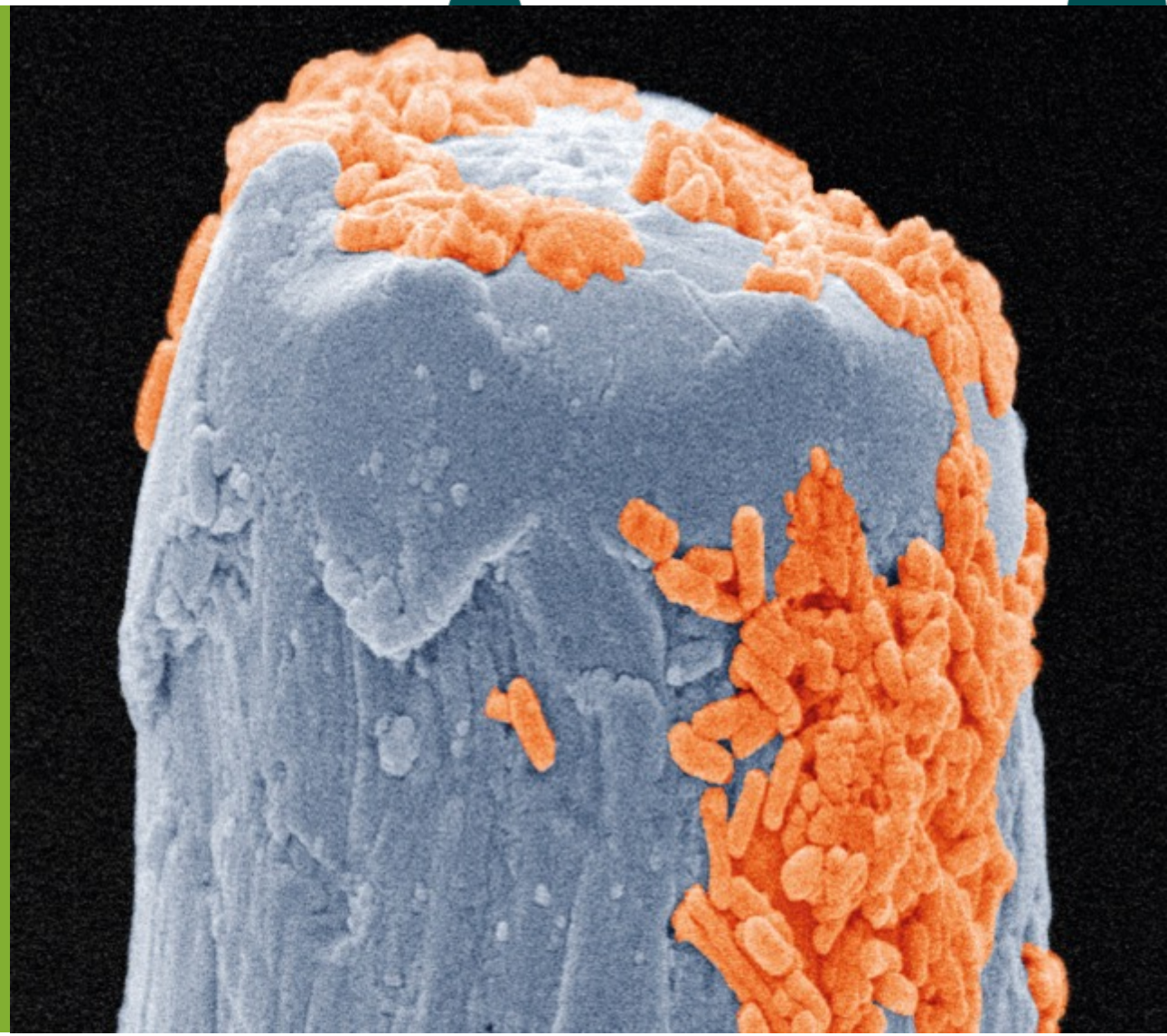
CHAPTER 2

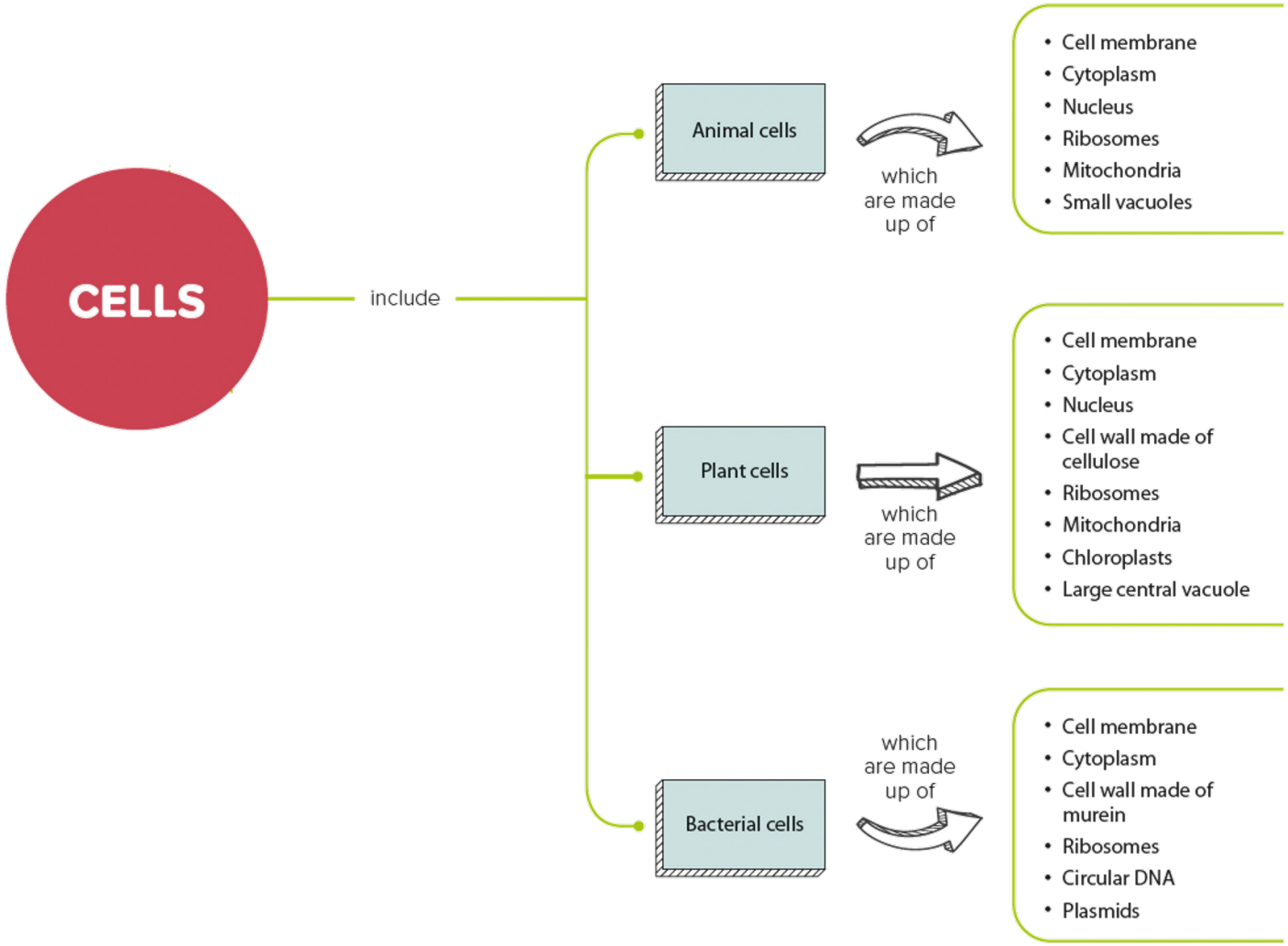
ORGANISATION OF THE ORGANISM



2.1 Cell Structure

In this section, you will learn the following:

- Describe the term *cell*.
- Describe the parts of animal cells, plant cells and bacterial cells, and their functions.
- Identify in diagrams and images the parts of animal cells, plant cells and bacterial cells.
- Compare the structures of plant cells and animal cells.



Imagining cells as chemical factories

- **Cells** are the building blocks of life.
- Cells are like chemical factories. Each cell is made up of different parts, and each part has a specific function.

Control Centre –
Security Check / Gate –
Energy Source - PLN

LINK

Recall the characteristics of life in Chapter 1.

How can we study cells and their parts?

- We can use a light microscope or an electron microscope to observe cells.
- **Light microscopes** can magnify objects up to 1500×.
- **Electron microscopes** can magnify objects to more than 200 000×.

Light microscope

Electron microscope

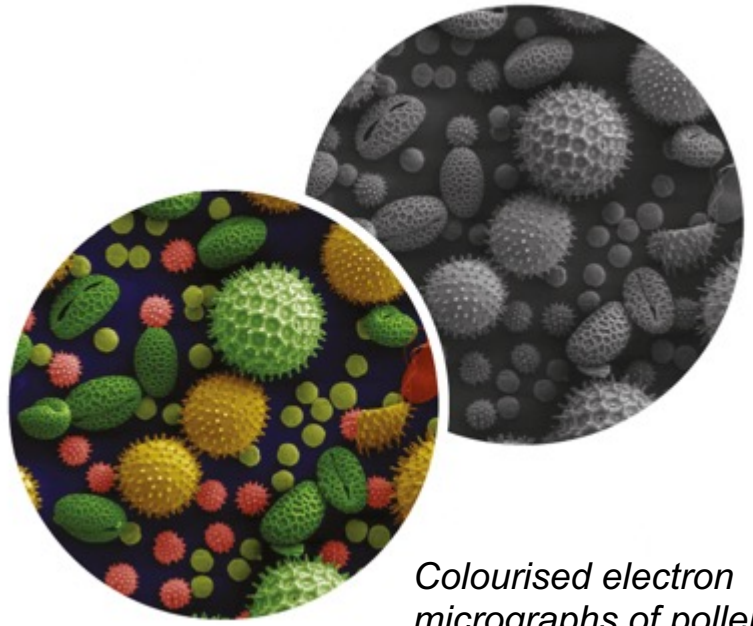
How can we study cells and their parts?

- Micrographs are photographs captured through a microscope.

- **Light micrographs** (**photomicrographs**) can come out as coloured images.

Photomicrograph of Salmonella

- **Electron micrographs** are black-and-white images, but they can be artificially colourised.

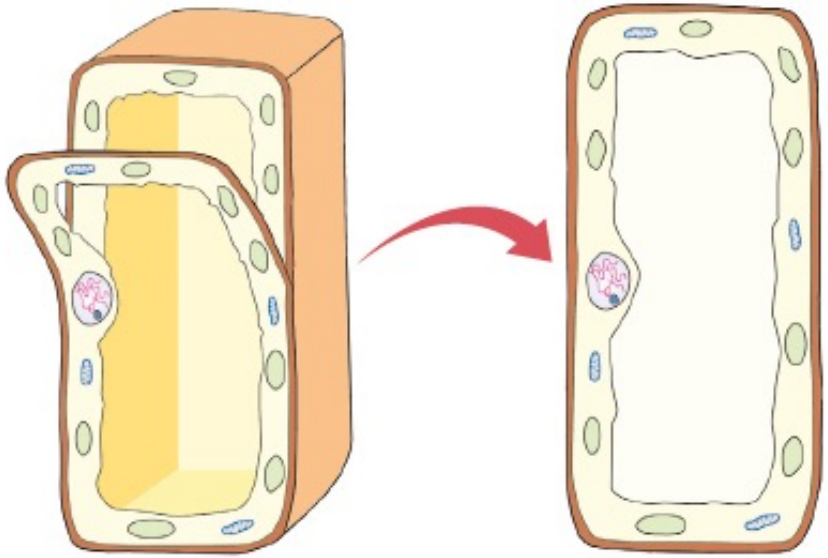


Original electron micrograph of pollen grains

Colourised electron micrographs of pollen grains

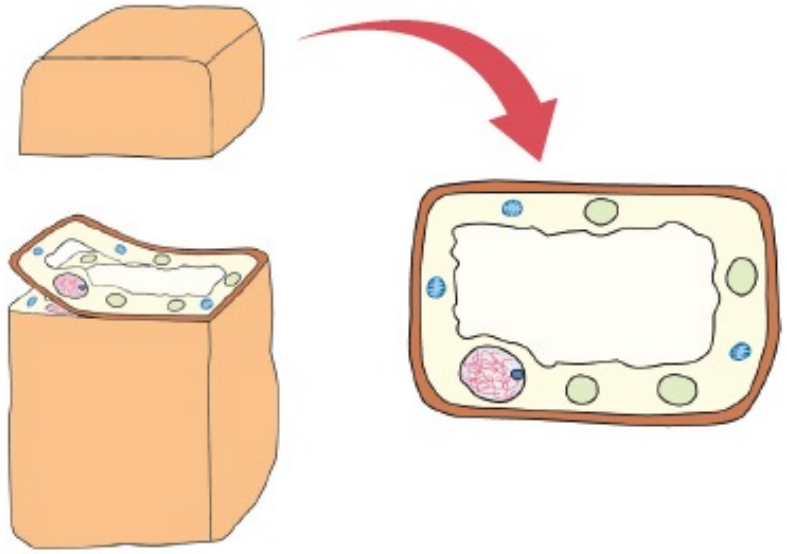
How can we get a clearer picture of cells?

A longitudinal section (L.S.) is made by cutting the cell *along* its length.



Cutting a longitudinal section

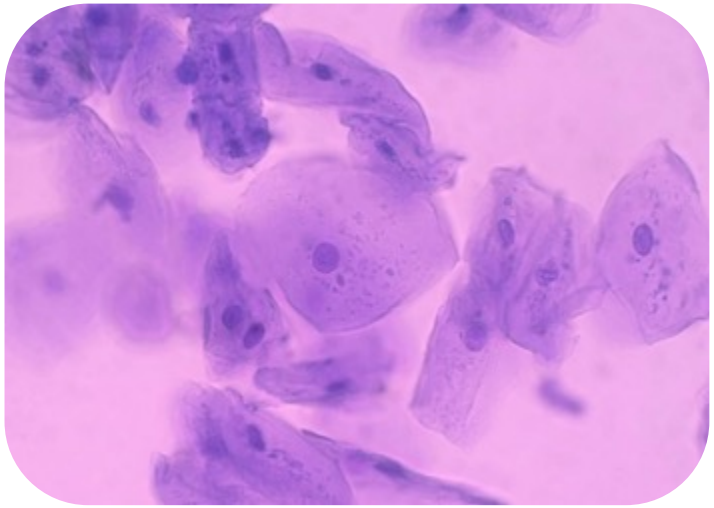
A transverse section (T.S.) is made by cutting the cell *across* its length.

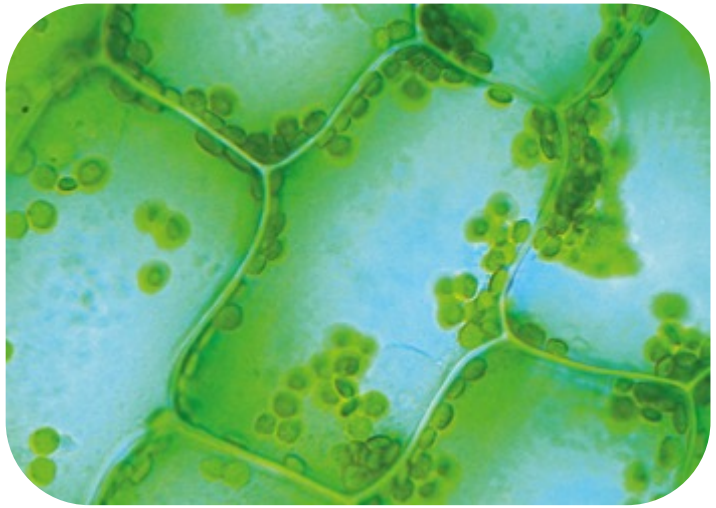


Cutting a transverse section

Cross-section

What makes up an animal cell and a plant cell?



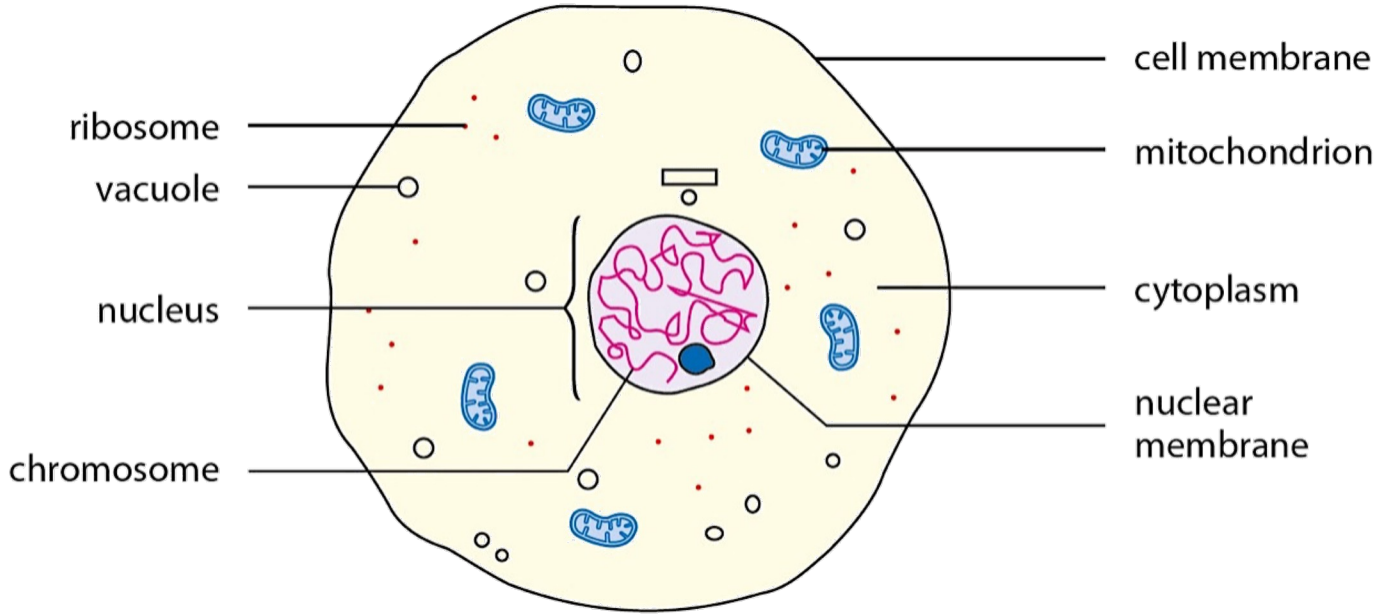


Which are animal cells and which are plant cells?

How can we differentiate between animal cells and plant cells?

What makes up an animal cell and a plant cell?

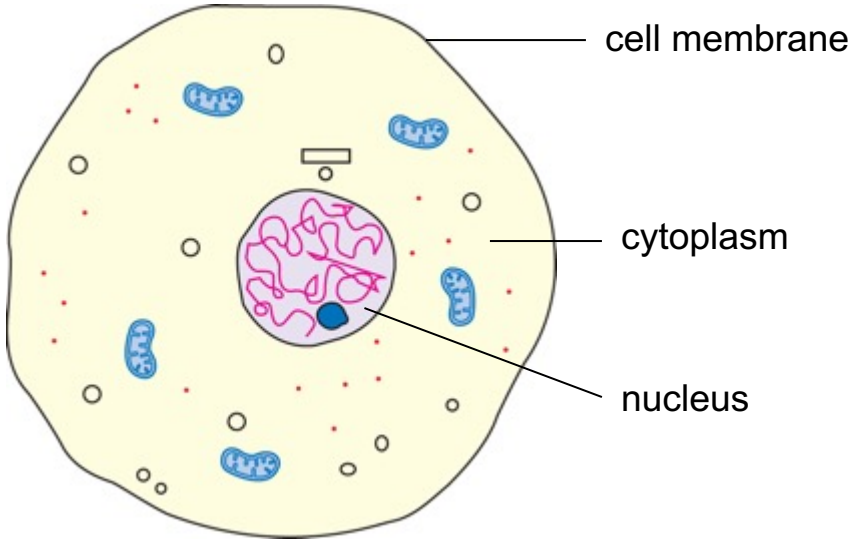
- Most cells have certain parts in common.
- The diagram shows an animal cell and its cell parts.



Generalised diagram of an animal cell showing some major parts (Figure 2.3 of Student's Book)

What makes up an animal cell and a plant cell?

Part	Description and function(s)
Cell membrane	• It is partially permeable. • It controls substances entering and leaving the cell.
Cytoplasm	• Most cell activities occur here. • It contains tiny structures that are specialised for particular functions.
Nucleus	• It controls cell activities such as cell growth and the repair of worn-out parts. • It is needed for cell division.



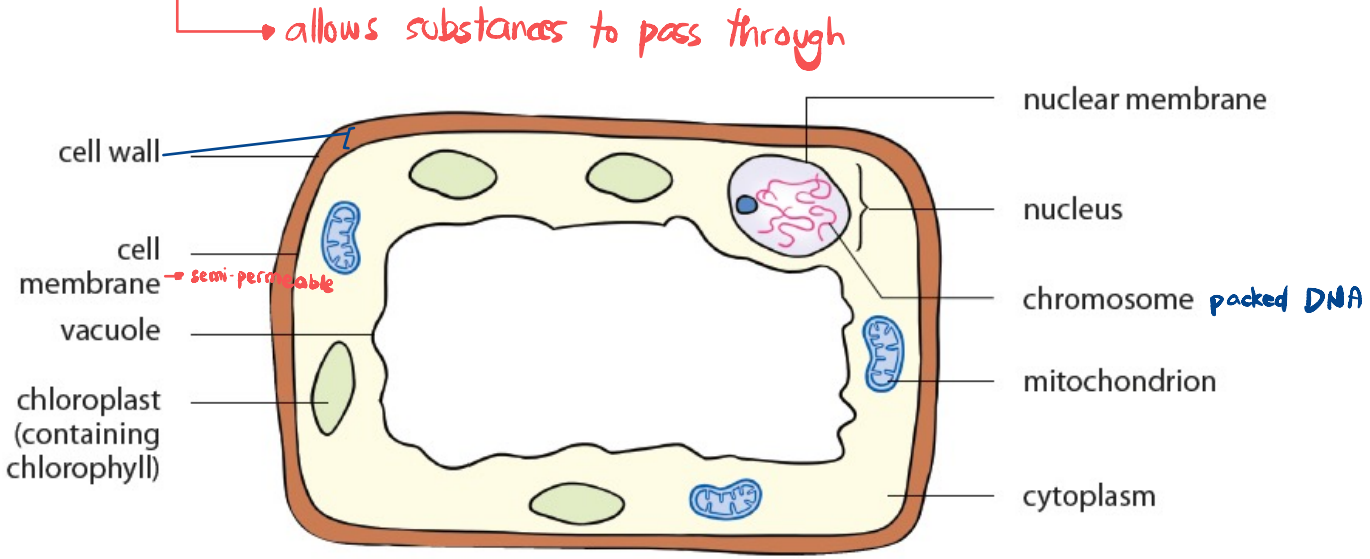
Generalised diagram of an animal cell showing some major parts (Figure 2.3 of Student's Book)

HELPFUL NOTES

The term *cell membrane* is used in this book to refer to the membrane enclosing the entire cell.

What makes up an animal cell and a plant cell?

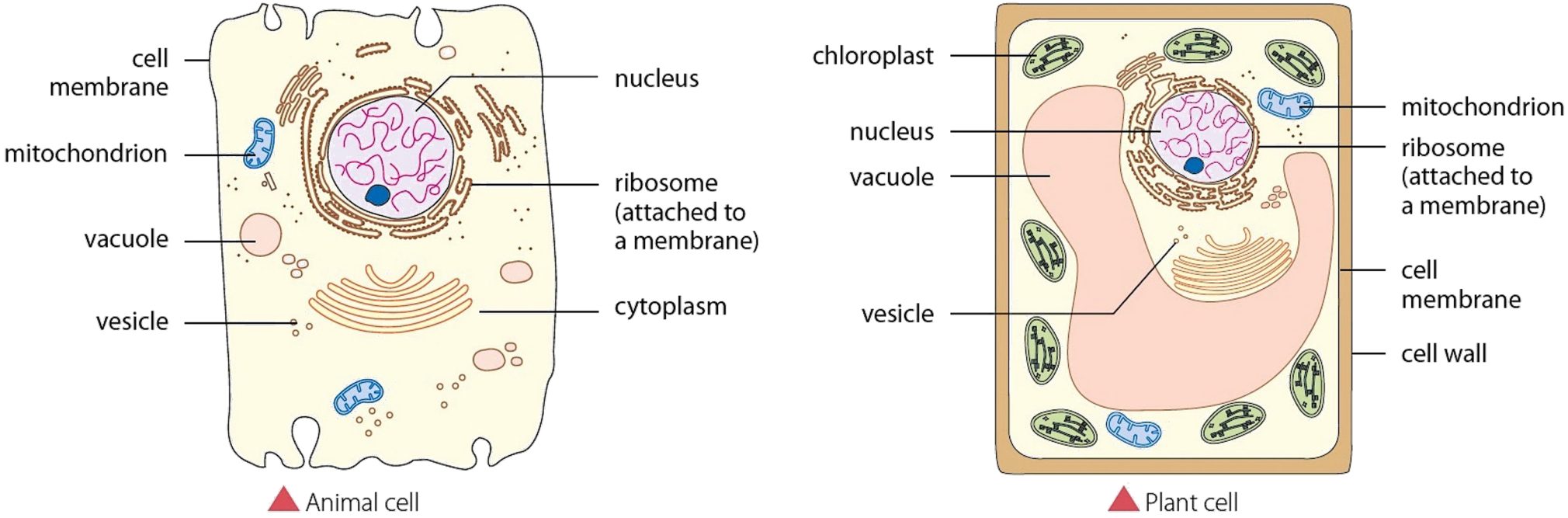
- A plant cell also has a **cell wall** that encloses the entire cell.
- The cell wall is fully permeable and is made mainly of cellulose. It protects the cell from injury and gives the plant cell its fixed shape.



Generalised diagram of a plant cell showing some major parts (Figure 2.5 of Student's Book)

What are the structures in the cytoplasm?

- Ribosomes, mitochondria, chloroplasts and vacuoles are examples of tiny structures in the cytoplasm.
- Some of these structures can only be seen under an electron microscope.

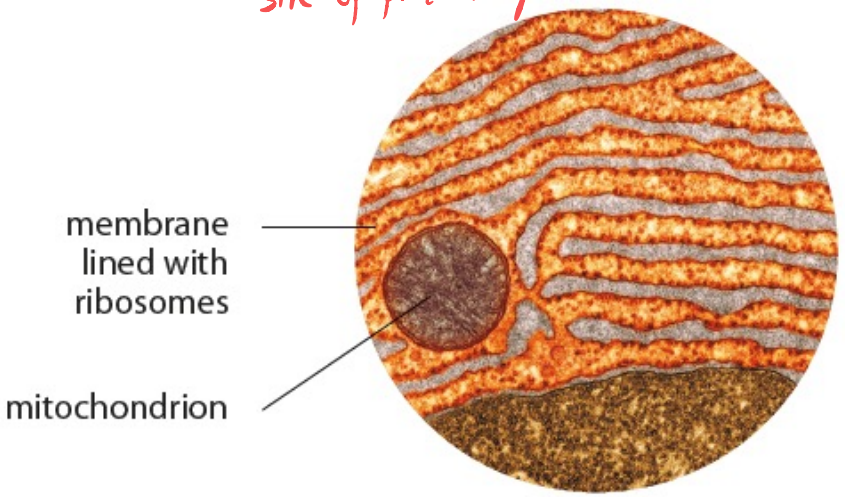


Animal and plant cells as seen under an electron microscope (Figure 2.6 of Student's Book)

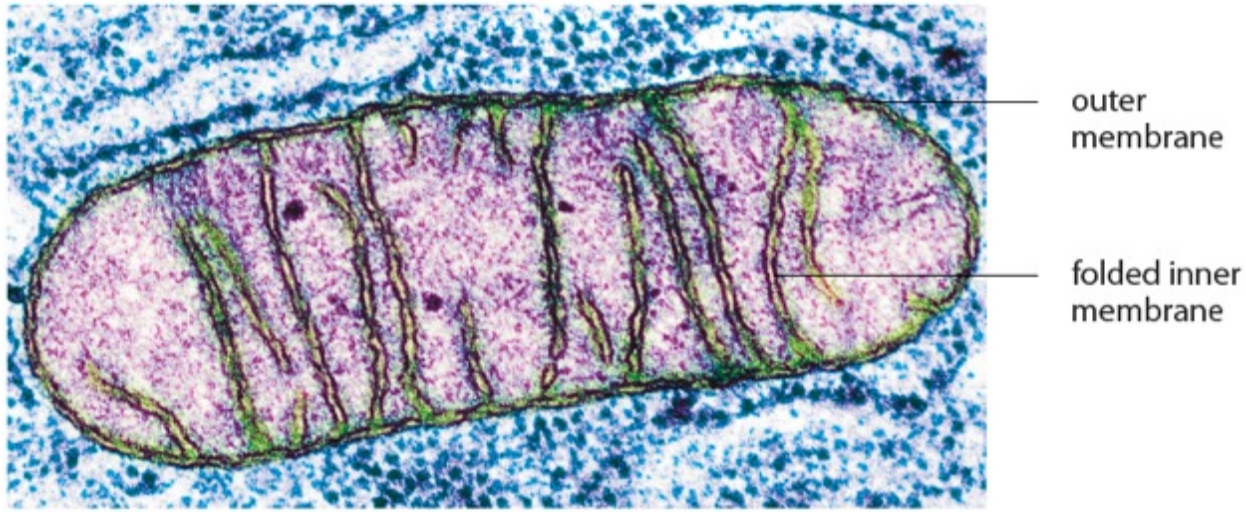
What are the structures in the cytoplasm?

- **Ribosomes** are attached to the membrane of endoplasmic reticulum or lie freely in the cytoplasm.
- They are needed to make proteins in the cell.

site of protein synthesis

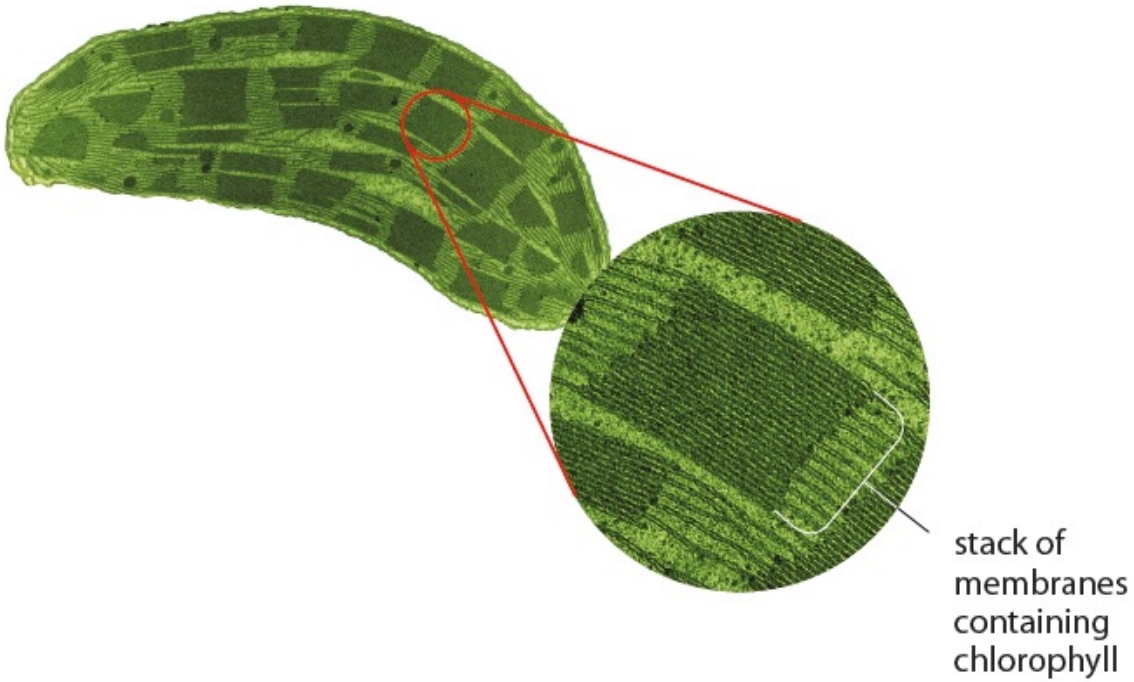


- Aerobic respiration occurs in the **mitochondria**.
- During respiration, oxygen is used to break down food substances to release energy for cell activities.

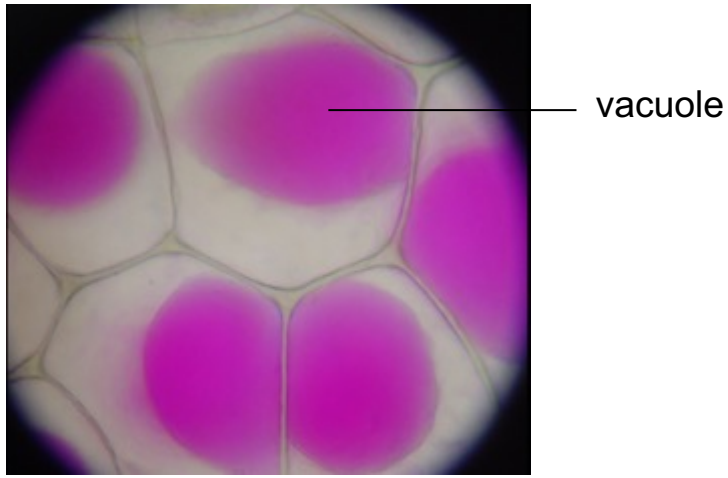


What are the structures in the cytoplasm?

- **Chloroplasts** are absent in animal cells.
- They contain chlorophyll that is essential for photosynthesis in plants.

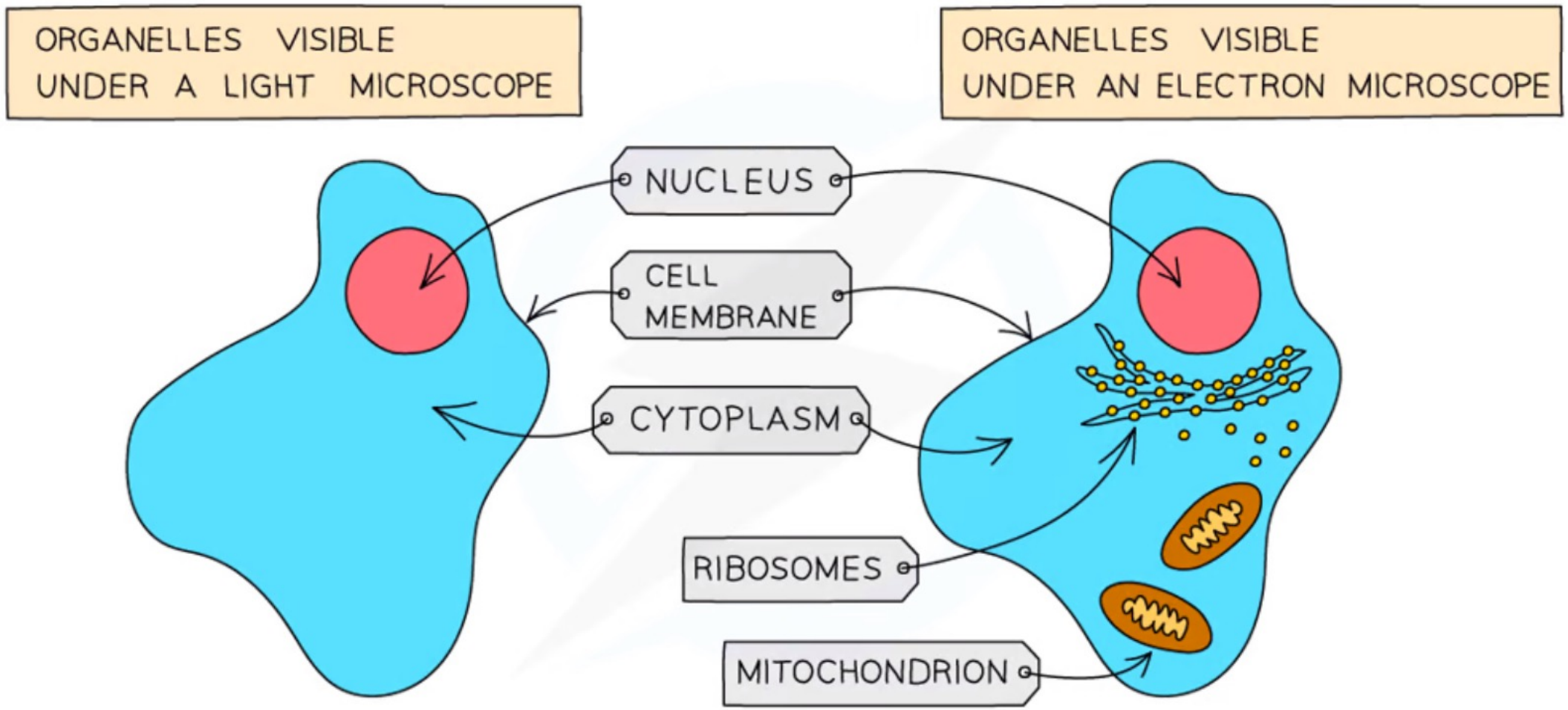


- **Vacuoles** are fluid-filled spaces that store substances within the cell.
- Plant cells have a large central vacuole that contains liquid called cell sap.
- Animal cells have small vacuoles, called vesicles that contain water and food substances.



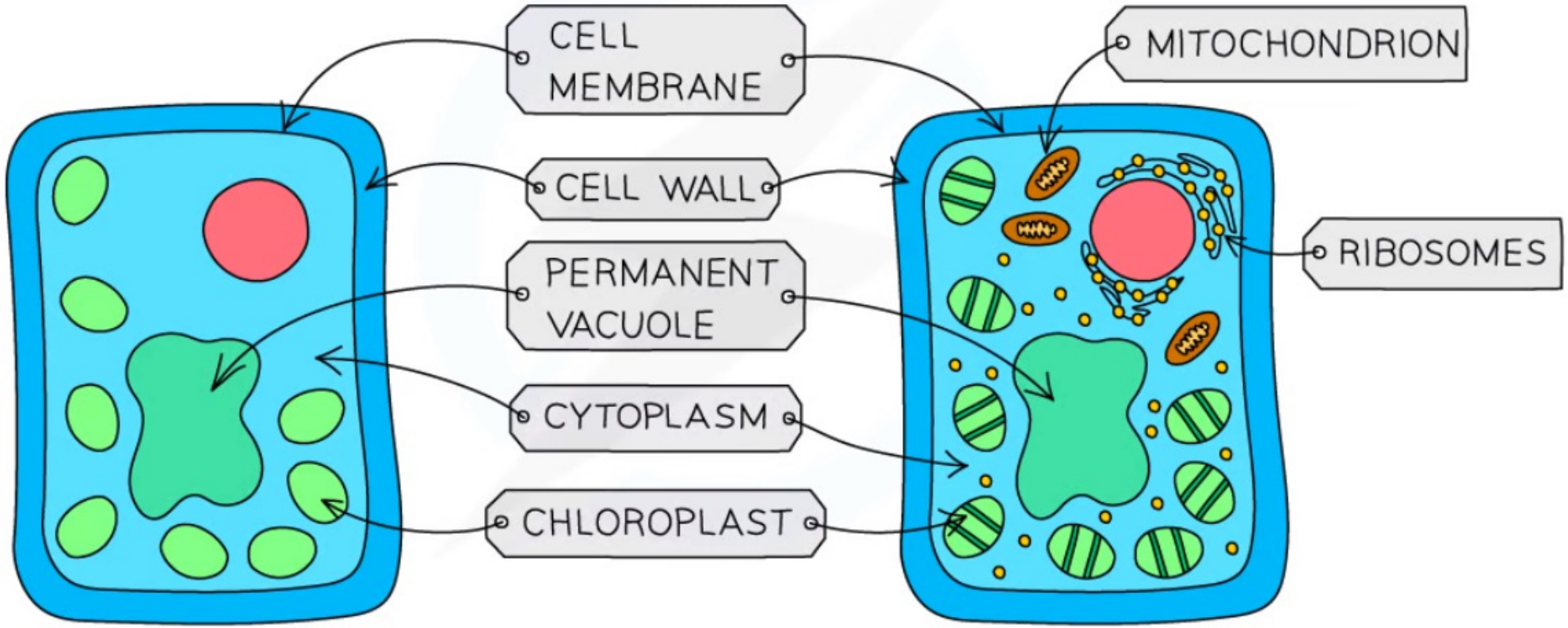
STRUCTURE	FUNCTION
NUCLEUS	– CONTAINS GENETIC MATERIAL IN CHROMOSOMES WHICH CONTROL HOW CELLS GROW AND WORK – CONTROLS CELL DIVISION
CYTOPLASM	– SUPPORTS CELL STRUCTURES – SITE OF MANY CHEMICAL REACTIONS – CONTAINS WATER AND MANY SOLUTES and the other cell parts
CELL MEMBRANE	– HOLDS THE CELL TOGETHER – CONTROLS SUBSTANCES ENTERING AND LEAVING THE CELL
CELL WALL	– GIVES THE CELL EXTRA SUPPORT AND DEFINES ITS SHAPE → plant cells
CHLOROPLASTS	– SITE OF PHOTOSYNTHESIS, PROVIDING FOOD FOR PLANTS – THE CHLOROPHYLL PIGMENTS ABSORB LIGHT ENERGY NEEDED FOR THE REACTION TO OCCUR
VACUOLE ↳ plant: one, center, permanent ↳ animal: - many - temporary - numerous and small	– CONTAINS CELL SAP → plant cells – USED FOR STORAGE OF CERTAIN MATERIALS – ALSO HELPS SUPPORT THE SHAPE OF THE CELL

STRUCTURE	FUNCTION
MITOCHONDRIA	– SITE OF AEROBIC RESPIRATION, PROVIDING ENERGY FOR THE CELL – CELLS WITH HIGH RATES OF METABOLISM (CARRYING OUT MANY DIFFERENT CELL REACTIONS) WILL HAVE SIGNIFICANTLY HIGHER NUMBERS OF MITOCHONDRIA THAN CELLS WITH LOWER NUMBERS OF REACTIONS TAKING PLACE IN THEM
RIBOSOMES	– SITE OF PROTEIN PRODUCTION IN PROTEIN SYNTHESIS
VESICLES → vacuole in animal cells	– USED TO SAFELY TRANSPORT SUBSTANCES FROM ONE PART OF THE CELL TO ANOTHER

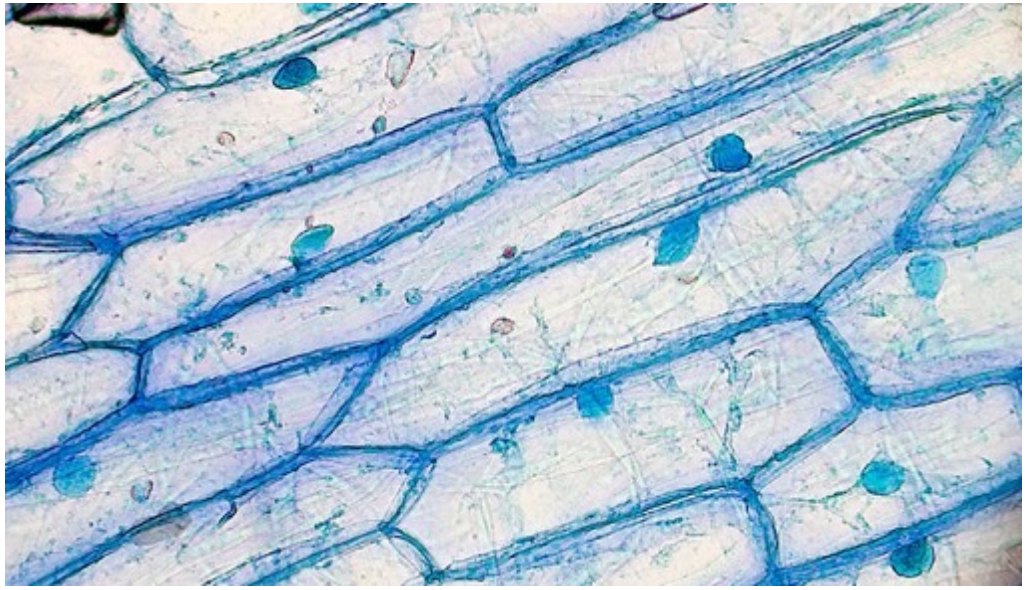


PLANT CELL VIEWED UNDER A LIGHT MICROSCOPE

PLANT CELL VIEWED UNDER AN ELECTRON MICROSCOPE



Let's Investigate 2B

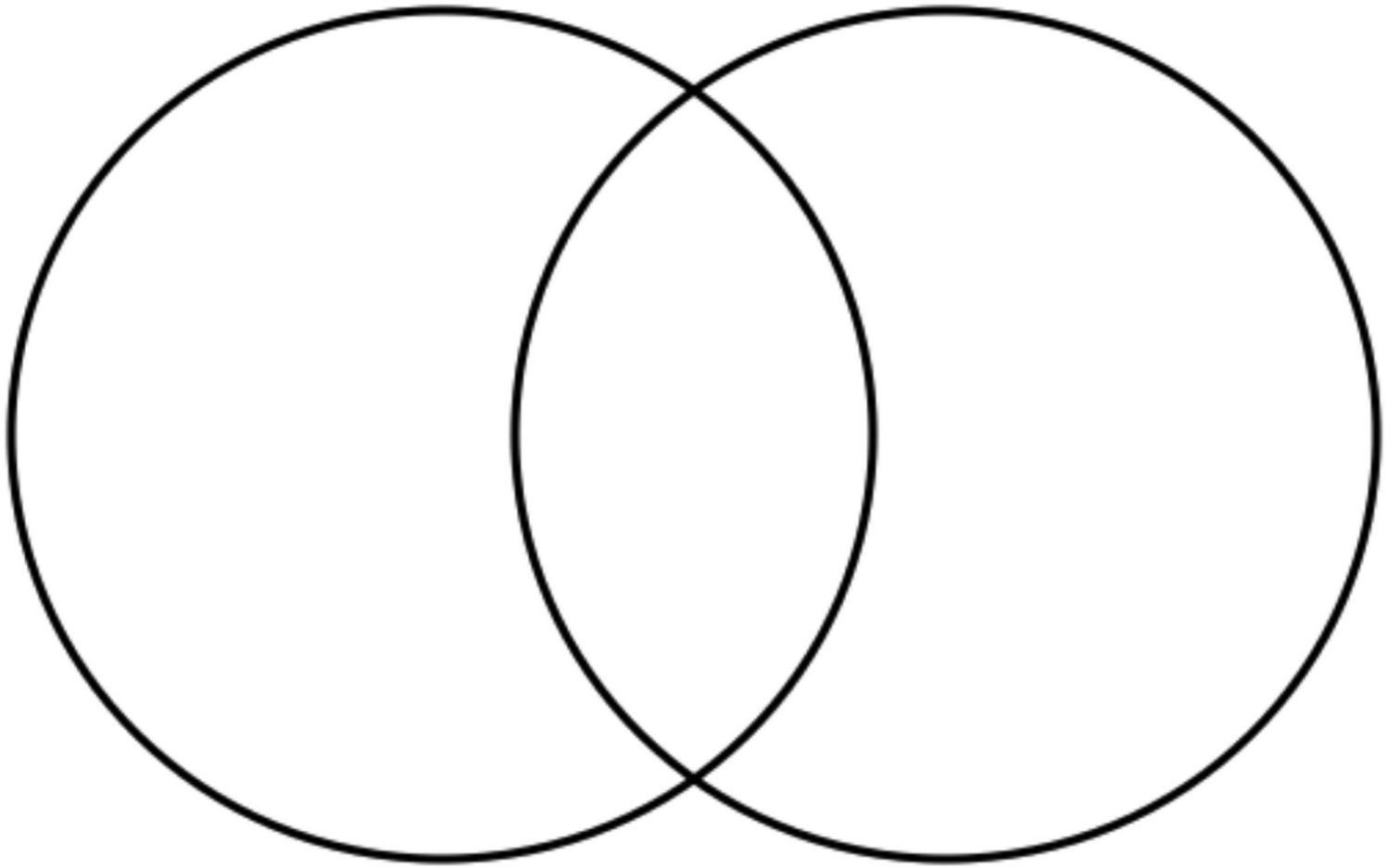


- Compare the epidermal cell with the diagram on Student's Book page 21. The epidermal cell does *not* contain chloroplasts.
- The mitochondria are *not* visible in the epidermal cell under the light microscope.

Venn Diagram

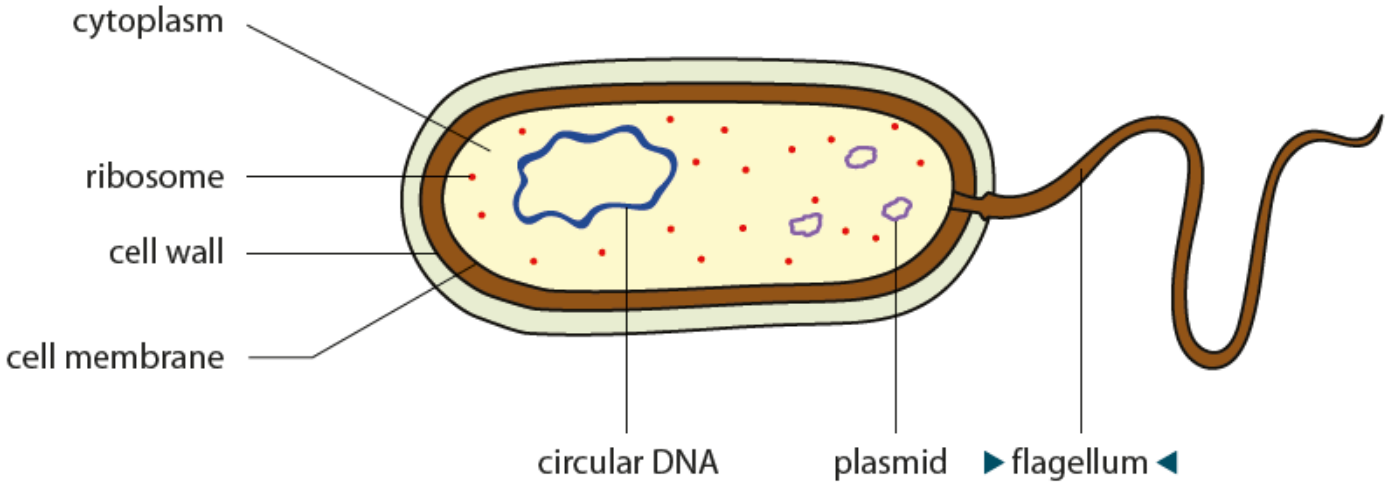
Animal Cell

Plant Cell



What makes up a bacterial cell?

- The **bacterium** is unicellular, that is, made up of only one cell.
- A bacterial cell has
  - a cell membrane;
  - cytoplasm;
  - a large circular DNA;
  - one or more small circles of DNA called plasmids.
- The plasmids contain additional genetic information that gives the bacterium its unique qualities.



Generalised diagram of a bacterial cell showing major parts (Figure 2.12 of Student's Book)

How are animal, plant and bacterial cells similar and different?

Animal Cells	Plant Cells	Bacterial Cells
Do not have a cell wall	Have a cell wall made of cellulose	Have a cell wall made of murein
Do not have chloroplasts	Have chloroplasts	Do not have chloroplasts
Have many small vacuoles	Have a large central vacuole	Some may have large vacuoles
Have a nucleus, enclosed by a nuclear membrane		Do not have a nucleus
Have membrane-bound structures, e.g. mitochondria		Do not have membrane-bound structures
DNA is linear		DNA is circular
Do not have plasmids		Have plasmids
Have a cell membrane, cytoplasm and ribosomes		

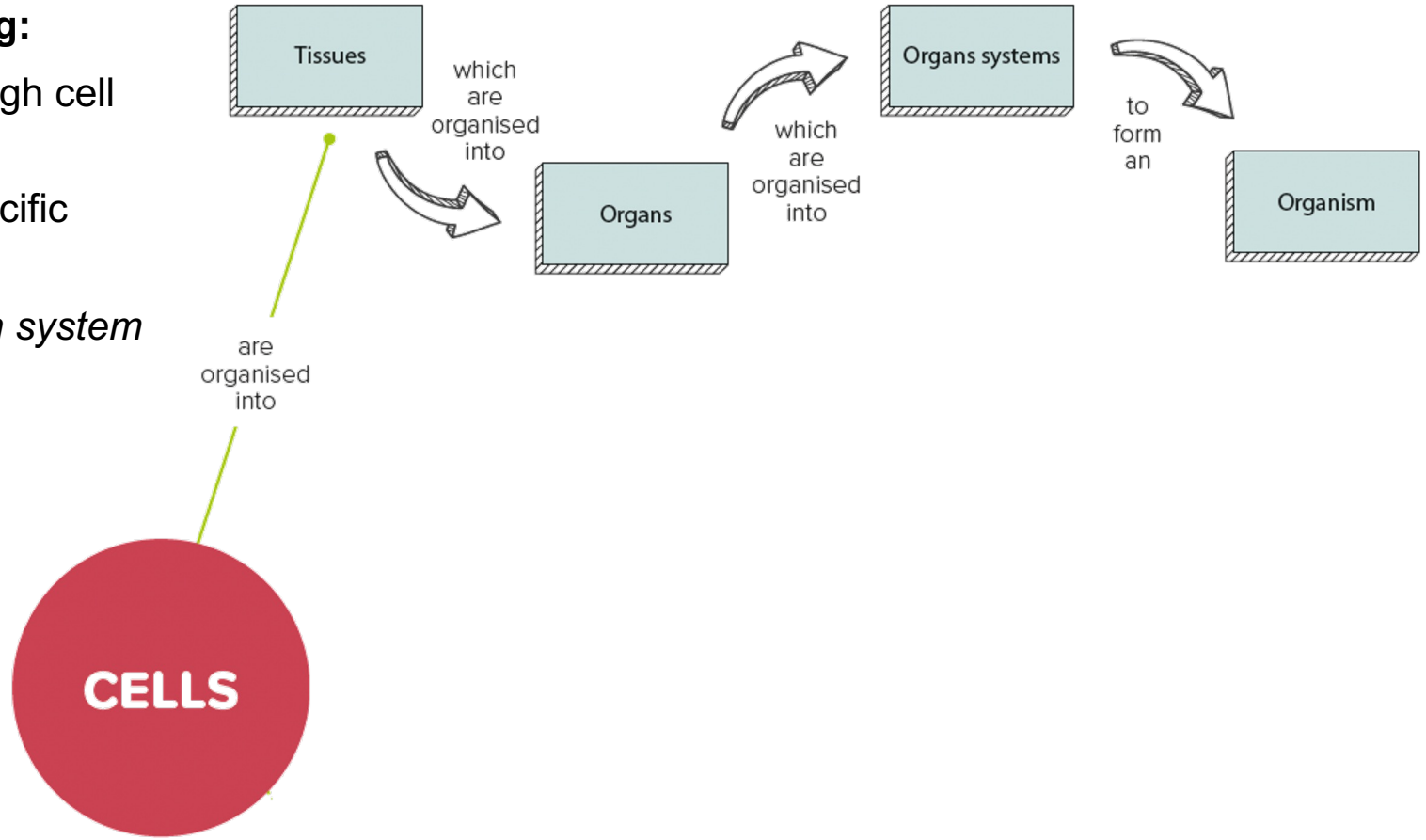
Let's Practise 2.1

1. State the functions of these cell parts.
   (a) Mitochondria
   (b) Chloroplasts
   (c) Ribosomes
   (d) Vacuoles
2. State and explain three differences between a plant cell and an animal cell.

2.2 Levels of Organisation

In this section, you will learn the following:

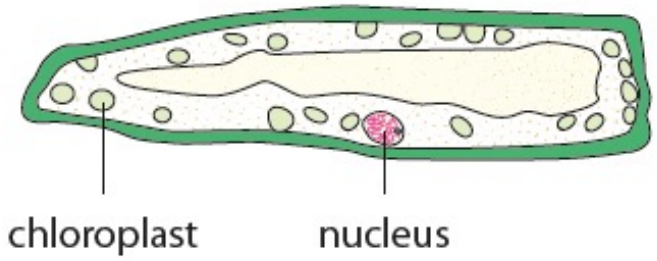
- State that new cells are produced through cell division.
- State that specialised cells perform specific functions.
- Describe the terms *tissue*, *organ*, *organ system* and *organism.*



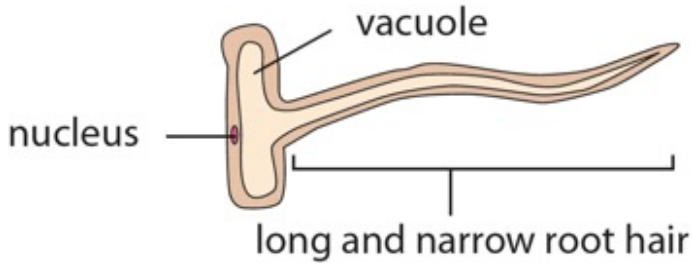
How is the structure of a cell related to its function?

- New cells are produced through the division of existing cells.
- Differentiation is the process by which a cell becomes specialised for a specific function.
- Examples of **specialised cells** and their specific functions:

1. **Palisade mesophyll cell** – for photosynthesis

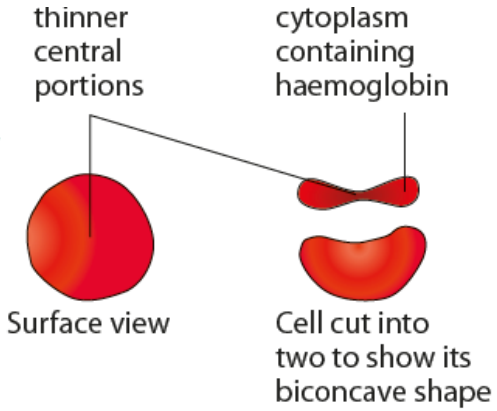


2. **Root hair cell** – for absorption of water and mineral ions

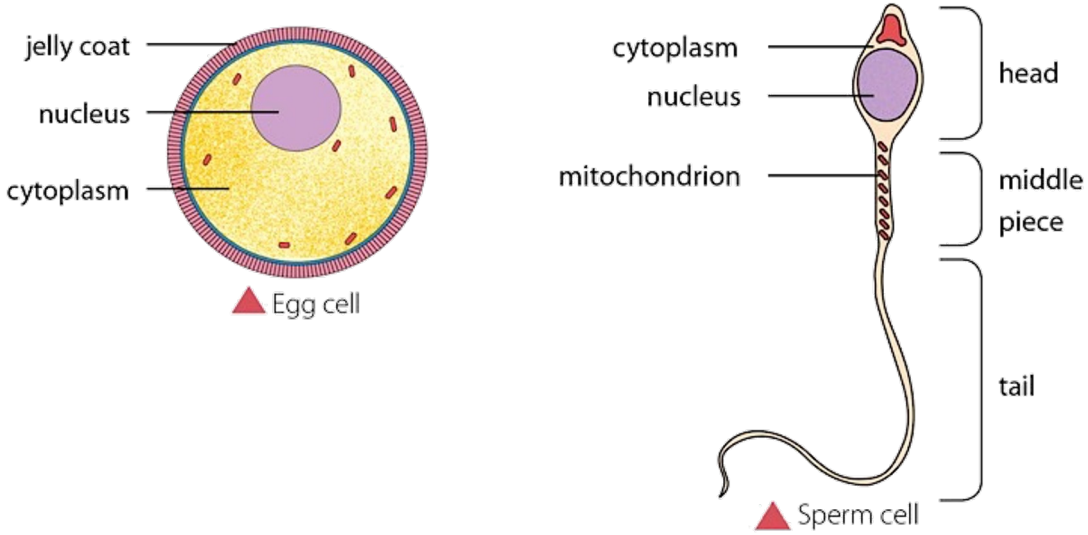


How is the structure of a cell related to its function?

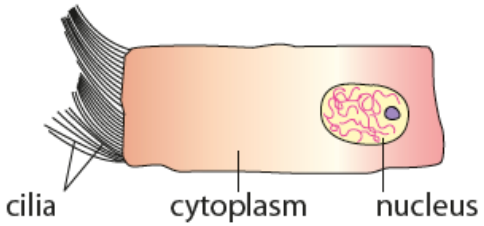
3. **Red blood cell** – for transport of oxygen



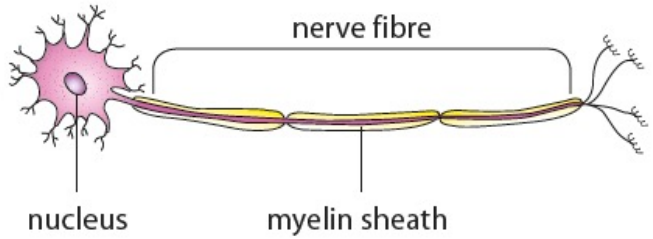
4. **Egg and sperm cells** – for reproduction



5. **Ciliated cell** – for movement of mucus in the trachea and bronchi

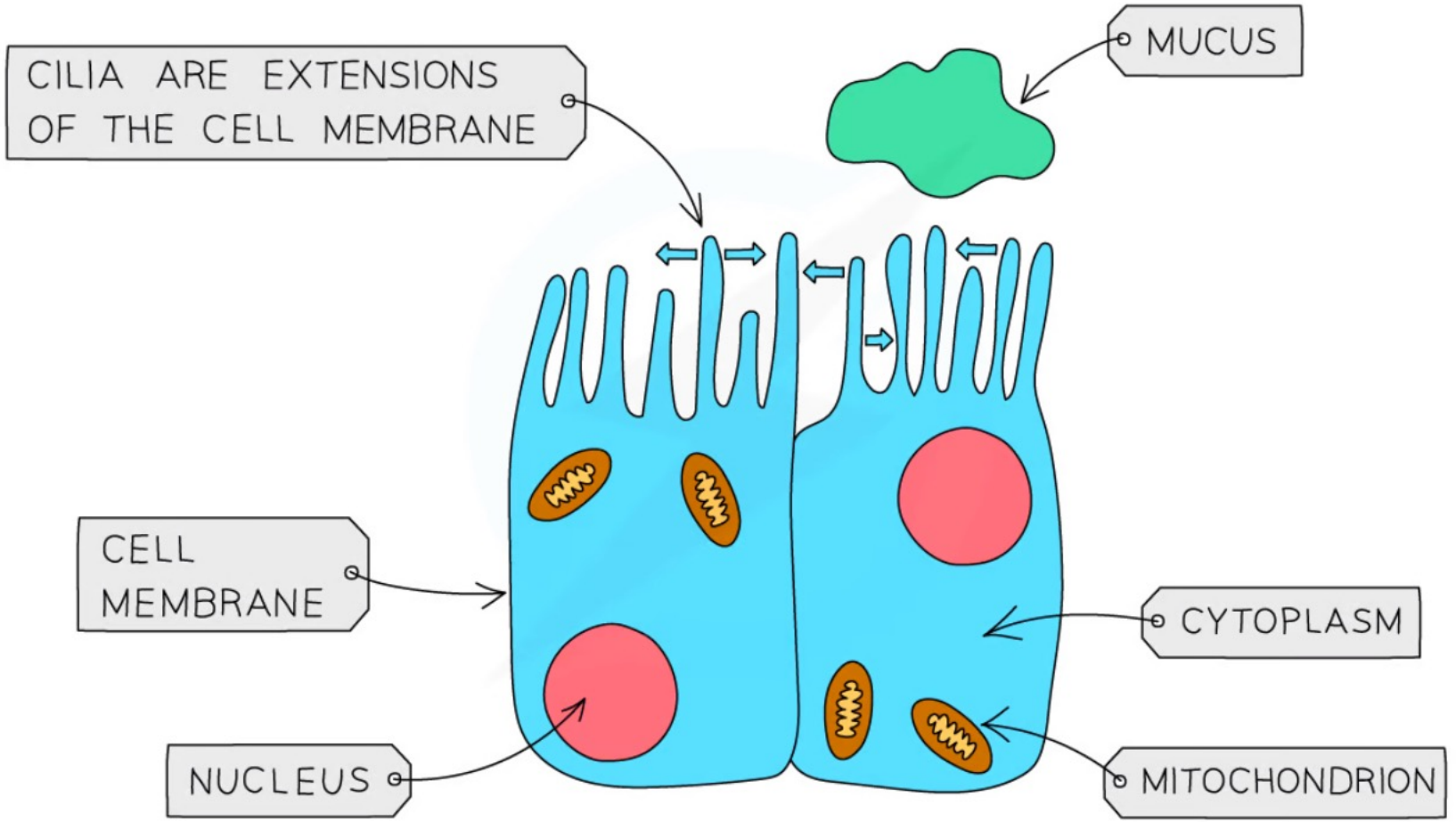


6. **Nerve cell (neurone)** – for transmission of electrical impulses

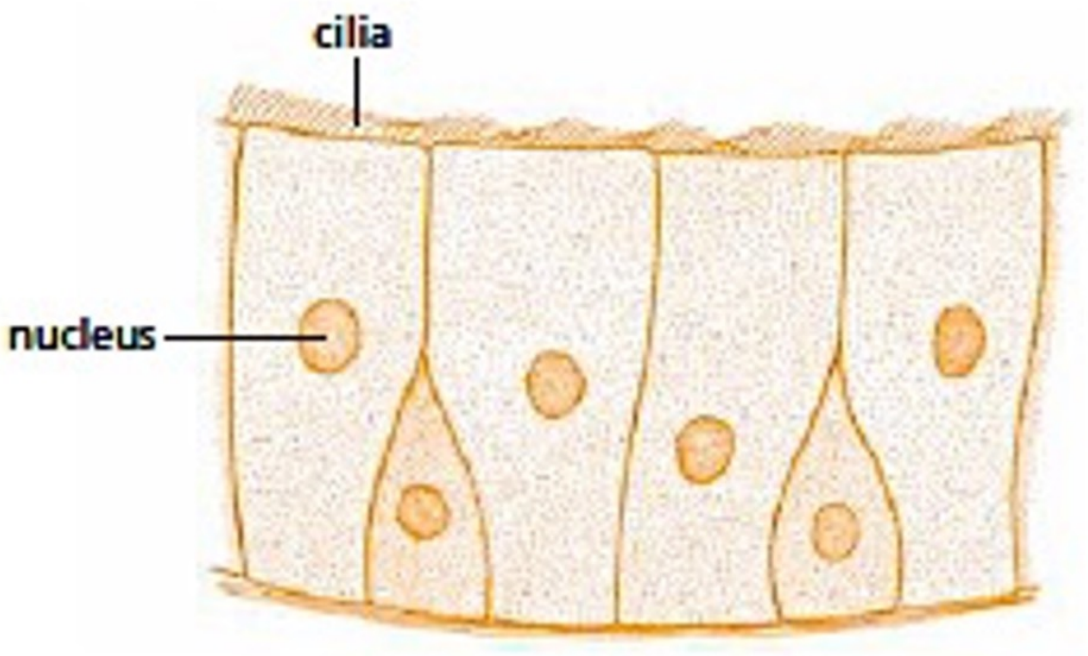


CELL	FUNCTION	ADAPTATIONS
CILIATED CELL	MOVEMENT OF MUCUS IN THE TRACHEA AND BRONCHI	– EXTENSIONS OF THE CYTOPLASM AT THE SURFACE OF THE CELL FORM HAIR–LIKE STRUCTURES CALLED **CILIA** WHICH **BEAT TO MOVE MUCUS** AND TRAPPED PARTICLES UP TO THE THROAT
NERVE CELL	CONDUCTION OF IMPULSES	– **LONG** SO THAT NERVES CAN RUN TO AND FROM **DIFFERENT PARTS OF THE BODY** TO THE CENTRAL NERVOUS SYSTEM – THE CELL HAS **EXTENSIONS AND BRANCHES**, SO THAT IT CAN **COMMUNICATE** WITH OTHER NERVE CELLS, MUSCLES AND GLANDS – THE AXON (EXTENSION OF CYTOPLASM AWAY FROM THE CELL BODY) IS COVERED WITH A **FATTY SHEATH**, WHICH **INSULATES** THE NERVE CELL AND **SPEEDS UP** THE NERVE IMPULSE
RED BLOOD CELL	TRANSPORT OF OXYGEN	– **BICONCAVE DISC** SHAPE **INCREASES SURFACE AREA** FOR MORE EFFICIENT DIFFUSION OF OXYGEN – CONTAINS **HAEMOGLOBIN** WHICH **JOINS WITH OXYGEN** TO TRANSPORT IT – CONTAINS **NO NUCLEUS** TO **INCREASE AMOUNT OF SPACE** AVAILABLE FOR HAEMOGLOBIN INSIDE CELL

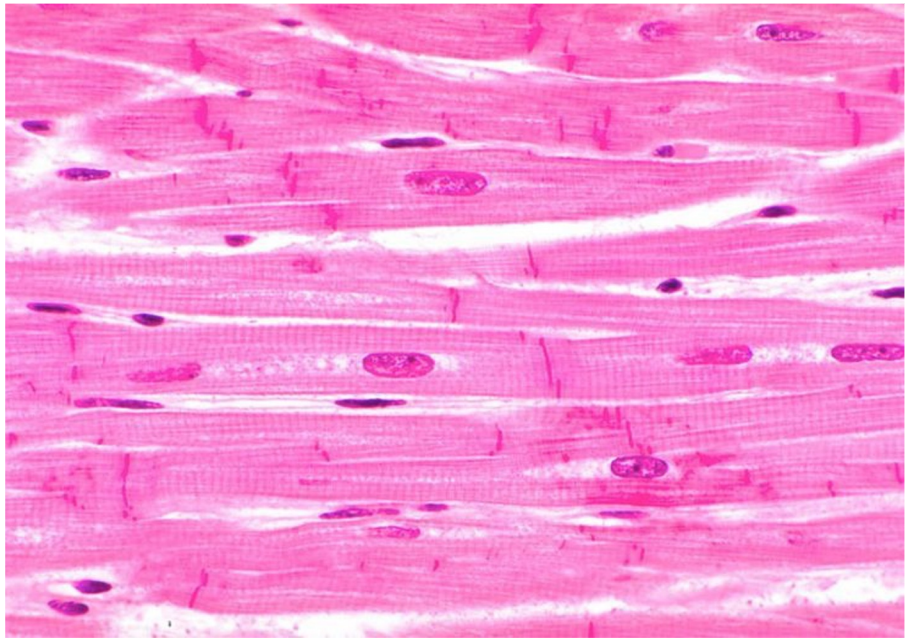
SPERM CELL	REPRODUCTION	– THE HEAD CONTAINS THE GENETIC MATERIAL FOR FERTILISATION IN A **HAPLOID NUCLEUS** (CONTAINING HALF THE NORMAL NUMBER OF CHROMOSOMES) – THE **ACROSOME** IN THE HEAD CONTAINS **DIGESTIVE ENZYMES** SO THAT A SPERM CAN PENETRATE AN EGG – THE MID-PIECE IS PACKED WITH **MITOCHONDRIA** TO RELEASE **ENERGY** NEEDED TO SWIM AND FERTILISE THE EGG – THE **TAIL** ENABLES THE SPERM TO **SWIM**
EGG CELL (OVUM)	REPRODUCTION	– CONTAINS A **LOT OF CYTOPLASM** WHICH HAS **NUTRIENTS** FOR THE GROWTH OF THE EARLY EMBRYO – **HAPLOID NUCLEUS** CONTAINS THE GENETIC MATERIAL FOR FERTILISATION – CELL MEMBRANE **CHANGES AFTER FERTILISATION** BY A SINGLE SPERM SO THAT **NO MORE SPERM** CAN ENTER

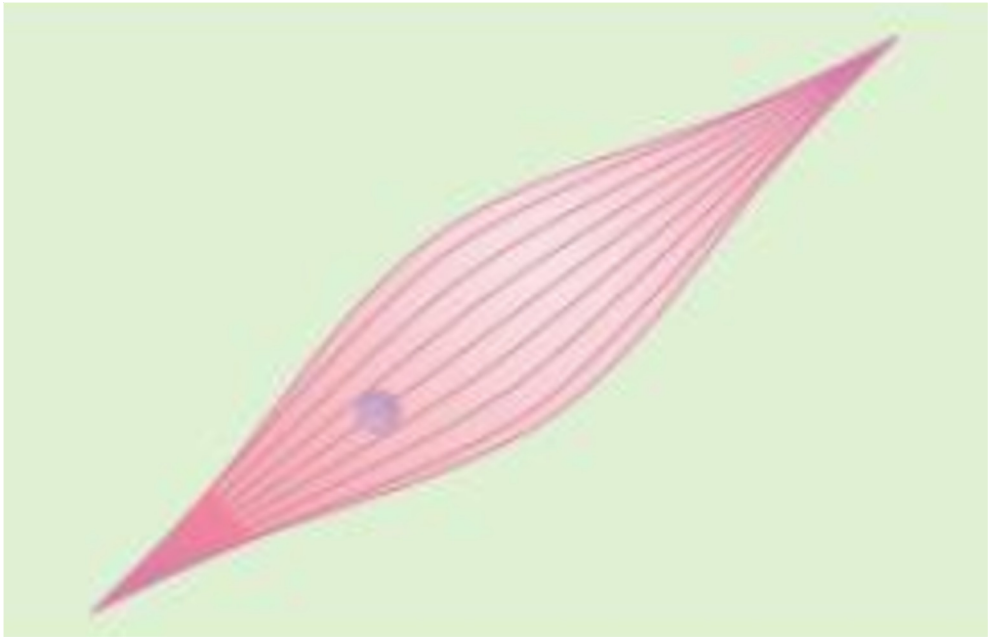


Has a layer of tiny hairs (cilia) which can **move and push mucus** from one place to another. The mucus can transport trapped dust and microbes when it is pushed by the cilia.

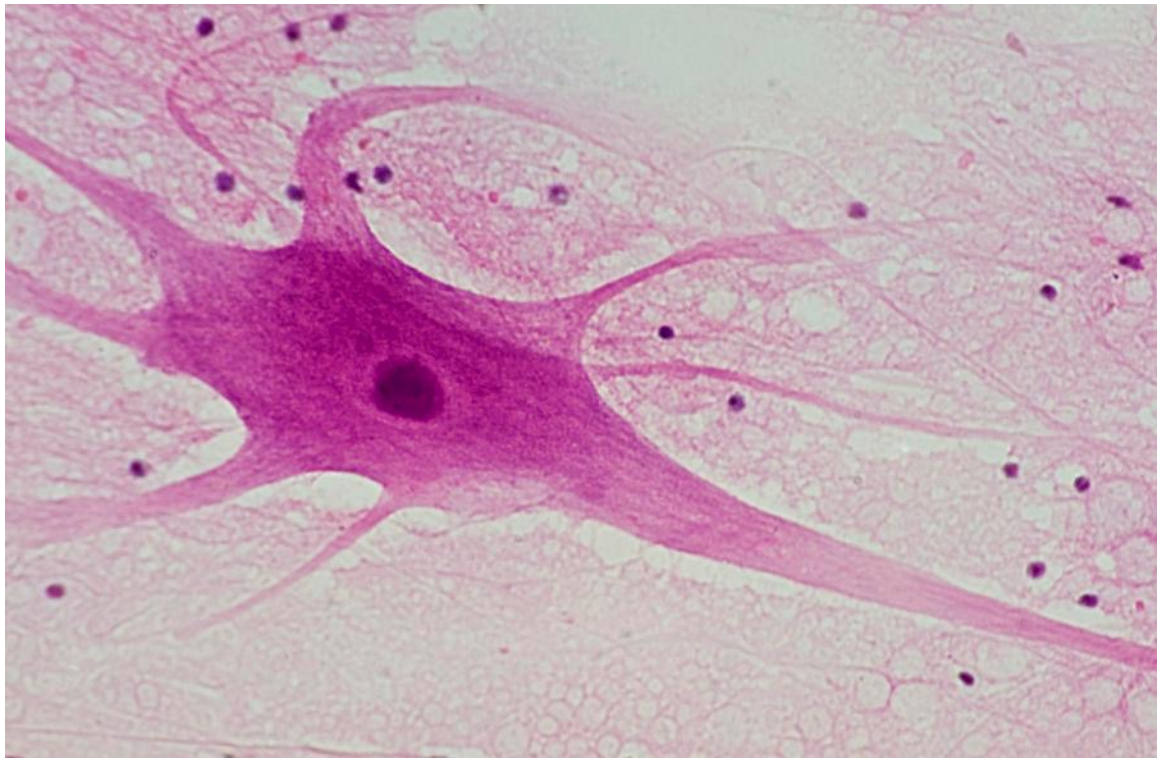


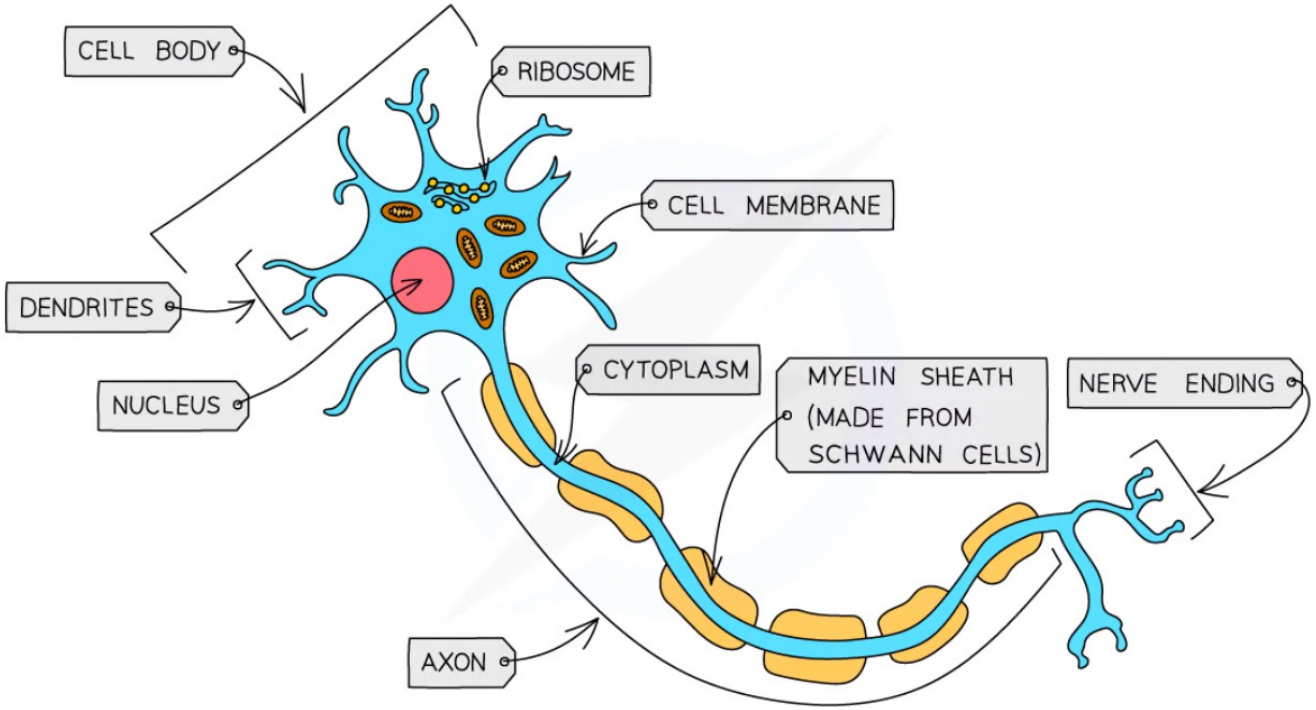
Contracts so that structures can be brought closer together. Muscle cells are long, and have many protein fibres in the cytoplasm. These fibres can shorten the cell when energy is available.

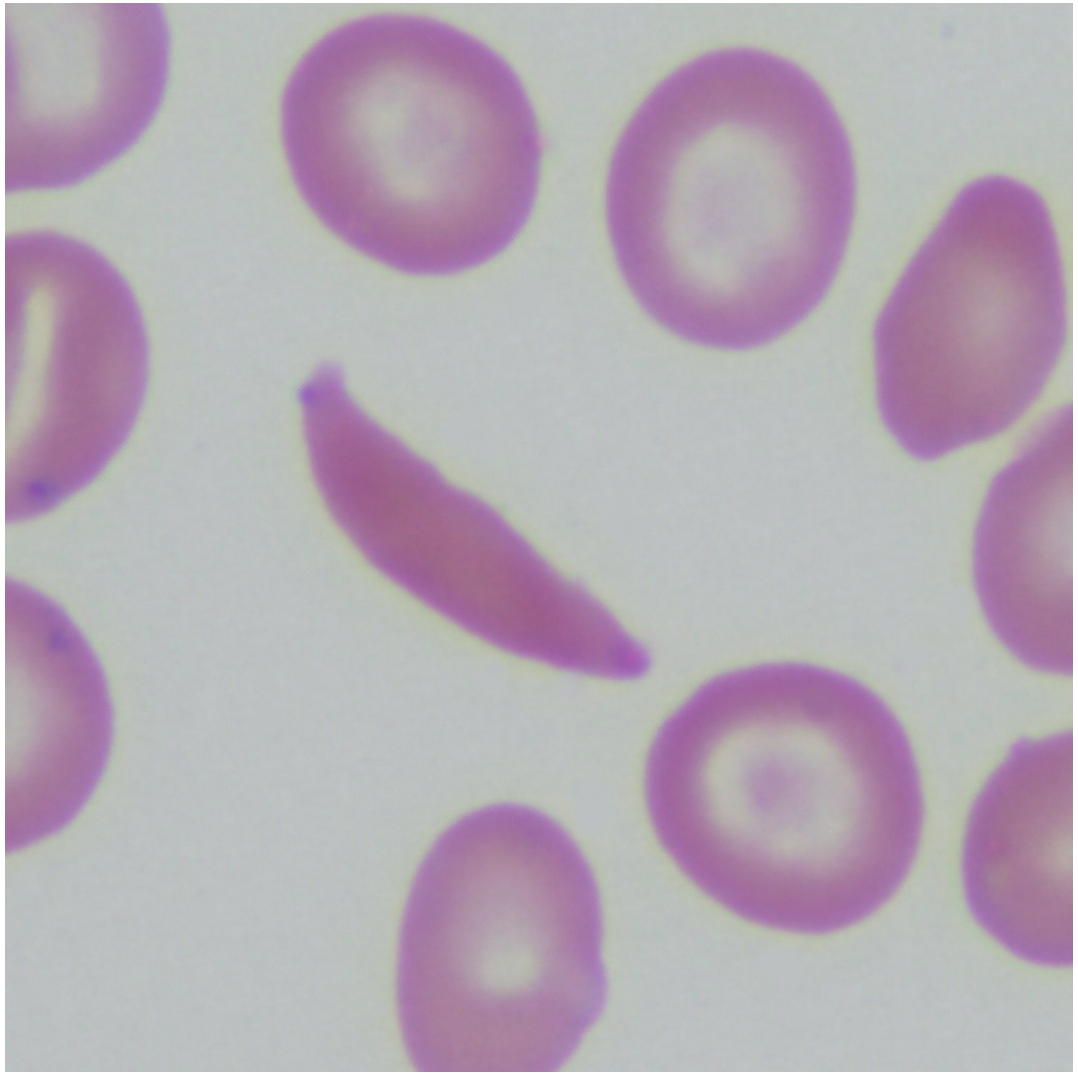




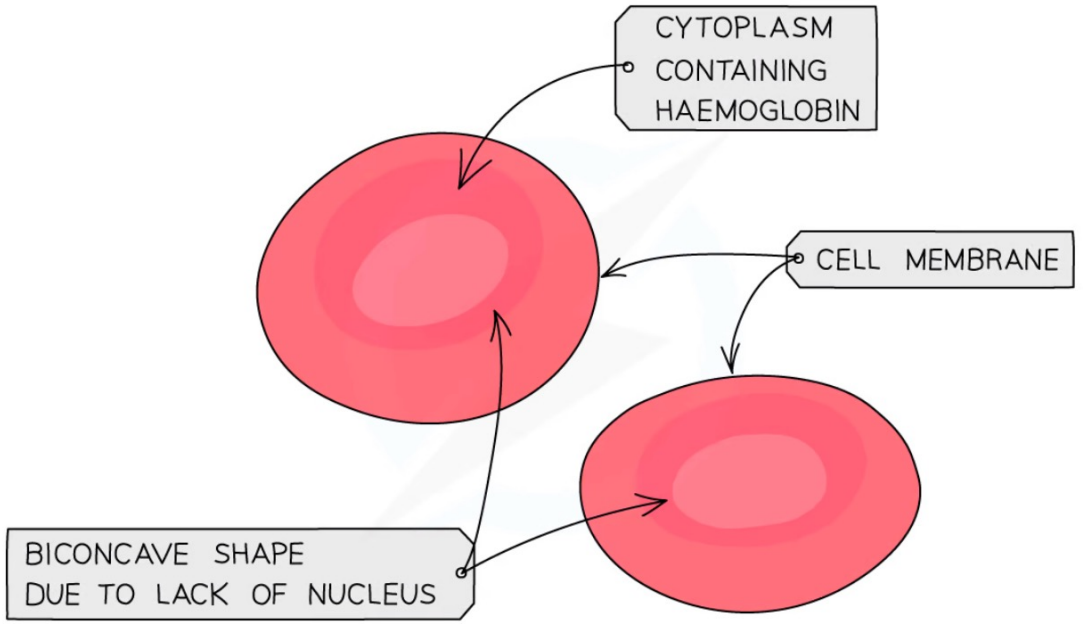
Conducts nerve impulses. The cell has a long fibre called an axon along which impulses travel, a fatty sheath which gives electrical insulation and a many-branched ending which can connect with many other cells.

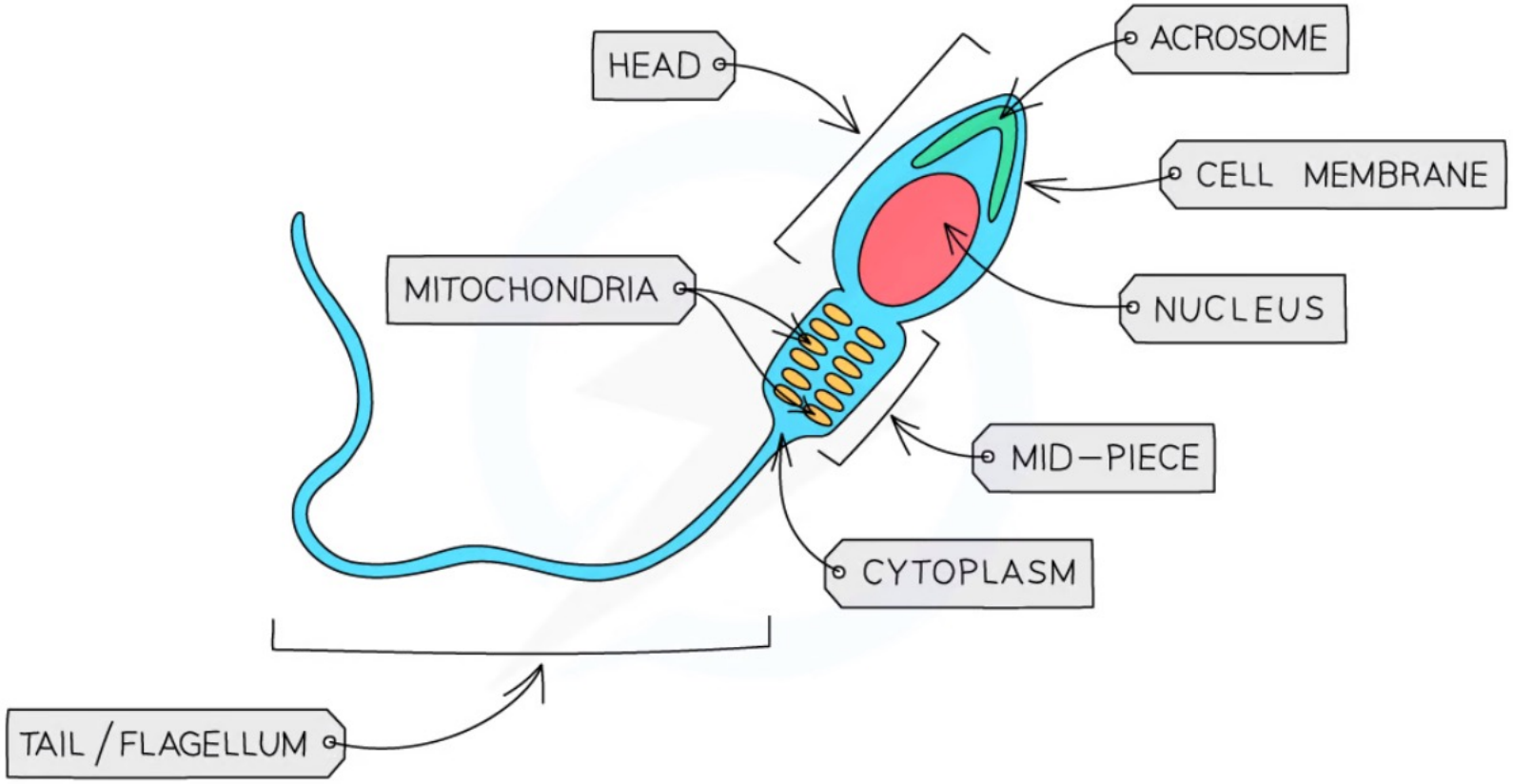


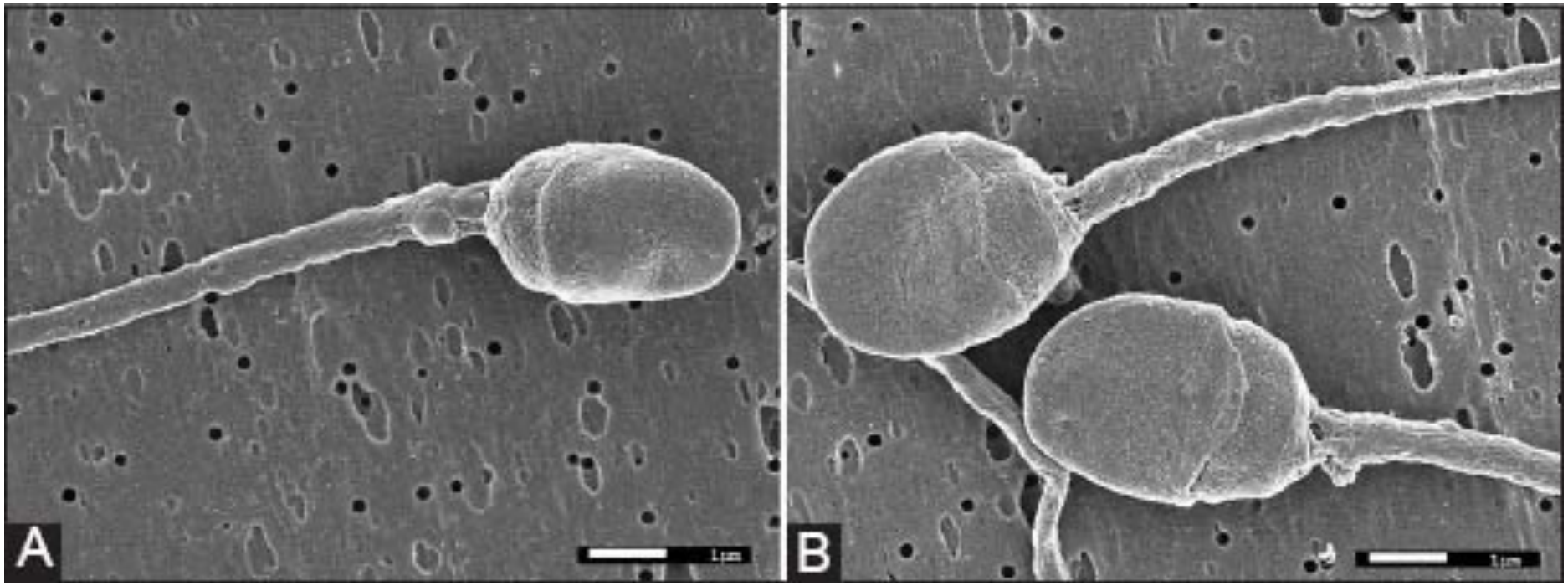


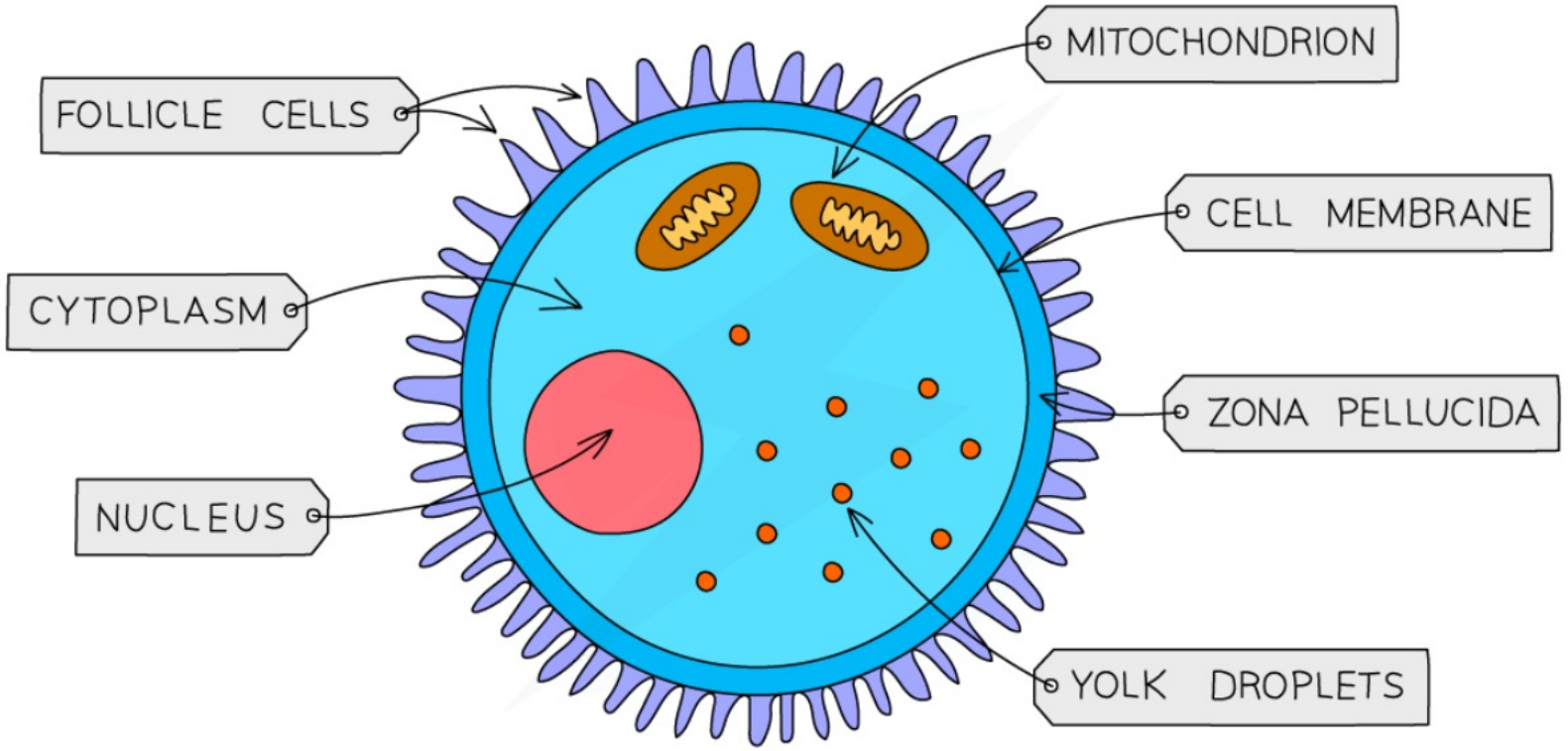


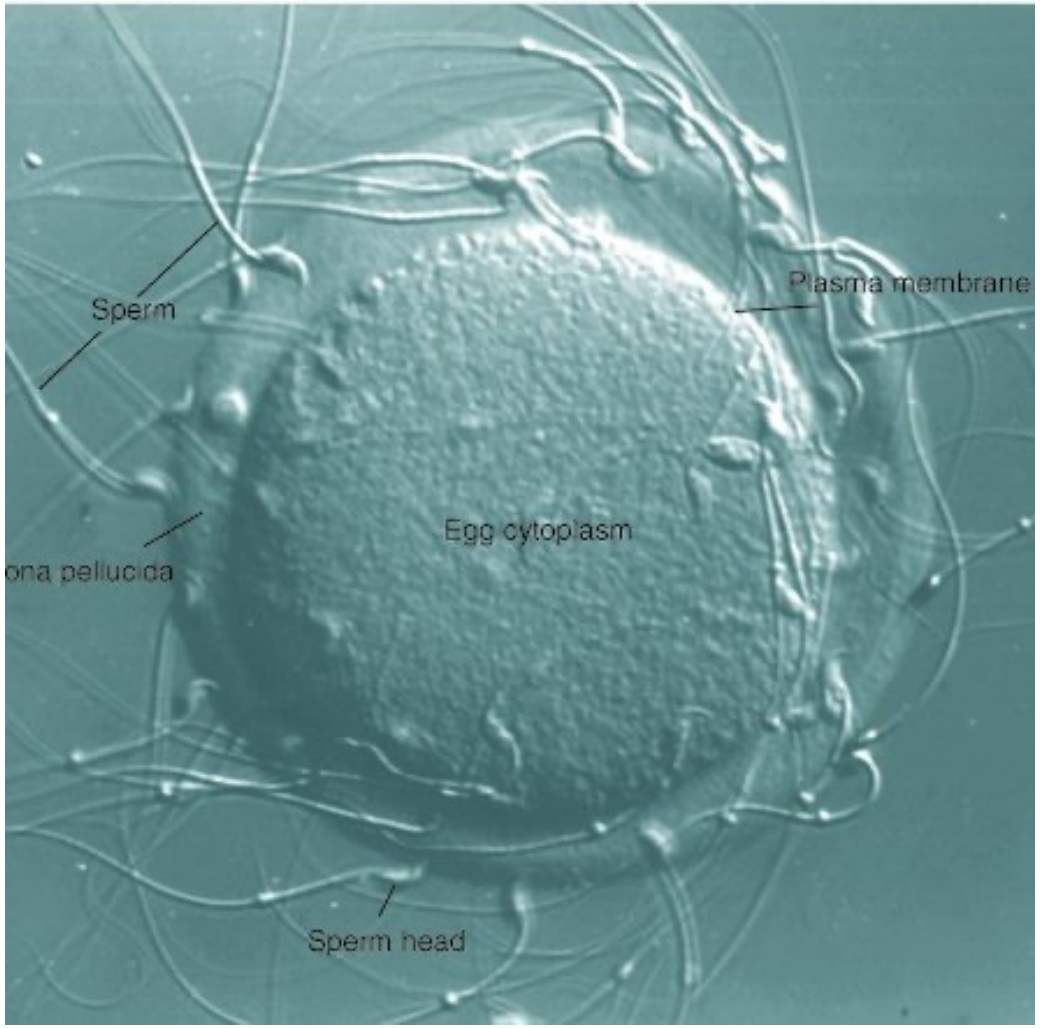
Transports oxygen from the lungs to the tissues where aerobic respiration occurs. The cytoplasm is filled with the pigment haemoglobin, which carries oxygen. The cells have no nucleus, leaving more space for haemoglobin, and they are very flexible (they can be forced through even the narrowest of blood vessels).

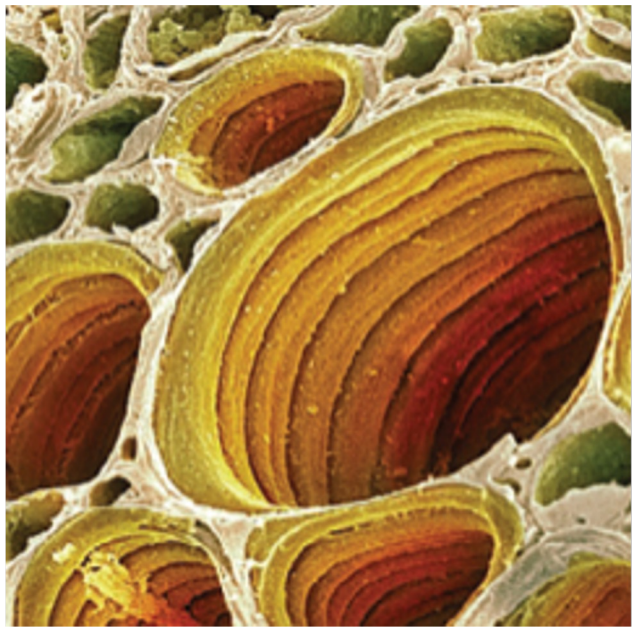


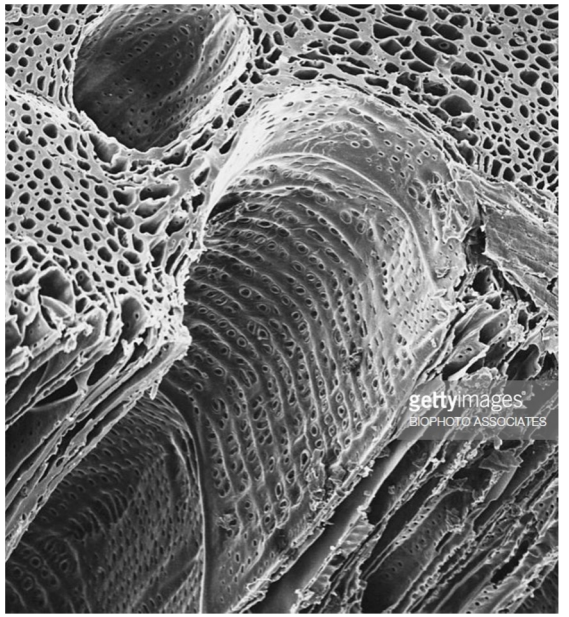




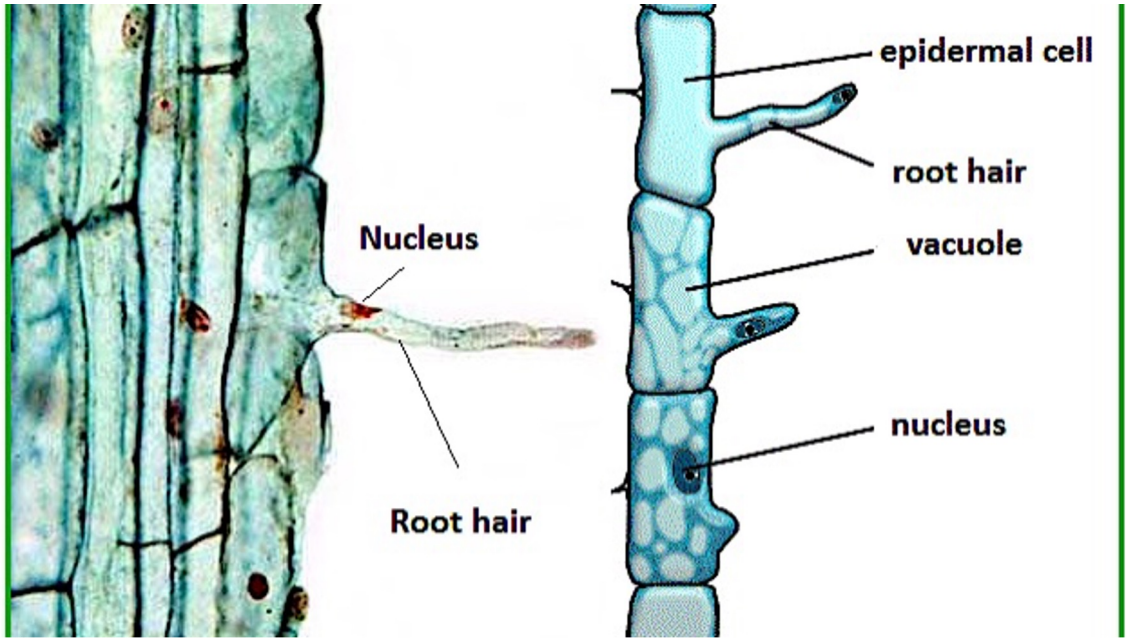








Transports water and supports the plant. The cell has no cytoplasm (so water can pass freely), no end wall (so that many cells can form a continuous tube) and walls strengthened with a waterproof substance called lignin.



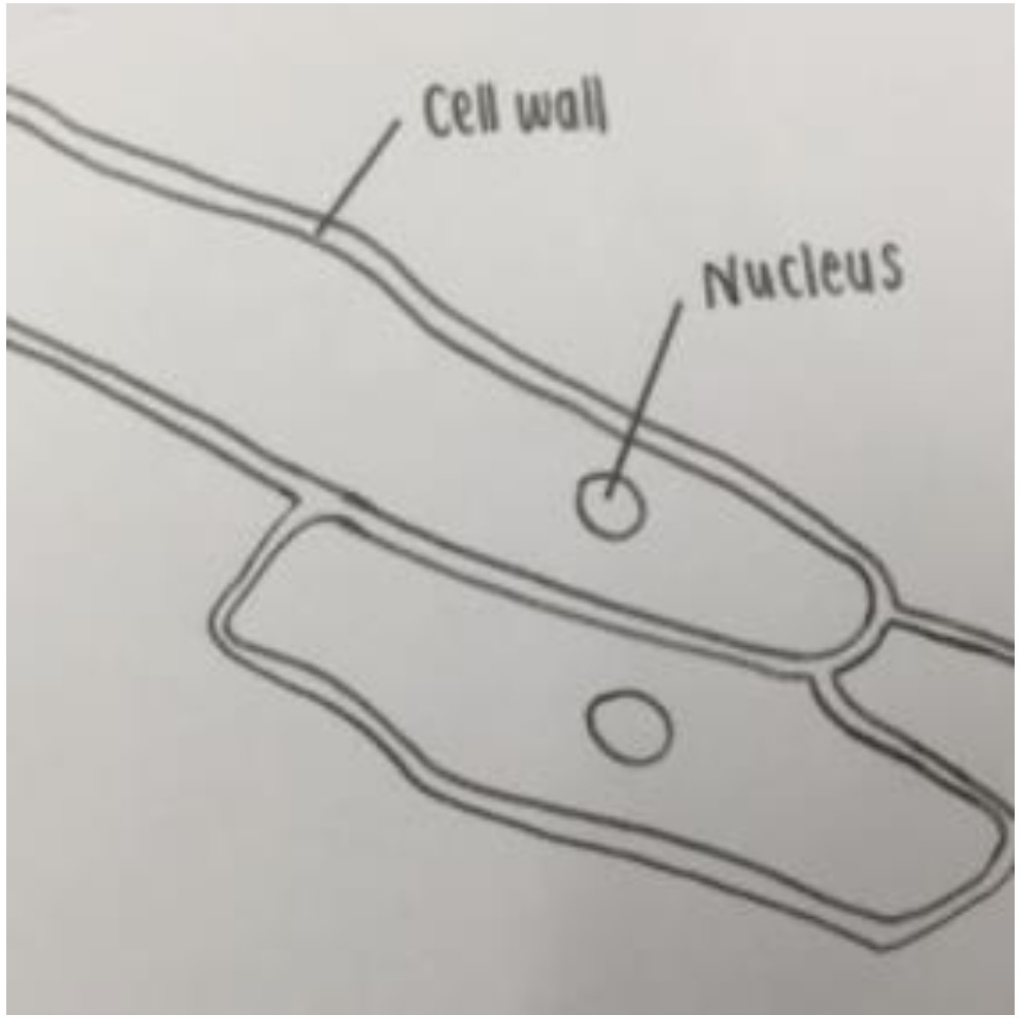
Absorbs minerals and water from the soil water. The cell has a long extension (a root hair) which increases the surface area for the absorption of materials.

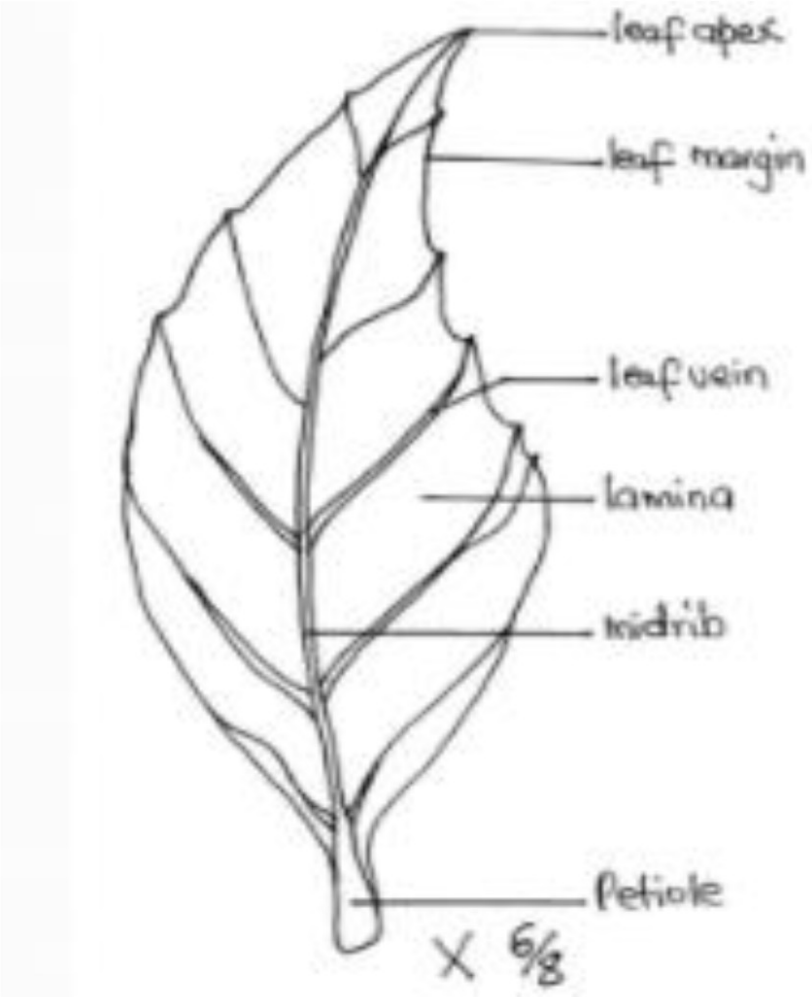
Biological drawing and Taking measurements

Drawings

1. These will be from specimens or photographs.
2. Read the question carefully, the drawing may have to be an accurate size e.g. twice the original.
3. Make each drawing as big as the space allows.
4. Use a ruler for labelling lines. Label lines should not cross each other.
5. Label in pencil.
6. Use one clear continuous outline (not overlapping) not an artistic drawing. Don't shade other than using very light dots.
7. Observe details carefully, such as number of seeds in a seed case, thickness of a layer in a shell, etc. Show these accurately on your drawing.

Marking: 1 mark for clear outline, 1 mark for labelling, ½ marks for detail





Taking measurements

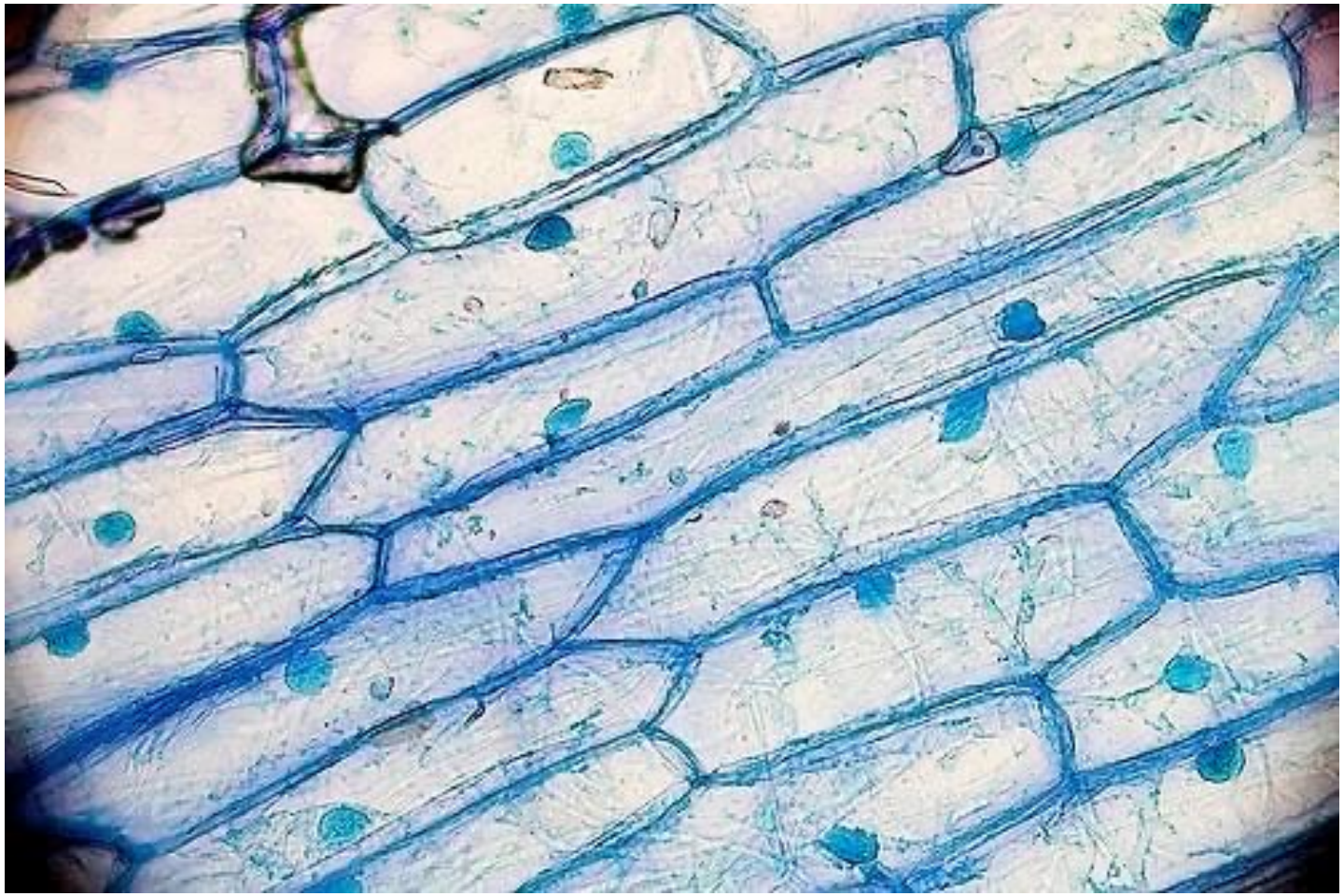
1. Make your measurements as accurate as you can. Measure to the nearest unit, e.g. mm. Don't try and 'guess' 0.5 mm.
2. Make sure you put units! Use the correct SI units, don't use other units; for example measure in millimetres not inches.
3. Always measure in millimetres, not centimetres.
4. If you have to make calculations on your measurements, use the blank pages within the paper but indicate if the answer is continued elsewhere on the blank pages. Don't write in the margins.
5. Write neatly and show your working. The person marking your paper might be able to give you marks for knowing what to do if you make a mistake or don't finish the calculation.

How to calculate magnification:

1. measure the structure in the photograph in millimetres (not centimetres).
2. look for the actual size of the object – you will be given this.
3. divide the length of the structure in the photograph (in mm) by the actual size (in mm).
4. the answer is the magnification; round up or down the answer from your calculator.
5. usually magnifications are given as whole numbers, so don't give the answer to one or more decimal places. (unless stated in the question)

How to calculate an actual size:

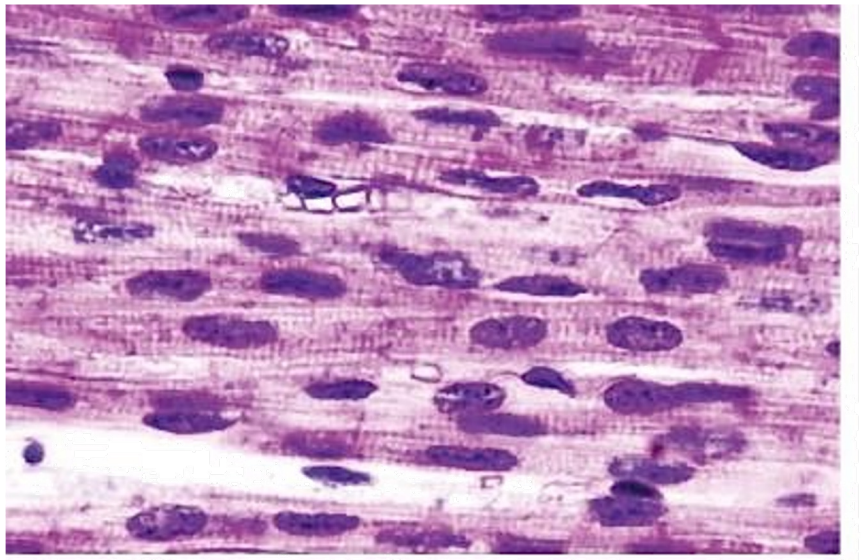
1. measure the structure in the photograph in millimetres (not centimetres).
2. look for the magnification – you will be given this.
3. divide the length of the structure in the photograph (in mm) by the magnification.
4. the answer is the actual size in millimetres; round up or down the answer from your calculator.
5. actual sizes could be given as whole numbers or you could include one or two decimal places, but no more.



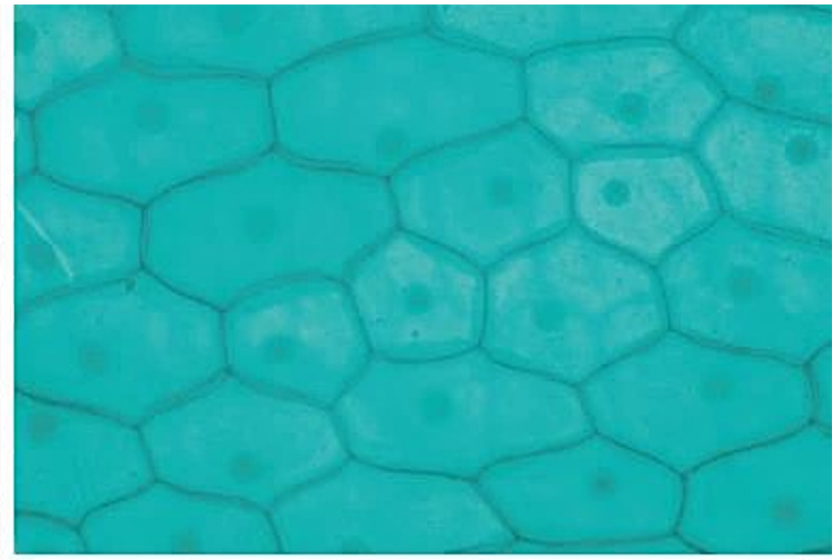
How are cells organised to form an organism?

Tissue

A **tissue** is a group of cells with similar structures that work together to perform a specific function.



Muscle tissue is made up of muscle cells.

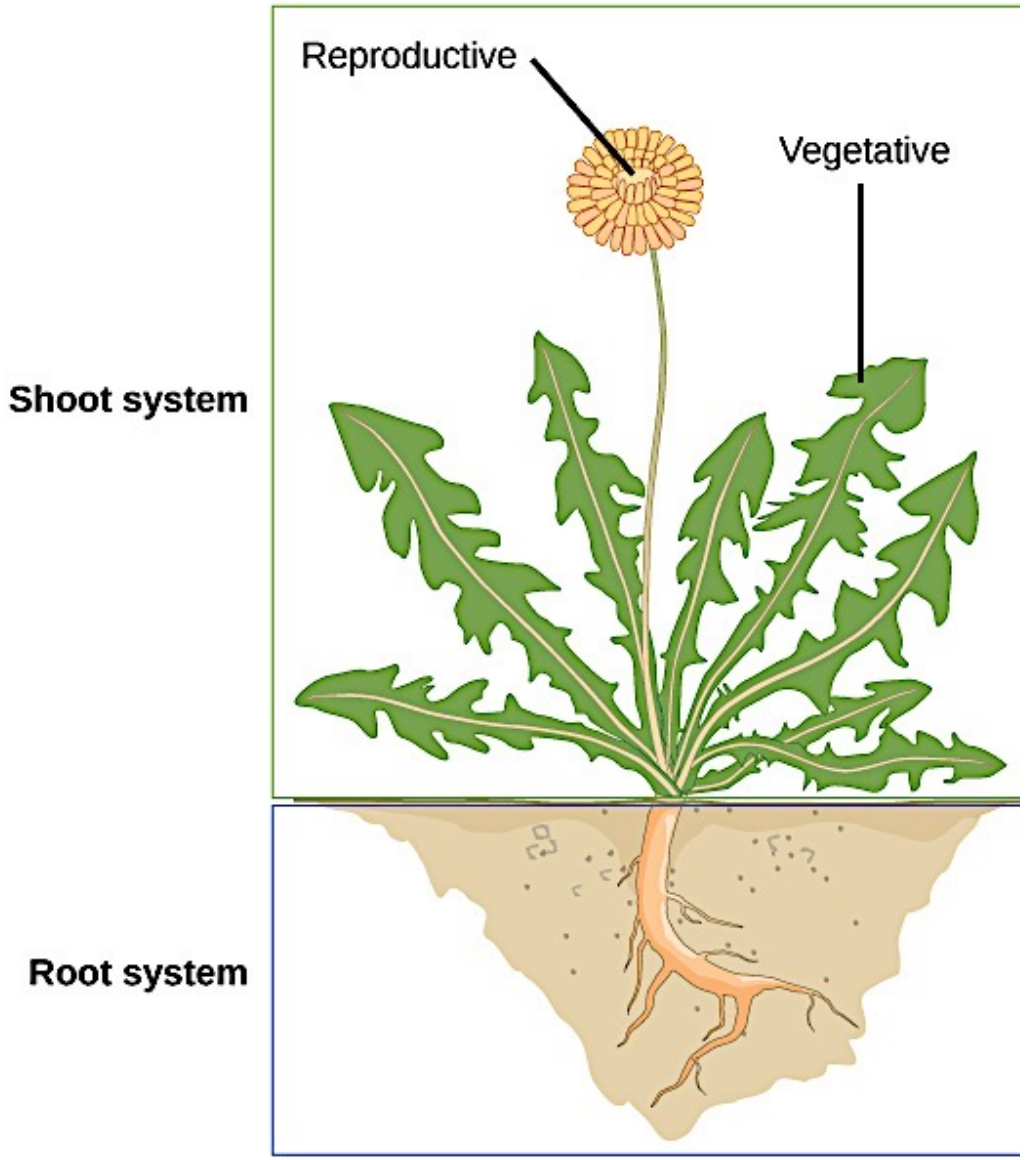


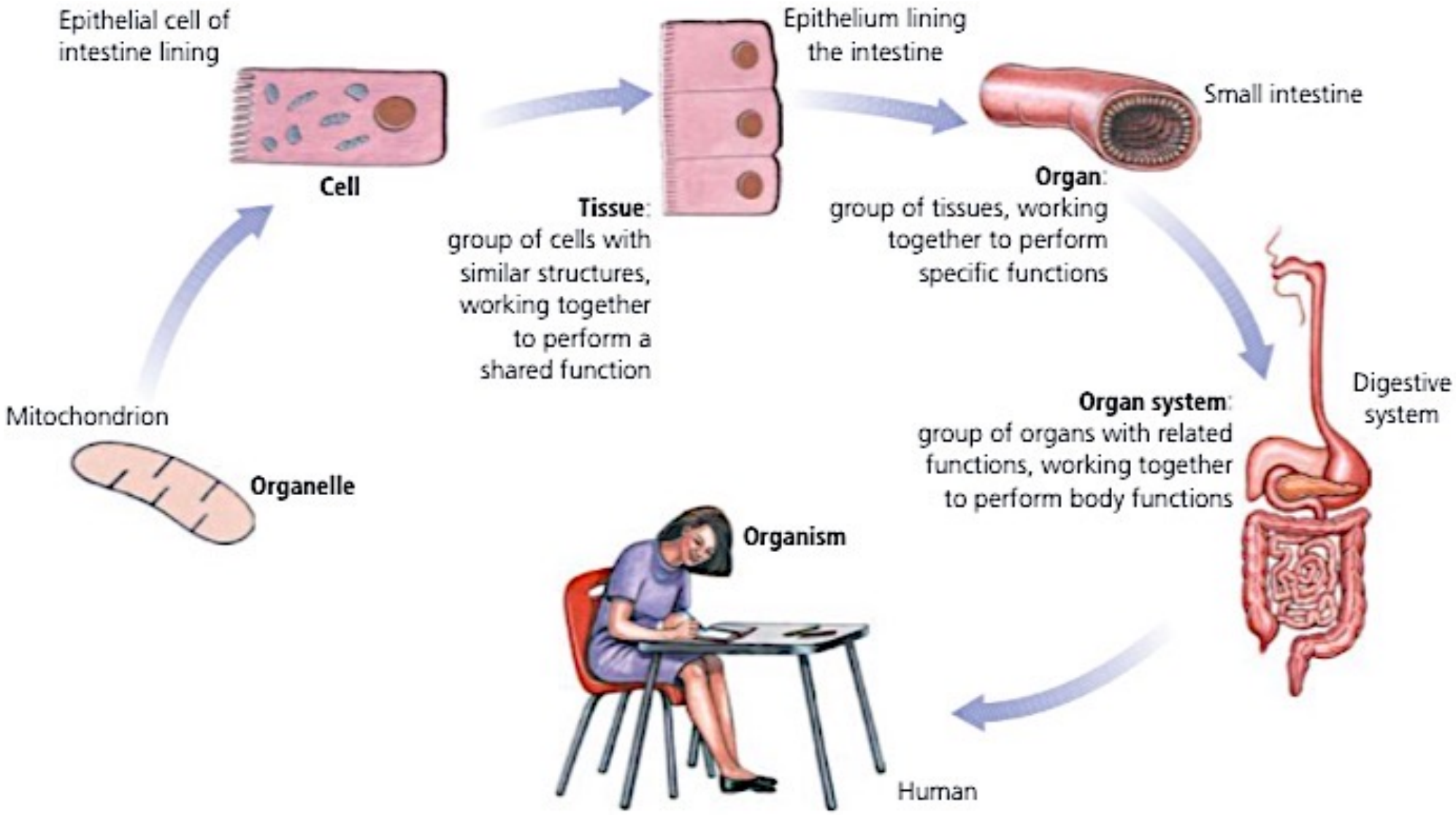
Leaf epidermis is made up of epidermal cells.

How are cells organised to form an organism?

Organ

- An **organ** consists of more than one kind of tissue, working together to perform a specific function.
- For example:
  - The stomach contains gland tissue, muscle tissue and nerve tissue. These work together for the digestion of food.
  - The leaf contains mesophyll tissue, xylem tissue and phloem tissue. These work together for plant nutrition and transport.





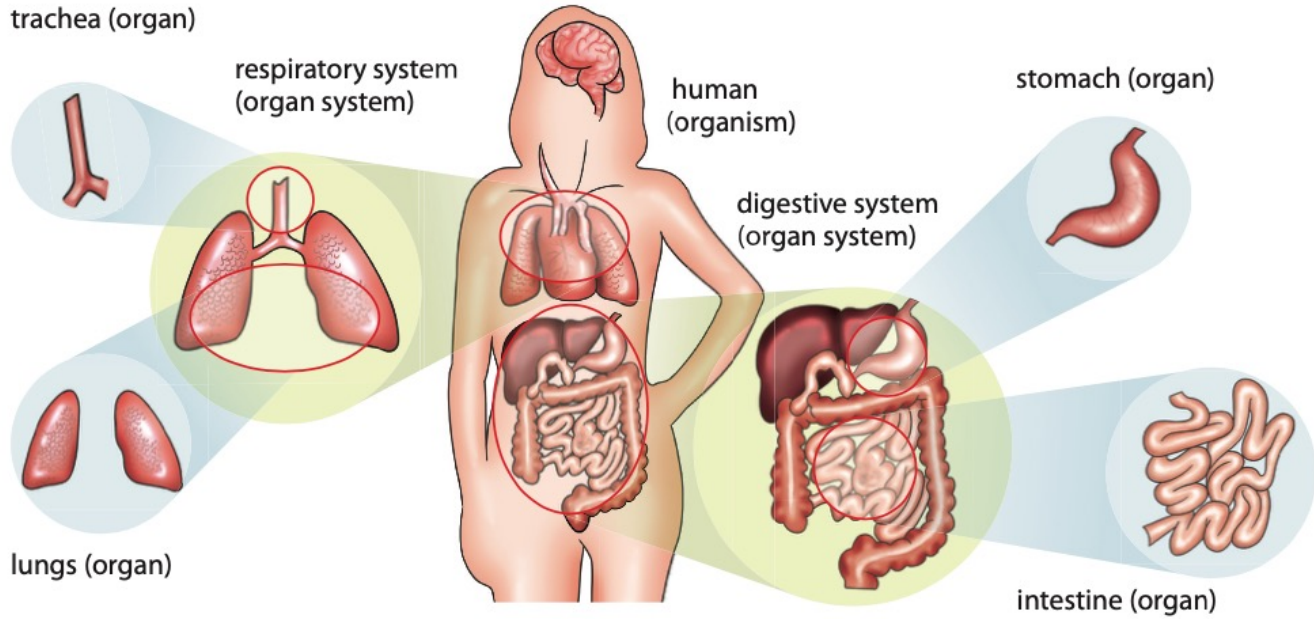
How are cells organised to form an organism?

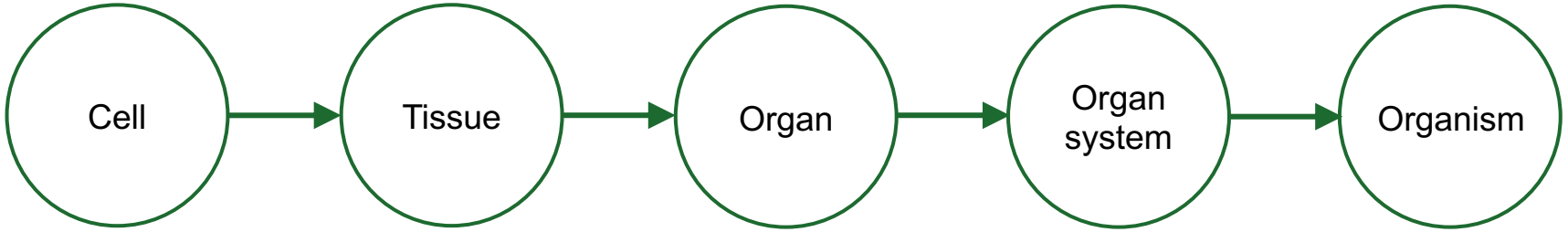
Organ system

- An **organ system** is made up of several organs working together for a common purpose.

Organism

- Various organ systems together make up the entire body of an organism.



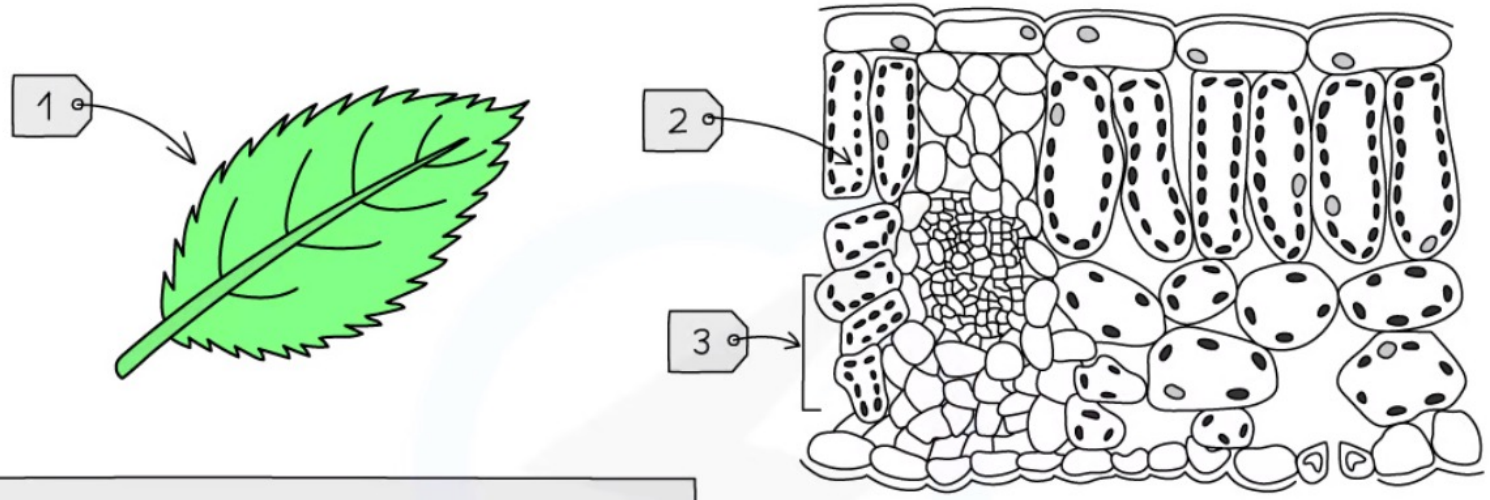


Examples of Organ Systems in Animals & Plants

ORGAN SYSTEM	ORGANS	TISSUE EXAMPLES
SHOOT SYSTEM	LEAF, STEM, FLOWER, FRUIT	– EPIDERMIS MESOPHYLL – XYLEM – PHLOEM
ROOT SYSTEM	ROOT, TUBER	– XYLEM – PHLOEM – GROUND TISSUE
DIGESTIVE SYSTEM	OESOPHAGUS, STOMACH, SMALL INTESTINE, LARGE INTESTINE	– MUSCLE – CONNECTIVE – NERVE – EPITHELIAL
CIRCULATORY SYSTEM	HEART, VEINS, ARTERIES	– MUSCLE – CONNECTIVE – NERVE – EPITHELIAL

IMMUNE SYSTEM	THYMUS, SPLEEN	– BONE MARROW
RESPIRATORY SYSTEM	TRACHEA, BRONCHI, LUNGS	– CONNECTIVE – MUSCLE – EPITHELIAL
EXCRETORY SYSTEM	LIVER, KIDNEY, SKIN, LUNGS	– MUSCLE – CONNECTIVE – EPITHELIAL – NERVE
NERVOUS SYSTEM	BRAIN, SPINAL CORD	– NERVE
REPRODUCTIVE SYSTEM	OVARY, CERVIX, UTERUS, VAGINA, TESTES, PENIS	– MUSCLE – CONNECTIVE – NERVOUS

THE DIAGRAMS SHOW A LEAF AND ITS INTERNAL STRUCTURE



WHAT ARE THE LEVELS OF ORGANISATION OF THE LABELLED STRUCTURES?

	1	2	3
A	CELL	TISSUE	ORGAN SYSTEM
B	ORGAN	CELL	TISSUE
C	ORGAN SYSTEM	TISSUE	CELL
D	TISSUE	CELL	ORGAN

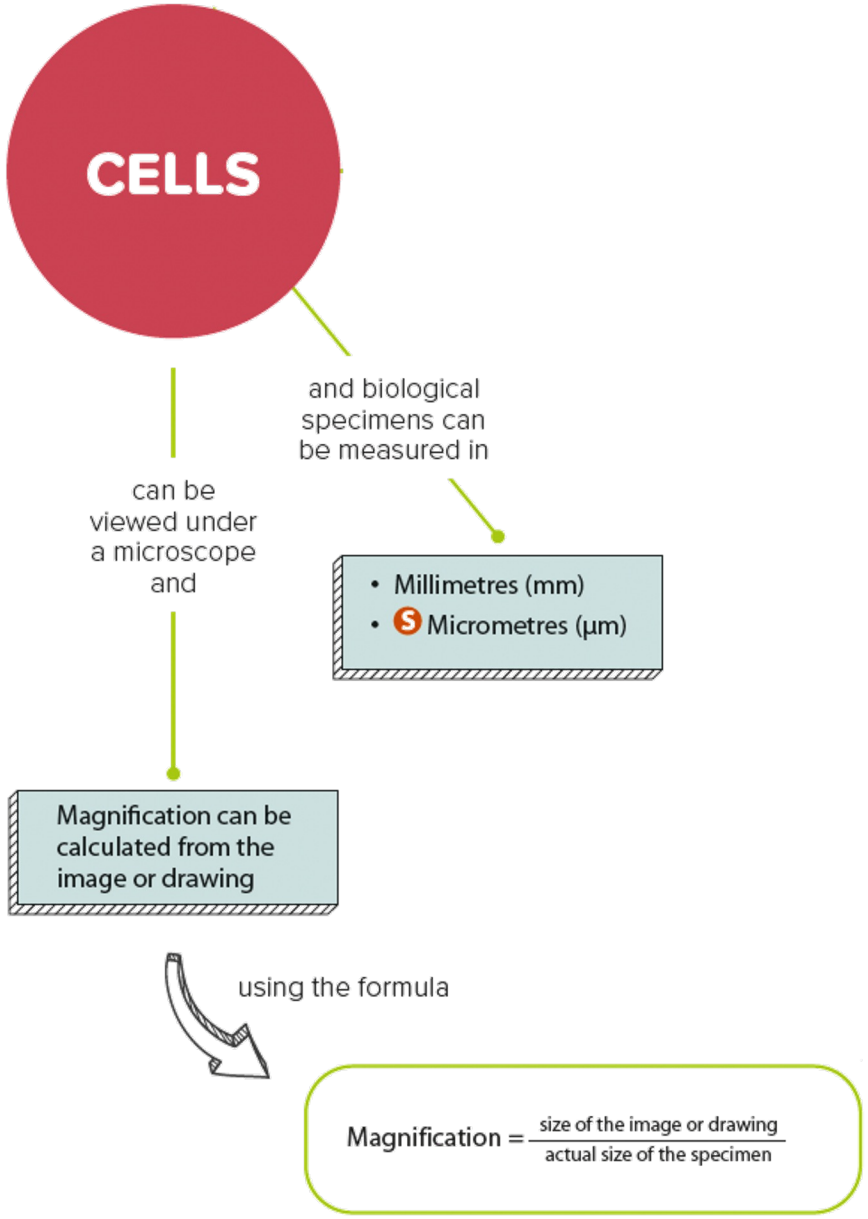
Exam Tip

Your syllabus requires you to identify the different levels of organisation in drawings, diagrams and images of unfamiliar material, ie structures you may not have seen before.In order to ensure the best chance of success, make sure you are very clear on **the difference between a cell, a tissue and an organ** and practise identifying these in past paper questions (they come up most frequently in the multiple choice paper).

2.3 Size of Specimens

In this section, you will learn the following:

- State and use the formula of magnification.
- Calculate magnification and the size of biological specimens in millimetres.
- (S) Convert measurements between millimetres and micrometres.



How do we calculate magnification?

- **Magnification** refers to how many times the image of a specimen is enlarged.
- Magnification = $\frac{\text{size of the image or drawing}}{\text{actual size of the specimen}}$

HELPFUL NOTES

Remember that magnification has no units

Worked Example 2A

Figure 2.17 shows the transverse section of a tomato fruit. The actual diameter of the tomato fruit is 50 mm. Calculate the magnification of the tomato fruit. Show your working.

Solution

$$\text{Magnification} = \frac{\text{size of the image or drawing}}{\text{actual size of the specimen}}$$

$$= \times \frac{40}{50}$$

$$= \times 0.8$$

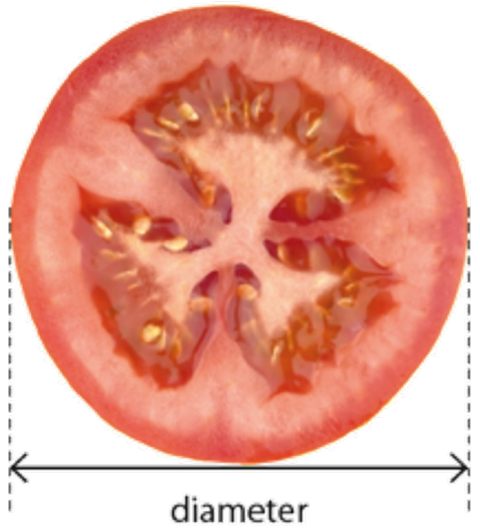


Figure 2.17 of Student's Book

How do we convert between micrometres and millimetres?

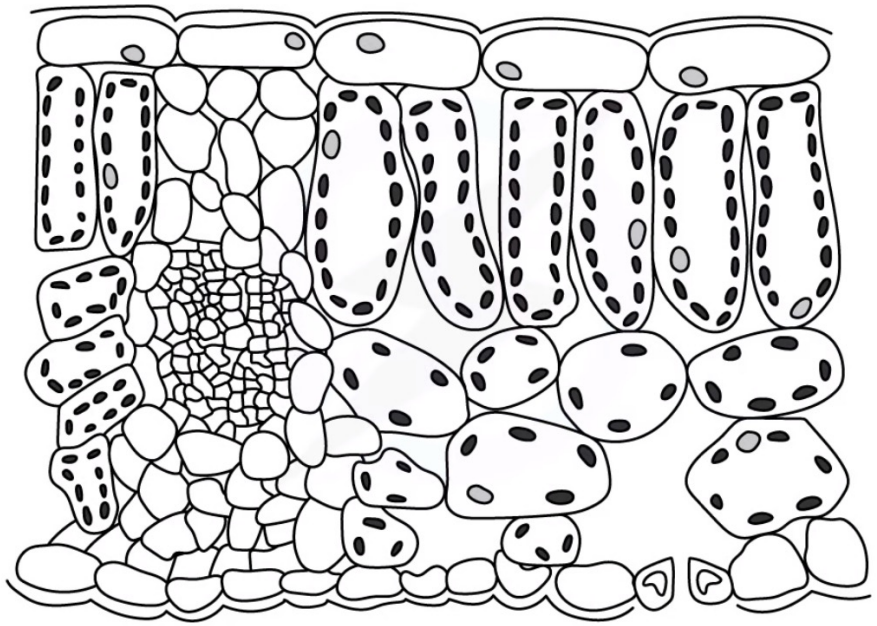
- There are 1000 μm in 1 mm.
- To convert from millimetres to micrometres, we multiply the value by 1000:

  1 mm = 1 × 1000 μm
- To convert from micrometres to millimetres, we divide the value by 1000:

  $1\ \mu m = \frac{1}{1000}\ mm$

UNIT	LENGTH IN mm
1 CENTIMETRE (cm)	10 mm
1 MILLIMETRE (mm)	1 mm
1 MICROMETRE (μm)	0.001 mm

THE ACTUAL THICKNESS OF THE LEAF BELOW IS 2000μm, BUT THE IMAGE SIZE OF THE LEAF IN THE DIAGRAM IS 50mm



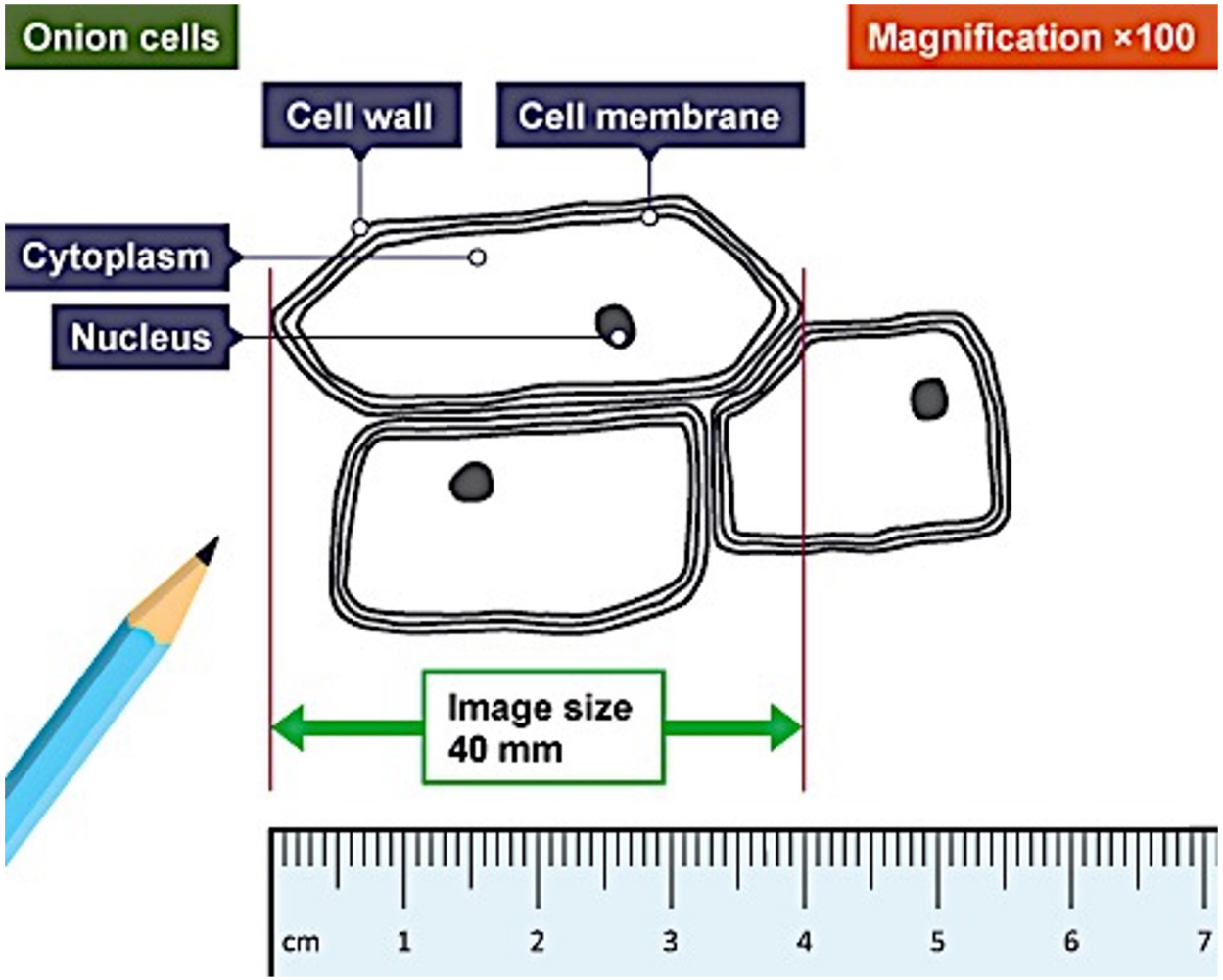
WHAT IS THE MAGNIFICATION OF THE DIAGRAM?

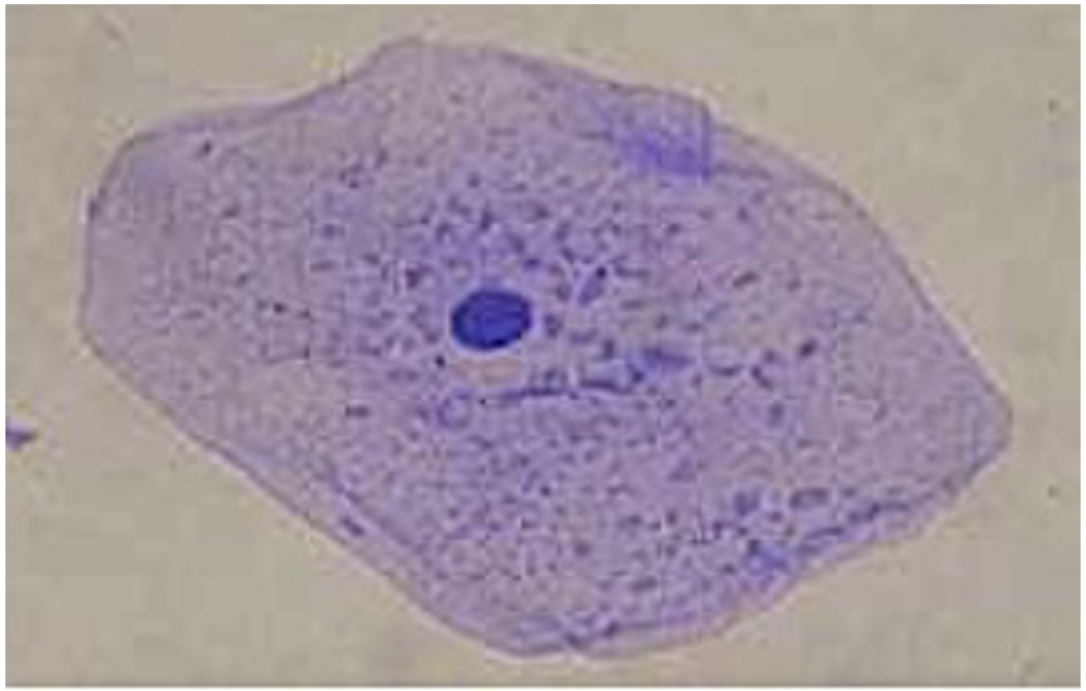
A ×0.025 B ×25 C ×100 D ×100 000

actual Size = $\frac{\text{image size}}{\text{magnification}}$

actual Size = $\frac{40 \text{ mm}}{100}$

actual Size = 0.4 mm

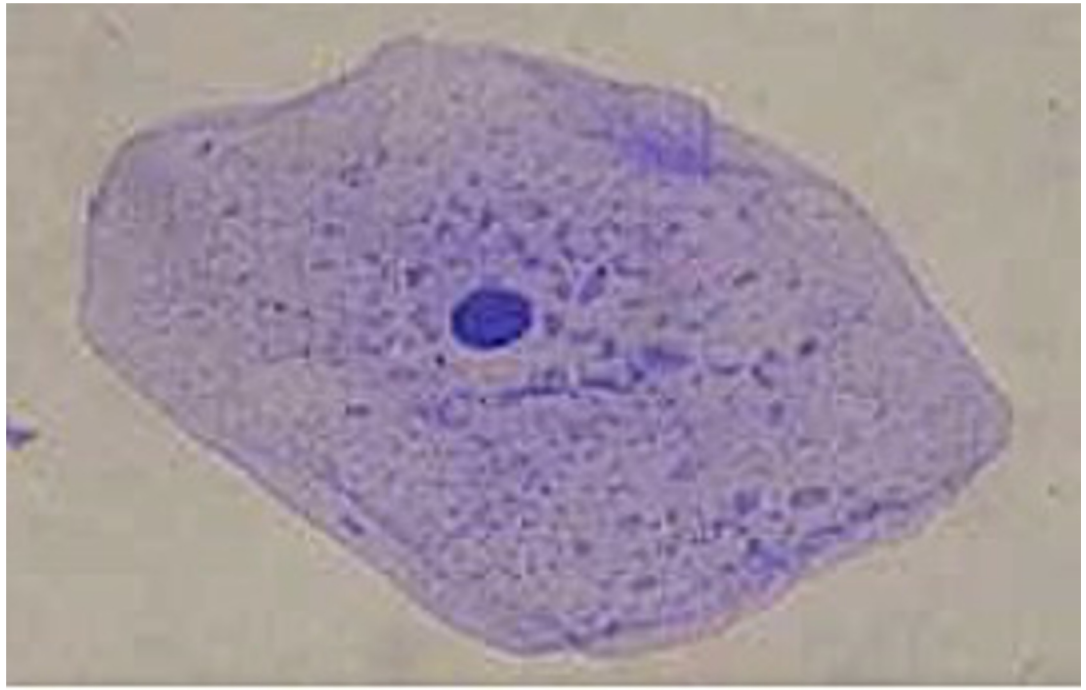




Magnification = $\frac{\text{image size}}{\text{actual size}}$

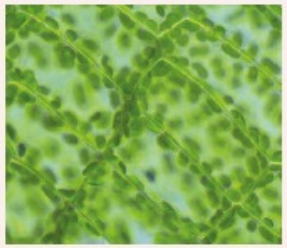
Magnification = $\frac{20\ \text{mm}}{60\ \mu\text{m}}$

Magnification = $\frac{20\ \text{mm}}{0.06\ \text{mm}}$

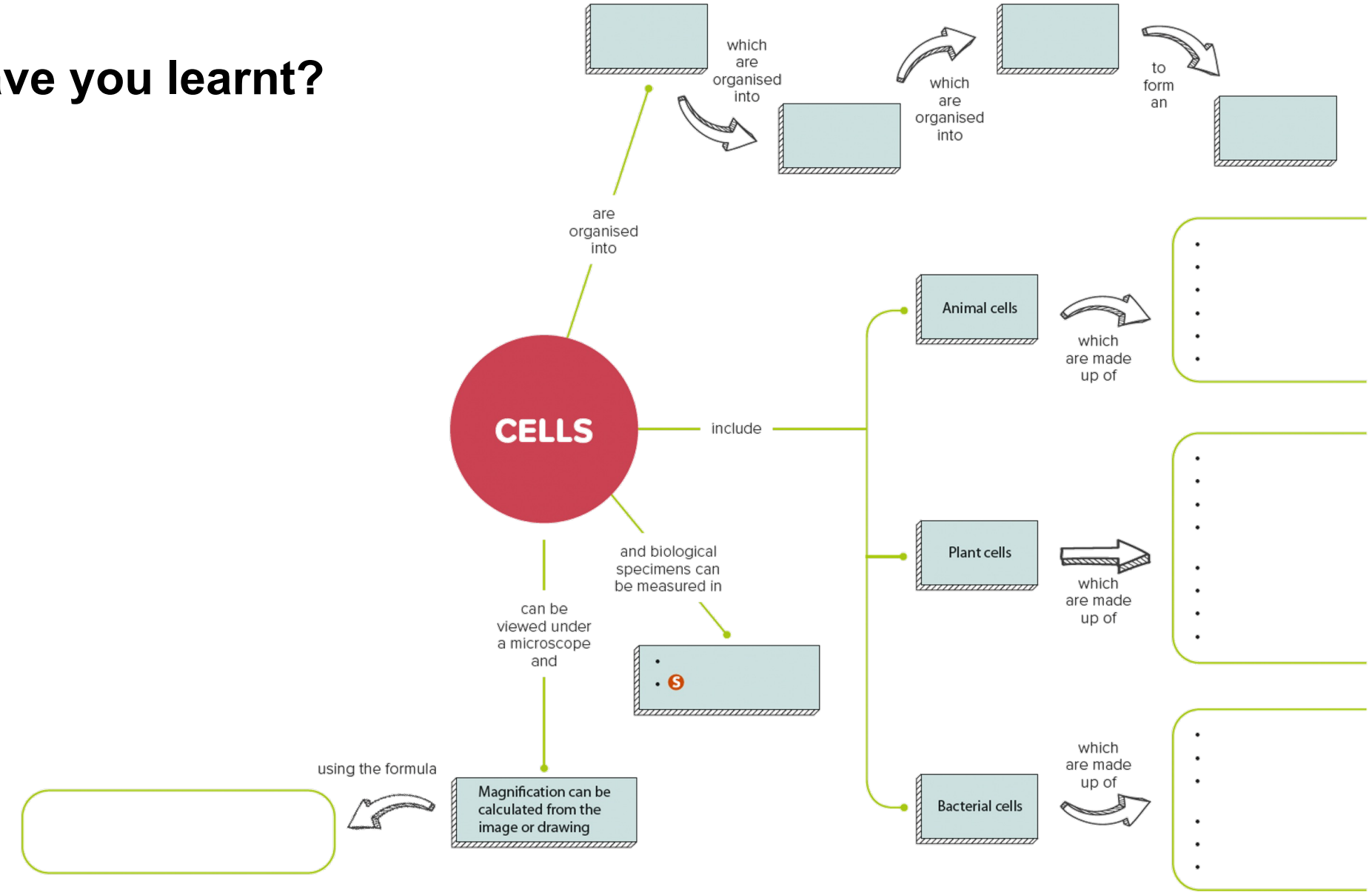


Let's Practise 2.2 and 2.3

Complete the table to describe how the cells have been adapted to carry out their functions.

Cells	Function	Important characteristic to serve the function well	How the characteristic helps the cells to carry out the function
(b) 	To absorb sunlight for photosynthesis		
(c) 	To deliver oxygen to all parts of the body		

What have you learnt?



What have you learnt?

Can you draw your own mind map?