Sexual Reproduction

Chapter 8
Pages. 255-261
Learning intentions

- To understand how an offspring from two parents has a unique genetic identity
- To be able to explain the key events in meiosis that result in the production of gametes from somatic cells
- To understand the significance of crossing over
- To be able to identify the biological advantages of sexual reproduction

Success Criteria

- I can explain the difference between mitosis and meiosis
- I understand the inputs and outputs of meiosis
- I can outline the advantages of sexual reproduction
Keywords for this chapter!

- Meiosis
- Gamete
- Diploid
- Haploid
- Recombination
- Crossing over
- Chiasmata
- Disjunction and Non-disjunction
- Fertilisation
- Bivalent
- Synapsis

- Ovaries
- Testes
- Gonads
- Germ Cells
- Egg (or ova)
- Sperm
- Aneuploidy
- Monsomy
- Trisomy
Previously we have explored asexual reproduction, as seen in prokaryotes and some eukaryotes.

All living organisms can reproduce sexually, according to the genetic instructions within the organisms themselves.

This requires the process of meiosis to form gametes.
Characteristics

Usually requires two individuals (male and a females) and appropriate behaviour to enable **fertilisation**.

**ADVANTAGES:**
- Genetically different individuals are formed
  - Creates genetic variation in a population
  - Allows a species to survive in a changing environment

**DISADVANTAGES:**
- Need to find a mate
- Requires more energy
- May be limited to certain times of the year (seasonal dependence)
GETTING YOUR FIRST CHROMOSOMES...

The chromosomes you inherit from your parents determine what you look like.
GROWTH - FROM ONE CELL TO YOU!

Blastocyst implanting on uterus: 1 week
Embryo: 5 weeks
Heartbeat at 3 weeks!
Embryo: 8 weeks
Every organ system present

Every cell in your body has the same copy of the chromosomes originally given to you by your parents!
Comparing male and female

Oogenesis

Spermatogenesis
Meiosis – the source of variability in offspring.

- This is the process of gametes being produced
- Only occurs in the gonads
- Instead of producing two identical daughter cells, meiosis produces four non-identical daughter cells, each with only half the number of chromosomes (e.g. 23 in humans)
There are 2 phases and 8 stages to Meiosis.

<table>
<thead>
<tr>
<th>Meiosis I</th>
<th>Meiosis II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separates homologous chromosomes</td>
<td>Separates sister chromatids</td>
</tr>
<tr>
<td>Prophase I</td>
<td>Prophase II</td>
</tr>
<tr>
<td>Metaphase I</td>
<td>Metaphase II</td>
</tr>
<tr>
<td>Anaphase I</td>
<td>Anaphase II</td>
</tr>
<tr>
<td>Telophase I</td>
<td>Telophase II</td>
</tr>
<tr>
<td>Brief interphase here, but cells do not duplicate</td>
<td></td>
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</tbody>
</table>
Modelling Meiosis

- Large piece of Paper
- Set of poppet beads
- Texta
Interphase

- Standard condition of cell
- DNA replicates
- Cell enters reproductive cycle with four copies of each chromosome
DNA super coils and chromosomes become visible

Nuclear membrane breaks down

Homologous pairs line up
Non-sister chromosomes join up and trade sections
Chiasmata – this is where chromatids remain in contact. At these points, the chromatids may break and re-join, sometimes re-joining to other chromatids. This process is called **crossing over** and results in sections of DNA being swapped along the chromatids.
Prophase I

- Non-sister chromosomes join up and trade sections
- Centrosomes migrate and spindles form
Homologous chromosomes line up on equator of cell

Random assortment takes place
Metaphase I

- Homologous chromosomes line up on equator of cell
- Random assortment takes place
Anaphase I

- Homologous chromosomes attach to spindles
- Spindles contract and pull homologous chromosomes apart
Telophase I

- Nuclear membrane reforms
- Chromosomes disperse
- Cytokinesis begins
Prophase II

- Chromosomes recondense
- Centrosomes migrate
- Nuclear membranes disperse
Metaphase II

- Chromosomes migrate to equator
Metaphase II

- Chromosomes migrate to equator
- Spindles form
Anaphase II

- Spindles contract
- Chromosomes migrate
- Nuclear membranes reform
- Chromosomes disperse
- Cytokinesis completes the cycle
It is the re-assortment of genetic material from both crossing over and disjoining that produces new genetic combinations. This is known as **recombination**.
When meiosis goes wrong...

- Sometimes a pair of chromosomes fail to disjoin or separate at anaphase.
- This event is called **non-disjunction** and it is an unpredictable error.
- If this involves sex chromosomes at all, the offspring will be born with clinical abnormalities e.g.
  - XXY – Klinefelter Syndrome
  - XO – Turner Syndrome
  - OY – non-viable
  - XXX – triple X syndrome
  - XYY – double Y syndrome

- Where there is an addition or loss of a chromosome the condition is called **aneuploidy**.
- \(2n+1\) = **trisomy**, \(2n-1\) = **monosomy**.
- Changes to the number of autosomes is far more drastic e.g. down syndrome (trisomy 21)
Karyotype
Karyotype
EXTRA INFORMATION
Two parental contributions

- Sexual reproduction involves genetic contributions, in the form of **gametes**, from two parental sources to their offspring.
- In animals, gametes are **eggs** (from the female) and **sperm** (from the male).
- Gametes are produced by specialised reproductive organs known as **gonads**. These are the **ovaries** for females and **testes** for males.
- The cells in the gonads that give rise to the gametes are termed **germ cells**.

![Pictomicrograph through mammalian testes](image1)

![Pictomicrograph of sections through human ovary, showing an egg (oocyte) within a follicle](image2)
How is variation created?

Let's go back to chromosomes!

- Chromosomes are the genetic information carriers.
- In a normal body cell (somatic cell) the number of chromosomes present is called the diploid number and is represented by the symbol $2n$.
- In humans the number of chromosomes in each somatic cell is 46, therefore $2n = 46$
- The chromosomes in a diploid cell exist as matching homologous pairs.

If an organism has a diploid number of 12 – how many matching homologous pairs of chromosomes are there?
In sexual reproduction, each parent makes essentially equal genetic contribution in the form of a gamete i.e. an egg and a sperm.

All normal somatic cells have 46 chromosomes in humans, their gametes have just 23 chromosomes. This is called the **haploid** number and is given the symbol \( n \).

So for people \( n=23 \).

The process of gamete formation is referred to as **MEIOSIS** and is a form of **reduction division**.

When the sperm **fertilises** the egg the diploid number is restored.
The diploid (2n) parents, have cells that undergo meiosis to make haploid gametes (n).

The gametes fuse during fertilisation to make a diploid (2n) offspring.

Offspring then undergo mitosis to become individuals.
Meiosis in males

- Occurs in the testes
  - Outside the body (temp. 35°C)
  - Make testosterone from puberty onwards which induces sperm production
- Each meiosis cycle makes 4 sperm
- This continues into old age
- Each ejaculation releases between 40 and 500 million sperm.
Meiosis in Females

- Gametes start to be made in the ovaries when still a foetus
  - start but do not complete it
  - remain dormant until puberty

- At puberty, an ovarian cycle starts
  - Approximately one egg a month completes meiosis and released from the ovary.
  - Only 1 egg is made from meiosis instead of the normal 4.