Eukaryotic cell organisation

Membrane-bound compartments allow different processes to operate under suitable conditions. Relate each structure to its function rather than memorising names alone.

1. CELL SURFACE MEMBRANE

A phospholipid bilayer with proteins forms a selectively permeable boundary. It regulates exchange, contains receptors for signalling, and participates in vesicle fusion. A plant cell wall does not replace this membrane.

2. NUCLEUS AND NUCLEAR ENVELOPE

The nucleus contains chromatin: DNA associated with proteins. Its double-membrane envelope separates nuclear contents from cytoplasm. Nuclear pores regulate exchange, including export of mRNA and ribosomal subunits.

3. NUCLEOLUS

A dense region inside the nucleus, not a membrane-bound compartment. It produces ribosomal RNA and assembles ribosomal subunits. These subunits leave through nuclear pores and join during protein synthesis.

4. RIBOSOMES

Small particles of rRNA and protein, made of two subunits and not surrounded by a membrane. They translate mRNA into polypeptides. Free ribosomes make many cytosolic proteins; ER-bound ribosomes make proteins entering the secretory pathway.

KEEP THE RIBOSOME LOCATIONS STRAIGHT

80S: free in the eukaryotic cytoplasm or attached to rough ER.

70S: inside mitochondria and chloroplasts, as specified for this course.

S describes sedimentation behaviour, not a length or a subunit sum.

Cambridge Biology 9700 syllabus: section 1.2, learning outcome 1, pp. 15-16.

Build, process and export

Secreted proteins move through a connected pathway. Ribosomes make the polypeptide; membranes and vesicles organise its processing and delivery.

A SECRETED PROTEIN: FOLLOW THE CARGO



Transport vesicles also carry cargo from the ER to the Golgi.

1. ROUGH ENDOPLASMIC RETICULUM

Flattened membrane sacs, called cisternae, have ribosomes on their cytoplasmic surface. Newly made proteins enter the ER for folding and initial processing. Transport vesicles carry selected cargo to the Golgi.

2. GOLGI BODY AND VESICLES

Stacks of flattened sacs receive, modify and sort cell products. Vesicles bud off with selected cargo. Secretory vesicles fuse with the cell surface membrane, releasing contents outside by exocytosis.

3. SMOOTH ENDOPLASMIC RETICULUM

A membrane network without attached ribosomes. It synthesises lipids; in appropriate cells it also contributes to detoxification and calcium storage. Smooth ER is not the main site of protein translation.

4. LYSOSOMES

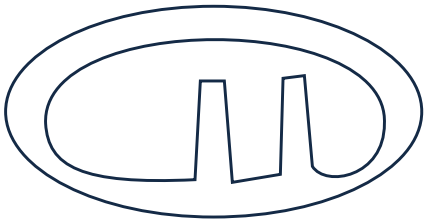
Single-membrane compartments contain hydrolytic enzymes in an acidic interior. They digest material delivered by vesicles and recycle worn cell components. The surrounding membrane separates digestion from the cytosol.

Further reading: OpenStax Biology 2e, 4.4 The Endomembrane System and Proteins.

Energy and plant-cell structures

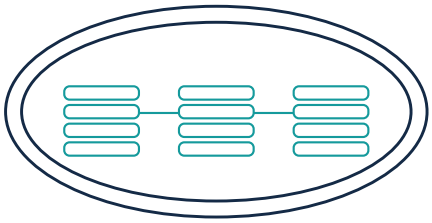
Mitochondria occur in plant and animal cells. Chloroplasts occur in photosynthetic plant tissues; a plant cell is not required to contain chloroplasts.

MITOCHONDRION



Double membrane; the inner membrane folds into cristae, increasing area for electron transport and ATP synthesis. Matrix enzymes support aerobic respiration.

CHLOROPLAST



Double envelope; chlorophyll-containing thylakoids form stacks called grana. Light reactions occur on thylakoids; carbon fixation occurs in the stroma.

Both have small circular DNA and 70S ribosomes. Schematics are not to scale.

1. CELLULOSE CELL WALL

Cellulose microfibrils provide tensile strength and resist excessive expansion as water enters. The wall supports the cell; selective exchange is controlled mainly by the cell surface membrane beneath it.

2. LARGE PERMANENT VACUOLE AND TONOPLAST

The vacuole contains cell sap, including dissolved ions and other solutes. Its membrane, the tonoplast, regulates exchange with cytoplasm. Water in the vacuole contributes to turgor pressure against the wall.

3. PLASMODESMATA

Membrane-lined cytoplasmic channels cross plant cell walls, allowing transport and communication between neighbouring cells.

Cambridge Biology 9700 syllabus: eukaryotic structures and functions, pp. 15-16.

Surface, movement and evidence

Some important cell structures are not membrane-bound organelles. Identify the visible feature, explain what it enables, then connect it to the cell's role.

1. MICROTUBULES

Hollow tubulin tubes form part of the cytoskeleton. They help maintain organisation, act as tracks for intracellular transport, and form spindle fibres that move chromosomes.

2. CENTRIOLES

Cylinders with nine triplets of microtubules. In many animal cells, a pair lies in the centrosome, which organises microtubules and contributes to spindle formation.

3. CILIA

Membrane-covered projections containing microtubules. Motile cilia usually have a 9 + 2 arrangement and beat to move fluid or material across the cell surface, such as mucus in airways.

4. MICROVILLI

Small cell surface projections supported by actin filaments. They increase membrane surface area for absorption, for example in the small intestine. They do not beat like motile cilia.

USE STRUCTURE AS EVIDENCE OF FUNCTION

Extensive rough ER + Golgi	Consistent with high production and secretion of proteins.
Many mitochondria	Consistent with high demand for ATP.
Dense microvilli	Consistent with a large surface area for absorption.

Use organelle abundance with the specimen's context: it is supporting evidence, not proof.
Cambridge Biology 9700 syllabus: outcome 1.2.1. Structure-function examples by Jimlaoshi.