

Monohybrid inheritance

Revision notes · Genetic terms, genetic diagrams and pedigrees, the test cross, codominance and ABO blood groups, and sex linkage.

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). **Supplement** is Extended content, only examined on Papers 2 and 4.

Monohybrid inheritance Spec 17.4

Key genetic terms Spec 17.4.1, 17.4.2, 17.4.3, 17.4.4, 17.4.5, 17.4.6, 17.4.7, 17.4.8, 17.4.9

Inheritance is the transmission of genetic information from generation to generation. Parents pass genes to their offspring in their gametes, so offspring have features like their parents.

Inheritance	The transmission of genetic information from generation to generation.
Genotype	The genetic make-up of an organism and in terms of the alleles present.
Phenotype	The observable features of an organism.
Homozygous	Having two identical alleles of a particular gene. Example: TT or tt.
Heterozygous	Having two different alleles of a particular gene. Example: Tt.
Dominant allele	An allele that is expressed if it is present in the genotype.
Recessive allele	An allele that is only expressed when there is no dominant allele of the gene present in the genotype.

Dominant alleles are written as capital letters (T) and recessive alleles as lower case letters (t). A heterozygous individual (Tt) shows the dominant feature, because the dominant allele is expressed.

Pure-breeding

Two identical **homozygous** individuals that breed together will be **pure-breeding**. For example, $TT \times TT$ can only give TT offspring, and $tt \times tt$ can only give tt offspring, so every generation looks the same.

A **heterozygous** individual will **not** be pure-breeding. A Tt parent makes two types of gamete (T and t), so its offspring can have different genotypes and different phenotypes.

Exam tip: Genotype is the alleles, such as Tt. Phenotype is what you can see, such as tall. Do not swap them, and do not say a recessive allele is 'weaker'.

Common mistake: Heterozygous and homozygous describe genotypes only. Do not use them for phenotypes.

Genetic diagrams, Punnett squares and pedigrees Spec 17.4.10, 17.4.11, 17.4.12

A **monohybrid cross** looks at the inheritance of one characteristic controlled by a single gene. You show the result using a genetic diagram or a **Punnett square**, which lists the possible gametes and the genotypes they can make.

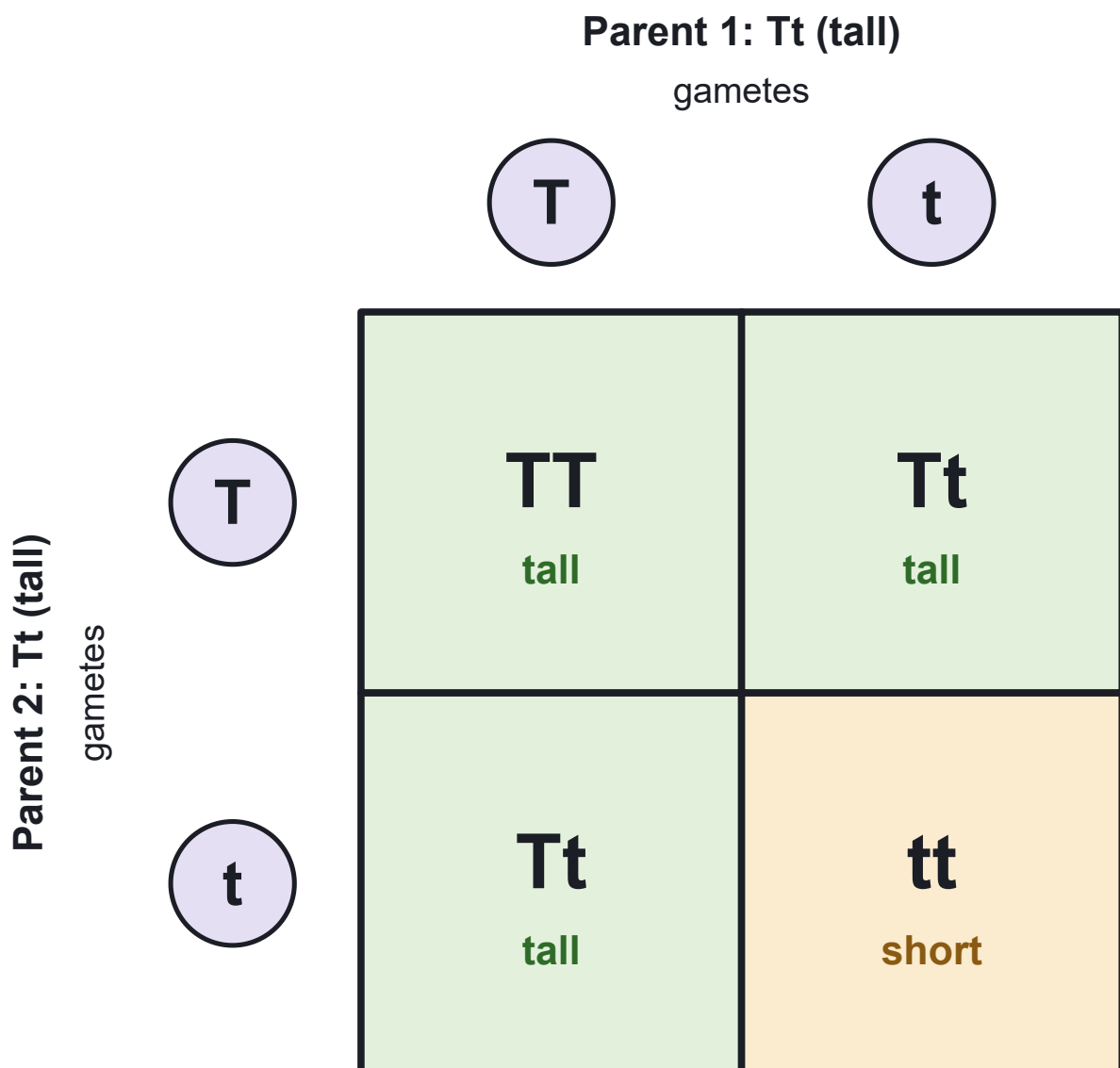
1. Choose letters for the alleles: a capital letter for the dominant allele and the same letter in lower case for the recessive allele.
2. Write the genotypes of the parents.
3. Write the gametes each parent can make. Each gamete has only one allele.
4. Put the gametes along the top and side of a Punnett square and fill in the boxes to show the possible offspring genotypes.
5. Write the phenotype for each genotype and work out the ratio.

Two heterozygous parents (3 : 1)

Tall (T) is dominant to short (t) in pea plants. Two heterozygous tall plants are crossed. Show the possible offspring and the phenotypic ratio.

1. Parents: Tt × Tt.
2. Gametes: T or t from each parent.
3. Punnett square boxes: TT, Tt, Tt, tt.
4. TT and Tt are tall. tt is short.

Answer: Genotypes 1 TT : 2 Tt : 1 tt. Phenotypes 3 tall : 1 short.



Tt × Tt gives 3 tall : 1 short (1 TT : 2 Tt : 1 tt).

Heterozygous × homozygous recessive (1 : 1)

Black fur (B) is dominant to brown fur (b) in guinea pigs. A heterozygous black guinea pig is crossed with a brown one. Show the possible offspring and the phenotypic ratio.

1. Parents: Bb × bb.
2. Gametes: B or b from the first parent; only b from the second.
3. Punnett square boxes: Bb, Bb, bb, bb.
4. Bb is black. bb is brown.

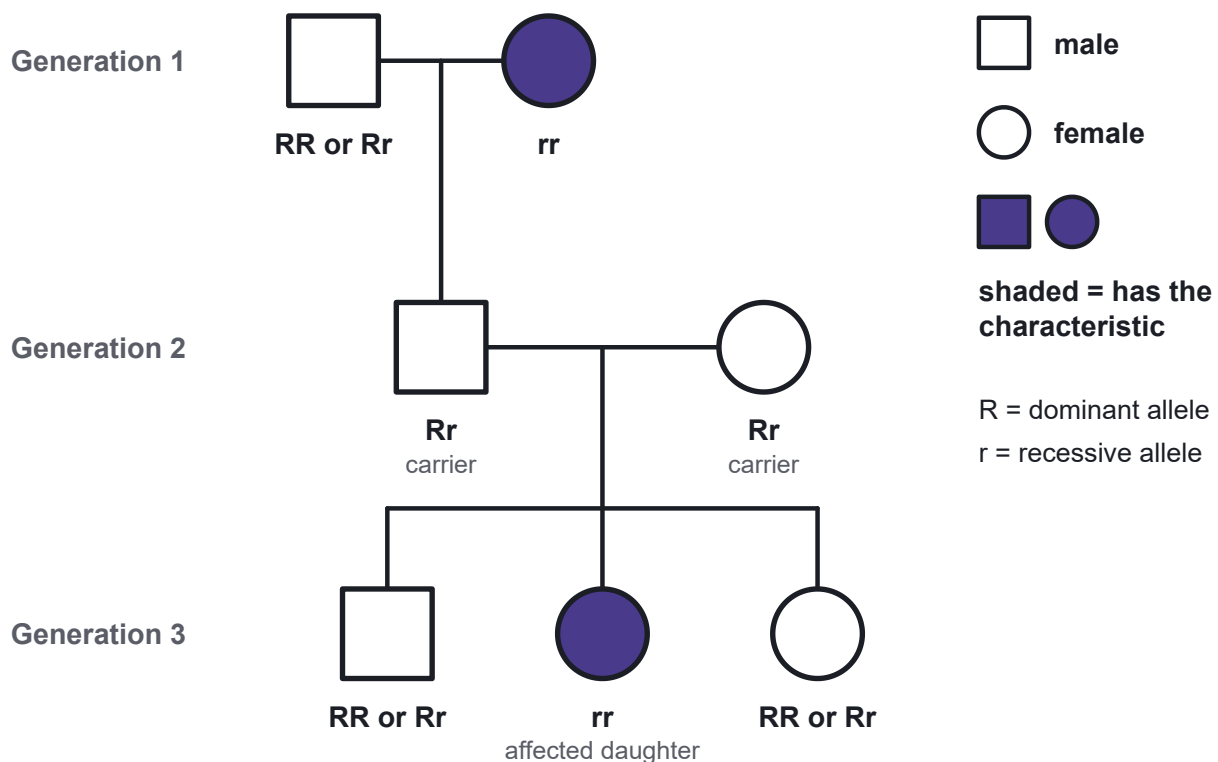
Answer: Genotypes 1 Bb : 1 bb. Phenotypes 1 black : 1 brown.

Exam tip: The ratios you need are 3 : 1 and 1 : 1. Circle the gametes, show every Punnett box, and write the phenotype beside each genotype.

Pedigree diagrams

A **pedigree diagram** (family tree) shows how a characteristic is inherited through a family. Squares are usually males and circles are females. Shaded shapes show people with the characteristic. A horizontal line joins parents and a vertical line leads to their children.

- Two parents **without** a characteristic who have a child **with** it: the characteristic is **recessive**, and both parents are heterozygous (carriers).
- Two parents **with** a characteristic who have a child **without** it: the characteristic is **dominant**, and both parents are heterozygous.



Two unaffected parents with an affected daughter: the characteristic is recessive and both parents are carriers (Rr).

Exam tip: In a pedigree question, find two parents with the same phenotype who have a child with the other phenotype. That tells you which allele is dominant.

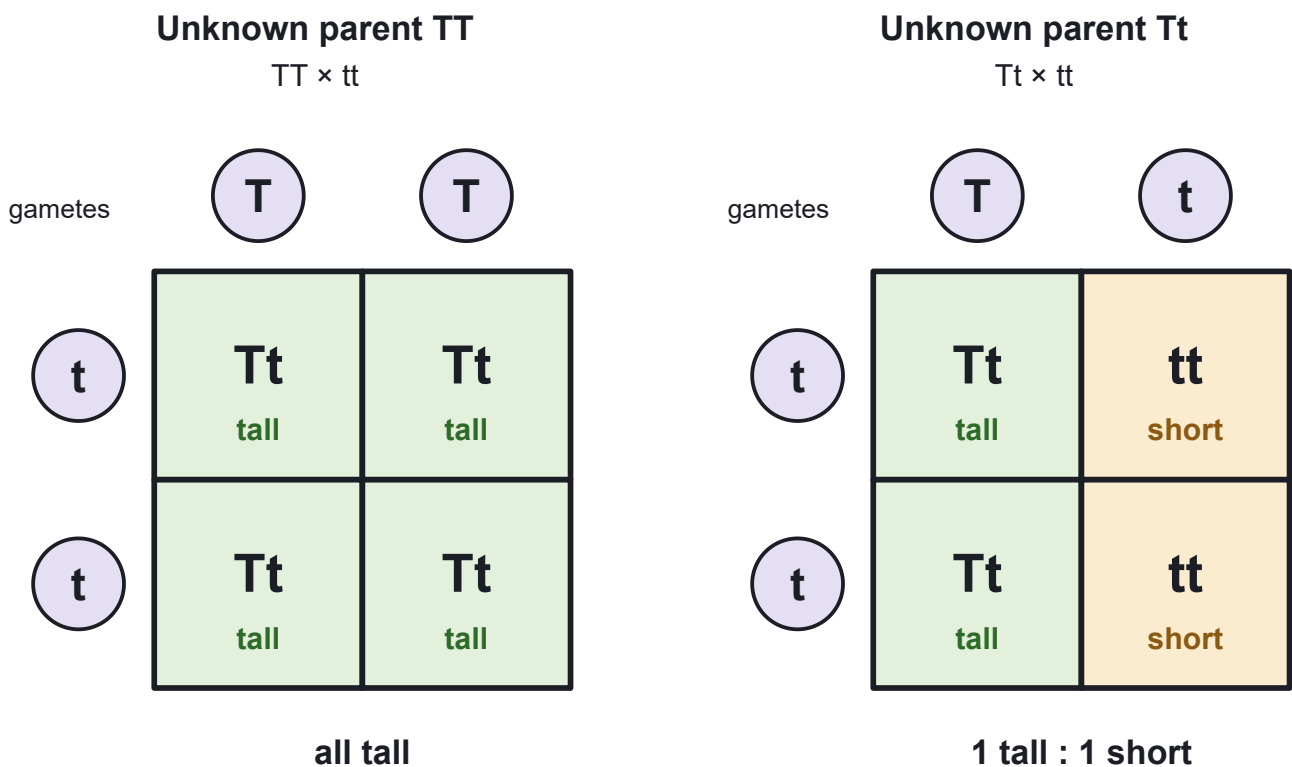
The test cross Spec 17.4.13 Supplement

An organism with the dominant phenotype can be homozygous dominant (TT) or heterozygous (Tt). You cannot tell which by looking at it. A **test cross** finds out the unknown genotype.

1. Cross the organism of unknown genotype with a **homozygous recessive** individual (tt).
2. Collect the offspring and record their phenotypes. A large number of offspring gives a more reliable result.
3. Compare the offspring with the expected results.

Results of a test cross (tall is dominant to short)		
Unknown parent	Cross	Offspring
Homozygous dominant (TT)	TT × tt	All Tt: all tall
Heterozygous (Tt)	Tt × tt	1 Tt : 1 tt: about 1 tall : 1 short

If any offspring show the recessive phenotype, the unknown parent must have been heterozygous, because each parent gave the offspring one recessive allele. If all the offspring show the dominant phenotype, the unknown parent is probably homozygous dominant.



A test cross with a homozygous recessive (tt) plant: any short offspring show that the unknown parent is **heterozygous**.

Exam tip: The tester is always homozygous recessive, because its phenotype tells you its genotype. Say that the offspring show whether the unknown parent has a recessive allele.

Codominance and ABO blood groups Spec 17.4.14, 17.4.15 Supplement

In **codominance**, both alleles in heterozygous organisms contribute to the phenotype. Neither allele is hidden and the two do not blend.

The ABO blood group is controlled by one gene with three alleles: I^A, I^B and I^o. Exam papers print the A, B and o as small raised letters after the I. A person inherits two alleles, one from each parent. **I^A and I^B are codominant**. I^o is recessive to both.

ABO blood groups

Phenotype (blood group)	Possible genotypes
A	$I^A I^A$ or $I^A I^o$
B	$I^B I^B$ or $I^B I^o$
AB	$I^A I^B$
O	$I^o I^o$

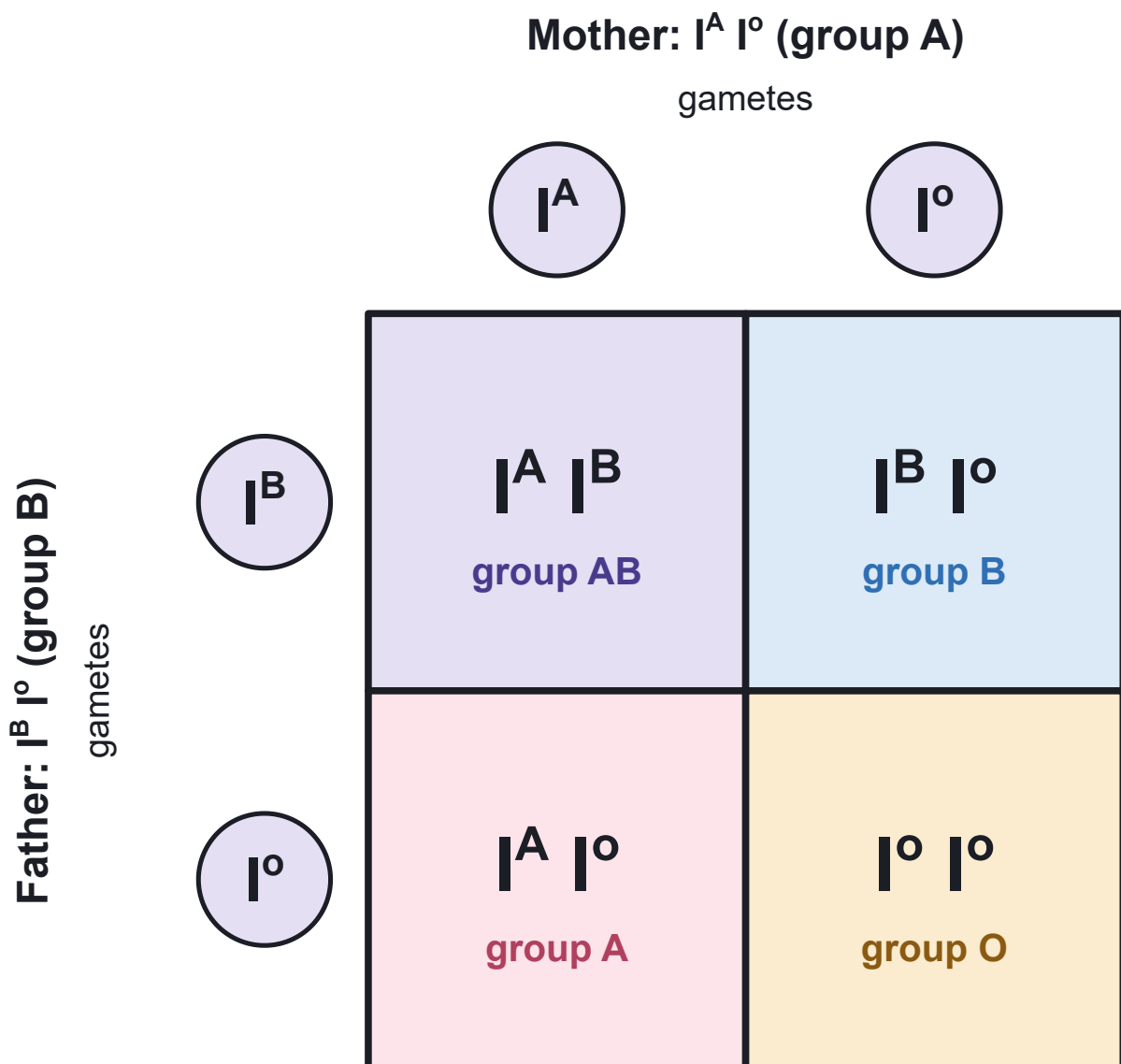
Group A mother and group B father

A mother is $I^A I^o$ and a father is $I^B I^o$. Which blood groups could their children have?

1. Mother's gametes: I^A or I^o . Father's gametes: I^B or I^o .
2. Punnett square boxes: $I^A I^B$, $I^A I^o$, $I^B I^o$, $I^o I^o$.

Answer: Group AB, A, B and O, each with probability 1 in 4 (25%), a ratio of 1 : 1 : 1 : 1.

Exam tip: $I^A I^B$ gives group AB because both alleles are expressed. Group O needs two I^o alleles.



$I^A I^o \times I^B I^o$ can give children of **all four blood groups**, each with a probability of 1 in 4.

Sex linkage and colour blindness Spec 17.4.16, 17.4.17, 17.4.18 Supplement

A **sex-linked characteristic** is a feature in which the gene responsible is located on a sex chromosome. This makes the characteristic more common in one sex than in the other.

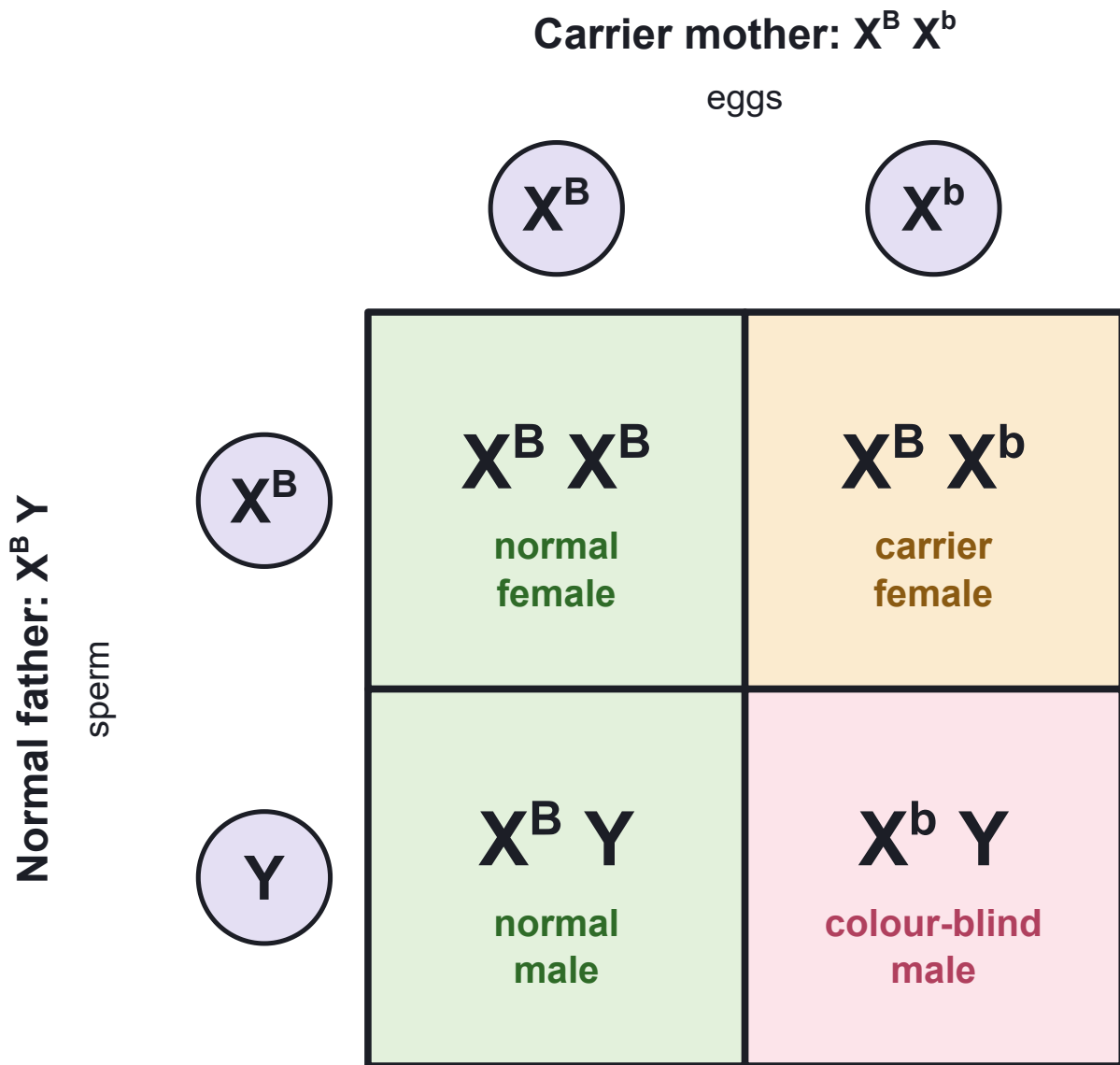
Red-green colour blindness is an example. The gene is on the X chromosome and the allele for colour blindness is recessive. The Y chromosome does not carry this gene.

- Males (XY) have only one X chromosome, so one recessive allele is enough to make them colour blind.
- Females (XX) need two recessive alleles to be colour blind. With one, they are **carriers** and have normal colour vision.
- So colour blindness is more common in males than in females.

Write the allele letter straight after the X: X^B is the normal allele and X^b is the colour blindness allele. Exam papers print the B or b as a small raised letter. The Y has no allele, so a male genotype is $X^B Y$ or $X^b Y$.

Carrier mother ($X^B X^b$) × normal father ($X^B Y$)		
	X^B (egg)	X^b (egg)
X^B (sperm)	$X^B X^B$ normal female	$X^B X^b$ carrier female
Y (sperm)	$X^B Y$ normal male	$X^b Y$ colour-blind male

The probability that a son is colour blind is 1 in 2 (50%). None of the daughters is colour blind, but half are carriers. Phenotypic ratio: 2 normal females : 1 normal male : 1 colour-blind male.



Half of the sons are expected to be **colour blind**; none of the daughters is, but half are carriers.

Exam tip: Always write sex-linked genotypes with X and Y and put the allele letter on the X. Write $X^b Y$, not bb , for a colour-blind male.

Quick check

1. Define phenotype.
2. What is a heterozygous genotype?
3. Two parents without a condition have a child with it. Is the allele dominant or recessive?
4. **Supplement** Which genotype is used as the tester in a test cross?
5. **Supplement** Why is red-green colour blindness more common in males?

Quick check answers

Monohybrid inheritance

1. The observable features of an organism.
2. Two different alleles of a particular gene, for example Tt.
3. Recessive, and both parents are heterozygous carriers.
4. Homozygous recessive.
5. Males have one X chromosome, so one recessive allele is enough. Females need two.