Transition to A Level Biology 2020

Welcome to RGS. We're delighted that you have chosen A Level Biology.

This pack will help you to prepare for the course by exploring cell ultrastructure and how we study cells. Completing the work provides a head start into A Level studies and will support your understanding of our first topic in September.

For each of the sections, there are video links to allow you to learn new information and questions to answer to check you have learnt key ideas. Type your answers into the spaces indicated with [ ]. Use the mark scheme at the end to check these.

1. Microscopy and studying cells
2. Eukaryotic cells
3. Prokaryotic cells

Websites for reading:

http://www.a-levelnotes.co.uk/biology-aqa-as-level-notes-new-spec.html

https://www.s-cool.co.uk/a-level/biology/cells-and-organelles

1. Microscopy and studying cells:

Watch: https://www.youtube.com/watch?v=3LIZBn7bS4s and https://www.youtube.com/watch?v=C6tbkXCx8XA

Units and prefixes

A key criterion for success in biological maths lies in the use of correct units and the management of numbers. The units scientists use are from the *Système Internationale* – the SI units. In biology, the most commonly used SI base units are metre (m), kilogram (kg), second (s), and mole (mol). Biologists also use SI derived units, such as square metre (m^2), cubic metre (m^3), degree Celsius (°C), and litre (l).

To accommodate the huge range of dimensions in our measurements they may be further modified using appropriate prefixes. For example, one thousandth of a second is a millisecond (ms). Some of these prefixes are illustrated in the table below.

Multiplication factor	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n

Practice questions

1. A burger contains 4500000 J of energy. Write this in:
   a. kilojoules [ ]

   b. megajoules [ ]

2. HIV is a virus with a diameter of between 9.0×10^{-8} m and 1.2×10^{-7} m.

   Write this range in nanometres [ ]

3. With reference to the images above, define the terms magnification and resolution.

[ ]

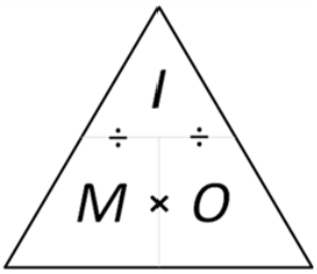
Rearranging formulae

Sometimes you will need to rearrange an equation to calculate the answer to a question. For example, the relationship between magnification, image size, and actual size of specimens in micrographs usually uses the equation:

$$M = \frac{I}{O}$$

where M is magnification, I is size of the image, and O = actual size of the object.

You can use the algebra you have learnt in Maths to rearrange equations, or you can use a triangle like the one shown:



Cover the quantity you want to find. This leaves you with either a fraction or a multiplication:

$M = I \div O$ $O = I \div M$ $I = M \times O$

Practice questions

4. A fat cell is 0.1 mm in diameter. Calculate the size of the diameter seen through a microscope with a magnification of ×50.

[ ]

5. A Petri dish shows a circular colony of bacteria with a cross-sectional area of 5.3 cm2. Calculate the radius of this area.

[ ]

6. In a photograph, a red blood cell is 14.5 mm in diameter. The magnification stated on the image is ×2000. Calculate the real diameter of the red blood cell.

[ ]

Magnification

To look at small biological specimens you use a microscope to magnify the image that is observed. The microscope was developed in the 17th century. Anton van Leeuwenhoek used a single lens and Robert Hooke used two lenses. The lenses focus light from the specimen onto your retina to produce a magnified virtual image. The magnification at which observations are made depends on the lenses used.

Calculating the magnifying power of lenses

Lenses each have a magnifying power, defined as the number of times the image is larger than the real object. The magnifying power is written on the lens.

To find the magnification of the virtual image that you are observing, multiply the magnification powers of each lens used. For example, if the eyepiece lens is ×10 and the objective lens is ×40 the total magnification of the virtual image is 10 × 40 = 400.

Practice questions

7. Calculate the magnification of the virtual image produced by the following combinations of lenses:

a) objective ×10 and eyepiece ×12

[ ]

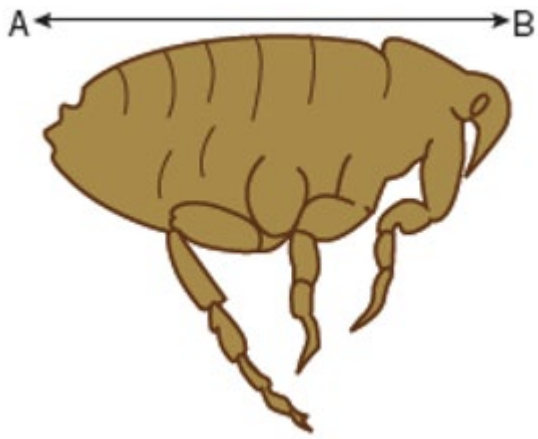
b) objective ×40 and eyepiece ×15

[ ]

Calculating the magnification of images

Drawings and photographs of biological specimens should always have a magnification factor stated. This indicates how much larger or smaller the image is compared with the real specimen.

The magnification is calculated by comparing the sizes of the image and the real specimen. Look at this worked example.



The image shows a flea which is 1.3 mm long. To calculate the magnification of the image, measure the image (or the scale bar if given) on the paper (in this example, the body length as indicated by the line A–B).

For this image, the length of the image is 42 mm and the length of the real specimen is 1.3 mm.

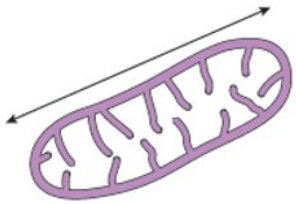
magnification = I / O

= 42/1.3 = 32.31

The magnification factor should therefore be written as ×32.31

Remember: Use the same units. A common error is to mix units when performing these calculations. Begin each time by converting measurements to the same units for both the real specimen and the image.

Practice question

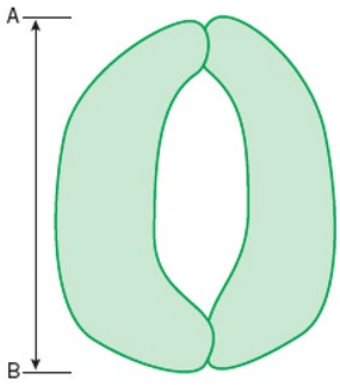


8. Calculate the magnification factor of a mitochondrion that is 1.5 µm long. The image is not to scale, assume the arrowed line has a length of 38mm

[ ]

Calculating real dimensions

Magnification factors on images can be used to calculate the actual size of features shown on drawings and photographs of biological specimens. For example, in a photomicrograph of a cell, individual features can be measured if the magnification is stated. Look at this worked example.



The magnification factor for the image of the open stoma is ×5000.

This can be used to find out the actual size of any part of the cell, for example, the length of one guard cell, measured from A to B.

Step 1: Measure the length of the guard cell as precisely as possible. In this example the image of the guard cell is 52 mm long.

Step 2:	Convert this measurement to units appropriate to the image. In this case you should use µm because it is a cell.

So the magnified image is 52 × 1000 = 52 000 µm

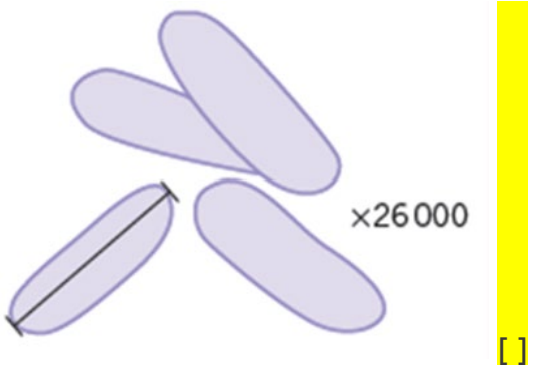
Step 3: Rearrange the magnification equation (see Topic 3.2) to get:

real size = size of image/magnification = 52 000/5000 = 10.4

So the real length of the guard cell is 10.4 µm.

Practice question

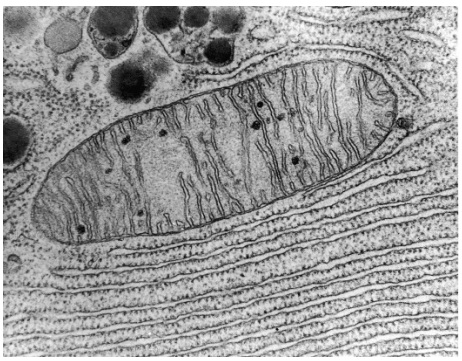
9. Use the magnification factor to determine the actual size of a bacterial cell. The image is not to scale, assume the arrowed line has a length of 46mm



Comparing types of microscope

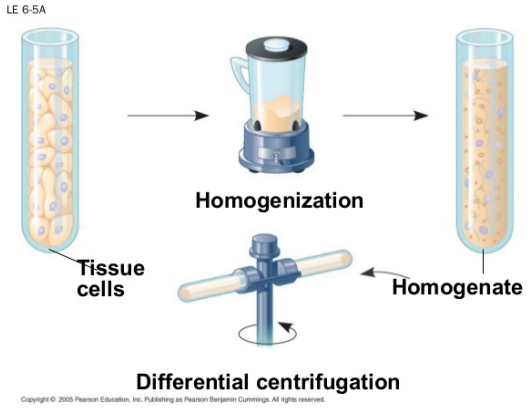
Light Microscope	Electron Microscope
Illuminating source is the Light.	Illuminating source is [ ]
Specimen preparation takes typically a few minutes to hours.	Specimen preparation takes typically a few days and a highly skilled technician to prepare the slides.
[ ]	Only Dead or Dried specimens are seen.
Condenser, objective and eye piece lenses are made of [ ]	All lenses are electromagnetic.
Have a maximum resolving power of approximately [ ]	Have a high resolving power (0.001µm), about 250 times higher than light microscope.
Have a maximum magnification of 400X to 2000X.	Have a maximum magnification of [ ]
The subject is 5µm or thicker.	The subject is 0.1µm or thinner.
Image is Coloured.	Image is [ ]
Vacuum is not required.	Vacuum is essential for its operation because [ ]
It is used for the study of detailed gross internal structure.	It is used in the study of external surface, ultra-structure of cell and very small organisms.

Suggest which kind of microscope was used to make the image below? Justify your answer.



[ ]

Cell fractionation and centrifugation



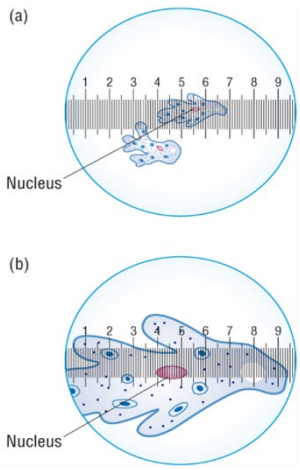
1. Cell fractionation and ultracentrifugation can be used to isolate organelles for study.
   a. Sequence the steps in the process

Centrifuge at moderate speed to sediment larger organelles	[ ]
Break apart cells using a blender	[ ]
Mix tissue sample with the isolation medium	[ ]
Filter to remove the whole or partial cells	[ ]
Ultracentrifuge at high speeds to sediment smaller fragments	[ ]

   b. Why is the isolation medium...?

Buffered to maintain pH	[ ]
The same water potential as the cytoplasm	[ ]
Cold	[ ]

Measuring objects using a light microscope



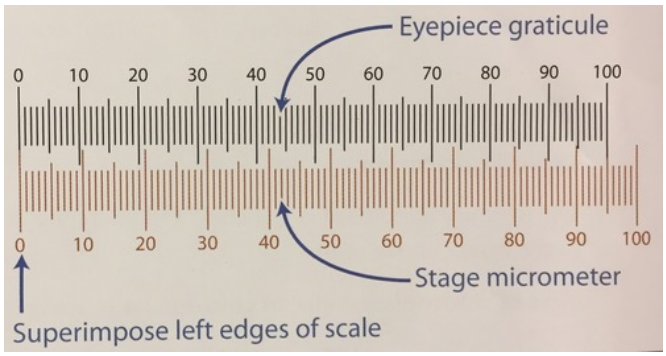
A **graticule** is a measuring device which is fitted into the eyepiece of a light microscope. In effect it is a ruler - a straight line subdivided into 100 eye piece units (**epu**).

The eyepiece can be rotated to align the graticule and the object you are measuring. The diagram below shows two amoebae next to a graticule. You can see that every 10epu are numbered - this is to help with counting.

In (a) we can see that an amoeba is 29 epu long. Image (b) is at a higher magnification and we can see that the nucleus is 13epu long. But this should instinctively sound wrong - a nucleus doesn't fill nearly half the cell!

Eye piece units are arbitrary - their real value in micrometres depends on the magnification being used (and, potentially, graticules may vary). So we should always calibrate our graticule to work out the "real

world" value of a single epu at different magnifications. To do this we use a **stage micrometer -** a 1mm ruler etched onto a slide (divided into 100 units - i.e. 10µm).

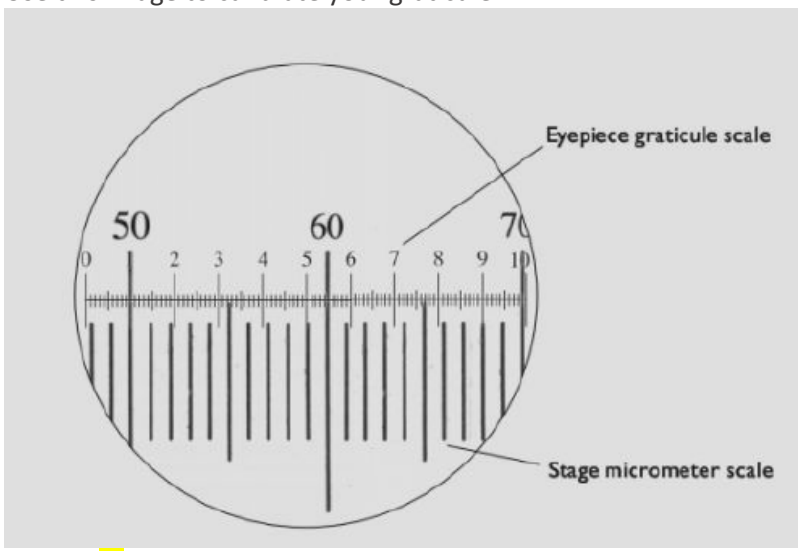


To calibrate the graticule you line it up with the stage micrometer so that they are parallel and the left hand edges are aligned, then read off the value in mm of 100epu

Here we can see 100epu = 0.95mm or 950µm. We divide this measurement by 100 to find out the distance represented by 1epu (9.5µm).

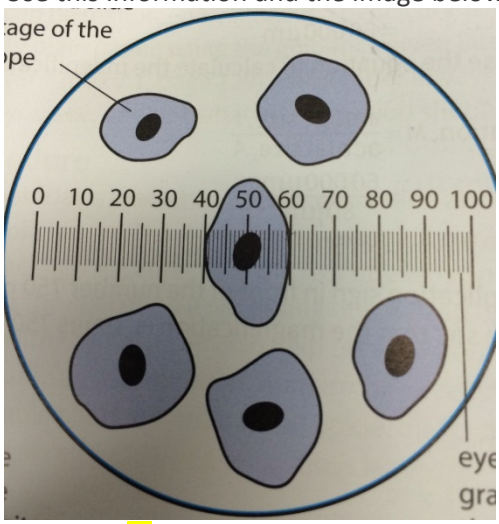
If this were the calibration for the graticule in (a) we could then calculate the real length of the amoeba: 29 x 9.5 = 275.5µm

Practice:
Use this image to calibrate your graticule:



1 epu = [ ]

Use this information and the image below to determine the diameter of the nucleus:

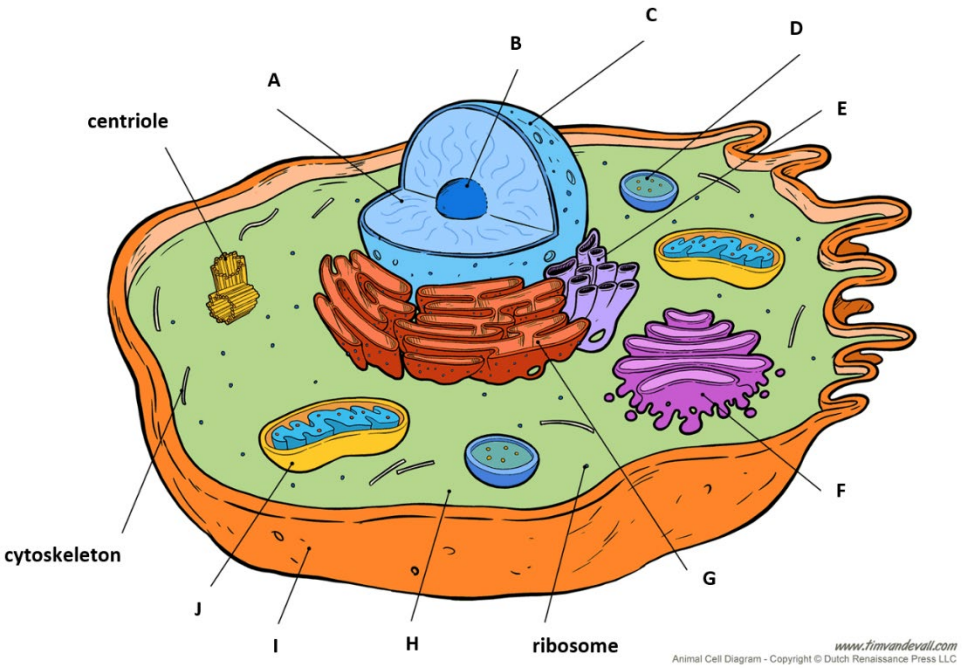


Nucleus = [ ]

2. Eukaryotic Cells

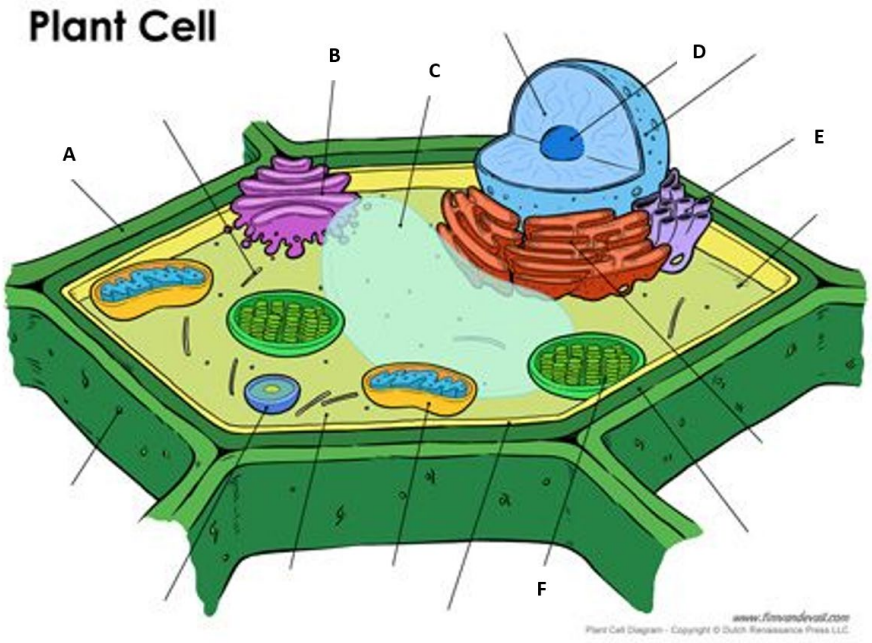
Watch: https://www.youtube.com/watch?v=WDkamxy3EOQ

1. Label the structures in the animal cell:



A: [ ]
B: [ ]
C: [ ]
D: [ ]
E: [ ]
F: [ ]
G: [ ]
H: [ ]
I: [ ]
J: [ ]

2. Label the structures in the plant cell:



A: [ ]
B: [ ]
C: [ ]
D: [ ]
E: [ ]
F: [ ]

3. Complete the table to describe the structure and functions of the structures found in animal and plant cells. An example is given:

Organelle	Description of structure	Description of function

Cell surface membrane	Bilayer of phospholipids with embedded proteins and some carbohydrate chains sticking out from surface (attached to proteins and lipids)	• Barrier between cell contents and external environment - selectively permeable to small molecules • Controls transport of substances into and out of the cell • Contains receptors, to detect hormones and other cells • Cell - cell attachment
Nucleus (nuclear envelope and chromatin)	[ ]	[ ]
Nucleolus (nucleus)	[ ]	[ ]
Mitochondria	[ ]	[ ]
Ribosome	[ ]	[ ]
Rough Endoplasmic Reticulum	[ ]	[ ]
Smooth Endoplasmic Reticulum	[ ]	[ ]
Golgi Apparatus	[ ]	[ ]
Lysosome	[ ]	[ ]
Chloroplast	[ ]	[ ]
Vacuole	[ ]	[ ]
Cell wall	[ ]	[ ]

4. How does the structure of an organelle relate to it's function?

Read the paragraph below describing how the structure of the nucleus relates to its function. Then write three sentences explaining how the structure of a mitochondrion relates to its function (look at the hints to help you)

The nucleus is surrounded by a double membrane, or envelope, which separates the contents of the nucleus from the cell and protects the DNA from damage by the enzymes in the cytoplasm. Protein pores in the envelope are a specific shape and size, allowing the movement of RNA molecules out of the nucleus.
The nucleolus is a dense region of proteins and nucleic acids, which contains the enzymes needed to synthesise ribosomes.
The DNA is wrapped around histone proteins, forming the more stable structure chromatin & protecting the DNA. Chromatin can be densely packed, preventing transcription and further protecting the DNA, or loosely packed, allowing RNA polymerase to bind and transcription of genes to occur.

Mitochondria:

a. [ ]
b. [ ]
c. [ ]

HINTS: Folded inner membrane (cristae); Matrix; Ribosomes and DNA

Chloroplasts:

b. [ ]
d. [ ]
e. [ ]

HINTS: Thylakoid membranes, stroma; Ribosomes and DNA

5. Give two similarities and two differences between the ultrastructure of plant and animal cells. (Compare)

[ ]

3. Prokaryotic cells

Watch: https://youtu.be/W_geqbT3KUc

Complete the table below:

Prokaryotic Cell Structure	Function of that structure	Compare and contrast with eukaryotic cells
Plasma membrane	( )	( )
Plasmid	Plasmids are extra-chromosomal circular DNA molecules that replicate independently of chromosomal DNA. Carries many genes which benefits bacteria for survival.	( )
Flagella	( )	( )
Pili	( )	Not seen in eukaryotic cells
Mesosome	Increases the internal surface area of the membrane increasing efficiency of aerobic respiration.	Has a similar role to cristae of mitochondria. Not as efficient as mitochondria as the membranes surrounding a mitochondrion allow for the control of conditions inside the organelle and allow an increased concentration of important chemicals and enzymes.
Ribosome	( )	( )
Nucleoid	( )	( )
Cell wall	( )	The major component of the bacterial cell wall is murein (a glycoprotein) whereas plant cell walls are composed from cellulose and fungal cell walls from chitin.
Capsule	( )	Not seen in eukaryotic cells.

Mark schemes:

1. Microscopy and studying cells:

Calculations - practice questions

1. A burger contains 4500000 J of energy. Write this in:
a. kilojoules (4500 kJ) b. megajoules (4.5 MJ)

2. HIV is a virus with a diameter of between 9.0×10^{-8} m and 1.2×10^{-7} m.
Write this range in nanometres (90 to 120 nm)

3. **Magnification** is the ability to make small objects seem larger, such as making a microscopic organism visible. **Resolution** is the ability to distinguish two objects from each other. In the above pictures the image of the flower is larger and has therefore been magnified but the blurry image means it is lower resolution, less detail can be made out.

4. O = 0.1 mm I = ? M = 50 $I = M \times O$ = 50 × 0.1 mm = **5 mm**

5. Area = 5.3 cm^2 radius? $A = \pi r^2$ $5.3 = \pi r^2$ $r^2 = 1.687$ r = 1.3 cm

6. 7.25×10^{-6} m (7.25 µm)

7. **a** objective ×10 and eyepiece ×12 = x120
b objective ×40 and eyepiece ×15 = x600

8. The line is given as 38mm, which is the same as 38,000 µm.
$M = I \div O$ *so 38,000* ÷ 1.5 = **x 25,333'**

9. The length of the line is given as 4.6mm so 46,000 µm
$O = I \div M$ *so* 46,000 µm ÷ 26,000 = **1.8 µm**

Types of microscope:

Light Microscope	Electron Microscope
Illuminating source is the Light.	Illuminating source is (a high voltage power supply known as an electron gun)
Specimen preparation takes typically a few minutes to hours.	Specimen preparation takes typically a few days and a highly skilled technician to prepare the slides.
(Living specimens may be observed)	Only Dead or Dried specimens are seen.
Condenser, objective and eye piece lenses are made of (glass)	All lenses are electromagnetic.
Have a maximum resolving power of approximately (0.25 µm).	Have a high resolving power (0.001µm), about 250 times higher than light microscope.
Have a maximum magnification of 400X to 2000X.	Have a maximum magnification of (transmission electron microscope up to x 500,000; scanning electron microscope up to x 30,000; scanning, tunnelling electron microscope can be as high as x 100,000,000)
The subject is 5µm or thicker.	The subject is 0.1µm or thinner.
Image is Coloured.	Image is (black and white, although computer generated false colours can be added)

Vacuum is not required.	Vacuum is essential for its operation because (electron beams require a vacuum otherwise the electrons would collide with air particles)
It is used for the study of detailed gross internal structure.	It is used in the study of external surface, ultra-structure of cell and very small organisms.

Which kind of microscope was used to make the image below? Justify your answer.
(A transmission electron microscope (TEM) as the details seen within the mitochondrion suggest the magnification and resolution is much higher than possible with a light microscope and the image is 2-D)

Cell fractionation and ultracentrifugation can be used to isolate organelles for study.

a. Sequence the steps in the process

Centrifuge at moderate speed to sediment larger organelles	[4]
Break apart cells using a blender	[2]
Mix tissue sample with the isolation medium	[1]
Filter to remove the whole or partial cells	[3]
Ultracentrifuge at high speeds to sediment smaller fragments	[5]

b. Why is the isolation medium...?

Buffered to maintain pH	[prevent denaturation of proteins]
The same water potential as the cytoplasm	[prevent osmosis, so no lysis or shrinkage of organelles]
Cold	[slows enzyme activity to prevent digestion of organelles]

Graticule practice

1 epu = [2.2 µm]

Use this information and the image below to determine the diameter of the nucleus:
Nucleus = [13.2 µm]

2. Eukaryotic cells:

1. animal cell structures

A: [Nucleus / chromatin]
B: [Nucleolus]
C: [Nuclear envelope / membrane]
D: [lysosome]
E: [smooth endoplasmic reticulum]
F: [Golgi apparatus]
G: [rough endoplasmic reticulum]
H: [cytoplasm]
I: [cell membrane]
J: [mitochondrion]

2. Label the structures in the plant cell:
A: [cell wall]
B: [Golgi apparatus]
C: [vacuole]
D: [nucleolus]
E: [smooth endoplasmic reticulum]
F: [chloroplast]

3. Complete the table to describe the structure and functions of the structures found in an animal cell. An example is given:

Organelle	**Description of structure**	**Description of function**
Cell surface membrane	*Bilayer of phospholipids with embedded proteins and some carbohydrate chains sticking out from surface (attached to proteins and lipids)*	• *Barrier between cell contents and external environment - selectively permeable to small molecules* • *Controls transport of substances into and out of the cell* • *Contains receptors, to detect hormones and other cells* • *Cell - cell attachment*
Nucleus (nuclear envelope and chromatin)	[DNA is surrounded by a double membrane envelope.]	[Stores the DNA (wound round histone proteins). The nuclear envelope separates the DNA from the rest of the cell's contents.]
Nucleolus (nucleus)	[A dense darker staining area in the nucleus]	[the site of ribosome synthesis]
Mitochondria	[Small oval structure, with a double membrane. The inner membrane is folded. The matrix – inner fluid – contains ribosomes and circular DNA]	[site of the reactions of aerobic respiration]
Ribosome	[Very small structure, made up of two subunits. Composed of RNA and proteins]	[site of protein synthesis]
Rough Endoplasmic Reticulum	[A very large folded double membrane, forming a network of tubes throughout the cell. The surface is studded with ribosomes]	[site of protein synthesis. These proteins are transported throughout the cell and can be moved to the Golgi in vesicles, or embedded in membranes]

Smooth Endoplasmic Reticulum	[A very large folded double membrane, forming a network of tubes throughout the cell.]	[Site of carbohydrate and lipid synthesis. These can then be transported throughout the cell]
Golgi Apparatus	[Stack of flattened membrane sacs, with lots of vesicles surrounding the structure]	[Modification of proteins and lipids, for example by adding carbohydrate groups; packing of enzymes, proteins and lipids into vesicles for transport]
Lysosome	[Small vesicle – sphere of membrane – containing digestive enzymes]	[digestion of old organelles, engulfed pathogens, etc]
Chloroplast	[oval membrane bound organelle, containing horizontal stacks of thylakoid membranes – which contain chlorophyll. Fluid stroma contains DNA, ribosomes and starch grains]	[carry out the reactions of photosynthesis]
Vacuole	[Large fluid filled space, surrounded by a membrane]	[Help to maintain turgor pressure; store sugars, amino acids and pigments]
Cell wall	cross-linked mesh of cellulose fibres (and sometimes lignin), joined to neighbouring cell walls by the middle lamellae, made of pectin]	[provide mechanical strength to prevent the cell bursting; provide mechanical strength to the plant; allow water and fluid movement]

4. How does the structure of an organelle relate to its function?

Mitochondria:

a. [The folded inner membrane (Cristae) provides a large surface area. This means there can be a large number of proteins carrying out the reactions of aerobic respiration and a faster rate of respiration]
b. [The matrix contains the enzymes and substrates needed for aerobic respiration. By keeping them concentrated in one place the rate of reaction is increased.]
c. [The mitochondria contains ribosomes and DNA, allowing it to synthesise some of the proteins needed in respiration]

Chloroplast:

- thylakoid membranes provide a large surface area, increasing the number of chlorophyll molecules available to absorb light energy for the first stage of photosynthesis
- Stroma contains the enzymes needed to make sugars in the second stage of photosynthesis
- Contains the DNA and ribosomes needed to make some photosynthetic enzymes
- Stores some of the products of photosynthesis as starch grains

5. Give two similarities and two differences between the ultrastructure of plant and animal cells. (Compare)
[Both have: nuclear envelope; nucleolus; mitochondria; lysosomes; smooth endoplasmic reticulum; rough endoplasmic reticulum; Golgi apparatus; ribosomes; cell surface membrane; nucleus; - 2 marks

Only plant cells have: chloroplasts; cell wall; vacuole; - 2 marks]

3. Prokaryotic cells:

Prokaryotic Cell Structure	Function of that structure	Compare and contrast with eukaryotic cells
Plasma membrane	The primary function of the plasma membrane is to protect the cell from its surroundings. The plasma membrane is selectively permeable to ions and organic molecules and regulates the movement of substances in and out of cells.	Similar to the plasma membranes of eukaryotic cells.
Plasmid	Plasmids are extra-chromosomal circular DNA molecules that replicate independently of chromosomal DNA; carries many genes that benefit bacteria for survival.	Not seen in eukaryotic cells.
Flagella	Flagella are primarily for cell movement. The prokaryotic flagellum spins, creating forward movement by a corkscrew shaped filament.	Prokaryotic flagella form from different proteins to Eukaryotic flagella. Prokaryotic flagella are smaller in size and narrower, while Eukaryotic flagella are larger in size and thicker.
Pili	A pilus is a thin, rigid fibre made of protein that protrudes from the cell surface. The primary function of pili are to attach a bacterial cell to specific surfaces or to other cells.	Not seen in eukaryotic cells.
Mesosome	Increases the internal surface area of the membrane increasing efficiency of aerobic respiration.	Has a similar role to cristae of mitochondria. Not as efficient as mitochondria as the membranes surrounding a mitochondrion allow for the control of conditions inside the organelle and allow an increased concentration of important chemicals and enzymes to be maintained.
Ribosome	Involved in protein synthesis.	The mass units of ribosomes are their Svedberg (S) values, which are based on and how rapidly the subunits settle to the bottom of test tubes in an ultracentrifuge due to their densities. The ribosomes of eukaryotic cells usually have Svedberg values of 80S. In contrast, prokaryotic cells contain ribosomes reaching 70S.
Nucleoid	Region in the prokaryotic cell in which a single chromosomal, circular, double-stranded DNA molecule is located.	Eukaryotic cells have a nucleus which is a membrane-bound structure where they store their genetic materials.
Cell wall	The cell wall is the protective, semi-permeable outer layer of many types of cell. A major function of the cell wall is to give the cell strength and structure, and to filter molecules that pass in and out of the cell.	The major component of the bacterial cell wall is murein (a glycoprotein) whereas plant cell walls are composed from cellulose and fungal cell walls from chitin.

Capsule	The capsule can help protect cells from engulfment by eukaryotic cells, such as phagocytes; capsules contain water, which protects the bacteria from drying out; make bacterial cells more resistant to viruses and toxic materials such as detergents; help cells adhere to surfaces.	Not seen in eukaryotic cells.