

Mendel's first law states that 'only one of a pair of contrasting characters may be represented in a single gamete'. His second law states that 'either of a pair of contracting characters may be combined with either of another pair.'

Explain how meiosis illustrates these laws.

Law 1.....
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..... [4]

Law 2:.....
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..... [4]

(a) There are 12 chromosomes in the somatic cells of the bean, *Vicia*.

(i) How many chromosomes does the offspring receive from the female parent via the egg cell nucleus?

..... [1]

(ii) How many chromosomes will be present in the primary endosperm nucleus?

..... [1]

(iii) A female sex chromosome is donated by X and a male sex chromosome by Y. Specify the sex chromosome content in the primary endosperm nucleus.

..... [1]

(b) The diploid chromosome number of a donkey is 66 chromosomes and that of a horse is 60 chromosomes.

(i) A mule is the offspring of a cross between a female horse and a male donkey. Calculate the number of chromosomes to be found in the somatic cells of the mule. Show your working.

Answer [2]

(ii) Bivalent formation occurs in prophase 1 of meiosis. What is the theoretical maximum number of bivalents that could form in the mule?

..... [1]

(iii) Suggest why mules are infertile.

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..... [2]

The Brindled Beauty (*Lycia hirtaria*) is a moth whose colour is controlled by a single gene with a pair of alleles.

(a) A homozygous brown and white individual was allowed to breed with a heterozygous individual.

- (i) Use the symbol B to represent the dominant allele for black (melanic) colour and b to represent the recessive allele for brown and white colour. Write down genotypes and phenotypes of the parents and offspring and the genotypes of the gametes.

Parents x [1]

Gametes x [1]

F₁ [1]

- (ii) The black offspring of this cross were allowed to interbreed together. State the genotypes and phenotypes of the offspring and their ratio.

Genotypes [1]

Phenotypes [1]

Ratio [1]

(b) Describe how you could find out whether black individuals were homozygous or heterozygous for the colour alleles.

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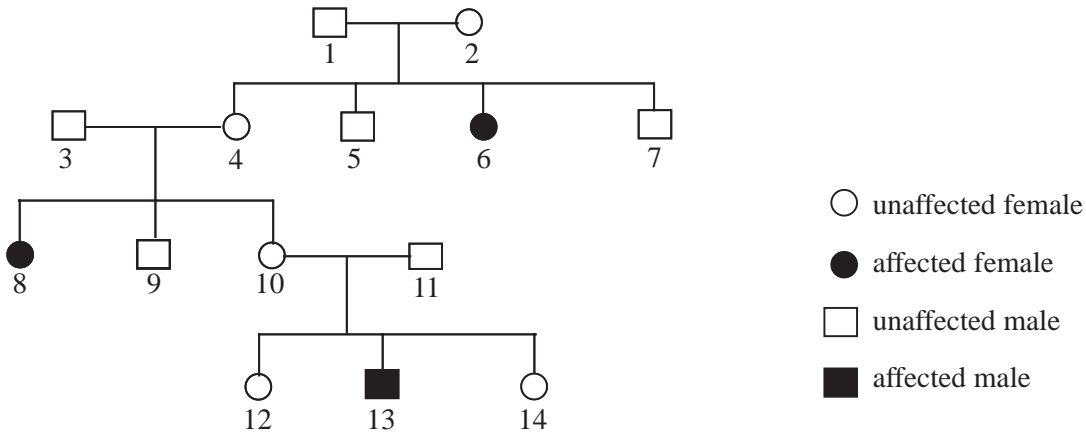
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[5]

Alkaptonuria is a harmless, rare autosomal genetic defect in humans. The family tree below shows the pedigree of a family affected by alkaptonuria. (Individuals are numbered 1 to 14).



(a) (i) Is the condition dominant or recessive? Explain your answer.

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[2]

(ii) State the numbers of all the individuals that are certain to be heterozygous for this gene.

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[3]

(iii) What is the probability that individual 14 is heterozygous for this gene?

.....

[1]

(b) Alkaptonuria occurs due to point mutation of the gene. State two other point mutation diseases of humans.

1. [1]

2. [1]

Alleles of the ABO blood group system are usually shown as I^A , I^B and I^O . I represents the gene locus and A, B and O represent the three alleles of the ABO gene.

(a) What is meant by the term 'gene locus'?

..... [1]

(b) By reference to the inheritance of the ABO blood group system explain what is meant by (i) multiple alleles, (ii) codominance and (iii) a recessive allele.

(i) Multiple alleles: [3]

(ii) Codominance: [2]

(iii) Recessive allele: [2]

(c) By means of a genetic diagram show the possible results of a cross between individuals of genotypes AO and BO.

[3]

(a) Explain the meaning of the term 'gene'.

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.....
.....

[3]

(b) Define each of the following terms.

(i) genotype:
..... [1]

(ii) phenotype:
..... [1]

(iii) heterozygous:
..... [1]

(c) Kerry type cattle with normal leg length are produced by a homozygous dominant genotype DD. Short legged Dexter type cattle are produced by the genotype Dd. The homozygous recessive genotype dd produces bulldog calves which are always stillborn.

(i) Give complete genetic diagrams to illustrate the following crosses:

Kerry cattle x Dexter cattle.

[3]

Dexter cattle x Dexter cattle.

[3]

(ii) Which of these crosses would be the better breeding programme for the farmer to use in order to obtain Dexter calves? Explain your answer.

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.....
.....

[2]

In pigs erect ears is controlled by the dominant allele **E** and flop ears by the recessive allele **e**. Black coat is controlled by the dominant allele **B** whilst red coat is controlled by the recessive allele **b**. The pairs of alleles are not linked.

- (a) (i) With the aid of a genetic diagram show the genotypes and phenotypes of a cross between two black erect eared heterozygous pigs and state the ratio of the phenotypes obtained.

[6]

- (ii) How do these results illustrate Mendel's second law?

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[2]

(b) With the aid of a genetic diagram show the genotypes, phenotypes and ratio of offspring produced by crossing a black erect eared heterozygous pig with a red flop eared pig. In this case assume that the genes are linked, in adjacent association on the same bivalent. Comment on the result obtained.

Comment

.....

..... [6]

Rats have a dominant allele **B** which gives black coat colour and a recessive allele **b** which gives a cream coat colour. This gene acts in association with a randomly assorting epistatic gene which possesses two alleles, dominant **E** which allows the development of colour and the recessive **e** which suppresses colour development, resulting in albino rats which have white coats and pink eyes.

(a) Write down the possible genotypes of the following rat phenotypes.

(i) a black rat: [1]

(ii) a cream rat: [1]

(iii) an albino rat: [1]

(b) What do you understand by the term 'randomly assorting epistatic gene'?

.....

[3]

(c) With the aid of a genetic diagram show the genotypes and phenotypes which could result from a cross between a cream individual of genotype $bbEe$ and a black rat heterozygous for both characters. Indicate the ratio of phenotypes possible.

[4]

TOTAL / 10 _____

The genetic disease 'progressive retinal atrophy' is caused by a mutant recessive gene in Irish Setter dogs. If the dog inherits the double recessive genotype then symptoms will develop by 10 weeks of age. Although the dogs become blind they are otherwise normal. The Irish Setters Breeders Society has run a breeding programme in an attempt to eliminate the disease. Use the symbol **R** to represent the normal condition and the symbol **r** to represent the disease condition. Dogs of genotype **Rr** do not show the disease but act as carriers.

(a) Describe and explain a suitable breeding programme which could be used to eliminate the blindness gene.

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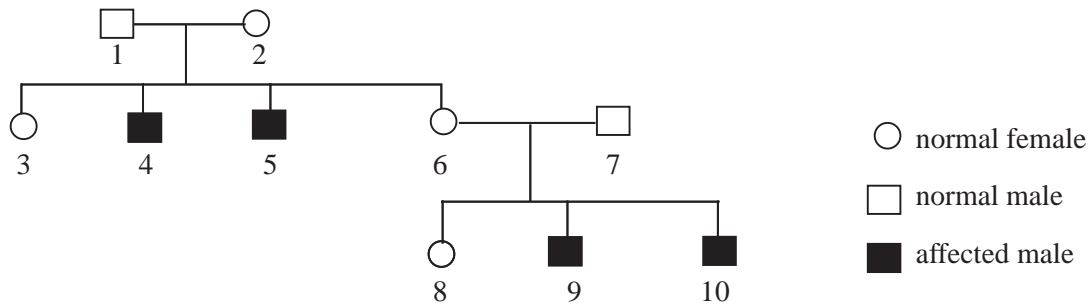
[6]

(b) Would such a breeding programme completely eliminate the gene causing blindness? Explain your answer.

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[2]

The family tree below shows the inheritance of Duchenne muscular dystrophy in a family. This disease is caused by a recessive allele of an X-linked gene.



(a) (i) Indicate below the possible genotypes of individuals 1 to 10. Use D for the normal gene and d for the Duchenne gene and X and Y for the sex chromosomes.

1. 2. 3.
 4. 5. 6.
 7. 8. 9.
 10.

[10]

(ii) What would a genetic counsellor say to parents 6 and 7 when explaining what the probability would be of their next child suffering from Duchenne muscular dystrophy?

.....

[4]

(b) Name two other X-linked diseases of humans.

- 1 [1]
 2 [1]

(a) The multiple allele inheritance system of the ABO blood group system contains the codominant alleles A and B and the recessive allele O. The table below shows possible crosses between people of certain ABO groups, the alleles they can contribute and the phenotypes of offspring which could not be produced as a result of the cross. Complete the table by writing in the alleles and blood group phenotypes in the empty boxes.

Cross blood groups	Possible alleles available		Impossible phenotypes in offspring blood groups
	Parent 1	Parent 2	
A × A	A, O	A, O	B, AB
A × B			
A × AB			
A × O			
B × B			
B × AB			
B × O			
AB × AB			
AB × O			
O × O			

[9]

(b) A husband suspects that his wife's third child has been fathered by another man. His own first two children possess blood groups O and AB. The third, suspect child, is blood group B. Are the husband's suspicions justified? Explain your answer.

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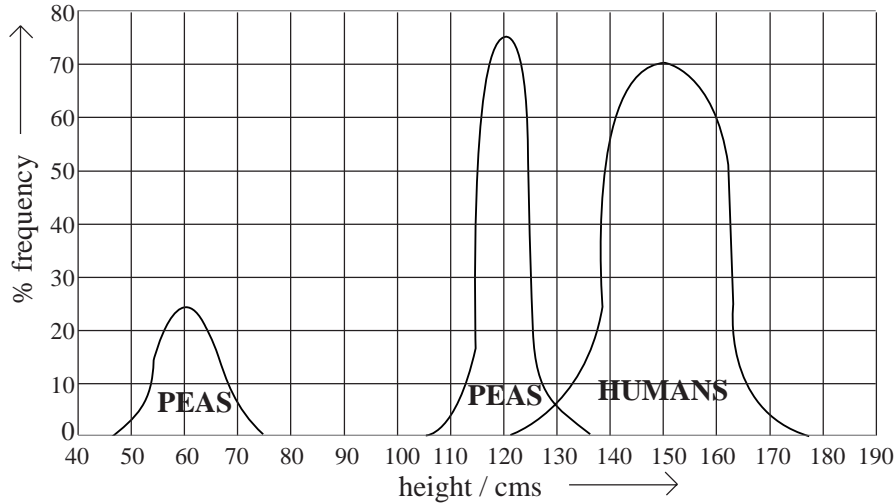
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[4]

The graph below represents the distribution of height in a pea plant population and in a human population.



(a) (i) What types of variation are shown by the pea plants and humans in relation to stature?

Peas: [1]

Humans: [1]

(ii) With reference to the genetic mechanisms involved explain the types of distribution of height in peas and humans.

Peas:

 [5]

Humans:

 [5]

(b) State three precautions which would be taken when obtaining the human data.

- 1:
- 2:
- 3:

Coat colour in horses is governed by a pair of alleles. The allele C^C governs the development of a cream coat and the allele C^H governs the development of a chestnut (brown) coat. If a pure bred cream horse is crossed with a pure bred chestnut horse then the resulting offspring is golden in colour with a white mane and this coat colour is referred to as palomino.

(a) (i) What name is given to this type of genetic result?

..... [1]

(ii) Write down a genetic diagram to show the cross between a pure bred cream horse and a pure bred chestnut horse. Show all genotypes, phenotypes and gametes.

[3]

(iii) What would be the probabilities of obtaining a palomino, cream or chestnut horse when two palominos are interbred?. Give a genetic diagram to explain your answer.

Probabilities: [1]

Genetic diagram:

[3]

(b) The Manx cat is a variety that has no tail. The trait is caused by a dominant allele **M**. In the homozygous condition this allele is lethal and results in stillborn kittens. The recessive allele, **m**, results in the tailed condition. How can breeders of Manx cats avoid getting stillborn kittens? Explain your answer with genetic diagrams.

How avoided: [1]

Genetic diagrams:

[6]