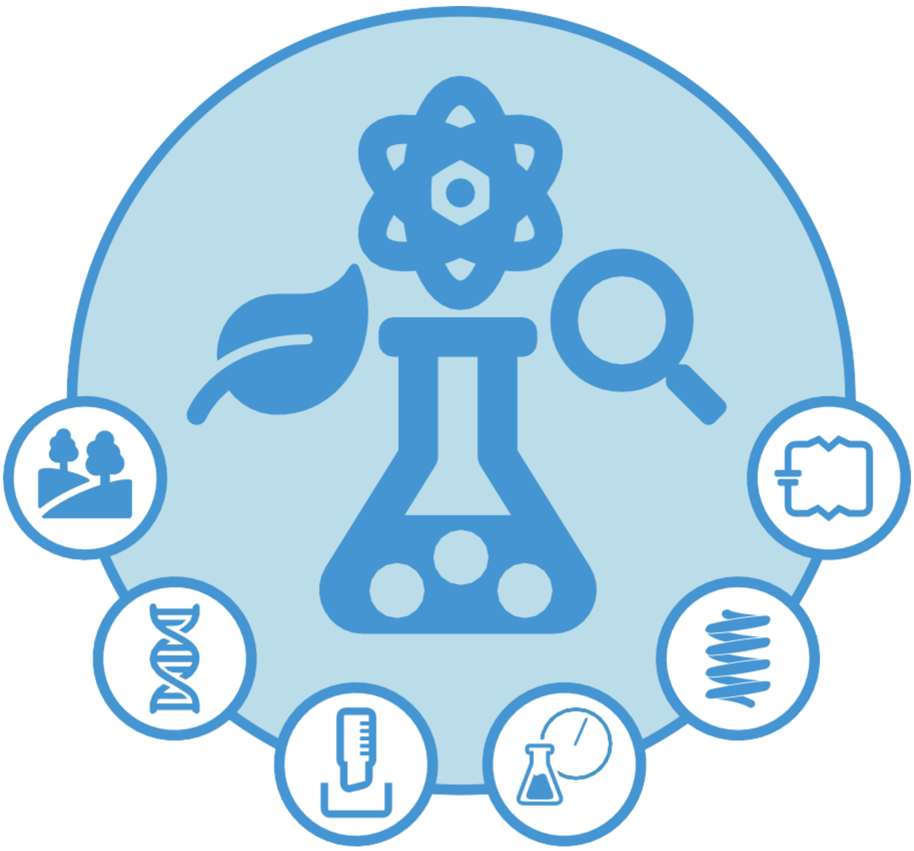
EXEMPLAR LESSON

THE STRUCTURE OF EUKARYOTIC CELLS



Acknowledgements

Ministry of Education

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CENDLOS, Ghana, for their collaboration and innovation in providing essential avenues for OpenSTEM Africa to reach learners and teachers.

Ghana Education Service, and the expert SHS science teachers, for their expertise in producing materials that are rooted in the Ghanaian school context, accessible and useful to learners and teachers.

For information on OpenSTEM Africa see: www.open.ac.uk/ido

OPITO for their generous support, which has made OpenSTEM Africa and the development of the Virtual Laboratory and these materials possible.

Contents

Exemplar lessons for the OpenSTEM Africa Virtual Laboratory applications

All the exemplar lessons are examples of lessons which could be used both individually and by whole classes of Senior High School (SHS) students in the elective sciences of Biology, Chemistry and Physics. Each of the lessons is linked specifically to one of the applications in the OpenSTEM Africa Virtual Laboratory. The exemplar lesson is created to give, both to SHS students and to SHS teachers, a clear example of the ways in which the applications can be used in the learning and teaching of practical science. There is a focus throughout the lesson on the student's development of the practical and experimental skills which, along with knowledge and understanding, are integral to the profile of learning, teaching and assessment in SHS sciences.

The 'you' in this lesson is 'you', the Senior High School student. Remember that you can repeat the experiments and activities in this lesson as often as you have time for in class. This freedom to repeat experiments and activities is also important if you are accessing the lesson outside the classroom, for example for homework. Every application in the OpenSTEM Africa Virtual Laboratory contains real data – the experiments are real experiments. This means you might make mistakes the first or second or third time you try an experiment or an activity – and that is exactly what often happens in the real world in the sciences. So, it is helpful for you as a student to share in some of the real-world trial and error of science as you develop your skills as a scientist.

The exemplar lesson also contains a set of teaching notes at the end of this document for 'you' the SHS science teacher, to suggest how you might want to set up this particular lesson with one of your classes. Hopefully it will also generate ideas for other lessons on the same topic, or other lessons which use the same OpenSTEM Africa Virtual Laboratory application.

The structure of eukaryotic cells

Lesson objectives

By the end of this lesson, you will be able to:

- Describe the basic structure of eukaryotic cells and give examples.
- Draw diagrams of plant and animal cells.
- Describe the similarities and differences between plant and animal cells.
- Explain the significance of key differences between plant and animal cells.

The following practical and experimental skills will be developed:

- Observation
- Manipulation
- Drawing
- Interpretation.

Background

In this lesson you will use a virtual light microscope to examine the structure of eukaryotic cells. Remember that living cells are divided into prokaryotes and eukaryotes. Examples of each type of cell are shown in Figure 1.

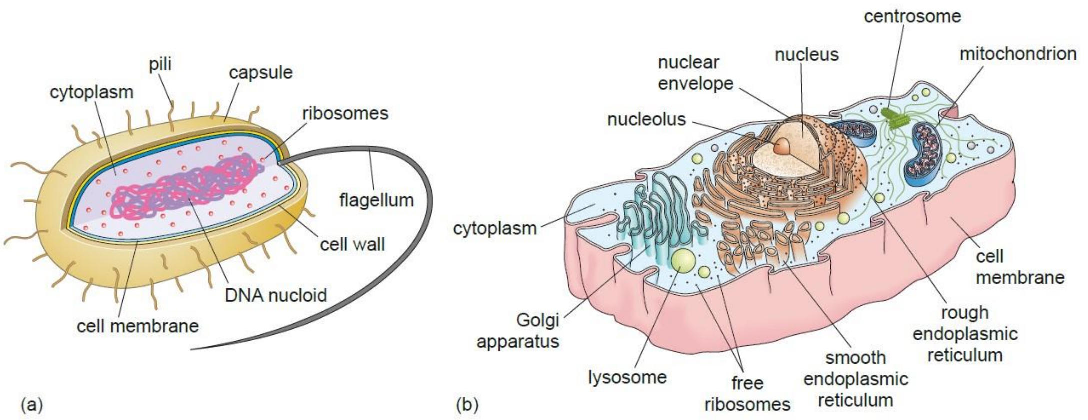


Figure 1. (a) an example of a prokaryotic cell; (b) an example of a eukaryotic cell.

What is the main difference you can see between the prokaryotic and eukaryotic cells shown in Figure 1?
Go to Appendix 3 for the answer.

All animal and plant cells are eukaryotic cells. This means they consist of cytoplasm, which is bound by a cell membrane. Within the cytoplasm are other membrane-bound structures, such as the cell nucleus. Organelles perform specific functions in the cytoplasm of eukaryotic cells and include the following structures:

- cell nucleus
- mitochondrion
- vacuole
- chloroplast
- rough endoplasmic reticulum
- smooth endoplasmic reticulum
- Golgi apparatus
- lyososome.

If you are unfamiliar with these terms, please refer to the Glossary section at the end of this lesson for a fuller explanation.

Can you think of an advantage that a cell might gain by having organelles?
Go to Appendix 3 for the answer.

All plant and animal cells are eukaryotic cells and generalised examples of both are shown in Figure 2.

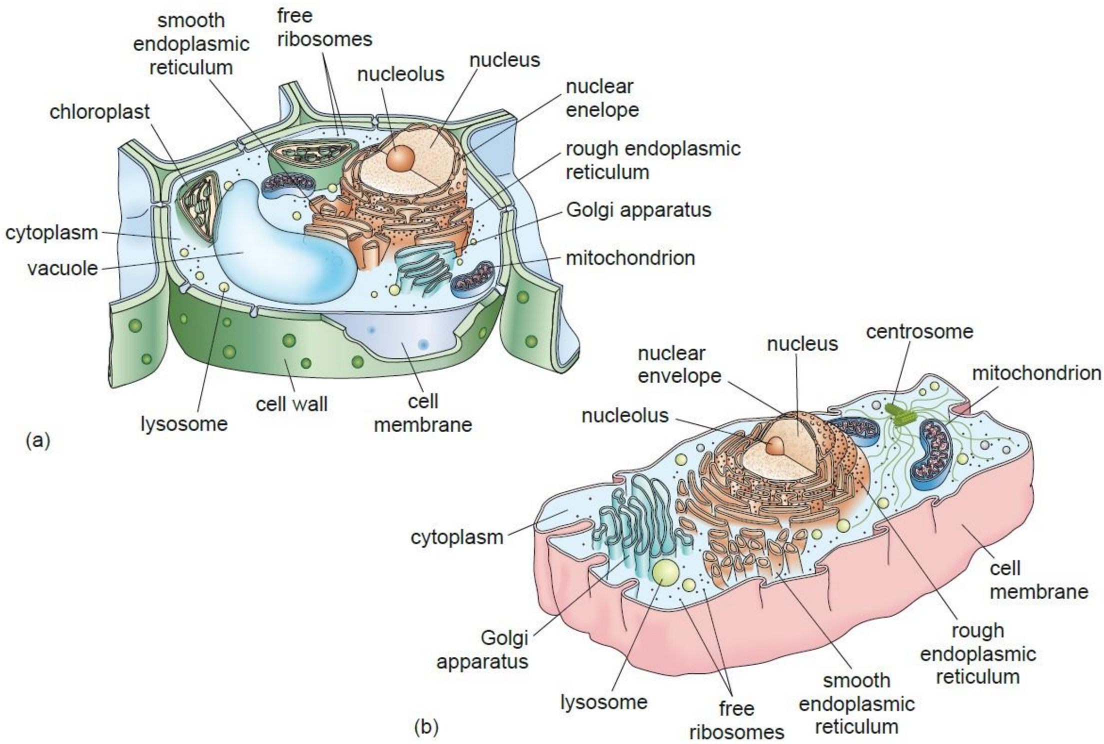


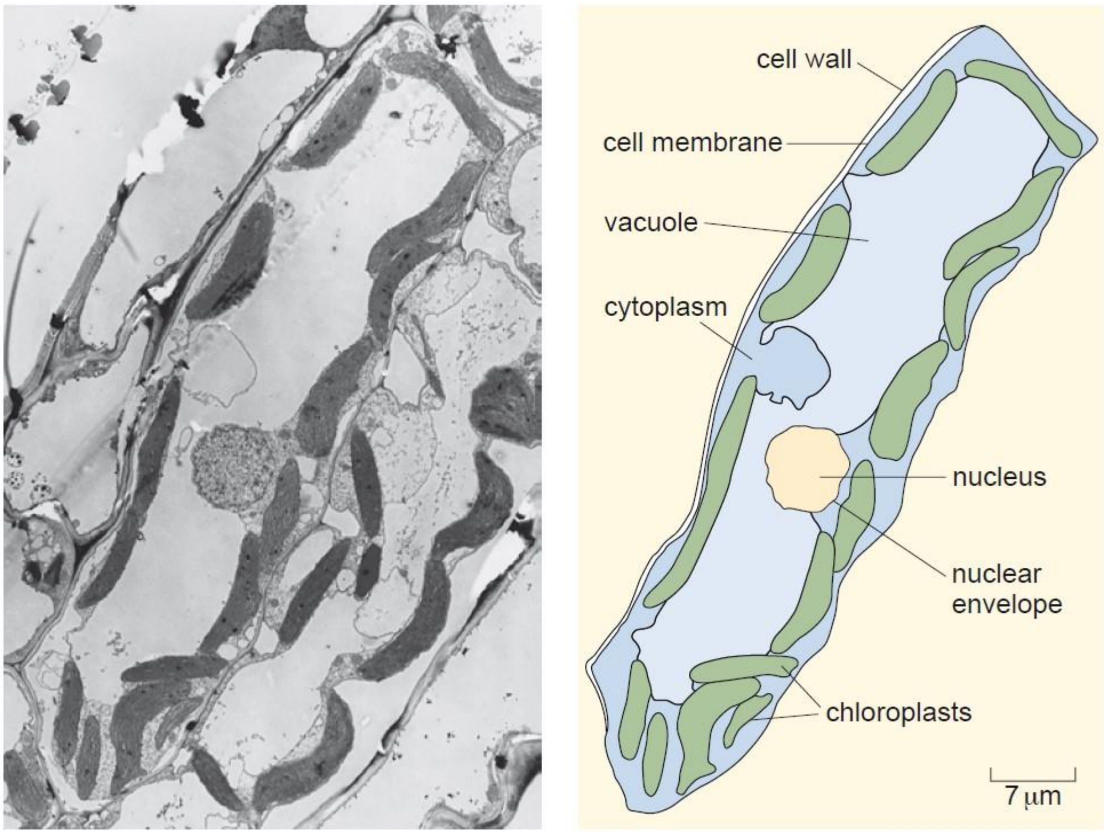
Figure 2. (a) a typical plant cell; (b) a typical animal cell.

The examples of eukaryotic cells shown in Figure 2 have been drawn in three-dimensional (3D) relief. This is so you can understand the shape and form of the cells, and structures they contain. The images you will see using the virtual microscope will be two-dimensional (2D), because they are observed in the focal plane of the microscope.

Activity 1

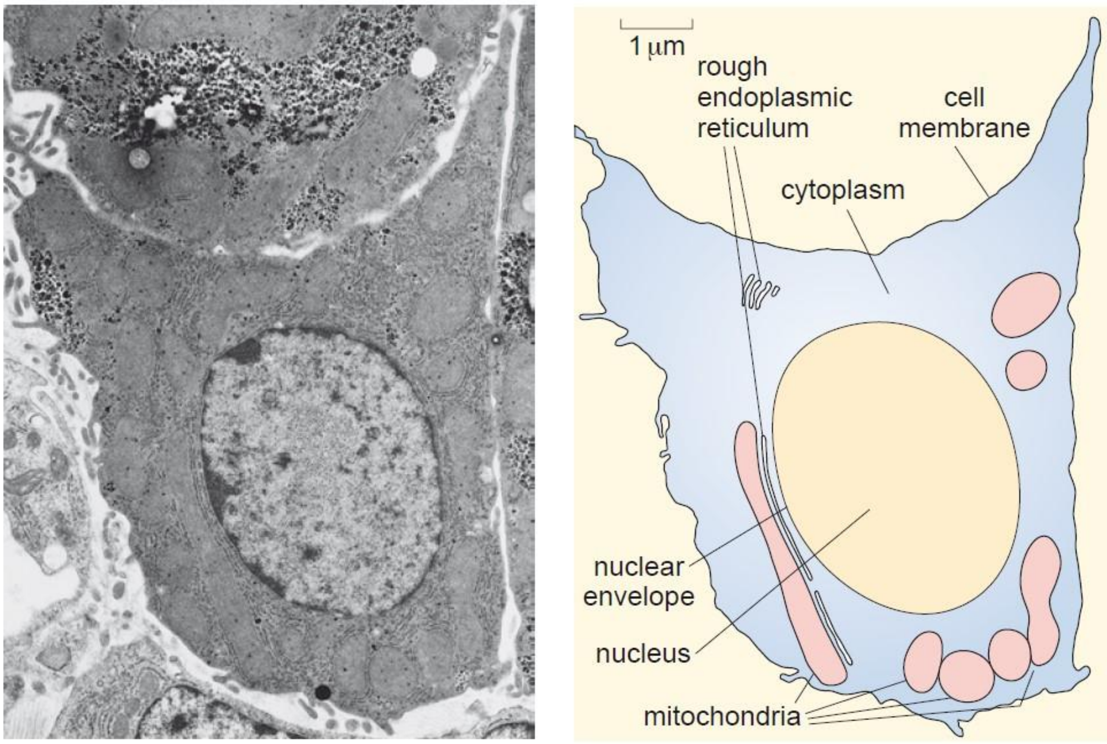
In your notebook, redraw each of the cells shown in Figure 2 as a simple 2D image and label the structures. If you are unsure what a 2D drawing looks like, refer to the ones in Figures 3(b) and 4(b) which are 2D drawings.

Not all organelles and cell structures are easily visible using a light microscope because the resolution is limited. Some such as mitochondria, ribosomes and the endoplasmic reticulum are best observed using an electron microscope, which uses a beam of electrons instead of light. The shorter wavelength of the electrons gives a better resolution. Figures 3 and 4 show electron micrographs of typical plant and animal cells.



(a) (b)

Figure 3. (a) an electron micrograph of a plant cell; (b) a 2D drawing of the plant cell shown in (a).



(a) (b)

Figure 4. (a) an electron micrograph of an animal cell; (b) a 2D drawing of the animal cell shown in (a).

Looking at Figures 3 and 4, what two conclusions can you draw based on the images shown? (Hint: look at the scale bars).
Go to Appendix 3 for the answer.

Now that you are familiar with the basic structure of eukaryotic cells it is time to use the virtual microscope.

Practical activity

In this activity you will use the virtual microscope to examine the structure of animal and plant cells.

Choose two animal cell slides and two plant cell slides from the slide set provided. In your notebook, write down the title of the slide, draw the cells you observe and wherever possible, label the structures you can see. Some slides will have more than one type of cell, so choose those cells that have more structural detail.

Click on the link below to access the application homepage. Before starting your investigation, first watch the introductory video to find out how the slide images were collected and how to use this virtual instrument.

Virtual Microscope
Go to the OpenSTEM Africa Virtual Laboratory. Click on the icon to access the Virtual microscope application homepage. Watch the introductory video before entering the experiment.

Summary

Now that you have had an opportunity to examine both plant and animal cells, you will have discovered that they share many structural features – yet there are also some major differences. You will have also observed that not all organelles are readily seen using a light microscope.

You should now be ready to take the end-of-lesson quiz, which will test what you have learned. Click on the link below to enter the quiz.

Quiz

Answer the questions, then search for the correct answers in Appendix 4.

Question 1

How do plant cells differ from animal cells?

Plants have the same organelles found in animal cells, but in addition have __________, and a vacuole, alongside a cell wall. Whilst the cell wall is not an organelle, it is nonetheless a distinctive structural component of a plant cell.

Select <u>one</u> word to fill in the gap:

[nucleus, mitochondria, chloroplasts].

Question 2

Which <u>one</u> of the following statements is correct?

1. Unlike animals, plants do not have bones or cartilage to help maintain their structure. Instead, they rely on cell walls and the vacuole to maintain their structure. The vacuole is the largest organelle found in a plant cell. It contains water and waste materials, which help it to provide internal pressure.

2. Unlike animals, plants do not have bones or cartilage to help maintain their structure. Instead, they rely on chloroplasts and sunlight to maintain structural integrity, particularly during the sunnier periods of the day.

Question 3

For each of the questions below, select the correct answer:

1. Which organelle found in plant cells converts sunlight into energy?
    a. Golgi apparatus
    b. Chloroplast
    c. Mitochondrion
2. Which organelle found in plant and animal cells contains most of a cell's genetic material (DNA)?
    a. Smooth endoplasmic reticulum
    b. Rough endoplasmic reticulum
    c. Cell nucleus
    d. Lysosome

Glossary

Cell wall – A structural layer that lies next to the cell membrane. It is tough and flexible, and can also be rigid, providing structural support.

Chloroplast – Plant cell organelles in which photosynthesis takes place. The layers of membranes within chloroplasts contain chlorophyll and are the site of the light reactions of photosynthesis.

Eukaryote – Eukaryotic cells contain membrane-bounded organelles, such as the cell nucleus. *Eu* the ancient Greek for *good* or *true*, and *karyon* means *nut* or *kernel*, referring to the cell nucleus – in other words, eukaryote means *true nucleus*.

Golgi apparatus – Modifies and prepares newly synthesised proteins for transport out of the cells. The proteins are packaged into vesicles that are made from the membrane walls of the Golgi apparatus.

Keratinised – Keratin is a fibrous structural protein found in skin, hair and nails. A cell that has a high concentration of keratin is said to be 'keratinised'. House dust consists mainly of dead skin cells and have a very high keratin content.

Lysosome – These membrane-bound structures contain digestive enzymes. They play an important role in removing excess or worn out organelles and other debris that can accumulate in a living cell.

Mitochondrion – (plural **mitochondria**)
These organelles are the site of aerobic respiration, a process that produces high levels of the energy molecule, ATP, the energy currency used by living cells.

Nucleolus – This structure is found within the cell nucleus and is involved in the production of ribosomes.

Nucleus – The organelle that houses DNA, the genetic material that contains the instructions required to make proteins and to sustain a living cell.

Phagocyte – A cell that is able to remove debris, pathogens, dead or dying cells by engulfing them. *Phago* comes from the Greek for *'to eat'*.

Prokaryote – Prokaryotic cells, such as bacteria, do not possess membrane-bound nucleus. *Pro* is the ancient Greek for *before*, and *karyon* means *nut* or *kernel*, referring to the cell nucleus – in other words, prokaryote means *before the nucleus*.

Ribosome – The structure that uses genetic information to assemble amino acids into proteins.

Rough endoplasmic reticulum – This organelle appears as 'rough' because it is covered in ribosomes, the proteins made here are then transported to the Golgi apparatus for further processing.

Smooth endoplasmic reticulum – This organelle appears 'smooth' because it is not covered in ribosomes. It is involved in the synthesis of lipids.

Vacuole – Plant organelle involved in storing water and wastes.

Appendix 1: Teacher notes – organisation of the lesson

Teaching notes for the virtual microscope and the lesson: *The Structure of Eukaryotic Cells*

Combined with using the virtual microscope, this lesson links directly to SHS 1 Section 2 Unit 2 Eukaryotic cells and the teaching and learning activities associated with it.

Ideas for organising this exemplar lessons link directly to activities and teaching examples in the OpenSTEM Africa CPD units *Organising practical work* and *Collaborative learning*.

A full list of the OpenSTEM Africa CPD units can be found at:
https://www.open.edu/openlearncreate/CPD_units

Overview

If possible, this lesson should take place in the ICT Lab in your school if this can be arranged through your Head of Science and the Head of ICT. If the lesson takes place in the ICT Lab, it may be possible for each student to work individually at a computer; otherwise divide the class so that students are in small groups at a computer.

If it is not possible to use the ICT Lab for this lesson, then try to set up this lesson in your classroom. You may be lucky enough in your school to have a set of 'empty' tablets or mobile phones which students can use. Or you may be able to bring into the classroom a laptop connected to the internet or to your school intranet – and perhaps connected to a projector to make it possible for the whole class to view at once. If access to ICT is a real challenge in your school but you want your students to view an experiment, you might be able demonstrate it to small groups of your students at a time, using your own mobile phone

Whatever way(s) you set up the class, it would still be helpful to the students to be able to work in pairs or small groups for at least some of the lesson. Do remember as well that students need desk space to be able to write in their notebooks and to draw diagrams.

Steps in organising the lesson

Step 1: (This could be pre-lesson homework). Have students pre-read the Background section of the exemplar lesson. At the beginning of the lesson, check understanding by asking them the questions.

Step 2: Organise the class to work individually, or into pairs, or – with a group leader – into small groups of 4. Have them draw in 2D the cells in the Background section Figure 2. If in a pair, one draws the plant cell and one draws the animal cell. Have them check each other's drawing for accuracy. This gives you the opportunity to go round and check each pair's/group's work.

Step 3: Make sure that all have access to/can see the computer screen to begin the practical activity. Ensure that each pair/group knows how to choose the slides – or if you are using a laptop/projector, that the class helps to choose the slides.

Step 4: Have the class follow the instructions for accessing the slides on the virtual microscope and then drawing the slides. If working in a pair on a PC, ensure that each student in the pair gets to choose 2 of the slides; if working in a group on a PC, have the group leader coordinate the choices of the group.

Step 5: Allow enough time for everyone in the class to use the microscope and study the cells in full. If the class is in pairs or groups, then you may need to reduce the drawing of the cells from four to two, for example, as they pair/group will only be able to work on the one cell at a time that they can see on the virtual microscope.

Step 6: Five minutes before the end of the lesson, tell the students to complete the quiz.

Other examples of lessons which use the virtual microscope include:

- Biology SHS 1, Section 1, Unit 5: The microscope
- Biology SHS 1, Section 3, Unit 1: Amoeba, Paramecium, and Euglena
- Biology SHS 1, Section 3, Unit 11: Scientific Inquiry Skills
- Biology SHS 2, Section 4, Unit 3: Transport
- Biology SHS 3, Section 1, Unit 1: Internal Structure of Roots, Stems and Leaves

Appendix 2: Teacher notes – output of the lesson

Key observations from this activity

Because of their size and the resolution limit of a light microscope, it will not be possible to see all of the organelles in a cell. A discussion point might be to consider the width of a cell membrane and that organelles are membrane bound structures – the bilayer structure of the cell membrane can only be visualised using an electron microscope. Ask your students, based on their observations using the virtual microscope, why it is possible to see some organelles and not others.

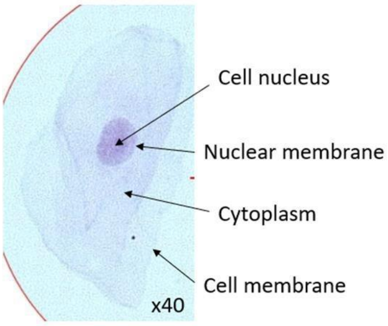
The animal cell slides include:

- Cheek cells
- Skeletal muscle tissue
- Human blood cells (a normal blood smear, sickle cell anemia blood smear).

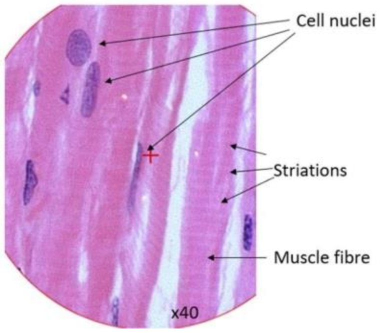
The plant cell slides include:

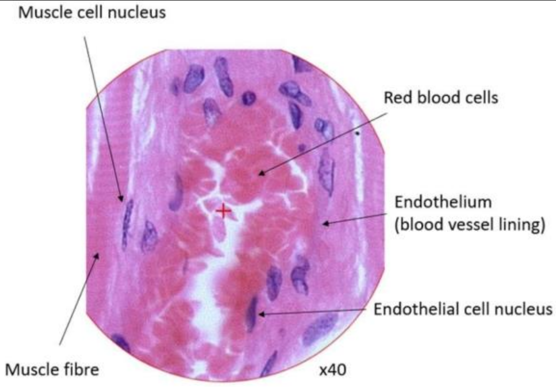
- Onion root
- Nymphaea (lily leaf).

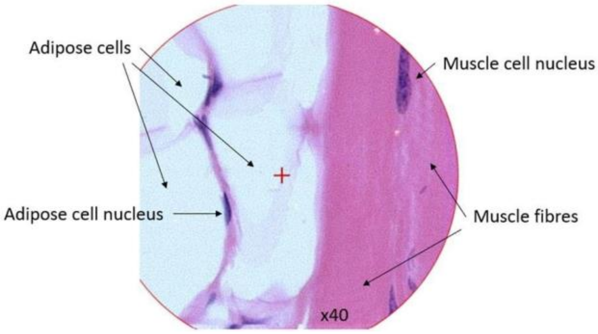
Below is a series of labelled images captured using the virtual microscope:

Human cheek cell


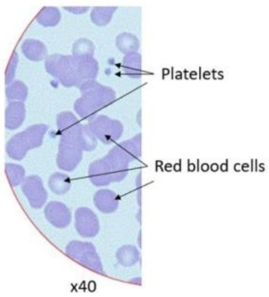
Skeletal muscle – consists of muscle fibres that are long, thin cells, containing many cell nuclei throughout their length. Other cells types are also present, such as fat cells (adipose cells), endothelial cells that line the blood vessels and blood cells.

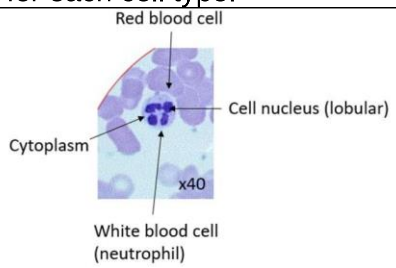


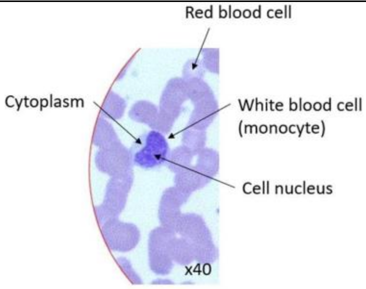


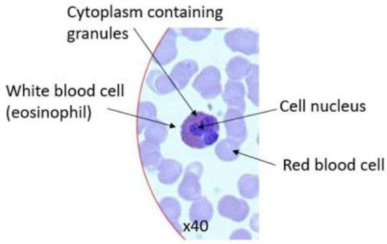


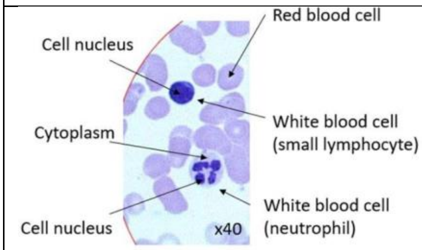
Blood cells – Seven different types of cells can be identified in the blood smear. Ask your students to consider the different distributions for each cell type.

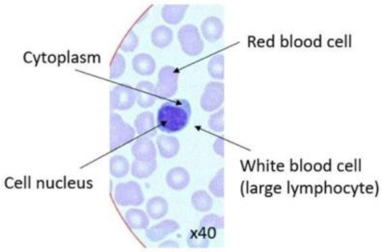




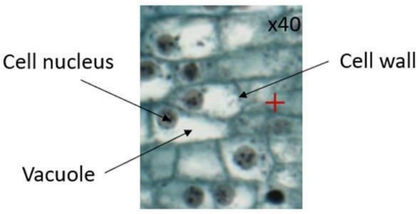


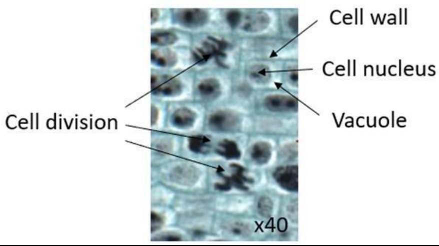




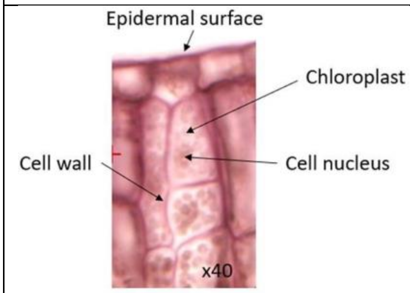


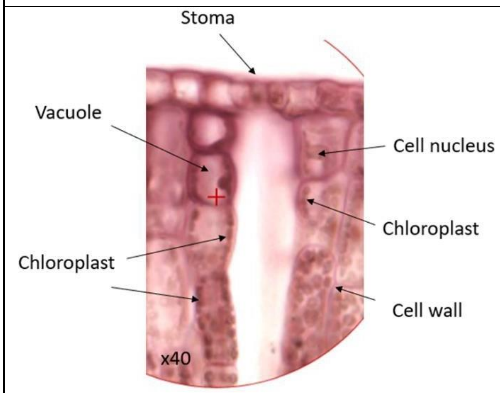
Onion root – ask your students where dividing cells can be found and the significance of their location (**hint** – cell growth and extension at the root tip).

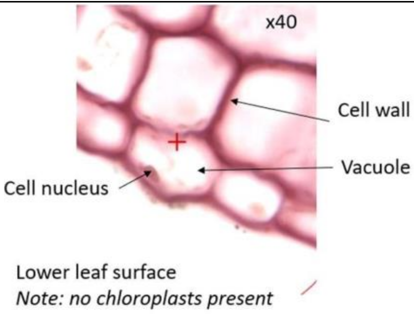




Nymphaea (lily leaf) – ask your students to think about which parts of the leaf are facing the sun and how the structure is adapted for the purposes of photosynthesis.







Lower leaf surface
Note: no chloroplasts present

Appendix 3: In-text question answers

What is the main difference you can see between the prokaryotic and eukaryotic cells shown in Figure 1?
Answer: Eukaryotic cells contain 'organelles' – these are components which are surrounded by a membrane and enable the cell to function properly. Prokaryotes, which are simpler organisms, do not have these structures to organise the cell processes.

Can you think of an advantage that a cell might gain by having organelles?
Answer: Each type organelle performs a specific function within the cell. This allows for better organisation of the living processes needed to maintain a healthy cell.

Looking at Figures 3 and 4, what two conclusions can you draw based on the images shown? (Hint: look at the scale bars).
Answer: (1) The cells in Figure 2 are drawn in 3D relief to show the arrangement of organelles within the cells. However, in the micrographs shown in Figures 3 and 4, only a few types of organelle can be seen – this is because electron microscopes only capture a thin section through the cell being imaged. (2) The plant cell shown in Figure 3 is larger than the animal cell shown in Figure 4.

Appendix 4: Quiz answers

Correct answers are highlighted in green.

Question 1

How do plant cells differ from animal cells?

Plants have the same organelles found in animal cells, but in addition have chloroplasts, and a vacuole, alongside a cell wall. Whilst the cell wall is not an organelle, it is nonetheless a distinctive structural component of a plant cell.

Select **one**:

[nucleus, mitochondria, chloroplasts].

Feedback

Chloroplasts are only found in plant cells where the use sunlight to generate energy and capture carbon dioxide for the synthesis of more complex molecules – a process called photosynthesis.

Question 2

Which one of the following statements is correct?

1. Unlike animals, plants do not have bones or cartilage to help maintain their structure. Instead, they rely on cell walls and the vacuole to maintain their structure. The vacuole is the largest organelle found in a plant cell. It contains water and waste materials, which help it to provide internal pressure.

2. Unlike animals, plants do not have bones or cartilage to help maintain their structure. Instead, they rely on chloroplasts and sunlight to maintain structural integrity, particularly during the sunnier periods of the day.

Feedback

Think about what happens when a wilted plant is watered. The water is taken up by the plant and stored in the vacuole, increasing the internal pressure within each plant cell, and together with the cell walls, help to maintain the plant's structure.

Question 3

For each of the questions below, select the correct answer:

1. Which organelle found in plant cells converts sunlight into energy?
   a. Golgi apparatus
   b. Chloroplast
   c. Mitochondrion
2. Which organelle found in plant and animal cells contains most of a cell's genetic material (DNA)?
   a. Smooth endoplasmic reticulum

b. Rough endoplasmic reticulum
c. Cell nucleus
d. Lysosome

Feedback

The process that converts sunlight to energy in a plant cell is called photosynthesis; a process that occurs in the chloroplasts. The genetic material, DNA, is found in all eukaryotic cells such as plant and animal cells and most of the DNA is stored within the cell nucleus. Other organelles, such as mitochondria also have small amounts of DNA.

ACKNOWLEDGEMENTS

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- Figure 3a and 3b: Heather Davies
- Figure 4a: Heather Davies
- Figure 4b: The Open University
- Human check cell: Kerry Murphy/The Open University
- Skeletal muscle: Kerry Murphy/The Open University
- Blood cells: Kerry Murphy/The Open University
- Onion root: Kerry Murphy/The Open University
- Nymphaea: Kerry Murphy/The Open University

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