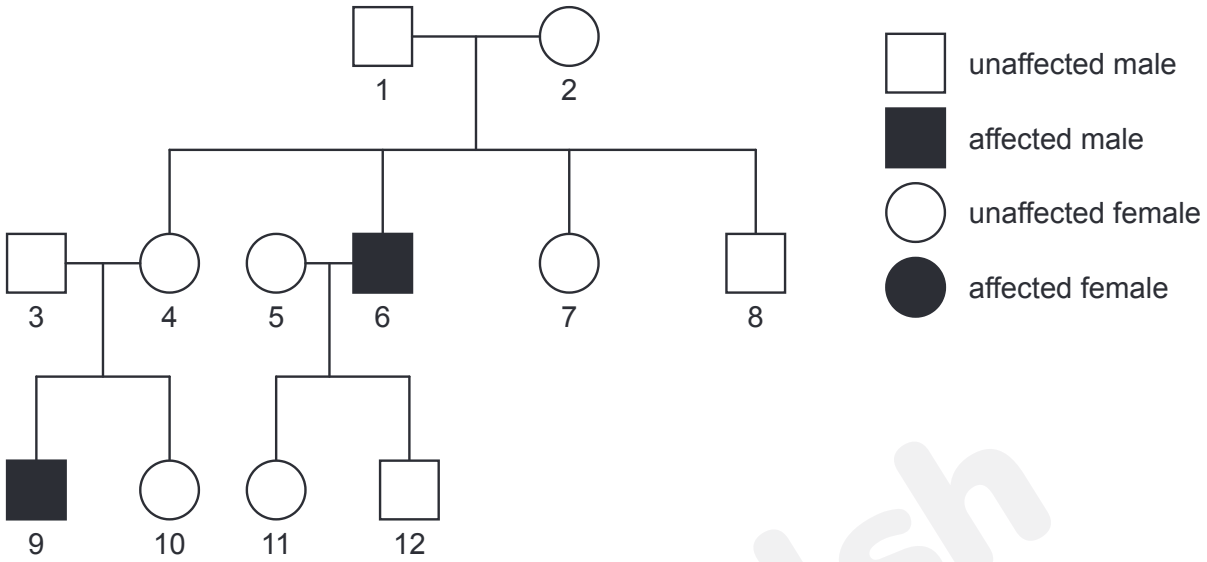



**Image 9.1**

(a) Explain why haemophilia A is much more common in males than in females. [2]

.....

.....

.....

.....

(b) Using $X^H$ for the normal allele and $X^h$ for the haemophilia allele, give the genotypes of individuals **2**, **6** and **11**. [3]

2 .....

6 .....

11 .....

(c) Explain why individual **4** must be a carrier even though she does not have haemophilia. [2]

.....

.....

.....

.....

Tutor only

(d) Individual **11** has a child with a man who does not have haemophilia. Calculate the probability that the child is a boy with haemophilia. [1]

Probability = .....

(e) Explain why the genotype of individual **7** cannot be determined from **Image 9.1**. [2]

.....

.....

.....

.....



10

Tutor only

**10.** Some forms of inherited deafness are caused by a single gene. **Image 10.1** shows a family in which one form of inherited deafness occurs.

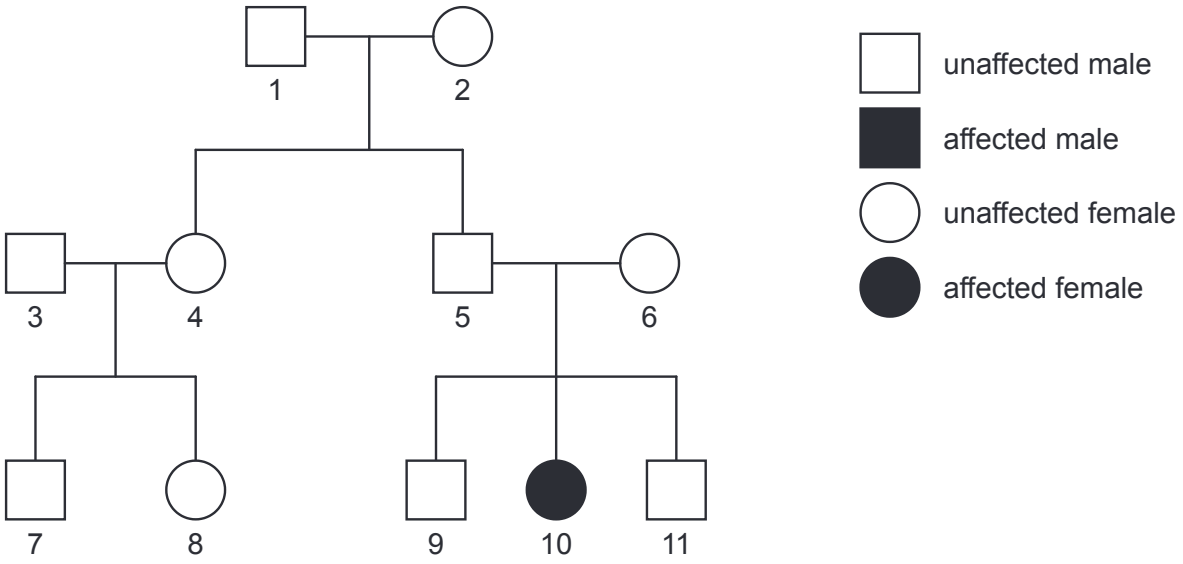



**Image 10.1**

(a) Using evidence from **Image 10.1**, explain why the allele causing this form of deafness is recessive. [2]

.....

.....

.....

.....

(b) Using evidence from **Image 10.1**, explain why the allele is **not** on the X chromosome. [2]

.....

.....

.....

.....

(c) Using **D** for the dominant allele and **d** for the recessive allele, give the genotypes of individuals **5**, **6** and **10**. [2]

5 .....

6 .....

10 .....

Tutor only

(d) Calculate the probability that individual **9** is a carrier of the allele. [2]

Probability = .....

(e) Explain why at least one of individuals **1** and **2** must carry the allele. [1]

.....

.....



9

Tutor only

**11.** **Image 11.1** is a light micrograph of a stained blood smear from a person with sickle cell anaemia.

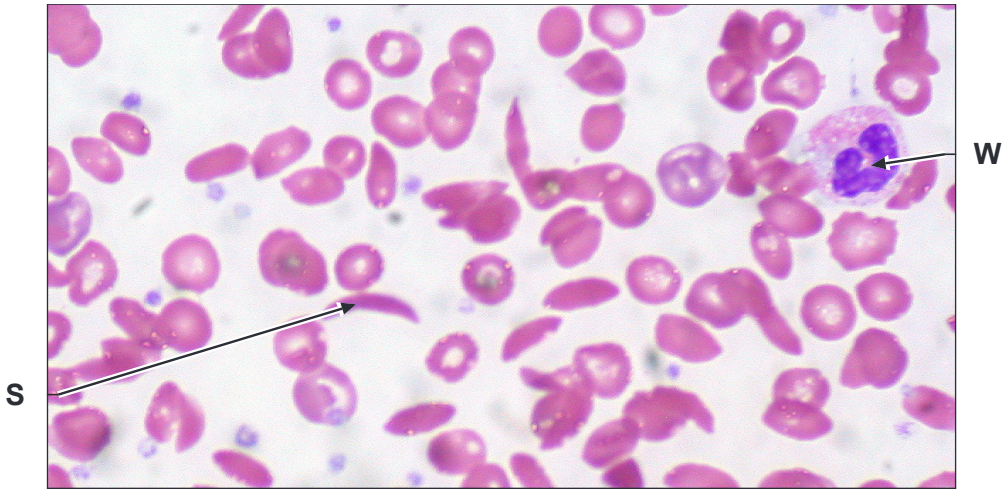



**Image 11.1**

(a) Identify the cells labelled **S** and **W**. [2]

S .....

W .....

Sickle cell anaemia is caused by a change in the gene for the β polypeptide of haemoglobin. **Table 11.2** shows the sixth triplet of the coding strand of DNA for the normal allele, $Hb^A$, and the sickle cell allele, $Hb^S$. The mRNA codon GAG codes for glutamic acid and GUG codes for valine.

(b) (i) Complete **Table 11.2**. [2]

**Table 11.2**

| | $Hb^A$ | $Hb^S$ |
|---|---|---|
| **DNA coding strand** | GAG | GTG |
| **mRNA codon** | ..... | ..... |
| **Amino acid** | ..... | ..... |

(ii) Name the type of gene mutation that produced the $Hb^S$ allele. [1]

.....

(c) Explain how this change produces cells like **S**. [3]

.....

.....

Tutor only

.....

.....

.....

.....

(d) The alleles $Hb^A$ and $Hb^S$ are codominant. Suggest why a heterozygous person usually has only mild symptoms, if any. [2]

.....

.....

.....

.....



10

Tutor only

**12.** Duchenne muscular dystrophy (DMD) is caused by recessive alleles of the dystrophin gene on the X chromosome. The gene has 79 exons. Many cases are caused by the deletion of one or more exons. Boys with some deletions have Becker muscular dystrophy instead, a milder condition that starts later in life. **Table 12.1** shows the deletions in two boys.

**Table 12.1**

| Boy | Exons deleted | Number of bases deleted | Condition |
|---|---|---|---|
| **P** | 45 | 176 | DMD |
| **Q** | 45, 46 and 47 | 474 | Becker muscular dystrophy |

(a) Explain why the deletion in boy **Q** does not change the amino acid sequence after the deleted region. [2]

(b) Explain why the deletion in boy **P** results in no functional dystrophin. [3]

(c) Suggest why boy **Q** has milder symptoms than boy **P**. [2]

(d) Some substitution mutations in the dystrophin gene have no effect on the protein. Explain why. [1]

Tutor only

.....

(e) State why DMD is extremely rare in girls. [1]

.....



9

Tutor only

**13.** **Image 13.1** shows meiosis in a cell during the formation of eggs. Only one pair of chromosomes, chromosome 21, is shown.

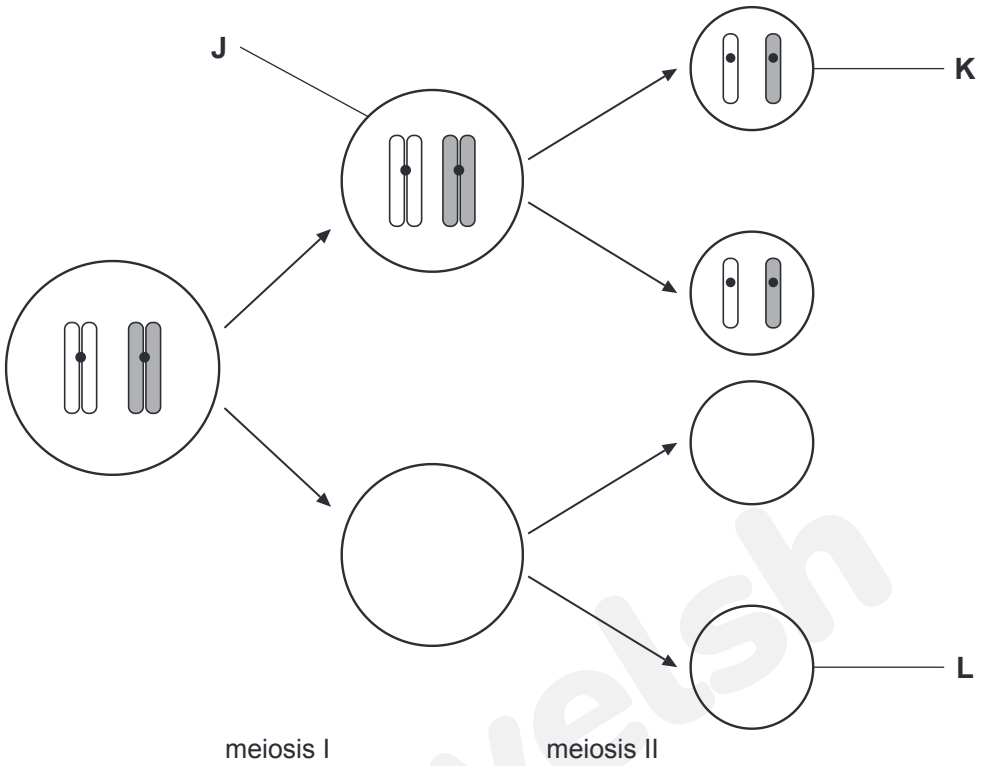



**Image 13.1**

(a) Name the error shown in cell **J**, and state the stage of meiosis at which it happened. [2]

.....

.....

.....

.....

(b) State the total number of chromosomes in human gametes **K** and **L**. [2]

K .....

L .....

(c) Explain how gamete **K** could lead to a child with Down's syndrome. [2]

.....

.....

.....

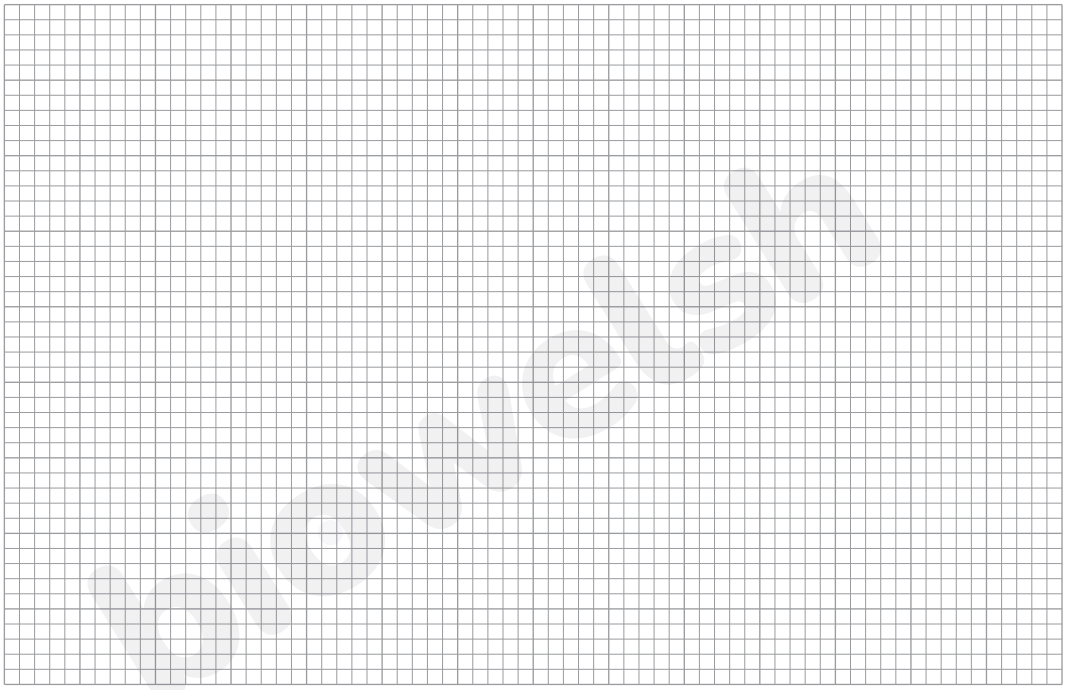
Tutor only

**Table 13.2** shows the number of babies born with Down's syndrome per 1000 births, for mothers of different ages.

**Table 13.2**

| Age of mother / years | 20 | 25 | 30 | 35 | 40 | 45 |
|---|---|---|---|---|---|---|
| Babies with Down's syndrome per 1000 births | 0.7 | 0.7 | 1.1 | 2.9 | 10.0 | 33.3 |

(d) Plot a graph of the data in **Table 13.2** on the grid below. Join the points with straight lines. [4]



(e) Suggest why the chance of non-disjunction increases with the age of the mother. [1]

11

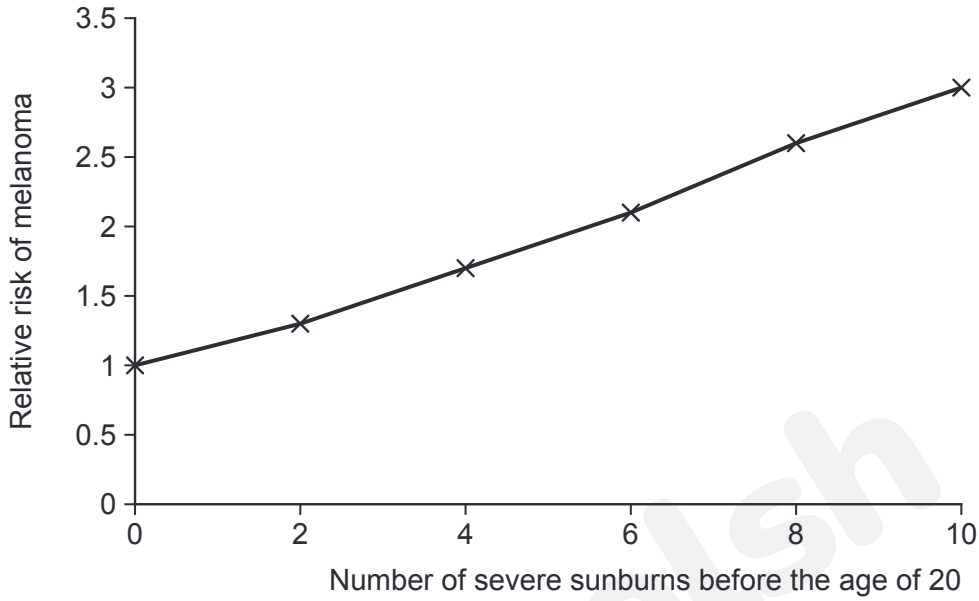




Turn over.

Tutor only

**14.** Melanoma is a cancer of the pigment cells in the skin. Researchers recorded the number of severe sunburns that people had before the age of 20, and their later risk of melanoma. **Graph 14.1** shows the results of the study.




**Graph 14.1**

(a) Describe the relationship shown in **Graph 14.1**. [2]

.....

.....

.....

.....

(b) Calculate the percentage increase in the risk of melanoma for a person with 6 severe sunburns compared with a person with none. [2]

Percentage increase = ..... %

(c) Ultraviolet light is a carcinogen. Explain how ultraviolet light can cause a melanoma. [3]

.....

.....

.....

Tutor only

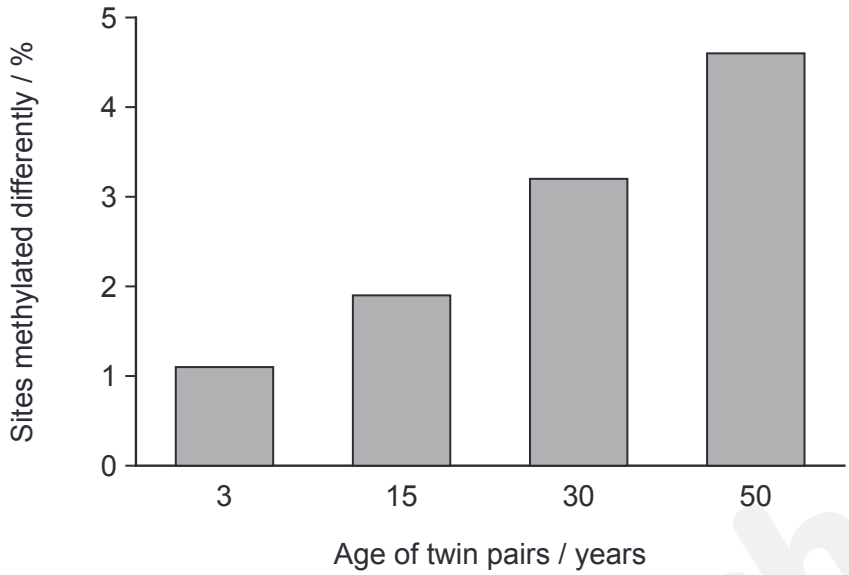
(d) Explain why these results alone do not prove that sunburn causes melanoma. [2]



9

Tutor only

**15.** Identical (monozygotic) twins develop from the same zygote, so they have the same DNA base sequences. Researchers compared the methylation of DNA at the same sites in the two members of pairs of identical twins of different ages. **Graph 15.1** shows the percentage of sites that were methylated differently in the two twins.




**Graph 15.1**

Explain what is meant by epigenetics, and describe how DNA methylation and the modification of histones control gene expression. Use **Graph 15.1** to describe the results and suggest explanations for them. Explain how epigenetic changes could lead to one twin developing a cancer that the other twin does not develop. [9 QER]

Tutor only

**END OF WORKSHEET**

9





**Turn over.**

## A Tutor Meets Tutee project

BioWelsh worksheets are written and checked by Tutor Meets Tutee tutors for WJEC A level Biology students.

Mark this worksheet with the BioWelsh mark scheme **BW-A2-4.3-W1** (MS).

### Acknowledgements

**Image 8.1**: Photo: National Human Genome Research Institute, public domain (Wikimedia Commons, 'NHGRI human male karyotype'). Letters and label lines added.

**Image 11.1**: Micrograph: Ed Uthman, CC BY 2.0 (Wikimedia Commons, 'Sickle Cell Anemia (5610746554)'), https://creativecommons.org/licenses/by/2.0. Cropped; letters and label lines added.