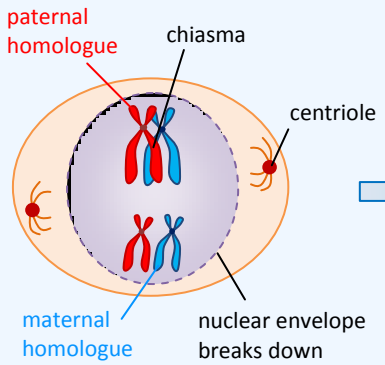
5.5 Meiosis

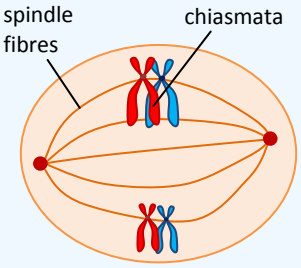
Cellular division for gametes (meiotic division) for reproduction

Organisms which reproduce sexually produce offspring which are genetically dissimilar from their parents and each other, and the process of **meiosis** is required for this. Unlike mitosis, meiosis is used only by special reproductive cells, called **gametes**. One gamete from each parent fuses together to produce a **zygote** at fertilisation. When two gametes fuse to make one cell, the chromosomes from each parent cell are combined into one daughter nucleus. Therefore, the number of chromosomes in each gamete needs to be **haploid** (one half the number of the original cell). This is as opposed to a **diploid** cell which contains the full number of chromosomes.



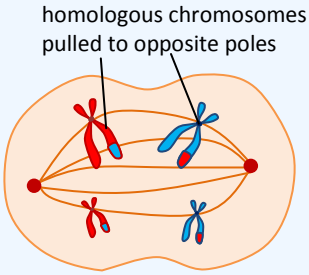
Prophase I

Chromosomes shorten and fatten (**supercoil**) and come together in homologous pairs to form a **bivalent**. The chromatids wrap around one another and attach at points called **chiasmata** where they may break and swap small sections of DNA in a process called **crossing over**. The nuclear envelope breaks down



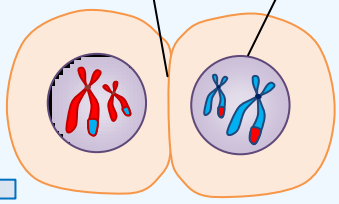
Metaphase I

Centromeres attach to the spindle fibres, and the bivalents arrange themselves randomly on the equator of the cell with each of a pair of homologous chromosomes facing the opposite pole



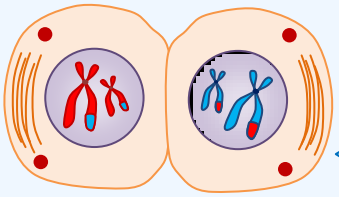
Anaphase I

One of each pair of homologous chromosomes is pulled by spindle fibres to opposite poles



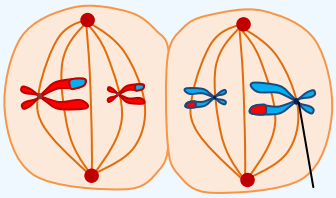
Telophase I

Nuclear envelopes reform around the chromosomes at each pole and the cell divides by **cytokinesis**



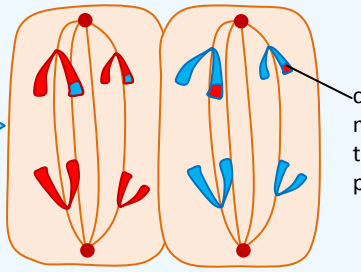
Prophase II

The nuclear envelopes break down again, chromosomes supercoil and spindle fibres form



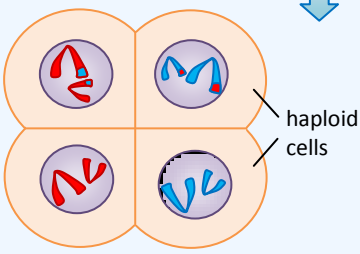
Metaphase II

The chromosomes arrange themselves on the equator of each cell, and are attached by their **centromeres** again to the spindle. Again, chromatids are randomly arranged along the equator



Anaphase II

The centromeres divide and the chromatids are pulled to opposite poles by the spindle fibres, and the chromatids randomly segregate



Telophase II

The **tetrad** of four cells is formed. Each cell has a haploid number of chromosomes, and crossing over during prophase I has introduced genetic variety giving cells of different composition

Interphase

Meiosis is complete, and the cell rests until the next meiotic division

Genetic variation

Meiosis and germline fertilisation increase genetic variation in a number of ways:

- through the process of **crossing over** during prophase I (this occurs where alleles can be shuffled between chromosomes where they cross over at points called **chiasmata**)
- through **genetic reassortment** due to the random distribution and subsequent segregation of the chromosomes during meiosis I (and the chromatids during meiosis II)
- through random **mutation**
- fertilisation itself introduces random variation: only one sperm contributes its DNA, and yet there are about 300 million sperm cells all genetically different

Crossing over and chiasmata

Crossing over occurs during prophase I, where the homologous chromosomes pair up, and come together to form **bivalents** and non-sister chromatids wrap around each other very tightly and attach to form *chiasmata*. On average, each meiotic division includes around two or three crosses over per chromosomal pair.

The chromosomes can break at chiasmata, where the broken ends of one chromatid can rejoin to the end of a different, non-sister chromatid in the same bivalent. This leads to similar sections of non-sister chromatids being swapped over, and whilst these sections contain the same genes, they may not contain the same **alleles** – which is one way in which meiosis introduced genetic variation. It produces new combinations of alleles on chromatids (which will become the chromosomes in daughter cells).