AS90948 Transfer of genetic information

Part 2: Monohybrid crosses

Mendel was a monk living in Austria in the 1880's. He is most famous for genetics experiments using the pea plant.

Humans – have 23 pairs of chromosomes in cells (except sex cells). Each pair of chromosomes contains genes inherited from mother and genes inherited from father. Genes occur in pairs, coding for the same characteristic. Eg two genes control eye colour. Different forms of the same gene are called **alleles**.

Dominant and recessive alleles. A dominant allele is represented with a capital letter (eg G) and recessive allele with the same lower case letter (eg g). A dominant allele always shows (eg shows if organism has the pair of genes GG *or* Gg). A recessive allele only shows when both the alleles are recessive (gg) (or when it is on its own because it's on a sex chromosome). The gene that is dominant masks (hides) the effect of the recessive gene. Eg The brown hair gene (B) is dominant to blond hair gene (b). The BB and Bb combinations both give brown hair, and only the bb combination gives blond hair.

- The way genes express themselves in the individual's appearance is their **phenotype**, eg "brown hair". The combination of alleles is called its **genotype**, eg Bb.

- **Homozygous** means having two of the same allele for a characteristic eg BB or bb, DD or dd etc. They are called true breeding. **Heterozygous** means having different alleles for a characteristic eg Bb, Dd etc. These are also called hybrids.

Punnett squares - can be used to work out the probability of a characteristic being passed on to the next generation.

Eg **D** represents the allele for tall pea plants (dominant). **d** represents the allele for dwarf pea plants (recessive). The plant, Dd, will be tall.

Tall plant

	D	d
D	DD	Dd
d	Dd	dd

Tall plant

Another way of representing the chance of the recessive characteristic being expressed is as a ratio. There will be on average three tall offspring for every one dwarf offspring, so the ratio in this case is 3 tall : 1 dwarf.

This is of course a theoretical ratio. In an experiment the ratio might be 2.96 : 1 or 3.08 : 1 : the discrepancy is due to statistical error. The larger the sample, the closer the actual results look like the theoretical ratio.

A cross between a single characteristic governed by two alleles is called a **monohybrid cross**.

Genotype ratio: 1DD : 2 Dd : 1 dd

Phenotype ratio: 3 tall : 1 dwarf

Remember that each parent has two alleles for a characteristic, which separate when sex cells are formed.

Extra notes

Corn seed colour is determined by a single gene. Purple seed (**P**) is dominant over yellow seed (**p**). Max buys some purple corn seeds from the local seed merchant. *Explain what he could do to determine whether the corn seed was homozygous or heterozygous. You may use Punnett squares as part of your answer.*

To test whether the plant is homozygous or heterozygous Max would do a **backcross**. This is where the individual is crossed with a **homozygous recessive** individual, eg **pp.**

	P	P
p	Pp	Pp
p	Pp	Pp

100% purple seeds,
100% Pp

	P	p
p	Pp	pp
p	Pp	pp

50% purple seeds,
50% yellow.
50% Pp, 50% pp

If 100% of the offspring have the phenotype "purple seed", then the plant was homozygous for seed colour (dominant) or PP. If the offspring are 50% purple seed, 50% yellow seed, then the plant was heterozygous for seed colour, or Pp.

Summary for monohybrid crosses

Parent genotypes	Offspring phenotypes
Homozygous dominant x anything	100 % of offspring with dominant trait
Heterozygous x homozygous recessive	50 % dominant trait, 50 % recessive trait
Heterozygous x Heterozygous	75 % with dominant trait, 25 % with recessive trait
Homozygous recessive x homozygous recessive	100 % with recessive trait

Family trees or pedigrees

A family tree has been drawn below. Females are represented by ○ and males by □. The genotypes for free or attached ear lobes of *some* members of this family have been written in.
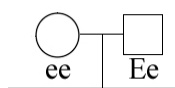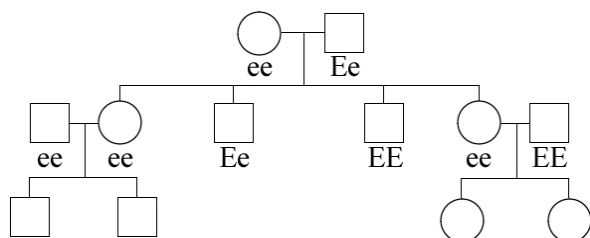
○—□
ee   Ee   means woman "ee" is married to man "Ee" (or at least they have had children together!)
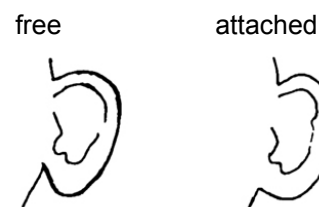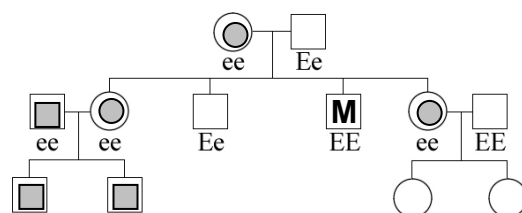
free   attached

Note:
E – the dominant form of the gene, it causes 'free' ear-lobes.
e – the recessive form of the gene, it causes 'attached' ear-lobes.

Example: *One of the genotypes has been written incorrectly. Put a M in the square or circle to show which genotype is incorrect. Shade in the ○ or □ of all those individuals who would have attached ear-lobes.*

ANSWER: To have "attached" ear lobes an individual must be ee since attached is recessive form of the gene. The person marked "M" must be a mistake – they cannot be EE since only one of their parents had the gene E. If their ear lobes are "free" they must be Ee. The children of ee and EE must all be Ee (heterozygous) and therefore have "free" ear lobes.

Inherited diseases – some examples

Huntington's disease affects the nervous system which breaks down, resulting in lack of coordination, shaking, loss of memory and mental deterioration. It is caused by a dominant allele and so only needs one parent to pass it on. There are no symptoms usually until people are in their 40's – which is usually after they have had children of their own. They have a 50% chance of passing on the gene to any child. However people can be tested to see if they carry the gene.

Cystic fibrosis affects cell membranes causing problems due to mucus forming in the breathing system. Caused by a recessive allele, it needs two parents who have the allele to pass it on to their children. The parents are **carriers** for cystic fibrosis and do not show any signs of the disease. If only one of the parents is a carrier, the offspring won't have the disease, but may be a carrier.

People with a history of a genetic disease in the family often seek advice about what will happen if they have children. **Genetic counselling** gives a couple an idea of how likely they are to have children with the particular disease, so they can decide whether to have children or not.

	C	c
C	CC	Cc
c	Cc	cc

When you do a Punnett square for the two heterozygous parents, the genotype ratio is 1 CC : 2 Cc : 1 cc. This means that the chances of having a child with the disease (cc) is 1 in 4 (25%) for heterozygous parents and the chances of having a normal child are (75%) 3 in 4. Do NOT think of the Punnett square is a predictor; and that if a couple has 4 children, then 1 of them will definitely have cystic fibrosis. Punnett squares show statistical probabilities only – for each child born to this couple the odds are the same. The individual with genotype Cc is called a carrier – they carry the gene for cystic fibrosis but they do not themselves suffer from the disease because they have a normal dominant gene C and well as the affected recessive gene c.

Inheritance of sex Sperm cells and egg cells (gametes) are formed by meiosis. They only contain one set of chromosomes. In fertilisation, a sperm cell & an egg cell fuse (join) together and form a zygote (fertilised egg cell), which grows into a baby. The baby's sex is controlled by the sex chromosomes. Men have XY sex chromosomes and women have XX. Half the sperm will contain the X chromosome and half will contain the Y chromosome. All the eggs will contain an X chromosome.

Whether the offspring will be male or female depends on which sperm fertilises the egg. The Punnett square below shows the possible combinations. If an X sperm fertilises the egg, it will be a girl (XX). If a Y sperm fertilises the egg, the offspring will be male, since the zygote will be XY. There is a 50% chance of either a male or a female resulting every time fertilisation occurs.

	X	X
X	XX	XX
Y	XY	XY

EXTENSION ONLY: Sex-linked characteristics (carried on the X chromosome). They are *usually* **recessive**. eg colour blindness. If **c** is used to represent the allele for colour-blindness, different combinations of alleles produce different characteristics. XX^c and X^cX are the same (see below)!!

XY = man, normal vision

X^cY = man, colourblind

XX = woman, normal vision

X^cX = woman, normal vision - she is a "carrier" - has the gene for colour blindness that she will pass on: her gametes are X^c and X

X^cX^c = woman, colour-blind

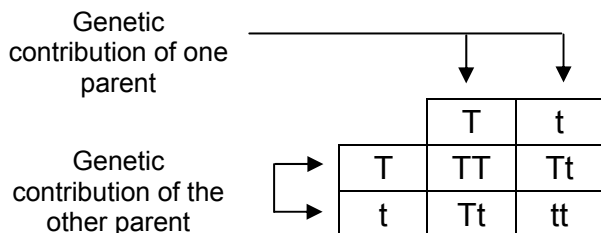|	X	Y
X^c	XX^c	X^cY
X	XX	XY

There is a 1 in 4 chance of a colour-blind child (X^cY)

There is a 50% chance (or 1:1 ratio) that any sons will be colour-blind (X^cY)

Half the girls would be expected to be carriers, but all have normal vision.

Practice writing out examples of monohybrid cross diagrams. The question may ask you about the offspring as a ratio, as fractions or as percentages. Try these:

Example: T = tall plant, t = dwarf plant

Genetic contribution of one parent

Genetic contribution of the other parent

	T	t
T	TT	Tt
t	Tt	tt

Phenotype ratio. 3 tall : 1 dwarf (or as a fraction, ¾ tall, ¼ dwarf, or as a %, 75% tall, 25% dwarf)

Genotype ratio: 1 TT : 2 Tt : 1 tt (or ¼ TT, ½ Tt and ¼ tt, or 25% TT, 50% Tt, 25% tt).

The genotype and phenotype ratios are different because both genotypes TT and Tt have the same phenotype - TALL

1. WW x ww

W = wide wings, w = narrow wings

	W	W
w		
w		

2. Rr x Rr

R = red flowers, r = white flowers

	R	r
R		
r		

3. aa x Aa

A = normal, a = albino

	a	a
A		
a		

Phenotype ratio

----- wide : ----- narrow

Genotype ratio:

_____ % -----

Phenotype ratio

----- red : ----- white

Genotype ratio:

----- RR : ----- Rr : ----- rr

Phenotype ratio

----- normal : ----- albino

Genotype ratio:

½ ____ , ____ ____

Sometimes monohybrid crosses are written out like this:

| parents' genotypes |

| gametes |

| offsprings' genotype |

Tt   Tt

T   t   T   t

TT   Tt   tt   Tt
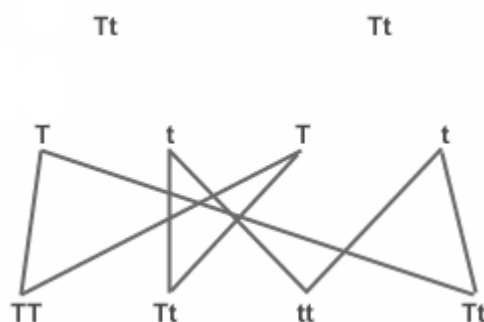
In some questions/examples it will refer to the **parental generation** – the 'parents', the **F1 generation** – the 'children' & the **F2 generation** – the 'grandchildren'. This could also refer to 2 flowers… their seeds and the seeds produced by flowers grown from their seeds

Flowers may be **self pollinated** (means bred with themselves) – so self pollinating a flower with genotype Bb would mean a genetic cross, Bb x Bb.