Mitotic index - measurement of how actively cells are performing mitosis, useful in cancer cell detection - cancer cells will divide more, so have a higher index --> ***cells in mitosis / total number of cells***

Meiosis

Gametes - haploid sex cells that contain one set of chromosomes compared to a diploid somatic (body) cell. In humans they are the ovum and the sperm cell that fuse to make one diploid cell (zygote).

PROCESS

Interphase (S phase) - this is when the DNA chromosomes are replicated to produce two identical copies (sister chromatids) that are held together at the centromere by cohesion proteins. The centrosomes also replicate.

MEIOSIS I

Prophase I

- The homologous chromosomes are attached at their tips to the nuclear envelope by proteins. The nuclear envelope breaks down and fragments and the chromosomes move closer and condense - supercoil
- The synaptonemal complex - a lattice of proteins forms between the homologous chromosomes until it covers the entire length. The tight pairing of the chromosomes is called synapsis.
- The genes of the chromatids are aligned and crossing - over takes place. This is where there is an exchange of DNA between chromatids on homologous chromosomes
- Chiasmata (twist around each other) forms between non-sister chromatids which allows the exchange of chromosomal segments between them.
- At the end of prophase I the pairs are held together at the chiasmata and are called tetrads (4 sister chromatids of each pair are visible) and spindle fibers emerge from the centrosomes.
- Genetic variation – crossed over chromosomes have the same genes, however the alleles are shuffled.

Prometaphase I

- The spindle fiber microtubules attach to the kinetochore proteins shared by the sister chromatids. Each homologous pair attaches to the opposite poles of the cell.
- The chromosomes continue to condense, and the nuclear envelope is broken down completely

Metaphase I

- The homologous chromosomes orient themselves at the metaphase plate where they are arranged by the microtubules from the spindle fibers. The tetrads are arranged randomly, and the arrangement is always different, but each chromosome lies next to its homologous partner -Independent assortment
- When the chromosomes are divided in pairs, the separation is random; each haploid cell contains both paternal and maternal genes.
- This increases genetic variation as the combinations of chromosomes (order of 1 – 23) changes
- Recombination - process that breaks and recombines pieces of DNA to produce new combinations of genes by scrambling pieces of maternal and paternal genes.

Anaphase I

- The microtubules pull the linked chromosomes apart, however the sister chromatids are still tightly bound together at the centromere.

Telophase I and Cytokinesis

- The separate sister chromatids arrive at the opposite poles and the chromosomes begin to decondense. A nuclear envelope forms around each chromatid.
- Cytokinesis separates the cell contents (cytoplasm) by forming a cleavage furrow. Resulting in two haploid cells, each containing one duplicated copy of each homologous chromosome pair.
- Plant cells don't split just move to meiosis II

MEIOSIS II

Prophase II - The sister chromatids condense (DNA Supercoils)and the nuclear envelope fragments into vesicles. New spindles are formed

Prometaphase II

- The nuclear envelope is completely broken down and spindles are fully formed.
- Each sister chromatid forms an individual kinetochore that attaches to the spindle fibers from opposite poles

Metaphase II - The sister chromatids are condensed to their maximum and are aligned at the metaphase plate

Anaphase II

- The kinetochore microtubules shorten/contract, causing the sister chromatids to be pulled apart.

11. There are multiple replication forks in a single DNA molecule, which speeds up the replication process and replication occurs in both directions in replication bubbles.
12. Once the whole DNA molecule is replicated, the individual segments join together and form two new DNA molecules, both identical to the parent molecule.

MESLESON AND STAHL

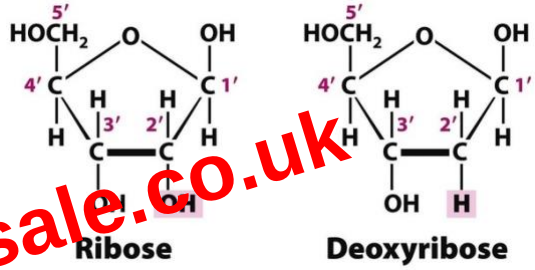
- Meselson and Stahl showed that DNA is replicated using the semi-conservative method.
- They grew bacteria in Nitrogen (^{14}N) and an isotope of Nitrogen (^{15}N), which has a higher molecular weight.
- Two samples of E. coli (a bacteria) were grown, one was grown in a normal culture media, containing the atom ^{14}N. The other one was grown in ^{15}N, so over time the bacteria would incorporate ^{15}N atoms into its DNA, so this bacterium is denser than the one grown in ^{14}N.
- A sample of DNA was then extracted from each batch of bacteria and spun in a centrifuge. The DNA from the denser nitrogen settled lower in the centrifuge tube.
- They then transferred the bacteria from the ^{15}N media to the ^{14}N media and allowed the bacteria to replicate once.
- Another DNA sample was extracted and spun in a centrifuge. This DNA settled between the original and denser levels in the tube, indicating the semi-conservative hypothesis.

The Structure of Mononucleotides

MONONUCLEOTIDE

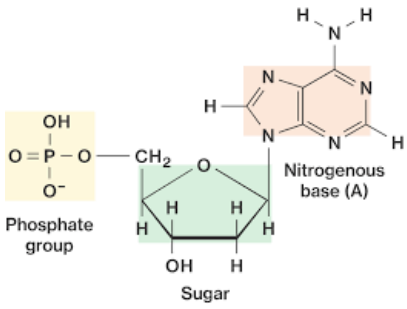
A mononucleotide is a biological molecule made up of a pentode sugar (5 carbon atoms), a nitrogen-containing base and a phosphate group.

- They provide energy in the form of adenosine triphosphate (ATP)
- Mononucleotides are the monomers that make up DNA and RNA



DNA

The pentose sugar in a DNA mononucleotide is deoxyribose (carbon 2 doesn't bond to any oxygen)
Each DNA mononucleotide has the same sugar and phosphate group, but the nitrogen-containing base varies. The four possible bases are Adenine (A), Thymine(T), Cytosine(C) and Guanine (G).

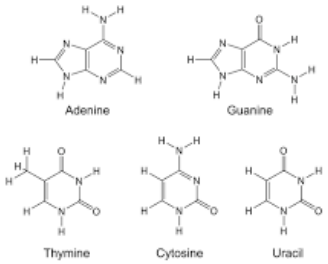


RNA

The pentose sugar in a RNA mononucleotide is ribose (carbon 2 has an oxygen bond)
RNA mononucleotides all contain a ribose sugar, a phosphate group and a nitrogen-containing base. The four possible bases are Adenine (A), Uracil(U), Cytosine(C) and Guanine (G); uracil replaces thymine.

COMPONENTS

The pentose sugar is a 5-carbon structure that forms part of the sugar-phosphate backbone.
The phosphate group (2 hydrogen atoms, 1 phosphate and 4 oxygens) joins to the pentose sugar at carbon 5; a condensation reaction occurs that results in the release of a water molecule and forming a phosphoester bond.
A nitrogenous base, bonds to the pentose sugar at carbon 1, when they bond its referred to as a nucleoside. So another condensation reaction occurs, resulting in the release of water.



The nitrogenous bases adenine and guanine are known as Purine nitrogenous bases as they contain 2 carbon – nitrogen rings and 4 nitrogen atoms

- Structure - round organelles that are membrane bound (surrounded by a membrane)
- Function - contain digestive enzymes that are used to breakdown materials or digest organelles that are worn out or destroyed. Can also self-destruct if a cell is mutated/old or under stress. Their enzymes are released and destroy the contents of the cell - apoptosis (programmed cell death)

Mitochondria - membrane bound
- Structure - double membrane, the inner one is folded to from cristae that are folded in the matrix - increasing surface area.
- Function - where aerobic respiration takes place and ATP is produced

Chloroplast - membrane bound
- Structure - found only in plants and some Protoctista, they contain two fluid separated membranes and the inner membrane is folded into thylakoids that form a grana.
- Function - the thylakoids contain chlorophyll that absorb light and allow photosynthesis to take place

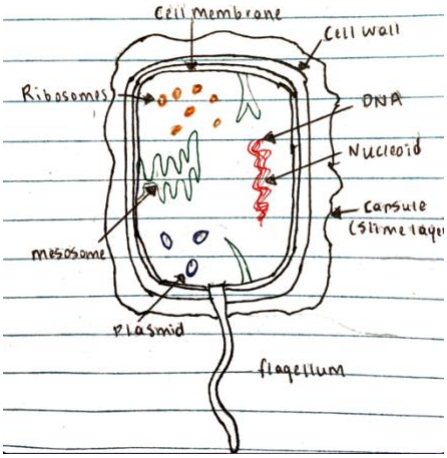
Vacuoles - membrane bound
- Structure - large vesicles, formed by the joining of many vesicles that contain water with different compounds
- Function - in plant cells they are important in maintaining a turgor pressure

Ribosomes - non-membrane bound
- Structure - small spherical organelles composed of two subunits(large and small) and made of ribosomal RNA and protein. Its either found on the rough ER or in the cytoplasm.
- Eukaryotic cells - main type is 80S(svedberg - unit to measure rate of particles settling at the bottom of a centrifuge) ribosomes. These type of ribosomes contain a 1:1 ratio of RNA : proteins and consists of a 60S large subunit and a 40S small subunit
- 70S ribosomes - in the mitochondria and chloroplast - more common in prokaryotic cells. Made up of a 50S large subunit and a 30S small subunit and ratio of RNA:Proteins is 2:1
- Function - translate genetic information in the form of mRNA to form proteins

Centriole - non-membrane bound
- Structure - made of microtubules, found next to the nucleus of animal cells
- Function - move chromosomes around by forming spindle fibers during cell division

Cell Wall - non-membrane bound
- Structure - usually contains three layers and is mostly made up of cellulose
- Function - provides tensile strength and protection against osmotic stress. It also allows cells to develop turgor pressure.
-

Prokaryotic Cells – contain no double-membrane bound organelles



Flagellum - long hair-like structure that rotates to make the cell move, not all prokaryotic cells have them and some may have more than one.
Plasmids - small loops of DNA that aren't part of the main circular DNA molecule. Contain genes for antibiotic resistance that can be passed between prokaryotes.
Mesosomes - inward folds in the plasma membrane. Some believe they play a role in cellular processes and some think they are just artefacts produced when preparing the cell for viewing by a electron microscope.
Capsule - slime(a type of protein) which can stop the cell drying out, sticks the cells together or is a form of protection against the hosts digestive enzyme