OCR (B) Biology A-level

3.1 Cell division and development

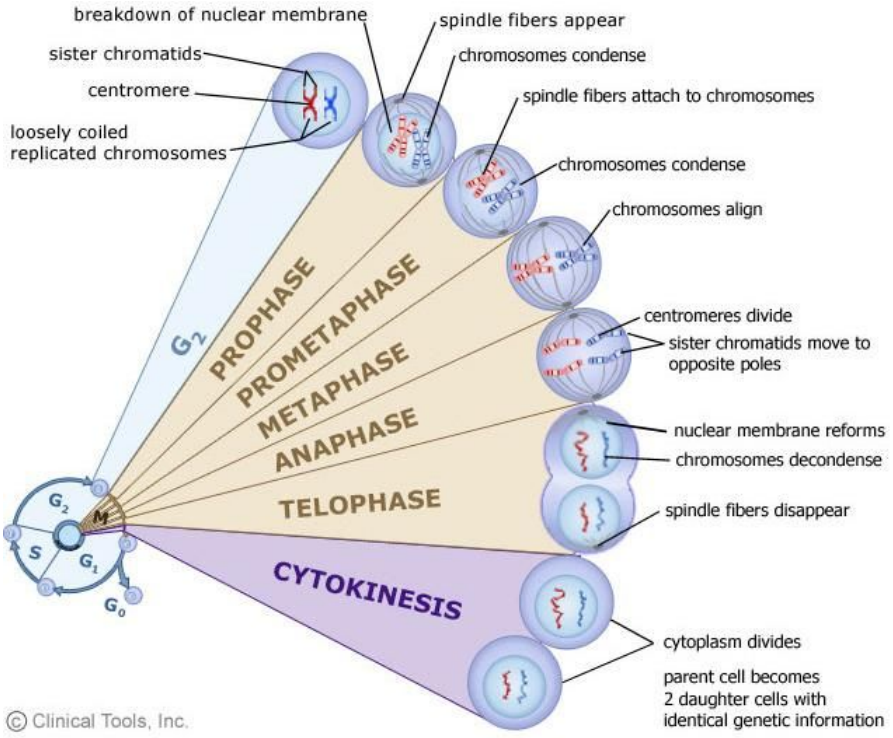
Notes

The role of **mitosis and the cell cycle** is to produce **identical daughter cells for growth and asexual reproduction** of cells. All the cells produced by mitosis are **genetically identical** therefore **mitosis does not give rise to genetic variation.**
During the cell cycle, a cell it forms, it grows and then divides to form daughter cells. There are three stages of the cell cycle and it is controlled by checkpoints.

- **Mitosis** – mitosis is a form of cell division that produces identical cells, there are four stages of mitosis: **prophase, metaphase, anaphase and telophase.**

- **Cytokinesis** – during cytokinesis the parent and replicated organelles move to opposite sides of the cell and the **cytoplasm divides** thus producing two daughter cells
- **Interphase** – during this stage the cell **grows and then prepares to divide** – chromosomes and some organelles are replicated, chromosomes also begin to condense

During **prophase**, the **nuclear envelope** breaks down and **subsequently disappears**. The chromosomes **condense** and the centrioles **move to opposite poles** of the cell for the purpose of **spindle formation**.
During **metaphase**, the chromosomes **move to the equator** and attach to the **spindle fibres** via **centromeres.**
In the **anaphase** stage, the sister **chromatids are separated**.
During **telophase**, the nuclear **envelope reforms**, creating two daughter cells. The **spindle is broken down** and subsequently disappears. The chromosomes **uncoil.**



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3.1.2 Meiosis, growth and development

Meiosis

Meiosis is a form of cell division that gives rise to **genetic variation**. The main role of meiosis is the production **of haploid gametes** as cells produced by meiosis have half the number of chromosomes. Meiosis produces genetically different cells, genetic variation is achieved through:

- **Crossing over of chromatids** where pairs of chromosomes line up and exchange some of their genetic material

- **Independent assortment of chromosomes** – there are various combinations of chromosome arrangement

This form of cell division is a two phase process in which **four haploid gametes** are generated from a diploid cell. During **meiosis I**, homologous chromosomes **separate** - therefore there is only one chromosome from every pair per gamete, whereas in **meiosis II** the sister chromatids separate.

The stages of meiosis I are **prophase I, metaphase I, anaphase I and telophase I**. Prophase I closely resembles the prophase stage of mitosis, with the exception of **synapsis** and crossing over of homologous chromosomes which allow the genetic exchange to occur. Subsequently, metaphase where the four chromosomes **align at the equator**. During **anaphase I**, the homologous chromosomes separate whereas during telophase I the **nuclear envelope reforms** around haploid nuclei containing double the number of chromosomes. During meiosis II composed of prophase II, metaphase II, anaphase II and telophase II, **another round of cell division occurs**, leading to the formation of four haploid daughter cells, containing single chromosomes.

Stem cells

Stem cells are **undifferentiated** cells which are genetically identical and have the ability to develop into any of the various kinds of cells. Stem cells have various uses in research and medicine, for instance **repair of damaged tissues**, treatment of **neurological disorders** such as **Parkinson's and Alzheimer's** as well as **studying development.**
The process by which a cell specialised to carry out a particular function is known as differentiation. Stem cells can be found in the **bone marrow** where they differentiate into **erythrocytes (red blood cells) and neutrophils (white blood cells).** The role of erythrocytes is **transporting oxygen in the blood**. They are relatively short lived as they are constantly destroyed and created. Whereas the neutroph**ils** are involved in attacking and destroying foreign microorganisms in the process of **phagocytosis.**
Plants **retain their ability to differentiate** into different types of cells throughout their life. Division of plant cells occurs at a high rate in **meristems.** Dividing meristem cells are known as the **cambium** and give rise to **xylem and phloem** tissue.

Other specialised cells:

- **Sperm cells** – male gametes, made in the testes throughout a man's life, they are adapted to **reach, penetrate and fertilise** the ovum i.e. the female gamete

- **Palisade cells** – most basic plant cell type, contain **many chloroplasts** and are specialised for **photosynthesis**

- **Root hair cells** – specialised **epidermal cells** found in **close proximity to root tips**. They have thin and long extensions which serve for the purpose of **increasing surface area and maximising the contact with water** which contains **essential mineral ions** which are absorbed through the roots. They are short-lived and are constantly produced in the **root tip**.

- **Guard cells** – found in pairs in the **epidermis of leaves** and are involved in controlling the **opening and closing of stomata**. **Guard cells** contain chloroplasts whereas epidermal cells do not. They respond to **water influx** which causes them to alter their shape, causing the stoma to open.

Antenatal care

In the UK, the antenatal (before birth) care programme provides people trying to conceive and those pregnant with advice, screenings and other help such as vouchers to optimise the health outcomes of the pregnancy, through the NHS.

Preconception care is given through advice and monitoring of health to improve the probability of conceiving for people who find it challenging. Preparing for conception and pregnancy involves things such as improving one's health, starting to take **folic acid** if aiming to become pregnant, improving diet and exercise to make conception more likely, learning how to track ovulation, and quitting noxious substances such as drinking and smoking. These steps can increase the likelihood of conception through maximising sperm production and health, fertilisation and a good starting point for the beginning of pregnancy.

Dietary changes during pregnancy:

- Folic acid – prevent neural tube defects
- Iron – prevent anaemia
- Calcium and vitamin D – maintain bone health
- Vitamin C

Avoid teratogenic substances such as Vitamin A, alcohol, smoking, certain soft blue cheeses, liver, raw shellfish.

Miscarriage, developmental issues such as Foetal Alcohol Syndrome and later issues such as learning difficulties are associated with drinking alcohol while pregnant. Severity of these problems increases with the amount of alcohol consumed. It's advisable to not consume any alcohol at all ideally.

Smoking harms the foetus and is associated with lower birth weights, cot death (sudden infant death) and other later issues including asthma.

Measuring foetal growth

Ultrasound scans can reveal information about the developing foetus. Various measurements, such as the **biparietal diameter (BPD) of the cranium (head)** and **crown-rump length** of the back can be used to determine the age of a pregnancy (gestational age) and assess whether the foetus is developing as expected in terms of size.

Diagnostic procedures regarding foetuses

include **ultrasonography**, **amniocentesis** and **chorionic villus sampling**.

Ultrasonography is **not invasive** and hence a very practical option for things such as sex determination from around 12 weeks. By visualising various features of the foetus, diagnostics can be run to check for conditions including Down's syndrome. A nuchal scan can reveal various conditions by measuring the thickness of the translucent portion beneath the foetus neck. This is **not conclusive**, and must be taken alongside other data such as the age of the person pregnant with the foetus.

Amniocentesis is carried out **invasively** and carries an up to 1% risk of miscarriage. It involves extracting a sample of amniotic fluid from near the foetus, and **analysing the DNA** in its residual foetal tissue for sex determination, checking for infections and chromosomal conditions. It is performed between 14 and 16 weeks of gestation.

Chorionic villus sampling (CVS) can be performed **earlier** than amniocentesis, at 10 - 12 weeks. It also **uses DNA** to check for chromosomal and genetic conditions. The data is based on a placental sample rather than amniotic fluid (the chorionic villi are part of the placenta). Carrying out chorionic villus sampling follows findings from ultrasonography, such as high nuchal translucency. The procedure's miscarriage risk is up to 2%, in addition to a risk of infection and leakage of amniotic fluid.

Karyotyping is the determination of an individual's chromosomes. It serves to indicate chromosomal conditions such as Down's syndrome (caused by chromosomal mutation) as well as sex determination.

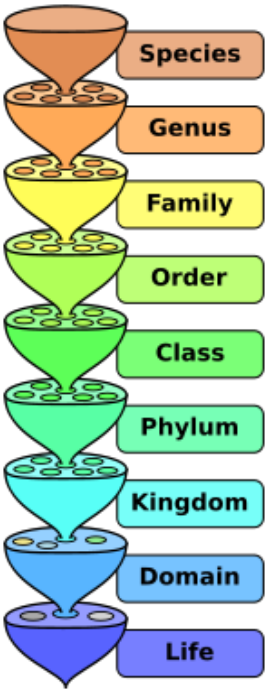
Down's syndrome involves an extra chromosome 21, and expresses itself in terms of many different features, some of which are detrimental to health. Common outcomes include unique facial features, slower overall development, higher incidence of congenital heart abnormalities, decreased or absent fertility and overall lower life expectancy.

Turner's syndrome is in a way the "reverse" of Down's syndrome as it presents one fewer chromosome rather than one extra. Specifically, it is a diminished or absent X chromosome. Since XY embryos missing their only X chromosome would not be viable, this syndrome only presents itself in births of would-be XX babies who end up having just one X chromosome or one X and a partial X.

Klinefelter's syndrome is a relatively common chromosomal variation (up to 1 in 500 male assigned births) where an XY individual has an extra X chromosome, hence being an XXY individual. Life expectancy is comparable to XY individuals. Symptoms of the condition

include reduced fertility or infertility, lower levels of testosterone, increased height, reduced muscle strength and coordination, breast growth and learning and speech difficulties.

3.1.3 The development of species: evolution and classification



Species and taxonomy

Classification is the process of **naming and organising organisms into groups based on their characteristics.** Organisms can be grouped into one of the five kingdoms: **animals, plants, fungi, prokaryotes and protoctista**. They can then be grouped further into **phylum, class, order, family, genus and species**. Each species is named according to the **binomial system**, the first part of the name is the genus and the second part of the name is the species.

The analysis of molecular differences in different organisms to determine the extent of their revolutionary relatedness is known as **molecular phylogeny**. The data obtained by molecular phylogeny has been accepted by scientists and this gave rise to new taxonomic groupings – all organisms can be separated into one of the **three domains: Bacteria, Archaea and Eukarya.** Archaea are prokaryotic cells; they often live in extreme conditions as they have strong membranes that are able to stand high temperatures and low pHs. Eukarya includes the plant, animal, fungi and protista kingdoms.

Viruses are not included in the three domains as they are **non-living** and are not classed as cells. In taxonomy, they are instead classified by the disease which the virus causes and the type and structure of their nucleic acid.

The scientific community evaluates the data in the following ways:

- The findings are published in **scientific journals** and presented **scientific conferences**.
- Scientists then study the evidence in a process called **peer review**
- Scientists start **collecting evidence** to either **support or reject the suggestion**

Key Terms:

- **Niche**-the niche of a species is its role within the environment
- **Ecosystem**-a community of organisms in an area working together with the physical environment
- **Species**-organisms in a species are able to breed to create fertile offspring.

Biodiversity is the **variety of living organisms**, over time the variety of life on Earth has become more extensive but now it is being **threatened by human activity** such as deforestation. Biodiversity can be measured in terms of:

- **Species richness** is the **number of different species in a community** and can be measured by simply counting the number of species present via methods such as **random sampling.**

- **Genetic diversity** is a measure of the **genetic variation** found in a particular species, in other words it is the **number of alleles in a gene pool**. It can be determined by calculating **the heterozygosity index (H),** the higher the heterozygosity index (H), the more genetically diverse the species.

H= number of heterozygotes / number of individuals in the population

Biodiversity can also be measured using the **index of diversity (D)** which can be calculated as following:

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

D = Diversity index
N = total number of organisms
n = total number of organisms of each species
Σ = the sum of