Life

LO1 List the major elements of life present in uniform relative amounts across organisms

- Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorus, Sulphur

LO2 Describe some properties of water that make it essential for life as we know it

Water

- Nearly all biological molecules have shapes and functions in response to water's physical and chemical properties
- Medium for most biochemical reactions that support life

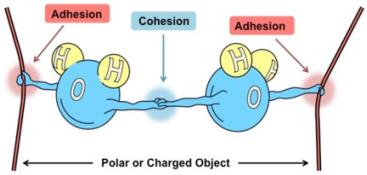
Water's structure

- 2 hydrogen atoms covalently bonded to an oxygen
- Oxygen is more electronegative (more proton to pull electrons) than hydrogen --> electrons unequally shared (polar) --> overall charge is not evenly distributed

Water adhesion

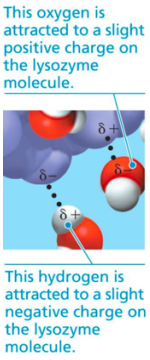
- Water form intermolecular associations with more charged/ polar surfaces e.g. glass walls of tube --> water flow in opposition of gravitational forces (capillary action)
- Capillary action: allow water to be transported up plant stems via transpiration system --> support life

Water tension - cohesion



- Water molecules at surface have strong hydrogen bonding which attract each other, resist low levels of external force e.g. small organisms can move along surface
- Water molecules near surface is exposed to air on one side, they are fewer water molecules to interact with hence form stronger bonds with surrounding water molecules e.g. below and adjacent

Excellent solvent e.g. sugar, CO_2



- Based on polarity in molecules
- A sphere of water molecules called a hydration shell, surround each solute ion
- Negative oxygen regions of polar water attract to Na+
- Positive hydrogen regions of water molecule attract to Cl-
- Lysozyme, water soluble protein (tears, saliva) has ionic and polar regions on its surface to attract partially charged regions on water (since it's polar)

Density of water

- Need high thermal energy to heat (high specific heat capacity) --> allow expansion
- Liquid form --> water interact more with hydrogen bonds getting closes together--> close proximity --> dense

Density of ice

- Low temperature --> molecules are further apart → interact less --> hydrogen bonds hold them in crystal lattice (spacious) --> less dense (ice has less molecules in equal amount of water) --> floats
- When water freezes, it floats on top but still allowing living organisms under to survive
- Each molecule is hydrogen bonded to four neighbours in 3-dimensional crystal

LO3 Changes in pH affect living organisms

Water is amphoteric

- Water can be ionized --> produce H+ / OH-
- pH of blood - 7.4 - buffered - prevents pH to change drastically which may affect physiological processes
- Respiration: $CO_2 + H_2O$ <--> H_2CO_3 <--> $H^+ + HCO_3^-$ (equilibrium shifts)

pH and body

- Skeletal muscle - anaerobic metabolism → lactic acid builds up (H+ is released) --> decrease pH (acidification of blood by ketonic bodies) --> coma in untreated diabetes
- Muscle glycogen (stored glucose) --> lactate to generate ATP

Water acidification

- When CO_2 is dissolved in water --> carbonic acid → dissociates to H+ (lowers pH) and HCO_3^- (bicarbonate ions)
- H+ combines with CO_3^{2-} and form more HCO_3^- --> less CO_3^{2-} available for calcification (formation of calcium carbonate) by marine organisms e.g. corals

Cells I

LO2 Explain how the diversity of life is classified

Classification

- Biologists identified about 1.8 million species → Classify into species and broader classifications
- Before: examining structures, functions, other obvious features
- Now: nucleic acid comparisons e.g. 16s rRNA in bacteria

Prokaryotes

1. Bacteria (domain)
   - Most diverse, widespread prokaryotes --> classified to multiple kingdoms
   - Range of morphologies (sizes, shapes)
   - No defined nucleus – Circular shaped DNA (circular chromosomes + plasmids) in contact with cytoplasm
   - Most have cell wall --> Gram positive (when bacteria are stained with purple as it has a thick layer of peptidoglycan protein polymer in cell wall)/ Gram negative (when bacteria are stained with pink)
   - Other features e.g. flagella - ability to produce endospores
   - Vary in metabolism - can respire not with oxygen

2. Archaea (domain)
   - Live in extreme environments e.g. salty lakes, boiling hot springs
   - Include multiple kingdoms
   - No defined nucleus - DNA in contact with cytoplasm
   - 2 µm - similar in size to bacteria but vary in shapes
   - Share some traits with eukaryotes e.g. process DNA and synthesise proteins BUT have unique features
   - Associate with humans e.g. mouth, gastrointestinal tract --> not pathogenic, unlike bacteria

Eukaryotes (domain)

Plant (kingdom), Fungi (kingdom), Animal (kingdom)

Protists

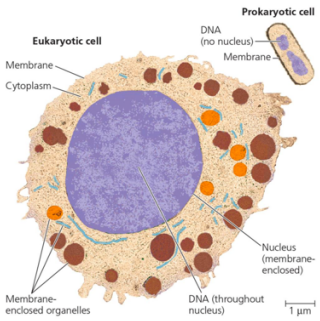
- 100 µm
- Mostly unicellular and some simple multicellular relatives

LO3 Define what a cell is

- Smallest unit of organisation that are specialised to perform all activities essential for life e.g. muscle cells
- All organisms are made of cells and have a membrane

LO4 List some characteristics of life

- Reproduce
- Grow and develop
- Respond to environment
- Metabolise to use and generate energy



▲ Figure 1.4 Contrasting eukaryotic and prokaryotic cells in size and complexity.

How about Viruses? - non living

- NOT A CELL - just DNA or RNA surrounded by protein
- Dependent on host cell's function for protein synthesis → no metabolism outside host
- NO ribosomes

How about Prions? – non living

- Infectious proteins (misfolded form) - cause degenerative brain diseases e.g. mad cow disease
- Can't replicate themselves

LO5 Explain the fundamental differences between prokaryotes and eukaryotes

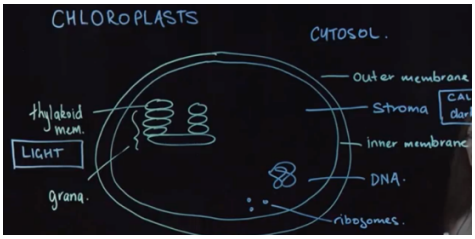
	Eukaryotic	Prokaryotic
Size	10 - 100 µm	Simpler, smaller Bacteria 1-5 µm; mycoplasma 0.1-1.0 µm
	Unicellular (amoeba, yeasts) / multicellular	Unicellular
Complexity	Membrane bound organelles - have nucleus enclosed in membrane	Lack organelles (No membrane bound structure)
DNA position	Linear chromosomes inside double membrane bound nucleus	Single, circular chromosome concentrated in nucleoid (not membrane bound)
Cytoplasm - everything inside cell	Between cell membrane and nuclear envelop (organelles outside nucleus)	Inside cell membrane

In common

- Plasma membrane (cell membrane) - double layer of specialised lipids (phospholipids)
    1. Selective barrier (semi-permeable) - separates cells' interior from surroundings
    2. Cytoplasm - region between membrane and nucleus - contains organelles
    3. Cytosol - jelly-like fluid filling cytoplasm - contain macromolecules, water, glucose, amino acids, ions - separated into compartments by membranes, fluid between organelles
    4. Controls traffic of materials into and out of cell (sugar, ions, amino acids, water)

- DNA (chromosomes)
    1. Contain genetic material of cell
    2. Use same genetic code (ATCG)
    3. All cells replicate their DNA and produce proteins by transcribing DNA to RNA and translate to proteins one amino acid at a time

- Ribosomes (protein synthesis)- made of ribosomal RNA and protein
    1. Not considered organelles - not surrounded by membranes
    2. Can exist free (in cytosol) or bound (nuclear envelop) state



LO6 Describe the concept of endosymbiosis

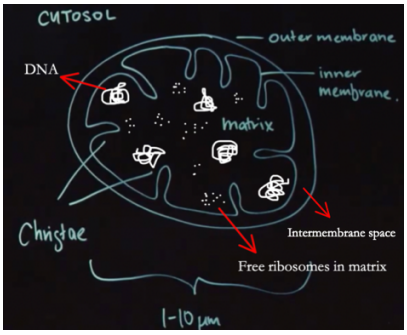
Eukaryotes: organelles

Chloroplasts

- Green portions of plants with green pigment - chlorophyll
- Double membrane: outer membrane, inner membrane; space between outer and inner = intermembrane
- Within chloroplasts - stacks of thylakoid membranes (light reactions of photosynthesis – Hill reaction) in stroma (dark reactions - Calvin cycle) = Grana
- Own circular DNA + ribosomes (make own proteins) --> independent activities (divide by binary fission)

Mitochondria - site of cellular respiration

- Found in almost all eukaryotic cells - fungi, animal, plant cells
- Inner membrane: selectively permeable + cristae foldings (increase surface area)
- Area between outer and inner membrane: intermembrane space
- Fluid + area inside inner membrane: matrix (has different ion concentration than outside cell since inner membrane is selectively permeable) - mitochondrial DNA and free ribosomes are found
- The inner membrane allows different ion concentration across as it is selectively permeable



Endosymbiotic theory

- Explains how eukaryotic ancestral cells came to have organelles like eukaryotes found today
    1. Ancestors of mitochondria - oxygen-using non-photosynthetic prokaryotes
    2. Ancestors of chloroplasts - photosynthetic prokaryotes
- Endocytosis - taking in matter from living cell by invagination of its membrane

Oxygen-utilising

1. Eukaryotic ancestral cell engulfed an oxygen utilising prokaryote - symbiotic relationship (interaction between two different organisms living in close physical association and merges to a single organism overtime) --> cell can utilise oxygen
2. Many generations with cell division and multiplication --> mitochondria
   Evidence: mitochondria's own DNA is similar to proteobacteria (prokaryote) from genome comparisons

Photosynthetic

3. Eukaryotic ancestral cell engulfed a photosynthetic bacteria (cyanobacteria) --> has its genome
4. Many generations with cell division and multiplication --> chloroplast

Over a lot of time

- Modern eukaryotic cell that is capable of utilising oxygen and carry out photosynthesis