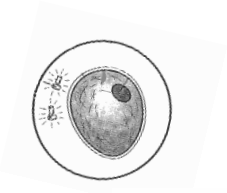
BIOLOGY 8923 v3
Describe mechanisms for the transfer of genetic information
Level 1, 3 credits

Mitosis

Mitosis occurs wherever an increase in number of cells is needed. Mitosis enables growth and repair to occur.
During mitosis a cell produces two copies of itself – 2 daughter cells.

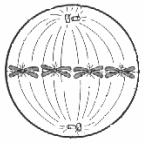
- Each is identical to the other and to the cell from which they were formed – the genetic material is copied exactly (replicated).
- It occurs in all cells (eg skin, liver, heart) except the sex cells (and red blood cells).



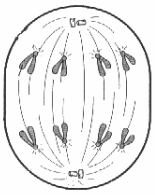
Before a cell divides, its chromosomes are copied exactly (replication). The chromosomes start to become visible.

The chromosomes each consist of two threads called chromatids, each an exact copy of the parent chromosome. The chromosomes shorten and fatten and become clearly visible. The chromatids are joined together at a point called the centromere.

The nuclear membrane disappears. The paired chromatids move to and line up along the mid line (equator), of the cell. A system of fibres called the spindle stretches across the cell.

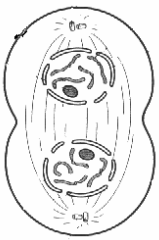


Each chromatid attaches to a spindle fibre. The fibres contract and the pairs of chromatids are separated and move toward the opposite poles.



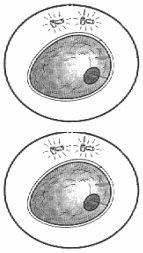
The chromatids are now considered to be daughter chromosomes, and a complete set is therefore now at each pole. A new nuclear membrane forms around them.

In plant cells, the daughter nuclei are separated by a new cell wall. In animal cells, the cytoplasm pinches in to form two daughter cells.



Cell division is complete. The chromosomes are no longer visible. Two daughter cells have been formed whose nuclei contain chromosomes identical to the original chromosomes of the parent cell.

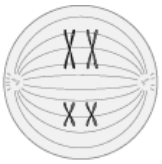
ADDITIONAL NOTES



<u>Meiosis</u> (‘reduction division”)

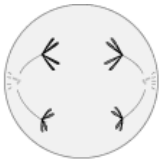
Meiosis is for the production of sex cells. It occurs in the reproductive organs (ovaries and testes). Meiosis involves 2 cell divisions and produces 4 daughter cells – the gametes - with half the number of chromosomes, and all genetically different from each other.
A human body cell contains 23 pairs of chromosomes (46 chromosomes). The gametes - sperm or eggs - contain half this number of chromosomes (23 chromosomes).

Before meiosis begins, the chromosomes are copied exactly. Each chromosome is replicated to form two chromatids. The chromosomes start to become visible.



The chromosomes arrange themselves into homologous pairs on the equator. Homologous means both coding for the same characteristics. (*At this point crossing over can occur where maternal and paternal chromatids can swap bits of DNA which increases the potential for variation in the gametes**.) The nuclear membrane disappears. *(*Crossing over is NOT needed for the US)*

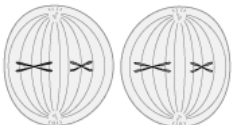
First division



Homologous pairs of chromosomes then separate and move to the poles of the parent nucleus. (*For each pair there is an equal chance which pole the paternal or maternal chromosomes migrate to, which creates even more variation in the gametes).*

The nucleus now divides to form two daughter nuclei, each with a mixture of paternal and maternal chromosomes. Each now contains just half the normal number of chromosomes (and no pairs at all). Nuclear membranes form and the cell splits into two.

Second division



New spindles form and the nuclear membranes disappear.

Each chromatid separates from its partner and moves to opposite poles of the cell.

Nuclear membranes form around the chromosomes and the cells split. The end result is four non-identical sex cells (gametes) each with half the original number of chromosomes (23 in humans)

ADDITIONAL NOTES

Simple monohybrid inheritance patterns

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.

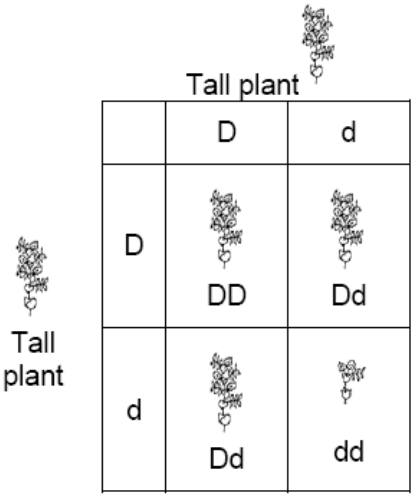
The way genes express themselves in the individual's appearance is their **phenotype**, eg "brown hair". The combination of alleles is called its **genotype**, eg Bb.

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). A plant, Dd, will be therefore be tall.

Example: A heterozygous plant (Dd) is self-pollinated (crossed with itself)



There will be on average three tall offspring for every one dwarf offspring, so the ratio in this case is 3 tall : 1 dwarf.

Phenotype ratio: 3 tall : 1 dwarf
This can also be written as
- 75% tall, 25% dwarf, Or
- ¾ tall : ¼ dwarf

Genotype ratio: 1DD : 2 Dd : 1 dd
This can also be written as
- 25% DD, 50% Dd, 25% dd, Or
- ¼ DD : ½ Dd : ¼ dd

The phenotype and genotype ratios are NOT the same because 2 genotypes (DD and Dd) will both produce the same phenotype – tall.

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 flowers… their seeds and the seeds produced by flowers grown from their seeds.

Sex Linkage

Sex-linked characteristics are 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.

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

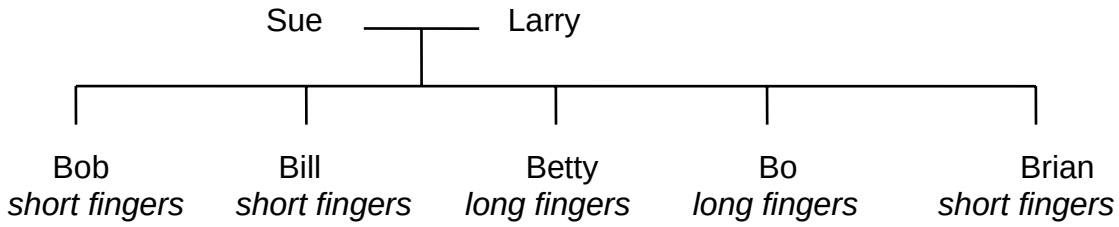
In the example opposite:

	X	Y
X^C	X^CX	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.

<u>Pedigree analysis</u>

Suppose the gene for **short** fingers is **dominant** to the gene for long fingers, in humans.
Sue (short fingers) marries Larry (long fingers) and they have 5 children.



1. Using S for short fingers and s for long fingers, write down the genotypes of Sue and Larry (parents) and their 5 children (F1 generation).
2. Bill marries Sally (long fingers) and they have 4 children (F2 generation). Predict the % that will have a) short fingers b) long fingers.

Answers

1. Sue must be Ss and Larry must be ss. He has to be ss to have long fingers. The fact that some (but not all) of their children have long fingers must mean that they have inherited a s gene from their mother Sue. Those with long fingers inherited a S gene from Sue.

2. Bill (short fingers) must be Ss (as he gained S from his mother and s from his father). Sally must be ss (since long fingers are recessive). Predicted 50% short, 50% long fingers

	S	s
s	Ss	ss
s	Ss	ss