

Genetic inheritance

4.6.1.6 · Inheritance, variation and evolution · revision notes

The language of genetics and how to use Punnett squares and family trees to predict the outcome of a single-gene cross. It comes up on almost every paper: definitions, Punnett squares, and probability or ratio questions.

Key facts

- Allele = a different form of a gene
- Dominant: expressed with one copy. Recessive: expressed only with two copies
- Homozygous = two alleles the same (BB, bb).
Heterozygous = two different alleles (Bb)
- Genotype = alleles present.
Phenotype = characteristic expressed
- $Bb \times Bb \rightarrow 1 BB : 2 Bb : 1 bb \rightarrow 3 : 1$ dominant : recessive phenotype
- $Bb \times bb \rightarrow 1 Bb : 1 bb$
- $BB \times \text{anything} \rightarrow$ all offspring show the dominant phenotype
- One box out of four = probability
 $0.25 = 25\% = \frac{1}{4} = 1 \text{ in } 4$

Notes

Key words

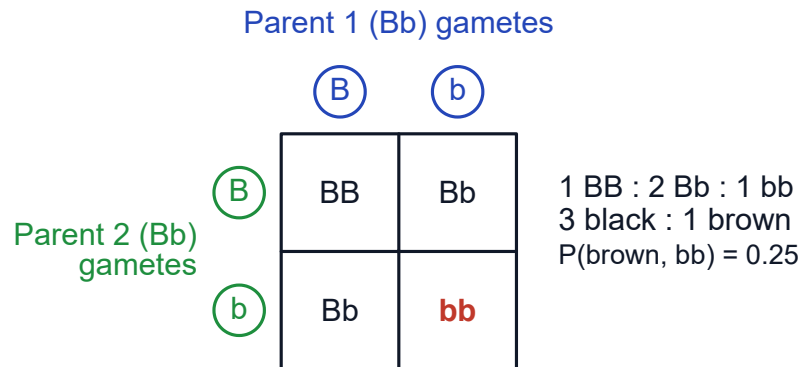
- **Gamete**: a sex cell (e.g. sperm or egg) with a single set of chromosomes.
- **Chromosome**: a structure in the nucleus that contains DNA. **Gene**: a small section of DNA on a chromosome.
- **Allele**: a different form of the same gene.
- **Dominant** allele: always expressed, even if only one copy is present (written as a capital letter, e.g. B).
- **Recessive** allele: only expressed if two copies are present, so there is no dominant allele (lower case, e.g. b).
- **Homozygous**: the two alleles are the same (BB or bb). **Heterozygous**: the two alleles are different (Bb).
- **Genotype**: the alleles present (e.g. Bb). **Phenotype**: the characteristic that is expressed (e.g. black fur).

Single genes and many genes

- Some characteristics are controlled by a **single gene**, e.g. fur colour in mice and red-green colour blindness in humans.
- The alleles present (genotype) work at a molecular level to develop the characteristics that are expressed (phenotype).
- **Most characteristics** are the result of **multiple genes** interacting, not a single gene.

Punnett squares

- Split each parent's genotype into its gametes: Bb makes B gametes and b gametes.
- Put one parent's gametes across the top and the other's down the side, then fill each box with one allele from each parent.
- Each box is an equally likely outcome, so each of the four boxes has a probability of 0.25.
- $Bb \times Bb$ gives $BB : Bb : bb$ in the ratio 1 : 2 : 1, so the dominant : recessive phenotype ratio is 3 : 1.

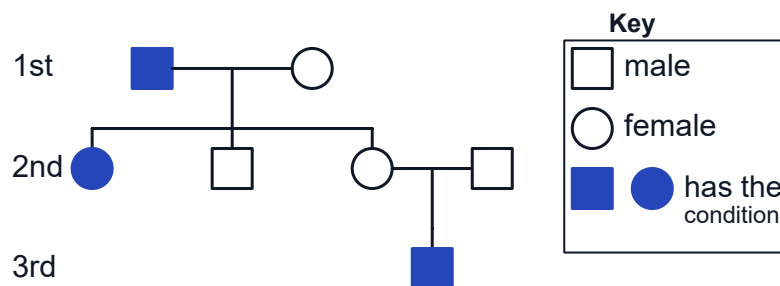


$Bb \times Bb$: each box has a probability of 0.25.

- $Bb \times bb$ gives $Bb : bb$ in the ratio 1 : 1.

Family trees

- Squares usually show males and circles females; shaded symbols show the characteristic. Always read the key.



Reading a family tree: a line between two people joins parents; the line below leads to their children.

How to answer each type of question

Use the genetic terms

1 to 3 marks

Grade 4

1. Learn precise definitions, especially dominant, recessive, homozygous and heterozygous.
2. If asked for a genotype, give letters; if asked for a phenotype, describe the characteristic in words.

Example. In mice, the allele for black fur (B) is dominant to the allele for brown fur (b).

- (a) Give the genotype of a mouse that is homozygous recessive.
- (b) Give the phenotype of a mouse with the genotype Bb.
- (c) What does heterozygous mean? [3 marks]

Model answer. (a) bb (1)

(b) Black fur (1)

(c) Having two different alleles of a gene (1)

Don't lose marks

- ✗ Turning a 3 : 1 ratio into a probability of $\frac{1}{3}$. The recessive phenotype is 1 out of 4 (0.25).
- ✗ Writing a ratio (like 1 : 4 or 1 : 3) when asked for a probability.
- ✗ Choosing letters that look alike in upper and lower case (such as S and s) and not making them clearly different.
- ✗ Saying a dominant allele is 'stronger' or 'more common'. It is simply expressed when only one copy is present.
- ✗ Thinking that if a couple's first child has a recessive condition, the next child cannot. The probability is the same for every child.

More tips

Memory tricks

- Homo = same: homozygous means the same alleles. Hetero = different.
- GenoType = the leTters; PHenotype = the PHysical characteristic.
- Learn the two key crosses: Bb × Bb gives 3 : 1, and Bb × bb gives 1 : 1.
- Check your Punnett square: every box has exactly two letters, one from each parent.

Exam technique

- Show the gametes and the Punnett square even when the question doesn't insist; they often carry marks.
- Give a probability in the form asked. 0.25, 25%, $\frac{1}{4}$ and '1 in 4' are usually all accepted, but a ratio such as 1 : 3 is not.
- Use the letters given in the question. If you choose your own, give a key.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

Define dominant and recessive alleles

A dominant allele is expressed even with one copy; a recessive allele is expressed only with two copies.

Grade 4

Use genotype, phenotype, homozygous and heterozygous correctly

Genotype is the alleles present, phenotype is the characteristic; homozygous means the same alleles, heterozygous different.

Grade 5

Complete a Punnett square

Put each parent's gametes on the outside and combine one allele from each in every box.

Grade 5

Give cross outcomes as ratios or probabilities

For example 3 : 1, or a probability of 0.25, 25%, $\frac{1}{4}$ or 1 in 4.

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