

Cells, tissues and organelles

Revision notes · Common features of cells, tissues to organ systems, eukaryotic and prokaryotic ultrastructure, protein transport and recognising organelles in micrographs.

For Pearson Edexcel International AS Biology XBI11 and International A Level Biology YBI11. **A Level only** is IA2 content (Units 4 to 6), not needed for the International AS.

Cells, tissues and organelles Spec 3.1-3.6

Features common to all living cells Spec 3.1

The **cell theory** says that all living organisms are made of cells and that the cell is the basic unit of life. Cells vary hugely in size and shape, but they share some common features.

- a **cell surface membrane** that controls what enters and leaves the cell
- **cytoplasm**, the gel-like fluid in which metabolic reactions take place
- **genetic material**, which is DNA, carrying the instructions for making proteins
- **ribosomes**, the sites of protein synthesis (translation)
- metabolic reactions, which are controlled by enzymes and use ATP as the energy currency

The two basic cell types		
Feature	Eukaryotic cell	Prokaryotic cell
DNA	Linear, in a nucleus with a nuclear envelope	Circular, free in the cytoplasm (not in a nucleus)
Membrane-bound organelles	Present (for example mitochondria, Golgi apparatus)	Absent
Ribosomes	Larger (80S)	Smaller (70S)
Examples	Animal, plant and fungal cells	Bacteria

Exam tip: A common-features question wants the feature and what it does. Write '**ribosomes, which make proteins**', not just '**ribosomes**'.

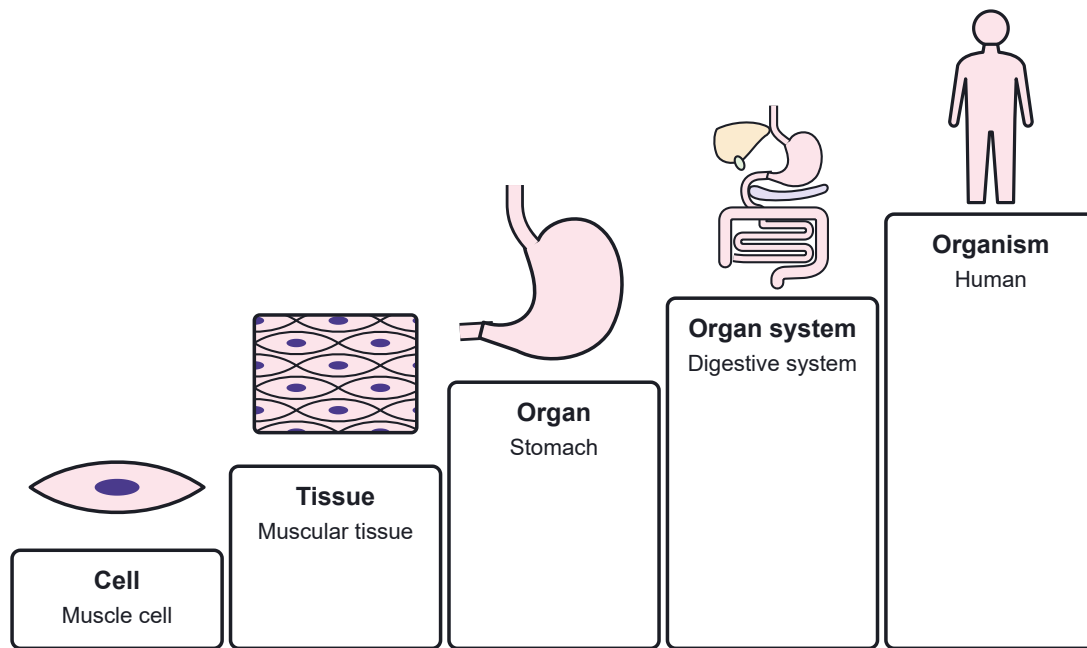
Tissues, organs and organ systems Spec 3.2

Cells in a multicellular organism are specialised for particular jobs. They are organised into levels of increasing complexity.

1. A **tissue** is a group of similar cells (with any extracellular material they make) that work together to perform a particular function, for example squamous epithelium, cardiac muscle or xylem.
2. An **organ** is a group of different tissues working together to perform a particular function, for example the stomach (epithelium, muscle, glandular and connective tissue) or a leaf.
3. An **organ system** is a group of organs working together to carry out a major body function, for example the digestive system (stomach, small intestine, pancreas, liver) or the circulatory system.

Specialisation means each cell type can be adapted to one task, and the tasks are coordinated, so the organism as a whole is more efficient than a collection of identical unspecialised cells. The same pattern

of organisation applies to animals and to plants.



Cells form **tissues**, tissues form **organs**, and organs form **organ systems**.

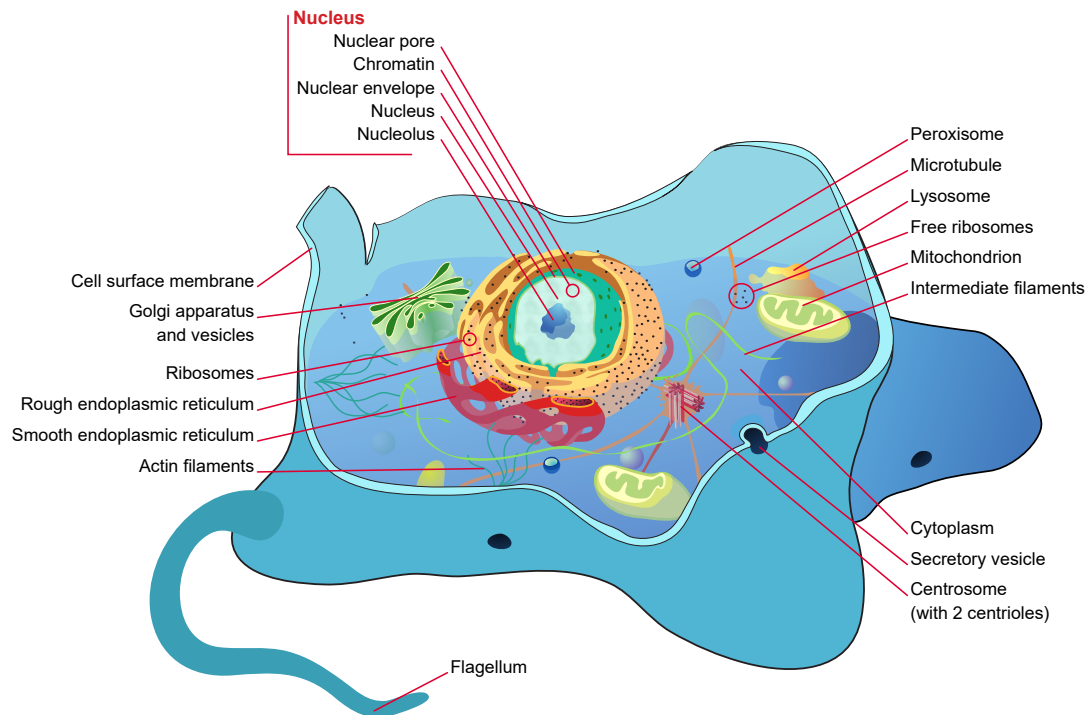
Ultrastructure of eukaryotic cells Spec 3.3

Ultrastructure is the fine detail of a cell that can only be seen with an electron microscope. The organelles you need to know are summarised below.

Eukaryotic organelles: structure and function

Organelle	Structure	Function
Nucleus	Surrounded by a double membrane (nuclear envelope) with nuclear pores; contains chromatin (DNA wound round histone proteins)	Stores genetic information; DNA is transcribed here; pores let mRNA out and proteins in; site of DNA replication
Nucleolus	Dense, darkly staining region inside the nucleus, with no membrane	Makes ribosomal RNA (rRNA) and assembles it with proteins into ribosome subunits
Ribosomes	Tiny, made of rRNA and protein, no membrane; free in the cytoplasm or attached to rough ER	Site of protein synthesis (translation)
Rough endoplasmic reticulum (rER)	System of flattened, membrane-bound sacs (cisternae) continuous with the nuclear envelope, with ribosomes on the outer surface	Proteins made on its ribosomes enter the lumen, where they are folded and transported
Smooth endoplasmic reticulum (sER)	Network of membrane-bound tubules with no ribosomes	Synthesises and transports lipids and steroids (for example steroid hormones)
Mitochondrion	Double membrane; inner membrane folded into cristae; fluid matrix inside	Site of aerobic respiration, producing ATP; cristae give a large surface area for the enzymes of the electron transport chain
Centrioles	A pair of short hollow cylinders at right angles to each other, each made of microtubules; found in animal cells	Form the spindle (organise the microtubules) during nuclear division
Lysosome	Small, round, single-membrane-bound sac, made by the Golgi apparatus, containing hydrolytic (digestive) enzymes	Digests worn-out organelles and material brought into the cell, such as bacteria engulfed by phagocytosis; can break down the cell itself after death
Golgi apparatus	A stack of flattened, membrane-bound sacs with vesicles budding from the edges	Modifies proteins (for example adds carbohydrate to make glycoproteins), packages them into vesicles, and makes lysosomes

Common mistake: Mitochondria do not 'make energy'. Say they produce ATP by aerobic respiration, which is the immediate source of energy for the cell.



Ultrastructure of a generalised animal cell. Only some animal cells have a flagellum.

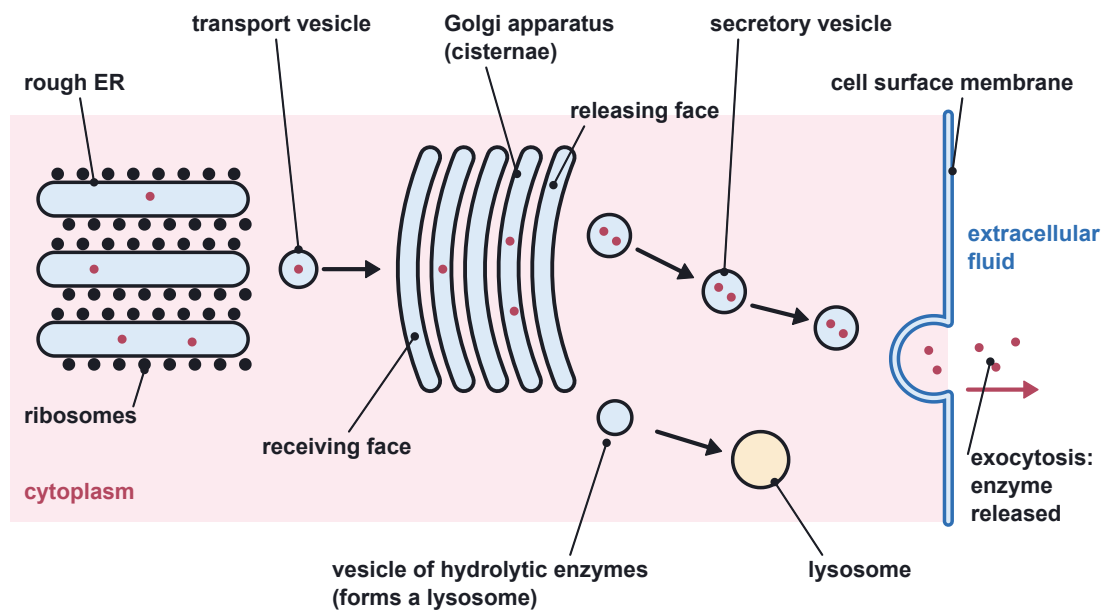
Image: Mariana Ruiz Villarreal (LadyofHats), Public domain, via Wikimedia Commons

Protein transport and extracellular enzymes Spec 3.4

Proteins that are to leave the cell, such as **extracellular enzymes** (digestive enzymes released by pancreatic cells are an example), follow a set route through the cell.

1. The gene is transcribed in the nucleus and the mRNA leaves through a nuclear pore.
2. The mRNA is translated by ribosomes on the **rough ER**. The new polypeptide passes into the lumen of the rER, where it is folded into its three-dimensional shape.
3. Small sections of rER bud off to form **transport vesicles**, carrying the protein to the Golgi apparatus.
4. The vesicles fuse with the Golgi apparatus. Here the protein is modified (for example carbohydrate is added to make a glycoprotein, or the protein is trimmed) and sorted.
5. The modified protein is packaged into **secretory vesicles** that pinch off from the Golgi apparatus.
6. Secretory vesicles move to the cell surface membrane (along the cytoskeleton), fuse with it and release the protein outside the cell by **exocytosis**.

The Golgi apparatus also packages hydrolytic enzymes into vesicles that remain in the cell as lysosomes. Cells that secrete a lot of protein, such as enzyme-secreting cells of the pancreas, have extensive rER and many Golgi stacks.



Route of a secreted protein: rough ER → transport vesicle → Golgi apparatus → secretory vesicle → exocytosis.

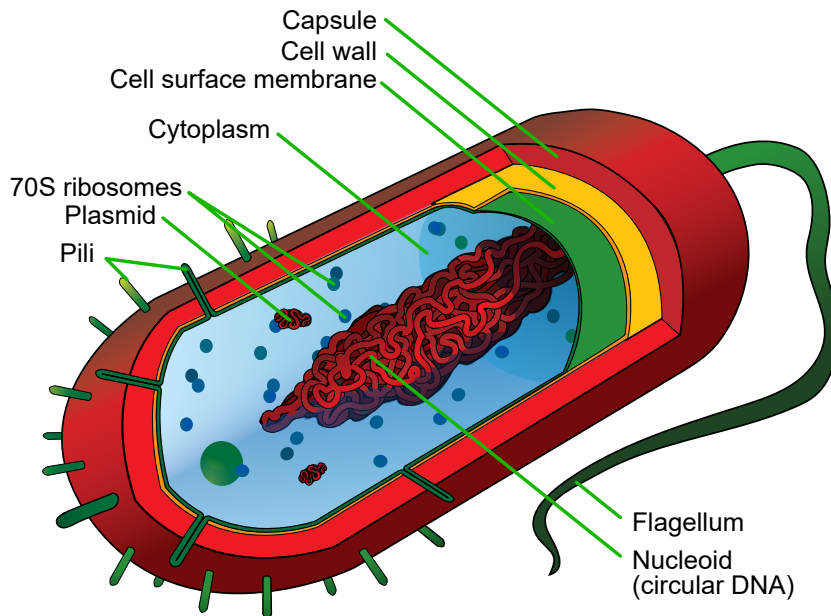
Exam tip: Give the route in the correct order (rER, transport vesicle, Golgi apparatus, secretory vesicle, cell surface membrane) and say what happens at each stage.

Ultrastructure of prokaryotic cells Spec 3.5

Prokaryotic cells (bacteria) are much smaller than eukaryotic cells and are structurally simpler. As well as a cell surface membrane and cytoplasm, you need to know these structures.

Structures in a prokaryotic cell		
Structure	Description	Function
Cell wall	Made of peptidoglycan (a polymer of sugars and amino acids)	Maintains the shape of the cell and prevents it bursting by osmosis
Capsule	Slimy layer of polysaccharide outside the cell wall (not all bacteria have one)	Protects the cell from drying out and from attack by the immune system, and helps cells stick to surfaces
Plasmid	Small loop of circular DNA, separate from the main DNA; may be many copies	Carries extra genes, for example for antibiotic resistance; can be passed to other bacteria
Flagellum	Long, thin, whip-like protein filament, rotated by a motor in the cell wall and membrane	Propels the cell (movement)
Pili	Short, thin protein hairs on the surface	Attach the cell to surfaces and to other cells; a special pilus allows DNA transfer between bacteria
Ribosomes	70S: smaller than eukaryotic 80S ribosomes	Protein synthesis
Circular DNA	A single, closed loop, not wound around histones, lying free in the cytoplasm in a region called the nucleoid	Carries the genes the cell needs

Common mistake: Prokaryotic DNA is not 'in a nucleus'. Say it is circular and lies free in the cytoplasm, with no nuclear envelope.



A prokaryotic cell: circular DNA free in the cytoplasm, **no nucleus** and no membrane-bound organelles.

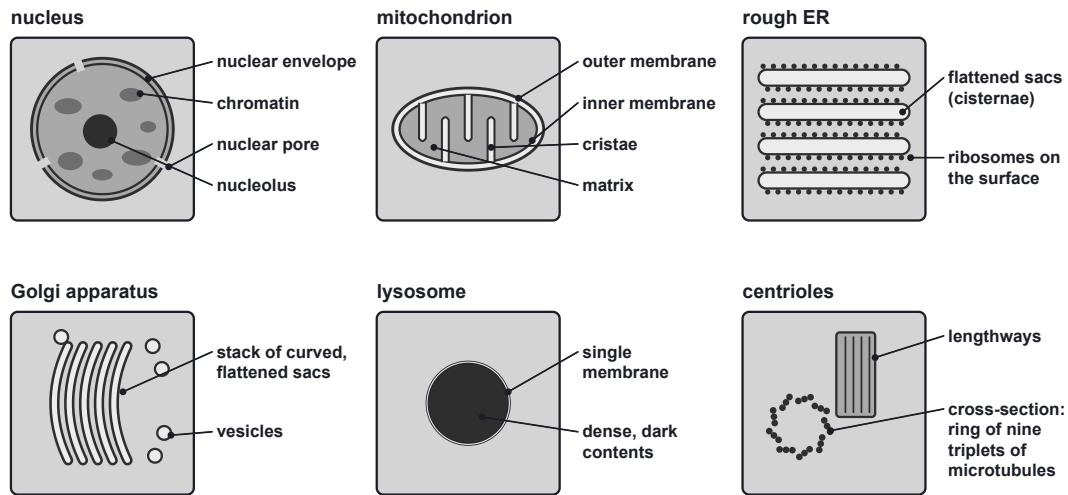
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Recognising organelles in electron micrographs Spec 3.6

Electron micrographs are black and white (any colour is added afterwards), and organelles are cut in section, so the shapes you see depend on how they were sliced. Look for these features.

How to recognise organelles in a transmission electron micrograph	
Organelle	What you see
Nucleus	Large, round or oval, with a double membrane broken by pores; dark patches of chromatin; a darker, denser nucleolus
Mitochondrion	Small oval or rod shape with a double membrane; the inner membrane folded into cristae, showing as lines or fingers inside
Rough ER	Parallel flattened sacs, often continuous with the nuclear envelope, with many tiny black dots (ribosomes) on the outer surface
Smooth ER	Branching tubules or sacs with no dots on the surface
Golgi apparatus	A stack of curved, flattened sacs, often with small vesicles near the ends
Lysosome	Small, round, single membrane, with dense, evenly dark contents
Ribosomes	Very small black dots, free or on rER
Centrioles	A pair of short cylinders at right angles: one is seen as a ring of microtubules in cross-section and the other lengthways

Exam tip: Describe what you see rather than guessing: 'double membrane with folded inner membrane' earns the mark for mitochondrion, and you can use it to identify the organelle.



Drawings of organelles as they appear in transmission electron micrographs (not to scale)

What to look for in a **transmission electron micrograph**.

Quick check

1. Name three features found in all living cells.
2. What is the function of the nucleolus?
3. Name the organelle that makes lysosomes.
4. How does prokaryotic DNA differ from eukaryotic DNA?
5. What are the features of a mitochondrion in an electron micrograph?

Quick check answers

Cells, tissues and organelles

- 1 . Any three of: cell surface membrane, cytoplasm, DNA (genetic material), ribosomes, enzyme-controlled metabolic reactions.
- 2 . It makes ribosomal RNA and assembles ribosome subunits.
- 3 . The Golgi apparatus.
- 4 . It is circular, not associated with histones and not enclosed in a nucleus.
- 5 . Oval shape, a double membrane and an inner membrane folded into cristae.