



Rabbit Fur Colour

A Level

c c c

In rabbits, there are two alleles concerned with dark pigment in the fur:

- the dominant allele, B, for black colour
- the recessive allele, b, for brown colour

Two male black rabbits of unknown genotype each mated with a different female brown rabbit.

Part A Two heterozygous males

What is the expected proportion of brown offspring if **both** male rabbits are heterozygous?

Part B One heterozygous male

What is the expected proportion of brown offspring if only **one** male rabbit is heterozygous?

Adapted with permission from NSAA 2020 Section 1 Q79



Eyesight Problems

A gene found on the X chromosome in humans has two alleles: dominant and recessive. Individuals who only have recessive alleles have a condition that affects their eyesight. The inheritance of the condition is shown in **Figure 1**.

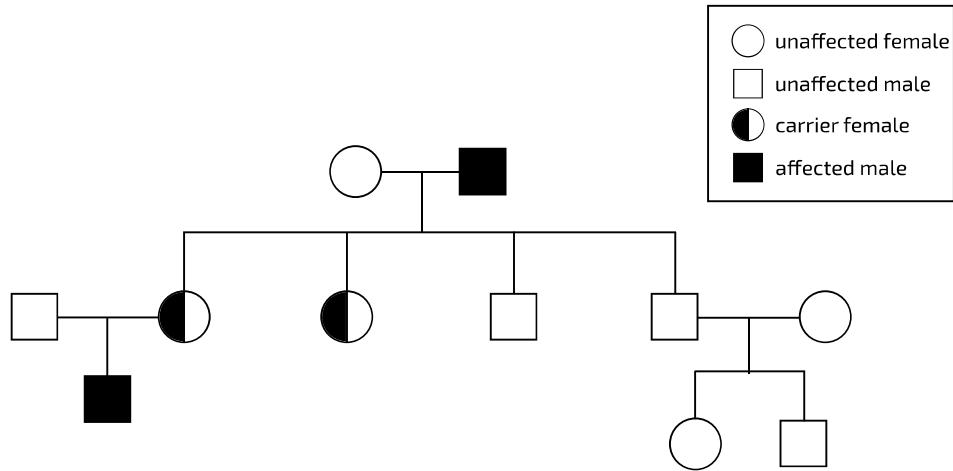


Figure 1: A family tree showing X-linked recessive inheritance. "Unaffected" individuals do not have the condition, "affected" individuals do have the condition, and "carrier" individuals do not have the condition but do carry the recessive allele. The key is shown in the top-right.

Part A Recessive & dominant alleles

If one living skin cell from each member of this family were analysed, how many recessive alleles (for this gene) would be found?

If one living skin cell from each member of this family were analysed, how many dominant alleles (for this gene) would be found?

Part B An affected female and an unaffected male

If an affected female mates with an unaffected male to produce a son, what is the probability that this individual has the condition?

If an affected female mates with an unaffected male to produce a daughter, what is the probability that this individual has the condition?

Part C X-linked recessive inheritance

Which of the following statements are true of X-linked recessive inheritance? Select all that apply.

- Females cannot have the condition but they can be carriers.
 - Females are more likely to have the condition than males.
 - All male offspring of an affected female will have the condition, regardless of the male parent's genotype.
 - All female offspring of an affected male will have the condition, regardless of the female parent's genotype.
 - Males cannot be carriers: they either have the condition or they do not.
 - Males are more likely to have the condition than females.
-

Adapted with permission from NSAA 2019 Section 1 Q68

Gameboard:

[**STEM SMART Biology Week 25 - Inheritance**](#)



Dominant and Recessive Conditions

A Level

c c c

Part A A dominant condition

Figure 1 shows the family tree of a family affected by a dominant genetic condition. All people who carry the mutation show symptoms of the condition.

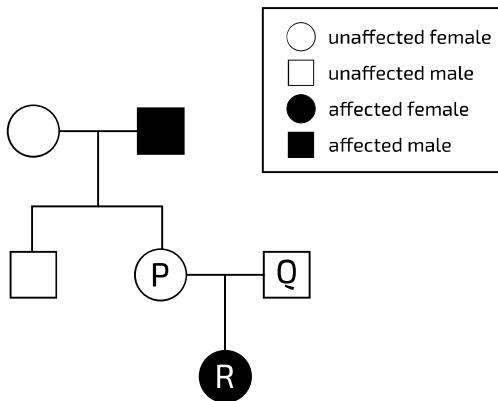


Figure 1: A family tree showing the inheritance of a dominant genetic condition.

Which of the following statements could explain the presence of the dominant condition in female R?

- The mutation occurs in P.
- The mutation occurs in R.
- The mutation occurs in Q's father.

Part B Cystic fibrosis and sickle cell anaemia

Cystic fibrosis and sickle cell anaemia are both recessive genetic conditions and the genes for these conditions are found on different Autosomes.

The following statements are true for one set of parents who only have one child:

- Both parents are heterozygous for cystic fibrosis
- One parent is homozygous recessive for sickle cell anaemia
- One parent is heterozygous for sickle cell anaemia

What is the probability of this child having both conditions?

Part C Pedigree probability

Figure 2 shows the inheritance of a phenotypic feature caused by a recessive allele. "A" represents an individual of unknown genotype.

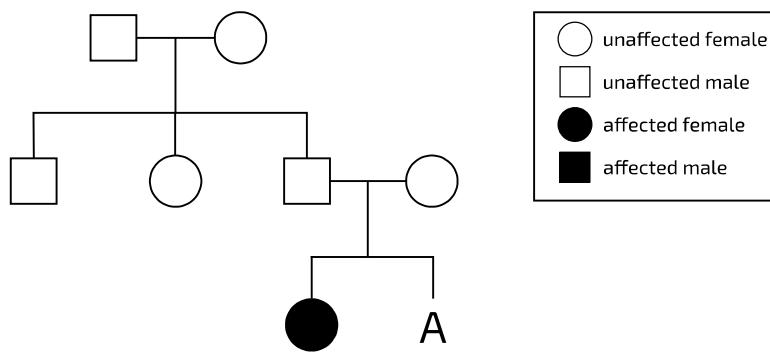


Figure 2: A family tree showing the inheritance of a recessive genetic condition.

What is the probability that individual A is an unaffected male?

Assume that no mutations occurred to this gene in this family tree.

Adapted with permission from NSAA 2018 Section 1 Q65, NSAA 2021 Section 2 Q41 & NSAA 2021 Section 1 Q74

Gameboard:

[STEM SMART Biology Week 25 - Inheritance](#)



Three Family Trees

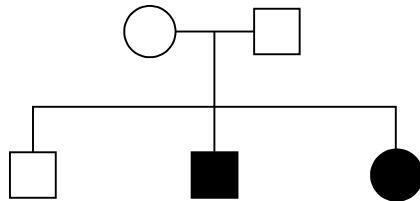
A Level

c c c

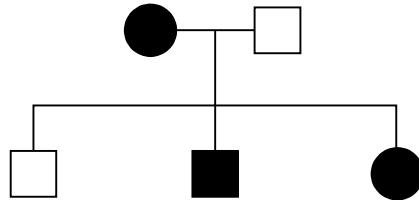
The three family trees below show the inheritance of three different genetic conditions, each controlled by one gene with one dominant and one recessive allele.

Circles represent females and squares represent males.

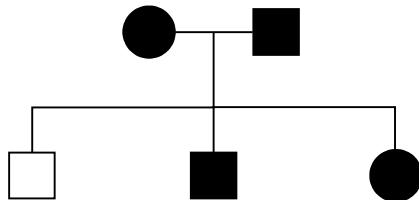
Black circles/squares represent affected individuals and white circles/squares represent unaffected individuals.



Family A



Family B



Family C

In the questions below, assume that no new mutations occur and that the genes are not found on the X chromosome.

Part A Heterozygous fathers

In which of the family trees **must** the male parent be heterozygous? Select all that apply.

- Family A
 - Family B
 - Family C
-

Part B Dominant conditions

In which of the family trees **must** the condition be a dominant genetic condition? Select all that apply.

- Family A
 - Family B
 - Family C
-

Part C Recessive conditions

In which of the family trees **must** the condition be a recessive genetic condition? Select all that apply.

- Family A
 - Family B
 - Family C
-

Adapted with permission from NSAA 2020 Section 1 Q80

Gameboard:

STEM SMART Biology Week 25 - Inheritance



An Allele Family Tree

A Level

c c c

Figure 1 shows the inheritance of a characteristic controlled by a single gene.

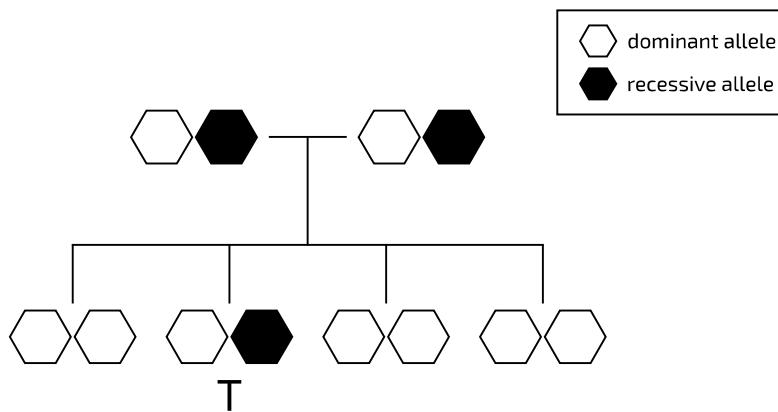


Figure 1: A family tree showing the inheritance of a characteristic controlled by a single gene. The genotype of each individual is shown by coloured hexagons (see key at top-right).

Individual T goes on to have a single offspring with an unrelated individual who has a recessive phenotype. The offspring has a dominant phenotype.

What is the ratio of dominant to recessive alleles for all of the individuals in this family (including T's mate and offspring)?

Enter your answer as a ratio in its simplest form (e.g. 2:1 **not** 4:2).

Adapted with permission from NSAA 2020 Section 2 Q41

Gameboard:

[STEM SMART Biology Week 25 - Inheritance](#)



Blood Types

A Level

c c c

Part A The ABO gene

The ABO gene codes for an enzyme involved in modifying cell-surface glycoproteins. Once modified, these glycoproteins act as antigens (cell-surface molecules that the immune system can recognise as self or non-self). There are multiple alleles for this gene, and these can be split into three main types: I^A , I^B , and i (alternatively named I^0). The I^A allele produces type A antigens and the I^B allele produces type B antigens. The i allele produces a non-functional enzyme, and therefore does not produce type A or type B antigens.

The table below shows how these alleles relate to blood type.

Blood Type	Antigens produced	Genotype
AB	type A and type B	$I^A I^B$
A	type A only	$I^A I^A$ or $I^A i$
B	type B only	$I^B I^B$ or $I^B i$
O	neither	ii

Fill in the blanks below.

- Allele I^A is allele I^B and allele i .
- Allele I^B is allele I^A and allele i .
- Allele i is allele I^A and allele I^B .

Items:

dominant to recessive to codominant with

Part B The Rh genes

The Rh genes are a group of genes that encode red blood cell membrane transporters. One of these genes, the RhD gene, encodes a membrane transporter that can act as [] (a cell-surface molecule that the immune system can recognise as self or non-self). There are two main types of alleles for this gene: RhD positive (+) and RhD negative (-). The RhD positive allele produces the RhD antigen, while the RhD negative allele does not. Individuals with one positive allele and one negative allele produce RhD antigens. Therefore, the RhD positive allele is [] and the RhD negative allele is [].

An individual's blood type is based on their ABO alleles and their Rh alleles. For example, an individual with one **I^A** allele, one **i** allele, one RhD positive allele, and one RhD negative allele, would have the blood type [].

Items:

A+ an antigen **A-** **O-** dominant codominant an antibody recessive **O+**

Part C Blood types and blood transfusion

Individuals will produce antibodies against antigens that their own cells []. If, during a blood transfusion, an individual receives blood cells of an incompatible type, an immune response will be triggered against these blood cells. Antibodies binding to blood cells can cause the blood cells to clump together, which can cause blood vessel blockage and rupture.

O- individuals [] antibodies against A antigens, B antigens, and RhD antigens. Therefore, they can receive [] during a blood transfusion. Their blood cells can be given to any other blood type, because they lack antigens. Because of this, O- individuals are called "universal donors".

AB+ individuals [] antibodies against A antigens, B antigens, and RhD antigens. Therefore, they can receive [] during a blood transfusion. Because of this, AB+ individuals are called "universal recipients".

Items:

produce do not produce only O- blood cells blood cells of any type only AB+ blood cells

Part D Offspring blood type(s)

In one family, the following blood types are present:

- Mother: A+
- Father: O-

Which of the following blood types could their children have? Select all that apply.

Assume no mutations occur.

AB+

AB-

A+

A-

B+

B-

O+

O-

Part E Maternal blood type(s)

In another family, the following blood types are present:

- Father: AB-
- Child 1: A-
- Child 2: B-

Which of the following blood types could the mother have? Select all that apply.

Assume no mutations occur.

AB+

AB-

A+

A-

B+

B-

O+

O-

Part F Paternal blood type(s)

In another family, the following blood types are present:

- Mother: O-
- Child 1: B-
- Child 2: A+

Which of the following blood types could the father have? Select all that apply.

Assume no mutations occur.

AB+

AB-

A+

A-

B+

B-

O+

O-

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