AP BIOLOGY | UNIT 2 | TOPICS 2.9, 2.10

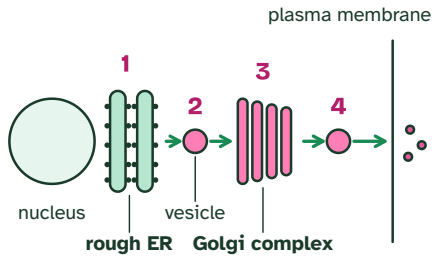
REVISION ON TWO PAGES

A cell of *compartments*

What to know, what to draw and what to say. Nothing else.

THE ONE IDEA

Internal membranes keep reactions apart and add surface for them. Mitochondria and chloroplasts began as free-living prokaryotes.



A protein for export. Once inside the ER it never crosses another membrane.

2.9.A START HERE

Membranes make *compartments*

- Membranes inside a eukaryotic cell divide it into compartments, each with its own enzymes and conditions: **compartmentalization**.
- Compartments **keep apart** reactions that would interfere, and hold enzymes and substrates **close together**, so they meet more often and reactions run faster.
- The **endomembrane system** passes membrane and cargo between its parts: the nuclear envelope, ER, Golgi complex, lysosomes, vacuoles and plasma membrane.

THE ROUTE OF A SECRETED PROTEIN

1. **Rough ER** makes it, threads it inside
2. **Vesicle** carries it to the Golgi
3. **Golgi** modifies it, sorts it
4. **Vesicle** fuses: exocytosis

2.9.A THE LYSOSOME

A safe place to *digest*

- A **lysosome** holds hydrolytic enzymes that digest proteins, fats, nucleic acids and carbohydrates, in an acid interior.
- Loose in the cytoplasm they would digest the cell. Inside membrane they break down a captured bacterium or a worn-out organelle, and the products go back to the cell.
- One compartment, two jobs: it keeps the enzymes apart and gives them the pH they need.

pH 5 inside a lysosome

pH 7.2 in the cytoplasm

2.9.A THE NUCLEUS

Genes behind an *envelope*

- The **nuclear envelope**, a double membrane, separates the DNA from the cytoplasm, where proteins are made.
- **Nuclear pores** let mRNA out and proteins in. Only finished mRNA leaves for the ribosomes.
- So in a eukaryote, making mRNA and making protein happen in turn, in two places.

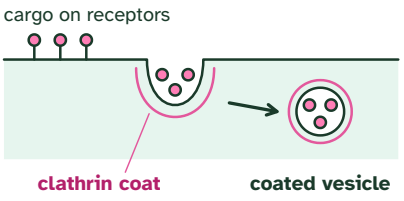
Prokaryote no nucleus
Ribosomes start translating an mRNA while it is still being made.

Eukaryote nucleus
mRNA is made and edited first, so the message is checked before any protein is made.

2.9.A VESICLES

Bubbles that *carry*

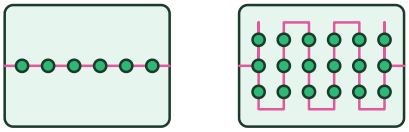
- A **vesicle** is a small sac of membrane. It buds off one compartment and fuses with another, so its cargo is never loose in the cytoplasm.
- Budding is not random: cargo binds receptors, and a coat protein bends the membrane into a pit.
- Vesicles leave the plasma membrane in endocytosis and join it in exocytosis.



2.9.B

Folded for *surface*

- Many reactions happen **on membranes**, because their enzymes are built into the membrane. The amount of membrane then limits the rate.
- Folding packs more membrane, and more enzymes, into the same volume: **more surface area**.
- Internal membranes help in two ways: they **minimize competing interactions** and give reactions more surface to happen on.



MITOCHONDRION
Cristae
Carry the proteins that make most of the cell's ATP.

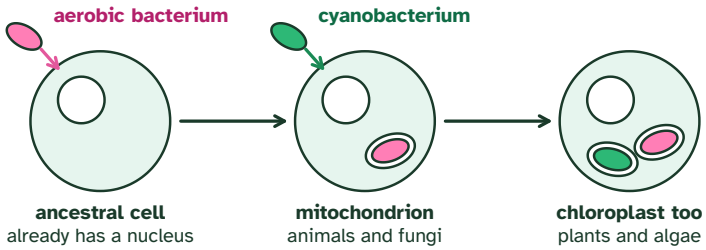
CHLOROPLAST
Thylakoids
Carry the pigments and proteins of the light reactions.

ENDOPLASMIC RETICULUM
Folded sheets
A large surface for making proteins and lipids.

2.10.A

The cell that *swallowed a bacterium*

- The theory of **endosymbiosis**: mitochondria and chloroplasts were once **free-living prokaryotes**.
- An ancestral cell, already with a nucleus, engulfed an **aerobic bacterium** and did not digest it. It used its host's food and supplied ATP: both gained. Over many generations it became the mitochondrion.
- Later some of these cells took in a photosynthetic **cyanobacterium** the same way: the chloroplast.



2.10.A THE EVIDENCE

Still *bacteria* inside

EVIDENCE	A FREE-LIVING BACTERIUM	A MITOCHONDRION OR CHLOROPLAST
Membranes	One plasma membrane.	**Two:** its own inner one, and an outer one from the vesicle that engulfed it.
DNA	One circular loop.	**Its own DNA:** a small circular loop, like a bacterium's.
Ribosomes	Small, prokaryote type.	**Its own ribosomes:** small, like a prokaryote's.
New ones	By binary fission.	**Only by dividing in two:** a cell cannot build one from scratch.
Job	Aerobic respiration; photosynthesis on the thylakoids of cyanobacteria.	**The same:** respiration on the inner membrane; photosynthesis on thylakoids.

Most of their genes have since moved to the nucleus, so neither can live on its own today.

One theory explains many separate observations

2.10.A

Two ways to *divide up the work*

- Prokaryotes generally have no membrane-bound organelles, but they are organized: they have **internal regions** with their own jobs.
- Eukaryotes partition the whole cell with **internal membranes**: one reason they can be so much larger.

Prokaryote by region
DNA gathers in the nucleoid. Ribosomes cluster where proteins are made. Some have internal membranes: folds of plasma membrane for respiration, thylakoids in cyanobacteria.

Eukaryote by membrane
A nucleus, an endomembrane system, mitochondria and, in plants and algae, chloroplasts: specialized compartments, each with its own conditions.

WATCH OUT

Five mistakes that *cost points*

- ✕ **The Golgi does not make proteins.** It receives them from the rough ER, modifies them and sends them on.
- ✕ **Compartments are not sealed boxes.** Membranes let some substances through and vesicles link them.
- ✕ **Folding does not make an organelle bigger.** It fits more membrane into the same volume.
- ✕ **Endosymbiosis is not about the nucleus or the ER.** It explains mitochondria and chloroplasts only.
- ✕ **A nucleoid is not a nucleus.** It is a region where the DNA gathers, with no membrane around it.

COVER THE SHEET

Can you *answer these?*

1. Describe two ways compartments help a cell.
2. Explain why lysosomal enzymes are kept inside a membrane.
3. Describe the route of a secreted protein out of a cell.
4. Explain why a bacterium can translate an unfinished mRNA.
5. Explain how cristae raise the rate of ATP production.
6. Describe how mitochondria are thought to have arisen.
7. Identify three features mitochondria share with bacteria.
8. Predict where a protein builds up if vesicles cannot fuse with the Golgi.

IN THE EXAM

Evidence, not the story: for endosymbiosis give a feature the organelle shares with bacteria (own circular DNA, own small ribosomes, division in two) and say what it shows.

GO FURTHER

Animated figures, a dry lab and a marked Check are in the full guide online.