

AS Biology Syllabus 9700

Unit 1: Cells and Cell Division

Recommended Prior Knowledge

Little prior knowledge is required but a basic knowledge of cell structure would be helpful. Students should know that the cell is the basic unit of all living organisms and should have an understanding of the difference between tissues and organs. Early on, students will need to be reminded, or taught, how to use a microscope. They will progress to using a graticule and micrometer to measure cells and therefore should have the ability to carry out simple mathematical calculations.

Context

This Unit deals with topics that are fundamental to almost every area of study that will be covered in the AS course. Cell structure, and the functions of the various organelles, will reappear in numerous contexts. An understanding of the process and outcome of mitosis will underpin later studies of genetic control.

Outline

This Unit covers cell structure, the functions of organelles, and the mitotic cell cycle.

A Cell structure

- The microscope in cell studies
- Cells as the basic units of living organisms
- Detailed structure of typical animal and plant cells, as seen under the electron microscope
- Outline functions of organelles in plant and animal cells
- Characteristics of prokaryotic and eukaryotic cells

E Cell and nuclear division

- Replication and division of nuclei and cells
- Understanding of chromosome behaviour in mitosis

There are good opportunities within this unit for students to develop their practical skills relating to Assessment Objectives in Group C (Experimental skills and investigations). During the unit, each student should be given some opportunity to work alone and under time pressure in preparation for the practical examination(s). This Unit lends itself to reinforcement by group presentation to peers – at the end of the unit students could revisit the syllabus learning outcomes and decide how the topics could be divided up equally between groups. Once students have a good knowledge and understanding of the subject matter within the Unit they should then obtain practice in using the knowledge gained in new situations or to solve related problems (the final learning outcome in each section)

AO Learning outcomes

A (f)
draw and label low power plan diagrams of tissues and organs (including a transverse section of stems, roots and leaves)

Suggested Teaching activities

Revise / teach use of a microscope. It is often a good idea to allocate each student, or pair of students, a particular microscope that they will always use. Ensure that students know the difference between the terms *tissue* and *organ*. There is some overlap with section G, learning outcome (d): students will need some knowledge of leaf structure and tissue distribution in root and stem sections.

Teach students how to draw a low power plan (that is, showing distribution of tissues but not details of individual cells). Using a video camera that can be attached to a microscope or projecting an electronic image onto a screen enables students to see what they should observe and allows a description of how to draw the image.

Class activities

1. Identifying tissues and drawing low power plan diagrams of TS of a leaf, stem or root can make a good introduction to the use of a microscope.
2. This can lead to the calculation of magnification of drawings made from microscope slides. Fresh materials (e.g. *Elodea* sp. leaf), the Bioscope, photomicrographs or websites (search images) can also be used.
3. Students should progress to drawing individual cells under high power.

Learning resources

Bioscope.

Many university department and microscope manufacturer websites have wide collections of photomicrographs that students will find interesting e.g.

<http://micro.magnet.fsu.edu/index.html>

The CIE Publications **Catalogue** (published twice a year in March and September) is available on the website:

<<http://www.cie.org.uk/orderpub>>

Slides are available to order, including those used in previous practical examinations.

AS and A Level Biology shows an example of a photomicrograph of TS leaf and a plan diagram made from it (Chapter 1, p.19). Root TS and stem TS are shown in Chapter 10.

Comprehensive Practical Biology, has information on how to use a microscope and how to draw plan diagrams.

Bio Factsheet 75: Microscopes and their uses in Biology

AO Learning outcomes

A (a) use an eyepiece graticule and stage micrometer scale to measure cells and be familiar with units (millimetre, micrometre, nanometre) used in cell studies;

(g) calculate linear magnification of drawings and photographs;

(h) calculate actual sizes of specimens from drawings and photographs;

Suggested Teaching activities

Explain how to use a stage micrometer to calibrate an eyepiece graticule. If students always use the same microscope, then they can do this once for each objective lens, and keep a record of it. This means that they do not have to use the stage micrometer again, which is advantageous as it saves time. The eyepiece graticules can be fitted permanently into the eyepiece of the microscope. Stage micrometers can be expensive, but only one is required (see 'Online resources')
Students can use the Bioscope to learn the principles of use of the stage micrometer and eyepiece graticule.

Class activities

1. Students can use their calibrated eyepieces to measure a range of microscopic specimens. They should measure the actual length of a part of a leaf on a slide. If they then measure the length that they have drawn on their diagram, they can calculate the linear magnification of their drawing.
2. Students should be able to apply their knowledge and understanding to calculate actual sizes from diagrams, photomicrographs and electron micrographs using given scale bars or magnifications.
3. Using a selection of relevant calculation questions from past papers also serves to introduce students to the exam-style questions

Learning resources

Bioscope - a superb teaching and learning tool for the skills required to use a graticule and stage micrometer successfully.

<http://www.philipharris.co.uk/Default.aspx>
Philip Harris has very cheap micrometer graticules printed on transparent film, which you can cut out and use as eyepiece graticules or
<http://www.cie.org.uk/profiles/teachers/orderpub>
for less expensive stage micrometer scale kits and eyepiece graticules.

Practical Advanced Biology and **Comprehensive Practical Biology** have helpful information about calibrating a graticule and using it to measure cells.

Advanced Biology: Principles and Applications. Study Guide, Clegg and Mackean pub. John Murray also has a useful procedure to follow (out of print, but 'used' copies available)

AS and A Level Biology clearly explains the use of a graticule (Chapter 1, p.7).

Photomicrographs and electron micrographs in textbooks have magnifications – these can be used by students to practise calculations of actual lengths.

AO Learning outcomes

A (b) explain and distinguish between resolution and magnification, with reference to light microscopy and electron microscopy

Suggested Teaching activities

Revise the meaning of the term *magnification* – this can be done with reference to the calculation students have made of the linear magnification of their leaf drawing. Introduce the term *resolution*: students should be able to define and give further detail.

Students should understand that increasing magnification is only desirable up to the limit of resolution. E.g. up to approx. $\times 1000$ for the light microscope (electron microscopes vary with type and advances in equipment).

Explain briefly how light microscopes and electron microscopes work (do not be tempted to go into more detail than needed) and use this to explain why the resolution of electron microscopes is much greater than that of light microscopes. A brief comparison of the TEM and SEM (no details of working required), will enable students to see the difference between scanning and transmission electron micrographs and understand the usefulness of each type.

Having achieved the learning outcome, students should be in a position to apply their knowledge to suggest advantages and disadvantages of the two types of microscope.

Class activities

1. Comparison of photomicrographs with electron micrographs.
2. Research range of magnifications achieved with electron microscopes e.g. using examples from text book(s).
3. Observe a range of micrographs and identify whether light, scanning or transmission.
4. Suggest / research advantages and disadvantages of the light and electron microscope.

Learning resources

http://www.biology4all.com/resources_library/tails.asp?ResourceID=10

light micrographs of cheek cells and plant cells, which could be used to contrast with electron micrographs, or be used for calculating magnification

http://www.biology.arizona.edu/cell_bio/tutorials/cells/cells2.html

provides an idea of sizes and introduces the scanning and transmission electron microscopes

http://www.philipharris.co.uk/secondary/biology/examples_of_photomicrographs

AS and A Level Biology, has light and electron microscope photographs of the same cell at the same magnification, illustrating the differences in resolution (Chapter 1, p.8). It also has an illustrated explanation of scanning and transmission electron microscopes (Chapter 1, pp.10 &11).

Advanced Biology, Jones and Jones, pub. CUP, uses photographs to explain the difference between magnification and resolution.

AO Learning outcomes

- A
- (c) describe and interpret drawings and photographs of typical animal and plant cells, as seen under the electron microscope, recognising the following: rough and smooth endoplasmic reticula, Golgi apparatus, mitochondria, ribosomes, lysosomes, chloroplasts, cell surface membrane, nuclear envelope, centrioles, nucleus and nucleolus;
- (d) outline the functions of the structures listed in (c)
- (e) compare and contrast the structure of typical animal and plant cells;

Suggested Teaching activities

Knowledge of the term *organelle* is not a learning outcome but students would benefit from understanding the term and avoiding confusion with *organ*. Similarly, students should have an idea of the advantages of cellular compartments.

Using diagrams and photographs, question and answer and whole class discussion, describe the cell structures in turn and discuss their functions.

Provide an overview of how different cellular structures are linked e.g. broad outline of sequence of events in protein production and secretion involving different cellular structures. Remember that students will know virtually no molecular biology at this stage: avoid too much detail if this is likely to confuse.

Present students with electron micrographs, at various magnifications, and ask them to identify particular cell structures. Include examples of both plant and animal cells (names of cell types not required).

With reference to plant and animal cells, introduce the terms *eukaryote* and *eukaryotic*.

Class activities

1. From a range of different cell types, identify whether plant or animal, stating the features that enabled them to make the choice.
2. Tabulate the features of the organelles.

Learning resources

<http://www.rothamsted.bbsrc.ac.uk/notebook/dex.html>

covers most aspects of cell biology; links to sites. Also with many links:

http://www.biochem4schools.org/results_topic.htm?qry=cell_biology

<http://publications.nigms.nih.gov/insidethecell/chapter1.html>

details of cell organelles

http://www.cellsalive.com/cells/cell_model.htm

interactive animation of animal and plant cell

<http://learn.genetics.utah.edu/content/begin/cells/insideacell/>

interactive site (Genetic Science Learning Center)

<http://www.bscb.org/?url=softcell/index>

images of, and extension notes for, cell organelles (British Society for Cell Biology)

<http://cellpics.cimr.cam.ac.uk/>

Cell images

<http://library.med.utah.edu/WebPath/HISTHTML/EM/EM006.html>

EM of 'happy' mitochondria!

AS and A Level Biology, has a variety of useful photomicrographs, electron micrographs and diagrams.

Bio Factsheet 4: Structure to function in eukaryotic cell

AO Learning outcomes

- A (i) describe the structure of a prokaryotic cell and compare and contrast the structure of prokaryotic cells with eukaryotic cells;

Suggested Teaching activities

Show students photographs and diagrams of typical prokaryotic cells. Discuss the major differences between prokaryotic and eukaryotic (plant and animal) cells.

Reference could be made to the bacteria involved in the nitrogen cycle and to the bacteria responsible for cholera and TB. These microorganisms are referred to in Unit 5. (Note also that *Escherichia coli* will be referred to in the A Level course)

Encourage students to suggest functions of prokaryotic structures, applying their knowledge of eukaryotic cell structures. Link back to (A) learning outcome (b) and discuss the idea that mesosomes are now considered to be artefacts from preparation for electron microscopy.

Class activities

1. Draw diagrams and tabulate lists of the main similarities and differences between prokaryotes and eukaryotes. Summarise these differences into a few bullet points.
2. Label a diagram of a typical prokaryote.
3. Examine photomicrographs and electron micrographs selected to emphasise the similarities and differences between eukaryotes and prokaryotes.

Learning resources

http://www.biology4all.com/resources_library/tails.asp?ResourceID=52

a Flash animation about prokaryotes and eukaryotes

<http://www.cellsalive.com/cells/bactcell.htm>
illustrated information

<http://www.ucmp.berkeley.edu/bacteria/bacteria.html>

additional reading

AS and A Level Biology, clearly contrasts prokaryotic and eukaryotic cells (Chapter 1, p.17).

Bio Factsheet 73: The prokaryotic cell

Bio Factsheet 107: Answering exam questions – cells

AO Learning outcomes

E (a) explain the importance of mitosis in the production of genetically identical cells, growth, repair and asexual reproduction;

Suggested Teaching activities

Discuss with students how their own growth occurs, involving the growth and division of cells, and how damaged tissue is repaired by cell division.

Remind students that the nucleus contains chromosomes and that each chromosome is a length of DNA organised into functional units (genes). Students need to know that the DNA carries a set of instructions for the cell. This is sufficient detail at this stage, although some students may already know that the instructions allow the synthesis of proteins.

Bring out the idea that, when a cell divides, it is essential that each new cell obtains a complete set of these instructions. Explain that the cell division which achieves this includes a nuclear division called mitosis. Emphasise that the cells produced by mitosis are **genetically** identical, with the same set of instructions (DNA) as the parent cell and the same number of chromosomes. This could lead to a discussion of how cells could be rejected if the daughter cells were genetically different.

Consider some simple examples where reproduction occurs by processes based on mitosis, for example *Hydra*, or a locally available plant that reproduces asexually. Students are likely to come across the terms *clone* and *vegetative propagation* in their research, so these could be discussed briefly.

Class activities

1. Brief written explanation of the biological importance of mitosis, from bibliographic and web-based research.
2. Investigate examples of organisms that use mitosis for asexual reproduction.

Learning resources

<http://www.nature.com/scitable/topicpage/reproduction-and-distribution-of-dna-during-mitosis-6524841>

a good introduction to the topic.

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC256985/pdf/03-10-0043_p214.pdf

provides an overview of sites of interest for teachers to obtain a greater insight.

http://www.sciencecases.org/mitosis_meiosis/mitosis_meiosis_notes.asp

is an interesting way of approaching mitosis (and meiosis) as a 'court case'.

AS and A Level Biology, has a section on the biological significance of mitosis (Chapter 6, p.81).

AO Learning outcomes

E (b) describe, with the aid of diagrams, the behaviour of chromosomes during the mitotic cell cycle and the associated behaviour of the nuclear envelope, cell membrane, centrioles and spindle (names of the main stages are expected);

Suggested Teaching activities

Set up a demonstration of a 'model' on a desk or OHP of a diploid cell with 4 chromosomes – using string for the cell and nuclear membrane, and 2 short and 2 long pipe cleaners for the chromosomes. Demonstrate need for replication before mitosis by twisting a second pipe cleaner around the first, to give 8 pipe cleaners in the nucleus, explaining that each pipe cleaner is a chromatid, and that each chromosome is now made up of two identical chromatids.

Facilitate whole class discussion / question and answer to build understanding of how the chromosomes line up and how the chromatids of each chromosome separate to each end of the cell, why the nuclear envelope breaks down (to make room for movement of chromosomes) and why nuclear division takes place before cell division.

Provide prepared slides of plant root tips, and Bioscope slides for cells at all stages of mitosis. Students can also search the Web images for animal cell mitosis.

Students can gain more practice with the eyepiece graticule by measuring the relative length and width of chromosomes and cells. They can use the calibrated eyepiece graticule to measure the size of chromosomes in μm .

Class activities

1. Correctly sequence images of a cell at various stages during the cycle, naming the stages and noting chromosome behaviour.
2. Make annotated diagrams of the key events in mitosis.
3. Prepare and examine root tip squashes (garlic or onion root tips with acetic orcein or toluidine blue) showing mitotic stages.
4. Draw cells (HP) to show the appearance of chromosomes at various stages.

Learning resources

<http://www.rothamsted.bbsrc.ac.uk/notebooks/courses/guide/movie/mitosis.htm>
a simple animation

<http://faculty.nl.edu/jste/mitosis.htm>
explanatory diagrams, animations and text

http://www.biology.arizona.edu/cell_bio/tutorials/cell_cycle/main.html

University of Arizona web site has animations of mitosis and tests

<http://www-saps.plantsci.cam.ac.uk/worksheets/ssheets/ssheet17.htm>

a very clear protocol for making a root tip squash

http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter2/animation_control_of_the_cell_cycle.html
animation and quiz (also site has mitosis animation).

AS and A Level Biology, covers nuclear division in Chapter 6.

Both **Practical Advanced Biology** and **Comprehensive Practical Biology** have protocols for observing mitosis in root tips.

Bio Factsheet 76: The eukaryotic cell cycle and mitosis

AO Learning outcomes

E (c) explain how uncontrolled cell division can result in cancer and identify factors that can increase the chances of cancerous growth;

(d) explain the meanings of the terms *haploid* and *diploid* and the need for a reduction division (meiosis) prior to fertilisation in sexual reproduction;

Suggested Teaching activities

This topic is best dealt with by discussion. The timing of cell division is controlled by a number of genes; if several of these are altered then the cell may begin to divide uncontrollably. This may happen naturally, but the risk is increased by a range of different environmental factors.

In their research, students will come across the terms *mutagen* and *carcinogen* so it will be helpful to explain the difference between the two. Students will need to understand the term carcinogen for section H, learning outcome (e) and could also spend some time identifying the main carcinogens in tobacco smoke. Detail is not required but teachers may wish to discuss proto-oncogenes, oncogenes and tumour suppressor genes

Students must understand that there are genetic changes that result in uncontrolled division, which will cause an abnormal mass of cells to form. Explaining the difference between benign and cancerous (malignant) growths will help understanding. Students may be interested in international statistics of the frequency of different types of cancer around the world.

Class activities

1. Bibliographic and web-based research: construct a list of factors that can increase the chances of cancerous growth.
2. Individual brief written outline of how a cancerous growth originates and the impact of such a growth

The pipe cleaner model may be useful again here. A haploid cell has one complete set of chromosomes, whereas a diploid cell has two complete sets. Students usually have no difficulty in understanding the need for reduction division before fertilisation. Do NOT go into any details of meiosis.

Learning resources

http://science.education.nih.gov/supplements/h1/cancer/guide/guide_toc.htm support for teachers and students, includes animations

<http://www.who.int/whosis/mort/profiles/en/index.html#C> the World Health Organisation web site with data tables for causes of mortality in many different countries, which students could use to practise data handling as well as investigating the occurrence of deaths from cancers

two sites for background interest:
<http://www.sanger.ac.uk/genetics/CGP/Census/> cancer genome project
<http://info.cancerresearchuk.org/cancerstats/causes/genes/cancergenes/index.htm> latest information about cancer genes

AS and A Level Biology, has a section on cancer (Chapter 6, pp.85-87).

Bio Factsheet 104: Biological basis of cancer

http://www.accessexcellence.org/RC/VL/GG/ecb/haploid-diploid_sexual_reproduction.php has an illustrated example of how sexual reproduction involves haploid and diploid cells.

AS and A Level Biology, explains these concepts at an appropriate level (Chapter 6, pp. 78-80).