2

SUPERVISOR'S USE ONLY

91157

911570

NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
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Level 2 Biology, 2015

91157 Demonstrate understanding of genetic variation and change

9.30 a.m. Monday 16 November 2015
Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of genetic variation and change.	Demonstrate in-depth understanding of genetic variation and change.	Demonstrate comprehensive understanding of genetic variation and change.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

If you need more space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

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Low Merit

TOTAL 15

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QUESTION ONE: BLACK ROBINS

http://nzbirdsonline.org.nz/species/black-robin

Introduced species such as cats and rats caused the Chatham Island black robin (*Petroica traversi*) population to plummet to five individuals in 1980. Due to intensive conservation efforts, the species now has over 250 individuals in the gene pool.

(a) Describe the term gene pool.

A gene pool is the total number of alleles present in a population. The more alleles, the larger the gene pool.

(b) Explain how genetic drift affects the black robin's gene pool.

Genetic drift is random changes in a gene pool. Events such as, introducing cats and rats, caused a random loss in alleles of the black robins gene pool. Genetic drift has a more pronounced effect in smaller populations, as opposed to large populations.

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(c) Female black robins usually lay eggs inside their nests. However, conservationists found some birds laid eggs on the rims of nests, where the eggs could not survive. So, they pushed the eggs back into the nests where they could be incubated and hatch successfully. However, this selection pressure from humans caused the rim laying allele to increase to 50% in the black robin population. They decided to stop pushing eggs back into the nests to prevent the behaviour from spreading throughout the population. In 2011 only 9% of the population laid eggs on the rims of nests.

Nest showing egg laid on rim.
www.math.canterbury.ac.nz/~r.sainudiin/preprints/plos_br_preprint.pdf

Discuss why some female black robins lay eggs on the rims of nests, while most lay eggs inside the nests, and how humans affected this behaviour.

In your answer include:

- a description of what allele and allele frequency mean
- an explanation of what selection pressures are, and how they affect natural selection
- a discussion of natural selection using the black robin egg laying example
- a discussion of why the rim laying behaviour increased with human intervention, then decreased once the intervention stopped.

An allele is a variation of a gene, such as blue and ~~black~~ brown eye colour. Allele frequency is ~~the~~ number of times an allele occurs in the gene pool. ~~The more allele~~ Natural selection is where the environment selects for certain phenotypes over others. Three types of natural selection have been identified. Stabilising selection ~~it~~ favours the average phenotypes. Directional selection favours ~~the~~ one extreme over another. Disruptive Selection favours both extremes to the detriment of those in the middle. Selection pressures are pressures in the environment such as predators, food and water availability, and climatic features that favours certain alleles over others. These favoured alleles are known as 'favourable alleles' and are beneficial to the ~~el~~ survival of the organism. Natural

There is more space for your answer to this question on the following page.

selection ultimately relies upon fertility and survival. An example of a selection pressure seen in the black robins environment was the human intervention of pushing the eggs away from the rim. Natural selection is seen in the black robins as by stopping pushing the eggs back, natural selection was able to play its role. ~~The alleles that~~ The black robins that layed their eggs on the rims of the nests ~~had~~ placed the eggs in a position where they were at a much higher risk of falling and the offspring dying. Therefore, the alleles that the birds that lay their eggs on the rim of nests could not effectively be passed down onto further generations. Therefore these birds had alleles that were selected against, and therefore decreased in frequency in the gene pool. ~~This is seen by the numbers~~ Thus, the birds who had the favourable alleles that layed there eggs away from the rim were able to pass on these alleles to future generations. This is seen by the numbers of birds who had the unfavourable alleles being only 9% in 2011, as they decreased in frequency in the gene pool. The rim layer behaviour ~~be~~ increased with human intervention, as ~~this~~ natural selection was not able to eliminate the non-favourable alleles from the gene pool, therefore non-favourable alleles were passed onto offspring, making this behaviour more common as they increased in frequency in the gene pool. Therefore, the behaviour decreased when human intervention stopped, as natural selection was able to select against this behaviour.

QUESTION TWO: BLOOD TYPE

There are multiple alleles that determine a human's blood type. These are known as I^A, I^B and i^O. Alleles I^A and I^B are dominant over i^O. However, when I^A and I^B are inherited together, they show co-dominance.

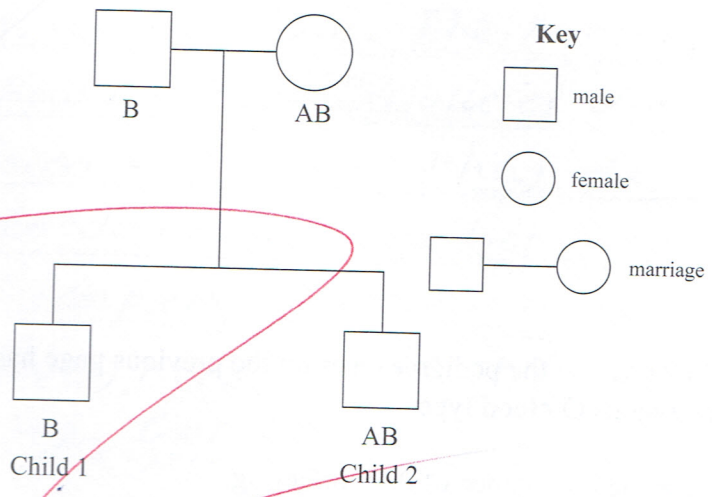
(a) Describe what multiple alleles are.

Multiple alleles are when more than ~~one~~ two alleles code for a particular trait. An example is ABO blood group.

(b) The pedigree chart below shows the two children and their phenotypes that result from a male with phenotype B and a female with phenotype AB.

Blood Types

Phenotype	Genotype
A	$I^A I^A$, $I^A i^O$
B	$I^B I^B$, $I^B i^O$
AB	$I^A I^B$
O	$i^O i^O$



Explain why Child 1 has two possible genotypes while Child 2 has only one possible genotype.

You may use diagrams in your answer.

Child one has two possible genotypes due to having both ($I^B I^B$) and ($I^B i^O$) as opposed to child two who has only one possible ~~phenoty~~ genotype ($I^A I^B$)

There is more space for your answer to this question on the following page.

(c) Child 2 (AB) in the pedigree chart on the previous page has children with a female having homozygous O blood type.

Discuss the inheritance of their offspring.

In your answer include:

- the possible phenotypes AND genotypes of the offspring
- an explanation of the difference between dominance and co-dominance
- a discussion of why none of their children will have the blood type O or AB.

You may use diagrams in your answer.

	$i^O i^O$	$I^A I^B$
$i^O i^O$	$i^O i^O$	$I^A I^B$, $i^O i^O$
$I^A I^B$	$I^A I^B$, $i^O i^O$	$I^A I^B$

The possible phenotypes and genotypes of offspring are reflected in the ~~of~~ punnet sq uare. ~~The ratio is 1:0:0:~~ The possible genotypes are i^Oi^O, I^AI^B. The possible phenotypes are O, AB, Co-dominance is when both alleles are fully expressed in the phenotype, creating a mixture of both equally dominant alleles (an example is roan cows, a mixture of red hairs and white hairs). ~~Co~~ Dominance or complete dominance is when one allele completley dominates the other. The homozygous form will always show the ~~dominant~~ allele(s) present and the heterozygous form will always show the dominant allele. Co-dominance ~~it is~~ has both homozygous forms completly dominant in the phenotype. However, none of the children will have the blood type O or AB.

ASSESSOR USE ONLY

N1

QUESTION THREE: COAT COLOUR

In 1905, Lucien Cuénot observed unusual ratios when studying inheritance of coat colour in mice. After mating two heterozygous yellow mice (Yy), he observed that the offspring never showed a normal 3:1 phenotypic ratio. Instead, he always observed a 2:1 ratio, with two yellow mice for every grey mouse. He concluded that yellow coat colour (Y) was dominant over grey coat colour (y), and by using test crosses he showed that all his yellow mice were heterozygotes. However, from his many crosses, Cuénot never produced a single homozygous dominant yellow mouse.

www.themouseconnection.org/t955-what-are-these-sooty-colors

Subsequently, it was confirmed that no homozygous dominant yellow mice were present because of a lethal allele.

(a) Describe a lethal allele(s).

~~Lethal alleles are when an allele controlling a gene~~

Lethal alleles are alleles that are controlled by a non-functional version of an essential protein. A combination of two lethal alleles in a genotype will cause a fatal response, death immediatly, or shortly after birth. (A homozygous form)

(b) Discuss how Cuénot used test crosses to determine that all the live yellow mice were heterozygous.

In your answer include:

- a description of homozygous AND heterozygous
- an explanation of what a test cross is
- a discussion of how Cuénot used the test crosses to observe a 2:1 ratio (two yellow mice for every grey mouse), and determine that all live yellow mice were heterozygous.

You may use diagrams in your answer.

Homozygous is the presence of either two recessive alleles, or two dominant alleles. Heterozygous is the presence of both one dominant allele and one recessive allele, in complete dominance the dominant allele is only presented in the organisms phenotype, however the organism remains a carrier of a recessive allele.

A test cross involves crossing an individual showing the dominant trait with a homozygous recessive

individual, as the ~~dd~~ individual ~~carry~~ expressing the dominant trait could be either heterozygous or homozygous dominant. Cuénot used the test cross to observe a 2:1 ratio and determined that all yellow mice were heterozygous. This was by recognising that all individuals who died were homozygous dominant, as they had ~~produce~~ a fatal allele combination. Therefore, all mice ~~the~~ that were alive showing the dominant trait (yellow coat colour) must be heterozygous (Yy) →

(c) The genetic disease cystic fibrosis is caused by lethal alleles. An affected individual is homozygous recessive, however heterozygous individuals are carriers of the lethal allele. Lethal alleles are caused by mutations. The mutation for cystic fibrosis occurs in the gametes.

Discuss how mutations cause lethal alleles, AND why cystic fibrosis alleles remain in the population.

In your answer include:

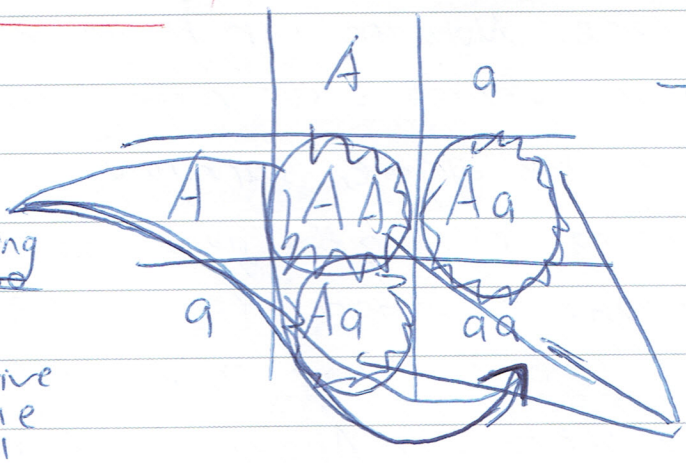
- a description of what a mutation is
- an explanation of the difference between a gametic mutation and a somatic mutation
- a discussion of why the cystic fibrosis lethal allele remains in the human population.

A mutation is a random permanent change in the base sequence of a gene. Mutations can be gametic or somatic. Gametic mutations occur in the gametes, and therefore affect the zygote, carrying the mutation onto offspring, entering the gene pool. ~~Somatic mutation~~ Somatic mutations occur in the body/somatic cells and therefore only affect the individual, not the offspring. An example of a somatic mutation is lung cancer. The cystic fibrosis lethal allele, remains in the human population

There is more space for your answer to this question on the following page.

Heterozygous individuals are carriers of the cystic fibrosis mutation. The heterozygous individual will not receive the lethal combination of homozygous recessive, and therefore will carry ~~the~~ cystic fibrosis in ~~it's~~ the genotype, ~~it~~ without the occurance of death. Since cystic fibrosis is a gametic mutation, the heterozygous individuals are therefore able to pass down the cystic fibrosis ~~mutat~~ lethal allele to offspring. Therefore, the cystic fibrosis lethal allele will continue to be passed onto offspring, increasing in allele frequency in the population. The heterozygous offspring will continue to pass onto offspring, and if reproduction happens with another heterozygous individual, the expected ratio of 3:1 will be 2:1 as offspring who has lethal combination of cystic fibrosis will die immediately, or shortly after death.

offspring of two carriers of cystic fibrosis:



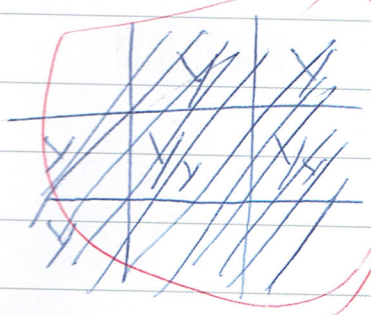
2 carriers : 1 non-carrier

offspring ~~of two~~ with two recessive allele will have lethal combination of cystic fibrosis (aa)

Extra paper if required.
Write the question number(s) if applicable.

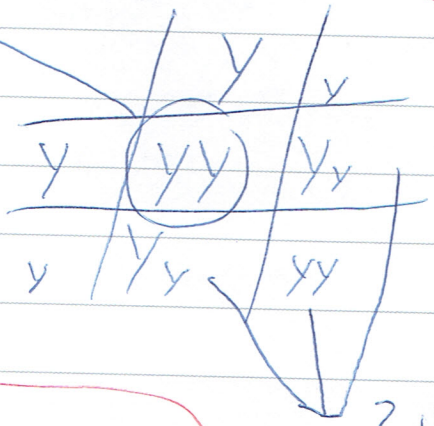
QUESTION NUMBER

3b)



By making two heterozygous mice (Yy) it can be seen that the homozygous dominant individual ~~can be~~ has a fatal allele combination, ~~of~~ giving a 2:1 ratio

all individuals (YY) died



2 yellow : 1 grey

Annotated Exemplar Template

Merit exemplar for 91157 - 2015		Total score	15
Q	**Grade score**	**Annotation**	
1	7	Correct definitions in part (a) (b) and (c). Provides a very good discussion integrating Selection Pressure and Natural Selection to survival of offspring. Does not mention the concept of "variation" in the Robin population which is vital to Natural Selection. Has implied that Natural Selection selects individuals after human intervention, but fails to link the idea to alleles no longer passed on to offspring which is a requirement for E8.	
2	1	Definitions are incomplete. Examples are out of context (eg: Roan Cows rather than blood groups).Dominance described as an allele dominates another (recessive not mentioned). Does not explain or discuss the about the children's inheritance of their genotypes in part (c).	
3	7	Provides correct definitions for (a) (b) and (c). Test cross defined correctly but explanation indicates a 2:1 ratio from a test cross which is incorrect. The 2: 1 ratio occurs as a deviation from 3:1 from mating of 2 heterozygous individuals as a result of Lethal alleles. The answer is evidence towards E7 as Cystic Fibrosis is discussed to an excellence level.	

91157

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2

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High Merit

TOTAL 17

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QUESTION ONE: BLACK ROBINS

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http://nzbirdsonline.org.nz/species/black-robin

Introduced species such as cats and rats caused the Chatham Island black robin (*Petroica traversi*) population to plummet to five individuals in 1980. Due to intensive conservation efforts, the species now has over 250 individuals in the gene pool.

(a) Describe the term gene pool.

Gene pool is the total number of allele combinations within a species

(b) Explain how genetic drift affects the black robin's gene pool.

Genetic drift affects the black robin's gene pool because it is only a small population therefore not all of the possible allele combinations will be present in the population. Genetic drift is the random change in an allele frequency

(c) Female black robins usually lay eggs inside their nests. However, conservationists found some birds laid eggs on the rims of nests, where the eggs could not survive. So, they pushed the eggs back into the nests where they could be incubated and hatch successfully. However, this selection pressure from humans caused the rim laying allele to increase to 50% in the black robin population. They decided to stop pushing eggs back into the nests to prevent the behaviour from spreading throughout the population. In 2011 only 9% of the population laid eggs on the rims of nests.

Nest showing egg laid on rim.
www.math.canterbury.ac.nz/~r.sainudiin/preprints/plos_br_preprint.pdf

ASSESSOR'S USE ONLY

Discuss why some female black robins lay eggs on the rims of nests, while most lay eggs inside the nests, and how humans affected this behaviour.

In your answer include:

- a description of what allele and allele frequency mean
- an explanation of what selection pressures are, and how they affect natural selection
- a discussion of natural selection using the black robin egg laying example
- a discussion of why the rim laying behaviour increased with human intervention, then decreased once the intervention stopped.

disruptive selection

An allele is an alternative form of a gene. Allele frequency is how common that allele is within the population. Selection pressures is when the pressure is put on the extreme values so that the median allele is favoured. This therefore affects natural selection because in natural selection the favourable alleles in the environment will be favoured as they will be ~~able to~~ best suited to the environment so will be able to reproduce and pass on their alleles to the next generation. When pressure is put on the extremes this means that the alleles best suited to the environment may not be passed on the next generations because very few of those alleles are present in the generation at the moment.

There is more space for your answer to this question on the following page.

In the example of the black robin laying egg, natural selection has occured. When humans intervened, disruptive selection became more popular among the black robins as it was the favourable place to lay eggs in the environment. Once the human intervention stopped, the black robin species was able to go back to natural selection where the laying of eggs inside the nests became more favourable than laying the eggs on the rim of the nests as the birds were able to grow and not be eaten by predators as they were incubated and protected.

A3

QUESTION TWO: BLOOD TYPE

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There are multiple alleles that determine a human's blood type. These are known as I^A, I^B and i^O. Alleles I^A and I^B are dominant over i^O. However, when I^A and I^B are inherited together, they show co-dominance.

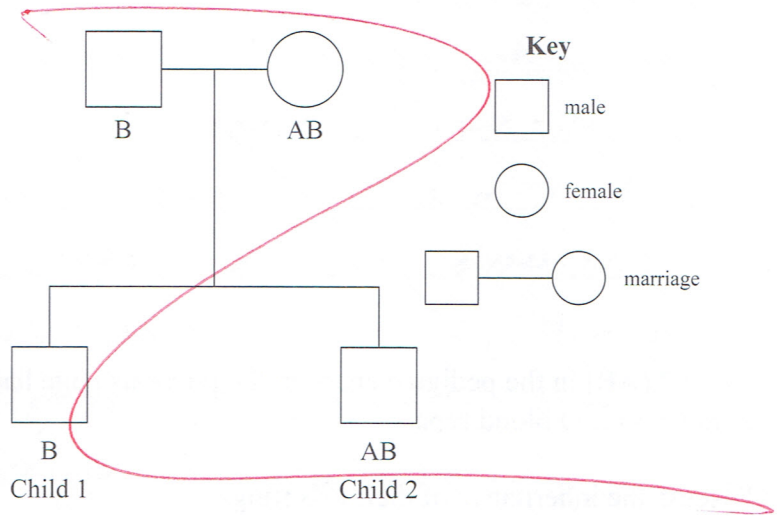
(a) Describe what multiple alleles are.

Multiple alleles are alleles that can be expressed in more ways than one.

(b) The pedigree chart below shows the two children and their phenotypes that result from a male with phenotype B and a female with phenotype AB.

Blood Types

Phenotype	Genotype
A	I^AI^A, I^Ai^O
B	I^BI^B, I^Bi^O
AB	I^AI^B
O	i^Oi^O



Explain why Child 1 has two possible genotypes while Child 2 has only one possible genotype.

You may use diagrams in your answer.

Child one has two possible genotypes because the phenotype B, has multiple alleles. The father could've contributed an B or an O allele and the mother only a B allele. Child 1 has 2 possible genotypes because they have not yet reproduced so we can't tell what is their exact genotype. If the Mother and father both contributed a B allele then the

There is more space for your answer to this question on the following page.

child would have the genotype $I^B I^B$ or if the father contributed an O allele then the child would have the genotype $I^B i^O$. Child 2 only has one possible genotype. ~~She~~ He has type AB blood so his mother must have contributed an ~~B~~ A allele and his father a B allele.

(c) Child 2 (AB) in the pedigree chart on the previous page has children with a female having homozygous O blood type.

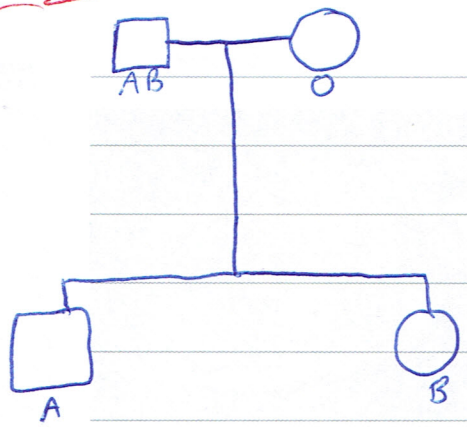
Discuss the inheritance of their offspring.

In your answer include:

- the possible phenotypes AND genotypes of the offspring
- an explanation of the difference between dominance and co-dominance
- a discussion of why none of their children will have the blood type O or AB.

You may use diagrams in your answer.

Dominance is where one allele is completely dominant over the other so will always be expressed in the phenotype ~~the offspring~~ even if the organism is heterozygous. Co-dominance is when both alleles are equally dominant so both will be expressed in the phenotype ~~an example~~ ~~Hair~~



The possible phenotypes of the offspring are A and B blood types. Their genotypes are ~~BB~~ $I^B I^B$, $I^B i^O$ for the B blood type and $I^A I^A$, $I^A i^O$ for the A blood type.

None of their children will have the blood type O or AB because you inherit one allele from your mother and one from your father. ~~Neither~~ Only one parent can contribute an O allele to the offspring so therefore in order to have O type blood you have to have 2 i^O alleles, which the parents can't give. Also in order to have AB blood type you have to have 1 A and 1 B allele. only one the father can give either of these alleles, the mother can only give O. therefore neither of the offspring are going to have AB or O blood types.

ASSESSOR'S USE ONLY

E7

QUESTION THREE: COAT COLOUR

In 1905, Lucien Cuénot observed unusual ratios when studying inheritance of coat colour in mice. After mating two heterozygous yellow mice (Yy), he observed that the offspring never showed a normal 3:1 phenotypic ratio. Instead, he always observed a 2:1 ratio, with two yellow mice for every grey mouse. He concluded that yellow coat colour (Y) was dominant over grey coat colour (y), and by using test crosses he showed that all his yellow mice were heterozygotes. However, from his many crosses, Cuénot never produced a single homozygous dominant yellow mouse.

Subsequently, it was confirmed that no homozygous dominant yellow mice were present because of a lethal allele.

www.themouseconnection.org/t955-what-are-these-sooty-colors

(a) Describe a lethal allele(s).

A lethal allele is an allele that when present in an organism is very harmful and kills the organism.

(b) Discuss how Cuénot used test crosses to determine that all the live yellow mice were heterozygous.

In your answer include:

- a description of homozygous AND heterozygous
- an explanation of what a test cross is
- a discussion of how Cuénot used the test crosses to observe a 2:1 ratio (two yellow mice for every grey mouse), and determine that all live yellow mice were heterozygous.

You may use diagrams in your answer.

Homozygous is ~~the~~ when either both the dominant alleles are expressed or both of the recessive alleles are expressed. Heterozygous is when one of the ~~homozygous~~ dominant alleles is present and one of the recessive alleles is present.

A test cross is when ~~the~~ two organisms are mated together to attempt to find out their genotypes by looking at the off spring

produced. The test crosses observe the 2:1 ratio because a homozygous dominant mouse dies, because of the lethal allele. Therefore there are only 3 possible living outcomes. The yellow colour allele is dominant over the grey allele so the two mice that are heterozygous are going to be yellow even though they have one of each colour of allele. In order for a mouse to be grey it has to be homozygous recessive, and one of these is produced in the test cross. This shows that all live yellow mice are heterozygous.

	Y	y
Y	YY	Yy
y	Yy	yy

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(c) The genetic disease cystic fibrosis is caused by lethal alleles. An affected individual is homozygous recessive, however heterozygous individuals are carriers of the lethal allele. Lethal alleles are caused by mutations. The mutation for cystic fibrosis occurs in the gametes.

Discuss how mutations cause lethal alleles, AND why cystic fibrosis alleles remain in the population.

In your answer include:

- a description of what a mutation is
- an explanation of the difference between a gametic mutation and a somatic mutation
- a discussion of why the cystic fibrosis lethal allele remains in the human population.

A mutation is a permanent change in the base sequence of DNA. A gametic mutation occurs in the ~~gonad~~ gonads (testes and ovaries). A mutation that occurs here is able to be passed on and inherited into the next generation because the gametes are used to reproduce. A somatic mutation occurs in the body cells and is unable to be inherited in the next generation because body cells are not used to reproduce. Mutations cause lethal alleles because it could mean

There is more space for your answer to this question on the following page.

that the protein that was originally going to be produced was altered with the permanent change in the DNA base sequence. This change could be very severe and result in a lethal allele being present in the organism produced. The cystic fibrosis remains present in the human population because it is a gametic mutation meaning it is able to be passed onto the next generation. Heterozygous individuals do not have the disease, however they are carriers of it. So therefore when two heterozygous individuals mate, there is a 1 in 4 chance that the offspring will have the lethal allele present in its phenotype.

This punnet square shows the 1 in 4 chance of when 2 heterozygous individuals mate that their offspring will have the cystic fibrosis lethal allele

	T	t
T	TT	Tt
t	Tt	tt

T = dominant

t = recessive

Tt = heterozygous.

ASSESSOR'S USE ONLY

E7

Annotated Exemplar Template

Merit exemplar for 91157 - 2015			Total score	17
Q	**Grade score**	**Annotation**		
1	3	Correct definitions in part (a) (b) and (c). Provides a very good discussion integrating Selection Pressure and Natural Selection to survival of offspring. Does not mention the concept of "variation" in the Robin population which is vital to Natural Selection. Has implied that Natural Selection selects individuals after human intervention, but fails to link the idea to alleles no longer passed on to offspring which is a requirement for E8.		
2	7	Definitions are incomplete. Examples are out of context (eg: Roan Cows rather than blood groups).Dominance described as an allele dominates another and (recessive allele not mentioned). Does not explain or discuss the about the children's inheritance of their genotypes (gametes from parents) in part (c).		
3	7	Provides correct definitions in (a) and (c). Does not provide sufficient discussion in (b). Has used punnet square of a cross of 2 heterozygous mice as stated in resource material, with no link of understanding why all yellow mice were definitely Yy and not YY. The Cystic Fibrosis question was clearly discussed to an E8 level with an annotated punnet square. The student did not receive an overall E8 as they were unable to answer part (b)		