Cambridge Assessment International Education

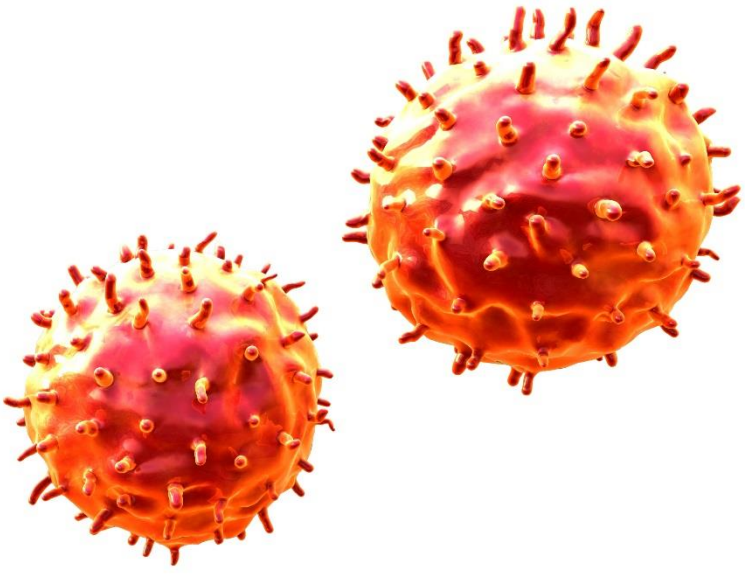
Teaching Pack

Cell structure and organisation: onion cells and cheek cells

Cambridge IGCSE™

Co-ordinated Sciences 0654

This *Teaching Pack* can also be used with the following syllabuses:
- Cambridge IGCSE™ (9–1) Biology **0970**
- Cambridge IGCSE™ Biology (US) **0438**
- Cambridge IGCSE™ Combined Science **0653**
- Cambridge IGCSE™ (9–1) Co-ordinated Sciences (Double Award) **0973**
- Cambridge O Level Biology **5090**
- Cambridge O Level Combined Science **5129**



Version 2.0

Cambridge Pathway

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Introduction

This *Teaching Pack* will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3 Experimental skills and investigations) in the course syllabus.

Important note
Our *Teaching Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 5 (Practical Test) or Paper 6 (Alternative to the Practical Test).

There are two options for practising experimental skills. If you have laboratory facilities this pack will support you with the logistics of running the experiment. If you have limited access to experimental equipment and / or chemicals, this pack will help you to deliver a virtual experiment.

This is one of a range of *Teaching Packs*. Each pack is based on one experiment with a focus on specific experimental techniques. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

Briefing lesson (1 hour*)
This lesson introduces the focus experimental skills to be developed. It also introduces any content needed for your learners to understand the experiment being carried out in the *Lab lesson*.

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Lab lesson (1 hour*)	
Option 1 – run the experiment	**Option 2 – virtual experiment**
This lesson allows the experiment to be run with your learners, providing an opportunity to practise the experimental skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experimental skills introduced in the *Briefing lesson*.

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Debriefing lesson (1 hour*)
This lesson consolidates and builds on the progress learners have made. In some cases, it will also provide the opportunity to practise extended writing skills.

** the timings are a guide only; you may need to adapt the lessons to suit your circumstances.*

In this *Teaching Pack* you will find the lesson plans, worksheets for learners and teacher resource sheets you will need to successfully complete this experiment.

Experiment: Cell structure and organisation – onion cells and cheek cells

This *Teaching Pack* focuses on the features of plant and animal cells that can be viewed under a light microscope. Plant and animal cells share some common features and some differences that are visible under a light microscope. In this experiment, onion cells and human cheek cells will be prepared on slides for viewing.

This experiment has links to the following syllabus content (see syllabus for detail):

- B2.1 Cell structure

The experiment covers the following experimental skills, adapted from **AO3: Experimental skills and investigations** (see syllabus for assessment objectives):

- make and record observational drawings, measurements and estimates
- interpret and evaluate observations and data in order to identify organelles
- evaluate experimental methods and suggest possible improvements.

Prior knowledge

Knowledge from the following syllabus topics is useful for this experiment.

- B1 Characteristics of living organisms

Going forward

The knowledge and skills gained from this experiment will be useful for when you teach learners about the features of organisms; cell structure and organisation; leaf structure and blood.

Briefing lesson: Making observations

Resources	• Worksheets A and B
Learning objectives	By the end of the lesson: • ***all*** learners should be able to provide descriptions of structures based on their observations • ***most*** learners should be able to calculate the magnification of an image using the original size of the structure and the image size • ***some*** learners will be able to calculate the size of an original structure using measurements from the image and the magnification.

Timings	Activity
15 min	**Starter/introduction** Give learners Worksheet A and ask them to describe what they see for each structure in the animal cell. Their description should make reference to size, shape and any distinctive features. For example, **D** could be described as a large, round structure with a defined outline and smaller dark area inside. Circulate the learners as they make their observations to encourage use of descriptive language; some example words are given on page 2. Reassure learners that they don't need to know what the organelles are in order to do the activity (many of the structures are Supplement only but the purpose of the activity is about observation, not content knowledge). Pause the task when learners have finished describing the structures in the animal cell, and tell them to use their observation skills to spot which structures are unique to the plant cell. They match each structure to a letter and then describe the structure as before. Ask learners to share their observations and, as a class, discuss the language used. Encourage differing opinions and discussion on how best to describe the images they see. If some learners use the name of the organelle, explain that isn't an observation or description of the structure, that's an interpretation of the observation. Read out the descriptions on the answer sheet and ask learners to tell you which structure (A, B, C, etc.) it refers to. Learners self-assess if their descriptions are similar to the ones read out. They can amend their descriptions if they think they could be improved.
5 min	**Main lesson** Ask learners what is meant by the term 'magnification'. They might talk about an image being made bigger. Explain that in biology magnification is used to describe how large an image or sample is in comparison to the original. Discuss that an image of a cell for example, that has been magnified ×500 times has been made 500 times bigger than the actual size of the cell. This allows scientists to study and identify very small cells. *Continues on next page …*

Timings	Activity
	Main lesson continued
10 min	Give learners Worksheet B. The first activity walks learners through calculating the magnification of the image provided. Learners can work through this task in pairs; perhaps with abler learners supporting less able learners. They are given a formula and have to substitute values into it. They are also required to make a measurement to substitute into the formula. After learners have completed this activity, ask some learners to propose the magnification. Discuss why some learners might have different answers.
10 min	The second activity asks them to use the given descriptions and their observations to identify the structure in each diagram. They are then asked to calculate the actual size of the nucleus from the image. Here the formula for magnification has been rearranged to create a formula to calculate the size of an organelle. You might want to talk learners through the rearrangement. The final activity consolidates the previous two questions by asking learners to use the descriptions to help them identify the organelles in each image, and then they have to calculate the actual size of each organelle. Tell learners that it is common practice to measure the widest part of the organelle when calculating the magnification, or original size of the organelle; grey lines have been added where measurements need to be made. Circulate the room to aid learners in their measurements and calculations.
10 min	Discuss learners' ideas and answers and ask them to self-assess their work, ticking or correcting their answers (you can distribute the answer sheet for this). Ask learners to explain their reasoning for their choices. Learners should be basing their selection on their observation (for example, it is a large empty space in the centre of the cell) combined with the measurements (it is 131 mm across in the image, at its widest part) to conclude what organelle this must be, e.g. a vacuole. Discuss with learners how important it is to be accurate when making measurements. Ask them to explain why this might be. Prompt them with the suggestion that cells are very small, magnified many times in order to produce the image and therefore the organelles inside are tiny, so any errors in measurement will be exaggerated significantly: exact measurements are needed as the scale of the organelle is so small.
	Plenary
10 min	Consolidate the idea of the required accuracy of the measurement being important by discussing the table below. Different learners measured an organelle in an image in order to determine its real size and their data was collected in a table. Explain that the magnification of the image was ×8000 and the actual size of the organelle is 0.011 mm to 2 dp. Discuss that although the difference in the students' measurements is only between 0.5 and 2 mm, which seems very small to us, it leads to the wrong size of the organelle. As the organelle is so small, a difference of 0.001 is relatively large. It would be like someone getting our height wrong by 2 cm.

	Length of organelle in image / mm	Actual size of organelle / mm
Student 1	83	0.010
Student 2	84	0.011
Student 3	83.5	0.010
Student 4	82	0.010

Lab lesson: Option 1 – run the experiment

Resources	• Learners' completed Worksheets A • Worksheets C, D (Part 1), D (Part 2) E (Part 1) and F • *Teacher walkthrough* video, *Teacher notes, Teacher method* • Equipment as outlined in the *Teacher method*
Learning objectives	By the end of the lesson: • ***all*** learners should be able to label a microscope based on their observations of how the different parts work • ***most*** learners should be able to follow instructions to view cells under a light microscope and draw what they see • ***some*** learners will be able to interpret and evaluate their results.

Timings	Activity
15 min	**Starter/introduction** Have light microscopes already set up on the work benches (or learners collect them carefully). Ask learners to observe and gently explore their microscope. They should use their observations to help them label the microscope on Worksheet C. Learners should work independently on this task. Challenge them to consider the function of each part of the microscope. They should use their observations to help them. Discuss the answers to the labelling activity and the possible functions as a class. Volunteers suggest the names for each part and a possible function; they should self-assess their worksheet and amend their answers, if appropriate. You can use prompts such as *'How do you view the image*?' '*What are the dials on the side used for*?' Ask learners what they think the function of the objective lens is. Link this to the term 'magnification' from the first lesson. Explain that the eyepiece of a microscope also magnifies an image ×10 in addition to the magnification of the objective lens. Discuss the term 'focus' using examples such as when an image is in focus (clear and sharp) or out of focus (unclear and fuzzy) on a camera or smartphone. This discussion should help learners to understand how the microscope works based on their observations. Most learners will struggle with the difference between fine adjustment and coarse adjustment dials, so you will need to clarify this. The coarse adjustment (larger dial) focuses the image by moving the stage or lens. The fine adjustment can be used to bring an image into sharp focus.
5 min	**Main lesson** Although it is recommended that each learner prepares both onion cells and cheek cells, if time is an issue or some learners are not capable, Worksheet D has been split into two self-containing methods: one for preparing onion cells (Worksheet D (Part 1)) and one for preparing cheek cells (Worksheet D (Part 2)). Give learners the appropriate method sheet(s) and Worksheet E (Part 1). Ask them to quickly read through the method(s) and look at the diagram of the prepared sample slide. Briefly outline the safety hazards of the experiment. *Continues on next page …*

Timings	Activity

Main lesson continued …

Risk	Hazard	Prevention
Scalpel or sharp knife	Could cut yourself	Carry the scalpel and knife carefully. Cut downwards onto a white tile. Keep fingers clear of blade.
Iodine solution and methylene blue	Could stain the skin; can cause irritation to the skin or eyes; dangerous if ingested.	Use a pipette to add the dye carefully; do not drop the coverslip on the dye, lower it gently. Wear eye protection and a lab coat. Avoid contact with skin; wash hands thoroughly if any gets on the skin; alert the teacher immediately if any gets on the skin or there are spillages.
Coverslips and glass slides	Could break or shatter and become lodged in the skin.	Do not allow the objective lens to touch the slide. Hold the slides carefully by the edges.

Ask learners what they think makes a good observational drawing. Learners should be able to suggest ideas such as: sharp pencil; clean, smooth lines; no shading; matching what is seen under the microscope; labelling any known structures; the magnification used written next to the image

Learners follow the step-by-step method on Worksheet D (Part 1) and Worksheet D (Part 2) and use Worksheet E (Part 1) to make drawings of their cell. Explain that they will be expected to draw their observations from the experiment. Support learners as they follow the method by circulating the room and helping their set-up, if required, start with the onion cells. When preparing cheek cells, circulate the room to make sure all used cotton buds are immediately placed in a biohazard bin.

Learners should use their completed Worksheet A and Worksheet C in order to support them in this task. Learners often find it difficult to set up microscopes and focus an image. They might need assistance with this.

Safety

Circulate the classroom at all times during the experiment so that you can make sure that your learners are safe and that the data they are collecting is accurate.

Ask learners to question the accuracy of their calculations for the size of the organelles; their drawings aren't drawn to scale so measuring the image does not provide an accurate value to use in the calculation. If learners didn't manage to see anything what could have gone wrong? Possible suggestions include that they didn't leave the stain long enough; they didn't wipe the correct end of the cotton bud on the slide; they weren't gentle enough with the epidermis and destroyed it.

Ask learners to evaluate their drawings by swapping their work with the person next to them. Use the criteria identified earlier as to what makes an effective drawing. Ask learners to suggest what they did well and what they could improve.

Plenary

Give learners Worksheet F to answer. Ask them to share their answers to the questions on. Learners should raise their hands to share their answers. Make sure that there is a discussion about why staining a sample is so important in viewing samples. Learners should be able to explain how they know what each organelle is using their observations from the briefing lesson. Discuss what they observed, what was absent in the onion cells that they would have expected to see? They should be able to say chloroplasts. Challenge learners to suggest why. This is because onions grow underground and so do not need chloroplasts as these cells do not photosynthesise.

Teacher notes

Watch the *Teacher walkthrough* video and read these notes.

Each group will require:

- a light microscope
- mounted needle
- sharp knife or scalpel
- forceps
- coverslips
- glass slides
- distilled water
- a white tile
- filter paper
- dropping pipette
- an onion (red or white) — for onion cells only
- iodine solution — for onion cells only
- methylene blue — for cheek cells only
- cotton buds — for cheek cells only
- disinfectant — for cheek cells only
- beaker — for cheek cells only

Safety

The information in the table overleaf is a summary of the key points you should consider before undertaking this experiment with your learners.

Some associated safety precautions include:

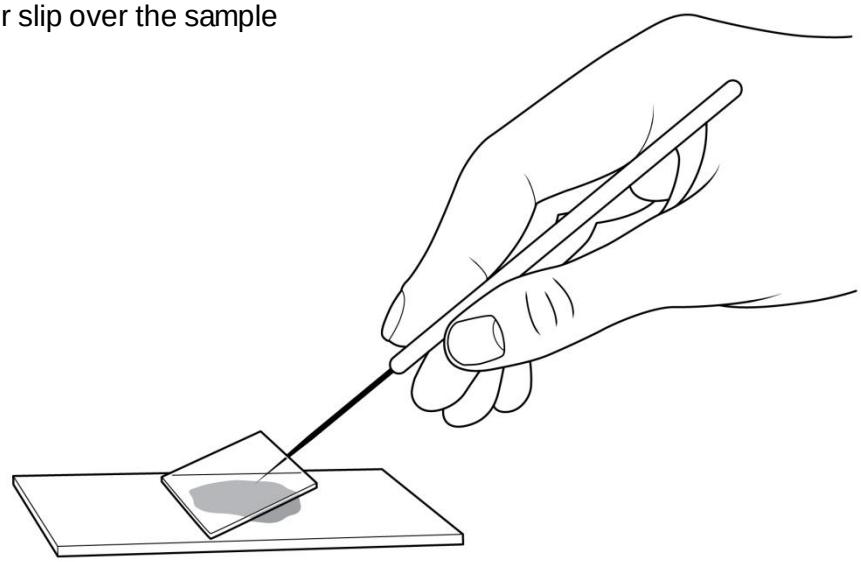
1. The lowest concentration possible of methylene blue should be used and eye protection should be worn.
2. Disposable gloves can be worn to reduce the risk of contact of methylene blue and iodine with the skin.
3. If the solvent used to make up the methylene blue is flammable, do not use near an open flame.
4. Learners should **not** make up the methylene solution themselves. When you or a technician make up the solution, do so in a fume cupboard to prevent powdered dyes and indicators escaping into the air. Solid / powdered methylene blue is harmful if it comes into contact with the skin, is ingested or is inhaled.
5. Count scalpels out and in to ensure they are all returned.
6. Demonstrate to learners how to use a knife / scalpel safely and effectively using clean downward cutting motions on a white tile or other chopping board.
7. Ensure that learners put the used cotton buds straight into a biohazard bin to remove the risk of pathogen transfer. If learners do not have direct access to a biohazard bin, they should place used cotton buds into a beaker filled with disinfectant and you should dispose of them accordingly.
8. Make sure learners disinfect the work area and wash their hands thoroughly using soap and running water after they have finished the experiment.
9. The coverslips and glass slides are fragile and can be easily broken. Learners should be careful not to raise the stage too high as this could shatter the slide on the lens. Learners should view the stage from the side when raising it to prevent breakage of the slides. Slides and coverslips should be held at the edges and pressure should not be applied to the middle of either.

It is **your** responsibility to carry out an appropriate risk assessment for this practical.

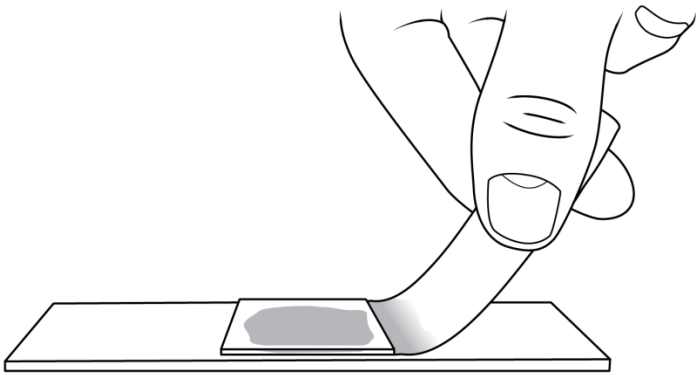
Substance	Hazard	First aid
Iodine solution [0.1 mol/dm^3]	 GHS09 (*hazardous to the aquatic environment* **N**)	**In the eye:** Flood the eye with gently-running tap water for 15 min. See a doctor. **Vapour breathed in:** remove the casualty to fresh air. Call a doctor if breathing is even slightly affected. **Swallowed:** do no more than wash out the mouth with water. Do not induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. **Spilt on the skin or clothing:** remove contaminated clothing. Drench the skin with plenty of water. If a large area is affected or blistering occurs, see a doctor. **Spilt on the floor, bench, etc.:** ventilate the room. For small amounts, use a damp cloth. Rinse well. For larger amounts, cover with mineral absorbent (e.g. cat litter) and scoop into a bucket.
Methylene blue, solid	HARMFUL	**In the eye:** Flood the eye with gently-running tap water for at least 10 minutes. See a doctor. **Swallowed:** Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. **Dust breathed in:** Remove the casualty to fresh air. See a doctor if breathing is difficult. **Spilt on the skin or clothing:** Remove contaminated clothing. Wash off the skin with soap and plenty of water. Rinse contaminated clothing. **Spilt on the floor, bench, etc.:** Scoop up solids (take care not to raise dust). Wipe up solution spills or any traces of solid with a damp cloth and rinse it well.
Methylene blue, dilute aqueous solution	LOW HAZARD	**In the eye:** Flood the eye with gently-running tap water for at least 10 minutes. See a doctor. **Swallowed:** Do no more than wash out the mouth with water. Do **not** induce vomiting. Sips of water may help cool the throat and help keep the airway open. See a doctor. **Dust breathed in:** Remove the casualty to fresh air. See a doctor if breathing is difficult. **Spilt on the skin or clothing:** Remove contaminated clothing. Wash off the skin with soap and plenty of water. Rinse contaminated clothing. **Spilt on the floor, bench, etc.:** Scoop up solids (take care not to raise dust). Wipe up solution spills or any traces of solid with a damp cloth and rinse it well.
Microorganisms from humans, e.g. finger dabs	BIOHAZARD	**Skin or clothing:** remove soiled clothing; wash skin thoroughly with soap and running water. **Spilt on the floor, bench, etc.:** For spills of cultures, place paper towels over the spill, pour disinfectant (e.g., Virkon) on top and leave for at least 15 minutes. Bleach is usually suitable in the home. **(You must do a risk assessment for any disinfectant or bleach used.)**
Sharps (e.g. scalpels, knives, cork borers, mounted needles, broken glassware)	Risk of cuts or puncture wounds due to sharps. Wounds can lead to infection, especially if the blade or point is contaminated.	**Minor cuts:** Rinse the wound with water. Get the casualty to apply a small, sterile dressing. **Severe cuts**: Lower the casualty to the floor. Raise the wound as high as possible. If feasible, ask the casualty to apply pressure on or as close to the cut as possible, using fingers, a pad of cloth or, better, a sterile dressing (adding further layers as necessary). If the casualty is unable to do so, apply pressure yourself, protecting your skin and clothes from contamination by blood if possible. Leave any embedded large bodies and press around them. Send for a first aider.
Latex gloves	Allergic reaction	Remove the gloves and wash hands under water. Look out for severe allergic reactions such as difficulty breathing and/or swelling of the face, body or tongue. Seek emergency medical attention immediately.

Experiment set-up

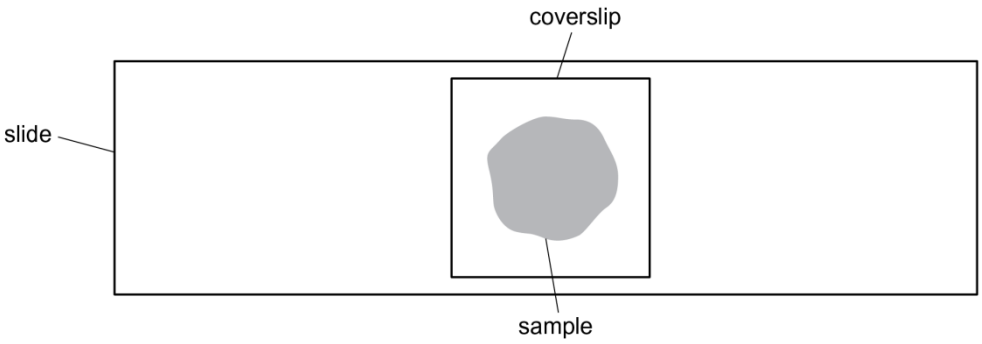
Placing the cover slip over the sample



Soaking up excess liquid



Sample ready for viewing under light microscope



Teacher method

This is your version of the method that accompanies the *Teacher walkthrough video*.

Do not share this method with learners. Give them Worksheet D (Part 1) and Worksheet D (Part 2).

Before you begin
Plan how you will group your learners during the experiment session.

Think about:
- if there are enough microscopes for learners to work independently
- if learners will work in groups, pairs or as individuals
- if microscopes will be set out on the desks ready or if learners will collect them themselves
- if learners will be preparing both onion and cheek cells, or just one or the other
- if learners are mature enough to safely use the knife and scalpels
- checking that knives / scalpels are sharp and safe to use.

Experiment
Circulate during the experiment in case learners encounter any difficulties.

Preparing and viewing onion cells

Step	Notes
1. Learners should collect their equipment.	*Make sure learners are carrying microscopes properly: by the arm and the base.*
2. Learners should hold the slide by the edges to prevent getting fingerprints on the glass, which would obscure their observations.	
3. Learners should add a drop of distilled water onto the glass slide using a pipette.	
4. Learners peel the onion and then slice the onion into 1 cm chunks using a sharp knife or scalpel. They should use a downward cutting motion onto a white tile.	*Decide whether learners will be using a knife or scalpel. Some learners might need assistance with cutting the onion. Make sure you count the scalpels / knives out and in.*
5. Learners should then take one of the chunks of onion and remove the epidermal layer of tissue using forceps.	
6. Learners place the epidermal layer on the glass slide using the forceps. They should use the mounted needle to position this epidermal tissue in the middle of the glass slide and to ease out any folds.	*Warn learners to be gentle as the epidermis is fragile.*

Step	Notes
7. Learners should then add a drop of iodine solution to the onion epidermis.	*Remind learners of the safety implications of using iodine solution.*
8. The iodine should be left for 1 minute to allow it to soak into the epidermis.	
9. Learners should pick up a coverslip making sure that they are holding it by the edges to avoid getting fingerprints on the face.	
10. Learners should then lower the coverslip onto the onion epidermis, avoiding air bubbles. Learners can avoid air bubbles by lowering the coverslip slowly at an angle, using a mounted needle for support.	*Air bubbles reflect light and make it difficult to see the prepared sample.*
11. Learners use filter paper to absorb excess water and iodine solution. They should hold the filter paper to the side of the covered epidermal layer and allow the liquid to be soaked up by the paper.	
12. Learners place the slide onto the stage, making sure the centre of the slide is over the hole in the stage.	
13. Learners should turn the objective lens so that it is on the lowest power magnification.	*This is the shortest objective lens.*
14. Learners then raise the stage as high as it will go. They should watch the stage as it rises from the side to make sure that it does not touch the objective lens.	*If learners raise the stage too high they will break the glass slide. If this happens, you will need to dispose of the glass and check the microscope for any glass pieces.*
15. Learners then look down the microscope and turn the coarse and fine dials until the image is clear.	*Check learners have turned on the light source or they will not be able to see. They should be able to see the uniform shape of the cells but will be unable to clearly identify the nuclei.*
16. Learners will then be asked to draw what they can see on Worksheet E (Part 1). Instruct them on proper drawing technique.	

Step	Notes
17. Learners should then move the stage down so that they can increase the magnification by selecting a different objective lens.	*The stage is moved down to avoid breaking the slide.*
18. Learners will then be asked to draw what they can see on Worksheet E (Part 1). Challenge them to identify any structures they can see.	*Learners should see uniform, oblong structures with clear outlines (cell wall), and might also be able to see the nucleus and some starch granules; the latter are dark, clearly defined circles, usually smaller than the nucleus.*
19. Learners should be able to see the uniform shape of the cells but will be unable to see the nuclei.	

Preparing and viewing cheek cells

1. Learners insert a cotton bud into their mouth and gently rub against the inside of the cheek using an up-and-down motion.	
2. Learners smear the cotton bud onto the centre of the glass slide. Learners should use smooth side-to-side movements to transfer any cells onto the slide.	
3. Learners should then put the cotton bud straight into a biohazard bin.	*If learners do not have direct access to a biohazard bin, create a central disinfectant beaker for learners to dispose of their used cotton buds.*
4. Learners should then add a drop of methylene blue to the area where the cheek cells were smeared.	*Remind learners of the safety precautions required when using methylene blue.*
5. Learners should leave the sample for 1 minute to allow the stain to take effect.	
6. Learners then follow steps 9 to 18 as per the method for preparing onion cells.	*At the lower magnification, learners should be able to see blue smudges or blobs, with a darker area (the nucleus); these will be sparse, separate and well spread out. At higher magnifications, they should see one or two cells that look a bit like a fried egg; the nucleus is stained dark blue and the cytoplasm is stained light blue.*

Clean-up

After the experiment learners should:

- turn off their microscopes
- tidy up their work space
- ensure any spillages have been mopped up
- return all equipment and any unused chemicals to you
- wipe their work bench down with disinfectant if they prepared cheek cells.

The used slides should be returned to be cleaned by the teacher or technician.

Lab lesson: Option 2 – virtual experiment

Resources	• Learners' completed Worksheet A • Worksheets C, D (Part 1), D (Part 2), E (Part 2), and F • *Virtual experiment video*
Learning objectives	By the end of the lesson: • ***all*** learners should be able to label a microscope based on their observations of how the different parts work • ***most*** learners should be able to follow instructions to view cells under a light microscope and draw what they see • ***some*** learners will be able to interpret and evaluate their results.

Timings	Activity
10 min	**Starter/introduction** Ask learners to look at the image of a light microscope on Worksheet C. Challenge them to consider the function of each part of the microscope. They should use their observations to help them. Learners should work independently on this task. Discuss the answers to the labelling activity and the possible functions as a class. Volunteers suggest the names for each part and a possible function; they should self-assess their worksheet and amend their answers, if appropriate. You can use prompts such as *'How do you view the image*?' '*What are the dials on the side used for?*' Discuss the term 'focus' using examples such as when an image is in focus (clear and sharp) or out of focus (unclear and fuzzy) on a camera or smartphone. This discussion should help learners to understand how the microscope works based on their observations. Most learners will struggle with the difference between fine adjustment and coarse adjustment dials, so you will need to clarify this. The coarse adjustment (larger dial) focuses the image by moving the stage or lens. The fine adjustment can be used to bring an image into sharp focus.
10 min	**Main lesson** Give learners Worksheet D (Part 1), Worksheet D (Part 2) and Worksheet E (Part 2). Ask them to read through the methods (Part 1 is for preparing onion cells, and Part 2 for preparing human cheek cells) and to look at the diagram of the prepared sample slide so they have an idea of what is to come. Explain that they will watch a video of someone preparing onion and human cheek cells for viewing under a microscope. They will then have to draw the cells as seen down the microscope from the video and make a note of any observations; they do this on Worksheet E (Part 2). Ask learners what they think makes a good observational drawing. Learners should be able to suggest ideas such as: sharp pencil; clean, smooth lines; no shading; matching what is seen under the microscope; labelling any known structures; and the magnification used written next to the image. Tell learners to think about the method they see as video plays, and note down any differences to the methods they read on Worksheet D. *Continues on next page …*

Timings	Activity
25 min	**Main lesson continued …** Questions about the method can be accessed by clicking on the 'Video question' buttons; some of these questions are the same as those in Worksheet F, which the learners will have to complete in the plenary. You could have a class discussion about them here for writing up later, or not choose not to reveal them. Play the video. The video will automatically pause on the images of the cells so that learners can note down any observations and to make a drawing. Before these shots appear, you will see a 'Data collection' button, which will explain to the learners what they have to do. When learners have finished their first drawing, resume the video. Again, the video will pause on the higher resolution of the cells, click on the 'Data collection' button to explain to learners what they need to do. Ask learners to repeat their observations and write down the key differences between the two views. The video will then show how to prepare human cheek cells for viewing. Again, the video will pause to allow learners to draw and write observations. This repeats for the higher magnification. Learners observe, draw and note any differences to the lower magnification. Learners complete Worksheet E by calculating the size of each of one example of each the structures they've drawn at the higher magnification. Challenge learners to interpret their results by attempting to identify the structure they can see. Learners should use their completed Worksheet A to support them in this task. Ask learners to question the accuracy of their calculations for the size of the organelles; their drawings aren't drawn to scale so measuring the image does not provide an accurate value to use in the calculation.
5 min	In the video, the voiceover mentions that the iodine stain didn't take, why do they think this could have been? Possible suggestions include that the iodine wasn't left for long enough or the solution was too dilute; also it is probably more effective to place a drop of iodine directly onto the sample and then place the coverslip on the sample, it's possible that the iodine simply didn't get pulled across the cells. Can they think of any other issues that could occur if they carried out the experiment themselves? (For example, not wiping the correct side of the cotton bud on the slide; they weren't gentle enough with the epidermis and destroyed it.)
10 min	**Plenary** Give learners Worksheet F to answer. Ask them to share their answers to the questions. Learners should raise their hands to share their answers. Make sure that there is a discussion about why staining a sample is so important. Learners should be able to describe *how* they know that what they saw was the nucleus, using their observations from the briefing lesson. Discuss what they observed, what was absent in the onion cells that they would have expected to see? They should be able to say chloroplasts. Challenge learners to suggest why. This is because onions grow underground and so do not need chloroplasts as these cells do not photosynthesise.

Debriefing lesson: Evaluating data collection

Resources	• Worksheet G and H
Learning objectives	By the end of the lesson: • ***all*** learners should be able to suggest when an estimate or exact measurement are suitable • ***most*** learners should be able to use observations and measurements to identify key components of blood • ***some*** learners will be able to evaluate methods and suggest possible improvements.

Timings	Activity
10 min	**Starter/introduction** Ask learners for definitions of 'estimate' and 'measurement' and to give an example of each. Give learners five minutes to discuss this in groups of 2–4, then take suggestions. Possible suggestions include: 'an estimate is a rough or educated guess' or 'is used to roughly count the number of something when in a large sample'. Examples could include estimating the number of cells in the body or the number of individual plant cells in plant tissue. An exact measurement is when equipment (such as scales or a ruler) are used to calculate with a high resolution (ability to distinguish between two points) an exact numerical value. An example is using a ruler to measure to the length of an image of a cell, then using the magnification and the image length to calculate the cell's actual size. Challenge learners to think of wider examples of exact measurements and estimates. You could ask them to use items around them in the classroom or for examples within biology.
10 min	**Main lesson** Based on their discussions in the starter, ask learners to think about when it is appropriate to use exact measurements and when it is appropriate to use estimates. Prompt and support them by asking them to consider the accuracy of measurements they made on Worksheet B and the discussion in the plenary of the *Briefing lesson*, where a small error in measurement led to a large error in the calculated size of an organelle. Contrast this with an electron microscope image of a plant leaf, if we wanted to know how many cells were in the leaf, is it necessary to count them all? Or could we estimate by placing a grid over the image and counting the number in one grid, then multiplying that count by the number of squares in the grid. It would be too time-consuming to count all the cells and an accurate number is not necessary to give an idea of the number of cells. Ask them to think back to the drawings they made in the *Lab lesson*. Were their observations accurate enough for the aim of the experiment? If the aim was simply to view and identify the different structures in the cell, then their drawings, which were an estimate, were sufficiently accurate. If, however, the aim was to accurately calculate the size of each structure, then their drawings (an estimate) weren't accurate enough; in that case a precise measurement is required, so their drawings would have to be exactly to scale. Discuss with learners that they could improve the accuracy of their measurements by using more accurate measuring equipment, for example, a ruler that measures parts of a millimetre. *Continues on next page …*

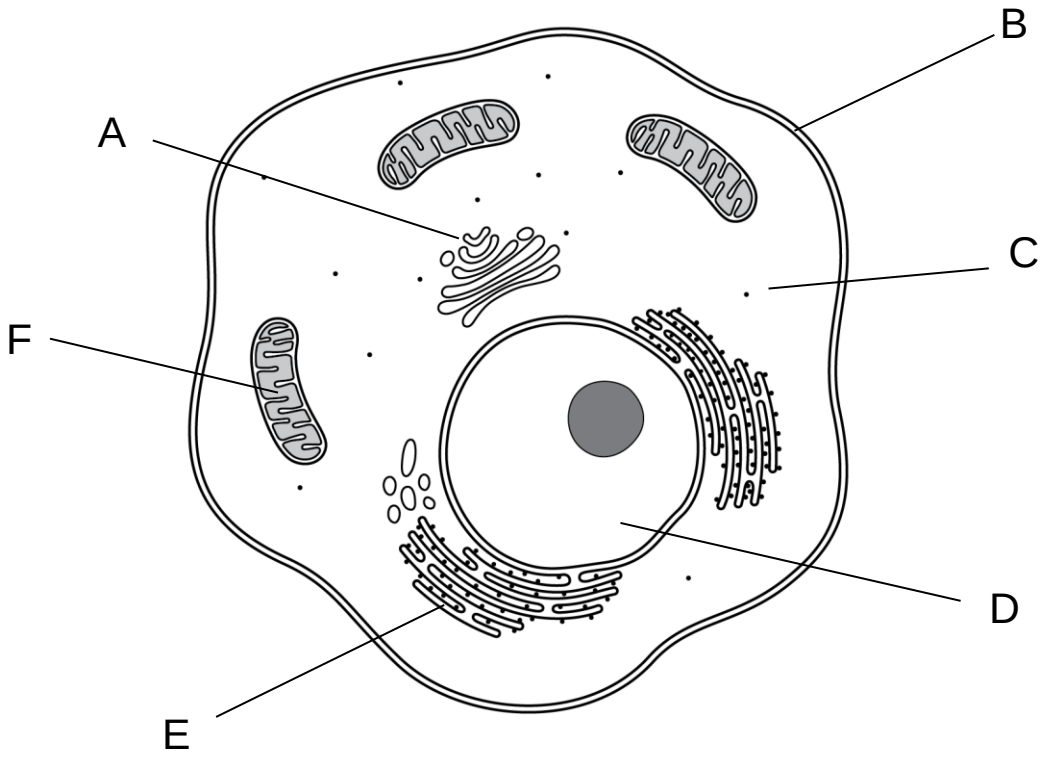
Timings	Activity
15 min	**Main lesson continued** Give learners Worksheet G, which is an experiment designed to investigate the components of blood. Ask learners to read through the method so that they have a sound knowledge of the procedure that will be undertaken. You could check understanding by asking learners to feedback to you how the experiment would run. You will have to explain to learners that a lancet is a small surgical blade that is used to remove a small section of blood. You could discuss that this is similar to a finger-prick test used by doctors to test blood sugar levels. Ask learners to read through the method and suggest any adjustments they could make to improve the collection of results based on their discussions about when it's appropriate to make estimates or measurements, and using their experiences from the *Lab lesson*. Suggestions might include: using a higher magnification when viewing the sample to make sure all components are visible; leaving the stain to soak for longer to make sure all components are visible.
15 min	Give learners Worksheet H, which gives the results from the investigation of a blood sample. Explain that the results show the components of blood. (Reassure learners that they do not need to already know this content to do the activity, if the topic of blood (9.4) hasn't been taught yet.) Ask learners if they think a low or high magnification has been used. Learners should be able to suggest that a high magnification was used because the individual components of the cells can be clearly seen. Learners complete the table to identify the components present in blood using their observations and making measurements. Some of the table has already been filled in. Learners are expected to recognise the red blood cell. Support learners with this if they do not by asking the group for a 'hands up' if they can identify the red blood cell from the image. Ask learners with their hands up to describe what it looks like and correct or praise if learners are correct. Learners will be asked to sketch the images using the good practice that they have learnt. Support learners in recording accurate descriptions of what they see by reviewing answers as a class. Learners will then be asked to estimate the percentage of the blood that is made up of each component using the results from the experiment. Some learners will need support with this task. There is a total of 15 cells in the sample. Learners will have to count the number of each type and work this out as a percentage of the sample. For example, 6 of the 15 cells are red blood cells. Therefore, 6/15 × 100 suggests that 40% of blood is composed of red blood cells. Stop learners after this task and review answers as a class.
10 min	**Plenary** Ask learners if their approximations of the composition of blood are accurate. Learners should be able to say that this is not accurate as they have only looked at one small sample of a much larger sample. Ask learners what they could do to improve their measurement of this data. Learners should be able to suggest that they should take multiple samples. The more samples, the more valid their data. They should also say that they should calculate a mean. Challenge learners to suggest why calculating a mean is an effective way to treat their data for effective interpretation. Prompt learners to think about how an anomaly or unusual result can be eliminated by calculating a mean.

Worksheets and suggested answers

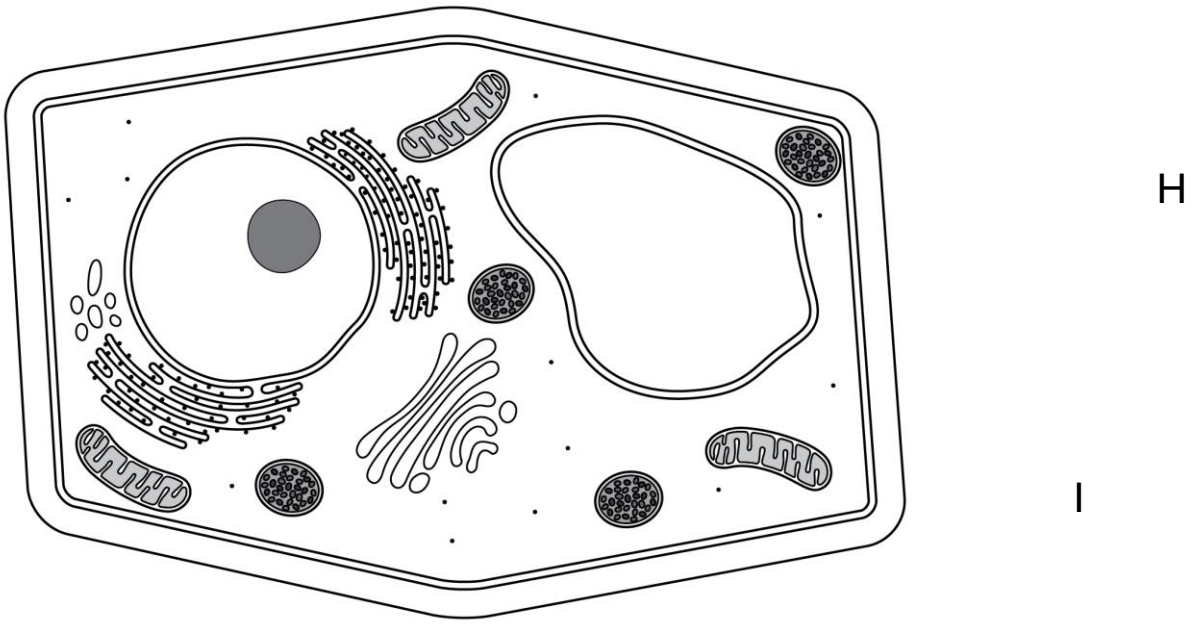
	Worksheets	Suggested answers
For use in the *Briefing lesson:*		
A: Making observations	**22–23**	**45**
B: Making measurements	**24–26**	**46**
For use in *Lab lesson: Option 1:*		
C: The light microscope	**27**	**47**
D: Method Part 1 (onion cells)	**28–30**	**—**
D: Method Part 2 (human cheek cells)	**31–33**	**—**
E: Drawing your samples (Part 1)	**34–36**	**—**
F: Thinking about the method	**40**	**48**
For use in *Lab lesson: Option 2:*		
C: The light microscope	**27**	**47**
D: Method Part 1 (onion cells)	**28–30**	**—**
D: Method Part 2 (human cheek cells)	**31–33**	**—**
E: Drawing your samples (Part 2)	**37–39**	**—**
F: Thinking about the method	**40**	**48**
For use in the *Debriefing lesson:*		
G: Viewing the components of blood	**41**	**—**
H: Experiment results	**42–44**	**49**

Worksheet A: Making observations

Describe each structure (A–F) within the animal cell by writing down what you see on page 2 of this worksheet. Use descriptive words such as 'round' and 'large'.



Look at the plant cell below. Identify which structures are not in the animal cell above by drawing a line from the structure to one of the letter labels. Describe these structures as you did before.



Here are some descriptive words that you might find useful.

Size: large, small, larger, smaller, the same as, narrow, wide, long, short, thin, thick, similar

Complexity: complex, simple, defined, undefined

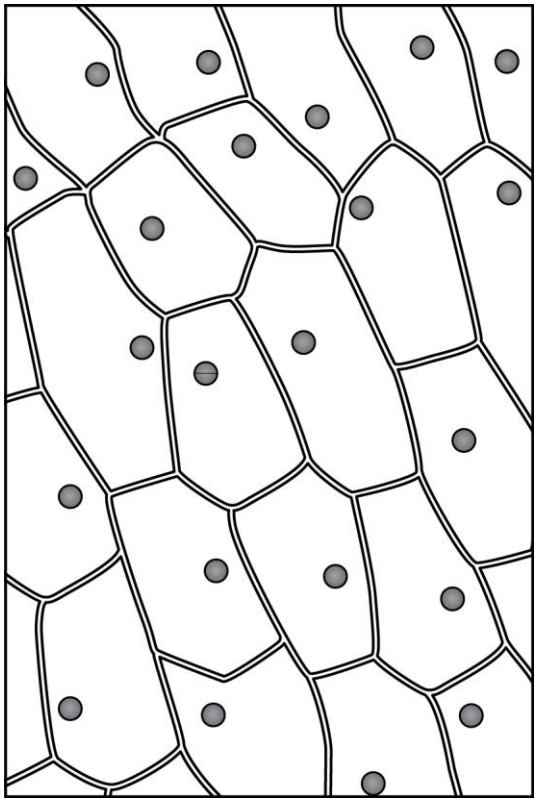
Colour: dark, light

Shape: circular, irregular, regular, oval, sausage-shaped, spherical, bean-shaped, semicircle, disc, kidney-shaped, arc, curved, straight, curly, rounded, fanned, spiral, flat, winding, dotted, diagonal, wiggly, round, outline, broken, solid, convex, concave, spotted, striped, veined, pointed, lines, tube, rows, spikey,

A	**B**	**C**
D	**E**	**F**
G	**H**	**I**

Worksheet B: Making measurements

1. The image below is a magnification of a section of onion epidermis.



It is possible to calculate the magnification of the image using the following formula:

$$\text{magnification} = \frac{\text{diameter of nucleus in image}}{\text{actual diameter of the nucleus}}$$

The organelle labelled **A** is the nucleus. Its actual diameter is 0.006 mm.

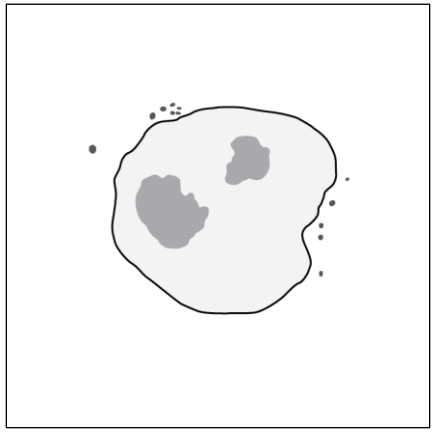
In the diagram, the diameter of the nucleus is the line shown going from left to right. Measure this line in mm and use this value to calculate the magnification of the image.

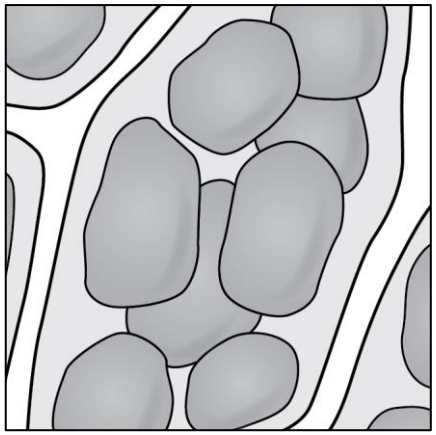
diameter of nucleus in image: _____

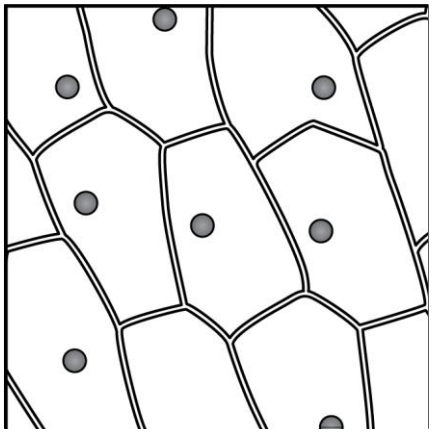
magnification = _____ / 0.006

= _____

2. Use the descriptions to identify each organelle. Write the correct name under each image.
   Note that in some pictures, more than one organelle is present.







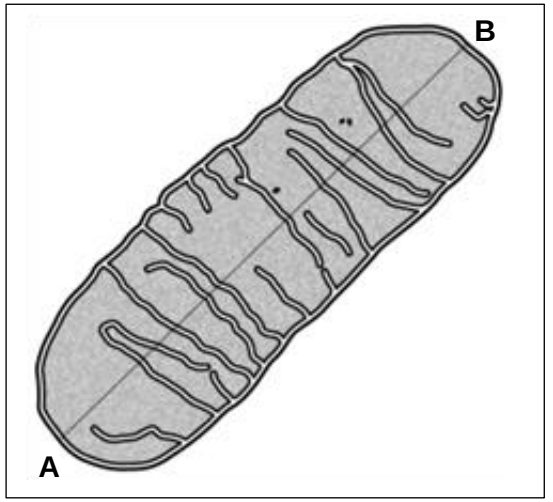
chloroplast: small irregular circular shape, there are lots of them in a cell

nucleus: large irregular circular shape with a defined outline, containing dark patches inside

cell wall: thick border around the outside of the cell

_____ _____ _____

3. The widest part of the structure in the image to the right is indicated by the line AB.
   Use a ruler to measure the length of AB in millimetres.



Length of **AB** in image = _____ mm

The image has a magnification of × 40 000, use the formula for magnification to calculate the actual size of the structure.

$$\text{magnification} = \frac{\text{length of } \mathbf{AB} \text{ in image}}{\text{actual length}} \quad \Rightarrow \quad \text{actual length} = \frac{\text{length of } \mathbf{AB} \text{ in image}}{\text{magnification}}$$

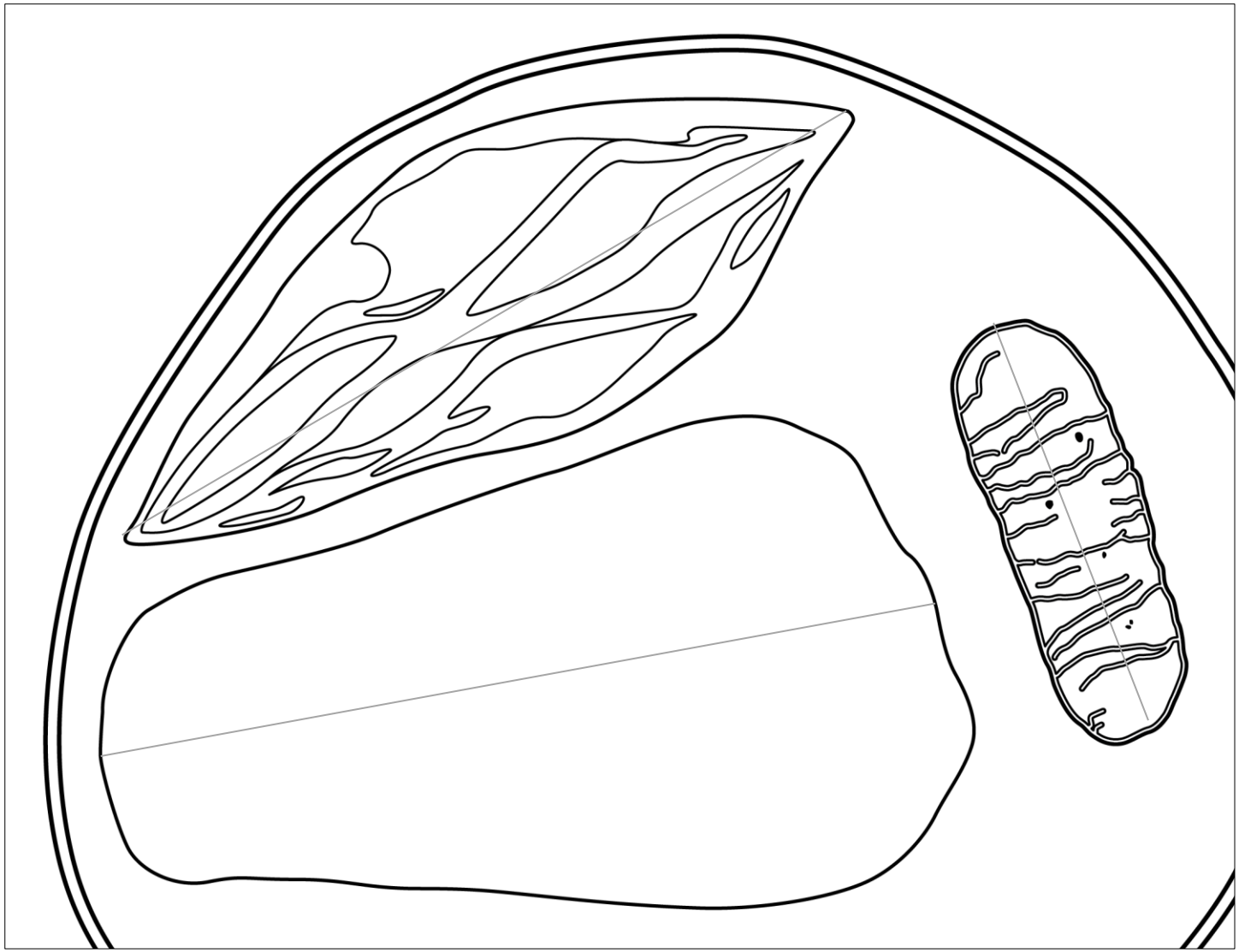
$$\text{actual length} = \frac{\text{length of } \mathbf{AB} \text{ in image}}{40\,000}$$

actual length = _____ mm (3 sf)

Extended: Multiply your measurement by 1000 to give the length in micrometres.

4. Use the descriptions given to identify the organelles in the image below, which has a magnification of × 36 000.

Calculate the actual size of each organelle. **Extended:** Multiply your measurement by 1000 to give the length in micrometres.



Grey lines have been added to the image for measuring.

vacuole: large empty space in the centre of the cell; in the image it has a length of 131 mm

chloroplasts: long oval with pointed ends; contains dark lines inside; very large, almost as long as the cell; in the image, it has a length of 130 mm

mitochondria: sausage-shaped, contains zig-zagging lines inside; in the image, it has a length of 67 mm

Explain your answers.

Worksheet C: The light microscope

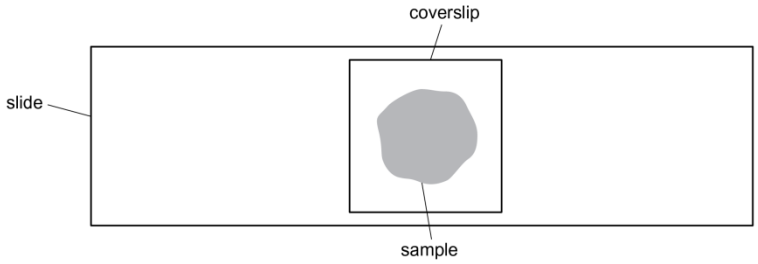
Label the microscope.

coarse adjustment	fine adjustment	stage	
light source	eyepiece	arm	objective lens

Challenge: Suggest the function of the different parts of the microscope.

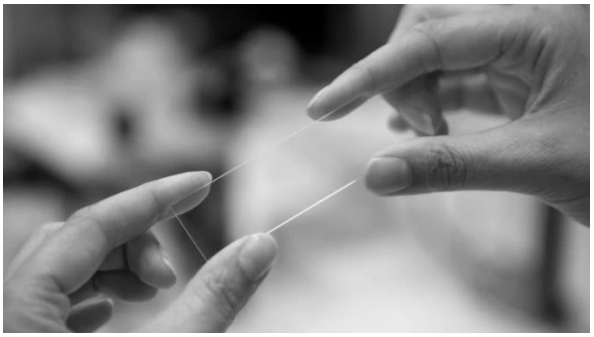
Worksheet D: Method Part 1 (onion cells)

Follow the instructions below to view onion cells under a light microscope. You will prepare a slide so that it looks something like the image below.



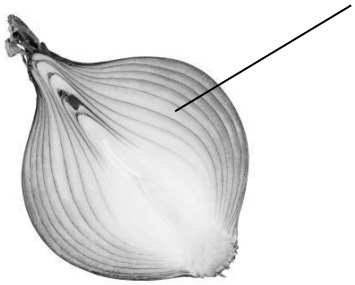
Viewing onion cells

1. Collect your equipment. Take care when carrying the sharp knife or scalpel. If transporting your microscope, make sure you hold it by the arm with one hand and support it by the base with your other hand.
2. Add a drop of distilled water onto the centre of a glass slide using a pipette.

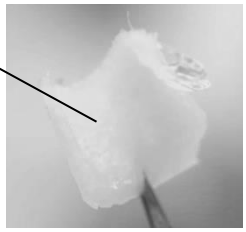


When handling the slides, make sure you hold them by the edges so that you do not get fingerprints on them. Be very gentle as they are fragile and break easily.

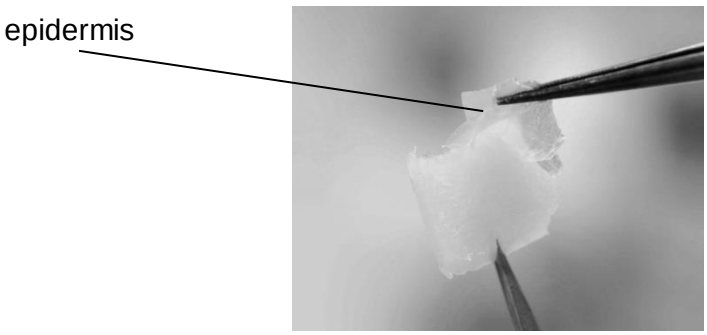
3. Remove the onion skin and cut a slice of onion about 1 cm thick. Cut the slice again into several pieces, each about 1 cm by 1 cm in size. Take care when using a sharp knife or scalpel; cut downwards onto a white tile.
4. Separate the fleshy leaves so you have just one, 1 cm by 1 cm, piece that is one fleshy leaf layer thick.



fleshy leaf



5. Use forceps to remove the epidermal layer of tissue. This is a very thin, almost translucent layer. It is only one cell thick.



6. Using the forceps, place the onion epidermis onto the water droplet on the glass slide. Use a mounted needle to help you to uncurl the edges so that it is flat on the centre of the slide.

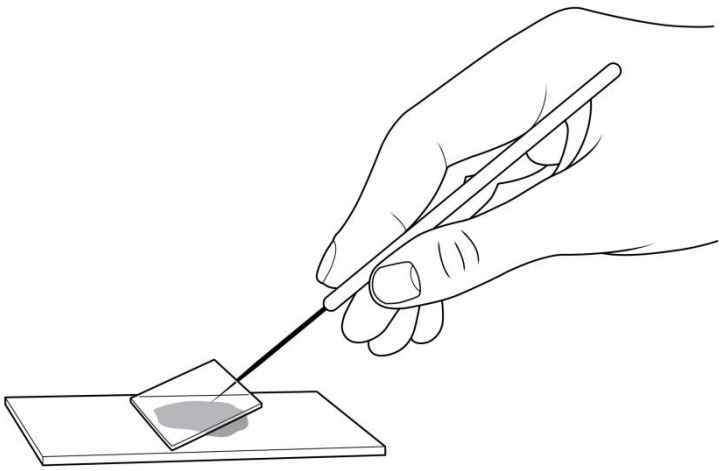
Make sure the epidermis is completely flat.

7. Iodine solution is a stain that can help you to see some of the features of the onion cells. This stains starch particularly well. Add a drop of iodine to the epidermis. Take care not to get any iodine solution on your skin or in your eyes, as it is an irritant.

8. Leave this for 1 minute, to allow time for the stain to take effect.

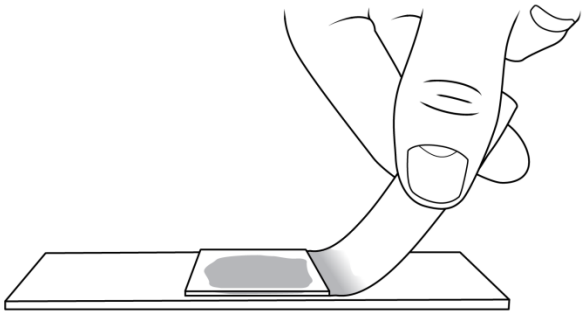
9. Pick up a coverslip, making sure you hold it by the edges like the slide.

10. Place one edge of the coverslip on the slide, to one side of the epidermis. Hold the coverslip at an angle over the epidermis, and then use a mounted needle to help you slowly lower the coverslip over the epidermis. The angle and slow movement is required to avoid air bubbles.



The angle and slow movement is required to avoid air bubbles.

11. There will be excess liquid under and around the coverslip. Place a piece of filter paper along one edge of the coverslip and allow the excess liquid to soak into the paper to remove it.



Now that the slide is prepared, you can view it under the microscope.

12. Move the objective lens so that the lowest power lens is in place.

13. Place the slide on the stage of the microscope, so that the stained epidermis sits over the hole in the stage.

Make sure the stained sample sits over the hole in the stage.

14. Look at the microscope from the side so that you can see the stage. Use the coarse adjustment dial to raise the stage as high as it will go. Make sure you do not go too far and touch the slide with the lens, as the slide might break.

15. Now, look down the eyepiece and turn the coarse adjustment dial in the opposite direction, to lower the stage. This moves the slide away from the objective lens. Stop when the cells come into focus.

16. Draw what you see on Worksheet E (Image 1).

Describe what you can see. Use the words from Worksheet A to help you.

17. Now view the cells under a higher magnification. First, use the coarse adjustment dial to move the stage down. Then, change to a different objective lens with a more powerful magnification.

18. Look down the eyepiece, and use the coarse adjustment dial to bring the cells into focus.

19. Use Worksheet E to draw what you see (Image 2).

Describe what you can see. Can you see more than before? Can you identify any of the structures? What do you think they are? Why?

20. Use Worksheet E to draw what you see (Image 2).

21. Use your diagram at the higher magnification to calculate the actual size of each organelle. Draw a straight line (**AB**) across the widest part of each organelle, then use the following formula.

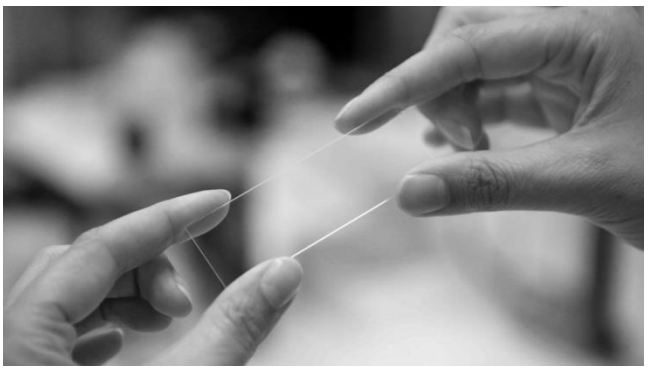
$$\text{actual size of structure} = \frac{\text{length of } \mathbf{AB}}{\text{magnification}}$$

Extended: Multiply your measurement by 1000 to give the length in micrometres.

Worksheet D: Method Part 2 (human cheek cells)

Follow the instructions below to view human cheek cells under a light microscope.

1. Collect your equipment. Take care when carrying the sharp knife or scalpel. If transporting your microscope, make sure you hold it by the arm with one hand and support it by the base with your other hand.



When handling the slides, make sure you hold them by the edges so that you do not get fingerprints on them. Be very gentle as they are fragile and break easily.

2. Insert a cotton bud into your mouth and gently rub it against the inside of your cheek using an up-and-down motion. This will transfer cheek cells onto the cotton bud.

3. Smear the used end of the cotton bud onto the centre of a glass slide. Use smooth side-to-side movements to transfer the cells onto the slide.

4. Put the cotton bud straight into the disinfectant.

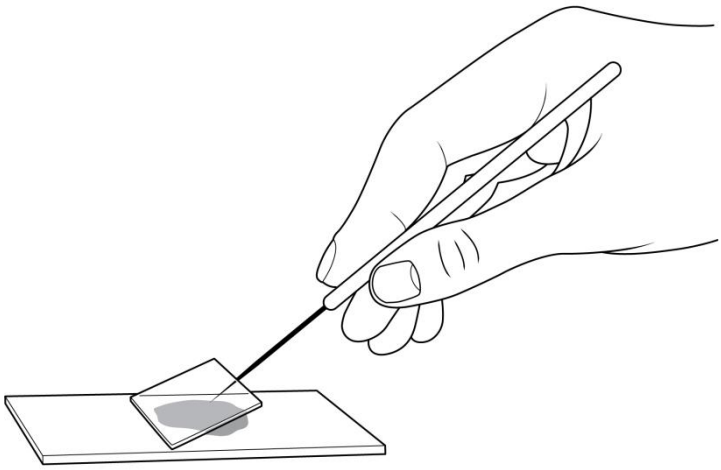
This is essential to reduce the risk of passing infection to another student.

5. Methylene blue is a stain that can be used to show some of the features of a cell. This stains DNA particularly well. Use a dropping pipette to add a drop of methylene blue to the area where the cheek cells were smeared.

6. Leave the methylene blue for a minute to give it time to stain the cells.

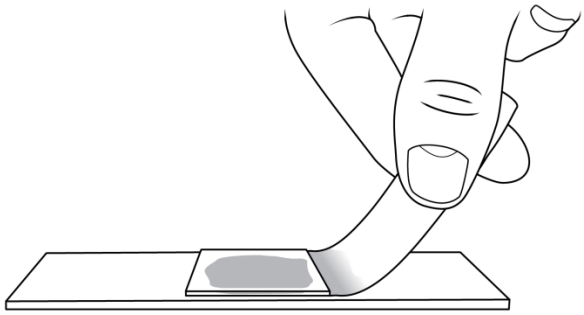
7. Pick up a coverslip, making sure you hold it by the edges like the slide.

8. Place one edge of the coverslip on the slide, to one side of the stained area. Hold the coverslip at an angle over the cells, and then use a mounted needle to help you slowly lower the coverslip over the cells. The angle and slow movement is required to avoid air bubbles.



The angle and slow movement is required to avoid air bubbles.

9. There will be excess liquid under and around the coverslip. Place a piece of filter paper along one edge of the coverslip and allow the excess liquid to soak into the paper to remove it.



Now that the slide is prepared, you can view it under the microscope.

10. Move the objective lens so that the lowest power lens is in place.

11. Place the slide on the stage of the microscope, so that the stained cells sit over the hole in the stage.

Make sure the stained sample sits over the hole in the stage.

12. Look at the microscope from the side so that you can see the stage. Use the coarse adjustment dial to raise the stage as high as it will go. Make sure you do not go too far and touch the slide with the lens, as the slide might break.

13. Now, look down the eyepiece and turn the coarse adjustment dial in the opposite direction, to lower the stage. This moves the slide away from the objective lens. Stop when the cells come into focus.

14. Draw what you see on Worksheet E (Image 3).

Describe what you can see. Use the words from Worksheet A to help you.

15. Now view the cells under a higher magnification. First, use the coarse adjustment dial to move the stage down. Then, change to a different objective lens with a more powerful magnification.

16. Look down the eyepiece, and use the coarse adjustment dial to bring the cells into focus.

17. Use Worksheet E to draw what you see (Image 4).

Describe what you can see. Can you see more than before? Can you identify any of the structures? What do you think they are? Why?

18. Use your diagram at the higher magnification to calculate the actual size of each organelle. Draw a straight line (**AB**) across the widest part of each organelle, then use the following formula.

$$\text{actual size of structure} = \frac{\text{length of } \mathbf{AB}}{\text{magnification}}$$

Extended: Multiply your measurement by 1000 to give the length in micrometres.

Worksheet E: Drawing your samples (Part 1)

Draw what you see under the microscope in the circles on this worksheet.

The circles represent the outline of the view you see when you look down the microscope. Each circle is split into four parts, this should make it easier for you to draw structures in the correct place and to better estimate their sizes compared to each other.

For each cell type, the first circle should be used for the lower magnification and the second circle for the higher magnification.

General drawing tips:

- Use a sharp pencil.
- Use clean, smooth lines.
- Do not add shading.
- Copy exactly what you see down the eyepiece.
- Label any structures that you have identified.
- Always write down the magnification that the sample was viewed at to get the image.

Tips when drawing from a microscope:

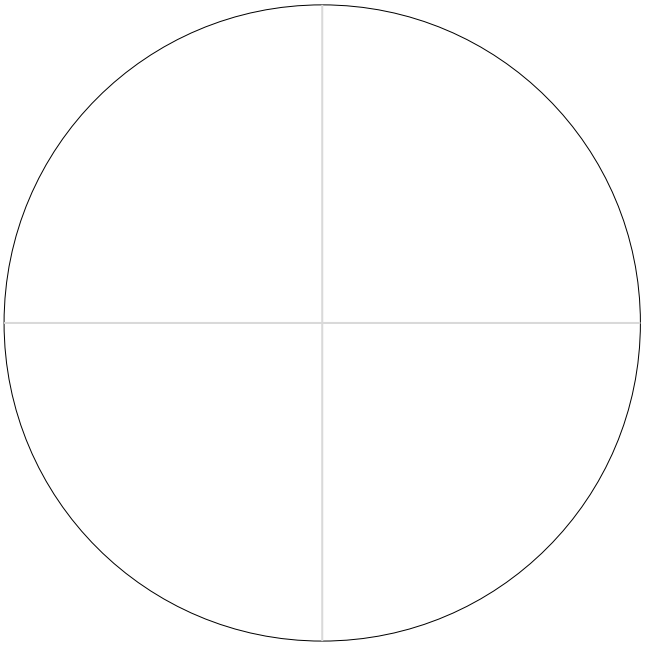
- Start by doing a very light sketch that can easily be rubbed out.
- Draw clear, smooth lines when you are happy with your sketch.
- Focus first on larger shapes and outlines – consider if the edges are straight or curved.
- Consider if lines / outlines cross each other.
- Think about the relative size and position of the visible structures – consider if there are shapes next to each other; overlapping; touching; far apart.
- Then focus on the detail inside the shapes and draw with clear, smooth lines.

Calculating the size of organelles from your diagram:

- Pick **one example** of **each** organelle you have observed.
- Draw a line across the organelle to represent its longest length.
- Take this line to be **AB**.
- Use the formula given in step 21 of Worksheet D.

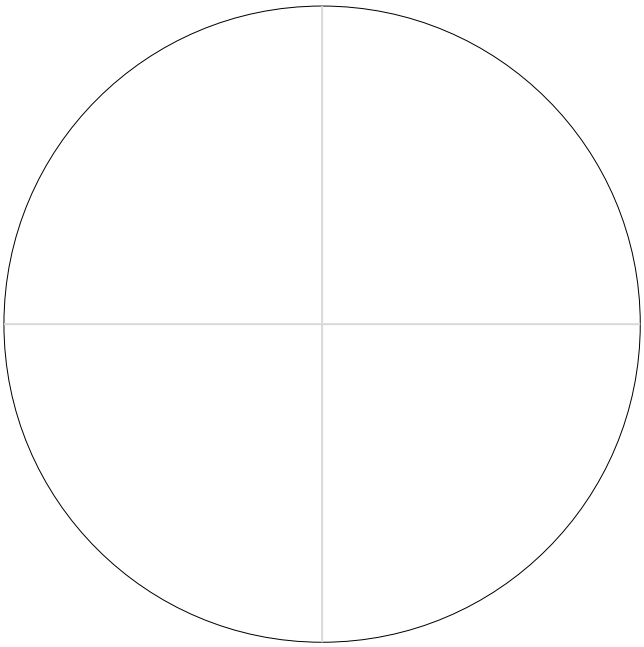
Onion cells

Image 1: this is the view of the onion cells under a low magnification.



Magnification:	
Stain used:	

Image 2: this is the view of the onion cells under a high magnification. Label structures if you can.

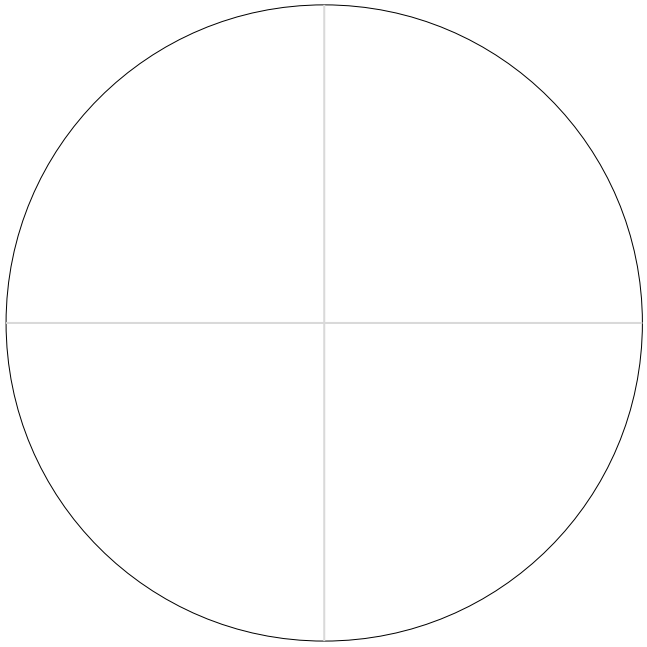


Magnification:	
Stain used:	

Calculations for organelle size (see step 21 on Worksheet D Part 1):

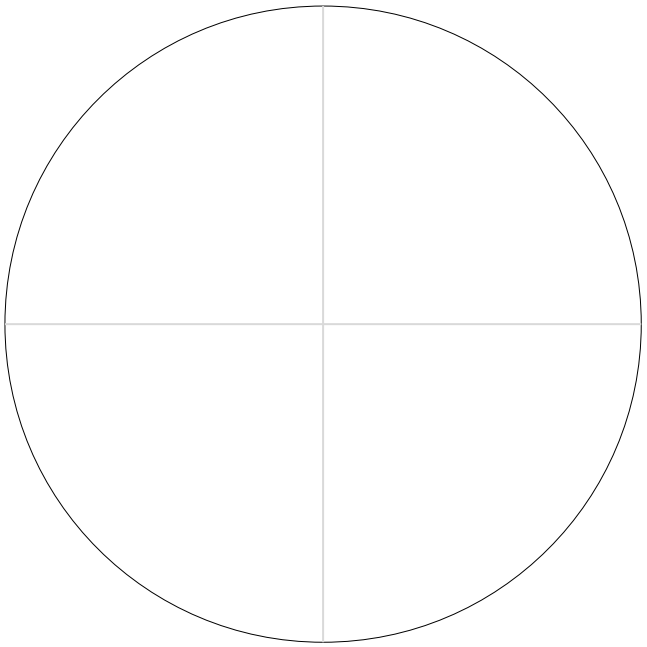
Cheek cells

Image 3: this is the view of the cheek cells under a low magnification.



Magnification:	
Stain used:	

Image 4: this is the view of the cheek cells under a high magnification. Label structures if you can.



Magnification:	
Stain used:	

Calculations for organelle size (see step 18 on Worksheet D Part 2):

Worksheet E: Drawing your samples (Part 2)

Draw what you see under the microscope in the rectangles on this worksheet.

The rectangle represents the outline of the view you will see from the video. Each rectangle is split into four parts, this should make it easier for you to draw structures in the correct place and to better estimate their sizes compared to each other.

For each cell type, the first rectangle should be used for the lower magnification and the second rectangle for the higher magnification.

General drawing tips:

- Use a sharp pencil.
- Use clean, smooth lines.
- Do not add shading.
- Copy exactly what you see down the eyepiece.
- Label any structures that you have identified.
- Always write down the magnification that the sample was viewed at to get the image.

Tips when drawing from a microscope:

- Start by doing a very light sketch that can easily be rubbed out.
- Draw clear, smooth lines when you are happy with your sketch.
- Focus first on larger shapes and outlines – consider if the edges are straight or curved.
- Consider if lines / outlines cross each other.
- Think about the relative size and position of the visible structures – consider if there are shapes next to each other; overlapping; touching; far apart.
- Then focus on the detail inside the shapes and draw with clear, smooth lines.

Calculating the size of organelles from your diagram:

- Pick **one example** of **each** organelle you have observed.
- Draw a line across the organelle to represent its longest length.
- Take this line to be **AB**.
- Use the formula given in step 18 of Worksheet D.

Onion cells

Image 1: this is the view of the onion cells under a low magnification.

Magnification:	
Stain used:	

Image 2: this is the view of the onion cells under a high magnification. Label structures if you can.

Magnification:	
Stain used:	

Calculations for organelle size
(see step 21 on Worksheet D Part 1):

Cheek cells

Image 3: this is the view of the cheek cells under a low magnification.

Magnification:	
Stain used:	

Image 4: this is the view of the cheek cells under a high magnification. Label structures if you can.

Magnification:	
Stain used:	

Calculations for organelle size
(see step 18 on Worksheet D Part 2):

Worksheet F: Thinking about the method

Answer the following questions about the method using the prepare onion cells and human cheek cells for viewing under a light microscope.

1. Why would it be a problem to get fingerprints on the slide? How would it affect your observations?

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2. Why is it important for the onion epidermis to be flat?

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3. Why is it important to leave the stain for 1 minute?

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4. Why is it important to avoid air bubbles?

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5. Why does the sample need to be over the hole in the stage?

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6. Why won't the sizes of the structures you calculated be accurate?

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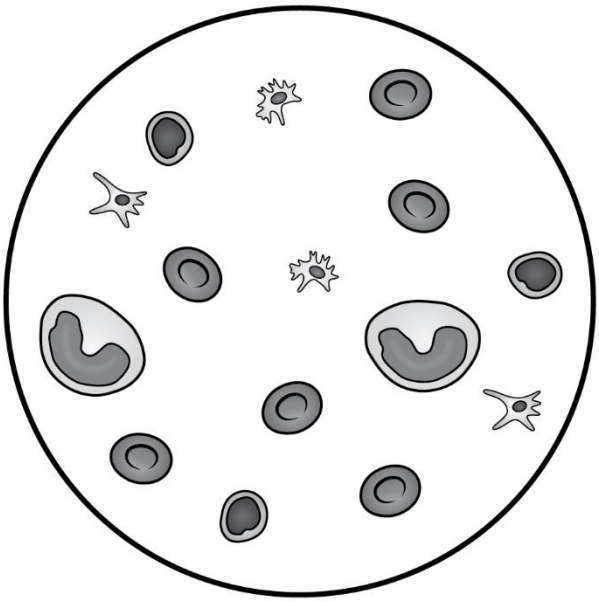
Worksheet G: Viewing the components of blood

1. Clean your finger by washing your hands and wiping them with an ethanol swab.
2. Collect a drop of blood using a sterile lancet.
3. Put a drop of blood onto a slide. Wash the small wound under a tap and put a plaster over the wound.
4. Smear the blood on the glass slide using a second sterile glass slide.
5. Leave the smear to dry for 5 minutes.
6. Dispose of the slide used to smear the blood by placing it in disinfectant.
7. Pour ethanol onto the dry smear and leave for about 2 minutes before pouring it off. This fixes the blood cells in place.
8. Place 5 drops of stain on the blood smear and leave for 1 minute.
9. Press lightly with filter paper to remove the excess liquid and wave in the air to dry.
10. Place a coverslip over the blood sample.
11. View under a microscope to observe the cells in the blood.

Worksheet H: Experiment results

Below are the results of the blood sample of one student, as seen under a microscope.



1. Do you think the student used a high or low magnification? Explain your answer.

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2. Look at the student's drawing. Discuss what you can see with a partner.
   Complete the table below by making observations and measurements; measure each cell at its widest point, not including any pointed sections.

Type of blood cell	Size (mm)	Description
Red blood cell		
Platelet		Irregular shape with pointed sections and a central dark area.
Monocyte	15	
Lymphocyte		Circular shape with a bean-shaped dark area inside, which almost fills the whole cell; looks similar to another cell but smaller.

3. Count the number of each of the different cell types and record them in the table below. Record the total number of cells visible in the sample.

Type of blood cell	Number
Red blood cell	
Platelet	
Monocyte	
Lymphocyte	
Total	

4. Use the data above to calculate what percentage of the sample is made up of each cell type.

$$\text{percentage of blood that is cell type } x = \frac{\text{number of } x \text{ cells in the sample}}{\text{total number of cells}} \times 100$$

Type of blood cell (*x*)	Percentage of blood cell in the sample
Red blood cell	
Platelet	
Monocyte	
Lymphocyte	

5. The student thinks they can apply these percentages to estimate the total number of different types of cell in the blood, for the whole body. Are they correct? Explain why.

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6. How could the student amend their method in order to make a much more accurate estimation of the number of different types of cell in the blood in the whole body?

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7. Why is the term ‘estimate’ more appropriate in this case than ‘exact measurement’?

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Challenge: Use your observations of the structure of each cell in the sample to complete the table below.

Cell type in sample	Adaptation of cell for its function
	Irregular, spikey shape helps them to stick when blood clots.
	Large nucleus enables it to coordinate an immune response.
	Large internal area releases components to fight pathogens.
	Lack of organelles inside maximises the space for carrying oxygen.

Worksheet A: Suggested answers

Possible descriptions of the structures are as follows.

1.

A: Very narrow, roughly oval tubes arranged in rows that fan out from a smaller tube.

B: Thin layer that goes around the outside of / encloses the cell; outermost layer of the cell.

C: Very small dark circles / dots; randomly distributed.

D: Large circle, nearly one quarter of the size of the cell; with a layer around the outside and a small dark area inside.

E: Rows of irregular / wiggly tubes with small dark spots on the outside.

F: Long and sausage-shaped / bean-shaped with wiggly structures / lines inside.

2. Learners can use any of the available letters to label the structure.

(Cell wall) Thick layer going around the outside of the cell; outermost layer of the cell.

(Chloroplast) Oval shaped with small dots inside.

(Vacuole) Large white / clear area that takes up a lot of the cell; about the same size as another large structure without a darker circle inside. It is surrounded by a thin layer.

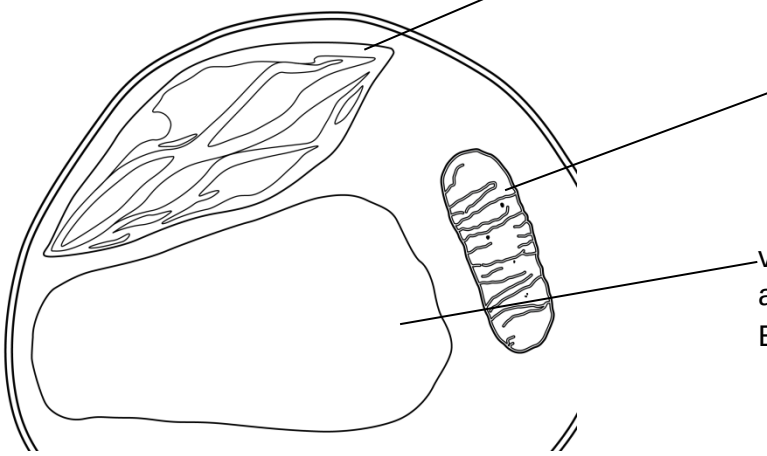
Worksheet B: Suggested answers

1. Diameter of nucleus in image = 3 mm
   Magnification = × 500

2. From left to right: nucleus, chloroplast and cell wall.

3. **AB** = 75 mm; actual size of structure = 0.00188 mm (3 sf); for Extended learners: 1.88 µm (3 sf).

4.



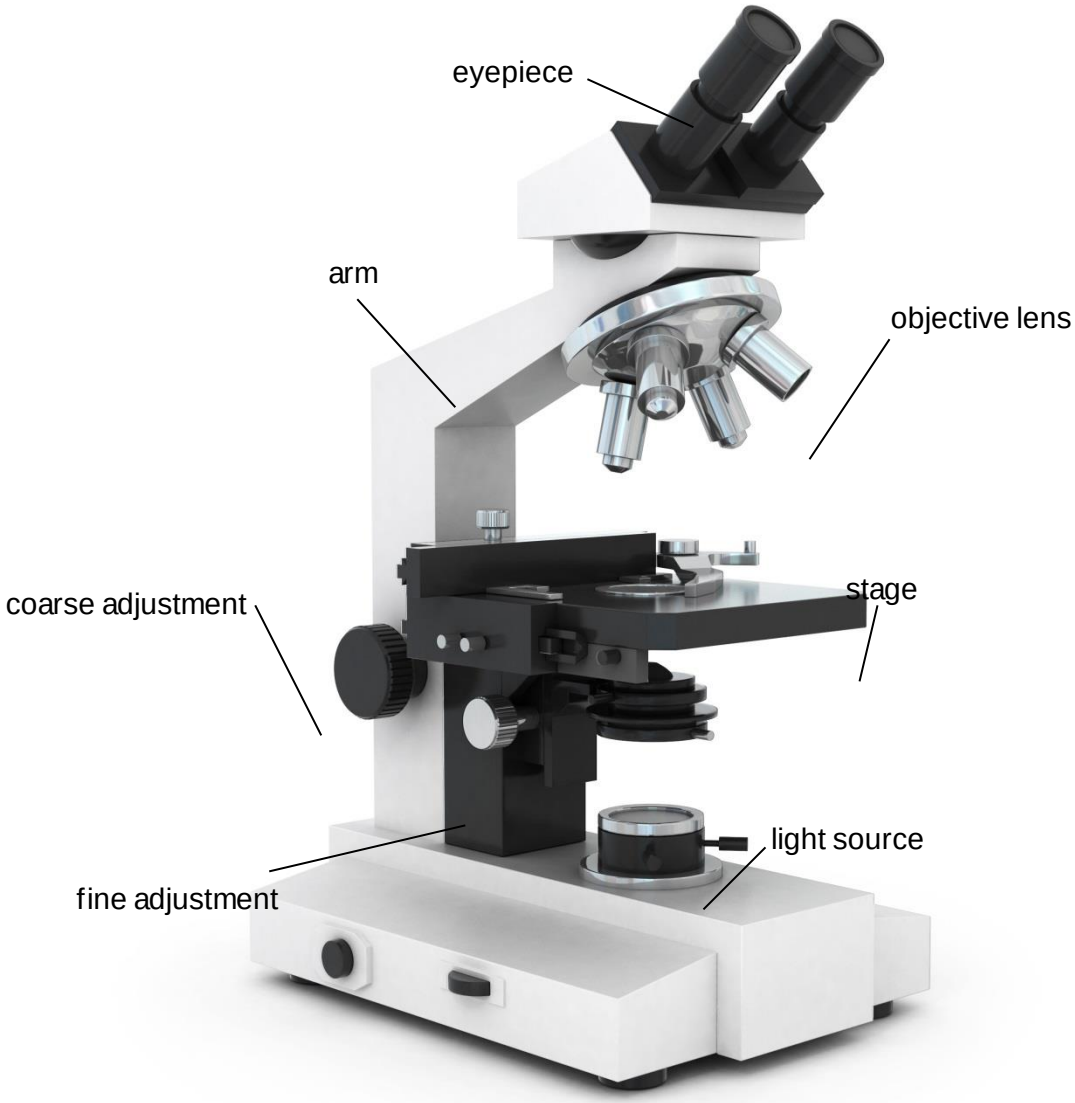
Explanations might include:

The chloroplast is large and oval shaped, with pointed ends and lines inside; it measures 130 mm on the image.

The mitochondria has zig-zagging lines inside it, it is large and sausage-shaped; it measures 67 mm on the image.

The vacuole is a large clear area taking up a large part of the inside of the cell; it measures 131 mm on the image.

Worksheet C: Suggested answers



Eyepiece: the lens that you look through to view the sample. This has a magnification of ×10.

Arm: this connects the body to the base of the microscope.

Coarse adjustment: this allows you to bring the sample into general focus.

Fine adjustment: this fine tunes the focus and increases detail.

Light source: this provides light under/through the sample so that it can be viewed.

Stage: the flat platform that holds the slide.

Objective lens: this magnifies the sample; a standard microscope has three.

Worksheet F: Suggested answers

1. Why would it be a problem to get fingerprints on the slide? How would it affect your observations?

   Fingerprints could make it difficult to see the samples as it will obstruct the view; skin cells might contaminate the sample; you might mistake part of a fingerprint to be a structure in the sample being viewed.

2. Why is it important for the onion epidermis to be flat?

   If the epidermis is folded over then it won't be possible to see the cells properly; the image will be distorted.

3. Why is it important to leave the stain for 2 minutes?

   So that there is time for the stain to soak into the sample and stain the different structures within the cell, making them easier to see.

4. Why is it important to avoid air bubbles?

   Air bubbles reflect light when viewed down the eyepiece, making it difficult to view the sample; obscures the view.

5. Why does the sample need to be over the hole in the stage?

   The hole in the stage allows the light from the light source to pass through the cells; it is also where the objective lens is aligned to; if the sample is not over the hole, you will not be able to see the sample.

6. Why won't the sizes of the structures you calculated be accurate?

   The drawings were not drawn accurately and to scale. We used a normal ruler and as the structures are so small it would have been more accurate to use a ruler with a higher resolution to measure small differences.

Worksheet H: Suggested answers

1. High, because it's possible to see internal structures of the cells.
2. Learners will provide their own descriptions but an exemplar answer is given below.

Type of blood cell	Size (mm)	Description
Red blood cell	8	*Circular, concave, no internal structures.*
Platelet	3	*Irregular shape with pointed sections and a central dark area.*
Monocyte	*15*	*Large circular shape with a U-shaped dark structure inside; similar in appearance to another cell in the sample but larger.*
Lymphocyte	7	*Circular shape with a dark area inside, which almost fills the whole cell; looks similar to another cell but smaller.*

3.

Type of blood cell	Number
Red blood cell	6
Platelet	4
Monocyte	2
Lymphocyte	3
Total	15

4.

Type of blood cell (*x*)	Percentage of blood cell in the sample
Red blood cell	40
Platelet	27
Monocyte	13
Lymphocyte	20

5. No. This is only one sample of blood taken at one time from one individual. There are over 5 litres of blood in the body so the sample is only a tiny proportion of the blood.

6. They should take multiple samples at different times of the day and calculate a mean for each sample.

7. As there is so much blood in the body, the number of blood cells would be huge; it would be incredibly difficult and time-consuming to count them accurately. Blood cells are also always moving, you could never count all of the blood cells in one person at one time. Estimations are a rough guide of the cell type and number over time.

Challenge

Cell type in sample	Adaptation of cell for its function
Platelet	Irregular, spikey shape helps them to stick when blood clots.
Monocyte	Large nucleus enables it to coordinate an immune response.
Lymphocyte	Large internal area releases components to fight pathogens.
Red blood cells	Lack of organelles inside maximises the space for carrying oxygen.

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