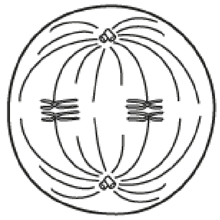
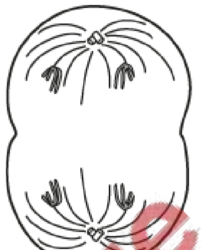
Inheritance – 2023 Biology A2 9700

1. March/2023/Paper_ 9700/42/No.5

Meiosis is described as a reduction division because the number of chromosomes in the daughter cells is reduced by half.

(a) Table 5.1 describes some of the events that take place during four of the different stages of meiosis in an animal cell.

Table 5.1

stage of meiosis	spindle fibres	diagram
metaphase I	attach to centromeres and arrange homologous pairs of chromosomes at the equator of the cell	
anaphase I		
	re-form spindle in daughter cells	
telophase II	disassemble	

Complete Table 5.1 by:

- outlining the behaviour of the spindle fibres during anaphase I
- identifying the stage of meiosis in which spindle fibres re-form the spindle in daughter cells
- drawing a diagram to show telophase II.

You do **not** need to add labels to your diagram showing telophase II.

[4]

(b) Explain the need for a reduction division during meiosis.

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[Total: 8]

2. June/2023/Paper_ 9700/41/No.6

Domestic rabbits vary in the length and colour of their fur.

Fig. 6.1 shows a domestic rabbit with short fur and a fur colour pattern called Himalayan.

Fig. 6.1

The two genes that determine the length and colour of the fur of this rabbit occur at the **A / a** locus and the **B / b^h / b** locus. These two gene loci are on separate chromosomes.

- The allele **A** results in short fur.
- The allele **a** results in long fur.
- **A** is dominant to **a**.

- The allele **B** results in black fur all over the body.
- The allele **b^h** results in black fur on the nose, ears, paws and tail of the rabbit, and white fur on the rest of the body (Himalayan pattern).
- The allele **b** results in white fur all over the body (albino).
- **B** is dominant to **b^h** and **b^h** is dominant to **b**.

(a) **(i)** List the **four** possible genotypes of the rabbit shown in Fig. 6.1.

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(ii) One phenotype of rabbit always breeds true. This means that when it is mated to a rabbit that looks the same as itself, all the offspring look the same as the parents.

Describe the **phenotype** of the rabbit that breeds true.

.... [1]

(b) A rabbit with long, black fur all over the body that was homozygous at both loci was crossed with a rabbit with short, white fur that was homozygous at both loci. The F1 offspring had short, black fur. These F1 rabbits were mated together to become the parents of the F2 generation.

Draw a genetic diagram to predict the F2 offspring genotypes and the ratio of F2 offspring phenotypes.

F1 genotypes:

gametes:

F2 offspring genotypes:

ratio of F2 offspring phenotypes:

[5]

(c) A rabbit breeder performed multiple crosses of the type described in **(b)**. This gave enough data to test the prediction that the genes for fur length and fur colour show independent assortment.

(i) Explain why the two genes assort independently.

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(ii) The rabbit breeder placed the results in a table and started to calculate the χ^2 value.

Table 6.1 shows the results and some of the calculations made.

Table 6.1

phenotype	**observed number (O)**	**expected number (E)**	**$(O - E)^2$**	**$\frac{(O-E)^2}{E}$**
short, black fur	25		4	0.148
long, black fur	11		4	0.444
short, white fur	8		1	0.111
long, white fur	4		1	0.333

Calculate the expected numbers and write them in the shaded column in Table 6.1. [1]

(iii) Use the formula provided and the figures in Table 6.1 to calculate the χ^2 value.

$$\chi^2 = \Sigma\frac{(O-E)^2}{E}$$

χ^2 = ... [1]

[Total: 13]

3. June/2023/Paper_ 9700/41/No.8

Fig. 8.1 shows a cell from the testis of a locust at the late prophase I stage of meiosis.

Fig. 8.1

Explain how the behaviour of the chromosomes in prophase I of meiosis results in the appearance shown in Fig. 8.1.

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[Total: 4]

4. June/2023/Paper_ 9700/41/No.10

Sweet peas are garden plants that vary in height.

- Tall sweet peas grow to 200 cm in height.
- Dwarf sweet peas grow to 30 cm in height.
- Tall sweet peas contain a dominant ***Le*** allele.
- Dwarf sweet peas are homozygous for the recessive ***le*** allele.

Explain how the ***lele*** genotype results in the dwarf phenotype in sweet peas, with reference to the effect of ***lele*** on:

- enzyme synthesis
- hormone production
- the expression of genes affecting plant growth.

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[Total: 6]

5. June/2023/Paper_ 9700/42/No.2

(a) In sexual reproduction, meiosis occurs to produce haploid gametes from a diploid cell.

Explain the meaning of the terms haploid **and** diploid.

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(b) Describe the behaviour of **chromosomes** during the main stages of meiosis I in animal cells.

prophase I ....

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metaphase I ....

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anaphase I ....

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telophase I ....

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[4]

(c) The production of haploid gametes by meiosis also involves division of the cytoplasm.

State the term used to describe this division of the cytoplasm.

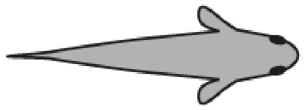
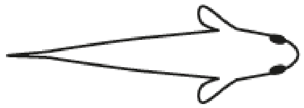
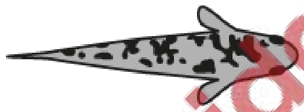
.... [1]

[Total: 7]

6. June/2023/Paper_ 9700/43/No.5

A freshwater fish species, *Oryzias latipes*, has individuals with four body colour patterns, as shown in Table 5.1.

Table 5.1

phenotype	body colour pattern
red	
white	
red with black spots	
white with black spots	

Two unlinked genes determine the body colour patterns shown in Table 5.1.

One gene controls whether the body colour is red or white:
- dominant allele **R** = red
- recessive allele **r** = white.

The other gene controls whether black spots are present or **not** present:
- dominant allele **B** = with black spots
- recessive allele **b** = without black spots.

A fish that is homozygous recessive at both loci is white.

Genetic crosses were carried out to investigate the inheritance of the four different body colour patterns.

Males that were red with black spots, and homozygous at both loci, were crossed with females that were white. The F1 offspring were all red with black spots.

These F1 offspring were then crossed to produce the F2 generation.

(a) Table 5.2 shows the observed numbers obtained of each of the four different phenotypes for the F2 generation.

Table 5.2

phenotype	**observed**	**expected**	***O–E***	***(O–E)*²**	$\frac{(O-E)^2}{E}$
red with black spots	279	281.25			
white with black spots	95	93.75	1.25	1.5625	0.017
red	96	93.75	2.25	5.0625	0.054
white	30	31.25			
				χ^2 = ...	

Table 5.2 compares the observed numbers with the numbers that would be expected in the F2 generation for a normal dihybrid ratio.

Calculate χ^2 for the F2 generation by completing Table 5.2.

The formula for χ^2 is:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

[3]

(b) The critical value at $p = 0.05$ and 3 degrees of freedom is 7.815.

Comment on whether the null hypothesis should be accepted or rejected.

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Further analysis of the results from the F2 generation in Table 5.2 showed that there were no white males or white males with black spots.

In *O. latipes*, females have two **X** chromosomes and males have an **X** and a **Y** chromosome.

It was deduced that, in *O. latipes*:

- the gene that controls body colour is located on the **X** chromosome **and** the **Y** chromosome
- the gene that controls whether black spots are present or **not** is located on an autosome.

(c) To produce the F2 generation, red males with black spots, $\mathbf{X^rY^RBb}$, were crossed with red females with black spots, $\mathbf{X^RX^rBb}$.

Complete the Punnett square in Fig. 5.1 to show the genotypes and phenotypes of the F2 generation.

- Use the symbols $\mathbf{X^R}$, $\mathbf{X^r}$ and $\mathbf{Y^R}$ for the alleles of the gene that controls body colour.
- Use the symbols **B** and **b** for the alleles of the gene that controls whether black spots are present or **not**.

Some of Fig. 5.1 has been completed for you.

	female gametes			
male gametes	$\mathbf{X^RB}$	$\mathbf{X^rB}$	$\mathbf{X^Rb}$	$\mathbf{X^rb}$
$\mathbf{X^rB}$	$\mathbf{X^RX^rBB}$		$\mathbf{X^RX^rBb}$	$\mathbf{X^rX^rBb}$
	female		female	female
	red + black spots		red + black spots	white + black spots
$\mathbf{Y^RB}$	$\mathbf{X^RY^RBB}$	$\mathbf{X^rY^RBB}$	$\mathbf{X^RY^RBb}$	$\mathbf{X^rY^RBb}$
	male	male	male	male
	red + black spots	red + black spots	red + black spots	red + black spots
$\mathbf{X^rb}$	$\mathbf{X^RX^rBb}$	$\mathbf{X^rX^rBb}$	$\mathbf{X^RX^rbb}$	
	female	female	female	
	red + black spots	white + black spots	red + no spots	
$\mathbf{Y^Rb}$		$\mathbf{X^rY^RBb}$		$\mathbf{X^rY^Rbb}$
		male		male
		red + black spots		red + no spots

Fig. 5.1 [4]

(d) Explain why there are no white males or males that are white with black spots in the F2 generation.

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(e) In another cross, red males with the genotype $\mathbf{X^rY^Rbb}$ were mated with white females with the genotype $\mathbf{X^rX^rbb}$. All the male offspring were expected to be red and all the female offspring were expected to be white.

The observed results showed that the offspring included two red females out of 253 and one white male out of 198.

Suggest an explanation for this unexpected result.

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[Total: 13]