Biology

Cell Structure & Exchange

(49 pages)

Contents

cells together. This sticky region can be seen as a line on electron micrographs and is called the middle lamella. When stretched around an expanded (turgid) cell, the cell wall makes a considerable contribution to the support of non-woody structures, e.g. leaves.The cell wall is fully permeable to water and dissolved solutes, but influences the exchange of these across the partially permeable cell membrane, by exerting various physical and chemical forces.The wall is perforated by tiny holes, through which strands of cytoplasm (**plasmodesmata**) pass giving direct communication between neighbouring cells.

In 'woody' parts the cell wall is impregnated with **lignin**. Lignin is a hard, impermeable substance, and lignification typically results in the death of the cell. Such dead lignified tissues are specialised for water transport (e.g. xylem) and support (e.g. xylem and sclerenchyma fibres).

As cells in a multicellular organism become more specialised (differentiated) for particular activities e.g. transmission of impulses in nerve cells, they lose the ability to carry out some of the life processes, e.g. under normal circumstances most nerve cells lose the ability to divide. However, if some of these differentiated cells are removed from the body and kept isolated in a special culture solution they are capable of surviving on their own, and may even regain some of the lost abilities, such as the ability to divide.

Multicellular organisms may also produce single cells which can live independently, e.g. spermatozoa.

Cells which lose their nucleus cannot survive or divide, because the nucleus controls all the life processes. If an Amoeba is cut into two, the part without the nucleus dies, but the part with the nucleus lives, grows and reproduces.

Cheek lining (squamous) cell under light microscope

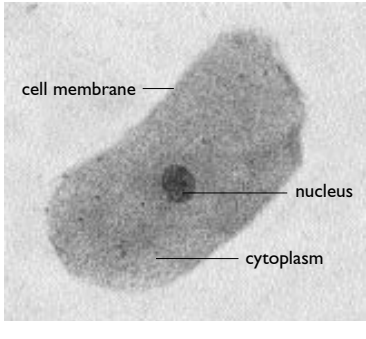
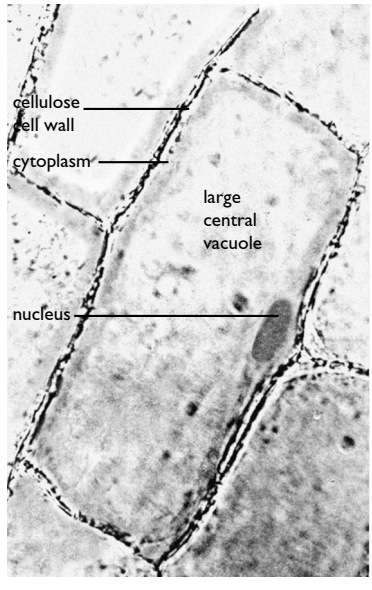


Table of differences between typical animal and plant cells seen under the light microscope.

Animal cells	Plant cells
Cell surface membrane	Cell surface membrane secretes cellulose cell wall
Small scattered vacuoles	Large central vacuole surrounded by membrane (tonoplast)
No chloroplasts	Chloroplasts with starch grains (in cells exposed to light)

Onion epidermis cells under light microscope



◆ CHECKPOINT SUMMARY

- ◆ Eukaryotes do have a true membrane bound nucleus containing chromosomes of DNA and histone proteins, and membrane bound organelles as described previously
- ◆ Eukaryotic cells typically form tissues in multicellular organisms
- ◆ Cell differentiation and specialisation prevent the easy definition of typical animal and plant cells
- ◆ 'Typical' cells would be those considered to show features common to the vast majority of cells in animals or plants
- ◆ A squamous (pavement) epithelium cell from the lining of the mouth could be considered as a 'typical' animal cell
- ◆ A mesophyll cell from a leaf could be considered as a 'typical' plant cell
- ◆ Under the best light microscope both the typical animal cell and the typical plant cell can be seen to possess a cell surface membrane, cytoplasm, nucleus with nucleolus, mitochondria, endoplasmic reticulum, and Golgi body
- ◆ In addition the typical plant cell can be seen to possess a cell wall around the cell surface membrane, a large central vacuole surrounded by the tonoplast membrane, and chloroplastids.

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The electron microscope and the technique of cell fractionation in the study of ultrastructure

Contents

Electron microscopes

- The difference between magnification and resolution.
- The principles and limitations of transmission and scanning electron microscopes

Cell ultrastructure

- Interpretation of electron micrographs (see teaching guides)
- Identification of the principal features and organelles of a eukaryotic cell. Cell wall and plasma membranes, nucleus, chloroplasts, mitochondria, lysosomes, ribosomes, endoplasmic reticulum, Golgi apparatus, microvilli and vesicles.
- The functions of these structures
- The principal features of a bacterium. Cell wall, capsule and genetic material

Cell fractionation

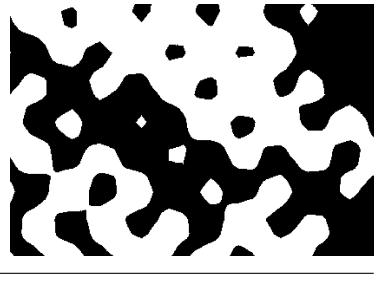
- Principles of cell fractionation and ultracentrifugation as used to separate cell components

ELECTRON MICROSCOPES

The difference between magnification and resolution

Magnification

For the visual study of cell structure it is necessary to enlarge (magnify) them by the use of microscopes. **Light microscopes** that you are most likely to come across in general Biology laboratories usually magnify up to 400 times (special techniques could take this up to 1000 times). However, to continue magnifying objects past a certain point reveals no further detail. In order to see more detail it is necessary to upgrade the resolving power (resolution).

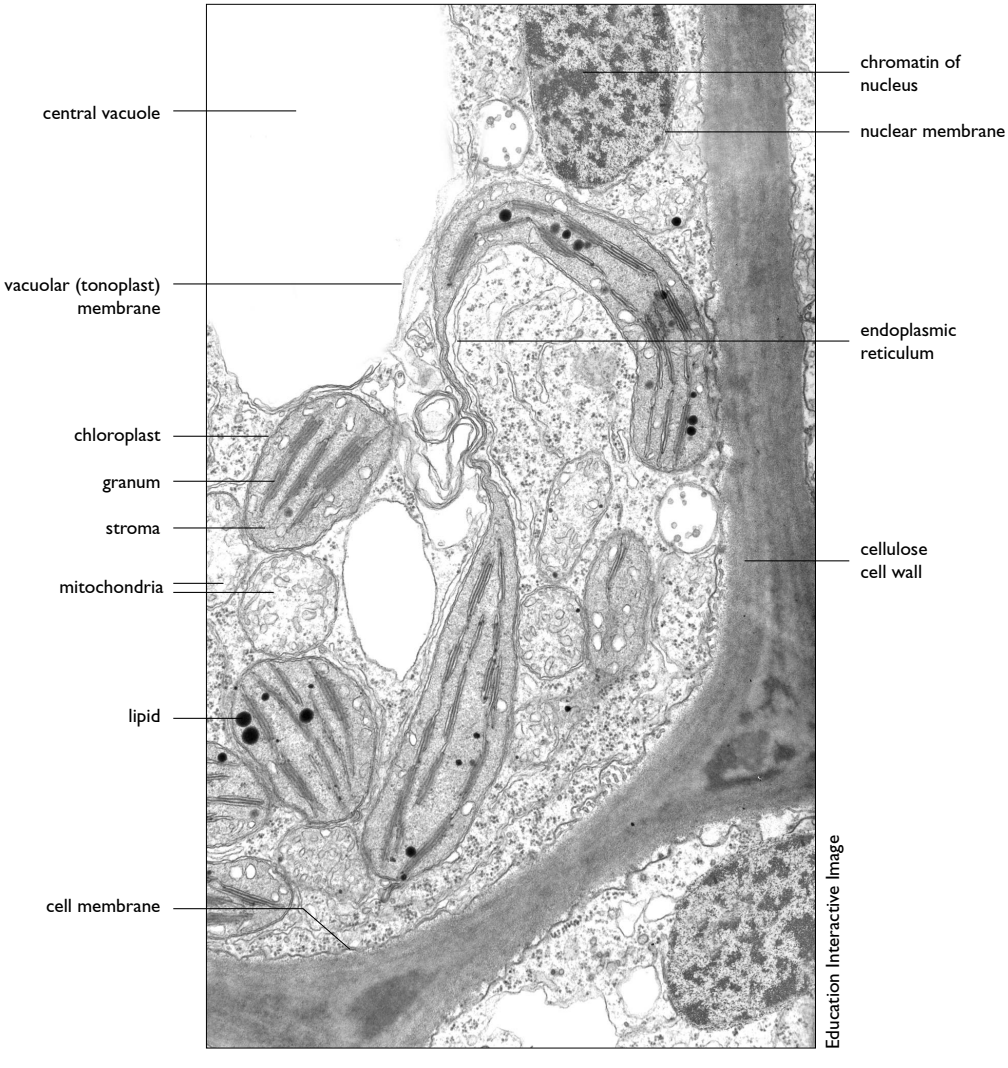


Resolution

Resolution or resolving power can be defined as the ability of an optical system (e.g.the light microscope, the eye) to distinguish (resolve) detail in an image of an object.

The amount of detail that can be seen in an image is determined by the resolving power of the microscope system being used. In the case of looking at material under the light microscope the resolving power depends upon the light being able to distinguish this detail. To do

EM part of plant leaf cell



Nucleus - the Control Centre

Even with the optical microscope, the nucleus is clearly visible, having an average diameter in animal cells (liver) of about 5 μm, and in plant cells (mesophyll) of about 15 μm. The nucleus stands out when cells are viewed under the microscope because of the material **chromatin**, a mixture of DNA and protein, which takes up the stains used in slide preparations. Chromatin is the material which forms the chromosomes just before nuclear division. The nucleus is surrounded by a double membrane, the **nuclear envelope** which has the same structure as, and is continuous with, the other membrane systems of the cell. Three or four thousand large pores (up to 100nm diameter) perforate the nuclear envelope, but plugs of protein and RNA appear to fill the pores.

outside of the cell membrane (**intrinsic proteins)**. A third kind, (**transmembrane proteins**), pass all the way through the membrane to create special channels. The carbohydrate component of cell membranes consists of short polysaccharide chains joined to membrane proteins or fats forming **glycoproteins** and **glycolipids** respectively, which project outside the cell membrane.

Individual molecules of phospholipid and protein in the membrane have a degree of **mobility** within the membrane. This fluidity, coupled with the bubbled appearance of the proteins on the surface of membranes gave rise to the the term '**fluid mosaic model**' when the structure was first proposed. Cholesterol stabilises membranes by limiting the movement of phospholipid molecules within the membrane.

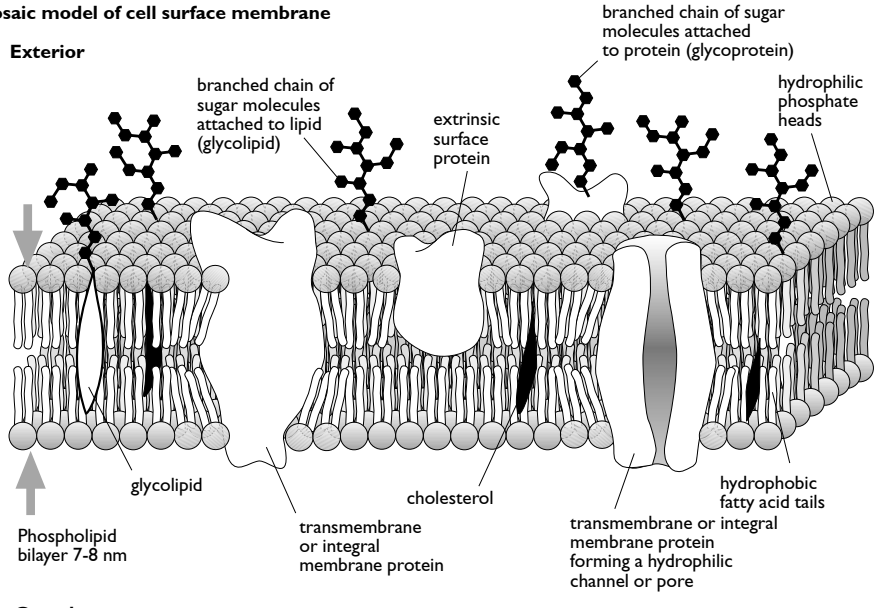
Cells have the ability to sense and respond to the presence of a great variety of molecules. This ability is due to proteins in the surface membrane which act as **receptors**. Hormones such as insulin and adrenaline, and many drugs and toxins lock onto recognition sites on receptor proteins triggering changes in the cell's behaviour.

Glycoproteins and glycolipids have a very important role in personalising a cell's identity. They are arranged in the membrane bilayer with the chain of sugar molecules to the outside. The possibility for variation in the structure and different combinations of these chains gives an endless range of different surface patterns, and forms the basis of a recognition system. Each individual has his or her own cell surface 'print'. 'Self' recognises 'self', and immune systems are mobilised when 'non-self' substances are encountered. The glycoproteins and glycolipids of the cell membrane are responsible for an individual's tissue type, a well known example of which is the blood groups.

◆ CHECKPOINT SUMMARY

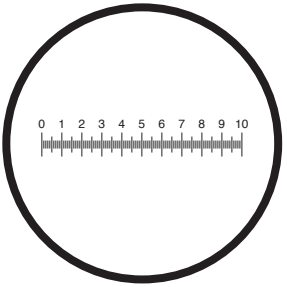
- ◆ All cell membranes are thought to share the same structure except the inner membrane of mitochondria
- ◆ This is based on a lipid bilayer formed from phospholipids aligning themselves with their hydrophobic poles next to each other within the membrane, and hydrophilic poles facing outwards
- ◆ This fluid arrangement is stabilised by the presence of another lipid - cholesterol
- ◆ Various proteins are embedded within this lipid bilayer
- ◆ Extrinsic proteins are found on the surface of the membrane
- ◆ Intrinsic proteins have one end embedded in the lipid bilayer and the other protruding out of the external surface of the membrane
- ◆ Transmembrane proteins span the lipid bilayer and create aqueous channels of pores through which water soluble substances can pass by diffusion.
- ◆ Short polysaccharide chains attached to proteins (glycoproteins) and to fats (glycolipids) protrude from the external surface and act as cell recognition sites (receptors or antigens)
- ◆ The patchwork arrangement of all these types of molecules in the lipid bilayer is the origin of the description 'mosaic'.

Fluid mosaic model of cell surface membrane

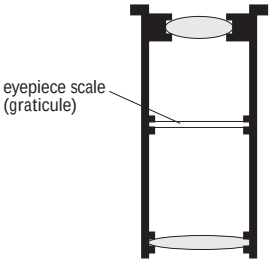


Measurement of size under the microscope

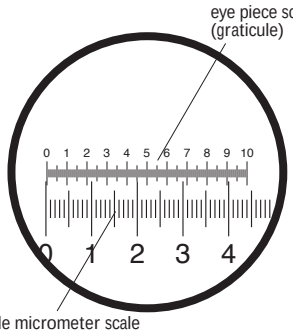
Eyepiece scale (graticule)



Eyepiece scale as seen when held up to the light away from the microscope.

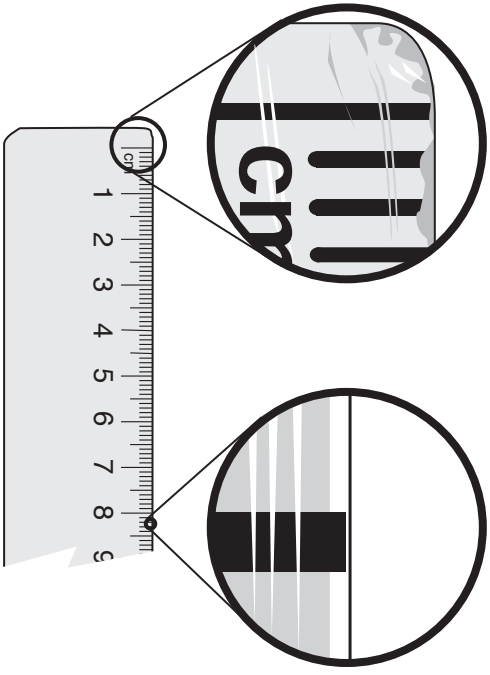


Scale in mm etched upon a microscope slide or a printed acetate sheet (slide micrometer)



Accurate measurements can be achieved using the two scales in combination through the lenses of the microscope.

More of the object is seen under low power objective lens



Less of the object is seen under high power objective lens

Questions & Mark Schemes