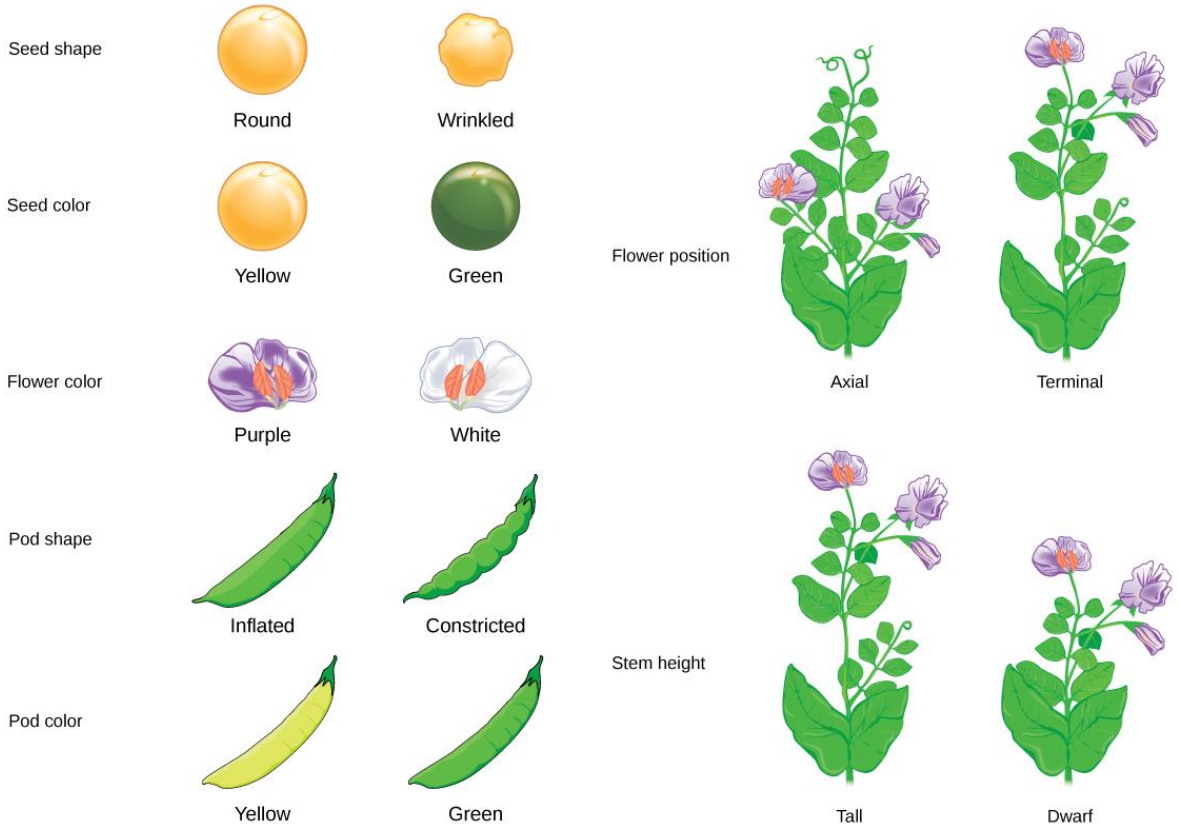
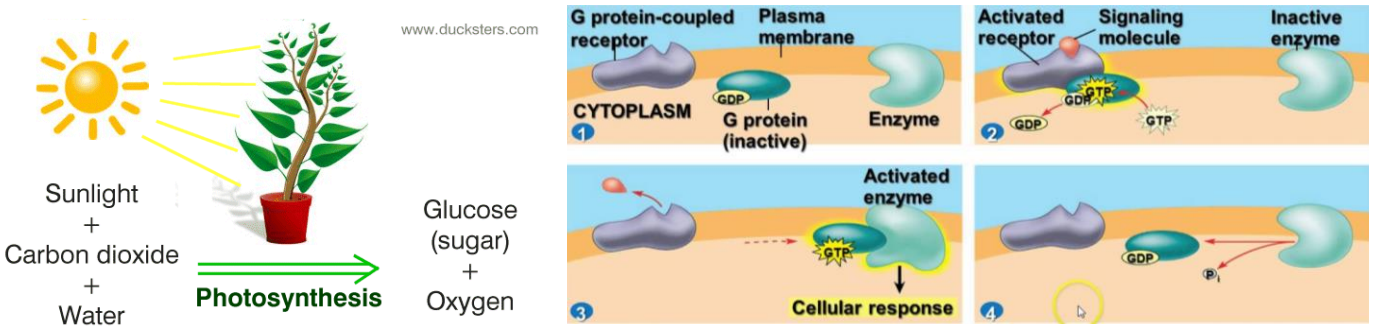




TOPIC NOTES FOR BIOL1102: MOLECULAR BASIS OF LIFE

Completed in 2016 with High Distinction

Contents

WK1: What's Science? And why do it? – (Professor Jim Mitchell)

In biology there are two main processes to scientific enquiry, discovery science and hypothesis-based science.

Discovery science: describing nature, this requires numerous observations and then extrapolating that pattern to ensure that it is consistent in all examples. However, there will always be uncertainty of this claim unless it is falsified.

Hypothesis-based science: explaining nature, it is used to seek the reasoning/explanation behind an observation.

"A hypothesis is a tentative answer to a well framed question, an explanation on trial."

A hypothesis must be testable and falsifiable (able to be supported or rejected).However, it cannot be proven merely supported, which occurs through multiple tests that attempt to disprove it.

In an experiment it is preferable to have two groups that differ by only a single factor. E.g. in a test on the effects of alcoholism there would be a control group of non-drinkers and an experimental group of drinkers. (this allows for a comparison to be made)

Scientific Theories: A broad explanation for a range of different phenomenon that may generate many specific hypotheses.

WK1: Cell Structure – (Professor Jim Mitchell)

All organisms are comprised of cells, which all share a set of common features:

- Bound by a plasma membrane
- They contain a semifluid substance called cytosol
- They contain Chromosomes
- They contain ribosomes

Cells are broadly divided into two different categories depending on their structure, prokaryotic cells or eukaryotic cells.

Prokaryotic cells are deemed simpler and less complex then eukaryotic cells. They lack a nucleus, instead their genetic material is found floating in the cytoplasm (this region where the DNA is located is called the nucleoid). Unlike eukaryotic cells, they also have no membrane bound organelles.

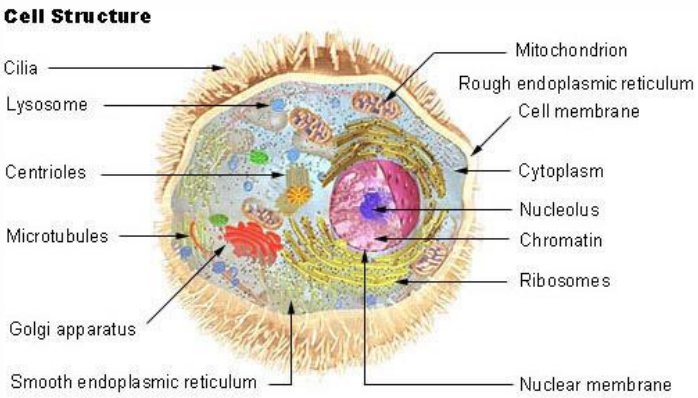
Prokaryotes were the Earth's sole inhabitants between about 3.5 to 2 billion years ago. However, they still make up most of the biomass on Earth and they can reproduce rapidly through binary fission, with some species dividing every 20 minutes.

Most prokaryotes are unicellular although some form colonies. The cells also come in a variety of shapes with spheres (cocci), rods (bacilli) and spiral being the most common. They also possess a cell wall which through the use of a technique called gram stain allows bacterial species to be classified as either gram-positive or gram-negative depending on the structure of their cell walls.

Most prokaryotes are able to propel themselves by specialised structures, either flagella or cilia.

Eukaryotic cells are much more complex and include the cells of animals, plants and fungi. These cells possess a true nucleus with the genetic material enclosed by the bi-lipid layer of the nuclear envelope. The primary differences that exist between animal and plant cells is that plants possess a large central vacuole, chloroplasts and a cell wall.

The cells contains an aqueous gel-like solution filled with molecules called cytosol. The cytosol and the organelles (excluding the nucleus) is referred as the cytoplasm. The cytoplasm and the nucleus together constitute the protoplasm.



Eukaryotic cell structure overview

Plasma membrane: A selective membrane allows for the passage of nutrients and waste both in and out of the cell.

Cytoskeleton: is a network of fibres that organises the structure and activities within the cell. It is composed of three types of fibres which also differ in the protein they are made of, microtubules (tublin), microfilaments (actin) as well as intermediate filaments (keratin).

Nucleus: an internal compartment within eukaryotic cells that house the DNA. It is encompassed by a bi-lipid layer called the nuclear envelope, which possess nuclear pores. Within the nucleus are spherical regions, nucleolus, that are the site of ribosome synthesis.

Ribosomes: composed of ribosomal RNA and proteins, these are large macromolecules that carry out protein synthesis.

Endoplasmic reticulum: there are two types of endoplasmic reticulum, smooth and rough. The smooth E.R. possess enzymes that allow this organelle to synthesise lipids, metabolise carbohydrates, store calcium and detoxify poison. The rough E.R. on the other hand is covered with ribosomes and is therefore a site of protein production (specifically cell membrane proteins, and proteins to be exported) and also produces membranes.

Lysomes: it is a membranous sac of hydrolytic enzymes responsible for macromolecule digestion.

Golgi apparatus: it is comprised of flattened sacs called cisternae. The Golgi apparatus manufactures certain macromolecules and modifies some of the products produced by the rough endoplasmic reticulum.

Mitochondria: this is the site of cellular respiration and are found in almost all eukaryotic cells. It is comprised of two membranes, a smooth outer membrane and an inner folded membrane with structures called crista, which maximise surface area via its shape. They also possess their own DNA.

Chloroplasts: are found in the leaves of plants and other green organisms. They possess chlorophyll which facilitates photosynthesis.

Cell wall: a structure of plant cells which distinguish them from animal cells. They are also made up of cellulose fibres.

WK2: Plasma membranes, fluid mosaic model and osmosis – (Professor Jim Mitchell)

The plasma membrane acts as a boundary between the contents of the cell and the surrounding environment. It is said to possess selective permeability, which refers to the fact that some substances cross more easily than others.

The fluid mosaic model refers to the fluidity of the plasma membrane as its components are free to move around, and while it is primarily comprised of phospholipids, it contains a mosaic of embedded proteins.

Lipids: are a class of hydrophobic, non-polar chemicals that include fats, phospholipids and steroids.

Fats: are comprised of two types of molecules, a single glycerol and usually three fatty acids. The fatty acids can either be saturated (maximum hydrogen atoms and only single bonded carbons) or unsaturated (possess one or more double or triple bonds).

Phospholipids: these are comprised of a phosphate group connected to two fatty acids. This results in a hydrophobic "tail" and a hydrophilic "head" making them amphipathic (both hydrophilic and hydrophobic regions). They comprise most of the plasma membrane in a bi-lipid layer and themselves are able to move within the membrane. This includes lateral movement (side to side which occurs approx. 10^7 times/sec) and flip-flop (approx. 1 time/month due to random lipid movement) flip-flop occurs so rarely due to the polarity differences of the phospholipids.

The fluidity of the phospholipids varies depending on the structure of the fatty acid chains. Unsaturated chains results in kinks increasing the fluidity. Saturated fatty acids produces straight chains, which increases its viscosity.

Steroids: an important example is cholesterol, which causes differences in the membrane's fluidity depending on the temperature.

Membrane Proteins

Proteins are found in two places on the membrane. Some are situated in the core of the hydrophobic lipid bi-layer and are called integral proteins. These are often transmembrane which completely span the membrane. Alternatively, there are peripheral proteins, which are loosely bound to the surface of the membrane.

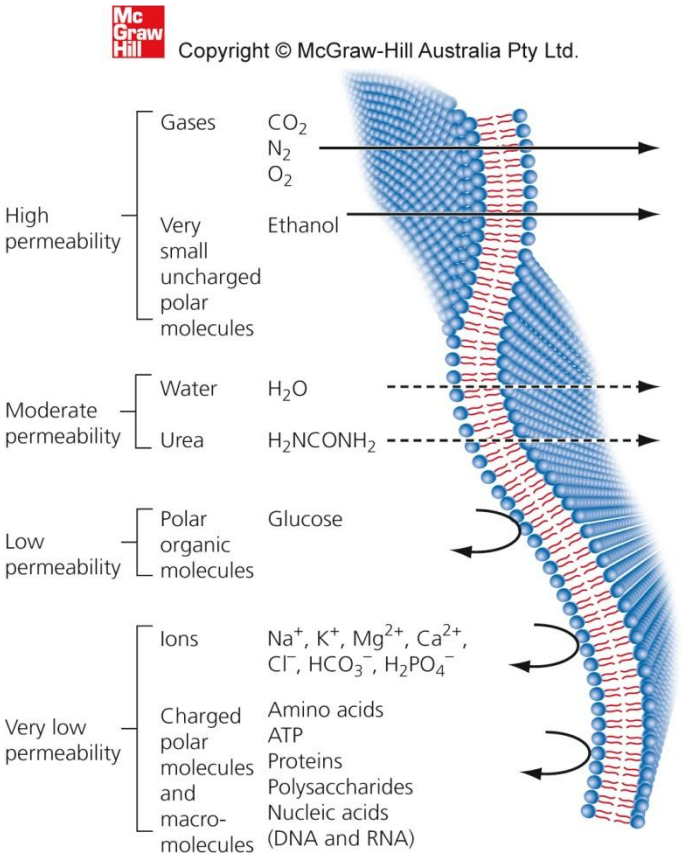
Proteins preform six major functions within the cell membrane.

- Transport: are able to transfer particles across the cell membrane. These can provide a hydrophilic channel that is selective for a particular solute. Others shuttle the substance across by changing the shape of this substrate.
- Enzymatic activity: these proteins are built into the membrane and possess an active site that alters substrates in the solution it is located at. Many enzymes can be situated together to form a team to carry out sequential steps of a metabolic pathway.
- Signal transduction: the protein acts as a receptor for a specific chemical messenger (such as a hormone) which relays messages to the cell.
- Cell-cell recognition: some glyco-proteins offer a form of identification, which is recognised by other cells.
- Intercellular joining: proteins that may 'hook' onto adjacent cells e.g. in muscles and organs

- Attachment to the cytoskeleton and extracellular matrix: some proteins bond to the cytoskeleton and assist in the maintenance of cell shape and stabilisation. Proteins attached to the extracellular matrix are involved in co-ordinating extra- and intracellular changes.

Lipid bi-layer Permeability

- Hydrophobic molecules: are lipid soluble and can pass through the membrane rapidly
- Polar molecules: can pass the membrane but not rapidly



Diffusion: the tendency for molecules to spread-out evenly (to move down/with their concentration gradient)

Osmosis: the diffusion of water across a semipermeable membrane. This is affected by the concentration gradient of dissolved solutes.

Tonicity: the ability of a solution to cause a cell to gain or lose water. This has a large impact on cells without cell walls.

- Isotonic: solute concentration is equal on both sides of the membrane (therefore no net water movement)
- Hypertonic: solute concentration is greater outside than inside the membrane causing the cell to lose water and shrivel.
- Hypotonic: solute concentration is less outside than cell than inside, causing the cell to gain water.