Biomedical Admissions Test (BMAT)

Section 2: Biology

Questions by Topic

B4 - Inheritance

B4: Inheritance - Questions by Topic

(Mark Scheme and explanations at the end)

1 The following questions are about inheritance.

1 The site of genetic material in a eukaryotic cell is the cytoplasm.
2 A genetic study showing a heterozygous phenotype means there is a minimum of two different alleles for the same gene.
3 The genetic constitution of an individual is called the phenotype.
4 A recessive trait is always expressed.
5 Chromosomes are found in the nucleus.

Which of these statements are correct?

A 1, 2, 3 and 4 only
B 1, 2, 3 and 5 only
C 1, 2 and 4 only
D 1, 2 and 4 only
E 1, 2 and 5 only
F 1 and 2 only
G 1 and 3 only
H 2 and 5 only

2 The following questions are about inheritance.

1 Linear chromosomes are present in the nucleus.
2 An organism's characteristics are determined by the individual's genes.
3 Each individual has two alleles for every gene.
4 An individual who can taste the chemical PTC will always have the genotype TT.
5 The observable characteristics of an individual is its phenotype.

Which of these statements are correct?

A 1, 2, 3 and 4
B 1, 2, 3 and 5
C 1, 2 and 3
D 1, 2 and 5
E 2, 4 and 5
F 1 and 2
G 2 and 4
H 2 and 5

3 The following statements are about inheritance.

1 As a cell is about to divide the chromosomes are no longer visible.
2 If an individual is homozygous for a recessive trait they will show the phenotype.
3 Red blood cells have a large nucleus.
4 In a punnett square, each letter represents one allele.
5 The nucleus controls the activities of the cell in most animals and cells.

Which of these statements are correct?

A 1, 2, 3 and 4 only
B 1, 2, 3 and 5 only
C 1, 2 and 4 only
D 2, 4 and 5 only
E 1, 2 and 5 only
F 1 and 2 only
G 1 and 4 only
H 2 and 3 only

4 Reproduction involves certain characteristics being passed on to the offspring. Therefore certain characteristics are inherited. These following statements are about inheritance.

1 Impact of several genes is looked at in a monohybrid cross.
2 The genotypes and phenotypes of both parents are shown in a genetic diagram.
3 Genetic crosses can also be shown using punnett squares.
4 The allele for tongue roller is dominant thus a genetic diagram would show that 50% of the offspring will be tongue rollers as both parents are heterozygous for the trait.
5 Each possible gamete is represented by two letters in a genetic cross.

Which of these statements are correct?

A 1, 2, 3 and 4 only
B 1, 2, 3 and 5 only
C 1, 2 and 3 only
D 1, 3 and 4 only
E 2, 3 and 4 only
F 1 and 2 only
G 1 and 3 only
H 2 and 3 only

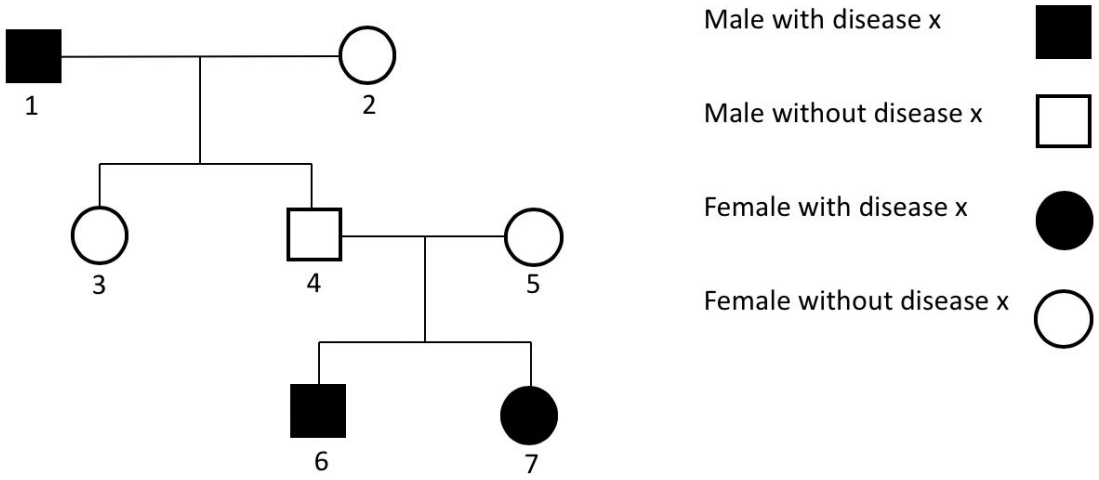
5 The following statements are about inheritance.

1 A punnett square showing two heterozygous parents will mean 50% of the offspring are homozygous recessive.
2 In a punnett square showing one homozygous recessive parent and one heterozygous parent 50% of the offspring will be heterozygous.
3 Ratios can be used to express the outcome of a punnett square.
4 In a punnett square showing a homozygous dominant and homozygous recessive 100% of the offspring will be heterozygous.
5 A cross is when two individuals mate.

Which of these statements are correct?

A 1, 2, 3 and 4 only
B 2, 3, 4 and 5 only
C 1, 2 and 4 only
D 1, 3 and 4 only
E 2, 3 and 5 only
F 1 and 2 only
G 2 and 4 only
H 4 and 5 only

6 A genetic condition can be inherited over several generations. Pedigrees can be used to show the inheritance of a genetic condition through many generations of a family. Below is a diagram showing the pedigree for generations of a family for disease x. The following statements are about the diagram.



1 Both individuals 4 and 5 must be carriers of disease x.
2 Individual 3 must be a carrier of disease x.
3 Individual 1 must have the one dominant allele and one recessive allele.
4 Individual 2 does not have the disease causing allele in their genotype.
5 Disease x is caused by a recessive allele.

Which of these statements are correct?

A 1, 2, 3 and 5 only
B 1, 2, 4 and 5 only
C 1, 2 and 3 only
D 1, 2 and 5 only
E 2, 3 and 5 only
F 1 and 2 only
G 2 and 3 only
H 2 and 5 only

7 Polydactyly is caused by a dominant allele (P). The following statements are about the inheritance of polydactyly.

1 If both parents are heterozygous for the condition then the ratio of offspring with and without polydactyly is 3:1.

2 If one parent is homozygous dominant and the other homozygous recessive for polydactyly 100% of the offspring will be heterozygous.

3 If one parent is homozygous dominant and the other heterozygous for polydactyly the ratio for offspring with and without polydactyly is 3:1.

4 An individual needs to only have one polydactyly dominant allele to have the condition.

5 If one parent is homozygous recessive and the other heterozygous 75% of the offspring will be heterozygous.

Which of these statements are correct?

A 1, 2, 3 and 4 only
B 1, 2, 4 and 5 only
C 1, 2 and 4 only
D 1, 3 and 4 only
E 2, 3 and 5 only
F 1 and 2 only
G 1 and 5 only
H 2 and 5 only

8 Cystic fibrosis is a genetic condition that is caused by a recessive allele (f). The following statements are about the inheritance of cystic fibrosis.

1 If both parents are heterozygous then the ratio of offspring that are carriers to offspring who are not carriers is 1:1.

2 If one parent is homozygous recessive and the other one is heterozygous 100% of the offspring will be carriers.

3 If one parent is heterozygous and the other homozygous recessive the ratio of offspring who are affected to those who aren't is 3:1.

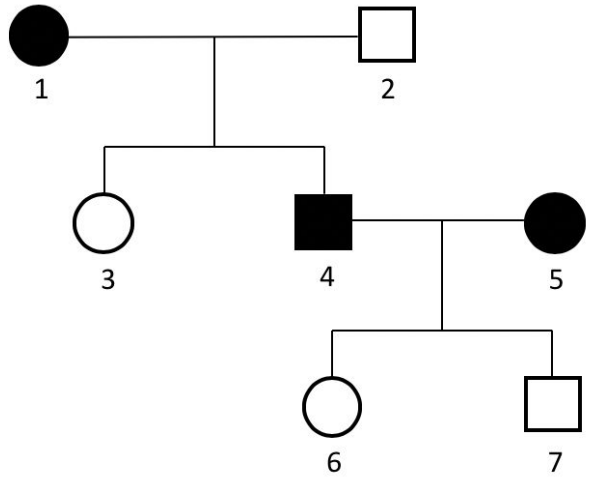
4 If one parent is heterozygous and the other homozygous dominant all of the offspring would be carriers.

5 Individuals affected by cystic fibrosis will have gained one recessive allele from each parent.

Which of these statements are correct?

A 1, 2, 3 and 4 only
B 1, 3, 4 and 5 only
C 1, 2 and 4 only
D 1, 2 and 5 only
E 2, 3 and 5 only
F 1 and 2 only
G 1 and 5 only
H 2 and 5 only

9 The diagram below is of disease z. It shows the presence of disease z in a family over many generations. The following questions are about the pedigree diagram below.



1 Individual 2 must be a carrier of disease z.
2 Disease z is caused by a dominant allele.
3 Individual 1 must be homozygous dominant.
4 Individuals 6 and 7 must be homozygous recessive.
5 Individual 4 must have a dominant allele in their genotype.

Which of these statements are correct?

A 1, 2, 3 and 5 only
B 1, 2, 4 and 5 only
C 1, 4 and 5 only
D 2, 3 and 5 only
E 2, 4 and 5 only
F 3 and 4 only
G 1 and 4 only
H 2 and 5 only

10 The following statements are about inheritance

1 One allele is inherited from each parent for a gene.
2 For a genetic disease caused by a dominant allele if only one parent has the disease, their offspring are 100% likely to inherit the genetic disease.
3 There are a small number of characteristics that are controlled by more than one gene.
4 If one parent is homozygous recessive for a genetic disease, caused by a recessive allele, and the other heterozygous there is a 50% chance that they will have a child who has inherited the genetic disease.
5 Height is a characteristic that is controlled by more than one gene.

Which of these statements are correct?

A 1, 2, 3 and 5 only
B 1, 2, 4 and 5 only
C 1, 4 and 5 only
D 2, 3 and 4 only
E 2, 3 and 5 only
F 1 and 2 only
G 2 and 5 only
H 3 and 4 only

Answers

1 The answer is H

1 is incorrect - this is because the place in the cell which is the **site of genetic material** in plant and animal cells in the **nucleus.** The nucleus contains the **chromosomes.** The nucleus is present in the cytoplasm of the cell, however the cytoplasm is not the site of genetic material in a cell.

2 is correct - it is correct that heterozygous means that the genotype will have **two different alleles of that gene.** This is shown using **capital and lowercase letters.** A dominant allele (e.g. R) is shown using a capital letter and a recessive allele is shown using a lowercase letter (e.g. r), therefore a heterozygous genotype with two different alleles can be shown as Rr.

3 is incorrect - the **genetic constitution of an individual organism** is called the **genotype**, not the phenotype. The **phenotype is the characteristics of an organism that are visible**, that result from the genotype and its interaction with the environment that the organism is in.

4 is incorrect - as a recessive trait is caused by a **recessive allele**, the trait is not expressed unless there are **two copies** of the recessive allele for that gene in each cell. Therefore if the genotype is **homozygous recessive** for a trait caused by a recessive allele, then this will **determine the phenotype.**

5 is correct - **genetic material** of a cell is stored in the **nucleus.** The genetic material is stored as linear chromosomes, and these are present in the nucleus.

Since **2** and **5** are the only correct statements, **H** must be the correct answer.

2 **The answer is C**

1 is correct - **linear chromosomes** are present in the nucleus, as the large amount of genetic information in the cell has been **condensed** into chromosomes that are linear.

2 is correct - the chromosome is a very long strand, **small sections of a chromosome are called genes**, which contain genetic information to code for one protein. Therefore genes determine the characteristics of an individual e.g. eye colour.

3 is correct - it is true that each individual has **two alleles for each gene.** One is **inherited from the father** and the other is **inherited from the mother.**

4 is incorrect - PTC is a chemical that can taste bitter to some people, and not others. The gene that controls the tasting of PTC codes for a taste receptor that is found on the tongue. As the ability to taste PTC is inherited, the allele that causes PTC to taste bitter is **dominant (T)** and the allele which means individuals cannot taste PTC is **recessive (t).** Therefore it is true that an individual who has the **genotype TT** will be able to **taste PTC as bitter.** However this is not the only genotype. As the ability to taste PTC is due to a dominant allele you **only need one allele present to be able to have the trait**, therefore an individual with the **genotype Tt** will also be able to taste PTC.

5 is incorrect - it is true that the **observable characteristics** that are determined by genes are called the **phenotype** of an individual.

Since **1, 2** and **3** are the only correct statements, **C** must be the correct answer.

3 **The answer is D**

1 is incorrect - this is because for most of the cell cycle the **chromosomes are not visible;** they are **only visible just before the cell is about to divide**, as they are **condensed.**

2 is correct - it is true that in order for a **recessive trait to determine the phenotype** there needs to be **two copies of the recessive allele present in each cell.** Therefore if an individual is **homozygous** for a recessive trait then the phenotype will be shown.

3 is incorrect - **red blood cells do not have a nucleus** and thus **do not have any chromosomes.** This is to create more space in order to carry oxygen.

4 is correct - genotype shows the **alleles of a gene** that are present in an individual. Each individual has **two alleles for a gene**, therefore a genotype can be written using two **letters**, each letter will represent an allele. E.g. a heterozygous genotype for tasting PTC (Tt) shows the dominant allele (T - capital letter) and a recessive one (t - lowercase letter).

5 is correct - it is true that the **nucleus controls the activities of the cell** in most animals and cells, as it contains **all the genetic information.**

Since **2, 4** and **5** are the only correct statements, **D** must be the correct answer.

4 **The answer is B**

1 is incorrect - it is true that **monohybrid crosses** are used to look at the **impact of genes.** However monohybrid crosses are used to look at and interpret the impact of **one gene only.**

2 is correct - it is true that the **genotype and phenotype of both parents** shown in a genetic diagram.

3 is correct - it is true that **punnett squares** is a method that can be used to **show genetic crosses.**

4 is correct - the allele to tongue roll is **dominant**, hence an individual **only needs one copy of this allele in order to the phenotype of tongue rolling to be expressed**. If one parent is **homozygous recessive** and the other **heterozygous** then there is a **50%** chance that the offspring will be tongue rollers. This can be worked out using a punnett square shown below. The phenotype and genotype of the parents is shown, as well as the possible gametes. The punnett square shows the potential crosses between the gametes. This shows there is a 50% chance that the offspring will be tongue rollers **(as they are heterozygous Tt)** and a 50% chance that the offspring are not tongue rollers **(as they are homozygous recessive tt).**

Parent phenotype	Parent 1: tongue roller	Parent 2: tongue roller
Parent genotype	Parent 1: Tt	Parent 2: Tt
Gametes	Parent 1: T & t	Parent 2: T & t

	T	**t**
t	Tt	tt
t	Tt	tt

Offspring genotype	TT	Tt	tt	tt
Offspring phenotype	Tongue roller	Tongue roller	Non-tongue roller	Non-tongue roller

5 is incorrect - it is true that the possible gametes are shown in a punnett square, however this is shown by **one allele not two.** As a gamete is **haploid,** therefore will only contain **one allele for a particular gene.**

Since **2, 3** and **4** are the only correct statements, **E** must be the correct answer.

5 **The answer is B**

1 is incorrect - a punnett square that shows a cross between **two heterozygous parents** will mean that there is a **25%** chance that the offspring will be **homozygous recessive.** For example, if the allele for hair on your toes is dominant (H) and the allele for no hair is recessive (h). Below is a punnett square showing heterozygous parents. The red circle shows the homozygous recessive genotype for the offspring, this shows that there is a ¼ chance the offspring will have a homozygous recessive genotype.

	H	**h**
H	HH	hh
h	Hh	Hh

2 is correct - it is true that if **one parent is heterozygous** and the other **homozygous recessive** then there is a **50%** chance that the offspring will be **homozygous recessive.** E.g. this is shown by a punnett square below with the dominant allele for toe hair (H) and the recessive allele (h) for no toe hair. The two red squares below show that 2/4 are homozygous recessive.

	h	**h**
H	Hh	Hh
h	hh	hh

3 is correct - it is true that **ratios can be used to show the outcome of punnett squares.** For example, Huntington disease is caused by a dominant allele (H), the punnett square below shows two heterozygous parents, who have Huntington disease. **The Huntington disease allele is dominant (H)** and the **normal allele is recessive (h).** The red circle shows the homozygous recessive genotype for offspring. The ratio for offspring with the huntington disease phenotype compared to the offspring with recessive phenotype is **3:1.** As **75%** of the offspring produced will have the **dominant allele for Huntington's disease** and **25%** of the offspring produced **will not have Huntington's disease.**

	S	**s**
S	SS	Ss
s	Ss	ss

4 is correct - it is true that a punnett square showing parents with a **homozygous dominant genotype** and **homozygous recessive genotype** will show that the chance the offspring produced will have a heterozygous genotype is **100%.** This is shown in

	H	**H**
h	Hh	Hh
h	Hh	Hh

the punnett square below, the red squares show all the heterozygous genotypes. Parents heterozygous genotypes: Hh.

5 is correct - it is true that when **two individuals mate** it is called a **cross**, this comes from the term **cross fertilise.**

Since **2, 3, 4** and **5** are the only correct statements, **B** must be the correct answer.

6 **The answer is D**

1 is correct - it is true that both individuals 4 and 5 must be **carriers** of disease x as they have mated to produce two offspring that are both affected by disease x. This can only occur if both individuals 4 and 5 carry the allele for disease x.

2 is correct - it is true that individual 3 must be a **carrier** of disease x. As the fact that **individuals 4 and 5 had children that were affected even though they do not have disease x**, means disease x is caused by a **recessive allele.** Therefore if individual 1 is affected their genotype must be **homozygous recessive**, therefore they must pass on one recessive allele to their offspring. Thus individual 3 must be **heterozygous**, as they are not affected but is a carrier of disease x.

3 is incorrect - as individual 2 is not affected this means that their genotype is **not homozygous recessive.** However this does not mean that they have to be a carrier, they do not have to have a heterozygous genotype (one recessive and one dominant allele), they can also be **homozygous dominant.**

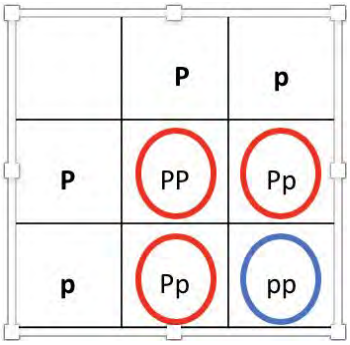
4 is incorrect - as it is possible that individual 2 can have the recessive disease causing allele in their genotype if they have a **heterozygous genotype** (one recessive and one dominant allele), and therefore are a **carrier** of disease x, so will **not be affected.**

5 is correct - it is true that disease x is caused by a **recessive allele.** The family pedigree shows this as **individuals 4 and 5 do not have disease x** however they have **offspring which have the disease** thus they must carry the disease allele, therefore they are **carriers** and have a **heterozygous genotype.** Each offspring (individual 6 and 7) have **inherited one recessive allele from each parent** and therefore their genotype is **homozygous recessive.**

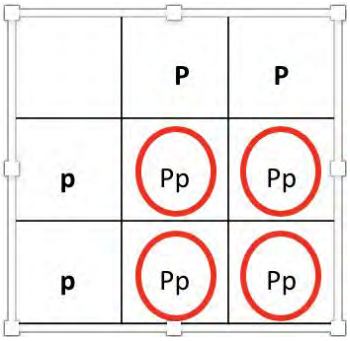
Since **1, 2** and **5** are the only correct statements, **D** must be the correct answer.

7 **The answer is C**

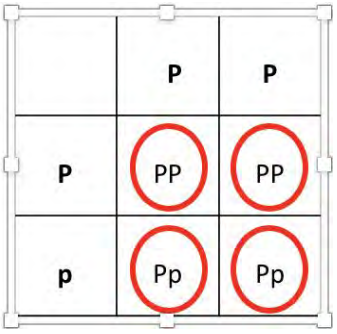
1 is correct - it is true that if **both parents are heterozygous** for the condition then the ratio of offspring produced that have polydactyly to those who do not is **3:1.** The three red circles show the genotype for offspring with polydactyly where the blue circle shows the genotype for offspring without polydactyly. Both parents have polydactyly as it is caused by a dominant allele, therefore **only one allele** is needed to determine the polydactyly phenotype. The normal allele is recessive: p.



2 is correct - it is true that if one parent is **homozygous recessive** and the other one is **homozygous dominant**, **100%** of the **offspring will be heterozygous.** This is shown in the punnett square below using the allele for polydactyly which is dominant (P) and the normal allele which is recessive (p). The red circles all show the offspring with heterozygous genotypes.

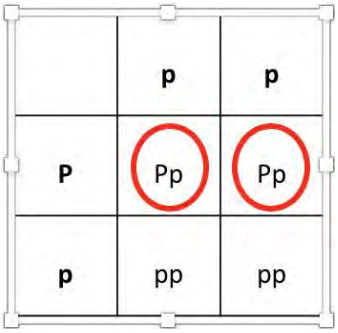


3 is incorrect - if one parent is **homozygous dominant (PP)** and the other parent is **heterozygous (Pp)** then **100%** of the offspring will be polydactyly. Therefore the ratio of offspring produced with polydactyly to offspring produced without polydactyly is not 3:1. This is because the **allele for polydactyly is dominant**, therefore only **one copy of the allele** is needed for the polydactyly phenotype to be shown in the individual. The red circles in the punnett square shows all the offspring genotypes that would have polydactyly.



4 is correct - it is true that is a disease/condition/phenotype is **caused by a dominant allele** then **only one copy of that allele** needs to be present in each cell for the phenotype to be shown.

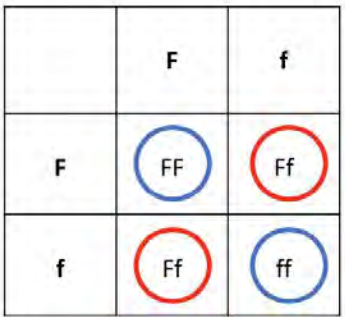
5 is incorrect - if one parent is **homozygous recessive** and the other parent **heterozygous** then **50%** of the offspring will be heterozygous not 75%. This is shown by the red circles on the punnett square below as 2/4 offsprings have the heterozygous genotype.



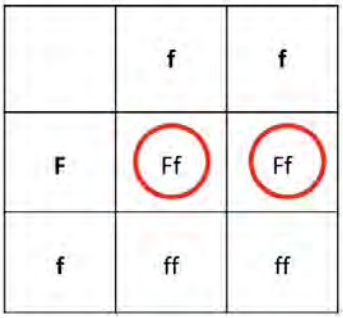
Since **1, 2** and **4** are the only correct statements, **C** must be the correct answer.

8 **The answer is G**

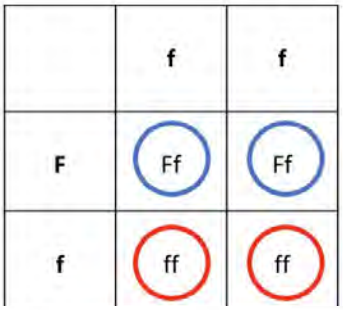
1 is correct - it is true that if **both parents are carriers**, therefore have a **heterozygous genotype (Ff)**, then the ratio of offspring that are carriers to offspring that are not carriers is **1:1.** This is shown below, the red circles show the offspring genotype that are carriers for cystic fibrosis and the blue circles show offspring genotypes that are not carriers for cystic fibrosis, showing the ratio of 1:1.



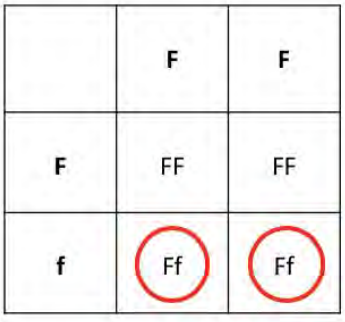
2 is incorrect - if one parent is **homozygous recessive (ff)** and if the other parent is **heterozygous (Ff)** then **50%** of the offspring will be carriers, as they would have a **heterozygous genotype (Ff)**, not 100% of the offspring produced. The other 50% of the offspring produced would have cystic fibrosis as they would have a homozygous recessive genotype (ff). The red circles in the punnett square below show the offspring that are carriers, which is 2/4.



3 is incorrect - if one parent is **heterozygous (Ff)** and the other **homozygous recessive (ff)** then the **ratio of offspring produced who are affected to those who are not is 1:1** not 3:1. The red circles in the punnett square show the offspring with a homozygous recessive genotype thus are affected by cystic fibrosis. The blue circles in the punnett square show the offspring that are not affected by cystic fibrosis.



4 is incorrect - if one parent is **heterozygous (Ff)** and the other parent is **homozygous dominant (FF)** then only **50%** of the offspring produced would be **carriers for cystic fibrosis.** The red circles in the punnett square below show that 2/4 are carriers.



5 is correct - it is true that individuals who have cystic fibrosis have **inherited one recessive allele from each parent (therefore both parents must be carriers Ff).**

For every gene we have one allele inherited from each parent. Individuals who are affected by cystic fibrosis have a **homozygous recessive genotype (ff)**, this is because **two copies of the recessive allele** need to be present **in order for the phenotype of a recessive trait to show.** Therefore the individuals affected by cystic fibrosis must have inherited one recessive allele from each parent.

Since **1** and **5** are the only correct statements, **G** must be the correct answer.

9 **The answer is C**

1 is correct - it is true that disease z is caused by a dominant allele. This is because both **individuals 4 and 5 both have disease z** however their **offspring individual 6 and 7 do not have disease z.** This situation can only occur if disease z is caused by a dominant allele.

2 is incorrect - as it is established that disease z is caused by a dominant allele it is **not possible for any individual to be a carrier of disease z.** This is because in order for a trait caused by a dominant allele to be expressed as the phenotype **only one copy** of the allele is necessary in each cell. Therefore if an individual has the dominant allele for disease z in their genotype they will have disease z and **cannot be a carrier.**

3 is incorrect - as disease z is caused by a dominant allele therefore any individual affected needs to **have only one dominant allele in each cell in order for the phenotype to be expressed.** Individual 1 is affected by disease z therefore their genotype can be **heterozygous** (one dominant disease causing allele and one recessive allele) or it can be **homozygous dominant.** It is incorrect that individual 1's genotype must be homozygous dominant.

4 is correct - it is true that individual 6 and 7's genotype must be **homozygous recessive.** This is because disease z is caused by a dominant allele and so even if **one copy of the dominant allele** is present in an individual's genotype they will have **disease z.** As individual 6 and 7 do not have disease z therefore their genotype must be homozygous recessive.

5 is correct - it is true that individual 4 must have a **dominant allele** in their genotype as disease z is caused by a dominant allele, therefore **one copy** of the dominant must be present in the genotype in order for disease z to be expressed.

Since **1, 4** and **5** are the only correct statements, **C** must be the correct answer.

10 **The answer is C**

1 is correct - it is true that **one allele is inherited from each parent,** and therefore a genotype of an individual for a particular gene is made up of **two alleles**, one from the mother and one from the father.

2 is incorrect - if a disease is caused by a **dominant allele** then **only one copy of the allele** has to be present in the genotype in order for the individual to have the disease. If only one parent has the disease this does not mean that 100% of the offspring will have the disease. The affected parent can have **heterozygous genotype** (one dominant and one recessive allele) or a **homozygous dominant genotype.** The other parent who is not affected will have a **homozygous recessive genotype** as they do not have disease z. If the affected parent's genotype is **homozygous dominant** then **100%** of the offspring will be affected. If the parent with the disease has a **heterozygous genotype** then only **50%** of the offspring will have the disease. This is shown by the punnett square below, the dominant allele causing the disease is P and the recessive allele is p. The red circles show the offspring that will be affected by the disease.

	P	p
p	Pp	pp
p	Pp	pp

3 is incorrect - this is because scientists have discovered that there are in fact a **large number of characteristics** that are inherited that are **controlled by multiple genes.**

4 is correct - it is true that if a disease is caused by a recessive allele, and one parent is **homozygous recessive** and the other parent is **heterozygous**, then there is a **50% chance** that the offspring produced will have the disease. Below the punnett square shows a cross between a parent with a homozygous recessive genotype and a parent with a heterozygous genotype. The recessive allele causing the disease is f and the normal dominant allele is F. The red circles show the offspring with the disease.

	f	f
F	Ff	Ff
f	ff	ff

5 is correct - it is true that **height** is a characteristic that is **controlled by more than one gene.** There are many different heights that a person can potentially grow to, and each height is not caused by a different gene. Therefore the height of an individual must be controlled by many genes.

Since **1, 4** and **5** are the only correct statements, **C** must be the correct answer.