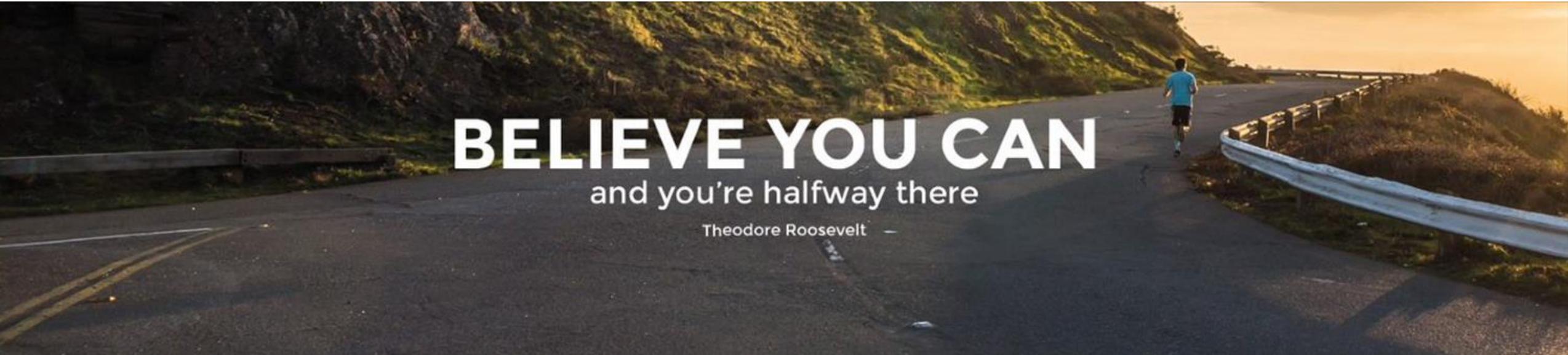


EB Education Revision Guide



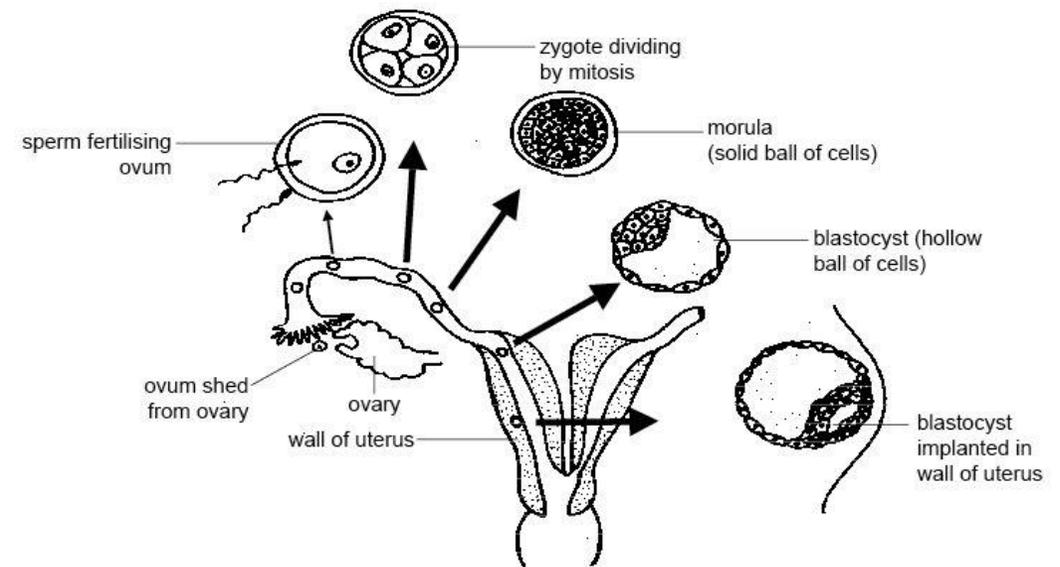
How to work with Genetics: Part 1

Genes and Alleles

Gametes are produced in sexual reproduction. In animals these gametes are sperm and egg cells. They are produced by meiosis. Each gamete produced is a **haploid** cell. This means they have half the number of chromosomes as a normal body cell. Cells with the full number of chromosomes are known as **diploid** cells.

When humans reproduce, fertilisation needs to happen. The nucleus of two gametes (a sperm and an egg) will combine to form a diploid zygote.

More information on this can be found in the guide [“How to work with Reproduction and Cell Division”](#).



Inheritance

Human body cells have 23 pairs of **chromosomes** in the nucleus.

23 of these come from the egg and 23 from the sperm.

Each pair of chromosomes contain the same genes in the same places. The genes come in different versions, so what characteristics you have, depends on which version you inherit from each parent.

One of the pairs of chromosomes controls the inheritance of biological sex - whether offspring are male or female:

- males have two different sex chromosomes, X and Y
- females have two X chromosomes, XX

Genes and Alleles

What is an allele?

Different genes control different characteristics.

Although some characteristics are controlled by a single gene, it is usually much more complicated. Most characteristics are controlled by several genes interacting with each other.

All genes exist in different versions called **alleles**. Alleles are represented in genetic diagrams using letters.

In your body you have two alleles of every gene, one on each chromosome in a pair (one allele from your father and one from your mother).

- An organism with two identical copies of an allele is **homozygous** for that particular gene (e.g. BB or bb)
- An organism with two different alleles for a particular gene is **heterozygous** for that gene (e.g. Bb)

Some alleles are **dominant**. These are represented using a capital letter (e.g. B).

The dominant allele is always expressed, even if only one copy of this allele is present. The dominant characteristic will be seen whether the organism has one or two dominant alleles (e.g. BB or Bb).

Some alleles are **recessive**. These are represented using small letters (e.g. b).

A recessive allele is only expressed if the individual has two copies and does not have the dominant allele of that gene (e.g. bb).

The **genotype** is the combination of alleles in an organism.

The **phenotype** is the characteristics expressed, for example blue eyes, which are determined by the genotype.

Genetic Diagrams

What is monohybrid inheritance?

The inheritance of a single characteristic is called **monohybrid inheritance**.

Genetic crosses of single gene combinations (monohybrid inheritance) can be shown and examined using Punnett squares.

This shows the possible offspring combinations that could be produced, and enables you to calculate the probability of these combinations.

In the Punnett square on the right, you can see that when you cross homozygous dominant with homozygous recessive genotypes, all the offspring will be heterozygous.

All the offspring have the genotype Tt and are tall.

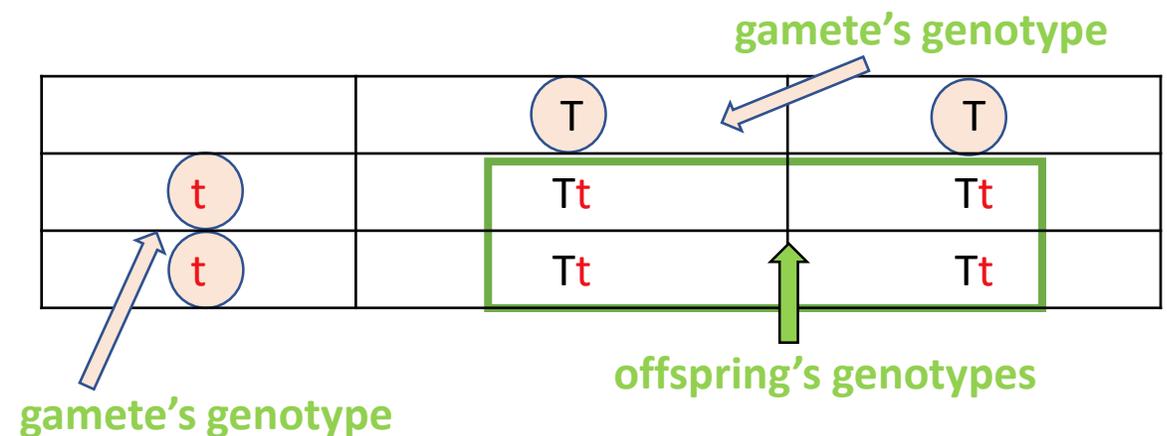
Example 1

The height of pea plants is controlled by a single gene.

The tall allele, T, is dominant.

The dwarf allele, t, is recessive.

Breed a tall homozygous dominant TT with a dwarf homozygous recessive (tt):



Genetic Diagrams

Example 2

The allele for tongue rolling is dominant (T).
Breed a heterozygous mother with a heterozygous father.

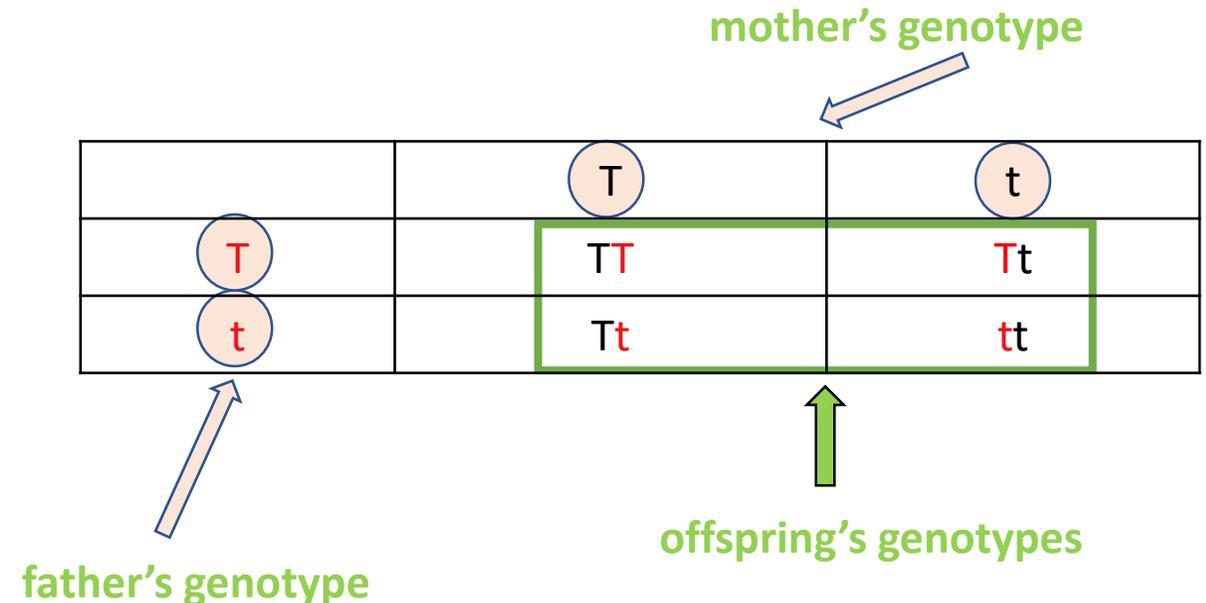
The probability of being:

Homozygous dominant (TT) is 25%

Heterozygous (Tt) is 50%

Homozygous recessive (tt) is 25%

75% (3:1 ratio) of the offspring will be able to tongue roll.



TOP TIP:

The capital letter (dominant allele) is always put first

Genetic Diagrams

Example 3: Determining Sex

As previously explained, females have two X chromosomes (XX), and males have an X and a Y chromosome (XY).

All eggs have one X chromosome.

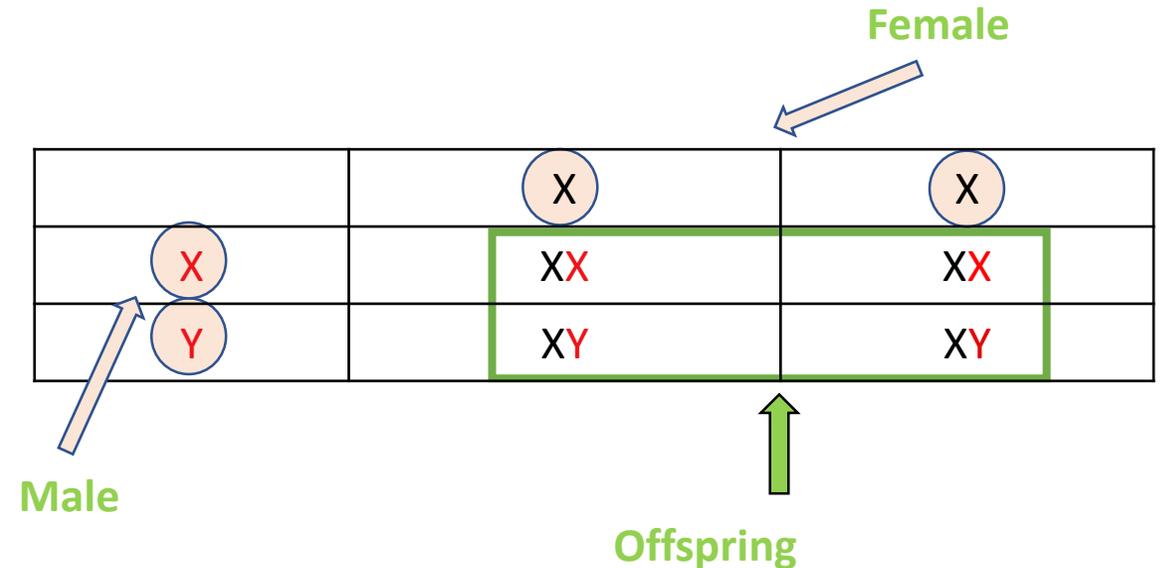
Sperm can have either an X or a Y chromosome.

A genetic diagram can be used to show how sex is determined in humans, in the same way as can be used to show how alleles are inherited, even though it is X and Y chromosomes which determine sex, not alleles.

The probability of being:

Female (XX) is 50%

Male (XY) is 50%





Your turn:

- Whether your earlobes are attached or detached depends on the alleles you inherit from your parents.

detached



attached



To have attached earlobes you must inherit a recessive allele from each parent, resulting in the genotype **ee**.

- What is the genetic term used to describe a person with the genotype **ee**?
.....

- Complete the Punnett square below to show the possible gametes and genotypes of offspring resulting from a male with genotype **ee**, and a female with genotype **Ee**.

	Female gametes	
Male gametes		

- What is the probability of the offspring having detached earlobes?
.....
- Calculate the % probability of a homozygous dominant father and a homozygous recessive mother having a child with attached earlobes?
.....



Your turn:

2. Eye colour is determined by alleles inherited from your parents. A mother has the genotype **Bb**, and has brown eyes. The father has the genotype **bb**, and has blue eyes.

a) Complete the Punnett square below, showing the parent's gametes and the genotypes of the offspring.

	Female gametes	
Male gametes		

b) What is the probability that the parents will have a child with blue eyes?
.....

c) State the genetic term to describe the genotype **BB**
.....

3. Warfarin can be used as a rat poison, but many rat populations have now developed a resistance to it. The allele for Warfarin resistance is recessive.

Complete the Punnett square below, showing how two rats, both of which are heterozygous for Warfarin resistance can produce offspring which are Warfarin resistant.

R = dominant r = recessive

	Female gametes	
Male gametes		

Your turn:

4. The phenotype of an organism is determined by its DNA.

The mutation of a single allele in tigers, can result in white tigers, rather than the usual orange and black fur. This mutation is recessive.

Makari is a male white tiger, and he was bred with Zima. They had three cubs, two of which had white fur, and one had orange and black fur.

a) What is Zima's genotype?

.....



b) The offspring with orange and black fur was then bred with a heterozygous tiger.

Complete the Punnett square below.

H = dominant h = recessive

	Female gametes	
Male gametes		

c) State the percentage possibility of the offspring having normal orange and black fur pigmentation.

.....

d) Explain how two parents with orange and black fur can produce offspring with white and black fur.

.....



1. Whether your earlobes are attached or detached depends on the alleles you inherit from your parents.

detached



attached



To have attached earlobes you must inherit a recessive allele from each parent, resulting in the genotype **ee**.

a) What is the genetic term used to describe a person with the genotype **ee**?
Homozygous recessive

Answers:

b) Complete the Punnett square below to show the possible gametes and genotypes of offspring resulting from a male with genotype **ee**, and a female with genotype **Ee**.

		Female gametes	
		E	e
Male gametes	e	Ee	ee
	e	Ee	ee

i) What is the probability of the offspring having detached earlobes?

50%

.....

ii) Calculate the % probability of a homozygous dominant father and a homozygous recessive mother having a child with attached earlobes?

0%



Answers:

2. Eye colour is determined by alleles inherited from your parents. A mother has the genotype **Bb**, and has brown eyes. The father has the genotype **bb**, and has blue eyes.

a) Complete the Punnett square below, showing the parent's gametes and the genotypes of the offspring.

		Female gametes	
		B	b
Male gametes	b	Bb	bb
	b	Bb	bb

b) What is the probability that the parents will have a child with blue eyes?

50%

c) State the genetic term to describe the genotype **BB**

Homozygous dominant

2. Warfarin can be used as a rat poison, but many rat populations have now developed a resistance to it. The allele for Warfarin resistance is recessive.

a) Complete the Punnett square below, showing how two rats, both of which are heterozygous for Warfarin resistance can produce offspring which are Warfarin resistant.

R = dominant r = recessive

		Female gametes	
		R	r
Male gametes	R	RR	Rr
	r	Rr	rr

This is homozygous recessive – so resistant to Warfarin

Answers:

4. The phenotype of an organism is determined by its DNA.

The mutation of a single allele in tigers, can result in white tigers, rather than the usual orange and black fur. This mutation is recessive.

Makari is a male white tiger, and he was bred with Zima. They had three cubs, two of which had white fur, and one had orange and black fur.

a) What is Zima's genotype?
 **heterozygous**



b) The offspring with orange and black fur was then bred with a heterozygous tiger.

Complete the Punnett square below.

H = dominant h = recessive

		Female gametes	
		H	h
Male gametes	H	HH	Hh
	h	Hh	hh

c) State the percentage possibility of the offspring having normal orange and black fur pigmentation.
 **75%**

d) Explain how two parents with orange and black fur can produce offspring with white and black fur.
 **Both parents must be heterozygous so that the offspring can inherit a recessive allele from each parent**

For more help and resources, or
to work with us as a tutor, please
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