

OCR A-LEVEL BIOLOGY B • H422

BIOLOGY



EXAM QUESTION PACK

5.1.1 PATTERNS OF INHERITANCE

SCORE

/177

PERCENTAGE

%

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- 1 Please refer to the Advance Notice article 'Mitochondrial DNA and mitochondrial disease' in the Insert for QP H422/02, November 2020.

Explain why raised concentrations of lactate confirm diagnosis of mitochondrial disease.

----- [2]

2(a) Model organisms such as *Drosophila melanogaster* (fruit fly) and *Pisum sativum* (common pea plant) are often used to study patterns of inheritance.

Suggest **one** advantage and **one** disadvantage of using *D. melanogaster* over *P. sativum* as a model organism.

advantage -----

disadvantage -----

[2]

(b) An experiment was carried out to investigate the inheritance of plant height and flower colour in *P. sativum*.

The allele for tall stems is dominant to the allele for dwarf stems. The allele for purple flower colour is dominant to the allele for white flower colour.

(i) Two plants, both heterozygous for each trait, were crossed. State the genotype of the parental plants using the letters **R** for plant height and **Y** for flower colour.

[1]

(ii) Crossing of the parental plants produced 320 offspring. The numbers of offspring with each phenotype are shown in the table below.

Phenotype	Observed (<i>O</i>)	Expected (<i>E</i>)	<i>O</i> – <i>E</i>	(<i>O</i> – <i>E</i>) ²	$\frac{(O - E)^2}{E}$
tall stems, purple flowers	175				
dwarf stems, purple flowers	57				
tall stems, white flowers	63				
dwarf stems, white flowers	25				

Calculate chi-squared, χ^2 .

Use the formula: $\chi^2 = \sum \frac{(O - E)^2}{E}$

You can complete the table to help.

$$\chi^2 = \dots\dots\dots [4]$$

(iii) The table below is a χ^2 significance table.

$p\%$	99	97.5	95	90	10	5.0	2.5	1.0	0.5
$\nu = 1$	0.0001	0.0010	0.0039	0.0158	2.706	3.841	5.024	6.635	7.879
2	0.0201	0.0506	0.103	0.211	4.605	5.991	7.378	9.210	10.60
3	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.34	12.84
4	0.297	0.484	0.711	1.064	7.779	9.488	11.14	13.28	14.86

With reference to the χ^2 significance table, what **statistical** conclusion can be made from this experiment?

[2]

(c) Scientists often model human genetic diseases, such as Huntington's disease, in *D. melanogaster*.

Describe the genetic basis of Huntington's disease.

[2]

3 A couple have a child. Both parents are heterozygous for the cystic fibrosis allele.

Which of the options, **A** to **D**, is the probability that the child will have cystic fibrosis?

A 0.25

B 0.5

C 0.75

D 1

Your answer

[1]

4 As well as being a popular food (corn on the cob), maize is a useful model for studying patterns of inheritance.

Each maize cob contains hundreds of seeds known as kernels.

In maize, one gene determines the colour of the kernels, which is either yellow or colourless.

Another gene determines the amount of endosperm in each kernel. Kernels filled with endosperm are smooth whereas kernels with shrunken endosperm appear wrinkled.

- (i) Two pure breeding strains of maize were crossed. One strain had smooth yellow kernels. The other strain had wrinkled colourless kernels.

All the kernels of the offspring (F_1) were smooth and yellow.

The plants in the F_1 generation were then crossed with plants that had pure-bred wrinkled colourless kernels.

State the parental genotypes and gametes of this cross.

Use the following to represent the alleles:

- **A** and **a** for colour (yellow or colourless)
- **B** and **b** for appearance (smooth or wrinkled).

parental genotypes: ×

gametes:

[2]

- (ii) Using a genetic diagram and your answer to (i), predict the phenotypic ratio that you would expect from the second cross.

phenotypic ratio: [2]

(iii) The actual results of the second cross are shown in Table 7.1.

Phenotype	Number of kernels
Smooth yellow	275
Wrinkled yellow	277
Smooth colourless	235
Wrinkled colourless	213

Table 7.1

Calculate χ^2 for these data.

Use the formula: $\chi^2 = \sum \frac{(f_o - f_e)^2}{f_e}$

You may use the table below for working out.

$\chi^2 = \dots\dots\dots$ [3]

(iv) Table 7.2 shows a χ^2 probability table.

Degrees of freedom	Probability (p)				
	0.50	0.10	0.05	0.01	0.001
1	0.46	2.71	3.84	6.64	10.83
2	1.39	4.61	5.99	9.21	13.82
3	2.37	6.25	7.82	11.35	16.27
4	3.36	7.78	9.49	13.28	18.47

Table 7.2

What can you conclude about the results shown in Table 7.1 based on the χ^2 value you calculated in (iii)?

-----[1]

(v) Suggest an explanation for your conclusion in part (iv).

-----[2]

5 Red-green colour blindness is a sex-linked inherited disorder that affects mostly males.

Suggest why red-green colour blindness affects mostly males.

[2]

6(a) Please refer to the Advance Notice article 'Learning from Iceland's model for genetic research' in the Insert for QP H422/02, June 19.

The article explains how Iceland has one of the most genetically homogeneous populations in Europe.

(i) State what is meant by the following genetic terms.

1. Gene -----

2. Allele -----

[2]

(ii) Allele frequencies will remain constant in a stable population. However, population changes can alter allele frequencies.

For each of the following events, give the term used to describe the effect on allele frequencies.

1. Iceland was settled by a relatively small number of explorers in the 9th century.

2. The Icelandic population decreased due to the two waves of plagues during the 15th century, smallpox in the early 1700s and a volcanic eruption in 1783.

[2]

(iii) Explain how the events described in (ii) resulted in the low genetic diversity of the Icelandic population.

[2]

(b) The article describes the use of flow cytometry ('automated blood analysers') to identify genetic variants linked to the risk of developing multiple myeloma.

Explain how flow cytometry could be used to identify genetic variants linked to the risk of developing multiple myeloma.

[4]

- (c) Some genetic diseases, such as sickle cell anaemia, are caused by single mutations.

Explain how a single gene mutation causes sickle cell anaemia.

[3]

- Evaluate the advantages and disadvantages of this approach compared with pedigree analysis.

[4]

(e) In MGUS, B cells produce an abnormal polypeptide called M protein.

Production of M protein involves the processes of transcription and translation.

Complete the table by putting a tick (✓) in the appropriate box to indicate whether the feature is involved in transcription, translation, both or neither.

Feature	Transcription only	Translation only	Both	Neither
C pairs with G				
A pairs with T				
Phosphodiester bonds are made				
Peptide bonds are made				

[4]

7(a) A Robertsonian translocation is a type of chromosomal translocation in which the long arms of two chromosomes fuse together.

Fig. 31.1 shows this event occurring between chromosomes 14 and 21.

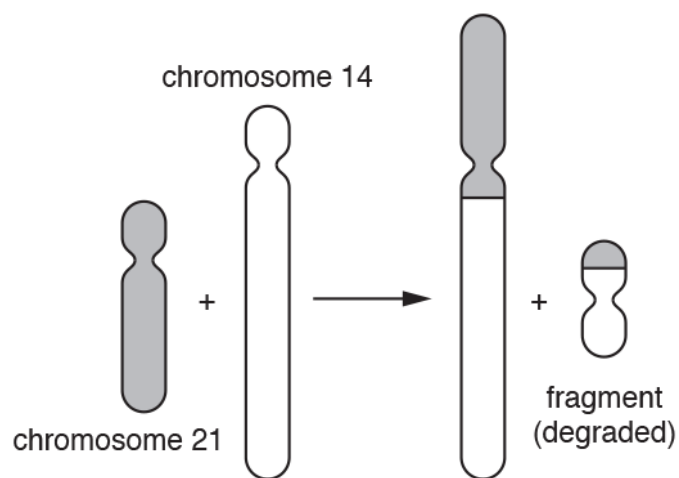


Fig. 31.1

An individual who inherits the translocated chromosome in Fig. 31.1 will either have Down's syndrome or be a carrier of the disorder.

A couple have a child. The mother is a carrier and the father is genetically normal. The genetic material with respect to chromosomes 14 and 21 in the somatic cells of the parents are shown in Fig. 31.2.

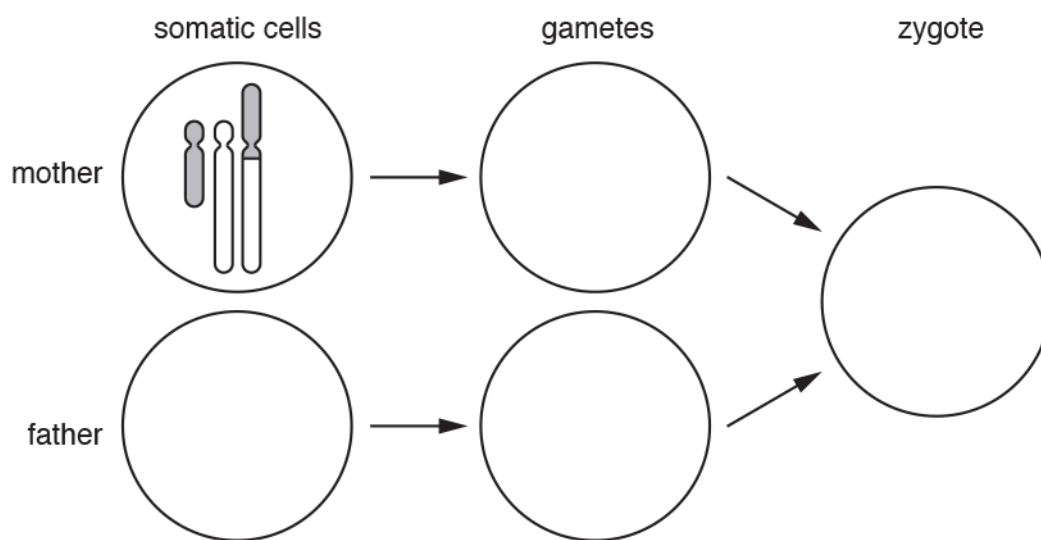


Fig. 31.2

(i) With reference to Fig. 31.2, suggest why the mother does **not** have Down's syndrome.

----- [1]

(ii) The child is born with Down's syndrome.

Complete the diagram in Fig. 31.2 to show the genetic material with respect to chromosomes 14 and 21 in:

- the somatic cell of the father
- the gametes of the mother and father
- the zygote of the child.

[Answer on Fig. 31.2]

[4]

(b) Down's syndrome is more commonly caused by a genetic event that is distinct from that shown in Fig. 31.1.

State the name of this event **and** outline how it arises.

----- [3]

(c) A sample of cells can be collected from a fetus to test for genetic disorders such as cystic fibrosis.

(i) Chorionic villus sampling (CVS) and amniocentesis are two methods of obtaining fetal cells.

State the **source** of fetal cells that are obtained through these methods.

CVS -----

Amniocentesis -----

[1]

(ii) The sample of fetal cells can be used to produce a karyotype for genetic analysis.

Explain why karyotyping can **not** be used to detect cystic fibrosis.

----- [1]

8 Which of the options, **A** to **D**, describes the type of gene mutation that causes Huntington's disease?

A change of nucleotide that affects the protein

B change of nucleotide that does not affect the protein

C deletion of nucleotides

D insertion of nucleotides

Your answer

[1]

- 9 Freeman was working on developing drought-resistant varieties of alfalfa using selective breeding, but this has proved difficult.

Drought resistance depends on the ability to withstand several abiotic factors, such as high temperatures and high light intensity.

- (i) Use your knowledge of inheritance to suggest why it is difficult to study the genetic basis of drought resistance.

----- [2]

- (ii) Alleles of the *miRNA* 156 gene regulate a group of transcription factors in alfalfa. These transcription factors activate or inhibit promoters that control genes related to drought resistance.

Explain how the *miRNA* 156 gene could be used to investigate the genetic basis of drought resistance.

----- [2]

- (iii) Scientists have made a plasmid that produces more of the *miRNA* 156 gene product than normal and want to use this to develop a drought-resistant alfalfa plant.

Explain how they could incorporate the plasmid into alfalfa cells.

----- [2]

10(a) The gene, *HBB*, codes for the beta polypeptide in haemoglobin.

A person with sickle cell anaemia has a mutation in *HBB*. This causes a change to the sixth amino acid in the beta polypeptide.

Describe the type of DNA mutation that causes the amino acid change in the beta polypeptide.

-----[1]

(b) A couple with no symptoms of sickle cell anaemia want to have a child. Both individuals have close relatives with the disease.

(i) Explain how a genetic counsellor can use knowledge of family history to provide genetic advice to the couple.

-----[2]

(ii) Suggest **two** ethical concerns that may be associated with the genetic testing of embryos for sickle cell anaemia.

1

2

-----[2]

- 11 The chi-squared (χ^2) test was used to determine whether the inheritance pattern of a dihybrid cross was statistically significant.

Four phenotypes were produced from the cross.

χ^2 was calculated as 8.62 and the significance level (p) was 0.05.

A table of χ^2 values is shown below.

	Probability (p)							
df	0.99	0.95	0.90	0.50	0.10	0.05	0.01	0.001
1	0.0016	0.0039	0.016	0.46	2.71	3.84	6.63	10.83
2	0.02	0.10	0.21	1.39	4.60	5.99	9.21	13.82
3	0.12	0.35	0.58	2.37	6.25	7.81	11.34	16.27
4	0.30	0.71	1.06	3.360	7.78	9.49	13.28	18.46

Which of the statements, A to D, is correct?

- A df is 3 and χ^2 is not significant
- B df is 3 and χ^2 is significant
- C df is 4 and χ^2 is not significant
- D df is 4 and χ^2 is significant

Your answer

[1]

12 Haemophilia A is a disease caused by a mutation in the gene coding for Factor VIII.

Factor VIII is involved in the blood clotting cascade.

(i) Scientists have found different types of mutation that can cause haemophilia A.

One type of mutation is a deletion of **two** bases. Suggest how this mutation causes the Factor VIII protein to lose its biological function.

----- [2]

(ii) Explain why haemophilia A is more common in males than in females.

----- [2]

(iii) A male with haemophilia A and a female who carries the disease have a child.

Complete the Punnett square below to determine the probability that the child will have haemophilia A. Use H/h to represent the alleles coding for Factor VIII.

		male	
			
female			
			

Catalase is a homotetramer molecule found in human cells. Homotetramers are molecules that contains four identical subunits.

- (i) What evidence in the Advance Notice article confirms that human catalase must be a homotetramer? Explain your answer.

[2]

- (ii) Name one other tetrameric protein molecule found in human cells **and** state one similarity and one difference between the structure of this protein molecule and the structure of catalase.

protein -----

similarity -----

difference -----

[3]

14(a) The appearance of blood samples viewed under a microscope can be used to diagnose a number of different conditions.

Fig. 7.1 shows a blood sample. An abnormal cell known as a **schistocyte** is labelled. Schistocytes are formed from fragments of red blood cells.

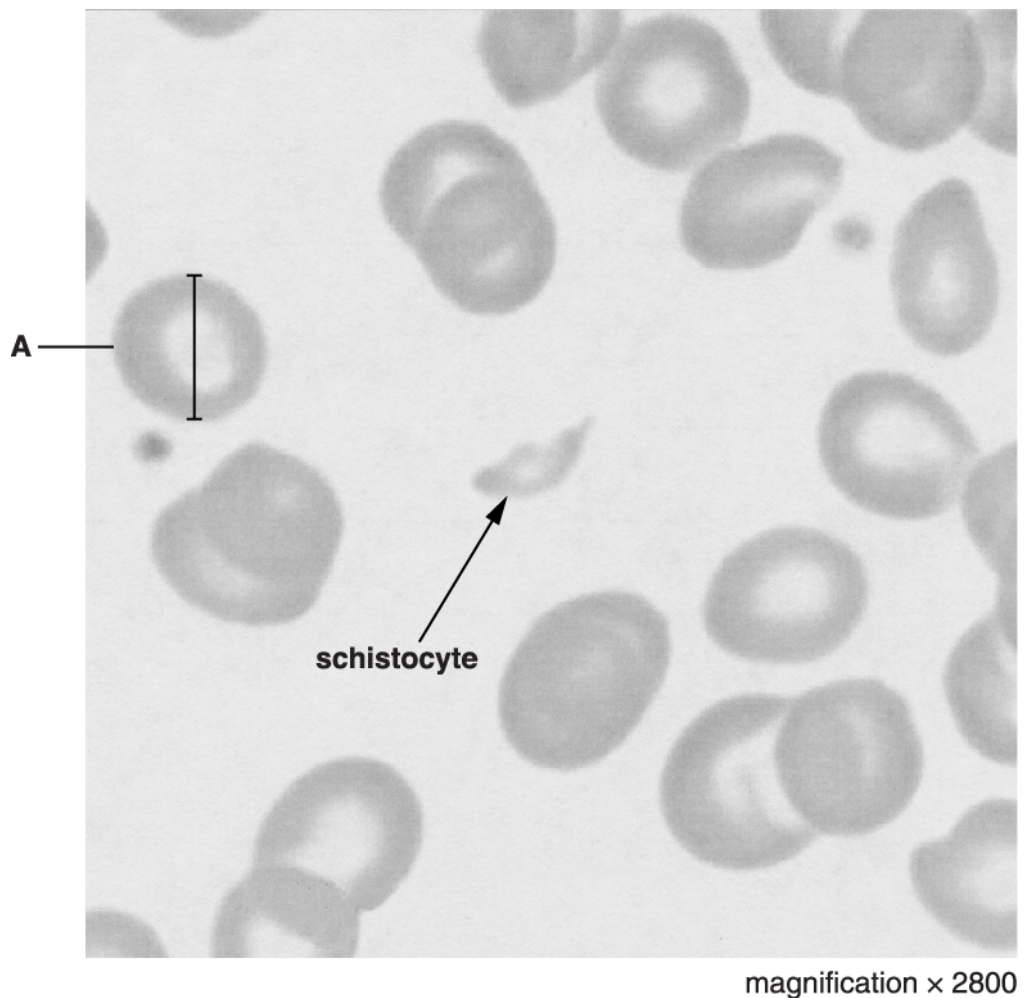


Fig. 7.1

(i) Use the information in Fig. 7.1 to calculate the size of cell A.

Show your working. Give your answer to the nearest whole number.

Answer = ... μm

[2]

- (ii) When activated platelets bind to the endothelium of small arterioles and capillaries, schistocytes are formed.

Suggest why the binding of activated platelets leads to the formation of schistocytes.

.....
..... [1]

- (iii) State one **genetic** disease that could be diagnosed by examination of a blood smear.

..... [1]

- (b) An infection by a strain of the bacterium *E. coli* called O157 can lead to the appearance of schistocytes in a blood sample.

Infections by this bacterium are the most common cause of acute kidney failure in children. This results in a condition called **HUS**.

Most children who develop HUS make a full recovery. A few children are left with permanent kidney damage.

- (i) Name the short-term treatment given to children with acute kidney failure and **outline** the alternative long-term treatment options that would be available if necessary.

[5]

- (ii) Suggest **one** further treatment that **HUS** patients may require to prevent them becoming anaemic. Explain your suggestion.

[3]

(c) Some forms of **HUS** are not associated with *E. coli* O157 infections. These are known as atypical **HUS** or **AHUS**.

Some cases of **AHUS** are known to be due to an inherited gene mutation.

Carefully read and then complete the following passage about the inheritance of **AHUS** and the role of the genetic counsellor.

Some inherited forms of **AHUS** are due to a _____ mutant allele.

Parents show no symptoms of the disease so, if they have a child who develops **AHUS**, the child must be _____ for this allele. Since neither parent shows symptoms, yet both carry the mutant allele, the allele does not show _____ linkage.

A genetic counsellor would use a _____ diagram to explain the risk of any further children either developing **AHUS** or being a carrier. Where unaffected parents have one child with **AHUS**, there would be a _____ percent chance of having a child who is a carrier.

[5]

15(a) Down's syndrome (DS) is a genetic condition that occurs in approximately 1 in every 800 births.

Fig. 2.1a shows a karyotype from a male with a rare form of DS. In this karyotype, there is an additional piece of genetic material attached to one copy of chromosome 14.

A larger diagram of both copies of chromosome 14 is shown in **Fig. 2.1b**.

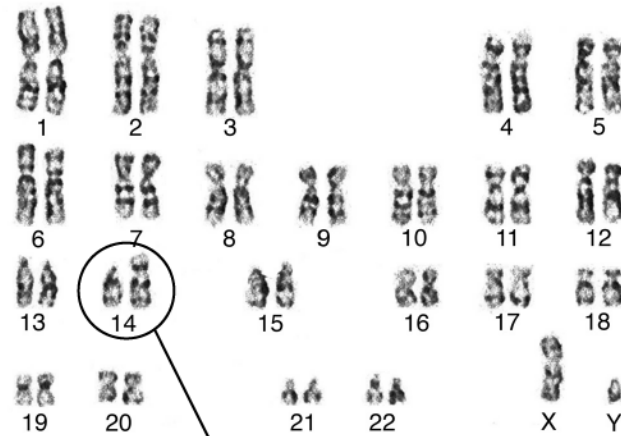


Fig. 2.1a

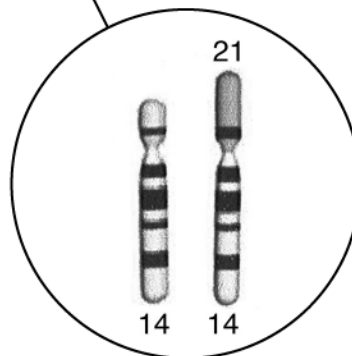
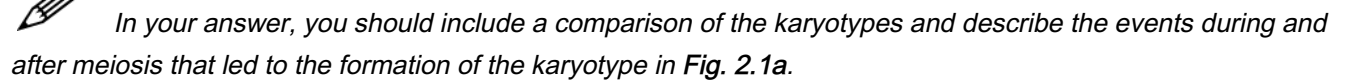


Fig. 2.1b

- Describe how the appearance of the karyotype shown in Fig. 2.1a differs from that of the more common form of DS.
- Suggest **when** and **how** the transfer of extra genetic material to chromosome 14 occurred, and what events led to cells with this karyotype being formed.

[71]

(b) The National Cytogenic Register for DS was set up in the United Kingdom in 1989.

This register holds anonymous data on families for over 26 000 cases of DS. These cases were diagnosed either antenatally or postnatally.

Fig. 2.2 shows the changes in the number of DS cases diagnosed between 1990 and 2005. It also shows the changes in the number of live births of children with DS for the same period.

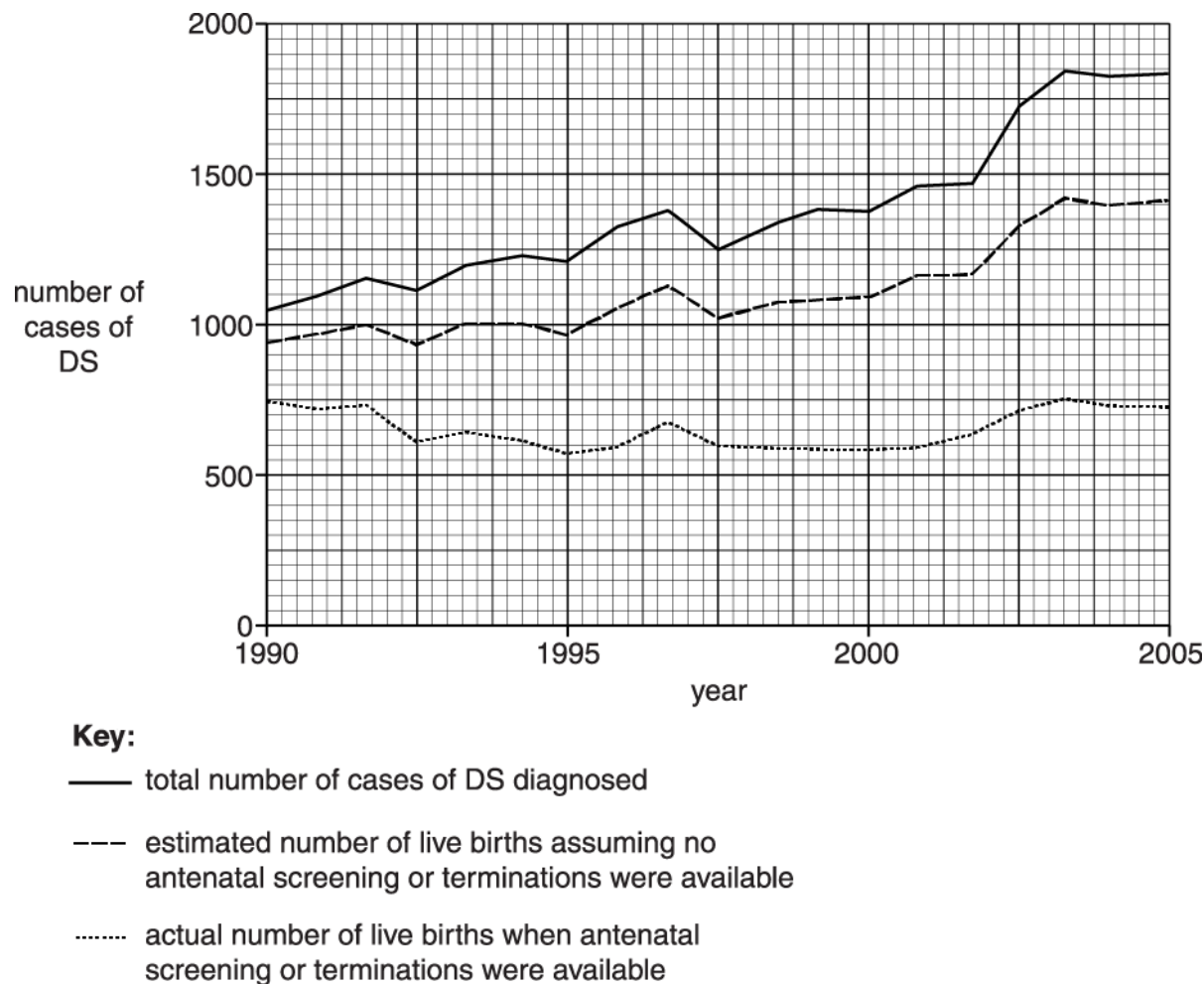


Fig. 2.2

(i) Suggest why the data on the National Cytogenic Register for DS are held anonymously.

----- [1]

(ii) Using the information in Fig. 2.2, suggest **why** the number of cases of DS **diagnosed** between 1990 and 2005 has changed.

[2]

- (iii) Suggest what factor the investigators took into account in estimating the number of children with DS who would have been **born**, assuming that no antenatal screening or terminations were available.

[1]

16(a) The functional unit of the kidney is the nephron. Fig. 5.1 shows a simplified diagram of a nephron.

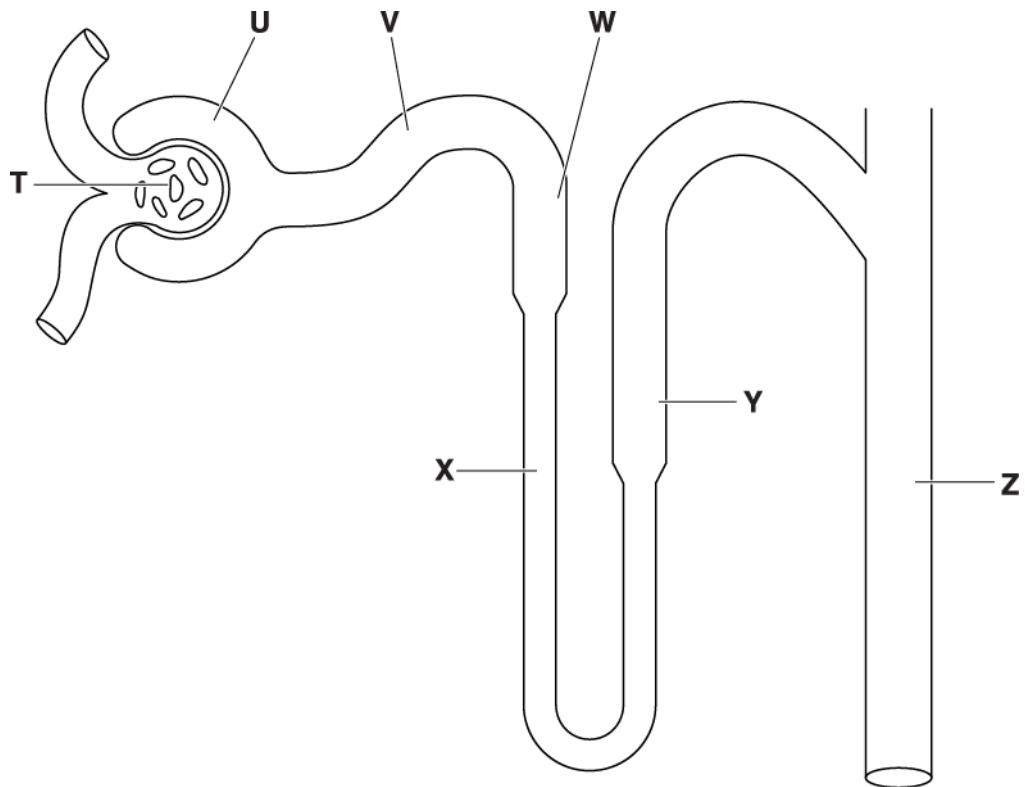


Fig. 5.1

- (i) Identify the structures T and U and state the region of the kidney where these structures are found.

T

U

Region of kidney -----

[3]

- (ii) Complete the following paragraphs about the passage of filtrate through the loop of Henle by inserting the most appropriate word.

Electrolytes such as sodium ----- are actively reabsorbed from the filtrate

at region Y, which is the ----- limb of the loop of Henle. This reabsorption

reduces the _____ of the

surrounding tissues in the _____ of the kidney.

The walls of the tubule in region **X** are _____ to water. The result is that

water is reabsorbed from the filtrate by the process of _____.

[6]

- (b) Reabsorption of glucose in the nephron takes place actively using glucose transport proteins. These transport proteins are located in regions **V** and **W** of the nephron.

In a condition known as familial glycosuria, the glucose transport proteins in region **W** are not functioning. This results in glucose being present in the urine.

- (i) Predict the effect of a non-functioning glucose transport protein on the **volume** of filtrate leaving the loop of Henle. Explain the reason for your prediction.

[3]

- (ii) Suggest why the management of familial glycosuria may involve a genetic counsellor.

[1]

- 17 Human genetic diseases, such as sickle cell anaemia and cystic fibrosis, are caused when mutated forms of a gene are inherited.

The study of how these alleles are distributed in human populations can be an indication of how a human population has evolved over time.

State **two** genetic diseases, other than sickle cell anaemia and cystic fibrosis, which are caused by the inheritance of mutant alleles.

1

2

[2]

18(a) Choroideremia is an inherited sex-linked recessive condition that results in degeneration of the choroid layer in the eye. This condition leads to a gradual breakdown of the retina and eventual blindness.

Using the normal conventions for constructing genetic diagrams and the letters **E** and / or **e**, choose appropriate symbols to represent:

(i) the allele for choroideremia

-----[1]

(ii) the possible genotype(s) of a person who develops choroideremia

-----[1]

(iii) the genotype of a carrier of choroideremia.

-----[1]

(b) The gene involved in choroideremia codes for a protein called REP-1.

Many of the gene mutations that cause choroideremia result in the formation of a protein that is much smaller than normal REP-1. This smaller protein is known as a **truncated protein**.

(i) State the **organelle** in the cell where the following occurs:

a complementary RNA copy of the gene is synthesised -----

the REP-1 protein is synthesised -----

[2]

(ii) Suggest **how** a mutation in the REP-1 gene could lead to the formation of a truncated protein.

-----[2]

(c) A phase 1 clinical trial was carried out using gene therapy to treat choroideremia. An outline of the method used is given below.

- A complementary DNA (cDNA) copy of the REP–1 gene was inserted into a viral vector.
- The retina of the patient was detached to expose the choroid layer.
- A fine needle was used to inject the virus into the choroid layer.

(i) Name the enzyme used to create a cDNA copy of the REP–1 gene.

-----[1]

(ii) What type of gene therapy has been used in the trial?

-----[1]

(iii) Discuss the reasons why genetic diseases such as choroideremia are good choices for treatment using gene therapy.

-----[3]

19(a) A successful organ transplant usually depends on a good genetic match between the organ donor and the recipient to avoid the transplanted organ being rejected.

Complete the following paragraph about the major histocompatibility (**MHC**) system by inserting the most appropriate term.

There are six major genes controlling the MHC complex located on chromosome 6. Each gene codes for a

_____, which is expressed on the cell surface membrane and acts as an

_____ Each of the six genes has many different alleles.

The gene _____ are close together on chromosome 6, making it unlikely that

_____ will occur between them during prophase 1 of _____

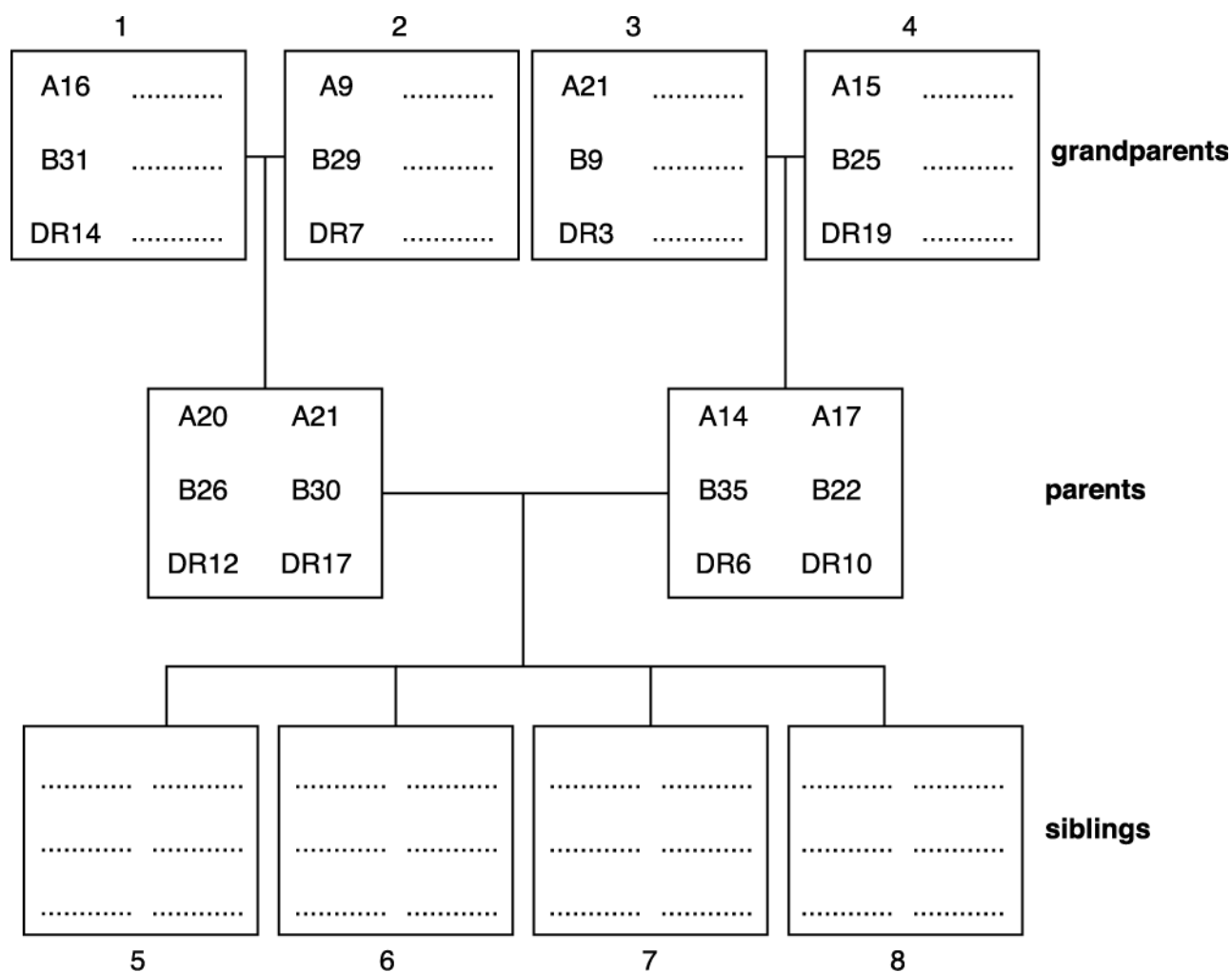
This means that one complete set of alleles or **haplotype** will be inherited from each parent. The MHC alleles

are said to be _____, as the alleles from both haplotypes are expressed in the phenotype.

[6]

- (b) For transplants of organs such as kidneys, the important genes are MHC genes **A**, **B** and **DR**. **A** has approximately 25 different alleles, **B** has 40 and **DR** has 20.

The following figure shows a pedigree diagram for the inheritance of haplotypes in three generations of one family.



- (i) Complete the figure to show the haplotypes of the grandparents **and** the four possible haplotypes of the siblings.

The answer to this question should be written on the figure.

[3]

- (ii) Suggest **two** reasons why organ donations from a grandparent to a grandchild are less likely to be successful

than those from a parent to a child.

[2]

- (c) A transplant is more likely to be successful if MHC haplotypes and the ABO blood group of the donor and the recipient are matched.

The genes controlling the ABO blood group are located on chromosome 9.

Explain how the children of parents who are heterozygous for blood group A could have identical MHC haplotypes but different blood groups.

[3]

- 20 Some varieties of maize plants have smooth kernels (seeds), whereas others have wrinkled kernels. This is a genetic trait.

Varieties with smooth kernels are rich in starch and useful for making flour.

A farmer has been given some smooth seeds all of the same unknown genotype. The farmer carries out a cross-breeding experiment using these seeds and some known to be heterozygous for this trait.

The results are shown in Table 4.1.

F ₁ phenotype	Observed results	Expected results
Smooth	547	
Wrinkled	185	
Total	732	

Table 4.1

The χ^2 statistic is calculated in the following way:

$$\chi^2 = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

- (i) Calculate the value of χ^2 for the above data. Show your working.

Answer [2]

- (ii) Table 4.2 shows a critical values table.

Degrees of freedom	probability, p			
	0.90	0.50	0.10	0.05
1	0.016	0.455	2.71	3.84
2	0.211	1.386	4.61	5.99
3	0.584	2.366	6.25	7.81
4	1.064	3.357	7.78	9.49

Table 4.2

Using your calculated value of χ^2 and Table 4.2 what conclusions should you make about the significance of the difference between the observed and expected results?

----- [2]

(iii) Describe the genotype of the seed the farmer was given. Give a reason for your answer.

----- [2]

- 21 This question is based on the Advanced Notice article **CHANGES IN THE NUCLEUS THAT LEAD TO CANCER**, which is an insert.

There are several different types of gene mutation. In substitution mutations one nucleotide is exchanged for another which produces a different base sequence.

Fig.1.1 represents part of a gene. The letters X and Y indicate two nucleotides that have been changed by a mutation.

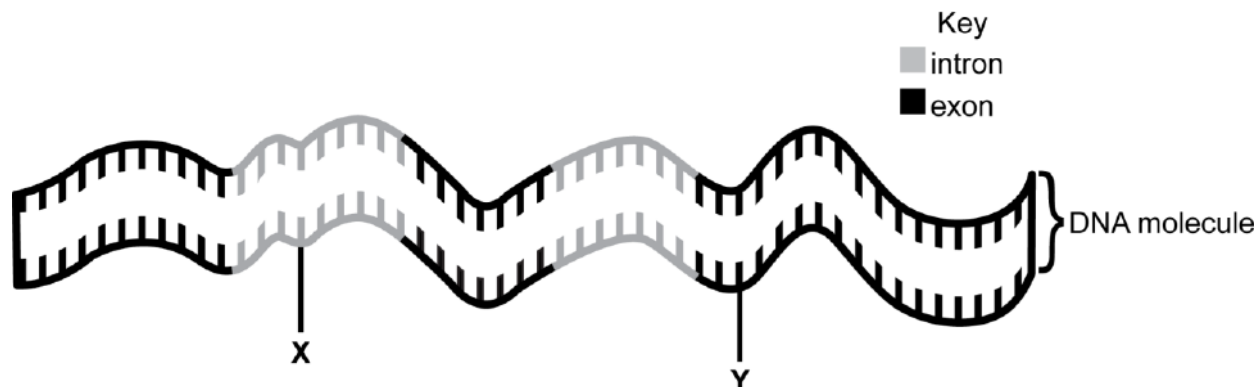


Fig. 1.1

- (i) Name one genetic disease caused by a **substitution** mutation. [1]

- (ii) Explain why a substitution mutation at point X will **not** result in a genetic disease. [2]

- (iii) The substitution mutation at point Y on the DNA molecule resulted in a change from the triplet AGA to AGG. This did **not** result in a genetic disease.

Suggest why **this** substitution mutation did **not** result in a genetic disease.

- 22 Thirty-three human blood group systems are known to exist. Two of these are the ABO blood group system and the Hh blood group system.

Explain why a person whose blood group is AB expresses both A and B antigens on the surface of their red blood cells.

----- [2]

- 23 The ABO blood group system in humans has three alleles for the antigen found on the cell surface membrane of erythrocytes. The three alleles are: I^O , I^A and I^B .

A male with the genotype $I^A I^O$ and a female with the genotype $I^B I^O$ have a child.

Which of the options, A to D, is the probability that this child will have a codominant genotype?

- A 0.25
- B 0.50
- C 0.75
- D 1.00

Your answer

[1]

24 A researcher carried out an investigation into patterns of inheritance using mice as a model organism and observed the coat colour of the mice.

- Coat colour is controlled by two alleles which are not sex linked.
- The allele for yellow coat colour (A) is dominant to the allele for normal (agouti) coat colour (a).

Heterozygous yellow mice were crossed with each other repeatedly and the offspring obtained are shown in Table 19.1.

Colour of coat	Number of offspring
yellow	1063
normal (agouti)	535

Table 19.1

Which of the following statements describes the correct way to analyse these results?

- A Use a student's t-test with an expected ratio of 2 : 1 yellow to normal mice.
- B Use a χ^2 test with an expected ratio of 2 : 1 yellow to normal mice.
- C Use a student's t-test with an expected ratio of 3 : 1 yellow to normal mice.
- D Use a χ^2 test with an expected ratio of 3 : 1 yellow to normal mice.

Your answer ☐

[1]

25 The Galapagos Islands is an ecosystem of exceptional biological interest.

The lava cactus, *Brachycereus nesioticus*, is found only in the Galapagos Islands. It speciated rapidly from a very few individuals of a parent species, perhaps only two. These individuals were carried on currents from the mainland of South America.

There is a gene that enables the mainland *Brachycereus* species to obtain water from damp mists in the atmosphere:

- let Q be the normal allele, allowing the cactus to obtain water from damp mists
- let q be a rare recessive allele that, when homozygous, could allow the cactus to obtain water from salty sea spray.

(i) Consider a cross between two heterozygous individuals.

What is the **theoretical** percentage of the offspring from these two individuals that would be able to obtain water from sea spray?

Use the space below for any working.

Answer = _____ % [1]

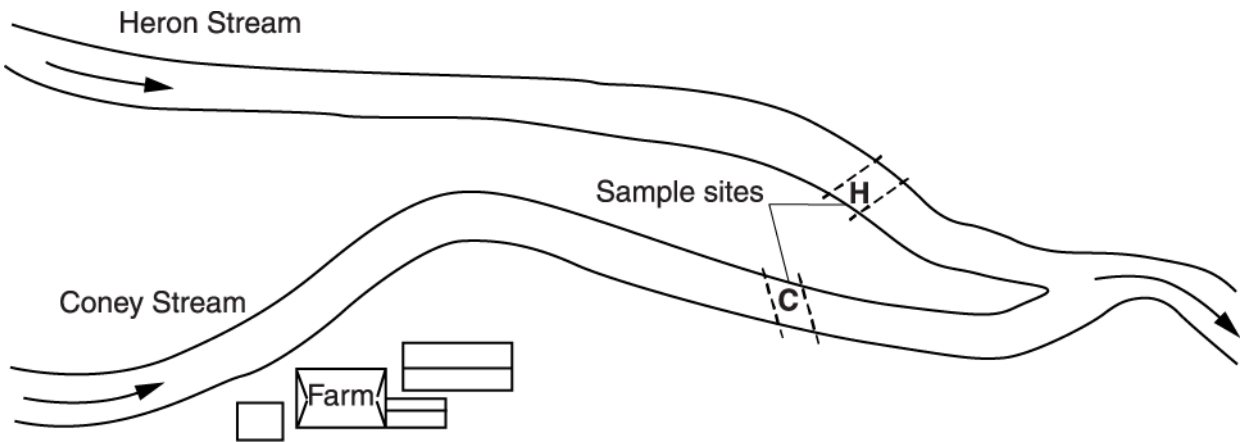
(ii) *B. nesioticus* colonises bare rock at the edge of the Galapagos Islands.

Explain how individuals homozygous for the q allele would soon come to dominate the gene pool.

The table lists some freshwater invertebrates, the presence of which indicates the level of water pollution.

Freshwater invertebrate	Water quality indicated
Stonefly nymph	Clean water
Freshwater shrimp	Slightly polluted water
Water louse	Badly polluted water
Sludge worm	Very badly polluted water

The figure below shows two streams draining the same piece of moorland. They are close together and the water in them should be of identical quality.



The farm beside Coney Stream was suspected of occasionally discharging polluting manure from the cattle sheds into the stream.

The indicator species living in a stream are a record of the level of pollution in the stream over time.

A Water Board biologist collected samples of invertebrates from Coney Stream and Heron Stream at the sites (H and C) indicated in the figure. The processed data from the samples collected are shown in the table.

Indicator species	Percentage of catch in Heron Stream sample (%)	Percentage of catch in Coney Stream sample (%)
Stonefly nymph	58	44
Freshwater shrimp	33	43
Water louse	7	12
Sludge worm	2	1

If no serious pollution was coming from the farm, there would be no significant difference in the percentages of each type of invertebrate collected from Coney Stream and Heron Stream. The percentages would be similar.

- (i) Use the formula and the table below to calculate the χ^2 value for the invertebrate samples from the two streams.

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

Indicator species	E	O	(O - E)	(O - E) ²	$\frac{(O - E)^2}{E}$
Stonefly nymph	58	44			
Freshwater shrimp	33	43			
Water louse	7	12			
Sludge worm	2	1			

$\chi^2 =$ _____ [4]

- (ii) Look on table to find the probability that the difference between Coney Stream and Heron Stream is due to chance and is not due to pollution from the farm.

Degrees of freedom	Probability of a larger value of χ^2							
	0.95	0.90	0.75	0.50	0.25	0.10	0.05	0.01
1	0.004	0.016	0.102	0.455	1.32	2.71	3.84	6.63
2	0.103	0.211	0.575	1.386	2.77	4.61	5.99	9.21
3	0.352	0.584	1.212	2.366	4.11	6.25	7.81	11.34
4	0.711	1.064	1.923	3.357	5.39	7.78	9.49	13.28
5	1.145	1.610	2.675	4.351	6.63	9.24	11.07	15.09

The Water Board biologist concluded that the farm beside Coney Stream had been causing water pollution.

Use your calculated value for χ^2 (on page 21) and the information in Table 6.3 to justify whether the biologist's conclusion can be supported or not.

[2]

END OF QUESTION PAPER

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance																				
1			any two from: (because there will be) <u>more</u> anaerobic respiration if mitochondria are not functioning ✓ lactate formed in anaerobic respiration ✓ functioning mitochondria required to , convert reduced NAD to NAD / re-oxidise reduced NAD / regenerate NAD ✓	2 AO2.1	ALLOW lactate accumulates in the absence of NAD ALLOW NADH for reduced NAD																				
			Total	2																					
2	a		<i>advantage</i> (any 1 from): short(er) generation time / reproduce quickly ✓ small size so ideal for laboratory ✓ <i>disadvantage</i> (any 1 from): difficult to handle / require killing or anaesthesia ✓ requirement for temperature control ✓	max 2 AO2.3	ALLOW genome closer to human ALLOW well characterised morphology / more complex appearance (so more traits can be studied) ALLOW ref to ethics																				
	b	i	RrYy ✓	1 AO2.1	DO NOT CREDIT ambiguously written letters																				
		ii	= 1.69 ✓✓✓✓	4 AO2.2	ALLOW E correct = 1 mark O-E & (O-E)² correct = 1 mark (O-E)²/E correct = 1 mark Σ correct = 1 mark ALLOW ecf <table><tr><th>Expected (E)</th><th>O – E</th><th>(O – E)²</th><th>(O – E)² / E</th></tr><tr><td>180</td><td>-5</td><td>25</td><td>0.139</td></tr><tr><td>60</td><td>-3</td><td>9</td><td>0.15</td></tr><tr><td>60</td><td>3</td><td>9</td><td>0.15</td></tr><tr><td>20</td><td>5</td><td>25</td><td>1.25</td></tr></table>	Expected (E)	O – E	(O – E) ²	(O – E) ² / E	180	-5	25	0.139	60	-3	9	0.15	60	3	9	0.15	20	5	25	1.25
Expected (E)	O – E	(O – E) ²	(O – E) ² / E																						
180	-5	25	0.139																						
60	-3	9	0.15																						
60	3	9	0.15																						
20	5	25	1.25																						
		iii	no significant deviation from expected results / deviation from expected results due to chance ✓ null hypothesis accepted ✓	2 AO2.2	ALLOW ecf from ii																				

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	c		gene mutation ✓ (autosomal) <u>dominant</u> ✓ insertion (mutation) / (tri)nucleotide / CAG, repeat / stutter ✓ in, huntingtin gene ✓	max 2 AO2.1	
			Total	11	
3			A	1 AO1.1	
			Total	1	

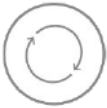
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance															
4		i	parental genotypes: AaBb x aabb ✓ gametes: AB, Ab, aB, ab (and ab) ✓	2 AO3.2	ALLOW marks for correct information given in genetic diagram if candidate has not used the prompt lines. ALLOW ecf from incorrect parental genotypes Examiner's Comments Few candidates correctly identified the parental genotypes and often incorrectly extrapolated the gametes from their genotype.  OCR support OCR delivery guides on 'Patterns of inheritance' (5.1.1): https://www.ocr.org.uk/qualifications/as-a-level-gce-biology-b-advancing-biology-h022-h422-from-2015/delivery-guide/module-bb05-module-5-genetics-control-and-homeostasis/delivery-guide-bbdg027-patterns-of-inheritance-511															
		ii	<table border="1"><tr><td></td><td>AB</td><td>Ab</td><td>aB</td><td>ab</td></tr><tr><td>ab</td><td>AaBb</td><td>Aabb</td><td>aaBb</td><td>aabb</td></tr><tr><td></td><td>yellow, smooth</td><td>yellow, wrinkled</td><td>colourless, smooth</td><td>colourless, wrinkled</td></tr></table> genotype AND phenotype of offspring ✓ phenotypic ratio = 1 : 1 : 1 : 1 ✓		AB	Ab	aB	ab	ab	AaBb	Aabb	aaBb	aabb		yellow, smooth	yellow, wrinkled	colourless, smooth	colourless, wrinkled	2 AO3.2	ALLOW marks for correct information given in genetic diagram if candidate has not used the prompt lines. ALLOW ecf from incorrect gametes in 7ci Examiner's Comments Very few candidates achieved full marks. Many were able to identify the ratio correctly but did not refer to the phenotypes in any part of their answer. Those candidates that incorrectly predicted a non-equivalent ratio did not appreciate that, without phenotypes, the ratio is not clear enough for a mark.
	AB	Ab	aB	ab																
ab	AaBb	Aabb	aaBb	aabb																
	yellow, smooth	yellow, wrinkled	colourless, smooth	colourless, wrinkled																

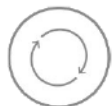
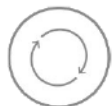
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance																																				
		iii	<table border="1"> <thead> <tr> <th>Pheno-type</th><th>[O]</th><th>[E]</th><th>O-E</th><th>(O-E)²</th><th>(O-E)²/E</th></tr> </thead> <tbody> <tr> <td>Smooth yellow</td><td>275</td><td>250</td><td>25</td><td>625</td><td>2.50</td></tr> <tr> <td>Wrinkled yellow</td><td>277</td><td>250</td><td>27</td><td>729</td><td>2.916</td></tr> <tr> <td>Smooth colour-less</td><td>235</td><td>250</td><td>-15</td><td>225</td><td>0.90</td></tr> <tr> <td>Wrinkled colour-less</td><td>213</td><td>250</td><td>-37</td><td>1369</td><td>5.476</td></tr> <tr> <td></td><td></td><td></td><td></td><td>$\chi^2 =$</td><td>11.792</td></tr> </tbody> </table> $\chi^2 = 11.79 / 11.8 \checkmark \checkmark \checkmark$	Pheno-type	[O]	[E]	O-E	(O-E) ²	(O-E) ² /E	Smooth yellow	275	250	25	625	2.50	Wrinkled yellow	277	250	27	729	2.916	Smooth colour-less	235	250	-15	225	0.90	Wrinkled colour-less	213	250	-37	1369	5.476					$\chi^2 =$	11.792	3 AO3.2	ECF from phenotypic ratio given in 7cii Correct answer = 3 marks even if no working shown. If answer is incorrect then award 1 mark if; [E] column correct ✓ AND Award 1 mark if ; (O-E)² column correct ✓ <u>Examiner's Comments</u> Most candidates used the table to assist with their calculations. Most candidates were able to recognise and apply the data in table 7.1 to correctly estimate the expected column, applying their ratio from the previous answer.  OCR support 'Mathematical skills handbook' contains worked examples using the chi squared test in biology. Section M1.9 'Select and use a statistical test': https://www.ocr.org.uk/Images/294471-biology-mathematical-skills-handbook.pdf
Pheno-type	[O]	[E]	O-E	(O-E) ²	(O-E) ² /E																																				
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Wrinkled colour-less	213	250	-37	1369	5.476																																				
				$\chi^2 =$	11.792																																				
		iv	there is <1% probability that the differences (between predicted and expected results) are, not significant / due to chance ✓ OR there is a >99% probability that the difference is significant / not due to chance. ✓	1 AO3.2	IGNORE ref to probabilities other than 0.01 <u>Examiner's Comments</u> Few candidates were able to use the correct, statistical terminology to answer this question. Many candidates referred to the results being significant or not, due to chance or not, without referring to the 'difference between pairs' as discussed for Question 3bi.																																				

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		v	there is <u>linkage</u> between the two <u>genes</u> (for colour and shape) ✓ the <u>genes</u> (for colour and shape) are on the same chromosome ✓	2 AO3.2	DO NOT ALLOW alleles for genes ECF for 7civ conclusion <u>Examiner's Comments</u> Very few candidates recognised this as a linkage effect. Most answers centred on the calculated value and the critical value.
			Total	0	
5			(fault) on the X chromosome ✓ no corresponding <u>allele</u> on Y chromosome ✓ only one (faulty) <u>allele</u> needed for colour blindness (in males) ✓	2 max AO1.1	<u>Examiner's Comments</u> This was well answered question with many candidates recognising this as an X chromosome disorder and some were able to link this with only 1 allele required for males to have the condition. The most common error was linking this to a Y chromosome disorder. Candidates should realise that sex linked disorders will always be on the X chromosome.  AfL It is visually effective for students to see the differences between some of the genes on the X and the Y chromosome, which can be found on images when performing a search on Y chromosome genes.
			Total	0	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
6	a	i	1 sequence of, DNA / nucleotides / bases, that code for a polypeptide ✓ 2 a gene variant ✓	2 AO1.1	Mark the first answer. If an additional answer is given that is incorrect, then = 0 marks ALLOW protein / amino acid sequence for 'polypeptide' ALLOW different versions of the same gene Examiner's Comments Most candidates could define allele and all candidates attempted the definitions. Gene descriptions were often given to GCSE standard with the use of 'coding for a characteristic' rather than protein.  AfL It is useful to tabulate or highlight key points that are extended at A Level compared to the candidate's GCSE knowledge/ specification.
		ii	1 <u>founder(s)</u> effect ✓ 2 <u>genetic bottleneck</u> ✓	2 AO2.1	Mark the first answer. If an additional answer is given that is incorrect, then = 0 marks Examiner's Comments This was a well answered question by candidates who could clearly identify the relevant terms in relation to the example given. A few candidates simply stated bottleneck for example 2.  AfL Splitting key terms to see their origins often helps to consolidate knowledge and avoid candidates attempting to summarise terms that then give a different meaning. Placing words separately into a search engine is a quick way of allowing students to suggest definitions of key terms they have not previously encountered.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	1 small / decreasing , gene pool ✓ 2 limited number / loss, of <u>alleles</u> ✓	2 AO2.1	<u>Examiner's Comments</u> Most candidates recognised that alleles would be lost and limited in these circumstances and some candidates related that to the size of the gene pool in the population. Answers often referred to inbreeding but did not connect this to limited allele number.
	b		Label cells with fluorescent marker ✓ (fluorescence attached to) antibodies ✓ (antibodies bind to) <u>antigens</u> on (white blood) cells ✓ (alternative) fluorescent DNA probe ✓ counts / sorts, cells (with genetic variant) ✓	4 max AO2.3	IGNORE red blood cells IGNORE fluorescent marker binds to antigens ALLOW section of DNA for 'DNA probe' <u>Examiner's Comments</u> Candidates clearly recognised this technique and most candidates discussed the counting of cells and the use of fluorescence. To achieve full marks, candidates had to follow a sequential logic of the labelling technique. Some candidates did refer to DNA probes as they made the connection between searching for genetic variants and the direct use of these probes.

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
	c	base / nucleotide, substitution ✓ mRNA codon changes OR different amino acid (attached) ✓ changes haemoglobin, (tertiary) structure / (3D) shape ✓ (abnormal) haemoglobin, clumps / crystallises (clumping) at low O₂ concentration ✓ (only present in) homozygous recessive individuals ✓	3 max AO1.1	ALLOW named bases ALLOW glutamic acid changed to valine ALLOW different primary structure IGNORE mutations in haemoglobin protein IGNORE red blood cells clump together ALLOW H^S H^S for 'homozygous recessive' <u>Examiner's Comments</u> Many candidates clearly knew the amino acid substitution causing sickle cell anaemia but often struggled to describe the type of mutation. Many candidates recognised it as a substitution but did not state base/nucleotide thus not differentiating it from the mark for amino acid substitution. Candidates then struggled to relate this change to an alteration in haemoglobin, referring straight to the altered erythrocyte shape. A few candidates discussed the gene mutation with the erythrocyte directly, confusing a cell with the protein inside.  OCR support OCR delivery guide on Population genetics and epigenetics (5.1.2) can offer support: https://www.ocr.org.uk/qualifications/as-a-level-gce-biology-b-advancing-biology-h022-h422-from-2015/delivery-guide/module-bb05-module-5-genetics-control-and-homeostasis/delivery-guide-bbdg028-population-genetics-and-epigenetics-512

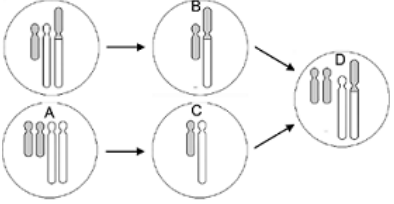
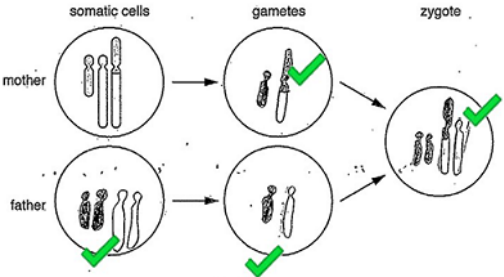
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance																									
	d		<i>advantages of the IMF approach:</i> (may) give a more accurate diagnosis ✓ treat / intervene, earlier ✓ identify people (at risk) who do not have family history OR removes worry for people that do have a family history ✓ <i>disadvantages of IMF approach:</i> results of the MGUS screening may give false positives ✓ more expensive (than pedigree analysis) ✓	4 max AO3.2	ALLOW ora throughout ALLOW prevents / cures, myeloma <u>Examiner's Comments</u> Candidates knew the relevance of pedigree analysis and answered this question from this perspective. It was clear the pre-release material had been read as the most common mark point was the expense of this technique from this section of the pre-release; '<i>Researchers at the IMF store thousands of blood These expensive tests allow the identification of genetic variants that might be linked to the risk of developing multiple myeloma.</i>' Many candidates also recognised the relevance of the 'identification' aspect of this quote and stated this approach was more accurate. All mark points were seen as some candidates not only used the pre-release material to gain information but realised the limitations of a pedigree analysis to those who have a family history and would not detect those who did not have this history.																									
	e		<table><tr><th>Feature</th><th>Transcription only</th><th>Translation only</th><th>Both</th><th>Neither</th></tr><tr><td>C pairs with G</td><td></td><td></td><td>✓</td><td></td></tr><tr><td>A pairs with T</td><td>✓</td><td></td><td></td><td></td></tr><tr><td>Phosphodiester bonds are made</td><td>✓</td><td></td><td></td><td></td></tr><tr><td>Peptide bonds are made</td><td></td><td>✓</td><td></td><td></td></tr></table>	Feature	Transcription only	Translation only	Both	Neither	C pairs with G			✓		A pairs with T	✓				Phosphodiester bonds are made	✓				Peptide bonds are made		✓			4 AO2.1	Mark the first answer. If an additional answer is given that is incorrect, then = 0 marks ALLOW crosses or any other unequivocal symbol as alternative to ticks. <u>Examiner's Comments</u> Few candidates achieved full marks, with many candidates scoring at least 2 marks. Most candidates did not realise that the T base would not be present during translation and that the only covalent bonds made during translation are peptide bonds.
Feature	Transcription only	Translation only	Both	Neither																										
C pairs with G			✓																											
A pairs with T	✓																													
Phosphodiester bonds are made	✓																													
Peptide bonds are made		✓																												
			Total	0																										

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
7	a	i	does not have trisomy 21 ✓	1	AW e.g. 'no excess of chromosome 21' ALLOW <u>only</u> has two of chromosome 21 <u>Examiner's Comments</u> This question required candidates to know that Down's syndrome is a disorder caused by extra genetic material relating to chromosome 21. This can be when there are three distinct copies of chromosome 21(trisomy 21) or some extra material relating to chromosome 21. In this case the mother does not have any extra genetic material and therefore does not have Down's syndrome.

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
ii	 A ✓ B ✓ C ✓ D ✓	4	ALLOW incorrect proportions of translocated chromosome ALLOW diagrams that do not show centromeric regions DO NOT ALLOW drawings without shading ECF (from A) ECF (from B and C) <u>Examiner's Comments</u> Very few candidates were able to complete all four of the diagrams correctly. Many candidates were not able to identify which chromosomes would be present in the gamete of the mother but were credited with subsequent marks if they understood that the zygote would result from a combination of the two gametes. Candidates need to be careful when completing diagrams such as these to make sure that they include the relevant shading or annotation to distinguish the relevant chromosomes. Exemplar 1  In this response the candidate completed the diagrams correctly. The shape and shading of the chromosomes was clear and unambiguous.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b		(meiotic) non-disjunction ✓ any 2 from: failure of <u>homologous chromosomes</u> to separate during meiosis I/anaphase I ✓ failure of <u>sister chromatids</u> to separate during meiosis II/anaphase II ✓ gamete has extra copy of chromosome (21) ✓	max 3	ALLOW for one mark - failure of <u>homologous chromosomes</u> or <u>sister chromatids</u> to separate during meiosis Examiner's Comments Few candidates were able to recall non-disjunction, but the question also required a precise description of what might happen during meiosis to result in the formation of a zygote with three chromosomes 21s. Exemplar 2 State the name of this event and outline how it arises. Non-disjunction homologous pair of chromosome fail to separate during anaphase I or sister chromatids fail to separate during anaphase II as a result one gamete will have a diploid number The resulting zygote has 3 copies of chromosome 21 [3] This response recalls the name and gives a succinct and clear description of events of meiosis. There was an implication that all the chromosomes failed to separate making the gamete diploid and therefore this response would not have been credited with the idea of the gamete having an extra chromosome 21. However, it gained the maximum of three marking points in the first four lines.
	c	i	CVS: placenta amniocentesis: amniotic fluid ✓	1	IGNORE chorionic villus Both required for 1 mark

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	1 from: (karyotype) cannot detect gene/allele (mutations) ✓ (karyotype) can only detect changes in chromosome size/shape ✓	1	AW e.g. abnormal base sequence <u>Examiner's Comments</u> Most candidates were able to identify the source of fetal cells. In order to explain why karyotyping cannot be used to test for CF, candidates had to have some knowledge of the cause of CF. Exemplar 3 <i>Karyotyping shows abnormal chromosomes / deformities in chromosomes but CF is caused by a deletion mutation in gene so chromosomes are normal? (1)</i> This response describes the cause of CF. Any idea of CF being a gene mutation would be sufficient. The response also explains why it would not be picked up on a karyotype.
			Total	10	
8			D	1	<u>Examiner's Comments</u> Huntingdon's disease is caused by insertion of many CAG repeats.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
9		i	(drought resistance) involves many, genes / loci ✓ Involves (possible), multiple / variety, alleles (at each locus) ✓	2	ALLOW (drought resistance) is polygenic IGNORE different alleles <u>Examiner's Comments</u> Some candidates were able to appreciate the polygenic aspect of drought resistance and successfully linked the information in the stem of the question with genes and inheritance. Many candidates did not recognise the relevance of 'inheritance' and 'genetic basis' in the stem of the question and discussed their answers in terms of phenotype only e.g. not many plants survive, so there are very few that can be studied.
		ii	(gene/ transcription factor) can be used to identify, genes / alleles, involved / activated, in drought resistance ✓ promoters allow, gene expression / transcription ✓ remove / knockout, (miRNA 156) gene and observe, phenotype / drought resistance ✓	2	ALLOW RNA Polymerase binds to promoters <u>Examiner's Comments</u> Candidates struggled to understand the relevance of the miRNA gene and confused this with RNA. However, many candidates did discuss knocking out miRNA to observe the phenotype and so exhibited a good understanding of knockout technology.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	place plasmid in <i>Agrobacterium</i> / use gene gun ✓ screen for, transgenic/ recombinant, cells ✓ details of selectable marker ✓	2 max	ALLOW use <i>Agrobacterium</i> as vector for 'place plasmid in <i>Agrobacterium</i>'. ALLOW a description of a gene gun IGNORE ref to viruses / liposomes IGNORE ref to antibiotics <u>Examiner's Comments</u> Few candidates scored full marks. Those that scored one mark usually referred to a gene gun for insertion of the plasmid. Most candidates did not appreciate that the alfalfa would be insertion into plant cells and referred to vectors relevant to animal cells e.g. viruses. There were a lot of descriptions using restriction enzymes and ligases to obtain the recombinant plasmid, not realising the focus of the question was on the incorporation of the plasmid.
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
10	a		substitution ✓	1	ALLOW ref to single base replacement. IGNORE point mutation Examiner's Comments (a) addressed AO1 criteria with the remaining parts of the question addressing AO2 and some AO3 in (b)(iii). (a) was generally done well.
	b	i	(construct) pedigree / genetic tree (diagram) ✓ to calculate, <u>probability / chance / likelihood</u> of disease inheritance ✓	2	IGNORE ref to genetic testing Examiner's Comments There were two common incorrect responses in (b)(i). Many candidates suggested that the role of the genetic counsellor was to work out the genotype of the parents rather than predict the probability of their child being born with a genetic disease. Secondly, there were some inaccurate descriptions of how they might do this referring to a genetic cross, Punnet square or family tree rather than the more scientific term of pedigree analysis.
		ii	any 2 from: may lead to abortion / decision as to whether child should be born ✓ damage to embryo and / or mother ✓ false positive / false negative, results ✓ idea that embryo cannot give consent ✓	max 2	ALLOW increased risk of miscarriage DO NOT ALLOW inaccuracy unqualified IGNORE ref to playing God Examiner's Comments Most candidates scored at least one mark for part (b)(ii) and did restrict their answers to ethical considerations. However, the question asked about testing for sickle cell anaemia and therefore more generalised responses suggesting that this might lead to designer babies were not credited.
			Total	5	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance										
11			B ✓	1	Examiner's Comments It was encouraging to see that this question, testing understanding of probability tables, was correctly answered by many candidates.										
			Total	1											
12		i	interrupts triplet code / causes frame-shift / production of premature stop codon ✓ (DNA) triplets code for different amino acids ✓ primary structure of protein changed ✓ protein cannot interact with other, proteins / named component ✓	max 2											
		ii	gene (encoding Factor VIII), on X chromosome / X-linked / sex-linked ✓ males lack second X chromosome ✓	2	ORA ORA										
		iii	male gametes <table><tr><td></td><td>X^h</td><td>Y</td></tr><tr><td rowspan="2">female gametes</td><td>X^H</td><td>$X^H X^h$</td><td>$X^H Y$</td></tr><tr><td>X^h</td><td>$X^h X^h$</td><td>$X^h Y$</td></tr></table> probability = 0.5 ✓✓		X^h	Y	female gametes	X^H	$X^H X^h$	$X^H Y$	X^h	$X^h X^h$	$X^h Y$	3	ALLOW H/h not superscripted on X ALLOW 50% or ½
	X^h	Y													
female gametes	X^H	$X^H X^h$	$X^H Y$												
	X^h	$X^h X^h$	$X^h Y$												
			Total	7											

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
13		i	<i>evidence</i> - only one gene (locus) (paragraph 8) ✓ <i>idea that</i> one gene codes for one polypeptide ✓	2	
		ii	<i>protein</i> - haemoglobin ✓ <i>similarity</i> - <i>idea of</i> same prosthetic group / haem attached to each sub-unit ✓ <i>difference</i> - <i>idea that</i> there are two different sub-units in haemoglobin / 2 alpha and 2 beta sub-units ✓	3	IGNORE reference to same number of sub-units ALLOW 'haemoglobin is not a homotetramer' or 'haemoglobin is a heterodimer' IGNORE 'haemoglobin is a heterotetramer'
			Total	5	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
14	a	i	7 (μm);;	2	Correct answer = 2 marks If answer is incorrect, award one mark for correct working $-(2 \text{ or } 20 \text{ or } 20\,000) \div 2\,800$ OR $(1.9 \text{ or } 19 \text{ or } 19\,000) \div 2\,800$ Award one mark for an answer which has not been rounded 7.142..... OR 6.785.... Examiner's Comments The calculation in (i) was done well by many candidates although many did not notice that the answer was required in μm or used incorrect factors of 10 in their calculations. Part (i) was synoptic with candidates needing to recall the role of platelets and suggest how this could cause red blood cell fragmentation.
		ii	<i>idea that</i> narrow lumen / roughened endothelium / blood clot, causes (red blood cells to fragment);	1	ACCEPT description of blood clot e.g formation of fibrin mesh causing fragmentation of red blood cells Examiner's Comments In (ii) a surprising number of candidates opted for haemophilia - possibly triggered by the platelets and blood clotting ideas in the previous part of the question.
		iii	sickle cell (anaemia) / AVP;	1	Examiner's Comments (iii) tested entirely AO1 objectives.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b	i	<i>Named treatment for short term:</i> Haemodialysis; peritoneal dialysis; <i>long term treatment</i> kidney transplant; <i>organ / donor detail</i> matched MHC antigens / blood groups between donor and recipient OR use of close relative to obtain tissue match OR ref to cadaver / xenotransplants; <i>recipient detail</i> use of immunosuppressant to prevent rejection; <i>idea of control of diet / low salt;</i> <i>operation detail</i> connection of renal artery and vein / connection to alternative artery (iliac) / old kidney left in place; <i>detail of alternative long term treatment</i> <i>peritoneal</i> <i>dialysis</i> dialysis fluid introduced into abdominal cavity OR peritoneum acts as the partially permeable membrane OR reference to CCPD / described	5	DO NOT CREDIT 'kidney or renal' dialysis DO NOT CREDIT haemodialysis as a long term treatment ACCEPT 'alternative treatment' as 'long term' ACCEPT alternative correct details CREDIT description of CCPD such as attached overnight to a dialysis exchanger Examiner's Comments In part (i) many candidates misread the question which was about treating kidney failure not treating an E.coli infection. The error was frequently compounded as description was only required for the long term treatment. Many candidates did score maximum marks but many failed to take into account the context of the question.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	(injections of) erythropoietin / EPO; <i>explanation:</i> (EPO) stimulates, RBC synthesis; as (damaged) kidneys not making EPO; OR (packed red blood cell, whole blood) transfusion; as {damaged} kidneys not making EPO; (so) RBC synthesis not stimulated (by EPO);	3	Examiner's Comments There were some good answers on EPO treatment and on blood transfusions in (ii) but many candidates again had lost the context of the question which was kidney damage and answered in terms of iron supplements.
	c		recessive; homozygous / double, recessive; sex; pedigree; fifty / 50;	5	Examiner's Comments Answers were good with the majority of candidates scoring at least 3 marks. The commonest mistakes were autosomal rather than sex linkage and mistake on the probability at the end suggesting this was a guess rather than using a Punnett square. Many scripts did show evidence that this is what good candidates did.
			Total	17	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
15	a		<i>karyotypes</i> K1 2.1a has 46 chromosomes / DS karyotype has 47; K2 2.1a has 2 copies of chromosome 21 / DS karyotype has 3; K3 2.1a Chromosome 14 copies are different sizes / DS chromosome 14 same size; 1 (translocation) occurs during meiosis; 2 chromosomes / chromatids, break and rejoin; 3 <i>idea that</i> a piece of chromosome 21 attaches (to chromosome 14); 4 both copies of chromosome 14 and 21 segregating independently; 5 <i>idea that</i> one gamete has (both) chromosome 21 an additional piece of chromosome 21; 6 <i>idea that</i> (this) gamete, fertilised by / fertilises, a normal gamete;	6	ACCEPT a stage in meiosis e.g. prophase 1 CREDIT mps 2 to 6 if shown on annotated diagrams. CREDIT sperm or oocyte for gamete in mps 5 and 6 CREDIT description of a normal gamete e.g. one copy of 21 ACCEPT mp6 in context of Trisomy 21

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			QWC;	1	LOOK FOR ONE mark from K1 - K3: AND mps 5 and 6 Examiner's Comments This was split between AO1 and AO2 criteria. This question was split into two parts. The first part required candidates to 'spot' differences between the karyotype shown and that of DS due to Trisomy 21. For many candidates, this was the only mark they achieved. Some weaker candidates confused DS with Turner's or Klinefelter's syndrome. Many candidates could successfully describe what happens in a translocation although some were describing the process but calling it a non-disjunction. However, very few candidates realised that, following translocation, the 'extended' chromosome 14 could segregate with the 'normal' 21 and that it was the fertilisation of a gamete with this combination of chromosomes by a 'normal' gamete that would lead to this karyotype. Candidates are clearly familiar with this inherited form of DS but need far more guidance as to how it is actually inherited.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b	i	<i>idea that</i> a reason given for information being sensitive;	1	Look for ideas such as: ‘women might not want people to know because they feel guilty OR people don't want to be discriminated against or judged OR to comply with legislation e.g. on safeguarding DO NOT CREDIT ideas about ‘privacy’ without some further qualification. Examiner's Comments This question addressed AO3 criteria. Weaker candidates referred to people ‘wanting’ to keep details private which was not enough to gain credit. Some further explanation was required and some very perceptive and thoughtful answers were seen.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	improvements in (antenatal) screening techniques / AW; increase in, population / birth rates / pregnancies; <i>idea that</i> more women now screened; more older women having children / AW; <i>idea that</i> increasing age is risk factor (for DS);	2	CREDIT example such as introduction of nuchal fold screening or serum testing or 'triple' test in antenatal care IGNORE reference to improvements in karyotyping ACCEPT improvements in medical technology ACCEPT idea that younger women are now being screened. Examiner's Comments In (ii) explanations were required and the commonest answers referred to either increased maternal age or increase in the screening. Good candidates also spotted that the data was not a rate and correctly suggested increasing birth rates. Weaker candidates described the data without necessarily explaining.
		iii	<i>idea of</i> fetal viability / AW;	1	CREDIT statements which refer to increase chance of a fetus with DS miscarrying naturally Examiner's Comments Part (iii) was a stretch and challenge question and many candidates correctly deduced that the viability of fetus with DS would have to be taken into account. Again, some candidates expressed their ideas with great sensitivity.
			Total	11	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
16	a	i	T glomerulus; U Bowman's / renal, capsule; <i>region</i> (renal) cortex;	3	Mark the first answer on each prompt line. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks IGNORE ref to nephron
		ii	ions; ascending; water potential; medulla; permeable; osmosis;	6	Mark the first answer on each prompt line. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks DO NOT CREDIT 'and potassium' as this implies it is the metals that are transferred rather than the ions <u>Examiner's Comments</u> Parts (i) and (ii) were accessible to most candidates with the commonest mistake being to confuse the cortex and medulla or to answer 'nephron' for the region in part (i) despite the fact that this was given in the question.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b	i	volume increases; plus any two from glucose (in filtrate) lowers water potential; (leading to) reduction in water potential gradient (between the filtrate and the cortex); less water reabsorbed (by osmosis), from descending limb / at X;	3	IGNORE ref to urine ACCEPT less water moves out (of loop) / less water leaves the filtrate <u>Examiner's Comments</u> Part (i) was a good discriminator. Weaker candidates implied that the extra glucose molecules added to the volume. Other candidates contradicted themselves and stated that more water would be reabsorbed but many good candidates could explain the reduction in water potential gradient leading to less water being reabsorbed.
		ii	<i>idea that</i> (condition is inherited so will assess) risk of passing disease to, children / AW; advise on, (genetic) testing / alternatives to having (own) children;	1	IGNORE 'this is a genetic disease' as this is implied by the question ACCEPT 'children could inherit the disease' as this implies a 'risk' <u>Examiner's Comments</u> Candidates were expected to identify the role of the counsellor in assessing the risk of children inheriting the condition and advising on the options for family planning. Weaker candidates wrote vague answers about advice on treatment.
			Total	13	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
17			Huntington's (disease); PKU / phenylketonuria; haemophilia; nail patella syndrome; muscular dystrophy / DMD; thalassaemia; AVP;;	2	Mark the first answer on each prompt line. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks IGNORE 'colour blindness' DO NOT CREDIT Turner's syndrome / Down's syndrome / Klinefelters syndrome <u>Examiner's Comments</u> This was done well although some candidates did not appreciate the significance of the term 'allele' in the question and gave answers which included Down's, Turner's or Klinefelter's. Very astute candidates gave familial glycosuria as an answer and this was credited. Hunter's syndrome was given as a response. This is a genetic disease and was credited although it was possibly an error on the part of the candidate. The question asked for two diseases to be stated rather than named so PKU was acceptable as were phonetic spellings although they needed to be approaching 'phenylketonuria'.
			Total	2	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
18	a	i	e;	1	CREDIT X ^e ACCEPT a single, lower case alternative letter IGNORE 'c' unless it is clearly 'lower case' IGNORE I ^e
		ii	X ^e Y and X ^e X ^e	1	ecf for the allele symbol in (i)
		iii	X ^E X ^e	1	ecf for the allele symbol in (i) Examiner's Comments While many were aware that 'e' would be the allele symbol for the condition, some put a genotype (ee) in (i) and only the better candidates went on to give the correct genotypes for (ii) and (iii).
	b	i	1. nucleus / nucleolus; 2. ribosomes;	1	ANSWERS MUST BE IN THIS ORDER ACCEPT RER / rough endoplasmic reticulum
		ii	<i>idea that</i> mutation (in DNA) leads to a, stop / termination, codon OR <i>idea that</i> DNA sequence is deleted OR <i>idea that</i> mutation leads to more RNA being spliced out; <i>idea that</i> translation is terminated by stop codon; no (more) amino acids are added (after the stop codon) / fewer amino acids (in truncated protein);	2 max	IGNORE ref to a base deletion in context of shorter DNA Examiner's Comments Part (i) was synoptic and answered well but in (ii) too many answers were given in terms of changing the sequence of amino acids rather than producing a protein with fewer amino acids.
	c	i	reverse transcriptase;	1	
		ii	somatic (gene therapy);	1	CREDIT augmentation (gene therapy)

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	<i>Idea that</i> disease involves a defect in a single gene; no other cause; <i>idea that</i> disease is easily identified in sufferers; gene / gene product, is known; gene can be delivered reliably to affected cells;	3	Mp2 ACCEPT idea that disease will be cured / vision will be restored. Mp3 CREDIT reverse argument 'easy to see if it has worked' ACCEPT 'easy to insert the gene' Examiner's Comments This was intended to be accessible so it was disappointing how many candidates did not 'spot' reverse transcriptase or the fact that this would be somatic gene therapy. In part (iii) many candidates did not pick up on the question rubric and answered in terms of germ line therapy or ethics. It would be a worthwhile discussion for Centres to have with their candidates as to what makes some genetic diseases targets for treatment using gene therapy while others are not.
			Total	12	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance																																				
19	a		1. polypeptide / protein / glycoprotein; 2. antigen; 3. loci; 4. cross(ing) over; 5. meiosis; 6. codominant;	6	2. ACCEPT receptor 3. ACCEPT 'locus or locuses' 4. CREDIT 'chiasma / chiasmata' Examiner's Comments This question proved to be very accessible to candidates. This was done well although some candidates failed to carry the information forward to the next part of the question.																																				
	b	i	Individual 1 and 2 correct; Individuals 3 and 4 correct; Individuals 5 to 8 all correct;	3	Individuals 1 and 2 <table><tr><td>A16 - A20</td><td>A9- A21</td></tr><tr><td>B31-B26</td><td>B29-B30</td></tr><tr><td>DR14-DR12</td><td>DR7-DR17</td></tr></table> CREDIT new haplotype in either column <table><tr><td>A21 - A14</td><td>A15- A17</td></tr><tr><td>B9-B35</td><td>B25-B22</td></tr><tr><td>DR23-DR6</td><td>DR19-DR10</td></tr></table> CREDIT new haplotype in either column CREDIT correct combinations in any order. <table><tr><td>A20</td><td>A14</td></tr><tr><td>B26</td><td>B35</td></tr><tr><td>DR12</td><td>DR6</td></tr></table> <table><tr><td>A20</td><td>A17</td></tr><tr><td>B26</td><td>B22</td></tr><tr><td>DR12</td><td>DR10</td></tr></table> <table><tr><td>A21</td><td>A14</td></tr><tr><td>B30</td><td>B35</td></tr><tr><td>DR17</td><td>DR6</td></tr></table> <table><tr><td>A21</td><td>A17</td></tr><tr><td>B30</td><td>B22</td></tr><tr><td>DR17</td><td>DR10</td></tr></table>	A16 - A20	A9- A21	B31-B26	B29-B30	DR14-DR12	DR7-DR17	A21 - A14	A15- A17	B9-B35	B25-B22	DR23-DR6	DR19-DR10	A20	A14	B26	B35	DR12	DR6	A20	A17	B26	B22	DR12	DR10	A21	A14	B30	B35	DR17	DR6	A21	A17	B30	B22	DR17	DR10
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Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	<i>idea that</i> there is less chance that there will be a similar, haplotype / alleles at all (with grand parents) OR <i>idea that</i> parents will always have (1) haplotype / (3) alleles the same; <i>idea of</i> organ from grandparent being (much) older (so increases possibility of organ functioning less well);	2	IGNORE references to blood type Examiner's Comments Part (i) was an AO2 question which used the MHC learning outcomes to test basic genetics. This was generally done very well although some candidates did introduce crossovers while others attempted to add or subtract the numbers. In (ii) while many candidates answered in terms of the age of an organ donated from a grandparent, only better candidates could explain why the chances of matching one haplotype would be greater using a parent. General discussions about tissue matching being necessary to avoid rejection were common while too many candidates referred to the genes being the same as opposed to alleles.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	c		1. ref to MHC genes and ABO genes being, unlinked / on separate chromosomes / on chromosomes 6 and 9; 2. ref to independent assortment (of chromosomes 6 and 9) in meiosis; 3. <i>idea that</i> gametes(s) contain same copy of chromosome 6 / different copies of chromosome 9; 4. children could be blood group O or A; 5 ref to 25% probability that a child could have, blood group O OR (only) 75% probability of, blood group A OR children could be $ii / I^O I^O$, $I^A I^A$, or $I^A i$ 6. ref to 25% chance of having same haplotype;	3 max	5. CREDIT this mark point on a genetic diagram Examiner's Comments Several candidates misread the question and assumed that it was similarities and differences between the parents and children that were being referred to. Since they had just completed a genetic diagram showing that this does not happen this was disappointing. Many candidates were able to explain how the children could have different blood groups although the term 'heterozygous' triggered some candidates to respond in terms of the AB blood group. The fact that the MHC alleles and the blood group alleles were on different chromosomes was spotted by several candidates but relatively few went on to discuss independent assortment and some referred to crossing over, indicating a basic misconception about which chromosomes are involved in crossover events.
			Total	14	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance												
20		i	expected results correctly calculated (1) <table border="1"><thead><tr><th>F₁ phenotype</th><th>Observed results</th><th>Expected results</th></tr></thead><tbody><tr><td>Smooth</td><td>547</td><td>549</td></tr><tr><td>Wrinkled</td><td>185</td><td>183</td></tr><tr><td>Total</td><td>732</td><td>732</td></tr></tbody></table> Chi squared value correctly calculated (1)	F ₁ phenotype	Observed results	Expected results	Smooth	547	549	Wrinkled	185	183	Total	732	732	2	$\chi^2 = \frac{(547-549)^2}{549} + \frac{(185-183)^2}{183}$ = 0.007 + 0.022 $\chi^2 = 0.029$ ALLOW one mark for correct working if Chi squared value is incorrect $\chi^2 = \frac{(547-549)^2}{549} + \frac{(185-183)^2}{183}$ ALLOW one mark for incorrect expected results used correctly in the equation to give a Chi squared value
F ₁ phenotype	Observed results	Expected results															
Smooth	547	549															
Wrinkled	185	183															
Total	732	732															
		ii	no significant difference between the observed and expected results / do not reject null hypothesis (1) test / chi squared value is smaller than the critical value at p = 0.05 (1)	2	To one degree of freedom ALLOW accept null hypothesis ALLOW ecf from (i) at correct degree of freedom												
		iii	heterozygote / heterozygous (1) presence of wrinkled seeds in F1 (1)	2	ALLOW contains both dominant and recessive alleles IGNORE any letters used in place of alleles												
			Total	6													

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
21		i	Sickle cell anaemia / PKU / Cystic Fibrosis	1	DO NOT ALLOW Huntington's ALLOW alternative correct suggestions
		ii	(X in intron) <i>idea that</i> code in this region does not appear in mature mRNA (1) <i>idea that</i> introns are transcribed but edited out (1)	2	ALLOW an explanation that this region does not code for amino acids
		iii	<i>idea that</i> genetic code is degenerate (1) <i>idea that</i> new triplet codes for an amino acid with a similar R group (1) no change in the tertiary structure of the protein (1)	2	ALLOW a description - some amino acids have more than one triplet ALLOW idea of 'little or no change' if second mark point is awarded ALLOW three dimensional protein structure DO NOT ALLOW 'no change in protein structure' without further qualification since 'structure' is given in the stem of the question
			Total	5	
22			Any 2 from: (A and B are) codominant <i>idea that</i> both genes are transcribed <i>idea that</i> both antigen proteins are produced	2	
			Total	2	
23			A	1	
			Total	1	
24			D	1	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
25		i	25 (%);	1	IGNORE working Examiner's Comments The majority of candidates were able to calculate the theoretical percentage of a heterozygous individual being produced in a cross between two heterozygous individuals.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	1. (island edges / cacti) subject to, sea/salt, spray; 2. qq (genotype) confers ability to obtain water from salt spray; 3. (gives) selective advantage; 4. (individuals with qq genotype) survive / reproduce; 5. allele / q, frequency increases; 6. directional selection; 7. geographic, isolation / barrier; 8. (means) no new alleles coming in;	4 max	ACCEPT ORA for mp 2 – 5 IGNORE mist / sea water for mp1 and 2 ACCEPT homozygous recessive / 'they' for qq genotype 2. ACCEPT qq gets water supply from salt spray 2. ACCEPT qq genotype confers tolerance to salt (spray) 3. ACCEPT description e.g. 'they are (at an advantage and are) selected for' 5. DO NOT CREDIT gene frequency increases 5. IGNORE 'qq frequency increases' 6. IGNORE natural selection Examiner's Comments Good responses were able to comprehensibly explain how individuals homozygous for the q allele would come to dominate the gene pool of the <i>Brachycereus</i> species of cactus in the Galapagos Islands. It was essential to refer to the local conditions where the cactus is subjected to salty sea spray. Candidates realising the prevailing conditions, correctly referred to the qq individuals being able to obtain water from the salty spray, giving them a selective advantage and allowing them to survive. A few acceptable alternative arguments were also seen for the other cacti with the Q allele being unable to thrive. A number of responses failed to go as far as explaining that this selective advantage would result in the frequency the q allele rapidly increasing. Rarely it mentioned that this was directional selection or that the cactus was geographically isolated with no new alleles coming into the population.
			Total	5	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance																																										
26		i	$\chi^2 = 10.48 / 10.480 / 10.5$;;;	4	<table border="1"> <thead> <tr> <th>Indicator species</th><th>E</th><th>O</th><th>O - E</th><th>(O - E)²</th><th>$\frac{(O - E)^2}{E}$</th></tr> </thead> <tbody> <tr> <td>Stonefly nymph</td><td>58</td><td>44</td><td>-14</td><td>196</td><td>3.38</td></tr> <tr> <td>Freshwater shrimp</td><td>33</td><td>43</td><td>10</td><td>100</td><td>3.03</td></tr> <tr> <td>Water louse</td><td>7</td><td>12</td><td>5</td><td>25</td><td>3.57</td></tr> <tr> <td>Sludge worm</td><td>2</td><td>1</td><td>-1</td><td>1</td><td>0.50</td></tr> <tr> <td></td><td></td><td></td><td>;</td><td>;</td><td>;</td></tr> <tr> <td></td><td></td><td></td><td></td><td></td><td></td></tr> </tbody> </table> Correct answer = 4 marks If answer is incorrect or missing then CREDIT correct working in table columns as follows: All figures in one column correct = 1 mark to 3 max DO NOT CREDIT column mark if minus signs on figs missing or incorrect IGNORE number of d.p.in table CREDIT fractions for last column ALLOW ecf from any incorrect column to the next and for χ^2. Examiner's Comments Most candidates gave the correct answer. Candidates usually gave their answer to 2dp although this was not a required marking point. The main problems were incorrect rounding and not knowing that squaring a negative produces a positive.	Indicator species	E	O	O - E	(O - E) ²	$\frac{(O - E)^2}{E}$	Stonefly nymph	58	44	-14	196	3.38	Freshwater shrimp	33	43	10	100	3.03	Water louse	7	12	5	25	3.57	Sludge worm	2	1	-1	1	0.50				;	;	;						
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		ii	calculated value / χ^2 / 10.48 / 10.5, is (much) larger than, critical value / 7.81; ORA <i>idea that</i> probability that these results are due to chance is (much) less than, 5% / 0.05; ORA conclusion is justified / result not due to chance / significant difference between observed and expected results (at the 0.05 level);	2	ALLOW ecf for a correct explanation that corresponds to the candidate's incorrect calculation for (a)(i) ACCEPT probability lies between, 5%/0.05, and 1%/0.01 confidence limits IGNORE ref to null hypothesis Examiner's Comments Most candidates correctly concluded that the biologist's conclusion 'could be supported'. However many chose the wrong critical value by using either the wrong degrees of freedom or using $p=0.01$ to find the critical value. Candidates generally knew they were deriving a probability, but were unclear about what exactly this meant. Many believed they were determining the probability of getting a bigger X^2 value. A few candidates did not understand the difference between the null hypothesis and the biologist's hypothesis/conclusion. They therefore correctly rejected the null hypothesis but also erroneously stated that the biologist's conclusion was false. It is helpful to give candidates opportunities to calculate chi-squared values for real-life examples where they will have a clear sense of whether the differences seen are due to chance or to some other reason. For example the colour distribution of sweets in a packet (equally distributed or not?) and woodlice distribution in a choice chamber (more woodlice in the dark and wet area?).
			Total	6	