Lecture 2

The most abundant elects in the universe is hydrogen, helium (running low on earth even though its the second most abundant element in the universe), oxygen and carbon.

Water-
water is two hydrogen atoms bonded to an oxygen atom. As the oxygen has a greater nucleus, the electrons of the hydrogens are pulled towards the oxygen. This creates a polar molecule as the charges are not evenly distributed. The slightly negative part of one molecules is drawn towards the positive part of another creating a hydrogen bond.

Capillary action of water allows for water to defy gravity and move up a tree to leaves at its peak. The water being released from a leave's stomata, the water in the plant is pulled up the tree. This is due to water molecules being attracted to one another.

At the surface of water, the water molecules at the top don't have any molecules above them meaning they must only react with the molecules to the side and the bottom of them. This gives a structure to the water. This creates water tension. due to hydrogen bonds, when pressure is added, it distorts and doesn't break (to a degree).

Water dissolves more substances than any other liquids. It is known as the 'universal solvent'. It will dissolve any polar molecule.

Fats an oils are hydrophobic. They are not charges at their poles and are not attracted to water. Soaps which have hydrophobic and hydrophilic ends are used to break up fats and oil droplets

Water expands and floats as it freezes. This is unique. In ice, molecules are further apart as a lattice structure full of holes. When water is a liquid, the molecules move and decrease the space between molecules. Ergo, more dense.

As humans, we make water as the body produces energy from fuels (fats, carbs, proteins, alcohol). Once glucose molecule yields 6 molecules of water.

What constitutes life-
CHONPS- carbon, hydrogen, nitrogen phosphorus, sulfur are the major elements of life. They are seen in quire uniform amounts across a range of organisms.

Stanley Miller (1953) set up a system to mimic conditions of early life. He collected a variety of organic compounds common in organisms. i.e. CH_2O, amino acids and hydrocarbons. Recently, small peptides have been identified in this same experiment.

This means organic molecules can be synthesised abiotically- without a biological system

A cell is the smallest uno of organisation that can perform all the activities essential for life. The actions of organisms are based on the activities of cells.

Cells share characteristics i.e. all cells have membranes and contain DNA. The two basic groups of cells is prokaryotes and eukaryotes. Eukaryotes have membrane bound

organelles. Prokaryotes don't. Most eukaryotes are larger than prokaryotes.

Characteristics of life-
- reproduce
- grow and develop
- respond to the environment
- metabolise to use and generate energy

Viruses are smaller and simpler than cells. They rely on the host to reproduce. They cannot carry out metabolism outside their host. They are not considered living.

Prions are infection proteins that appear to cause a variety of degenerative brain diseases such as ‘mad cow disease’. They cannot replicate themselves; they simply refold a normal protein into the shape of the prion. They are also not considered not living

At the highest level, life is classified into three domains, eukarya, prokarya, archaea (microbes living in extreme environments)

Lecture 3

Prokaryotes: Archaea-
- Similar in size of bacteria and vary in size
- often found in extreme environments
- Share some traits with eukaryotes e.g.. how they process DNA (transcription and translation) and synthesise proteins
- The composition of the cell membrane and its structure is unique to archaea
- can be found in humans (mouth and gastrointestinal tract)
- They are not pathogenic- cannot cause disease

Bacteria
- 10x more bacteria than human cells in a human
- have a range of morphologies (size and shapes)
- Most have a cell wall that can be classified as either Gram positive or Gran negative (the colour they stain when a particular stain is applied depends on their cell wall composition)
- many have features such as a flagella and the ability to produce endospores
- vary in their metabolism (some are photosynthetic, others require sugar, some are anaerobic)

Prokaryotes are normally smaller
- Bacteria are 1-5 um
- the smallest mycoplasma are 0.1-1 um

Eukaryotes are typically 10-100 um in diameter
The size is determined the surface area and the required diffusion that must offer between the environment and the cell (large limit). Also dependant on its ability to encapsulate and replicated DNA (small limit)

Both prokaryotes and eukaryotes have a
- plasma membrane- a selectively permeable barrier that surrounds a jelly like substance called cytosol
- DNA and ribosomes

Cytoplasm of eukaryotes includes the cytosol and the organelles excluding the nucleus

Prokaryotes-
- contain a single chromosome that is concentrated in the nucleoid which doesn't have a membrane

Eukaryotes
- carry chromosomes contained within a double membrane called the nucleus

Ribosomes-
- made of ribosomal RNA (rRNA) and protein
- they are not organelles as they lack a membrane
- they can exist freely in the cytosol or bound to the endoplasmic reticulum (depending on their function)
- number of ribosomes in cells will vary depending on the amount of protein synthesis that is required of the cell

Biological membrane
- the plasma membranes the structure separating the inside of the cell from the outside of the cell
- controls movement of materials into and out of the cell
- it is a phospholipid bilayer which have a polar hydrophilic head pointed towards the centre of the cell and two hydrophobic tails pointed towards the outside environments.
- The fluid mosaic mode describes the membrane as a fluid stricter were phospholipids and proteins can move two dimensionally. They are not static. They do not move up and down.

Organelles Look at textbook

- Mitochondria
- present in almost all eukaryotic cells and carry out respiration
- the number of them is determined by how metabolically active the cell is
- It has two membranes- the outer membrane which is quite porous letting many molecules through and an inner membrane which is selectively permeable and has many folds (christae) to increase its surface area
- inside the second membrane there is the matrix (many folds where the energy is made)
- they possess DNA which mainly focus on what the cell needs. Some extra proteins are transcribed and transcribed by the nucleus
- coloured greenish by cytochromes

- Chloroplasts
- has a double membrane
- have their own DNA
- contain green pigment- chlorophyll
- thylakoid membranes stacked are grant and reside in the stroma. This is where the DNA and ribosomes are

- Peroxisomes
- single membranes that contain enzymes that transfer hydrogen atoms to molecular oxygen forming hydrogen peroxide (toxic)
- they compartmentalise reactions forming damaging substances

- this is then converted to water

- describe the concept of endosymbiosis
- Endosymbiotic theory states that some organelles of eukaryotes, mitochondria and chloroplasts originated from the symbiosis of single celled microorganism
- An ancestral cell has taken up a non-photosynthetic eukaryotic cell and they have lived symbiotically
- eventually, the over generations they have formed a single cell

Endomembrane system-
regulates protein traffic and performs metabolic functions
- Endoplasmic reticulum
- some membranes are part of the endomembrane system i.e. ER
- membranes interact by physical contact or vesicle formation
- smooth ER doesn't have bound ribosomes. Makes lipids, stores ions, performs drug detoxification
- rough ER has bound ribosomes. Associated with secreted proteins

- Golgi body
- when proteins arrive from the ER they can be modified, stored and transported onwards
- it consists of cristernae- flattened membranous sacs with directionality. Normally a protein will go from the top of the body (cis side), go through the body and come out the trans side

- Lysosomes
- the membrane segregates an acidic environment auth contains enzymes that hydrolyse macromolecules
- lysosomes break down lipids, carbs and proteins into small molecules
- Lysosomes also remove junk and clutter i.e. pathogens

- Vacuole
- Vesicles derived from the ER or Golgi body that contain an environmental difference to the cytosol which differs depending on its function
- The central vacuole of plant cells act as an ion repository

- list and briefly describe the main components of the cytoskeleton

A cytoskeleton is a network of fibres that extend through the cytoplasm on a eukaryotic cell. There are 3 types of fibres giving the cell structure; microtubules, microfilaments and intermediate filaments

Microtubules
- hollow tubes
- 25-15 nm diameter lumen
- main function is maintenance of cell shape and motility (as flagella), chromosome and organelle movement

Microfilaments (actin filaments)
- two intertwined strands of actin

- 7nm diameter
- main functions are maintains and changes cell shape, muscle contractions, cytoplasmic streaming in plant cells, division of animal cells

Intermediate filaments
- fibrous proteins coiled into cables
- 8-12nm

main function is maintenance of cell shape, anchorage of nucleus and other organelles

Lecture 4

Objectives

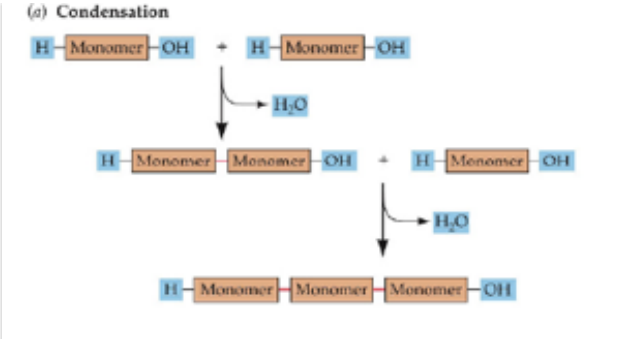
- Provide a broader definition of the term macromolecules
- A large organic molecule formed by the joining of smaller molecules, usually by a dehydration reaction (condensation reaction).
- They are chain-like molecules called polymers (with the exception of some lipids)
- polymer are formed by covalent linkages (very strong chemical bond) of smaller units called monomers (subunits)
- monomers may be identical or similar in their molecular structure
- list four major classes of macromolecules

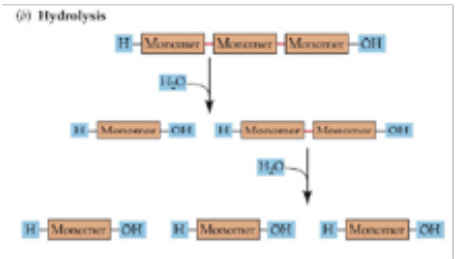
carbs, lipids, proteins, nucleic acids

Macromolecule	Monomer
Carbohydrate	monosaccharide e.g. glucose
Lipid	fatty acids (but some lipids are not polymers)
protein	amino acids
nucleic acids	nucleotides (with nitrogenous bases ACTG or U)

- explain the way in which macromolecules are synthesised and broken down by organisms

Building macromolecules (all 4 classes)
- macromolecules are made from smaller monomers through a condensation or dehydration reaction in which an(-OH) from one monomer is linked to a (-H) from another monomer. Water is produced





Breaking down
- The reverse reaction is a hydrolytic reaction. Water is added and is used to split the

covalent bond between two monomers

- briefly describe the general structural features of each of the four major classes of macromolecules

Carbohydrates—> monosaccharides
- The simplest form of carbohydrates e.g. glucose
- joining two monosaccharides creates water and a disaccharide. The bond between the monomers is called a glycosidic linkage or glycosidic bond
- polysaccharides are composed of hundreds to hundreds of thousands of monosaccharides each joined by a glycosidic bond. They act as energy store and transport molecules
- they also serve as a structural component
- Storage polysaccharides:
  - Starch- stored by plants as granules within various cellular structure. This stored energy can be later accessed via hydrolysis
  - Glycogen (highly branched polymer of glucose): stored by animals mainly in liver and muscle cells. Hydrolysis of glycogen releases glucose when the demand for energy increases

Lipids
- they're hydrophobic (non-polar) molecules
- they're insoluble in water and result from covalent bonds of hydrogen and carbons
- they are the one class that do not consist of polymers
- Function
  energy storage and transport- fats (triglycerols)
  structural components of cells- phospholipids, sterols
  chemical messengers- steroids
  photocreceptors- carotenoids
  coverings- wax

dehydration synthesis joints 3 fatty acid molecules to a glycerol by an ester

saturated fatty acids obtain only single carbon bonds i.e. no double bonds. They tend to be solids at room temperature

unsaturated fats contain one or more double bonds. This kinks the molecule. They tend to be liquids at room temperature

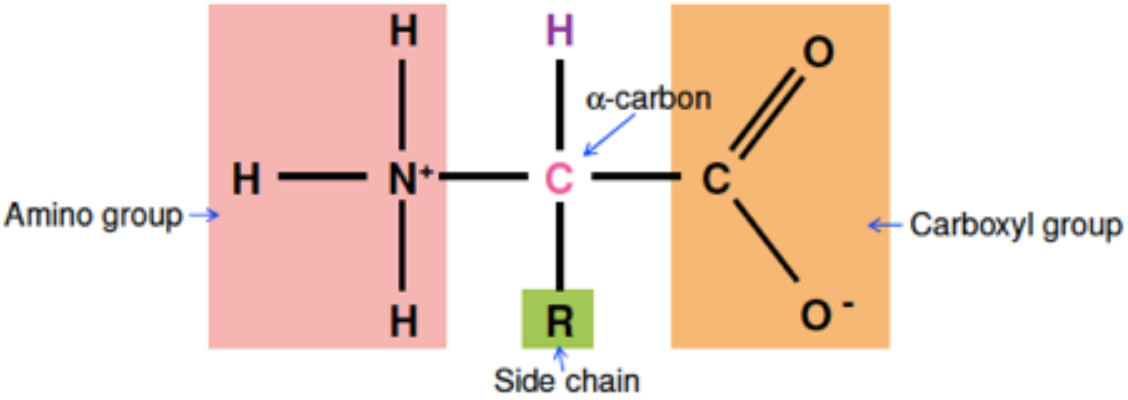
Phospholipids
- Have two hydrophobic fatty acid tails and one hydrophilic phosphate group head attached to the glycerol
- they orientate themselves so that hydrophilic phosphate group faces the water and the hydrophobic tails face away forming a phospholipid bilayer
- cell membranes are structured this way

Steroids
- e.g. cholesterol
- is found in cell membranes as an important component to maintain membrane fluidity

Nucleic acids
- nucleic acids are polymers of nucleotides
- there are two types- DNA or RNA
- the amino acid sequence of a polypeptide is determined by a unit of inheritance known as a gene which is composed of DNA
- DNA directs protein synthesis through mRNA

Proteins

- the function of proteins are related to their shape and chemical structure of their monomers
- some roles include energy storage, structural support, transport, protection and defence, regulation of metabolic activities, movement, growth and development and enzymes
- proteins are polymers of of amino acids. They are molecules with diverse structures and functions
- Folding is crucial to the function of a protein an dis influenced largely by th sequence of amino acids
- polypeptides are polymers that are unbranched and are built from 20 amino acids
- proteins are biologically functional molecules that consist of one or more peptides, each folded into a specific structure



- all amino acids share a common structure:
- a central carbon attar attached to
- an amino group (NH3+)
- carboxyl group (COO-)
- hydrogen atom
- a variable side chain- R
- Amino acids are classified based on the characteristics of their R groups
  some have charged hydrophilic side chains
  some are polar but have uncharged side chains
  some are non polar
  cysteine has a sulfhydryl)-SG) which can form disulphide bridges with other cysteine molecules
  glycine has a hydrogen atom as the R
  proline ahs a monidided amino group forming a covalent bond with the R group making a ring
- the bond between proteins are called peptide bonds between amino acids
- a functional protein consists of one or more polypeptides

- primary structure-
- the sequence of amino acids, starting at the amino end to the carboxyl end
- secondary structure- interactions between the backbone
- tertiary structure- a single polypeptide will fold. results from the kinds of bonds
- quaternary structure- the overall protein structure that results from the aggregation of two or more polypeptide subunits

- Enzymes
  they're catalytic proteins that selectively speed up chemical reactions without being consumed

enzyme activity can be significant affected by factors inc. concentration (of substrate and enzyme), temperature, pH
chemical reactions involve breaking and forming of bonds
the initial around of energy required to start a chemical reaction is called the activation energy
this energy is often supplied by temperature. The enzyme reduces the activation energy meaning a reaction is able to occur more frequently in a lower temperature
This is done by through the active site
if heated or ph is changed to much, the enzyme denatures